Demonstrating Success

in the

Beaty Creek Watershed

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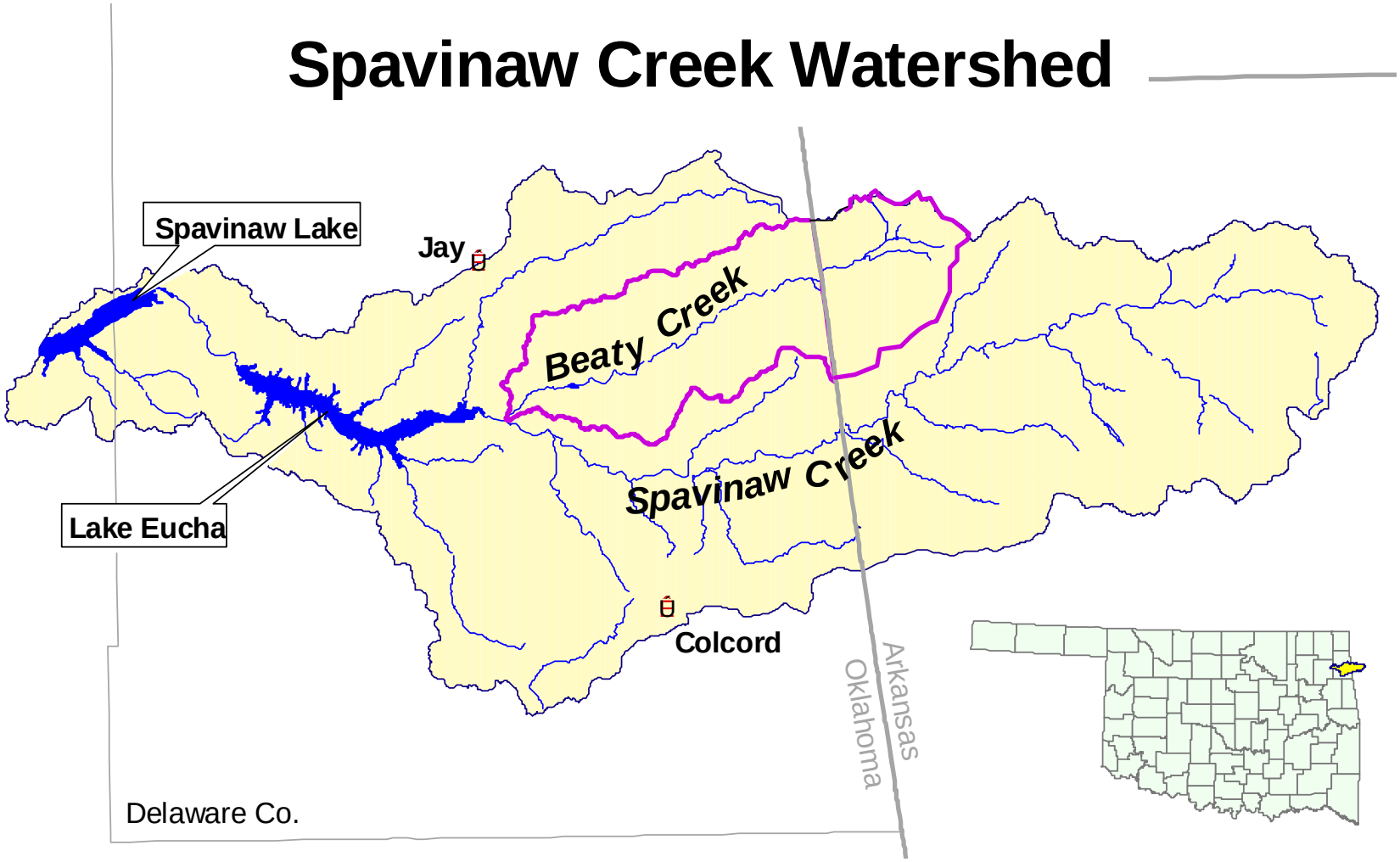
Spavinaw Creek Watershed



Spavinaw watershed = 230,000 acres
Beaty watershed = 38,000 acres

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Background

- **1990s:** algae blooms and taste/odor issues in Lakes Eucha and Spavinaw

(water supply for City of Tulsa metro area)

- **1997:** Clean Lakes Study determines that excessive phosphorus loading to Lake Eucha is primary cause of problems

Primary phosphorus sources include:

1) agricultural practices associated with poultry and cattle
2) discharge from WWTP in Decatur, AR (includes poultry processing wastes)

Background, continued

- **1998:** OCC begins a 319 demonstration project in the Beaty Creek watershed (in OK and AR) to assess the potential to improve water quality through best management practices (BMPs)

- **2003:** OCC expands 319 project to encompass the entire Oklahoma portion of the Spavinaw watershed

Background, continued

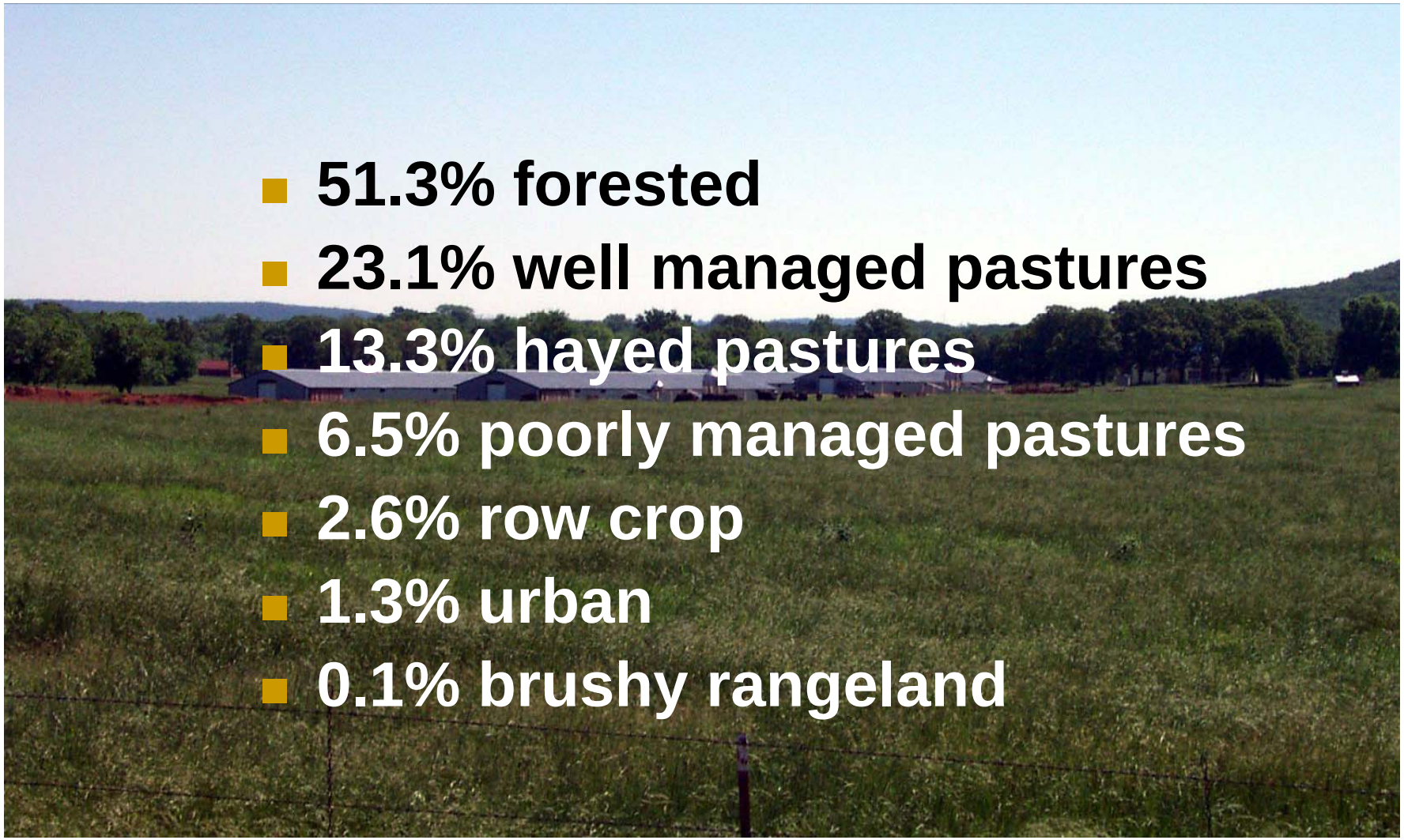
- **2009:** TMDL by Oklahoma DEQ

  Recommendations to achieve acceptable water quality conditions (TSI=62 or less) in Lake Eucha:

  - ***95% reduction in phosphorus loading***

  Since 2006, 80% reduction in phosphorus discharge from Decatur, AR WWTP (1.0 mg/L limit)—this has reduced point source loading

Land use in the watershed:



- 51.3% forested
- 23.1% well managed pastures
- 13.3% hayed pastures
- 6.5% poorly managed pastures
- 2.6% row crop
- 1.3% urban
- 0.1% brushy rangeland

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Agricultural activities appear to be the major NPS sources of impact

- Significant poultry production
  - Capacity to produce 77 million birds annually; > 73,000 tons of litter produced annually
- Strong beef cattle production; dairy and hog farms also present

- Poor/nonexistent riparian areas
  - Removal of vegetation and uncontrolled livestock access
  - Significant streambank erosion and habitat loss

Current Status of Waterbodies [303(d) list]

- **Beaty Creek** – designated "High Quality Water"
  - Pathogens impairment in 2000
  - *Enterococcus* and *E. coli* impairment in 2004
  - Delisted for *E. coli* in 2006

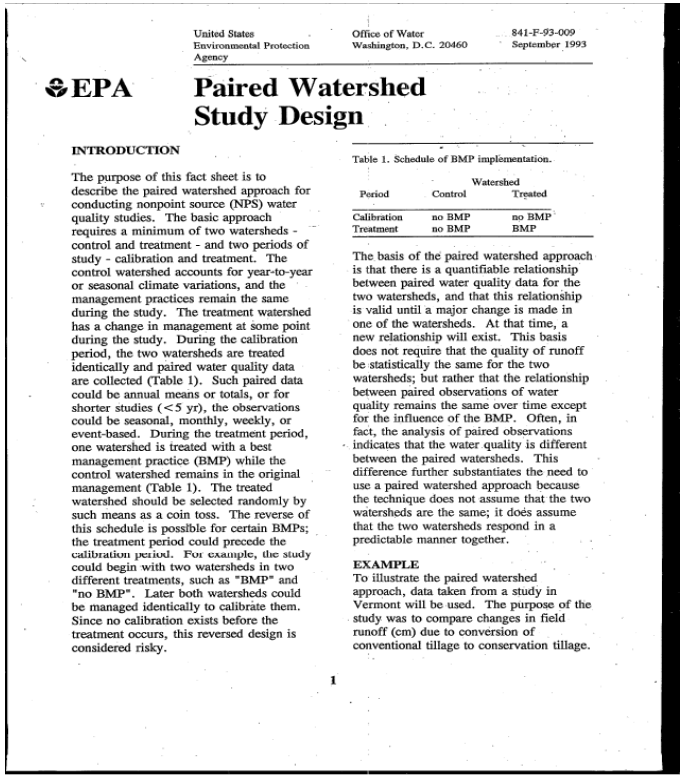
- **Spavinaw Lake and Eucha Lake** – designated "Sensitive Water Supply" and "Nutrient Limited Watershed"
  - Nutrients (now "Phosphorus") impairment since 1998
  - Low dissolved oxygen since 2002
  - High chlorophyll-*a* (TSI>62) since 2008

Paired Watershed Method

- Method published in 1993; used for many NPS projects across the nation
- Control (no BMPs) and Treatment (BMPs) watersheds
  - watersheds should be similar in size, slope, location, soils, and land cover/use
  - does not require same water quality
  - control accounts for year-to-year and seasonal climate variations
- Calibration Period of 1-2 years

  Pre-implementation monitoring to establish relationship between watersheds
- Post-implementation Period

  Monitor after BMPs have been installed



United States Environmental Protection Agency | Office of Water Washington, D.C. 20460 | 841-F-93-009 September 1993

EPA

Paired Watershed Study Design

INTRODUCTION

The purpose of this fact sheet is to describe the paired watershed approach for conducting nonpoint source (NPS) water quality studies. The basic approach requires a minimum of two watersheds - control and treatment - and two periods of study - calibration and treatment. The control watershed accounts for year-to-year or seasonal climate variations, and the management practices remain the same during the study. The treatment watershed has a change in management at some point during the study. During the calibration period, the two watersheds are treated identically and paired water quality data are collected (Table 1). Such paired data could be annual means or totals, or for shorter studies (<5 yr), the observations could be seasonal, monthly, weekly, or event-based. During the treatment period, one watershed is treated with a best management practice (BMP) while the control watershed remains in the original management (Table 1). The treated watershed should be selected randomly by such means as a coin toss. The reverse of this schedule is possible for certain BMPs; the treatment period could precede the calibration period. For example, the study could begin with two watersheds in two different treatments, such as "BMP" and "no BMP". Later both watersheds could be managed identically to calibrate them. Since no calibration exists before the treatment occurs, this reversed design is considered risky.

Table 1. Schedule of BMP implementation.

Period	Watershed Control	Watershed Treated
Calibration	no BMP	no BMP
Treatment	no BMP	BMP

The basis of the paired watershed approach is that there is a quantifiable relationship between paired water quality data for the two watersheds, and that this relationship is valid until a major change is made in one of the watersheds. At that time, a new relationship will exist. This basis does not require that the quality of runoff be statistically the same for the two watersheds; but rather that the relationship between paired observations of water quality remains the same over time except for the influence of the BMP. Often, in fact, the analysis of paired observations indicates that the water quality is different between the paired watersheds. This difference further substantiates the need to use a paired watershed approach because the technique does not assume that the two watersheds are the same; it does assume that the two watersheds respond in a predictable manner together.

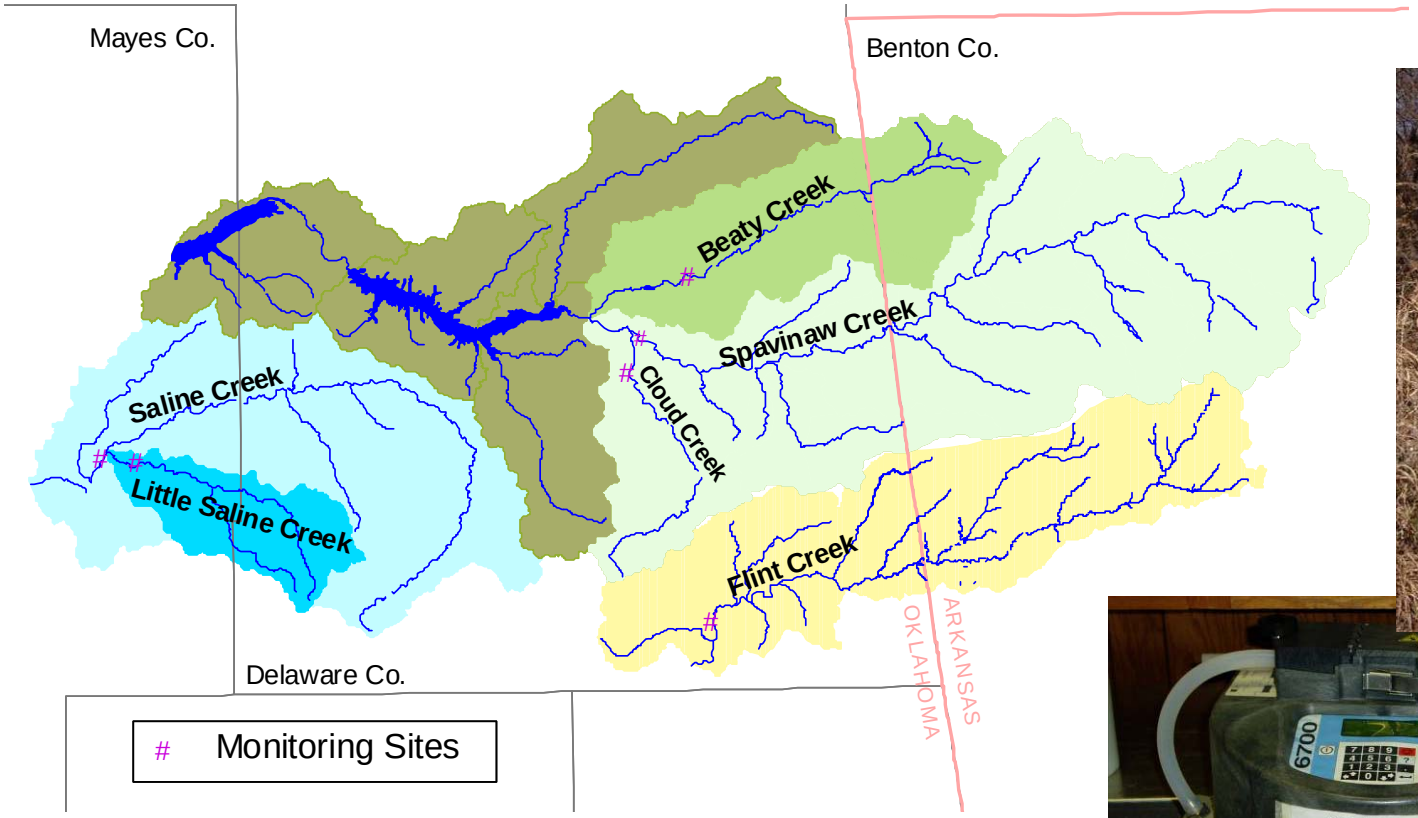
EXAMPLE

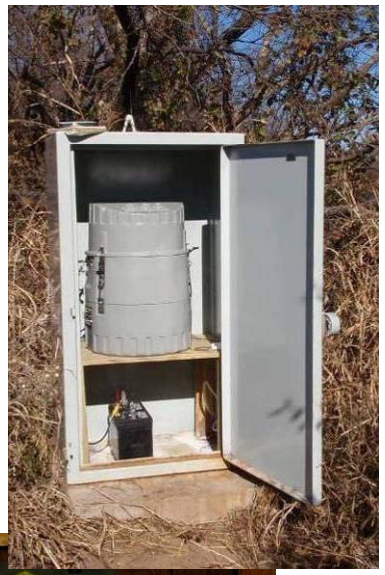
To illustrate the paired watershed approach, data taken from a study in Vermont will be used. The purpose of the study was to compare changes in field runoff (cm) due to conversion of conventional tillage to conservation tillage.

1

EPA method 841-F-93-009 developed by J.C. Clausen and J. Spooner

Water Quality Monitoring





Autosamplers used to collect continuous, flow-weighted composite samples weekly

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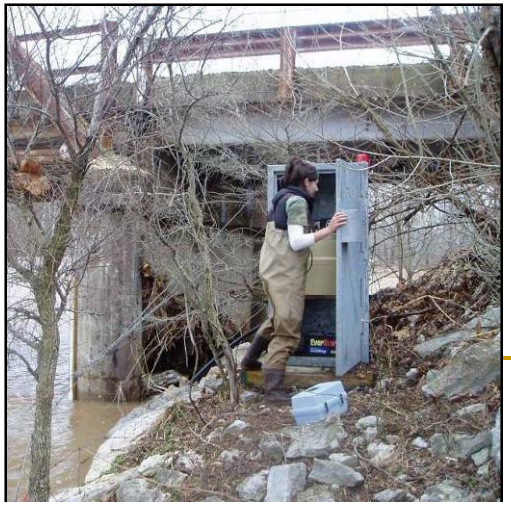
Parameters Measured

- ***Autosampler***
  Weekly + storms:
  total phosphorus
  ortho-phosphorus
  nitrate nitrogen
  ammonia nitrogen
  total Kjeldahl nitrogen

- ***Grab samples***
  Monthly:
  total hardness
  TSS
  chloride
  sulfate
  bacteria *(May through September)*



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Parameters Measured

- ***In-situ (weekly):***

  dissolved oxygen

  pH

  temperature

  turbidity

  conductivity

  alkalinity

  instantaneous discharge

- ***Biological:***

  Fish—biannually

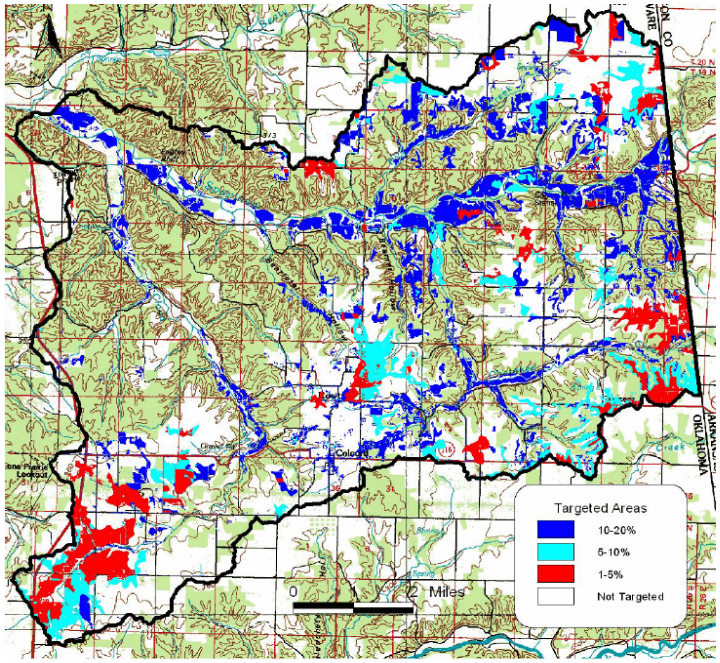
  Habitat—biannually

  Macroinvertebrates—twice a year

Calibration Monitoring from 1999-2001, then….

BMP Implementation 2001-2008

- **Hired local project coordinator**
- Worked through **local Conservation District** and with local NRCS
- Based practices and cost-share rates on advice of **Watershed Advisory Group**
- **Targeted practices** towards most significant sources in “hotspot” areas based on SWAT modeling



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Practices and Cost-Share Rates

- **Riparian Area Establishment / Management & Buffer Zone / Filter Strip Establishment –**

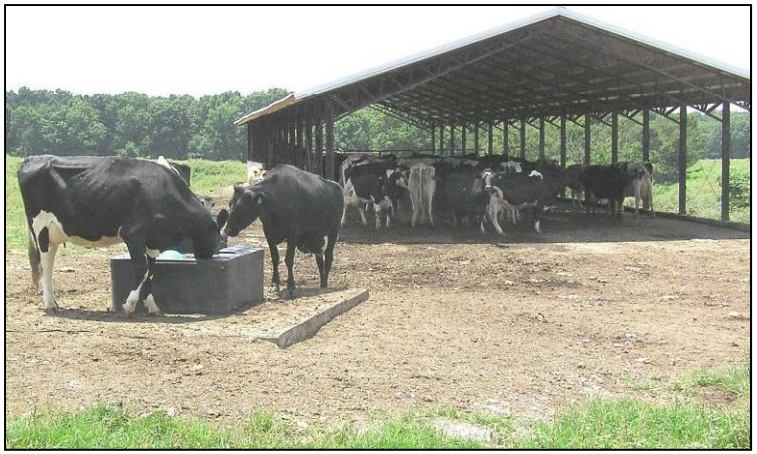
  80% to 100% cost-share

  - 485 acres of protected riparian area established since 1998

- **Streambank Stabilization** - *80% cost-share*
  - 55 acres of critical area planting

Practices and Cost-Share Rates

- **Composters / Animal Waste Storage Facilities** - *60% cost-share*
  - 14 cakeout houses and 49 waste storage facilities constructed since 1998



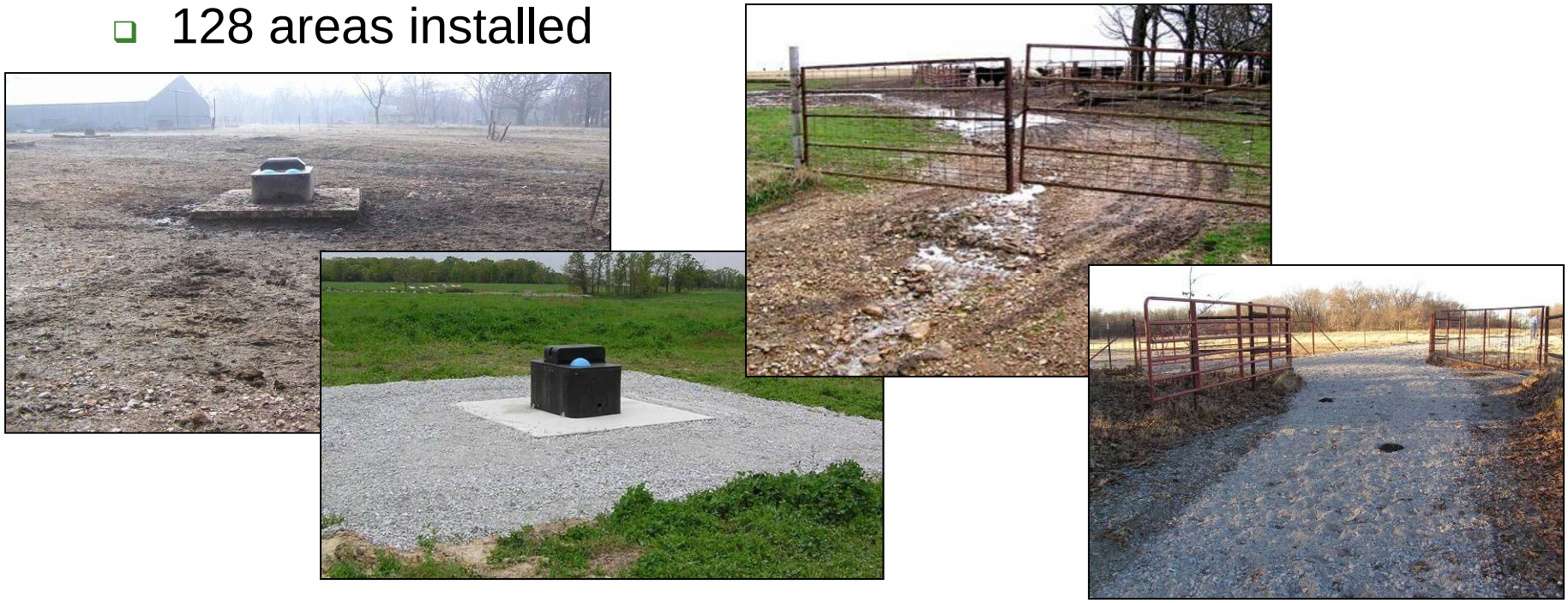
- **Proper Waste Utilization** - *8¢ to 15¢ per pound of litter* applied properly or moved out of watershed
  - approximately 28,000 tons of litter

Practices and Cost-Share Rates

- **Pasture Establishment / Improvement / Management –** *60% cost-share*
  - 398,241 linear feet of cross-fence
  - over 2,600 acres of planting and fertilizing pasture
  - 188 water tanks, 49 ponds, 60 wells to optimize pasture usage

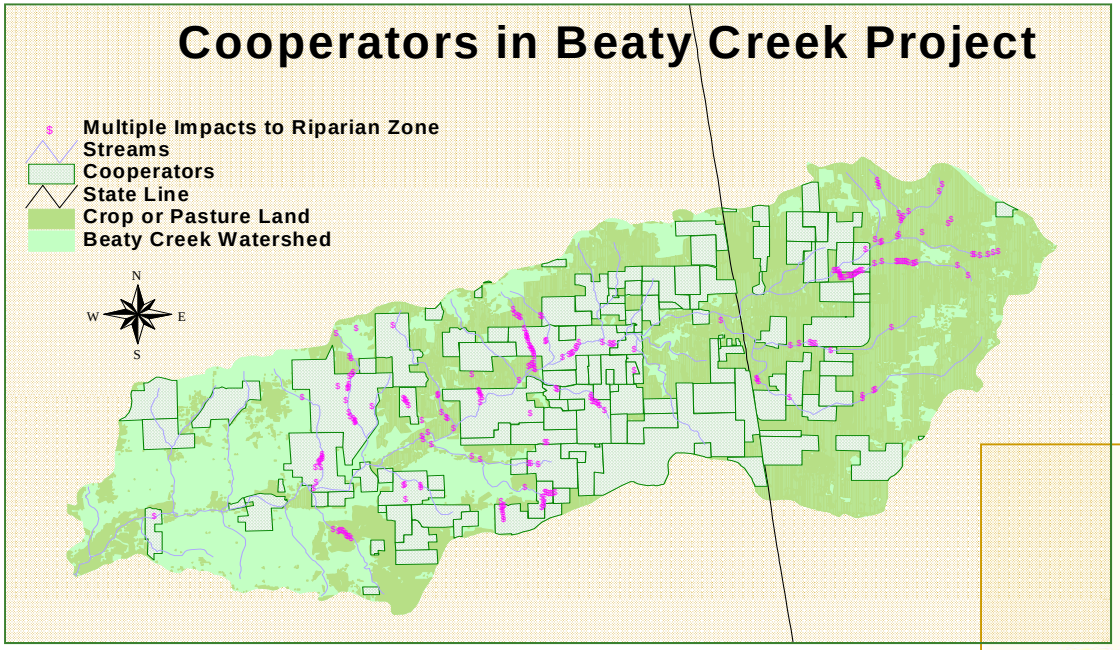
Practices and Cost-Share Rates

- **Heavy Use Areas** - *60% cost-share*
  - 128 areas installed

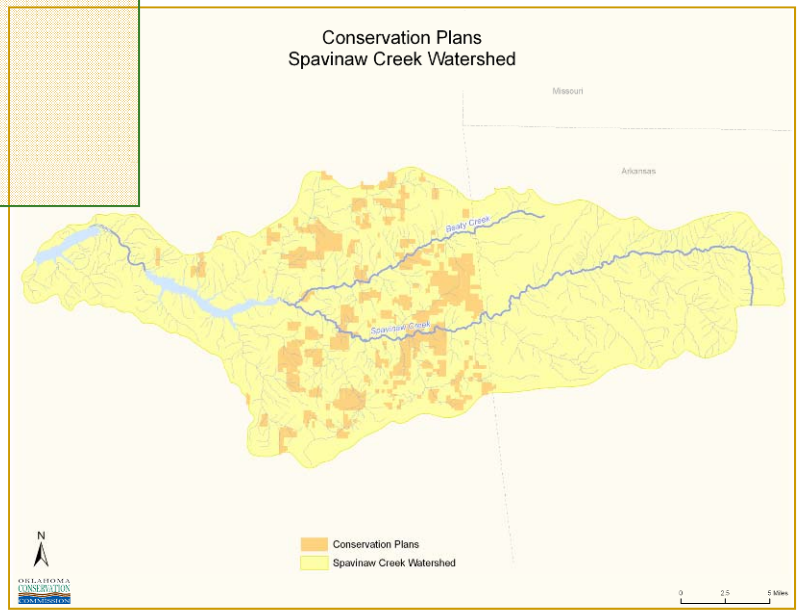


- **Rural Waste Systems** - *80% cost-share*
  - 87 septic systems installed
  - 23 systems pumped out

Implementation Results



1998 Project



2003 Project

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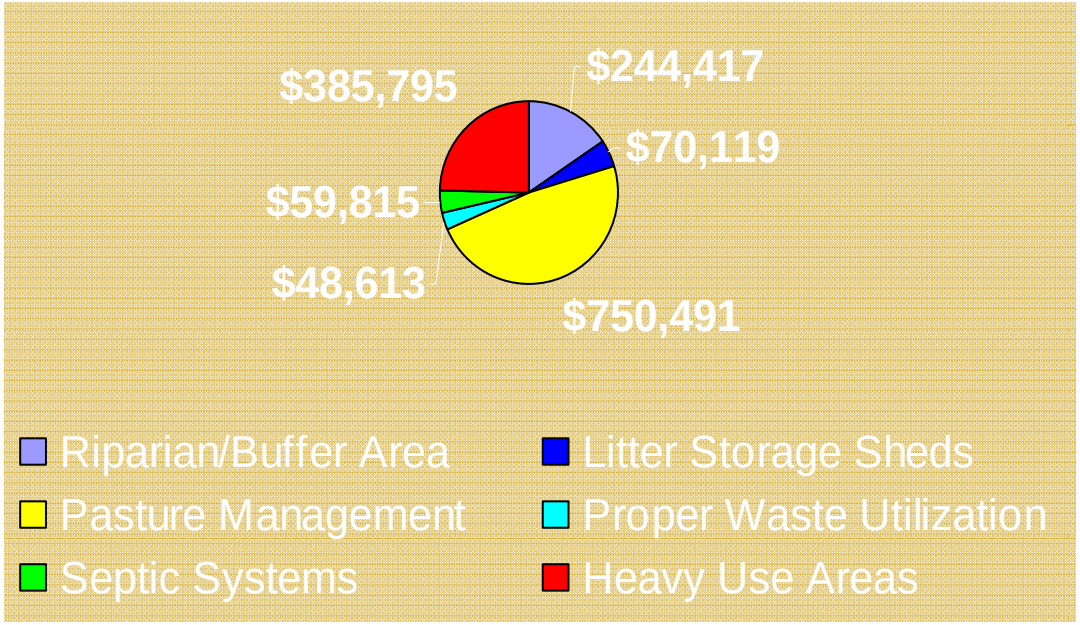
Funding

- **1998 Beaty Creek Project**

  Implementation Total – $1,559,250

  (cooperators paid 29%)



- **2003 Spavinaw Creek Project**

  Implementation Total - $2,337,441

  (cooperators paid 43%)

Nearly $4 million dollars of implementation in a decade!

Monitoring Results

- **Conducted post-implementation monitoring from 2003 through present**
- **Data analysis:**
  - **Linear Regression** to determine relationship between watersheds for pre-implementation and post-implementation periods
    - $p<0.001$ for most parameters
  - **ANCOVA** to determine difference between periods (pre-imp. & post-imp.) for each parameter
  - **Determined load reductions** by comparing expected loads with actual loads during the treatment period
    - Expected loads are modeled loads based upon the calibration period relationship

  *% reduction = (calibration – postimplementation) / calibration * 100*

Monitoring Results

Monitoring Results—Total P

- Two-years post-implementation:

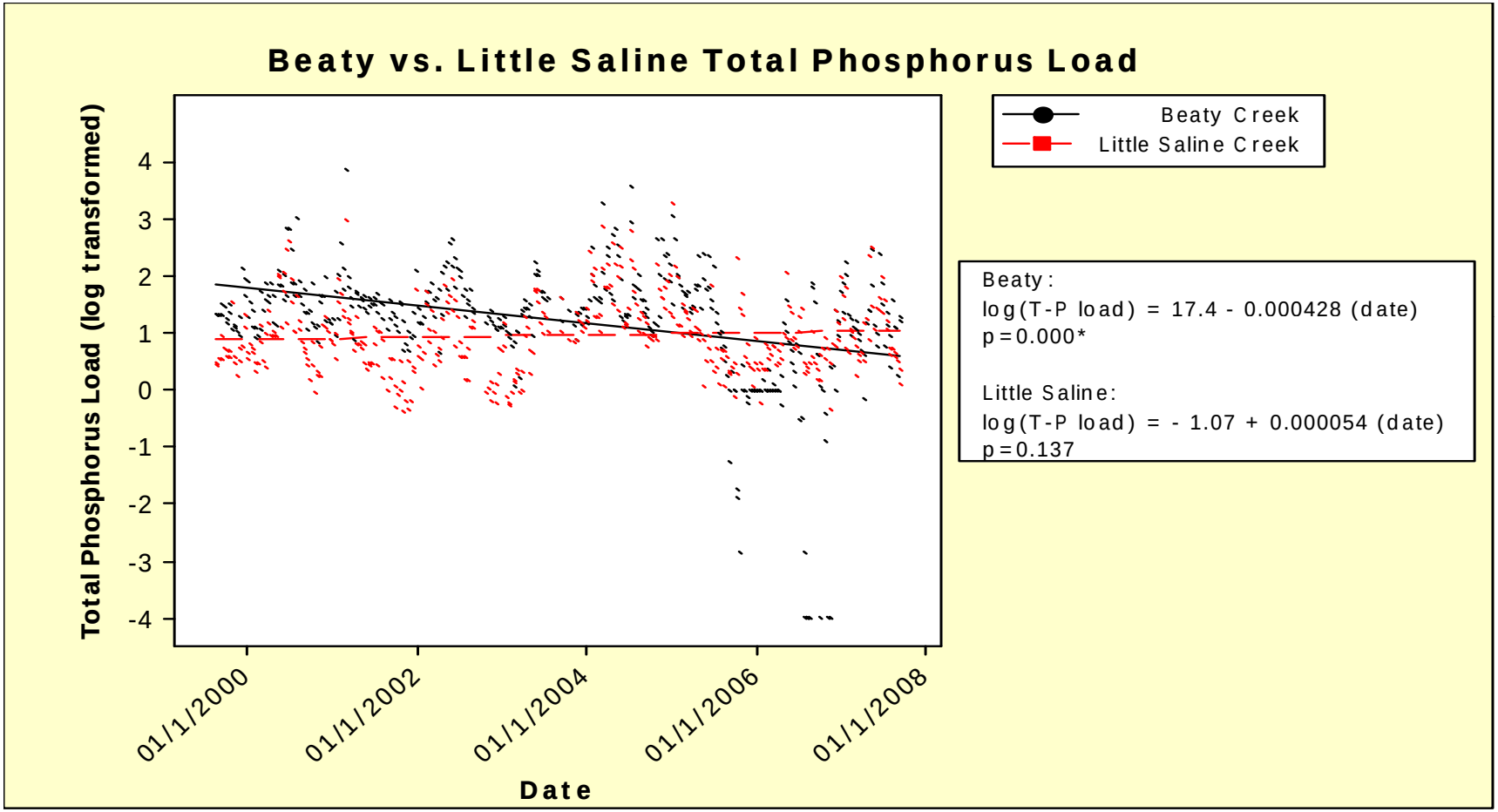
	Mean Weekly Total P Load (lbs)
Calibration Period (1999-2001)	
Little Saline (control)	**30.77**
Beaty	**138.99**
Post-implementation Period (2003-2005)	
Little Saline (control)	**75.80**
Beaty (observed)	**161.87**
Beaty (predicted)	**234.61**
Change in P Load	**-31%**

Monitoring Results—Total P

- Four-years post-implementation:

	Mean Weekly Total P Load (lbs)	
Calibration Period (1999-2001)		
Little Saline (control)	**30.77**	
Beaty	**138.99**	
Post-implementation Period (2003-2007)		
Little Saline (control)	**48.48**	
Beaty (observed)	**116.85**	
Beaty (predicted)	**343.70**	
Change in P Load	**-66%**	

Monitoring Results—Total P



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Notes about Method

- Beaty Creek watershed had significant reductions (ANOVA) in actual nutrient loading 4 years after implementation—not detected previously
- Use of ANCOVA allowed detection of loading reductions much faster than if used regression data (trends over time) or ANOVA (comparing pre- and post-implementation means)
- ANCOVA takes out / accounts for variable environmental conditions that occur over project period that would otherwise influence results
- Continuous, flow-weighted data provided a very large data set and allowed more accurate calculation of loads relative to weekly grab samples

Results for Other Parameters

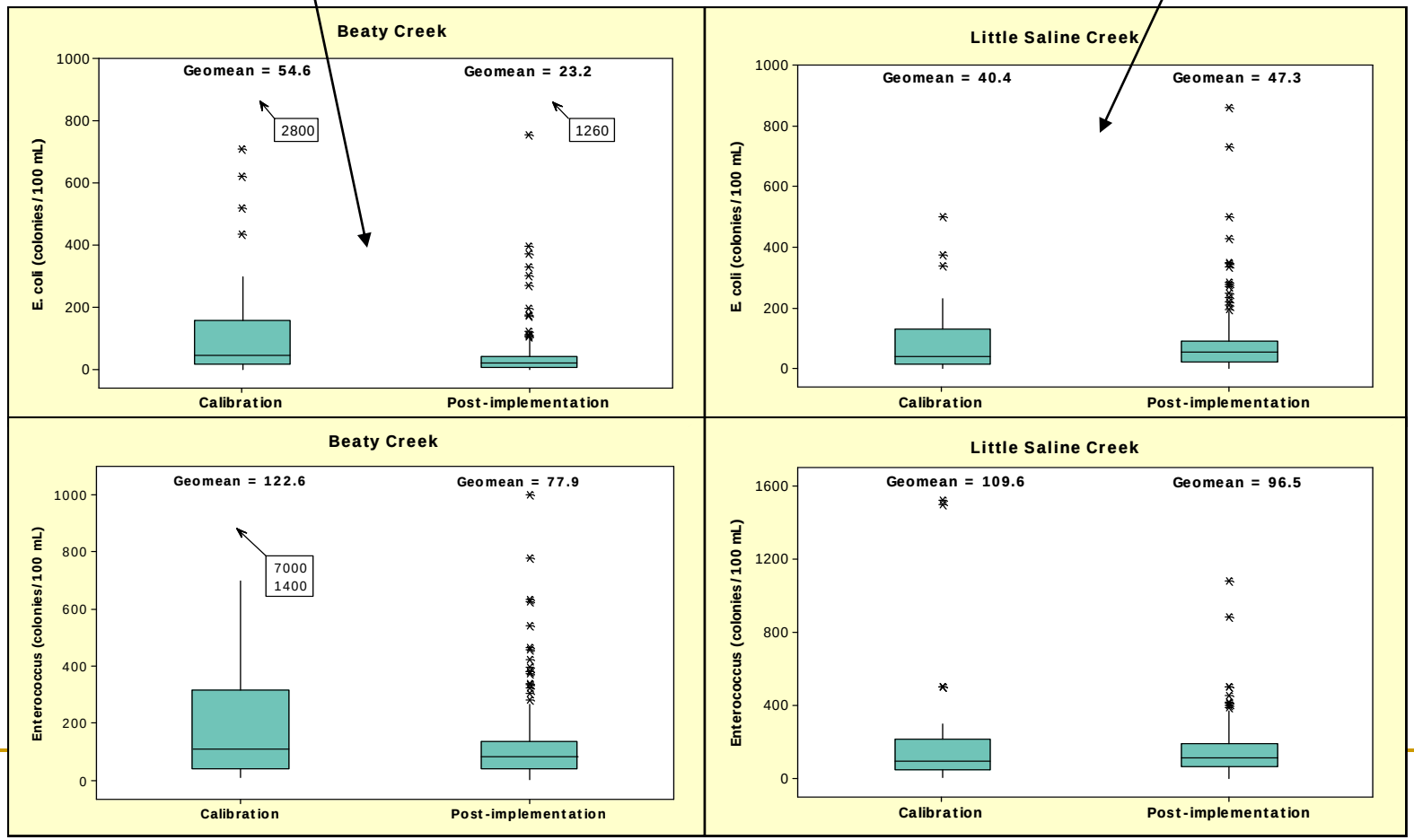
(modeled load reductions)

- **80% reduction in total Kjeldahl nitrogen loading**
- **53% reduction in total ortho-phosphorus loading**
- **87% reduction in ammonia loading**

Significant Reductions in Bacteria

Trmt: Significantly lower ($p<0.01$) bacteria concentrations after BMP implementation

Control: No significant difference btwn periods



Continued Efforts in the Spavinaw Creek Watershed

- **2008 Spavinaw Creek Project**
  - Implementation Total, projected – $716,000*
  - Project Total, projected – $1,228,910*

  **includes expected $200,000 landowner contribution (approx. 40%)*

- **Conservation Reserve Enhancement Program (CREP)**
  - $20.6 million to Protect Riparian Areas for at least 15 years
  - City of Tulsa has pledged at least $1.25 million for permanent easements

Monitoring will continue into the future……..

*To see **success**, it takes long-term commitment from landowners and government.*

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