This document contains responses to questions that STAC has received about STAC's scientific peer review of the ANPC/LimnoTech report *Comparison of Load Estimates for Cultivated Cropland in the Chesapeake Bay Watershed*.

Question: The STAC review says, "LimnoTech used CBP model predictions for 2009 land use and land management conditions rather than results that are available for 2005, which are more comparable to the 2003-2006 conditions considered by the CB-CEAP model." Can you tell me or share with me which CBP model 2005 data set you all used to generate the corrected CBP numbers in Table 2?

Response: On July 28, the review committee met with the lead developers of both models (Gary Shenk from EPA-CBPO for the CBP model and Lee Norfleet from USDA-NCRS for the CB-CEAP model). We all discussed the two models and the most appropriate comparisons of their results. Gary Shenk then provided the review committee with the numbers from the CBP model run with land use and management conditions from 2005. Here they are:

CB WM Phase 5.3 2005 Scenario (Gary Shenk, USEPA-CBPO, personal communication)									
Basin	Total	Cultivated Crop	Hay	Pasture	Other Ag	Total Ag	Developed	WWTP	Forest
Nitrogen 1000 pounds									
Susquehanna	125,012	50,441	8,208	5,338	7,197	71,185	11,759	14,205	27,864
Upper Chesapeake	39,946	14,615	394	490	441	15,940	7,452	12,437	4,116
Potomac	59,302	15,501	4,329	4,852	3,620	28,302	8,879	11,472	10,648
Lower Chesapeake	47,921	6,866	2,343	2,222	1,841	13,271	6,306	18,432	9,912
Sum of Basins	272,182	87,423	15,274	12,902	13,099	128,699	34,396	56,546	52,540
Phosphorus 1000 pounds									
Susquehanna	4,606	1,147	228	385	224	1,985	461	1,425	736
Upper Chesapeake	2,970	1,351	19	51	49	1,469	539	714	248
Potomac	4,669	1,008	125	1,013	261	2,407	736	940	586
Lower Chesapeake	5,803	979	65	906	241	2,191	915	1,786	910
Sum of Basins	18,047	4,486	436	2,355	775	8,051	2,651	4,865	2,480
Sediment 1000 tons									
Susquehanna	1,430	728	170	68	7	973	148	10	300
Upper Chesapeake	362	175	16	7	1	199	117	3	43
Potomac	1,363	422	150	335	9	916	252	15	179
Lower Chesapeake	1,160	176	139	440	8	762	142	14	242
Sum of Basins	4,315	1,500	476	850	25	2,850	660	42	763

Question: The STAC review says, "LimnoTech compared controllable nutrient or sediment loads from the CB-CEAP model to total nutrient or sediment loads from the CBP model." Can you tell me how this conclusion was reached? LTI used the CEAP-Bay loads from the 2003-2006 period which reflects the NRCS estimates of the loads from crop fields receiving whatever conservation treatments were found there by the NRI survey. So those definitely are the baseline "treated" loads as the CEAP considered them. Those loads were compared to the CBP model baseline load estimates in the 2009 run – which was the baseline used as the starting point for the load reductions called for in the TMDL. So those CBP model baseline loads should/would also reflect whatever consequences from the conservation practices that were fed to CBP model by Scenario Builder, no? In that sense, both baselines would represent the controlled loads. Is this not correct?

Response: As the review committee noted in the report, "The total load from crop fields can be divided into two components, the background load that would be expected if the fields were in a non-agricultural use (like unmanaged grassland or forest) and the additional load (the controllable load) generated by cropping activities (tillage and nutrient application)." That is,

$T = B + C$,

where T is the total load, B is the background load, and C is the controllable load from tillage and nutrient addition. CB-CEAP describes the concept of the background load on page 12 and the background scenario simulation on page 108.

We'll use the results for sediment to illustrate the problems with LTs calculations, but the same issues apply to the LT interpretations of nitrogen and phosphorus loads (which are reported by CB-CEAP using sets of tables that are analogous to the two sediment tables cited here). Tables 40 and 41 report the cropland sediment loads leaving HUC8 outlets. These are total loads (T) from the APEX output, and the background scenario is *not* involved in calculating these numbers. Table 41 also includes the total loads from other source areas as simulated by SWAT plus the sum of the loads from all sources. Table 42 presents the loads from all sources that are actually delivered to the Bay. These numbers can be different from the loads leaving the HUC8 outlets because sediment can be lost to deposition as it is transported through the river network from the HUC8 outlet to the Bay. Thus the delivered load from all sources for the Susquehanna and Upper Chesapeake (Table 42) are lower than the loads at the HUC8 outlets (Table 41). However, the loads delivered to the Chesapeake from the Potomac and Lower Chesapeake HUCs are actually higher than the loads at the HUC8 outlets, possibly because additional sediments can be mobilized from river banks or floodplains between the HUC8 outlets and the Bay.

Now, here's the tricky part--if you estimate cropland loads from Table 42, you get controllable loads only (C), unlike the cropland loads in Table 41, which are total loads (T). The "Percent of load attributed to cultivated cropland" in Table 42 is calculated as

100*(load from all sources– background sources)/load from all sources.

The load from all sources is total cropland load (B+C) plus the load from other sources O. The background load is the cropland background load B plus loads from other sources O. The numerator of the above equation is then ([B+C+O] - [B+O]). The B and O terms cancel, leaving just C. So, the "Percent of load attributed to cultivated cropland" in Table 42 accounts only for the controllable portion of cropland load (C) delivered to the Bay. The background part of cropland load (B) is omitted.

LimnoTech used Table 42 to estimate the cropland loads delivered to the Bay (Crop numbers for NRCS Baseline in LT Appendix B), so their estimates are for the controllable cropland load only (C). There is nothing wrong with reporting the controllable load (C), but it cannot be directly compared to the CBP cropland loads, which are total cropland loads (B+C).

It appears that LT made some additional mistakes in summarizing the loads in Tables 41 and 42. LT took the ratio of cropland load from Table 42 divided by the cropland load in Table 41 as an estimate of the fraction of cropland sediment from the HUC8 outlet that actually reached Chesapeake Bay. Then LT assumed that the same fraction of hay and pasture loads from Table 41 also reached the Bay. This gave the Hay+pasture numbers for NRCS Baseline in LT Appendix B. Finally, LT assigned to the Other category all the remaining load delivered to the Bay from all sources (Table 42) that was not accounted for as Crop or Hay+pasture. This gave the Other numbers for the NRCS Baseline in LT Appendix B.

These further calculations are wrong because the cropland load from Table 41 is a total load (B+C) while the cropland load from Table 42 is the controllable load only (C); so their ratio

underestimates the fraction of total HUC8 cropland load delivered to the Chesapeake (a correct delivery ratio would need a total cropland load in both the numerator and the denominator). The sediment delivery ratio is too low, so when it is applied to the hay and pasture numbers of Table 41, it underestimates the load from these agricultural sources actually delivered to the Bay. The final step attributes to the Other category the entire remaining load to the Bay from all sources that was not accounted for by the Crop and Hay+pasture. The Other category is then incorrectly inflated. Besides the load from Other land, it also includes the background load from cropland and some of the load from hay and pasture, which was underestimated by the delivery ratio estimate that was too low.

In short, the cropland load that LT reports from Table 42 is controllable load only and can't be compared to the CBP estimates of total cropland load. Further errors in the calculations mean that LTs reported loads for Hay+pasture underestimate the actual CEAP predictions for delivery from Hay+pasture to the Bay while LTs loads from Other land overestimate the actual CEAP predictions for delivery from Other land to the Bay. The same errors occurred for nitrogen (Tables 46 and 46) and for phosphorus (Tables 49 and 50).

You can see that something is wrong with LTs sediment results if you compare the loads from different sectors in CEAP Table 41 with the loads from the LT method.

		Load in thousand tons					**% of all sources**		
		All sources	Crop	Hay + past	Other		Crop	Hay+ past	Other
Loads at HUC8 outlets (CB-CEAP Table 41)									
	Susquehanna	4246	1429	847	1970		34%	20%	46%
	Upper Chesapeake	1119	218	86	815		19%	8%	73%
	Potomac	2010	196	286	1528		10%	14%	76%
	Lower Chesapeake	1780	127	247	1406		7%	14%	79%
	Sum of Basins	9155	1970	1466	5719		22%	16%	62%
Loads delivered to the Bay (LimnoTech method)									
	Susquehanna	1427	132	78	1217		9%	5%	85%
	Upper Chesapeake	934	139	55	740		15%	6%	79%
	Potomac	2364	108	158	2098		5%	7%	89%
	Lower Chesapeake	2058	65	126	1867		3%	6%	91%
	Sum of Basins	6783	444	417	5922		7%	6%	87%
Loads delivered to the Bay (STAC method)									
	Susquehanna	1427	480	285	662		34%	20%	46%
	Upper Chesapeake	934	182	72	680		19%	8%	73%
	Potomac	2364	231	336	1797		10%	14%	76%
	Lower Chesapeake	2058	147	286	1626		7%	14%	79%
	Sum of Basins	6783	1040	978	4765		15%	14%	70%

For any HUC8 basin, the difference between the outlet load and load delivered to the Bay should only reflect the sediment lost (or gained) in moving loads through major rivers from the HUC8 outlet to the Bay. The individual basin results from the LT method would imply that somehow the agricultural contribution went way down in that transport process while the contribution from Other sources went up. SWAT doesn't model river transport of sediment from different sources separately, so that's not possible. The changes in source attribution between a HUC8 outlet and the Bay that are seen with the LT method result from the errors described above. In contrast, with the STAC method, the loads delivered to the Bay from each HUC have the same source attribution as the loads at the HUC8 outlet.

Question: I should add, relative to the preceding question…what is the nature of the correction that was applied to the load figures in Table 2 to deal with the controlled vs uncontrolled load issue as the STAC review team saw it? I can't tell from the write up what was done, mathematically, to arrive at and apply the correction.

Response: We used the numbers from the "all sources" column in the upper parts of tables 41, 45, and 49 of the final CB-CEAP report as estimates of total sediment, N, and P loads delivered to the HUC8 watershed outlets from all sources. From tables 42, 46, and 50; we took the numbers from the "load from all sources" column as loads delivered to the Bay. For each material and each HUC, we calculated a delivery ratio to the Bay as the ratio of the delivered to the Bay load divided by the delivered to HUC8 outlet load. We applied those delivery ratios to the individual source loads in tables 41, 45, and 49. This estimated the delivered to the Bay load from each source. Those estimates were used to construct Tables 2, 3, and 4 of the STAC review. This method was discussed during the July 28 review committee meeting with Gary Shenk of EPA-CBPO and Lee Norfleet of USDA-NRCS, and we all agreed that it was a valid way to estimate total loads from the CB-CEAP model that could be compared with the CBP total load estimates.

		Average annual loads at HUC8 watershed outlets							Average Annual Loads Delivered to Chesapeake Bay							
	Basin	All sources	Cultivated cropland	Hayland	Pasture & Grazing	Urban NPS	Point sources	Forest & other	All sources	Delivery ratio	Cultivated cropland	Hayland	Pasture & Grazing	Urban NPS	Point sources	Forest & other
Nitrogen CB-CEAP Tables 45 and 46 in thousand pounds																
	Susquehanna	140,802	58,939	13,891	15,822	9,335	24,760	18,046	125,260	0.89	52,433	12,358	14,076	8,305	22,027	16,054
	Upper Chesapeake	53,112	22,592	543	4,111	5,047	16,419	4,397	46,634	0.88	19,836	477	3,610	4,431	14,416	3,861
	Potomac	78,256	12,761	4,457	12,601	9,743	28,250	10,441	80,365	1.03	13,105	4,577	12,941	10,006	29,011	10,722
	Lower Chesapeake	57,326	7,319	1,856	6,302	6,840	23,916	11,091	55,977	0.98	7,147	1,812	6,154	6,679	23,353	10,830
	Sum of Basins	329,496	101,611	20,747	38,836	30,965	93,345	43,974	308,236		92,521	19,224	36,779	29,421	88,808	41,467
Phosphorus CB-CEAP Tables 49 and 50 in thousand pounds																
	Susquehanna	10,599	3702	1316	554	580	3885	562	3,815	0.36	1,332	474	199	209	1,398	202
	Upper Chesapeake	2,726	1152	15	132	198	1015	214	2,362	0.87	998	13	114	172	879	185
	Potomac	4,717	1077	270	602	531	1895	341	4,000	0.85	913	229	510	450	1,607	289
	Lower Chesapeake	4,714	499	87	406	417	2870	436	4,636	0.98	491	86	399	410	2,823	429
	Sum of Basins	22,756	6430	1689	1693	1726	9664	1552	14,813		3,735	801	1,224	1,241	6,707	1,106
Sediment CB-CEAP Tables 41 and 42 in thousand tons																
	Susquehanna	4,246	1429	708	139	1274	0	696	1,427	0.34	480	238	47	428	0	234
	Upper Chesapeake	1,119	218	7	79	473	0	342	934	0.83	182	6	66	395	0	285
	Potomac	2,010	196	139	147	1083	0	445	2,364	1.18	231	163	173	1,274	0	523
	Lower Chesapeake	1,780	127	69	178	787	0	619	2,058	1.16	147	80	206	910	0	716
	Sum of Basins	9,155	1970	924	543	3617	0	2102	6,783		1,040	487	491	3,007	0	1,758