Stillwater Creek

Watershed Implementation Project

FY 2001 319(h) Project 3

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Prepared by:

Oklahoma Conservation Commission
Water Quality Division
2800 N. Lincoln Boulevard, Suite 160
Oklahoma City, Oklahoma 73105

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Introduction

The Stillwater Creek watershed is identified among the state of Oklahoma's top 25 priorities for nonpoint source (NPS) control implementation in the Oklahoma Section 319 Management Program. Sediment and turbidity are the major NPS concerns for the watershed, primarily due to agriculture, roadside erosion, urban runoff, and oil and gas exploration. The Stillwater Creek Watershed Implementation Project facilitated watershed education, demonstration, and installation of best management practices (BMPs) in order to initiate a long-term, watershed scale effort to reduce NPS loading to levels where impairments and threats to Stillwater Creek and Lake Carl Blackwell are eliminated. This project involved the collaboration of government agencies as well as Oklahoma State University and local landowners. Data was collected from Oklahoma Conservation Commission stream monitoring sites and Oklahoma Water Resources Board lake sites in order to determine the effects of the implementation project on water quality, although positive results are not expected to be evident immediately.

Project Location

The Stillwater Creek Watershed is located in north central Oklahoma in Payne, Noble, and Logan Counties and is part of the Lower Cimarron sub-basin. The watershed area is 276 square miles (176,640 acres) and includes Hydrologic Unit Codes 11050003030 and 11050003040. Stillwater Creek discharges to the Cimarron River, draining the town of Stillwater, the Oklahoma State University Campus, and the OSU research farms. The watershed includes two large reservoirs, Lake Carl Blackwell and Lake McMurtry.

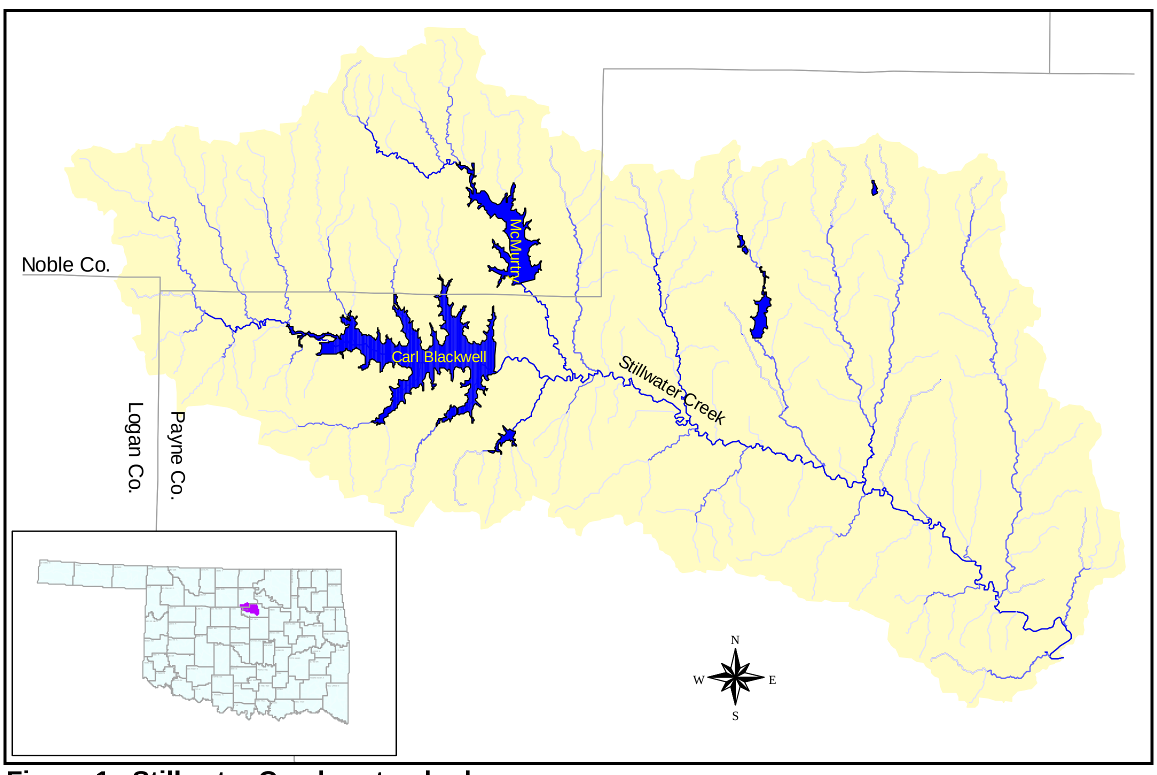


Figure 1. Stillwater Creek watershed.

Lake Carl Blackwell, a water supply and recreation lake, was created in 1937 by impounding Stillwater Creek west of Stillwater and contains 61,500 ac-ft of water supply storage, with an annual yield of 7,000 ac-ft (6.23 mgd). The surface area of Lake Carl Blackwell is 3,370 acres. Lake McMurtry (OK620900040240), a water supply, flood control, and recreation lake completed in 1971, is owned and operated by the City of Stillwater. The lake is located on North Stillwater Creek in Noble County and contains 5,000 ac-ft of flood control storage and 19,733 ac-ft of water supply storage, with a surface area of 1,155 acres. Boomer Lake (OK620900040190), also owned by the City of Stillwater and constructed for hydroelectric power and recreational uses, has a surface area of only 260 acres and a volume of 3,200 ac-ft.

Landuse in the watershed includes pasture and rangeland, forested areas, cropland, and urban areas (Figure 2, Table 1). Land is primarily privately owned, although a large portion, including Lake Carl Blackwell, is owned by Oklahoma State University (OSU). OSU operates cattle, pig, sheep, and dairy farms as well as range cattle operations. Research crop farms are present as well. Outside the University, most farmland is rangeland with low-intensity grazing.

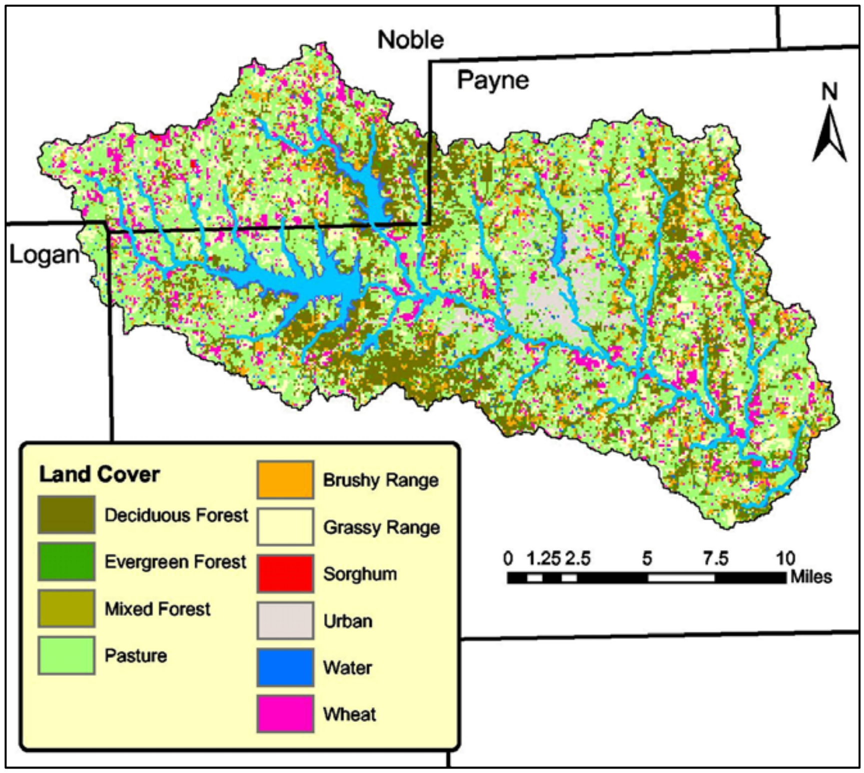


Figure 2. Landuse in the Stillwater Creek watershed (Storm et al. 2003).

Table 1. Landuse in the Stillwater Creek watershed (Storm et al. 2003).

Landuse	Percent	Landuse	Percent
Urban/Roads	7.11%	Range/Pasture, poor condition	12.96%
Deciduous Forest	17.65%	Range/Pasture, good condition	39.15%
Mixed Forest	2.52%	Rangeland with invasive cedar	7.69%
Evergreen Forest	0.78%	Wheat	7.88%
Row Crop	0.09%		

Assigned beneficial uses in the Stillwater Creek watershed include public, private, and emergency water supply; primary and secondary body contact recreation; fish and wildlife propagation (warm water and habitat limited aquatic community); agriculture; aesthetics; sensitive water supply; and industrial and municipal processes and cooling water.

Problem Statement

The City of Stillwater and the OSU campus are both experiencing rapid growth, with construction of homes, apartment buildings, and dormitories. 64% of the stream miles in the Stillwater Creek watershed are listed on the 303(d) list, most of them due to sediment-related issues. Three sites on Stillwater Creek, as well as Little Stillwater Creek, Brush Creek, and Lake Carl Blackwell were listed on the 1998 303(d) list for siltation and suspended solids (ODEQ 1998). In addition, one site on Stillwater Creek was listed for pesticides and nutrients on the 1998 list, and one site was listed for unknown toxicity. Turbidity and low dissolved oxygen (DO) are causes for listing Stillwater Creek on the 2002 303(d) list, while Little Stillwater Creek is on the 2002 list for nitrate exceedances, with septic systems and pesticides listed as the sources of impairment (ODEQ 2002). Lake Carl Blackwell is listed on the 2002 303(d) list as not attaining its designated beneficial use of Warm Water Aquatic Community due to turbidity exceedances.

Potential sources of pollution in the watershed include numerous unpaved county roads, poor grazing management, riparian and buffer zone degradation or removal, oil and gas activities, municipal wastewater, urban runoff, construction activities, and animal waste. There is continuing concern for overuse and improper disposal of home and garden chemicals and a continuing problem of roadside trash dumps. Nutrients and pesticides are likely associated largely with the urban/suburban sector in and near Stillwater and with the building and grounds maintenance program of the OSU campus. Other sources of fertilizer nutrients include the research crop fields and animal waste application areas associated with the OSU farms to the west of the OSU campus.

Table 1. Waterbodies on the 303(d) list in 1998 and 2002. I=insufficient data; X=not assessed.

Site Name	OK WBID	1998 Cause	2002 Cause
Stillwater Creek	OK620900040010	siltation, suspended solids, pesticides, nutrients	I / X
Stillwater Creek: Lower	OK620900040040	siltation, suspended solids	I / X
Little Stillwater Creek	OK620900040050	siltation, suspended solids	nitrate
Stillwater Creek: Upper	OK620900040070	siltation, suspended solids	I / X
Brush Creek	OK620900040090	siltation, suspended solids	X
Stillwater Creek (above L. Carl Blackwell)	OK620900040270	unknown toxicity	low DO, turbidity
Lake Carl Blackwell	OK620900040280	siltation, suspended solids	turbidity

There are three NPDES facilities in the watershed, one of which is a major discharger (the City of Stillwater). In addition, there is a municipal landfill, eight total retention lagoons, and four CAFOs. Three of the CAFOs are owned by OSU for research: two are swine facilities, one with 280 animals and the other with 982 animals, while the other is a beef cattle facility with 980 animals. The remaining CAFO, closest to Lake Carl Blackwell, has 740 beef cattle.

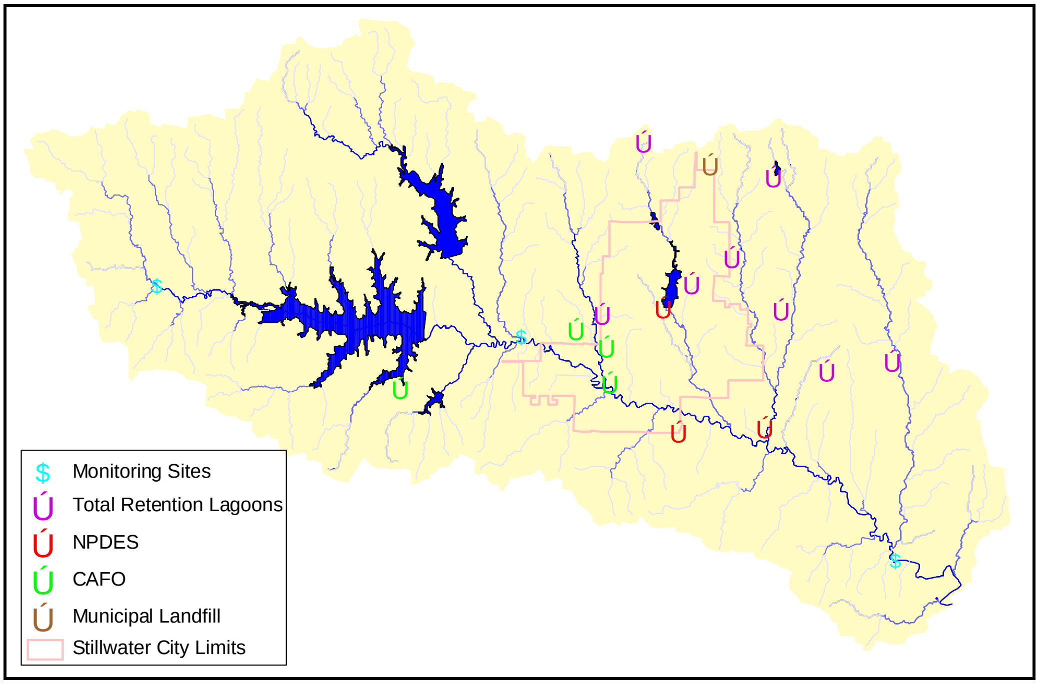


Figure 3. Permitted activities in the Stillwater Creek watershed.

This project focused on the nonpoint source (NPS) water quality problems identified to date. Several distinct projects were included in the Stillwater Creek Watershed Implementation Project: 1) Modeling and Land Cover Classification, 2) Implementation of Best Management Practices (BMPs), 3) Erosion Control on Rural Roads, 4) Shoreline Stabilization, 5) Assessment of Oil and Gas Field Related Impacts to Streams, and 6) Nonpoint Source Education Programs.

Program Partners

Considerable efforts have been made to identify the causes, extent, and sources of water quality threats and impairments in the basin, and extensive remedial efforts have been carried out and will continue into the future. Previous efforts include studies of the reservoirs and watershed conducted by Oklahoma State University (OSU), the Oklahoma Conservation Commission (OCC), and the Oklahoma Water Resources Board (OWRB) which identified the causes and some of the sources of water quality impairment in the watershed. Monitoring of the water quality in the watershed will continue in order to track any changes, positive or negative, in the magnitude of the impairments present in the watershed.

Public outreach efforts are essential in order to reach the water quality goals of restoring beneficial use support and attaining water quality standards in the watershed. The

Payne and Noble County Conservation Districts, partnered with the Natural Resources Conservation Service (NRCS), have been among the primary agencies responsible for public outreach in the watershed. Additional work includes educational programs developed by OSU, the Oklahoma Cooperative Extension Service (OCES), the OCC, the OWRB, and various other programs to reduce nonpoint source loading from various sources in the watershed.

The specific roles of these groups and current programs are summarized below:

- The Oklahoma Conservation Commission (OCC)

  The OCC, as the state's technical lead nonpoint source agency, devoted approximately $975,000 towards implementing best management practices, establishing demonstration sites, and educating the residents of the watershed to reduce nonpoint source pollution. In support of these activities, the OCC worked with local partners to establish a Watershed Advisory Group (WAG), to monitor the success of the program, and to implement an educational program (Blue Thumb) in the watershed. The OCC's main function was to provide technical guidance to the WAG and local conservation districts for implementation of the BMPs. The OCC was also responsible for monitoring the success of and providing administrative support for the project.

- County Conservation Districts and Natural Resources Conservation Service (NRCS)

  These agencies were critical in ensuring participation of local landowners in water quality improvement programs and in accounting for local cost-share funds. The Payne and Noble Conservation Districts and local NRCS offices tracked program progress and promoted local education events and demonstrations. The districts and NRCS worked one-on-one with citizens of the watershed to reduce pollution and educate about the importance of protecting water resources. The districts and NRCS also organized or participated in seminars, training sessions, and meetings to interact with local people and provide technical assistance and information (detailed later in this report).

- Oklahoma Water Resources Board (OWRB)

  The OWRB designed and implemented a project to assess various shoreline stabilization methods in Lake Carl Blackwell. In addition, Water Watch, a volunteer lake monitoring program through the OWRB, provided educational trainings focused on OSU students and staff in order to expand the volunteer base monitoring Lake Carl Blackwell.

- Oklahoma State University Cooperative Extension Service (OCES)--Education Program

  The OCES worked closely with the conservation districts and the NRCS to promote water quality awareness through numerous educational programs throughout the watershed. OCES provided technical assistance to landowners and contractors and developed demonstration sites to educate producers about the effectiveness of certain best management practices. The OCES also held public meetings and workshops to educate landowners on topics such as pesticide and fertilizer management, no-till, and erosion issues (urban and rural).

  Youth education is another significant effort pursued by OCES, NRCS, and the conservation districts. Most youth education activities focused on general water quality maintenance and improvement and included activities such as 4-H group water quality monitoring and education, Earth Day activities, and county fairs where hundreds of elementary school children and their parents are exposed to environmental education. More information can be found in the education section of this report.

- Oklahoma Corporation Commission (Corp. Comm.)

  Corp. Comm., as the state agency with jurisdiction over oil and gas mining activities, completed work to identify the location and severity of erosion related to well sites and pipelines in the watershed (detailed later in this report).

- Oklahoma State University, Division of Agricultural Sciences and Natural Resources

  OSU provided modeling of the landuse in the basin and targeting data necessary for optimal implementation of best management practices. In addition, OSU designed and implemented a study on rural road improvement in order to address a major source of sediment in the watershed. OSU also cooperated with the following groups in education efforts throughout the watershed:

  OSU Cooperative Extension Service
  OSU Agricultural Experiment Station
  OSU Center for Local Government Technology
  Payne County Cooperative Extension
  Payne County Conservation District
  Payne County Commissioners
  City of Stillwater

Demonstration of Best Management Practices

The Stillwater Creek workplan states that the primary intent of the project is "to demonstrate the benefits of NPS implementation on the water resources of the Stillwater Creek Watershed. Objectives of the project are to:

- promote protection and re-establishment of buffer zones and riparian areas,
- demonstrate practices necessary to achieve the sediment and nutrient control needed to restore and protect Stillwater Creek beneficial uses,
- implement practices and programs…to improve water quality."

To facilitate this demonstration, the OCC partnered with the Payne and Noble County Conservation Districts and local NRCS in both counties. The OCC employed a local project coordinator, who was responsible for a number of tasks, but mainly for coordinating the Watershed Advisory Group (WAG) and for working with the individual landowners to develop conservation plans and agreements to participate in the program, then verifying whether the practices had been implemented and maintained.

The Stillwater Creek WAG provided essential guidance towards the direction of the project and locally-led effort to solve local problems. The purpose of the WAG was to give guidance on the 319 program that the OCC implemented in the Stillwater Creek Watershed by recommending practices and cost-share rates to be offered through the program. The WAG was made up of local community leaders representing the nonpoint source interests in the watershed. WAG members included:

Robert Priess (Chairman)	Producer
Norman Durham	Producer
Mike Dicks	Producer
Chuck Thomas	City of Stillwater
Mike Smolen	OSU
Brandon Burns	NRCS
Rusty Peterson	NRCS
David Hungerford	NRCS

The Project Coordinator and/or NRCS District Conservationist (DC) visited landowners who were interested in participating in the program and drafted a conservation plan to detail practices necessary to address NPS pollution sources on their land. The OCC or NRCS staff worked with the landowner to select a suite of BMPs that were amenable to the landowner wishes. That suite of practices was then rated and assigned a ranking score. Highest ranked plans received preferential funding, while lower plans only received funding if monies remained after implementation of the highly ranked plans. The Coordinator and District Conservationists worked to insure that landowners with holdings in the targeted area were aware of the program and to sign as many of them to the program as possible.

Stillwater Creek Watershed Targeting and Load Reduction Goals

In order to ensure that BMPs were most effective, the Stillwater Creek watershed was intensively assessed with regard to land use and soils, and, based on the modeling results, certain areas were targeted as high priority to reduce NPS loading related to nutrients, pesticides, siltation, and suspended solids. Two primary targeting techniques were used for this watershed. The first included utilization of remotely-sensed and electronically mapped data. A data layer was created in a Geographic Information Systems (GIS) environment that represented hydrology, soils, slopes, and distribution of land use (see Figure 2 for land use). This information was used to target those producers whose proximity to water bodies is very close. In addition, aerial photography identified critical problem landuse areas, such as those without any riparian vegetation. Production areas close to waterbodies that also have degraded riparian areas were actively targeted for BMP implementation and inclusion in the program. Watershed reconnaissance identified critical areas of in-field and streambank erosion.

Soil surveys were also used in targeting, and highly erosive soil types within the watershed were identified (Figure 4). The most erosive areas, identified in Figure 4 by the darkest color, tend to be fields, overgrazed pastures, and construction areas. The most erodible areas shown are eroding at a rate of about 20 mtons/ha or about 10 tons per acre; however, small areas may erode at much higher rates (Smolen et al. 2003). Location of erosive soils and critical problem landuses were superimposed in an electronic environment to target likely sources of sediment loading (Figure 5). Phosphorus and nitrate loading, as predicted by SWAT models, are shown in Figure 6.

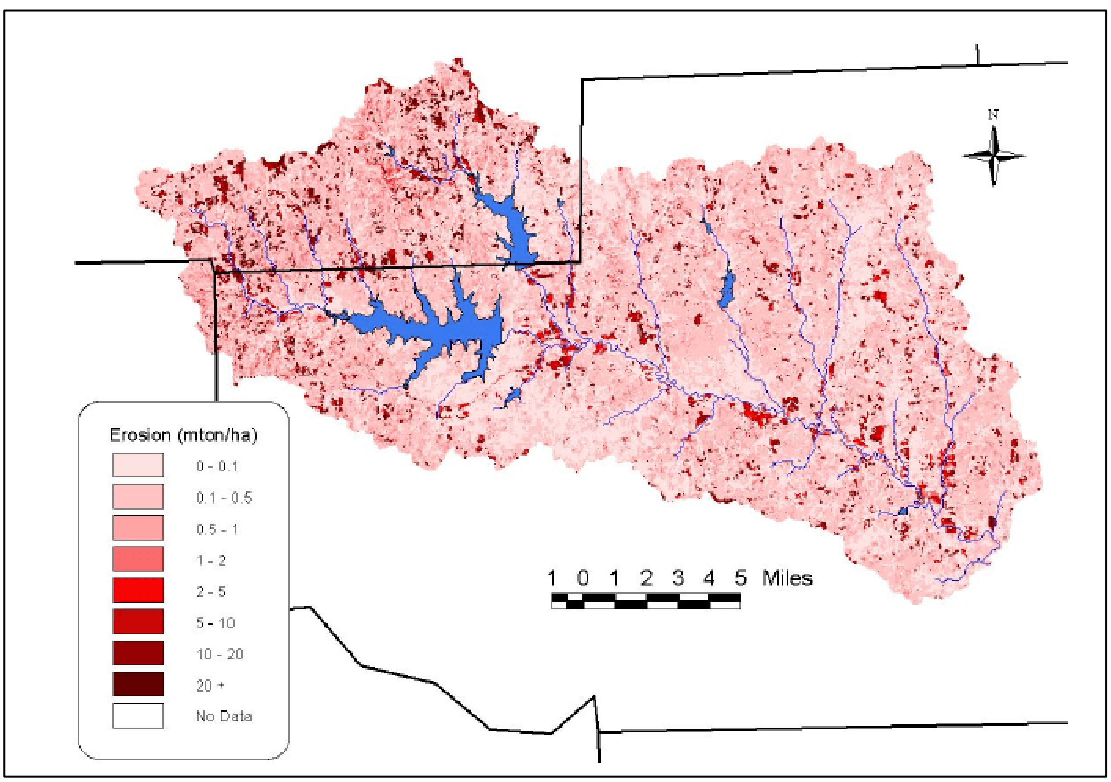


Figure 4. High resolution erosion in the Stillwater Creek Basin (Storm et al. 2003).

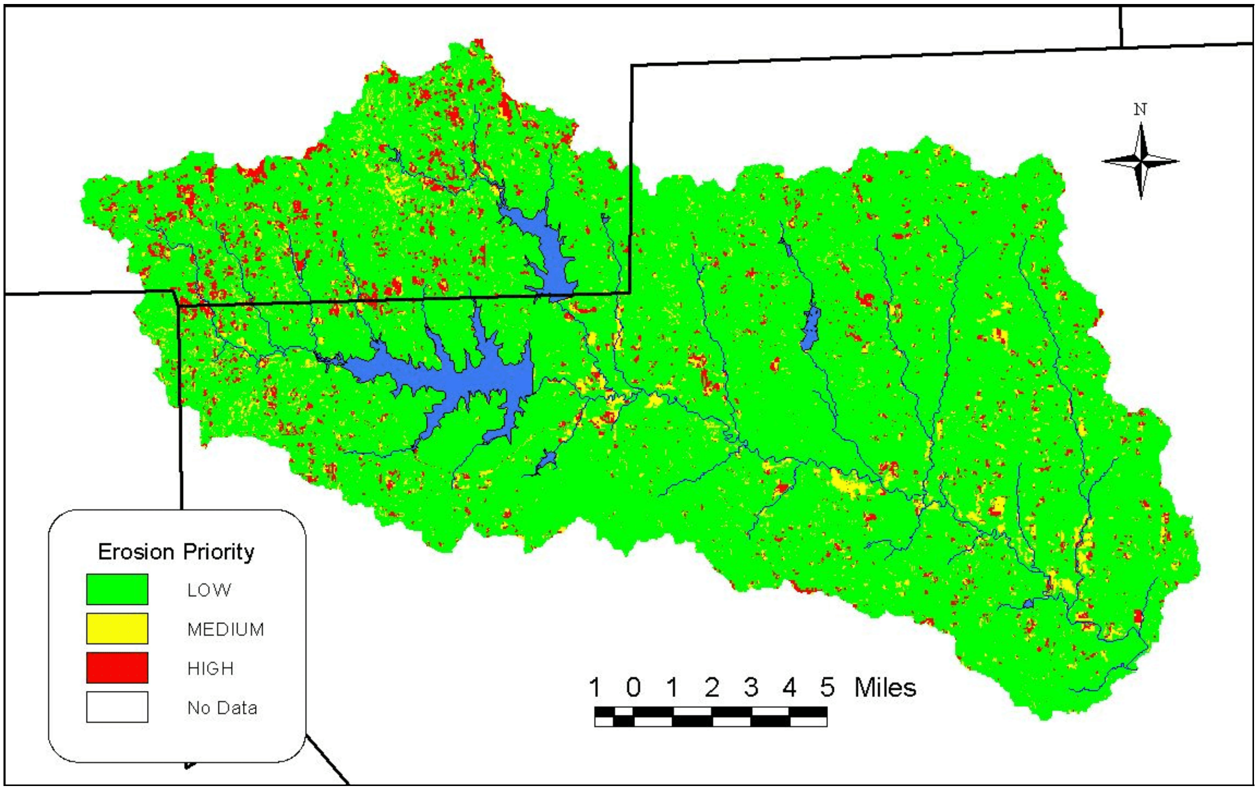


Figure 5. Erosion Targeting Map for the Stillwater Creek Basin. High Priority is 5% of the basin with the highest predicted erosion, Medium Priority includes the next highest eroding 5%, and Low Priority covers the remainder (Storm et al. 2003).

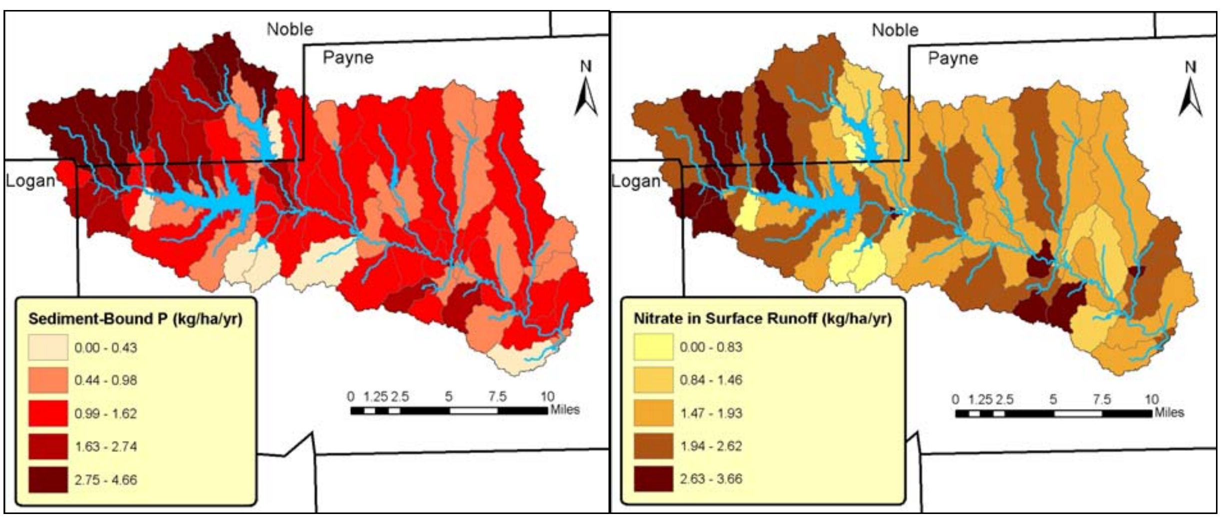


Figure 6. Sediment-bound mineral phosphorus and nitrate loading in the Stillwater Creek Basin as predicted by the SWAT 2000 model (Storm et al. 2003).

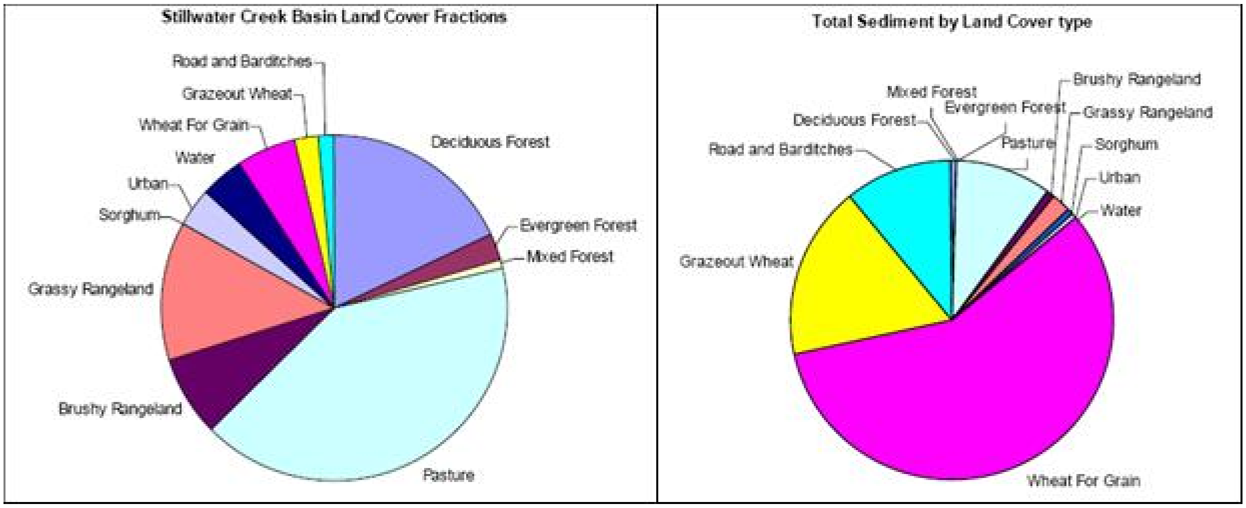


Figure 7. Fraction of basin area and total sediment yield by land cover type (Storm et al. 2003).

Modeling using the PRedICT model (Evans et. al. 2003) with input from the targeting and SWAT model runs completed by Storm et al. (2003) suggested that implementation dollars available could be sufficient for a 20% reduction in phosphorus (reduction of 36,895 kg/yr) and sediment (reduction of 23,691,200 kg sediment/yr) loading to Stillwater Creek. However, the targeting suggested that as much as 75% of the sediment load comes from 7.8% of the basin (mostly small grains and row crop areas; Figure 7).

Best Management Practices

Best management practices (BMPs) promoted in this project were prioritized and grouped into four major categories: (1) riparian establishment and management, (2) erosion control, (3) pasture and cropland management, and (4) waste management. The focus of the practices was to implement nutrient and sediment reductions to Stillwater Creek and Lake Carl Blackwell, with the ultimate goal of achieving beneficial use support. The program focused implementation in the targeted areas along the tributaries and mainstems of Stillwater Creek as defined by the SWAT targeting mechanism (Figures 4, 5, 6). In addition, the project used a ranking index for land owner water quality impacts and practice benefits to ensure maximum benefit for project funds.

Establishment and management of riparian areas was the top priority, followed by erosion control practices, then land management, and lastly, waste management. Some of the high priority practices which were offered were not implemented due to lack of cooperator interest (detailed below). A $20,000 cap was set on all agreements, and cost share rates were generally set at 75%, requiring a 25% match from the landowner:

Cost Share Practices		***Cost Share Rate***
Riparian Area Establishment/Management		
Components:	(1) Vegetative Plantings	75 %
	(2) Off Site Watering	80 %
	(3) Fencing	75 %
	(4) Stream Crossings	75 %
	(5) Use Exclusion	100%
Roadside Erosion and Special Projects		
Components:	(1) Vegetative Plantings	75 %
	(2) Structural Practices	75 %
	(3) Site Preparation	75 %
Land Management, Pasture and Cropland		
Components:	(1) Vegetation Plantings	75 %
	(2) Pasture and Hay Planting	75 %
	(3) Prescribed Grazing	75 %
	(4) Cross Fencing	75 %
	(5) Watering Facilities	80 %
	(6) Field Border	75 %
	(7) Heavy Use Areas	75 %
	(8) Structural Practices	75 %
	(9) Use Exclusion	100%
Waste Management/Nutrient Management		
Components:	(1) Septic System With Tank & Lateral Lines	75 %
	(2) Rock Reed Absorption Filters With Septic Tank	75 %
	(3) Residential Sewage Lagoons	75 %
	(4) Vegetation Plantings	75 %
	(5) Soil Testing	100%

Figure 8. Stillwater Creek Project Cooperators.

In Payne County, 31 landowners participated in BMP implementation, and 22 landowners participated in Noble County. Cooperator landholdings included approximately 3% of the total watershed, about 5,300 acres. State funds paid $135,537.78 toward BMP installation while EPA funds provided $146,337.43. In total, landowners in the two counties contributed $165,964.99 in match funds, or approximately 37%. Specific funding by practice is given in Table 2.

Table 2. Best management practices implemented in the watershed.

Practice	Total # Cooperators	Amount Implemented	Units	319/State Funds
Riparian management				
Fertilizer	1	2	acres	$37.50
Offsite watering--pond	5	7	ponds	$17,410.51
Offsite watering--tank	5	4	tanks	$3,778.24
Fencing	13	14,840	linear feet	$16,139.66
Erosion control				
Permanent vegetative establishment	1	16	acres	$94.80
Fertilizer	8	92	acres	$1,518.38
Critical area planting	12	17.65	acres	$2,037.34
Grassed waterway construction	2	1.61	cubic yards	$684.98
Grade stabilization structure	12	13	structures	$27,755.36
Land management				
Fertilizer	5	25	acres	$461.25
Filter strip	2	60	acres	$3,157.50
Pasture / hay planting (Bermuda)	2	22	acres	$1,237.50
Pasture / hay planting (other grasses)	2	1,099	lbs. live seed	$3,112.13
Heavy use area protection (gravel)	2	66	cubic yards	$881.25
Heavy use area protection (geotextile)	1	187	square yards	$175.31
Heavy use area protection (concrete pad)	1	2	cubic yards	$337.50
Heavy use area protection (embankment)	1	4,195	cubic yards	$3,775.50
Feeding facility	1	1	structure	$12,792.00
Water facility--pond	18	19	ponds	$62,719.43
Water facility--tank	8	9	tanks	$11,754.35
Fencing	7	21,011	linear feet	$16,577.79
Waste management				
Septic system installation	20	20	systems	$83,195.25
Septic system upgrade	2	2	upgrades	$7,110.00
Septic lagoon	1	1	lagoon	$1,246.50

The bulk of implementation was focused towards Land Management Practices, with approximately 42 percent of total implementation dollars spent on these types of practices (Figure 9). Thirty-four percent of the total budget was used for Waste Management practices, with Riparian Area and Erosion Control practices consuming approximately equal amounts of the budget.

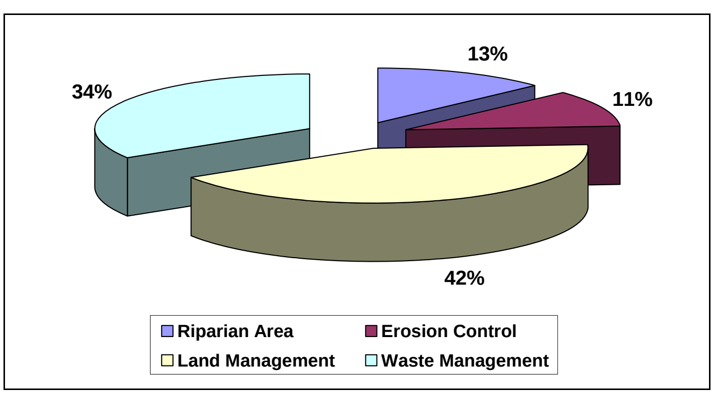


Figure 9. Distribution of project funds among BMP categories.

The amount of installation compared to total watershed size was far short of other priority watershed projects in watersheds with similar water quality problems and land uses. It is possible that the availability of EQIP funds in this watershed reduced interest in the OCC program. NRCS has an active program in both Payne and Noble counties, with approximately 73 Payne Co. landowners receiving $252,173.00 from 2001 to 2006, and 35 Noble Co. landowners receiving $238,272.00 in the same time period. Practices that have been implemented through EQIP in these counties include grade stabilization structures, waterways, terraces, ponds, fencing, grass planting, and filter strips, some of the same practices that were popular in the OCC program, as well as gully shaping, cedar tree removal, lespedeza spraying, musk thistle spraying, mixed brush spraying, and water control structures.

Riparian Establishment and Management

The demonstration of the cumulative benefit of comprehensive buffer and riparian management incentives was a top priority. Priority treatment went to the small waterways and first order streams, which make up the greatest portion of a watershed drainage system. The Conservation Districts, under guidance by the WAG, implemented the following practices in order to reduce the nitrogen and sediment load:

1) Fencing for Riparian Management

Landowners look upon the riparian areas as critically needed, highly productive pasture. However, heavily grazed riparian areas function poorly as nutrient traps, and cattle trails become channels for direct transport of nutrients to the stream. Fencing to exclude cattle from a certain area along a stream was recommended to control these problems. Incentives were used to establish 30 feet beyond the timber line on each side of the stream following the 3 zone buffer system. In order to take advantage of existing fences, the buffer widths occasionally varied slightly. Fences were built above the flood prone area elevation to lower maintenance costs.

Landowners were given the option of riparian protection with total livestock exclusion with a $50/acre incentive payment, riparian protection with limited hay production (with haying allowed only in vegetative zone of the buffer and only during a time of the year to allow sufficient regrowth prior to the end of the growing season) for a $45/acre incentive payment, or riparian protection with limited grazing for a $40/acre incentive payment. Limited grazing or flash grazing would allow landowners to grant livestock access to the riparian zone for a brief period in summer when streambanks were most stable (due to lack of rain) and with sufficient time for regrowth before the end of the growing season. In addition, during limited grazing, landowners agreed to pull livestock out of the area prior to the point where it became overgrazed.

2) Permanent Vegetative Establishment

The planting of bermuda and other grasses within the riparian zone was encouraged by providing cost share funds for seed, seedbed preparation, and fertilizer (if necessary). Permanent vegetation in riparian buffer areas should help to reduce runoff of both sediment and nutrients from cropland and pasture. While no landowners planted grasses within the riparian zone, some fertilizer was applied to the existing vegetation to improve the riparian zone.

3) Off Stream Watering

Pastures where the stream is the primary or sole source of water for livestock were provided with an alternate source to allow riparian management. Studies have shown that off-stream water sources can substantially reduce the impact of cattle even without fencing the stream. Off-stream watering was budgeted only for the perennial sections of the stream because the landowners already had provided water supplies for livestock where the stream does not supply permanent water. Watering options included pond excavation and two types of freeze-proof water tanks. Many of the ponds were also fenced to prevent cattle from loafing in them.

Figure 10 shows the locations of the alternative water supplies which were implemented. Seven ponds and four water tanks were installed as part of the riparian management practices. In addition, 14,840 feet of fencing was built around ponds and along riparian areas.

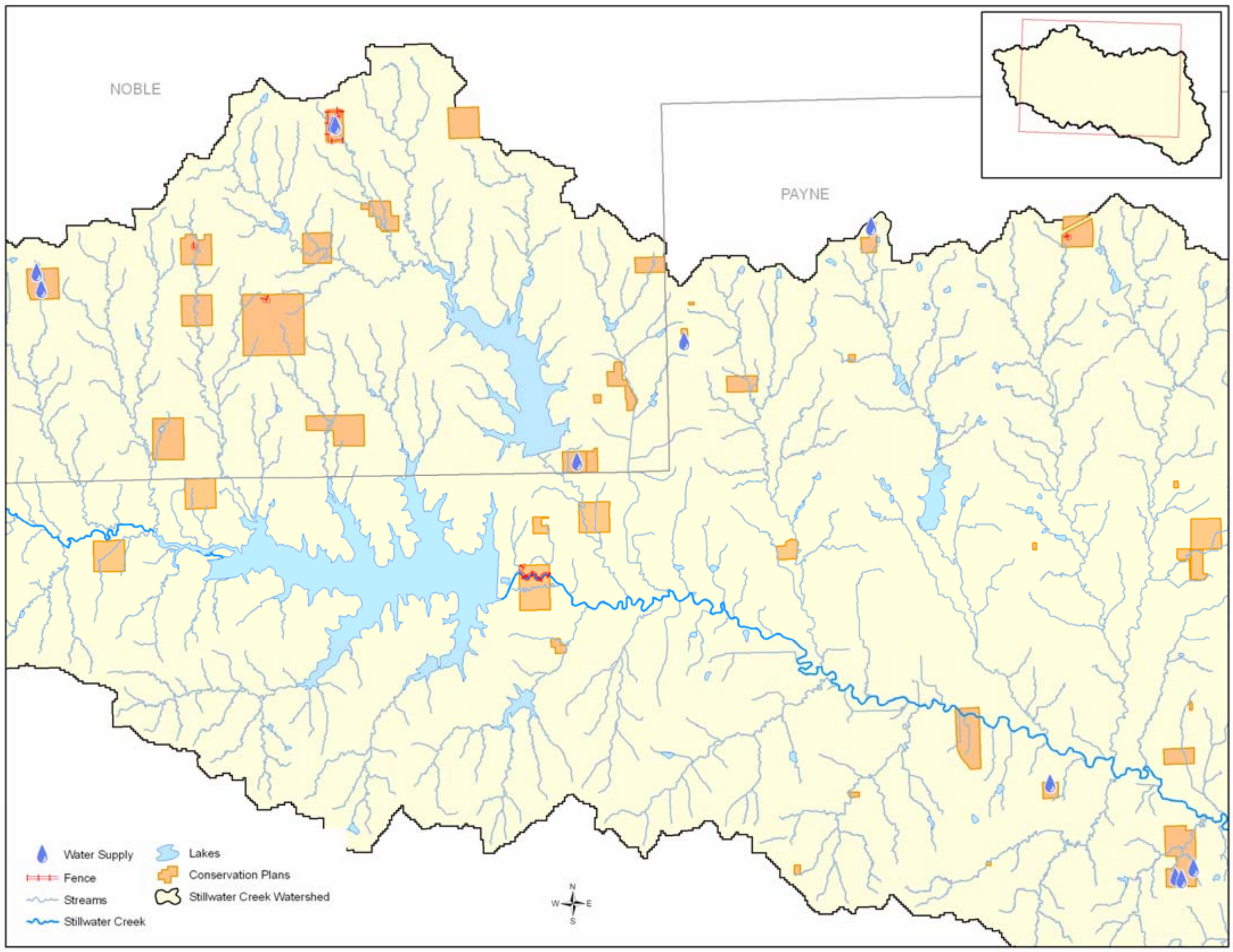


Figure 10. Riparian management practices implemented.

Erosion Control

1) Permanent Vegetative Establishment

Erosion control was one of the top priorities for BMP implementation. Poorly managed pastures and croplands can contribute a great deal of sediment to a stream, so establishing good vegetative cover on the land is an important BMP. Over thirty acres were planted with bermuda, and 92 acres were fertilized to improve vegetation. One cooperator seeded 16 acres, while others focused on planting only in small, critical areas, often around ponds and grade stabilization structures.

2) Structural Practices

Thirteen grade stabilization structures, mostly consisting of a "barrel and riser" design, were installed in order to retard or prevent the erosion of soil on hillsides. In addition, two landowners established grassed waterways to slow the movement of soil during runoff events.

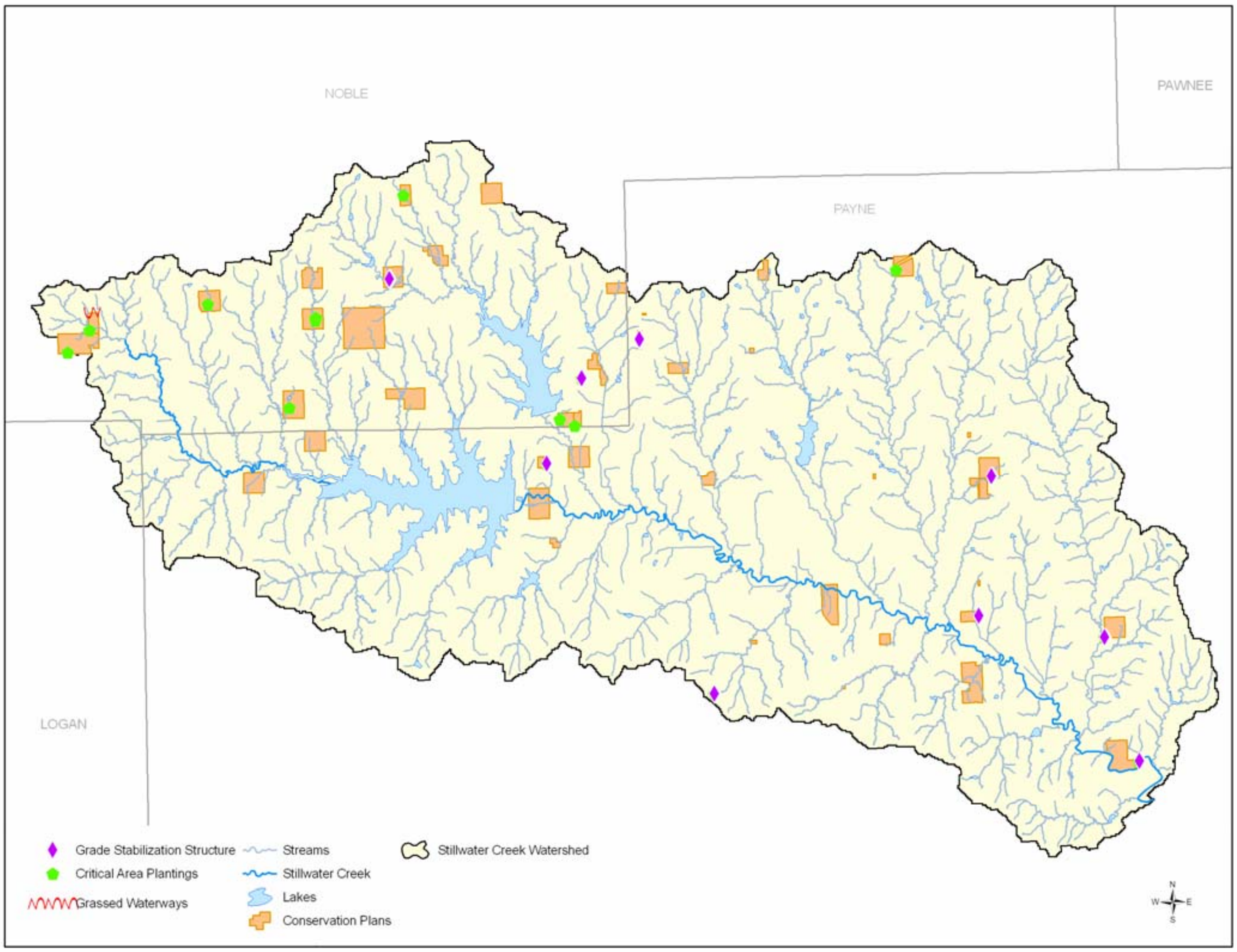


Figure 11. Erosion control practices installed.

Land Management

1) Vegetative Plantings

Over-grazed and poorly grassed fields and pastures were found to be a significant source of erosion in the watershed. Fertilization of 25 acres of poor pastureland and cropland in the watershed allowed for the establishment of better quality and quantity of vegetative cover. Sixty acres of grass was planted to create field borders and filter strips which will reduce the amounts of nutrients and sediment which enter streams due to runoff. In addition, 22 acres of bermuda and 1,099 pounds of live seed were planted to improve the pastures of four landowners in the watershed.

2) Heavy Use Areas

As large animals, cattle can severely impact areas around feeding or watering facilities where heavy traffic compacts soil and destroys stabilizing vegetative cover, increasing soil erosion from the area. In addition, heavy traffic is usually accompanied by increased waste deposition, which can lead to increased nutrients and bacteria in runoff from these areas. Installation of concrete feeding pads for round hay bale feeding or gravel and grading in loafing areas are modifications that can reduce runoff of soil, nutrients, and bacteria from these heavy use areas.

Winter feeding facilities are more elaborate structures which are similarly designed to reduce runoff of nutrients, bacteria, and sediment from cattle supplemental feeding areas. Landowners typically overwinter and often feed cattle in the same areas of a pasture, areas that are chosen because they are easy to get to and provide a reliable source of shelter and water for overwintering stock. This often means they are close to the creek or a ravine or dry channel where shelter from the wind is available and the running water in the creek generally insures that it does not freeze often. Unfortunately, these areas become trampled, overgrazed, and laden with waste, and, hence, are susceptible to runoff. By providing a sheltered feeding area away from the stream, winter feeding facilities reduce this problem. The structure has a concrete floor with a lip all around to contain waste. In addition, the back 1/3 of the structure is devoted to dry manure storage, sized sufficiently to store up to 3 months worth of manure until such a time it can be properly land applied. Three cooperators installed heavy use areas, and one built a winter feeding facility for his livestock.

3) Use Exclusion—Cross-Fencing

In order to keep pastures in optimal condition, overgrazing must be avoided. Landowners may use cross-fencing to rotate cattle to various pastures and, thus, prevent overgrazing. 21,011 linear feet of fence was erected to exclude livestock from pastures at certain times.

4) Water Facilities

To successfully cross-fence livestock, water must be available in each pasture. As part of the land management BMPs, 19 ponds and 9 freeze-proof water tanks were installed in the watershed.

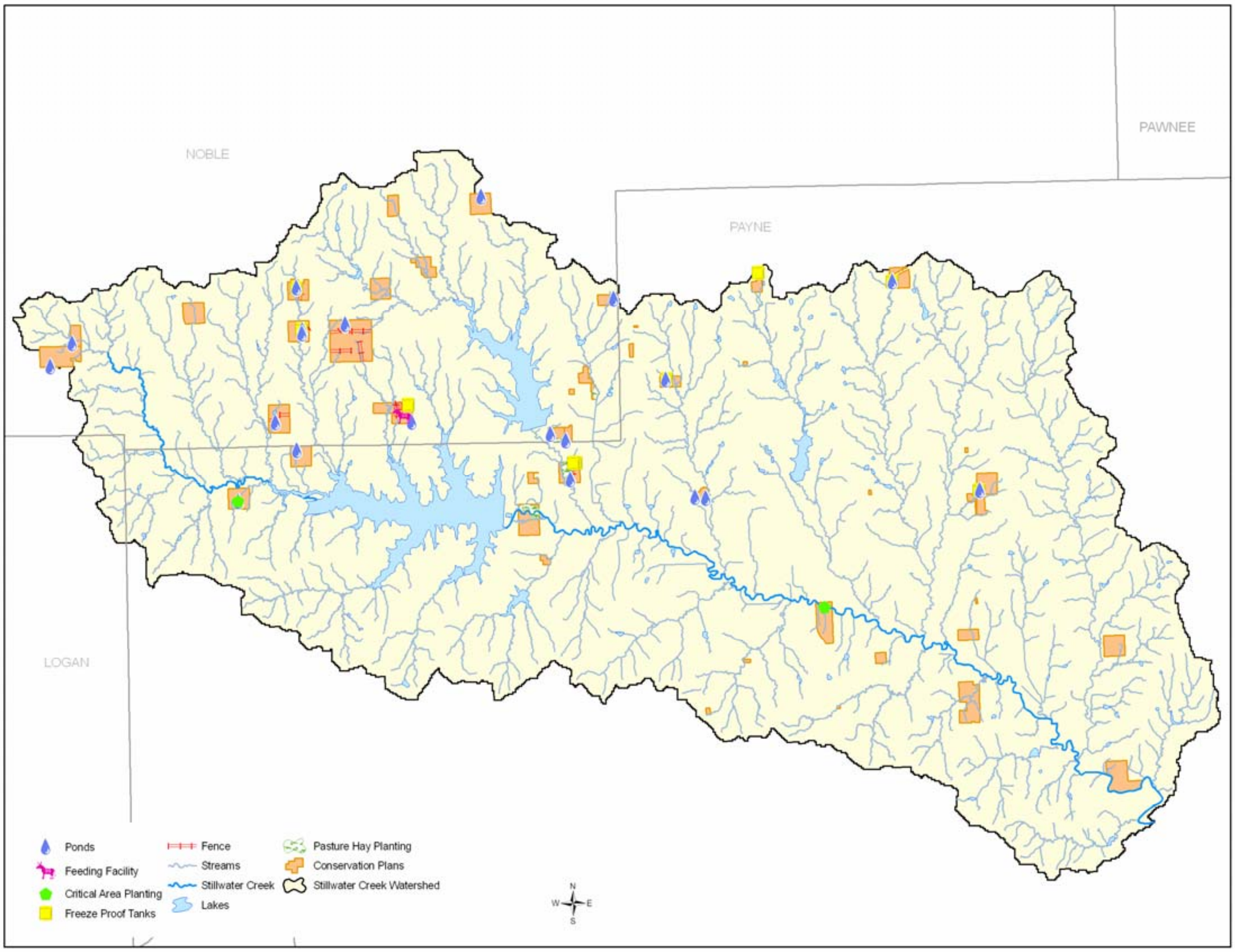


Figure 12. Land management practices implemented.

Waste Management

1) Septic Systems

Although the human population in the watershed does not likely contribute significantly to watershed loading through septic tanks, the WAG felt it was important for the program to demonstrate BMPs to address even potential NPS pollution in the watershed. In addition, there was quite a bit of interest in septic system BMPs. Twenty septic systems were installed (18 aerobic systems and 2 standard systems). Two existing systems had infiltrators installed, and one lagoon was constructed.

2) Soil Testing

To ensure that the appropriate septic system was installed or that the existing system was properly upgraded, "perc" tests were performed. A total of 21 tests and certifications were funded through this project. In addition, a soil test was required prior to fertilizer application to prevent excessive or unneeded nutrients. Eight soil tests were funded through this project, followed by fertilizer application for optimum vegetative growth in riparian areas, buffer and filter strips, and pastures.

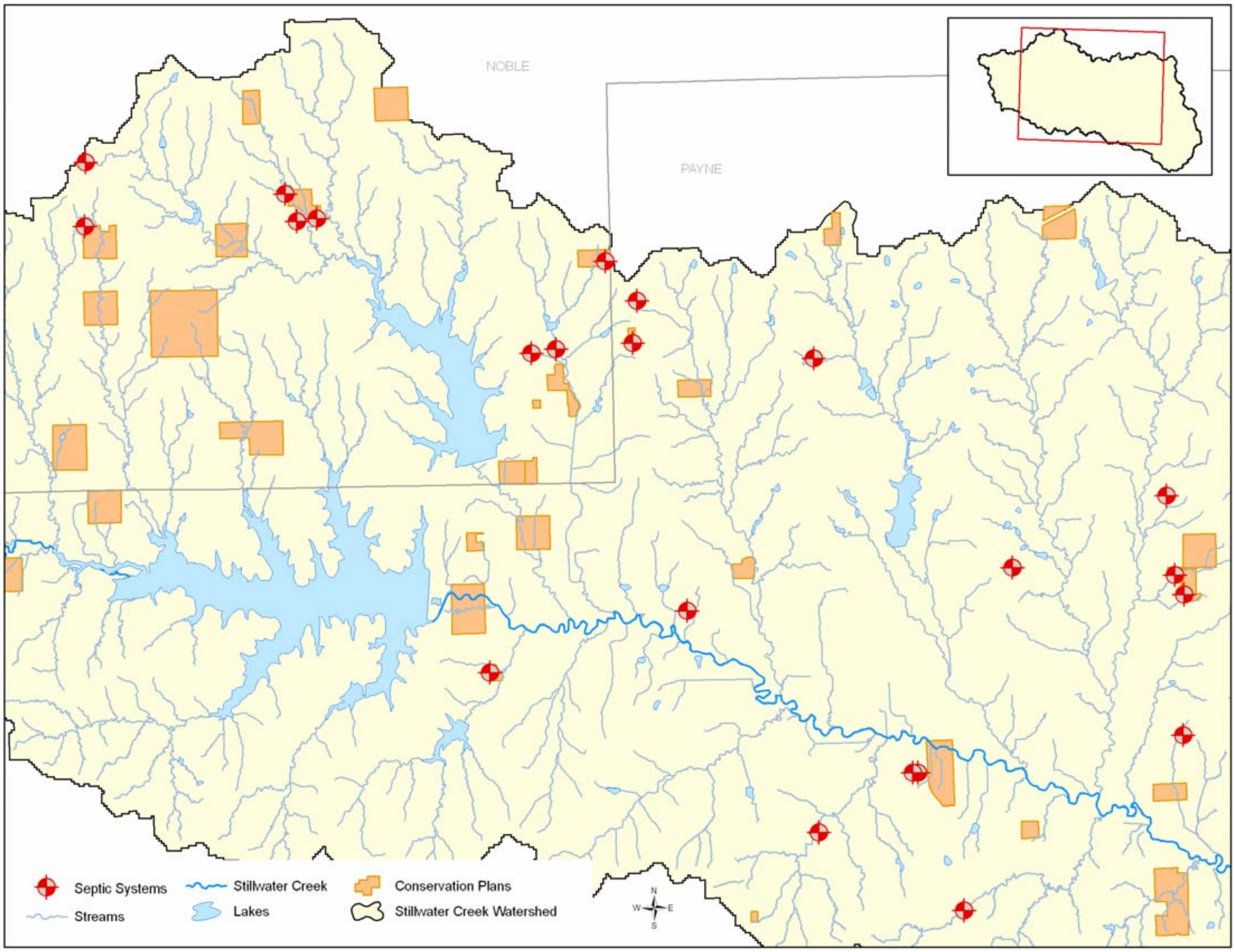


Figure 13. Waste management practices installed.

Assessment of Oil and Gas Field Related Impacts (Oklahoma Corporation Commission)

Erosion related to oilfield activities and oilfield related pollutants were alleged to be among the sources contributing to the degradation of this watershed. Excess sediments could be eroding due to poor practices, including the ongoing building and maintenance of drilling and production sites and access roads, or from historic abandoned and/or brine damaged sites. Pollutants (especially produced brines) can be released into surface waters from current leaks and spills; from abandoned pits, salt water disposal sites, and brine scarred land; from improperly plugged wells that are now unloading oil, gas, or brines to the surface; and from subsurface groundwater pollution plumes via seeps on land and directly into streams. The exact sources for the alleged excess sediment and pollutant problems in this watershed were unknown, so the Corporation Commission undertook a project to:

1. Locate the sources (spills and leaks, unloading improperly plugged wells, salt scarred and other eroding damaged surface areas) within oil and gas fields in the Stillwater Creek watershed that are contributing to threats and/or impairments of stream and lake water quality and farmland (crop and pasture) productivity,
2. Begin the process of correcting the identified problems via education and, if necessary, enforcement,
3. Conduct education, both one on one with operators on proper site management and via demonstration projects on either proper well plugging or on restoring damaged sites to productive crop or pastureland use.

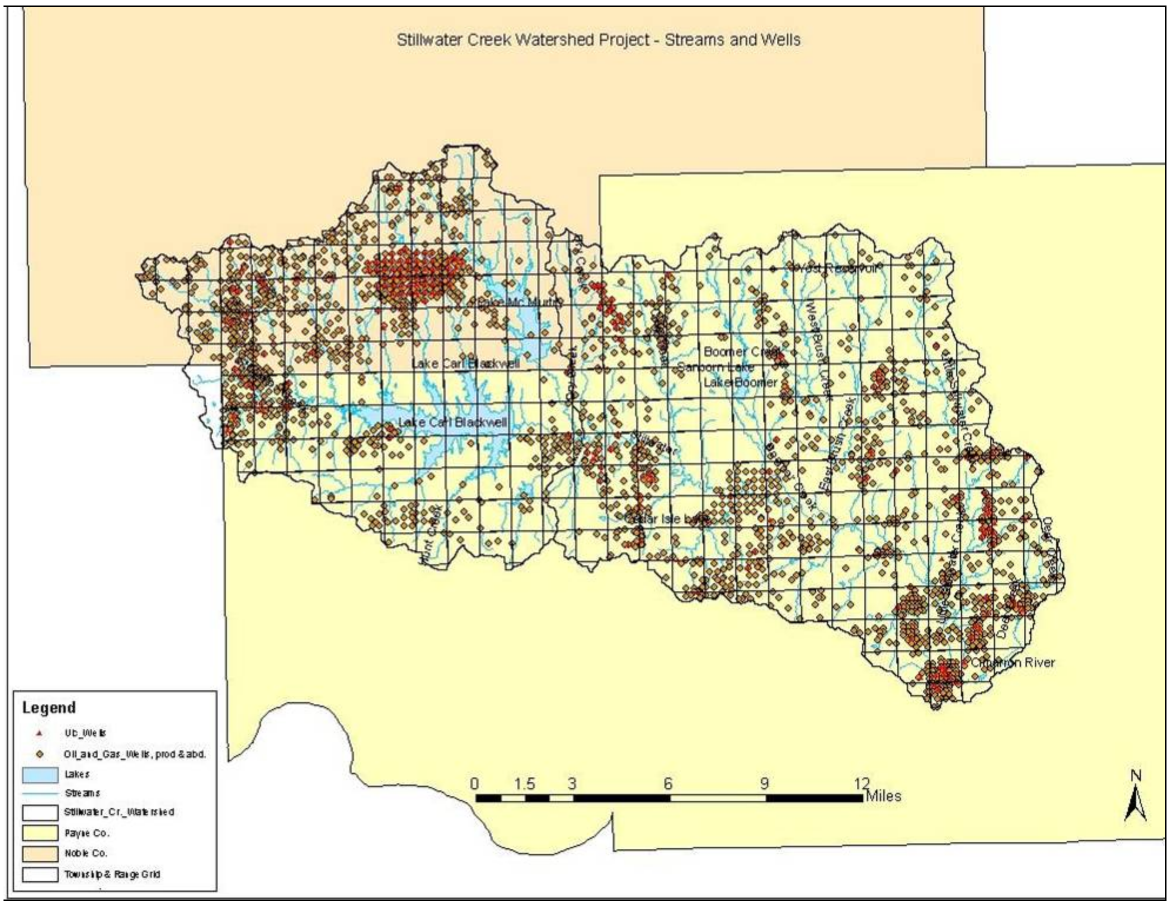


Figure 14. Location of oil and gas wells in the Stillwater Creek watershed (from Corp Comm Report 1).

During the course of this project,

- 1963 aerial photographs associated with the old USDA county soil survey books were examined, and soil areas noted as having oilfield waste were listed for an inspection of historically impacted areas.
- Modern (within the last five years) aerial photos were checked for signs of erosion associated with oil & gas wells.

- All current and accessible abandoned well sites around Lake Carl Blackwell, out to the edges of the watershed, were visually inspected by Corp. Comm. field personnel, as well as the forty square mile area north and south of the Oklahoma State University Campus in Stillwater.
- The Assistant District Manager and District Hydrogeologist held a meeting with 5 major pipeline companies (Conoco, Williams, Sun, MidContinent, and Equilon) regarding this project, proper erosion prevention and notification procedures, site remediation, and proper line abandonment.
- Several producers were counseled regarding inadequate spill prevention berms around their tanks.
- TDS meter readings were taken in a few streams in the areas inspected.
- One abandoned site needing remediation was referred to the OERB.

All TDS readings were in the 200 to 700 ppm range, well below state water quality standards, indicating that there is no general brine problem in these areas. Most of the erosion problems were not primarily associated with oilfield production but were, instead, in cropland and overgrazed pasture areas. Thus, no significant impact from sediment eroded from oil and gas sites is expected. No wells were found which needed plugging, and no OERB cleanup work was done in this watershed, so the expected actions and funding matches from the OERB and state plugging funds did not occur. Appendix A contains the reference for the final report on this project.

Shoreline Stabilization (OWRB)

Lake Carl Blackwell is on the state's 303(d) list for turbidity. The lake's problem originates with the drainage basin where highly erosive soils are washed into the reservoir. This problem is exacerbated by wind and wave action eroding the shores and banks which contribute to the resuspension of fine particles in the water column. Land use also negatively affects this area, as cattle graze much of the surrounding land to the shoreline, and landowners mow up to the water's edge. There is virtually no woody vegetation on the shoreline to protect the banks' edge or aquatic vegetation in the littoral zone to help trap and reduce the suspended solids.

The OWRB, in cooperation with the Payne County Conservation District, the NRCS, and OSU Lake Carl Blackwell Staff, devised a shoreline stabilization project. The main objectives of this project were to:
1. Develop a shoreline erosion plan,
2. Implement bioengineering techniques to minimize shoreline erosion,
3. Monitor the erosion control techniques to determine effectiveness.

As part of the initial task, sites were selected by consultation with NRCS Technical Staff. While stabilizing a few sites on this lake will have a very small impact on the overall quality of the lake, the intent of these demonstrations was to devise and plan methods of shoreline stabilization that are practical in cost, labor, and time, so that lake managers will desire to implement the procedures themselves lake-wide and, thus, make a significant difference to the overall health of the lake.

As part of task 2, two different types of breakwater were installed and tested for effectiveness with respect to sediment accumulation as well as plant growth. In addition, nine species of aquatic and emergent plants were planted both within cages and without cages to examine the survival of different types of vegetation in the study areas. Two demonstration sites had breakwaters constructed of cut cedar trees, while a third site had a breakwater constructed of Coir Geotextile Rolls (CGRs). The CGRs were planted with rooted stems of emergent aquatics or woody plants. Further detail about the construction of the erosion control structures and the study sites can be found in the final report “Demonstration Project: Mitigation of Non-point Source Impact to Littoral Zone of Lake Carl Blackwell, Payne County, Oklahoma” (see Appendix A for the reference).

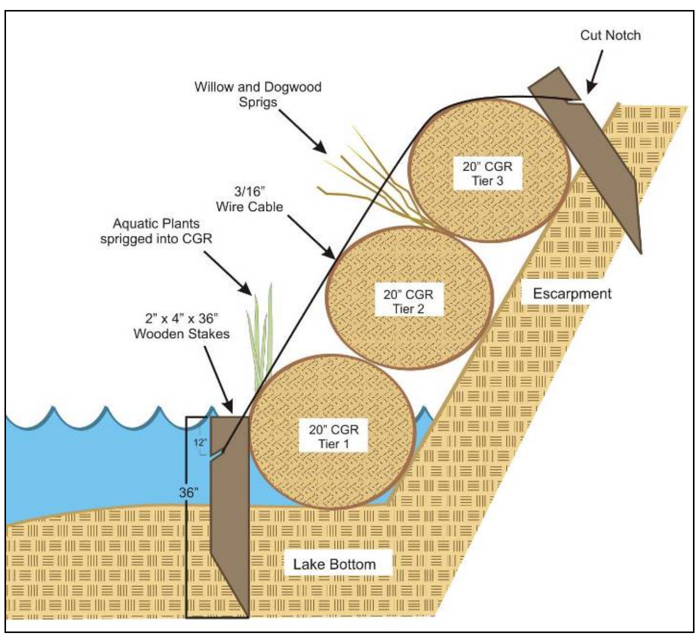


Figure 15. Side cross-section of 3 tiered CGR installation (from OWRB Shoreline Stabilization Plan).

Preliminary monitoring of the project, task 3, indicates that breakwaters, whether constructed of cedar trees or CGRs, were generally not effective in accumulating sediment or in protecting plants from wave action at the study sites. However, CGRs were effective in protecting willow plantings and preventing further bank erosion when placed against the escarpment as in Figure 15. Softstem bulrush had good survival and growth, which suggests that it could be an effective plant to slow erosion; however, most plants will need to be planted within wire enclosures for protection from herbivory.

As a result of this project, the OSU Lake Carl Blackwell staff is continuing erosion control work on the lake. In addition, the OSU Agriculture Research Department was educated and advised about BMPs that exclude livestock from the lake shoreline, since approximately 70% of the lake's shoreline is accessed by cattle. This should result in reduced shoreline erosion.

OWRB also expanded the Oklahoma Water Watch (OWW) Volunteer Monitoring program at Lake Carl Blackwell by obtaining the equipment needed for in-lake multi probe vertical profile sampling, chlorophyll-a testing, and turbidity sampling in order to allow for better documentation of suspended solids status. Additional monitoring sites will be established in the future. OWW was utilized as an educational tool for volunteers, students, and Lake Staff on the water quality of Lake Carl Blackwell. See Appendix A for the reference to the final report on the expansion of Water Watch at Lake Carl Blackwell.

Erosion Control on Rural Roads

This project was intended to assess sediment loss from unpaved rural roads in Payne County, demonstrate BMPs to reduce erosion and sediment yield, measure and compare erosion from road segments with and without BMPs, and educate county road crews, county commissioners, city road crews, and the general public about controlling erosion and sedimentation from unpaved roads.

There are approximately 480 km of unpaved roads in the Stillwater Creek watershed. Rural roads in the region are typically incised below the surrounding land, which means that there is little opportunity for sediment to be routed away from the roads before it reaches streams. About 80% of the unpaved roads in the Lake Carl Blackwell drain directly into streams, while the remaining 20% drain into vegetated areas where some filtering of sediment may occur (Turton et al. 2004).

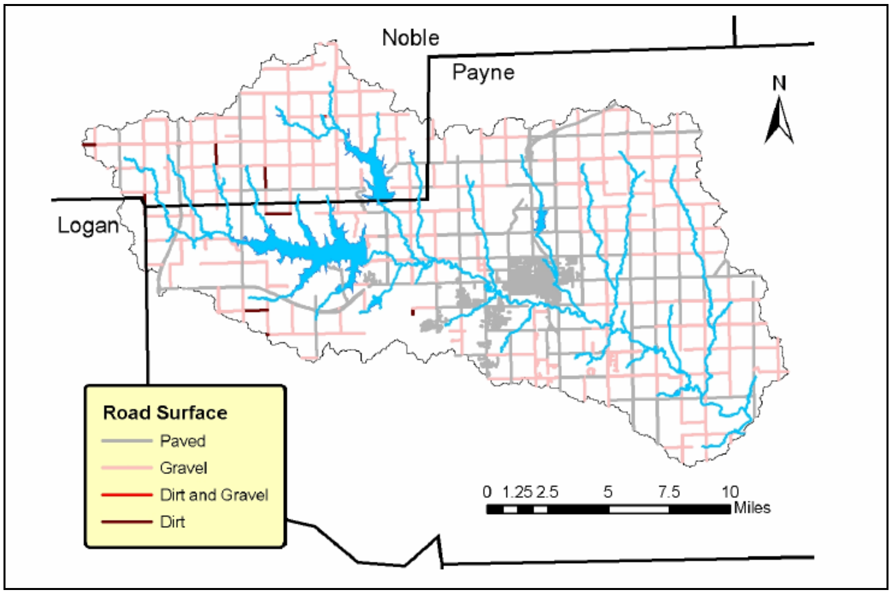


Figure 16. Road surface conditions in the Stillwater Creek Basin (Storm et al. 2003).

Several studies have examined the sediment load due to rural roads in this watershed. Turton et al. (2004) estimated that the annual sediment load delivered to streams from roads in the Stillwater Creek watershed is 70,690 Mg/yr (77,900 tons), correlating to 60% of the annual predicted watershed sediment budget. However, Storm et al. (2003) estimated the long-term mean annual load from road erosion to be only 12,730 Mg/yr (about 14,000 tons; Table 3), or 11% of the annual sediment budget in the watershed. Note that 3,000 tons are contributed by paved roads because eroding side slopes and ditch lines are a source of sediment (Table 3). Based on either of these two estimates, unpaved roads contribute a significant amount to the overall annual sediment budget in Stillwater Creek despite the fact that they occupy only 1.3% of the watershed area.

Table 3. Erosion from roads and ditches predicted by computer model (from Smolen 2006 presentation; data from Storm et al. 2003).

Road Type	Tons/mile	Miles	Tons
Paved	10.6	301	3176
Gravel	35.4	291	10,310
Dirt	76.8	6	429
TOTAL			13,915

A study was initiated to investigate the effectiveness of certain types of road improvement to control erosion at two locations. Measurements of rainfall, flow, and sediment yield were collected using sediment collection stations at each site for each storm over a 2 calendar year period, one year before the BMPs were installed (June 1, 2004- May 31, 2005) and one year after the BMPs were installed (June 1, 2005 – May 31, 2006).

The implementation of the road improvement project used personnel from the Local Technology Assistance Program (LTAP) at Oklahoma State University, which provides training to county commissioners and road crews in the proper design and maintenance of county roads through their "Roads Scholar" program, since they could incorporate the demonstration sites and results into their existing training programs. This allowed rapid and efficient education of the county commissioners and road crews in the Stillwater Creek watershed.

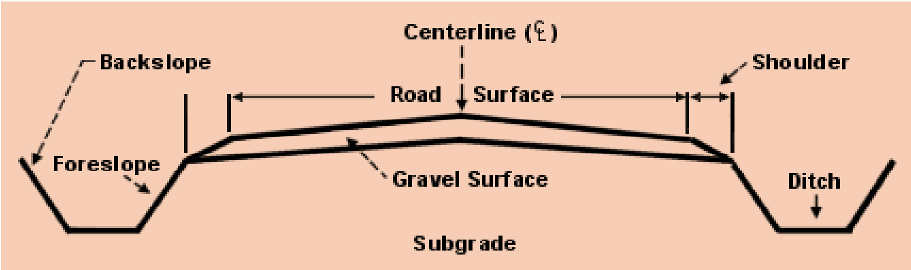


Figure 17. Cross-section of a properly constructed road and ditch.

A segment on each of two roads (19th St. and 32nd St.) in the Stillwater Creek watershed was improved, with proper shaping and grading as well as proper ditch construction (Figure 17). Then, one segment of one road (19th St.) was treated with a geotextile matting and gravel to control erosion. The other road (32nd St.) had a segment with the same reshaping, grading, ditch construction, and gravel, but no geotextile fabric was installed. Both were compared to sections of unimproved road at the same locations.

19th St.: Geotextile matting laid onto newly shaped and graded road; followed by overlay of gravel.

Turton et al. (2006) found that the BMPs applied in this project were effective in reducing erosion and sediment loads. Mean flow-weighted sediment concentrations were reduced by 160% on the 19th St. segment (with the geotextile matting installed) and by 99% on the 32nd St. segment as a result of BMP application. These were both statistically significant reductions ($p<0.01$).

To determine to what degree sediment yields were reduced during the second year following BMP installation, the pre-BMP regressions were used to predict what the accumulated sediment yields would be during the post-BMP period had the BMPs not been installed. The total accumulated sediment yields from the control segments were entered into the pre-BMP regression equations for their respective sites. The predicted accumulated sediment yield for the post-BMP period with BMPs applied was determined using the post-BMP regression equations. The accumulated sediment yield at the end of the pre-BMP period was subtracted from each of the predicted values to determine what the savings in sediment yields were for the post-BMP period only. The quantity of sediment that was eliminated by installing the BMPs was determined by subtracting the two predicted totals. The percent reduction in accumulated sediment yield was calculated by: ((predicted w/o BMPs – predicted w/BMPs) ÷ predicted w/o BMPs)*100%. The reduction in accumulated sediment yield resulting from the application of BMPs on the road segments was 60% and 81% for the two sites, respectively (Figure 18). Appendix A contains the reference for the complete final report on this project.

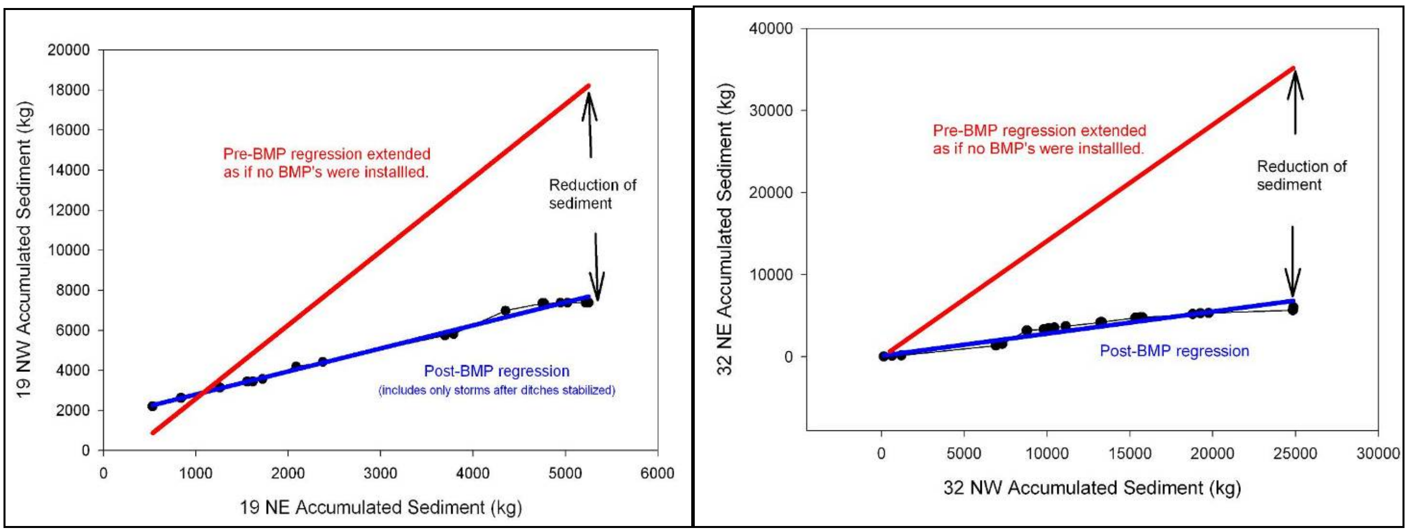
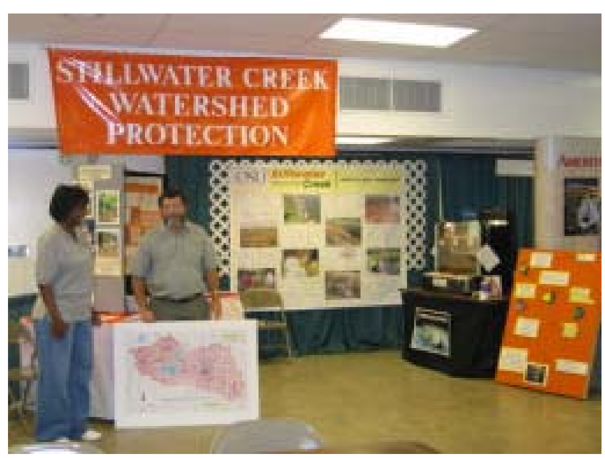


Figure 18. Linear regression lines of the relationships of accumulated sediment yield between the BMP and non-BMP stations for the post-BMP period. One line represents the relationship had BMPs not been installed (extension of the pre-BMP regression). The other line is based on post-BMP measurements. The difference between the 2 lines represents the quantity of sediment saved by installing BMPs (from Turton et al. 2006).

Nonpoint Source Education Program



The OSU Cooperative Extension Service was contracted to provide educational programs in the Stillwater Creek watershed. The primary goal of the Stillwater Creek education program was "to educate the residents of Stillwater Creek on prevention of nonpoint source pollution." Numerous tasks were carried out to accomplish this goal, which targeted both urban and rural residents.

Educational materials on NPS pollution

issues and watersheds in general were distributed through the Payne County Cooperative Extension, the City of Stillwater, local homeowners associations, OSU, the Audubon Society, the Payne Conservation District, and the Oklahoma Conservation Commission. Booths educating the public about the Stillwater Creek Watershed and NPS were set up at three Audubon Nature Days (approximately 500 in attendance), the 2003 and 2005 Earth Day events at OSU, the 2004 and 2005 Payne County Fairs (over 800 participants), and the 2004 and 2005 Payne County Home and Garden Shows (over 1000 in attendance at each event). Additional information was disseminated at the Stillwater Waste Collection Day as well as through public schools in the watershed.

Other activities organized and promoted as a part of the education program include marking storm drains to reduce dumping and increase the public awareness of NPS pollution and expansion of the Blue Thumb volunteer stream monitoring program in the watershed. Twenty-two volunteers were trained and three organizational groups were qualified to monitor streams in Stillwater Creek watershed through the Blue Thumb Program. Consequently, three new stream sites will be monitored. Nine volunteers received training at the OSU hydraulic lab in order to monitor stream flow/discharge and have agreed to measure stream stage at designated sites.

Four large tasks were delineated to accomplish the bulk of the education in the Stillwater Creek watershed, as described below. The details of these tasks can be accessed in the education final report (see Appendix A for the reference).

Task 1. Conduct survey to determine knowledge of and attitudes toward pollution control among urban and rural residents (pre- and post-project).

A telephone survey was conducted to assess the level of knowledge among residents before and after the presentation of education programs in the watershed. Three hundred and eighty-three phone calls were completed pre-implementation, while 387 were completed post-project. A significant increase in knowledge was observed with regard to water quality NPS pollution issues. In addition, individual/local responsibility for pollution control was realized by many of the participants, which represented an important change in attitude toward NPS pollution.

Task 2. Conduct sediment control education program with the City of Stillwater.

State Specialists worked with City of Stillwater officials to set up training classes for City staff and developers. The training classes addressed urban storm water and sediment control on construction sites. Tours of sites which demonstrated common problems were a component of the classes, which taught design, installation, and maintenance of urban BMPs. Eleven city officials and three OSU

Extension staff attended the training. In addition, a training module was developed for the city, to be given to new employees and contractors.

Task 3. Conduct pesticide and fertilizer education program with City of Stillwater and OSU campus.

State Specialists in Entomology/Plant Pathology, Horticulture, and Plant and Soil Sciences educated the community through on-campus demonstrations and various public programs. The program focused on household, lawn, and garden use of fertilizer and chemicals and, specifically, promoted soil sampling and integrated pest management (IPM) techniques to reduce use of chemicals.

Specific programs accomplished as a part of this task include:

- Free soil testing of 54 homes in two neighborhoods
- IPM and pond management lectures for homeowners
- Workshops and field days for ornamentals and turf care/management for homeowners (three consecutive sessions) and for OSU grounds staff and landscape professionals (four sessions, one per year; over 200 professionals)
- Workshop on bioretention cells (“raingardens”)
- Workshop on calibrating fertilizer and pesticides for homeowners in Payne County (13 participants), which showed significantly increased knowledge after the program relative to before

Task 4. Conduct education / demonstration program on agricultural BMPs.

A riparian demonstration site was established on the OSU farms, west of campus. This site, along with riparian demonstration areas developed by the Conservation District, was highlighted on project tours sponsored by the counties. Other BMPs such as no-till wheat, filter strips, fertilizer management, and integrated pest management (IPM) were demonstrated in educational programs at the OSU farms. Project results were shared with the public through Extension newsletters in Payne and Noble counties.

In addition, educational information and presentations were given at the 2005 Cattlemen’s Association Annual Banquet and a meeting of the Fruit and Vegetable Growers Association. A pesticide container collection was organized which targeted agricultural producers and allowed further dissemination of NPS pollution information. An “Oklahoma A*Syst” workshop in Payne County provided education on well water to both suburban and rural residents. As a result of these efforts, in part, an increase in the implementation of BMPs has been observed in the Stillwater Creek watershed.

The positive behavior changes resulting from the Stillwater Creek educational materials and programming are expected to continue and should eventually help to reduce the pollution in the watershed.

Water Quality Assessment

Water quality monitoring is critical to the project for purposes of determining the causes and sources of NPS derived pollution in the watershed and ascertaining whether or not project efforts have had an effect on water quality. A considerable amount of water quality monitoring has occurred since 2000 and is ongoing in the Stillwater Creek Watershed. Data collected from 2000-2006 at three OCC sites on Stillwater Creek (Figure 19; Table 4) was examined to assess whether any detectable changes in water quality are occurring.

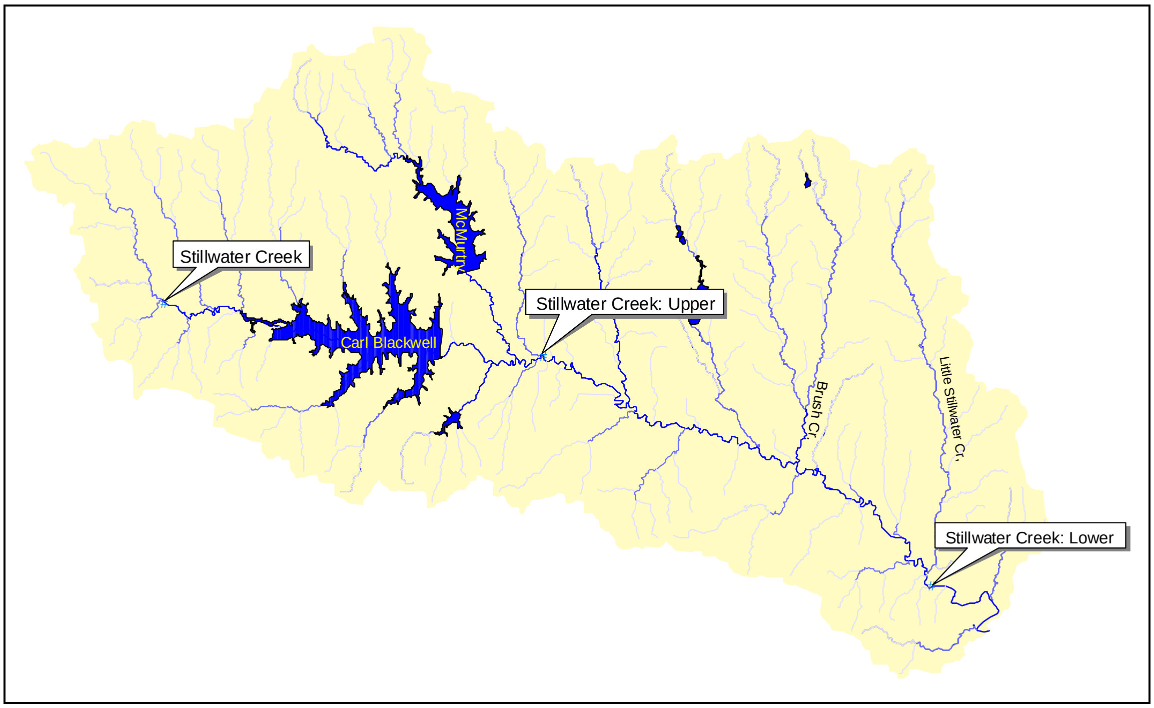


Figure 19. OCC monitoring sites.

Table 4. OCC monitoring sites in Stillwater Creek Watershed.

Site Name	WBID	Latitude	Longitude	Legal
Stillwater Creek: Lower	OK620900-04-0040C	36.0400	-96.9445	W.B. Section 13 18N 3E
Stillwater Creek: Upper	OK620900-04-0070T	36.1305	-97.1401	NE¼ Section 13 19N 1E
Stillwater Creek	OK620900-04-0270G	36.1499	-97.3300	Section 5 19N 1W

Figure 20 presents total phosphorous and orthophosphorous data from each site, with instantaneous discharge presented on each graph. Figure 21 similarly depicts total nitrogen and available nitrogen, and Figure 22 shows turbidity and total suspended solids for each site during the project period.

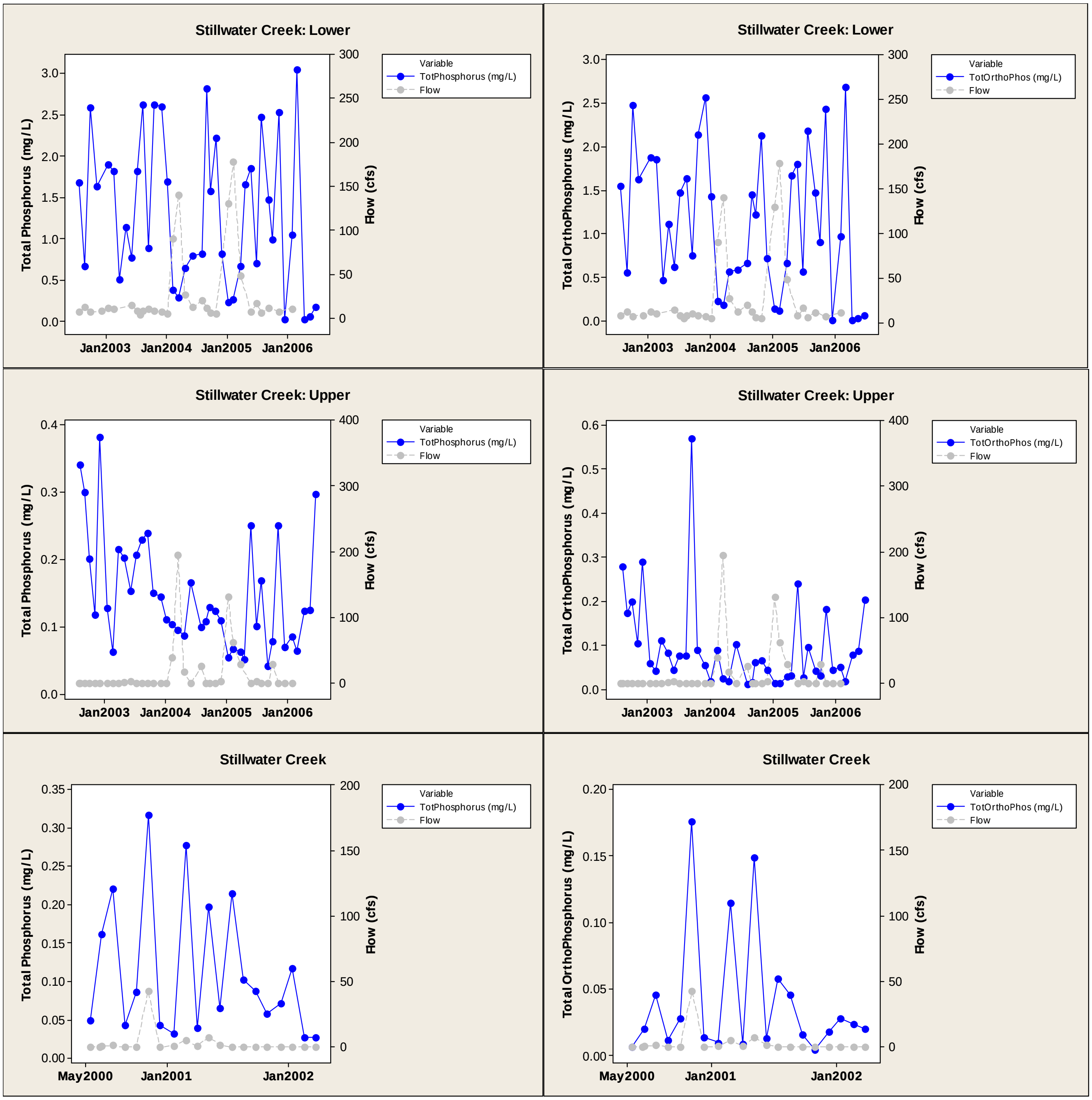


Figure 20. Phosphorus data from each OCC monitoring site.

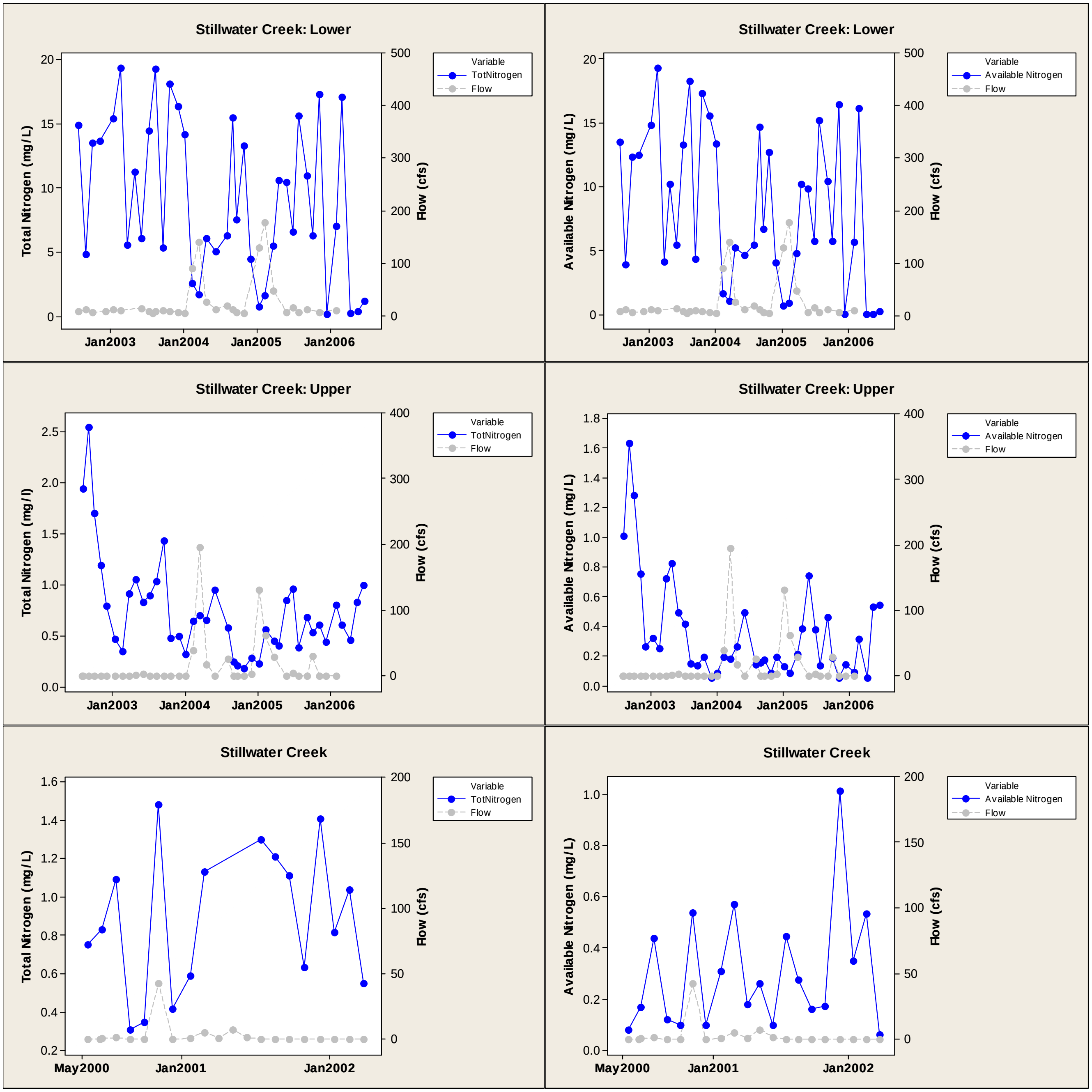


Figure 21. Nitrogen data from each OCC monitoring site.

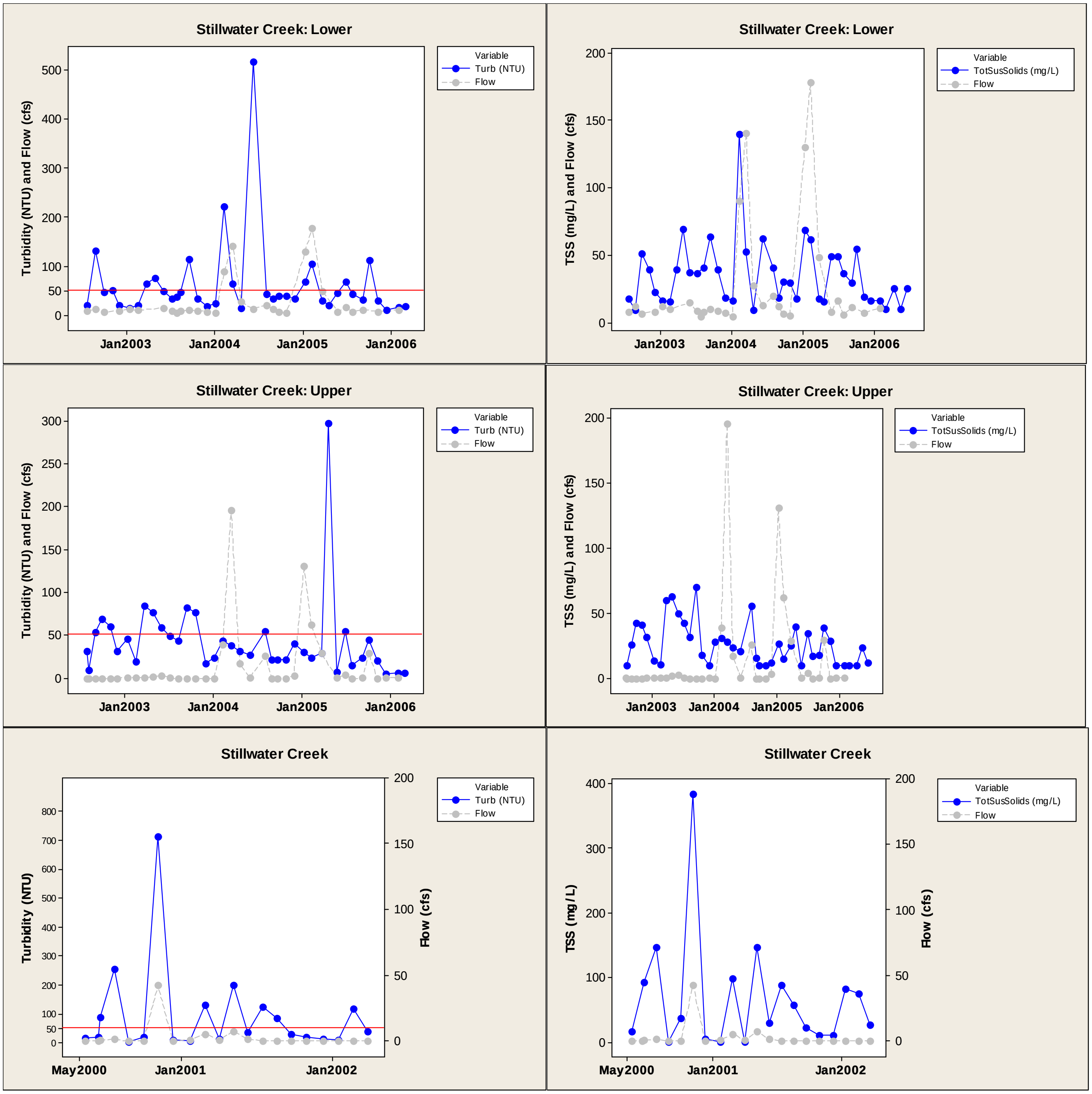


Figure 22. Sediment data from each OCC monitoring site. The red line in the turbidity graphs indicates the criterion cutoff (50 NTU) at which a water sample is considered exceeding for the FWP--WWAC use.

For the "Stillwater Creek: Upper" and "Stillwater Creek: Lower" sites, high nutrient and sediment values tend to be inversely related to high flow. At the site "Stillwater Creek," located above Lake Carl Blackwell, high nutrient levels tend to correspond with high discharge values. These relationships seem to indicate that point sources may contribute significantly to the nutrient and sediment load in Stillwater Creek downstream of Lake Carl Blackwell, while nonpoint source pollution is responsible for much of the nutrient and sediment load upstream of the lake.

Table 5. Descriptive statistics by site.

Variable	SiteName	N	N*	Mean	SE Mean	StDev	Min.	Q1	Median	Q3	Max.
Alkalinity ($CaCO_3$)	Lower	39	3	117.41	8.19	51.14	37.00	84.00	113.00	140.00	272.00
	Upper	39	4	211.50	13.80	86.10	26.00	150.00	194.00	252.00	429.00
	Stillwater Crk	21	0	275.70	16.50	75.80	132.00	214.00	296.00	331.00	436.00
Ammonia (mg/L)	Lower	40	2	0.15	0.06	0.37	0.02	0.02	0.05	0.09	2.21
	Upper	41	2	0.11	0.02	0.16	0.02	0.02	0.05	0.10	0.64
	Stillwater Crk	20	1	0.11	0.02	0.09	0.01	0.05	0.06	0.15	0.33
cBOD5 (mg/L)	Lower	41	1	2.80	0.16	1.02	2.00	2.00	2.20	3.45	5.00
	Upper	41	2	3.15	0.28	1.80	2.00	2.00	2.30	3.65	8.70
Chloride (mg/L)	Lower	41	1	155.20	25.30	161.80	32.80	72.50	117.00	160.70	770.90
	Upper	41	2	37.42	3.70	23.68	12.60	28.05	32.10	39.25	157.40
	Stillwater Crk	20	1	461.10	61.50	275.20	93.20	237.30	447.40	600.00	1052.80
Conductivity (uS/cm)	Lower	39	3	913.30	69.70	435.00	401.10	658.00	890.00	1058.00	2952.00
	Upper	38	5	623.80	33.10	204.20	339.30	457.90	611.50	778.50	1142.00
	Stillwater Crk	21	0	1750.00	182.00	833.00	182.00	1261.00	1802.00	2355.00	3409.00
DO (mg/L)	Lower	37	5	8.04	0.45	2.76	4.47	6.01	6.90	10.49	13.67
	Upper	39	4	6.15	0.54	3.36	0.93	3.31	5.99	8.00	15.04
	Stillwater Crk	21	0	7.47	0.76	3.49	2.02	4.83	6.27	10.55	15.29
DO, %Sat.	Lower	36	6	80.24	2.79	16.72	55.00	65.65	75.20	96.78	111.00
	Upper	37	6	58.92	4.35	26.43	9.60	34.95	63.60	80.20	108.50
Flow	Lower	31	11	28.12	7.93	44.14	5.07	8.01	10.99	17.15	178.32
	Upper	37	6	14.89	6.46	39.27	0.00	0.15	0.45	3.83	195.66
	Stillwater Crk	21	0	2.96	2.03	9.29	0.00	0.00	0.09	1.16	42.57
Nitrate (mg/L)	Lower	41	1	8.31	0.91	5.82	0.02	4.06	6.71	13.28	19.24
	Upper	41	2	0.23	0.03	0.22	0.02	0.07	0.16	0.29	0.94
	Stillwater Crk	10	11	0.20	0.09	0.29	0.01	0.01	0.04	0.41	0.85
Nitrate/Nitrite	Lower	41	1	8.39	0.91	5.84	0.04	4.08	6.73	13.33	19.25
	Upper	41	2	0.26	0.04	0.24	0.04	0.09	0.18	0.31	1.00
	Stillwater Crk	20	1	0.19	0.05	0.22	0.02	0.03	0.10	0.29	0.86
Nitrogen, Available	Lower	40	2	8.44	0.94	5.94	0.06	4.09	6.27	13.47	19.32
	Upper	41	2	0.37	0.05	0.35	0.06	0.14	0.22	0.50	1.64
	Stillwater Crk	20	1	0.30	0.05	0.24	0.06	0.11	0.22	0.44	1.01
Nitrogen, Total	Lower	40	2	9.20	0.95	6.01	0.22	4.97	7.32	14.78	19.36
	Upper	41	2	0.75	0.07	0.48	0.18	0.45	0.65	0.93	2.54
	Stillwater Crk	17	4	0.88	0.09	0.37	0.31	0.57	0.83	1.17	1.48
pH (SU)	Lower	38	4	7.66	0.06	0.35	6.99	7.39	7.65	7.91	8.46
	Upper	40	3	7.61	0.05	0.30	7.03	7.42	7.62	7.77	8.28
	Stillwater Crk	20	1	7.76	0.06	0.29	7.31	7.49	7.81	8.02	8.12
Temp (°C)	Lower	39	3	17.54	1.47	9.20	1.60	8.50	19.60	25.30	30.90
	Upper	40	3	16.91	1.41	8.93	1.90	7.38	18.75	23.78	29.60
	Stillwater Crk	21	0	15.70	1.90	8.71	2.00	7.55	17.50	24.20	27.50
Total OrthoPhosph.	Lower	40	2	1.14	0.13	0.81	0.01	0.56	1.04	1.77	2.69
	Upper	41	2	0.10	0.02	0.11	0.01	0.03	0.06	0.10	0.57

Variable	SiteName	N	N*	Mean	SE Mean	StDev	Min.	Q1	Median	Q3	Max.
(mg/L)	Stillwater Crk	20	1	0.04	0.01	0.05	0.01	0.01	0.02	0.05	0.18
Total Phosphorus (mg/L)	Lower	40	2	1.32	0.14	0.90	0.03	0.65	1.10	1.90	3.05
	Upper	41	2	0.15	0.01	0.08	0.04	0.09	0.12	0.21	0.38
	Stillwater Crk	20	1	0.11	0.02	0.09	0.03	0.04	0.08	0.19	0.32
Total Suspended Solids (mg/L)	Lower	41	1	35.66	3.81	24.37	10.00	17.50	30.00	50.00	140.00
	Upper	41	2	26.59	2.57	16.44	10.00	11.50	24.00	37.00	70.00
	Stillwater Crk	20	1	67.60	19.70	88.20	1.00	12.00	34.00	92.80	385.00
Turbidity (NTU)	Lower	39	3	62.30	13.60	85.10	11.80	21.40	39.40	64.20	517.00
	Upper	39	4	43.64	7.54	47.10	5.10	21.30	31.60	54.40	297.00
	Stillwater Crk	21	0	93.80	34.50	158.30	4.50	13.80	29.10	122.00	715.00

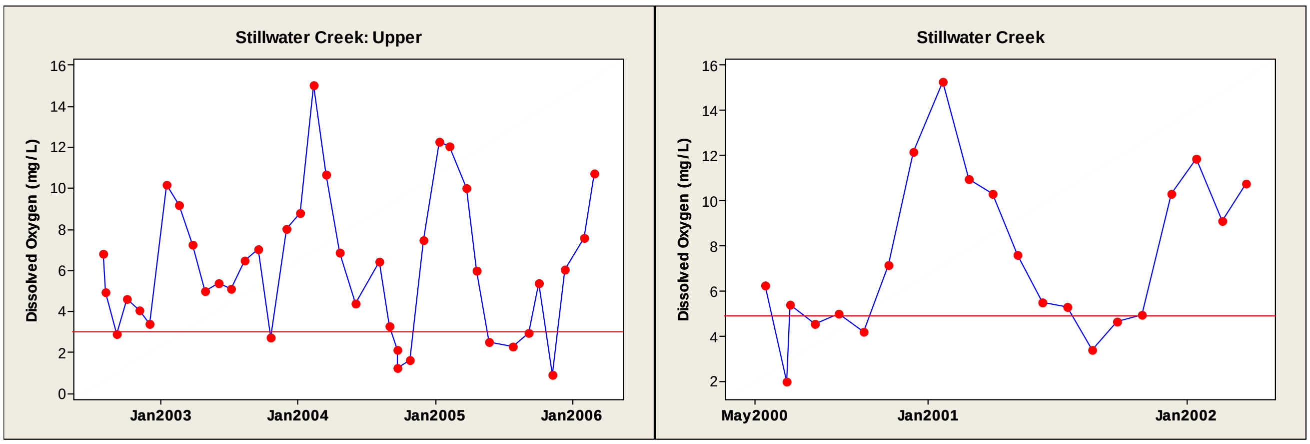
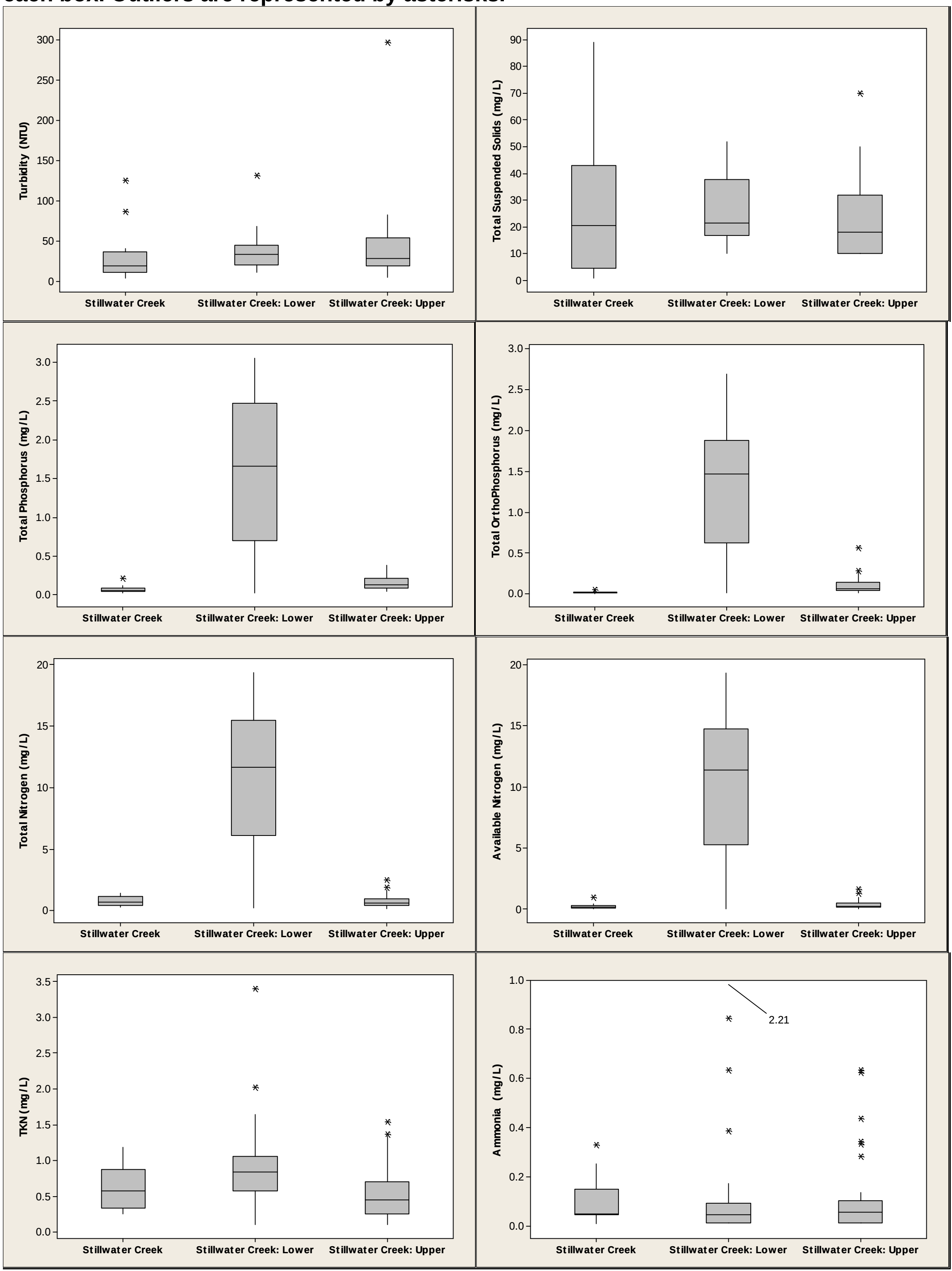
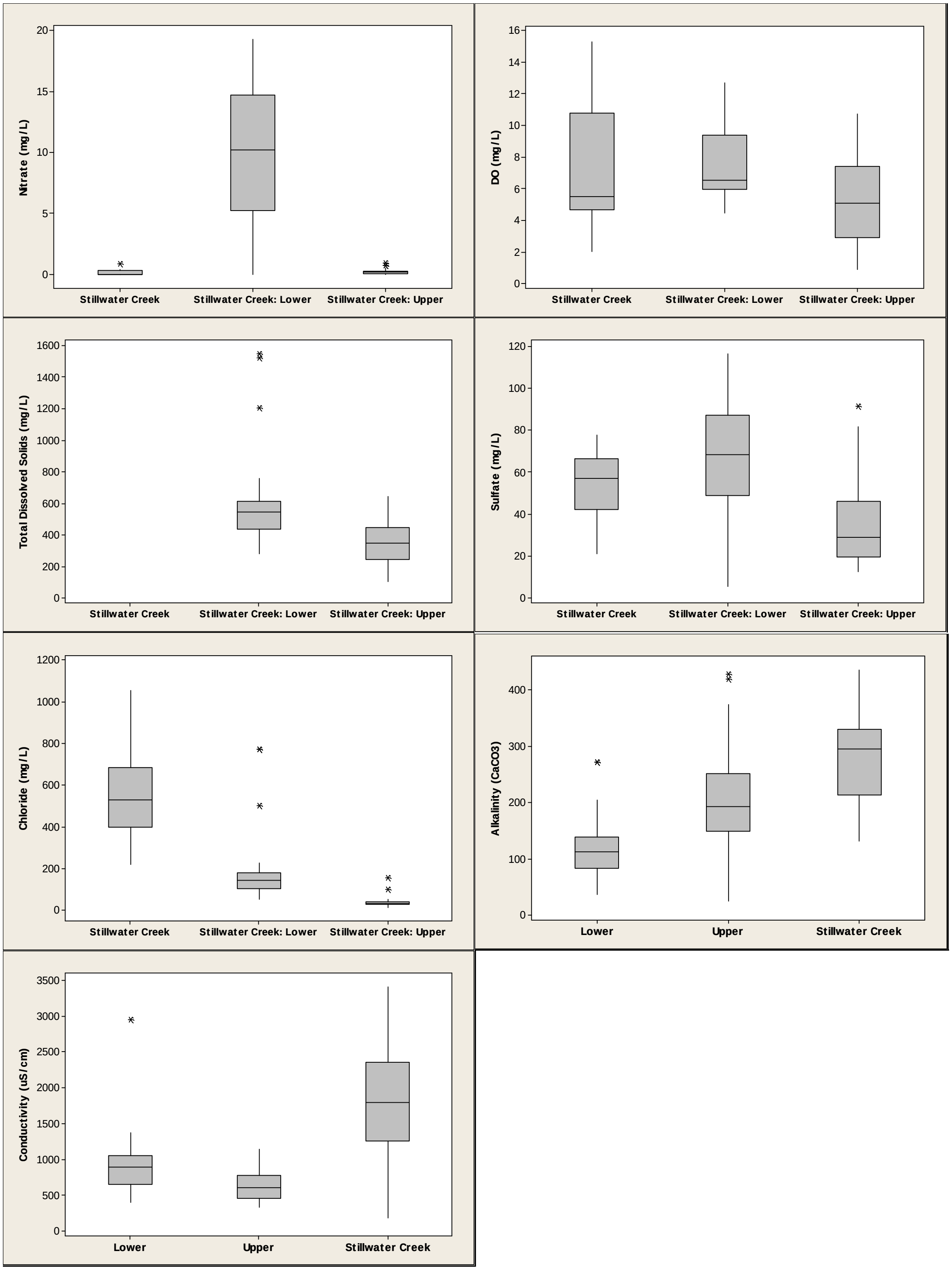


Figure 23. Dissolved oxygen (DO) values for “Stillwater Creek: Upper” and for “Stillwater Creek.” Both of these sites have low DO, as indicated by values below the red line which shows the criteria for the appropriate Fish and Wildlife Propagation designated use.

Figure 24. Interquartile ranges of water quality parameters. The top and bottom box edges mark the first and third quartiles of the data. Median values are indicated by horizontal lines within each box. Outliers are represented by asterisks.




Nitrate (mg/L)
Stillwater Creek
Stillwater Creek: Lower
Stillwater Creek: Upper
DO (mg/L)
Stillwater Creek
Stillwater Creek: Lower
Stillwater Creek: Upper
Total Dissolved Solids (mg/L)
Stillwater Creek
Stillwater Creek: Lower
Stillwater Creek: Upper
Sulfate (mg/L)
Stillwater Creek
Stillwater Creek: Lower
Stillwater Creek: Upper
Chloride (mg/L)
Stillwater Creek
Stillwater Creek: Lower
Stillwater Creek: Upper
Alkalinity (CaCO3)
Lower
Upper
Stillwater Creek
Conductivity (uS/cm)
Lower
Upper
Stillwater Creek

One fish collection and habitat assessment was performed for each of the three sites over the course of the project. In addition, macroinvertebrate collections were attempted twice a year, once during the winter period (January 1 to March 15) and once during the summer (July 1 to September 15). Sampling efforts included attempts to procure animals from all available habitats at a site; thus, total effort at a site may have entailed up to three total samples with one from each of the following habitats: rocky riffles, streamside vegetation, and woody debris. Lack of flow may have prevented the collection of macroinvertebrates at times.

Tables 6 and 7, below, show summary metrics used to assess the condition of the biota at the sites. The methods used to determine the condition of the biological communities at each site are based on and modified from methods outlined in the EPA Rapid Bioassessment Protocols (Plafkin et al., 1989). The biological data is compared relative to data from high quality sites in the Central Great Plains ecoregion. The detailed protocol can be accessed in the methods section of OCC document "Small Watershed Rotating Basin Monitoring Program Year 3" (2006).

Table 6. Fish metrics used for calculating an Index of Biological Integrity (IBI).

SiteName	Date of Collection	Total Individuals	Total Species	# Sensitive Benthic Spp.	# Sunfish Spp.	# Intolerant Spp.	Proportion Tolerant Individuals	Proportion Insect. Cyprinid Individuals	Proportion Lithophilic Spawners	% of Reference Condition (IBI)	Condition
Stillwater Creek	6/14/2000	124	10	0	6	0	96.77	0.00	0.00	0.65	fair
Stillwater Creek: Upper	7/30/2002	312	18	2	5	1	99.36	0.32	0.32	1.00	excellent
Stillwater Creek: Lower	7/28/2003	283	17	2	4	0	97.53	21.20	0.35	0.91	good

Table 7. Macroinvertebrate metrics (averaged over collections per season and type) used for calculating an Index of Biological Integrity (IBI).

Site	Summer or Winter	Type	Total Species	EPT Taxa	Percent EPT	Shannon Diversity	HBI	Percent dominant 2 taxa	% of Reference Condition (IBI)	Condition
Stillwater Creek	s	riffle	13	4	0.72	1.77	4.25	0.63	0.80	nonimpaired
Stillwater Creek	s	wood	11	5	0.59	1.62	5.09	0.66	0.94	nonimpaired
Stillwater Creek	w	riffle	10	3	0.14	1.26	5.86	0.80	0.62	slightly impaired
Stillwater Creek	w	wood	6	1	0.02	0.62	5.96	0.93	0.23	impaired
Stillwater Creek: Upper	s	veg	15	3	0.28	2.27	6.10	0.44	0.75	slightly impaired
Stillwater Creek: Upper	s	wood	20	7	0.32	2.23	6.38	0.43	1.00	nonimpaired
Stillwater Creek: Upper	w	veg	21	0	0.00	2.55	7.22	0.37	1.00	nonimpaired
Stillwater Creek: Upper	w	wood	20	2	0.05	2.37	7.36	0.43	0.77	slightly impaired
Stillwater Creek: Lower	s	riffle	10	3	0.40	1.77	5.90	0.62	0.73	slightly impaired
Stillwater Creek: Lower	s	wood	8	4	0.54	1.47	5.39	0.69	0.94	nonimpaired
Stillwater Creek: Lower	w	riffle	13	1	0.20	2.12	6.61	0.41	0.92	nonimpaired

Table 8. Habitat assessment values.

Site Name	Date	Instream Cover	Pool Bottom Substrate	Pool Variability	Canopy Cover Shading	Presence of Rocky Runs or Riffles	Flow	Channel Alteration	Channel Sinuosity	Bank Stability	Bank Vegetation Stability	Streamside Cover	Total Points	% of Reference
Stillwater Creek	14-Jun-00	3.4	6.5	15.7	7.7	2.2	0	5.8	4	6.8	5.8	9.1	67	0.81
Stillwater Creek: Upper	30-Jul-02	4.9	1	15.7	19.8	0	1	15.1	2.4	7.2	2.7	8.7	79	0.95
Stillwater Creek: Lower	28-Jul-03	2.3	0.4	0	8.4	4.1	15	15.1	3	9.7	4.4	10	72	0.87

In general, the biological communities of the three Stillwater Creek sites were healthy relative to the high quality sites in the ecoregion. Of the three sites, Stillwater Upper had the best fish collection, the best habitat, and the highest average macroinvertebrate scores. The Stillwater site above Lake Carl Blackwell had the lowest fish and habitat scores but about the same average macroinvertebrate score as the Lower site. The biological communities and the habitat of the sites will be monitored in the future to assess any changes.

Stillwater Creek (above Lake Carl Blackwell) was not listed on the 303(d) list for pathogens in either 1998 or 2002 due to insufficient data, and it still does not have sufficient data to assess the designated Primary Body Contact Recreation (PBCR) use. However, Stillwater Creek Lower is nominated for listing on the 2006 list as not attaining the PBCR use due to both *E. coli* and *Enterococcus* exceedances (Figure 25). Stillwater Creek Upper has been assigned a Secondary Body Contact Recreation (SBCR) use, and it meets the required bacteria levels to attain that designated use.

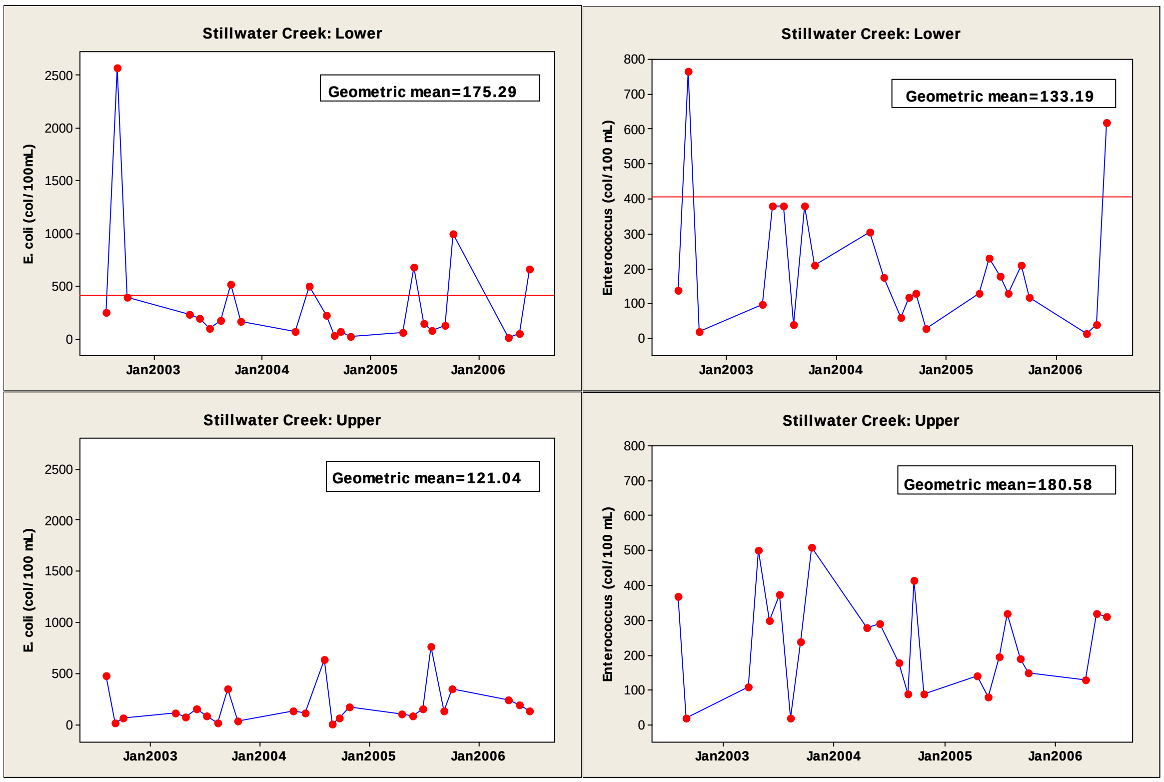


Figure 25. Bacteria values at each site. Red lines indicate the critical values for meeting the PBCR criteria.

In order to assess the effectiveness of the implemented BMPs, regressions were performed to look for improving trends in water quality during the project period. The only significant trends, positive or negative, were observed at the Stillwater Creek: Upper site. Both TSS and turbidity had significant linear regressions, indicating decreasing amounts of sediment from July 2002 to June 2006 (Figure 26). Only seasonal baseflow data were used in these analyses, with elevated flow data omitted. The turbidity data required natural log (ln) transformation to achieve normality prior to performing the regression.

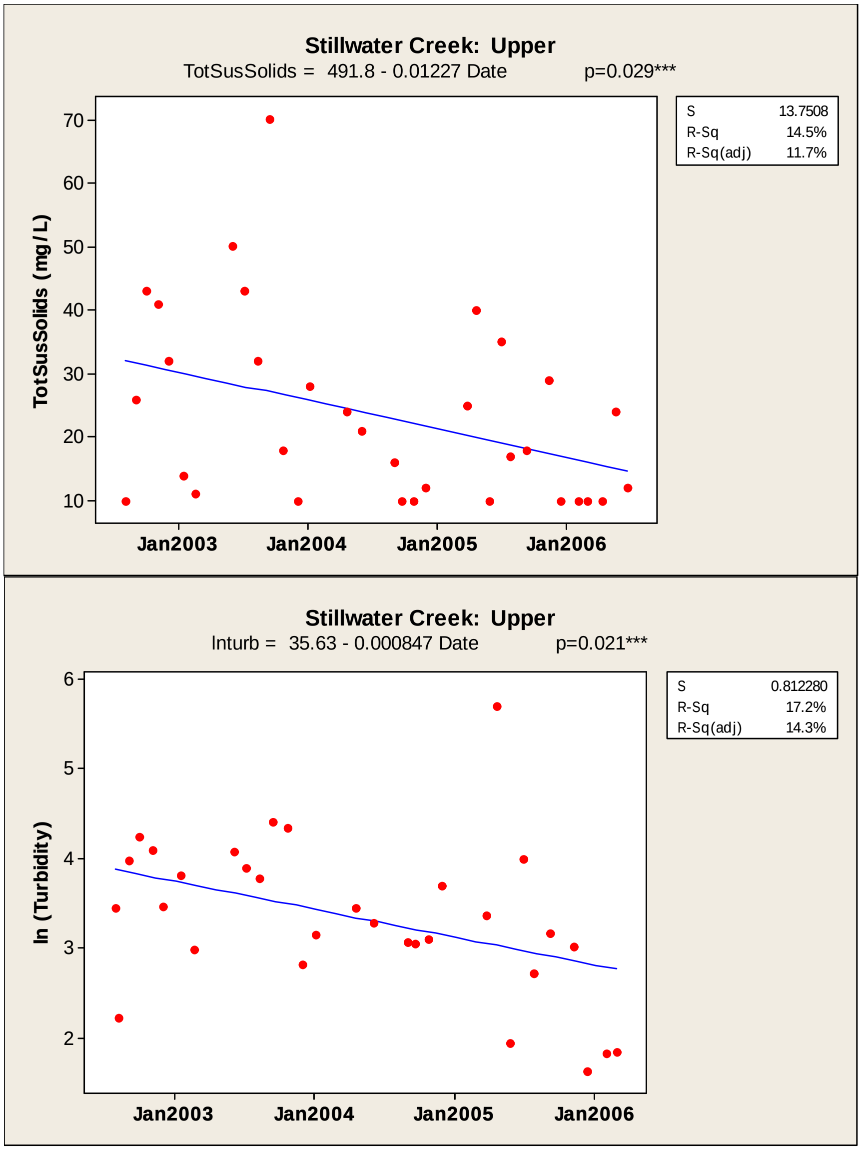


Figure 26. Significant regressions using seasonal baseflow data.

Measures of Success

The Stillwater Creek Watershed Implementation Project brought together numerous groups, with the ultimate goal of restoring and protecting all designated beneficial uses in the watershed. Sources of sediment and nutrients were modeled and targeted in order to maximize the potential for improvement of water quality. Under the direction of a locally led WAG, BMPs were demonstrated and implemented, both in rural and urban settings. While some of the high priority BMPs were not embraced to the degree that was originally planned, others were quite popular.

Significant decreasing trends are already evident in both total suspended solids and turbidity at the Stillwater Upper site. It is expected that water quality will continue to improve since some practices have just recently been implemented, and significant improvement is rarely, if ever, evident in a short timeframe. Importantly, educational efforts should be long-lasting and wide-reaching, and vital partnerships between groups which were formed as a result of this project are expected to continue (for example, OSU lake managers are working with OWRB and seeking additional funding for more shoreline stabilization). The lake and several watershed streams remain listed on the 303(d) list for NPS related impairments, so additional work is likely needed in the watershed to fully address the problems.

The NRCS has established a “Lake Carl Blackwell Local Emphasis Area (LEA)” consisting of all land that drains into Stillwater Creek and Lake Carl Blackwell. As part of this project, Logan, Payne, and Noble counties are implementing practices to provide sediment and erosion control measures on land that will reduce excessive sedimentation into Stillwater Creek and Lake Carl Blackwell. Special consideration is given to establishing permanent vegetation on cropland, adopting conservation tillage practices, and the development and/or protection of conservation buffers. The NRCS will continue to focus available EQIP funding in the watershed through this project, which should result in further water quality improvements.

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Turton, D. C., E. Stebler, and M. D. Smolen. 2006. *Demonstrating the Effectiveness of Rural Unpaved Road Erosion Control Practices in Reducing Erosion in the Stillwater Creek Watershed.* Depts. of Natural Resource Ecology and Management and Biosystems and Agricultural Engineering, Oklahoma State University, Stillwater, OK

Appendix A

Reports Generated as Part of the Stillwater Creek Watershed Implementation Project

Corporation Commission:

Oklahoma Corporation Commission FY 2001 Project 4: Stillwater Creek Watershed Implementation Project, Final Report.

Oklahoma State University:

Demonstrating the Effectiveness of Rural Unpaved Road Erosion Control Practices in Reducing Erosion in the Stillwater Creek Watershed, Technical Report. Donald J. Turton, Elaine Stebler, and Michael D. Smolen. Oklahoma State University. Departments of Natural Resource Ecology and Management and Biosystems and Agricultural Engineering. Stillwater Creek 319 Project Task #7.5.1.

Oklahoma State University Cooperative Extension Service:

Erosion Control on Rural Unimproved Roads in the Stillwater Creek Watershed 2003-2006, Final Report. CWA Section FY2001 319(h) Project 3, Task 7. Oklahoma Conservation Commission Project File-01-003. OSU Project Account AC-AC-5-95130.

Stillwater Creek Watershed Education Project 2003-2006, Final Report. CWA Section FY2001 319(h), Project 3, Task 6. Oklahoma Conservation Commission Project File 01-003. OSU Project Account AC-AC-5-95130.

Oklahoma Water Resources Board:

Demonstration Project: Expansion of Oklahoma Water Watch Volunteer Monitoring Program to Support Erosion Control Efforts, Final Report. FY-01 319(h) Project 3 Grant #C9-996100-09, Task 5, Oklahoma Water Resources Board, Water Watch Program.

Demonstration Project: Mitigation of Non-point Source Impact to Littoral Zone of Lake Carl Blackwell, Payne County, Oklahoma, Final Report. FY-01 319(h) Task #01-003. CA #C9-996100-07 Project 3, Subtask 5.1.2 Bioengineering Demonstration and Subtask 5.1.3 Erosion Control Monitoring. Oklahoma Water Resources Board.

Appendix B

Watershed Advisory Group Minutes

Stillwater Creek Watershed
Advisory Group
Minutes
December 11, 2003
Central Rural Electric Coop
7:00 pm

Attendees

Norman Durham	Producer
Chuck Thomas	City of Stillwater
Mike Dicks	Producer
Bob Priess	Producer
Mike Smolen	OSU
Jim Leach	OCC
Brandon Burns	NRCS
Rusty Peterson	NRCS
Joe Creech	OCC
Mike Thralls	OCC

Welcome and Introduction

Joe Creech, Project Coordinator, welcomed those in attendance and introduced Bob Priess, WAG Chairman. Mr. Priess welcomed everyone and asked them to introduce themselves and tell their reason for attending.

Water Quality Mission

Mr. Priess introduced Mike Thralls, Executive Director of the Oklahoma Conservation Commission. Mr. Thralls discussed the Mission of the Water Quality Division emphasizing the efforts to monitor and actively work toward improving water resources. The Conservation Commission works with other agencies including the Oklahoma Water Resources Board, Department of Environmental Quality, and NRCS, Corporation Commission, etc. to continue to preserve our natural resources. The relationship between the 319 program and its relationship with the State Budget.

Why Stillwater Creek & Mission of the WAG

Jim Leach, Assistant Director of the Water Quality Division of the OCC explained the history of 319 projects in the state. He also gave a history on how the ranking system was developed in conjunction with the Oklahoma Water Resources Board. Mr. Leach presented the problems identified in Lake Carl Blackwell. He also emphasized the importance of local involvement in the progress of the project. Mr. Leach explained that through the targeting work five percent of the watershed was identified as producing 90 percent of the pollution in the watershed. He asked for the input of those in the watershed to help with what practices will work in the area and with the promotion of the program in the watershed.

Targeting Methodology

Dr. Mike Smolen, Oklahoma State University and Joe Creech, OCC showed the priority map that identifies the top ten percent problem areas in the watershed. The Soil and Water Assessment Tool (SWAT) was used to estimate sediment and nutrient loading in the watershed. Erosion on county roads was estimated by using the Water Erosion Prediction Project (WEPP) model. A road and bar ditch inventory was conducted by OCC and the Payne County Conservation District in conjunction with the use of Geographic Information Systems (GIS) technology. The WAG was shown a map identifying roadside erosion levels.

Education Efforts

Dr. Mike Smolen, Oklahoma State University described early education efforts conducted by OSU. A survey was conducted in the watershed to identify public perception and homeowner practices related to nutrient management, pesticide and herbicide use and control. The community education programs along with the roadside erosion control plan were discussed. The agriculture education effort will be conducted closer to implementation.

Other Project Components

Joe Creech, OCC, described the other project participants and their roles. The Oklahoma Corporation Commission will be responsible for locating oil and gas production related sources in the area, correct the problems and conduct education. Lake Carl Blackwell will be the site of the Oklahoma Water Resources Board's demonstration project to limit Nonpoint Source (NPS) impact on the shoreline. They will also be working to expand the volunteer Oklahoma Water Watch program in the area. Oklahoma State University will be conducting NPS education programs in the City of Stillwater and throughout the watershed. OSU Agricultural Sciences and Natural Resources will be conducting education and research on roadsides. They will also make results available to county road crews and the OSU Center for Local Government Technology.

BMP's Cost Share Rates and Funding Caps

The floor was opened for discussion on BMP's, rates and funding caps. Mr. Dicks asked if there was a targeted priority area for the Conservation Reserve Program. His idea was to be able to tie in with the 319 program, to stretch funds, and to give an incentive to producers to participate. The group discussed practices and approved the priorities as follows.

#1. Riparian area
#2. Roadside Erosion
#3. Land Management, Pasture and Farmland, (education emphasis)
#4. Human Waste

Discussed and approved the payment of incentives on a six month basis rather than an annual payment. $50.00/acre/6 months for total exclusion, $45.00/acre/6 months for hay production, $40.00/acre/6 months for limited grazing.

Most all of the practices will be offered at a cost share rate of 75 percent.

A cap of $20,000.00 per producer was agreed upon.

Next Meeting
Monday January 5, 2004, 6:30 p.m., at the Payne County Conservation District Conference room.

Stillwater Creek Watershed
Advisory Group
Minutes
January 5, 2004
Payne County Conservation District
6:30 p.m.

Attendees

Robert Priess	Producer
Chuck Thomas	City of Stillwater
Mike Dicks	Producer
Jim Leach	OCC
David Hungerford	NRCS
Joe Creech	OCC

Welcome

Chairman Priess welcomed those in attendance.

Approval of Minutes

The minutes were reviewed and Mr. Dicks made a motion to approve and Mr. Thomas seconded it. Motion carried.

Discussion of Priority Practices and BMP's

Members reviewed the list of Conservation practices and Cost Share rates. Mr. Dicks wanted to confirm that the priorities were in the order of importance. Mr. Priess and Mr. Thomas felt that the Practices were in the appropriate order.

Mr. Hungerford and Mr. Thomas asked about the incentive payments and how those rates were developed. Joe Creech explained that these numbers were developed after several regional meetings with producers and other participants in earlier projects.

Discussed the possibility of using some new provisions of CRP to lengthen the incentive period on Riparian Areas and Buffer Zones. Mr. Hungerford mentioned that many times the different programs did overlap and cover the same or similar items.

Mr. Dicks inquired about the ranking system to determine who would receive assistance. Joe Creech explained that the process had begun but was not ready at the time of the meeting. After discussion it was recommended that the planner insure that demonstrations projects for all the priorities are completed.

Mr. Hungerford mentioned that the exclusion statement on the criteria form might keep many people from participating do to the short time frame of the program. After discussion it was recommended that we look at allowing the participants that have a need for one practice must be willing to treat at least that one practice.

Mr. Thomas left the meeting at 7:00 p.m.

Mr. Dicks asked if it was possible to tie the 319 programs with EQIP in order to increase the reach of the project. Mr. Hungerford felt at this time it was possible to tie a producer in with the NRCS program in conjunction with 319.

Mr. Dicks asked where the sign-ups would occur. After discussion it was determined that it would be best to have them come in to the district offices to sign-up.

The group revisited the ranking system and confirmed that they desired one of each of the priorities be applied for demonstration purposes.

It was pointed out that some producers might not have an NRCS farm plan. The OCC planner will prepare a farm plan for that property.

Mr. Leach noted the change in language on the septic system that clarifies that mobile homes are not eligible for the program.

Mr. Hungerford asked about the language concerning the qualifying location for the septic systems. It was suggested that it be changed to read within 1000 feet of a blue line on a topographic map.

Next meeting was tentatively set for late spring.

Meeting adjourned at 8:30 p.m.