HYDROLOGY

Precipitation

The average annual precipitation for the Big River basin is 41 inches/year, with 29 inches being rainfall (MDNR 1986). Precipitation usually peaks in May (13") and is lowest in February (6"). Average annual runoff is 12.8 inches.

U.S. Geological Survey Gaging Stations

Three U.S. Geological Survey (USGS) gaging stations (numbers 07017200-Irondale, 07018100-Richwoods, and 07018500-Byrnesville), all on Big River, are active within the basin (Figure gs). The Irondale station (RM 115) measures flow from 175 square miles of watershed, and its period of record is July, 1985 to present (Appendix 4). Some water quality data were collected during 1986 (Appendix 5).

The Richwoods (formerly DeSoto) station (RM 53.7) measures flow from 735 square miles of watershed, and its period of record is October 1942 to present (Appendix 4). Sporadic water quality sampling has taken place since 1963, but only 1986 to present is summarized (Appendix 5).

The Byrnesville station (RM 14.1) measures flow from 917 square miles of watershed, and its period of record is October 1921 to present (Appendix 4).

Instantaneous discharge (Appendix 4) and some water quality data (Appendix 5) have been taken on Coonville Creek at St. Francois State Park since 1992.

Five other low-flow, partial-recording gaging stations were operated on Big River, Dry Branch, Hopewell Spring, Mineral Fork, and Old Mines Creek until the early 1970s. They are currently inactive.

Streamflow Characteristics

Big River's average annual discharge is 862 cubic feet per second (cfs) at Byrnesville (USGS 1994). Mean streamflow is lowest in August and highest in April (Figure ms). The lowest and highest instantaneous flows recorded, 25 cfs (August 30, 1936) and 63,600 cfs (September 25, 1993), occurred at the Byrnesville gaging station (Table 3; USGS 1994). However, an estimated discharge (from high-water marks) of 80,000 cfs, at Byrnesville on August 21, 1915, may have been the highest instantaneous flow (USGS 1994). Flows of 116 cfs, 337 cfs, and 1,720 cfs were exceeded 90%, 50%, and 10% of the time, respectively, at the Byrnesville gaging station (Table 3).

Data from Big River's Byrnesville gaging station were used to construct a flow duration curve (Figure fd) and a 90:10 ratio. The 90:10 ratio of 15 to 1 indicates stable, high flow (Miller et al. 1974).

Frequency of 7-day Q values (low-flow discharges; Table 4) and low slope index of 2.3 represent well sustained base flows (Miller et al. 1974), despite only 5 springs of note (6.6 cfs combined, Figure sp) being present (Vineyard 1982). Base flows are aided by ample precipitation, numerous small springs and seeps located in fractured limestone and subsurface chert, and artesian flow from old exploratory bore holes in the Old Lead Belt. During leadmining activities, base flow in the upper Big River at Leadington and Flat River was increased by 100-200% by lead mine discharges (Missouri Water Pollution Board 1964).

Flood magnitude for Big River (Table 5) is somewhat low for a basin of its size (Hauth 1974). However, increasing urbanization of the watershed and subsequent increased stormwater could increase flood magnitudes. A flood, which on average would happen once/100 years, would generate flows of 40,500 cfs (Table 5). The "Great Flood of '93" (63,600 cfs) was well above the 100-year flood level.

Dam and Hydropower Influences

One mainstem dam (RM 132) forms 440-acre Council Bluff Lake along the Washington-Iron County line. The lake was completed in 1981 for flood control and recreation. Five old mill dams , all in Jefferson County, affect Big River (Figure mld). The dams at Byrnesmill (RM 7.9), Cedar Hill (RM 18.8), and Morse Mill (RM 29) have been breached and are in varying degrees of disrepair. The dams at House Springs (RM 9.4) and Byrnesville (RM 13.8) remain intact, impounding over 2 miles of river. All these dams can be barriers to fish movement during normal flows.

In 1974, Congress authorized the United States Army Corps of Engineers (USCOE) to proceed with the Meramec Basin flood control project by constructing 5 impoundments on the Big, Bourbuese, and Meramec rivers (USCOE 1982). Two impoundments, 3,700-acre Pine Ford (RM 41) and 4,600-acre Irondale (RM 118) were designed for mainstem Big River. Intense public opposition forced deauthorization of these projects in 1982.

The Big River watershed contains many large (impounding $\geq$50 acre-feet of water with a dam height $\geq$ 25'), privately-owned dams, with Jefferson, Franklin, and Washington counties each containing over 100 (MDNR 1986). The largest, 360-acre Sunnen Lake in Washington County, impounds a portion of Fourche a Renault Creek.

Jefferson, St. Francois, and Washington counties contain 45 dams which retain finely-ground (tailings) and coarsely-ground (chat) lead and barite mine waste (Appendix 6). Most of these dams were improperly constructed or maintained, which has led to erosion of mine waste or dam collapse and large influxes of mine waste.

In a 1992 study, USCOE found that only one of the 45 Big River basin mine dams was safe and 27 received the worst possible rating--high-hazard, unsafe--and could fail during a severe flood or earthquake (Appendix 7). Perhaps the greatest danger to humans is from the St. Joe State Park dam which could bury Park Hills, Missouri, under 10 to 30 feet of mining waste and inject millions of tons of mine waste into Big River if it should fail. The USCOE study concluded that the Federal government should help stabilize 17 of the high-hazard, unsafe dams based on threat

to human life, property loss, extreme long-term environmental damage, and magnitude of the problem (USCOE 1992).

Three lead tailings dams (Leadwood, Eaton, and St. Joe State Park) and tailings piles (including sites at National, Bonne Terre, and Elvins) in St. Francois County are being studied by Missouri Department of Natural Resources (MDNR) and the United States Environmental Protection Agency (USEPA) to determine the proper method of remediation. The Leadwood tailings pond dam was stabilized and spillway enlarged in 1996 (J. Czarnezki, personal communication). A plan for stabilization of the St. Joe State Park dam has been approved. Stabilization of lead tailings began in 1997.

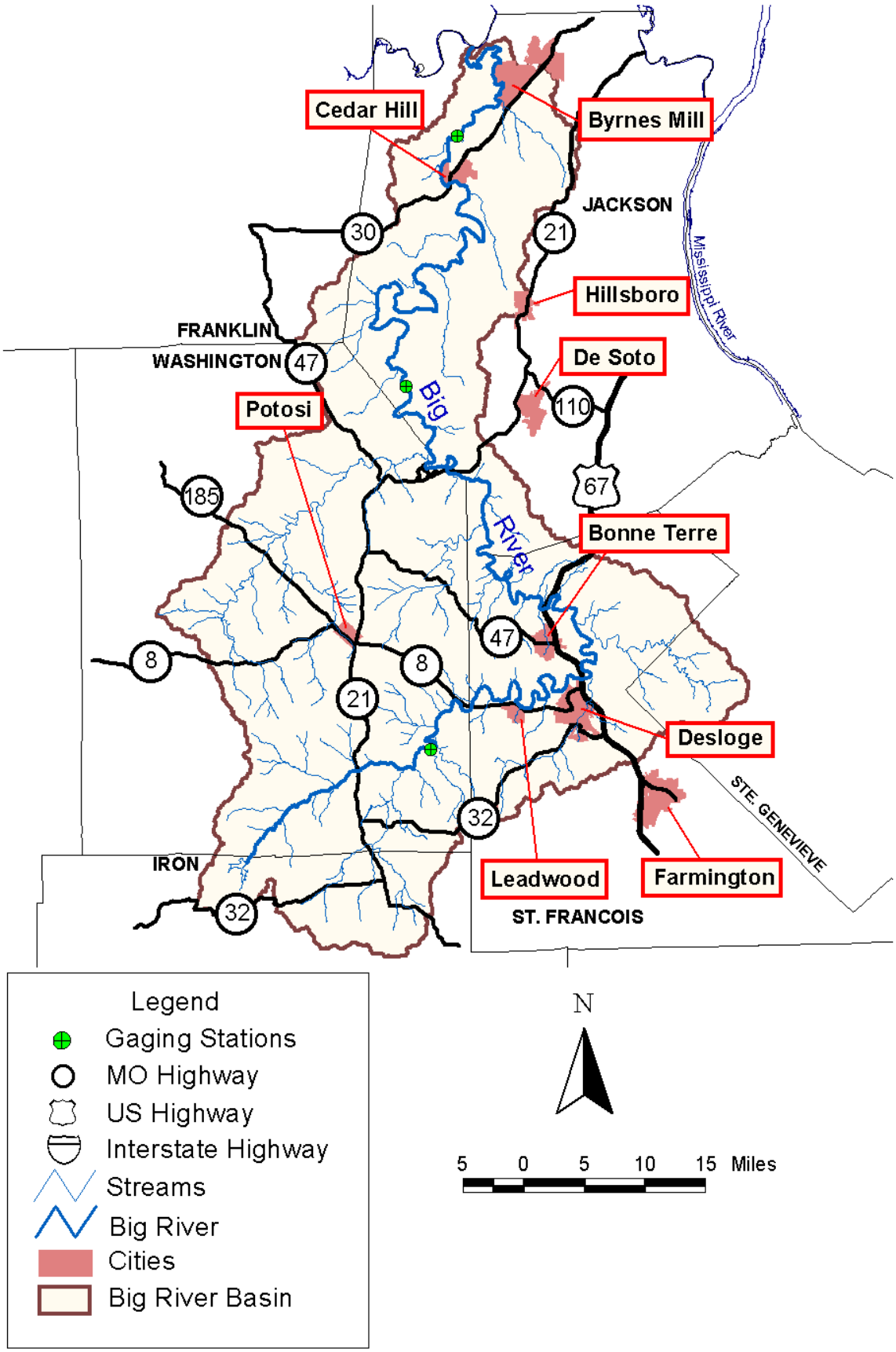


Figure gs. Gaging station locations within the Big River Basin

Appendix 4. Active USGS gaging, discharge, and water quality data gathering stations within the Big River basin (USGS 1993).

Station Number	Station Name	Location	Type	Record
00717200	Big River at Irondale, Washington County	SE1/4, SW1/4, sec.15, T36N, R3E; on the right bank, 50' upstream State Highway U bridge, 0.2 miles upstream from Mill Creek, 0.8 miles west of Irondale	D/C/Q	1965-present
07018100	Big River at Richwoods, Jefferson County	Sec.33, T40N, R3E; on left downstream bank side of the State Highway H bridge, 1.8 miles east of Fletcher and 6.8 miles east of Richwoods.	D/Q	1942-present
07018500	Big River at Byrnesville, Jefferson County	SE1/4, Sec.12, T42N, R3E; on right downstream bank side of a pier of a privately-owned bridge at Byrnesville, 4.0 miles upstream from Heads Creek.	D	1921-present
07017605	Coonville Creek at St. Francois State ParkSt. Francois County;	Sec.25, T38N, R4E; at first culvert on park road off U.S. Route 67.	Q	1992-present

C = Crest-gage station
D = Continuous counting record gaging station
L = Low-flow station
Q = Water quality station

Appendix 5. Water quality data for Big River basin streams taken from USGS gaging stations (USGS,1993).

Station	Parameter	Sample Size	Max	Min	Mean
RICHWOODS at Big River (1986 to present)	Specific conductance (us/cm)	51	598	194	419
	pH	51	8.5	7.3	8.0
	Oxygen, dissolved (mg/l)	44	17.0	5.6	10.0
	COD (mg/l)	42	126	63	91
	Fecal coliform (c/100ml)	43	5500	1	412
	Total hardness (mg/l)	22	310	170	247
	NO2+NO3, total (mg/l)	43	0.9	--	0.3
	Nitrogen, ammonia (mg/l)	42	0.11	--	0.03
	Phosphorus, total (mg/l)	43	0.18	0.01	0.04
	Copper, total (ug/l)	22	4.0	--	2.0
	Copper, dissolved (ug/l)	10	6.0	1	2.7
	Iron, total (ug/l)	15	790	30	255
	Iron, dissolved (ug/l)	10	100	4	23
	Lead, total (ug/l)	15	89	8	31
	Lead, dissolved (ug/l)	32	9.0	--	3.7
	Zinc, dissolved (ug/l)	10	47	4	20
IRONDALE at Big River (1986)	Specific conductance (us/cm)	7	378	245	305
	pH	7	8.1	6.3	7.5
	Hardness, total (mg/l)	7	210	130	167

Appendix 5 continued.

	Alkalinity (mg/l)	**7**	**209**	**109**	**152**
	Copper, dissolved (ug/l)	**7**	**--**	**--**	**--**
	Iron, dissolved (ug/l)	**7**	**12.0**	**4.0**	**7.4**
	Lead dissolved , (ug/l)	**7**	**--**	**--**	**--**
St. Francois State Park at Coonville Creek (1992 to present)	**Specific conductance (us/cm)**	**6**	**420**	**155**	**344**
	pH	**6**	**8.1**	**7.3**	**7.9**
	Oxygen , dissolved	**6**	**13.8**	**8.4**	**10.9**
	COD (mg/l)	**6**	**36**	**--**	**<10**
	Fecal coliform (c/100ml)	**6**	**3600**	**34**	**861**
	Hardness, total (mg.l)	**3**	**270**	**190**	**233**
	NO2+NO3, total (mg/l)	**6**	**0.13**	**0.04**	**0.07**
	Nitrogen, ammonia (mg/l)	**6**	**0.03**	**<0.01**	**0.02**
	Phosphorus, total (mg/l)	**6**	**0.04**	**<0.01**	**0.02**
	Copper, total (ug/l)	**3**	**1.0**	**<1.0**	**<1.0**
	Copper, dissolved (ug/l)	**7**	**1.0**	**1.0**	**1.0**
	Iron, total (ug/l)	**3**	**39**	**7**	**20**
	Iron, dissloved (ug/l)	**7**	**93**	**7**	**26**
	Lead, total (ug/l)	**3**	**27**	**5**	**15**
	Lead, dissolved (ug/l)	**3**	**3.0**	**3.0**	**3.0**
	Zinc, dissolved (ug/l)	**7**	**110**	**70**	**93**

--below detection

Figure ms. Monthly maximum, minimum, and mean streamflow at the Big River Byrnesville gaging station for the period of record (1921-1993).

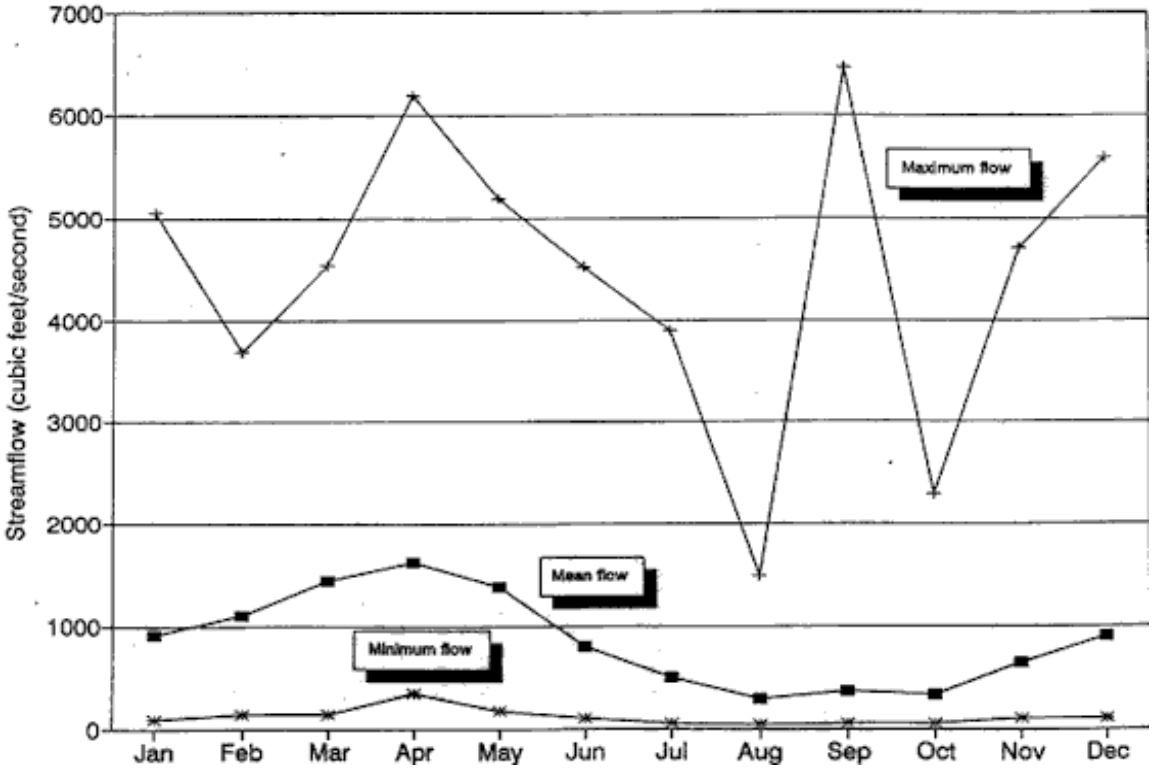


Table 3. Discharge data (cfs) for Big River at Irondale, Richwoods, and Byrnesville gaging stations (USGS 1994).

Location	Maximum	Minimum	10% Exceeds	50% Exceeds	90% Exceeds
Irondale	43,200	2.2	363	59	10
Richwoods	59,800	20.0	1310	280	99
Byrnesville	63,600	25.0	1720	337	116

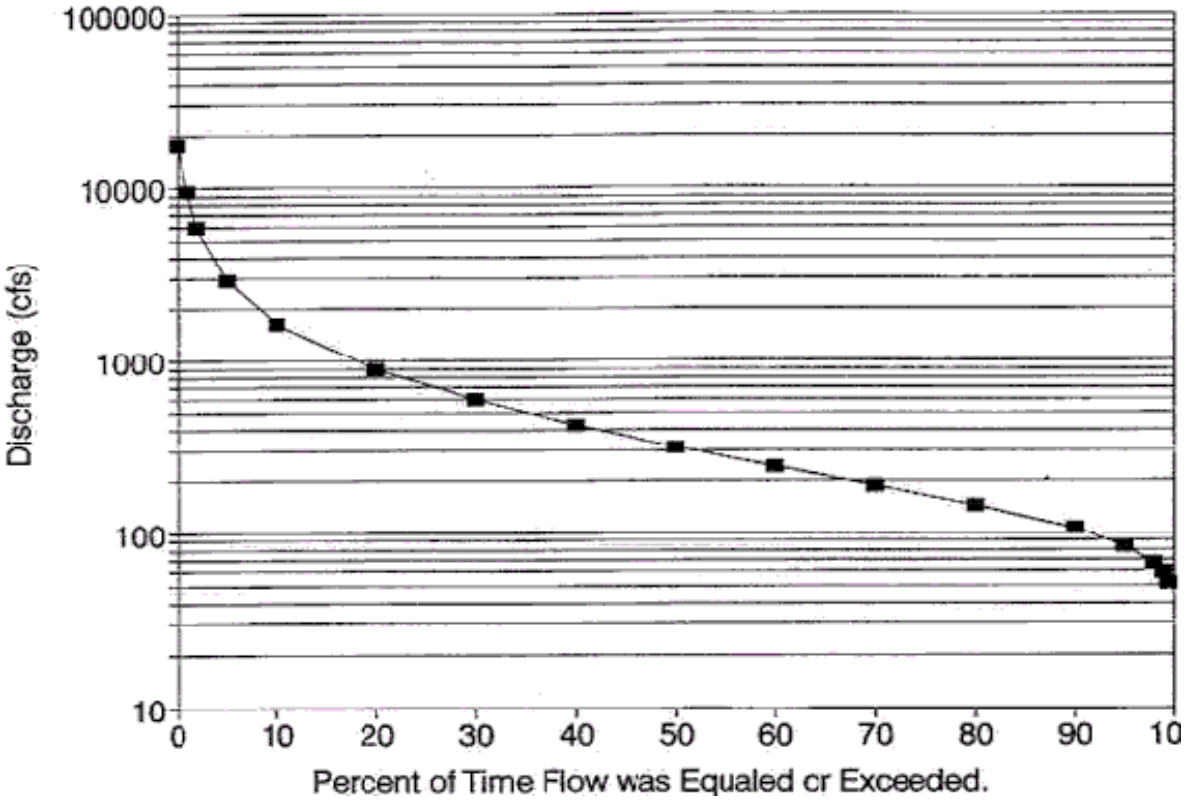
Table 4. Seven-day low-flow frequency data for the Big River, Richwoods and Byrnesville gaging stations (Miller et al. 1974).

Location	Period of Record	Drainage Area (sq. Mi)	Seven-day low-flow (cfs) for recurrence interval (years)				
			2	5	10	20	50
Richwoods	1942-69	735	89	60	44	34	27
Byrnesville	1921-69	917	96	62	50	41	32

Table 5. Flood frequency data for Big River, Byrnesville gaging station (Hauth 1974). Flood Frequency (years)

	2	5	10	25	50	100
Magnitude of flood (cfs)	14,900	22,500	27,300	32,900	36,800	40,500

Figure fd. Flow duration curve for the Big River at the Byrnesville gage (USGS, 1994).



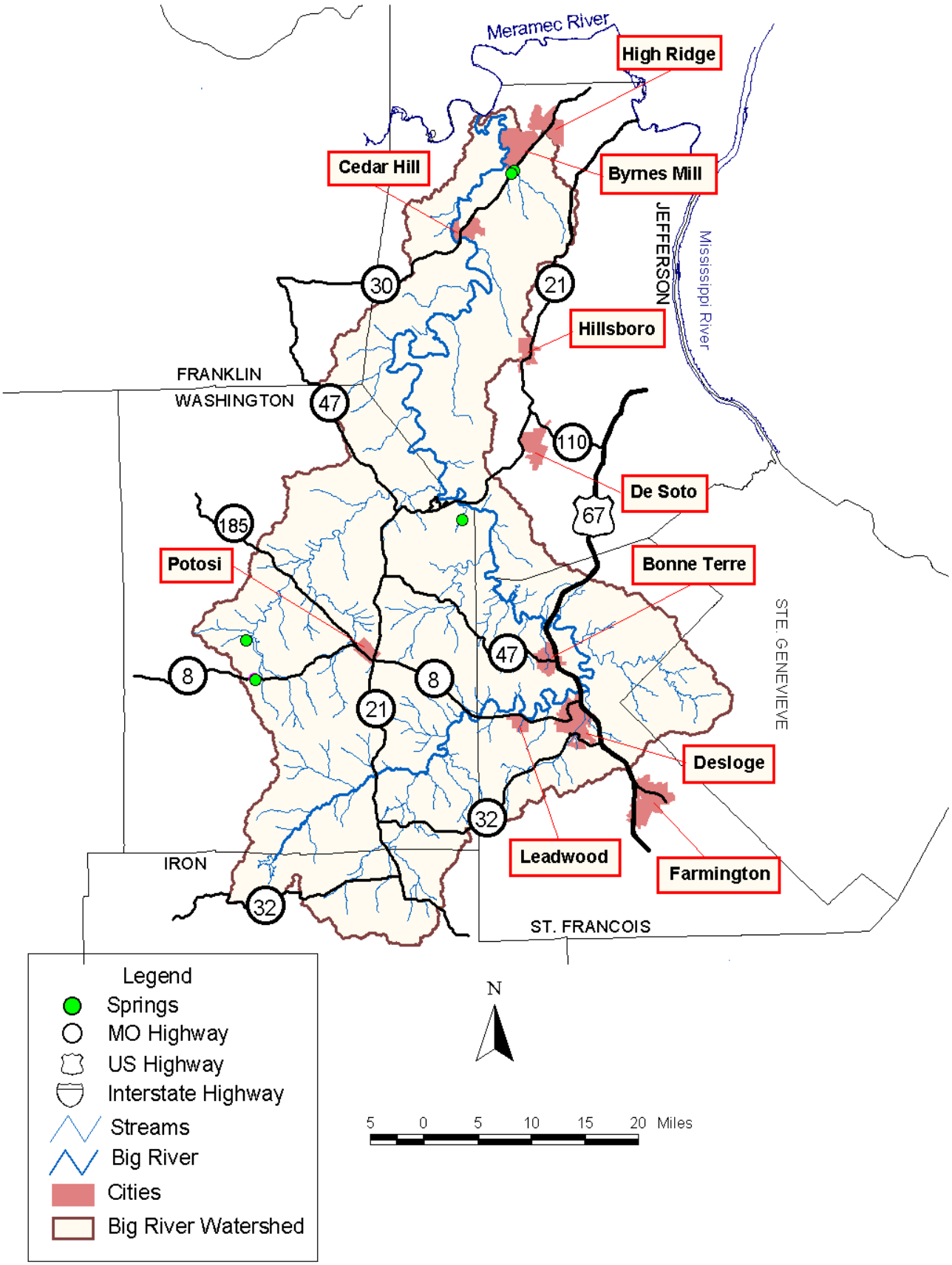


Figure sp. Springs within the Big River Basin

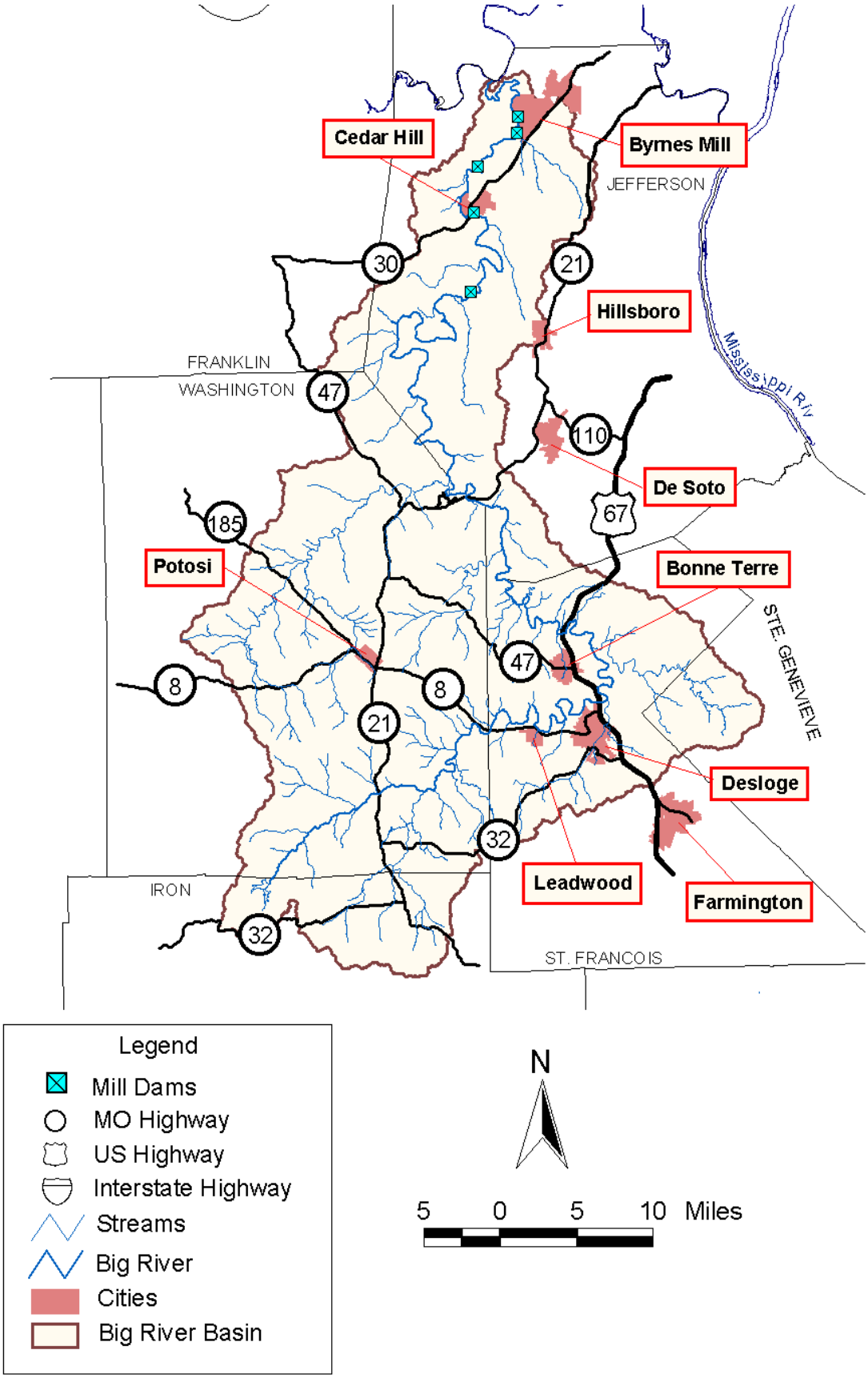


Figure mld. Mill dams in the Big River Basin.

Appendix 6. Hazard rating of lead and barite tailings dams and piles in the Big River basin (USCOE and MDNR 1980).
GP--COE 404 General Permit; LR--DNR Land Reclamation Permit; IP-Individual Permit.

ID	Name	County	Material	Rating
DAMS				
1	Richwoods "WW" Dam	Jefferson	barite	high
2	Dresser #11 Dam	Jefferson	barite	low
3	Desoto B Dam	Washington	barite	high*
4	Richwoods Mine B Dam	Washington	barite	high*
5	Richwoods Pond Dam	Washington	barite	high*
6	Ditch Creek Dam	Washington	barite	high*
7	Big Four Mine Dam	Washington	barite	high*
8	Desoto Mining Co. A Dam	Washington	barite	high*
9	Kingston #1 Dam	Washington	barite	high*
10	Star Mine Dam	Washington	barite	high*
11	P&P Gravel Co.	Washington	barite	high*
12	Dorlac Lake Dam	Washington	barite	high*
13	Eshbaugh_Martin Dam	Washington	barite	high*
14	Carter Lake Dam	Washington	barite	high*
15	Sun Mine Dam	Washington	barite	high*
16	Blackwell Mine Dam	Washington	barite	high*
17	New Dresser No.4 Dam	Washington	barite	high*

Appendix 6 continued.

18	NL Industries Tiff Dam	Washington	barite	high*
19	Dresser No.4 Dam (failed)	Washington	barite	high*
20	Bottom Diggins Dam	Washington	barite	high*
21	Cadet #2 Dam	Washington	barite	low
22	Cadet No.1 Dam	Washington	barite	sign
23	Old Wolf Dam	Washington	barite	high*
24	Cadet Mine Tailings Dam	Washington	barite	high*
25	Racola Tailings Dam	Washington	barite	high*
26	Old Mines Tailings Dam	Washington	barite	sign
27	Arnault Branch Mine Dam	Washington	barite	high*
28	Lutrell Lake Dam Upper	Washington	barite	high*
29	Moeckel Dam	Washington	barite	high*
30	Keyes Branch Mine Dam	Washington	barite	high*
31	Mineral Point No.2 Dam	Washington	barite	high
32	Mineral Point #1 Dam	Washington	barite	high
33	Dresser Minerals #7 Dam	Washington	barite	low
34	Dresser Mineral #7 Dam South	Washington	barite	sign
35	Old Washer #1 Dam	Washington	barite	high*
36	Black Tailings Dam	Washington	barite	high*

Appendix 6 continued.

37	Pond Creek Tailings Dam	Washington	barite	high*
38	Cadet #3 Dam	Washington	barite	high*
39	Dresser Indust. Old #1 Dam	Washington	barite	high*
40	Dresser #1 D	Washington	barite	high*
41	Blackwell Pond Dam	St. Francois	barite	high*
42	Dresser #10 Dam	Jefferson	barite	–*
43	Eaton Dam	St. Francois	lead	–*
44	Leadwood Tailings Dam	St. Francois	lead	high*
45	St. Joe State Park Dam	St. Francois	lead	high*

	TAILINGS PILES			
A	Bonne Terre Lead Tailings	St. Francois	lead	
B	East Bonne Terre Tailings	St. Francois	lead	
C	Desloge Lead Tailings Pile	St. Francois	lead	
D	National Lead Tailings Pile	St. Francois	lead	
E	Elvins Lead Tailings Pile	St. Francois	lead	
F	Federal Lead Tailings Pile	St. Francois	lead	
G	Leadwood/Eaton Lead Tailings	St. Francois	lead	__

_ unknown

<u>DNR Hazard Ratings</u>
low = no permanent structures downstream of dam
sign = 1_9 permanent structures downstream of dam
high = 10+ permanent structures downstream of dam
*** USCOE "unsafe" designation**

Appendix 7. Repair costs of high-hazard, unsafe mine dams located within the Big River basin USCOE, 1992).

Dam Name	Dam Height (ft.)	Storage (acre-feet)	Mine Waste	Renovation Cost ($) *
St. Joe	134	6,100	lead	14,000,000
Leadwood	60	1,000	lead	1,500,000
Desloge	40	3,000	lead	12,400,000
Eaton	30	4,500	lead	1,300,000
EastBonne Terre	40	3,000	lead	4,300,000
Blackwell Mine	87	4,000	barite	10,300,000
Dresser #10	107	1,100	barite	2,700,000
Old Mines	61	1,200	barite	1,800,000
Cadet #2	77	650	barite	6,000,000
Richwoods B	48	1,750	barite	2,600,000
Cadet Mine	96	950	barite	600,000
Esbaugh-Martin	115	650	barite	-
DeSoto Mine A	76	3,700	barite	5,800,000
Kingston #1 (Pfizer)	85	1,700	barite	-
Moeckel	85	2,400	barite	-
Dresser #11	100	600	barite	3,900,000
Big Four Mine	71	2,000	barite	600,000

*** USCOE estimates, 1981**