

**DECLARATION OF RICH BURTELL ON THE NON-  
NAVIGABILITY OF THE SAN PEDRO RIVER AT AND PRIOR  
TO STATEHOOD**

*In re Determination of Navigability of the San Pedro River  
(Case No. 03-004-NAV)*

**March 2013**

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**DECLARATION OF RICH BURTELL ON THE NON-NAVIGABILITY OF THE SAN PEDRO RIVER AT AND PRIOR TO STATEHOOD**

**I. INTRODUCTION AND SUMMARY OF OPINIONS**

1. I am a Registered Geologist (AZ No. 33746) and Principal at Plateau Resources, LLC with degrees in hydrology and geology.

2. Before founding Plateau Resources, I worked at the Arizona Department of Water Resources (ADWR) for twelve years. At ADWR I was Manager of the Adjudications Section and, as Manager of that section, was frequently involved in evaluating the nature and occurrence of surface water in Arizona streams.

3. My education, experience, and expertise are detailed in my *Curriculum Vitae*, included as **Attachment A**.

4. I have been asked by Freeport-McMoRan Corporation (Freeport) to evaluate the navigability of the San Pedro River at and prior to statehood. This declaration provides supplemental evidence in a case currently before the Arizona Navigable Stream Adjudication Commission (ANSAC). On October 22, 2012, ANSAC voted to reopen the record for receiving evidence on six remanded cases. These cases address the navigability of the Gila River, San Pedro River, Santa Cruz River, Lower Salt River, Upper Salt River and the Verde River. The San Pedro case will be reheard first.

5. In evaluating the navigability of the San Pedro River, I am mindful that ANSAC intends to receive, review, and consider evidence on two issues: (a) the navigability or non-navigability of the San Pedro River in its “ordinary and natural condition” prior to the State of Arizona’s admission to the United States on February 14, 1912, consistent with the Arizona Court of Appeals decision in *State v. Arizona Navigable Stream Adjudication Comm’n*, 224 Ariz. 230, 229 P.3d 242 (App. 2010); and (b) segmentation of the San Pedro River consistent with the United States Supreme Court’s decision in *PPL Montana, LLC v. Montana*, 556 U.S. \_\_\_, 132 S.Ct. 1215 (2012).

6. In preparing this declaration, I reviewed: (a) the evidence log from ANSAC’s first San Pedro hearing (Hearing No. 03-004-NAV); (b) ANSAC’s October 18, 2006 document *Report, Findings and Determination Regarding the Navigability of the San Pedro River from the Mexican Border to the Confluence with the Gila River*; (c) legal memoranda filed in 2003, 2004 and 2012 by various parties regarding the San Pedro River and posted on ANSAC’s website ([www.ansac.az.gov](http://www.ansac.az.gov)); and (d) authorities cited in those legal memoranda. If additional information becomes available, I reserve the right to revise or supplement my opinions.

7. Based on my review of existing information and the supplemental evidence presented here, it is my opinion that the San Pedro River was not susceptible to navigation in its ordinary and natural condition at and prior to statehood. It is also my opinion that if the San Pedro River was divided into segments, none of the individual reaches of the watercourse would have been navigable at that time.

8. The remainder of this declaration is organized into four sections – Ordinary

and Natural Conditions (Section II), Absence of Commercial Boat Travel At and Prior to Statehood (Section III), Reported San Pedro Lake (Section IV), and Conclusions (Section V). References cited herein follow the last section.

## II. ORDINARY AND NATURAL CONDITIONS

### A. Historic Accounts

9. Fuller (2004, Chapter 3) suggests that, beginning in the 1870s, San Pedro River streamflows were reduced by agricultural diversions. Diversions increased during the 1880s as the watershed was further developed. The 1880s were also a period when downcutting began to entrench portions of the river. Explanations for the channel entrenchment vary and include natural causes, such as climate change and the 1887 Sonora Earthquake, as well as cultural affects from grazing and timber harvesting.

10. As described in *State v. ANSAC*, and presented later in this declaration, development of the San Pedro River since the 1870s does not preclude use of more recent evidence to assess its navigability.

11. **Table 1** lists historic accounts of San Pedro River streamflow conditions made before 1870. The accounts were taken from Fuller (2004) with associated page numbers referenced in the table. I divided the river into three, roughly equal reaches by length and grouped the historic accounts accordingly. The reaches include: a) the International Border to Benson (“Upper San Pedro River”); b) Benson to Redington (“Middle San Pedro River”); and c) Redington to the Gila River confluence (“Lower San Pedro River”). See **Figure 1** for a map showing the location of the accounts. Note that these reaches were selected for ease of discussion and are not an effort to divide the river into distinct hydrologic segments.

12. Fuller (2004, pp. 7-1 and 9-2) indicates that the San Pedro River can be broken into two reaches with “somewhat distinct hydrologic conditions.” The reaches are divided at “The Narrows” a bedrock constriction located about 15 miles north of Benson. The upper San Pedro River was described as “perennial from about Hereford to Fairbank, and intermittent downstream of Fairbank” and “generally consisted of a small braided stream.” The lower San Pedro River “also had a small braided channel” and was “characterized by an entrenched, broad, braided channel with only isolated reaches of perennial flow near areas of shallow bedrock.” Fuller (2004, p.5-4) adds that “Geologically, this division is arbitrary since environmental and geomorphic variables are transitional between the two reaches.” In a June 8, 2012 legal memorandum, the Arizona State Land Department (ASLD) recommends that the San Pedro River not be segmented for purposes of determining its navigability. I agree with that recommendation.

13. The historic accounts in **Table 1** indicate that, before 1870, beavers were common along all three reaches of the watercourse. As discussed further in Section III, beaver dams would have posed an obstacle to navigation at the time. Intermittent and discontinuous flow conditions were also reported along the middle and lower reaches indicating the variable nature of flow. The former would have caused temporal limits on boat travel and the latter would have further restricted this travel by requiring portages. Commercial boat travel would not have been feasible under such temporal and spatial limitations.

14. Not presented in Fuller (2004) are historic accounts of the San Pedro River

made during an 1891-1896 resurvey of the International Border. As noted in **Table 1**, the original border survey was conducted by Bartlett in 1851. During the resurvey, the San Pedro River was described in the vicinity of the border as “ordinarily a stream of about 15 feet in width and 6 or 8 inches in depth, fringed with a fine growth of cottonwood and willow...” No mention was made of any navigation on the San Pedro River. In contrast, the Colorado River was described as “generally navigable by light draft steamers throughout the year for several hundred miles above its mouth.” Relevant pages from an 1898 Boundary Commission report are included in **Attachment B**. As described below, little or no diversions were affecting streamflows in the upper portion of the watershed at the time so this 1890s stream account is representative of ordinary and natural conditions.

## **B. Historic Streamflow Records**

15. **Table 2** summarizes streamflow data collected by the U.S. Geological Survey (USGS) on or before statehood along the Upper San Pedro River. See **Figure 1** for a map of the USGS gaging stations and Chapter 7 of Fuller (2004) for a discussion of data availability.

16. **Table 2** lists median monthly flows measured at the Charleston gage from 1904-1911 and flow measurements taken periodically at a gage near Fairbank in 1912. Also listed in **Table 2** are average channel depths estimated based on these flows and historic rating curves developed by Fuller (2004, p.7-12 and Appendix E).<sup>i</sup> According to Fuller (2004, p.7-9), “median (50%) flow rates are probably best representative of ‘typical’ flow conditions...floods with high peaks tend to skew the average...”

17. In 16 of the 40 months with data (40%), channel depths at Charleston prior to statehood were typically less than 1 foot. Such shallow water would have precluded commercial boat travel. Although collected after the 1870s, these data are representative of ordinary and natural conditions because the USGS noted in 1911 that diversions above the station were limited to the amount used to irrigate only about 50 acres.

18. **Table 2** also lists periodic streamflow measurements made during 1912 at a gage near Fairbank. This gage was a few miles downstream of Charleston and located below a diversion dam for Boquillas Ranch. Streamflows were measured below the dam and, as necessary, were added to diversions made above the dam. For three of the four months with data, estimated channel depths were less than 1 foot, which would have precluded commercial boat travel.

19. In the decade following statehood, streamflows were periodically measured upstream of Charleston at Hereford. These data are listed in **Table 3**. Although Fuller (2004) does not provide a rating curve for the Hereford station, available flow data suggest that channel depths there were also relatively shallow. During 12 of 16 months (75%), flow rates were less than 14 cubic feet per second (cfs). Based on long-term streamflow records described below, such flow rates are associated with San Pedro channel depths of less than 1 foot. According to the USGS, little or no diversions occurred above this gage, so these measurements are also representative of ordinary and natural conditions.

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<sup>i</sup> Cross sections of desert streams are rarely uniform in shape and often exhibit high points (islands and point bars) and low points (pools). The San Pedro River is no exception and is characterized by Fuller (2004, p.9-2) as a braided channel. The average depth of such channels represents the mean of the varying water depths encountered across its width, including both high and low points.

### **C. Long-term Streamflow Records**

20. Fuller (2004, Chapter 7) presents long-term streamflow records for six USGS gaging stations along the San Pedro River. These records extend well into the 20<sup>th</sup> century and, due to cultural diversions, probably do not represent the ordinary and natural condition of some reaches of the watercourse at and prior to statehood. However, these records are presented here to provide context to the early Hereford flow data described above and to rebut recent statements made by the Arizona Center for Law in the Public Interest (ACLPI).

21. **Table 4** summarizes typical flow conditions at the six gaging stations based on median streamflows and available rating curves. Channel depths were typically less than 1 foot even with median flow rates up to 14 cfs.

22. On pages 12, 13, and 15 of their September 7, 2012 memorandum regarding the navigability of the San Pedro River, ACLPI characterizes channel depths for the watercourse based on data presented in Fuller's 2004 report. Reference is made to tables on pages 7-13 and 7-15 through 7-17 of that report. Review of these tables indicates that they were prepared using average annual and monthly flow rates rather than median flows. As discussed in Paragraph 16 of this declaration, median flows better reflect ordinary conditions because floods can skew average flow rates. The channel depths associated with median flow rates, as listed in **Table 4**, are considerably more meaningful for assessing the susceptibility of the San Pedro River to navigation.

## **III. ABSENCE OF COMMERCIAL BOAT TRAVEL AT AND PRIOR TO STATEHOOD**

### **A. Supplying Military Posts**

23. As described by Fuller (2004, pp. 3-22 through 3-26), "the primary means of transportation along the San Pedro River has always been overland." This includes the period before the 1870s. Although Fuller mentions military expeditions that passed through the area, first on horseback and later using wagons, the only mention of how early military posts in the region were supplied was that "by 1870, a road ran up the Gila River to Camp Grant." This indicates that goods were transported to the camp along the river rather than on it.

24. **Attachment C** presents relevant pages from two books written on providing supplies to military posts in the southwest before and after the Civil War. Consistent with Fuller's description, these books discuss the use of wagons to ship supplies to the camps and forts of the territory. Prior to the Civil War, these posts included Fort Breckinridge located along the Lower San Pedro River near the confluence with Aravaipa Creek. Shortly after the war, the former site of Fort Breckinridge was renamed Camp Grant and Fort Wallen was constructed near Elgin along the Upper San Pedro River. Included in **Attachment C** is an 1871 photograph of an ox train near Camp Grant.

25. The Colorado is the only river mentioned in these books as having been used to transport supplies to Arizona military posts. Before railroads arrived, most military supplies that were not produced locally were shipped from San Francisco and transported by boat up the Colorado River to Yuma and La Paz. From there,

supplies were distributed to inland posts via wagon trains.

26. Neither book mentions the use of the San Pedro River to haul supplies to Arizona's early military posts.

### **B. Occurrence of Beaver Dams**

27. Fuller (2004, pp. 3-13 and 5-9) states that James Ohio Pattie trapped beaver along the San Pedro River during two trips, the first between December 1824 and April 1825, and the second between October 1827 and February 1828. Each time he went down the Gila River to the San Pedro River and then trapped up the San Pedro before returning to the Gila. After trapping some "200 skins", he called the San Pedro the "Beaver River."

28. According to the Bureau of Land Management (BLM), by 1894, beavers had been extirpated from the Upper San Pedro River where the San Pedro National Conservation Area (SPRNCA) is now located. BLM reintroduced 15 beavers to SPRNCA between 1999 and 2000 and by 2008 their numbers had increased to about 150, with 46 beaver dams counted. Flooding has since reduced their population to about 100 and the number of dams is currently about 30.

29. **Attachment D** provides further information on the occurrence of beavers in SPRNCA in addition to several ground-level photographs of beaver dams taken in the area during April 2012. Review of the photographs shows that the dams are typically from two to three feet high and span the width of the river. If a similar size and number of beaver dams existed on the San Pedro River at and prior to statehood – which Fuller's description of Mr. Pattie's trapping indicates to be the case – then, these would have posed a significant obstacle to commercial boat travel.

30. Given the frequency of beaver dams and how quickly beavers can multiply and repair their dams, such conditions would have posed a continuous impediment to pre-1870s boat travel on the San Pedro River. Moreover, if theoretically all of the dams could have been removed at the same time, it would have drained the pools formed behind them and locally lowered stream levels, rendering the already shallow San Pedro River even shallower in these locations.

## **IV. REPORTED SAN PEDRO LAKE**

31. On page 17 of their September 7, 2012 memorandum regarding the navigability of the San Pedro River, ACLPI describes the following evidence of navigation along the Lower San Pedro River:

Although there are no documented historical accounts of boating, included in the oral histories of the State Report was an account by a Mr. Houston Evans who responded to a mass-mailing letter. According to Mr. Evans, who (sic) lived near the river during the 1940s. Mr. Evans recalled that the river had clear water, about two to three feet deep year round during the 1943 to 1945 period. He said that there was a large lake in the middle of the river between Aravaipa-San Pedro confluence and Dudleyville that is no longer there. He, along with other young family members and friends, would canoe on the San Pedro River from the Mammoth area down to the

lake, where they had a raft. State Report, Appendix C, p.53.

32. To evaluate the occurrence of this reported lake on the San Pedro River, I reviewed historic maps and aerial photograph of the area. The documents I reviewed are presented in **Attachment E** and include: (a) General Land Office maps surveyed in 1877; (b) a 1:24,000 scale topographic map surveyed by the USGS in 1911; (c) 1935 and 1947 aerial photographs; and (d) 1:24,000 and 1:62,500 scale topographic maps published by USGS in 1949 based on 1947 aerial photography.

33. The maps and photographs in **Attachment E** show no evidence of a large lake in the middle of the San Pedro River between the Aravaipa Creek confluence and Dudleyville. In fact, the only reference to a lake in this area is Cooks Lake located about ½ mile east of the San Pedro River and about 2 miles below the Aravaipa Creek confluence. As mapped in 1949, Cooks Lake was about 500 feet long, less than 200 feet wide, and adjacent to a wooded marsh or swamp. Even if this was the lake that Mr. Evans referenced, given its size and location, it would not have rendered the San Pedro River navigable.

#### **V. CONCLUSIONS**

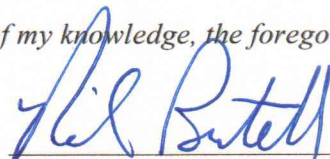
34. It is my opinion that, in its ordinary and natural condition, the San Pedro River was not navigable or susceptible to navigation at or prior to statehood.

35. It is also my opinion that if the San Pedro River was divided into segments, none of the individual reaches of the watercourse would have been navigable at or prior to statehood.

36. I base these opinions on my review of existing and supplemental evidence presented in this declaration including, but not limited to: (a) historic accounts; (b) historic and long-term streamflow records; (c) descriptions of how early military posts in Arizona were supplied; and (d) the occurrence of beaver dams in the area.

*I declare under penalty of perjury that, to the best of my knowledge, the foregoing is true and correct.*

Executed on this 22<sup>nd</sup> date of March, 2013

  
RICHARD T. BURTELL



**REFERENCES**

- JE Fuller/ Hydrology & Geomorphology, Inc. (Fuller), 2004. *Arizona Stream Navigability Study for the San Pedro River: Gila River Confluence to the Mexican Border*. Original prepared by CH2MHILL, SWCA Environmental Consultants and the Arizona Geological Survey in November 1993; revised by Fuller in June 1997 and January 2004.
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- \_\_\_\_\_, 1906. *Report of progress of stream measurements for the calendar year 1905, Part XI – Colorado River Drainage above Yuma*. Water-Supply and Irrigation Paper No. 175.
- \_\_\_\_\_, 1905. *Report of progress of stream measurements for the calendar year 1904, Part X – Colorado River and the Great Basin Drainage*. Water-Supply and Irrigation Paper No. 133.

# **TABLES**

TABLE 1 - PRE-1870s ACCOUNTS OF SAN PEDRO RIVER STREAMFLOW CONDITIONS<sup>1</sup>

LOCATION	YEAR	DESCRIPTION	SOURCE	PAGE(S) IN FULLER (2004)	COMMENTS
<b>UPPER SAN PEDRO RIVER (International Border to Benson)</b>					
International Boundary	1854-1855	"At this point, approaching from the east, the traveler comes within a mile of the river before any indications of a stream are apparent. Its bed is marked by trees and bushes, but it is some sixty or one hundred feet below the prairie, and the descent is made by a succession of terraces. Though affording no great quantity of water, this river is backed up into a series of large pools by beaver-dams, and is full of fishes."	Emory	3-11, 3-16	Beaver dams would have posed obstacles to commercial boat travel at the time.
Hereford to Benson	December 1846	"On we pushed, and finally, when twenty paces off, saw a fine bold stream! There was the San Pedro River we had so long and anxiously pursued (on 12/9)...Fish are abundant in this pretty stream. Salmon trout are caught by the men in great numbers; I have seen them eighteen inches long (on 12/10)...An abundance of fine fish are caught, some that are three feet long..." (on 12/11).	Cooke	3-14, 5-10	Cooke followed the San Pedro from south to north over five days before travelling west to Tucson.
		"...a small clear stream which runs into the Gulf of California...one of our mess brought 6 fine Trout that he caught today to camp."	Bliss	3-14	Member of Mormon Battalion commanded by Cooke.
near Lewis Springs	1854	"The San Pedro River, where we struck it, in latitude 31° 34' is a small stream at this stage, about eight feet wide, and shallow; between steep banks 10 feet high and 25 to 50 feet apart...At three points that I have crossed it, it is a living stream with large fish...Occasional bunches of mezquite and cotton-wood are seen upon its borders."	Gray	3-17	
near mouth of Dragoon Wash	September 1851	"We looked in vain for a line of trees, or of luxuriant vegetation to mark the course of the San Pedro--when all of a sudden we found ourselves upon the banks. The stream...was here about two feet deep and quite rapid. The water, though muddy, was pleasant to the taste."	Bartlett	3-11, 3-15	Account suggests storm water conditions.
		"The San Pedro was pretty high when we arrived here. It is very muddy, with a quick current, resembling very much the Pecos, or Rio Puerco, for this is its proper name--which means dirty or muddy river...My assistant, Mr. Clark, took from this stream several new species of fishes..."	Graham	3-16	Member of Bartlett's boundary survey party; account suggests storm water conditions.
<b>MIDDLE SAN PEDRO RIVER (Benson to Redington)</b>					
near Benson	February 1854	"The stream is about eighteen inches deep and twelve feet wide, and flows with a rapid current, at about twelve feet below the surface of its banks, which are nearly vertical, and of a treacherous miry soil, rendering it extremely difficult to approach the water, now muddy and forbidding. The banks are devoid of timber, or any sign indicating the course or even the existence of a stream, to an observer but a short distance removed..."	Parke	3-17	
at Tres Alamos	1830s	"Tucson settlers planted and harvested crops on the San Pedro River at Tres Alamos. Because of the Apache menace, they were escorted to and from their fields by presidio soldiers."	Officer	3-3, 3-4	Recent (1987) description by Officer of historic conditions at Tres Alamos
	1854	"At the Tres Alamos the stream is about fifteen inches deep and twelve feet wide and flows with a rapid current over a light, sandy bed about fifteen feet below its banks, which are nearly vertical. The water here is turbid, and not a stick of timber is seen to mark the meandering of its bed."	Parke	3-17	
above The Narrows	March and April 1858	"The San Pedro, at the first point reached in the present road, has a width of about twelve (12) feet, and depth of twelve (12) inches, flowing between clay banks ten or twelve feet deep, but below it widens out, and from beaver dams and other obstructions overflows a large extent of bottom land, forming marshes, densely timbered with cottonwood and ash, thus forcing the road over and around the sides of impinging spurs. This stream is not continuous all the year, but in the months of August and September disappears in several places, rising again, however, clear and limpid."	Hutton	3-18, 5-10	Beaver dams and marshy conditions would have posed obstacles to commercial boat travel at the time.
	September 1858	"Exceedingly to the surprise of every member of the expedition who had passed over this route in the months of March and April it was discovered after a march of a few miles that the waters of the San Pedro had entirely disappeared from the channel of the stream...Where the present reporter took quantities of fine trout in March and April 1858 not a drop of water was to be seen."	Leach	3-18	Intermittent flow would cause temporal limits on any possible boat travel.
within and below The Narrows	1854	"In the gorge below and in some of the meadows, the stream approaches more nearly the surface, and often spreads itself on a wide area, producing a dense growth of cottonwood, willows, and underbrush, which forced us to ascend and cross the out-jutting terraces. The flow of water, however, is not continuous. One or two localities were observed where it entirely disappeared, but to rise again a few miles distant, clear and limpid."	Parke	3-17	Discontinuous flow would require portages and could restrict any possible boat travel.
<b>LOWER SAN PEDRO RIVER (Redington to Gila River)</b>					
a few miles above Gila River confluence	November 1846	"An insignificant stream a few yards wide, and only a foot deep"	Emory	3-13, 5-13	
		"An active man could jump across"	Johnson	3-4, 5-13	
	1854	"Water sinks below the surface and rarely runs above it."	Parke	5-13	Discontinuous flow would require portages and could restrict any possible boat travel.
<b>SAN PEDRO RIVER (unspecified reach)</b>					
downstream to mouth of Aravaipa Creek	late 1857	"The Sanpedro river as they Call it--is a stream one foot deep six feet wide & runs a mile & half an hour & in ten minutes fishing we Could Catch as many fish as we Could use & about Every 5 miles is a beaver dam this is a great County for them--& we have went to the river & watterd & it was running fine & half mile below the bed of the river would be as dry as the road--it sinks & rises again & we went down as far as the aravipa & 8 miles below that the pedro Emties into the hela river."	Tevis	3-18	Discontinuous flow would require portages and could restrict any possible boat travel; beaver dams would have also posed obstacles at the time.

## Notes:

<sup>1</sup> According to Fuller (2004, pp.3-10 and 3-12), Apache raids were an obstacle to colonization of the San Pedro Valley throughout the Mexican Period and, from 1846 through 1859, United States military expeditions and parties of forty-niners found the area filled with ruins of abandoned ranches and large herds of wild cattle. During the Civil War, military posts in Arizona were abandoned and the San Pedro River was "largely left to the Apaches" until homesteaders began to resettle the area in 1867. The accounts presented in this table are believed to represent a period of limited cultural impact on San Pedro River streamflows.

TABLE 2 - UPPER SAN PEDRO RIVER STREAMFLOWS ON AND BEFORE STATEHOOD

YEAR / MONTH	1904		1905		1906		1910		1911		1912	
	Q (cfs) <sup>1</sup>	D (ft) <sup>2</sup>	Q (cfs) <sup>1</sup>	D (ft) <sup>2</sup>	Q (cfs) <sup>1</sup>	D (ft) <sup>2</sup>	Q (cfs) <sup>1</sup>	D (ft) <sup>2</sup>	Q (cfs) <sup>1</sup>	D (ft) <sup>2</sup>	Q (cfs) <sup>1</sup>	D (ft) <sup>2</sup>
<b>at Charleston<sup>3</sup></b>												
Jan	ND	---	30	1.0 to 1.5	58	1.0 to 1.5	ND	---	23(1)	0.5 to 1.0	ND	---
Feb			53.5		76							
Mar	22(3)	0.5 to 1.0	110	1.5 to 2.0	55				15(1)	0.5 to 1.0		
Apr	22		65	1.0 to 1.5	30			18(1)				
May	22		24	1.0	17	0.5 to 1.0			ND	---		
Jun	11.5	< 0.5	18	0.5 to 1.0	9	<0.5			ND	---		
Jul	100	1.5	15		25	0.5 to 1.0			100(1)	1.5		
Aug	565(23)	2.5 to 3	86	1.0 to 1.5	50	1.0 to 1.5			70(1)	1.0 to 1.5		
Sep	60.5		63		25(1)							
Oct	42	1.0 to 1.5	30	1.0 to 1.5	ND	---	12.5(2)	<0.5	ND	---		
Nov	31		42(28)					13(1)	0.5	12(1)	<0.5	
Dec	29.5		54(15)				15(1)	0.5 to 1.0	ND	---		
<b>near Fairbank<sup>4</sup></b>												
Jan	ND	---	ND	---	ND	---	ND	---	ND	---	14(1)	0.5 to 1.0
Feb											ND	---
Mar											21.9(1)	0.5 to 1.0
Apr											17.7(1)	
May												
Jun											ND	---
Jul												
Aug											766(1)	>2.0
Sep												
Oct												
Nov											ND	---
Dec												

Notes:

- <sup>1</sup> Median discharge (Q) in cubic feet per second (cfs); italics indicate number of days during month that Q was measured if other than all days. "ND" indicates no data were collected during month.
- <sup>2</sup> Average channel depth (D) in feet (ft) at Q based on historic rating curves presented on p.7-12 and in Appendix E of Fuller (2004). Warmer colors denote shallower depths. "---" indicates no discharge data available to estimate D.
- <sup>3</sup> Discharge data from U.S. Geological Survey (USGS) Water-Supply and Irrigation Papers 133 and 175 and Water-Supply Papers 211, 289 and 309. Diversions above station reported in 1911 as "about 50 acres irrigated".
- <sup>4</sup> Discharge data from USGS Water-Supply Paper 329. Values calculated, as necessary, by summing streamflows measured below Boquillas diversion dam with diversions measured in 2 sluiceways and 2 canals above the dam. Diversions above station reported in 1912 as "some water is used for irrigation above Charleston. Nearly the entire low-water flow is diverted at the dam for irrigation on Boquillas ranch."

TABLE 3 - UPPER SAN PEDRO RIVER STREAMFLOWS AT HEREFORD IN DECADE FOLLOWING STATEHOOD

YEAR / MONTH	Q (cfs) <sup>1,2,3</sup>										
	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	
Jan	ND	ND	ND	ND	ND	ND	ND	174 to 179 (2)	ND	ND	
Feb								ND			
Mar	2.4 (1)							6.6 (1)			
Apr	ND							3.8 (1)			
May								4.2 (1)	ND		
Jun								2.1 (1)			
Jul							ND	12.3 to 30.7 (2)	491 (1)		
Aug	ND						5.5 to 90 (3)	11.7 (1)	185 (1)		10.8 to 37.5 (2)
Sep							ND	ND	ND		
Oct								4.0 (1)			
Nov		54(1)	3.3 (1)								
Dec	ND	ND	7.4 (1)								

Notes:

- <sup>1</sup> Discharge (Q) in cubic feet per second (cfs); italics indicate number of days Q was measured during month; "ND" indicates that no data were collected.
- <sup>2</sup> Data collected by U.S. Geological Survey (USGS) personnel and compiled by them in the unpublished September 1977 report *Discharge measurements made at points other than gaging stations in Arizona through the 1976 water year*.
- <sup>3</sup> USGS Water-Supply Paper 309 reports that in 1911 San Pedro River diversions above the Charleston gage, which includes the Hereford area, were "about 50 acres irrigated." USGS Water-Supply Paper 719 reports that in 1931 there were "no diversions above (the Palominas) station in Arizona and probably none in Mexico." Palominas is located about four miles upstream of Hereford.

TABLE 4 - TYPICAL FLOW CONDITIONS AT USGS GAGING STATIONS ON THE SAN PEDRO RIVER<sup>1</sup>

GAGE LOCATION	DISCHARGE DATA <sup>2</sup>		AVERAGE HYDRAULIC CHARACTERISTICS <sup>3</sup>			RATING CURVE PERIOD <sup>4</sup>
	Period of Record	Median Flow (cfs)	Depth (ft)	Velocity (ft/sec)	Top Width (ft)	
Palominas	1931-1981	2.7	---			NP
Charleston	1905-1989	14	0.5	3.0	5	1904-1906
			0.4	1.3	24	1982-1992
Tombstone	1968-1986	13	0.7	2.4	9	1915-1924
			0.4	1.4	24	1981-1986
Benson	1967-1976	0	0	0	0	NP
Redington	1944-1989	0.6	0.2	0.6	4	1981-1992
Winkelman	1967-1978	3	---			NP

## Notes:

<sup>1</sup> Data from Fuller (2004).

<sup>2</sup> See pp. 7-9 and 7-10 of Fuller; median flow in cubic feet per second (cfs) is equivalent to the "50% Flow Period".

<sup>3</sup> See pp. 7-14 through 7-18 of Fuller; hydraulic characteristics in feet (ft) and feet per second (ft/sec) were estimated by comparing median flows to station rating curves.

<sup>4</sup> See Appendix E of Fuller; rating curves were not provided (NP) for the Palominas, Benson, and Winkelman stations.

# **FIGURE**

**FIGURE 1 – LOCATION OF HISTORIC STREAMFLOW ACCOUNTS AND USGS GAGING STATIONS ALONG THE SAN PEDRO RIVER**

