HYDROLOGY

Precipitation

Precipitation averages 40 inches per year. Runoff averages about 10 inches per year. Annual snowfall is approximately 14 inches (MDNR 1986). The highest runoff is in April-May and the lowest in December-January, coinciding with seasonal rainfall patterns.

Gauging Stations

There have been 22 gauging stations used in the Sac River basin to monitor stream flows and water quality (Table 3; USGS 1999). The longest running active gauging station is station 06919500 on Cedar Creek near Pleasant View. It has been in service from 1923-1926 and 1948 to present (USGS 1999a). Currently active stations include: 06918440 on the Sac River near Dadeville, 06918460 on Turnback Creek above Greenfield, 06918493 on the South Dry Sac near Springfield, 06918740 on the Little Sac River near Morrisville, 06918990 on Stockton Lake near Stockton, 06919020 on the Sac River at Highway J below Stockton, 06919500 on Cedar Creek near Pleasant View, and 06919900 on the Sac River near Caplinger Mills. Figure 14 shows the average annual discharge for three gauging stations in the Sac River basin.

Stream Order

Stream orders were assigned using 7.5 minute USGS topographic maps and the methodology originally proposed by Horton (1932) and detailed by Gordon et al (1992). Table 4 depicts the number of streams third order and larger and stream mileage by sub-basin for the Sac River basin.

Losing streams

It takes 4.7 square miles of area to maintain one mile of permanently flowing stream in the Sac River basin (MDNR 1986). Funk (1968) listed the Sac River basin as having 419 miles of permanently flowing stream and 173 miles of intermittently flowing streams with permanent pools. There are several losing streams in the Sac River basin primarily located in the Upper Sac River, Turnback Creek, and Little Sac River watersheds. Table 5 lists losing streams along with their location and Figure 15 gives a graphic location of these stream reaches in the Sac River basin.

Stream Flow

The highest recorded discharge for the Sac River (post-impoundment) at gauging station 06919900 near Caplinger Mills was 61,500 cubic feet per second (cfs) on April 12, 1994 (USGS 1999). The highest recorded discharge for gauging station 06919000 near Stockton, Missouri (pre-impoundment) was 120,000 cfs on May 19, 1943 (USGS 1999). The impoundment of the Sac River by Stockton Dam has dramatically effected the hydrology in the river and its tributaries below the dam. Flood events prior to impoundment were undoubtedly larger in magnitude and most likely of shorter duration. The flow magnitude at present, from the records presented, are probably half the historic magnitude but could be weeks or even months longer in duration. Peaking hydropower operations probably simulate daily mini-floods and droughts as pulses of water are repeatedly sent downstream through the generation turbines. Short term flow fluctuations can be dramatic. Instantaneous flows can vary rapidly between less than 20 cfs to more than 8,300 cfs in the Sac River below Stockton Dam during peaking operations. Flow

Table 3. Gauging stations operated in the Sac River basin.

Gauge Number	Location	Gauge Type[1]	Years of operation
06918400	Pickerel Creek near Republic	Miscellaneous site	1968-1970
06918420	Sac River at Ash Grove	Miscellaneous site	1962-65, 67, 71
06918430	Clear Creek near Phenix	Miscellaneous site	1962-64, 67, 70-71
06918440	Sac River near Dadeville	Continuous discharge	1966 to present
		Water quality	1974 - 87, 94-95
06918444	Chesapeake Spring at Chesapeake	Miscellaneous site	1926, 32, 36, 54, 63-68
06918450	Limestone Creek at South Greenfield	Miscellaneous site	1962-64, 66-67, 71-72
06918460	Turnback Creek at Greenfield	Continuous discharge	1965 to present
06918470	Turnback Creek near Greenfield	Miscellaneous site	1943, 45-46, 49, 62-65
06918480	Sac River near Neola	Miscellaneous site	1964-1965, 1967
06918490	Sons Creek near Neola	Miscellaneous site	1964-65, 67
06918493	S. Dry Sac near Springfield	Continuous discharge	1996 to present
06918600	Little Sac at Walnut Grove	Water quality	1974 - 90, 94-96
06918700	Oak Grove Branch near Brighton	Miscellaneous site	1958-72
06918740	Little Sac near Morrisville	Continuous discharge	1968 to present
06918750	Franca Branch near Brighton	Crest gauge	1955-84
06918800	Little Sac at Aldrich	Miscellaneous site	1962-65, 67-68
06918990	Stockton Lake near Stockton	Continuous discharge /water quality	1969 to present
06919000	Sac River near Stockton	Continuous discharge	1921- 89
06919020	Sac River near Stockton (Hwy J)	Continuous discharge	1973 to present
06919200	Sac River Tributary near Caplinger Mills	Crest gauge	1955 - 62, 63 - 84
06919500	Cedar Creek near Pleasant View	Continuous discharge	1948 to present
06919900	Sac River near Caplinger Mills	Continuous discharge	1974 to present

06919950	Brush Creek near Collins	Continuous discharge	1995 to present

1 - Miscellaneous sites were set up and run for specific information needs and time periods. They may have been discharge, water quality, crest, or other types of gauging stations.

Table 4. Number of streams third order and larger and stream mileage by sub-basin for the Sac River basin.

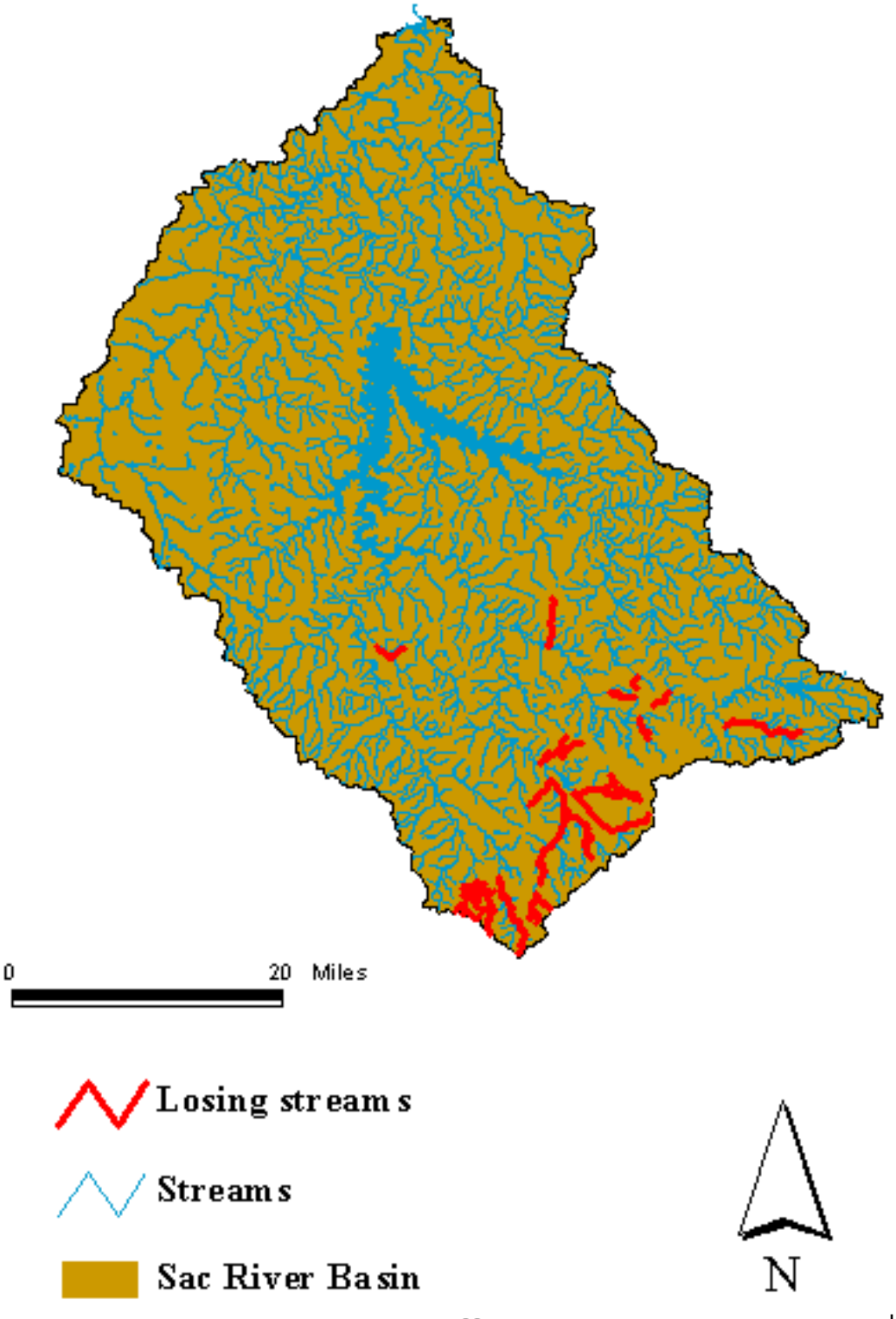
Sub-basin name	Number of streams (>3 order)	Total stream miles
Bear Creek	10	84.7
Brush Creek	18	93.3
Coon Creek	8	38.5
Horse-Cedar-Alder Creeks	42	328.9
Little Sac River	26	254.4
Sons Creek	10	71.0
Turnback Creek	23	197.4
Turkey Creek	3	31.9
Sac River + minor tributaries	43	353.2
Sac River basin (total)	183	1,453.4

Table 5. Losing streams in the Sac River basin in Missouri.

Stream	Receiving Stream	Location		
		T	R	Sec.
First Order Tributary	Turnback Creek	27N	24W	6,7,8,17,20
First Order Tributary	Second Order Tributary	27N	25W	4
Second Order Tributary	Goose Creek	28N	25W	26, 34, 35
Second Order Tributary	Goose Creek	27N	25W	1, 2, 13
		28N	25W	26, 35, 36
First Order Tributary	Second Order Tributary	27N	25W	2
		28N	25W	35
First Order Tributary	Pickerling Creek	28N27N	24W	33
			24W	3
First Order Tributary	Pickerling Creek	27N	24W	4, 9
		28N	24W	33
Pickerling Creek	Sac River	28N	24W	2, 10, 11, 15, 16, 22, 21, 28
		29N	24W	22, 23, 26, 35
First Order Tributary	Sac River	28N	23W	1, 6, 7, 12, 18
		29N	24W	35, 36
First Order Tributary	Pickerel Creek	29N	24W	21, 22, 28, 29
First Order Tributary	Sac River	29N	23W	23, 30, 34, 35
		29N	24W	5, 25, 24
		28N	23W	3, 4, 5
Second Order Tributary	Sac River	29N	23W	19-22, 27-29
Second Order Tributary	Sac River	29N	23W	1, 2, 9, 10, 11
First Order Tributary	Clear Creek	29N	23W	2, 3
		30N	23W	35
First Order Tributary	Clear Creek	30N	23W	26, 27, 28
First Order Tributary	Clear Creek	30N	24W	2
		31N	24W	23, 26, 35
First Order Tributary	Little Sac River	30N	23W	25
		30N	22W	19, 30

South Dry Sac	Little Sac River	29N 30N 30N	21W 21W 22W	3, 4, 5 31, 32 36
Stinking Creek	Turnback Creek	30N	26W	10, 11, 12
First Order Tributary	Asher Creek	30N	23W	14, 23

Figure 15. Losing streams in the Sac River basin.



fluctuations of this nature can drastically alter stream channel hydrology, contribute to extensive streambank erosion and interfere with recreational use of the lower Sac River.

Stream base flows in the basin tend to be well maintained in Turnback Creek, Upper Sac River, and Little Sac River sub-basins due to the permeable nature of the soils and bedrock in those areas. Springs also tend to be more common in these sub-basins. Base flows become less stable further north and west in the basin due to the changes in soil permeability and bedrock.

Appendix A shows stream information for third order and larger streams in the Sac River basin.

7-Day Q_2 and Q_{10} Low Flows

Low flows for streams in the Sac River basin are listed in Table 6. The 7-day Q_2 is the minimum flow expected for a seven day period that will occur on average once in two years. The 7-day Q_{10} is the minimum flow expected for a seven day period that will occur on average once in ten years. The lowest flows usually occur in the late summer and fall (August, September, and October).

Flows tend to be sustained through dry periods by springs and groundwater. Flows are variable for the Sac River basin, but the ready infiltration of surface water into the groundwater system reduces the magnitude of high flows. The corollary discharge of groundwater during dry periods tends to maintain stream flow. This exchange between groundwater and surface water tends to moderate and maintain more "consistent" flows in all but extreme conditions. In the lower Sac River flows tend to be lower in magnitude but sustained over longer periods of time due to the operation of Stockton Reservoir dam releases. Water temperatures are lower as a result of deep water releases through the hydro-power generation outlets. Also, oscillations from high flow to low flow conditions in the lower Sac River tend to be rapid and dramatic due to the "peaking" method of electrical generation. Hydrology in the lower Sac River and the lower Sac River basin tributaries has been dramatically altered due to impoundment and hydro-power operations.

Dam and Hydropower Influences

A total of 39 miles of the Sac River has been lost to impoundment by Stockton Dam. Stockton Dam began impounding water in 1969 (Vandike 1995). The dam is 5,100 feet long, projects 153 feet above the Sac River streambed, and creates a 24,900 acre reservoir with 298 miles of shoreline. Normal pool is at 867 feet msl with storage of 875,000 acre-feet. The flood storage capacity of Stockton Lake is 1,674,000 acre-feet of water at an elevation of 892 feet msl. The surface area of Stockton Lake at flood pool swells to 63,200 acres. Stockton Lake is operated primarily for flood control and hydroelectric generation and has an installed capacity to produce 45,200 kilowatts of electricity (MDNR 1986).

Stockton Dam operation has negatively impacted the lower Sac River and lower basin tributaries. Impacts include bank erosion, siltation, instream flow problems, poor water quality, loss of riparian corridor, loss of invertebrate habitats (and concurrent reduction in productivity), and reduction of spawning habitat for fish (MDC 1999a). As a result of extensive streambank sloughing along the Sac River below Stockton Dam, the COE has purchased sloughing easements from streamside landowners. Positive impacts of Stockton Lake are water supply, electricity production, recreation/tourism, and flood control. Prior to the building of Stockton Dam, average monthly discharge was less uniform than it is today (Figure 16). The economic impact of recreation/tourism on the area around Stockton Lake has been substantial. The estimated combined annual benefit of angling for Stockton Lake was $23,098,263 in

Table 6. Seven-day Q_2 and 7-day Q_{10} low flows for streams in the Sac River basin.

USGS Gauge No.	Stream	Period of Record	7-Day Q_2 (cfs)	7-Day Q_{10} (cfs)
06918400	Pickerel Creek near Republic	1968-1970	0	0
06918420	Sac River at Ash Grove	1962-65, 67, 71	13.0	3.5
06918430	Clear Creek near Phenix	1962-64, 67, 70-71	5.0	1.0
06918440	Sac River at Dadeville	1966-72	18.0	6.0
06918444	Chesapeake Spring	1926, 32, 36, 54, 64-69	0.9	0.5
06918450	Limestone Creek at South Greenfield	1962-64, 66-67, 71-72	2.3	0.3
06918460	Turnback Creek above Greenfield	1965-72	22	4.5
06918470	Turnback Creek near Greenfield	1943, 45-46, 49, 62-65	23.0	4.5
06918480	Sac River near Neola	1964-1965, 1967	64	23
06918490	Sons Creek near Neola	1964-65, 67	0	0
06918700	Oak Grove Branch near Brighton	1958-72	0	0
06918740	Little Sac River at Morrisville	1968-72	6.0	0
06918800	Little Sac River at Aldrich	1962-1965, 1967	5	
06919500	Cedar Creek near Pleasant View	1949-1972	0.7	0.0

Source: Skelton (1976).

1999 (Banek, MDC, pers. com). Diversification of sport fisheries for species including walleye, largemouth bass, and white bass have been an additional impact of Stockton Lake. Lakes with large areas of deep open water also provide opportunity for boating, skiing, and sailing that are not available on streams. Management objectives and summary information concerning the Stockton Lake fishery are available by contacting MDC's Southwest Region Fisheries staff in Springfield.

Fellows Lake was constructed by damming the Little Sac River in 1955. The dam was raised to enlarge storage capacity in 1992. The lake covers 812 surface acres at normal pool with a storage capacity of 10.1 billion gallons. The primary purpose for Fellows Lake is drinking water (Watershed Committee of the Ozarks 1999). McDaniel Lake was constructed by damming the Little Sac River in 1929. The dam was raised to enlarge storage capacity in 1990. The lake covers 226 surface acres at normal pool with a storage capacity of 1.5 billion gallons. The primary purpose for McDaniel Lake is drinking water (Watershed Committee of the Ozarks 1999).

There are a few small public and private lakes and a large number of farm ponds in the Sac River basin. Due to small size and ease of construction, the number of ponds can change very rapidly. Many ponds are built without needing permits and statistics on ponds are usually compiled by county rather than watershed. These factors complicate getting accurate, up-to-date information on ponds. Concern exists over the effects these ponds have on low-flow conditions as they intercept runoff and allow little or no adjustment for maintenance of stream flows.