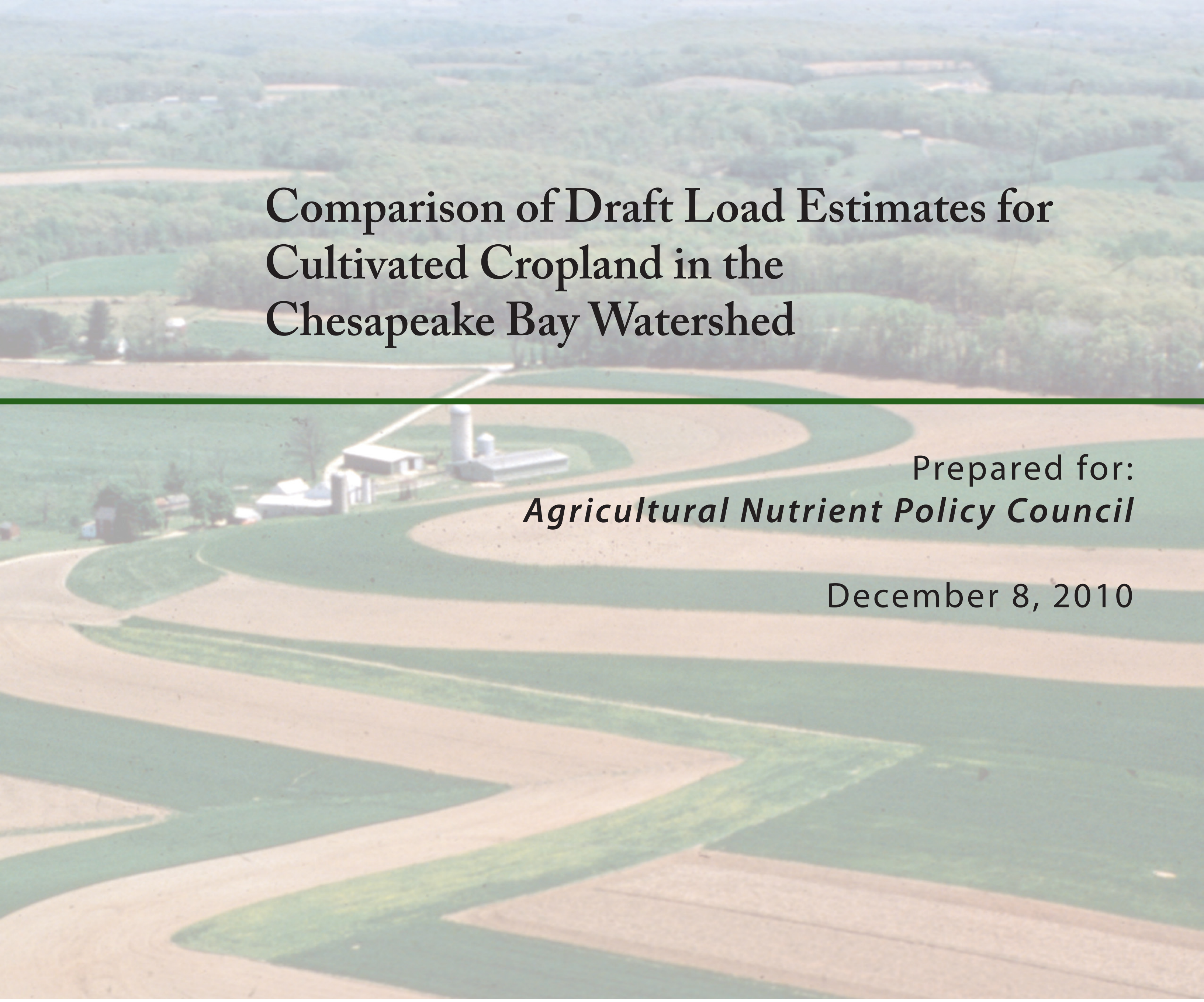
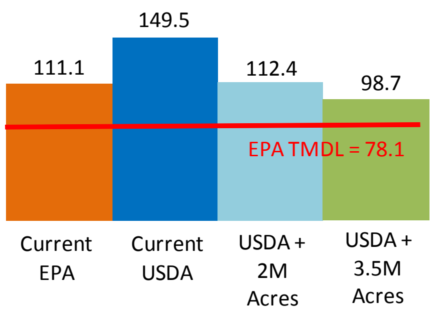


Comparison of Draft Load Estimates for Cultivated Cropland in the Chesapeake Bay Watershed

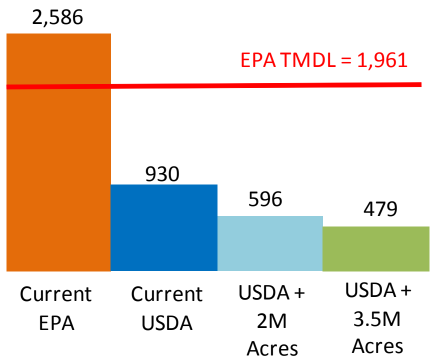
Prepared for:
Agricultural Nutrient Policy Council

December 8, 2010

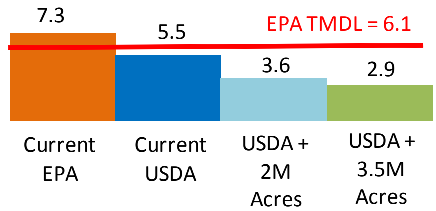
Agricultural Nitrogen (million pounds)



Agricultural Sediment (1,000 tons)



Agricultural Phosphorus (million pounds)



LimnoTech
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Comparison of Draft Load Estimates for Cultivated Cropland in the Chesapeake Bay Watershed

December 8, 2010

LimnoTech

LimnoTech's clients face the most challenging and costly water issues in the nation today. We help them make decisions about their water problems based on sound science and practical economic realities. They trust our ingenuity, expertise, objectivity, and passion for sustainable clean water.

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Cover photo

Courtesy of the Chesapeake Bay Program. Photos-Landscapes. Accessed December 6, 2010 from http://www.chesapeakebay.net/photos.aspx?menuitem=16851.

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Summary

The Chesapeake Bay Program represents one of our country's best efforts to use scientific tools to help determine management actions that are needed to restore a treasured national resource. As stated in Boesch, et al. (2010) "[b]oth the Draft TMDL and the component models that underpin it incorporate extensive monitoring data, research outcomes and alternate modeling approaches." In particular, the Watershed Model provides considerable value in understanding how nitrogen, sediment, and phosphorus loads from different sources are delivered to the Bay. It also provides a useful tool to help make decisions about prioritizing actions to control those loads.

The Watershed Model was originally developed when the Chesapeake Bay Program was a voluntary partnership between the states, the District of Columbia, and the Environmental Protection Agency (EPA). Now that the model is being applied in a regulatory environment, every pound of pollutant that exceeds the allocations in the total maximum daily load (TMDL) will result in mandated requirements on cities, businesses, industries, and private citizens to install and operate new technologies, without regard to economic feasibility of implementation. It is therefore critical that the precision and accuracy of the models be defined. This report provides a comparison of the results of the EPA Watershed Model with a recently released, draft estimate of loads within the Bay watershed by the United States Department of Agriculture (USDA). The report calls for a "timeout" on the TMDL. This timeout is needed to make sure that EPA does not somehow push the use of the model beyond its original design.

USDA's draft report, Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Chesapeake Bay Region (NRCS, 2010), presents very different estimates of pollutant loads to the Chesapeake Bay. The Agricultural Nutrient Policy Council (ANPC) asked LimnoTech to provide an objective comparison of the pollutant load estimates in the USDA report and EPA's draft TMDL. The ANPC wanted to know if the differences in the two estimates are substantial enough to call into question the estimates in the draft TMDL, particularly for cultivated cropland.

LimnoTech found that there are substantial differences between the USDA and EPA pollutant load estimates. We believe there is justification for EPA to not finalize the TMDL and, instead, EPA should work with USDA to reconcile the differences in the estimates. Specifically, the two federal agencies need to reconcile differences in:

- Land use and total acreage of the Bay watershed;
- Hydrology;
- Assumptions about conservation practices;
- Model frameworks; and
- Model results.

EPA and watershed jurisdictions based the allocations in the draft TMDL and the state watershed implementation plans on EPA's Chesapeake Bay Watershed Model. The differences between USDA's and EPA's pollutant load estimates call into question the legitimacy of these allocations and must be reconciled before the draft TMDL is finalized.

New or revised permits for discharges in the Chesapeake Bay Watershed must be consistent with the wasteload allocations of the TMDL once it is issued, notwithstanding cost or the feasibility of controls, so the TMDL will have immediate regulatory consequences. States and the regulated community also must begin taking action to meet all wasteload and load reductions immediately upon issuance of the final Chesapeake Bay TMDL because EPA has said it will take actions, such as objecting to permits or withholding federal funding, if immediate progress (evaluated based on two-year milestones) is not made.

If EPA's assumptions about pollutant loads are wrong then states and the regulated community will misdirect their resources. In addition, public support for the Chesapeake Bay TMDL may be eroded and public confidence in EPA may be severely undermined, particularly if it is determined that EPA was aware that its pollutant load estimates may not be representative of the actual conditions in the Chesapeake Bay watershed. USDA and EPA therefore need to make sure they agree that the pollutant load estimates used to determine the allocations in the draft TMDL and state watershed implementation plans are reasonable.

In reconciling these differences, it would be appropriate to seek input from the six states, the District of Columbia, agricultural scientists from across the nation, and affected stakeholders. USDA and EPA will need to compare the statistical and scientific accuracy of estimates at multiple scales (watershed, State, County, and city/township) because EPA's Chesapeake Bay Watershed Model is being used by EPA and states to specify TMDL load reductions across these multiple scales.

Ensuring that EPA's Watershed Model is correct is important to all stakeholders in the Chesapeake Bay Watershed. Achieving a healthy bay will require an enormous investment of resources. As EPA seeks to hold everyone accountable for achieving the pollutant load reductions called for in the TMDL, it is important to municipalities, industry, agriculture, forestry, and the general public that these investments are properly directed and will actually result in restoration of the Chesapeake Bay.

Our six key concerns are discussed below.

Key Concern 1

EPA Should Not Finalize The TMDL Until USDA and EPA Reconcile Differences in the Estimates

By December 31, 2010, EPA intends to finalize a TMDL for nitrogen, sediment, and phosphorus loads to the Chesapeake Bay. In cases where a water body, such as the Chesapeake Bay, is considered to be impaired (not meeting water quality standards), the Clean Water Act requires states to identify the water body on an impaired waters list- the federal 303(d) list. States (or EPA) are then required to develop a TMDL – or "pollution diet" – to determine the amount of pollution the water body can handle and still be considered healthy. A TMDL is a calculation, which identifies the level of pollutants deemed necessary to meet water quality standards, with seasonal variations and a margin of safety.[1] Point sources receive wasteload allocations and load allocations are assigned to nonpoint sources and natural background loads. [2] The TMDL is the sum of the wasteload and load allocations.

The Bay TMDL is the most complex TMDL undertaken to date. It covers parts of six states and all of the District of Columbia – around 64,000 square miles. For this TMDL (unlike others that have been completed), EPA made a policy decision that states will need to demonstrate, every two years, that they are making progress towards achieving TMDL-mandated load reductions, with all controls in place by 2025. EPA also has made a policy decision that States will need to show that they have achieved 60 percent of the mandated load reductions by 2017.

The Chesapeake Bay TMDL covers parts of six states and the District of Columbia.
Watershed map courtesy of the Chesapeake Bay Program

Generally, TMDLs are developed by states for individual water bodies (i.e., lakes, streams, or rivers). A TMDL can include specific wasteload allocations for large individual permitted sources, broad wasteload allocations for smaller permitted sources and categories of sources covered under general permits, and broad load allocations for categories of nonpoint sources. In the case of the Chesapeake Bay TMDL, EPA has instead developed a draft TMDL for three pollutants in 92 separate water bodies in six states and the District of Columbia that includes very specific individual wasteload allocations for very small sources.

EPA used a computer model (the Watershed Model) to develop the Bay TMDL. The computer model calculates

1 The draft Bay TMDL includes an implicit margin of safety for nutrients (meaning that the uncertainty in the models is used) and a variable, explicit margin of safety for sediment (meaning that EPA reduces the allowable sediment load because of uncertainty in the model estimates).
2 The term point source is defined in the Clean Water Act as any discernible, confined and discrete conveyance. The definition specifically includes concentrated animal feeding operations and specifically excludes agricultural stormwater discharges and return flows from irrigated agriculture. The term nonpoint source is not defined but is treated by courts and EPA as a source of pollutants that does not meet the definition of point source. Nonpoint source pollutants generally are carried to water in diffuse runoff from the land surface.

how much nitrogen, sediment, and phosphorus is expected to reach the Bay and its tidal tributaries. Another computer model, called the "Scenario Builder", is used to estimate the loads generated by agriculture (and other sources) and then those loads are input into the Watershed Model to simulate sediment and nutrient transport throughout the Bay watershed. These tools are then used to estimate how effective agriculture (and other sources) can be in reducing pollutant loads at their source. EPA feeds different scenarios from "Scenario Builder" to the Watershed Model and makes predictions regarding whether water quality standards can be achieved under those scenarios. These predictions are the basis for the allocations in both EPA's draft TMDL and the state watershed implementation plans. It is important to note that while the Watershed Model has been tested and reviewed prior to the draft TMDL being issued, the Scenario Builder has not. It is also not clear whether the assumptions in these models are well understood or whether the models are accurate at geographic scales used in the TMDL.

The TMDL will impose a federal mandate on States, cities, farmers and private industries to reduce pollutant loadings. As proposed by EPA, the TMDL includes allocations to sources that would require them to reduce their loads with single-pound precision (individually or collectively) based on the model calculations. This is the case even though it is not clear that the Chesapeake Bay Watershed Model is accurate at that scale. [3] It is very important from a scientific standpoint that USDA and EPA not only agree on basic model assumptions but also provide credible scientific justification for estimates of how much pollution is actually reaching the Bay. As of December 1, 2010, EPA modelers question the validity of their model and are still compiling a list of recently identified data gaps and long-standing problems with the Bay models.[4]

As noted above, the TMDL will have immediate regulatory consequences upon issuance. However, if the assumptions in the EPA models are wrong then EPA's entire regulatory framework will be wrong as well, misallocating resources and undermining public confidence.

3 As noted in Boesch, et al. (2010), the models "are not designed to assess the loads or effects on water quality for a given year, nor should they be trusted to precisely determine the reduction in loading to the Bay of a specific management practice in a specific part of the watershed."

4 During a December 1, 2010 Chesapeake Bay Watershed Technical Workgroup call, issues about the Watershed Model calculations were still being discussed (see www.chesapeakebay.net/committee_tribstratwork-group_meetings.aspx?menuitem.aspx?menuitem=16745).

Key Concern 2

Differences in Land Use are Substantial

In EPA's Watershed Model[5], there are 41.1 million acres, excluding water surface areas in the Chesapeake Bay and tidal tributaries. As shown in Figure 1, this is 1.39 million acres (2,171 square miles[6]) less than USDA's estimate. This 3.4% difference is significant when EPA considers the TMDL to be accurate to a single pound. For cropland, the differences are even more significant. EPA estimates 3.33 million acres (1.68 plus 1.65 million acres) are used for crops. USDA estimates that 4.38 million acres are in such use, a difference of 1.05 million acres, or approximately 32 percent.

There are also substantial differences in estimates of total agricultural land (the sum of pasture/hay, cropland under conservation tillage, and cropland under conventional tillage). USDA estimates that there are 12.12 million acres attributed to agriculture; EPA estimates there are 9.0 million acres. USDA therefore estimates there are 3.12 million acres (5,194 square miles) more agricultural land in the watershed than EPA.

With respect to cropland and tillage practices, EPA estimates that 50 percent of cropped acres are farmed using conservation tillage (no-till) and 50 percent are farmed using conventional tillage. USDA estimates that 88 percent of cropland is farmed using conservation tillage (no-till or mulch till); five (5) percent is between conservation tillage and conventional tillage; and seven (7) percent is in conventional tillage.

These differences in assumptions about total acres, land use, and conservation tillage versus conventional are significant when predicting different loading estimates.

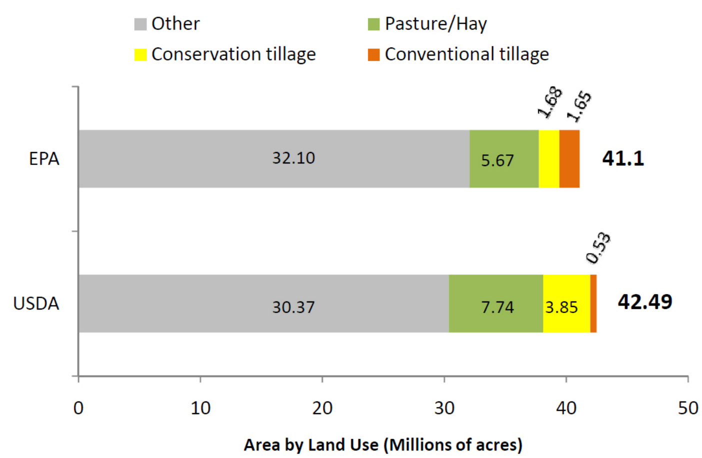

Figure 1. Comparision of Land Uses in the EPA and USDA Model Frameworks.

5 LimnoTech used EPA's 2009 progress scenario for comparison purposes (see Appendix A).

6 The State of Delaware is 1,954 square miles (land mass only).

Key Concern 3

Differences in Hydrology and Their Implications Need to be Investigated

The EPA and USDA models differ in that they operate at very different time scales (hourly versus daily), have been run for different time periods, and do not use the same rainfall conditions (hourly versus daily, different rainfall data processing). The models also have different representations of the watershed land areas, which leads to differences in hydrology and transport of pollutants.

Both models simulate the full hydrologic cycle on the land surface accounting for rainfall, surface runoff, subsurface flow, groundwater losses/transport, evaporation and transpiration from soil and plants (crops, grasses, trees, etc.). They do, however, represent these processes with different equations and assumptions. Identifying and understanding these differences is critical to interpreting differences in hydrology and pollutant loads.

The EPA model simulates hydrology on an hourly basis and is therefore able to simulate effects of intense, short-duration rainfall events. The USDA model simulates hydrology based on daily rainfall and does not capture the effects of intense, short-duration rainfall events.

The USDA model simulates hydrology for a 47-year period (1960 to 2006); the reported load estimates therefore represent long-term average rainfall conditions. EPA simulated a 10-year period (1991 to 2000) which is within the range of USDA model time period. The EPA estimates may, or may not, be representative of "average" rainfall conditions. Differences in the loading estimates between the models may in part reflect differences in rainfall.

Both models use a technique (called spatial processing) to estimate precipitation across the watershed. This technique allows the modelers to use sparse precipitation data to better represent rainfall conditions over smaller parcels of land. It is not clear if the techniques and the rainfall data that were used by EPA and USDA are significantly different.

According to EPA's draft TMDL, the Watershed Model divides the Chesapeake Bay into approximately 1,000 segments/sub-basins with an average size of 64 square miles (U.S. EPA, 2010a). The USDA models (APEX and HUMUS/SWAT or SWAT) simulate hydrology at the field-scale (APEX) for cultivated cropland and at the 8-digit HUC watershed scale, comprised of hydrologic response units (HRUs). These HRUs are homogenous combinations of land use, soil, and management practices for all other land uses (SWAT), which defines the spatial resolution of the USDA models applied to the Chesapeake Bay watershed. As discussed previously and in Appendix A, LimnoTech found differences between EPA's and USDA's interpretation of watershed areas.

http://photogallery.nrcs.usda.gov

Key Concern 4

USDA and EPA Model Assumptions Regarding Cropland Differ Dramatically

The USDA's approach to estimating the effect of tillage on loads from agricultural cropland appears to be more directly related to agricultural practices than what is represented in EPA's models.

According to USDA, "[m]ost of the cropped acres (96 percent) in the Chesapeake Bay region have some kind of water erosion control practice—either reduced tillage or structural practices or both" (NRCS, 2010, at 35). The USDA estimates account for conventional tillage (high till), mulch tillage (moderate till), and no-till practices. USDA estimates that seven (7) percent of cropped acres are under conventional tillage, five (5) percent of cropped acres have a level of tillage between conservation tillage and conventional tillage, and 88 percent of cropped acres are under conservation tillage (mulch till or no-till) practices.

EPA assumes two types of tillage practices, a high till practice equated to conventional tillage (moldboard plowing) and a low till practice equated to conservation tillage (no-till). Based on an evaluation of EPA model data, EPA estimates that 50 percent of cropped acres are under conventional tillage and 50 percent are under conservation practices.

In general, the cultivated cropland conservation practices incorporated in USDA's model framework are documented and statistically valid in sufficient detail to allow a general understanding of practices accounted for in the modeling, the assumptions made regarding specific conservation practices, and the level of implementation. A similar level of detail and documentation is not, however, available for the EPA model framework. It is therefore not possible to make an accurate assessment of the differences in the level of implementation as well as any assumptions made regarding cultivated cropland conservation practices between the EPA and USDA modeling efforts. Without further documentation of the EPA model framework, it is not possible to evaluate the validity of EPA assumptions or conclusions.

The EPA "2009 Progress Scenario" includes the best management practices tracked and reported by the watershed jurisdictions through 2009. In contrast, the USDA "Baseline Scenario" includes conservation practices reported in the National Resources Inventory (a statistical approach) – Conservation Enhancement Assessment Program (NRI-CEAP) Cropland Survey (2003-2006), National Resource Conservation Services (NRCS) field offices, USDA Farm Service Agency (FSA), and the 2003 NRI.

USDA uses the data collected from the NRI sample points about the conservation and nutrient management practices in use to estimate statistically the use of those practices across the cropland in the Bay region. USDA then estimates the loading effects of those practices through the use of the field-scale APEX model. In comparison, EPA assumes that conservation practices are applied at the county-level scale in Scenario Builder and in the Watershed Model.

USDA and EPA dealt with animal feeding operations (AFOs) and confined animal feeding operations (CAFOs) differently. EPA attempts to model loads from the CAFO production areas, where animals are housed and manure stored, while USDA does not. Both EPA and USDA appear to model manure application on cropland on a nitrogen basis. USDA estimates that 38 percent of cropped acres have manure applied. It is not possible to determine from the available EPA documentation how much of the cropland in the EPA model receives manure.

Key Concern 5

Major Differences in the Model Frameworks and Their Implications Need to be Understood

LimnoTech compared published model results for the EPA Phase 5.3 Chesapeake Bay Watershed Model (U.S. EPA, 2010b and Appendix A) and the draft report *Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Chesapeake Bay Watershed* (NRCS, 2010). Because EPA was still in the process of updating documentation associated with the draft TMDL during this review, we extracted and processed information (particularly the 2009 Progress Scenario) believed to be comparable with the draft TMDL and the draft USDA report.[7] These observations are based on the available documentation.

The models developed for the draft TMDL and the USDA report were developed for different, yet not contradictory, purposes. Table 1 summarizes the model frameworks used in the EPA and USDA assessments.

The USDA model provides a representation of actual agricultural practices and conservation practices for cultivated cropland in the watershed when compared to EPA's assumptions and modeling efforts. This is based on the following observations:

- USDA used an agricultural field-scale model, which was designed to represent actual agricultural practices. EPA used Scenario Builder and the Watershed Model, which is an application of HSPF (Hydrologic Simulation Program Fortran). Scenario Builder is not a complete agricultural model and it has significant limitations. It was not designed to be a full crop growth model; the finest scale of resolution is at the county level, each year is modeled independently, etc. HSPF does not have the capability to represent and simulate complex agricultural practices (e.g., tillage operations, double cropping, etc.). Instead, Scenario Builder is used to represent farm scale operations, but as mentioned above, it has significant limitations and has not been peer reviewed.
- USDA appears to be using more detailed data -NRI-CEAP Cropland Survey (2003-2006), NRCS field offices, USDA Farm Service Agency (FSA), and the 2003 NRI. EPA used five year Agricultural Census data, literature sources, Chesapeake Bay Program, Agricultural Nutrient and Sediment Workgroup input, etc.
- The USDA model framework seems to more accurately represent real world, Chesapeake Bay watershed agricultural operations and management practices (e.g., crop rotations, varying levels of tillage (no-till, mulch till, conventional till), actual nutrient management practices, etc.) based on the USDA and EPA documentation that is currently available.

7 The USDA report also is being refined. For example, the draft report does not incorporate the increase in the use of cover crops since 2006. The next iteration of the report will incorporate that information, which will likely reduce the estimates of pollutant loadings from cropland.

Perhaps the most significant difference is that the USDA model framework accounts for year-to-year variations in agricultural land practices at the field-scale. The Chesapeake Bay Program models do not appear to account for rotations in cropland and different management practices. As discussed above, it appears that the Chesapeake Bay Program has recognized that additional refinements to the EPA model framework are needed to properly represent pollutant reductions associated with various controls, for sources including agriculture, particularly at a local scale (see December 1, 2010 conference call of the Chesapeake Bay Program's Watershed Technical Workgroup).

Table 1. Model Frameworks for the Chesapeake Bay TMDL and the USDA

	EPA	USDA
Model Framework	Scenario Builder, Watershed Model (WSM) Phase 5.3 (HSPF)	APEX, HUMUS/SWAT
Model Application Objective	Quantify sediment and nutrient source loads from agriculture and other sources (e.g., urban/suburban runoff) in the Chesapeake Bay TMDL and allocate loads to attain water quality standards	Quantify the effect of commonly used conservation practices on cultivated cropland in the Chesapeake Bay Region
Model Scale/Resolution	Approximately 1,000 segments/subbasin with an average segment/subbasin size of 40,960 acres (64 square miles)	Field-scale to 8 digit hydrologic unit code (HUC) watersheds
Simulation Period	10 year simulation period, based on 1991 to 2000 climate/hydrology, and varying land practices	47 year simulation period, based on 1960-2006 climate/hydrology, and 2003-2006 land practices
Agricultural Land Practices	Agricultural land practices are represented on a county scale in the Scenario Builder tool. Agricultural land practices are independent of the previous and subsequent years. There is no capability in the model framework to account for year to year variation in agricultural practices at the field-scale	Agricultural land practices for cultivated crops are represented in detail using a field-scale model, which accounts for farming operations used to grow crops. The farming operations include planting time, tillage before and after planting, application of commercial fertilizer, application of manure, irrigation, and harvest time. The model framework is able to account for year to year variation in agricultural land practices at the field-scale, which includes crop rotations and more complex practices such as perennial hay in rotations, replanting, cover crops, etc.
AFO/CAFOs	AFO/CAFO sources are directly accounted for in the modeling	Manure from AFO/CAFOs are accounted for in cropland

References: Brosch, 2010; U.S. EPA, 2010a; U.S. EPA, 2008.

Key Concern 6

The Model Results are Substantially Different and Raise Significant Concens That Should be Investigated and Resolved Before the TMDL is Finalized

Because of the differences in land use and acreage, hydrology, conservation assumptions and model frameworks, there is substantial uncertainty about comparisons between EPA and USDA's estimates. There are also substantial differences in the assumptions about load reductions that can be attained. The differences are significant enough that USDA and EPA need to thoughtfully investigate and resolve the implications of these differences before the TMDL is finalized.

(a) Differences in Assumptions Regarding Land in Agricultural Use and Pollutant Load per Acre from Agricultural Land.

USDA's estimate of the total nitrogen load from agriculture (149.5 million pounds) is 25 percent higher than EPA's estimate (111.1 million pounds). The differences in estimates may be attributed to the differences in cropland acreage within the watershed estimated by EPA and USDA. Load per acre is the amount of load that runs off an acre of land that is estimated to be delivered to the Bay or its tidal tributaries. Load per acre calculations for total agriculture were similar for nitrogen but significantly different for sediment (three to four times) and phosphorus (1.5 to two times). These differences are significant.

The differences in load per acre and their potential effect on total loads for the Bay are shown in Tables 2 to 4 for nitrogen, sediment, and phosphorus. Each table lists the total load and total acreage and then the calculated load per acre for the EPA and USDA estimates. Calculations are presented for cropland; hay and pasture; CAFO (EPA only); and total agriculture.

As shown in Table 2, USDA estimates that there are 12.12 million acres of agricultural land in the watershed, which is 3.12 million more acres than EPA's estimate (excluding areas associated with confined animal feeding operations, or CAFO). USDA therefore has 34 percent

Table 2. Total Nitrogen Load per Acre for EPA and USDA Estimates

Description	Cropland	Hay & Pasture	CAFO*	Total Agriculture
EPA -Total Nitrogen (million pounds)	*74.3*	*27.8*	*9.0*	*111.1*
EPA - Land Use (million acres)	3.33	5.67	0.02	9.02
EPA- Total Nitrogen Load per Acre (pounds per acre)	**22.3**	**4.9**	**469.3**	**12.3**
USDA - Total Nitrogen (million pounds)	*94.7*	*54.8*	*na*	*149.5*
USDA - Land Use (million acres)	4.38	7.74	na	12.12
USDA - Total Nitrogen per Acre (pounds per acre)	**21.6**	**7.1**	**na**	**12.3**

*EPA has a combined animal feeding operation (CAFO) load number that the USDA does not — USDA allocates this to land applicatiion or reflects the common practice of manure being transported out of the Bay watershed for land application elsewhere.

more agricultural land in its model than EPA has in its model. Based on the significant increase in agricultural land in USDA's estimate, it is not surprising that USDA's estimate of total nitrogen load from agriculture is greater than EPA's estimate. This suggests that the differences in nitrogen loads may be directly associated with assumptions in the amount of agricultural land.

Table 2 also points out some other important differences in the model estimates. For cropland, EPA estimates 0.7 more pounds of nitrogen (22.3 minus 21.6) reach the Bay on a per acre basis from cropland than does USDA- an 3 percent difference. For hay and pasture, USDA estimates 2.2 more pounds of nitrogen (7.1 minus 4.9) reach the Bay on per acre basis than does EPA– a 45 percent difference.

As shown in Tables 3 and 4, the differences in sediment and phosphorus estimates do not appear to be related to differences in assumptions about the amount of agricultural land. EPA sediment load estimates are nearly three times larger than USDA estimates. EPA phosphorus loading estimates are larger (1.3 times) than the USDA estimates. In terms of load per acre, EPA estimates are three to four times larger than USDA estimates for sediment (Table 3) and 1.5 times larger for phosphorus (Table 4).

Table 3. Sediment Load per Acre for EPA and USDA Estimates.

Description	Cropland	Hay & Pasture	CAFO	Total Agriculture
EPA -Sediment (1000 tons)	*1,270*	*1,294.3*	*20.9*	*2,585.3*
EPA - Land Use (million acres)	**3.33**	**5.67**	**0.02**	**9.02**
EPA- Sediment Load per Acre (pounds per acre)	**761.9**	**456.6**	**2,176.3**	**573.1**
USDA - Sediment (1000 tons)	*522.7*	*407.7*	*na*	*930.4*
USDA - Land Use (million acres)	4.38	7.74	na	12.12
USDA - Sediment Load per Acre (pounds per acre)	**238.7**	**105.4**	**na**	**153.5**

Table 4. Total Phosphorus Load per Acre for EPA and USDA Estimates

Description	Cropland	Hay & Pasture	CAFO*	Total Agriculture
EPA -Total Phosphorus (million pounds)	*4.1*	*2.7*	*0.5*	*7.3*
EPA - Land Use (million acres)	3.33	5.67	0.02	9.02
EPA- Total Phosphorus Load per Acre (pounds per acre)	**1.2**	**0.5**	**24.2**	**0.8**
USDA - Total Phosphorus (million pounds)	*3.5*	*2.0*	*na*	*5.5*
USDA - Land Use (million acres)	4.38	7.74	na	12.12
USDA - Total Phosphorus Load per Acre (pounds per acre)	**0.8**	**0.3**	**na**	**0.5**

(b) Differences in Assumed Baseline Loadings of Nitrogen, Phosphorus, and Sediment to the Chesapeake Bay from All Sources and From Agriculture.

Figure 2 illustrates graphically the differences in the EPA and USDA estimates of both total loads of nutrients and sediments delivered to the Bay and its tidal tributaries, and the loads attributed to agriculture. These differences are significant.

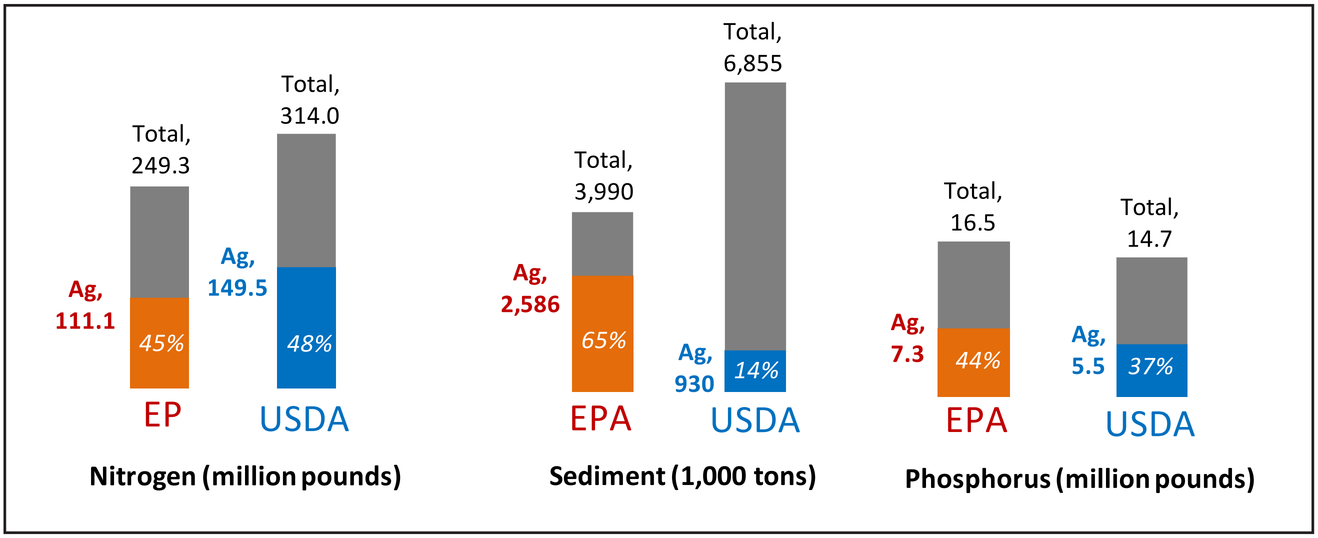

Figure 2. Differences in Estimates of Current Delivered Loads to the Chesapeake Bay, All Sources

EPA estimates that the total load of nitrogen delivered to the Bay from all sources is 249.3 million pounds. This is 64.7 million pounds (21 percent) less than the amount estimated by USDA (314.0 million pounds). EPA estimates that the total load of sediment delivered to the Bay from all sources is 3.99 million tons. This is 2.865 million tons (42 percent) less than USDA's estimate. EPA estimates that the total load of phosphorus delivered to the Bay from all sources is 16.5 million pounds. This is 1.8 million pounds (12 percent) more than USDA's estimate.

EPA's estimate of the percent of the load of nitrogen delivered to the Bay from agriculture land uses (cropland, hay/pasture, and CAFOs) is similar to USDA's estimates. EPA estimates that 45 percent of the total nitrogen load is attributable to agriculture while USDA estimates that agriculture's contribution is 48 percent, a difference of 3 percent. For phosphorus, the difference is greater. EPA estimates that 44 percent of the total load of phosphorus is attributable to agriculture while USDA estimates that agriculture's contribution is 37 percent, a difference of 7 percent. The EPA and USDA estimates are substantially different for sediment. EPA estimates that agriculture contributes 65 percent of the total load of sediment delivered to the Bay while USDA estimates that agriculture's contribution is 14 percent.

(c) Geographic Differences in Estimated Agricultural Loads.

The geographic differences in the estimated agricultural loads that are currently delivered to the Bay were evaluated. As shown in Figure 3, nitrogen loads by geographic region (defined by the USDA) compare relatively well. Differences are substantial for the Susquehanna and Upper Chesapeake for sediment. For phosphorus, differences in the Susquehanna and Lower Chesapeake are substantial. The USDA regions cut across different states. This suggests that States may need additional time to work with EPA to resolve differences prior to making decisions about additional controls that are needed throughout the Bay (based on model estimates).

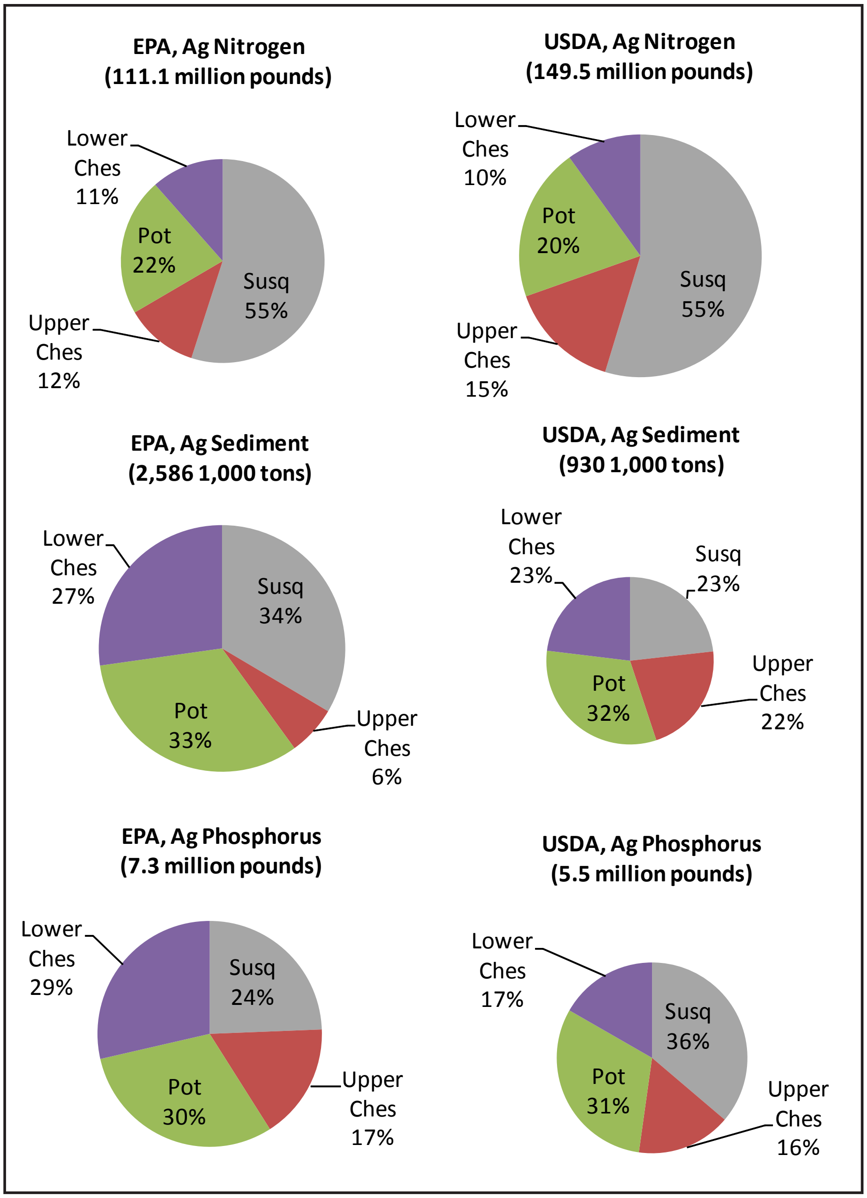

Figure 3. Regional Differences in Estimates of Current Delivered Loads to the Chesapeake Bay, Agricultural Sources

(d) Differences in Assumptions Regarding Agricultural Loadings and Feasible Reductions.

The draft TMDL compounds the problems with assumptions about current agricultural practices (discussed previously) with assumptions about what is feasible in terms of additional conservation practices. LimnoTech compared the current EPA and USDA loads with scenarios where the USDA examined reductions that could be hypothetically achieved if additional acreage were brought under conservation management. Figure 4 provides this comparison with USDA's estimates of an additional 2.5 and 3.5 million acres being brought under a highly aggressive conservation management regime, above and beyond the erosion control and nutrient management practices already in place on these acres.[8] This additional conservation management regime is assumed adopted irrespective of the economic feasibility of the adoption of such aggressive measures on such a wide geographic scale.[9]

The USDA report indicates that relative to the EPA draft TMDL backstop allocations for phosphorous and sediment, agriculture is already well below the assigned loads. The same is not true in the case of nitrogen. The loads to the Bay depicted in the USDA scenarios (where an aggressive conservation management regime is adopted in addition to the practices already in place and irrespective of economic feasibility) indicate that it may not be feasible to reach EPA's target levels for nitrogen delivered to the Bay from croplands. This obviously has significant management implications for agriculture and other sources.

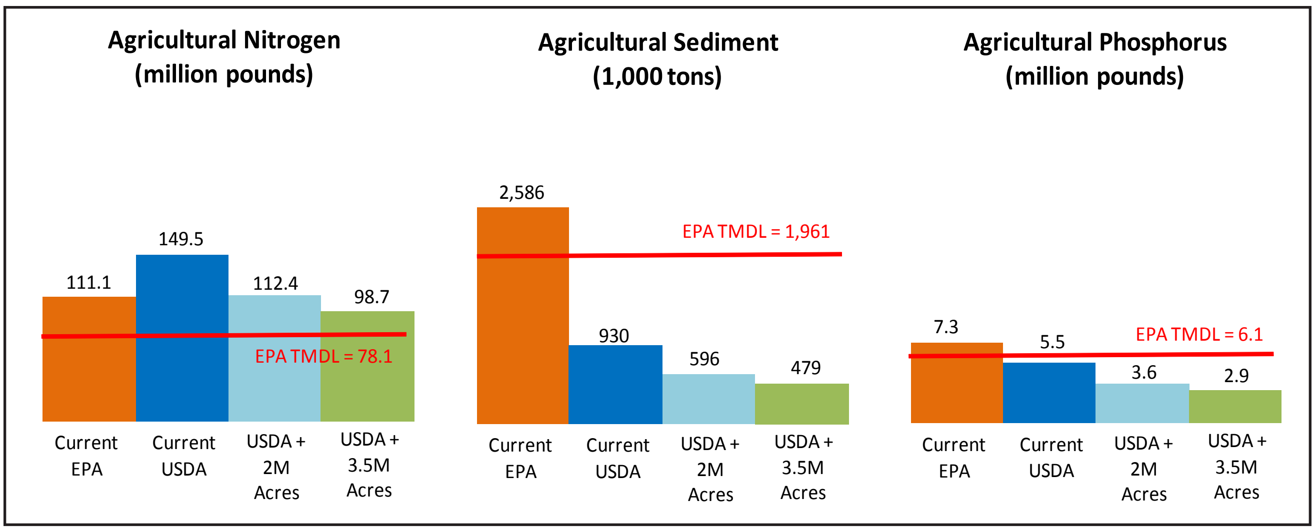

Figure 4. Comparison of USDA Estimates of Delivered Loads to the Draft TMDL

8 See Appendix 2 for a summary of current agricultural load estimates from EPA and USDA and assumed reductions in the draft TMDL and the USDA report.

9 As stated in the draft USDA report: "The level of conservation treatment is simulated to show potential environmental benefits, but is not designed to achieve specific environmental protection goals. Treatment scenarios were also not designed to represent actual program or policy options for the Chesapeake Bay region. Economic and programmatic aspects--such as producer costs, conservation program costs, and capacity to deliver the required technical assistance--were not considered in the design of the treatment scenarios." NRCS 2010, at 123.

While the USDA scenarios do not assume changes in land use patterns in the Bay, EPA's model assumes significant changes in land use under the TMDL. As shown in Table 5, EPA moved 20 percent (roughly 630,000 acres) of land out of crop production to pasture or forest to help achieve the allocations in the TMDL. It is not possible to ascertain from the available EPA documentation the reasoning or justification that EPA used to support the removal of 20 percent of cropland from crop production under the TMDL. This 20 percent reduction in crop production is assumed on top of the 28 percent decrease in cropland in EPA's baseline assumptions, discussed above. Thus, EPA's draft TMDL assumes a 48 percent reduction in cropland when compared to USDA's assumptions.

Table 5. Comparision of Land Use Assignments in the TMDL

Land Use	EPA Current (acres)	Draft TMDL (acres)	Difference (acres)
Cropland	3,333,949	2,702,791	-631,158
Pasture and Hay	5,668,918	6,017,518	348,600
AFO/CAFO	19,215	18,637	-578
Forest	28,693,725	29,017,859	324,134
Regulated Stormwater	992,607	1,857,241	864,634
Unregulated Stormwater	1,965,550	1,058,706	-906,844
Non-tidal Water Deposition*	424,199	425,348	1,149
Total	**41,098,163**	**41,098,100**	**-63**

*Acres of non-tidal water deposition represent the areas of the Chesapeake Bay watershed (such as ponds, streams, and non-tidal rivers) that receive a nitrogen load from atmospheric deposition.

References

Boesch, D.F.; Wells, J.; and Wardrop, D.H. (2010). Letter Re: Docket ID No. EPA-R03-OW-2010-0736. Submitted to Water Docket, Environmental Protection Agency. Nov. 8, 2010.

Brosch, C. 2010. Estimates of County-Level Nitrogen and Phosphorus Data for Use in Modeling Pollutant Reduction Documentation for Scenario Builder Version 2.2. September 2010. URL: http://archive.chesapeakebay.net/pubs/SB_Documentation_Final_V22_9_16_2010.pdf [Accessed October 14, 2010]

Natural Resources Conservation Service (NRCS). (2010). DRAFT Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Chesapeake Bay Watershed. U.S. Department of Agriculture, NRCS. Conservation Effects Assessment Project (CEAP). October 2010.

U.S. Environmental Protection Agency (U.S. EPA) (2010a). DRAFT Chesapeake Bay Total Maximum Daily Load. U.S. EPA, Region 3, Water Protection Division, Office of Regional Counsel, Philadelphia, PA; U.S. EPA, Region 3, Chesapeake Bay Program Office, Annapolis, MD; and U.S. EPA, Region 2, Division of Environmental Planning and Protection, New York, NY; in collaboration with Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia and the District of Columbia. Sep. 24, 2010.

U.S. EPA (2010b). Chesapeake Bay Phase 5 Community Watershed Model (In preparation). EPA XXX-X-XX-010. Chesapeake Bay Program Office, Annapolis, Maryland. December 2010. URL:http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169 [Accessed November 17, 2010]

U.S. EPA, 2008. Chesapeake Bay Phase 5 Community Watershed Model Documentation. U.S. Environmental Protection Agency, Region 3 Chesapeake Bay Program Office, Annapolis, MD. URL: ftp://ftp.chesapeakebay.net/Modeling/phase5/documentation/ [Accessed December 17, 2009].

Appendices

Appendix A

EPA Data Sources

Results for the EPA model were extracted from summary spreadsheets posted by EPA at ftp://ftp.chesapeake-bay.net:

- Baseline results were extracted from the columns titled "p53_2009aveCSO" in ftp://ftp.chesapeakebay.net/Modeling/phase5/Phase53_Loads-Acres-BMPs/P5.3_Loads-Acres_07302010_UpdatedVA.xls
- TMDL Q-1 results were extracted from ftp://ftp.chesapeakebay.net/Modeling/phase5/Phase53_Loads-Acres-BMPs/DraftWip_DraftTMDL_Inputs_OutPuts/EPAScenarios/P53_Loads_Acres_2010EPA19-20.xls
- EPA model results presented in this report were generally calculated by aggregating individual segment results according to different grouping criteria for hydrologic region and for land use.

Hydrologic subregions (4-digit HUCs). Many summary tables in this report present both EPA and NRCS model results broken out by the following hydrologic subregions: Susquehanna River, Upper Chesapeake, Potomac, and Lower Chesapeake. The NRCS and EPA delineations of the subregions are consistent except in the lower part of the Eastern Shore. In order to make the subregion results comparable, LimnoTech aggregated EPA model results for the following cells into the Lower Chesapeake subtotals instead of Upper Chesapeake:

Table A-1. Upper Chesapeake Segments in EPA Model Treated as Lower Chesapeake

UNIQID	CNTYNAME	FIPSCATWAT	Acres
6480	ACCOMACK	A51001EL0_6480_0000N	15851.3744887
6550	ACCOMACK	A51001EL0_6550_0000N	14833.2828470
6610	ACCOMACK	A51001EL0_6610_0000N	23906.1567190
6610	NORTHAMPTON	A51131EL0_6610_0000N	25403.6783119
6610	ACCOMACK	A51001EL0_6610_0000Y	72615.1522016
6610	NORTHAMPTON	A51131EL0_6610_0000Y	47807.8271582
6920	NORTHAMPTON	A51131EL0_6920_0000N	17026.3295733
6920	NORTHAMPTON	A51131EL0_6920_0000Y	34870.5629324
7060	NORTHAMPTON	A51131EL0_7060_0000N	11629.0376693
7060	NORTHAMPTON	A51131EL0_7060_0000Y	28009.4240242
7220	NORTHAMPTON	A51131EL0_7220_0000N	9961.82993113
7220	NORTHAMPTON	A51131EL0_7220_0000Y	85943.2787113
5973	ACCOMACK	A51001EL0_5973_0000N	8896.36340825
6191	ACCOMACK	A51001EL0_6191_0000N	10491.7002677
6190	ACCOMACK	A51001EL0_6190_0000N	49210.3012536

Land use. The tabulated NRCS results presented results for cultivated crops, hay and pasture that correspond to several different land use categories used in the EPA model. The following assignments were used to aggregate the EPA model results into similar groupings:

Table A-2. Groupings used for EPA Model Land Uses

Grouping	P533 Landuse/Source Designation	P53 Landuse/Source Name
Agriculture - CAFO	Afo	animal feeding operations
	Cafo	confined Animal feeding operations
Agriculture - Crop	hwm	high-till with manure
	nhi	high-till with manure nutrient management
	hom	high-till without manure
	nho	high-till without manure nutrient management
	lwm	low-till with manure
	nlo	low-till with manure nutrient management
	urs	nursery
Agriculture - Other	hyw	hay with nutrients
	nhy	hay with nutrients nutrient management
	alf	alfalfa
	nal	alfalfa nutrient management
	hyo	hay without nutrients
	pas	pasture
	npa	pasture nutrient management
	trp	pasture corridor
Forest	for	forest
	hvf	harvested forest
Other	wat	water
	atdep	atmospheric deposition to non-tidal water
	puh	high-intensity pervious urban
	imh	high-intensity impervious urban
	bar	bare-construction
	ext	extractive
	css	combined sewer system
	septic	septic
	pul	low-intensity pervious urban
	iml	low-intensity impervious urban
	ps	wastewater

NRCS/CEAP Data Sources

Results are taken from Tables 24, 25, 28, 29, 32, 33, 52, 53, 55, 56, 58, and 59 in the USDA October 2010 Review *Draft of Assessment of the Effects of Conservation Practices in the Chesapeake Bay Region*.

Cropland loads delivered to the Bay were calculated by multiplying "average annual instream load delivered to the Chesapeake Bay from all sources" by "percent of load attributed to cultivated cropland sources". The ratio of cropland loads delivered to the Bay to cropland loads delivered to watershed outlets was used as the delivery ratio for cropland, hay and pasture loads.

Appendix B

Table B-1 presents a comparison of the EPA and USDA estimates of sediment (1000 tons), nitrogen (Million pounds) and phosphorus (Million pounds) for both the current conditions and assumptions about achievable reductions under the TMDL and additional conservation enhancement assessment programs (CEAPs). In the table, Q-1 represents EPA's definition of the draft TMDL; Q-2 represents EPA's full backstop TMDL; 2M represents the USDA assumption of 2 Million additional acres under conservation; and 3.5M represents the USDA assumption of 3.5 Million additional acres under conservation.

Table B-1. Comparison of Baseline Load Calculations and Reduction Estimates

Sediment (1000 tons)

Scenario	Ag	Crop	Hay & Pasture	CAFO	Other	Total
Current EPA	2,586	1,270	1,294	21	1,405	3,990
Current USDA (CEAP)	930	523	408	na	5,925	6,855
EPA Q-1 TMDL	1,961	1,645	2,244	34	1,183	3,144
EPA Q-2 TMDL	1,961	1,643	2,244	34	1,173	3,133
Q-1 Reduction from Current EPA	*24%*	*-30%*	*-73%*	*-64%*	*16%*	*21%*
Q-2 Reduction from Current EPA	*24%*	*-29%*	*-73%*	*-64%*	*17%*	*21%*
CEAP - 2M acres add cons	596	189	408		5,925	6,521
CEAP - 3.5M acres add cons	479	72	408		5,925	6,404
CEAP 2M reduction	*36%*	*64%*				
CEAP 3.5M reduction	*48%*	*86%*				

Nitrogen (Million pounds)

Scenario	Ag	Crop	Hay & Pasture	CAFO	Other	Total
Current EPA	111.1	74.3	27.8	9.0	138.2	249.3
Current USDA (CEAP)	149.5	94.7	54.8	na	164.6	314.0
EPA Q-1 TMDL	78.1	46.3	28.2	3.6	108.0	186.1
EPA Q-2 TMDL	91.6	49.8	38.2	3.6	95.9	187.4
Q-1 Reduction from Current EPA	*30%*	*38%*	*-2%*	*61%*	*22%*	*25%*
Q-2 Reduction from Current EPA	*18%*	*33%*	*-37%*	*60%*	*31%*	*25%*
CEAP - 2M acres add cons	112.4	57.6	54.8		164.6	277.0
CEAP - 3.5M acres add cons	98.7	43.9	54.8		164.6	263.2
CEAP 2M reduction	*25%*	*39%*				
CEAP 3.5M reduction	*34%*	*54%*				

Phosphorus (Million pounds)

Scenario	Ag	Crop	Hay & Pasture	CAFO	Other	Total
Current EPA	7.3	4.1	2.7	0.5	9.2	16.5
Current USDA (CEAP)	5.5	3.5	2.0	na	9.3	14.7
EPA Q-1 TMDL	6.1	3.3	2.6	0.2	6.4	12.4
EPA Q-2 TMDL	7.3	3.6	3.4	0.2	5.0	12.3
Q-1 Reduction from Current EPA	*16%*	*19%*	*6%*	*59%*	*31%*	*25%*
Q-2 Reduction from Current EPA	*0%*	*10%*	*-25%*	*58%*	*46%*	*26%*
CEAP - 2M acres add cons	3.6	1.6	2.0		9.3	12.9
CEAP - 3.5M acres add cons	2.9	1.0	2.0		9.3	12.2
CEAP 2M reduction	*35%*	*54%*				
CEAP 3.5M reduction	*46%*	*72%*				