Final Report

On

FY 93 104(b)(3) Assessment of Water Quality Along The Eastern Oklahoma Border (Continuation of the FY 1991 104(b)(3) Project).

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INTRODUCTION

Considerable gaps exist in the information base concerning the water quality of surface waters in Oklahoma. This is a statewide phenomenon; however, the lack of data along the eastern border has resulted in a number of inter-state discussions between Oklahoma and Arkansas. Specifically, these discussions pertained to the effects of land uses in each state on the quality of water in the other. Although some of this discussion was based on factual information, much consisted of unfounded finger pointing. The purpose of the FY 93 104(b)(3) project was to provide additional monitoring by both states along their respective border to develop a scientific basis on which to base these discussions and to help fill some of the data gaps. Data gathered also identified problem areas for future projects and provided supporting data for TMDL development in this region. Specifically, this data provided a more complete picture regarding the effects of changing landuse along the border between Oklahoma and Arkansas.

The Oklahoma Conservation Commission (OCC) collected data from streams in far southeastern Oklahoma between 1991 and 1993 as part of a FY 91 §104(b)(3) grant. Through that project, OCC developed an understanding of the range of conditions under various land uses in the study area and their effects on downstream water quality. The focus of the FY 93 104(b)(3) project was to continue monitoring those streams which best represented local land uses and add additional sites in other areas to the north of the initial study area. By expanding sites northward to link with sites under the Poteau River study, OCC could establish a water quality database for the majority of the Arkansas border area. Areas to the north of the Poteau River drainage have already largely been assessed through the expanded Illinois River Basin project.

STUDY AREA AND METHODS SELECTED

A total of 42 sites were sampled. These include sites in the Arkansas River and Red River Basins in southeast Oklahoma. The final list of sites is shown as Table 1. Figures 1 – 5 display location of sampling sites. These sites were chosen based upon the characteristics of the watershed as representative of major land use patterns in the study area (i. e. forested vs. non-forested watersheds). Sampling was conducted on a quarterly basis under baseflow conditions. Field measurements collected included dissolved oxygen, temperature, specific conductance, pH, alkalinity, turbidity, and instantaneous discharge. Laboratory analysis included nitrate/nitrite, orthophosphate, total phosphorus, total suspended solids, chloride, sulfate, and hardness. Bioassessment of 10-20 streams was conducted using EPA Rapid Bioassessment Protocols (RBP) for fish and benthic macroinvertebrates and quantitative habitat assessment protocol as modified by the OCC. These streams were selected to give a representative cross section of the water quality, habitat, and biota of the study are and to characterize the biological response to the water quality and

Table 1. Sampling sites for water quality along the eastern Oklahoma border, FY 94 104(B)(3).

USGS SITE #	SITE	
USGS 07337055	HANOBIA CREEK AT HANOBIA, OK	34320 0945555
USGS 0733075	WATSON CREEK NR NASHOBA, OK	342709 0951003
USGS 07337080	PICKENS CREEK NR NASHOBA, OK	342441 0950857
USGS 07337110	HOLLY CREEK NR CLOUDY, OK	341940 0950851
USGS 07337130	CANEY CREEK NR CLOUDY, OK	341615 0951051
USGS 07337175	TERRAPIN CREEK NR RINGOLD, OK	341524 0950522
USGS 07337510	WHITE OAK CREEK NR WRIGHT CITY, OK	340304 0950307
USGS 07337540	CYPRESS CK AT WRIGHT CITY, OK	340411 0950109
USGS 07337630	HORSE HEAD CK AT WRIGHT CITY, OK	340346 0945917
USGS 07337700	W. FORK GLOVER R. NR BATTIEST	342811 0945743
USGS 07337705	EAST CREEK NR BATTIEST, OK	342827 0945603
USGS 07337740	W. FORK GLOVER R. AT BATTIEST	342338 0945630
USGS 07337760	SILVER CREEK NR BATTIEST, OK	342312 0945734
USGS 07337785	E. FORK GLOVER R. AT BETHEL, OK	342208 0945053
USGS 07337870	GLOVER RIVER, LOWER	
USGS 07337860	CEDAR CREEK NR GLOVER, OK	341034 0945431
USGS 07338400	LUKFATA CREEK NR IDABEL, OK	335805 0944557
USGS 07338505	YASHOO CREEK NR BROKEN BOW, OK	335949 0944454
USGS 07338510	MUD CREEK NR HAWORTH, OK	335058 0944422
USGS 07338530	YANUBBEE CREEK BELOW COON CREEK	335952 0944241
USGS 07338733	BEECH CREEK NR BEACHTON, OK	342914 0943222
USGS 07338735	SIX MILE CREEK NR PLUNKETVILLE, OK	342744 0942950
USGS 07338737	DRY CREEK AT WATSON, OK	342638 0943314
USGS 07338740	ROCK CREEK AT SMITHVILLE, OK	342821 0943811
USGS 07338792	CUCUMBER CREEK NR OCTAVIA, OK	343357 0944229
USGS 07338800	LITTLE EAGLE CREEK NR OCTAVIA, OK	343102 0944409
USGS 07338810	BIG EAGLE CREEK NR SMITHVILLE, OK	342703 0943948
USGS 07338820	MOUNTAIN FORK ABOVE WARD CREEK	342348 0944113
USGS 0733 8710	MOUNTAIN FORK IN ARKANSAS	
USGS 07338830	E. BOKTUKLO K NR SMITHVILLE, OK	342345 0944357
USGS 07338850	MINE CREEK NR WATSON, OK	342241 0943255
USGS 07338860	BIG HUDSON CREEK NR WATSON, OK	342201 0943636
USGS 07338865	BUFFALO CREEK NR WATSON, OK	342209 0943722
USGS 07338842	BUFFALO CREEK UPPER	
	BLACK FORK CREEK	344543 0942923
	SUGAR LOAF CREEK	345956 0943432
	JAMES FORK CREEK	350959 0942832
	LITTLE SALLISAW CREEK	352542 0944637
07245470	SALLISAW CREEK	352747 0945132
	KIAMICHI RIVER	343814 0943913
	BUFFALO CREEK	344322 0951608
07249865	JENKINS CREEK	353907 0943720

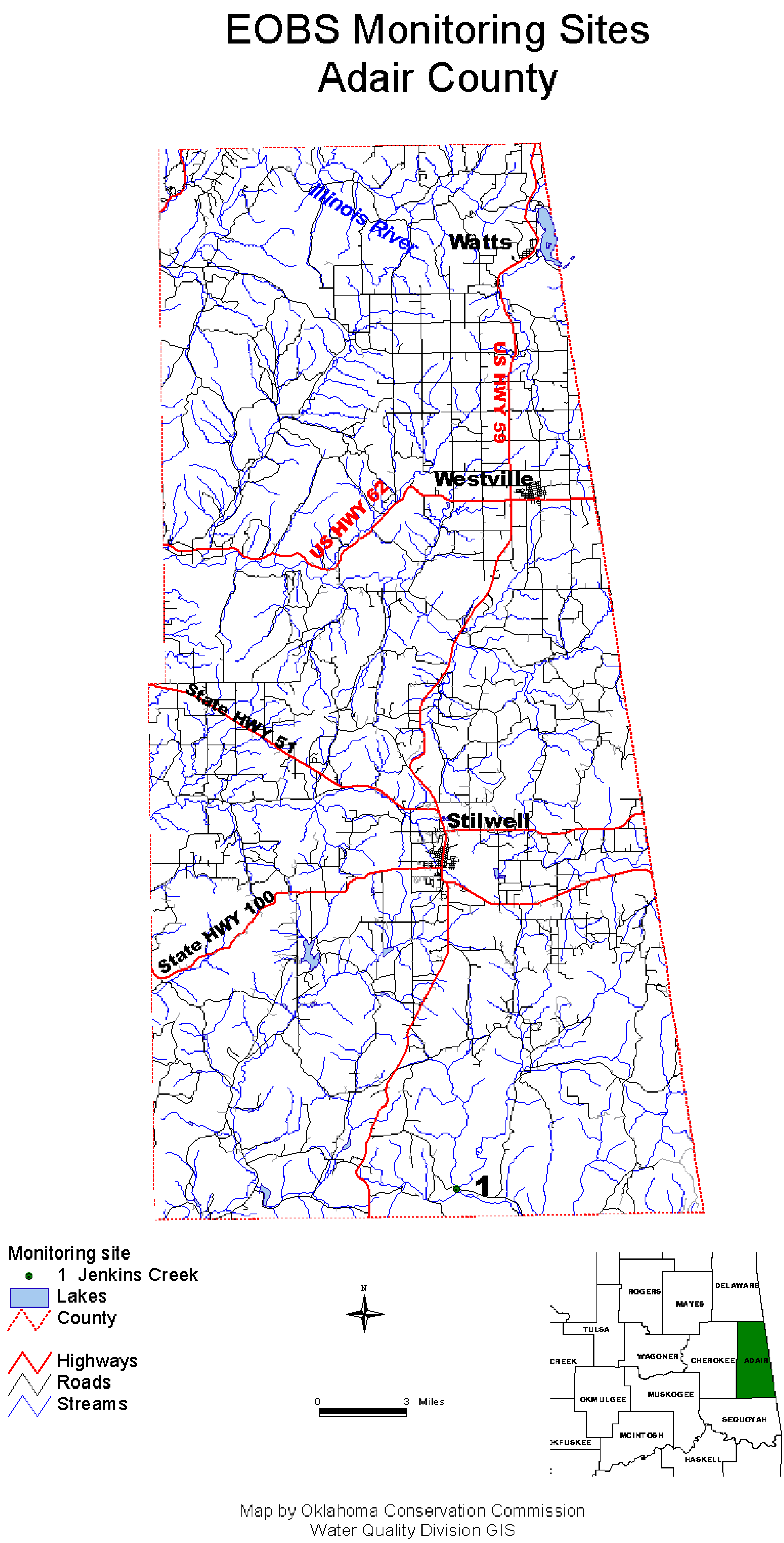

Figure 1. EOBS Monitoring Sites in Adair County, OK.

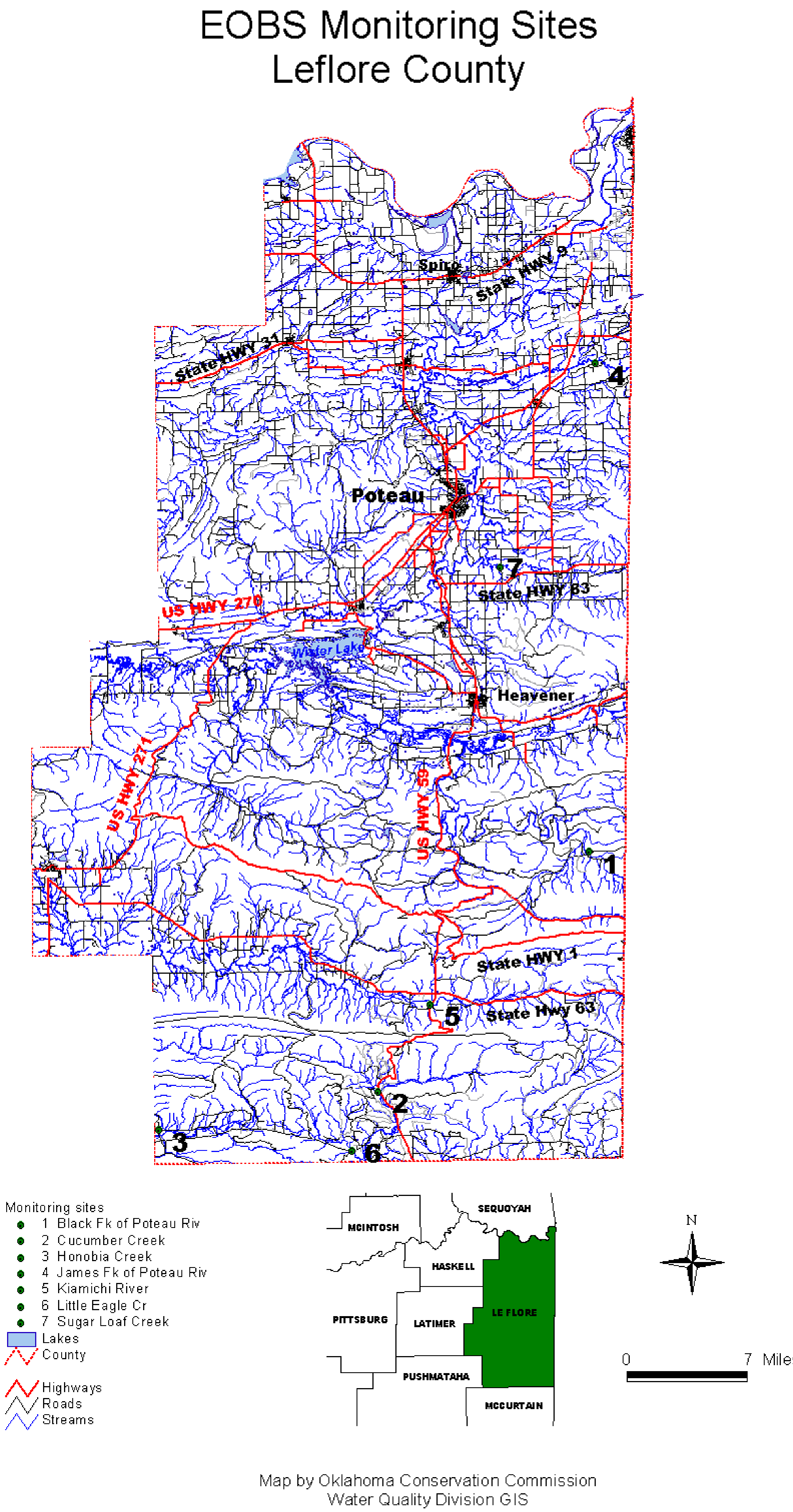

Figure 2. EOBS Monitoring Sites in LeFlore County, OK.

Monitoring Sites
McCurtain County

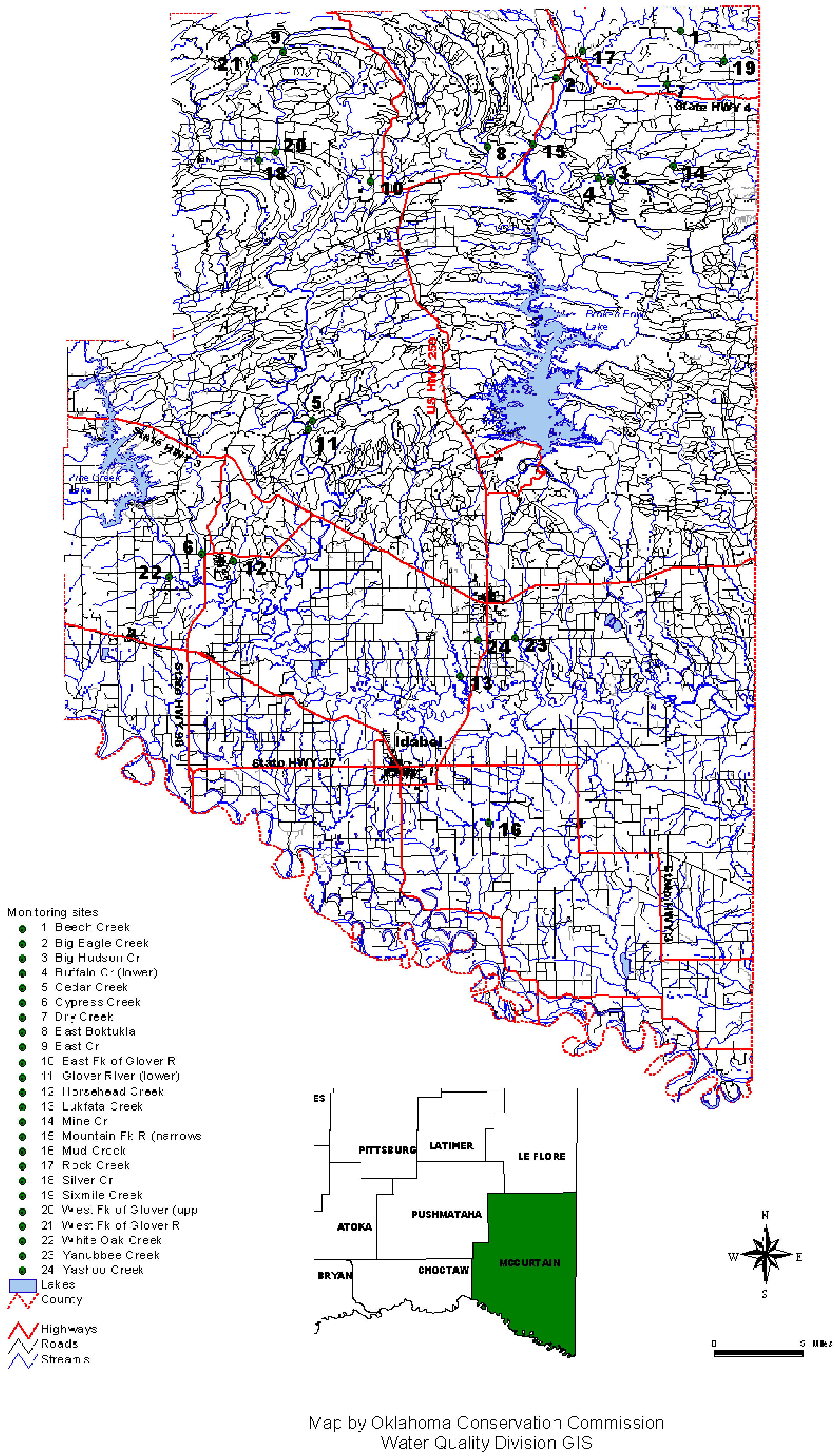

Figure 3. EOBS Monitoring Sites in McCurtain County, OK.

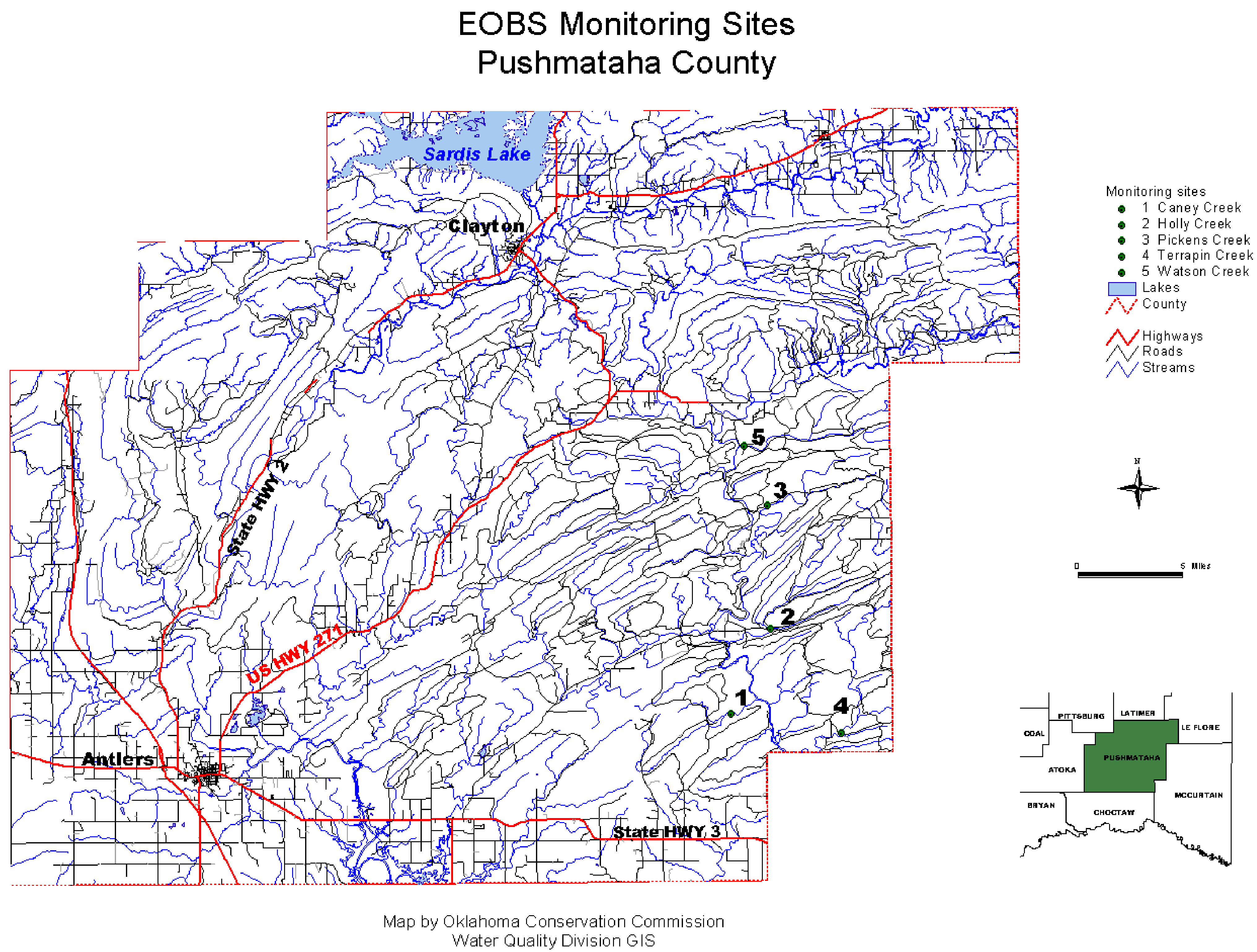

Figure 4. EOBS Monitoring Sites in Pushmataha County, OK.

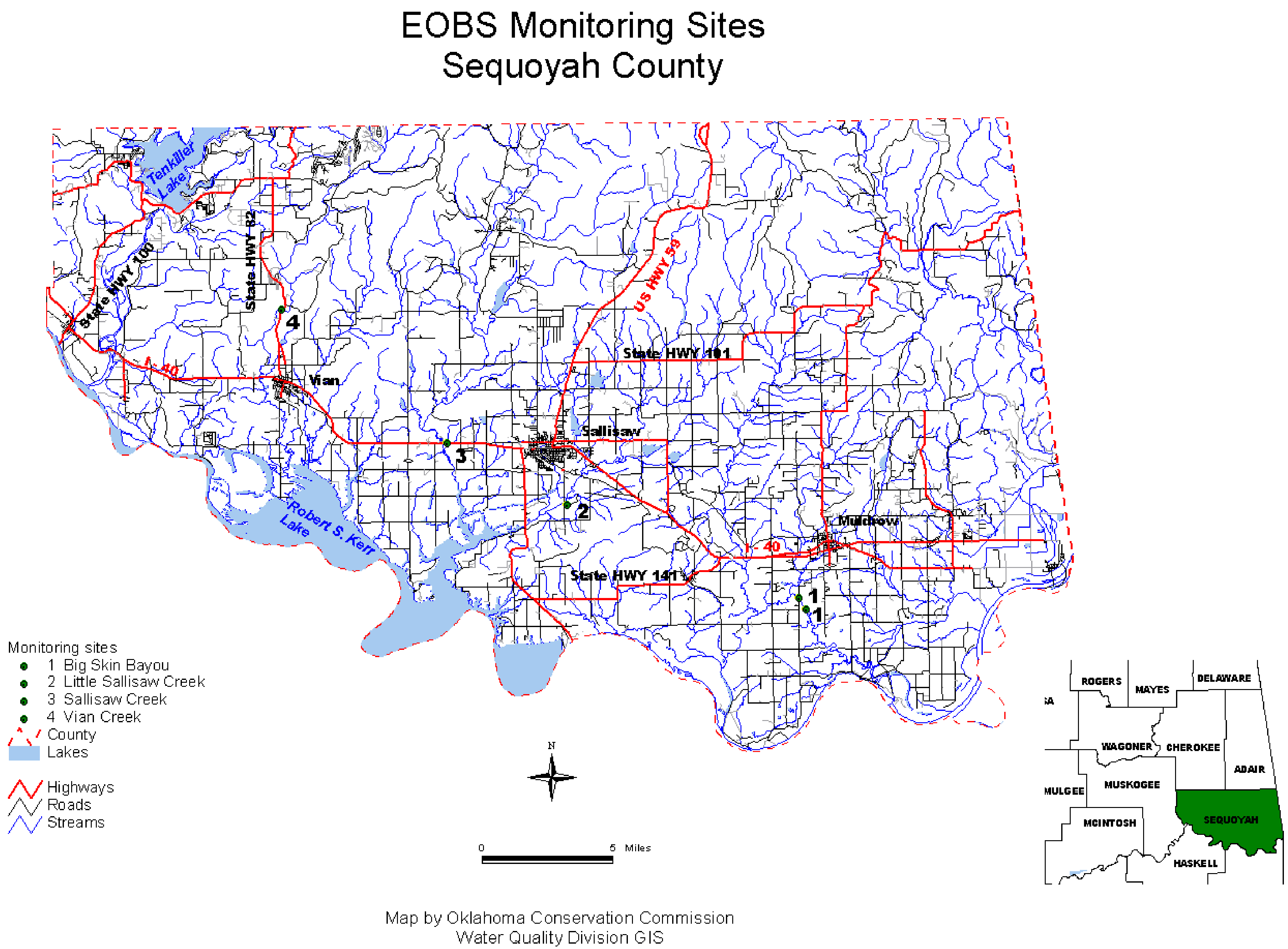

Figure 5. EOBS Monitoring Sites in Sequoyah County, OK.

land use. Certain creeks were considered as positive and negative reference sites for biological collections during the study. These are listed below:

BIOLOGICAL REFERENCE SITES IN SOUTHEASTERN OKLAHOMA

Positive Reference	
Small Perennial Stream	Mine Creek
Medium Perennial Streams	Big Hudson Creek
	Cedar Creek
	Caney Creek
Large Perennial Streams	Cucumber Creek
	Terrapin Creek
Negative Reference	
	Dry Creek
	Silver Creek
	Buffalo Creek in Arkansas

Only four of the streams in the study area receive permitted discharges. Yanubbee Creek receives discharges from Broken Bow Public Works, Mud Creek from City of Idabell, Horse Head Creek from Wright City, and the Mountain Fork River from Mountain Fork Water Supply. In addition to these discharges, Beaver's Bend State Park is a potential discharger to the Mountain Fork River.

The sampling sites were located in the several different Ecoregions (Figure 6). Most of the stations were located in the Ouachita Mountains Ecoregion. However, stations were also sampled in the Boston Mountains Ecoregion, the Arkansas Valley Ecoregion, and the Central Oklahoma/Texas Plains Ecoregion. Thus, the watersheds are highly variable in slope, vegetation, and drainage patterns. However, there is also similarity between the ecoregions on vegetation types, soil types, and climate.

The Ouachita Mountains Ecoregion is dominated by the geologic features of the region (McNab and Avers 1994, Omernick 1987). Rockslides, broken rock, and bare rock outcrops are common in the ecoregion. Tectonic faulting and uplift of resistant bedrock formed it into a narrow band of metamorphosed, parallel (east-west) mountain ranges. This was followed by mass wasting and steep and gentle stream valley erosion with fluvial transport. About 75 percent of the area consists of open high hills. Also included are open low mountains. Elevation ranges from 330 to 2,600 ft (100 to 800 m). Rocks formed during the Paleozoic (50 percent), Mesozoic (40 percent), and Cenozoic (10 percent) Eras. Paleozoic strata consist of Cambrian marine deposits (carbonates and shales); Ordovician marine deposits (carbonates, shales, and limestones); Mississippian marine deposits (sandstone), and Pennsylvanian marine deposits (sandstone). Mesozoic strata consist of Lower and Upper Cretaceous marine deposits (limestone). Cenozoic strata consist of Quaternary marine deposits. Soils are mainly Udults. Soils are generally deep, often stony, and have adequate moisture for use by vegetation during the growing season. The vegetation was historically dominated by oak-

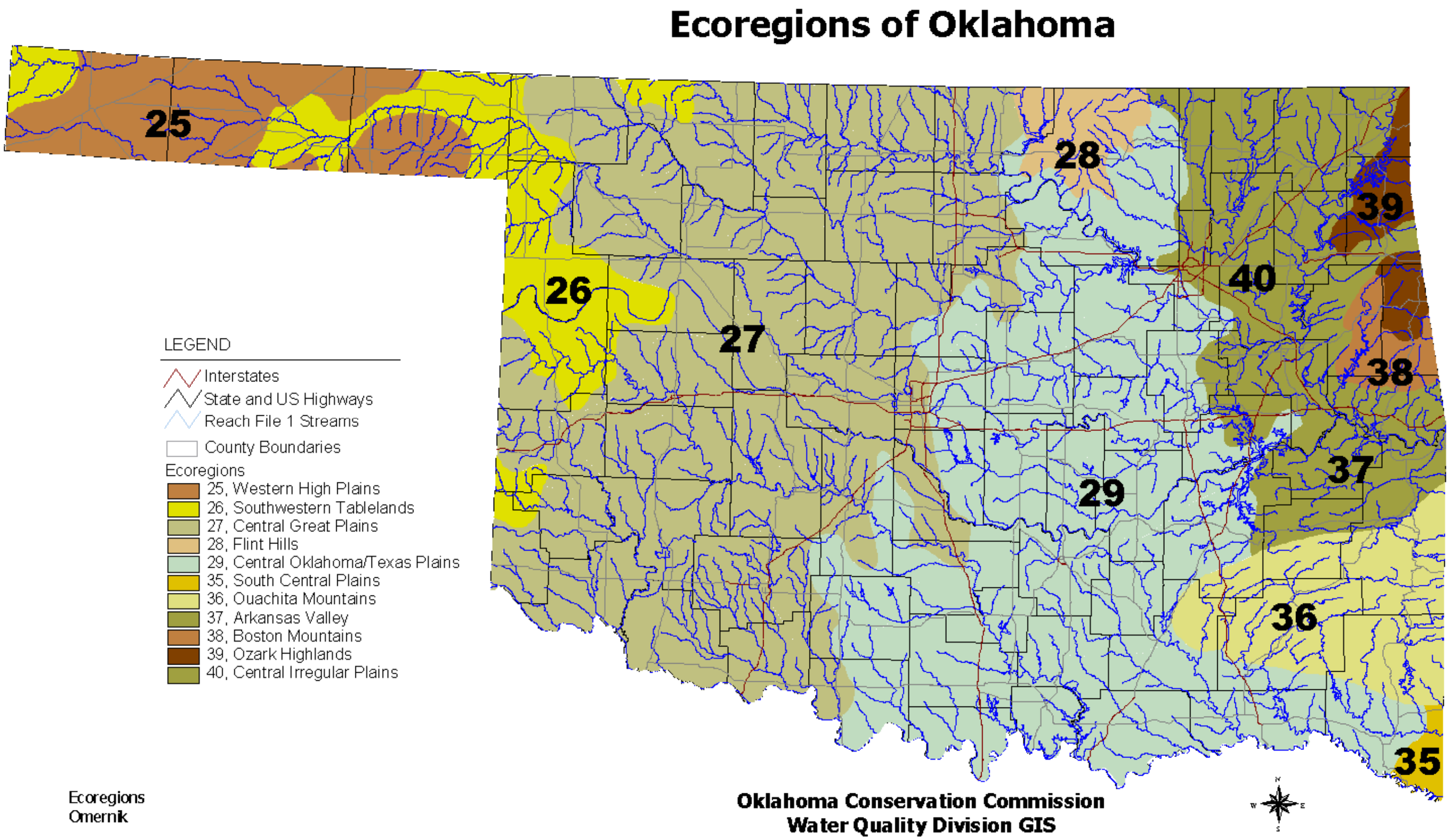

Figure 6. Ecoregions of Oklahoma.

hickory-pine forest. Existing forest types are mainly loblolly-shortleaf pine. The predominant vegetation form is evergreen needle-leafed forest and a small area of cold deciduous, broad-leaved forest. Loblolly pine and shortleaf pine cover types occur widely. Lesser areas of a shortleaf-oak type (southern red, scarlet, black, post, and blackjack oaks) and oak-hickory (black, scarlet, post, and white oaks and pignut and mockernut hickories) occur in Oklahoma. Average precipitation is 48 to 56 in (1,220 to 1,420 mm). Mean annual temperature is 61 to 63 ºF (16 to 17 ºC). The growing season lasts 200 to 240 days. There is a high density of small to medium size perennial streams and associated rivers; those in intermountain basins have moderate rates of flow, and some on mountainsides are characterized by high rates of flow and velocity. A trellis drainage pattern has developed, largely with bedrock structural control. Major rivers include the Fourche Maline and Dutch Creek, which flow into the Arkansas River. Fire has historically been the principal disturbance. Climatic influences include occasional summer droughts, winter ice storms, and infrequent tornadoes. Insect disturbances are often caused by southern pine beetles. Natural vegetation has been cleared for agriculture on about 25 percent of the area.

The Boston Mountains Ecoregion is in the Ozark Plateau geomorphic province (McNab and Avers 1994, Omernick 1987). Geomorphic characteristics include broad uplift of generally flat-lying marine sediments to a plateau, followed by fluvial erosion, resulting in a strongly dissected region with dendritic drainages. About 80 percent of the Section has landforms of low mountains; 20 percent consists of open hills and plains with hills. Elevation ranges from 650 to 2,600 ft (20 to 80 m). Rocks in this Section formed during the Paleozoic Era. Geologic strata consist of 20 percent Mississippian marine deposits (cherts and limestone) and 80 percent Pennsylvanian marine deposits (sandstone, shale, coal, and limestone). Soils are mostly Udults. These soils are generally medium textured, stony to nonstony, and shallow to moderately deep. Vegetation is dominated by oak-hickory forest and oak-hickory-pine forest. Common oak species in the oak-hickory forest type include white oak, black oak, and northern red oak. Hickories include pignut and mockernut. The shortleaf pine-oak cover type occurs on drier sites where post, scarlet, and blackjack oaks dominate with shortleaf pine. Annual precipitation averages 45 to 52 in (1,150 to 1,320 mm). Temperature averages 58 to 64 ºF (14 to 17 ºC). The growing season lasts about 180 to 205 days. There is a high density of small to medium size perennial streams and associated rivers; those in intermountain basins have moderate rates of flow, and some on mountainsides are characterized by high rates of flow and velocity. A dendritic drainage pattern has developed on strongly dissected surfaces, largely with influence from the underlying bedrock.

The Arkansas Valley Ecoregion is in the Ouachita geomorphic province (McNab and Avers 1994, Omernick 1987). The area consists of a folded, faulted, and uplifted belt of parallel valleys and ridges, moderately dissected by differential erosion, mass wasting, fluvial erosion and transport and deposition. About 80 percent of this land consists of plains with hills and 20 percent includes open low mountains. Elevation ranges from 330 to 3,000 ft (100 to 900 m). Rocks formed during the Paleozoic Era. Strata consist of Pennsylvanian marine deposits (sandstone, shale, coal, and limestone). Soils are predominately Udults. Soils are variable in characteristics, ranging from shallow to deep, but most are well drained. Soil moisture is adequate for plant growth during most of the growing season. Vegetation is classified as oak-hickory forest, oak-hickory-pine forest, cross-timbers, and southern floodplain forest. The predominant vegetation form is about equal areas of cold-deciduous, broad-leaved forest and needle-leafed evergreen trees. Principal forest cover types are oak-hickory and loblolly-shortleaf pine. Species include white, black, bur, post, and blackjack oaks; pignut and mockernut hickories; and loblolly and shortleaf pines. Oak-gum-cypress forest type is dominant along major river bottoms and includes cottonwood, sugarberry, river birch, and green ash. Annual average precipitation is 44 to 50 in (1,120 to 1,270 mm). Average temperature is 61 to 63 ºF (16 to 17 ºC). The growing season lasts 200 to 240 days. This Section has a high density of small to medium size perennial streams and associated rivers; those in intermountain basins have moderate rates of flow and some on mountainsides are characterized by high rates of flow and velocity. A trellis drainage pattern has developed. One of the large rivers draining this Section is the Arkansas.

The Central Oklahoma/Texas Plains Ecoregion (also called the Cross-Timbers and Prairies Ecoregion) is in the Central Lowlands geomorphic province (McNab and Avers 1994, Omernick 1987). The predominant landform on about 70 percent of the Section consists of irregular plains that originated from uplift of level bedded continental sediments, that had been deposited into a shallow inland sea, followed by a long period of erosion. Other landforms include plains with hills and open high hills. Elevation ranges from 330 to 1,300 ft (100 to 400 m). Rock units were formed during the Paleozoic (30 percent) and Mesozoic (70 percent) Eras. Paleozoic strata consist of Pennsylvanian marine deposits (sandstone, shale, coal, and limestone). Mesozoic strata consist of Lower Cretaceous marine deposits (limestone). Soils in the Cross Timbers area of the region are mainly Ustalfs and are deep, well drained, and moderate textured; moisture is limited for use by vegetation during part of the growing season. Soils in the Prairie areas of the region are Ustolls, Userts, and Ochrepts. Generally, soils are deep, fine textured, and well drained; moisture is limited for use by vegetation during parts of the growing season. Vegetation is classified as cross-timbers, oak-hickory forest, and oak-hickory-pine forest. The predominant vegetation form is cold-deciduous broad-leaved forest and extensive areas of tall grassland with a tree layer. Forest cover consists of post, live, and blackjack oaks, and pignut and mockernut hickories. Grasses consist of big and little bluestems, indiangrass, and sunflower. Precipitation averages 35 to 40 in (900 to 1,050 mm). About 5 to 18 in (120 to 450 mm) of snow falls annually. Temperature averages 55 to 63 ºF (13 to 17 ºC). The growing season lasts 190 to 235 days. This Section has a low to moderate density of perennial streams and associated rivers, mostly with low to moderate rates of flow and moderate velocity. Dendritic drainage patterns have developed. One of the major rivers draining this Section is the Red. A relatively large number of water reservoirs have been constructed. Fire and drought have probably been the principal historical sources of disturbance. Natural vegetation has been cleared for agricultural crops on about 75 percent of the area.

RESULTS

Stream and Watershed Size

Streams sampled ranged between small, medium, and large in terms of watershed size, stream order, and stream flow. In addition, streams varied widely within classifications. For example, fourth order streams ranged from small to large sized watersheds and low to high average flows. This variability was expected due to the objectives of the project being to "fill in" data gaps rather than to compare streams within a certain ecoregion or other stream classification.

Stream order of EOBS stations (based upon 1:24,000 digital raster files) ranged from second to sixth order streams (Table 2). The majority of stations sampled were on third and fourth order streams.

Table 2. Strahler Stream Order at EOBS Stations.

WBID#	Site	Strahler Stream Order	County
OK410210-06-0010M	Mountain Fk R (narrows)	6	McCurtain
OK410210-06-0010T	Mountain Fk R (upper)	5	Polk
OK410210-06-0160G	Big Eagle Creek	5	McCurtain
OK410210-08-0010G	Glover River (lower)	5	McCurtain
OK220100-01-0070T	James Fk of Poteau River	4	LeFlore
OK220100-01-0160G	Sugar Loaf Creek	4	LeFlore
OK220100-02-0040T	Black Fk of Poteau River	4	LeFlore
OK220200-01-0030G	Big Skin Bayou	4	Sequoyah
OK220200-02-0040G	Little Sallisaw Creek	4	Sequoyah
OK220200-03-0010G	Sallisaw Creek	4	Sequoyah
OK410210-01-0070G	Cypress Creek	4	McCurtain
OK410210-02-0150G	Terrapin Creek	4	Pushmataha
OK410210-02-0260G	Holly Creek	4	Pushmataha
OK410210-02-0450G	Watson Creek	4	Pushmataha
OK410210-06-0020G	Buffalo Creek (lower)	4	McCurtain
OK410210-06-0170G	Little Eagle Creek	4	LeFlore
OK410210-09-0070M	West Fk of Glover R	4	McCurtain
OK410210-09-0100G	Silver Creek	4	McCurtain
OK410310-02-0010G	Kiamichi River	4	LeFlore
OK220200-05-0050G	Jenkins Creek	3	Adair
OK410200-01-0150G	Yanubbee Creek	3	McCurtain
OK410200-01-0230G	Yashoo Creek	3	McCurtain
OK410210-01-0110G	White Oak Creek	3	McCurtain
OK410210-02-0240G	Caney Creek	3	Pushmataha
OK410210-02-0380G	Pickens Creek	3	Pushmataha

OK410210-03-0150G	Honobia Creek	3	LeFlore
OK410210-06-0060G	Mine Creek	3	McCurtain
OK410210-06-0120G	East Boktukla	3	McCurtain
OK410210-06-0210G	Cucumber Creek	3	LeFlore
OK410210-06-0240G	Rock Creek	3	McCurtain
OK410210-06-0270G	Dry Creek	3	McCurtain
OK410210-06-0310G	Sixmile Creek	3	McCurtain
OK410210-06-0320G	Beech Creek	3	McCurtain
OK410210-07-0010G	Lukfata Creek	3	McCurtain
OK410210-08-0120G	Cedar Creek	3	McCurtain
OK410210-09-0010G	East Fk of Glover R	3	McCurtain
OK410210-09-0070U	West Fk of Glover (upper)	3	McCurtain
OK410210-09-0180G	East Creek	3	McCurtain
OK220200-02-0130G	Vian Creek	2	Sequoyah
OK410200-01-0210G	Mud Creek	2	McCurtain
OK410210-01-0060G	Horse Head Creek	2	McCurtain
OK410210-06-0020T	Buffalo Creek (upper)	2	Polk
OK410210-06-0030G	Big Hudson Creek	2	McCurtain

EOBS stations occurred in both the Arkansas and Red River drainage basins (Table 3). Within these two basins, EOBS streams drained into the Poteau, Glover, Kiamichi, Little, and Mountain Fork Rivers, as well as directly into the Arkansas and Red Rivers. Percent slope was calculated by comparing headwater elevation to elevation at sampling site. Percent slope was widely variable among the basins, ranging from 1 – 18. Some basins were headwater streams high in the Ouachita and Kiamichi Mountains, while others were bottomland drainages in the river valleys. As expected, based on the variability in stream order, drainage area was also highly variable, ranging from 8.49 – 182.47 square miles.

Table 3. Drainage Basin Characteristics of EOBS Stations.

Watershed name	Drainage 1	Drainage 2	Percent Slope	Area (miles^2)	Area (meters^2)
Big Skin Bayou	Arkansas River	Arkansas River	4	80.06	207366294.98
Jenkins Creek	Arkansas River	Lee Creek/Arkansas River	10	14.93	38663874.28
Vian Creek	Arkansas River	Arkansas River	10	21.07	54575609.22
Little Sallisaw Creek	Arkansas River	Arkansas River	3	65.32	169188496.63
Big Skin Bayou	Arkansas River	Arkansas River	4	80.06	207366294.98
Sallisaw Creek	Arkansas River	Arkansas River	8	182.87	473623442.56
Black Fk of Poteau River	Arkansas River	Poteau River	11	44.69	115754456.01
Sugar Loaf Creek	Arkansas River	Poteau River	11	60.77	157382154.56
James Fk of Poteau River	Arkansas River	Poteau River	6	177.82	460550259.90
West Fk of Glover (upper)	Red River	Glover River	13	10.26	26582557.14
East Creek	Red River	Glover River	11	10.99	28456672.21
Cedar Creek	Red River	Glover River	10	20.16	52218597.96
West Fk of Glover R	Red River	Glover River	7	24.59	63691269.47
East Fk of Glover R	Red River	Glover River	9	29.00	75119239.29

Silver Creek	Red River	Glover River	6	34.97	90563121.13
Glover River (lower)	Red River	Glover River	5	164.88	427048068.26
Kiamichi River	Red River	Kiamichi River	17	48.92	126696935.51
White Oak Creek	Red River	Little River	2	10.00	25887684.50
Horse Head Creek	Red River	Little River	3	10.99	28466976.29
Mud Creek	Red River	Little River	1	11.63	30112093.31
Pickens Creek	Red River	Little River	12	11.83	30638258.67
Caney Creek	Red River	Little River	5	15.08	39052947.72
Holly Creek	Red River	Little River	9	17.58	45536873.18
Watson Creek	Red River	Little River	14	21.16	54793529.98
Yanubbee Creek	Red River	Little River	2	22.50	58274178.08
Yashoo Creek	Red River	Little River	2	23.67	61302797.79
Cypress Creek	Red River	Little River	2	40.70	105418471.67
Lukfata Creek	Red River	Little River	4	41.57	107672283.37
Honobia Creek	Red River	Little River	17	43.38	112362775.49
Mine Creek	Red River	Mountain Fork River	5	8.49	21984117.92
Big Hudson Creek	Red River	Mountain Fork River	12	10.80	27977985.88
Buffalo Creek (upper)	Red River	Mountain Fork River	3	13.08	33865004.53
Dry Creek	Red River	Mountain Fork River	3	14.17	36697654.35
East Boktukla	Red River	Mountain Fork River	14	14.22	36828812.58
Rock Creek	Red River	Mountain Fork River	10	20.48	53044655.93
Beech Creek	Red River	Mountain Fork River	14	22.37	57932139.38
Big Eagle Creek	Red River	Mountain Fork River	7	24.19	62664092.25
Little Eagle Creek	Red River	Mountain Fork River	10	24.90	64501618.66
Sixmile Creek	Red River	Mountain Fork River	5	30.60	79251507.21
Cucumber Creek	Red River	Mountain Fork River	18	40.41	104656990.78
Buffalo Creek (lower)	Red River	Mountain Fork River	4	76.40	197875160.77
Mountain Fk R (narrows)	Red River	Mountain Fork River	5	123.51	319880794.83
Mountain Fk R (upper)	Red River	Mountain Fork River	10	145.74	377470991.37

EOBS Stations also varied greatly in number of stream miles and in number of miles per stream order (Table 4).For example, James Fork of the Poteau River and Sugar Loaf Creek, both fourth order streams, had 297 and 117 total miles of stream, respectively.

Table 4. Miles of Stream Order per EOBS Station Watershed.

WBID#	Site	Stream Order (Miles per Watershed)						
		Stream Order						
		1st	2nd	3rd	4th	5th	6th	Total
OK220100-01-0070T	James Fk of Poteau River	193.05	47.57	35.59	20.55	0.00	0.00	296.76
OK220100-01-0160G	Sugar Loaf Creek	80.88	18.22	5.56	12.70	0.00	0.00	117.36
OK220100-02-0040T	Black Fk of Poteau River	59.01	16.37	11.73	0.84	0.00	0.00	87.95
OK220200-01-0030	Big Skin Bayou	0.00	0.00	0.00	0.52	0.00	0.00	0.52
OK220200-01-0030G	Big Skin Bayou	98.55	19.68	22.64	0.45	0.00	0.00	141.32
OK220200-02-0040G	Little Sallisaw Creek	70.24	23.43	9.46	7.24	0.00	0.00	110.37
OK220200-02-0130G	Vian Creek	14.81	10.02	0.00	0.00	0.00	0.00	24.83

OK220200-03-0010G	Sallisaw Creek	160.39	50.62	19.64	20.89	0.00	0.00	251.54
OK220200-05-0050G	Jenkins Creek	12.07	2.43	4.84	0.00	0.00	0.00	19.34
OK410200-01-0150G	Yanubbee Creek	24.74	11.90	8.51	0.00	0.00	0.00	45.15
OK410200-01-0210G	Mud Creek	12.47	5.62	0.00	0.00	0.00	0.00	18.09
OK410200-01-0230G	Yashoo Creek	25.99	8.04	7.88	0.00	0.00	0.00	41.91
OK410210-01-0060G	Horse Head Creek	12.11	7.43	0.00	0.00	0.00	0.00	19.54
OK410210-01-0070G	Cypress Creek	44.85	18.99	5.76	9.99	0.00	0.00	79.59
OK410210-01-0110G	White Oak Creek	11.01	7.74	0.17	0.00	0.00	0.00	18.92
OK410210-02-0150G	Terrapin Creek	51.63	29.57	14.10	1.37	0.00	0.00	96.67
OK410210-02-0240G	Caney Creek	16.61	12.40	0.48	0.00	0.00	0.00	29.49
OK410210-02-0260G	Holly Creek	19.37	21.68	3.42	2.35	0.00	0.00	46.82
OK410210-02-0380G	Pickens Creek	0.00	8.47	2.55	0.00	0.00	0.00	11.02
OK410210-02-0450G	Watson Creek	23.31	14.96	2.86	5.75	0.00	0.00	46.88
OK410210-03-0150G	Honobia Creek	57.30	5.60	11.79	0.00	0.00	0.00	74.69
OK410210-06-0010M	Mountain Fk R (narrows)	143.66	43.55	13.86	0.42	28.33	4.84	234.66
OK410210-06-0010T	Mountain Fk R (upper)	164.57	55.78	22.29	14.78	2.45	0.00	259.87
OK410210-06-0020G	Buffalo Creek (lower)	84.18	37.56	11.90	15.72	0.00	0.00	149.36
OK410210-06-0020T	Buffalo Creek (upper)	14.41	10.07	0.00	0.00	0.00	0.00	24.48
OK410210-06-0030G	Big Hudson Creek	11.90	5.22	0.00	0.00	0.00	0.00	17.12
OK410210-06-0060G	Mine Creek	9.35	5.47	1.23	0.00	0.00	0.00	16.05
OK410210-06-0120G	East Boktukla	15.02	2.55	8.30	0.00	0.00	0.00	25.87
OK410210-06-0160G	Big Eagle Creek	27.09	4.81	1.57	7.35	7.30	0.00	48.12
OK410210-06-0170G	Little Eagle Creek	33.91	8.25	5.78	0.94	0.00	0.00	48.88
OK410210-06-0210G	Cucumber Creek	39.75	11.78	7.38	0.00	0.00	0.00	58.91
OK410210-06-0240G	Rock Creek	23.56	11.02	3.31	0.00	0.00	0.00	37.89
OK410210-06-0270G	Dry Creek	15.61	11.14	2.50	0.00	0.00	0.00	29.25
OK410210-06-0310G	Sixmile Creek	0.00	8.61	9.97	0.00	0.00	0.00	18.58
OK410210-06-0320G	Beech Creek	23.92	5.87	7.81	0.00	0.00	0.00	37.60
OK410210-07-0010G	Lukfata Creek	46.07	17.18	15.18	0.00	0.00	0.00	78.43
OK410210-08-0010G	Glover River (lower)	181.68	76.57	27.84	15.57	26.48	0.00	328.14
OK410210-08-0120G	Cedar Creek	22.22	14.44	4.87	0.00	0.00	0.00	41.53
OK410210-09-0010G	East Fk of Glover R	31.86	13.04	8.74	0.00	0.00	0.00	53.64
OK410210-09-0070M	West Fk of Glover R	27.10	6.19	3.06	5.78	0.00	0.00	42.13
OK410210-09-0070U	West Fk of Glover (upper)	12.19	3.42	1.05	0.00	0.00	0.00	16.66
OK410210-09-0100G	Silver Creek	38.53	22.72	12.28	0.19	0.00	0.00	73.72
OK410210-09-0180G	East Creek	9.97	10.48	0.17	0.00	0.00	0.00	20.62
OK410310-02-0010G	Kiamichi River	58.26	15.75	1.70	7.58	0.00	0.00	83.29

Drainage Density (total length of stream per unit area) varied among EOBS stations, ranging from 0.53 to 2.66 based on 1:24,000 digital raster files (Table 5). Drainage density can reflect the permeability of the geology of a watershed (Carlston, 1963). Where rocks are highly permeable, transmissivity is high and a greater portion of the total precipitation is transmitted as groundwater. When rocks are not permeable, a greater portion of incoming precipitation cannot infiltrate and flows downslope as surface water. Over time, the surface water flow develops channel networks and higher drainage density (Grant 1997). This suggests that basins with lower drainage densities, like Sixmile, Pickens, Vian, Jenkins, Sallisaw, Cucumber, and Mud Creeks probably have a slightly more karstic geology than basins with higher drainage densities like Holly, Watson, Silver, Dry, Terrapin, Cedar, and Yanubbee Creeks.

Table 5. Drainage Densities for EOBS Station Watersheds.

WBID#	Site	Drainage Density (mi/m^2)
OK220100-01-0070T	James Fk of Poteau River	1.67
OK220100-01-0160G	Sugar Loaf Creek	1.93
OK220100-02-0040T	Black Fk of Poteau River	1.97
OK220200-01-0030G	Big Skin Bayou	1.76
OK220200-02-0040G	Little Sallisaw Creek	1.69
OK220200-02-0130G	Vian Creek	1.18
OK220200-03-0010G	Sallisaw Creek	1.37
OK220200-05-0050G	Jenkins Creek	1.29
OK410200-01-0150G	Yanubbee Creek	2.01
OK410200-01-0210G	Mud Creek	1.56
OK410200-01-0230G	Yashoo Creek	1.77
OK410210-01-0060G	Horse Head Creek	1.78
OK410210-01-0070G	Cypress Creek	1.96
OK410210-01-0110G	White Oak Creek	1.89
OK410210-02-0150G	Terrapin Creek	2.06
OK410210-02-0240G	Caney Creek	1.96
OK410210-02-0260G	Holly Creek	2.66
OK410210-02-0380G	Pickens Creek	0.93
OK410210-02-0450G	Watson Creek	2.22
OK410210-03-0150G	Honobia Creek	1.72
OK410210-06-0010M	Mountain Fk R (narrows)	1.90
OK410210-06-0010T	Mountain Fk R (upper)	1.78
OK410210-06-0020G	Buffalo Creek (lower)	1.96
OK410210-06-0020T	Buffalo Creek (upper)	1.87
OK410210-06-0030G	Big Hudson Creek	1.59
OK410210-06-0060G	Mine Creek	1.89
OK410210-06-0120G	East Boktukla	1.82
OK410210-06-0160G	Big Eagle Creek	1.99
OK410210-06-0170G	Little Eagle Creek	1.96
OK410210-06-0210G	Cucumber Creek	1.45
OK410210-06-0240G	Rock Creek	1.85
OK410210-06-0270G	Dry Creek	2.06
OK410210-06-0310G	Sixmile Creek	0.61
OK410210-06-0320G	Beech Creek	1.68
OK410210-07-0010G	Lukfata Creek	1.89
OK410210-08-0010G	Glover River (lower)	1.99
OK410210-08-0120G	Cedar Creek	2.06
OK410210-09-0010G	East Fk of Glover R	1.85

OK410210-09-0070M	West Fk of Glover R	1.71
OK410210-09-0070U	West Fk of Glover (upper)	1.62
OK410210-09-0100G	Silver Creek	2.11
OK410210-09-0180G	East Creek	1.88
OK410310-02-0010G	Kiamichi River	1.70

Median stream flow (taken at seasonal baseflow) was highly variable among streams (Figure 7). Median values ranged from 1.0 – 121.5 cfs (n = 7 – 10 per site). Median flows at James Fork of the Poteau River, Sallisaw Creek, Mountain Fork (narrows), Big Eagle Creek, and Lower Glover River were significantly higher than other stations. This was expected given the large stream order of these streams. However, median flows were not significantly higher at other large order such as Upper Mountain Fork, East Fork of the Glover, West Fork of the Glover , Upper West Fork of the Glover, and the Kiamichi River at Big Creek than low order streams.

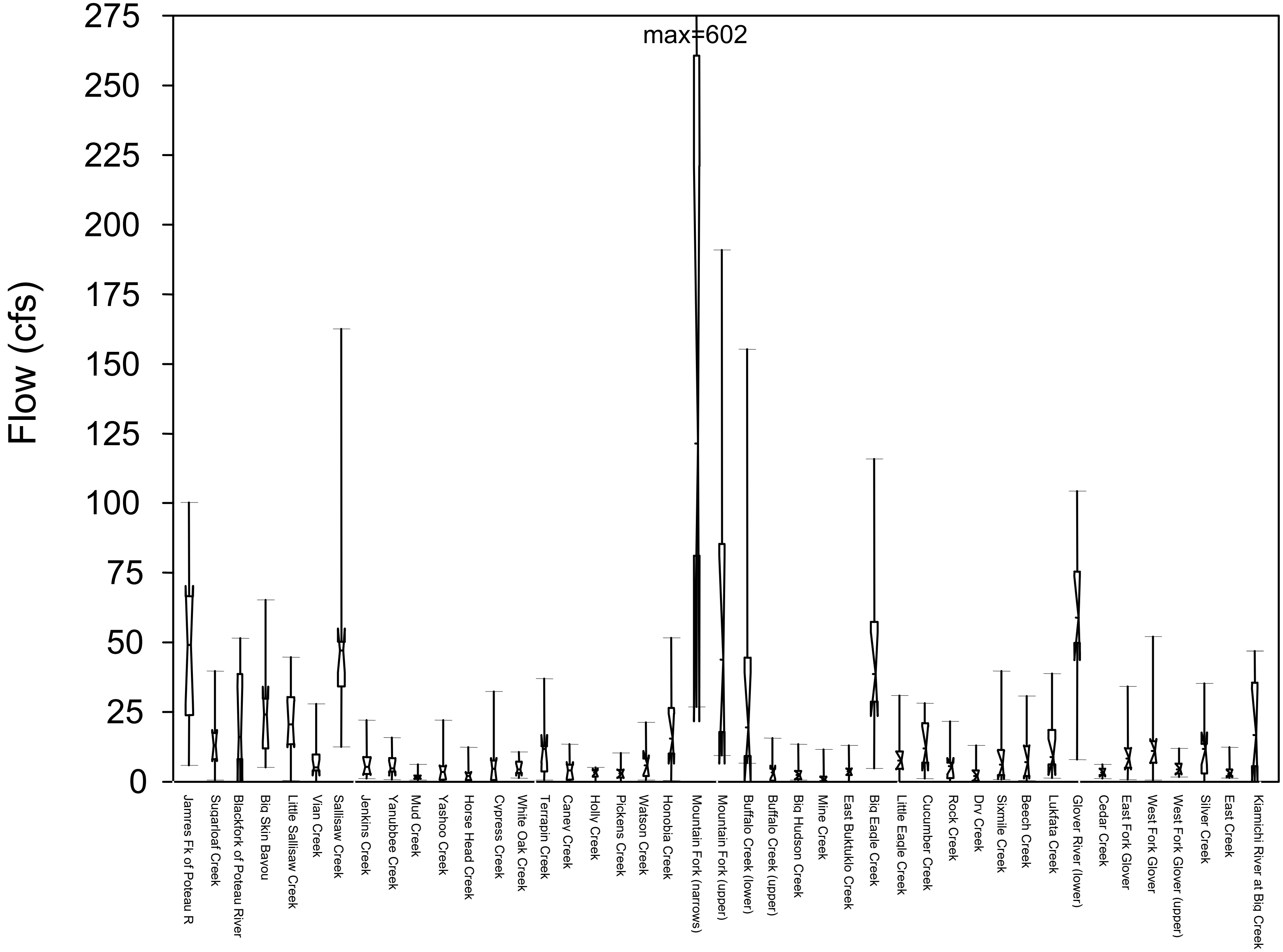

Figure 7. Flow Ranges for EOBS Stations.

Physicochemical Parameters

Temperatures varied during the sampling period, as expected, ranging between 1.6 and 33.5 ºC (Figure 8). Median values ranged between 12.75 and 20.55 ºC. Median values did not vary significantly among creeks with the following exceptions: 1) Glover River median temperature was significantly higher than median temperature at Vian Creek, Sallisaw Creek, Pickens Creek, Jenkins Creek, Sixmile Creek, and Rock Creek, and 2) Cedar Creek median temperatures were significantly higher than median temperatures at Jenkins Creek, Sixmile Creek, and Rock Creek. Generally, higher temperatures were recorded at large order streams (Glover River, Blackfork of the Poteau River, and Mountain Fork River) and lower temperatures at small order streams (Sixmile Creek, East Creek, Jenkins Creek). A standards violation was noted on 7-18-95 at the Black Fork on the Poteau River Station with a temperature of 33.5 ºC.

Dissolved oxygen concentrations varied seasonally and between stations (Figure 9). Median dissolved oxygen concentration at Mud Creek was significantly lower than many stations (Vian, Sallisaw, Jenkins, Terrapin, Caney, Pickens, Honobia, Upper Mountain Fork, East Boktukla, Big Eagle, Little Eagle, Cucumber, Rock, Sixmile, East Fork of the Glover, West Fork of the Glover, Upper West Fork of the Glover, East Creek, and Silver Creeks). Median dissolved oxygen concentrations at Yanubbee and White Oak Creeks were significantly lower than at Jenkins Creek, Little Eagle Creek, and Upper West Fork of the Glover River. Median dissolved oxygen concentration at Cedar Creek was significantly lower than at Jenkins or Little Eagle Creeks. Dissolved Oxygen concentrations standards violations were noted at some stations, mainly during summer months (Table 6).

It should be noted that dissolved oxygen criteria were violated during a previous (1991-1992) OCC study in Cypress Creek (1 violation), West Fork of the Glover River (2 violations), Caney Creek (2 violations), White Oak Creek (1 violation), Silver Creek (1 violation), Cedar Creek (1 violation), Lukfata Creek (2 violations), Yashoo Creek (3 violations), Upper Mountain Fork River (1 violation) Yanubbee Creek (2 violations), Beech Creek (2 violations), Big Eagle Creek (1 violation), Upper and Lower Buffalo Creek (1 violation per site), and Mud Creek (1 violation). Comparison between the previous and current studies suggests perhaps temporary but certainly chronic occurrences of dissolved oxygen problems in Mud Creek, Upper and Lower Buffalo Creek, Lukfata Creek, Yanubbee Creek, Cypress Creek, and Big Eagle Creek.

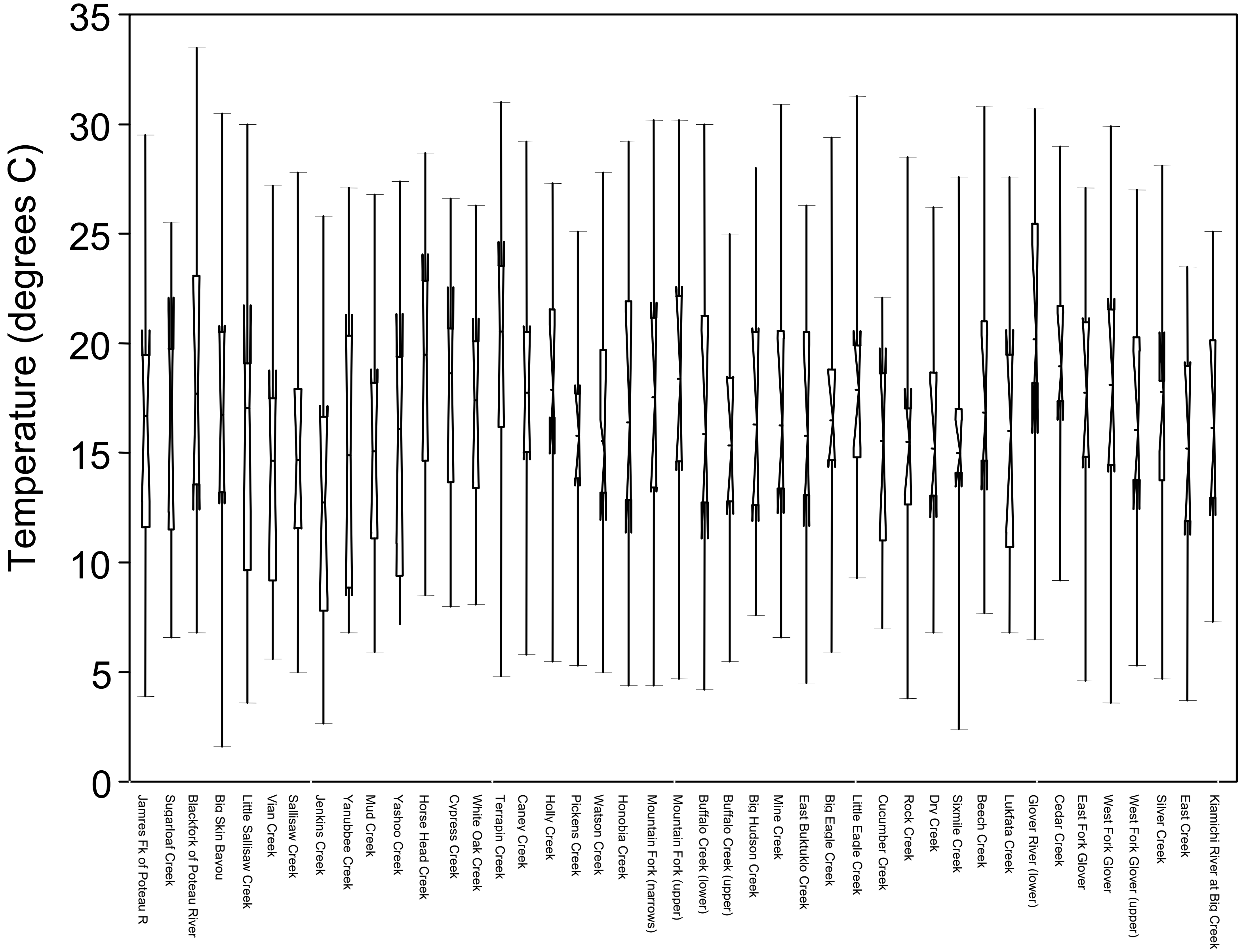

Figure 8. Temperature Ranges for EOBS Stations.

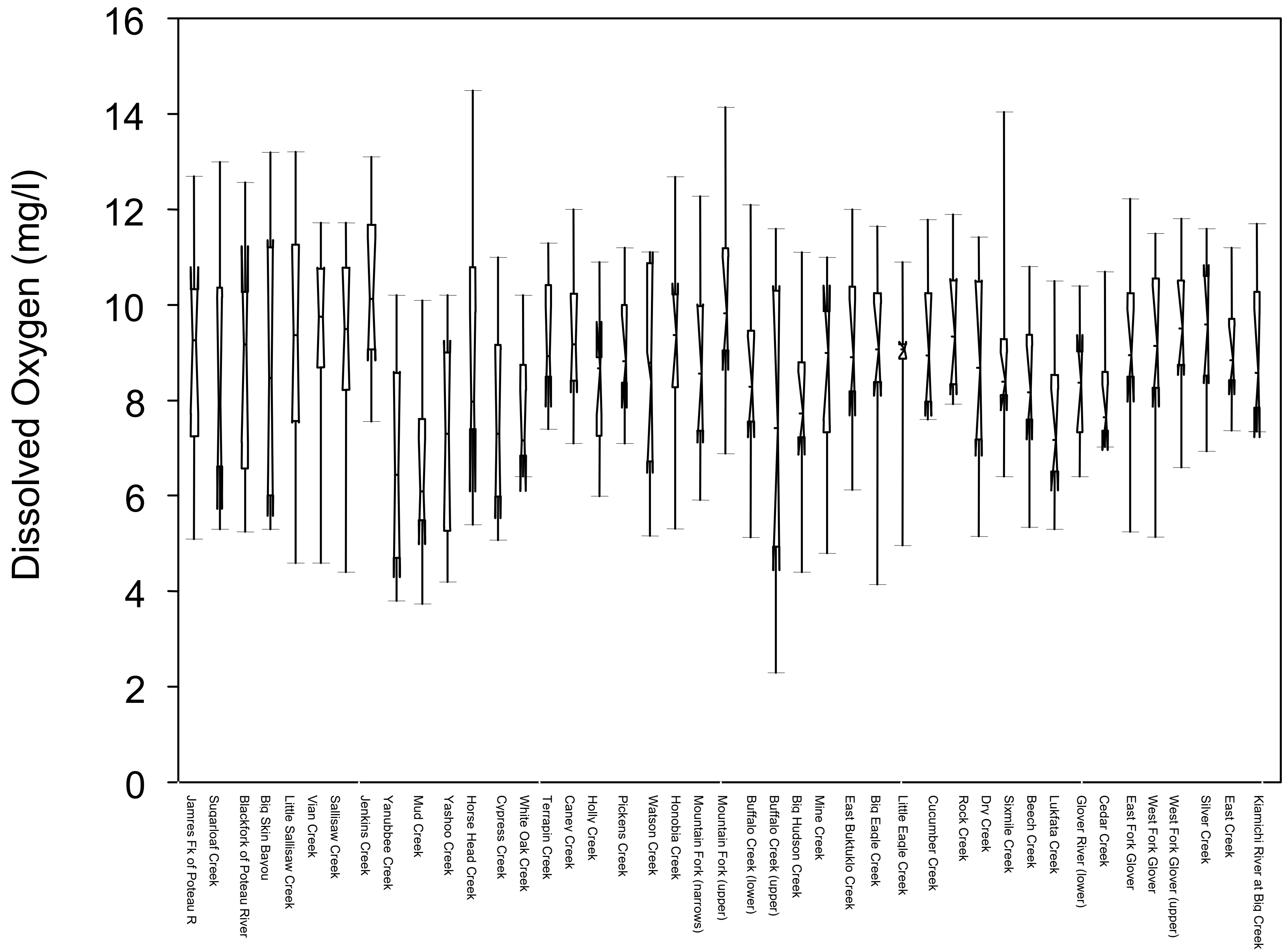

Figure 9. Dissolved Oxygen Concentrations for EOBS Stations.

Table 6. Dissolved Oxygen Standards Violations.

Stream	Date	D.O. (mg/l)	Stream	Date	D.O. (mg/l)
Little Sallisaw Creek	7-17-95	4.6	Vian Creek	7-17-95	4.6
Sallisaw Creek	7-17-95	4.4	Yanubbee Creek	7-17-95	4.4
Mud Creek	7-17-95	4.3		4-11-96	4.8
	6-24-97	3.7		6-24-97	3.8
Yashoo Creek	7-17-95	4.6	Cypress Creek	7-17-95	5.6
	10-10-95	4.2		6-24-97	5.1
Mountain Fork (narrows)	7-17-95	5.9	Buffalo Creek (lower)	7-17-95	5.1
Buffalo Creek (upper)	7-17-95	2.3	Big Hudson Creek	7-17-95	4.4
	10-8-96	4.4	Mine Creek	7-17-95	4.8
	7-8-97	5.1	Big Eagle Creek	7-17-95	4.15
Little Eagle Creek	7-17-95	4.96	Beech Creek	7-18-95	5.35
Lukfata	7-17-95	5.3	East Fork of the Glover	7-17-95	5.25
	6-24-97	5.9	West Fork of the Glover	7-17-95	5.14

pH values generally ranged from neutral to slightly acidic (Figure 10). Median pH at Vian, Sallisaw, Jenkins, Horse Head, Beech, Lukfata, and Cedar Creeks and the Lower Glover River were significantly higher (neutral to slightly basic) than at most other stations. Oklahoma Water Quality Standards states that pH values must be between 6.5 and 9.0 for waters designated for fish and wildlife habitat (all EOBS streams are either designated as warm water or cold water aquatic communities)(OWRB 1996). Every station except Lukfata, Lower Glover, Cedar, Silver, Vian, Jenkins, Sallisaw, Mud, Horse Head, White Oak, Terrapin, Caney, and Holly violated this standard (had values lower than 6.5) at least one time. These violations were noted most often in October and January of 1995 sample collections. During the 1991-92 OCC study, pH violations were recorded at every station except Boktuklo Creek, Mine Creek, Big Hudson Creek, Lukfata Creek, Yashoo Creek, Big and Little Eagle Creeks, and Horsehead Creeks. This trend suggest pH violations are a long-term problem in the study area.

Median turbidity values ranged from 1.2 – 22.4 NTU (Figure 11). Median turbidity was not significantly different among stations except Black Fork of the Poteau River, Sugar Loaf Creek, Big Skin Bayou, and Little Sallisaw Creek. Median turbidity at these four stations was significantly higher than at all other stations except Jenkins, Holly, Watson, and Rock Creeks. Oklahoma Water Quality Standards state that baseflow turbidity should not exceed 10 NTU for Cold Water Aquatic Communities and 50 for Warm Water Aquatic Communities. Exceedances were noted on several occasions at many creeks (Table 7). At most stations, these exceedances were episodic and likely associated with runoff events. However, at some stations, criteria exceedance was noted often during the sampling period and median turbidity exceeded Oklahoma Water Quality

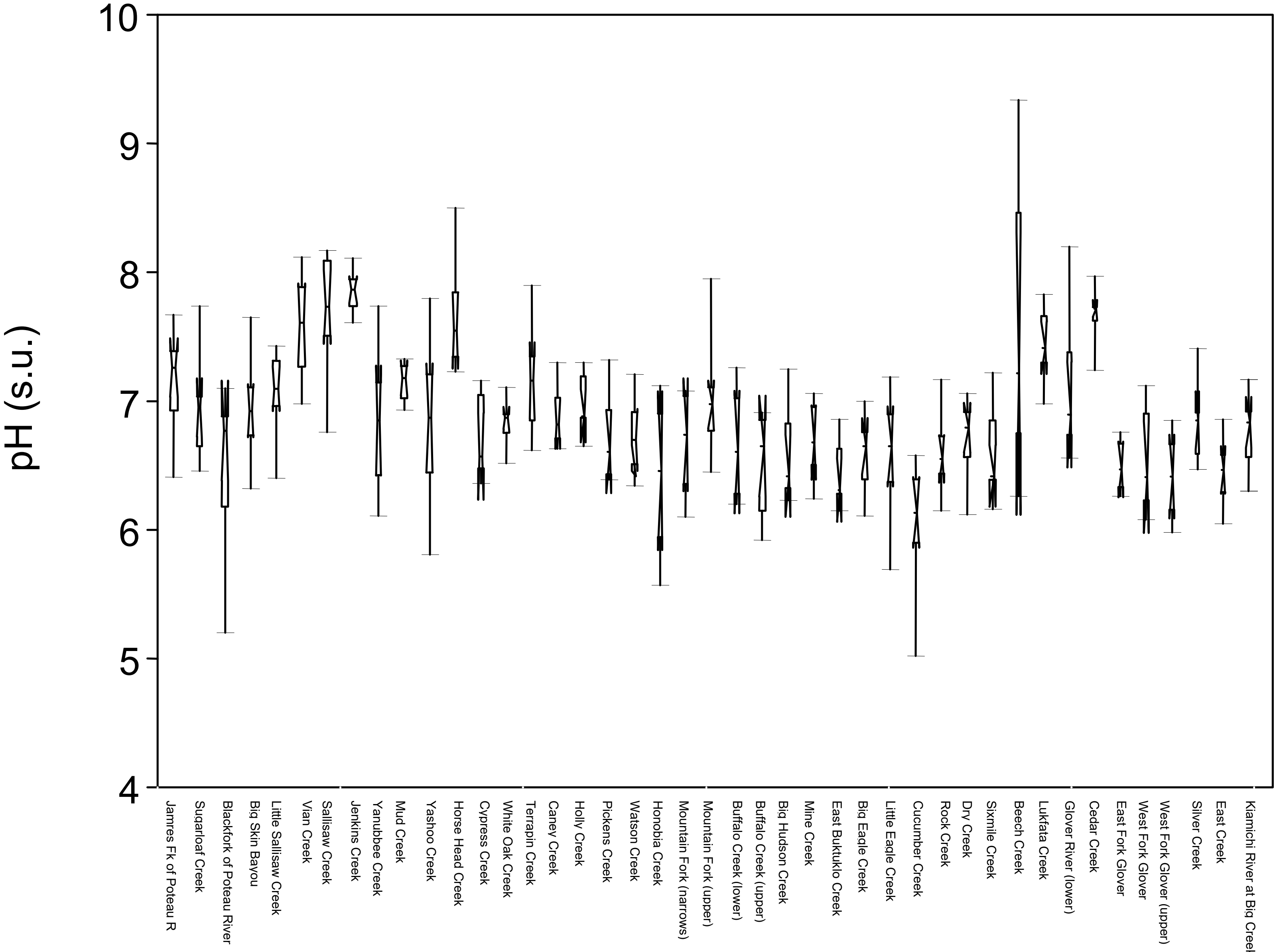

Figure 10. pH Ranges for EOBS Stations.

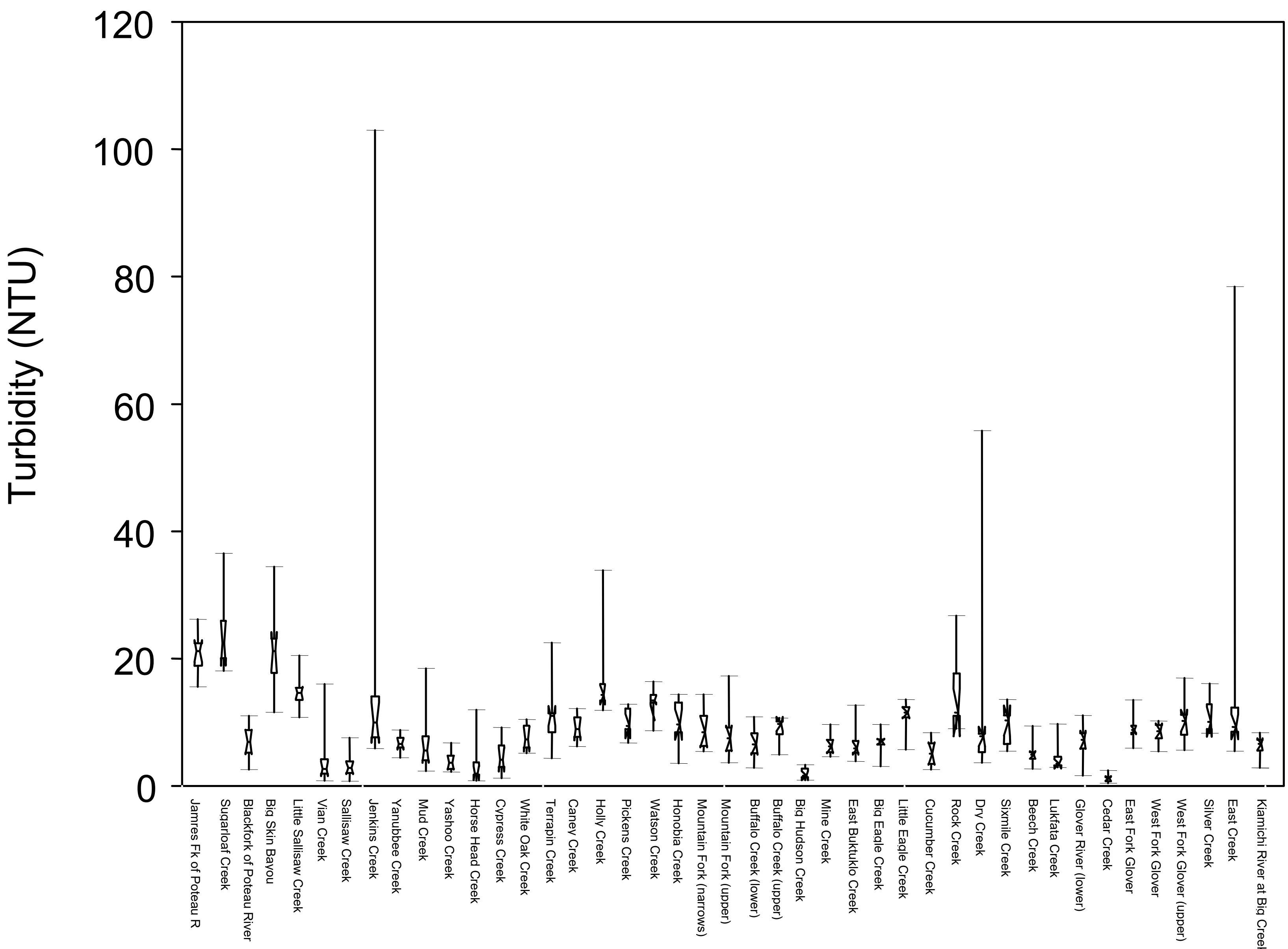

Figure 11. Turbidity Ranges for EOBS Stations.

Table 7. Exceedance Values for Turbidity at EOBS Stations.

Station	Date	Turbidity (NTU)	Station	Date	Turbidity (NTU)
Black Fork of Poteau River	4/1/97	11.0	Vian Creek	4/3/95	12.0
Terrapin Creek	1/11/95	11.0		4/10/96	16.0
	10/9/95	22.5	Mountain Fork (narrows)	1/10/95	14.4
	4/10/96	17.6		10/9/96	13.1
	10/7/96	11.4		6/26/97	11.0
Buffalo Creek (lower)	1/10/95	10.9	Mountain Fork (upper)	1/10/95	10.3
Buffalo Creek (upper)	4/1/97	10.9		4/1/97	17.3
	7/8/97	10.7	East Boktukla Creek	6/26/97	12.7
Little Eagle Creek	1/10/95	11.5	Rock Creek	1/10/95	11.9
	4/3/95	10.8		10/9/95	26.8
	10/9/95	12.4		2/8/96	11.1
	2/8/96	10.7		4/11/96	11.2
	4/11/96	11.1		10/8/96	18.1
	10/8/96	13.6		3/31/97	10.7
	4/1/97	13.0		6/25/97	17.6
	6/26/97	12.4	Dry Creek	4/1/97	55.8
Upper West Fork of Glover	1/11/95	17.0	Lower Glover River	6/23/97	11.1
	10/9/95	10.8	East Fork of the Glover River	6/25/97	13.5
	3/31/97	10.8	East Creek	7/18/95	77.7
	6/25/97	12.4	Jenkins Creek	7/7/97	103.0

Standards. Median turbidities exceeded criteria at Little Eagle, Upper West Fork of the Glover River, Terrapin Creek, and Rock Creek. Turbidity violations were noted during the 1991-92 study on the following creeks and rivers: Watson (4 violations), Pickens (4 violations), Caney (5 violations), White Oak (4 violations), East (5 violations), Silver (5 violations), Sixmile (5 violations), Dry (5 violations), Mine (5 violations), Black Fork (2 violations), Upper Mountain Fork (4 violations), Terrapin (4 violations), Holly Creek (6 violations), Upper West Fork of the Glover (5 violations), East Fork of the Glover (5 violations), Lukfata (1 violation), Beech (1 violation), Rock (5 violations), Big Eagle (3 violations), Cucumber (1 violation), Little Eagle (2 violations), and Upper and Lower Buffalo (4 violations at each station). This comparison suggests long term turbidity problems in many of the creeks listed in Table 7.

Total Suspended Solids concentrations were generally low at EOBS Stations (Figure 12). Median concentrations ranged from below detection limit (<0.1) to 19.25 mg/l. Sites with higher suspended solids generally had also higher turbidities.

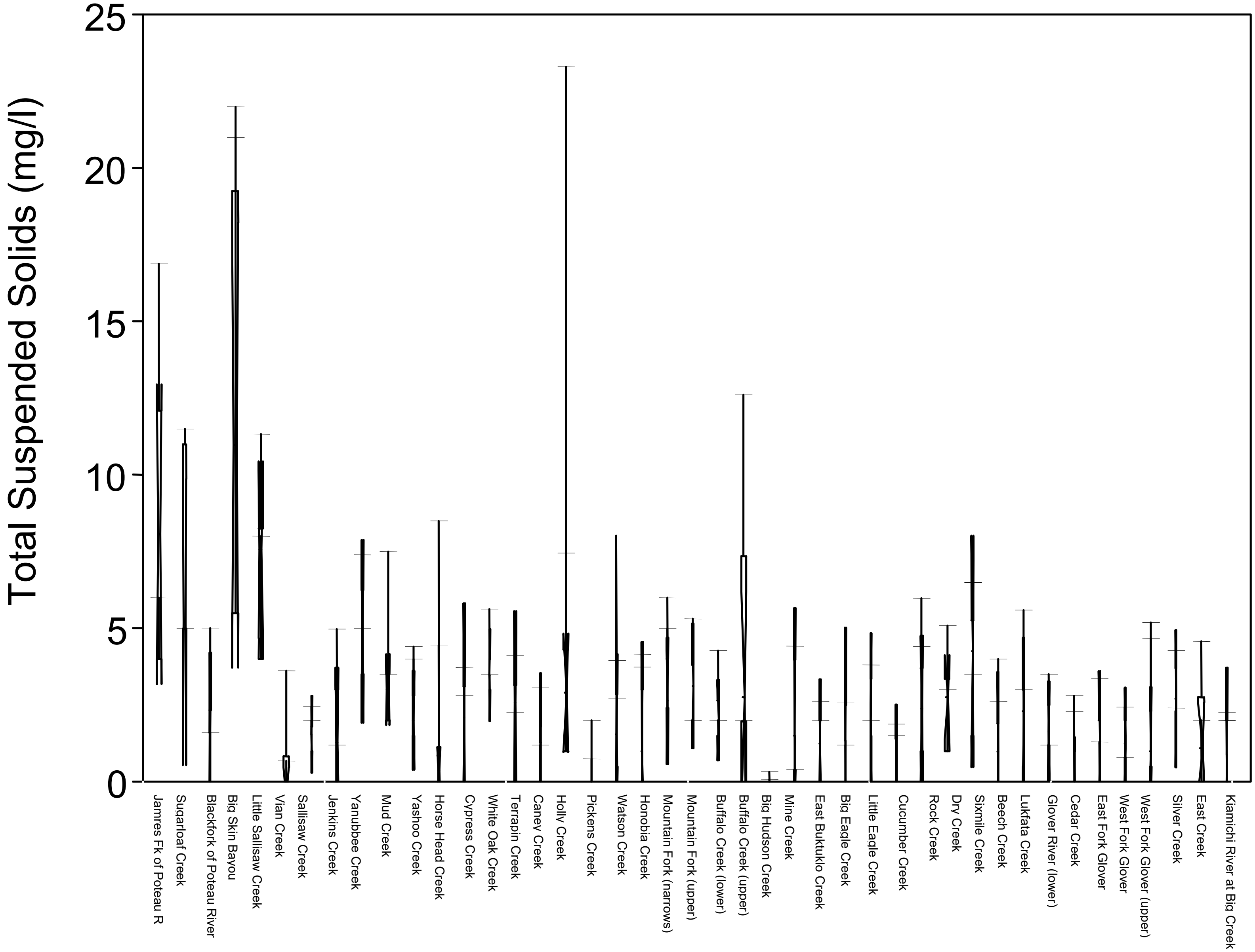

Figure 12. Total Suspended Solids Concentrations at EOBS Stations.

Conductivities at EOBS stations were low to moderate, with medians ranging from 20 – 329 :s/cm (Figure 13). These did not exceed Oklahoma Water Quality Standards equivalent criteria for total dissolved solids. Median conductivity did not vary significantly among most stations. However, median conductivity was significantly higher at James Fork of the Poteau River, Big Skin Bayou, Little Sallisaw Creek, Vian Creek, Sallisaw Creek, Jenkins Creek, Yanubbee Creek, Mud Creek, Yashoo Creek, Horse Head Creek, and Lukfata Creek.

Chloride concentrations were low at most EOBS and median concentrations varied little among stations (Figure 14). Median concentrations ranged from 2.55 – 33 mg/l at EOBS Stations. Median chloride concentration was higher at Mud Creek than at Yanubbee Creek. Median concentration at Yanubbee Creek was higher than at any other EOBS station. Chloride concentrations did not exceed Oklahoma Water Quality Standards criteria.

Sulfate concentrations were widely variable at EOBS Stations, ranging from high to low (Figure 15). Median concentrations fell into three groups: James Fork of the Poteau River, Little Sallisaw Creek, and Mud Creek had the greatest sulfate concentrations, Sugar Loaf Creek, Big Skin Bayou, Vian Creek, and Yanubbee Creek had the moderate concentrations, and the remaining creeks fell into the lowest group. These sulfate concentrations were within the normal range for freshwater (Wetzel 1983) and did not violate Oklahoma Water Quality Standards.

Alkalinity and Hardness varied similarly among EOBS stations (Figures 16 and 17). Stations with higher alkalinity generally had higher hardness values. Median alkalinities ranged from 3.5 – 93.5 mg $CaCO^3$/l. Median hardness ranged from 8 – 108.5 mg $CaCO^3$/l. Median alkalinity was significantly higher at Vian, Sallisaw, Jenkins, Yanubbee, Mud, Yashoo, Horse Head, Lukfata, and Cedar Creeks than at other stations. Median hardness was significantly greater at James Fork of the Poteau River, Big Skin Bayou, Little Sallisaw, Vian, Jenkins, Yanubbee, Mud, Yashoo, Horse Head, Lukfata, and Cedar Creeks than at other stations. Median hardness would be classified as soft at all stations except Mud, Jenkins, Sallisaw, Lukfata, and Vian Creeks, which would be classified as moderately hard (Sawyer and McCarty 1978).

Total phosphorus concentrations ranged from <0.01 – 0.41 mg/l(Figure 18). Median concentrations ranged from 0.01 – 0.15 mg/l. Median concentrations at Yanubbee and Mud Creek were significantly greater than at most other stations. Average concentrations greater than 0.05 mg/l are indicative of excess phosphorus loading (Sawyer and McCarty 1978). Median concentrations were greater than 0.05 at Sugar Loaf Creek, James Fork of the Poteau River, Big Skin Bayou, Yanubbee Creek, and Mud Creek. Total phosphorus concentrations collected during the 1991-92 OCC study were greater than 0.05 mg/l at the following creeks (occurrences > 0.05 mg/l): Watson (1), White Oak (1), Silver (4), Boktuklo (3), Sixmile (1), Dry (2), Black Fork (1), Cypress (1), Upper West Fork of the Glover (1), Cedar (1), Lukfata (4), Yanubbee (8), Upper

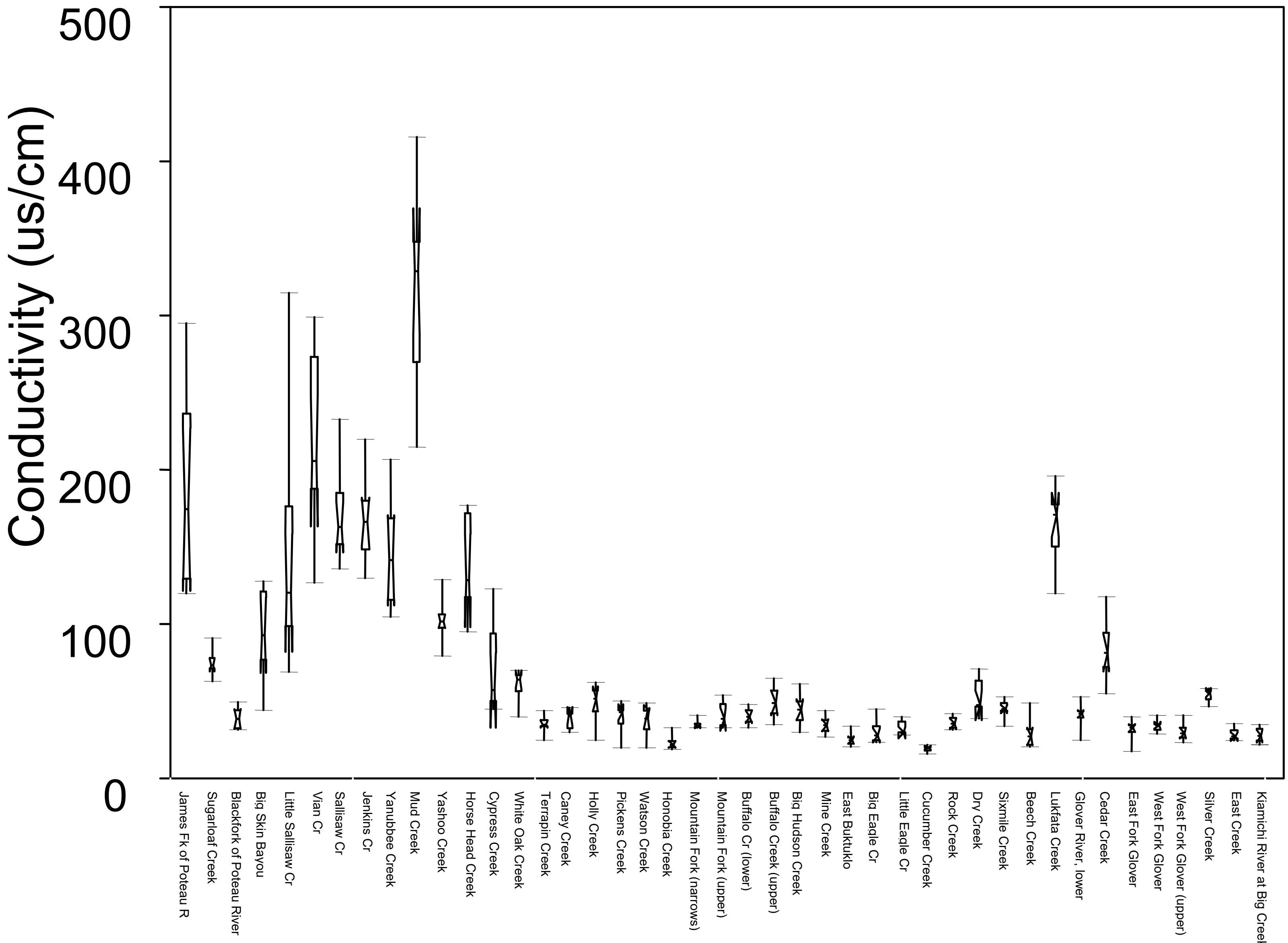

Figure 13. Conductivity Ranges for EOBS Stations.

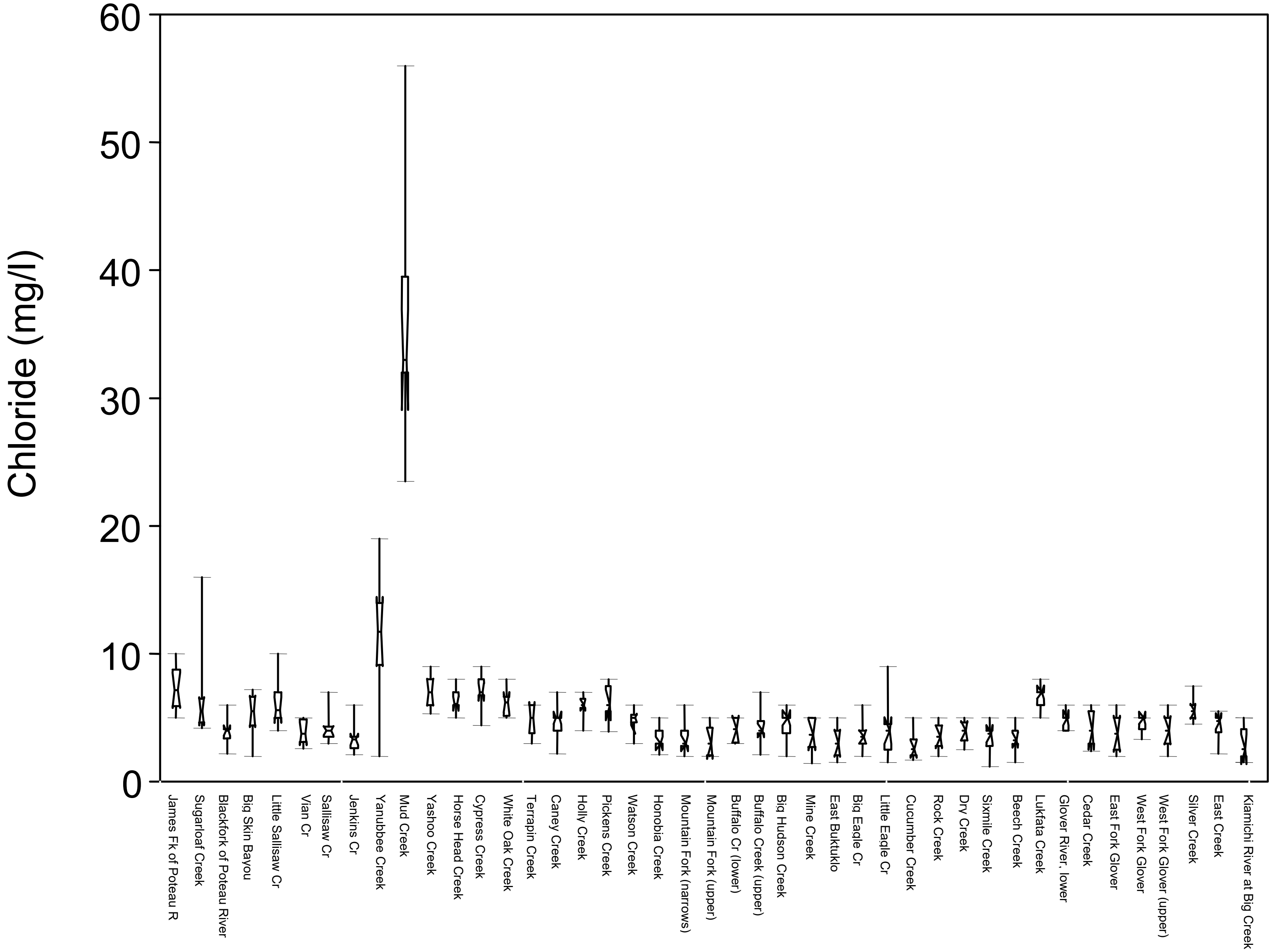

Figure 14. Chloride Ranges for EOBS Stations.

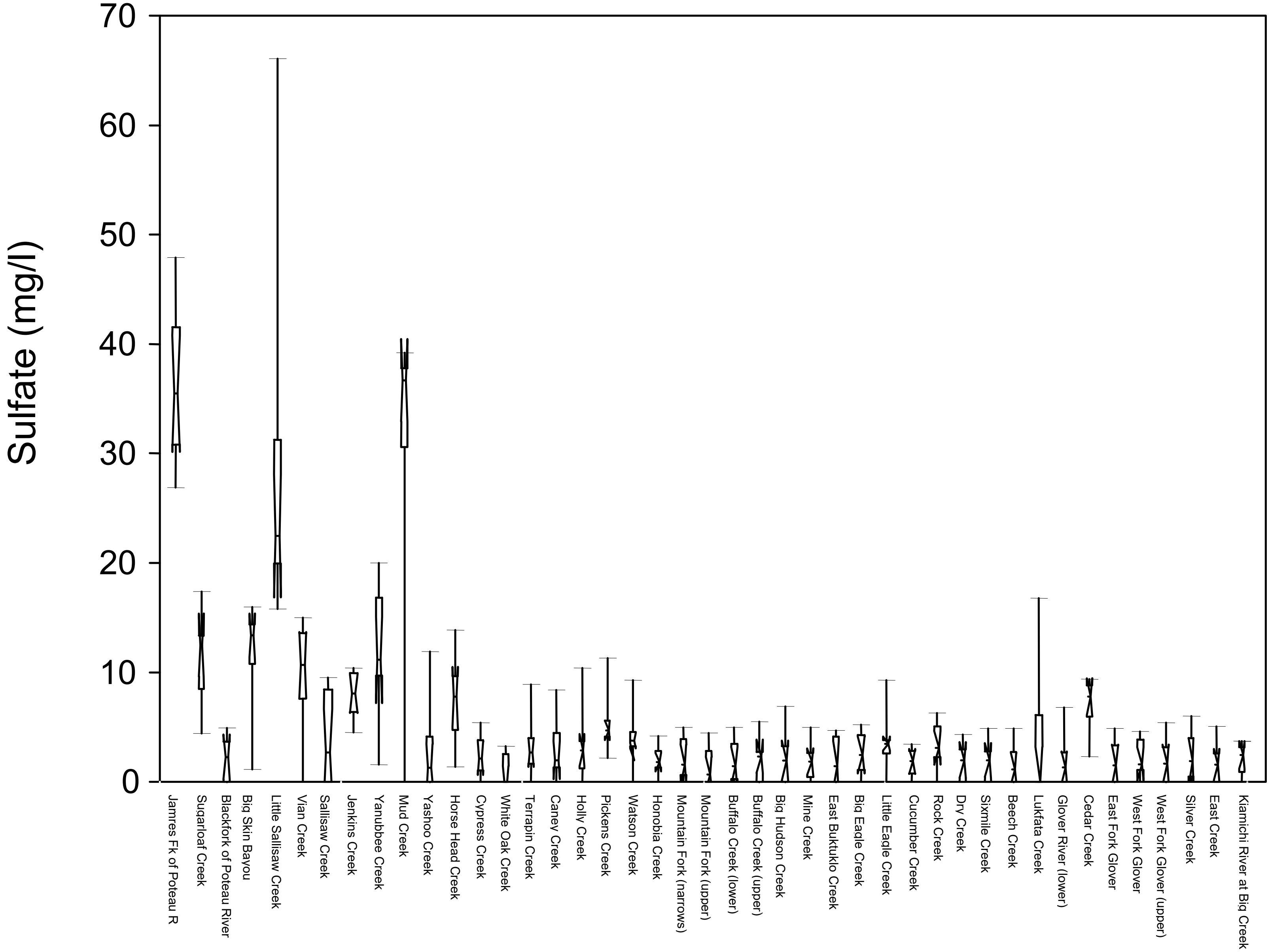

Figure 15. Sulfate Ranges for EOBS Stations.

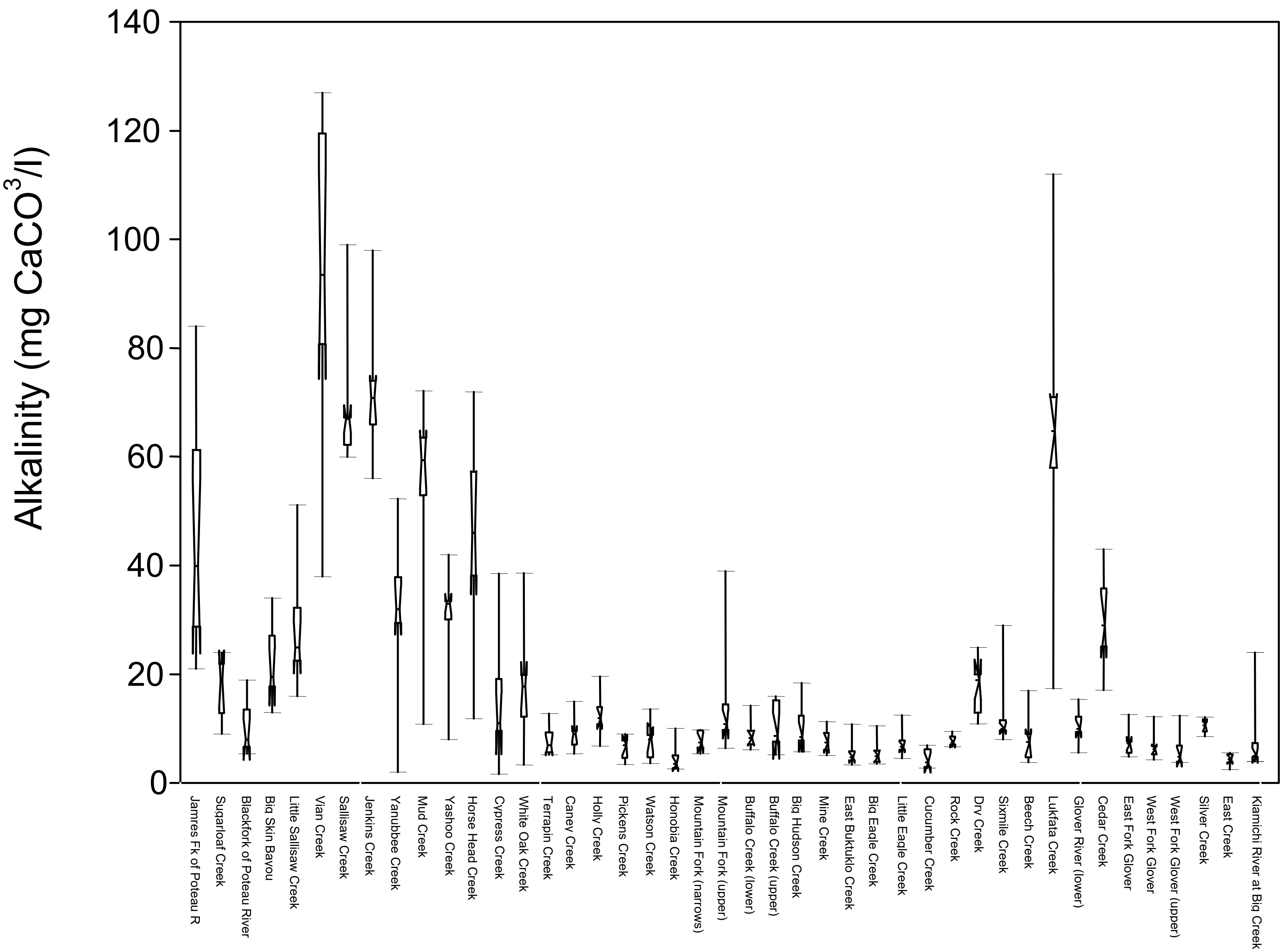

Figure 16. Alkalinities for EOBS Stations.

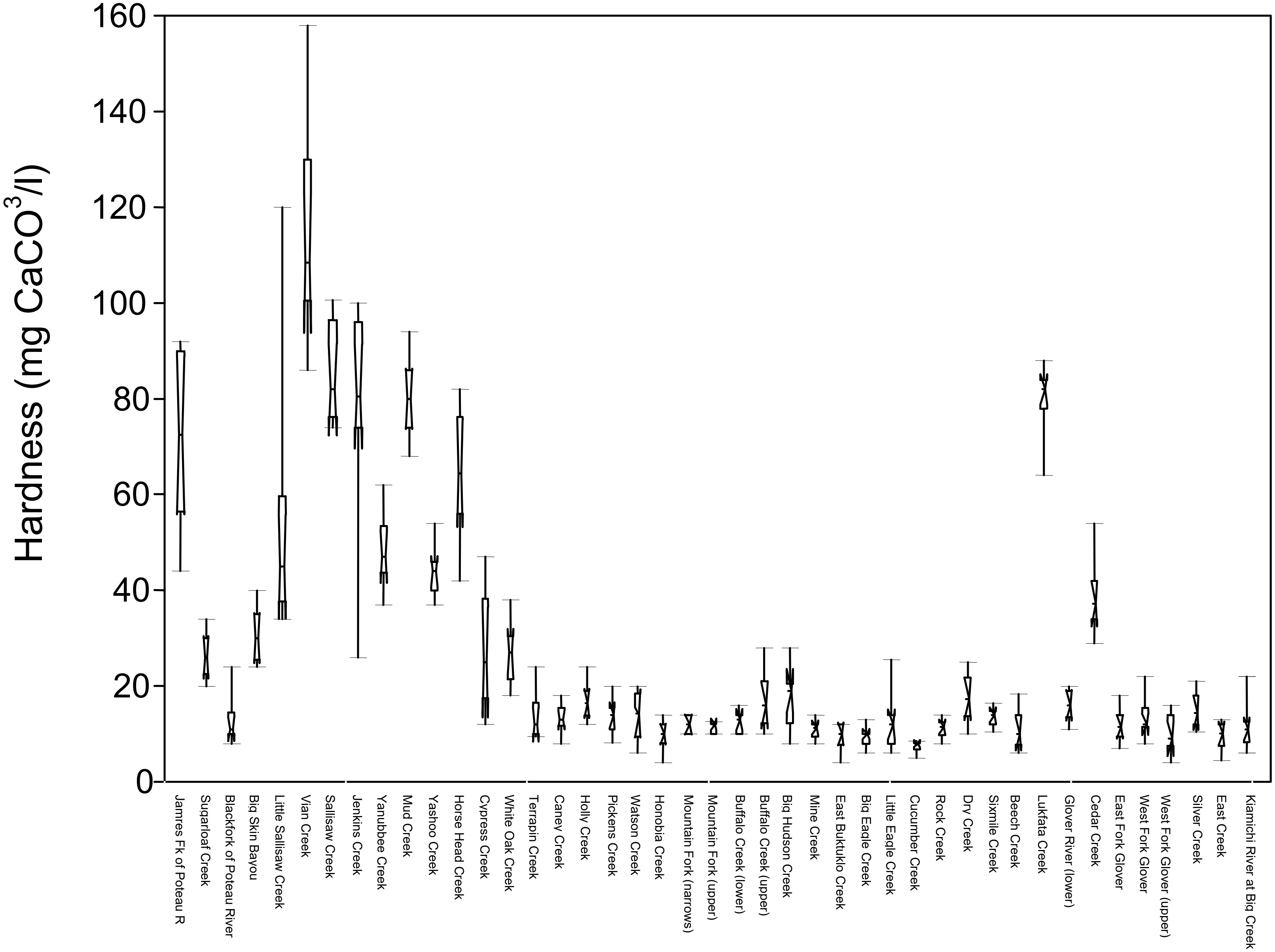

Figure 17. Hardness for EOBS Stations.

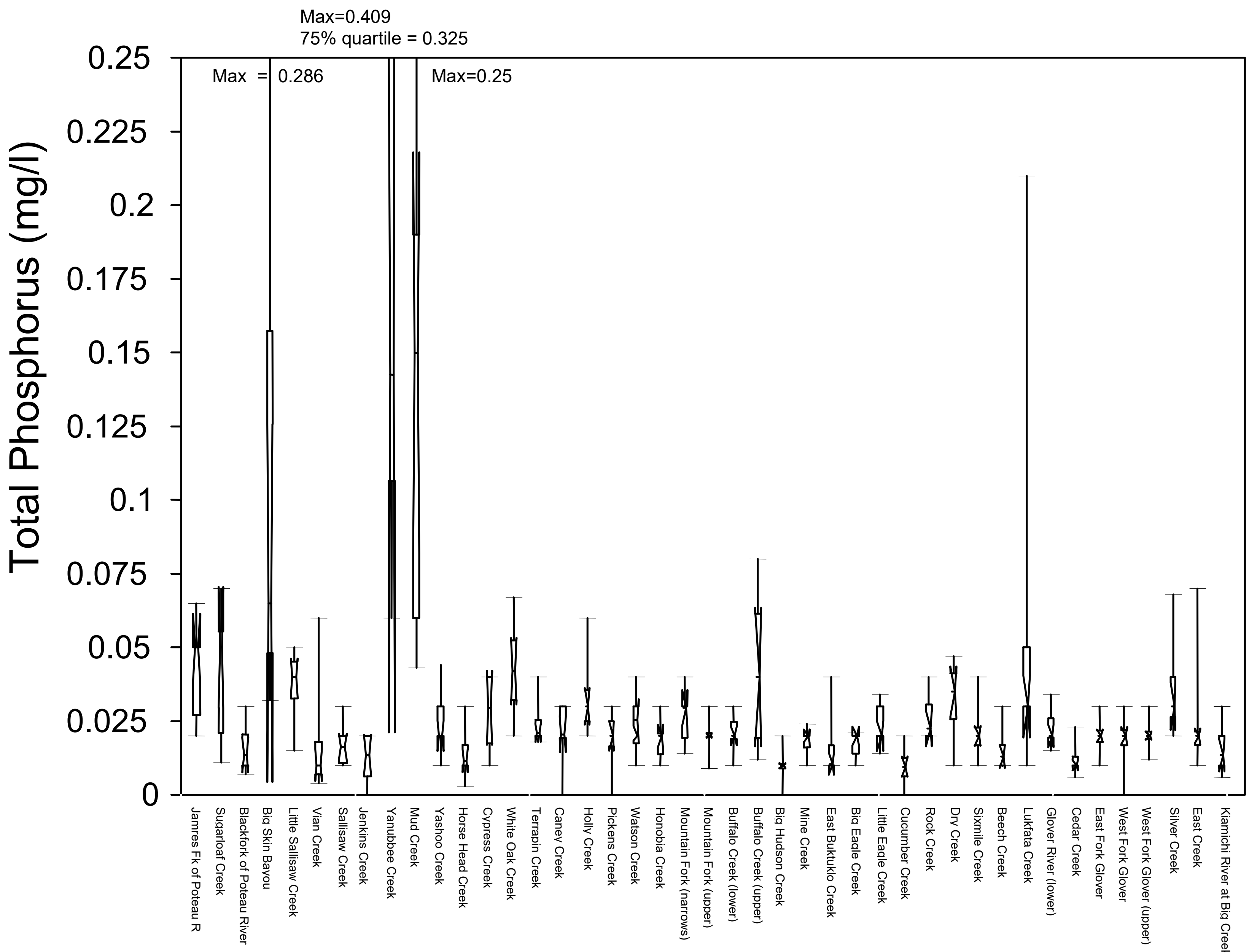

Figure 18. Total Phosphorus Ranges for EOBS Stations.

Mountain Fork (2), Holly (1), Big Eagle (1), Little Eagle (1), Upper Buffalo (1) Lower Buffalo (2), Horsehead (2), and Mud (8).

Median orthophosphate concentrations were not collected at all stations or during every sampling event. However, when collected, concentrations were often at or below detection limits (Figure 19). Median concentrations were significantly higher at Big Skin Bayou than at other stations, but below the critical 0.05 mg/l value. These low orthophosphorus concentrations indicate that most of the phosphorus in the system was tied up, either in biomass or attached to particulate matter.

Total Kjeldahl Nitrogen (TKN) concentrations ranged from <0.01 – 1.96 mg/l (Figure 20). Median concentrations ranged from 0.03 – 0.58 mg/l and were significantly greater at Mud Creek and Big Skin Bayou than at most other stations. Nitrate concentrations are the second highest of the nitrogen compounds (Figure 21). Nitrate concentrations ranged from <0.003 – 2.1 mg/l. Median concentrations ranged from <0.003 – 1.39 mg/l. Median nitrate concentrations were significantly higher at Yanubbee and Mud Creek than at other EOBS Stations. This suggests higher rates of organic pollution in those two creeks than at other EOBS Stations.

Nitrite and ammonia nitrogen concentration data was sparser than other data as these parameters were not measured during every sampling event. However, the data collected indicates these parameters were generally at or below detection limits (<0.002 mg/l - <0.1 mg/l) and thus are not a consistent problem at EOBS Stations (Figures 22-23). This was as expected in streams where the water is oxygenated and no direct point sources exist. Nitrite concentrations were notable at Blackfork of the Poteau River, Big Skin Bayou, Jenkins Creek, Mud Creek, and most importantly at Yanubbee Creek, where concentrations were always above detection limits.

Critical levels for nitrogen range from 1 – 3 mg/l (Wetzel 1983, Sawyer 1947). Although TKN does not include all nitrogen parameters, (does not account for nitrate, nitrite, or ammonia), TKN and nitrate usually account for the bulk of total nitrogen in relatively unimpacted streams. This principle holds true for EOBS streams. Total Nitrogen concentrations for EOBS Stations were estimated by adding nitrate and Total Kjeldahl Nitrogen concentrations (Figure 24). Median values did not differ significantly among stations with the exception of two creeks nor were median values greater than critical levels. Median values at Yanubbee and Mud Creeks were significantly greater than other creeks at 2.08 and 1.43 mg/l, respectively. Although other creeks had values greater than 1 mg/l, these median values were the only medians above critical values for total nitrogen.

Chemical Oxygen Demand (COD) was measured at selected EOBS Stations on 01 April and 07 July 1997. Generally, COD was higher in July than in April (Figure 25). COD concentrations were highest in both April and July in Dry

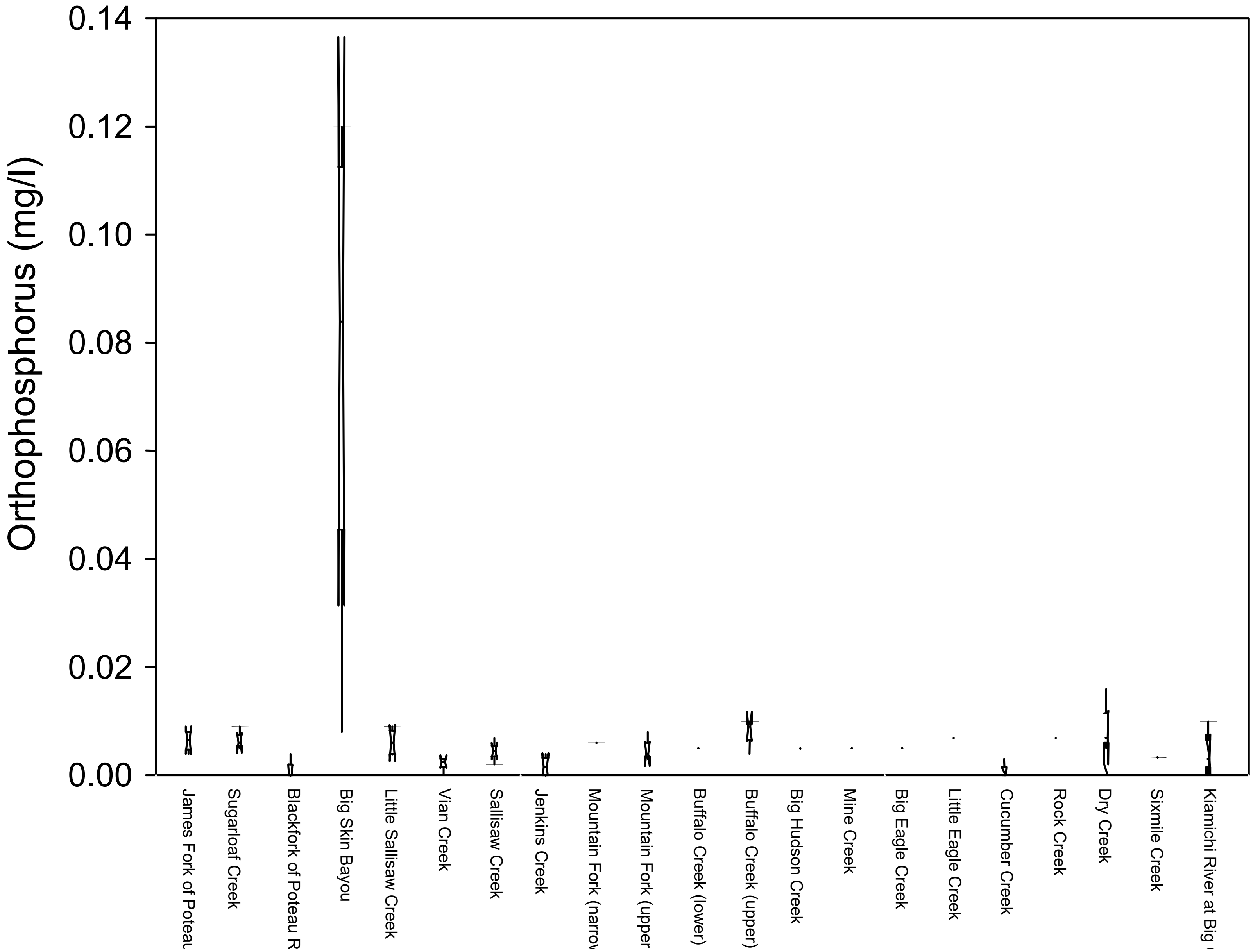

Figure 19. Orthophosphate Concentrations at Limited EOBS Stations.

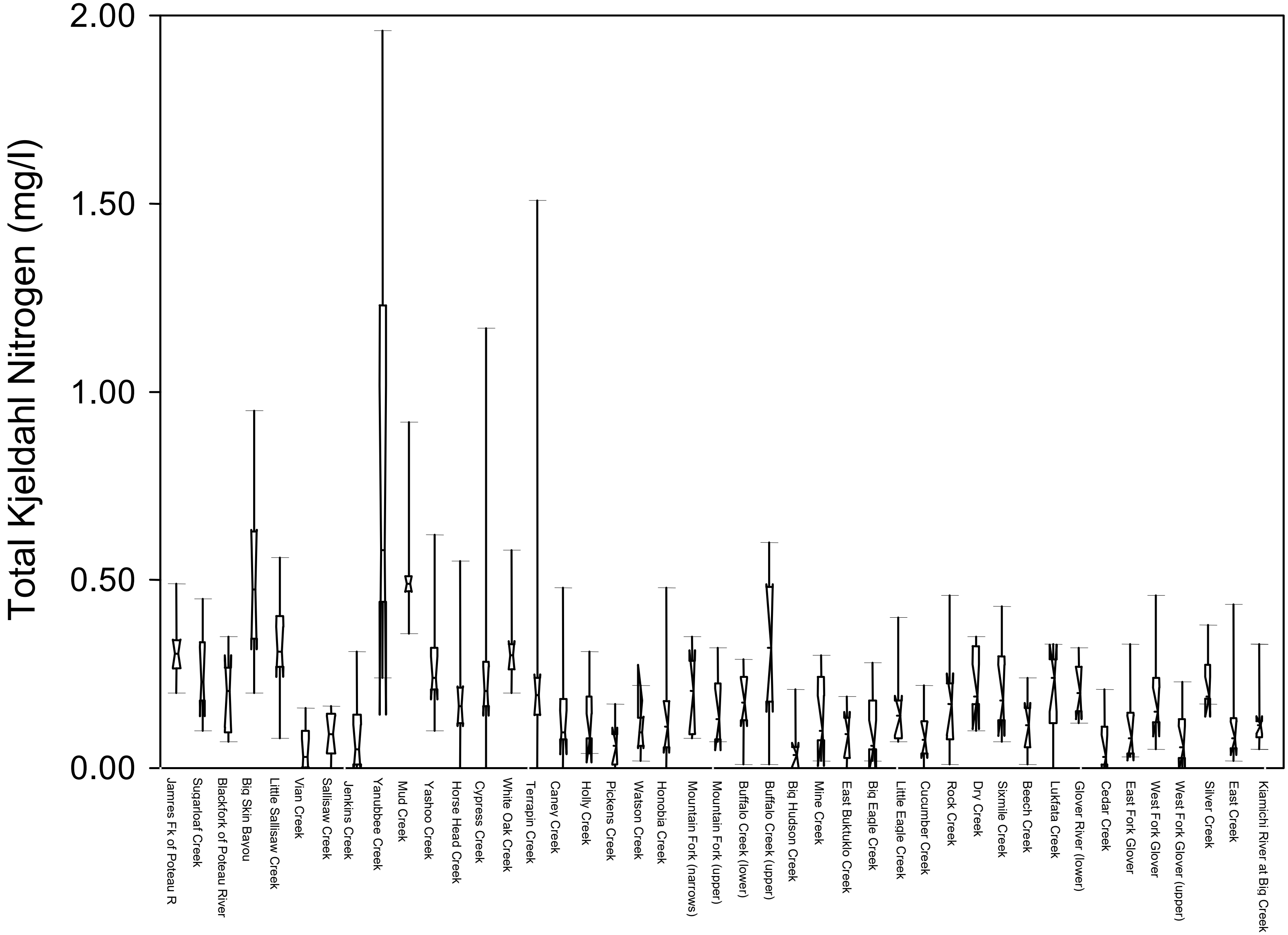

Figure 20. Total Kjeldahl Nitrogen Concentrations for EOBS Stations.

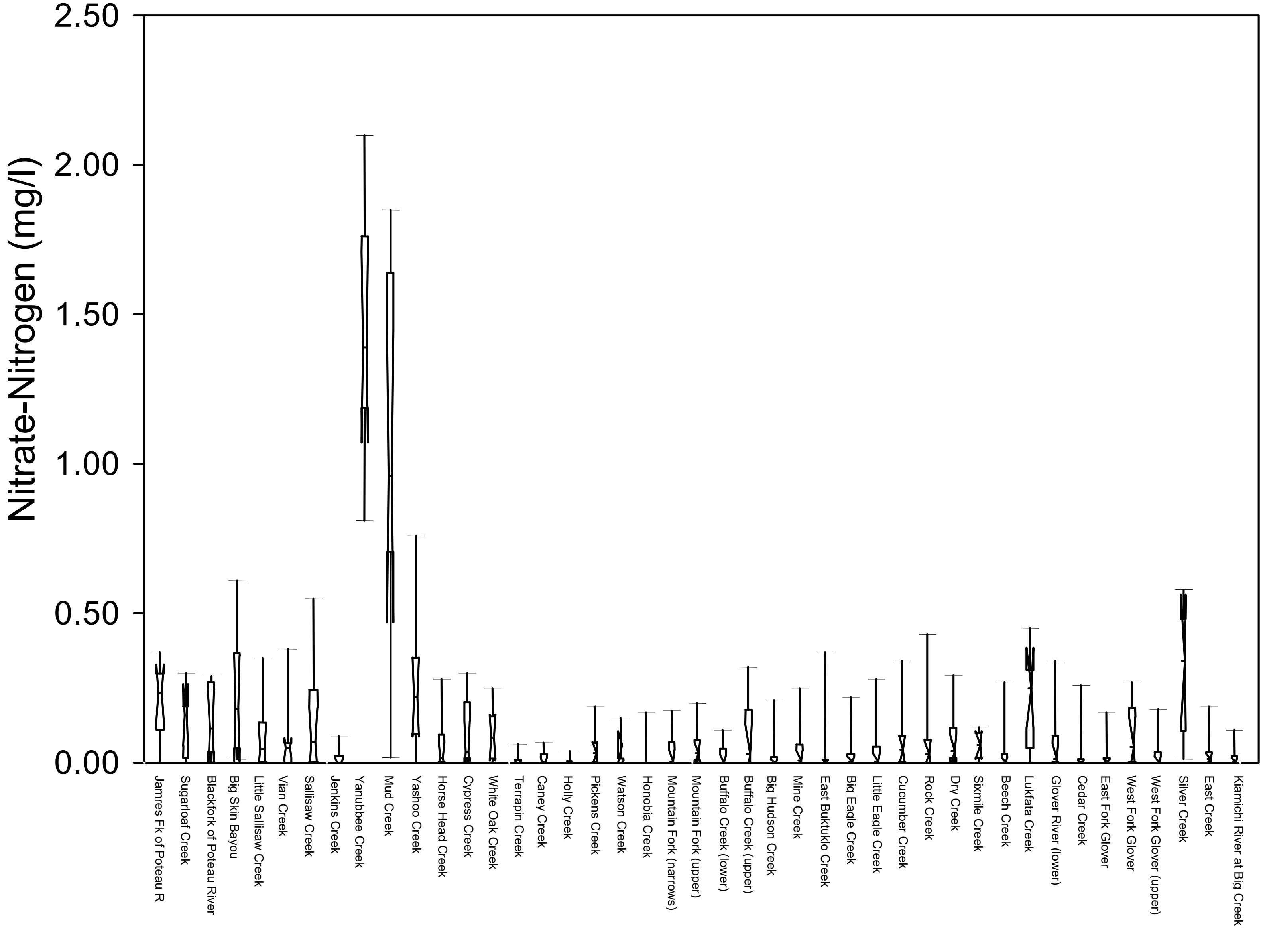

Figure 21. Nitrate-Nitrogen Concentration Ranges for EOBS Stations.

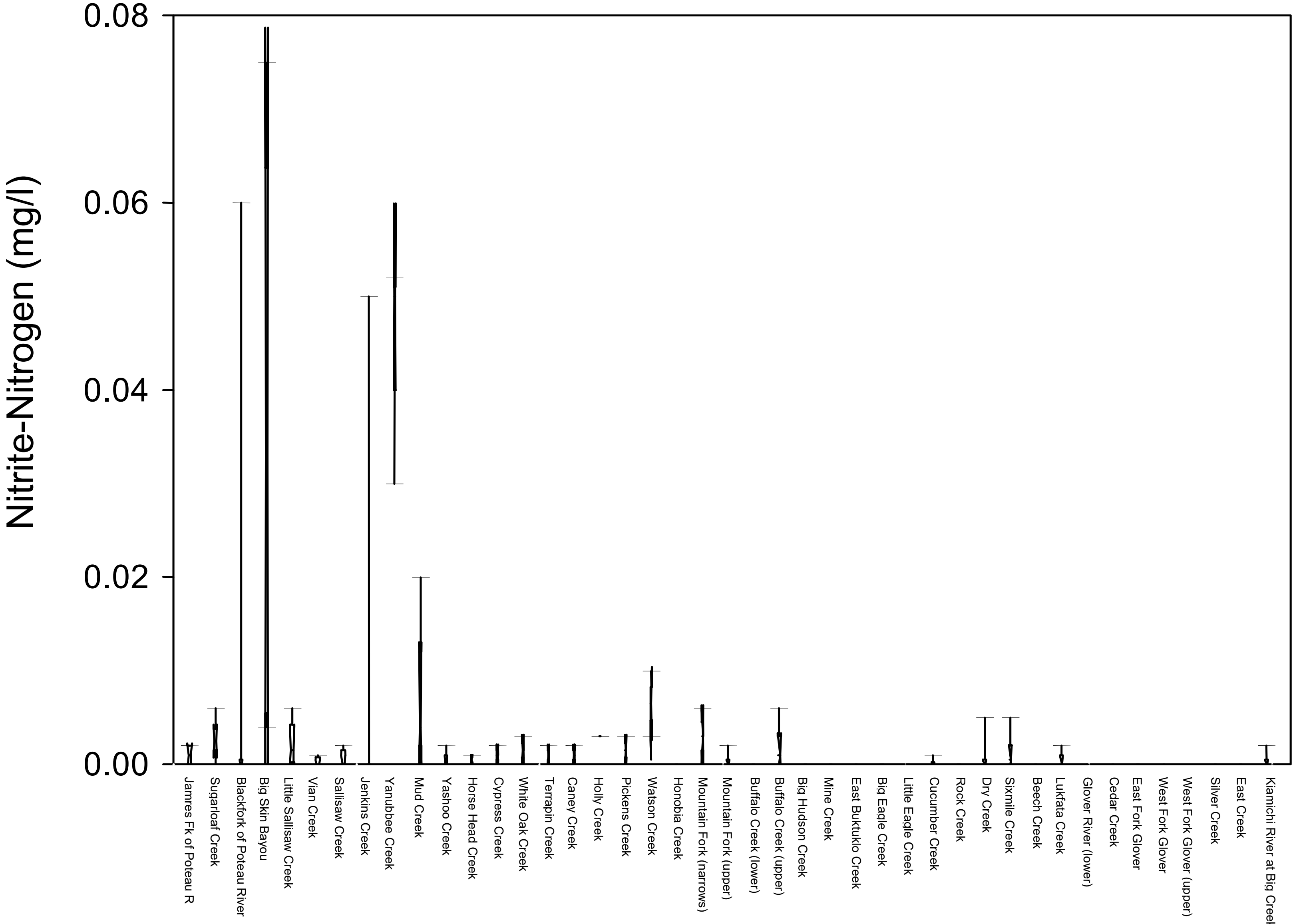

Figure 22. Nitrite Nitrogen Ranges for EOBS Stations.

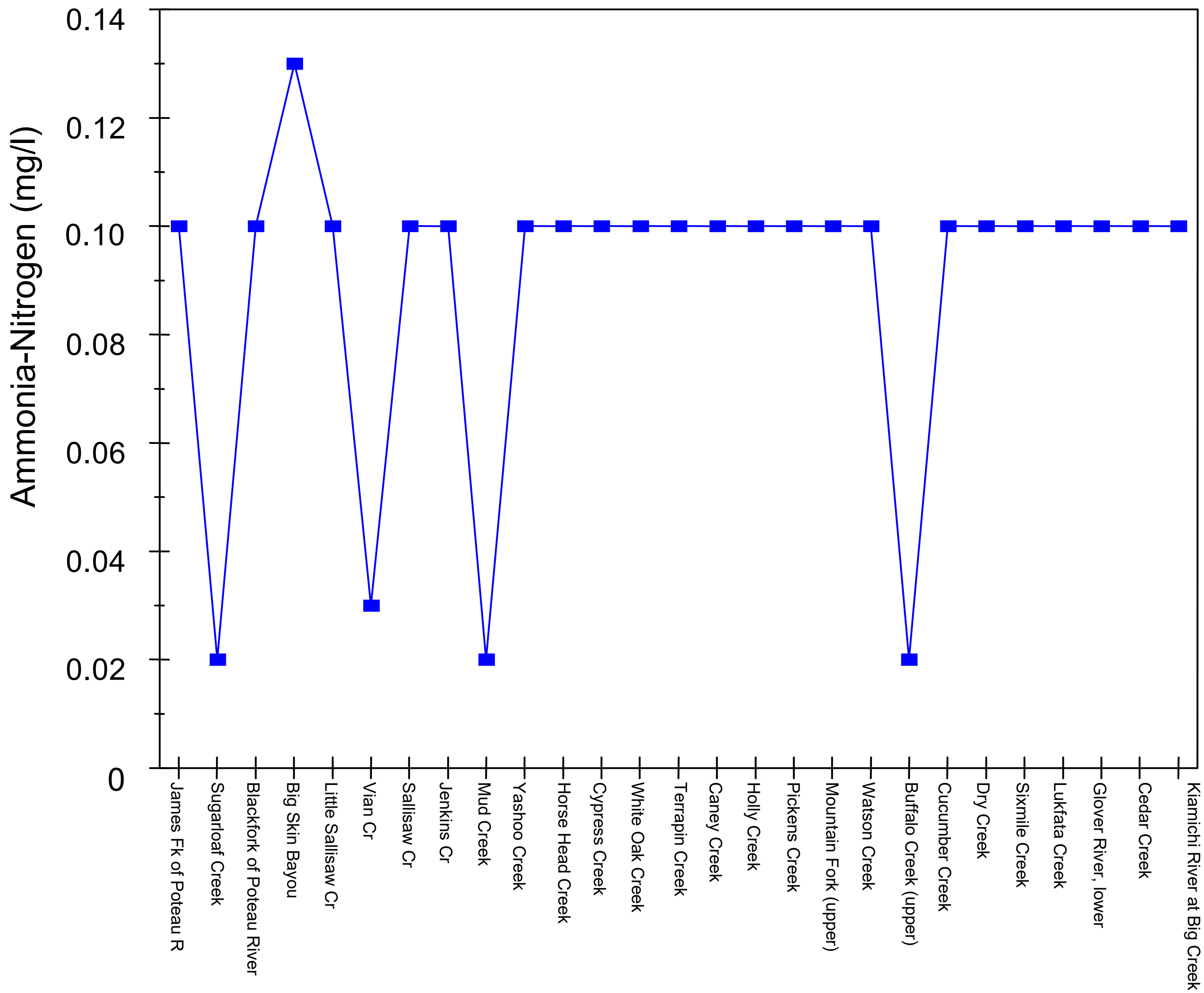

Figure 23. Ammonia Concentrations for EOBS Stations on 9-10 October 1995.

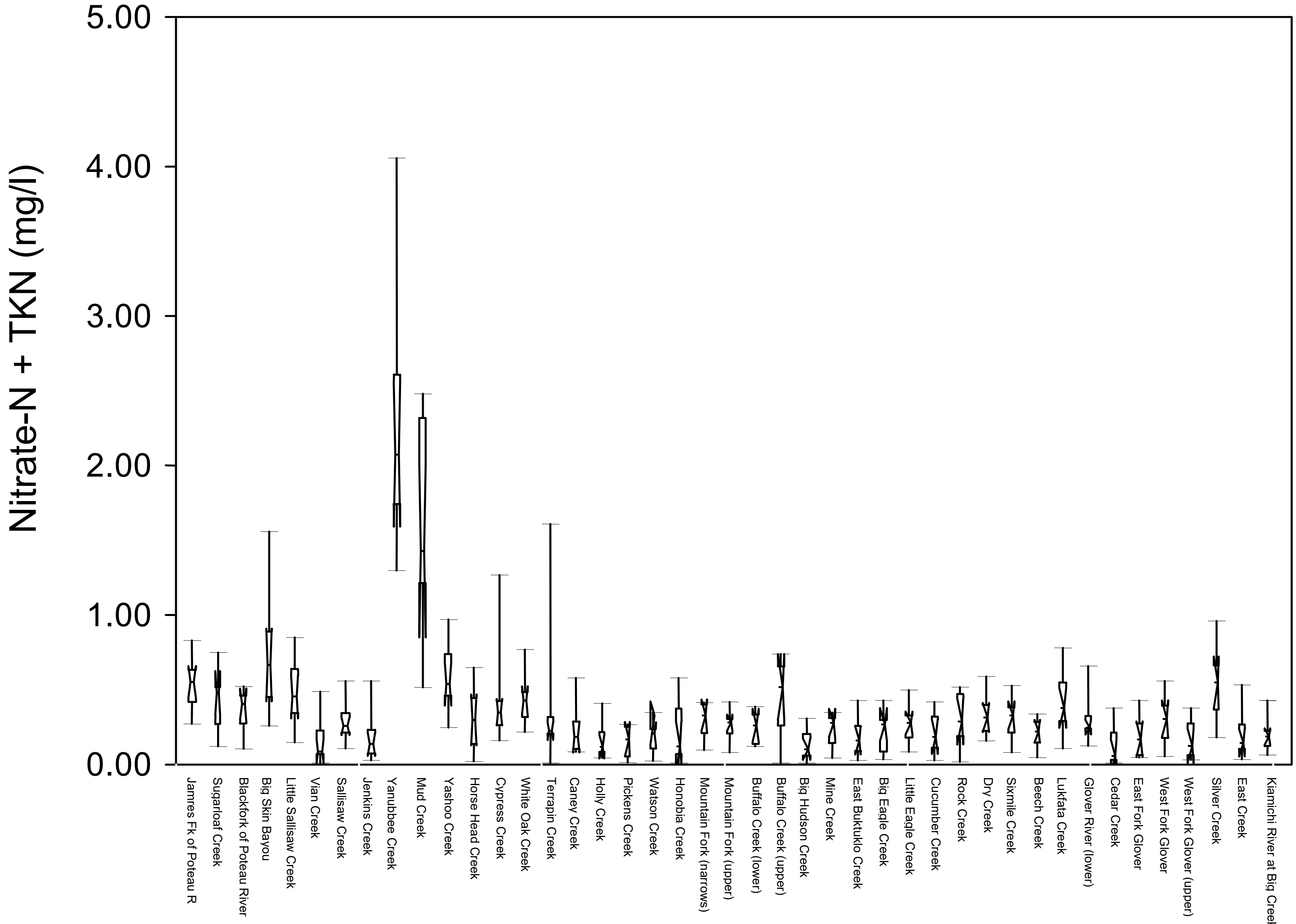

Figure 25. Total Nitrogen Estimate Ranges for EOBS Stations.

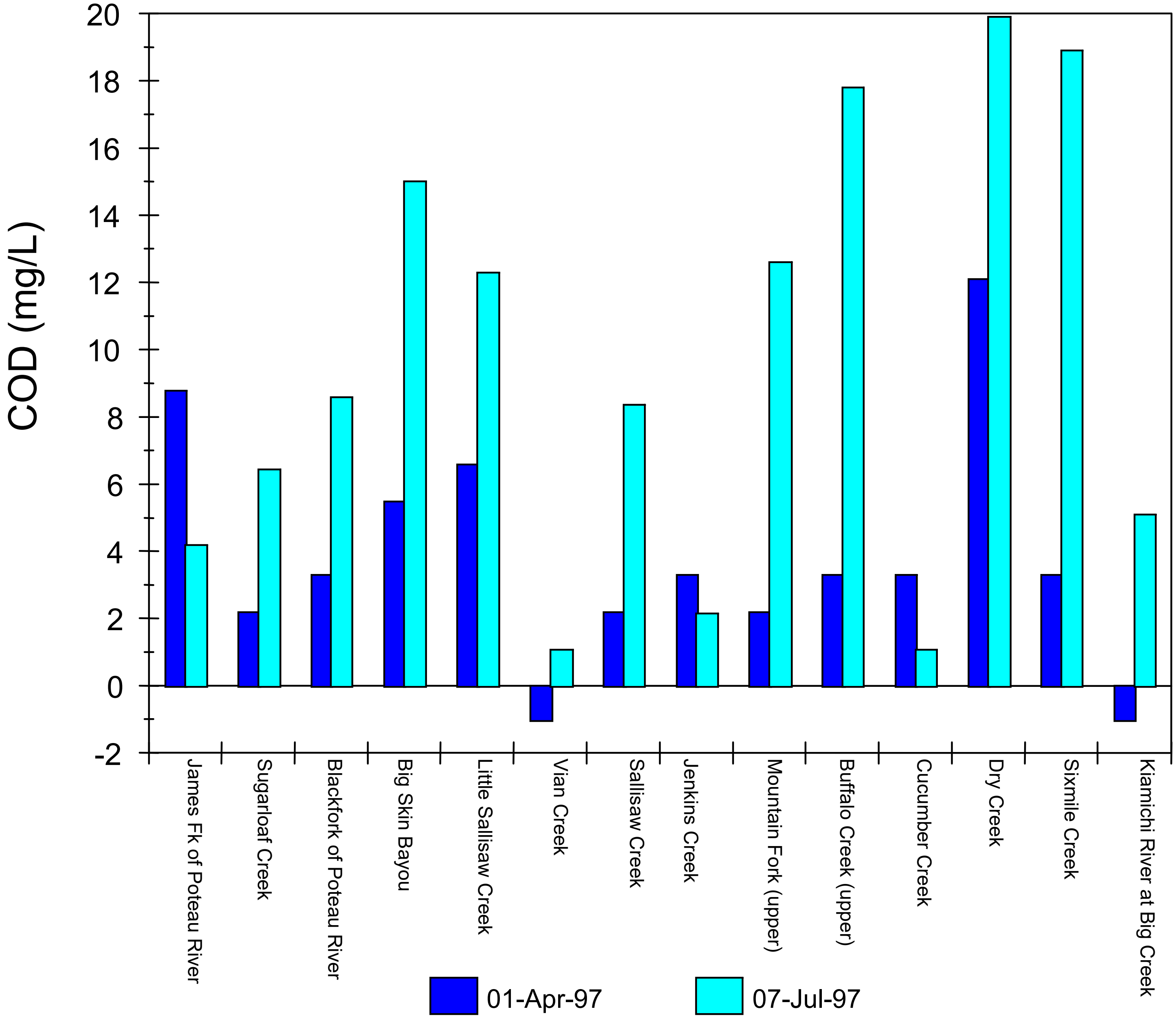

Figure 26. COD Concentrations for EOBS Stations on 1 April and 7 July 1997.

Creek. High July COD concentrations at all stations except Vian Creek, Jenkins Creek, Cucumber Creek, and the Kiamichi River indicate potentially low dissolved oxygen concentrations at those sites.

Habitat

The habitat assessments were conducted to determine the ability of the physical characteristics of the stream to support biological communities. The method is as described in the OCC Standard Operating Procedures, modified from EPA's Rapid Bioassessment Protocol III (EPA 1989). Scores were given to each stream based on habitat assessment surveys. The criteria for scoring included: depth, width, instream substrate, habitat type, percent area of instream cover, flow measurements, riparian stability, shading, and channel sinuosity. A habitat survey assigns one estimated value to each criteria. Habitat assessments involve multiple measurements of stream and riparian characteristics. The parameters can be grouped into primary, secondary. and tertiary categories-these categories and their corresponding parameters are listed below.

Primary: *Substrate and instream cover*- This category includes instream cover, pool bottom substrate, pool variability, canopy cover shading, rocky runs or riffles, and flow.

Secondary: *Channel morphology*- This category includes channel alteration. and pool/riffle or run/bend ratios.

Tertiary: *Riparian and bank structure*- This category includes bank stability, bank vegetation, and streamside cover.

Habitat was surveyed during the spring and summers of 1994, 1995, and 1996. Results of Habitat collections are seen in tables 8 and 9. Dry Creek and Cucumber Creek received the lowest habitat scores and Cypress and Silver Creek received the highest habitat scores. Most creeks had optimal or adequate instream cover, streamside cover and bank stability and scored well in channel alteration. However, most streams also had poor sinuosity. Overall, most streams surveyed had adequate habitat to support a healthy benthic macroinvertebrate community.

Table 8. Habitat Scores for EOBS Streams.

Stream	Date	Instream Cover	Pool Bottom Substrate	Pool Variability	Canopy Cover Shading	Rocky Runs and Riffles	Flow	Channel Alteration	Channel Sinuosity	Bank Stability	Bank Vegetation Stability	Streamside Cover	Total
Big Skin Bayou	8/15/95	8.37	14.09	18.18	17.90	9.00	6.64	15.00	0.00	5.67	4.80	6.41	106.06
Big Skin Bayou	10/3/96	9.47	20.00	0.00	19.50	20.00	20.00	15.00	0.00	8.11	8.00	9.24	129.32
Little Sallisaw Creek	8/17/95	15.30	20.00	0.00	14.67	20.00	2.26	13.67	15.00	5.46	2.43	3.64	112.41
Vian Creek	7/23/96	15.95	14.89	12.50	9.75	11.67	9.63	15.00	0.00	10.00	10.00	10.00	119.39
Sallisaw Creek	8/21/96	19.23	14.72	6.67	1.05	6.00	16.53	15.00	0.00	10.00	10.00	7.77	106.97
Jenkins Creek	3/18/94	17.78	13.65	18.75	18.35	0.00	5.20	15.00	15.00	6.06	1.11	8.00	118.90
Cypress Creek	7/12/94	17.75	13.06	20.00	18.55	8.00	20.00	13.67	3.80	10.00	6.90	7.77	139.49
Terrapin Creek	7/28/94	18.21	19.38	6.25	0.00	6.00	11.53	15.00	4.50	10.00	9.30	8.00	108.16
Caney Creek	7/13/94	16.49	9.40	11.00	12.17	8.00	5.01	15.00	0.60	10.00	9.75	8.00	105.42
Big Hudson Creek	7/26/94	18.31	14.44	16.67	4.50	20.00	11.69	15.00	0.60	6.89	2.15	8.00	118.25
Mine Creek	8/4/94	15.96	15.72	14.33	12.92	13.33	5.95	15.00	0.60	9.29	7.30	8.00	118.40
Cucumber Creek	7/15/94	18.18	17.67	16.67	5.95	0.00	6.34	15.00	1.20	7.88	1.98	8.00	98.86
Dry Creek	7/20/94	13.72	11.15	0.00	19.55	6.00	11.79	9.00	1.95	8.01	2.95	8.00	92.12
Lukfata Creek	7/14/94	10.86	15.58	8.33	17.65	0.00	15.08	15.00	1.95	8.27	4.20	8.00	109.92
Cedar Creek	8/04/94	17.44		0.00	15.20	5.82	6.71	15.00	3.15	8.06	2.94	8.00	
Silver Creek	7/29/94	15.72	17.92	12.50	15.45	9.00	15.11	15.00	1.95	10.00	8.75	8.00	129.39

Table 9. Habitat Ratings for EOBS Streams.

Stream	Date	Instream Cover	Pool Bottom Substrate	Pool Variability	Canopy Cover Shading	Rocky Runs and Riffles	Flow	Channel Alteration	Channel Sinuosity	Bank Stability	Bank Vegetation Stability	Streamside Cover
Big Skin Bayou	8/15/95	fair	adequate	optimal	optimal	fair	fair	optimal	poor	adequate	fair	adequate
Big Skin Bayou	10/3/96	fair	optimal	poor	optimal	optimal	optimal	optimal	poor	optimal	optimal	optimal
Little Sallisaw Creek	8/17/95	optimal	optimal	poor	adequate	optimal	poor	optimal	optimal	adequate	poor	fair
Vian Creek	7/23/96	optimal	adequate	fair	poor	adequate	fair	optimal	poor	optimal	optimal	optimal
Sallisaw Creek	8/21/96	optimal	adequate	fair	poor	fair	optimal	optimal	poor	optimal	optimal	adequate
Jenkins Creek	3/18/94	optimal	adequate	optimal	optimal	poor	fair	optimal	optimal	adequate	poor	optimal
Cypress Creek	7/12/94	optimal	adequate	optimal	optimal	fair	optimal	optimal	fair	optimal	adequate	adequate
Terrapin Creek	7/28/94	optimal	optimal	fair	poor	fair	adequate	optimal	fair	optimal	optimal	optimal
Caney Creek	7/13/94	optimal	fair	adequate	adequate	fair	fair	optimal	poor	optimal	optimal	optimal
Big Hudson Creek	7/26/94	optimal	adequate	optimal	poor	optimal	adequate	optimal	poor	adequate	poor	optimal
Mine Creek	8/4/94	optimal	optimal	adequate	adequate	adequate	fair	optimal	poor	optimal	adequate	optimal
Cucumber Creek	7/15/94	optimal	optimal	optimal	poor	poor	fair	optimal	poor	adequate	poor	optimal
Dry Creek	7/20/94	adequate	adequate	poor	optimal	fair	adequate	adequate	poor	optimal	poor	optimal
Lukfata Creek	7/14/94	adequate	optimal	fair	optimal	poor	optimal	optimal	poor	optimal	fair	optimal
Cedar Creek	8/04/94	optimal		poor	optimal	fair	fair	optimal	fair	optimal	poor	optimal
Silver Creek	7/29/94	optimal	optimal	fair	optimal	fair	optimal	optimal	poor	optimal	optimal	optimal

Benthic Macroinvertebrates

Benthic macroinvertebrates were sampled during summers and winters of 1994 – 1996 (Table 10). Sampling procedures followed EPA's Rapid Bioassessment Protocol III, modified for use in the pertinent ecoregions of Oklahoma. Riffle, vegetation, and woody debris habitats were sampled. However, vegetation and woody debris samples were not available from all streams and thus collections were not made every sampling event. In addition, certain creeks only have winter or summer collections. These "holes" in the data set result from samples which have been collected, but have not yet been identified

Table 10 Collection Dates for EOBS Macroinvertebrate Samples.

Stream	WBID	County	Date
Black Fork of Poteau	OK220100-02-0040T	LeFlore	03/17/94
Little Sallisaw Creek	OK220200-02-0040G	Sequoyah	03/24/95
Vian Creek	OK220200-02-0130G	Sequoyah	02/19/94
			03/06/95
			10/06/95
Sallisaw Creek	OK220200-03-0010G	Sequoyah	03/24/95
			10/06/95
Jenkins Creek	OK220200-05-0050G	Adair	02/24/94
			09/17/94
			03/06/95
Cypress Creek	OK410210-01-0070G	McCurtain	03/17/94
			07/07/94
			03/05/95
Terrapin Creek	OK410210-02-0150G	Pushmataha	03/17/94
			07/25/95
Caney Creek	OK410210-02-0240G	Pushmataha	03/17/94
			07/07/94
			03/05/95
Buffalo Creek (Upper)	OK410210-06-0020T	Polk, Ark.	03/18/94
			07/27/95
Big Hudson Creek	OK410210-06-0030G	McCurtain	03/18/94
			07/26/95
Mine Creek	OK410210-06-0060G	McCurtain	03/18/94
			07/08/94
Cucumber Creek	OK410210-06-0210G	LeFlore	03/18/94
			07/08/94
Dry Creek	OK410210-06-0270G	McCurtain	03/18/94
Beech Creek	OK410210-06-0320G	McCurtain	07/27/95
Lukfata Creek	OK410210-07-0010G	McCurtain	03/17/94
			07/26/95
Cedar Creek	OK410210-08-0120G	McCurtain	03/17/94
			03/05/95
			07/07/97
Silver Creek	OK410210-09-0100G	McCurtain	03/18/94

One aspect which should be considered is that in 1995, the OCC changed their standard operating procedure concerning collection of benthic macroinvertebrates. Prior to 1995, benthics had been collected from riffle, vegetation, and woody debris habitats following RBP III collection protocols. Following 1995, the whole stream habitat was characterized and bugs were collected from appropriate stream reaches rather than only from certain habitat types.

The total number of taxa or taxa richness reflects the health of the community through a measure of the variety of taxa present; the higher the number, the healthier the community. However, this index does not appear to be very descriptive about differentiating between positive and negative reference EOBS streams. Values for negative reference streams are not significantly different from values for positive reference streams. Average taxa richness for summer collections was 17 and 20 for winter collections (Figure 27 and 28). This is a small difference and because most of the streams were measured both in summer and winter, it is a negligible difference. Although in some cases values were higher in winter than summer collections, other streams had higher summer values than winter values. Summer collections were significantly below average values for Upper Buffalo Creek. Winter values were significantly below average for Black Fork of the Poteau River.

The modified Hilsenhoff's Biotic Index (HBI) summarizes overall benthic macroinvertebrate population tolerance to organic pollution. Tolerance values range from 0 to 10, increasing as water quality decreases. Average values were 4.6 for summer collections and 4.3 for winter collections (Figure 29 and 30).. Values were more variable during winter collections than summer collections. Summer collections from vegetation in Sallisaw Creek, woody debris in Jenkins Creek, vegetation and woody debris in Caney Creek, riffles in Upper Buffalo Creek, and vegetation and woody debris in Cedar Creek were greater than 5. Vian Creek, Cypress Creek, Terrapin Creek, Lukfata Creek, Cedar Creek, and Silver Creek all had Winter collection values greater than 5. A consistent difference between HBIs for positive and negative reference sites was not observed in either winter or summer collections.

The ratio of scrapers to filterers provides an indication of the periphyton community composition and availability of suspended Fine Particulate Organic Matter associated with organic enrichment. Predominance of a particular feeding group may represent an unbalanced community resulting from an overabundance of a particular food supply. Most systems appeared fairly balanced with respect to ratio of scrapers to filterers; ratios were close to 1 (Figures 31 and 32). However, certain creeks had very high ratios of scrapers to filterers. These included summer collections at Vian, Sallisaw, Jenkins, and Big Hudson Creek and Winter collections at Black Fork of the Poteau River, Sallisaw Creek, Jenkins Creek, Cypress Creek, Caney Creek, Upper Buffalo Creek, and Dry Creek. The high ratio of scrapers to filterers suggests higher periphyton

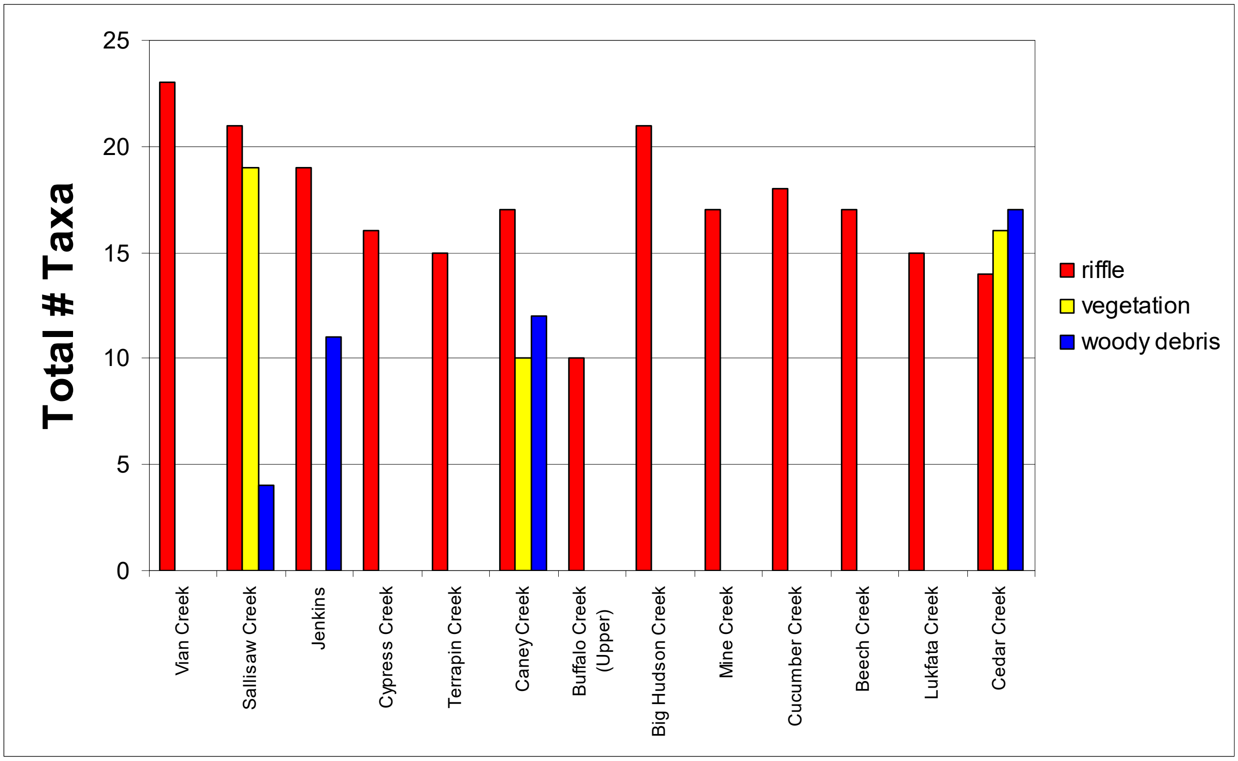

Figure 27. Summer Macroinvertebrate Collection Total Number of Taxa.

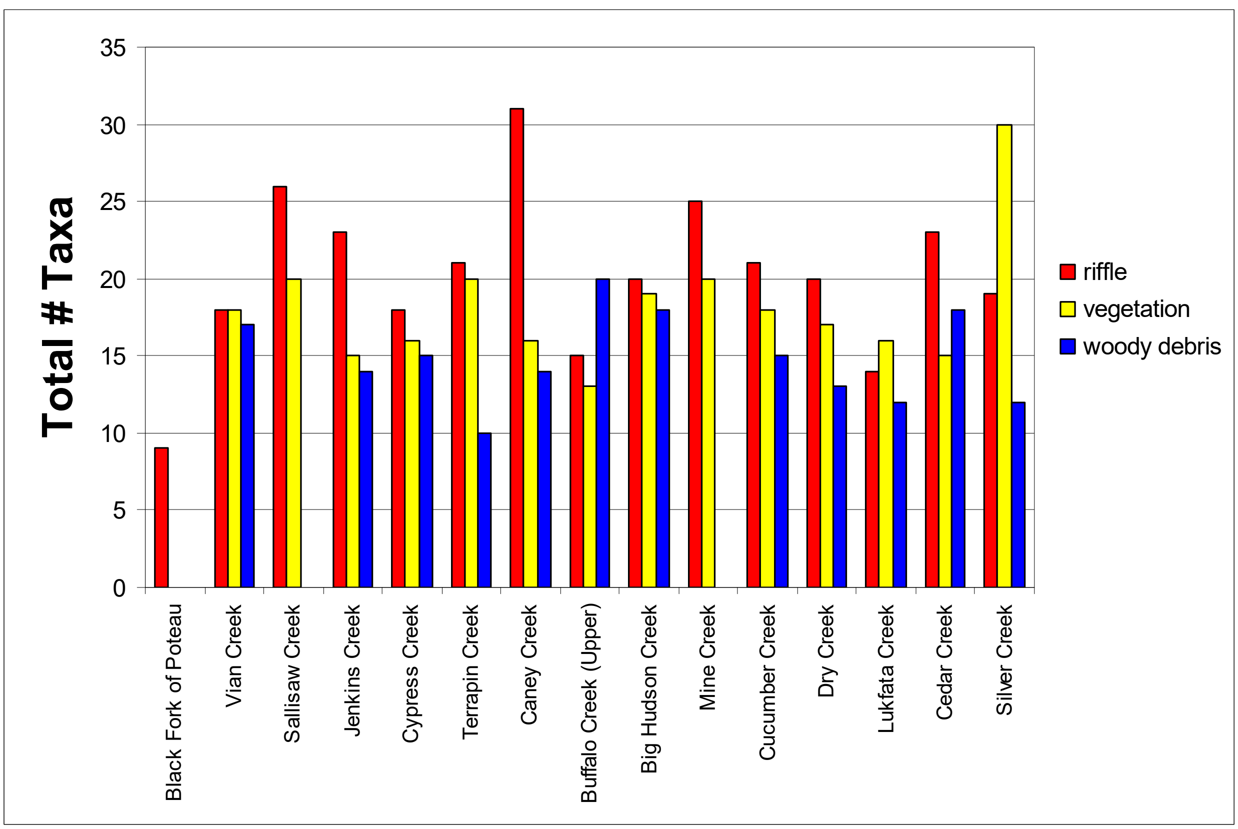

Figure 28. Winter Macroinvertebrate Collection Total Number of Taxa.

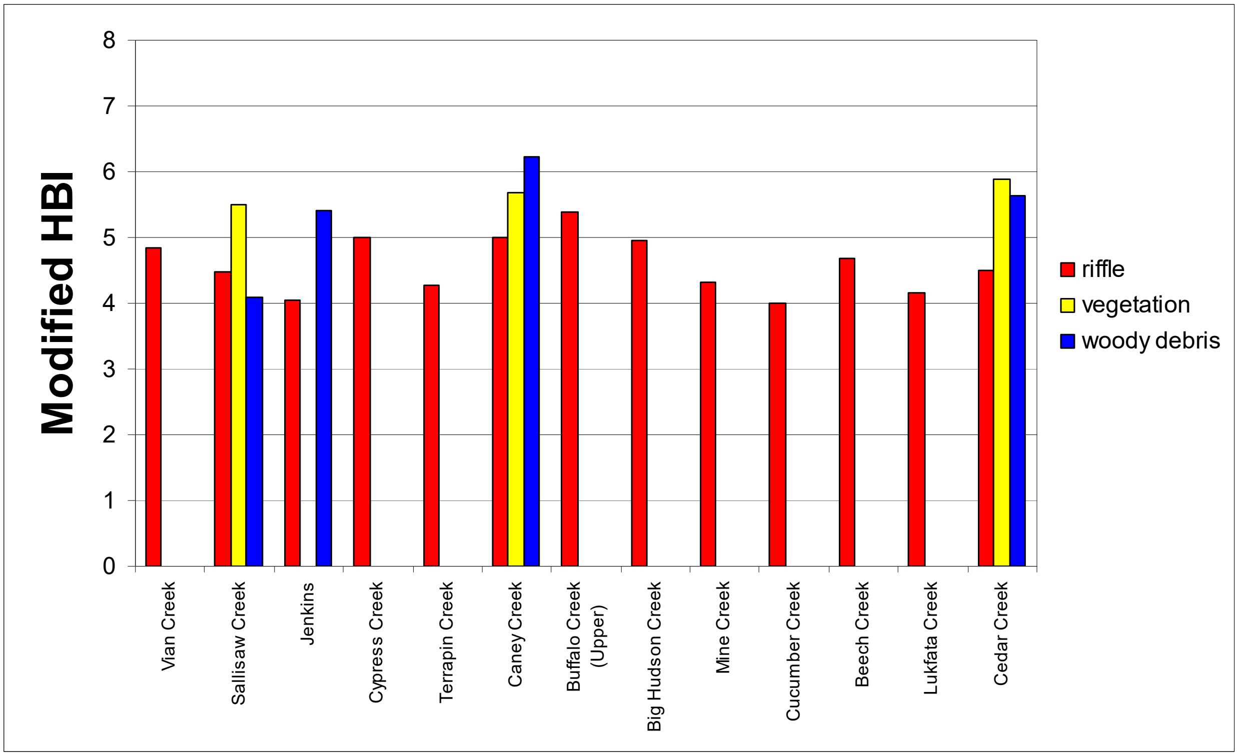

Figure 29. Summer Macroinvertebrate Collection Modified Hilsenhoff Biotic Index.

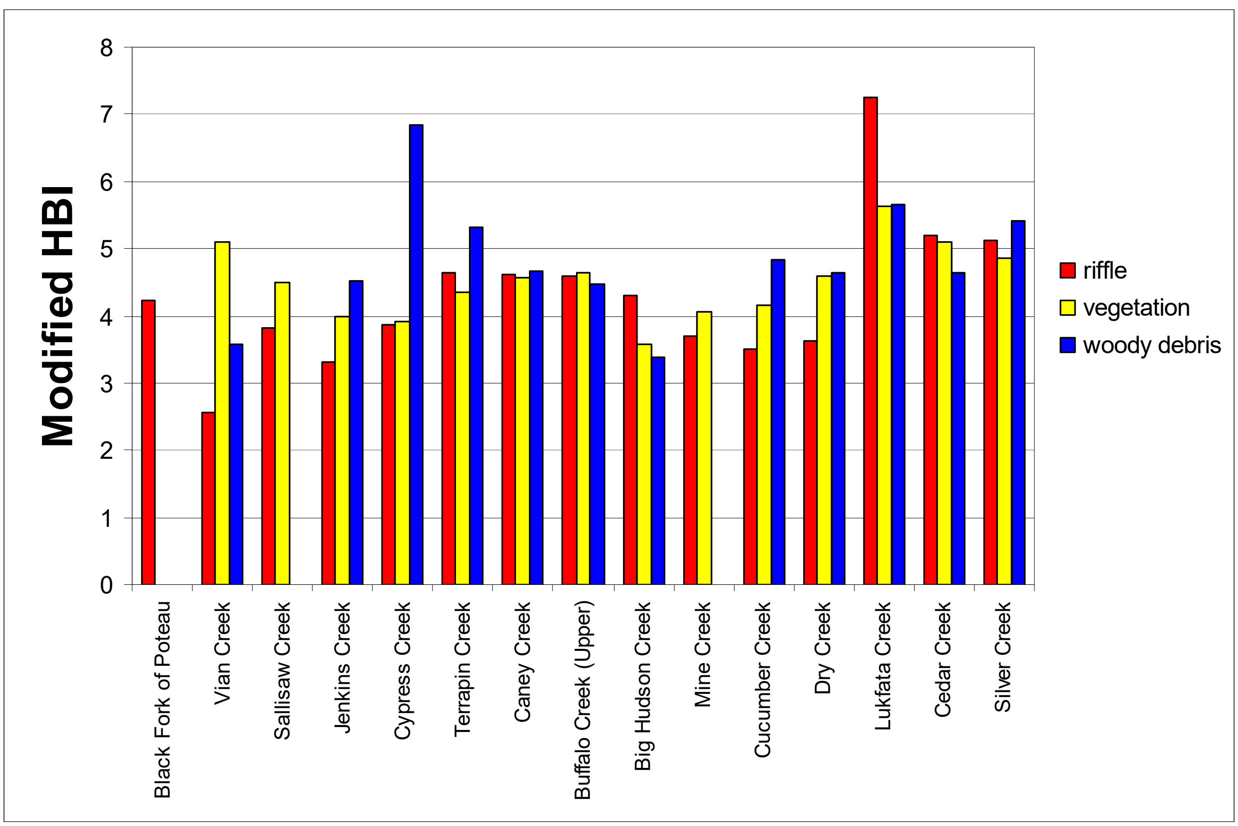

Figure 30. Winter Macroinvertebrate Collection Modified Hilsenhoff Biotic Index.

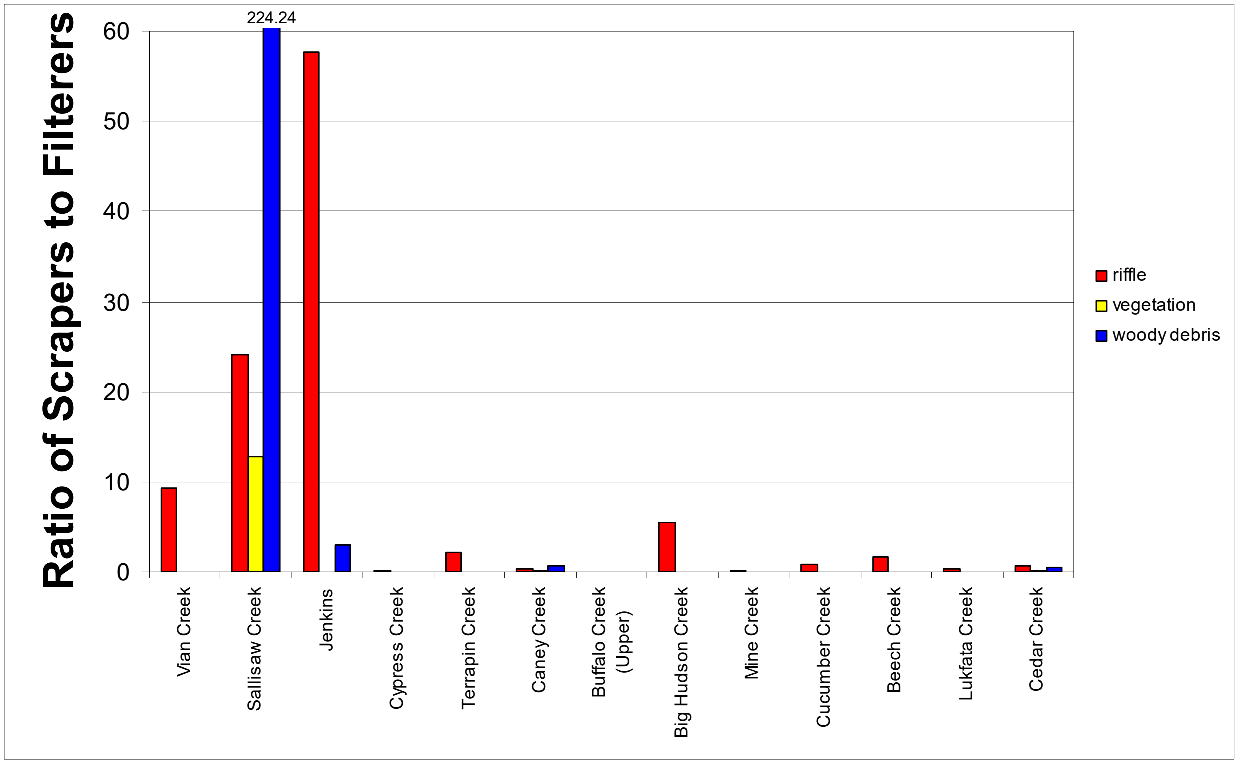

Figure 31. Summer Macroinvertebrate Collection Percent Scrapers and Filterers.

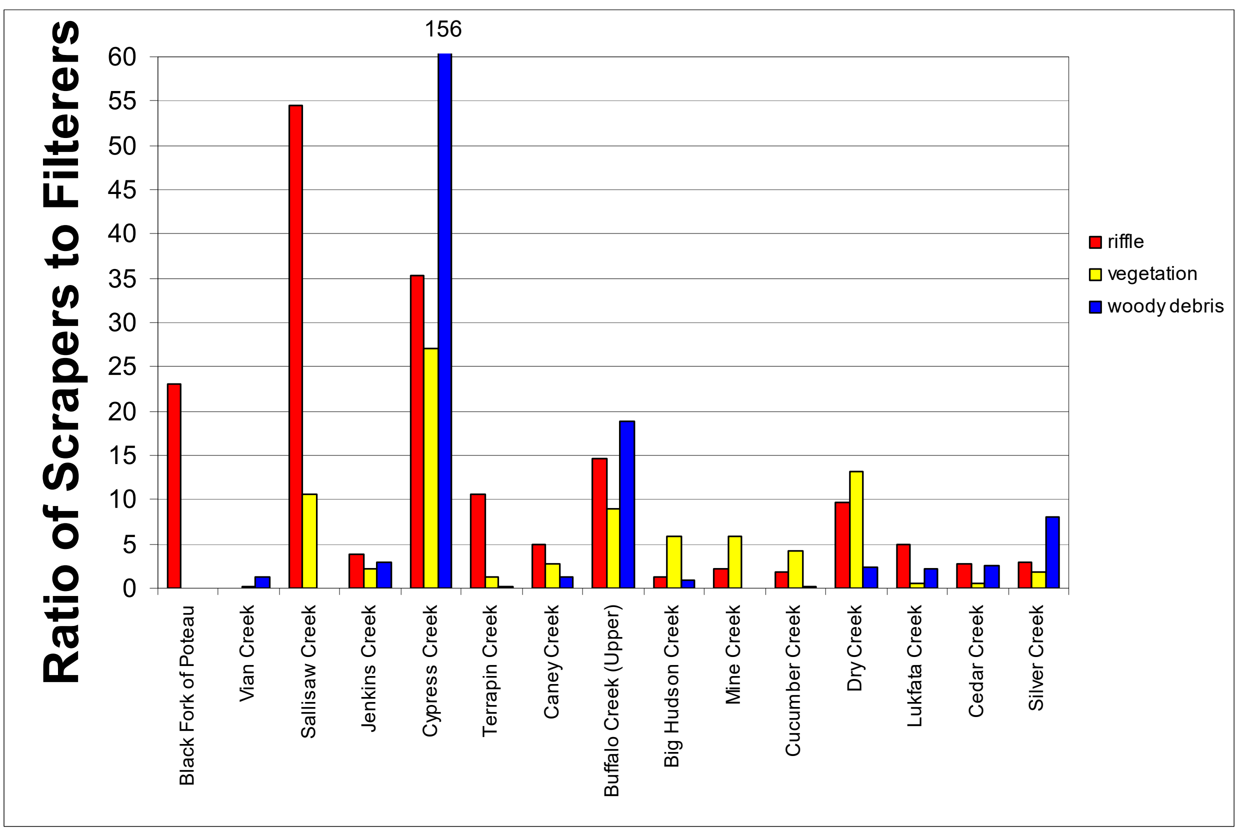

Figure 32. Winter Macroinvertebrate Collection Percent Scrapers and Filterers.

growth and lower growth of filamentous algae. Higher numbers in winter than summer are expected given the preference of filamentous algae for warmer temperatures. On the other extreme, creeks with more filterers than scrapers (ratio of scrapers to filterers < 1) included summer collections of Cypress Creek, Caney Creek, Cucumber Creek, and Lukfata Creek. This suggests lower periphyton concentrations and perhaps more filamentous algae or aquatic mosses and macrophytes at these sites.

Percent Shredders gives a measure of the amount of coarse particulate organic matter in a stream. The shredder community is particularly sensitive to riparian zone impacts. Shredders represent a low proportion of the community in most streams surveyed (Figures 33 and 34). Shredders were generally more concentrated in Winter collections than in summer collections. This trend could be expected due to the impacts of leaf fall on the food base for the shredder community. The expected differences in the shredder community between positive and negative reference streams was evident during summer and winter collections when positive reference streams generally had higher percent shredders than negative streams. Average percent shredders for positive reference streams was 2.14% in the summer and 5.0% in the winter. Average percent shredders for negative reference streams was 0% in summer collections and 0.93% in winter collections.

The ratio of EPT and chironomid abundance compares the number of pollution sensitive groups (Ephemeroptera, Plecoptera, and Trichoptera) to the pollution tolerant Chironomid taxa as a measure of community balance. In general, EPT and chironomid abundance should be around a ratio of 3:4 (75%) in a balanced community. Anything greater than 3:4 (75%) would be a population with more pollution intolerant species than tolerant species, and anything less would be a population with more tolerant species. Most creeks fell within acceptable ranges (plus or minus 10%) for this index during both winter and summer collections (Figures 35and 36). Exceptions with low index values were summer collections in Sallisaw Creek (vegetation and woody debris), Jenkins Creek (woody debris), Cypress Creek (riffle), Caney Creek (vegetation and woody debris), Upper Buffalo Creek (riffle), and Cedar Creek (vegetation and woody debris). Winter Collections with low ratios were collected in Sallisaw Creek (vegetation), Jenkins Creek (vegetation and woody debris), Cypress Creek (riffle), Cucumber Creek (vegetation), Dry Creek (vegetation and woody debris), Lukfata Creek (riffle, vegetation, and woody debris), Cedar Creek (riffle, vegetation, and woody debris), and Silver Creek (riffle, vegetation, and woody debris). These creeks had a disproportionately large population of pollution tolerant species. Creeks with more intolerant species than normally present in a balanced community included summer riffle collections in Sallisaw Creek and Jenkins Creek. Winter collections with higher number of intolerant species included Vian Creek (riffle), Cypress Creek (woody debris), Caney Creek (vegetation and woody debris) and Big Hudson Creek (riffle, vegetation and woody debris). This index was generally consistently different between positive and negative reference

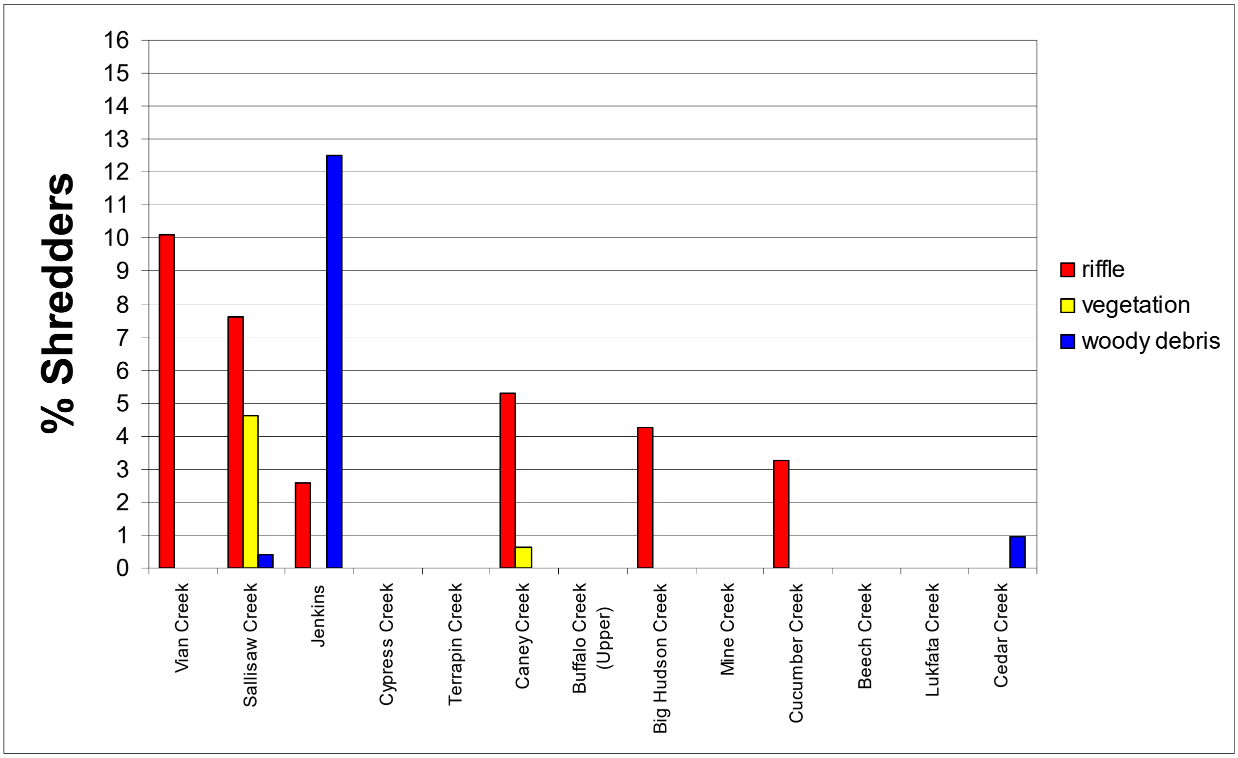

Figure 33. Summer Macroinvertebrate Collection Percent Shredders.

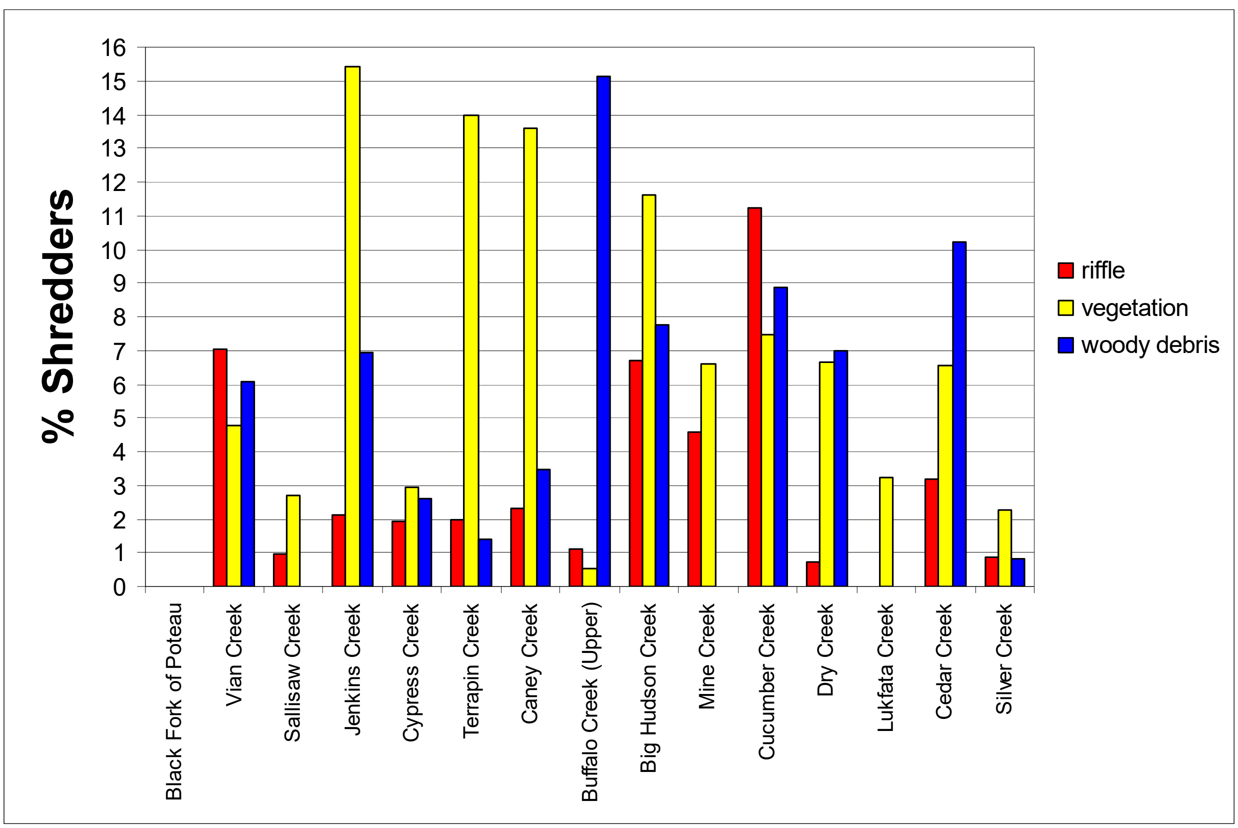

Figure 34. Winter Macroinvertebrate Collection Percent Shredders.

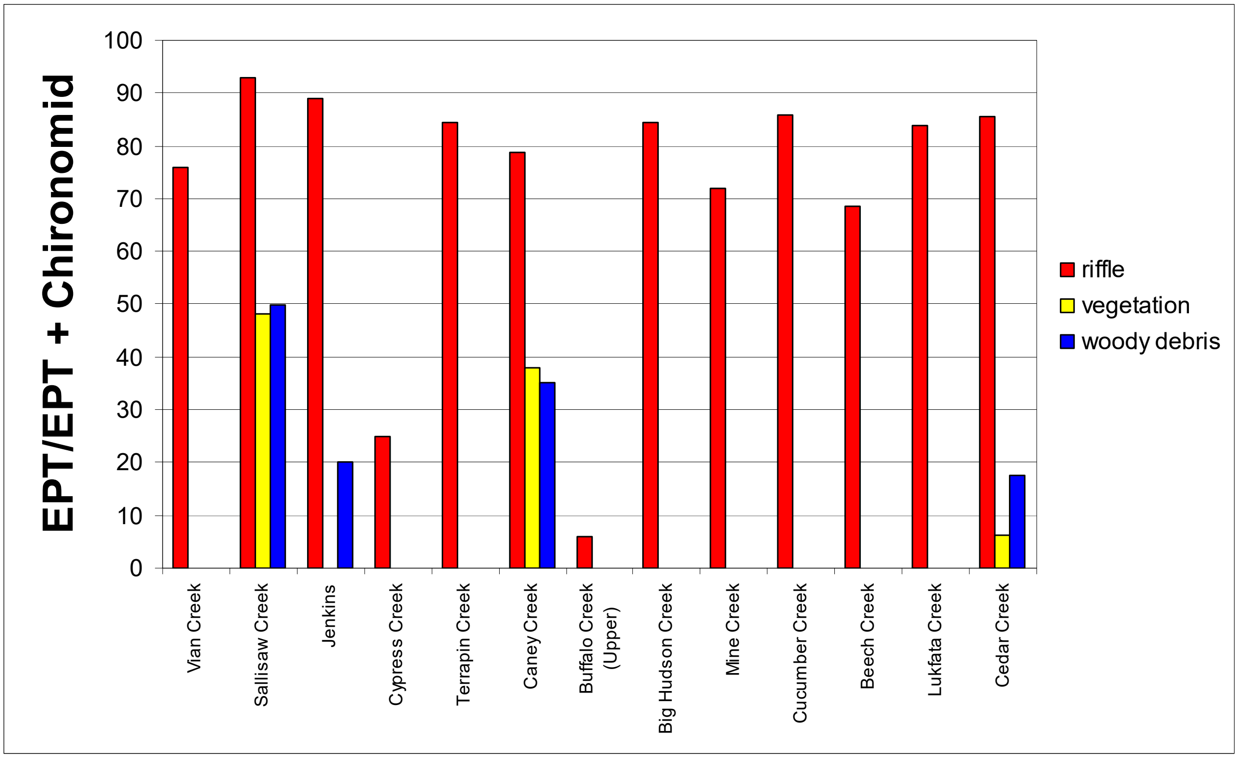

Figure 35. Summer Macroinvertebrate Collection EPT/EPT + Chironomid Index.

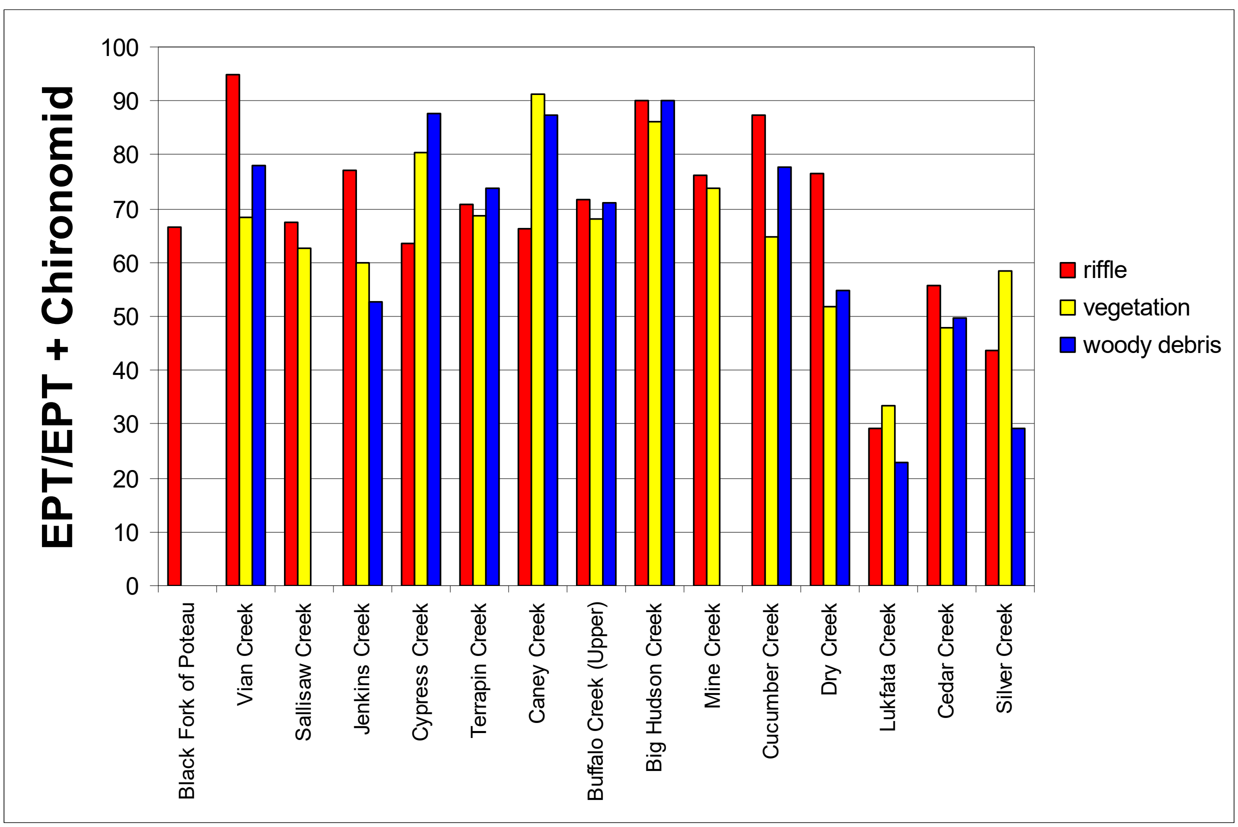

Figure 36. Winter Macroinvertebrate Collection EPT/EPT + Chironomid Index.

streams during summer but not winter collections. Average values for positive reference streams was 81% in summer collections and 74% in winter. Average values for negative reference streams was 24% in summer collections and 74% in winter collections.

The EPT Index is the number of distinct taxa within the orders Ephemeroptera, Plecoptera, and Trichoptera. This index generally increases with increasing water quality as it summarizes the richness of pollution intolerant species. Summer values were generally lower than winter values (Figures 37 and 38). Values were similar among creeks, exdcluding summer collections of Upper Buffalo Creek and winter collections in Black Fork of the Poteau River and Lukfata Creek. EPT index was a fairly good predictor to show the difference between negative and positive reference. Average values for positive reference streams were 6 for summer and 13 for winter collections. Average values for negative streams were 3 for summer collections and 9 for winter collections.

Although the number of EPT Taxa is important, the ratio of EPT Taxa to the total number of taxa collected provides a measure of the percentage of the population that is pollution intolerant. A higher percentage of surveyed populations were pollution intolerant during winter than summer collections (Figures 39 and 40). Collections with low EPT Taxa ratios included Cypress Creek (riffle), Upper Buffalo Creek (riffle), and Cedar Creek (vegetation) in summer collections. Winter collections with low EPT Taxa ratios included Caney Creek (woody debris), Dry Creek (vegetation), Lukfata Creek (riffle), and Silver Creek (vegetation). This measure was a better indicator of differences between positive and negative reference streams during summer than winter collections. Values for positive reference streams were 37 in summer and 55 in winter. Values for negative reference streams were 22 in summer and 49 in winter.

The Percent Contribution of Dominant Taxa is another measure of community balance. Rapid Bioassessment Protocols suggest anything greater than 30% is representative of a slightly to moderately impaired community. Creeks with greater than 30% contribution by dominant taxa include Sallisaw Creek (woody debris), Jenkins Creek (riffle), Caney Creek (riffle, vegetation, woody debris), Upper Buffalo Creek (riffle), Mine Creek (riffle), Lukfata Creek (riffle), and Cedar Creek (vegetation and woody debris) for summer collections (Figure 41). Winter collections had higher percent contributions of dominant taxa (Figure 42). Percent contributions exceeded 30% in all but Black Fork of the Poteau River, Sallisaw Creek, Mine Creek, and Cedar Creek. Percent Contribution of Dominant Taxa was a fair representation of the difference between positive and negative reference streams for summer collections, but less so for winter collections. Values for positive reference streams were 28 and 24 in summer and winter, respectively. Values for negative reference streams were 44 in summer collections and 30 in winter collections.

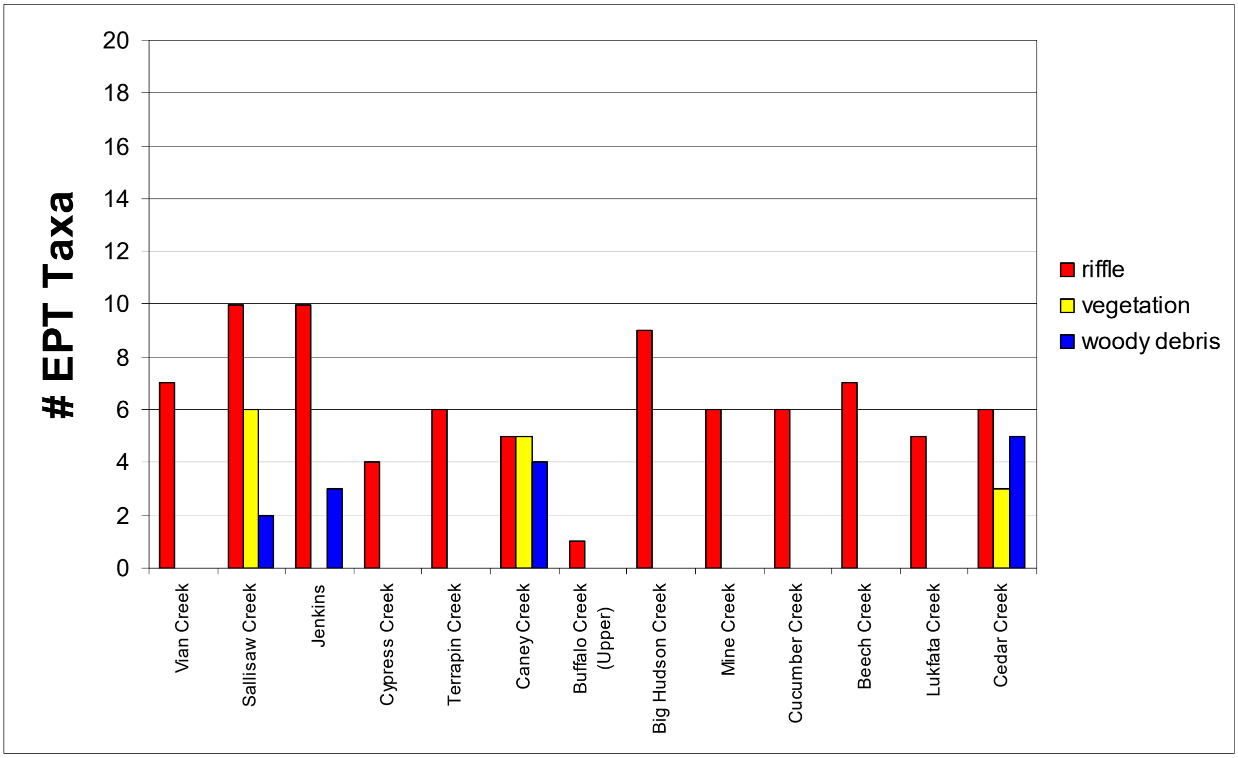

Figure 38. Summer Macroinvertebrate Collection Number of EPT Taxa.

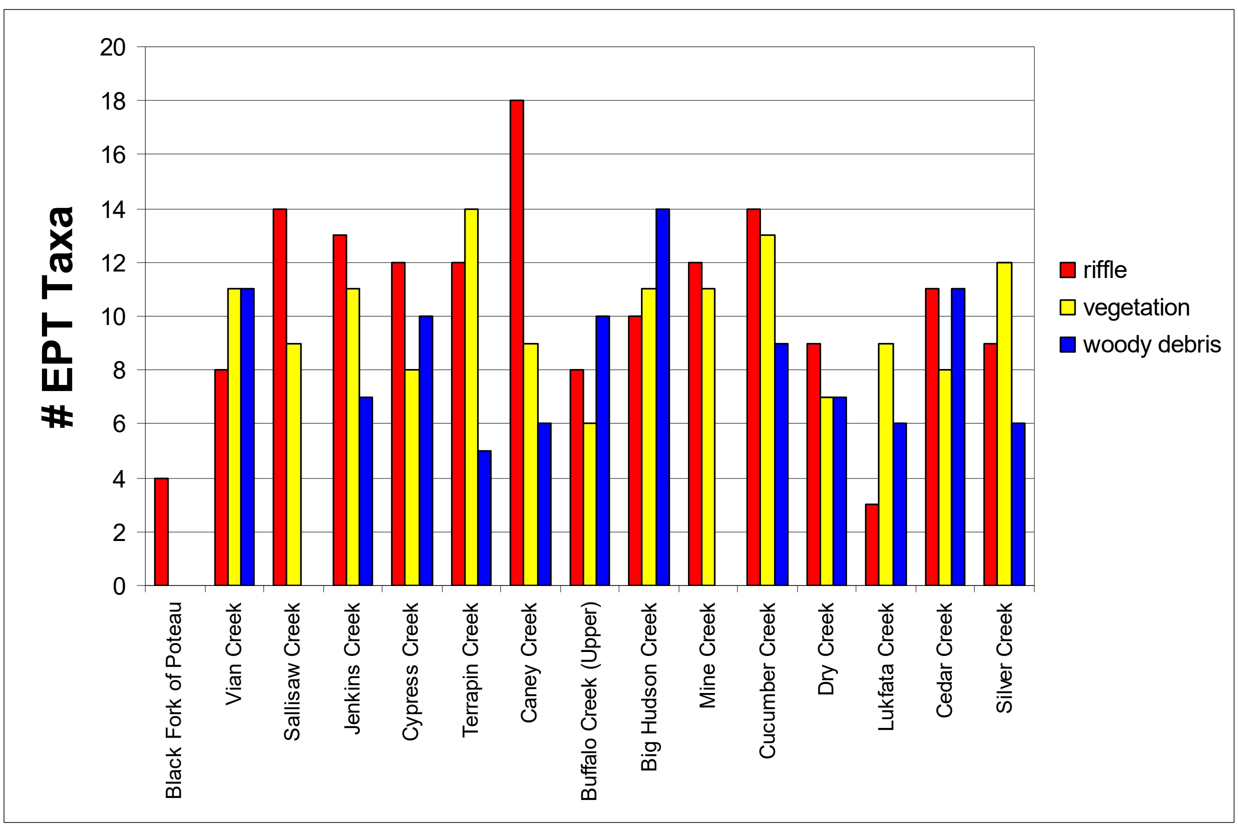

Figure 37. Winter Macroinvertebrate Collection Number of EPT Taxa.

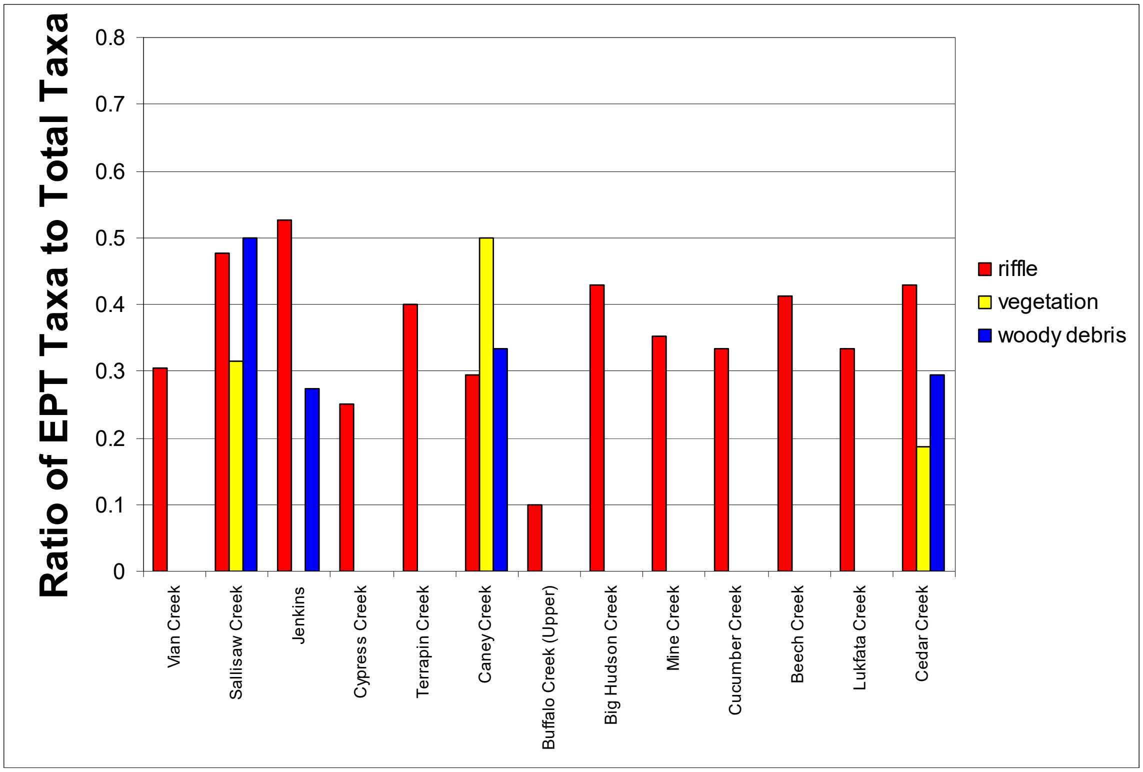

Figure 39. Summer Collection Ratio of EPT Taxa to Total Taxa.

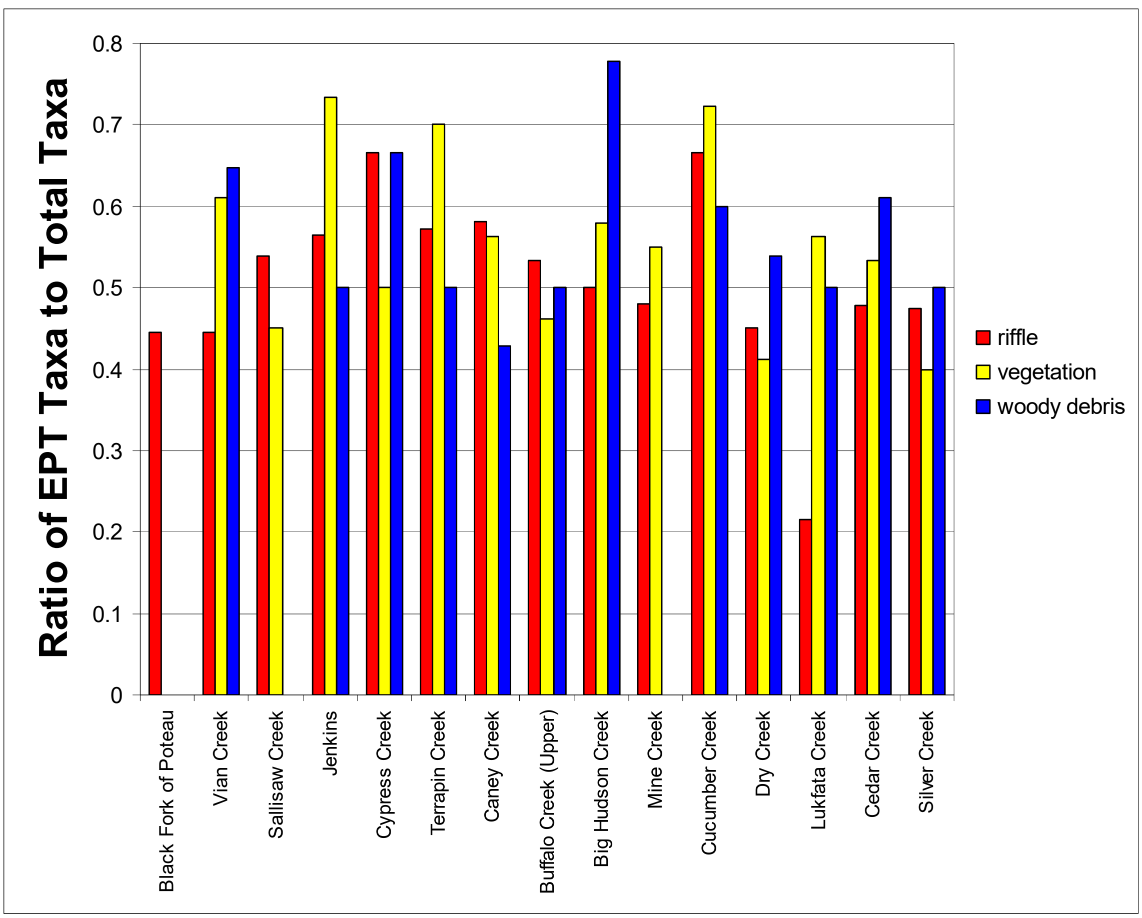

Figure 40. Winter Collection Ratio of EPT Taxa to Total Taxa.

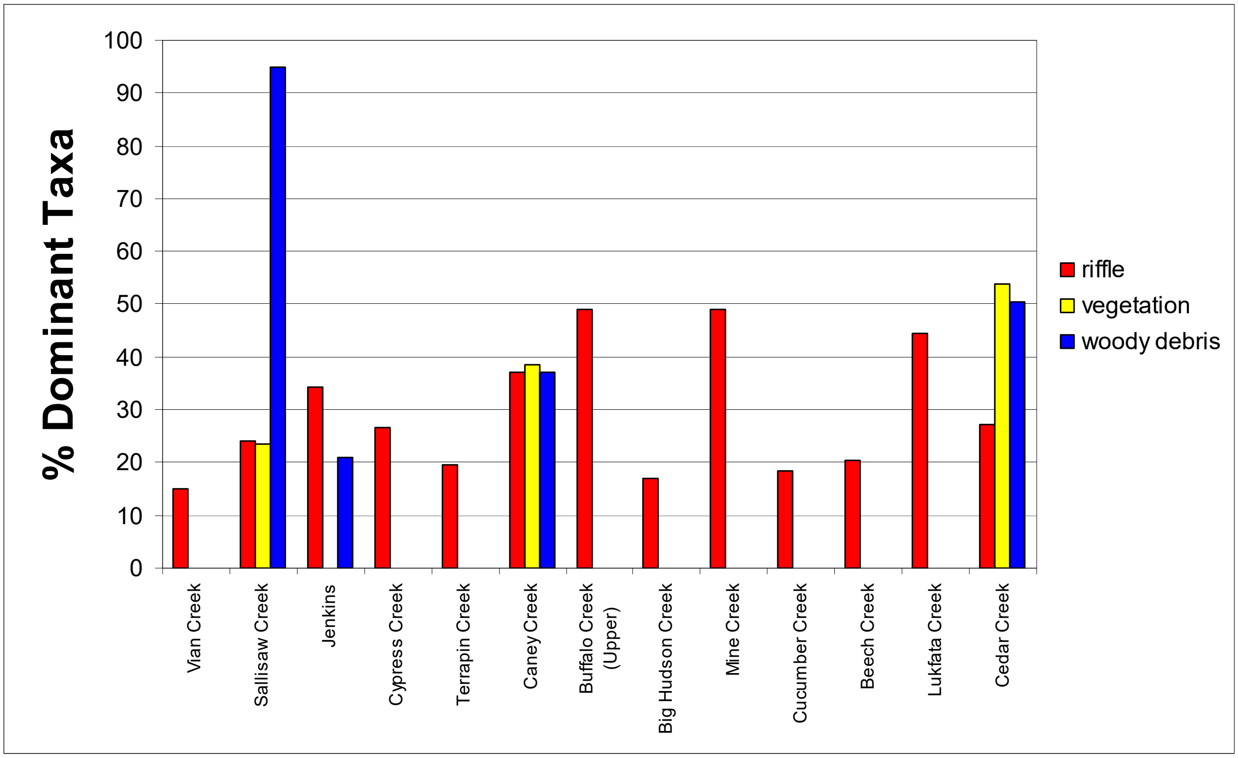

Figure 41. Summer Macroinvertebrate Collection Percent Dominant Taxa.

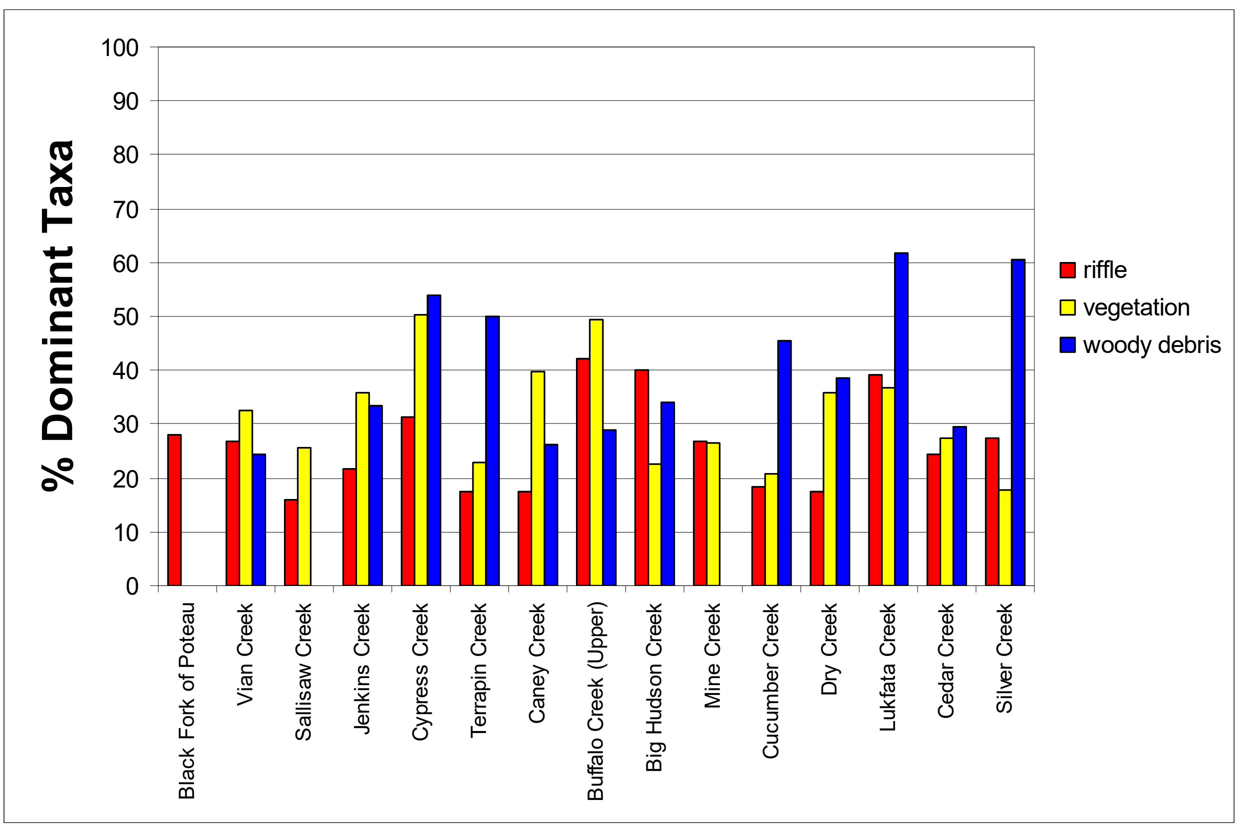

Figure 42. Winter Macroinvertebrate Percent Dominant Taxa.

The Shannon-Weaver Diversity index provides another measure of community balance and of diversity in the community. Communities with higher indices are interpreted to be healthier and more balanced. Diversity indices were fairly uniform for EOBS Stations with exceptions for summer collections at Upper Buffalo Creek (Figures 43 and 44). The difference between positive and negative reference streams was not evident using the Shannon-Weaver function.

Overall, the largest differences between positive and negative reference streams were seen using the Ratio of Scrapers to Filterers, Percent Shredders, and the Percent dominant taxa. Comparison of streams to average reference stream values indicates that Vian Creek, Sallisaw Creek, Jenkins Creek, Terrapin Creek, Caney Creek, Big Hudson Creek, Mine Creek, Cucumber Creek, Beech Creek, and Cedar Creek are in fairly good shape with respect to benthic macroinvertebrate populations. These creeks could be classified as slightly to nonimpaired. Black Fork of the Poteau River, Cypress Creek, Buffalo Creek, Dry Creek, Lukfata Creek, and Silver Creek could be classified as moderately to severely impaired based on their macroinvertebrate community structure.

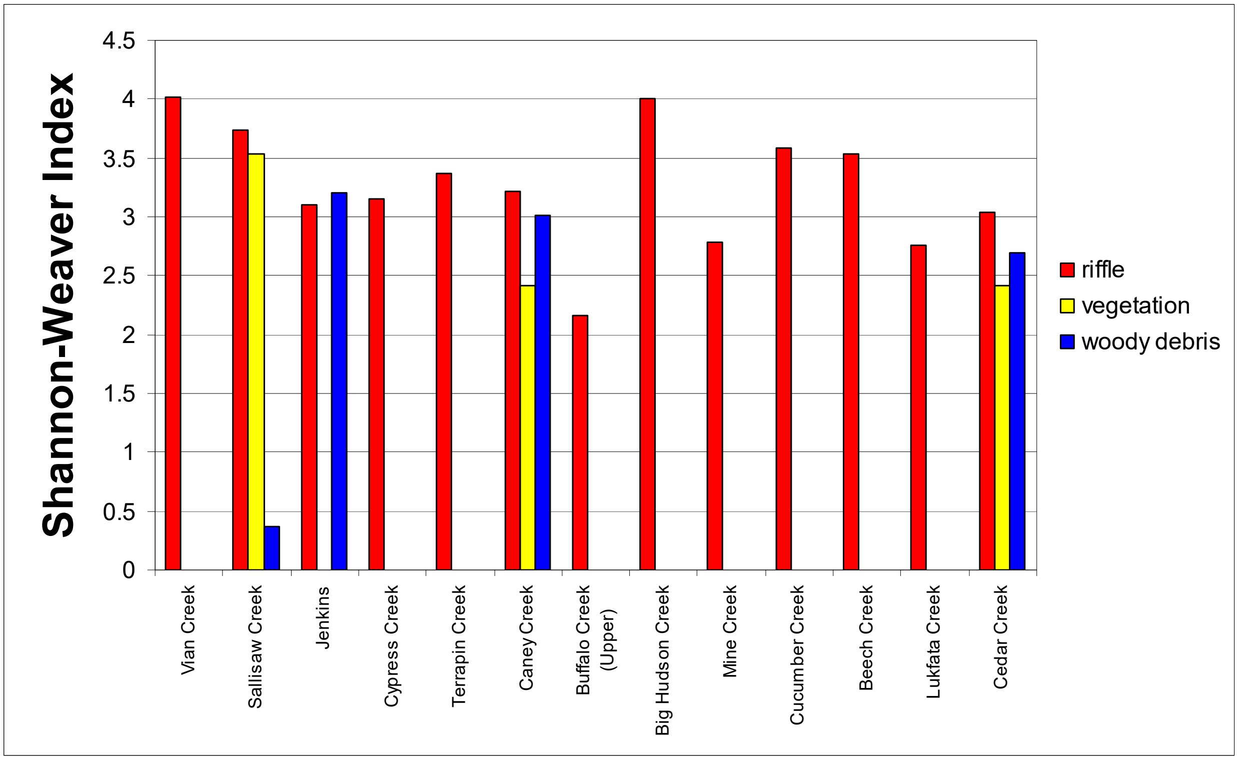

Figure 43. Summer Macroinvertebrate Collection Shannon-Weaver Diversity Index.

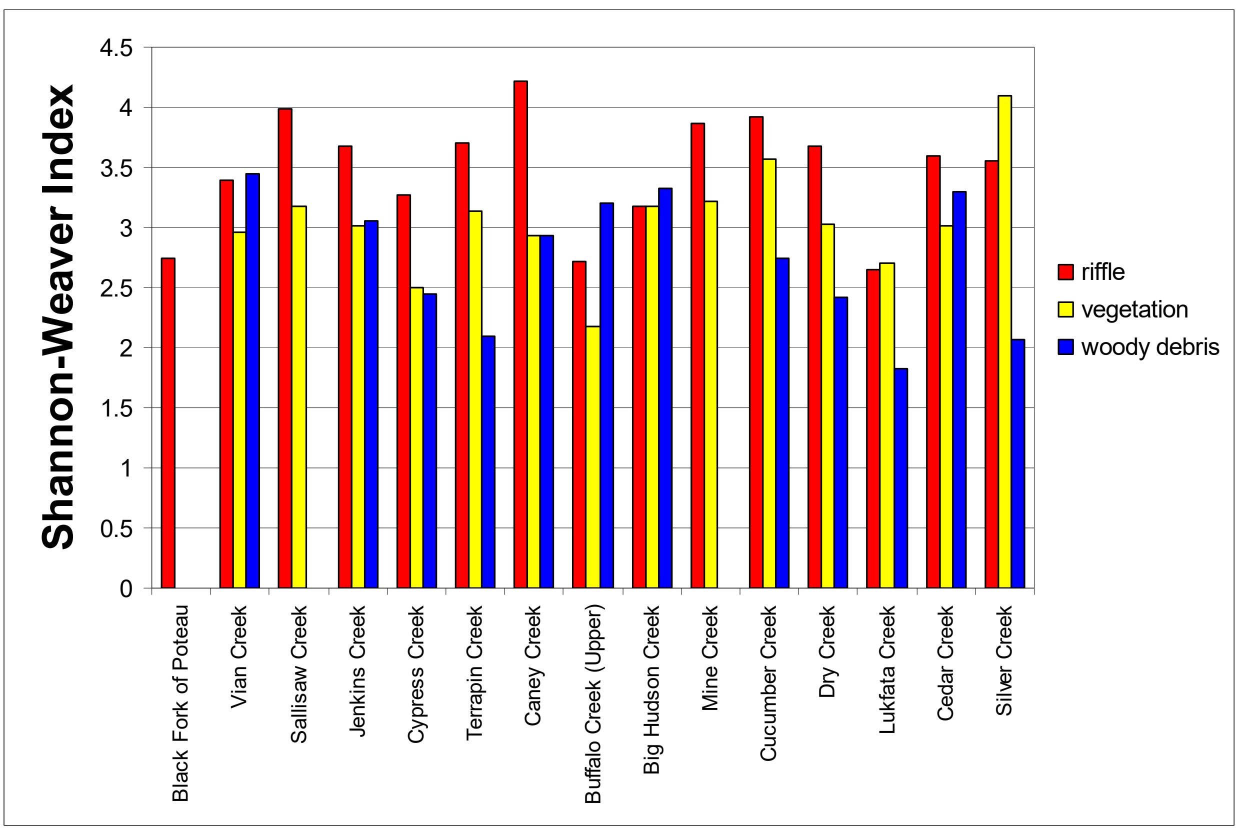

Figure 44. Winter Macroinvertebrate Collection Shannon-Weaver Diversity Index.

Fish Community Structure

The Index of Biological Integrity (IBI) was used to measure the condition of fish communities in the EOBS streams. The IBI is designed to assess fish communities based on taxonomic and trophic composition and the abundance and condition of fish. The index is composed of 13 metrics that assess these different perspectives of the fish community. Eleven of these metrics were found to be appropriate for assessing the fish communities of streams in the EOBS.

Metric 1: Total number of fish species- High numbers of fish species are associated with good water quality and habitat conditions; therefore, the number of species is expected to decrease as a result of stream quality degradation. Available habitat and the number of species will increase with increasing stream size. Thus, when using this metric it is necessary to account for these changes using determined relationships between the number of species and stream size for reference streams.

Metric 2.- Number and identity of darter or benthic species- These species are sensitive to degradation resulting from siltation and benthic oxygen depletion because they feed in benthic habitats. Many require the interstices of rubble as habitat. The organisms considered sensitive benthic species are *Phenacobius, Campostoma, Etheostoma, and Percina*. Scoring of this metric is also dependent on the species richness/waterbody size relationship.

Metric 3: Number and identity of sunfish species- This metric is based on sunfish species dependence on the presence of non-degraded pools and instream cover. In smaller streams, the number of sunfish will be dependent on stream size. Any *Centrarchid* organism is considered a sunfish.

Metric 4: Number and identity of minnow species- Because sucker species are more common in larger streams and the EOBS streams include a wide variety of stream sizes, minnow species-Cyprinid species (except *Cyprinus carpio*) were substituted for this metric. These species generally dominate the biomass of streams. Minnows are generally sensitive to both habitat and water quality degradation.

Metric 5: Number and identity of intolerant species- This metric uses the presence of species which have been determined to be restricted to only the highest quality streams. A list of these organisms is available from the EPA Rapid Bioassessment Protocols. The absence of such species may result from various chemical and/or physical impacts on water quality. This metric is useful for differentiating between high and moderate quality streams.

Metric 6: Proportion of individuals as very tolerant species- Green sunfish, black bullhead, mosquitofish, and red shiner are generally dominant in disturbed streams and are therefore useful in distinguishing between low and moderate quality streams.

Metric 7: Proportion of individuals as omnivorous- The percent of omnivorous will generally increase as habitat deteriorates. A list of these organisms is available from the EPA Rapid Bioassessment Protocols.

Metric 8: Proportion of individuals as insectivorous cyprinids- These species are associated with streams which support the abundant and diverse populations of invertebrates found in higher quality streams. A list of these organisms is available from the EPA Rapid Bioassessment Protocols. This metric assesses streams of moderate quality.

Metric 9: Proportion of individuals as top carnivores- The top carnivores are those which, as adults feed on other fish. crayfish or other vertebrates. This metric is useful for streams of high to moderate quality.

Metric IO: Number of individuals in sample- This metric is expressed as catch per unit effort and is dependent on consistent technique. The scoring of this metric is also dependent on stream size. This metric is most useful in streams that have experienced some significant form of chemical degradation.

The average number of species for positive reference EOBS streams was 13. Most streams were above this value with the exception of Little Sallisaw and Vian Creeks in which 6 and 5 species were collected, respectively (Figure 45). The greatest numbers of fish were collected in Big Skin Bayou and Sugar Loaf Creek.

The average total number of sensitive benthic species for positive reference streams was two. Again, most streams had at least two species with the exception of Little Sallisaw, Vian, and Mud Creeks (Figure 46). These low numbers likely resulted from poor or disturbed habitat in these creeks. Black Fork and Jenkins Creeks had the greatest number of sensitive benthic species collected (six species).

The average number of sunfish species collected in positive reference streams was three. Most common species included bluegill (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), and longear sunfish (*Lepomis megalotis*). None of the EOBS creeks had significantly fewer than 3 sunfish species collected. The greatest number of sunfish species were collected at Cypress and Lukfata Creeks.

The average number of minnow species collected in positive reference streams was three. Little Sallisaw, Lukfata, and Vian creeks had fewer than three minnow species collected (Figure 48). This suggested that these creeks were of less

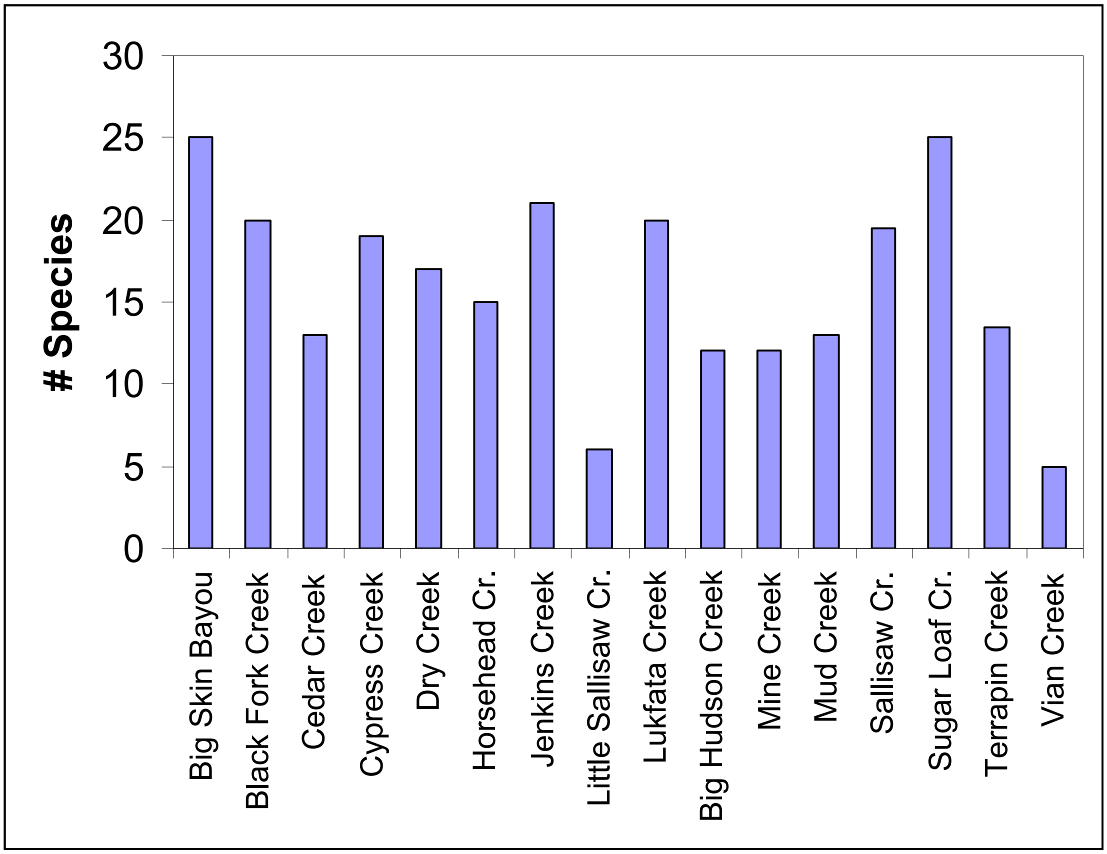

Figure 45. Metric 1: Total Number of Species Collected.

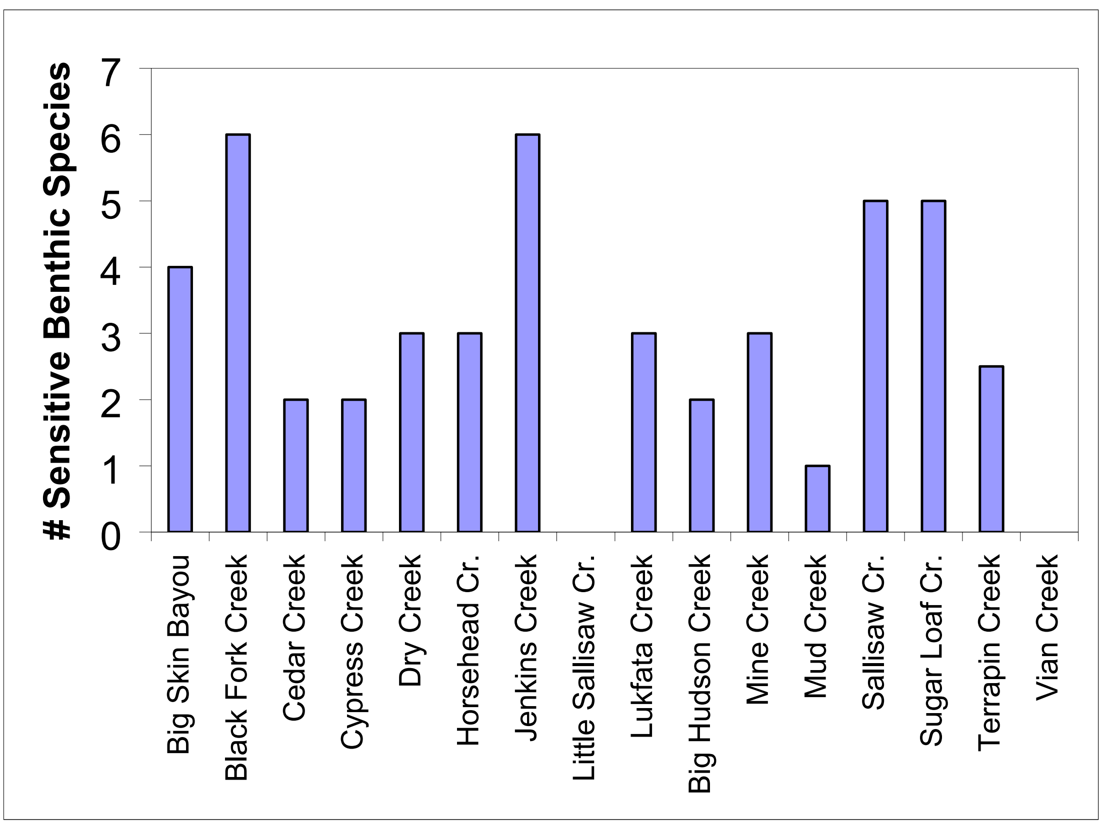

Figure 46. Metric 2: Total Number of Sensitive Benthic Species Collected.

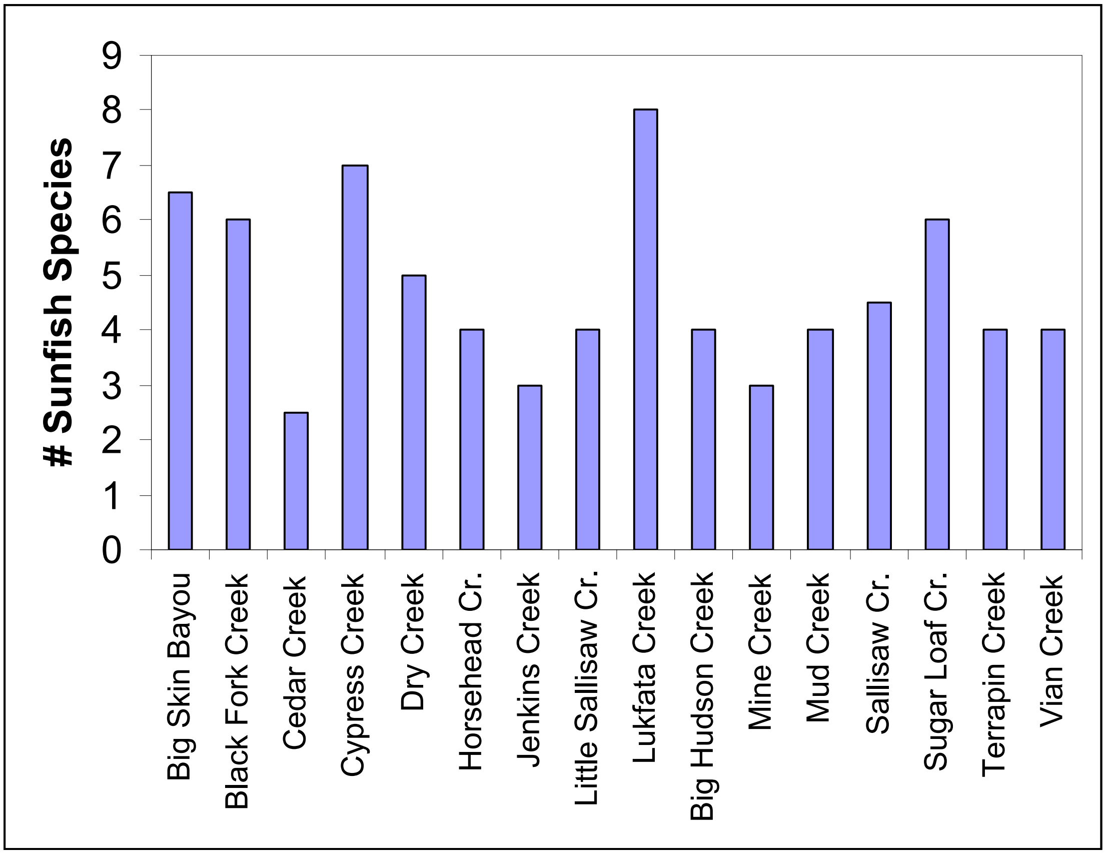

Figure 47. Metric 3: Total Number of Sunfish Species Collected.

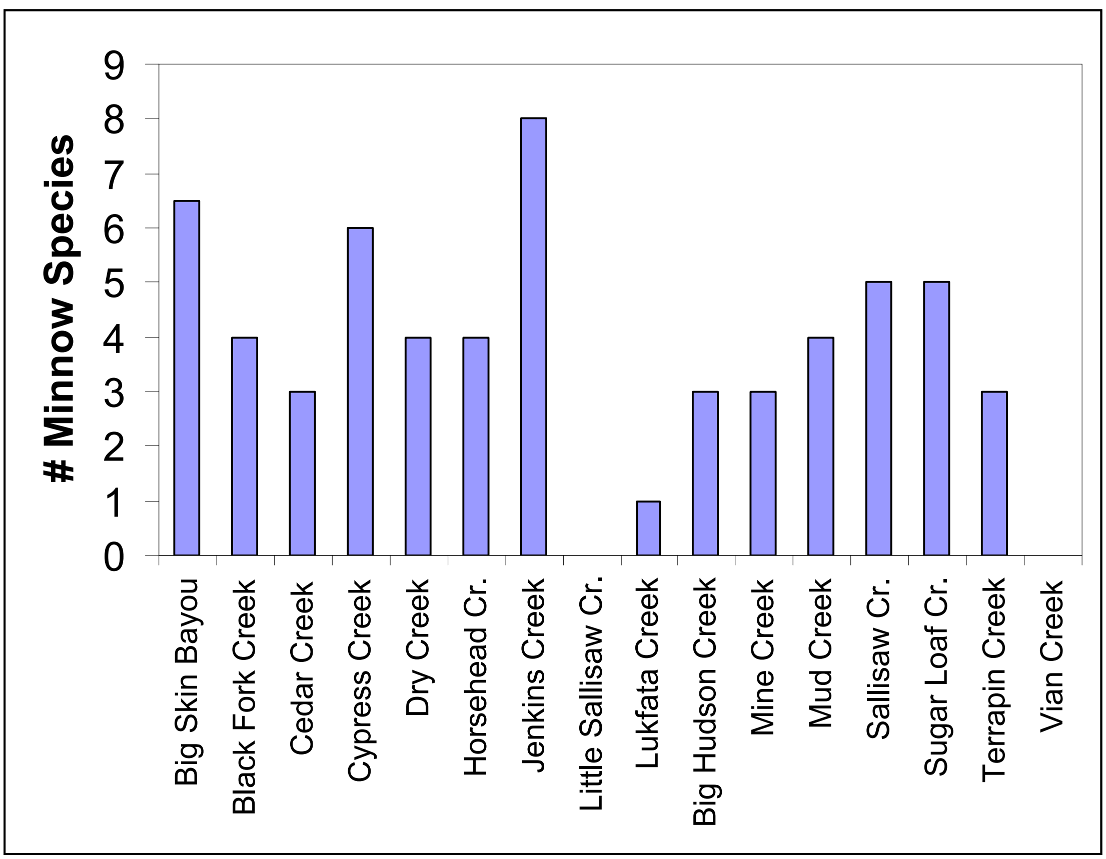

Figure 48. Metric 4: Number of Minnow Species Collected.

than moderate water quality. Jenkins Creek, Big Skin Bayou, and Cypress Creeks had the highest number of minnow species collected, suggesting that these streams were at least of moderate water quality.

The average number of intolerant species in positive reference streams was four. Little Sallisaw Creek, Lukfata Creek, and Vian Creek were the only creeks with significantly (based on IBI scoring criteria) fewer than four pollution intolerant species (Figure 49). Jenkins and Sallisaw Creek had the greatest number of pollution intolerant species. This suggested that water quality was better in Jenkins and Sallisaw than in Little Sallisaw, Lukfata, or Vian Creeks.

The average number of very tolerant species for positive reference streams was one. Many creeks had significantly more than one very tolerant species (Figure 50). These included Big Skin Bayou, Cypress Creek, Horsehead Creek, Jenkins Creek, Lukfata Creek, Mine Creek, Mud Creek, Sallisaw Creek, and Sugar Loaf Creek. However, the proportion of tolerant species to the total number of species collected was low on all but Little Sallisaw and Vian Creeks.

The average proportion of individuals as omnivores for positive reference streams was 0.3. Several creeks had a significantly higher proportion of omnivores, including Big Skin Bayou, Black Fork, Cypress, Dry, Little Sallisaw, and Sugar Loaf Creeks (Figure 51). This indicates that physical and chemical habitat in these creeks may be deteriorated over that of the positive reference streams. No omnivores were collected in Horsehead, Lukfata, Big Hudson, Mine, Mud, Sallisaw or Vian Creeks.

The average proportion of individuals as insectivorous cyprinids in positive reference streams was 15. Little Sallisaw, Lukfata, and Vian Creeks had significantly smaller proportions as insectivorous cyprinids which suggests these streams may have had lower benthic macroinvertebrate populations than other EOBS streams (Figure 52). Sallisaw, Mud and Cypress Creeks had the highest proportion of individuals as insectivorous cyprinids.

The average proportion of individuals as top carnivores in positive reference streams was 1.4. Horsehead, Little Sallisaw, Mud, and Sallisaw Creeks had significantly lower proportions of top carnivores (Figure 54). Low top carnivore percentages indicate these streams may not be high integrity fisheries. Vian Creek had the highest percentage of top carnivores collected.

The average total number of individuals collected in positive reference streams was 301. Little Sallisaw, Mud, and Vian Creeks had significantly lower numbers, suggesting these sites were of lower integrity than other sites (Figure 55). Highest population sizes were collected at Jenkins and Sallisaw Creeks.

IBI scores were lowest in Little Sallisaw and Vian Creeks and moderately low in Lukfata and Mud Creeks (Figure 55). This suggests a somewhat impaired fishery in these systems.

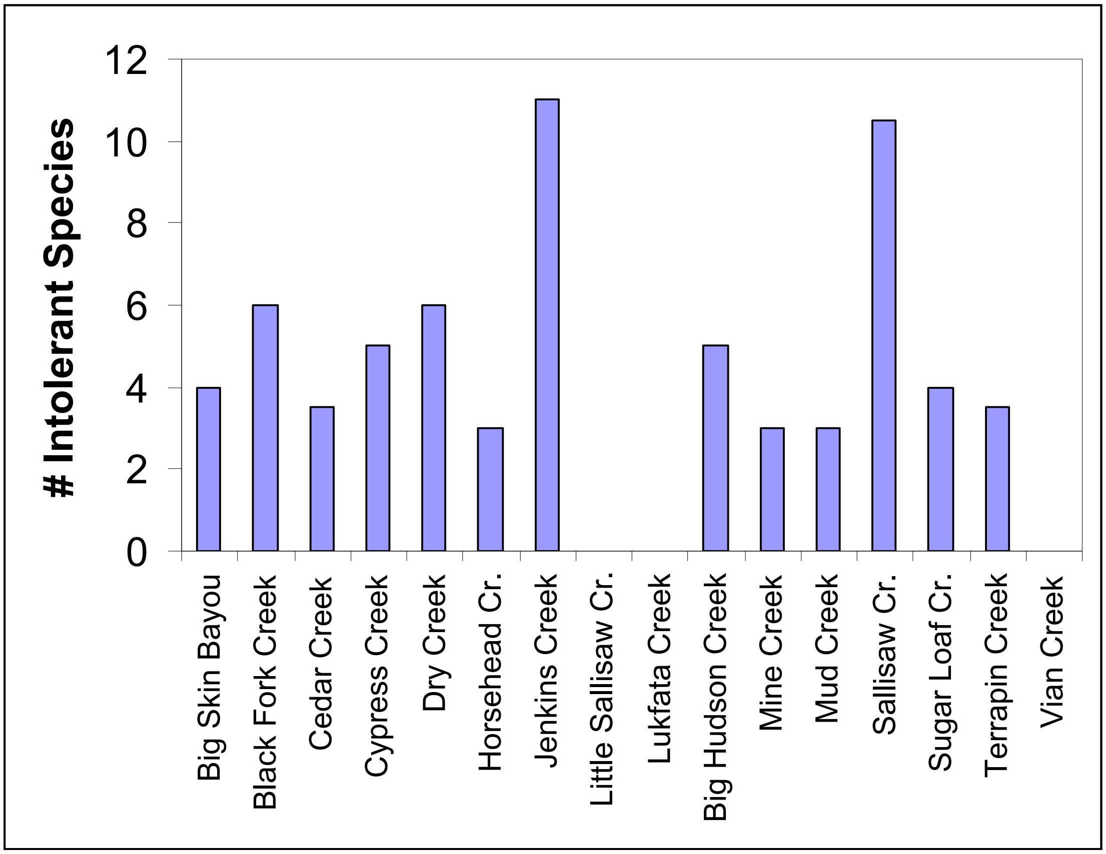

Figure 49. Metric 5: Number of Intolerant Species Collected.

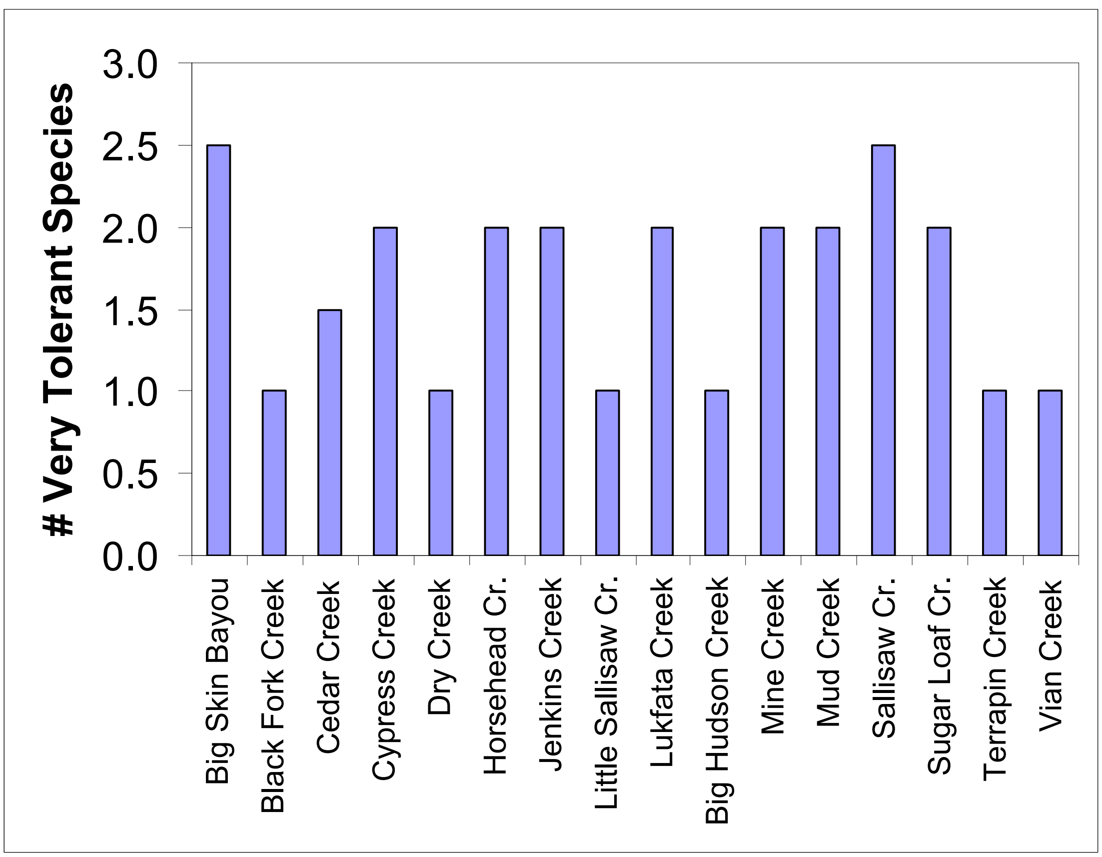

Figure 50. Metric 6: Number of Very Tolerant Species Collected.

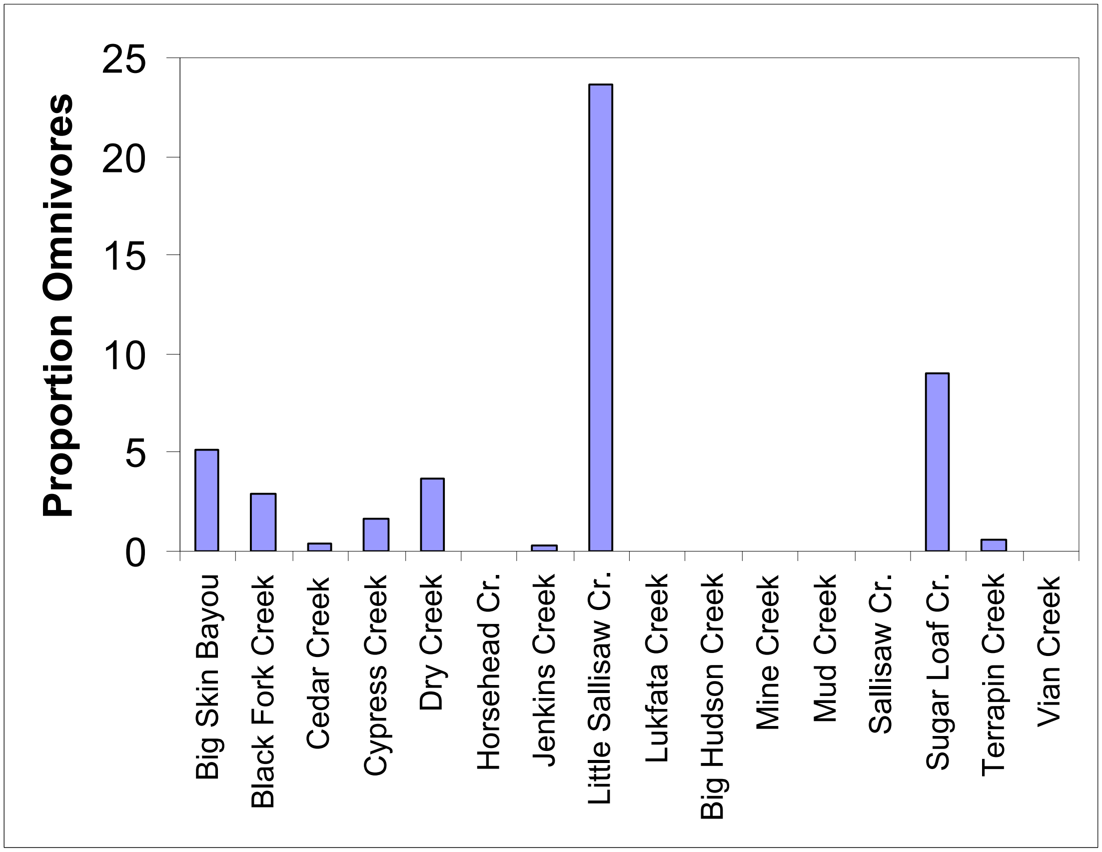

Figure 51. Metric 7: Proportion of Individuals as Omnivores.

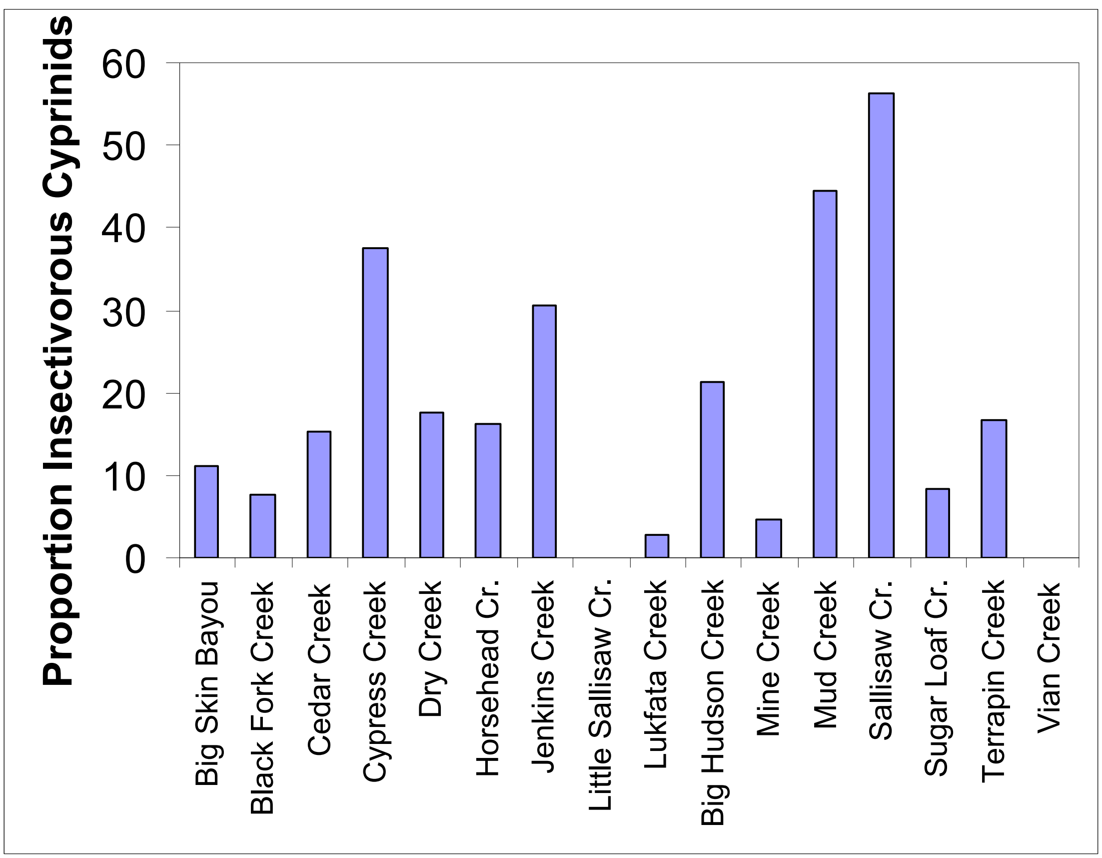

Figure 52. Metric 8: Proportion of Individuals as Insectivorous Cyprinids.

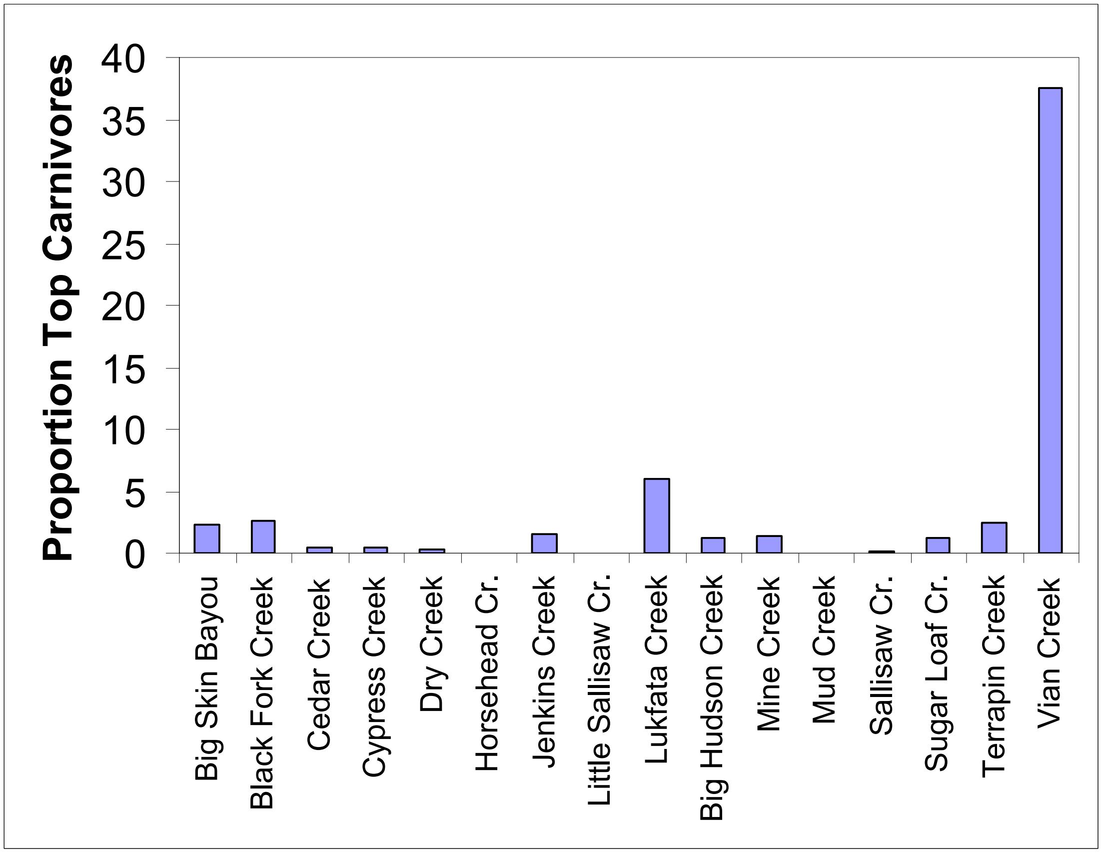

Figure 53. Metric 9: Proportion of Individuals as Top Carnivores.

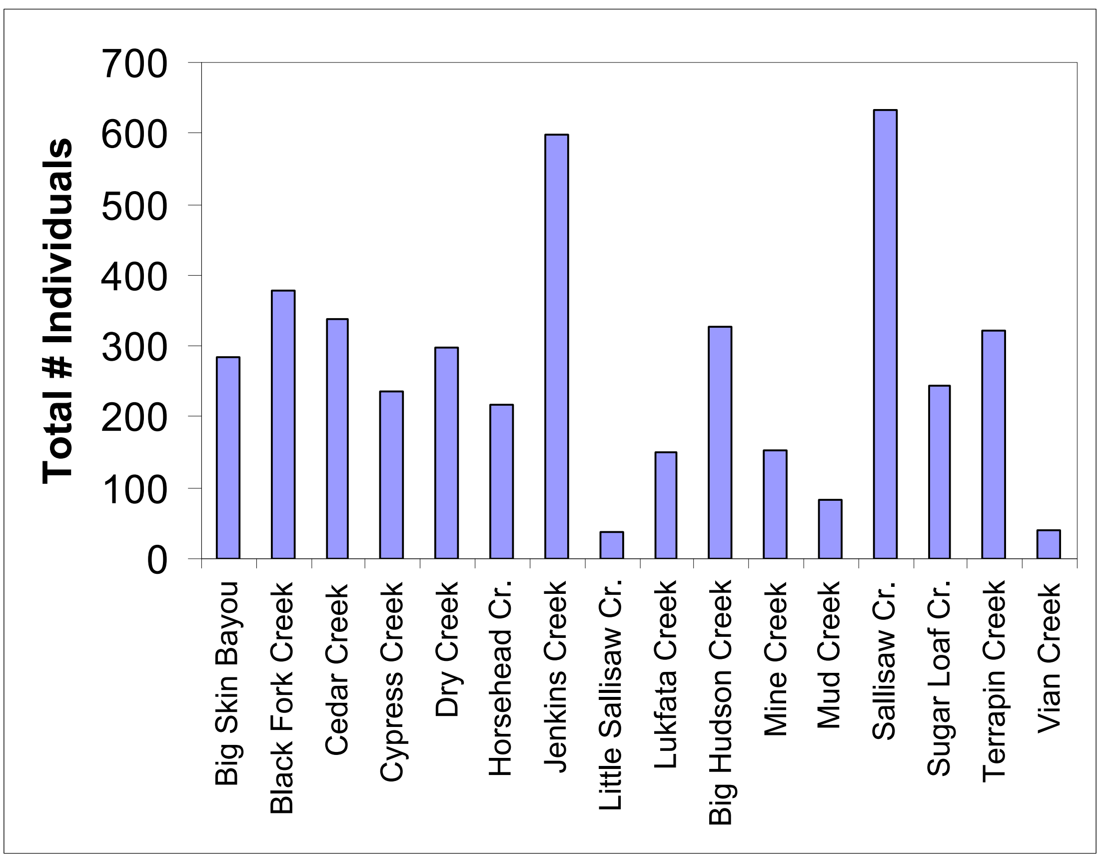

Figure 54. Metric 10: Total Number of Individuals Collected.

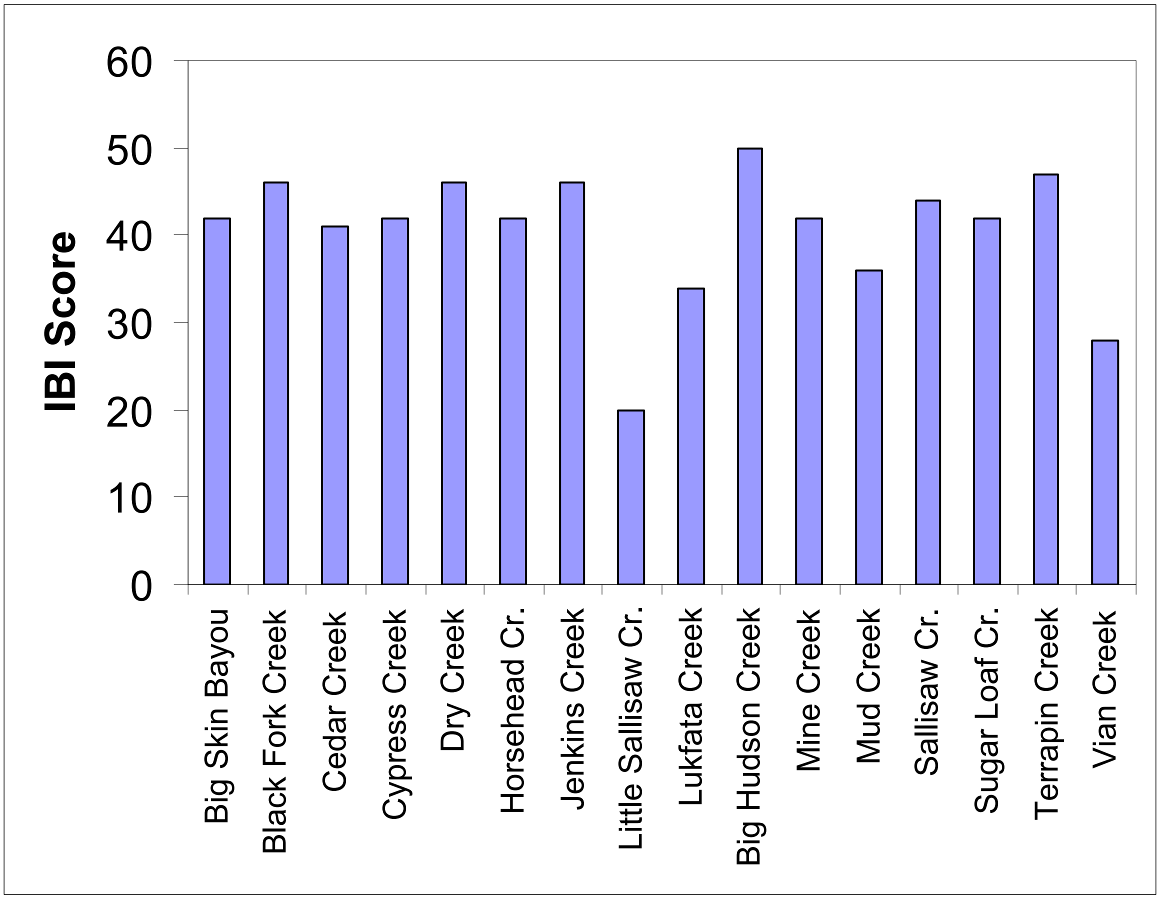

Figure 55. EOBS IBI Scores.

SUMMARY

Water quality at most EOBS stations was generally good during the period of record. Although potentially deleterious conditions were measured at nearly every stream at one time or another, most streams generally had adequate quality to support their beneficial uses as either warm or cold water aquatic habitat. Two notable exceptions were Mud and Yanubbee Creeks that displayed more standards violations and potentially harmful conditions than other streams. Violations or potentially harmful conditions recorded at Mud and Yanubbee Creeks included low dissolved oxygen concentrations, low pH, and high phosphorus, nitrite, nitrate, and total nitrogen concentrations. It is important to note that Mud Creek had a habitat and substrate type unlike any other creek surveyed. All other creeks had generally rocky substrates, either cobbles, gravel or bedrock, but Mud Creek had a silty substrate. These two creeks both received discharge from municipal wastewater systems. Other streams with somewhat lower water quality than most EOBS streams included Upper Buffalo Creek, Big Skin Bayou, Lukfata Creek, and James Fork of the Poteau River. Streams with potentially the best water quality included Pickens, Cucumber, Cedar, Big Hudson, Yashoo, Jenkins, and Mine Creeks.

Comparison of water quality to stream size (order, watershed size) suggests no direct relationship, streams with poorer water quality include both lower and higher order streams and smaller and larger watersheds. Nor does any solid link appear between ecoregion and water quality. Streams with good and bad water quality are found in all ecoregions. Water quality is likely then most closely related to the activities in each specific watershed rather than on geology or watershed size.

Habitat data was available for all EOBS streams. However, of the fifteen creeks surveyed, most scored well on habitat metrics. Two creeks were somewhat lower than the rest, Dry, and Cucumber Creeks, suggesting potentially poorer habitat in these creeks.

Benthic macroinvertebrate collections suggested that of the creeks surveyed, Black Fork of the Poteau River, Cypress Creek, Buffalo Creek, Dry Creek, Lukfata Creek and Silver Creek had somewhat impaired macroinvertebrate communities. Comparing this to available habitat data suggests that the poorer macroinvertebrate community in Dry Creek may be the result of poor habitat while the poorer community in Upper and Lower Buffalo Creek, Lukfata Creek, and Mud Creek may be due to poorer water quality in those streams.

Fish communities were poorer in Little Sallisaw, Vian, Mud, and Lukfata Creeks than in other creeks where fish were collected. Comparison to water quality, bug and habitat data suggests this is most likely related to poorer water quality at these sites than in other streams.

Five EOBS streams are currently listed on Oklahoma's §303(d) list of waters needing a TMDL (Table 11). This study supports the listing of Big Eagle Creek, but not Mud or Sallisaw Creeks for pH excursions. This study also supports the listing of Yanubbee Creek for organic enrichment and DO excursions. The potential for unknown toxicity or pesticides contamination was not directly measured, although indirect measurements may be indicated by biological collections. This unknown toxicity may account, in part, for the poor fish community in Mud Creek. The biological communities were not monitored during this study in Big Eagle or Horsehead Creeks to assess potential impacts of pesticides or unknown sources of toxicity.

Table 11. EOBS Streams Listed on Oklahoma's 1998 303(d) list.

Waterbody ID	Name	Cause(s)	Source(s)	Priority	Schedule
OK410210060160	Big Eagle Creek	Pesticides, pH	unknown	4	2008-2010
OK410210010060	Horsehead Creek	Unknown toxicity	unknown	4	2008-2010
OK410200010210	Mud Creek	Unknown toxicity, pH	unknown	4	2008-2010
OK220200030010	Sallisaw Creek	Pesticides, pH	Non-irrigated crop production, Pasture land, Range land, Feedlots, Animal Holding / Management, Mine Tailings, Unknown Sources	4	2008-2010
OK410200010150	Yanubbee Creek	Organic enrichment/DO	Wastewater	2	2000-2003

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