Chapter 8

Setting Up a Computer Simulation Model in an Arkansas Watershed for the MRBI Program

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Additional information is available at the end of the chapter

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Abstract

The Mississippi River Basin Healthy Watersheds Initiative (MRBI) program launched by the USDA Natural Resources Conservation Service (NRCS) aims to improve the water quality within the Mississippi River Basin. Lake Conway Point Remove (LCPR) watershed, being one of the MRBI watersheds, is a potential candidate for evaluating the effectiveness of MRBI program. Recommended best management practices (BMPs) for LCPR watershed are pond, wetland, pond and wetland, cover crops, vegetative filter strips, grassed waterways, and forage and biomass planting. Before simulating these practices, it is essential to prepare the data needed for model setup to avoid the issue of garbage in, garbage out. This chapter focuses on detailed steps of preparing the data for model setup along with the calibration and validation of the model. The calibration and validation results were within the acceptable bounds. The results from this study provide the data to help simulate the MRBI best management practices effectively and prioritize monitoring needs for collecting watershed response data in LCPR.

Keywords: best management practices, modeling, water quality, SWAT, MRBI

1. Introduction

The Mississippi River Basin Healthy Watersheds Initiative (MRBI) program aims at implementing best management practices (BMPs) to control water quality. Quantifying the impacts of BMPs is important to demonstrate the worth of the MRBI program. Out of various MRBI-selected watersheds, the Lake Conway Point Remove (LCPR) watershed is the one listed in the 2011–2016 priority watershed by the Arkansas Natural Resources Commission (ANRC) [1, 2].

Field studies can be laborious and time-consuming; therefore, watershed modeling technique is generally used for analyzing the effects of BMPs on water quality. The Soil and Water Assessment Tool (SWAT, [3]) model was selected for this study. The SWAT model has been widely applied across the globe to assess the impact of various BMPs [4]. SWAT has also been applied to various watersheds in Arkansas—L'Anguille River Watershed [5, 6], Cache River Watershed [7], and Illinois River Watershed [8]. SWAT allows modifications of various parameters to simulate BMPs [9] and was applied at various spatial and temporal scales [10]. SWAT has been used to simulate impacts of land uses and BMPs [11, 12], develop maximum daily load plans [13, 14], and evaluate impacts on water quality [15, 16]. However, before simulating BMPs, it is essential to acquire and process the data needed for setting up a good model.

The goal of this chapter is to describe the steps in detail for acquiring and processing the data needed to set up, calibrate, and validate the SWAT model for the LCPR watershed.

2. Methodology

2.1. Study area

The Lake Conway Point Remove (LCPR) watershed is a 2950 km^2 (1140 miles^2) watershed located in central Arkansas within the counties of Conway, Faulkner, Perry, Pope, Pulaski, Van Buren, and Yell (**Figure 1**). The watershed has mixed land uses of forest, pasture, urban, and

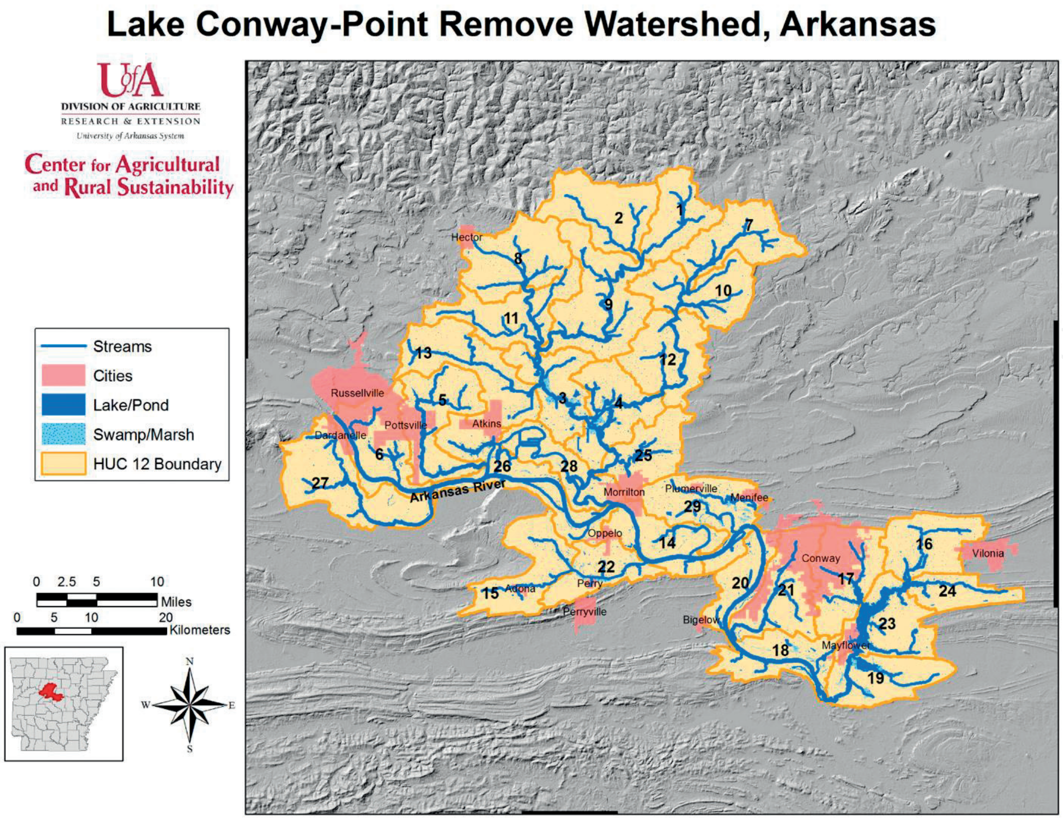

Figure 1. Lake Conway Point Remove watershed.

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cropland. An increase in urbanization, in parts of the watershed, has occurred since 1999. The subwatersheds within LCPR along with the area and hydrological unit codes (HUC) can be seen in **Table 1**.

2.2. Data preparation

The objective of this task was to collect and organize all data needed for the SWAT model setup at a 12-digit hydrological unit code within the LCPR watershed. Geospatial, watershed management,

Subwatershed	Subwatershed name	Area (km^2)	HUC no.
1	Trimble creek-west fork point remove creek	77.0	111102030102
2	Brock creek	113.1	111102030101
3	Devils creek-west fork point remove creek	88.2	111102030107
4	Barns branch-east fork point remove creek	102.7	111102030204
5	Galla creek	118.0	111102030303
6	Whig creek-Arkansas river	106.3	111102030302
7	Mountain view-east fork point remove creek	97.8	111102030201
8	Upper clear creek	120.4	111102030103
9	Rock creek-west fork point remove creek	156.2	111102030105
10	Sunny side creek-east fork point remove creek	100.9	111102030202
11	Lower clear creek	106.5	111102030104
12	Prairie creek-east fork point remove creek	106.9	111102030203
13	Gum log creek	130.4	111102030106
14	Portland bottoms-Arkansas river	90.9	111102030503
15	Headwaters rocky Cypress creek	100.1	111102030501
16	Jim creek-Palarm creek	92.4	111102030402
17	Little creek-Palarm creek	106.8	111102030403
18	Beaverdam creek-Arkansas river	88.0	111102030507
19	Little Palarm creek-Palarm creek	89.9	111102030405
20	Taylor creek-Arkansas river	65.1	111102030506
21	Tupelo bayou	110.8	111102030505
22	Outlet rocky cypress creek	70.5	111102030502
23	Pierce creek-Palarm creek	100.0	111102030404
24	Little cypress creek-Palarm creek	53.4	111102030401
25	Overcup creek	81.1	111102030205
26	Khun Bayou-Arkansas River	131.1	111102030304
27	Long Lake-Harris creek	148.2	111102030301
28	Point remove creek	80.2	111102030206
29	Miller Bayou-Arkansas river	116.4	111102030504

Table 1. List of HUC 12 subwatersheds and area in LCPR watershed.

water quantity, and point source data that were available and usable at the time of modeling were collected and reorganized in a consistent format for use in the SWAT model.

2.2.1. Elevation

The elevation dataset was retrieved at a 5 m resolution from GeoStor. This 5 m dataset was resampled to a 10 m resolution to reduce the size of huge files and increase the computation efficiency. The elevation map for LCPR can be seen in **Figure 2**.

2.2.2. Soils

The soil data were acquired from the Soil Survey Geographic (SSURGO) database for all LCPR counties in Arkansas and combined to make a soil map for the entire watershed. The SSURGO is the most comprehensive and detailed soil dataset available for LCPR. The soil map for LCPR can be seen in **Figure 3**.

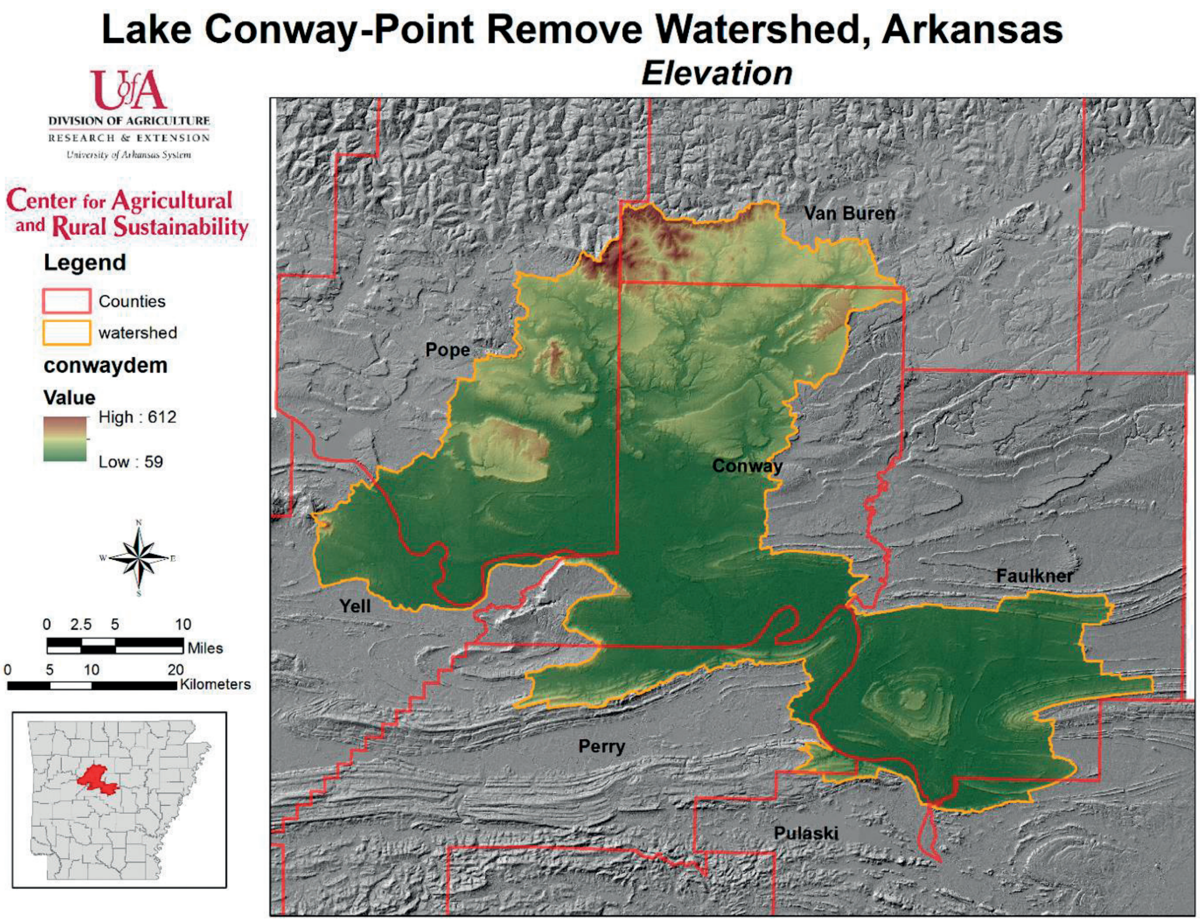

Figure 2. Lake Conway Point Remove watershed elevation.

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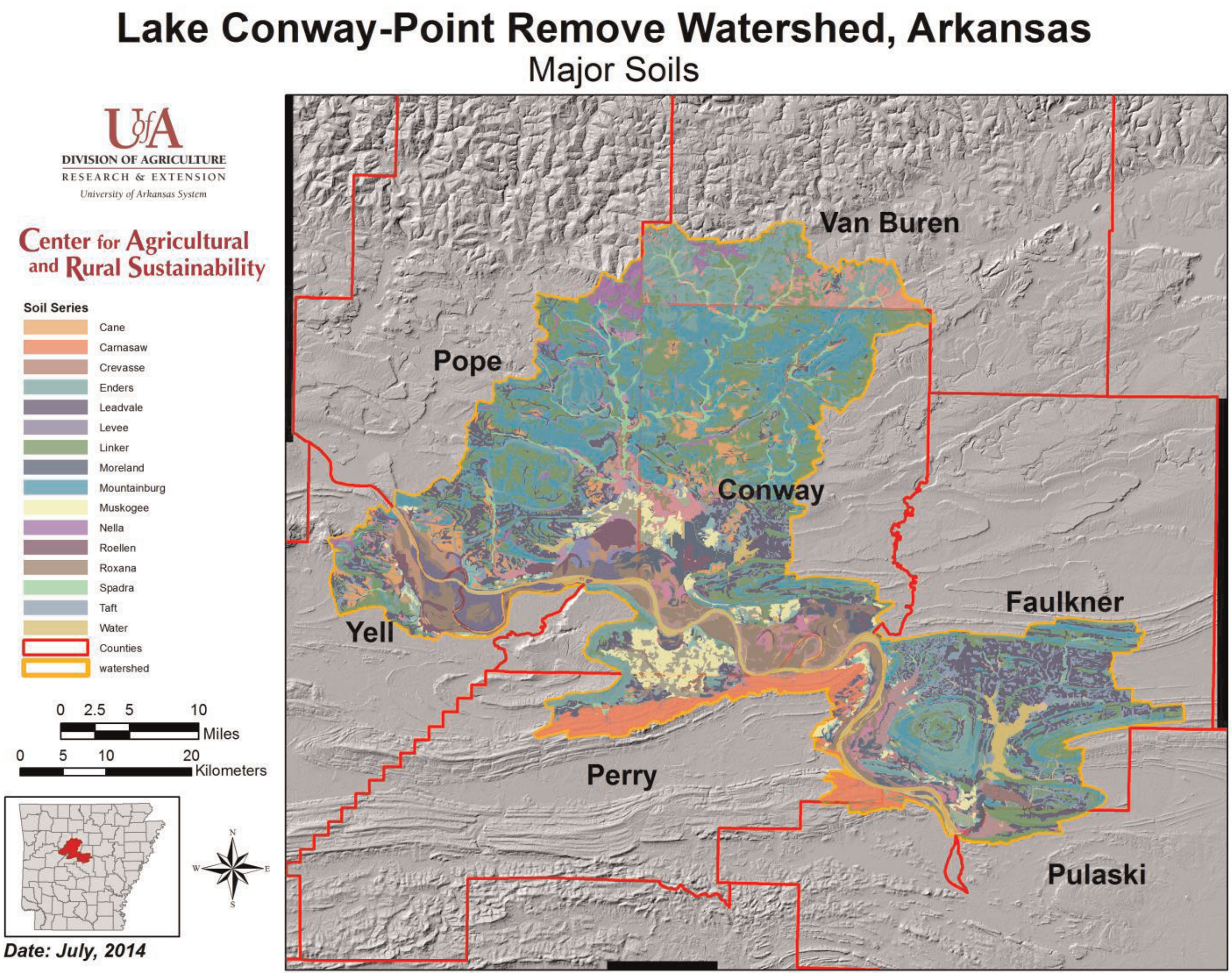

Figure 3. Soil map of Lake Conway Point Remove watershed, Arkansas, showing major soil series.

2.2.3. Land use/land cover

Land use and land cover data were acquired for 1999, 2004, and 2006 from GeoStor. Forest area was observed to be the most dominant land use and cover in the LCPR watershed. All land use and land covers were reclassified to make it compatible with the SWAT model. The land use and land cover map for LCPR can be seen in **Figure 4**.

2.2.4. Climate

Climatic data specifically daily precipitation and maximum and minimum temperature data were obtained from 90 climate stations from the NOAA's National Climatic Data Center (NCDC). Data are available from 1980 to 2012 for at least one of the climatic parameters. The procedure recommended by USDA-ARS in developing SWAT-formatted climate data were followed. Daily climate data were obtained using an inverse distance-weighted interpolation algorithm. The average data were calculated for each subwatershed using a pseudo-weather

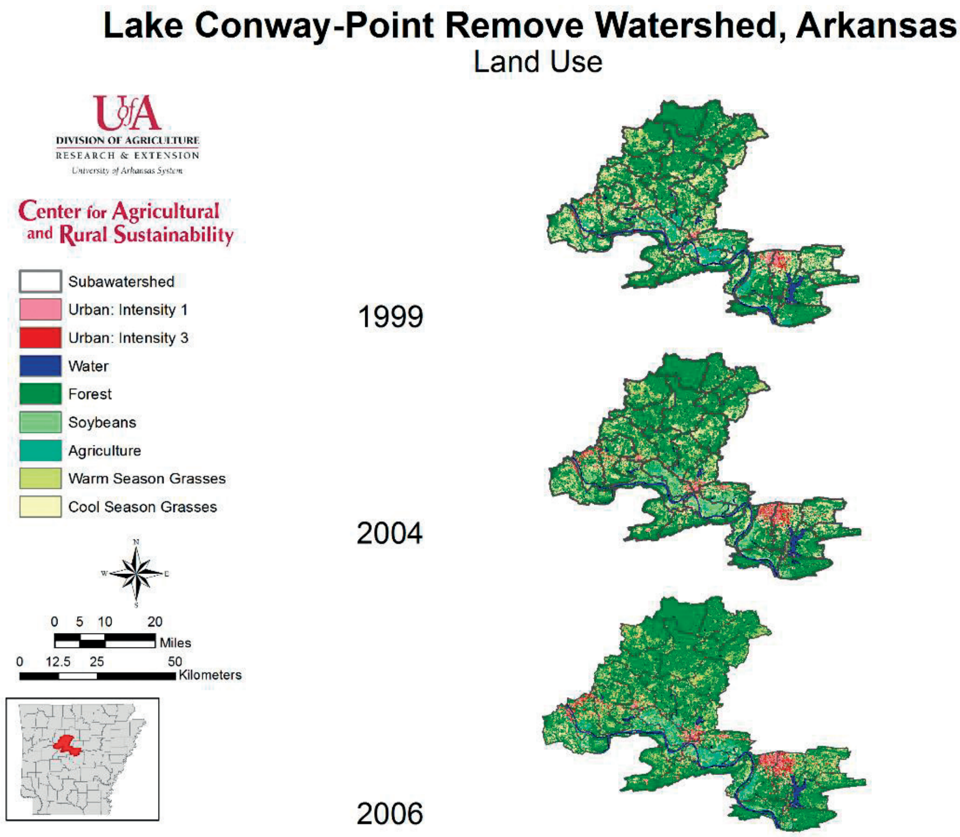

Figure 4. Land use and land cover in the Lake Conway Point Remove watershed.

station. NCDC validation results at each calibration station using leave-one-out cross-validation technique can be seen in **Table 2**. NEXRAD data were obtained from the Arkansas Basin River Forecasting Center (ABRFC).

2.2.5. Streamflow

The flow data are available for the West Fork Point Remove Creek near the Hattieville monitoring station from the US Geological Survey (USGS). This monitoring station is located in subwatershed 3 and covers approximately 20% of LCPR. The flow data were split between surface and baseflow using the baseflow filter program by [17].

2.2.6. Point sources

Point source data were obtained from the Arkansas Department of Environmental Quality (ADEQ) and was processed in the SWAT-compatible format. Point source data were available for flow, total suspended solids, organic nitrogen, organic and mineral phosphorus, nitrate nitrogen, ammonia nitrogen, and carbonaceous biochemical oxygen demand (CBOD). Locations for active point source facility that was incorporated in the SWAT model can be seen in **Table 3**.

Station	Parameter	DRAIN[1]	DNO_RAIN[2]	ME[3]	d[4]	PBIAS[5]%	R2[6]	NSE[7]	MAE[8]	RMSE[9]
Center Ridge, 4.S, AR, USA	PRCP	0.94	0.86	−0.12	0.95	−0.3	0.83	0.83	15.48	45.03
Conway, AR, USA	PRCP	0.91	0.79	−0.64	0.87	−1.9	0.59	0.58	23.53	63.56
Dardanelle, AR, USA	PRCP	0.95	0.79	0.51	0.85	1.5	0.54	0.52	24.55	71.4
Hattieville, AR, USA	PRCP	0.95	0.82	0.08	0.92	0.2	0.74	0.73	18.13	57.15
Morrilton, AR, USA	PRCP	0.90	0.82	0.97	0.9	2.8	0.69	0.68	19.84	59.78
North Little Rock Airport, AR, USA	PRCP	0.90	0.81	0.23	0.85	0.7	0.56	0.55	24.37	69.37
Perry, AR, USA	PRCP	0.90	0.82	−1.19	0.89	−3.3	0.65	0.64	21.71	64.82
Russellville Municipal Airport, AR, USA	PRCP	0.68	0.84	1.85	0.67	5.9	0.24	0.03	34.7	99.07
Conway, AR, USA	TMAX			0.45	0.99	0.2	0.95	0.95	14.49	22.31
Dardanelle, AR, USA	TMAX			−5.02	0.99	−2.2	0.95	0.94	15.14	22.95
Morrilton, AR, USA	TMAX			−1.9	0.99	−0.8	0.94	0.94	17.39	23.86
North Little Rock Airport, AR, USA	TMAX			4.05	1	1.8	0.99	0.99	9.03	11.83
Russellville Municipal Airport, AR, USA	TMAX			2.42	0.99	1	0.95	0.95	13.71	22.57
Conway, AR, USA	TMIN			−7.55	0.98	−7.1	0.95	0.94	15.59	22.75
Dardanelle, AR, USA	TMIN			−7.89	0.99	−7.8	0.95	0.95	14.18	21.36
Morrilton, AR, USA	TMIN			5.27	0.98	5.7	0.94	0.94	15.89	23.35
North Little Rock Airport, AR, USA	TMIN			−9.94	0.99	−8.3	0.97	0.95	14.79	19.68
Russellville Municipal Airport, AR, USA	TMIN			6.76	0.99	6.9	0.96	0.95	13.11	20.5

[1]NEXRAD detection conditioned on exceeding a given threshold gauge observations (DRAIN).
[2]NEXRAD detects no rainfall event (DNO_RAIN).
[3]Mean error (ME).
[4]Index of agreement (d).
[5]Percent bias (PBIAS).
[6]Coefficient of determination (R2).
[7]Nash-Sutcliffe efficiency (NSE).
[8]Mean absolute error (MAE).
[9]Root-mean-square error (RMSE).

Table 2. NCDC precipitation and minimum and maximum temperature validation results at each calibration station using leave-one-out cross-validation.

2.2.7. Cattle grazing, manure deposition, and poultry litter application

The detailed method for estimating pastures that should be receiving litter applications can be seen below.

No.	Subbasin	Facility	NPDES_ID	Latitude	Longitude
1	5	City of Pottsville	AR0048011	35.23	−93.05
2	6	City of Dardanelle	AR0033421	35.19	−93.14
3	6	Dardanelle water treatment plant	ARG640149	35.21	−93.15
4	6	Tyson Foods Inc., Dardanelle	AR0036714	35.22	−93.16
5	6	Russellville Water and Sewer System, City Corporation	AR0021768	35.25	−93.12
6	6	Freeman Brothers, Inc., d/b/a Bibler Brothers Lumber Company	AR0044474	35.25	−93.13
7	7	SEECO, Inc., J and R Farms SE1	AR0052221	35.43	92.56
8	7	Hamilton Aggregates	ARG500026	35.44	−92.54
9	8	Dover Water Works	ARG640148	35.40	−93.12
10	9	Quality Rock/Jerusalem Quarry	ARG500039	35.39	−92.80
11	10	KT Rock LLC	ARG500031	35.41	−92.67
12	11	SEECO, Inc., Campbell Thomas SE1	AR0052141	35.40	−92.83
13	13	City of Atkins	AR0034665	35.25	−92.92
14	14	Environmental Solutions and Services, Inc.	AR0051357	35.09	−92.71
15	14	Green Bay Packaging, Inc., Arkansas Kraft Division	AR0001830	35.10	−92.74
16	16	Rogers Group, Inc., Beryl Quarry	AR0047520	35.07	−92.25
17	16	Roy Nunn	ARG550322	35.07	−92.37
18	16	Waste Water Management, Inc. d/b/a Oak Tree Subdivision	AR0050792	35.08	−92.35
19	16	Fritts Construction, Inc., Hayden's Place Subdivision	AR0050253	35.09	−92.34
20	16	BHT Investment Company, Inc.	AR0044997	35.09	−92.33
21	16	Rolling Creek POA	AR0042536	35.11	−92.33
22	16	Genesis Water Treatment, Inc.	AR0051152	35.11	−92.34
23	17	Faulkner County Public Facility Board, d/b/a Preston Community WW Utility	AR0050571	35.03	−92.41
24	17	Wilhelmina Cove property owner	AR0048682	34.93	−91.11
25	17	City of Conway, Stone Dam Creek	AR0033359	35.05	−92.44
26	17	Coreslab Structures (ARK), Inc.	AR0050474	35.06	−92.43
27	17	MAPCO Express, Inc. #3059	AR0045071	35.07	−92.42
28	17	Flushing Meadows Water Treatment, Inc.	AR0048879	35.06	−92.37
29	17	Jesse Ferrel d/b/a Jesse Ferrel Rental Development	AR0049832	35.09	−92.37
30	18	City of Mayflower	AR0037206	34.95	−92.45
31	18	Carla Knight	ARG550430	34.97	−92.48
32	19	Construction Waste Management, Inc. Class IV Landfill	AR0051764	34.93	−92.44
33	19	Grassy Lake Apartments	AR0050334	34.94	−92.43
34	20	City of Bigelow	AR0049999	35.00	−92.61
35	20	City of Conway, Tucker Creek WWTP	AR0047279	35.07	−92.50

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No.	Subbasin	Facility	NPDES_ID	Latitude	Longitude
36	21	Conway Corporation, Tupelo Bayou WWTP	AR0051951	35.05	−92.54
37	22	City of Oppelo	AR0047643	35.08	−92.76
38	24	Faulkner County POID, Seven Point Lake Project	AR0050903	35.02	−92.18
39	25	Rogers Group, Inc.	ARG500066	35.24	−92.65
40	26	Lentz Sand and Gravel, LLC	ARG500072	35.12	−92.76
41	26	City of Atkins, South WWTP	AR0034673	35.22	−92.93
42	29	Rogers Group, Inc., Toad Suck Quarry	AR0047104	35.11	−92.56
43	29	City of Morrilton	ARG160001	35.13	−92.70
44	29	City of Menifee	AR0049361	35.14	−92.55
45	29	Gericorp, Inc.	AR0048623	35.15	−92.72

Table 3. Active point source facility location incorporated into the SWAT model.

Detailed methods for estimating pastures that received litter application:

1. Create buffer of a random radius around the active poultry houses.
2. Extract pasture areas under the buffer.
3. Assuming a grazing density of 1 cow/0.8 ha of litter amended pasture, calculate the number of cows that can fit the buffer.
4. Compare the calculated number of cows to the number of cows in the subwatershed.
5. Repeat steps 1–4 to obtain the best agreement between estimated numbers of cows.
6. Apply litter to pasture HRUs that fall under the best buffer radius.

The SWAT compatible data for cattle grazing, manure deposition, and poultry litter application can be seen in **Table 4**.

2.2.8. Urban pasture management

The pasture management schedule relating to specific operation and crop can be seen in **Table 5**.

2.2.9. Ponds and wetlands

SWAT input parameters relating to ponding were PND_FR, PND_PSA (ha), PND_PVOL (104 m^3), PND_ESA, PND_EVOL, and PND_VOL. These ponding parameters can be seen in **Table 6**. SWAT input parameters relating to wetland were WET_FR, WET_NSA (ha), WET_NVOL 104 (m^3), WET_MXSA (ha), WET_MXVOL 104 (m^3), and WET_VOL 104(m^3). These wetland parameters can be seen in **Table 7**.

Subbasin	Cattle grazing rate (kg/day/ha)	Cattle manure deposition rate (kg/day/ha)	Litter application/grazing
1	14.38	5.59	Yes
2	12.59	4.90	Yes
3	9.16	3.57	Yes
4	11.46	4.46	Yes
5	6.11	2.38	Yes
6	5.83	2.27	Yes
7	13.18	5.13	Yes
8	6.27	2.44	Yes
9	11.43	4.45	Yes
10	11.46	4.46	Yes
11	7.34	2.86	Yes
12	11.46	4.46	Yes
13	6.11	2.38	Yes
14	10.51	4.09	Yes
15	9.05	3.52	Yes
16	12.03	4.68	No
17	12.03	4.68	No
18	11.98	4.66	No
19	12.44	4.84	No
20	6.44	2.51	No
21	12.03	4.68	No
22	9.24	3.60	Yes
23	12.03	4.68	No
24	12.03	4.68	Yes
25	11.46	4.46	Yes
26	7.84	3.05	Yes
27	4.50	1.75	Yes
28	9.15	3.56	Yes
29	10.70	4.16	Yes

Table 4. Cattle grazing, manure deposition, and poultry litter application data incorporated into the SWAT model.

2.3. Model setup

SWAT divides a watershed into subwatersheds and further subwatersheds into hydrological response units. User-defined approach for delineating subwatersheds was used. ArcSWAT

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Date	End	No. of days	Operation	Comment	Crop
				Cool-season grass (fescue)	
1-Apr			Fertilizer	Poultry litter@1 ton/acre of auto-fertilize	BERM
1-May			Planting	Warm-season grass (Bermuda)	BERM
15-May	31-Oct	170	Grazing		BERM
15-Jun			Hay cutting	85% removal	BERM
15-Jul			Hay cutting	85% removal	BERM
15-Aug			Hay cutting	85% removal	BERM
15-Sept			Hay cutting	85% removal	BERM
15-Oct			Hay cutting	85% removal	BERM
1-Mar			Fertilizer	Poultry litter@1 ton/acre of auto-fertilize	BERM
15-May	30-Oct	170	Grazing		BERM
15-Jun			Hay cutting	85% removal	BERM
15-Jul			Hay cutting	85% removal	BERM
15-Aug			Hay cutting	85% removal	BERM
15-Sept			Hay cutting	85% removal	BERM
15-Oct			Hay cutting	85% removal	BERM
1-Apr			Fertilizer	Poultry litter@1 ton/acre of auto-fertilize	BERM
				Warm-season grass (Bermuda)	
31-Aug			Fertilizer	Poultry litter@1 ton/acre of auto-fertilize	FESC
1-Sept			Planting	Cool-season grass (fescue)	FESC
15-Mar	1-Jun	79	Grazing		FESC
15-May			Hay cutting	85% removal	FESC
15-Jun			Hay cutting	85% removal	FESC
1-Sept			Fertilizer	Poultry litter@1 ton/acre of auto-fertilize	FESC
1-Oct			Grazing		FESC
15-Oct			Hay cutting	85% removal	FESC
21-Feb			Fertilizer	Poultry litter@1 ton/acre of auto-fertilize	FESC
15-Mar	1-Jun	79	Grazing		FESC
15-May			Hay cutting	85% removal	FESC
15-Jun			Hay cutting	85% removal	FESC
1-Sept			Fertilizer	Poultry litter@1 ton/acre of auto-fertilize	FESC
1-Oct	30-Nov	61	Grazing		FESC
21-Feb			Fertilizer	Poultry litter@1 ton/acre of auto-fertilize	FESC

Table 5. Pasture management schedule incorporated into the SWAT model.

Subwatershed	PND_FR	PND_PSA (ha)	PND_PVOL (104 m^3)	PND_ESA	PND_EVOL	PND_VOL
1	0.068	30	30	40	40	30
2	0.007	4	4	6	6	4
3	0.290	146	146	195	195	146
4	0.330	194	194	258	258	194
5	0.066	45	45	60	60	45
6	0.090	55	55	73	73	55
7	0.138	77	77	103	103	77
8	0.062	43	43	57	57	43
9	0.064	57	57	76	76	57
10	0.059	34	34	45	45	34
11	0.080	49	49	65	65	49
12	0.088	54	54	71	71	54
13	0.087	65	65	87	87	65
14	0.126	65	65	87	87	65
15	0.072	41	41	55	55	41
16	0.102	54	54	72	72	54
17	0.098	60	60	80	80	60
18	0.068	34	34	45	45	34
19	0.200	103	103	137	137	103
20	0.225	84	84	112	112	84
21	0.067	42	42	56	56	42
22	0.097	39	39	52	52	39
23	0.096	55	55	73	73	55
24	0.111	34	34	45	45	34
25	0.128	60	60	79	79	60
26	0.109	82	82	109	109	82
27	0.087	74	74	98	98	74
28	0.053	24	24	33	33	24
29	0.190	126	126	168	168	126

Table 6. Pond input parameters for each subwatershed.

was used to develop the SWAT2012 model with a revision number 635. A threshold of 0% for land use, 5% for soil, and 0% for slope was used to delineate HRUs resulting in 3402 HRUs. Some past studies reported the relationship between watershed response and HRU delineation approach [18, 19].

Subwatershed	WET_FR	WET_NSA (ha)	WET_NVOL 104 (m^3)	WET_MXSA (ha)	WET_MXVOL 104 (m^3)	WET_VOL 104 (m^3)
1	0.0000	0.00	0.00	0.00	0.00	0.00
2	0.0000	0.00	0.00	0.00	0.00	0.00
3	0.0249	65.97	32.99	219.90	109.95	6.60
4	0.0151	46.43	23.22	154.78	77.39	4.64
5	0.0004	1.38	0.69	4.61	2.30	0.14
6	0.0040	12.62	6.31	42.06	21.03	1.26
7	0.0001	0.15	0.08	0.50	0.25	0.02
8	0.0000	0.00	0.00	0.00	0.00	0.00
9	0.0000	0.00	0.00	0.00	0.00	0.00
10	0.0000	0.00	0.00	0.00	0.00	0.00
11	0.0000	0.00	0.00	0.00	0.00	0.00
12	0.0000	0.00	0.00	0.00	0.00	0.00
13	0.0018	7.18	3.59	23.92	11.96	0.72
14	0.0146	39.90	19.95	133.01	66.51	3.99
15	0.0093	27.84	13.92	92.79	46.39	2.78
16	0.0003	0.96	0.48	3.20	1.60	0.10
17	0.0000	0.00	0.00	0.00	0.00	0.00
18	0.0142	37.57	18.79	125.24	62.62	3.76
19	0.0058	15.53	7.77	51.78	25.89	1.55
20	0.0019	3.77	1.89	12.57	6.28	0.38
21	0.0052	17.23	8.62	57.45	28.72	1.72
22	0.0331	70.06	35.03	233.53	116.76	7.01
23	0.0017	5.04	2.52	16.79	8.40	0.50
24	0.0040	6.33	3.16	21.09	10.54	0.63
25	0.0000	0.00	0.00	0.00	0.00	0.00
26	0.0081	31.88	15.94	106.25	53.13	3.19
27	0.0002	0.81	0.41	2.70	1.35	0.08
28	0.0060	14.39	7.20	47.97	23.99	1.44
29	0.0364	127.13	63.56	423.75	211.88	12.71

Table 7. Wetland input parameters for each subwatershed.

2.4. Calibration and validation

Before calibrating a model, sensitivity analysis is usually performed to reduce the number of parameters. Latin hypercube (LH) one-at-a-time (OAT) method [20] was used to identify the sensitive parameters that might affect the output results. A total of 22 flow parameters were tested, and the following 12 were found sensitive: SOL_AWC, CN2, ALPHA_BF, SOL_K, CH_N2, CH_K2, CANMX, RCHRG_DP, SURLAG, GW_DELAY, OV_N, and GW_REVAP.

The model calibration period was from 1987 to 2006 and the validation period was from 2007 to 2012. The first 3 years of calibration period were selected as a warm-up period so that the model parameters can be initialized. The calibration started with baseflow followed by surface flow adjusting related parameters affecting baseflow and surface flow. The SWAT Check tool [21] was used before calibration to make sure that the simulated outputs were within the reasonable ranges. The Load Estimator (LOADEST) tool [22] was used on a water quality dataset available from Sept 2011 to Dec. 2012 at Hattieville and Apr. 2012 to Dec. 2012 at Morrilton. The regression coefficients were found to be statistically significant ($p < 0.05$) at Hattieville and Morrilton for sediment, total phosphorus, and nitrate nitrogen. The performance of the model was determined mainly using the coefficient of determination (R^2).

3. Results and discussion

3.1. Calibration and validation results

Various SWAT parameters that were calibrated along with their parameter ranges and final calibrated values can be seen in **Table 8**. The annual calibrated R2 for the total, surface, and

File/ parameter	Definition	MIN	MAX	Units	Calibrated value	Notes
.bsn						
ESCO	Soil evaporation compensation factor	0	1		0.95	Based on water balance
EPCO	Plant uptake compensation factor	0	1		1	Based on water balance
.gw						
GW_DELAY	Groundwater delay	0	500		2	Calibrated value
ALPHA_BF	Baseflow alpha factor	0	1	Days	0.0932	Baseflow separation factor
GW_REVAP	Groundwater "revap" coefficient	0.02	0.2		0.072	Calibrated value
REVAPMN	Threshold depth of water in the shallow aquifer for "revap" to occur	0	1000		750	Calibrated value
RCHRG_DP	Deep aquifer percolation fraction	0	1		0.06	Calibrated value
GWQMN	Threshold depth of water in the shallow aquifer required for return flow to occur	0	5000	mm	800	Calibrated value
.rte						
CH_N2	Manning's "n" value for the main channel	−0.01	0.3		0.014	Calibrated value

File/ parameter	Definition	MIN	MAX	Units	Calibrated value	Notes
CH_K2	Effective hydraulic conductivity	−0.01	500	mm/hr	6	
.hru						
CANMX-Forest	Maximum canopy storage	0	100	mm	6	Wu et al., [23]
CANMX-Ag	Maximum canopy storage	0	100	mm	2.8	
CANMX-Pasture	Maximum canopy storage	0	100	mm	4	
CANMX-Urban	Maximum canopy storage	0	100	mm	0.1	
SURLAG	Surface runoff lag time	1	24	Days	2	Calibrated value
HRU_SLP	Average slope steepness	0	1	m/m	Reduce by 10%	Based on identified high sediment yield on high-slope agricultural HRUs
.mgt						
CN2	SCS runoff curve number for moisture condition II	35	98		CN + 1	Calibrated value
.sol						
SOL_AWC	Soil available water capacity	0	1	mm/mm	SOL_AWC × 1.13	Calibrated value

Table 8. SWAT model parameter ranges and the final calibrated values.

baseflow was 0.83, 0.85, and 0.16. The validated R2 was 0.91, 0.93, and 0.60 for the total, surface, and baseflow. The monthly calibrated R2 was 0.73, 0.73, and 0.54 and validated R2 was 0.84, 0.78, and 0.76 for the total, surface, and baseflow, respectively. The calibration and validation scatter plots for total flow, surface flow, and baseflow can be seen in **Figure 5**. The validated R^2 for water quality was 0.5–0.7 at Hattieville and 0.7–0.87 at Morrilton. The results are within acceptable limits of other modeling studies relating to limited data availability [24, 25].

4. Conclusions

Modeling studies are gaining popularity due to rapidness of insight generation before actually performing field experiments. The initiative led by the Mississippi River Basin focused on analyzing the water quality benefits from intended best management practices with the help of modeling studies. However, merely simulating best management practices will not be able to provide reliable results unless the model has been set up correctly and robust. This chapter focused on the detailed discussion for setting up the model to a point where the model setup procedure can be replicated. The model was set up with all relevant information, and each data

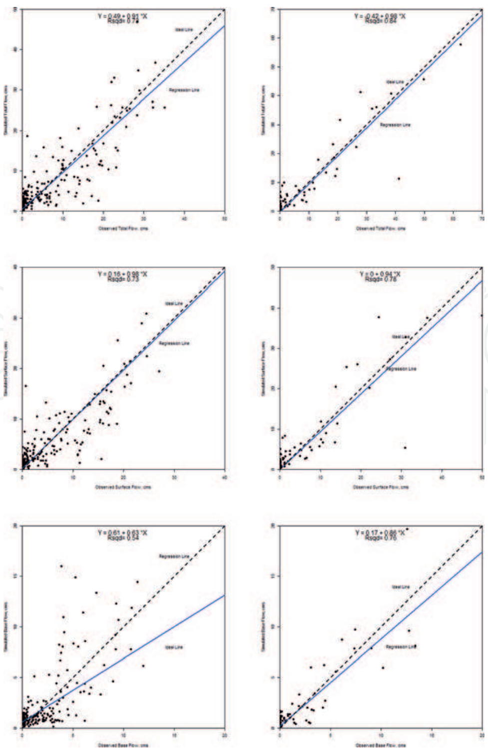

Figure 5. Calibration [left] and validation [right] scatter plots for total flow, surface flow, and baseflow.

preparation step has been explained in detail. The model was calibrated and validated for flow at Hattieville. Due to limited water quality data, the model was validated for sediment, total phosphorus, and nitrate nitrogen at Hattieville and Morrilton. The results were satisfactory and within the ranges reported by previous studies. Results from this study can be used to evaluate the relative effectiveness of MRBI-recommended agricultural BMPs for analyzing pollutant load reductions and improving water quality in similar data-limited watersheds.

Conflict of interest

The authors declare no conflict of interest.

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