Assessment of Microbiological Contamination of the Jacks Fork within the Ozark National Scenic Riverways, Missouri—Phase I

—by Jerri V. Davis and Joseph M. Richards

Introduction

The Ozark National Scenic Riverways (ONSR), the Nation's first scenic riverway, was created by an Act of Congress (Public Law 88-492) on August 24, 1964, for "the purpose of conserving and interpreting unique scenic and other natural values and objects of historic interest, including preservation of parts of the Current River and the Jacks Fork River in Missouri as free-flowing streams, preservation of springs and caves, management of wildlife, and provisions for use and enjoyment of the outdoor recreation resources thereof by the people of the United States" (National Park Service, 1981). The primary natural resources protected by the park are 134 miles of the Current and Jacks Fork Rivers (fig. 1). About 1.5 million people visit the ONSR annually to take advantage of excellent recreational opportunities, including canoeing, johnboating, swimming, fishing, tubing, camping, hiking, caving, horseback riding, and hunting.

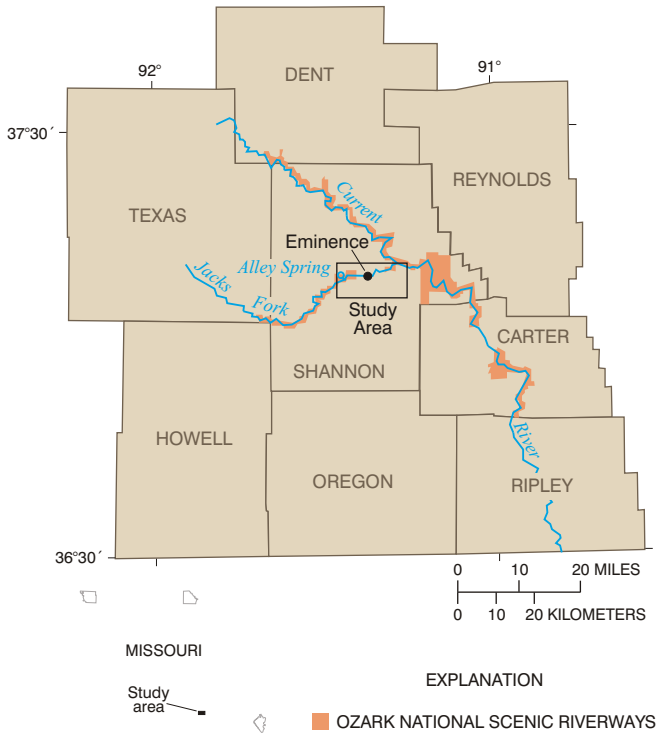


Figure 1. Location of study area.

The Current and Jacks Fork Rivers are located in the Ozark Plateaus physiographic province (Fenneman, 1938) in southeast Missouri, which is an area characterized by deep, narrow valleys and sharp ridges. The two rivers flow through mature karst terrain and gain the majority of their base flow from springs. Karst topography (springs, sinkholes, and losing streams) and structural features (folds, faults, and fractures) greatly affect water quantity and quality.

The Jacks Fork is the largest tributary of the Current River, and like the Current River, has been classified as an Outstanding National Resource Water by the U.S. Congress (Missouri Department of Natural Resources, 1999). Outstanding National Resource Waters have national recreational and ecological significance and receive special protection against any degradation in quality. The river has been designated for the following five beneficial uses by the State of Missouri: livestock and wildlife watering, aquatic life protection, cool-water fishery, whole-body-contact recreation, and boating and canoeing (Missouri Department of Natural Resources, 1999). From its source in Texas County, the Jacks Fork drains an area of about 422 square miles. Alley Spring, Missouri's seventh largest spring, discharges an average of about 125 cubic feet per second into the Jacks Fork (Vandike, 1995) about 6 miles upstream from the town of Eminence (fig. 1).

Water Quality and 303(d) Listing of the Jacks Fork

The intense recreational use of the Jacks Fork has caused concerns regarding the impacts that this heavy use might be having on the river. A river use management plan prepared by the National Park Service (Sullivan and others, 1989) states that the increasing popularity of the recreational area has created problems associated with greater competition for the use of a finite resource base. Also, because of inappropriate or intensive use, resource damage has increased in some areas. Problems include crowding and increased conflicts between river users, the need to improve and provide more sanitation facilities, the proliferation of litter, congestion at river accesses and campgrounds, and balancing the need to protect water quality with the recreational needs of the public.

Section 303(d) of the Federal Clean Water Act requires that each state identify those stream segments with documented pollution problems for which existing required pollution controls are not adequate to implement the state water-quality standards. For these impaired stream segments, states are required to establish total maximum daily loads (TMDLs) of the identified pollutant. A TMDL specifies the maximum amount of the identified pollutant allowed to be present in a water body, allocates allowable pollutant loads among sources, and provides the basis for attaining or maintaining water-quality standards within the affected water body.

In 1998, a 5-mi (mile) reach of the Jacks Fork from the town of Eminence to its confluence with the Current River was included on Missouri's list of impaired waters as required by Section 303(d) of the Federal Clean Water Act. The identified pollutant on the Jacks Fork is fecal coliform bacteria, whose presence in large numbers indicates contamination by fecal wastes of humans and other warm-blooded animals. The State standard for safe whole-body-contact recreation is 200 col/100 mL (colonies per 100 milliliters) of sample (Missouri Department of Natural Resources, 1999). Potential sources of fecal contamination to the Jacks Fork could include a large cross-country horseback riding operation; the Eminence Wastewater Treatment Plant; campground pit-toilet or septic-system effluent; canoeists, boaters, and tubers; and cattle. Studies conducted by the U.S. Geological Survey (Barks, 1978; Davis and Bell, 1998), Emrie (1986), National Park Service (National Park Service, written commun., 1997), and the Missouri Department of Natural Resources (1998) have suggested that heavy recreational use is causing adverse impacts on the water quality of the river, including elevated fecal coliform bacteria densities that, on occasion, exceed the water-quality standard for whole-body-contact recreation.

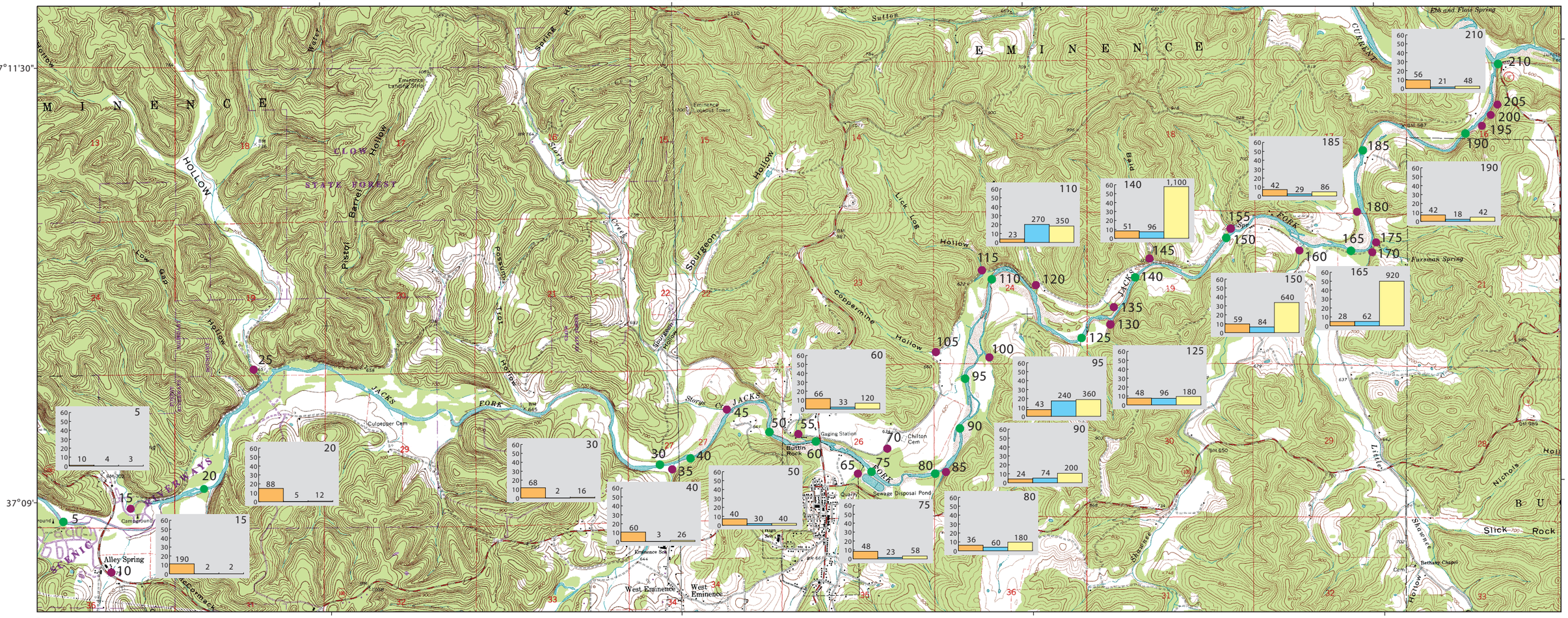
Typical reach of the Jacks Fork just upstream of Alley Spring. Photo courtesy of R.B. Jacobson, U.S. Geological Survey.

Trail riders crossing the Jacks Fork.

Jacks Fork Microbiological Study—Phase I

Substantive regulatory efforts by the State to control and eliminate fecal coliform bacteria inputs to the Jacks Fork depend on identification of sources. The U.S. Geological Survey, in cooperation with the National Park Service, is conducting a study to better understand the extent and sources of microbiological contamination within the Jacks Fork from Alley Spring to the mouth, which includes the 5-mi 303(d) reach (fig. 1). The results of this study are expected to provide the National Park Service and other natural resource management agencies in Missouri with information needed to make effective resource management decisions. Specific objectives of the three-phase study include determining the locations and magnitude of microbiological contamination (Phase I); establishing a water-quality sampling network to further understand the sources of microbiological contamination (Phase II); and establishing sampling locations for routine long-term water-quality monitoring (Phase III). This report presents results of Phase I.

The locations of microbiological contamination were determined in Phase I through three intensive synoptic surveys. A synoptic survey consists of the measurement of selected constituents at many sites during a brief period representative of a particular hydrologic or seasonal condition. A reconnaissance of the Jacks Fork from the Alley Spring Campground to the mouth was done to locate sampling sites, locate potential sources of microbiological contamination, and map hydrologic features for inclusion in a geographic information system (GIS) data base. Each location or feature was identified by geographic coordinates as determined by a global positioning system (GPS). Based on information collected during the reconnaissance, 42 sampling sites were selected (fig. 2).



Base from U. S. Geological Survey digital data
Eminence 1:24,000, 1965, photoinspected 1982
Alley Spring 1:24,000, 1965, photorevised 1985

JACKS FORK TRIBUTARIES AND EMINENCE WASTEWATER TREATMENT PLANT

SITE 10			SITE 25			SITE 35			SITE 45			SITE 65			SITE 70		
19	--	--	8	10	110	86	68	130	330	140	1,500	71	220	--	0	0	230
10,200	--	--	15,900	2,830	25,500	706,200	163,700	298,200	336,400	55,500	339,800	20,100	623	--	0	0	27,400

SITE 105			SITE 115			SITE 120			SITE 130			SITE 145			SITE 155		
82	600	--	100	3,000	--	140	--	--	15	250	1,100	52	--	--	6	130	5
3,480	28,900	--	7,080	51,000	--	1,190	--	--	1,440	20,500	43,600	3,830	--	--	323	8,470	283

SITE 160			SITE 170			SITE 175			SITE 200		
23	130	120	20	42	210	96	28	1,200	370	--	--
97,700	405,000	214,100	26,600	39,200	83,200	40,800	6,340	302,400	14,700	--	--

NOTE: For each site the top row is fecal coliform density, in colonies per 100 milliliters of sample, and the bottom row is fecal coliform load, in colonies per second; --, indicates no sample collected; orange represents May 10-12, blue represents June 22-24, and yellow represents August 10-12. No samples were collected at sites 55, 85, 100, 135, 180, 195, and 205 because there was no flow at time of sampling. Direction of flow of the Jacks Fork is west to east. Site 70 is the Eminence Wastewater Treatment Plant.

EXPLANATION

U.S. GEOLOGICAL SURVEY WATER-QUALITY SAMPLING SITE

- Jacks Fork main stem
- Jacks Fork tributary

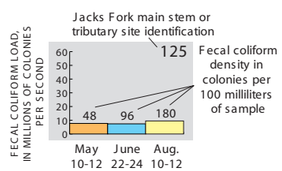


Figure 2. Synoptic survey sampling sites and fecal coliform results in May, June, and August 1999.

The first intensive synoptic survey was done May 10 to 12, 1999, during spring base-flow conditions before the start of the recreational season (late May through early September). Rainfall in the Alley Spring and Eminence areas on May 5 caused an increase in discharge in the Jacks Fork [2,270 ft^3/s (cubic feet per second) above Alley Spring and 2,920 ft^3/s at Eminence on May 5], which was still in the process of receding during the May 10 to 12 synoptic survey (discharge decreased from 252 to 218 ft^3/s above Alley Spring and from 590 to 481 ft^3/s at Eminence). The second and third intensive synoptic surveys were done during the recreational season on June 22 to 24 and August 10 to 12, 1999, during early-summer (93 ft^3/s above Alley Spring and 226 ft^3/s at Eminence) and late-summer (66 ft^3/s above Alley Spring and 171 ft^3/s at Eminence) base-flow conditions. Rainfall in the Alley Spring and Eminence areas on June 23 during the synoptic survey did not result in runoff or an increase in discharge in the Jacks Fork. Rainfall on August 8 did cause a slight increase in discharge in the Jacks Fork, but conditions had returned to base flow by August 10.

Mill at Alley Spring. Photo courtesy of Charlotte Pepmiller, U.S. Geological Survey.

During the three intensive synoptic surveys, samples were collected and analyzed by the U.S. Geological Survey at each site for fecal coliform, *Escherichia coli* (*E. coli*), and fecal streptococci bacteria according to procedures described in Myers and Wilde (1997). Samples also were collected and analyzed for nutrients. The additional bacteria and nutrients were analyzed to help identify the sources of the fecal coliform bacteria. All chemical analyses were done by the U.S. Geological Survey National Water Quality Laboratory in Lakewood, Colorado. Onsite analysis of specific conductance, pH, temperature, and dissolved oxygen were done at each site according to procedures described by Wilde and Radtke (1998). Stream discharge was measured at each tributary site and at most Jacks Fork main stem sites.

Phase I Results

Fecal coliform bacteria data from the three Phase I intensive synoptic surveys are shown in figure 2. Results are shown as densities of fecal coliform bacteria in col/100 mL and instantaneous loads of fecal coliform bacteria in colonies per second. The fecal coliform bacteria density is a measure of the number of fecal coliform bacteria in 100 mL of sample. The fecal coliform instantaneous load (the product of density times stream discharge) is a measure of the number of fecal coliform bacteria present in the volume of water that passes by a specific location in one second. A small stream with large bacteria densities may contribute small loads, whereas a large stream with small bacteria densities may contribute large loads. Some of the 42 selected sites were not sampled during one or more of the synoptic surveys because the streams were not flowing at the time of sampling.

Fecal coliform bacteria densities and loads increased between sites 5 and 20 on the main stem of the Jacks Fork and then generally decreased along the main stem from site 20 to the mouth during the May 10 to 12, 1999, synoptic survey. Counts ranged from 10 to 88 col/100 mL, and loads ranged from 870,000 to 14,900,000 col/s (colonies per second) on the main stem. The large increase between sites 5 and 20 can be attributed to the input of fecal coliform bacteria from Alley Spring (site 15), which probably resulted from the rainfall on May 5 and the subsequent increase in discharge.

Fecal coliform bacteria densities and loads generally were larger in the 303(d) reach downstream of Eminence than upstream of Eminence during the June 22 to 24 and August 10 to 12, 1999, synoptic surveys. During the June 22 to 24 survey, the median fecal coliform density upstream of Eminence was 4 col/100 mL, and the median from Eminence downstream was 62 col/100 mL; the median fecal coliform load upstream of Eminence was 192,000 col/s, and the median from Eminence downstream was 4,880,000 col/s. During the August 10 to 12 survey, the median fecal coliform density upstream of Eminence was 16 col/100 mL, and the median from Eminence downstream was 180 col/100 mL; the median load upstream of Eminence was 806,000 col/s, and the median from Eminence downstream was 9,680,000 col/s. With the exception of Alley Spring, tributaries appeared to have little effect on the fecal coliform bacteria densities in the Jacks Fork because of the relatively small discharge of the tributaries relative to the discharge of the Jacks Fork.

Canoeing on the Jacks Fork.

Phase I results indicate that fecal coliform bacteria are a problem in the Jacks Fork. The State standard for whole-body-contact recreation (which applies only to the main stem of the Jacks Fork) was exceeded at sites 95 and 110 during the June synoptic survey and at sites 95, 110, 140, 150, and 165 during the August synoptic survey. Additional monitoring during Phase II and Phase III will help to further understand the extent and sources of microbiological contamination in the Jacks Fork.

References

Barks, J.H., 1978, Water quality in the Ozark National Scenic Riverways, Missouri: U.S. Geological Survey Water-Supply Paper 2048, 57 p.

Davis, J.V., and Bell, R.W., 1998, Water-quality assessment of the Ozark Plateaus study unit, Arkansas, Kansas, Missouri, and Oklahoma—Nutrients, bacteria, organic carbon, and suspended sediment in surface water, 1993–95: U.S. Geological Survey Water-Resources Investigations Report 98–4164, 95 p.

Emrie, G.E., 1986, Fecal coliform as an indicator of water quality and recreational carrying capacity at Ozark National Scenic Riverways: Southwest Missouri State University, unpublished M.S. thesis, 65 p.

Fenneman, N.M., 1938, Physiography of eastern United States: New York, McGraw-Hill Book Co., Inc., 689 p.

Missouri Department of Natural Resources, 1998, Water quality investigation of the Jacks Fork River, Shannon and Texas Counties, May–November, 1998: Jefferson City, Mo., Division of Environmental Quality, Environmental Services Program, 133 p.

——— 1999, Missouri water quality standards—Chapter 7, Water quality: Jefferson City, Mo., Clean Water Commission, 136 p.

Myers, D.N., and Wilde, F.D., eds., 1997, National field manual for the collection of water-quality data—Biological indicators: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A7, 38 p.

National Park Service, 1981, Draft general management plan and development concept plan—Ozark National Scenic Riverways, Missouri: U.S. Department of the Interior, National Park Service, Denver Service Center, 132 p.

Sullivan, A.E., Foster, D.I., Given, D., Einwalter, D.C., Graham, T., and Simpson, J., 1989, River use management plan—Ozark National Scenic Riverways: U.S. Department of the Interior, National Park Service, Denver Service Center, 46 p.

Vandike, J.E., 1995, Surface water resources of Missouri—Missouri State Water Plan Series Volume 1: Rolla, Missouri Department of Natural Resources, Division of Geology and Land Survey, Water Resources Report Number 45, 122 p.

Wilde, F.D., and Radtke, D.B., eds., 1998, National field manual for the collection of water-quality data—Field measurements: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6, 238 p.

For more information contact any of the following:

For water information:
U.S. Geological Survey, District Chief
1400 Independence Road, Mail Stop 100
Rolla, Missouri 65401
(573) 308-3664 or “http://missouri.usgs.gov”

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