

Part II: Cross-Cut Analysis of Crediting Models for Carbon/GHG, Water Quality and Water Quantity - Input Requirements; Model Validation; Model Calibration; Required Linkages; Prior Market Applications; Estimate of Uncertainty; Model Transparency, Modifiability and Support; Notes (2018)

Quantification Model	INPUT REQUIREMENTS			MODEL VALIDATION	MODEL CALIBRATION			REQUIRED LINKAGES TO ADDITIONAL MODELS OR DATABASES (Y/N; F Yes, else of use with APX)	PRIOR MARKET APPLICATIONS	ESTIMATE OF UNCERTAINTY IN MODEL OUTPUTS (L/M/H)	MODEL TRANSPARENCY, MODIFIABILITY, AND SUPPORT							NOTES (1)	Suggested Addition: The Drainage (Y/N)	
	Input Data Needs	Input Data Availability (L/M/H)	Expertise Required to Run Model (L/M/H)	Expertise Required to Validate Model (L/M/H)	Model Calibration Data Needs	Calibration Data Availability	Level of Effort to Calibrate Model (H/L/M)				Clear Versioning of Model (Y/N)	Peer-Reviewed Documentation (Y/N)	Original Developers	Developer Accessibility (L/M/H)	Developer Responsiveness (L/M/H)	Open Source (Y/N)	Third-Party Access (Y/N)			User Community Activity (H/L/M)
Carbon/GHG Models																				
DNDC (DeNitrification-DeComposition)	Moderate	Low, Moderate	Low, Moderate	Moderate, High	Crop yield, N2O emissions, soil C sequestration and soil water	Crop yield and soil water are fairly easily available; emission data may be difficult to find	Low, Moderate	No	(Used in rice CH4 and cropland N2O management projects); COM (used in rice protocol); NCCAR-Monsanto (used in carbon offsetting framework)	Unknown (Uncertainty analysis can be performed)	Yes	Yes	University of New Hampshire	Low	TBD	Yes	No	Low*	Specific grazing/management practices include: # Grazing/Cutting Applications, Livestock Type, Grazing Hours/Day and Stocking Rate, Type of Manure, # Applications, C:N Ratio of Manure/Slur Community. http://www.globaleed.net/information/about-us-1.html	
DAYCENT (Daily Century Model)	Moderate	Low, Moderate	Moderate, High	Moderate, High	Crop Yield, Soil Water Content, Soil Emissions	Crop yield and soil water are fairly easily available; emission data may be difficult to find	Moderate, High	No	(Proponents run DayCent for ACDIS projects); CAR (used to develop default emission factors for grasslands protocol)	TBD	Yes	Yes	Colorado State University	Moderate	TBD	Yes	No	TBD	Also used in COMET calculators	
RoHC (Reformed Carbon Model)	Low	Moderate, High	Low	Low	TBD	TBD	TBD	TBD	VCS (Proponents run RoHC for SALM projects)	No Uncertainty Analysis	TBD	Yes	Rothenmet Research, UK	High	TBD	Yes	TBD	TBD		
PuSIM (Pasture Simulation Model)	Moderate	Low, Moderate	TBD	TBD	TBD	TBD	TBD	TBD	CarboEurope IP, NitroEurope IP, CARBO-Extreme* (European); CLIMATOR, VALEATE* (France)	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	Research projects aiming at understanding the C and N cycles, carbon sequestration, greenhouse gases emissions (GHG) and the effects of climate variability and climate change.	
AgroC	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD		
ECOSSE (Estimation of Carbon in Organic Soils - Sequestration and Emissions)	Unknown	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD		
ORCHIDEE (Organising Carbon and Hydrology in Dynamic Ecosystems)	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	LMD, LSCE, LOGE	TBD	TBD	TBD	TBD		
Water Quality Models																				
APEX (Agricultural Policy/Environmental eXtender)	Extensive (Tools are available to prepare the data)	High	High	High	Local hydrology and water quality data	Dependent on local availability	High	No	Vermont Phosphorus Protocol	Low (if calibrated properly)	Yes	Yes	J.R. Williams, et al., Blackland Research and Extension Center, Texas A&M University, and USDA-NRCS, Temple, TX	TBD	TBD	Yes	No	Low	Long-Term Nitrogen modeled using equations from the CERTRM model	Yes
NTT (Nutrient Tracking Tool with APEX)	Extensive (Requires minimum effort with NTT's web interface)	High	Low	High	Local hydrology and water quality data	Dependent on local availability	TBD	No	Iowa Nutrient Reduction Exchange (Model currently under consideration)	High (calibration effort ongoing)	No	Yes	M. Saha, et al., Texas Institute for Applied Environmental Research, Tarrant State University, Stephenville, TX	TBD	TBD	No	No	Low	Soil health and Carbon outputs can be added	Yes
Snap-Plus (WI Soil Nutrient Application Planner)	Moderate (Requires less effort with program's web interface)	High for WI; Low for other states	Moderate	High	Local sediment and nutrient loading data (calibration not needed for WI)	Dependent on local availability (Calibration not needed for WI)	Moderate (Calibration not needed for WI)	No	Wisconsin Water Quality Trading Program	Low to Moderate for WI; High for other states	Yes	No	Laura Ward Good, et al., U of WI Madison	TBD	TBD	TBD	No	High	Underlying models: RUS2E and P Index	No
EPA Region 5 Calculator	Low	High	Low	High	No Model Calibration Required	No Model Calibration Required	No Model Calibration Required	No	Michigan Trading Rules	High	Yes	No	USEPA through Tetra Tech, Inc.	TBD	TBD	Yes	No	TBD		No
STEPL (Spreadsheet Tool for Estimating Pollutant Load)	Low	High	Low	High	No Model Calibration Required	No Model Calibration Required	No Model Calibration Required	Yes (good ease-of-use)	Great Miami River, EPRi Ohio River Pilot, Iowa Nutrient Reduction Exchange	High	Yes	No	USEPA through Tetra Tech, Inc.	TBD	TBD	Yes	No	TBD	These three models/tools are fundamentally similar in 1) underlying model (TRCS-D) method, and soil erosion (RUS2E) models and 2) tool user interface (see-attached)	No
Nonpoint Source Nitrogen Calculation Spreadsheet; Nonpoint Source Phosphorus Calculation Spreadsheet (PA)	Low	High	Low	High	No Model Calibration Required	No Model Calibration Required	No Model Calibration Required	No	Pennsylvania Nutrient Trading Program	High	No	No	PA Department of Environmental Protection	TBD	TBD	Yes	No	TBD		No
SWAT (Soil Water Assessment Tool)*	Extensive (GIS-based tools, e.g., ArcSWAT available for data preparation)	High	High, Moderate with HAWQS modeling system	High	Local/regional hydrology and water quality data	Dependent on local/regional availability	High	No	Trading Feasibility Study in the Great Miami River, OH	Low (if calibrated properly)	Yes	Yes	J.G. Arnold, et al., USDA-NRCS Grassland, Soil, and Water Research Lab, Temple, TX	High	High	Yes	Yes	High	SWAT used in water quality feasibility study but not in crediting. Larger watersheds can be modeled by connecting individual simulated HUCs	Yes
HSPF (Hydrologic Simulation Program-FORTRAN*)	Extensive (Tools available for the Chesapeake Bay watershed; USEPA's BASINS modeling system available for all U.S.)	High	High	High	Local/regional hydrology and water quality data	Dependent on local/regional availability	High	No	Nutrients in Chesapeake Bay Watershed states (e.g., VA); Bacteria in Big Sioux River (SD, MN, IA)	Low (if calibrated properly)	Yes	Yes	T. Donigan, B. Bicknell, et al., Aquatic Tera Consultants, RESPEC, SD	Moderate	Moderate	Yes	Yes	Low	HSPF not used in crediting application. Larger watersheds can be modeled by connecting individual simulated HUCs or smaller watersheds. Additional water quality pollutant reduction outputs can be added as a parameter for users	No
MIKE-SHE*	Extensive	Moderate	High	High	Local/regional hydrology data	Dependent on local/regional availability	High	Yes (MIKE-Hydro River stream hydraulic model; ease-of-use with APX unclear)	None	Low (if calibrated properly)	Yes	Yes	Danish Hydraulic Institute (private software engineering firm)	Unknown	Unknown	No (proprietary)	No	Unknown	MIKE-SHE is a hydrologic model with no prior market applications. Spatial scale should be limited only by computing power. Time step is adaptive. Streamflow and Streambank Erosion modelling linked MIKE-Hydro River model	No (but probably can be accommodated with some model modification)
WARBMF (Watershed Analysis Risk Management Framework*)	Extensive (Can use USEPA's BASINS modeling system, available for all U.S.)	High	High	High	Local/regional hydrology and water quality data	Dependent on local/regional availability	High	Yes (Requires input for non-point source loads; ease-of-use with APX unclear)	EPRi Ohio River Basin Trading Pilot (for nutrient attenuation factor determination)	Low-moderate (if calibrated properly)	Yes	Yes	Sybase Water Resources, Inc. (funded by EPRi)	Unknown	Unknown	No (software publicly available; model code probably not)	No	Low	Model used for calculating nutrient attenuation factor but not crediting; larger watersheds can be modeled by connecting individual simulated HUCs	No (but probably can be accommodated with some model modification)
NutrientNet (with APEX)*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Pennsylvania Nutrient Trading Program (Prior); Kalamazoo River Water Quality Trading (Prior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Model not further assessed due to the model's 1) math functions having been replaced by NTT; 2) limited availability for only 4 watersheds in 5 states; and 3) lack of updates (last update was probably in 2007) (http://www.nutrientnet.org/)	N/A
Virginia BMP Enhancement and Land Conversion Offsets Calculations Worksheet (Based on HSPF)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Chesapeake Bay Watershed Nutrient Credit Exchange Program (Virginia)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Model not further assessed as the worksheet reflects the results from a HSPF model (the Chesapeake Bay Model v. 4.3)	N/A
Water Quantity Models																				
SWAP (Statewide Agricultural Production Model)	Variable	Moderate	Moderate	Moderate	N/A	N/A	N/A	No	None known	Moderate	Yes	Yes	Wageningen University (Netherlands)	TBD	Unknown	No	No	Low		
IDSCU (Integrated Decision Support Consumptive Use Model)	Limited	High	Low	Low	N/A	N/A	N/A	No	CO Water Rights Transfers	Low	Yes	Yes	Colorado State University	TBD	Unknown	No	No	None		
CROPWAT	Limited	High	Low	Low	N/A	N/A	N/A	No	None known	Low	Yes	Yes	FAO	TBD	Unknown	No	No	Low		
Custom Spreadsheet Model	Variable	Depends	Low	High	N/A	N/A	N/A	No	Extensive history of Water Transfers	Varies	N/A	No	N/A	N/A	N/A	Yes	No	None		

Legend: Model (either 1) is related to WQST but does not currently have a WQST crediting application OR 2) has a WQST crediting application but was not assessed in this analysis (further explained in the model's notes column)