Geospatial Model Development for Watershed Based Fecal Coliform Estimation and Comparison with Virginia Tech's Bacteria Loading Calculator

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Applying knowledge to improve water quality

National Water Program

A Partnership of USDA CSREES & the Land Grant System

Presentation Outline

- Background
- Objectives
- Bacterial loading water quality geospatial model development procedure
- Virginia Tech's 'Fecal Coliform Calculator' use for bacterial load calculation
- Results and Discussion
  - **Bacterial Loading Calculations/Results with the developed Geospatial Model**
  - **Bacterial Loading Calculations/Results with the Fecal Coliform calculator**
- Comparison
- Conclusions

Background of the Study

- Most of the cited waterbodies in Section 303(d) in requirement of a TMDL are impaired from fecal coliform (FC) load
- FC mostly comes from two main sources, i.e.,
  - Nonpoint (land use practices and land cover)
  - point sources (concentrated animal feedlot operations, livestock, wild animals, and septic systems)
- Remote calculation of fecal coliform load using developed geospatial model or any mathematical calculator is a necessity to assuage watershed end-users about the health of their water bodies

Background of the Study

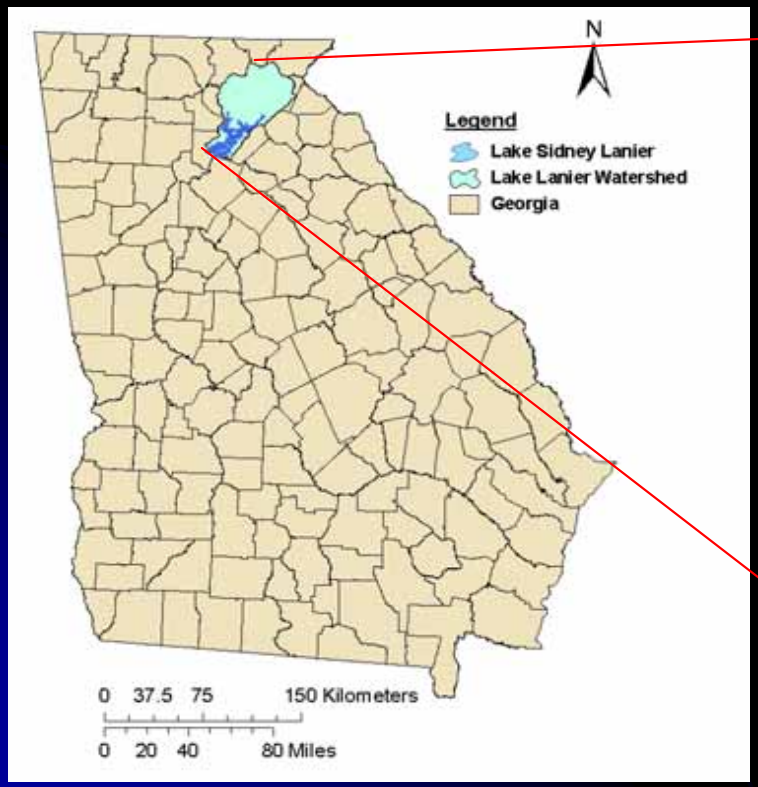
- Virginia Tech's 'Fecal Coliform Load Calculator (FCLC)' is one such tool developed through MS-Excel macro coding to calculate the FC load to the stream from the watershed
  - The calculator incorporates both sources (without differentiating point and non-point) in the FC load calculation
- Automated geospatial models developed in ArcGIS ModelBuilder platform have the ability to calculate FC load with single click in ArcGIS environment
  - As GIS is a amazing tool that introduces spatial aspects of our watershed (earth) in such environmental analysis

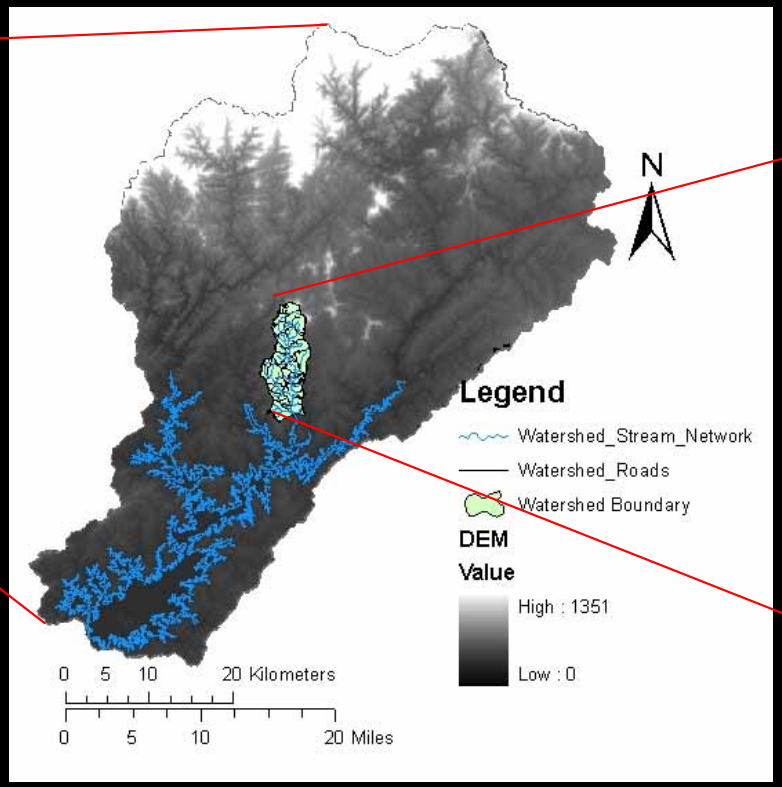
Objectives of the Study

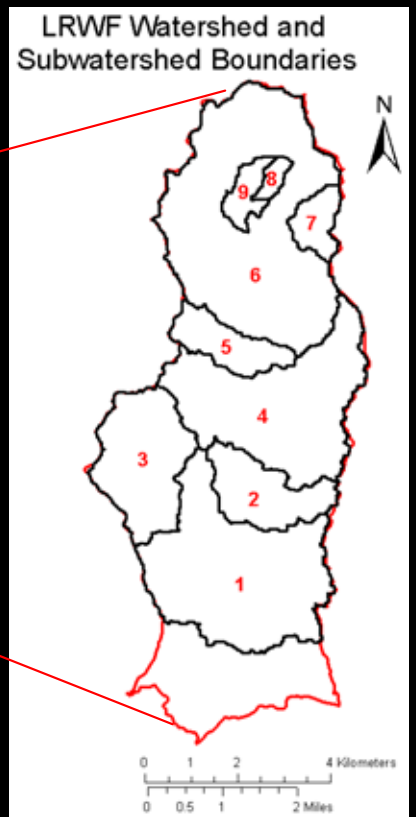
- To develop a watershed-based Fecal Coliform geospatail model in ArcGIS 9.2 ModelBuilder platform to calculate the FC load at various exit points (watershed and subwatersheds) in the study area
- To use the Virginia Tech's 'Fecal Coliform Load Calculator to estimate the FC load in the watershed
- To compare both techniques

Study Area

- West Fork Little River(WFLR) watershed
  - A 12-digit HUC watershed (# 031300010402)
  - a sub-catchment of the northern portion of the Upper Chattahoochee River watershed which feeds into Lake Sidney Lanier
  - The watershed is divided into nine subwatersheds

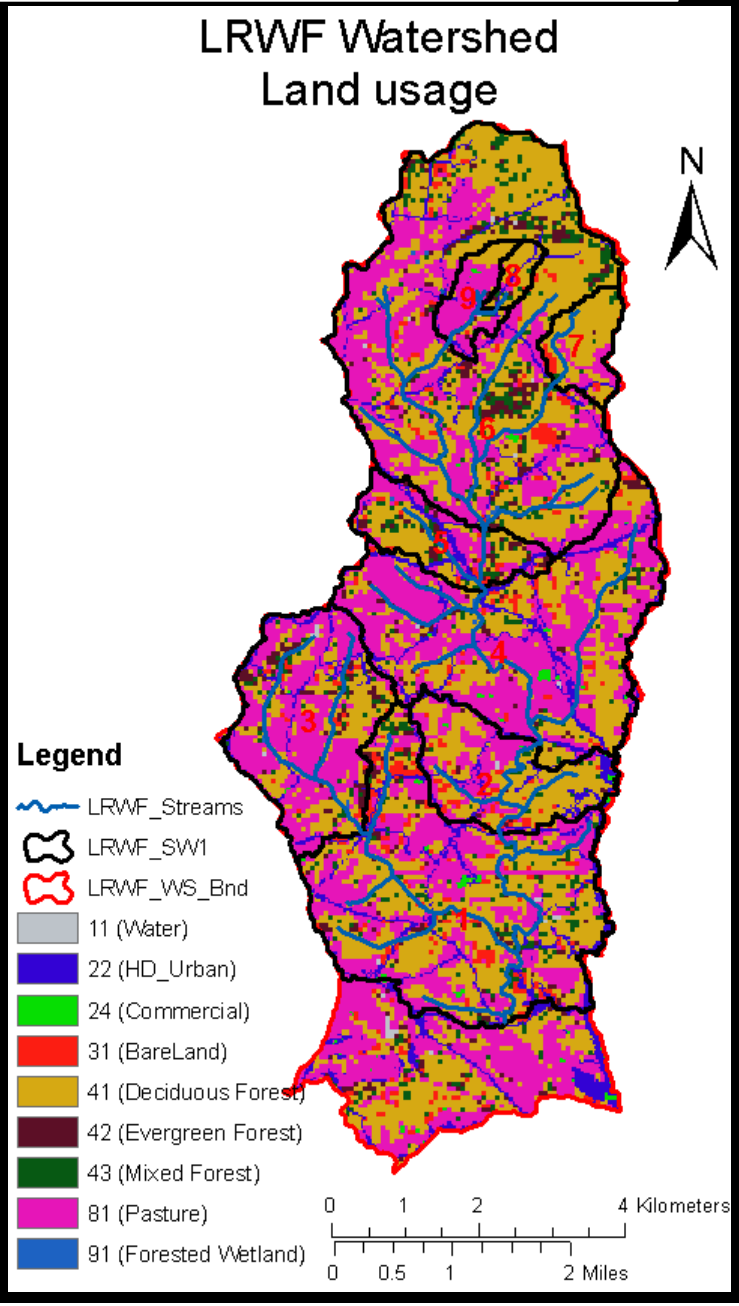






Potential Bacteria Sources

- Non-point bacteria sources
  - Different land use and land cover type
- Point sources
  - Concentrated Animal Feedlot Operations (CAFOs)
  - Livestock (cattle, goats, horses, sheep, hen, hogs, and chickens)
  - Water birds
  - Septic Systems

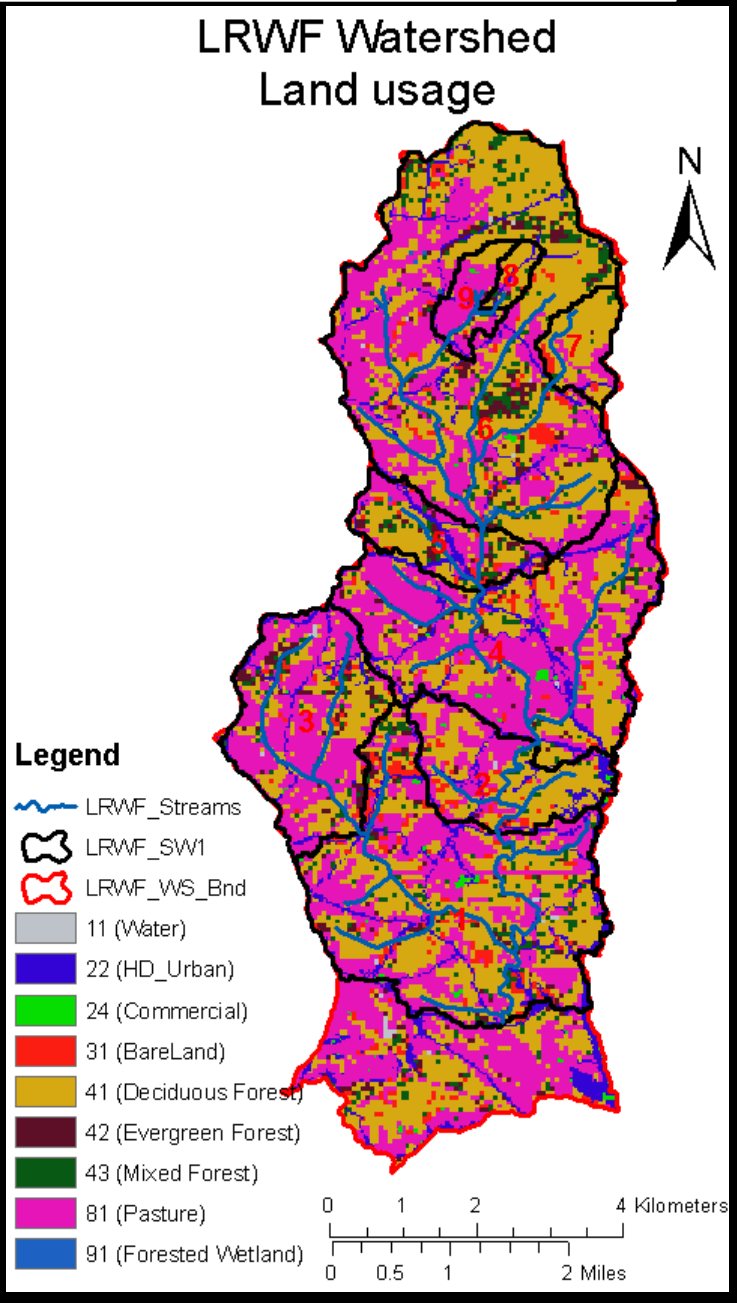


Materials and Methods

- ArcGIS 9.2
  - Model Builder
- AVSWAT model
- Fecal Coliform Workbook : A Virginia Tech program for Fecal Coliform load analysis
- LULC (NLCD 2005), DEM, Stream (RF1)
- Precipitation record for the watershed
- Animal data for the watershed
- Septic tank information for the watershed

Procedure to Delineate subwatersheds

- AVSWAT (Soil and Water Assessment Tool) watershed model software was used to delineate nine subwatersheds with pre-designated exit points
- Fecal coliform load calculation was conducted for the watershed and subwatersheds



Non-Point Source Bacterial Loadings Procedure

- Basic Equation (by Quenzer):

$$L = Q * C$$

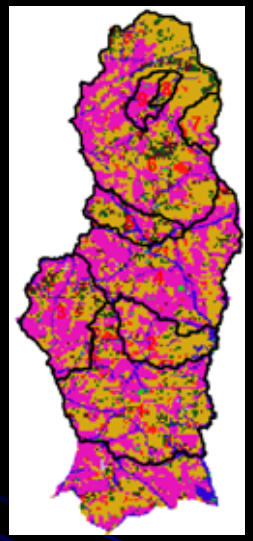
L = Bacterial loadings (cfu/year)

Q = Runoff (m^3/year)

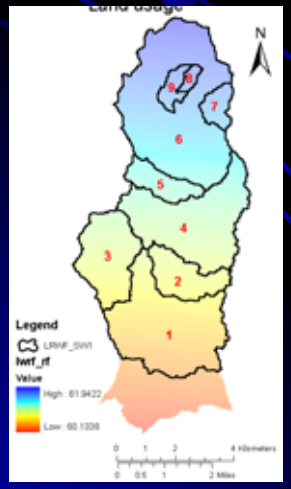
C = Fecal coliform concentration (cfu/m^3)

Runoff (Q) Calculations

- Development of Runoff raster for the watershed
  - Based on: **land use** and **precipitation**



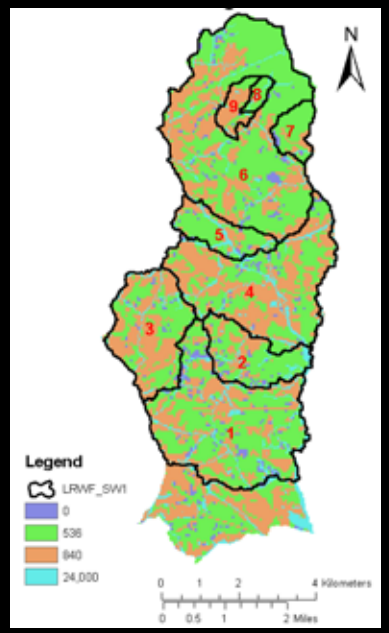
Land Use Land Cover Data



Precipitation Data
(inches/year)

Quenzer Equations

Agriculture:
Q = 0.008312 * exp (0.011415 * P)
Forest:
Q = 0.0053 * exp (0.010993 * P)
Urban:
Q = 0.24 * P
Open Water:
Q = 0
Where:
Q = Runoff (mm/year)
P = Precipitation (mm/year)



Runoff, Q
(m^3/year)

Table for Fecal Colonies per Land-use Types

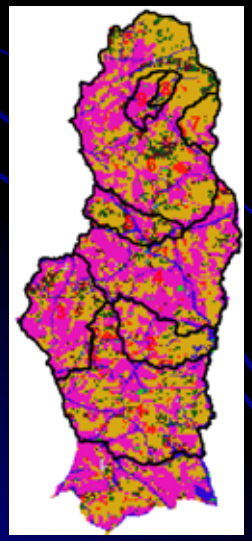
Land Use Code	Category	Fecal Colonies per 100 mL
11	Open Water	0
21	Low Intensity Residential	22,000
22	High Intensity Residential	22,000
23	Commercial/Industrial/Transportation	22,000
31	Bare Rock/Sand/Clay	0
32	Quarries/Strip Mines/Gravel Pits	0
41	Deciduous Forest	1,000
42	Evergreen Forest	1,000
43	Mixed Forest	1,000
51	Shrubland	2,500
61	Orchards/Vineyards/Other	2,500
71	Grasslands/Herbaceous	2,500
81	Pasture/Hay	2,500
82	Row Crops	2,500
83	Small Crops	2,500
85	Urban/Recreational Grasses	22,000
91	Woody Wetlands	200
92	Emergent Herbaceous Wetlands	200

Creation of EFC (Estimated Fecal Coliform) Grid

Attributes of EMC_Values

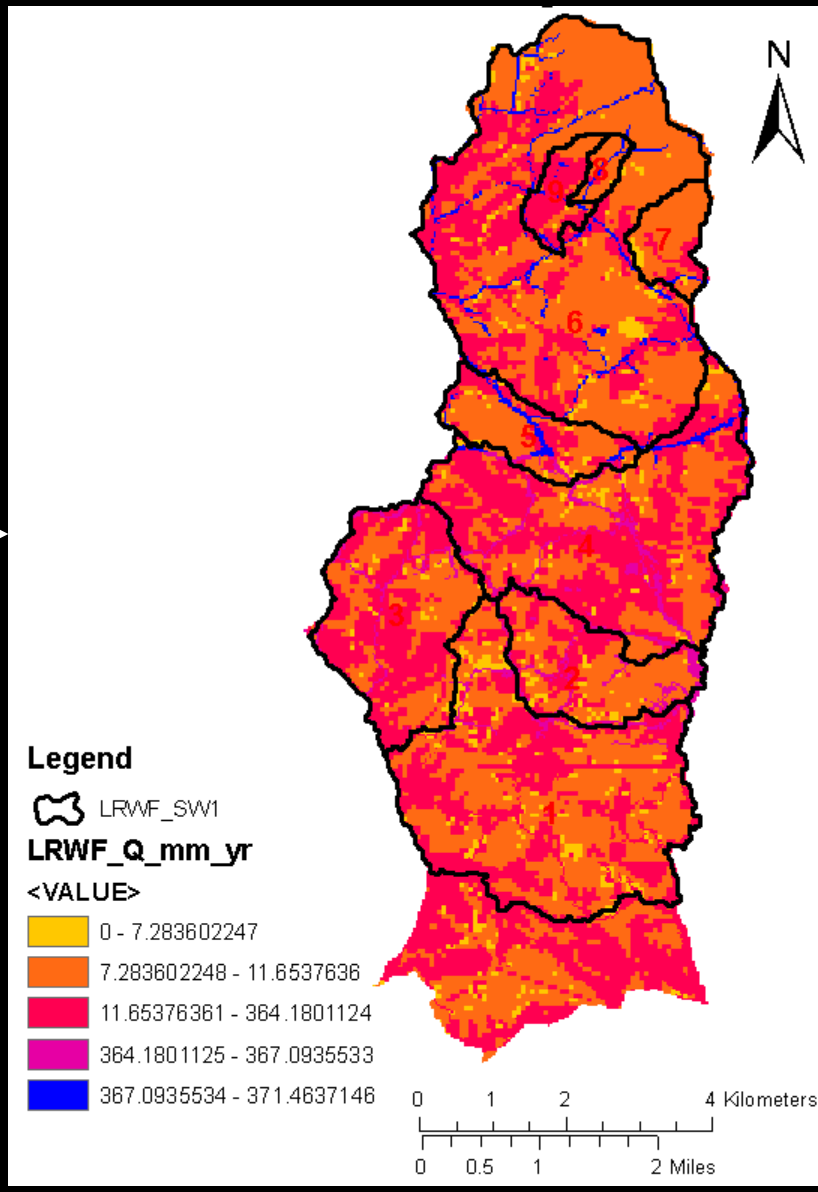
OBJECTID*	Value*	Fecal Colonies per 100mL
1	11	0
2	21	22000
3	22	22000
4	23	22000
5	31	0
6	32	0
7	41	1000
8	42	1000
9	43	1000
10	51	2500
11	61	2500
12	71	2500
13	81	2500
14	82	2500
15	83	2500
16	85	22000
17	91	200
18	92	200

EFC dbf table



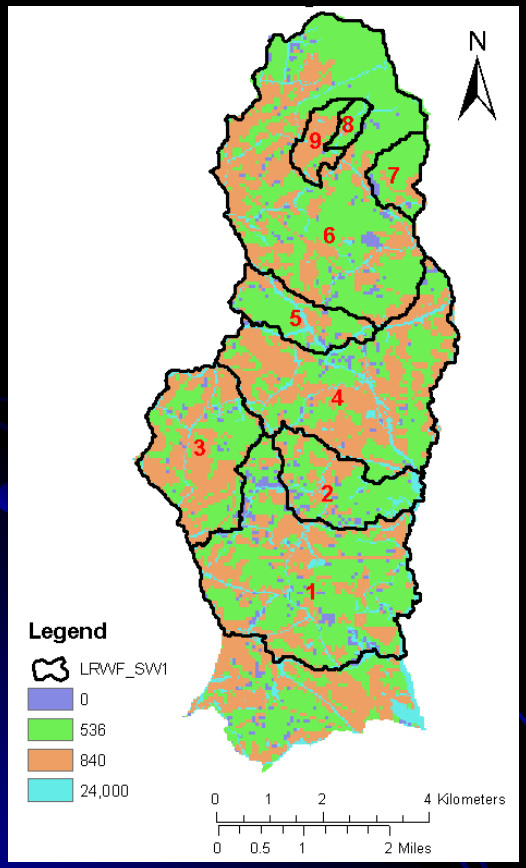
Land Use Land Cover Data

Join based on land use code



Non-Point Bacterial Loading Grid

Q (runoff)



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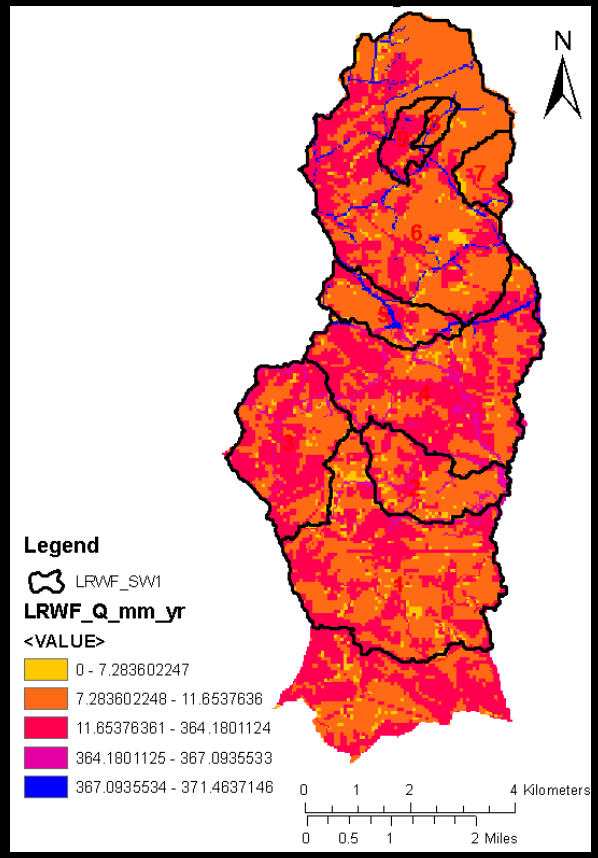
EFC grid



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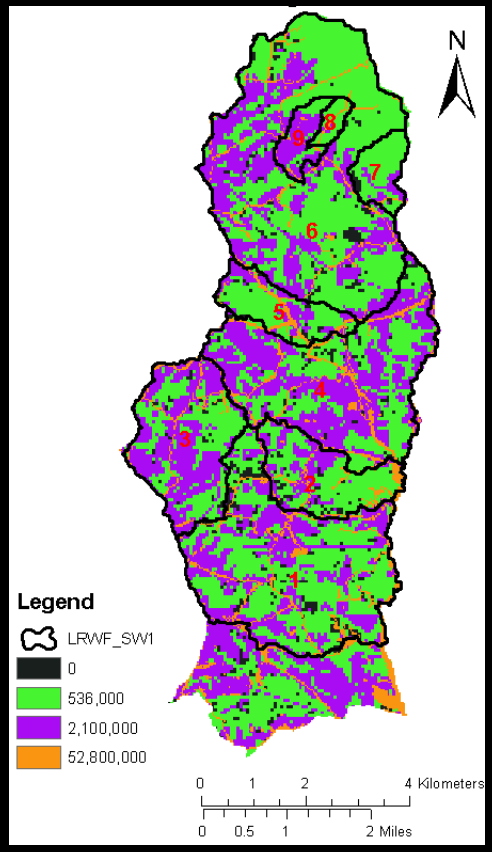
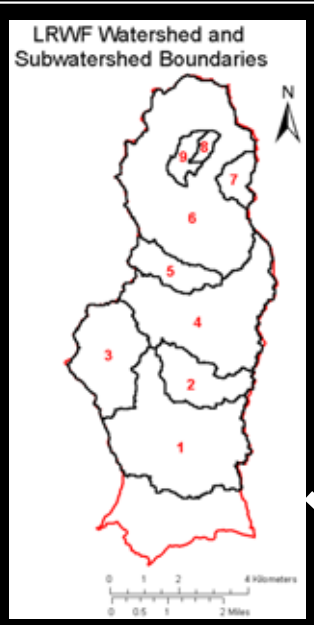
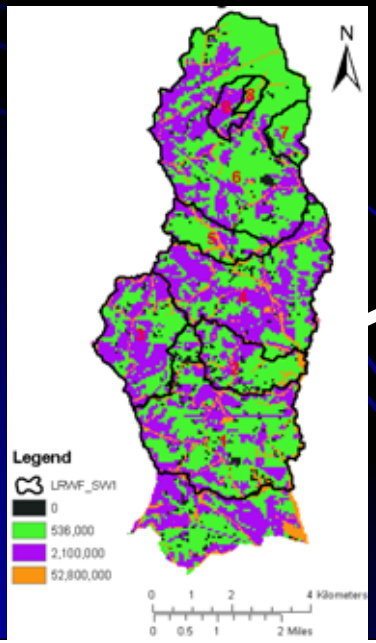
Annual Bacterial Loading per Grid Cell (cfu / 100 ml / yr)



NPS Loading per Subwatershed

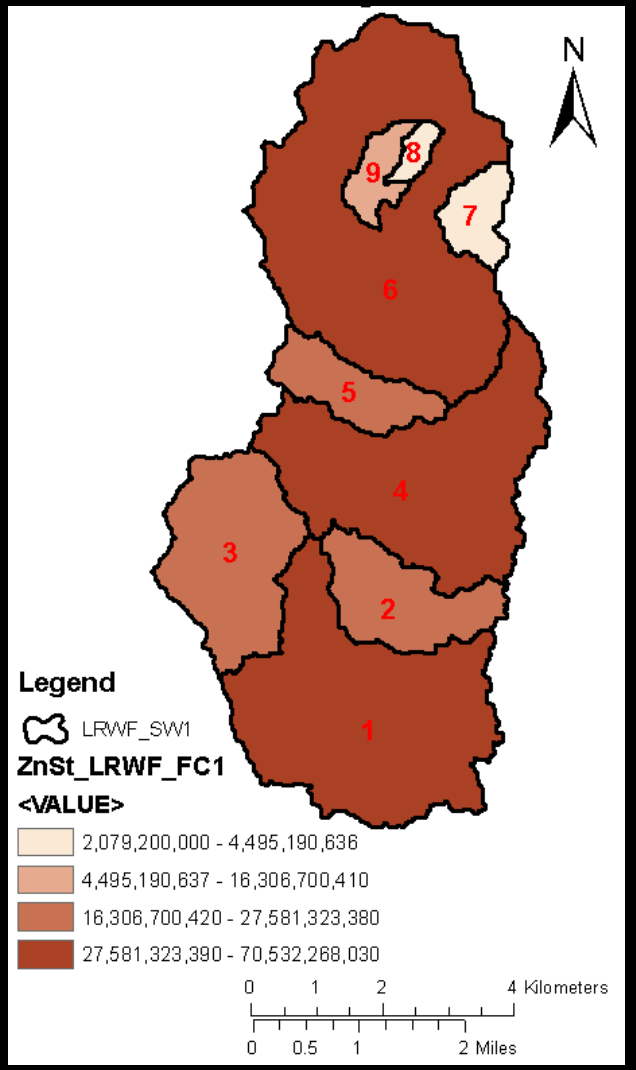


Delineated Watersheds using AVSWAT



Annual Bacterial Loading per grid cell (cfu/100 ml/year)

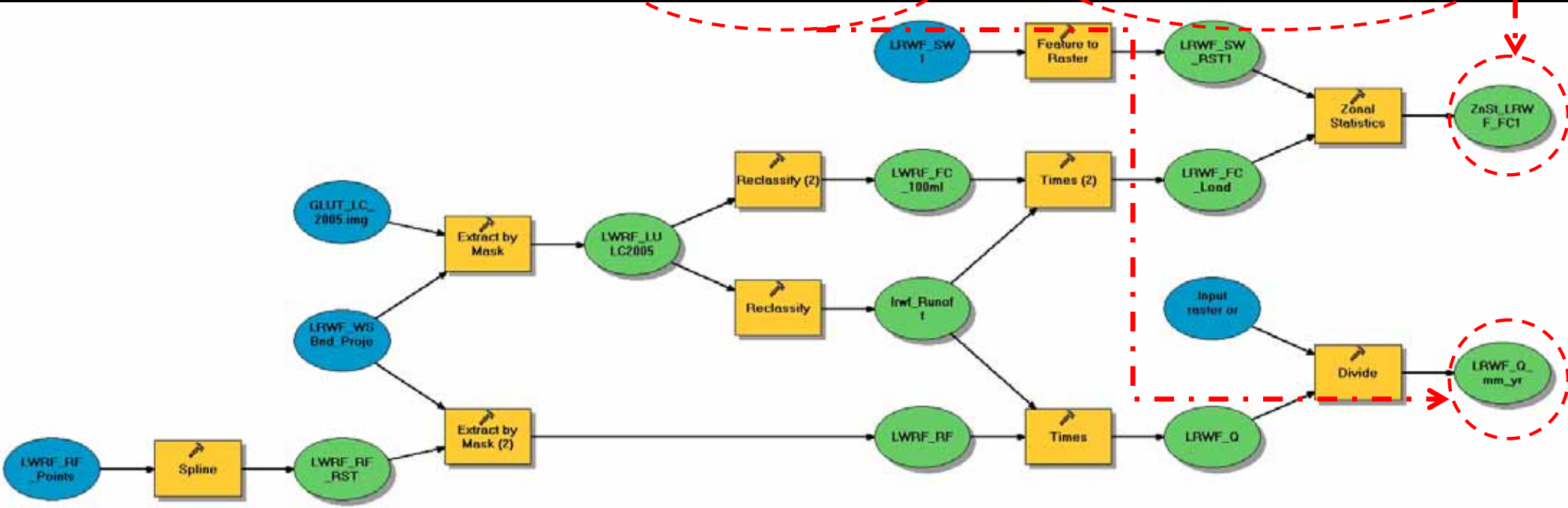
Zonal Statistics



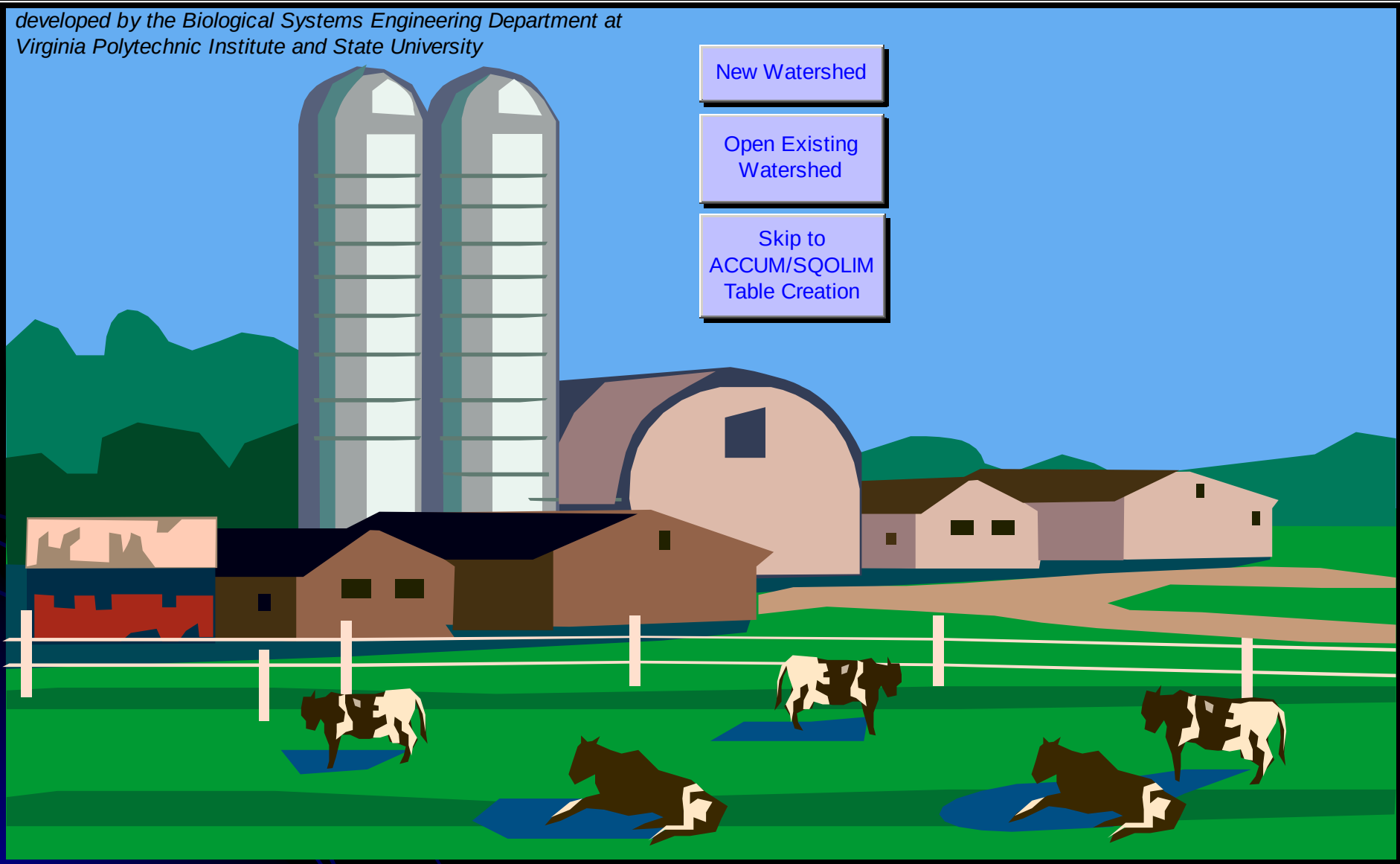
Annual Bacterial Loading per Watershed (cfu/100 ml/year)

Final Fecal Coliform Calculation Geospatial Model

- The entire procedure followed to calculate the non-point source FC load for WFLR watershed and subwatersheds are modeled in ArcGIS 9.2 ModelBuilder
- The model is an automated single click model to provide FC load for watershed and subwatersheds.



Virginia Tech's Fecal Coliform Calculator



- It is a MS-Excel Macro based workbook

FC Load Calculations Procedure

❖ Table of animal data

	Cattle				Chickens			Turkeys			Horses	Ewes	Goats
Subwatershed	Dairy			Beef	Layers	Broilers	Broiler Breeders	Toms	Hens	Breeders			
	M	D	H										
LRWF	500	300	600	1000	2000	5000	5000	100	200	50	50	200	50







Subwatershed	Deer	Raccoons	Muskrats	Beavers	Geese			Ducks			Wild Turkeys
					Peak	Season 2	Season 3	Peak	Season 2	Season 3	
LRWF	300	200	200	300	500	200	200	500	150	150	500

❖ Table for LU data

Subwatershed	Total Forest Acreage	Total Cropland Acreage	Total Pasture Acreage	Loafing Lot Time		Pasture 1 Fraction of Total	Pasture 2 Fraction of Total	Pasture 3 Fraction of Total	Stream Access Pasture 1	Stream Access Pasture 2	Stream Access Pasture 3	Straight Pipes
				Dairy	Beef							
LRWF	6527	0	5182	0	0	0.35	0.5	0.15	100	200	300	0.25

❖ Table for Human Activities

	Persons/	Persons/	Number	Number	Septic Systems			Straight Pipes		
Subwaters	Unsewer	Sewered	Unsewer	Sewered	oldest	mid-age	newest	oldest	mid-age	newest
LRWF	6	4	500	600	100	100	200	20	40	40

Calculation Values and Sources

- Example of the pre-developed values of FC load from different land-uses, animals, and human activities that are part of the FCLC workbook

	Parameter	LRWF Value	Units	Source
Dairy Cow Parameters				
	Weight of milk or dry cow	1400	lbs	Livestock Waste Facilities Handbook, MWPS - 18
	Weight of heifer	640	lbs	study
	Manure production by heifers	40.7	lbs/day	Livestock Waste Facilities Handbook, MWPS - 18
	Ratio of dairy cows on: Pasture 1	4	ratio	
	to Pasture 2	2	ratio	
	to Pasture 3	1	ratio	
	Fraction of cows defecating in stream as compared to the cows that are in/around streams (dairy)	0.3	ratio	assumed
	Fecal coliform production by milk or dry cow	2.50E+10	total cfu/day-animal	
	Manure excreted by milk or dry cow	115	lb/day-animal	Virginia Department of Conservation and Recreation
	Liquid manure produced by confined milk cows	17	gal/day-animal	Virginia Department of Conservation and Recreation
	Fraction of fecal coliform produced per milk cow lost in milk parlor wash-off	0.025	ratio	
	Die-off coefficient for liquid manure	0.375	1/day	Kimberly Panhorst's research
	Die-off coefficient for solid manure pile	0.05	1/day	Kimberly Panhorst's research
	Survival factor for liquid manure	0.0345	factor	
	Survival factor for solid manure	0.068	factor	
Beef Cow Parameters				
	Average weight of beef cow	1000	lb	
	Fecal coliform production by 1000-lb			

Calculation Values and Sources (Some More Example)

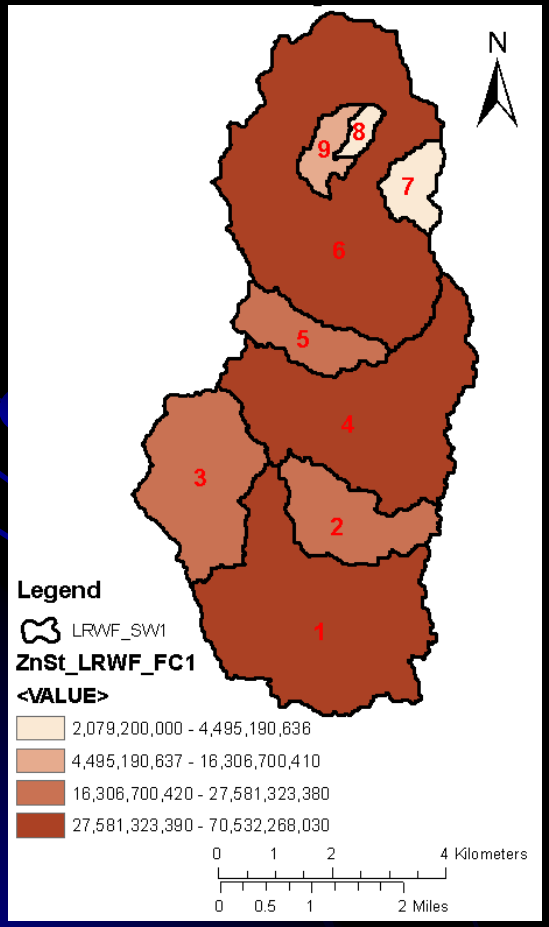
	beef cow	3.[illegible]	[illegible]	
	Ratio of beef cattle on: Pasture 1	4	ratio	Assumed to be 4:2:1 based on information gathered from
	to Pasture 2	2	ratio	beef extension specialists at Virginia Tech.
	to Pasture 3	1	ratio	
	Manure excreted by beef cow	60	lb/day-animal	Livestock Waste Facilities Handbook, MWPS - 18
	Fraction of cows defecating in stream as compared to the cows that are in/around streams (beef)	0.3	ratio	assumed
Sheep and Goat Parameters				
	Ewe Weight	60	lbs	ASAE 1998 Standards: D384.1 DEC93
	Lamb Weight	30	lbs	BPJ - 1/2 weight of ewes
	Goat Weight	140	lbs	ASAE 1998 Standards: D384.1 DEC93
	How many lambs should be associated with each ewe?	2	lambs/ewe	BPJ
	Ratio of sheep and goats on: Pasture 1	3	ratio	
	to Pasture 2	2	ratio	
	to Pasture 3	0	ratio	
	Fraction of sheep defecating in stream as compared to the sheep that are in/around streams	0	ratio	
	Fecal coliform production by 60-lb sheep	1.20E+10	total cfu/day-animal	ASAE 1998 Standards: D384.1 DEC93
	Manure excreted by sheep	2.4	lb/day-animal	ASAE 1998 Standards: D384.1 DEC93
Horse Parameter				
	Fecal coliform production by 1000-lb horse	4.20E+08	total cfu/day-animal	
	Ratio of horses on: Pasture 1	1	ratio	Assume all are on pasture 1 right now
	to Pasture 2	0	ratio	
	to Pasture 3	0	ratio	
	Fraction of horses defecating in stream			

Calculation Values and Sources (Some More Example)

	as compared to the horses that are in/around streams	0	ratio	
Poultry Parameters				
	Length of layer cycle (including down time)	336	days	
	Length of broiler cycle (including down time)	56	days	
	Length of turkey cycle (including down time)	70	days	
	Manure production by layers	0.256	lb/day-bird	ASAE D384.1 DEC93
	Manure production by broilers	0.168	lb/day-bird	ASAE D384.1 DEC93
	Manure production by turkeys	0.705	lb/day-bird	ASAE D384.1 DEC93
	Fecal coliform production by layers	1.40E+08	cfu/day-bird	ASAE D384.1 DEC93
	Fecal coliform production by broilers	8.90E+07	cfu/day-bird	based on relative manure production of layers & broilers
	Fecal coliform production by turkeys	9.30E+07	cfu/day-bird	ASAE D384.1 DEC93
	Layer litter produced	30	lb/cycle-bird	Va. Nutrient Management Handbook
	Broiler litter produced	2.6	lb/cycle-bird	Va. Nutrient Management Handbook
	Turkey litter produced	18	lb/cycle-bird	Va. Nutrient Management Handbook
	Occupancy Factor for layers	0.958	ratio	
	Occupancy Factor for broilers	0.787	ratio	
	Occupancy Factor for turkeys	0.865	ratio	
	Die-off coefficient for poultry litter	0.035	1/day	Kimberly Panhorst's research
	Survival Factor for poultry litter	0.099	factor	
Wildlife Parameters				
	Deer fecal coliform produced	3.50E+08	total cfu/day-animal	
	Fraction of deer defecating in stream	0.01	ratio	
	Raccoon fecal coliform produced	5.00E+07	total cfu/day-animal	
	Fraction of raccoons defecating in stream	0.1	ratio	
	Muskrat fecal coliform produced	2.50E+07	total cfu/day-animal	
	Fraction of muskrats defecating in			

Results and Discussion (For Developed Geospatial Model)

- Results of Model for LULC contribution for Fecal Coliform load



- The results shown indicate lower levels of fecal coliform runoff in the area of the restoration.
- In the image the lighter colors indicate less fecal coliform runoff.

Results from Fecal Coliform Load Calculator

Stream Load

							LRWF								
Month	Milk Cows	Dry Cows	Heifers	Beef Cows	Horses	Sheep	Deer	Raccoons	Muskrats	Beavers	Geese	Wild Turkeys	Ducks	Straight Pipes	Total
January	9.14E+13	1.32E+14	1.2E+14	6.66E+14	0	0	3.26E+10	3.1E+10	3.88E+10	9.3E+08	3.1E+12	1.44E+10	9.3E+12	3.72E+13	1.06E+15
February	8.33E+13	1.2E+14	1.1E+14	7.13E+14	0	0	2.97E+10	2.83E+10	3.53E+10	8.48E+08	2.83E+12	1.31E+10	8.48E+12	3.39E+13	1.07E+15
March	3.29E+14	3.29E+14	3.01E+14	2.01E+15	0	0	3.26E+10	3.1E+10	3.88E+10	9.3E+08	1.24E+12	1.44E+10	2.79E+12	3.72E+13	3.01E+15
April	4.95E+14	4.25E+14	3.88E+14	2.67E+15	0	0	3.15E+10	3E+10	3.75E+10	9E+08	1.2E+12	1.4E+10	2.7E+12	3.6E+13	4.02E+15
May	7.68E+14	6.58E+14	6.02E+14	4.26E+15	0	0	3.26E+10	3.1E+10	3.88E+10	9.3E+08	1.24E+12	1.44E+10	2.79E+12	3.72E+13	6.33E+15
June	1.73E+15	1.49E+15	1.36E+15	9.87E+15	0	0	3.15E+10	3E+10	3.75E+10	9E+08	1.2E+12	1.4E+10	2.7E+12	3.6E+13	1.45E+16
July	1.79E+15	1.54E+15	1.4E+15	1.05E+16	0	0	3.26E+10	3.1E+10	3.88E+10	9.3E+08	1.24E+12	1.44E+10	2.79E+12	3.72E+13	1.52E+16
August	1.79E+15	1.54E+15	1.4E+15	1.07E+16	0	0	3.26E+10	3.1E+10	3.88E+10	9.3E+08	1.24E+12	1.44E+10	2.79E+12	3.72E+13	1.55E+16
eptember	7.43E+14	6.37E+14	5.82E+14	4.57E+15	0	0	3.15E+10	3E+10	3.75E+10	9E+08	3E+12	1.4E+10	9E+12	3.6E+13	6.58E+15
October	5.12E+14	4.39E+14	4.01E+14	1.93E+15	0	0	3.26E+10	3.1E+10	3.88E+10	9.3E+08	3.1E+12	1.44E+10	9.3E+12	3.72E+13	3.33E+15
Jovember	3.18E+14	3.18E+14	2.91E+14	1.47E+15	0	0	3.15E+10	3E+10	3.75E+10	9E+08	3E+12	1.4E+10	9E+12	3.6E+13	2.45E+15
December	9.14E+13	1.32E+14	1.2E+14	6.37E+14	0	0	3.26E+10	3.1E+10	3.88E+10	9.3E+08	3.1E+12	1.44E+10	9.3E+12	3.72E+13	1.03E+15

Forest Load

	LRWF							
Month	Deer	Raccoons	Muskrats	Beavers	Geese	Wild Turkeys	Ducks	Total
January	1.8E+12	2.79E+11	0	9.3E+08	9.3E+12	7.96E+11	2.79E+13	4.01E+13
February	1.64E+12	2.54E+11	0	8.48E+08	8.48E+12	7.25E+11	2.54E+13	3.65E+13
March	1.8E+12	2.79E+11	0	9.3E+08	3.72E+12	7.96E+11	8.37E+12	1.5E+13
April	1.74E+12	2.7E+11	0	9E+08	3.6E+12	7.7E+11	8.1E+12	1.45E+13
May	1.8E+12	2.79E+11	0	9.3E+08	3.72E+12	7.96E+11	8.37E+12	1.5E+13
June	1.74E+12	2.7E+11	0	9E+08	3.6E+12	7.7E+11	8.1E+12	1.45E+13
July	1.8E+12	2.79E+11	0	9.3E+08	3.72E+12	7.96E+11	8.37E+12	1.5E+13
August	1.8E+12	2.79E+11	0	9.3E+08	3.72E+12	7.96E+11	8.37E+12	1.5E+13
September	1.74E+12	2.7E+11	0	9E+08	9E+12	7.7E+11	2.7E+13	3.88E+13
October	1.8E+12	2.79E+11	0	9.3E+08	9.3E+12	7.96E+11	2.79E+13	4.01E+13
November	1.74E+12	2.7E+11	0	9E+08	9E+12	7.7E+11	2.7E+13	3.88E+13
December	1.8E+12	2.79E+11	0	9.3E+08	9.3E+12	7.96E+11	2.79E+13	4.01E+13

Pasture Load

	Milk Cows			Dry Cows			Heifers			Beef			Horses		
Month	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
January	3E+12	2.14E+12	3.21E+11	4.32E+12	3.08E+12	4.63E+11	3.95E+12	2.82E+12	4.23E+11	2.18E+13	1.56E+13	2.34E+12	6.51E+11	0	0
February	2.73E+12	1.95E+12	2.93E+11	3.93E+12	2.81E+12	4.22E+11	3.6E+12	2.57E+12	3.85E+11	2.34E+13	1.67E+13	2.5E+12	5.93E+11	0	0
March	-5.3E+13	-3.8E+13	-5.7E+12	-5.3E+13	-3.8E+13	-5.7E+12	-4.8E+13	-3.5E+13	-5.2E+12	-3.2E+14	-2.3E+14	-3.5E+13	6.51E+11	0	0
April	-1.3E+14	-9.1E+13	-1.4E+13	-1.1E+14	-7.8E+13	-1.2E+13	-1E+14	-7.2E+13	-1.1E+13	-6.9E+14	-4.9E+14	-7.4E+13	6.3E+11	0	0
May	-2.7E+14	-1.9E+14	-2.9E+13	-2.3E+14	-1.7E+14	-2.5E+13	-2.1E+14	-1.5E+14	-2.3E+13	-1.5E+15	-1.1E+15	-1.6E+14	6.51E+11	0	0
June	-8.1E+14	-5.8E+14	-8.7E+13	-6.9E+14	-4.9E+14	-7.4E+13	-6.3E+14	-4.5E+14	-6.8E+13	-4.6E+15	-3.3E+15	-4.9E+14	6.3E+11	0	0
July	-8.3E+14	-6E+14	-8.9E+13	-7.2E+14	-5.1E+14	-7.7E+13	-6.5E+14	-4.7E+14	-7E+13	-4.9E+15	-3.5E+15	-5.2E+14	6.51E+11	0	0
August	-8.3E+14	-6E+14	-8.9E+13	-7.2E+14	-5.1E+14	-7.7E+13	-6.5E+14	-4.7E+14	-7E+13	-5E+15	-3.6E+15	-5.4E+14	6.51E+11	0	0
eptember	-2.6E+14	-1.9E+14	-2.8E+13	-2.3E+14	-1.6E+14	-2.4E+13	-2.1E+14	-1.5E+14	-2.2E+13	-1.6E+15	-1.2E+15	-1.7E+14	6.3E+11	0	0
October	-1.3E+14	-9.4E+13	-1.4E+13	-1.1E+14	-8.1E+13	-1.2E+13	-1E+14	-7.4E+13	-1.1E+13	-5E+14	-3.6E+14	-5.3E+13	6.51E+11	0	0
November	-5.1E+13	-3.7E+13	-5.5E+12	-5.1E+13	-3.7E+13	-5.5E+12	-4.7E+13	-3.4E+13	-5E+12	-2.4E+14	-1.7E+14	-2.5E+13	6.3E+11	0	0
December	3E+12	2.14E+12	3.21E+11	4.32E+12	3.08E+12	4.63E+11	3.95E+12	2.82E+12	4.23E+11	2.09E+13	1.49E+13	2.24E+12	6.51E+11	0	0

Sheep			Deer			Raccoons			Muskrats			Beavers		
1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
9.85E+13	9.38E+13	0	4.99E+11	7.13E+11	2.14E+11	0	0	0	4.07E+10	5.81E+10	1.74E+10	0	0	0
8.98E+13	8.55E+13	0	4.55E+11	6.5E+11	1.95E+11	0	0	0	3.71E+10	5.3E+10	1.59E+10	0	0	0
9.85E+13	9.38E+13	0	4.99E+11	7.13E+11	2.14E+11	0	0	0	4.07E+10	5.81E+10	1.74E+10	0	0	0
9.53E+13	9.08E+13	0	4.83E+11	6.9E+11	2.07E+11	0	0	0	3.94E+10	5.63E+10	1.69E+10	0	0	0
9.85E+13	9.38E+13	0	4.99E+11	7.13E+11	2.14E+11	0	0	0	4.07E+10	5.81E+10	1.74E+10	0	0	0
9.53E+13	9.08E+13	0	4.83E+11	6.9E+11	2.07E+11	0	0	0	3.94E+10	5.63E+10	1.69E+10	0	0	0
9.85E+13	9.38E+13	0	4.99E+11	7.13E+11	2.14E+11	0	0	0	4.07E+10	5.81E+10	1.74E+10	0	0	0
9.85E+13	9.38E+13	0	4.99E+11	7.13E+11	2.14E+11	0	0	0	4.07E+10	5.81E+10	1.74E+10	0	0	0
9.53E+13	9.08E+13	0	4.83E+11	6.9E+11	2.07E+11	0	0	0	3.94E+10	5.63E+10	1.69E+10	0	0	0
9.85E+13	9.38E+13	0	4.99E+11	7.13E+11	2.14E+11	0	0	0	4.07E+10	5.81E+10	1.74E+10	0	0	0
9.53E+13	9.08E+13	0	4.83E+11	6.9E+11	2.07E+11	0	0	0	3.94E+10	5.63E+10	1.69E+10	0	0	0
9.85E+13	9.38E+13	0	4.99E+11	7.13E+11	2.14E+11	0	0	0	4.07E+10	5.8				0

Geese			Wild Turkeys			Ducks			Total		
1	2	3	1	2	3	1	2	3	1	2	3
0	0	0	2.21E+11	3.16E+11	9.47E+10	0	0	0	1.33E+14	1.19E+14	3.87E+12
0	0	0	2.01E+11	2.88E+11	8.63E+10	0	0	0	1.25E+14	1.11E+14	3.9E+12
0	0	0	2.21E+11	3.16E+11	9.47E+10	0	0	0	-3.8E+14	-2.5E+14	-5.1E+13
0	0	0	2.14E+11	3.06E+11	9.17E+10	0	0	0	-9.3E+14	-6.4E+14	-1.1E+14
0	0	0	2.21E+11	3.16E+11	9.47E+10	0	0	0	-2.1E+15	-1.5E+15	-2.4E+14
0	0	0	2.14E+11	3.06E+11	9.17E+10	0	0	0	-6.6E+15	-4.7E+15	-7.2E+14
0	0	0	2.21E+11	3.16E+11	9.47E+10	0	0	0	-7E+15	-5E+15	-7.6E+14
0	0	0	2.21E+11	3.16E+11	9.47E+10	0	0	0	-7.1E+15	-5.1E+15	-7.7E+14
0	0	0	2.14E+11	3.06E+11	9.17E+10	0	0	0	-2.2E+15	-1.6E+15	-2.5E+14
0	0	0	2.21E+11	3.16E+11	9.47E+10	0	0	0	-7.5E+14	-5.1E+14	-9E+13
0	0	0	2.14E+11	3.06E+11	9.17E+10	0	0	0	-2.9E+14	-1.8E+14	-4.1E+13
0	0	0	2.21E+11	3.16E+11	9.47E+10	0	0	0	1.32E+14	1.18E+14	3.77E+12

LRWF

Month	Rural Pets	Urban Pets	Failed Septic Systems	Total
January	6.98E+12	8.37E+12	2.46E+13	3.99E+13
February	6.36E+12	7.63E+12	2.24E+13	3.64E+13
March	6.98E+12	8.37E+12	2.46E+13	3.99E+13
April	6.75E+12	8.1E+12	2.38E+13	3.86E+13
May	6.98E+12	8.37E+12	2.46E+13	3.99E+13
June	6.75E+12	8.1E+12	2.38E+13	3.86E+13
July	6.98E+12	8.37E+12	2.46E+13	3.99E+13
August	6.98E+12	8.37E+12	2.46E+13	3.99E+13
Septembe	6.75E+12	8.1E+12	2.38E+13	3.86E+13
October	6.98E+12	8.37E+12	2.46E+13	3.99E+13
Novembe	6.75E+12	8.1E+12	2.38E+13	3.86E+13
Decembe	6.98E+12	8.37E+12	2.46E+13	3.99E+13

Comparison of Two Techniques

- The developed geo-spatial model easily (an automated process) calculated the bacteria load from non-point source on grid basis
- Virginia Tech's FCLC Workbook compiled the point source FC load results, based on different land uses (Forest, pasture, stream); but as such non-point source FC load was not calculated
- For the FCLC workbook, there was additional GIS processing was required and the result was for either the entire watershed or subwatersheds
- However, the geospatial FC model calculated FC load on 900 sq. m. grid basis
- The results of the load calculation were pretty close with both techniques

Conclusions

- The results obtained indicate an improvement in the area of restoration (subwatershed 8) and also indicate a greater quantity of fecal runoff in urban areas
- The Fecal coliform calculator software from Virginia Polytechnic is a tool for evaluating fecal coliform runoff and determining which sources contribute the most
- As a future project, another geospatial model for spatial calculation of fecal coliform load from point sources is being developed

Acknowledgements

- Fecal Coliform Workbook - Virginia Polytechnic
- ArcGIS 9.2 and the ModelBuilder
- AVSWAT

QUESTIONS??

Please refer to Dr. Sudhanshu Panda @ spanda@gsc.edu