TECHNICAL MEMORANDUM

DATE: **July 5, 2016**

TO: **U.S. Environmental Protection Agency**

FROM: **West Central Wisconsin Regional Planning Commission**
Wisconsin Department of Natural Resources

RE: **Supplemental explanation of STEPL and SWOT modeling techniques used during the preparation of Health Soil & Health Waters—A Community Strategy for the Eau Claire River Watershed**

This technical memorandum is a supplement to *Health Soil & Health Waters—A Community Strategy for the Eau Claire River Watershed*, which was developed in accordance with EPA's nine-key element planning framework for nonpoint source pollution planning at the watershed level. Due to the technical nature of the information here, it was decided to provide this memorandum as a supplement, rather than including it within the text of the main plan document. This memorandum will also be useful for future reference by local, county, regional, and State staff when evaluating plan progress and updating plan models and goals.

Supplement to Section IV.C. STEPL Pollutant Loading Estimates

The STEPL tool was used during the planning process in two ways:

#1 For each HUC 12 subwatershed, the annual nutrient loading was calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution. The annual sediment load (sheet and rill erosion only; does not include bank erosion) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using the known, typical BMP efficiencies (e.g., how good a BMP is at reducing pollutant loading). West Central Wisconsin Regional Planning Commission and WDNR worked with Olson Environmental Research to fine-tune the land use and model assumptions to local conditions. The STEPL results were then used to create the three maps in Section IV.C.

#2 The STEPL tool was also used to help develop the 10-year phosphorus reduction "goals" (10-year indicators) in Section VIII of the plan using the following process:

a) The Land Conservation Departments (LCDs) from each of the 5-counties in the watershed estimated the total acreage of current, commonly used best management practices (BMPs) on the landscape by HUC-12 subwatershed and by type of BMP. We do not know specifically where within each HUC-12 each BMP is occurring. The BMPs were largely taken the BMP list (with definitions) in Appendix E of the plan.

b) The LCDs also estimated the acreage of potential future BMPs (by HUC-12 and type) based on each LCD's knowledge of current land uses, resource availability, familiarity with the landowners, and the potential for implementation. The LCDs were asked to be realistic and feasible on what could be accomplished in the next ten years given expected resources. The table with these results is included in Section XIII.C. of the plan and will be used to help guide BMP implementation.

c) The LCD estimates needed to be further modified to create a potential scenario that accounts for multiple cropland BMPs on the same cropland acreage. Working with WCWRPC, County LCD staff identified three of the most typical BMP combinations.

d) Since Nutrient Management Planning (NMP) and Reduced Tillage were common to all three levels of combination BMPs, and are frequently used in combination with other BMPs, the maximum total cropland combination BMP acreage in any given HUC-12 would be the highest acreage from one of these two BMPs. Applying these maximums to the total cropland acres, we were able to estimate that, on average across the watershed, 36% of current cropland acreage have two or more BMPs and 51% of future (10-year) cropland acreage could have more than one BMP. These averages, across the watershed, were used to develop an average cropland combination BMP for the scenario; the actual distribution of combination BMPs will vary significantly by HUC-12, but we lacked sufficient data to develop subshed-specific estimates at this time.

e) Based on County LCD knowledge of farming practices in the watershed, the 36% and 51% were distributed among the three cropland combination BMP levels:

Combination BMP Assumptions		% of cropland acres	
		Current	Future
Level 1:	NMP + Contour Farming + Reduced Till	21.0%	19.0%
Level 2:	Level 1 + Filter Strips	9.0%	16.0%
Level 3:	Level 2 + Cover Crops	6.0%	16.0%
		36.0%	51.0%

f) To create our scenario, the above cropland combination BMP percentage assumptions were applied to each HUC-12. The acreages for each cropland BMP for each HUC-12 in the original spreadsheet were then reduced by the corresponding combination acreages. For example, current Reduced Till acreages were reduced by 36% since it is part of all three combination levels, while current Cover Crop acreages were reduced by 6% since it is only part of Level 3. After this adjustment, four HUC-12s still had total cropland BMP acreages in excess of 100%, so their largest, standalone BMP was reduced so that the HUC-12's total would not exceed 100%. This scenario suggested that in ten years, if we have the resources, 66% of cropland acres could have at least one BMP and 51% could have two or more BMPs.

g) The results of the above were then used in the STEPL model to estimate potential phosphorus load reductions from primary cropland BMPs for the next ten years. Though current and 10-year acreages for Streambank Stabilization & Fencing were collected, the P reductions were not modeled in STEPL due to varying types of stabilization and fencing projects and the challenges in identifying the acreages impacted by adoption.

h) Further, Feedlots, Pastureland, and Forest Management BMPs are not specific to cropland, so are potential reductions in addition to the cropland BMPs. While estimated current and 10-year future acreages for these other BMPs were included in the table in Section VIII.C., the P reductions were not modeled in STEPL due to a variety of associated challenges. For example, the phosphorus loading and reductions for Feedlot BMPs were not calculated using STEPL because we did not have watershed-wide estimates for the following as required by the STEPL tool: (i) the acreage of feedlots receiving practices and (ii) an estimate of how many feedlots directly discharge to adjacent waterways.

i) The Replacement of Failing Septic Systems was also considered as a BMP and addressed separately (or in addition to) the other cropland BMPs using the following approach:

   i. Since point data for septic systems or structures is not available throughout the watershed, WCWRPC estimated the number of homes with private drainfields within riparian areas by using GIS to identify all parcels that have their centroid within 300 feet of a surface water AND have assessed residential improvements AND are not part of a parcel with agricultural lands. Agricultural lands were excluded given their large parcel sizes resulted in great variation in the centroid.

   ii. Parcels located in cities and villages were excluded, since it is assumed that most of these are on public sewer.

   iii. Based on experience, WDNR uses the following equation for estimating septic system failure rates:

 # riparian residences X .2 failure rate X 0.32-.16 lbs/capita/yr X # people per residence = annual lbs eliminated by replacing failing systems

   iv. It was estimated that 1,377 “riparian area homes” were located in the incorporated towns and on private septic systems. The watershed averages 2.52 persons per household. By applying the above failure rate (20%), this yielded an estimated 275 failing septic systems near surface waters. The numbers from this analysis are included in the table following this section.

   v. Initially, the results of the above analysis was to be provided to WDNR as inputs into the STEPL model to estimate phosphorus load reductions if failing septic systems were replaced. Later, it was decided to use the reduction estimates from the above equation (0.32-16 lbs/capita/year) for the watershed as a whole instead of including specific HUC-12 reduction targets.

The results of the scenario were then reflected in the 10-year reductions by HUC-12 in the first table in Section VIII.C. of the plan, except for reductions related to failing septic systems that are included in the third action plan recommendations in Section VIII.D.

STEPL Cropland BMP Acreage Assumptions

STEPL Watershed ID	Name	Area (acres)	Cropland (acres)	Combo Cropland BMPs (scenario)						Estimated Cropland Non-Combo BMP Acreages by HUC12 watershed												Streambank Stabilization & Fencing (P lbs reduction not estimated)	
				Current - Level 1	Future - Level 1	Current - Level 2	Future - Level 2	Current - Level 3	Future - Level 3	Current - Contour Farming	*Future - Contour Farming*	Current - Diversion	*Future - Diversion*	Current - Filter Strip/Grassed Waterway	*Future - Filter Strip/Grassed Waterway*	Current - Reduced Tillage	*Future - Reduced Tillage*	Current - Cover Crops	*Future - Cover Crops*	Current - NMP	*Future - NMP*	Current - Streambank Stabilization and Fencing	*Future - Streambank Stabilization and Fencing*
W1	Headwaters North Fork E.C. River	22,172	11,704	2,458	2,224	1,053	1,873	702	1,873	0	0	0	0	0	0	0	0	0	0	0	0	34	34
W2	Goggle-Eye Creek-North Fork E.C. River	18,129	13,141	2,760	2,497	1,183	2,103	788	2,103	0	0	0	0	0	0	4,269	5,298	0	0	0	298	0	0
W3	Sterling Creek-North Fork E.C. River	15,058	7,545	1,584	1,434	679	1,207	453	1,207	0	0	0	0	0	0	0	152	0	0	1,331	3,548	0	0
W4	Little Otter Creek-Wolf River	23,166	14,737	3,095	2,800	1,326	2,358	884	2,358	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W5	Wolf River	28,874	17,986	3,777	3,417	1,619	2,878	1,079	2,878	0	0	0	0	0	0	2,424	2,726	0	0	0	0	0	0
W6	Simes Creek-North Fork E.C. River	12,607	693	146	132	62	111	42	111	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W7	North Fork E.C. River	12,004	211	44	40	19	34	13	34	0	0	11	11	74	84	0	0	8	8	0	0	106	106
W8	Headwaters South Fork E.C. River	14,429	10,318	2,167	1,960	929	1,651	619	1,651	0	0	0	0	0	0	1,286	1,738	413	413	0	0	0	0
W9	St. Hedwig Cemetary-South Fork E.C. River	18,192	13,431	2,821	2,552	1,209	2,149	806	2,149	0	0	0	0	0	0	0	0	537	537	317	1,150	0	0
W10	Norwegian Creek-South Fork E.C. River	17,761	6,663	1,399	1,266	600	1,066	400	1,066	0	0	0	0	0	0	0	602	267	267	283	102	0	0
W11	Black Creek-South Fork E.C. River	9,771	1,626	341	309	146	260	98	260	0	0	49	49	0	0	0	0	0	0	0	0	0	49
W12	Mead Lake-South Fork E.C. River	14,276	6,110	1,283	1,161	550	978	367	978	0	0	0	0	0	0	0	0	244	244	0	0	0	0
W13	Hay Creek-South Fork E.C. River	39,227	4,296	902	816	387	687	258	687	0	0	0	0	0	0	0	0	172	172	0	0	0	0
W14	Dickison Creek-South Fork E.C. River	12,352	888	186	169	80	142	53	142	0	0	0	0	0	0	80	47	36	36	0	0	0	0
W15	South Fork E.C. River	21,459	66	14	13	6	11	4	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W16	Black Creek-E.C. River	37,672	6,348	1,333	1,206	571	1,016	381	1,016	0	0	16	16	0	0	0	0	254	254	0	0	0	0
W17	Muskrat Creek	21,655	5,657	1,188	1,075	509	905	339	905	0	0	0	0	0	0	0	0	0	0	0	0	679	679
W18	Hay Creek-E.C. River	26,105	12,507	2,626	2,376	1,126	2,001	750	2,001	0	0	375	375	0	0	0	0	0	0	0	0	3,002	3,002
W19	Lake E.C.-E.C. River	16,917	369	77	70	33	59	22	59	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W20	Beaver Creek-Otter Creek	8,288	4,710	989	895	424	754	283	754	0	0	0	0	236	0	0	0	0	0	0	0	1,884	1,884
W21	Otter Creek	34,185	13,338	2,801	2,534	1,200	2,134	800	2,134	0	0	0	0	667	0	0	0	0	0	0	0	5,335	5,335
W22	Thompson Valley Creek	8,378	4,058	852	771	365	649	243	649	0	0	812	812	853	609	365	0	568	568	0	0	1,623	2,029
W23	Bridge Creek	37,725	9,029	1,896	1,716	813	1,445	542	1,445	0	0	0	0	0	0	0	0	361	0	0	0	451	903
W24	Bears Grass Creek	17,665	9,406	1,975	1,787	847	1,505	564	1,505	0	0	0	0	470	0	1,317	847	2,257	3,198	0	0	3,762	4,703
W25	Fall Creek	11,213	5,259	1,104	999	473	841	316	841	0	0	0	0	789	158	473	210	1,787	2,210	317	0	3,155	3,418
W26	Beaver Creek-E.C. River	11,588	3,512	738	667	316	562	211	562	0	0	0	0	0	0	140	0	492	316	0	0	2,458	2,458
W27	Sand Creek-E.C. River	17,709	4,948	1,039	940	445	792	297	792	0	0	0	0	0	0	198	0	693	1,188	0	0	247	495
W28	Deinhammer Creek-E.C. River	12,460	3,653	767	694	329	584	219	584	0	0	0	0	0	0	146	0	146	0	0	0	1,827	1,827
W29	Ninemile Creek-E.C. River	11,319	3,602	756	684	324	576	216	576	0	0	0	0	0	0	144	0	0	0	0	0	2,161	2,161
W30	Altoona Lake-E.C. River	13,272	3,135	658	596	282	502	188	502	0	0	0	0	157	0	125	0	1,066	909	0	0	157	157
Totals		565,629	198,946	41,779	37,800	17,905	31,831	11,937	31,831	0	0	1,262	1,262	3,245	851	10,969	11,620	9,301	10,320	2,248	5,098	26,882	29,239

STEPL Cropland BMP Scenario Estimates Phosphorus Reductions

STEPL Watershed ID	Name	Area (acres)	Cropland (acres)	Cropland BMP Scenario Estimated Acreage, Loading, and Reductions (incudes cropland combination and non-combo BMPs, but excludes Streambank Stabilization/Fencing)									
				Current - BMP Total acres	% of Current Cropland (Current BMPs)	STEPL - Current P lbs	STEPL - Current Sediment TONS	*Future - BMP Total acres*	*% of Current Cropland (Future BMPs)*	*STEPL - Future P lbs*	*STEPL - Future sediment TONS*	*Cropland P lbs Reduction*	*% Cropland P lbs Reduction*
W1	Headwaters North Fork E.C. River	22,172	11,704	4,213.4	36%	15,029	2,639	5,969.0	51.0%	11,841	2,081	3188	21.2%
W2	Goggle-Eye Creek-North Fork E.C. River	18,129	13,141	9,000.0	68%	13,138	3,363	12,298.1	94%	7,868	1,041	5270	40.1%
W3	Sterling Creek-North Fork E.C. River	15,058	7,545	4,047.0	54%	7,175	1,646	7,548.0	100%	5,021	1,266	2154	30.0%
W4	Little Otter Creek-Wolf River	23,166	14,737	5,305.3	36%	19,256	3,591	7,515.9	51%	15,172	2,832	4084	21.2%
W5	Wolf River	28,874	17,986	8,899.3	49%	21,325	3,569	11,899.3	66%	16,605	2,832	4720	22.1%
W6	Simes Creek-North Fork E.C. River	12,607	693	249.5	36%	595	88	353.4	51%	469	63	126	21.2%
W7	North Fork E.C. River	12,004	211	168.8	80%	110	18	210.6	100%	59	10	51	46.4%
W8	Headwaters South Fork E.C. River	14,429	10,318	5,412.7	52%	12,242	2,323	7,412.7	72%	8,818	1,600	3424	28.0%
W9	St. Hedwig Cemetary-South Fork E.C. River	18,192	13,431	5,689.2	42%	17,750	3,503	8,537.2	64%	13,340	2,725	4410	24.8%
W10	Norwegian Creek-South Fork E.C. River	17,761	6,663	2,948.5	44%	6,341	1,370	4,368.4	66%	4,472	931	1869	29.5%
W11	Black Creek-South Fork E.C. River	9,771	1,626	634.1	39%	1,441	234	878.0	54%	1,125	183	316	21.9%
W12	Mead Lake-South Fork E.C. River	14,276	6,110	2,444.0	40%	5,620	1,067	3,360.5	55%	4,388	837	1232	21.9%
W13	Hay Creek-South Fork E.C. River	39,227	4,296	1,718.4	40%	3,346	259	2,362.8	55%	2,610	202	736	22.0%
W14	Dickison Creek-South Fork E.C. River	12,352	888	435.5	49%	685	77	535.5	60%	547	67	138	20.1%
W15	South Fork E.C. River	21,459	66	23.8	36%	53	4	33.7	51%	42	3	11	20.8%
W16	Black Creek-E.C. River	37,672	6,348	2,555.1	40%	5,486	832	3,507.3	55%	4,318	645	1168	21.3%
W17	Muskrat Creek	21,655	5,657	2,036.5	36%	5,260	982	2,885.1	51%	4,145	775	1115	21.2%
W18	Hay Creek-E.C. River	26,105	12,507	4,877.7	39%	12,008	2,549	6,753.8	54%	9,378	2,001	2630	21.9%
W19	Lake E.C.-E.C. River	16,917	369	132.8	36%	218	41	188.2	51%	171	32	47	21.6%
W20	Beaver Creek-Otter Creek	8,288	4,710	1,931.1	41%	6,821	957	2,402.1	51%	5,661	792	1160	17.0%
W21	Otter Creek	34,185	13,338	5,468.6	41%	15,975	2,632	6,802.4	51%	13,257	2,178	2718	17.0%
W22	Thompson Valley Creek	8,378	4,058	4,058.8	100%	1,943	512	4,058.3	100%	1,506	432	437	22.5%
W23	Bridge Creek	37,725	9,029	3,611.6	40%	8,470	1,680	4,604.8	51%	6,733	1,331	1737	20.5%
W24	Bears Grass Creek	17,665	9,406	7,430.7	79%	8,383	2,171	8,841.6	94%	5,721	1,548	2662	31.8%
W25	Fall Creek	11,213	5,259	5,259.1	100%	3,505	976	5,260.2	100%	3,126	891	379	10.8%
W26	Beaver Creek-E.C. River	11,588	3,512	1,896.5	54%	2,954	533	2107.2	60%	2,426	442	528	17.9%
W27	Sand Creek-E.C. River	17,709	4,948	2,671.9	54%	4,093	695	3,711.0	75%	3,091	552	1002	24.5%
W28	Deinhammer Creek-E.C. River	12,460	3,653	1,607.3	44%	3,004	421	1863.03	51%	2,493	351	511	17.0%
W29	Ninemile Creek-E.C. River	11,319	3,602	1,440.8	40%	4,192	523	1837.02	51%	3,389	433	803	19.2%
W30	Altoona Lake-E.C. River	13,272	3,135	2,476.7	79%	2,130	334	2,508.0	80%	1,819	288	311	14.6%
Totals		565,629	198,946	98,645	49.6%	208548		130,613	65.7%	159611	29,365	48937	23.5%

Private Septic System (POWTS) Assumptions

Improved Residential Parcels within 300ft of Lakes and Rivers (HUC 12)

HUC 12	Name	Total Number of Parcels	Parcels in Cities & Villages	Parcels in Towns	Estimated Annual Lbs P from Failing POWTS
070500060101	Headwaters North Fork E.C. River	24	3	21	3.39
070500060201	Headwaters South Fork E.C. River	13	0	13	2.10
070500060102	Goggle-Eye Creek North Fork E.C. River	113	61	52	8.39
070500060104	Little Otter Creek-Wolf River	168	103	65	10.48
070500060105	Wolf River	59	0	59	9.52
070500060103	Sterling Creek-North Fork E.C. River	34	0	34	5.48
070500060202	St. Hedwig Cemetery-South Fork E.C. River	27	0	27	4.35
070500060203	Norwegian Creek-South Fork E.C. River	20	0	20	3.23
070500060204	Black Creek-South Fork E.C. River	11	0	11	1.77
070500060106	Simes Creek-North Fork E.C.	5	0	5	0.81
070500060207	Dickison Creek-South Fork E.C. River	10	0	10	1.61
070500060205	Mead Lake-South Fork E.C. River	157	0	157	25.32
070500060206	Hay Creek-South Fork E.C. River	132	0	132	21.29
070500060208	South Fork E.C. River	1	0	1	0.16
070500060107	North Fork E.C. River	0	0	0	0.00
070500060302	Muskrat Creek	29	0	29	4.68
070500060303	Hay Creek-E.C. River	106	48	58	9.35
070500060304	Lake E.C.-E.C. River	198	0	198	31.93
070500060301	Black Creek-E.C. River	33	19	14	2.26
070500060502	Bridge Creek	128	86	42	6.77
070500060501	Thompson Valley Creek	5	0	5	0.81
070500060503	Bears Grass Creek	9	0	9	1.45
070500060506	Sand Creek-E.C. River	7	0	7	1.13
070500060505	Beaver Creek-E.C. River	12	0	12	1.94
070500060507	Deinhammer Creek-E.C. River	11	0	11	1.77
070500060504	Fall Creek	22	20	2	0.32
070500060508	Ninemile Creek-E.C. River	34	0	34	5.48
070500060401	Beaver Creek-Otter Creek	20	0	20	3.23
070500060402	Otter Creek	111	53	58	9.35
070500060509	Altoona Lake-E.C. River	342	71	271	43.71
	Total	**1841**	**464**	**1377**	**222.08**

Parcels in Cities/Villages	
City of Stanley	103
Village of Boyd	48
Village of Lublin	3
City of Thorp	61
City of Altoona	64
City of E.C.	60
Village of Fall Creek	20
City of Augusta	86
Village of Fairchild	19
Total	**464**

Methodology: These figures represent all residential improved parcels whose centroid is within 300 feet of a river, lake, or stream. For estimating purposes, parcels located in cities and villages were assumed to be on public sewer and parcels in unincorporated towns were assumed to be on private septic systems (POWTS).

Supplement to Section IV.D. WDNR SWAT Phosphorus-Loading Model

The Soil and Water Assessment Tool (SWAT) model previously developed for the Eau Claire River Watershed (Freihoefer et al. 2009) was used to determine how much phosphorus-loading reduction is needed in each HUC 12 in order to meet Wisconsin's maximum allowable phosphorus concentration standards. The results were used to develop the HUC-12 and overall phosphorous reduction target objectives in Section VIII. of the plan

The SWAT model is a physically based model that simulates stream flow, sediment loss, and nutrient exports (Neitsch et al. 2002). The SWAT model incorporates the effects of weather, surface runoff, evapotranspiration, crop growth, irrigation, groundwater flow, nutrient loading, and water routing for varying land uses. SWAT divides a large watershed into subwatersheds, which are further subdivided into hydrologic response units (HRUs) which are defined as unique combinations of soil, land cover type, and management practices in a subwatershed. The SWAT model has successfully been used to evaluate agriculturally dominant watersheds for sediment and nutrient TMDLs (Cadmus, 2012; Cadmus 2011; USEPA 2004).

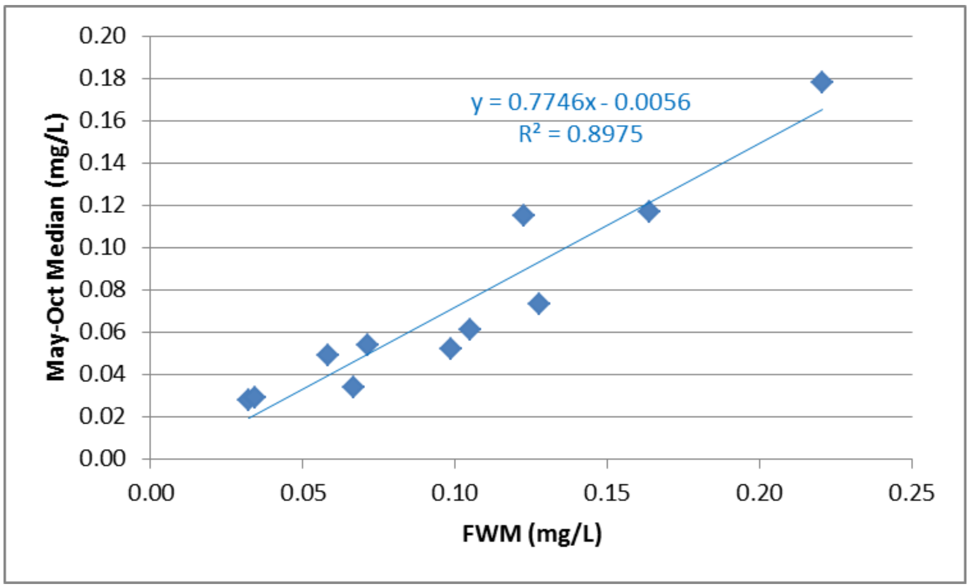
The SWAT model methodology has many elements in common with the EVAAL and STEPL models, the most important of which is that they all share some modification of the Universal Soil Loss Equation as the basis of predicting soil erosion. However, SWAT carries with it the distinctive advantage of being able to be calibrated to account for local phenomena. This calibration process allows the model to accurately predict nutrient transport and to match real world data. In the case of the Eau Claire River Watershed, the SWAT model was calibrated to data from eight phosphorus load monitoring station scattered throughout streams in the watershed.

Due to the manner in which the Eau Claire River Watershed SWAT model was developed, the raw SWAT model outputs needed some adjustment in order to mesh with the EVAAL and STEPL models and plan target objectives. These adjustments primarily relate to the land cover and subwatershed boundaries. The Eau Claire River Watershed SWAT model was developed based on a customized land cover data set based 2001 Clark County land coverage and a modified version of the WDNR 1992 WISCLAND coverage. The STEPL analysis was based on the USGS NLCD 2006 Land Cover data set. The subbasin boundaries in the SWAT model tended not to match up with the Federal HUC12 subwatershed watershed boundaries used in the other modeling efforts.

Because STEPL will be used to estimate and track load reductions at the HUC12 scale during implementation, the SWAT results needed to be translated to this land cover and subbasin scheme. To do this translation, the SWAT model HRU outputs (water and phosphorus yields) were aggregated by SWAT land cover type in each SWAT subbasin to obtain site-specific unit area export coefficients for each land cover type. These export coefficients were then assigned to a corresponding NLCD land cover and HUC12 subwatershed boundary to estimate the long-term average water and phosphorus yield at the HUC12 scale.

Two different tools were used to determine the relationship between watershed phosphorus loading and resultant lake and stream water quality:

i. For the streams, the goals (or targets) were initially based on meeting the local stream criteria for phosphorus which is a May – October median of 75 µg/L. Many streams in the basin currently exceeded the criteria; however there are a number of streams that are well below the criteria. This latter group of streams generally is in watersheds dominated by forest lands. Recently completed monitoring as part of the development of the Wisconsin River TMDL has demonstrated that a fairly simple regression relationship exists between the annual flow-weighted mean phosphorus concentration (i.e. phosphorus yield ÷ water yield) and the May – October median concentration. This regression equation forms the basis for reductions needed to meet the local stream water quality criteria.



ii. For the impoundments in the watershed, the goals (or targets) are largely based on summer algal bloom frequencies as measures by chlorophyll-a. The goal is to limit "nuisance algae blooms" (i.e., >20 ug/L chlorophyll-a) to less than of 30% of days during the sampling season. For Lake Altoona, Lake Eau Claire, Coon Fork Lake, Mead Lake, and Rock Dam Lake previously developed Bathtub models (insert references) were used to examine phosphorus loading reduction scenarios. Bathtub is a set of empirical lake response models for predicting total phosphorus, chlorophyll-a, and Secchi transparency (Walker 1996).

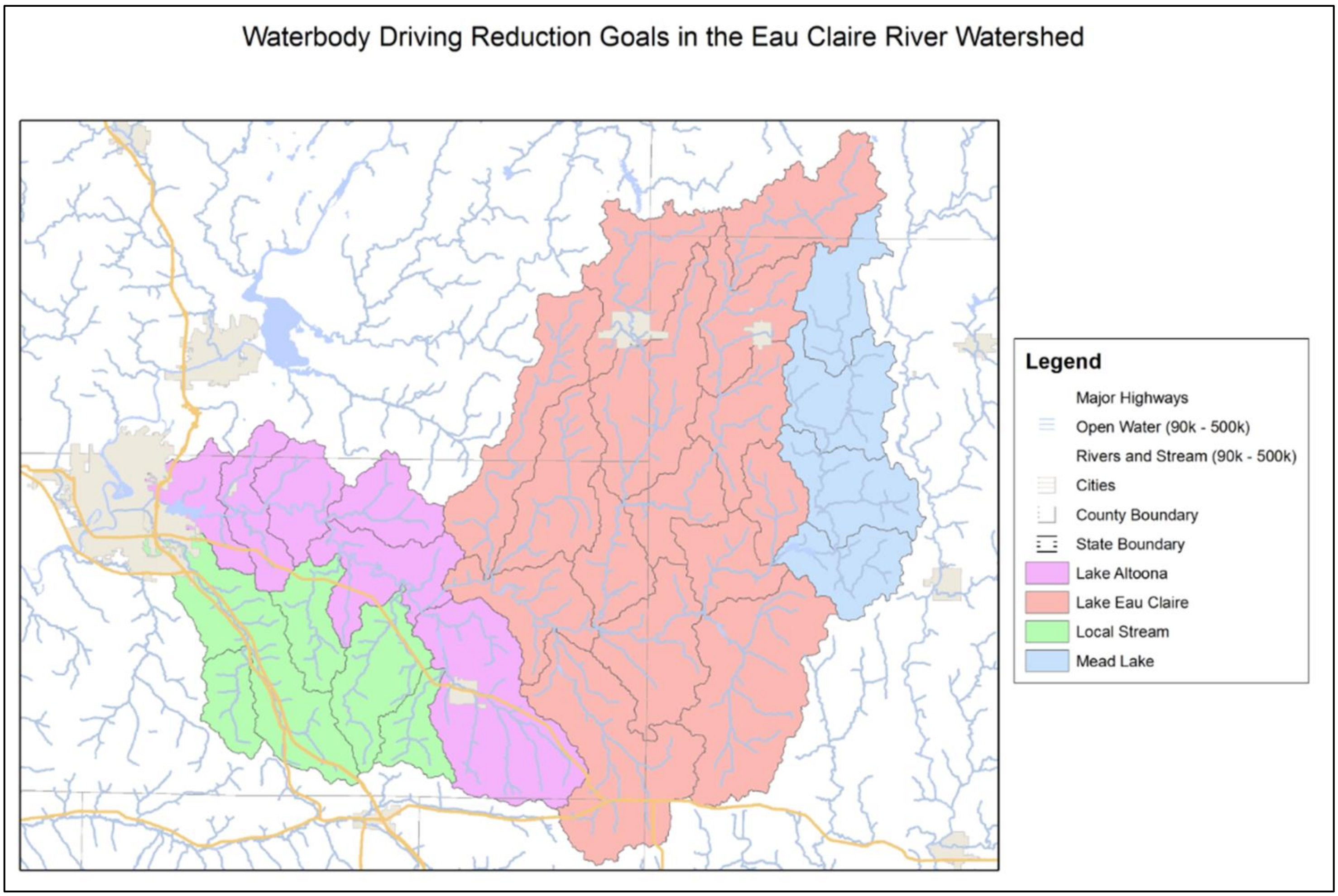
Setting the phosphorus reduction target objectives in Section VIII for the watershed was done in a sequential fashion to first ensure that local water quality target were met and then determine if additional reductions were needed to meet downstream water quality targets:

1. By HUC12, calculate the load needed to meet the stream water quality criterion.
2. Where reductions are needed, reduce anthropogenic (i.e. urban and agricultural) sources until load targets are met.
3. Starting at the upstream most impoundment, calculate the load needed to meet the lake water quality targets.
4. Where reductions are needed, reduce anthropogenic (i.e. urban and agricultural) sources until load targets are met. If there are multiple HUC12s above the lake, reduce anthropogenic sources

by the same percentage in each watershed, unless a higher percentage is needed to meet the local stream water load target. This was done by first reducing the estimated average cropland yields in all contributing watershed to that of the lowest in the group and then uniformly reducing all watershed yields until the impoundment goal was met.

5. Repeat process 3 & 4 working sequentially downstream through the watershed to Lake Altoona.
6. Urban phosphorus yields were reduced from 0.6 to 0.4 lbs/ac. Cropland yields were reduced by variable amounts depending on the waterbody needs within the lowest yield being 0.18 lbs/ac.

The results of this analysis is summarized in the table on the following page. The limiting factor for each HUC-12 is also represented in the map below.



SWAT-Based Phosphorus Loads, Goals, and Reductions by HUC-12

HUC12	P Baseline	P Goal	Percent Reduction Total	Percent Reduction Agriculture	W_yield_goal	Ag_yield_goal	W_yield_base	Ag_yield_base	Limit_factor
070500060101	6997	3291	53%	63%	0.15	0.19	0.32	0.50	Lake Eau Claire
070500060102	9206	3103	66%	70%	0.17	0.19	0.51	0.62	Lake Eau Claire
070500060103	5223	2028	61%	69%	0.13	0.19	0.35	0.59	Lake Eau Claire
070500060104	11232	3577	68%	73%	0.15	0.19	0.49	0.69	Lake Eau Claire
070500060105	15157	4318	72%	76%	0.15	0.19	0.53	0.77	Lake Eau Claire
070500060106	1434	1048	27%	70%	0.08	0.19	0.11	0.63	Lake Eau Claire
070500060107	1070	951	11%	70%	0.08	0.19	0.09	0.63	Lake Eau Claire
070500060201	6257	2190	65%	68%	0.15	0.18	0.43	0.56	Mead Lake
070500060202	9574	2927	69%	72%	0.16	0.18	0.53	0.64	Mead Lake
070500060203	5706	2204	61%	73%	0.12	0.18	0.32	0.66	Mead Lake
070500060204	1727	966	44%	69%	0.10	0.19	0.18	0.61	Lake Eau Claire
070500060205	6344	2140	66%	78%	0.15	0.18	0.44	0.83	Mead Lake
070500060206	5313	3354	37%	69%	0.09	0.19	0.14	0.61	Lake Eau Claire
070500060207	1571	1081	31%	70%	0.09	0.19	0.13	0.63	Lake Eau Claire
070500060208	1707	1675	2%	70%	0.08	0.19	0.08	0.61	Lake Eau Claire
070500060301	6915	3749	46%	70%	0.10	0.19	0.18	0.62	Lake Eau Claire
070500060302	5869	2327	60%	77%	0.11	0.19	0.27	0.80	Lake Eau Claire
070500060303	11964	3535	70%	78%	0.14	0.19	0.46	0.85	Lake Eau Claire
070500060304	1699	1495	12%	70%	0.09	0.19	0.10	0.63	Lake Eau Claire
070500060501	5818	2436	58%	60%	0.29	0.35	0.70	0.86	Local Stream
070500060502	10891	8259	24%	29%	0.22	0.38	0.29	0.54	Lake Altoona
070500060503	11174	5174	54%	55%	0.29	0.36	0.63	0.81	Local Stream
070500060504	8149	2904	64%	66%	0.26	0.34	0.73	0.99	Local Stream
070500060505	2751	1986	28%	36%	0.17	0.38	0.24	0.60	Lake Altoona
070500060506	4363	3431	21%	30%	0.19	0.38	0.24	0.55	Lake Altoona
070500060507	2739	2052	25%	32%	0.16	0.38	0.22	0.57	Lake Altoona
070500060508	2854	2126	26%	31%	0.19	0.38	0.25	0.56	Lake Altoona
070500060509	2958	2265	23%	31%	0.17	0.38	0.22	0.56	Lake Altoona
070500060401	6011	2302	62%	63%	0.28	0.35	0.73	0.93	Local Stream
070500060402	19003	9068	52%	55%	0.27	0.40	0.56	0.91	Local Stream
	191676	87962							