

Evaluating the impact of implemented BMPs in Richard Chambers Watershed of Texas

SWAT model setup and calibration

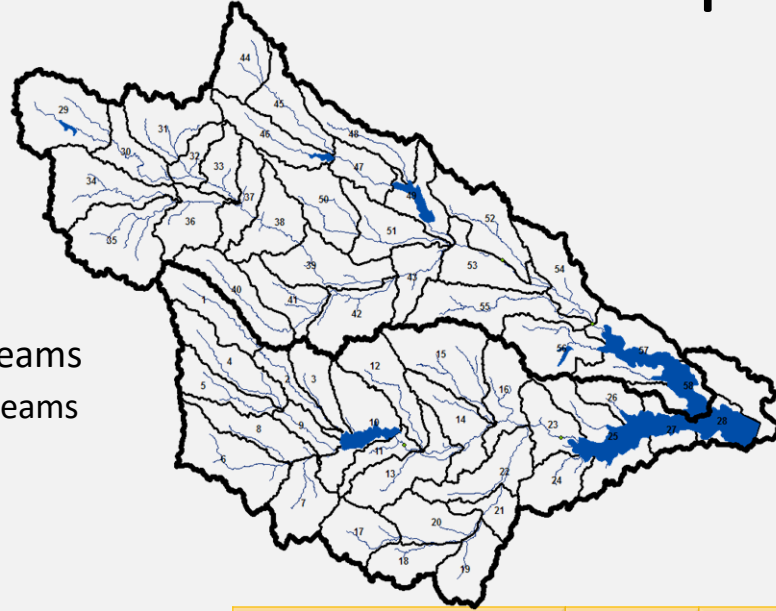


Prasad Daggupati
Raghavan Srinivasan

Outline

- Detailed Inputs used in model
 - Basic inputs
 - Land management
 - Ponds and reservoirs
- Calibration – Flow, sediment & Nutrients
- Results
- Future plans

Data inputs and SWAT model setup



- ArcSWAT 2012 interface used
 - Rev 565 (latest)
- Watershed characterization
 - Predefined Subwatersheds and streams
 - 30m DEM, 12 digit HUCs, NHD streams
 - Total of 58 subbasins
- Landuse landcover
 - 30m Landuse land cover
 - NLCD and NASS combined

- Soils
 - SSURGO soils
 - 1:24,000-scale
 - 282 soil varieties

% Water.Area	Name	HYDGRP
5.19	Houston Black Soil	D
4.74	Crockett	D
3.91	Houston Black	D
3.68	DUMMY	D
3.04	Houston Black	D

- HRU's
 - 2672 (including BMPs: Discussed later)

LANDUSE	SWAT Code	Area [ha]	Area[acres]	%Wat.Area
Range-Grasses	RNGE	154222	381090	30.37
Pasture	PAST	121564	300392	23.94
Forest-Deciduous	FRSD	54965	135822	10.82
Residential-Low Density	URLD	30953	76487	6.1
Winter Wheat	WWHT	26437	65327	5.21
Corn	CORN	26199	64739	5.16
Water	WATR	24264	59958	4.78
Grain Sorghum	GRSG	23640	58415	4.66
Hay	HAY	11720	28960	2.31
Upland Cotton-harvested with	COTS	9437	23321	1.86
Sunflower	SUNF	5878	14525	1.16
Residential-Medium Density	URMD	4919	12154	0.97
Wetlands-Mixed	WETL	4849	11982	0.95
Oats	OATS	3377	8345	0.67
Range-Brush	RNGB	2689	6644	0.53
Forest-Evergreen	FRSE	1425	3521	0.28
Agricultural Land-Row Crops	AGRR	1254	3099	0.25

- Ponds

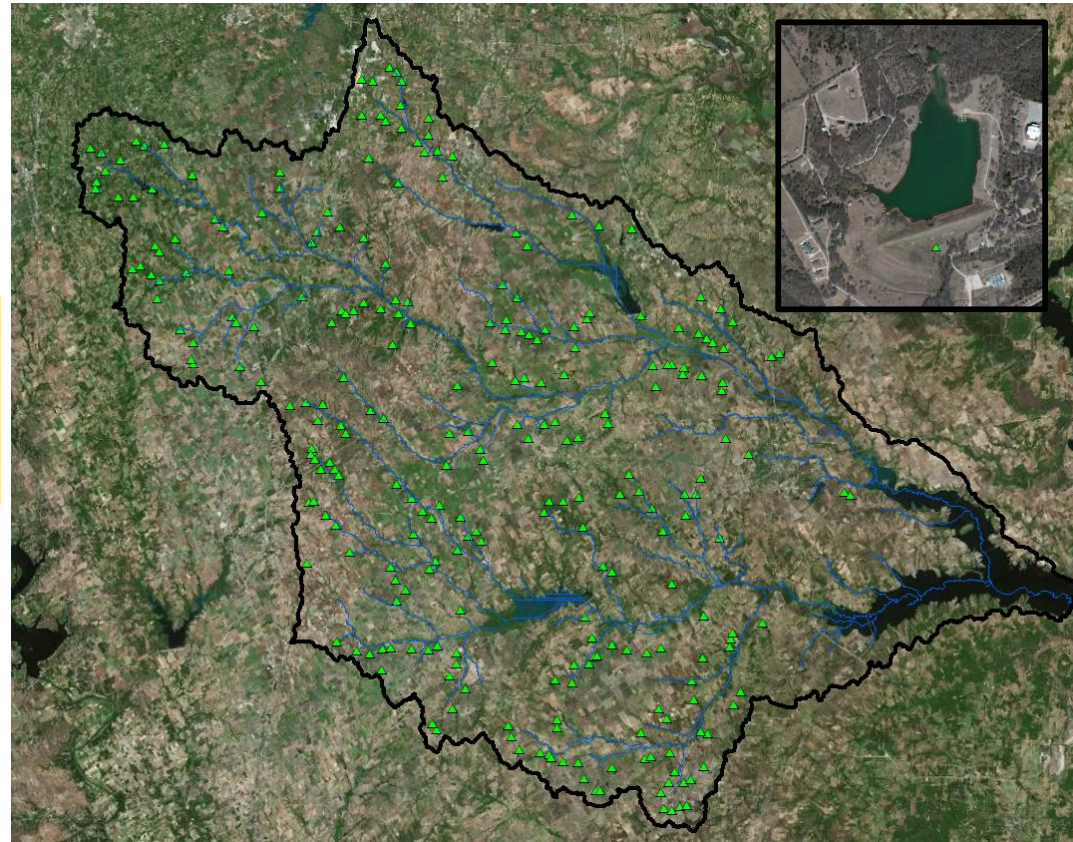
- 263 Ponds

- NRCS

- Surface area (P and E)
 - Volume (P and E)

Decade	No of ponds	Percent
50's	33	13%
60's	152	58%
70's	70	27%
80's	8	3%

County	No of ponds	% ponds
Ellis	76	29%
Hill	61	23%
Johnson	26	10%
Limestone	22	8%
Navarro	78	30%

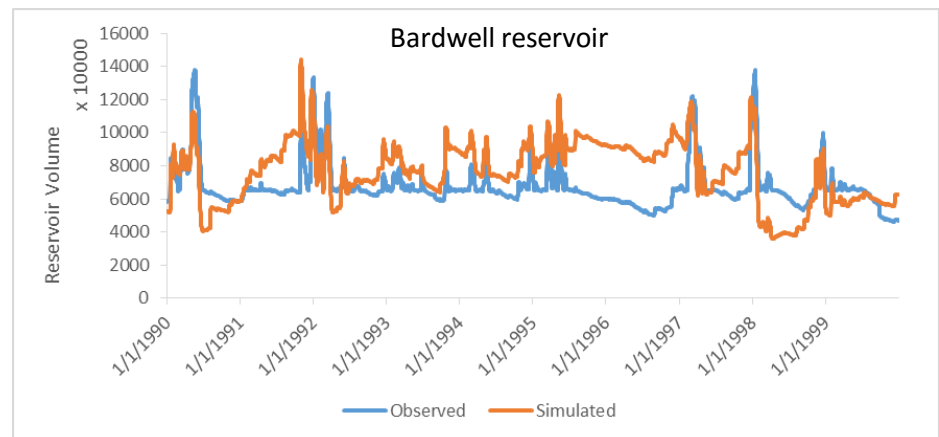


- 2 Reservoirs

- Bardwell (1965)

- Navarro mills (1963)

- Surface area (P and E)
 - Volume (P and E)



- Best Management Practices

Watershed information	Area (ha)	%
Total Subbasin	507792.21	
Total BMPs applied	102008.23	20%
Total BMP area modeled	97432.53	19%

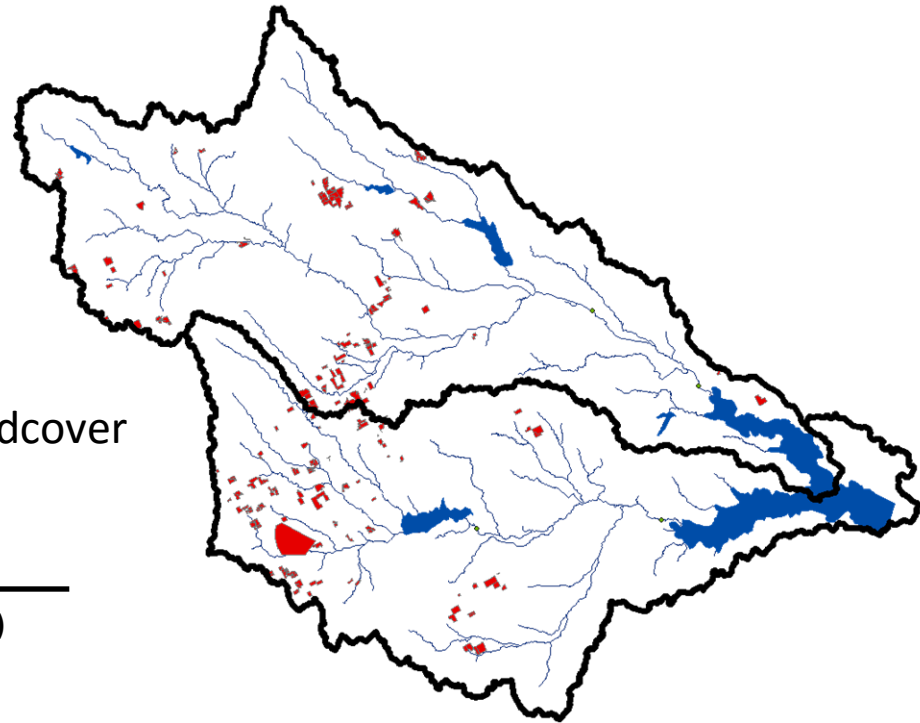
- Structural BMPs (only in cropland)

- Merged structural BMPs with landuse-landcover

- Assigned new SWAT landuse code

- Eg. AGCF – contour farming

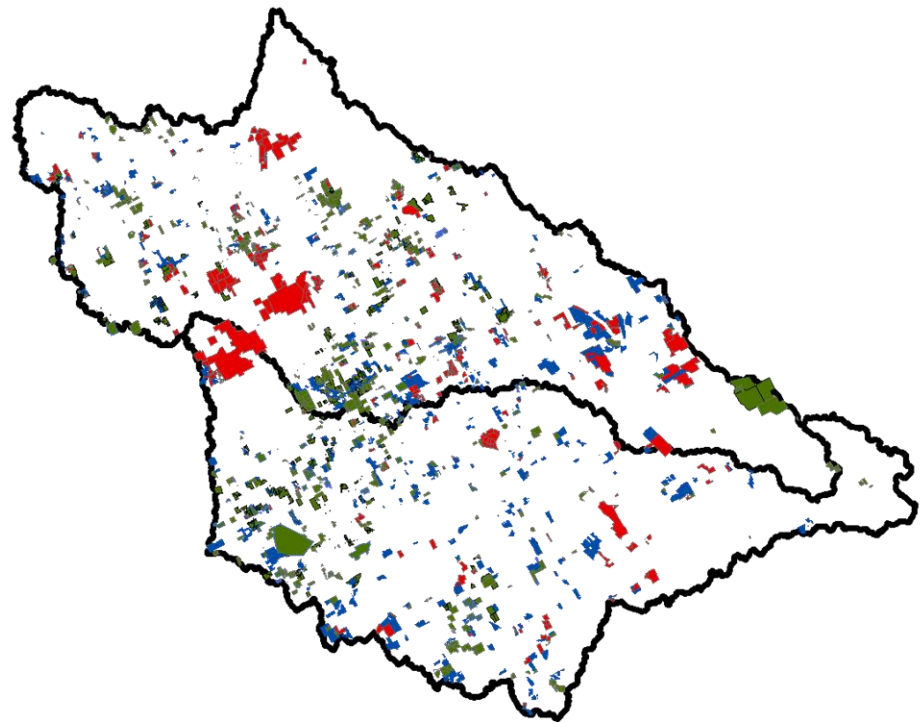
SWAT code	Total Sturctural BMPs	Area (ha)
AGCF	Contour farming	754
AGFS	Filter strips	1342
AGGW	Grassed Waterways	1528
AGTR	Terraces	1024
ATCF	Terraces with contour	850
ATGW	Terraces with grassedwater	1269
	Total practices	6767
	% in watershed	1%



- Non-Structural BMPs

- Data available for each field parcel
 - Multiple Practices and years

RC_Pract_6	RC_Pract_7	RC_Pract_8
2003	595	Integrated Pest Management (IPM)
2003	590	Nutrient Management
2003	328	Conservation Crop Rotation
2003	344	Residue Management, Seasonal
2004	344	Residue Management, Seasonal
2004	590	Nutrient Management
2004	595	Integrated Pest Management (IPM)
2004	328	Conservation Crop Rotation
2004	590	Nutrient Management
2004	645	Upland Wildlife Habitat Management
2008	645	Upland Wildlife Habitat Management
2008	512	Forage and Biomass Planting
2008	595	Integrated Pest Management (IPM)
2008	590	Nutrient Management
2009	511	Forage Harvest Management
2011	511	Forage Harvest Management



- Combined multiple practices in each field for each landuse (range, pasture and cropland)
 - Assumption: Start year of practice is same (2003 onwards)
- Selected most dominant BMP combinations in each landuse
 - Eg. Residue Management (RM)+ Conservation Crop rotation(CCR)
 - Eg. RM+CCR+NM+IPM
- Post processing in GIS to create BMP combinations in each landuse as additional HRU's in SWAT model
 - Each selected BMP combination for each landuse was converted to shapefiles
 - Zonal Stats was used to determine following for each BMP combination in each landuse within each Subbasin
 - Fraction of area, dominant soil, slope etc – SWAT parameters in database
 - Updated HRU, sol, septic, mgt1&2 tables in database
 - **Total HRU's = 2672**
 - **Cropland: 179 HRU's; Pasture: 158; Range: 124**

- Non Structural BMPs analysis

	Cropland (ha)	Pasture (ha)	Rangeland (ha)
BMP applied	43107.09	24228.43	27905.72
BMP simulated	40536.06	23199.97	26929.50
% BMP simulated	94%	96%	97%

Cropland

SWAT code	Practice	Area (ha)	%Cropland BMP	% Watershed
AG11	RM+CCR+NM+IPM	16074.46	37.3%	3.2%
AG22	CCR+NM	1818.69	4.2%	0.4%
AG33	RM+CCR	10273.26	23.8%	2.0%
AG44	NM	7577.03	17.6%	1.5%
AG55	CCR	4792.59	11.1%	0.9%

Pasture

SWAT code	Practice	Area (ha)	% Pasture BMP	% Watershed
PS11	PG+BM+NM	1649.76	6.8%	0.3%
PS22	PG+NM	11621.86	48.0%	2.3%
PS33	PG+BM	1428.45	5.9%	0.3%
PS44	PG	8499.87	35.1%	1.7%

Range

SWAT code	Practice	Area (ha)	% Rangeland BMP	% Watershed
RG11	PG+BM+NM	17287.61	62.0%	3.4%
RG22	PG+NM	3445.20	12.3%	0.7%
RG33	PG+BM	5966.97	21.4%	1.2%
RG44	PG	229.71	0.8%	0.0%

- Land Management

- Cropland

- Corn
- Sorghum
- Winter wheat
- Cotton
- Sunflower

Crop	Simulated yield (t/ha)	Observed yield (t/ha)
Corn	6.79	6 (100bushels)
Sorghum	3.66	4.2 (70 bushels)
Wheat	3.05	3 (50bushels)
Cotton	0.8	0.56 (1bale per ac)
Sunflower	2.04	3.6 (60 bushels)

- Pasture and Rangeland

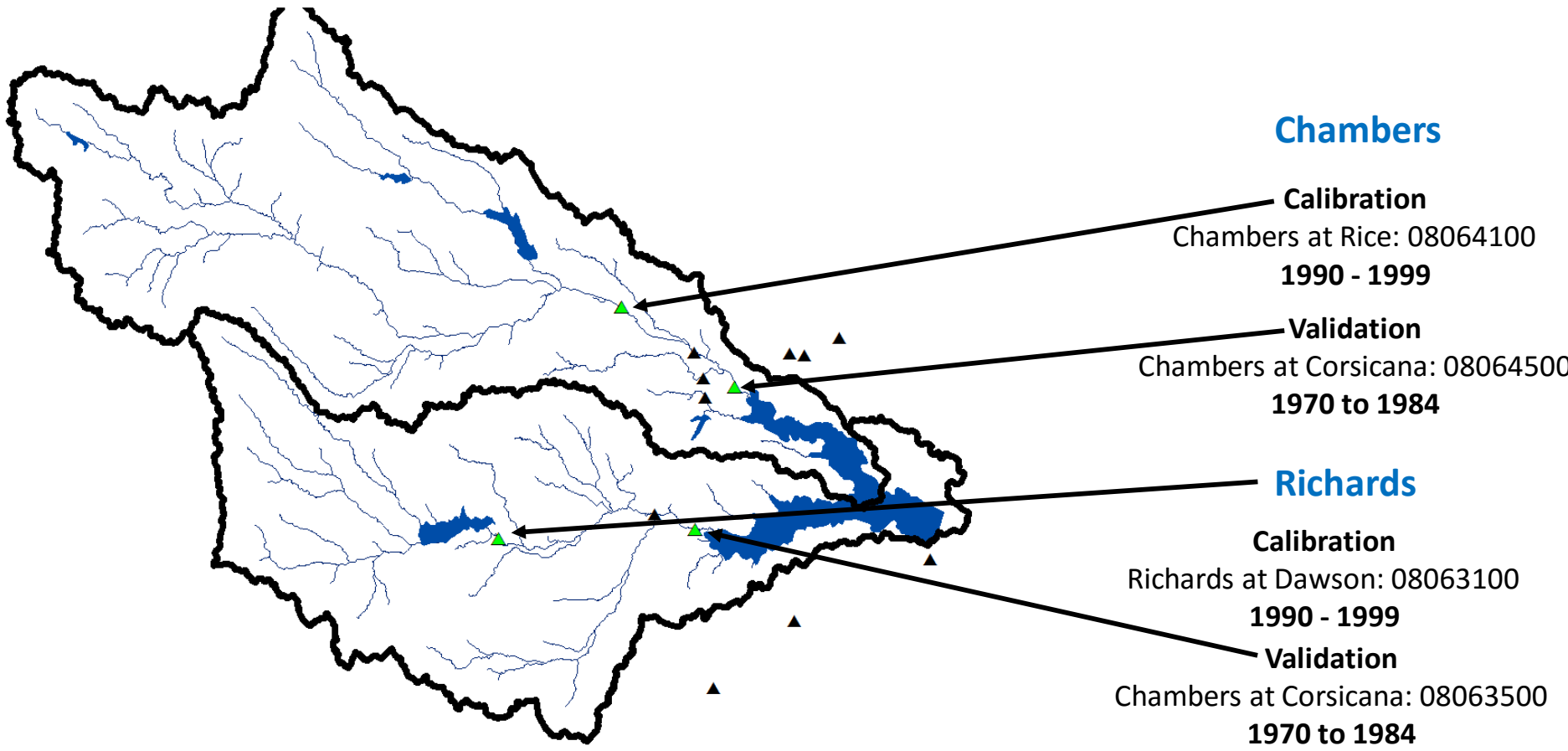
- Pasture –
 - plant species in SWAT: Coastal Bermuda grass
 - Grazing: 1 cow in 5 acres => eats 12 kg/day; grazing 250 days (starting Feb 15)
 - Fertilizer application in January
 - Biomass simulated: 1200 kg/ha
- Rangeland –
 - plant species in SWAT: Range Grasses
 - Grazing: 1 cow in 12 acres => eats 12 kg/day; grazing 250 days (starting Feb 15)
 - Biomass simulated: 1500 kg/ha

Corn and Grain Sorghum				
Year	Date	Operation	Info	lbs/ac
1	1-Feb	Tillage	Field Cultivator Ge15ft	
1	1-Mar	Fertilizer	Elemental Nitrogen and P	50N 50P
1	1-Mar	Plant	Corn	
1	15-Apr	Fertilizer	Elemental Nitrogen	50
1	15-Aug	Harvest and Kill		
1	20-Aug	Tillage	Tandem Disk Plw Ge19ft	
1	1-Sep	Tillage	Tandem Disk Plw Ge19ft	
1	20-Nov	Tillage	Field Cultivator Ge15ft	
1	30-Feb	Tillage	Field Cultivator Ge15ft	
1	15-Mar	Fertilizer	Elemental Nitrogen	56
1	1-Apr	Plant	Grain Sorghum	
1	15-Feb	Fertilizer	Elemental Phosphorus	35
1	1-Aug	Harvest and Kill		
1	15-Aug	Tillage	Tandem Disk Plw Ge19ft	
1	15-Sep	Tillage	Tandem Disk Plw Ge19ft	
1	20-Nov	Tillage	Field Cultivator Ge15ft	

Calibration

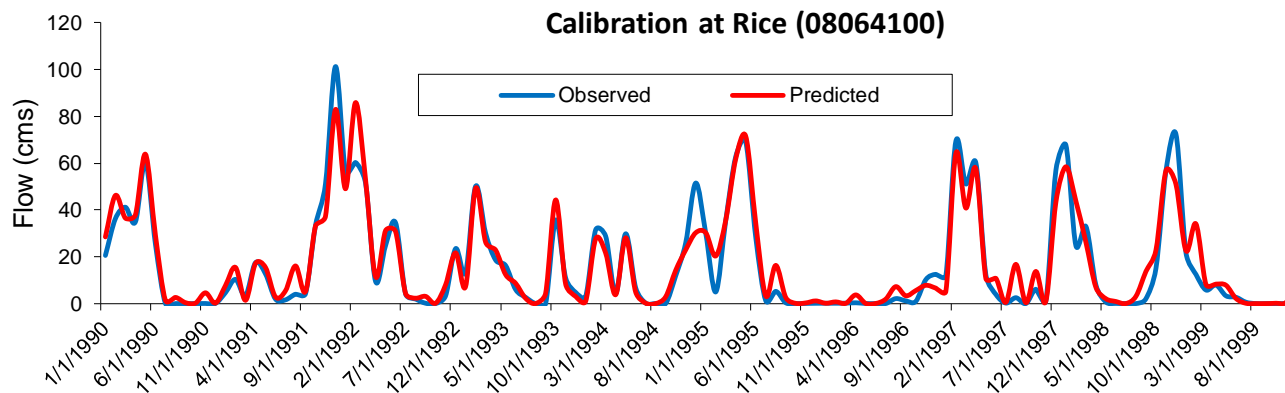
- Flow

- Monthly and daily simulated and observed flow compared using statistics
 - NSE, PBIAS
- Manual calibration of parameters to capture overall hydrology in watershed
- SWATCUP used to automate further calibration
 - SUFI2 Algorithm



- Flow calibration results

Stream	Calibration/Validation	Time period	Time step	R2	NSE	Pbias
Chambers	Calibration at 08064100	1990-1999	Daily	0.71	0.68	-4.83
			Monthly	0.91	0.90	-5.18
	Validation at 08064500	1970 -1984	Daily	0.56	0.49	-11.73
			Monthly	0.89	0.88	-11.98
Richland	Calibration at 08063100	1990-1999	Daily	0.89	0.86	-22.13
			Monthly	0.92	0.86	-21.96
	Validation at 08063500	1970 -1984	Daily	0.60	0.57	2.28
			Monthly	0.91	0.91	2.29



- Flow was also cross validated at inflows into Bardwell and Navarro lakes
 - Inflows computed by <http://waterdatafortexas.org/>

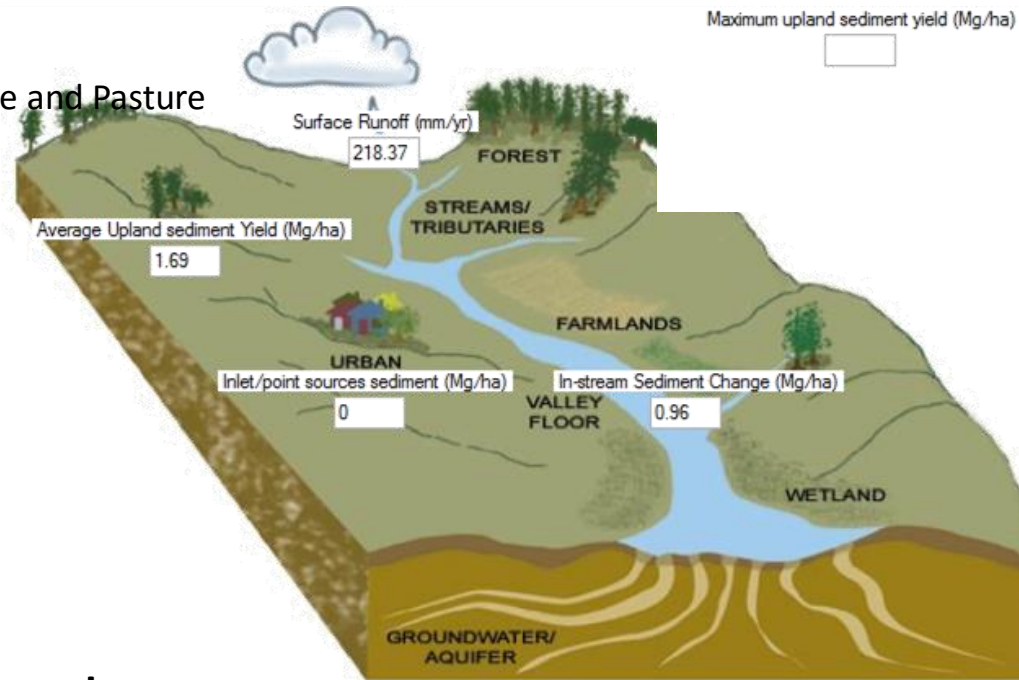
	Time period	Time step	R2	NSE	Pbias
Bardwell inflow	1990-1999	Daily	0.65	0.62	5.10
		Monthly	0.78	0.78	4.78
Navarromills inflow	1990-1999	Daily	0.73	0.72	0.31
		Monthly	0.81	0.81	-0.13

- Sediment

- Observed sediment data from daily grab sample (mg/L) converted to monthly loads (tons) using Loadest program (USGS)
 - Chambers @ FM 3041
 - Richland @ SW0030 RD
- Monthly simulated and observed sediment (Loadest estimate) compared using statistics
 - Rsqr, NSE, PBIAS
- Overland sediment calibration
 - BIO_MIN and BIO_TRMP adjusted in Range and Pasture
 - No major adjustments in cropland

Average annual values

LULC	AREA km2	SED th	NO3 kgh
OATS	6.40	6.63	1.68
GRSG	119.50	6.15	0.53
CORN	617.88	5.97	0.85
SUNF	49.02	3.03	0.42
COTP	45.50	2.91	0.73
BERM	335.95	2.63	5.81
WWHT	133.77	1.17	0.25
RNRC	1,548.80	0.99	0.12
BERP	1,189.42	0.93	0.32



- Stream bank erosion is a major component

- Cedar creek study showed 30% of stream bank erosion
- Changed channel parameters to reflect 30% erosion
 - SPCON, SPEX, Channel cover

Sediment Budget

Upland Sediment Yield (Mg/ha)

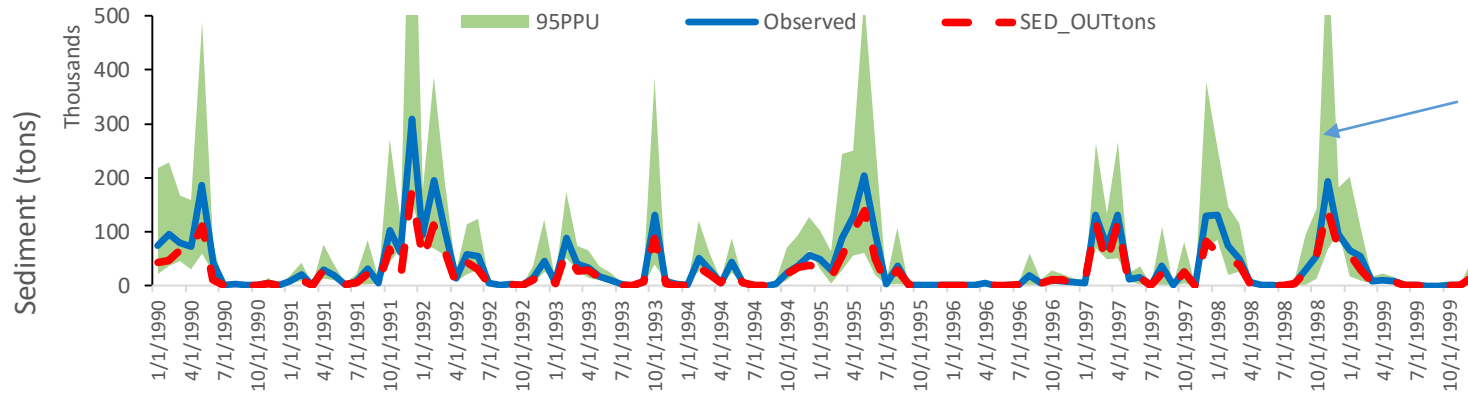
Instream Sediment Change (Mg/ha)

Channel Erosion (%)

Channel Deposition (%)

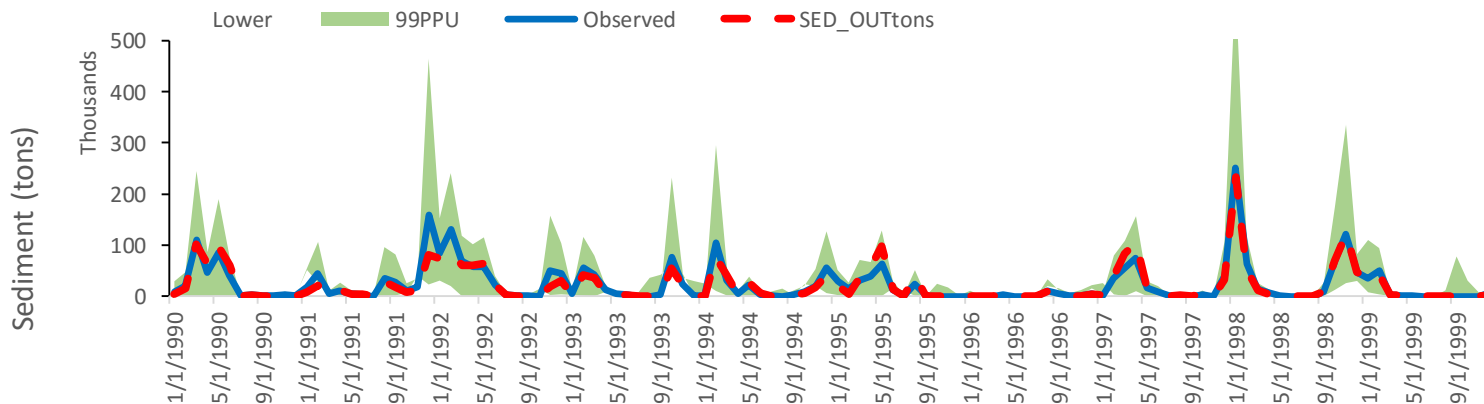
- Sediment results

Chambers @ FM 3041							
Monthly Output	Average		Standard Deviation		Statistics		
	Measured	Simulated	Measured	Simulated	R ²	PBIAS (%)	NSE
Sediment (tons)	36373.3	24838.5	53359.8	35637.1	0.95	32	0.81



Uncertainty band
Upper and lower
bound (95%) in
Loadest program

Richland @ SW030 RD							
Monthly Output	Average		Standard Deviation		Statistics		
	Measured	Simulated	Measured	Simulated	R ²	PBIAS (%)	NSE
Sediment (tons)	23506.6	21767.3	37543.7	34227.8	0.91	7	0.90



Nutrients

- Observed Nutrient (Total Nitrogen and Phosphorus)

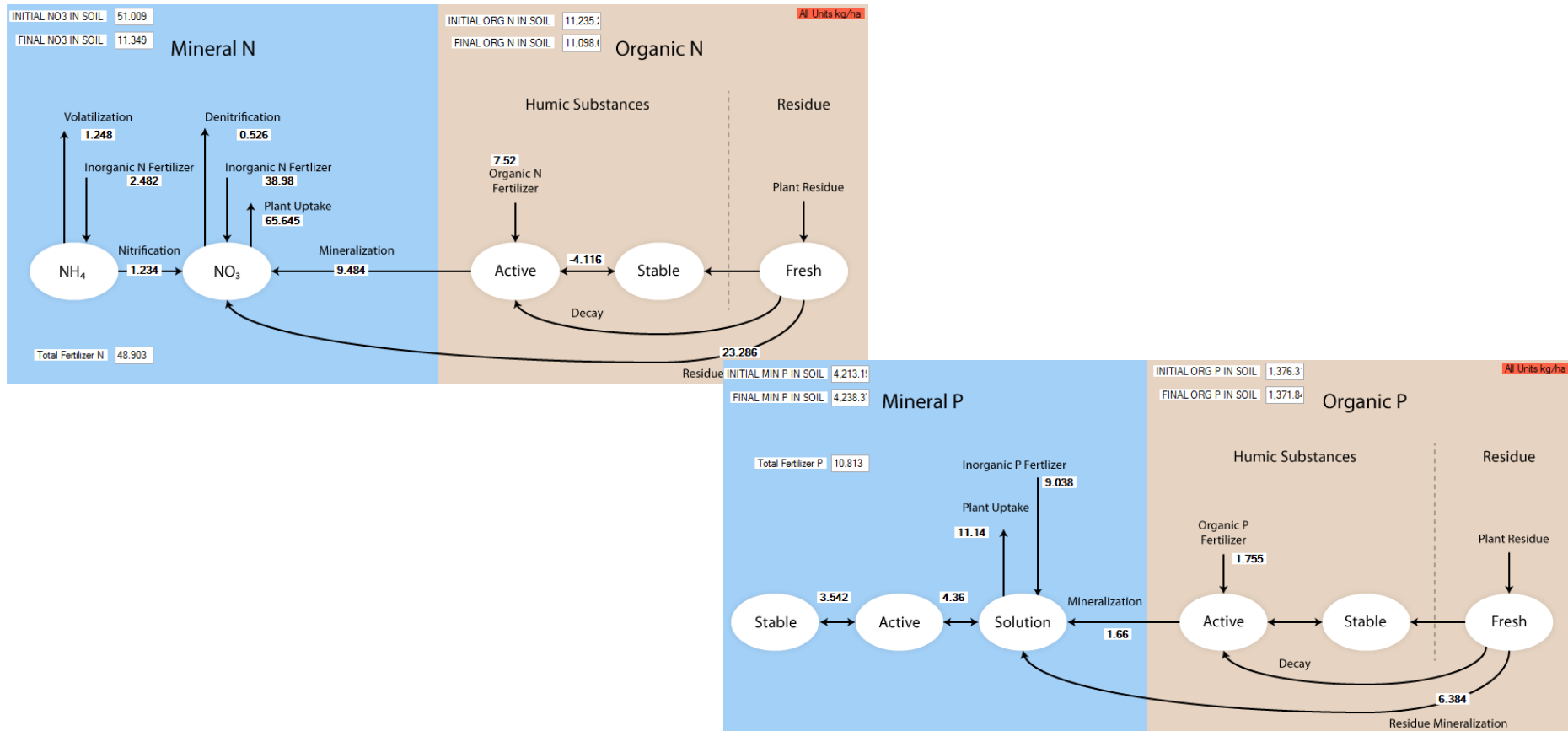
- data from daily grab sample (mg/L) converted to monthly loads (tons) using Loadest program (USGS)
 - Chambers @ FM 3041
 - Richland @ SW0030 RD

- Monthly simulated and observed nutrients (Loadest estimate) compared using statistics

- Rsq, NSE, PBIAS

- Overland nutrient calibration

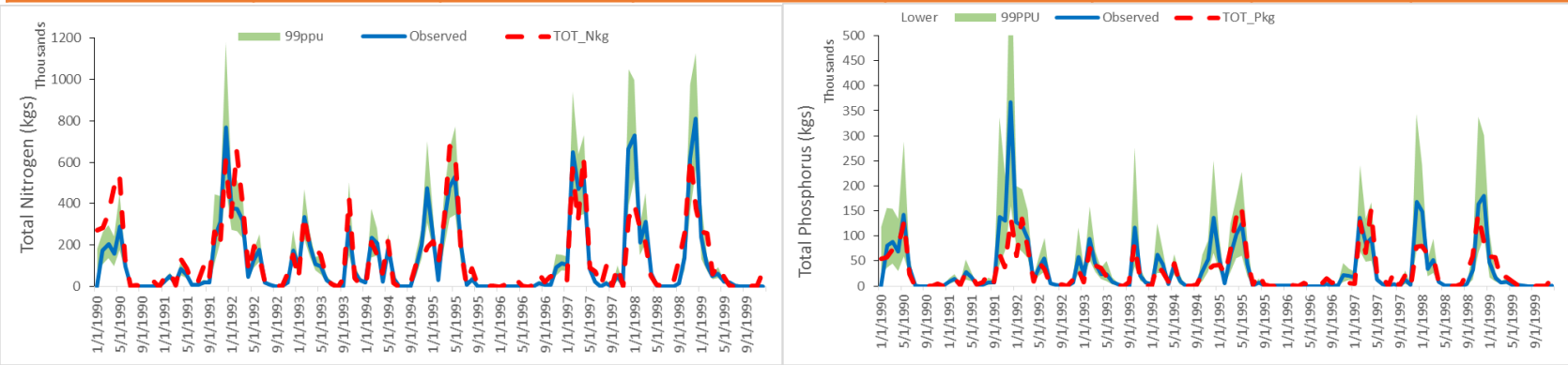
- RCN, PPERCO, NPERCO in bsn file
- ERGOGN, EROGP in hru file



- Nutrients results

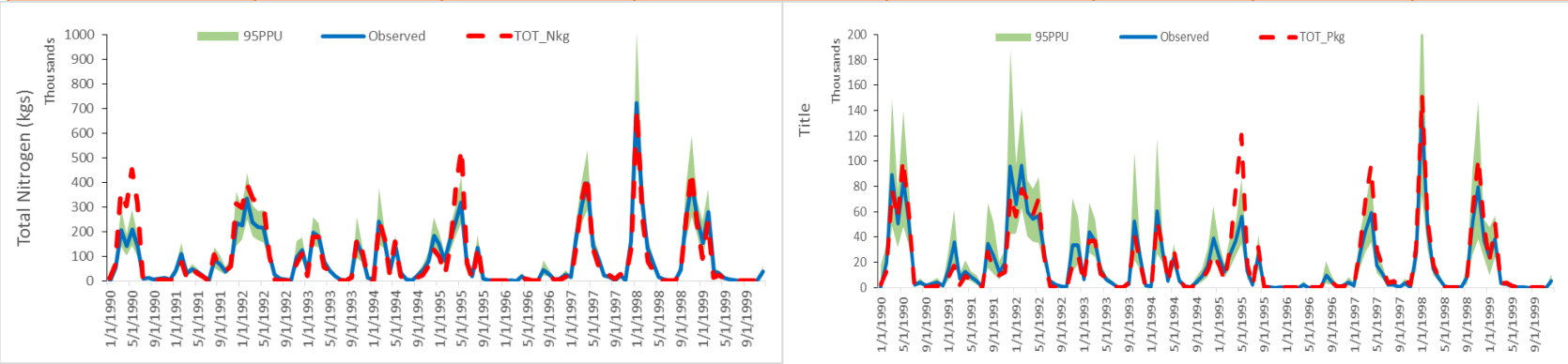
Chambers @ FM 3041

Monthly Output	Average		Standard Deviation		Statistics		
	Measured	Simulated	Measured	Simulated	R ²	PBIAS (%)	NSE
Total Nitrogen (Kgs)	125356.9	135304.3	185444.4	173820.4	0.73	-8	0.72
Total Phosphorus (Kgs)	34238.6	29245.8	55127.7	38210.8	0.68	15	0.65



Richland @ SW0030 RD

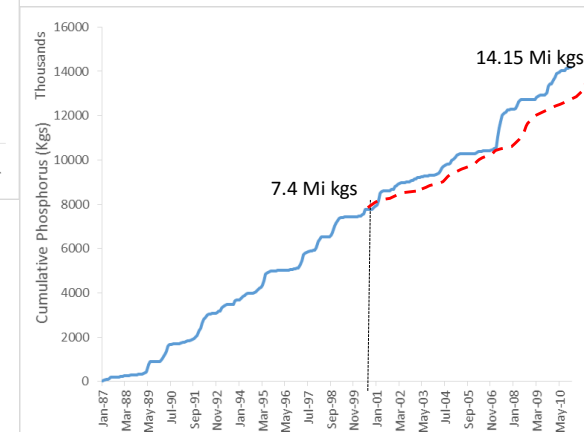
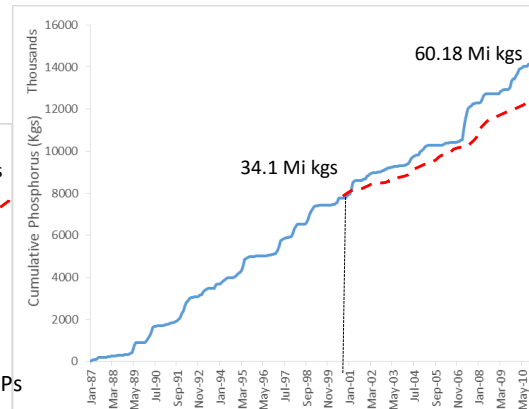
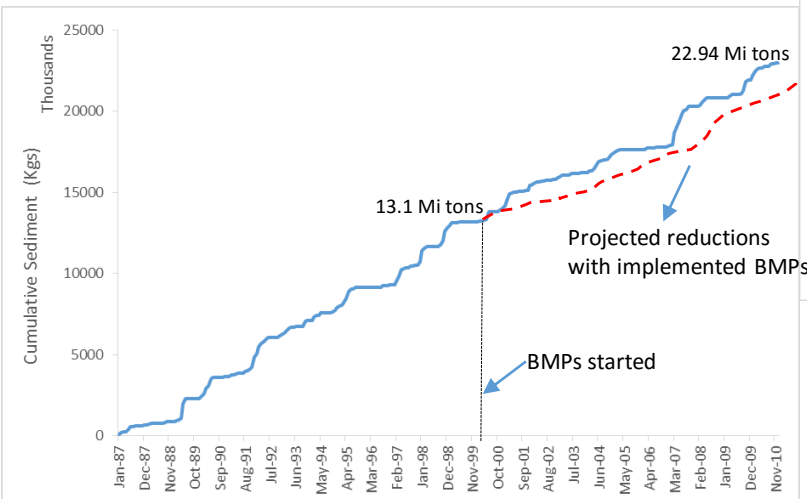
Monthly Output	Average		Standard Deviation		Statistics		
	Measured	Simulated	Measured	Simulated	R ²	PBIAS (%)	NSE
Total Nitrogen (Kgs)	87582.6	92633.3	113949.5	136332.5	0.88	-6	0.81
Total Phosphorus (Kgs)	19124.2	19998.6	25704.2	29413.9	0.88	-5	0.84



Reservoirs

Reservoir	% Trapped			Evaporation (%)
	Sediment	Phosphorus	Nitrogen	
Navarromills	90.48	45.13	34.17	3.8
Bardwell	89.79	53.14	42	3.2

- Richland Chambers reservoir (1987 impoundment)
 - Sediment survey report (The Texas Water Development Board)
 - 2007 -- **43,361 acre-feet of sediment** since impoundment in 1987
 - 22.2 Million tons** of sediment with specific wt of **26 lb/ft3**
 - SWAT model simulated is **20.81 Million tons**
 - Roughly 10 Million tons every year



Next steps

- Fine tune model further based on stream erosion data
- Implement management practices
 - Need information on practices
 - What do they do for each practice
- Evaluate the effective of BMPs
 - Reduction in overland
 - Reduction in amount entering RC reservoir

Thanks