Scientific and Technical Advisory Committee Review of Nutrient Input Estimation for the Chesapeake Bay Watershed Model

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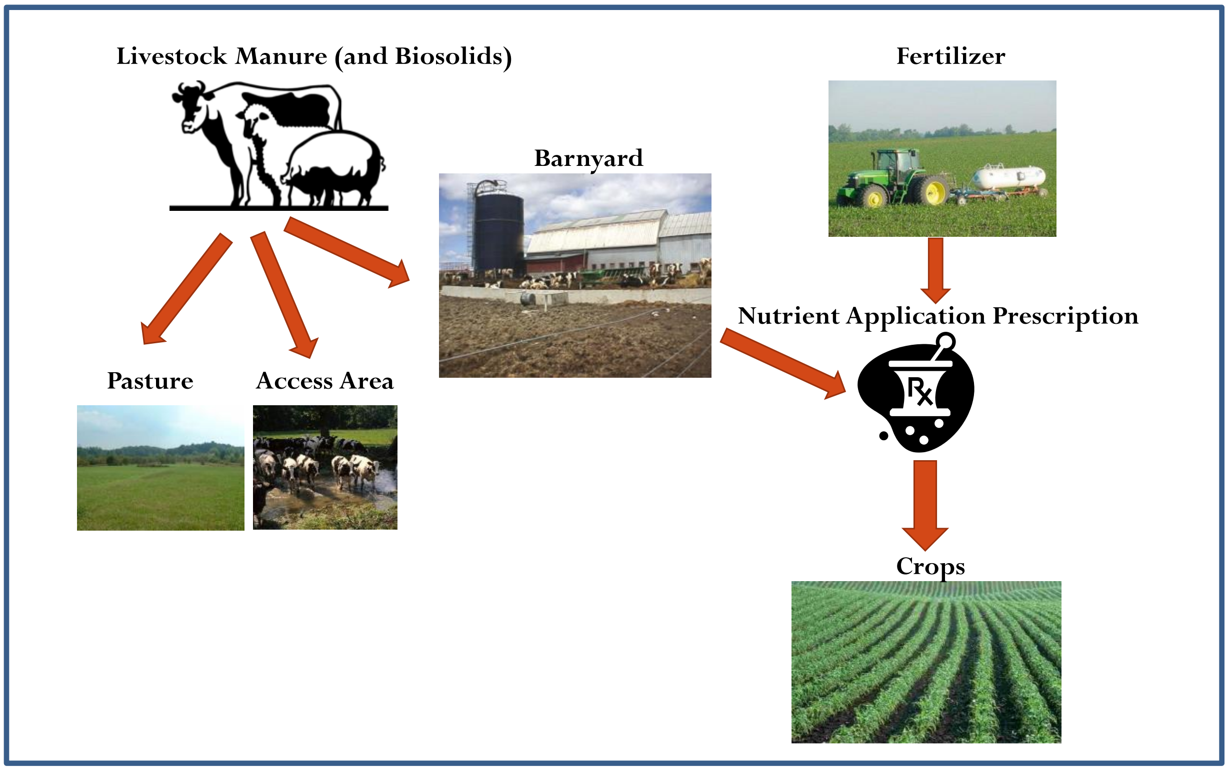

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- Marc Ribaudo, USDA-Economic Research Service, Chief, Conservation and Environment Branch; STAC Member
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We were also most appreciative of the comprehensive introduction to the review provided by Matt Johnston, CPBO Non-Point Source Analyst, as well as his prompt responses to various questions from individual Review Team members. Additionally, we would like to thank Matt, and other CBPO staff, Gary Shenk, and Gopal Bhatt, for their thoughtful and explanatory written responses to questions by Review Team members that arose during the review. CBPO staff cooperation was crucial in being able to produce the fast turn-around time called for in this review.

Finally, we would like to acknowledge Natalie Gardner, former CRC STAC Coordinator, who steered us through the initial hoops of getting the team organized, organizing the initial review team webinar, and securing the formal review request, all in the final days of her tenure with CRC before moving on to her current position as a Fisheries Program Support Specialist with NOAA. We also thank Rachel Dixon, current CRC STAC coordinator, for her important role in helping to bring this report to completion.

Executive Summary

The following is a report by an independent review panel assembled by the Scientific and Technical Advisory Committee (STAC) concerning the methods and documentation used by the Chesapeake Bay Partnership for evaluation of nutrient inputs to Phase 6 of the Chesapeake Bay Watershed Model.

The "STAC Review of Nutrient Input Estimation for the Chesapeake Bay Watershed Model" (previously referred to as the "STAC Review of Scenario Builder") has long been on the list of planned reviews by STAC to assist the Chesapeake Bay Program Office (CBPO) in the development of Phase 6 of the Chesapeake Bay Watershed Model. The final set of charge questions for this review was received by STAC from the CBPO Modeling Workgroup on June 21, 2016. That document is included as **Appendix A** of this report.

Several documents explaining the CBPO's proposed "Phase 6" approach to watershed modeling (hereafter referred to as "Phase 6 Watershed Model documents") were provided along with the charge questions. The originally provided documents are listed below with their associated version dates:

- Section 1 – Overview (04/19/2016)
- Section 3 – Terrestrial Inputs (02/01/2016)
- Section 5 – Land Use (02/01/2016)
- Section 6 – BMPs (02/01/2016)
- Appendix 3A – Terrestrial Inputs Appendices (no date given)

The review team was provided this documentation with the understanding that the documents were in draft form and subject to modification by decisions that were being made by the Chesapeake Bay Partnership concurrently with this review.

The review team consisted of Gene Yagow (Chair), Amy Collick, Marc Ribaudo, Wade Thomason, and Tamie Veith. The charge questions are listed below, with each question followed by relevant recommendations from the Review Team. Although the questions were not originally numbered, they have been numbered in this document to facilitate referencing.

This Executive Summary includes the major recommendations by the review team pertinent to all charge questions. Although only one major recommendation is listed for Question #5 in this summary, many additional editorial remarks and suggestions for improved readability of the documentation are included in the body of the report. Overall, the recommendations from the Review Team focused on increasing consistency in parameter evaluation across states, improvements in data sources, and modifications to data transformations and assumptions.

Recommendations

Question #1: Given the state of available manure and fertilizer data, please comment on the overall appropriateness of the methods used to estimate total manure and fertilizer available for application to agricultural lands.

The Review Team felt that the methods used to estimate total manure and litter seemed reasonable and defensible in that they are using the best available information from local cooperators. The flow chart in Figure 3-3 of the documentation was particularly helpful in visualizing the manure application process and the various estimation components. Many manure application components relied on well-founded procedures used by USDA-NRCS for estimating animal numbers, recoverable fractions of manure, and nutrient content. Since the methods to estimate total fertilizer were undergoing concurrent evaluation through additional alternative model runs, few of our comments directly addressed this aspect. The methods used to determine timings of fertilizer and manure applications were based on local state application data which we agree is the best source of data, though we did not agree with all of the data transformations. The use of a 3-yr moving average by state, the distribution of state populations based on Census of Agriculture (CoA) data, the cross-check with NASS production numbers, and the ASAE recommended nutrient species concentrations by livestock type, all seem appropriate and well-reasoned. Our recommendations related to this question focus on improving the details for distributing nutrient inputs across the landscape and in estimating temporal contributions from some of the nutrient phases.

1. We recommend that a comparative analysis of nutritive content at different stages of decomposition and application be performed across animal types to evaluate volatilization in the storage process and under typical best management practices (BMPs).
2. The current 'Scenario Builder' approach assumes zero nitrate nitrogen is available in animal manure. We recommend that this assumption be reviewed. Chastain et al. (2001) found that "the amount of nitrate-N can be significant in poultry litter that has gone through several 'heats' in a stacking shed. Manure stored in stacking sheds should be tested for nitrate-N in addition to ammonium-N, and organic-N". Nitrogen can transform speciation quickly, and while ammonium may be the most common form of inorganic N in manure, it can be oxidized rapidly to nitrate.
3. Mineralization of organic nutrients in manure transforms previously unavailable nutrients into forms that can be used for plant uptake. We recommend that the contribution of manure N mineralization from previous years' applications be credited to the system and the current year crop N demand consequently reduced.
4. Information for separating manure into areas of deposition is provided by jurisdictions. We recommend that a review of inputs be conducted to ensure relative consistency

among the states, and that any differences in values among states be explained and documented.

5. Direct deposition of manure on pasture is currently assumed to not meet any portion of the nutrient needs of pasture. While this may have made some sense historically prior to the widespread use of nutrient management, this assumption is now suspect. We recommend that some fraction of the direct deposition be counted towards meeting the "crop needs" of the pasture, perhaps evaluated from recent credits given to this source in nutrient management plans based on P. In this regard, and although the associated documentation was not provided as part of this review, we have observed from results of the alternative Beta3A scenario that many counties already have amounts of direct deposition on pasture in excess of their "crop needs", without any applications from any other source.
6. We recommend that efforts to continually refine the values of manure nutrients in storage be encouraged in order to improve national excreted N and P values.
7. Since storage and handling losses are some of the most well-documented and understood losses, we recommend calculating storage and handling losses (and perhaps nutrient reductions due to feed additives), before calculating ammonia losses.
8. The current use of crop application curves to allocate excess manure ignores the fact that for many farms, manure is actually spread first on land operated by the facility. On most farms, vegetables are not likely to be grown in conjunction with those crops most associated with animal operations, such as corn, soybeans, and alfalfa. We recommend that the crop application curve procedure be modified with the Economic Research Service's analyses of Census of Agriculture data to incorporate consideration of crops grown within animal operation systems in its analysis of manure distribution within the Chesapeake Bay watershed (http://www.ers.usda.gov/publications/err-economic-research-report/err166.aspx).
9. As a further modification of the crop application curves, we recommend considering BMPs, such as New York's Precision Feed and Forage Management Practice, which prioritizes quality hay over corn. This procedure minimizes farm inputs by balancing crop nutrient needs and dollars spent (Ghebremichael et al. 2007). Implementation and nutrient reduction data from the last 10 years may provide additional allocation mechanisms for excess manure.

Question #2: Understanding that farmer-reported nutrient application rates are not available for the majority of agricultural acres throughout the calibration period (1984-2013), please comment on the overall appropriateness of the methods used to distribute applications to crops, hay and pasture.

The Review Team felt that the overall distribution concept was logical and reasonable, given the scale being considered and the detail of data currently available. The assumptions regarding nutrient application goals by crop appear to be reasonable, as were the nutrient management guidelines used to determine "eligible" crop types and monthly fractions of nutrient application goals that could be met from manure and biosolids. The assumptions used to calculate inorganic fertilizer application goals also appeared to be reasonable and responsive to feedback from the jurisdictions. The following recommendations focus on improving comparability of data provided by the partner states and jurisdictions.

10. We recommend that the prioritization process of manure application to crops be revisited and vetted with experts within each state. Transparency should be ensured through the use of written justification for recommended values.
11. We recommend that the rate of allowable application above the application goal be re-reviewed by an appropriate group of regional experts. The justification for how these values were established should be documented and the decision substantiated.
12. The Association of American Plant Food Control Officials (AAPFCO) data provides information on the fertilizer form (urea, DAP (diammonium phosphate), etc.) and the amount sold (tons). We recommend using these data to calculate the actual ratio of ammonia and nitrate N in the fertilizer sold (*e.g.*, urea=100% ammonia; UAN=50% ammonia and 50% nitrate) as a baseline and/or as a check against the 75:25 assumption.
13. Although hard data are not available to decisively argue for a plateauing relationship at higher yields versus the linear relationships used in the Phase 6 (P6) equations for crop application goals, it is known that major crops cannot always achieve maximum yield. For example, water stress (even in high-clay soils) may restrict corn growth despite an abundance of nutrients. Thus, applying more nutrients under the assumption that maximum yields can be approached is not realistic and may result in increased nutrient loss. We therefore recommend that further research be explored to identify and quantify these plateauing breakpoints to further refine nutrient distribution guidelines and procedures.

Question #3: Given the lack of data available to estimate acres on which two crops were harvested (double-cropped acres), please comment on the overall appropriateness of the method used to estimate these acres.

The Review Team felt that the overall framework of using Census of Agriculture data, specifically looking at the overlap between "Major Field Cropland Harvested Area" and "Major Field Crops", cross-checked with NASS cropland data layer data, is an appropriate method for identifying double-cropped acres. The following recommendation relates to the specific categories used to look at the overlap between "Major Field Cropland Harvested Area" and "Major Field Crops".

14. We recommend that the list of major field crops subject to double-cropping be revisited, as it appears that there are currently too many land use categories included under "Major Field Cropland Harvested Area," whose acreage will never be used to double-crop the crops listed under "Major Field Crops". This would lead to an under-estimation of the

amount of identified double-cropped acreage. A suggested list of crop types to be considered under "Major Field Cropland Harvested Area" (for potential double-crop) would only include: i) alfalfa hay; vi) other managed hay; viii) small grain hay; x) wild hay; xiv) field and grass seed crops; xvii) canola; and xviii) popcorn.

Question #4: Considering the current state of the science related to agricultural forecasting and agricultural economics, please comment on the overall appropriateness of the agricultural forecasting method. Are there alternative forecasting methods you would recommend?

The Review Team was generally supportive of using a combination of long-term and short-term trends to forecast livestock numbers and cropland acreages. Our recommendations below focus on using additional sources of information to inform those trends.

15. We recommend that the effect of climate change on agricultural forecasting be considered in future forecasting efforts, since climate change may impact crop selection and nutrient inputs.
16. We recommend that the alpha and beta weighting factors of 0.8 and 0.2 be reevaluated, and that this be based on the agricultural acres and changes in cropland (or individual crop), and not validated using the poultry or cattle data. Trends in crop acreage cannot be expected to follow trends in animal numbers. In fact, under an assumption that crop acres respond to commodity prices, high feed grain prices would be expected to stimulate more feed grain acreages but reduced animal numbers, as animal production is adversely affected by feed grain prices. The hypothetical example in Table 5-3 shows an approximate 30% error rate compared to actual reported acres (Yt) for Aft from 1987 to 2012. If this large discrepancy exists for other crop types/uses, a new strategy is needed. One potential source of forecasting data would be past, current, and future National Agricultural Statistics Service's (NASS) Cropland Data Layer (CDL) maps to look at apparent trends in crop groupings and rotations. Although CDL maps provide less breakdown of specialty crops than the Ag Census, the CDL groupings are at the level more related to the groupings used by Scenario Builder. CDL appears to show year to year fluctuations in overall cropping selection choices (possible relationships to economics, weather, and crop damaging insects). Whatever data sources are eventually used to establish the weighting factors, they should be validated, and the hypothesized cause and effect relationship justified.

Question #5: Does the documentation sufficiently describe the data and methods used to estimate nutrient inputs for the Watershed Model? Please expand if there are particular sections that should be expanded upon or improved.

The Review Team felt that the documentation generally explained the estimation of nutrient inputs for the Watershed Model, at an appropriate technical level for a broad range of readers.

However, many sections of the documentation could be clarified or elaborated on, as suggested by the additional editorial remarks and suggestions from the Review Team that are provided in the body of this report.

17. We strongly recommend that, in order to improve the transparency of the documentation, references and citations for all of the assumptions and values used in the process (including sources of data used in figures) be included.

Question #6: Do the reviewers have any concerns or comments about the data or methods described within the documentation aside from those already listed above?

18. Concerns were previously raised about the relative evaluation of the Revised Universal Soil Loss Equation, Version 2 (RUSLE2) C sub-factors for the "plow" scenario among states by the Ag Loading Rate Review Steering Committee (ALULRSC) in its December 17, 2015, report: "Although our Sub-group endorsed the use of RUSLE2 for generating sediment loads and relative loading ratios, our review revealed inconsistencies in the range of sub-factor values evaluated between states and crop management zones (CMZs), …[and] our Sub-group strongly felt that these inconsistencies must be addressed before the relative loading rates as used by Scenario Builder will be a valid representation of erosion rates among states and CMZs." An example of this variability was provided in Table 4 from the ALULRSC report for the "crop residue %" sub-factor for the pasture/range land use.
    While the sub-factor values were independently estimated by National Resources Conservation Service (NRCS) personnel in each state, no attempt was made to normalize them so that they would be comparable across states. The results were highly variable sub-factor values across states. We support and reiterate the previous recommendation by the ALULRSC to provide a cross-state review of all RUSLE2 C sub-factor values which are used to establish relative values of detached sediment by land use, especially noticeable in pasture.
19. We recommend applying the buffer credit to the same upland land use from which the buffer is taken, rather than applying it to all agricultural land uses in the land-river segment. If the majority of buffers are related to livestock exclusion, it is incorrect and potentially misleading to apply the filtering credit to cropland.
20. The Agricultural Modeling Subcommittee - Pasture Subgroup (PSG) has proposed that all (100%) of manure deposited in riparian pasture areas be directly deposited (DD) to the stream. We recommend, instead, that DD be evaluated as a fraction of the manure load in riparian pasture areas consistent with the P532 loads from degraded riparian pasture areas. The PSG analysis in Appendix B indicates that 74% of the directly deposited total nitrogen (TN) load and 38% of the total phosphorus (TP) load would actually be comparable to the respective P532 loads. If the PSG's recommended 100% of deposited

manure is used, the livestock exclusion BMP in P6 would get bonus reductions of about 35.5% for TN and 163.8% for TP, over that credited under the P532 version of the model.

Question #7: Are there additional technical data or scientific findings that could be employed by the Chesapeake Bay Program now, or developed in the future, to better inform nutrient input estimates across the watershed?

21. Suggested sources of additional technical data or scientific findings include:
    a. Nutrient management planners and the extensive non-proprietary data contained in nutrient management plans could be engaged by CBPO to refine model characterization of local farming practices, manure/fertilizer application rates and timing, and conservation techniques.
    b. Results presented at the 2016 Soil and Water Conservation Society (SWCS) annual meeting which showed that a majority of farmers sought fertilizer rate and timing recommendations from local fertilizer sales companies and agribusinesses (Embertson 2016). These results deserve careful consideration, and recommendations of the sales companies and agribusinesses should be evaluated in relation to other means of estimation. In particular, fertilizer retailers could be surveyed to refine fertilizer sales by crop type.
    c. Updated manure production numbers by animal type would help improve manure nutrient load estimates.
    d. Applied academic studies could be used to better support and/or inform nutrient and land management estimates, including a more comprehensive representation of rotational land management.
    e. Mineralized N from previous year manure applications should be incorporated into future versions of the watershed model.

Nutrient Inputs to the Watershed Model: STAC Reviewer Comments and Clarifying CBPO Responses

The following is a report by a STAC Review Team concerning the methods and documentation used by the Chesapeake Bay Partnership for evaluation of nutrient inputs to Phase 6 of the Chesapeake Bay Watershed Model.

The following Review Team members were recruited during the month of May:

- Amy Collick, University of Maryland Eastern Shore, Assistant Research Professor
- Marc Ribaudo, Economic Research Service, Chief, Conservation and Environment Branch
- Wade Thomason, Virginia Tech, Crop & Soil Environmental Services, Professor
- Tamie Veith, USDA-ARS-Pasture Systems and Watershed Management Research Unit, Agricultural Engineer
- Gene Yagow, Virginia Tech, Biological Systems Engineering, Sr. Research Scientist – Review Team Chair

The final set of charge questions was received by STAC from the CBPO Modeling Workgroup on June 21, 2016 (**Appendix A**). Although the questions were not originally numbered, they have been numbered in this document to facilitate referencing:

An initial webinar with the Review Team was used to mark the starting point of the review on June 22, 2016. During this webinar, Matt Johnston (UMD/CBPO) presented the charge and provided reviewers with further background on the model inputs. The original CBPO Phase 6 Watershed Model documents provided for review and their versions are listed below:

- Section 1 – Overview (04/19/2016)
- Section 3 – Terrestrial Inputs (02/01/2016)
- Section 5 – Land Use (02/01/2016)
- Section 6 – BMPs (02/01/2016)
- Appendix 3A – Terrestrial Inputs Appendices (no date given)

The Review Team was provided these documents with the understanding that these documents are currently drafts and are subject to modification by decisions that are in the process of being made by the Chesapeake Bay Partnership in parallel with this review.

STAC formally approved the review charge and documentation on July 1, 2016. Members of the Review Team individually reviewed the original documents and submitted their initial comments to the Review Team chair for compilation by July 11, 2016. During compilation of the individual responses, the chair discovered that a large number of the reviewer comments were in the form of follow-up questions. In order to provide a more informed response to the charge questions, the questions from individual reviewers were compiled and submitted to CBPO for further clarification. CBPO staff Matt Johnston, Gary Shenk, and Gopal Bhatt collaborated on the responses to the reviewer questions and provided written responses back to the Review Team on July 25, 2016. A conference call on July 28, 2016 between Matt Johnston and the Review Team allowed an opportunity for follow-up questions by the reviewers, enabling Review Team members to convert their questions into informed comments on the various documents wherever possible. Review Team members were then given an opportunity to provide written responses to the CBPO answers to their questions through August 9, 2016.

The body of this report is organized by each of the 7 review charge questions. Reviewers' comments are organized by document section numbers under each charge question. Due to the back and forth exchange that took place during the review, reviewer comments are followed in some cases by responses from the CBPO team to clarifying questions posed by the reviewers, and subsequent follow-up responses by the reviewers (where applicable).

Question #1: *Given the state of available manure and fertilizer data, please comment on the overall appropriateness of the methods used to estimate total manure and fertilizer available for application to agricultural lands. Relevant sections: 3.2.1-3.2.5 (manure estimates); 3A (for additional information regarding poultry nutrient generation estimates); 3.3.1 (inorganic fertilizer estimates).*

Section 3.2.

- Averaging nutrient application across land use types dampens the response of the plants to nutrients –a number of errors interact and accumulate. Water quality response is also dampened. I am sure that this averaging was necessary given the amount of input data or perhaps watershed model limitations, but I think that providing some analysis of the impact of this would be helpful if possible.

Section 3.2.1.

- Manure generation is estimated using the best available information from local cooperators, and Chesapeake Bay region specific data have been collected and verified by the Partnership. Updating of the animal manure generation estimates has been ongoing, with final values trickling in piecemeal. Some table or synopsis of the data source, current decision point in the process of approval and consistent framework for comparing this information would be useful to be transparent about how reliable each estimate is. For example, the turkey and swine projects going on for the Ag Workgroup do not appear to be as rigorous as the poultry (chicken) panel's.
- Comparative analysis of nutritive content at different stages of decomposition and application should also be performed to account for volatilization by animal type in the storage process and under typical BMPs.
- Values for manure and litter seem reasonable and defensible.
- A clarification is needed regarding the stated assumption that manure generated within a county is available for deposition or application only within that county. However, the text later states that each jurisdiction is responsible for tracking manure which is moved out of the county, which is inconsistent with the assumption.

Section 3.2.1.1.

- Equation 3.2 seems unnecessarily complicated. If the problem is that you don't know the total number of animals per year, then why use the census for all except the current cycle and then add back in the current inventory? This is just either a complicated way to get back to the annual total or adds unnecessary variation to the answer. Simply use census or multiply inventories by assumed production cycle.

- In regard to Table 3.2, and eq 3.2: How do these estimates for broilers and turkeys (12/31 inventory) compare with the USDA reported yearly numbers? Would that validate this approach for the other classes?
  - **CBPO:** The equation was not tested to validate how the resulting turkeys and broilers populations would compare to NASS annual production values for these animal types. The equation is used by USDA to estimate animal populations, and the AMS did not attempt to further validate it.
  - **Reviewer:** The estimates for broiler and turkey inventory used by the CBPO (NASS state level data) should also be estimated using equation 3-2 as a crosscheck and validation for using equation 3-2 for hogs and pullets.
- In regard to Table 3-4: The manure nutrient species concentrations for livestock are well documented in American Society of Agricultural Engineers (ASAE) 2003, 2005 and the other documentation. Universities (Penn State, University of Maryland, Cornell, etc.), government and private agricultural laboratories may be additional sources of data concerning manure analysis, such as nutrient species concentrations, at a local scale and could be informative for the model. Appendix 3A describes how poultry manure contents are established from laboratory results over multiple years.
- The process for estimating animal numbers is consistent with NRCS.
- The processes for estimating nutrient content of manure generated are consistent with NRCS.

Section 3.2.1.2.

- "Scenario Builder assumes zero nitrate nitrogen is available in animal manure." Please provide the justification or a reference for this assumption.
  - **CBPO:** This assumption was used to simplify the breakup of manure nitrogen forms based upon the following statement from the 2006 Mid-Atlantic Water Program's Nutrient Management Handbook (pg. 2016): "Inorganic manure N can be either ammonium or nitrate. The most common form of inorganic N in manure is ammonium, which is specified in most laboratory analyses."
  - **Reviewer:** This assumption should be reviewed. An example reference would be Chastain et al. (2001). This text states: "The amount of nitrate-N can be significant in poultry litter that has gone through several "heats" in a stacking shed. Manure stored in stacking sheds should be tested for nitrate-N in addition to ammonium-N, and organic-N".

Section 3.2.1.3.

- Do NH3-N input estimates already assume volatilization to barnyard and field, before BMPs are considered? (more on NH_3-N calculations in later questions)

- **CBPO:** Pounds (lbs.) of NH3-N in Table 3-5 are pre-volatilization in the barnyard and field. Volatilization further reduces the NH3-N, while ammonia emission reduction BMPs can conserve NH3-N within the manure.
- **Reviewer:** Figure 3-3 provides a clear flowchart for the model processes. I think some of the text in various sections that is meant to provide extra insight may actually hinder comprehension. For example, section 2.1 is about estimating manure available. So in section 3.2.1.3, I do not think that you need to mention the future volatilization of NH3-N, but instead focus on the input data for NH3-N into the Scenario Builder. Later on you discuss factors for calculating volatilization.

Section 3.2.1.4.

- In regard to mineralized nitrogen: "Mineralization of organic nutrients in manure transforms previously unavailable nutrients into a form of that can be used for plant uptake. This process occurs continually within the soil for years after application of manure. Scenario Builder does not directly account for previous years' nutrient applications when calculating current or future year applications to crops." Please clarify if the Watershed Model accounts for this transformation over time.
  - **CBPO:** Scenario Builder does not DIRECTLY account for previous years' applications, but does assume that applications occurred in previous years. This is done by assuming a three-year mineralization rate for the current year's application, assuming that similar applications occurred in previous years on the same ground.

    Once applications by year are provided by Scenario Builder to the Watershed Model, those applications influence future runoff estimates due to the lag time it takes for nutrients to move through the watershed. This process is explained in detail in section 10.5 of the documentation.

    Previous applications of phosphorus are also important in simulating current or future-year P runoff which is sensitive to changes in the Mehlich 3 soil test phosphorus values based upon the Annual Phosphorus Loss Estimator (APLE) Model. This model is described in section 4.2.4 of the documentation.
  - **Reviewer:** The contribution from manure N mineralization from previous years' applications should be credited to the system and the current year crop N demand consequently reduced.

Section 3.2.1.5.

- In regard to organic nitrogen: "Organic nitrogen is not considered to be available for plant uptake. This portion of the nitrogen from manure is still applied to the land, and thus is available for runoff into nearby water bodies." Does this include leaching into groundwater? If so, please clarify. If not, why not?

- **CBPO:** Yes. The term runoff should be assumed to mean "surface +sub-surface." The Phase 6 Watershed Model uses sensitivities of nitrogen runoff and leaching derived from the Phase 5.3.2 Watershed Model. These sensitivities are described in section 4.3. The Phase 5.3.2 Watershed Model directly simulated leaching of nitrogen species into groundwater.
- **Reviewer:** No follow-up response.

Section 3.2.1.8.

- In regard to feed-additive BMPs: What about current implementations of these? Do incoming data account for the % of county's manure that is or isn't in that BMP? It is mentioned in the documentation that input data are adjusted for current BMPs, but it is not clear what is considered as a current BMP and how data are adjusted.
  - **CBPO:** States report the number of animals being treated under these BMPs by county and year. Any animal not reported as being treated is assumed to produce manure and nutrients as described in Table 3-3 and 3-4.
  - **Reviewer:** I think that this is handled reasonably based on the available data. I would suggest clarifying in the documentation how this BMP is incorporated. All the pieces are there but not tied together clearly, in my opinion. Figure 3.3 shows that manure is generated and then some portion goes to the feed additive BMPs and some continues on. Perhaps incorporate the "Feed-Additive BMPs" box inline under "Manure Generated" and then in text (3.2.1.8 or elsewhere) provide explanation that manure-generated amounts of nutrients are adjusted based on state reports of the number of animals treated. Perhaps, include a foot note to Table 3-3 and 3-4, or a clarification in section 3.2.1.8, that the non-treated values are as in Tables 3.4 and 3.5 and the reductions used for the treated animals are {XX% of non-treated for P, …. etc.}.

- There is mention of swine feed additives, e.g. phytase, but no mention of this or other additives for poultry. We suggest that poultry additives be accounted for, and/or that the documentation be more explicit about additives for all animal types.

Section 3.2.2.

- In regard to separating manure into areas of deposition: Jurisdictions provide this information. Does any effort go into ensuring there is some relative consistency among the states in how they parse the livestock time among pasture, riparian access, and barnyard? This parsing could be somewhat objective and it would be good to have some documentation or process to ensure there is consistency among jurisdictions and justification for these decisions.

- **CBPO:** Each state was asked to work with their livestock experts to define these fractions, and resulting values from each state were shared. Regardless of this sharing, there are still differences amongst the states, and I agree the final numbers would benefit from another round of collective review. An example of time spent in confinement by month for dairy cows is provided below.

Month	MD	DE	VA	PA	NY	WV
1	1.00	1.00	0.76	1	0.95	0.76
2	1.00	1.00	0.76	1	0.95	0.76
3	0.70	0.85	0.61	1	0.90	0.62
4	0.66	0.85	0.54	0.5	0.77	0.55
5	0.58	0.85	0.52	0.3	0.76	0.53
6	0.58	0.85	0.51	0.3	0.76	0.51
7	0.58	0.85	0.50	0.3	0.81	0.5
8	0.58	0.85	0.50	0.3	0.80	0.5
9	0.58	0.85	0.49	0.3	0.76	0.5
10	0.58	0.85	0.49	0.5	0.88	0.5
11	0.58	0.85	0.54	1	0.92	0.55
12	0.75	1.00	0.71	1	0.95	0.71

- **Reviewer:** A cross-jurisdictional review of the by-state inputs in Section 3.2.2 Separating Manure into Areas of Deposition is needed to ensure comparability among states. The differences in values among states should be explained and documented.

- My understanding is that monthly data are collected, combined together, reduced by some set amounts for NH_3 volatilization and feed BMPs, and then split back out into months based on time in pasture. If this understanding is correct, why not split it back out into seasons or production cycles? It seems that these time periods, plus the jurisdictional inputs on time-in-pasture for the same time periods, would be more agronomically meaningful? Can the jurisdictions provide information on time-in-pasture variations due to management type as opposed to just animal and month (grass-fed, free-range, etc.)? {This later question may be more applicable to future interests – if there are even enough data to be useful.}

  - **CBPO:** Scenario Builder's database is set up to handle everything on a monthly basis, but those months could certainly be combined into seasons having similar values for four straight months, for example. Many of the values provided for this purpose actually do correspond to seasons in just this way. For example, Table 3-8 shows that WV assumes no barnyard access in the spring and summer.

  - **Reviewer:** This method makes sense, as explained by CBPO. I think that much of my initial confusion was in the explanation of how the monthly and annual manure amounts are determined and then how they are adjusted. I think clarification of the text along with the by-state distribution table (as discussed in the previous comment) will help considerably.

Section 3.2.2.1.

- Direct deposition on pasture is added to land use application but not applied toward crop need. Is this realistic? Also, if this contributes to water quality, can there be adjustments to account for ammonia volatilization as done for the barnyard?
    - **CBPO:** It is assumed not to count towards the crop application goal for pasture because the crop application goal is representative of average, additional applications of manure and inorganic fertilizer above and beyond direct deposition. For example, crop application goal for pasture is 15 lbs of N/acre, which is based upon farmer-reported applications of manure and inorganic fertilizer found from the Maryland Department of Agriculture's Annual Implementation Report. The agronomic need for pasture would be much higher, and would be met in part by direct deposition. Yes, the in-field volatilization rate currently assumed for no incorporation on cropland could also be assumed for deposition to pasture.
    - **Reviewer:** I suggest making clarification in the documentation between "crop application goal" and "agronomic need." For example, currently the text reads "not applied toward crop need" when, it seems that "not included in the crop application goal" or "not included in the "nutrient management calculations for additional manure spreading" might be clearer. Also, I recommend assuming some in-field volatilization, at least in the warmer months.

Section 3.2.2.2.

- I do not believe the estimates of how much manure is deposited in riparian areas are anything more than guesses. Is this really necessary? False precision?
- Is riparian pasture deposition considered equal to direct deposition to stream? This may be reasonable if the baseline version of the model is intended to represent the worst case situation of the modelled time period. Is there a model constraint that necessitates 100% deposition? Or for the sake of future scenarios and possibly fencing BMPs, is it feasible to use some percentage of the riparian pasture deposition that reaches the stream? One example of some data on the % pre- and post-BMP may be James et al. (2007).
    - **CBPO:** This is the baseline condition which makes it possible for fencing BMPs to reduce direct deposition in the access area. States report the area of fencing, and that area is tied to an assumed stocking rate of animals per acre. The associated manure deposited within the access area for those animals is "transported" upslope to become direct deposition on pasture if a fencing BMP is reported.

- **Reviewer:** Under this method, the total pastured animal numbers need to correspond to the state level data on pastured animals per month, and the calculations for amount of manure in the riparian zone needs to be clearly documented. This method appears to assume uniform stocking rates across all pastures throughout each month and no shade or waterers away from the stream (which have been shown to draw cattle from the stream). Fencing BMPs should not be considered to fully reduce direct deposition to the stream unless they include both a riparian buffer zone between the fence and stream and also prevent all unsupervised stream access (i.e., any stream crossings need to be blocked off except during active herd relocation).

- The Agricultural Modeling Subcommittee (AMS) - Pasture Subgroup (PSG) has proposed that all (100%) of manure deposited in riparian pasture areas be directly deposited (DD) to the stream. In this reviewer's original discussions with the PSG concerning this method, I had conveyed to them that the VT-BSE bacterial TMDL studies in Virginia, which they cite as sources of this methodology, only applied 30% of that load directly to streams. The PSG expressed concerns that livestock exclusion in P6 get similar reductions as they had in P532, since many WIPs rely on this BMPs for their planned reductions. I suggested a comparison with P532 and then adjusting that fraction (percentage) based on the comparative analysis. In order to justify the use of the DD method and to show its similarities with P532 loads, the PSG report rightly compares loads from the DD methodology with those from the P532 degraded riparian pasture (DRP) land use loads, but despite the differences (the report cites them as being in the "same order of magnitude"), they considered these to be acceptable and continue recommending simulating manure N and P as 100% of the manure load deposited in the riparian area. The PSG analysis in Appendix B, Table 3, indicates that 74% of the directly deposited TN load and 38% of the TP load would actually be comparable. If the PSG's recommended 100% of deposited manure is used, the livestock exclusion BMP in P6 would get bonus reductions of about 35.5% for TN and 163.8% for TP over that credited under the P532 version of the model. This does not seem to be consistent with what was intended. Another concern raised by Table 3 is that the large amount of streambank sediment reduction under P532 will no longer be credited to this BMP in the P6 model.

Section 3.2.2.4.

- Table 3-9 values are unsupported – can you provide reference or refer to expert opinion panel or support with NRCS estimates as in footnote?
    - **CBPO:** Unfortunately, the exact reference was never cited in the original Scenario Builder documentation, and these values have not been updated by the AMS. I will look into these values further and present this issue to the AMS. Suggested references for ammonia volatilization from reviewers are welcome.
    - **Reviewer:** While there are a number of studies of volatilization in the past 15 years, I do not readily see a nice summary of values. Regardless, I do not think that stating

the reduction fraction out beyond 2nd decimal is reasonable. Yes, when multiplying against large numbers the number of decimals specified makes a big difference in the result, however, that level of precision is not realistic.

Section 3.2.2.5.

- The ammonia reduction BMPs in this section appear to be a work in progress, so no review can be made at this time.

Section 3.2.3.

- Ongoing efforts in the Agriculture Workgroup to refine manure nutrients in storage should be continued, improving national excreted N and P values. Best estimates for local nutrient sources should be considered more reliable than fertilizer sales older than 10 years and State Chemists' (or their contemporaries) methods of collection for AAPFCO should be scrutinized in a similar manner as the 2007 STAC workshop report (Angstandt 2007) to determine reliability or necessary transformations before consideration as an input dataset. – Recommendation for future research.
- Can cleaning of animal housing, manure storage, and other manure storing facilities be simulated? Are these included in storage and handling loss? Although not quite in the "barnyard", are the use of filter strips and other filtering practices considered?
    - **CBPO:** Cleaning of the barnyard area is not an approved BMP. However, manure storage facilities (e.g., NRCS-313 practice) are simulated as reducing the amount of manure that washes off the barnyard. The reduced runoff is assumed to be conserved in the storage facility so it can be made available to crops.

      Filter strips for the barnyard are not directly simulated, but filter strips on cropland or hay or pastureland are. Barnyard runoff controls (e.g., NRCS-558 practice) are also simulated as a reduction in stormwater runoff from the barnyard.
    - **Reviewer:** Chapter 6 will likely address the particulars of the different BMPs as described in CBPO's response.
- If storage and handling losses are some of the most well-documented and understood losses, then that seems to provide a good argument for calculating storage and handling losses first and then ammonia losses. It may even be necessary to calculate storage and handling before accounting for feed additives due to the data, even though this means a slightly backwards calculation (but no more so than adjusting the NH_3 as done currently).
- The use of NRCS recoverable fractions of manure seems very appropriate. The recoverable fractions of manure N and P in Table 10, however, are no longer being applied, as presented in Matt Johnston's 06/22/16 presentation to the Nutrient Input Review Team, since they

included volatilization, which is already accounted for separately. This will require an update of values in Table 3-11, as well.

Section 3.2.3.1.

- AWMS BMPs is also a work in progress and no review can be made at this time.
- The global 75% storage and handling loss seems a bit simplistic, particularly given current concerns on types and lengths of storage (3mo, 6 mo, 12 mo, daily-haul) and the resulting land application timing impacts. I f you stick with the 75%, then subsequent references to "AWMS BMPs" are confusing and possibly misleading.

Section 3.2.4.

- Also worth noting in this section is that the total weight on the manure is also a factor in the logistics of how much can be transported and applied in a given trip, and how it is done.

Section 3.2.5.

- Ammonia volatilization after transport (and thus after application) is tied to the method of application. Between this and section 3.2.3, I wonder if it would be more straightforward to move the ammonia volatilization calculations into the model. That way they could be a function of application, handling, and tillage.

Section 3.2.8.

- Unknown what is meant by the highlighted statement: "Note that the Watershed Model only sees organic nitrogen and ammonia nitrogen from manure. While mineralized nitrogen is tracked separately within Scenario Builder, it is considered by the Watershed Model to be ammonia nitrogen." Please clarify.
  - **CBPO:** This statement should be revised or removed from the Phase 6 documentation. According to Gopal Bhatt of the Modeling Team, the Watershed Model calculates runoff based upon total lbs of nitrogen, not the individual species. Section 4.3 of the documentation describes this procedure.
  - **Reviewer:** No response.
- I have an issue with the way manure is allocated to crops. Scenario builder uses application curves that optimize application to higher-commodity crops such as vegetables and corn before applications occur on crops such as pasture, hay and other legumes. This process ignores the fact that manure is actually spread first on land operated by the facility. Therefore, the crops receiving manure are those grown on the facility, which are not likely to include vegetables. Crops grown on animal operations run heavily into corn, soybeans, and alfalfa. ERS used Census of Ag to get data on crops grown on operations with animals in its

analysis of manure use in the Chesapeake Bay watershed. Scenario Builder can do the same thing for Census years. The ERS study can be found at http://www.ers.usda.gov/publications/err-economic-research-report/err166.aspx.

Section 3.3.

- Although actual nutrient management plans are not often accessible, nutrient management planners (private and government) may offer insight into fertilizer and manure availability and application on farms that have plans and those that do not for the planners' vicinities. Information on timing of applications may also be developed.

Section 3.3.1.

- In regard to determining fertilizer available in county: It is noted that the AAPFCO data can vary dramatically by state each year. How are data reported? At the county level? If so, is there any way to review the data at a finer scale to determine, for example, if certain counties have greater variability than others? If so, maybe there is some way to "normalize" or cull the data from these counties with high variability? Also, could the CEAP (Conservation Effects Assessment Project) data be used to verify, or provide another line of evidence to support, the assumptions about fertilizer application?
  - **CBPO:** The data are reported at a county level and it would be possible to remove outliers at this level. However, removing outliers at the state level proved very useful in smoothing out the volatility seen in some states for some years.

    The AMS also smoothed the data by applying a three-year rolling average fraction of the total sales labeled as "farm use" understanding that states often varied from year-to-year on the quality of reporting sales as "farm" vs. "unknown."

    Dr. Lee Norfleet recommended the AMS check the fertilizer estimate for the watershed by comparing the average Phase 6 watershed-wide estimate from 2001-2006 to the watershed-wide fertilizer use estimates published in the initial CEAP report. The comparison is included in the table below.

Data Source	Lbs Inorganic PAN	Lbs Inorganic P	% Delta from CEAP N	% Delta from CEAP P
Fert Sales (CBPO Estimate)	405,182,999	80,360,063	-0.20%	-0.60%
CEAP	406,020,000	80,870,000	NA	NA

- **Reviewer:** A comparison of the amount of fertilizer available, estimated by the CBPO and the CEAP reported values should be included, as well as examples illustrative of good matches and poor matches at the county level.

Section 3.3.1.1.

- In Table 3-16, does the table show pounds of N in fertilizer sold, or pounds of fertilizer containing N? There is a big difference as different fertilizer compounds contain different amounts of N.
  - **CBPO:** This is total pounds of N sold. The AAPFCO data provides tons of fertilizer, the type of fertilizer (e.g., DAP), and an estimate of N or P concentrations in each type. This information is used to transform tons of raw fertilizer into pounds of N and P sold.
  - **Reviewer:** Here and elsewhere in the model documentation, it is important to be very clear in whether the text is referring to (for example) the mass of N in fertilizer or in nitrate (NO_3-N) versus the mass of fertilizer or nitrate (NO_3) itself. All readers will not use a convention of automatically reporting the elemental value and possibly short-cutting the labelling.
- Data from CEAP can be used to check whether the procedure using sales data produces acceptable nitrogen fertilizer use estimates.

Section 3.3.1.4.

- Shouldn't forecasted agricultural acres (Section 5.3.1) also be used to inform the calculation of future fertilizer use? I'm okay with the current estimation methods, if they are on a per-yield or per-acre basis. Otherwise, consideration of future forecast acres should also be factored in. Alternatives are also under consideration by the AMS, as this methodology is also still under development.

- **CBPO:** That process as described is occurring. Section 3.3.1.4 describes how 2013 fertilizer use was derived using historic fertilizer information and forecasted acres and yields.
- **Reviewer:** Despite what is currently being done and the explanation from CPBO, no mention is made of "forecasted acres and yields" in the April 2016 version of Section 3.3.1.4, and it still is in need of a more complete description.

Section 3.3.4.

- What particular methods are used to determine timings of fertilizer and manure applications?
  - **CBPO:** Each state provided the following information per crop: total lbs of application goal/yield unit; days after planting that applications should be made; fractions of yearly applications that should be made on that date; and an indicator of whether or not each application could be made with organic nutrient s (manure or biosolids) or had to be made using inorganic fertilizer only. When combined with average plant dates for each crop, the days after planting are transformed into monthly applications. An example for corn in Maryland is included below.

Crop Name	Nutrient	Days After Planting	Fraction Applied	Fertilizer Only
Corn for Grain Harvested Area	TN	-20	0.6	No
Corn for Grain Harvested Area	TN	0	0.2	Yes
Corn for Grain Harvested Area	TN	45	0.2	Yes
Corn for Grain Harvested Area	TP	-20	0.8	No
Corn for Grain Harvested Area	TP	0	0.2	Yes

  - **Reviewer:** Unless the approach of application timing is described in documentation anywhere else in the Scenario Builder, it would be necessary to include the full explanation of application timing and rates for the different seasons. This may need to include any account of farms without manure storage (i.e., daily haul) or only short-term storage.

Section 3.3.5.

- The inclusion of data from major lawn care companies seems quite appropriate and informative.

Appendix 3A: Poultry Litter

- The various methods used, including using a 3-yr moving average by state, the distribution of state populations based on Census of Agriculture (CoA) data, the NASS production numbers, the USDA and ASAE recommended values, and state concentration data, all seem appropriate and well-reasoned. I support the findings of the Poultry Litter Subcommittee (PLS) and their recommendations for future data collection to improve the poultry load estimates.

Question #2: *Understanding that farmer-reported nutrient application rates are not available for the majority of agricultural acres throughout the calibration period (1984-2013), please comment on the overall appropriateness of the methods used to distribute applications to crops, hay and pasture. Relevant sections: 3.2.7 (manure applications); 3.3.3-3.3.4 (inorganic fertilizer applications).*

Section 3.2.7.

- When distributing out the manure, is it done by month regardless of crops? So, for example, Jan-March loads distributed to all specialty and grain crops and then, with those needs met, rest starts going to other crops. This time-related discussion in second paragraph of 3.2.8 is not clear. How/when does more manure N become available, and what is the corresponding time-step and cycle of the optimization program? In a recent study, I tried to use Bay Model inputs for a single watershed as input for another model. The distribution of manure over the year related to the applied crops was essentially meaningless relative to trying to actually grow the crop and to practical application of the manure a given stages of crop growth. While I realize that incorporating detailed crop growth is not feasible, realistic timing of manure application, crop growth, and weather is crucial to estimating soil moisture and plant uptake, which is necessary to reasonably predict nutrient losses from the land.
  - **CBPO:** Agreed that the second paragraph is unclear. Applications occur on a monthly basis depending upon each crop's application goal that month. There will be some months where applications do not occur at all, and others where applications might occur across all crops, requiring the curves. The curves are employed at the monthly application step. So, all the manure available is compared to all the crop need and distributed to crops based upon relative percentages using those curves. It is not applied in a step-wise fashion as described in the second paragraph. Sorry for the confusion.
  - **Reviewer:** The CBPO response was very helpful here. Based on this clarification, I think that the method of partitioning manure is done logically and based on the best available data. Revision of the text would probably help clarify the method.
- All of the assumptions regarding nutrient application goals by crop appear to be reasonable, as were the nutrient management guidelines used to determine the eligible crop types and monthly fractions of nutrient application goals that could be met from manure. However, section 3.2.7.1 states that a multiplier of 1.1 would be used to mimic optimistic yield goals, which the 06/22/16 presentation from Matt Johnston used the figure of 1.25, which seems to be a bit extreme. Did the AMS committee change their recommendation?
  - **CBPO:** Yes.
  - **Reviewer:** Whichever value is chosen, its use should be substantiated and justified.

Section 3.2.7.1.

- Equation 3.9 seems to assume a linear relationship in N and yield? Is this realistic or is it more likely that the relationship will plateau (as in Liu et al. 2016), particularly if trying to push the yield beyond the NASS values.
  - **CBPO:** It would not surprise the AMS or Ag Workgroup if actual applications and utilization of N by crops would plateau at higher yields. However, published land-grant university recommendations across the watershed have not yet taken those into accountpublished recommendations were the basis for the application goals provided by each state.
    The 1.1 multiplier for yields is an assumption that will be revisited by the AMS.
  - **Reviewer:** While I do not agree with a non-plateauing relationship, I do not have any additional data to provide. During discussion with CBPO there was a comment that it is known that major crops are not at maximum yield. While this may be the case, studies have shown that water stress (even in high-clay soils) may restrict corn growth despite an abundance of nutrients. I am sure there are similar studies for other crops and other growth factors. Thus, applying more nutrients under the assumption that maximum yields can be approached is not realistic. In fact, because those nutrients may not be taken up by the crops, they may add to the water quality issues. The assumptions around crop N response and relationship of yield and N-rate applied (assumption driving Equation 3.9) should be revisited and vetted with scientists in the states.

Section 3.2.8.

- Are specialty crops likely to get manure or more customized, non-pathogenic fertilizer? How does this distribution choice compare with available data?
  - **CBPO:** Each state provided a list of crops (including the specialty crops) that could receive manure and a list of crops that could receive biosolids. Applications of these nutrient sources are only made on "eligible" crops. The AMS is unaware of independent data other than land-grant university recommendations that could be used to validate the total amount of nutrients being applied to specialty crops.
  - **Reviewer:** This makes sense. I must have missed this in the documentation text.
- This section states that the Scenario Builder optimizes application of manure to higher-commodity crops. Given the available data, and historical practices, this may be the most accepted method. However, I wonder about the impact of considering BMPs such as NY's Precision Feed and Forage Management Practice, which prioritizes quality hay over corn. By doing this and minimizing farm inputs they can balance nutrients and create a profit (Ghebremichael et al. 2007). If this practice has become widely adopted enough in the past

10 years and they have data on the nutrient reduction, it may be worth incorporating. This practice demonstrates that farmers do not necessarily prioritize the typical "higher-commodity" crops.

- Fig 3.4 needs to include distance from manure source in the distribution. I think that the crops available on a given operation (or short distance from the operation) drive this to a great degree and the crops most common around intensive livestock facilities tend to be rowcrop and pasture/hay, not specialty. I question carrying out manure application up to 300% of N need on corn if there's excess? Don't these farms mostly have mandatory NM plans? What about acres in a county with P based or p limited plans? Can we use that to more accurately estimate where this is going; i.e. moving off site or to other crops instead of being over-applied to one crop?
    - **CBPO:** The Phase 6 Model is built with two major assumptions: 1) that there is a finite amount of manure and fertilizer available for application in each county; and 2) 100% of available manure and fertilizer must be applied in the county. These two assumptions can result in over-applications in excess of application goal, applications under the goal. This process allows the Phase 6 Model to test the impact of a broad set of conditions if needed. For example, managers may want to test the impact of doubling or tripling animal populations in a county. Without a single governing rule that all manure must be applied or transported, this type of assessment would not be possible.

      States can report the amount of manure that is transported across county lines from counties with excess manure to counties with limited manure. This results in lower applications in the county of manure generation.

    - **Reviewer:** The "flow path" of prioritization of manure application to crops should be revisited and vetted with experts in each state. This process should also be made transparent with the justification for recommendations or suggestions included. New figure 3-6. The rate of allowed application above the application goal should be re-reviewed by an appropriate group of experts. The justification for how these values were established should be reported and the decision substantiated. I may be unnecessarily concerned with this, but if we really have instances in the model where we are showing 200, 300, 400% over-application then I think that points to a serious flaw in either how manure is distributed among crop or in how we are estimating manure production in a county.

Section 3.3.1.

- Does not account for the fact that price varies significantly across the watershed based on distance from port or terminal. Therefore, counties far away spend more for the same nutrients. It looks like they are buying more than they are.

Section 3.3.1.3.

- Given what we know about the degree of overestimation of fertilizer input when using the inorganic crop application goal, should the $ spent (adjusted for distance to source) be weighted more heavily?
  - **CBPO:** The Agriculture Workgroup recently approved NOT placing any weight on the dollars spent from the Ag Census. Instead, the sum of fertilizer estimated to be sold across the watershed will be distributed to counties based upon each county's relative crop application goal after manure is applied. The logic was that those dollars spent reflected management changes due to BMPs such as nutrient management. In the Phase 6 Model, acres of nutrient management will reduce crop application goal, thus reducing the relative goal and resulting fertilizer assumed to be distributed to the county.
  - **Reviewer:** No response.

Section 3.3.2.

- How do the 75:25 values for ammonia and nitrate match with the AAPFCO data? Why are we discarding actual data for assumptions?
  - **CBPO:** The AAPFCO data does not provide concentrations of each nutrient species. It only provides the concentration of total nitrogen in each formulation.
  - Reviewer: I believe that the AAPFCO data provides information on the fertilizer form (urea, DAP, etc) and the amount sold (tons). From this it should be possible to calculate the actual ratio of ammonia and nitrate N in the fertilizer sold (e.g. urea = 100% ammonia; UAN = 50% ammonia and 50% nitrate) as a baseline (or as a check against the 75:25 assumption).

Section 3.3.3.

- Simply stated, the application goals are too high and do not reflect the intent of the data tables. The limitation on the amount of nutrient supply is conversely too low and the method of distributing the fertilizer is too complicated, both at the basin scale parsing fertilizer to counties and crops, as well as the crop sequence utilizing prioritization curves. Crop application goals (the metrics that drive the allocation of manure and fertilizer) should be transparent and available.
- A model with a goal of only providing the relative loading of crops should focus on relative inputs, outputs and "leakiness" rather than a mass balance approach. Masses of nutrients can provide a good check for the total simulation. Until studies illustrating the 'leakiness' of certain cropping systems exists, physiology of specific crops should be better documented for supply amounts and timing in the simulation.

- The line between hay and pasture in the real world is blurry and should necessarily be blurred in the model instead of over parameterizing two distinct land uses.
- The assumptions used to calculate inorganic fertilizer application goals appear reasonable and responsive to feedback from the jurisdictions.

Section 3.3.4.

- Agricultural guidelines published by Penn State and University of Maryland provide common application rates and timing for major crops in the watershed and in effect, can provide helpful insight into ideal applications or a check of the current method.
- Re: Figs 3.5 and 3.6 - Why would a producer continue to apply (purchase) N at 200 or 300% of need? If we find we are much over 125% of use for any crop land use, except perhaps truck crops, I think we are dramatically overestimating the amount of N going into that county.
    - **CBPO:** This is the kind of ongoing review that states are currently conducting as they look across applications to crops in the latest beta version.
    - **Reviewer:** New Figs 3-6 and 3-7. The rate of allowable application above the application goal should be re-reviewed by an appropriate group of experts. The justification for how these values were established should be reported (not that "appropriate people were asked and this is sort of what they said") and the decision substantiated. Again, it may just be the scope of the rate ranges shown in the figures that is causing me concern. However, application of purchased inorganic fertilizer at rates much greater than 100% of crop need make even less sense than those high rates of manure. If this is what's being simulated then it suggests to me that there are major problems with the assumptions going into this.

Question #3: *Given the lack of data available to estimate acres on which two crops were harvested (double-cropped acres), please comment on the overall appropriateness of the method used to estimate these acres. Relevant sections: 5.3.3.*

Section 5.3.3.

- Several crops in these lists, such as corn, sunflowers and some beans (excluding soy), are not grown in a multiple crop/calendar year system as the timing of plant and harvest indicate.
- The method seems appropriate since it pinpoints those crops most commonly grown as double crops in the regions and represented in the Scenario Builder. Two different harvest estimates: (1) total harvested area minus harvested area of crops not double cropped, and (2) total harvested area of crops that are double cropped, from local (county-level) harvest information in the Census of Agriculture are then compared to determine double cropping area.
- Since the National Agricultural Statistics Service (NASS) Cropland Data Layer (CDL) has been expanding coverage, updated on an annual basis, and includes double cropped areas and major crop areas, has there been any consideration to use the Cropland Database to corroborate the double cropped area? Furthermore, since the CDL is released annually, it has been employed to generate crop rotations over extensive areas (e.g., Penn State Center for Nutrient Solutions, Wisconsin by the Wisconsin Department of Natural Resources, and US Western Corn Belt), even on a pixel-by-pixel basis.
    - **CBPO:** Yes. The CDL was just recently used to compare acres of double-cropped major row crops with acres of the same crops from the Phase 6 Model. The comparison should similar results, but the CDL estimated slightly more acres. This information has led the AMS and Ag Workgroup to take a closer look at the double-cropped approach.
    - **Reviewer:** Some of the checks that have been done, such as the one just described, for the different methods and approaches provided in Scenario Builder may be useful in the documentation because it offers further evidence of the effort extended by the CBP to best represent nutrient inputs in the model.
- In addition, the CDL contains similar land use classifications as suggested by the Census, thus offering a potential option for additional support to inform land use differentiation and double cropped acreage. The information from the annual CDLs could help corroborate the land use area interpolated between publications of the Census of Agriculture published every five years.
- In table 5-2, I do not believe sod should be included with Other Agronomic Crops (cotton, tobacco). It would fit better under Other Hay.

- Why is cropland on which 'all crops failed or were abandoned' treated as Other Hay? Why not Ag Open Space?
    - **CBPO:** Ag open space is reserved for non-cropland upon which applications of nutrients would never occur. Failed crops may have received nutrients and may have a different soil cover than Ag open space.
    - **Reviewer:** True, but they may also have not received nutrients and may have different cover than "Other Hay." I'm not sure intent of Ag Open Space was to ever have nutrients applied. Some land use other than Hay could be used as a proxy, but on the nutrient issue, Ag Open Space should be disqualified. I suggest letting Hay be Hay.
- I wonder about the possibility of abandoned/unharvested acres and whether the long list of eligible crops might not result in potential errors in estimates.
- This method seems acceptable given the census data. However, it seems the documentation could be made much clearer and more straightforward with an example and/or graphic.
- It appears to me that too many major field crops are listed in step a) whose acreage will never be used to double-crop the crops listed under step b). This would lead to an under-estimation of the amount of double-cropped acreage. Although I have not looked at the exact Census of Agriculture definitions, I would suggest a reduced list under step a) that would only include: i) alfalfa hay; vi) other managed hay; viii) small grain hay; x) wild hay; xiv) field and grass seed crops; xvii) canola; and xviii) popcorn.
- The final sentence in this section is incorrectly stated. As stated, double-cropped acres will always be a negative number. The sentence should read: "If "Major Field Crops" (harvested acres) minus "Major Field Cropland Harvested Area" >0…".

Question #4: *Considering the current state of the science related to agricultural forecasting and agricultural economics, please comment on the overall appropriateness of the agricultural forecasting method. Are there alternative forecasting methods you would recommend? Relevant sections: 5.3.1.*

Section 5.3.1.

- Commodity prices track fairly well opposite market trend data. Yield and nutrient management have very different drivers than acreage. Fertilizer costs and development of Ag lands are going to be largely disconnected from the important metrics for forecasting.
- My first thought was that crop pricing and weather would be important for forecasting tools. Different weather projections are now openly available. If a crop price is projected to rise, more fields may be planted accordingly, or if high rains or very low rains are predicted, crop selection and the number of fields put into production may be affected.
- The effect of climate change on agricultural forecasting may need to be broached in continued forecasting efforts, especially over the longer term. Climate change may impact crop selection and nutrient inputs.
- Re: Forecasting agricultural acres - "The choices of the alpha and beta weighting factors, of 0.8 and 0.2 respectively, were chosen based upon an analysis of which factors best predicted both poultry and cattle populations reported in the 2007 Census of Agriculture." Why is the number of agricultural acres based on predictions for poultry and cattle populations? Wouldn't it make more sense to use the projections based on the changes in actual acres over time? If not, then the rationale for using poultry and cattle needs to be explained.
    - **CBPO:** The numbers of forecasted agricultural acres are not based upon poultry and cattle populations. Future agricultural acres are based upon trends in past agricultural acres. Future animal populations are based upon trends in past animal populations.
      The Ag Workgroup asked the CBPO to validate the use of 0.8 and 0.2 as weighting factors for the forecasting procedure. There have been significant trends in both cattle and poultry over time across the watershed, so the procedure was tested using these two categories.
    - **Reviewer:** The alpha and beta weighting factors of 0.8 and 0.2 should be tested on the agricultural acres (or individual crop) dataset, not the poultry or cattle data. Selection criteria and examples for these weighting factors should be based on the agricultural acres and changes in cropland. Flexibility and constraints that limit changes in numbers are different among crop and livestock operations.
- The choices of the alpha and beta weighting factors for the smoothing procedure were chosen based upon an analysis of poultry and cattle populations. This is totally unacceptable. Trends in crop acreage cannot be expected to follow trends in animal numbers. In fact, assuming crop acres respond to commodity prices, high feed grain prices would stimulate

feed grain acreages but reduce animal numbers, as animal production is adversely affected by feed grain prices.

- Should more weight be given to the longer-term trend, rather than the shorter term?
  - **CBPO:** This is definitely a subjective decision. 0.8 and 0.2 worked well when predicting cattle and poultry, and so the Ag Workgroup felt comfortable using these weighting factors. An argument could certainly be made for placing more weight upon the longer-term trend.
  - **Reviewer:** The alpha and beta weighting factors of 0.8 and 0.2 should be reevaluated and tested on cropland acres (changes in crop acres). The hypothetical example in table 5-3 shows approximately 30% error rate in actual reported acres (Yt) and Aft from 1987 to 2012. If this large discrepancy exists for other crop types/uses, a new strategy is needed.
- Potentially compare Scenario Builder forecasting methods with past, current, future CDL maps to look at apparent trends in crop groupings and rotations. Although CDL doesn't give as much breakdown in specialty crops, the groupings are at the level more related to the groupings used by Scenario Builder. CDL seems to show year to year fluctuations in overall cropping selection choices (possible relationships to economics, weather, crop damaging insects).
- Define what is meant by "short-term" and "long-term". "The most recent CoA value" does not comprise a trend, which takes at least two points. If this is the actual methodology being proposed, replace the word "hypothetical" with "example".
  - **CBPO:** "Short-term" is a predicted trend based upon the most recent real values from the Ag Census. "Long-term" is a predicted trend based upon the values from all previous Ag Censuses. The Ag Workgroup voted to place more emphasis on the short-term values because they reasoned that trends in the near-future (2 or even 10 years out) would look more like the recent past than the distant past. All forecasts will be updated when the 2017 Ag Census is released.
  - **Reviewer:** No response.
- A graph alongside Table 5-3 would be helpful in illustrating the trends in actual values, along with the unadjusted and adjusted forecasts.

Question #5: *Does the documentation sufficiently describe the data and methods used to estimate nutrient inputs for the Watershed Model? Please expand if there are particular sections that should be expanded upon or improved.*

- The use of external sources, such as the National Landcover Database (NLCD) and the CDL, were only limitedly explained in regards to estimating land use areas. A more complete description of how the different datasets are integrated into the land use estimates would be helpful.

Section 3.2.1

- Explain that the calculations in Section 3.2.1 are for animals, each with an assumed average weight, consistent with CoA inventories, and then describe what these typical weights are.
- Since "hogs for slaughter" and pullets animal weights vary by region and throughout the year, explain that manure is calculated slightly differently and will be explained in Section 3.2.1
- Explain the "D-filling procedure (Section 5.3.2) and cite a reference.
- The order of tables does not align with the text very well. Move Fig. 3.3 and its discussion to the end of Section 3.2.
- Table 3-4 should come after the discussion of its various components.
- Include somewhere in this section the explanation from Appendix A about the justification for use of 6 significant digits.

Section 3.2.4

- A few sentences of this section seem to have typos that create confusion. "The percent moisture of each ton reported can differ significantly, thus causing under-or-over-estimates of nutrient transport for this BMP is (as?) moisture is not standardized. This is an issue that the Partnership has not yet taken up for the Phase 6 Model, but should do so before final calibration occurs. Table 3-12 lists the assumed moisture content of each type of manure for Phase 6. Broiler moisture fractions were provided by ASAE, 2003 and 2005 with broiler moisture fractions taken from the Poultry Litter Subcommittee report."

Section 3.2.5

- Please describe how in-field ammonia volatilization fractions were derived. Not enough information is given at this time to review.

Section 3.2.8.

- Suggestions for areas to expand are included in the above responses. In addition, the x axis of Figure 3-4 is not clear (should it just be "Percent Application Goal by crop"?).
    - **CBPO:** Is this in reference to Figure 3-7: Inorganic Nitrogen Application Curves by Crop Group? If so, the x axis refers to the reference line of "specialty crops." All other applications are made relative to this reference line.
    - **Reviewer:** No response.

Section 3.3.1

- It would be helpful to label the steps outlined in 3.3.1 in the following sections, e.g., 3.3.1.1 Aggregating Fertilizer Sales to Regional (Step 1). Explain why 1997 values were not considered.

Sections 3.3.2

- Explain the basis for the fertilizer fraction assumptions on page 3-29.

Sections 3.2.8 and 3.3.4

- The labels on Figures 3-4, 3-5, and 3-6 are not very explanatory. I interpret the Y-axis on Figure 3-4 as "Application Rate as Percent of Individual Crop Group N Needs", and the X-axis as "Percent of Manure Available Relative to Total Crop N Needs in each County". An example is needed about how to use the graphs given a certain number of tons of excess manure and how it translates into the units in the graph. Describe the origin and basis of the curves.

Section 3.3.4

- Examples of some of the more complicated concepts may be appropriate. The figures are a bit confusing so the examples in the text are useful and remedy the confusion.
- Sources of data shown in figures and tables should be cited in all cases or appropriately described (if calculated or modeled).
- Agricultural nutrient loading comes from atmospheric deposition, manure, biosludge, and chemical fertilizer. What about the contribution from plant residues, tree litter (particularly riparian), and wildlife?
    - **CBPO:** Plant residues are not directly accounted for in the simulation, but the crop application goals for each crop were based upon an assumption that farmers would credit some previous plant residue input. For example, the crop application goal for corn is 0.92 lbs N/bushel/acre. Most nutrient management planners typically quote 1

lb N/bushel/acre, but the Agricultural Modeling Subcommittee reasoned that 0.92 was more realistic given that a planner would adjust applications down to account for residue.

Tree litter and wildlife contributions are not directly accounted for in the simulation. However, the Watershed Model is calibrated to non-tidal water quality monitoring data. This means that, all else being equal, a forested area with greater wildlife populations may have a higher delivery of N and P to nearby waters. The Partnership can't describe those areas of greater wildlife populations, but their impact is implicit in the water quality modeling data, and thus, the calibration.

- **Reviewer:** I am not convinced that a planner would adjust down unless required, as this is more restrictive in the amount that they can later apply. It seems more likely to me that they would plan for all possible need, in order to maximize the potential to use all manure available, and then perhaps not always meet that need.

Appendix C

- Include units wherever possible, as well as brief explanations of the raw data sets. Clarify Rule 5, Step 1 (does MAX YIELD RATIO = "USDA Combined Yields" / "Max Yield"? The text is not specific.) The last line in the Appendix appears to have been separated from other text and is meaningless in the present context (1984 a=1985).

Appendix D:

- The basic concept of using RUSLE2 to calculate crop canopy cover appears reasonable, including its use of crop management zone/state combinations, representative soils, slopes and slope lengths by crop type, and to calculate detached sediment (DETS) using "no plow" and "plow" scenarios.
- The Table 5 caption states that both L and S factor inputs are included. The table, however, appears to only include S inputs (in comparison with Table 4), so either the table is incomplete or the caption is incorrect. The footnote linked to CMZ 4.1, PA4 in Table 4 should be "4", not "44", and CMZ 65, PA2 in Table 4, was probably meant to be PA4.
- The PA slope and length relationship guidance described after Table 14 appears to be incomplete, as no increments of slope steepness appear in the list.

General suggestions

- Word equations throughout the document can be difficult to follow due to ambiguity, especially when they get lengthy. I would suggest replacing them with simplified equations, such as A = B x C +D, and then defining the name and units of each term.
- Cite units and data sources footnoted in each table, not just in the text.

- Specific wording changes recommended in the February 1, 2016, version of the draft documentation:
  - Figure 1-1: Update the number of WQGIT workgroups, shown as 6 in the figure, 7 in the text on page 1-3, and 12 listed on the web site. I think it would also be helpful to show where WTWG, AgWG, AMS, and STAR fit into the figure, since they are all discussed in the text following the figure.
  - Page 1-7: "subdivided ~~in~~ to allow…"
  - Pages 1-8 to 1-9: "addition of approximately…Atlantic Ocean. Were removed from the model domain as it was determined that this drained.
  - Since Terrestrial Inputs are relative to given land uses, the report would be more logically organized if the Land Use chapter preceded the Terrestrial Inputs chapter. Crop Groups are mentioned in section 3.2, but not discussed until Chapter 5. The "D-filling" procedure is referenced in 3.2.1.1, but not discussed until section 5.3.2.
  - Section 3.2.1, page 3-3: Explain that all livestock are assumed to have a given average weight which is why weight units are omitted from the equations for loads from livestock. Maybe these could be included in a column in Table 3-3. Explain why "hogs for slaughter" and poultry are exceptions.
  - Page 3-5: "More detailed methods for estimating poultry populations and TN and TP loads are …".
  - Section 3.2.1.1: I think the discussion in this section would be more straight-forward, if Table 3-4 was moved after the discussion of the component nutrient species (after 3.2.1.7), since it is the culmination of all of the interim derived coefficients.
  - Section 3.3, page 3-19: "developed ~~a~~ the following unique fertilizer use …".
  - Section 3.3.2: Please explain the basis for the assumptions on the average make-up of a pound of nitrogen and phosphorus fertilizers.
  - Section 3.3.5, page 3-31, last paragraph: Both fertilizer products are listed as 29-2-4, but the average TN:TP ratio of these identical products is given as 33:1. Please explain how that was calculated, as 29:2 appears to be the correct ratio.
  - Page 3-33: "…and grows for ~~3~~ 2 months …". Please specify the units for Table 3-26. Are the units in Table 3-27 correct? Shouldn't uptake be in units of lbs/max yield/yr? or lbs/ton/yr?
  - Page 3-37: Define "crop basal temperature" and cite a reference.
  - Page 3-38: Equation 3-15 is incomplete.
  - Section 3.7: "…eroded due to ~~plowing~~ field operations for each land use …", "…to simulate sediment ~~erosion~~ yield from …".
  - Page 5-2: The land use link does not work and needs updating. In the last sentence, "Acre of each agricultural land use in each county …".
  - Page 5-10: "…are reduced in ~~the following~~ a stepwise fashion from the following land uses, taking acres …". Explain what is meant by "stepwise fashion" and how it is applied to the list.

- Page 5-12: Clarify whether Equation 5-3 is per animal type, or whether the right-hand side should be a summation over all animal types.
- Page 6-1: Be consistent in use of the term “pass-through fraction”, and replace instances of references to “pass-through values”.
- Page 6-2: I would recommend applying the buffer credit to the same upland land use from which the buffer is taken, rather than from all agricultural land uses in the land-river segment. If the majority of buffers are related to livestock exclusion, it doesn’t make sense to take the filtering credit from cropland.
- Page 6-3: Explain why the “≤ 1” qualifier is included in Equation 6-3.

__Question #6__: *Do the reviewers have any concerns or comments about the data or methods described within the documentation aside from those already listed above?*

- See other reviewer's note on RUSLE2 estimates.

Section 3.3.5

- - Is there an estimate of the % of all turf that receives fertilizer? Perhaps from AAPFCO non-farm and the amount of acres under professional management. I'm thinking there are lots of lawns that receive much less to no fertilizer.
    - **CBPO:** There is currently no estimate of the area that does not receive turf. The Urban Stormwater Workgroup is tackling this problem in much the same way the Ag Workgroup tackled pasture: there are acres that receive a lot, and acres that receive nothing, so the model will simulate the average condition wiping out both extremes.
    - **Reviewer:** We assume the statement meant to say "There is currently no estimate of the turf area that does not receive fertilizer"! I believe that AAPFCO data does include a category for nutrients applied to turf (as non-crop). Regardless, assumptions of turf nutrient use should be reconciled with AAPFCO and state-provided data.

Section 3.4.

- The numbers in Table 3-26 seem pretty high – what is the source? At least for VA they don't match the credits listed in the nutrient management Standards and Criteria.
    - **CBPO:** This is likely in reference to the new Table 3-37: Total Nitrogen Pounds Fixated by Leguminous Crops by Growth Region. This table and the method for estimating legume inputs has been completely revised in the most recent beta version. I've included a new table below that shows the average lbs of N fixed/acre by crop assuming no application of inorganic or organic N. When applications occur, these values will be reduced. This method is based upon a paper by Meisinger and Randall, 1991[1], which stated that lbs of N fixed/acre was directly related to the crop's nitrogen need and applications from other sources.

Crop Name	Avg Lbs N Fixed/Acre
Alfalfa Hay Harvested Area	240.2
Alfalfa seed Harvested Area	158.3
Birdsfoot trefoil seed Harvested Area	88.5

[1] Meisinger, J.J. and Randall, G.W., 1991. Estimating Nutrient Budgets for Soil Crop Systems in Chapter 5 of *Managing Nitrogen for Groundwater Quality and Farm Profitability*. Soil Science Society of America. Madison, WI. 1991.

Cropland used only for pasture or grazing Area	16.2
Dry edible beans, excluding limas Harvested Area	68.8
Green Lima Beans Harvested Area	106.1
Haylage or greenchop from alfalfa or alfalfa mixtures Harvested Area	81.2
Other haylage, grass silage, and greenchop Harvested Area	16.2
Pastureland and rangeland other than cropland and woodland pastured Area	16.2
Peanuts for nuts Harvested Area	140.9
Peas, Chinese (sugar and Snow) Harvested Area	106.1
Peas, Green (excluding southern) Harvested Area	106.1
Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	106.1
Red clover seed Harvested Area	109.7
Snap Beans Harvested Area	106.1
Soybeans for beans Harvested Area	152.5
Vetch seed Harvested Area	195.0

- **Reviewer:** I appreciate the update and added information. It's clear that these values are an estimate of the total N fixation by the crop. What is not clear is how these values are used in terms of crop N demand, uptake and any potential excess. This should be explained here or else citation should be given to a section where it is described.

Section 3.5.1.

- In regard to Table 3-27: Why use theoretical max yields when we have actual county estimates for many crops?
  - **CBPO:** This is in reference to the new Table 3-38. Theoretical yields are used for the majority of crops because the yield data for non-major crops is very poor and extremely variable.
  - **Reviewer:** I was confused by the fact that both "major" crops, with uptake calculated on a yield basis and "non-major" crops with uptake calculated on an acre basis are presented intermixed in the same table. I suggest that it would also improve the clarity of this point if the Maximum Yield column were dropped from those entries where it is not used as part of the calculation (major crops).

Section 3.5.2

- Can this approach be validated on one or more of these crops?
  - **CBPO:** The crop uptake for all crops, not just non-major crops is currently being revisited. We would welcome any suggested references for uptake that reviewers could provide.

- **Reviewer:** The source for N and P uptake estimates (per unit of measure) and theoretical maximum yield by crop should be cited. I don't have personal experience with many of these crops but for those I do, I have concerns about what's in this table based on the data I can lay hands on.
    - Cotton yield: 8.36 bale max yield * 0.61 ~ 2450 lb/ac. Actual 5 year mean cotton yields in Virginia are ~990 lb/ac.
    - Canola yield: 4000 lb/ac max yield * 0.61 = 2440 lb. Actual 5 year mean yields in our two locations of canola variety testing in VA (Orange and Petersburg, VA) are 1818 lb/ac (and these are small plot tests on the best land under very good management).
    - A recent summary of nutrients removed in wheat straw reported 16.2 lb N and 2.4 lbs P removed per ton. 57 and 54% less, respectively, than what's shown in Table 3-38. http://blogs.ext.vt.edu/ag-pest-advisory/files/2015/06/Straw_Value_17June2015.pdf.

- Now that the Scenario Builder and Watershed Model are becoming more linked, it may be worth considering the move of some calculations that are not based on specific input data into the watershed model. For example, ammonia volatilization. This may not be feasible without major restructuring, but then clarifying that briefly in the documentation may help justify for readers why the calculations need to remain in the order/location that they are.

- Some conservation management such as contour cropping, cover cropping and minimum-tillage has become much more common in the past decade in regions where the climate permits. Although this may only cover that later portion of the period simulated by the model, I think it would be helpful to readers to explain how these practices are considered in the baseline simulation or explain why they are removed. If the input data is considered to incorporate these practices in recent land use and crop estimates, that would be useful to point out.

Section 3.2.6.

- In P532, only Virginia reported biosolids. Have these quantifications been expanded to include all states for Phase 6? Please describe.

Appendix D:

- The C sub-factor inputs are not provided in the appendix. They are erroneously listed as being outputs in the text after Table 5. The only simulated outputs from the "C subfactor by day" tab and table should be EI% (although there is no explanation of how that gets used) and slope soil loss (which appears to be duplicative of output cited previously from the "Erosion by day" tab.

- Annual summary statistics are provided for the “no plow” scenario, but similar statistics are not provided for comparison with the “plow” scenario.
- Concerns about the relative evaluation of the C sub-factors for the “plow” scenario among states was raised previously by the Ag Loading Rate Review Steering Committee (ALULRSC) in its December 17, 2015 report: “Although our Sub-group endorsed the use of RUSLE2 for generating sediment loads and relative loading ratios, our review revealed inconsistencies in the range of sub-factor values evaluated between states and crop management zones (CMZs). … our Sub-group strongly felt that these inconsistencies must be addressed before the relative loading rates as used by Scenario Builder will be a valid representation of erosion rates among states and CMZs.” An example of this variability is illustrated with an example in the following Table 4 from the ALULRSC report for the “crop residue %” sub-factor for the pasture/range land use. The sub-factor values were independently estimated by NRCS personnel in each state, but no attempt was made to harmonize them so that they would be comparable across states, resulting in the variability shown in the example in Table 4. To my knowledge, these concerns have not been addressed, even though an informal recommendation to CBPO personnel was made to use a retired regional USDA-NRCS RUSLE2 database developer to provide such an assessment earlier in March of this year.

  Table 4. RUSLE2 “crop residue %” variability for Pasture/Range among state/CMZ combinations (ALULRSC 2015)

State:	DE	MD				NY	PA		VA			WV
CMZ:	**59**	**4.1**	**59**	**65**	**66**	**4.1**	**4.1**	**65**	**64**	**66**	**67**	**62**
Month	**crop residue %**											
Jan	31	55	20	43	44	56	7	27	32	30	29	73
Feb	30	54	19	44	44	57	7	27	39	37	36	72
Mar	24	53	33	41	41	56	6	32	36	33	33	70
Apr	18	46	47	42	40	18	5	36	34	31	31	58
May	16	39	36	32	30	1	4	29	33	30	29	40
Jun	21	32	38	34	33	1	3	27	32	28	28	42
Jul	27	30	50	49	48	1	6	32	30	27	26	52
Aug	22	29	47	48	47	0	9	29	27	25	24	63
Sep	16	28	38	40	38	0	9	24	26	24	23	72
Oct	25	40	26	37	36	11	6	22	24	22	21	76
Nov	29	50	22	40	40	25	6	25	24	22	21	75
Dec	33	55	21	42	43	47	7	26	24	22	22	74
Average	**24**	**43**	**33**	**41**	**40**	**23**	**6**	**28**	**30**	**27**	**27**	**64**

- The APLE model was used to develop P sensitivities for the various crop types and sources of P. Although documentation for this effort has not been provided and was not part of the formal review, it is very much a component of how P inputs are represented in the P6 model. An outstanding recommendation from the ALULRSC with regards to this component was that "…current results from APLE2.4 simulated phosphorus loads are based on RUSLE and soil P concentrations from Phase 5.3.2" whose loading rates for pasture were deemed excessively high relative to other land uses. The committee recommended that the analysis be updated using the RUSLE2 erosion loads (from Phase 6) and the updated soil P test results, which to our knowledge has also not been performed.

***<u>Question #7</u>**: Are there additional technical data or scientific findings that could be employed by the Chesapeake Bay Program now, or developed in the future, to better inform nutrient input estimates across the watershed?*

- As the Cropland Data Layer continues to be expanded and improved, it may prove to be useful for corroboration of land use and crop areas and for development of rotational scenarios. Other remotely-sensed spatial data may become more useful as the technologies advance.
- Nutrient management planners may offer insight into local farming practices that can be informative to manure/fertilizer application rates, timing and conservation techniques. In some of the Chesapeake Watershed states, large datasets covering the extensive information contained in nutrient management plans from several thousand farms (minus any private information) may be available from nutrient management planners and their associated organizations.
- Agricultural guidelines may provide fertilizer/manure application rates and timing for major crops represented in Scenario Builder.
- Possible fertilizer application rates and timing estimates: Based on survey results presented at the Soil and Water Conservation Society (SWCS) annual meeting, a majority of farmers sought fertilizer rate and timing recommendations from local fertilizer sales companies and agribusinesses because those working at these companies and business are often from the local communities and/or family.
- Survey fertilizer retailers on sales by crop type.
- Update manure production by animal type.
- Reconcile assumptions with best management practices, at least since late 1990's.
- For the future, work by the EPA-funded PSU Center for Nutrient Solutions (http://agsci.psu.edu/aec/research-extension/research-centers/center-for-nutrient-solutions) may provide some methods and results from more detailed watershed modeling to support and/or inform nutrient and land management estimates. In particular, the use of CDL layers and regional agronomy guides has provided the data to create a comprehensive representation of rotational land management (with nutrient inputs) for parts of PA. This management data could probably be extended and generalized for the surrounding PA cropping region, as delineated by the Scenario Builder.

Section 3.2.1.4.

- Suggested improvement for future versions of the model - Have the model account for mineralized N from previous year manure applications.

Section 3.2.4.

- For manure transport, % moisture appears to be very important. Would it be reasonable to request that this information be collected and reported in the tracking system, in addition to the type and tons of manure transported, in order to reduce the uncertainty in calculating the dry weight loads?
    - **CBPO:** That was considered, but instead of directly asking for the information, the Watershed Technical Workgroup (who manages tracking and reporting requirements) recommended that each state report dry weight or assume the default moisture content.
    - **Reviewer:** Great!

Section 3.3.1.3

- The AMS currently is considering alternatives 3A and 3B. There appears to be greater confidence in the fraction of crop application goal than in the fraction of fertilizer sales, yet currently they are weighted equally. Is there a way to quantify the uncertainty, even subjectively, in order to provide a better weighting of these two components, rather than just averaging?
    - **CBPO:** The Ag Workgroup recently approved the use of 3A, an approach that assumed the following:
        - Total fertilizer lbs applied across the watershed are equal to total lbs estimated as used across the watershed based upon methods described in Sections 3.3.1.1 and 3.3.1.2.
        - Total fertilizer lbs used across the watershed will be distributed to each county based upon ONLY each county's relative fraction of crop need, NOT upon dollars spent from the Ag Census. This change will be reflected in a future update to Section 3.3.1.3.

      The rationale for this change was that, subjectively, the dollar spent from the Ag Census has more uncertainty as it relates to fertilizer use than the crop need remaining in a county.
    - **Reviewer:** No follow-up response.

References

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Appendix A

Request for Scientific and Technical Advisory Committee (STAC) Peer Review of the Nutrient Inputs to the Watershed Model
June, 2016

The Chesapeake Bay Program's Modeling Workgroup requests a review of the procedures used to estimate nutrient inputs[2] to the landscape in the Phase 6 Watershed Model. These procedures are described in the Phase 6 Watershed Model's documentation. All questions listed reference the sections of the documentation relevant to the nutrient input procedures.

The Chesapeake Bay Program and Modeling Workgroup are currently reviewing all procedures within the Phase 6 Watershed Model, and adjusting procedures as necessary based upon comments received. The Modeling Workgroup requests responses to the questions/requests listed below by August 31, 2016 in order to ensure that STAC's comments are adequately addressed, and any potential changes to nutrient procedures resulting from these comments can be addressed by the workgroup.

Questions/Requests for STAC Review of the Phase 6 Watershed Model's Nutrient Input Procedures

- Given the state of available manure and fertilizer data, please comment on the overall appropriateness of the methods used to estimate total manure and fertilizer available for application to agricultural lands.
    - Relevant sections: 3.2.1 – 3.2.5 (manure estimates); 3A (for additional information regarding poultry nutrient generation estimates); 3.3.1 (inorganic fertilizer estimates)
- Understanding that farmer-reported nutrient application rates are not available for the majority of agricultural acres throughout the calibration period (1984-2013), please comment on the overall appropriateness of the methods used to distribute applications to crops, hay and pasture.
    - Relevant sections: 3.2.7 (manure applications); 3.3.3 – 3.3.4 (inorganic fertilizer applications)
- Given the lack of data available to estimate acres on which two crops were harvested (double-cropped acres), please comment on the overall appropriateness of the method used to estimate these acres.
    - Relevant sections: 5.3.3

[2] The Phase 6 Model will incorporate all sub-models and database systems into a single tool available to managers and partners at the push of a button through on online portal. Scenario Builder was a term used in previous model versions to describe the database system which provided the Watershed Model with nutrient applications, land use, best management practices and other data inputs for any given management scenario. In this way, Scenario Builder could be thought of as the "input model." The Watershed Model then ran separately to estimate runoff of nutrients and sediment into the rivers and the Chesapeake Bay. In this way, the Watershed Model could be thought of as the "fate and transport model." Because the tools were separate and required extensive run-time, online users could only receive approximate results when setting up a given management scenario. Now the "input model" and "fate and transport model" will be combined, allowing users to receive exact results each and every time they run a management scenario.

- Considering the current state of the science related to agricultural forecasting and agricultural economics, please comment on the overall appropriateness of the agricultural forecasting method. Are there alternative forecasting methods you would recommend?
    - Relevant sections: 5.3.1
- Does the documentation sufficiently describe the data and methods used to estimate nutrient inputs for the Watershed Model? Please expand if there are particular sections that should be expanded upon or improved.
- Do the reviewers have any concerns or comments about the data or methods described within the documentation aside from those already listed above?
- Are there additional technical data or scientific findings that could be employed by the Chesapeake Bay Program now, or developed in the future, to better inform nutrient input estimates across the watershed?