# *WATER QUALITY AND USE*

## Beneficial Use Attainment

Approximately 264 stream miles and 10 impoundment acres within the Big Piney Watershed are classified and have designated beneficial uses as presented in Tables G and H of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality (Table Wq01) (MDNR 2001). These waters must meet or exceed established criteria as defined in Table A of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality for those beneficial uses (MDNR 2003b). All watershed streams and impoundments listed in Tables G and H are designated for livestock/wildlife watering as well as protection of aquatic life. In addition, Roby Lake, the single classified impoundment within the watershed is also designated for whole body contact recreation and boating. Approximately 99 miles of the Big Piney River, from its mouth to Township (T) 29N, Range (R) 10W, Section (S) 16, are designated for irrigation, livestock and wildlife watering, protection of aquatic life, cool water fishery, whole body contact recreation, boating, and drinking water supply. Another 8 miles of the Big Piney River, from T29N, R10W, S16 to T28N, R11W, S12, are designated for livestock and wildlife watering, protection of aquatic life, whole body contact recreation, boating, and drinking water supply. Three other streams within the watershed also have additional designated beneficial uses. These streams include Bald Ridge Creek, Hog Creek, and Spring Creek. In addition to the aforementioned designated uses, 6.5 miles of Spring Creek (USFS) has been designated as "Outstanding State Resource Waters" (MDNR 2001).

Section 303(d) of the Federal Clean Water Act requires that states identify impaired waters (MDNR 2003b). This is accomplished by comparing data from those waters with water quality criteria established for designated beneficial uses of those waters. Waters that do not meet their criteria are then included in the 303(d) list (MDNR 2003b). The state must then conduct Total Maximum Daily Load (TMDL) studies on those waters in order to determine what pollution control measures are required and then insure those measures are implemented. Currently, a 0.2 mile segment of Brushy Creek is included in the 1998 303(d) listing. This segment is listed due to impairment by non-filterable residues from the Houston Sewage Treatment Plant.

The Clean Water Act requires that the 303(d) list be updated every four years (MDNR 2003b). At the time of this writing (2003), the 2002 303d list is currently open for public comment and therefore has not been finalized. The draft 2002 303d list for Missouri does include changes from the 1998 listing. More Information can be found regarding the Draft Missouri 2002 303d list on the EPA's Region 7 TMDL website.

## Water Quality

Data regarding surface and ground water quality within the Big Piney Watershed has been collected by several different entities since the 1960s. Government agencies which are or have funded or conducted water quality sampling within the watershed include the Environmental Protection Agency (EPA), FLW, MDC, Missouri Department of Natural Resources Clean Water

Commission, USFS, and the USGS. In addition some water quality data has been collected by Stream Team organizations. The extensive amount of water quality data available for various parameters and varying time periods within the Big Piney Watershed makes an adequate summary of water quality data within this document impractical.

In order to avoid going beyond the scope of this document by attempting to provide a comprehensive summary of all water quality data by all agencies for all available years, six USGS stations within the Big Piney Watershed were selected in order to provide a glimpse of selected water quality values within the watershed (Figure Wq01). These included 2 stations on the Big Piney River, one station on Big Paddy Creek, and one station at Shanghai, Miller, and Sandstone Springs. Water quality was analyzed using data available for the latest five years of operation for a specific station. Water quality parameters selected for analysis (where available) included temperature, pH, dissolved oxygen, fecal coliform, total ammonia nitrogen, phosphorous, sulfate, chloride, and nitrate. These values were compared with state standards (when available) and the number of exceedences were noted (Table Wq02).

Analysis of water quality from selected USGS stations within the watershed reveals that water quality at these stations consistently met water quality standards for the selected parameters during the years examined with the exception of fecal coliform bacteria. Three out of the six stations examined experienced levels of fecal coliform that exceeded state standards for whole body contact recreation. These stations included the Big Piney River near Big Piney, the Big Piney River at Devils Elbow, and Shanghai Spring.

Although there currently is no state standard regarding total phosphorous, 3 stations experienced levels which periodically exceeded the standard for phosphorous recommend by the EPA. These stations included the Big Piney River near Big Piney, Miller Spring, and Shanghai Spring.

Readers should note that due to the limited number of parameters, as well as the limited spatial, and temporal scope of the aforemention analysis, this summary can in no way be viewed as a comprehensive examination of water quality within the Big Piney Watershed.

A relatively extensive FLW-funded study of water quality as well as geohydrology in the FLW area was conducted by the USGS in 1994 and 1995 (Imes et al. 1996). The study area included portions of both the Big Piney and Roubidoux watersheds. Ground water, spring, and surface water quality were all examined as part of this study.

Sampling was conducted at ten surface water quality sites within the Big Piney Watershed as part of the aforementioned water quality and geohydrology study. While no detectable concentrations of volatile, semi-volatile organic compounds or explosives were found to be present in any surface water samples, five pesticide compounds were found to be present. These included tebuthiuron, atrazine, deethylatrazine, and p,p'-DDE (a degradation product of DDT) (Imes et al. 1996).

The presence of karst features within and around the Big Piney Watershed such as Spring Creek, Dry Creek, and Big Paddy Creek (losing streams), increases the risk of ground water contamination from point and non-point sources of pollution located on the surface. In addition,

portions of the permanent flow within the watershed are enhanced by springs such as Stone Mill and Boiling Springs. Thus any contaminant which affects ground water quality is likely to affect surface water quality. There are several ways in which contaminants can enter the groundwater system. These include losing streams, sinkholes, and abandoned wells. As indicated by dye traces performed within the watershed, ground water movement is not always restricted by surface watershed boundaries. Examples of this are the detections of groundwater movement from the Upper Little Piney Creek to Relfe Spring as well as groundwater movement to Shanghai Spring from two points outside the surface watershed (Figure Ge02).

As part of the aforementioned USGS study, water quality sampling was conducted at 3 springs within the Big Piney watershed including Shanghai, Miller, and Pumping Station Springs. Imes et al. (1996) states that both Shanghai and Pumping Station Springs "exhibit probable effects of septic contamination". In addition, the pesticides prometon and simazine were detected in high-base flow samples from both springs. Water quality samples from Shanghai Spring also contained detectable concentrations of trichloromethane and tetrachloroethene as well as higher than background concentrations of dissolved and total sodium, dissolved chloride, total nitrite plus nitrate as nitrogen, total phosphorous, and dissolved and total boron. In addition, the high-base flow sample contained higher than background concentrations of dissolved sulfate and ammonia, while the low-base flow sample contained higher than background dissolved potassium and specific conductance values (Imes et al. 1996).

Imes et al. (1996) indicates that the source for the higher than background levels of the various aforementioned constituents may possibly be a sewage treatment plant located on Dry Creek, a losing stream on FLW known to contribute to the recharge of Shanghai Spring. The high-base flow sample from Pumping Station Spring contained higher than background levels of total organic carbon while higher than background levels of dissolved and total sodium, dissolved chloride, and total nitrite plus nitrate as nitrogen were noted in the low-base flow sample (Imes et al. 1996).

Ground water quality of the study area examined in Imes et al. (1996) was determined to be similar to the "regional water quality of the Ozark Aquifer". Thirteen groundwater samples in the study area contained elevated zinc or total zinc levels of between 68 and 760 micrograms per liter. Imes et al. (1996) indicates the elevated zinc levels were likely the result of the corrosion of galvanized pipes used in many public and private water supply wells. Small concentrations of trihalomethane compounds, possibly resulting from the chlorination of wells or sample contamination, were detected in samples from six wells. In addition, two samples contained the fuel additive methyltertiarybutylether (MTBE) in concentrations of 0.3 and 0.6 microgram per liter. An additional single sample contained total xylenes concentration of 0.3 microgram per liter. Tentative identification of one or more "non-target" volatile organic compounds was also noted in samples from three wells. There were no detections of compounds associated with explosives or semivolatile organic compounds in any groundwater samples. Samples from four wells in the study area resulted in detections in one or more pesticide compounds at each site. These compounds included diazinon, p,p'-DDE, and tebuthiuron.

As stated previously, a large amount of water quality data for a variety of parameters is available for the Big Piney Watershed. Water quality data is available for additional parameters from the

USGS Historical Water Quality Data Website and the annual USGS Water Resources Data Reports as well as the EPA Storage and Retrieval (STORET) Database. Volunteer water quality monitoring data is available from the Missouri Stream Team online database. In addition, extensive water quality data continues to be collected in the FLW area as part of monitoring programs and studies the FLW is funding or otherwise associated with. For additional information regarding this data, contact the FLW Directorate of Public Works, Environmental Division, 320 MANSCEN Loop STE 120, Fort Leonard Wood, Missouri 65473-8929. Additional State Water Quality Standards are available in the most current document of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality.

## USGS Pesticides National Synthesis Project

The USGS conducted water quality samples within the Big Piney Watershed from 1993-1995 as part of the Pesticides National Synthesis Project in an effort to determine the spatial and temporal distribution of contamination by pesticides in the water resources of the United States (USGS 1999b). The watershed was part of the Ozark Plateau Study Unit of the National Water Quality Assessment Program. Two surface water sampling sites and one ground water sampling site were selected within the watershed (Figure Wq01) (USGS 1998c and 1998d). A single sample was taken at the ground water sampling site in 1993. Five samples were collected at a single surface water sites between 1994 and 1995, while two samples were taken at a second site during the same period (USGS 1998c and 2000a).

A total of five pesticide or pesticide related compounds were detected from samples collected within the watershed (Table Wq03). These compounds included Atrazine, Deethyl Atrazine, Diazinon, Metolachlor, and Thiobencarb. Pesticide compounds were detected at both surface sample sites. Site 2 had the most detections of pesticide compounds with four of the five previously mentioned compounds present. These included Thiobencarb, Metolachlor, Atrazine, and Deethyl Atrazine. Site 1 had detections of three of the previously mentioned compounds including Thiobencarb, Metolachlor, Diazinon. No pesticide compounds were detected in the single sample collected from the ground water site. For comparison; 39 of 43 surface water sites within the Ozark Plateau Study Unit had detections of pesticides with 18 sites having samples with six or more pesticide detections (Bell et al. 1997). In addition 73 of 215 ground water sample sites within the Ozark Plateau Study Unit had pesticide detections with a maximum of 5 pesticides detected in any one sample (Adamski 1996). It is important to note that the number of samples at individual sites varied. It is also important to note that analysis for specific pesticide compounds varied from site to site and/or sample to sample.

## Point Source Pollution

Table Wq04 lists 20 municipal and non-municipal waste water and water treatment facilities within the Big Piney Watershed (Figure Wq02) (MDNR 1998b, 2000c). There are 6 municipal waste water facilities within the watershed. These serve the cities/towns of Cabool, Houston, Licking, and Raymondville. Discharges from these facilities have a combined flow of approximately 2.59 million gallons per day (mgd). Two public sewer district facilities also exist in the watershed. These have a combined flow of 0.04 mgd. In addition, two facilities serving

the FLW Military Reservation also exist within the watershed. These two facilities, one a waste water facility and the other which is a water treatment facility, have a combined flow of 5.80 mgd. Dry Creek, a losing stream which has been shown to contribute to the recharge of Shanghai Spring, has been known to be negatively impacted by discharge from one of the FLW facilities in the past. Table Wq04 lists individual flows for public/municipal facilities.

The MDNR "Incidents of Mines Occurrences, and Prospects" (IMOP) Database contains data on 15 mines listed as "producer" and 44 mines listed as "past producer" within the Big Piney Watershed (MDNR 2001b). All mines listed as producers are sand and gravel removal operations with the exception of 3 limestone quarries. Improper gravel mining techniques and unsuitable site locations have the potential to threaten water quality as well as aquatic and riparian habitats within the watershed. The negative impacts of improper gravel mining have been shown to include channel incision, sedimentation of downstream habitats, accelerated bank erosion, the formation of a wider and shallower channel, the lowering of the flood plain water table, and channel shift (Roell 1999). The majority of past mining activity is relatively evenly divided between iron, limestone, and gravel mining. Other less significant mining activity within the watershed has been directed at lead, clay, and barium (MDNR 2001b). Nearly all past producers within the watershed are surface mines. When these occur as open pits they have the potential to act as a direct link to the ground water system and thus pose a threat to ground water quality if pollutants are allowed to enter. This can affect wells from which the watersheds population receives its water.

## Non-point Source Pollution

Perhaps one of the more difficult challenges to address within any watershed is non-point source pollution. Whereas point source pollution can be traced to a single discharge point or area such as a waste water treatment plant discharge, non point source pollution, such as sheet erosion of topsoil, runoff of nutrients from pastures, or pesticide or fertilizer runoff from fields, is much more difficult to detect as well as remedy. It takes the cooperation of the landowners within a watershed to minimize non-point source pollution and its impacts. While currently there appear to be no substantial non-point source pollution problems within the watershed, prevention of potential problems will be an important component in ensuring the quality of surface and ground water within the watershed.

Land disruption from road and bridge construction and maintenance as well as urban expansion often results in increased sediment loads to receiving water systems. Bridge construction can also result in stream channel modification, which affects stream flow both up and downstream from the bridge. Within the Big Piney Watershed, there are approximately 1,737 miles of highways, streets, and county and private roads based on analysis of transportation route geographical information system (GIS) data of the U.S. Bureau of the Census (1997). This is approximately 2.3 miles of road per square mile of watershed area. Approximately 60-70 percent of these roads are probably unpaved. This is based on the assumption that most county and private roads not intersecting a municipality are unpaved. According to the Missouri Department of Transportation Highway and Bridge Construction Schedule, there are currently (2003) no state highway projects which involve drainage and/or bridge construction or maintenance scheduled within the watershed from 2004-2008 (MDT 2003).

It is estimated that approximately 57% of the human population within the Big Piney Watershed lives within municipalities or otherwise urban type areas and thus are serviced by a public waste water treatment facility. The remaining 43% likely rely on on-site waste treatment systems such as septic systems. The potential for contamination of groundwater by septic systems has been shown by Aley (1972 and 1974) to be increased in areas of soluble bedrock (MDNR 1984). Aley and Aley (1987) state that according to a 1972 Missouri Clean Water Commission publication, sewage production is approximately 100 gallons per person per day. Using this information and assuming that nearly all of the populations of the municipalities within the watershed are served by municipal waste water treatment facilities, it can be estimated that 1,772,800 gallons of septic system effluent is generated per day within the Big Piney Watershed. Both Shanghai and Pumping Station Springs are believed to "exhibit probable effects of septic contamination" Imes et al. (1996). It is important to stress that proper septic system installation and maintenance remains important to the protection of both surface and ground water systems.

As with many other watersheds in the state, livestock, and in particular cattle populations, can potentially adversely affect water quality within the Big Piney Watershed. This is especially true when livestock are allowed to linger in riparian zones. Estimated animal unit density (animal units/acre) for the Big Piney Watershed, based on the 1992 Census of Agriculture, was 0.130 (MUWASC 1998). An animal unit is equal to "roughly one beef cow or 1000 pounds live weight" (MUWASC 1998). Much of the livestock population data currently available is based on county estimates. Analysis of United States Department of Agriculture-National Agriculture Statistics Service (USDA-NASS 2000) data indicates that in 2001, counties intersecting the Big Piney Watershed had an average of 9.1 head of hogs per square mile and 56.9 head of cattle per square mile. For comparison, the average for counties statewide was 23.2 head of hogs per square mile and 60.9 head of cattle per square mile. The majority of livestock within the watershed are probably pastured. This makes the presence of nutrient filtering timbered stream corridors and limited livestock access to streams important tools landowners can use to minimize the impacts of livestock on water quality.

Five permitted concentrated animal feeding operations (CAFOs) existed in the watershed between 1988 and 1998 (Figure Wq02) (MDNR 1999). All were related to dairy operations and all were classified as non-point operations with between 86 and 214 animal units.

The Big Piney Watershed is unique to many other watersheds in Missouri in that a large military installation, at least in part, is located within its boundaries. The presence of FLW presents unique water quality concerns which are not applicable to many other watersheds. Since 1982, several studies have been conducted regarding the presence of contaminants on the installation and the potential effects on ground water and surface water quality as well as soil (USAEC 2003). In 1985, the Installation and Restoration Program (IRP) was initiated at FLW. The IRP is "a comprehensive program to identify, investigate, and cleanup contamination from hazardous substances and wastes resulting from past DoD activities on active installations and formerly-used DoD lands" (USDOD 1998). As part of this program, 68 (42 within the Big Piney Watershed) sites have been identified in association with FLW as "having the possibility to cause contamination" (USAEC 2003). Contaminants of concern which have been noted at these sites include metals, solvents, pesticides, petroleum (oils and lubricants), explosives, PCP (pentachlorophenol), and PCE (a type of chlorinated solvent). Remediation or interim

remediation activities have been conducted at 11 sites (9 within the Big Piney Watershed). A total of 56 sites (33 within the Big Piney Watershed) are listed as "response completed" sites, while 12 sites (9 within the Big Piney Watershed) "have been identified for further investigation and/or remediation" or are otherwise considered active sites (USAEC 2003). Currently, all remediation activities are on track to be completed by 2009, with the installation's IRP program scheduled to be completed in 2017.

As part of the FLW Stormwater Runoff Monitoring Program, water quality data has been routinely collected at 7 sites within the Big Piney Watershed since 1995. This program is funded by FLW and conducted by the USGS. Additional information regarding this program may be obtained by contacting the FLW Directorate of Public Works, Environmental Division, 320 MANSCEN Loop STE 120, Fort Leonard Wood, Missouri 65473-8929.

An increased awareness by the public will be important to the protection of both surface and ground water quality from non-point sources of pollution within the Big Piney Watershed.

## Water Pollution and Fish Kill Investigations

Sixteen water pollution, potential water pollution, and fish kill incidents have been investigated in the Big Piney Watershed since 1990 (Table Wq05) (MDC 2003). The stream impacts associated with these incidents ranged from less than one eighth of a mile to 14 miles, with the impacts of two incidents unknown. Three fish kills were observed in relation to the aforementioned incidents. One fish kill on Brushy Creek was attributed to sewage. Another fish kill on a tributary to Elk Creek was alleged to be the result of cattle manure from a feedlot within the drainage. The remaining fish kill which occurred on the Big Piney River, was attributed to the natural occurrence of "summer kill".

## Fish Consumption Advisories

Currently (2004), all waters within the Big Piney Watershed are included in a statewide fish consumption advisory for largemouth bass. Women who are pregnant, who may become pregnant, nursing mothers and children twelve (12) years of age and younger should not eat any Largemouth Bass over twelve (12) inches in length from anywhere in Missouri due to elevated levels of mercury (MDHSS 2003 and EPA 2004). Additional information regarding fish consumption advisories may be found on the EPA's National Listing of Fish and Wildlife Advisories website, or by contacting the Missouri Department of Health and Senior Services at (866)628-9891.

## Water Use

Water use data for the Big Piney Watershed obtained from the USGS National Water Use Database (1998c) indicate that total water withdrawn from the Big Piney Watershed in 1995 was 4.72 million gallons per day (mgd) (Table Wq06). Most of the water withdrawn from the watershed was from the groundwater system. Groundwater withdrawn from the watershed was 2.66 mgd while surface water withdrawn was 2.06 mgd.

Estimated water withdrawal for domestic purposes (self supplied and public supply delivered) was the most prevalent use within the Big Piney Watershed in 1995, with 1.3 mgd in public deliveries and 0.58 mgd being self supplied (USGS 1998c). Livestock use was the second most prevalent within the Big Piney Watershed with 0.78 mgd withdrawn, of which 0.58 was from surface water supplies.

Major water use information for the Big Piney Watershed was obtained from the MDNR, Division of Geology and Land Survey. The MDNR maintains records of "major" (those facilities capable of withdrawing 100,000 gallons/day or more) surface and ground water users throughout the state. Recent records (2001) indicate there were a total of 12 major water users withdrawing nearly 2 billion gallons of water from 27 groundwater and surface water wells and/or intakes combined in 2001 (Table Wq07)(MDNR 2003c). The majority of water (55.6%) was acquired from surface water withdrawal from the Big Piney River with the remaining 44.4% coming from ground water. Withdrawals by government entities accounted for nearly 89% of water pumped in the watershed, with the United States Army Maneuver Support Center FLW accounting for the largest amount of water withdrawn.

## Recreational Use

In 1982, the Big Piney River was ranked with 36 other major watersheds in Missouri according to recreational value (MDC and MDNR 1982). Results were obtained by surveying professional staff from six state and federal agencies. The Big Piney River was ranked 13$^{th}$ in mean recreational value within the state. Its recreational worth was expected to remain unchanged in the future.

Angler surveys are useful for evaluating angler use, species preference, and satisfaction. Angler surveys can also be used to identify changes or trends in angler responses over time. These surveys provide the information necessary for managers to meet angler needs, as well as improve and validate decisions to change or maintain regulations. Results from statewide annual angler surveys which were conducted by the MDC from 1983 to 1988, estimate that on an annual basis, an average of 29,780 total days were spent angling on the Big Piney and its tributaries (Weithman 1991).

Results from a more narrow seasonal probability angler survey conducted by the MDC on 17.1 miles of the Big Piney from the Highway 17 bridge to Boiling Spring Bridge during the period of April 1-October 31 indicate that an estimated average of 6,800 angler hours were spent on this section of river during the years of 1995-1998 (MDC 1999).

Angler surveys have been conducted by FLW staff for the past four years. It is estimated that an average of 4,330 angler trips were made annually to the 0.3 miles of Stone Mill Spring trout fishery (Zurbrick, Personal Communication). In addition, it is estimated that an average of 1,250 angler trips were made annually to five impoundments on FLW within the Big Piney Watershed.

In addition to angling, the Big Piney River and its tributaries provide a variety of recreational opportunities such as canoeing and tubing. Fourteen stream accesses exist within the watershed and at least 5 outfitters offer float trips on the Big Piney.

**Table Wq01. Missouri Department of Natural Resources use designations for selected streams and impoundments within the Big Piney Watershed (MDNR 2001). Locations are given in section, township, range format.**

| Stream Name | Class[1] | Miles Acres* | From | To | Designated Use[2] |
|---|---|---|---|---|---|
| Roby Lake | L3 | 10 | 3,32n,11w | | lww,aql,wbc,btg |
| Anderson Cr. | C | 1.9 | Mouth | 31,33n,09w | lww,aql |
| Arthur Cr. | P | 4.5 | Mouth | 14,31n,9w | lww,aql |
| Arthur Cr. | C | 2.5 | 14,31n,9w | 26,31n,9w | lww,aql |
| Bald Ridge Cr. | C | 10.0 | Mouth | 13,33n,11w | lww,aql,wbc |
| Bear Cr. | C | 2.0 | Mouth | 25,29n,10w | lww,aql |
| Beeler Br. | P | 1.5 | Mouth | 7,28n,10w | lww,aql |
| Beeler Br. | C | 1.0 | 7,28n,10w | 18,28n,10w | lww,aql |
| Bender Cr. | P | 3.0 | Mouth | 13,31n,9w | lww,aql |
| Bender Cr. | C | 3.0 | 13,31n,9w | 8,31n,8w | lww,aql |
| Big Paddy Cr. | C | 4.0 | Mouth | 32,33n,10w | lww,aql |
| Big Piney R. | P | 99.0 | Mouth | 16,29n,10w | irr,lww,aql,clf, wbc,bgt,dws |
| Big Piney R. | P | 8.0 | 16,29n,10w | 12,28n,11w | lww,aql,wbc, btg,dws |
| Boiling Spring | P | 0.1 | Mouth | 24,32n,10w | lww,aql |
| Boone Cr. | P | 3.0 | Mouth | 16,32n,9w | lww,aql |
| Boone Cr. | C | 3.0 | 16,32n,9w | 15,32n,9w | lww,aql |
| Brushy Cr. | P | 3.0 | Mouth | Hwy. 63 | lww,aql |
| Brushy Cr. | C | 4.0 | Hwy. 63 | 14,30n,09w | lww,aql |
| Burton Br. | C | 2.0 | Mouth | 13,31n,10w | lww,aql |
| Camp Br. | C | 3.5 | Mouth | 35,29n,10w | lww,aql |
| Cathcart Hol. | C | 1.6 | Mouth | 20,31n,09w | lww,aql |
| Elk Cr. | P | 3.0 | Mouth | 24,29n,10w | lww,aql |
| Elk Cr. | C | 2.0 | 24,29n,10w | 30,29n,9w | lww,aql |
| Emery Hol. | C | 3.9 | Mouth | 28,31n,10w | lww,aql |
| Hamilton Cr. | P | 4.5 | Mouth | 5,29n,10w | lww,aql |
| Hamilton Cr. | C | 2.0 | 5,29n,10w | 7,29n,10w | lww,aql |
| Hazelton Spring | P | 0.1 | Mouth | 34,33n,10w | lww,aql |
| Hog Cr. | P | 4.5 | Mouth | 06,29n,9w | lww,aql,clf |
| Hog Cr. | C | 5.1 | 06,29n,9w | 16,29n,09w | lww,aql |
| Indian Cr. | P | 4.0 | Mouth | 30,30n,9w | lww,aql |
| Indian Cr. | C | 3.0 | 30,30n,9w | 27,30n,9w | lww,aql |
| Jacktar Hol. | C | 5.1 | Mouth | 22,32n,10w | lww,aql |
| Johnson Br. | C | 1.0 | Mouth | 29,30n,9w | lww,aql |
| L. Paddy Cr. | C | 3.5 | Mouth | 36,33n,11w | lww,aql |
| L. Pine Cr. | C | 1.5 | Mouth | 12,33n,12w | lww,aql |
| Mineral Spring Hol. | C | 0.8 | Mouth | 30,31n,09w | lww,aql |

Table 1 continued

| Stream Name | Class[1] | Miles Acres* | From | To | Designated Use[2] |
|---|---|---|---|---|---|
| Mooney Br. | C | 2.0 | Mouth | 3,33n,10w | lww,aql |
| Opossum Cr. | C | 2.0 | Mouth | 36,30n,11w | lww,aql |
| Potters Cr. | P | 4.0 | Mouth | 16,28n,10w | lww,aql |
| Potters Cr. | C | 2.0 | 16,28n,10w | 22,28n,10w | lww,aql |
| Roaring Springs | P | 0.1 | Mouth | 35,33n,10w | lww,aql |
| Rock Br. | C | 1.6 | Mouth | 10,32n,10w | lww,aql |
| Sand Hol. | C | 0.3 | Mouth | 24,31n,10w | lww,aql |
| Schoolhouse Hol. | C | 0.3 | Mouth | 19,31n,09w | lww,aql |
| Slabtown Br. | C | 3.3 | Mouth | 23,33n,10w | lww,aql |
| Spring Cr. | P | 6.5 | Mouth | 31,35n,9w | irr,lww,aql, cdf,wbc,btg |
| Spring Cr. | P | 11.5 | 31,35n,9w | 16,33n,9w | lww,aql |
| Spring Cr. | C | 3.5 | 16,33n,9w | 26,33n,9w | lww,aql |
| Trib. to Spring Cr. | C | 0.7 | Mouth | 26,35n,10w | lww,aql |
| Spurlock Hol. | C | 2.7 | Mouth | 15,30n,11w | lww,aql |
| Stream Mill Hol. | P | 3.0 | Mouth | 27,32n,10w | lww,aql |
| Stream Mill Hol. | C | 2.0 | 27,32n,10w | 28,32n,10w | lww,aql |
| Trib. to Beeler Br. | C | 1.0 | Mouth | 20,28n,10w | lww,aql |
| W. Piney Cr. | P | 11.0 | Mouth | 33,30n,11w | lww,aql |
| W. Piney Cr. | C | 2.0 | 33,30n,11w | 5,29n,11w | lww,aql |

**Note:** This table is not presented as a final authority.

[1] **L1**- Lakes used primarily for public drinking water supply.
**L2**- Major reservoirs.
**L3** -Other lakes which are waters of the state. For effluent regulation purposes, publicly owned lakes are those for which a subtantial portion of the surrounding lands are publicly owned or managed.
**P** - Streams that maintain permanent flow even in drought periods.
**C** - Streams that may cease flow in dry periods but maintain permanent pools which support aquatic life.

[2] **lww**-livestock & wildlife watering
**aql**-protection of warm water aquatic life and human health-fish consumption.
**cdf**-cold water fishery
**clf**-cool water fishery
**wbc**-whole body contact recreation
**btg**-boating & canoeing
**irr**-Irrigation

*****Acres given for Impoundments.

**Table Wq02. Water quality data for selected stations and parameters within the Big Piney Watershed (MDNR 2001, USGS 2003c). Applicable of state standards used for comparison of values at each site are in *italics* and may include one or more of the following: AQL Protection of aquatic life, CLF cool water fishery, CDF cold water fishery, DWS Drinking Water Supply, IRR Irrigation, LWW Livestock and Wildlife Watering, WBC Whole-body-contact recreation, and BTG Boating.**

| **Station 06929315 (Paddy Creek above Slabtown Spring)** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | ***AQL*** | ***IRR*** | **CLF** | **CDF** | **DWS** | **LWW** | **BTG** | **WBC** | **Min-Max** | **Exceed** |
| Temperature ($^{o}$F) (warm water fishery) | 90.0 Max | | 84 | 68 | | | | | 35.6-75.9 | 0/41 |
| pH | 6.5-9.0 | | | | | | | | 7.1-8.4 | 0/41 |
| Oxygen, dissolved (mg/l) (warm water fishery) | 5.0 Min | | 5.0 | 6.0 | | | | | 5.6-13.5 | 0/41 |
| Coliform, fecal (colonies / 100 ml) | | | | | | | | 200 | 1-4500 | N/A |
| Nitrogen, Total Ammonia (mg/l as N) | 0.1-2.5 | | 0.2-3.9 | 0.1-2.8 | | | | | 0.01-0.08 | 0/41 |
| Phosophorus, Total[3] (mg/l as P) | | | | | | | | | 0.01-0.1 | 0/41 |
| Sulfate (mg/l) | | | | | 250 | | | | 2.4-5.3 | 0/41 |
| Chloride(mg/l) | 230/360 | | | | 250 | | | | 0.7-2.6 | 0 |
| Nitrate (mg/l) | | | | | 10 | | | | 0.0-0.56 | 0 |
| **Station 06930000 (Big Piney River near Big Piney)** | | | | | | | | | | |
| **Parameter** | ***AQL*** | ***IRR*** | ***CLF*** | **CDF** | ***DWS*** | ***LWW*** | ***BTG*** | ***WBC*** | **Min-Max** | **Exceed** |
| Temperature ($^{o}$F) (warm water fishery) | 90.0 Max | | 84 | 68 | | | | | 46.4-79.3 | 0/7 |
| pH | 6.5-9.0 | | | | | | | | 7.2-8.3 | 0/7 |
| Oxygen, dissolved (mg/l) (warm water fishery) | 5.0 Min | | 5.0 | 6.0 | | | | | 6.8-10.9 | 0/7 |

Table 2 continued

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Coliform, fecal (colonies / 100 ml) | | | | | | | | 200 | 32-230 | 1/4 |
| Nitrogen, Total Ammonia (mg/l as N) | 0.1-2.5 | | 0.2-3.9 | 0.1-2.8 | | | | | 0.012-<0.048[E] | 0/6 |
| Phosophorus, Total[3] (mg/l as P) | | | | | | | | | 0.01-0.12[<] | 1/6 |
| Sulfate (mg/l) | | | | | 250 | | | | 3.6-5.1 | 0/5 |
| Chloride (mg/l) | 230/360 | | | | 250 | | | | 2.9-4.7 | 0/5 |
| Nitrate (mg/l) | | | | | 10 | | | | N/O | |
| **Station 06930450 (Big Piney River at Devils Elbow)** | | | | | | | | | | |
| **Parameter** | ***AQL*** | ***IRR*** | ***CLF*** | **CDF** | ***DWS*** | ***LWW*** | ***BTG*** | ***WBC*** | **Min-Max** | **Exceed** |
| Temperature ($^{o}$F) (warm water fishery) | 90.0 Max | | 84 | 68 | | | | | 36.5-80.4 | 0/28 |
| pH | 6.5-9.0 | | | | | | | | 7.3-8.4 | 0/28 |
| Oxygen, dissolved (mg/l) (warm water fishery) | 5.0 Min | | 5.0 | 6.0 | | | | | 6.2-13.5 | 0/28 |
| Coliform, fecal (colonies / 100 ml) | | | | | | | | 200 | 2[e-]650 | 2/28 |
| Nitrogen, Total Ammonia (mg/l as N) | 0.1-2.5 | | 0.2-3.9 | 0.1-2.8 | | | | | <0.024-0.06[e] | 0/27 |
| Phosophorus, Total[3] (mg/l as P) | | | | | | | | | 0.03-<0.06[e] | 0/23 |
| Sulfate (mg/l) | | | | | 250 | | | | 4.1-6.7 | 0/9 |
| Chloride(mg/l) | 230/360 | | | | 250 | | | | 3.1-6.9 | 0/9 |
| Nitrate (mg/l) | | | | | 10 | | | | N/A | |

Table 2 continued

| Station 374749092051901 (Shanghai Spring) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | ***AQL*** | ***IRR*** | ***CLF*** | **CDF** | ***DWS*** | ***LWW*** | ***BTG*** | ***WBC*** | **Min-Max** | **Exceed** |
| Temperature ($^{o}$F) (warm water fishery) | 90.0 Max | | 84 | 68 | | | | | 56.3-65.1 | 0/45 |
| pH | 6.5-9.0 | | | | | | | | 6.9-7.6 | 0/13 |
| Oxygen, dissolved (mg/l) (warm water fishery) | 5.0 Min | | 5.0 | 6.0 | | | | | 3.0-9.0 | 0/9 |
| Coliform, fecal (colonies / 100 ml) | | | | | | | | 200 | 200[e] | 1/1 |
| Nitrogen, Total Ammonia (mg/l as N) | 0.1-2.5 | | 0.2-3.9 | 0.1-2.8 | | | | | 0.0024-<0.018 | 0/5 |
| Phosophorus, Total[3] (mg/l as P) | | | | | | | | | 0.06-0.59[e] | 13/35 |
| Sulfate (mg/l) | | | | | 250 | | | | 6.8-10.4[E] | 0/42 |
| Chloride (mg/l) | 230/360 | | | | 250 | | | | 4.4-24.8 | 0/42 |
| Nitrate (mg/l) | | | | | 10 | | | | N/O | |
| **374203092041601 (Miller Spring)** | | | | | | | | | | |
| **Parameter** | **AQL** | **IRR** | **CLF** | **CDF** | **DWS** | **LWW** | **BTG** | **WBC** | **Min-Max** | **Exceed** |
| Temperature ($^{o}$F) (warm water fishery) | 90.0 Max | | 84 | 68 | | | | | 56.3-57.6 | 0/3 |
| pH | 6.5-9.0 | | | | | | | | 6.9-7.6 | 0/3 |
| Oxygen, dissolved (mg/l) (warm water fishery) | 5.0 Min | | 5.0 | 6.0 | | | | | 2.2-8.3 | 0/2 |

Table 2 continued

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Coliform, fecal (colonies / 100 ml) | | | | | | | | 200 | 20[e] | 0/1 |
| Nitrogen, Total Ammonia (mg/l as N) | 0.1-2.5 | | 0.2-3.9 | 0.1-2.8 | | | | | 0.019-0.006 | 0/2 |
| Phosophorus, Total[3] mg/l as P) | | | | | | | | | 0.008-0.190 | 1/2 |
| Sulfate (mg/l) | | | | | 250 | | | | 3.6-5.7 | 0/2 |
| Chloride(mg/l) | 230/360 | | | | 250 | | | | 1.7-2.5 | 0/2 |
| Nitrate (mg/l) | | | | | 10 | | | | N/O | |
| **374418092045101 (Sandstone Spring)** | | | | | | | | | | |
| **Parameter** | **AQL** | **IRR** | **CLF** | **CDF** | **DWS** | **LWW** | **BTG** | **WBC** | **Min-Max** | **Exceed** |
| Temperature ($^{o}$F) (warm water fishery) | 90.0 Max | | 84 | 68 | | | | | 55.2-64.6 | 0/8 |
| pH | 6.5-9.0 | | | | | | | | 7.2-8.2 | 0/8 |
| Oxygen, dissolved (mg/l) (warm water fishery) | 5.0 Min | | 5.0 | 6.0 | | | | | 3.0-9.8 | 2/6 |
| Coliform, fecal (colonies / 100 ml) | | | | | | | | 200 | 38-104[e] | 0/2 |
| Nitrogen, Total Ammonia (mg/l as N) | 0.1-2.5 | | 0.2-3.9 | 0.1-2.8 | | | | | <0.0024-0.018 | 0/7 |
| Phosophorus, Total[3] (mg/l as P) | | | | | | | | | <0.02-0.04 | 0/6 |
| Sulfate (mg/l) | | | | | 250 | | | | 4.8-17.1 | 0/6 |
| Chloride(mg/l) | 230/360 | | | | 250 | | | | 3.1-8.96 | 0/6 |
| Nitrate (mg/l) | | | | | 10 | | | | N/O | |

**N/O** No observations

**k** Non-ideal count of colonies (too large a sample, colonies merged)

**e** Range includes laboratory estimated value.
<Range includes measurement(s) in which actual value is known to be lower than value shown.
[1] Based on maximum chronic and acute standards for cold-water fishery. Levels are pH and temperature dependent. For specific criteria at varying pH and temperatures consult Table B of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality.
[2] Based on maximum chronic and acute standards for general warm-water fishery. Levels are pH and temperature dependent. For specific criteria at varying pH and temperatures consult Table B of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality.
[3] State standard for phosphorus is currently unavailable. The Environmental Protection Agency currently recommends a maximum of 0.1mg/L for rivers (Christensen and Pope 1997).
[4] Based on maximum chronic and acute standards for all waters. Levels are hardness dependent. For specific criteria at varying hardness consult Table A of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality.
[5] Based on maximum chronic and acute standards for cold water fishery. Levels are hardness dependent. For specific criteria at varying hardness consult Table A of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality.

**Table Wq03. Results of Pesticides National Synthesis Project water quality sampling for pesticide compounds within the Big Piney Watershed (USGS 1998b and 2000a).**

| Station | Name | Type | Pesticide Compound Detected |
|---|---|---|---|
| 1 | Big Piney River nr. Big Piney | S | Thiobencarb, Metolachlor, Diazinon |
| 2 | Paddy Creek above Slabtown Spring | S | Thiobencarb, Metolachlor, Atrazine, Deethyl Atrazine |
| 3 | N/A | GW | Non-Detection |

**Type: S**-Surface **GW**-Ground Water

| Pesticide Compound | Pesticide Type |
|---|---|
| Atrazine | Herbicide |
| Diazinon | Insecticide |
| Deethyl Atrazine | Degradation Product (Atrazine) |
| Metolachlor | Herbicide |
| Thiobencarb | Herbicide |

**Table Wq04. Public/municipal and non-municipal waste water and water treatment facilities within the Big Piney Watershed (MDNR 1998b, 2000d, 2000e).**

| Facility Name | County | Facility[1] Type | Receiving Stream | Flow* (mgd) |
|---|---|---|---|---|
| Cabool WWTF | Texas | POTW | Big Piney River | 1.70 |
| Houston-Brushy Creek | Texas | POTW | Brushy Creek | 0.40 |
| Licking Northwest WWTP | Texas | POTW | Br. Of Spring Creek | 0.43 |
| Pcsd #1-Wyndridge Es. | Pulaski | SEWDI | Big Piney River | 0.02 |
| Pcsd-Thousand Hills | Pulaski | SEWDI | Trib Dry Creek | 0.02 |
| Raymondville WWTP | Texas | POTW | Arthur Creek | 0.06 |
| Usa-Ft Leonard Wood WWTP | Pulaski | BASE | Dry Fork | 5.54 |
| Willard-St. Robert Quarry | Pulaski | LIM Q | Dry Branch | |
| Interstate Ready-Mix Inc. | Pulaski | LIM Q | Trib Big Piney River | |
| Grandview Courts | Pulaski | MHP | Trib Big Piney River | |
| Chastain Trailer Court | Pulaski | MHP | Trib. Dry Cr | |
| Waynesville Super 8 Motel | Pulaski | MOTEL | Trib Week Hollow | |
| Bluffview Apartments | Pulaski | SUBD | Trib. Big Piney | |
| Country Oaks Est Subd | Pulaski | SUBD | Trib. Dry Creek | |
| Usa-Ft Leonard Wood WTP | Pulaski | WATER | Trib. To Big Piney River | 0.26 |
| Matherly Concrete-Cabool | Texas | LIM Q | Big Piney River | |
| Country Aire MHP | Texas | MHP | Ditch Big Piney River | |
| Houston Redi-Mix | Texas | CONCR | Brushy Creek | |
| Texas Co Residential Care | Texas | HEAL | Trib. Indian Creek | |
| El Rancho Truck Stop | Texas | TRU S | Trib. To Beeler Creek | |

Note: Table is not a final authority. Data subject to change.
*Only Flows of public/municipal waste water facilities are given (millions of gallons a day).

**1** Facility Type:
**BASE-**Military Base
**CONCR-**Concrete Products
**HEAL-**Health Care (Private)
**LIM Q-**Limestone Quarry
**MHP-**Mobile Home Park
**MOTEL-**Motel & Hotel
**POTW-**Publicly Owned Treatment Works **SEWDI-**Public Sewer District
**SUBD-**Public Subdivision,
**TRU S-**Truck Stop.
**WATER-**Public Water Treatment Plant

**Table Wq05. Water pollution incidents and potential water pollution incidents and fish kills investigated within the Big Piney Watershed from 1990-2002 (MDC 2003).**

| Year | County | Stream | Cause | Fish kill | Damage |
|---|---|---|---|---|---|
| 1990 | Texas | Big Piney River | Oak tree pollen | No | <1/4 mile |
| 1991 | Texas | Big Piney River | Treated sewage and process water | No | <1/4 mile |
| 1992 | Pulaski | Dry Creek | Sewage and biological sludge | No | 4 miles |
| 1993 | Texas | Brushy Creek | Sewage sludge. | No | 200 yards. |
| 1993 | Texas | Big Piney River | Excessive algal bloom | No | 14 miles |
| 1993 | Texas | Big Piney River | Summerkill | Yes | 3 miles |
| 1993 | Texas | Big Piney River | Sewage. | No | |
| 1993 | Texas | Tributary to Bender Creek | Gasoline | No | <1/8 mile |
| 1994 | Texas | Arthur Creek | Diesel | No | 1 to 3 miles. |
| 1994 | Texas | Big Piney River | Hog feed suppliment (whey) | No | <1/8 mile |
| 1996 | Texas | Tributary to Elk Creek | Cattle manure (alledged) | Yes | <1/4 mile |
| 1996 | Texas | Big Piney River | Milk product (undetermine) | No | <1/8 mile |
| 1997 | Texas | Beeler Branch/ Big Piney River | Milk | No | 1 & 10+ miles |
| 1997 | Pulaski | Hooker Hollow | Trash | No | 1/4 mile |
| 1997 | Texas | Branch of Spring Creek | Stormwater | No | unknown |
| 2001 | Texas | Brushy Creek | Sewage | Yes | 1 Mile |

**Table Wq06. Water withdrawals in millions of gallons per day by use category within the Big Piney Watershed in 1995 (USGS 1998c).**

| Use | Ground Water | Surface Water | Total |
|---|---|---|---|
| ***Public Supply Total*** | ***1.45*** | ***0.83*** | ***2.28*** |
| Domestic (delivered) | | | 1.3 |
| Commercial (delivered) | | | 0.25 |
| Industrial (delivered) | | | 0.04 |
| ***Self Supplied (total)*** | ***1.21*** | ***1.23*** | ***2.44*** |
| Domestic | 0.58 | 0.00 | 0.58 |
| Commercial | 0.01 | 0.00 | 0.01 |
| Industrial | 0.37 | 0.00 | 0.37 |
| Livestock | 0.20 | 0.58 | 0.78 |
| Irrigation | 0.05 | 0.65 | 0.70 |
| ***Watershed Total*** | ***2.66*** | ***2.06*** | ***4.72*** |

**Table Wq07. Major water users within the Big Piney Watershed (MDNR 2003c).**

| Owner | Total Gallons Pumped in 2001 | Acres Irrigated |
|---|---|---|
| City Of Cabool | 39,951,230 | |
| City Of Cabool | 41,335,122 | |
| City Of Cabool | 49,657,000 | |
| City Of Houston | 30,179,600 | |
| City Of Houston | 43,136,800 | |
| City Of Houston | 30,385,000 | |
| City Of Licking | 58,259,000 | |
| City Of Licking | 26,133,000 | |
| City Of Licking | 20,280,000 | |
| City Of St. Robert | 19,595,000 | |
| City Of St. Robert | 74,298,100 | |
| Dairy Farmers Of America Inc. | 3,412,800 | |
| Dairy Farmers Of America Inc. | 98,352,000 | |
| Dairy Farmers Of America Inc. | 116,376,480 | |
| Missouri Dept. Of Conservation<br>George O. White State Forest Nursery | 6,115,000 | |
| Missouri Dept. Of Conservation<br>George O. White State Forest Nursery | 12,500,000 | |
| Missouri Dept. Of Conservation<br>George O. White State Forest Nursery | 12,500,000 | |
| Public Water Supply Dist. #4 | 22,603,700 | |
| Pulaski County Pwsd #2 | 70,784,100 | |
| Texas County P.W.S.D. #1 | 0 | |
| Texas County P.W.S.D. #1 | 20,401,676 | |
| Texas County P.W.S.D. #1 | 22,450,531 | |
| Texas County P.W.S.D. #1 | 40,649,354 | |
| Texas County P.W.S.D. #2 | 14,127,000 | |
| Texas County P.W.S.D. #2 | 21,027,900 | |
| Us Army Maneuver Support Center Fort Leonard Wood | 1,082,615,123 | 20.0 |
| Village Of Raymondville | 10,158,740 | |
| ***Total*** | ***1,947,333,026*** | ***20.0*** |

Figure Wq01.

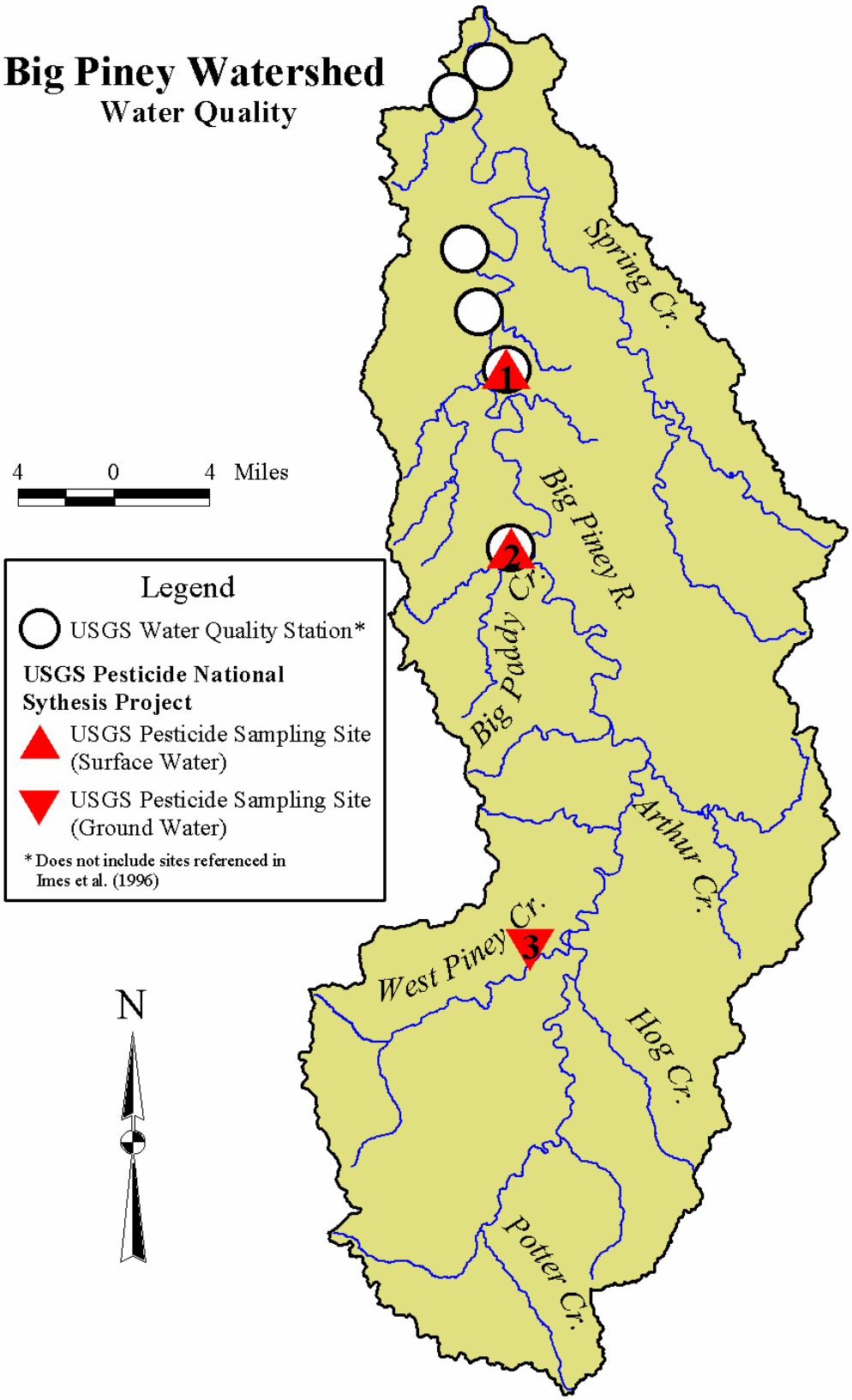
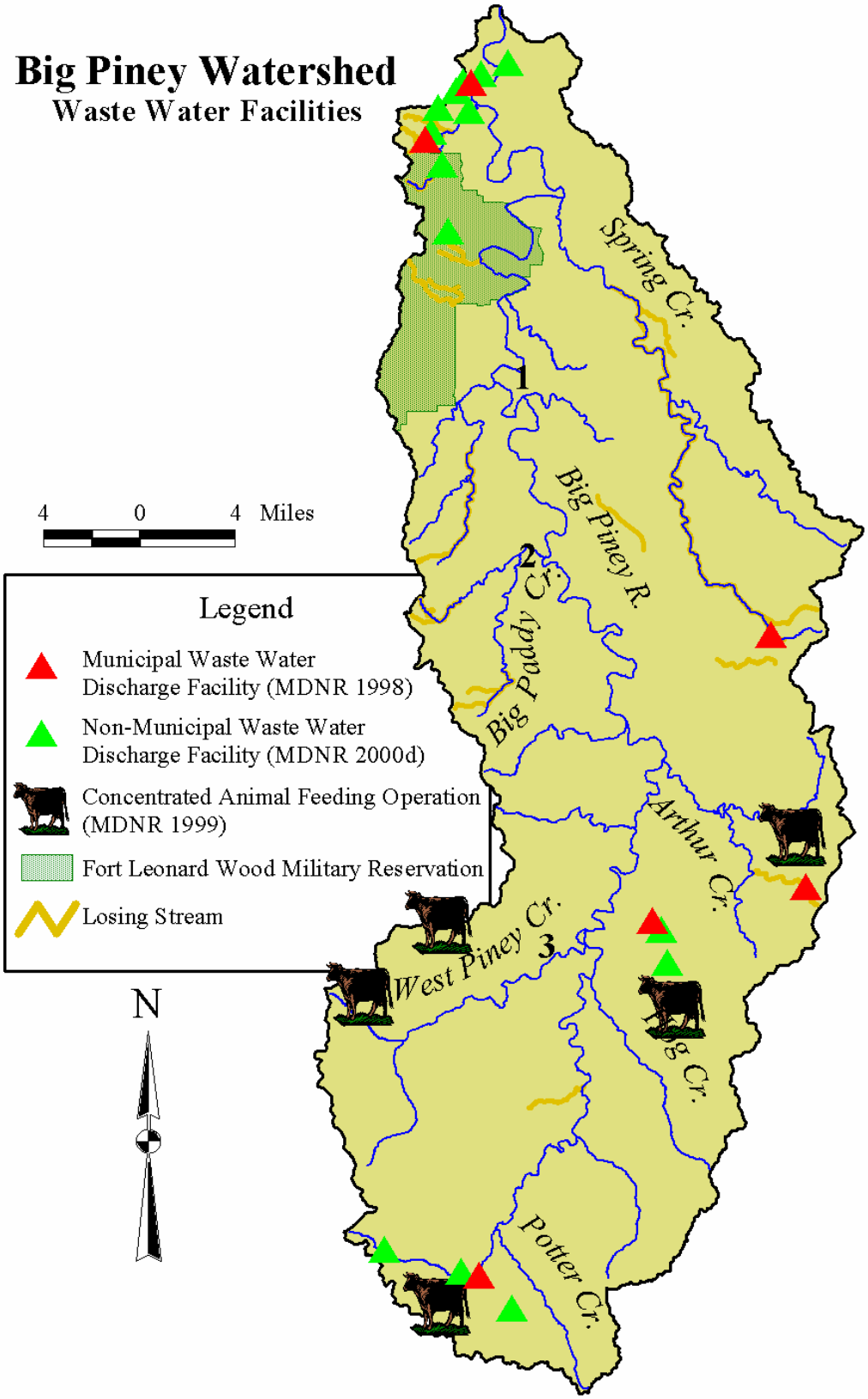

Big Piney Watershed
Water Quality
4 0 4 Miles
Legend
USGS Water Quality Station*
USGS Pesticide National Sythesis Project
USGS Pesticide Sampling Site (Surface Water)
USGS Pesticide Sampling Site (Ground Water)
* Does not include sites referenced in Imes et al. (1996)
N
Spring Cr.
Big Piney R.
Big Papp Cr.
Arthur Cr.
West Piney Cr.
Hog Cr.
Potter Cr.
1
2
3

Figure Wq02.


Big Piney Watershed
Waste Water Facilities
Spring Cr.
1
Big Piney R.
2
Big Paddy Cr.
Arthur Cr.
West Piney Cr.
3
Potter Cr.
4 0 4 Miles
Legend
Municipal Waste Water Discharge Facility (MDNR 1998)
Non-Municipal Waste Water Discharge Facility (MDNR 2000d)
Concentrated Animal Feeding Operation (MDNR 1999)
Fort Leonard Wood Military Reservation
Losing Stream
N