ASSESSMENT OF WATER RESOURCE CONDITIONS IN SUPPORT OF INSTREAM FLOW WATER RIGHTS FOR ARAVAIPA CREEK

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ASSESSMENT OF WATER RESOURCE CONDITIONS IN SUPPORT OF INSTREAM FLOW WATER RIGHTS FOR ARAVAIPA CREEK

Introduction

During 1981, the Bureau of Land Management (BLM) submitted an Application for Permit to Appropriate Water to the Department of Water Resources (DWR). The purpose of the application was to seek and perfect a water right for the maintenance of perennial flow occurring in that portion of Aravaipa Creek located within the Primitive Area (now designated as a Wilderness Area). The application number assigned was 33-87114.

The application was initiated to protect the natural attributes of the Primitive Area. The remoteness of the area and the ecological values (i.e. flowing water, riparian vegetation, good water quality) provide ideal conditions for numerous and varied wildlife and native fish species, as well as an attraction for nature lovers and outdoor enthusiasts. People use the canyon to enjoy the recreational opportunities the area offers. The goal of the instream flow right is to protect and enhance these values by maintaining naturally occurring flows.

Two years prior to the submission of the application (in early 1979), BLM initiated in situ flow measurements, with a current meter, at the east end of the Primitive Area. During mid to late 1980, two streamgaging stations were installed to collect daily streamflow data. The BLM realized that sometime in the near future, they would have to quantify and appropriate the minimum amount of water needed to protect and maintain the flow through the canyon and the uses associated with that flow.

On August 28, 1984, the 4,044-acre Primitive Area was designated a BLM Wilderness Area, with some additional acreage along tributaries included with the new designation. The 6,699-acre wilderness area includes portions of the following tributaries: Parson's, Hell Hole, Paisano, Booger, Horse Camp, Virgus, Javelina, Hell's Half Acre, and Painted Cave Canyons. The beginning and ending points of the creek itself remained unchanged. Figure 1 shows current wilderness boundaries and locations of BLM gaging stations.

Environmental Setting

Aravaipa Creek, a tributary to the San Pedro River, is located in Pinal and Graham Counties of southeastern Arizona. Its watershed begins in the Galiuro Mountains, extending 10 to 15 miles to the central ridge of the Santa Teresa Mountains, and ends about 35 miles to the north. The watershed comprises 541 square miles and includes elevations between 2,160 and 8,441 feet (above mean sea level).

Of the approximately 17 miles of perennial surface flow, 11 1/2 miles are located within the Aravaipa Canyon Wilderness managed by the BLM. It is this stretch of flow for which instream flow is being quantified. A detailed discussion of the hydrology and geology of Aravaipa Creek is contained in Ellingson (1980).

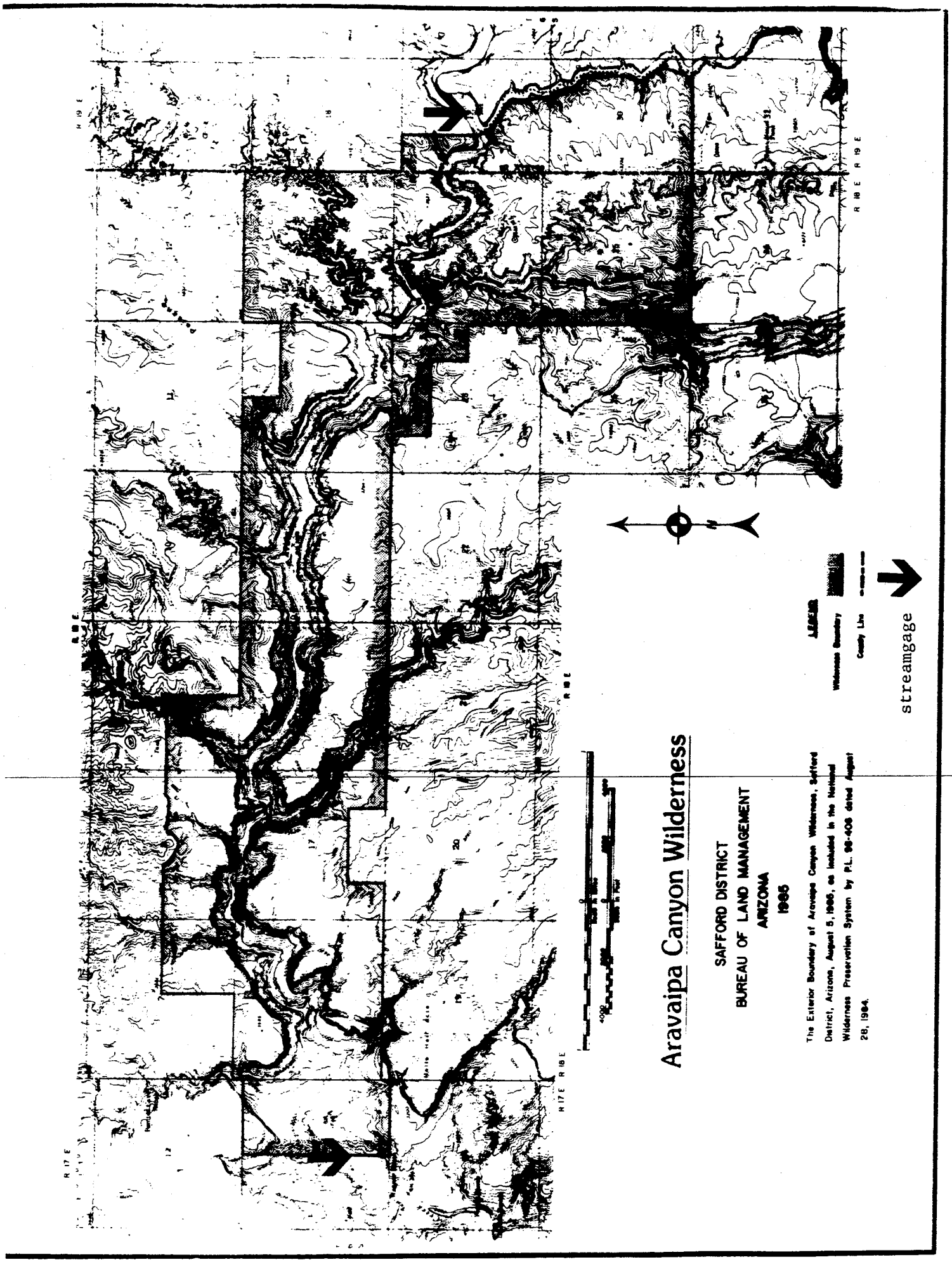

Figure 1. Aravaipa Canyon Wilderness and BLM Streamgages.

Precipitation patterns are characterized by spring droughts, summer monsoons, and regular winter rainfall. Precipitation over the watershed averages about 16" per year, or 480,000 acre-feet, of which an estimated 95% is lost to evaporation and transpiration. Of the 7,400 acre-foot base flow, another 2,400 acre-feet can be expected to be lost to evapotranspiration.

Temperatures in the canyon consist of hot summers with mild winters. Mean maximum temperatures range from 90 to 100 degrees Fahrenheit from June through September, while mean minimums are between 30 and 40 degrees from November to February.

Vegetation varies from open woodland and chaparral communities in the upper watershed to grassland, desert-scrub, and riparian in the lower portions. Approximately 300 species have been recorded on the watershed, half of which occur in the wilderness. A list of species can be found in Appendix A of Minckley (1981).

Specifics of the Application

The application requested a quantity of in situ surface flow in the amount of 10,860 acre-feet, or 15 cubic feet per second (cfs), per annum. The given legal description, as amended, includes the entire length of the surface flow contained within the then Primitive Area, as follows:

T. 6 S., R. 19 E.	Sec. 19, W½
T. 6 S., R. 18 E.	Sec. 24, N½
	Sec. 23, NE
	Sec. 14
	Sec. 15, N½
	Sec. 16, N½
	Sec. 17, N½
	Sec. 18
	Sec. 8, SW
	Sec. 7, SE
T. 6 S., R. 17 E.,	Sec. 13, E½

The quantity of flow claimed on the application was broken into two separate use categories. The first category claimed 10 cfs (7,240 acre-feet) yearlong for wildlife and fisheries consumptive and non-consumptive use. The rest of the Explanatory section listed the threatened and endangered fish and wildlife species found in or adjacent to the main channel. The second category claimed an additional five cfs yearlong (3,620 acre-feet) for riparian ecosystem maintenance and aesthetic recreational values.

The separation of the quantities of flow into two different beneficial uses should not be construed as two separate and distinct requests for instream flow, but should be considered as a single request for a quantity of water to fulfill each and all of the stated uses. Initially, the reasoning was that separate flows should be distinguished according to the beneficial uses applicable under state law. In retrospect, the uses should not have been separated but should have been combined to avoid the belief that the quantities were indeed separate.

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Water Resource Values

The natural values of Aravaipa Canyon are inextricably linked to the water resource. The riparian habitat created by the perennial water flow is unique from the surrounding Lower Sonoran desert-shrub. Without the water, many plant and animal species would disappear. The biological diversity would be reduced as the existing riparian community was eliminated. Instream values and recreational experiences are also dependent upon instream flow (including floods and related groundwater conditions). Baseflows and riparian zone water tables are maintained almost entirely by inflows from the upstream Aravaipa Valley watershed. Depletion of the streamflow from upstream diversions could reduce instream flows, eventually affecting the riparian habitat and fish populations within the canyon.

Perennial water in the southwestern United States draws people for numerous water-based recreational activities. Aravaipa Canyon provides the user with a chance to be closely associated with nature through immediate contact with the surface flow and all of the water-dependent attributes or qualities.

The existing natural resources and the quality of the recreational experience are totally dependent upon a sufficient quantity of flow through the canyon. Very low flows (less than 10 cfs) could be tolerated by the entire system for short periods of time. But, extensive low flows (in excess of two months) coupled with high summer temperatures may cause stresses on the flora and fauna from which they could never recover. Long duration low flows would certainly affect the quality of the recreational users' experience.

Streamflow Measurement

East End

In March of 1979, the District initiated streamflow measurements at the east boundary of Aravaipa Primitive Area. These measurements provided the base data prior to the installation of a streamgaging station. The streamgaging station was installed in late July of 1980, and became fully operational by August 1, 1980.

Due to problems with this station over the years, this flow data will not be used for analyzing instream flows. Only the monthly/semi-monthly flow measurement will be inserted for a comparison with the monthly/semi-monthly measurements collected at the west end (see Appendix 2). Flow has been continuously measured at this site nearly every month, and more often twice a month (see Appendix 1). All measurements are in accordance with U.S. Geological Survey (USGS) standards.

West End

In September, 1980, the District installed a streamgaging station at the west end of Aravaipa Canyon, where the flow exits from the wilderness area; the station became fully operational in December.

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This station continued to record data until October, 1983, when all of the instrumentation and flow measuring equipment was lost during that flood. Included in the loss were three months of chart data. Flow measurements were not taken until May 1984 when new equipment was obtained. The gaging station was restored to operational status and has been functional since. Consistency in measurement has been maintained since 1982 by using the permanent Park Ranger who lives near the site.

Streamflow Data

West End

Earlier problems with the data have been resolved due to the development of a new rating curve. The original computations were taken from one early-developed rating curve even though the staff gage had been lost and replaced several times. Steps have been taken to ensure that the data conforms to USGS standards. A minimum of two flow measurements are taken each month and routine station maintenance is carried out at least three times a month.

Nearly six years of flow data is tabulated for the West Aravaipa gaging station (Appendix 2). Of the six years of data, the lowest flow (a discharge of 7.0 cfs) occurred during July of 1982. Unfortunately the chart data for July 1983 was lost preventing an examination for comparative flow. Since the 1983 flood, the lowest discharge, 18.2 cfs, occurred on July 23, 1987.

A quick examination of the tabulated flow data reveals that, in portions of the columns there are no numbers for daily cfs. This lack of data occurred because very few flow measurements were taken during, or after periods of flooding. Most flow measurements occurred during lower flows. Although data in excess of 100 cfs is lacking, the range of flows of primary concern to BLM is 10-100 cfs. Therefore, lacking actual high flow data, the rating curve for this station is projected. The projection line allows a "best guess" for flows above 100 cfs.

Since BLM's application is for naturally occurring flows in the range of 10 to 40 cfs, the greatest emphasis in accuracy is placed on measurements in this range.

BLM Gaging Station vs USGS Gaging Station

The use of the BLM gaging station to measure the Aravaipa streamflow has advantages over using the USGS gaging station located downstream. The advantages are enumerated as follows:

1. The BLM gaging station measures the flow as it exits from the canyon, while the USGS station is located 5.75 air miles further downstream.

2. The BLM station is maintained two to four times a month while the USGS station is usually serviced once a month.

3. Flow is usually measured twice a month at the BLM station.

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4. A number of domestic residences exist between the two stations. Many of the residences use irrigation from the creek for their gardens, orchards, and fields. This use would have to affect the quantity of flow occurring at the lower gaging station.

5. The USGS rates the data from Station No. 09473000 as fair due to irrigation occurring upstream.

Although the BLM gage provides measurement of flow exiting directly from the canyon, only seven years of data are available for the station. Most of this was collected in wet years and does not accurately reflect long-term averages.

Due to upstream irrigation withdrawals, the USGS gaging station records lower flows than the BLM gage. This affects the months of April through September but is especially apparent in the data between April and June. The USGS gage provides a long-term view of flow trends, and may provide a better overall average since it includes data from both wet and dry years. For this reason, the 21 years of USGS flow data summarized by Minckley was considered along with the BLM data for purposes of comparison.

The following chart summarizes mean monthly flows for both stations:

Month	J	F	M	A	M	J	J	A	S	O	N	D
USGS 21-yr. avg.	25	58	43	14	10	9	21	30	23	28	15	39
BLM, West 7-yr. avg.	34	40	49	29	24	21	26	29	28	24	26	35

Wildlife Considerations

Aravaipa Canyon supports a wide variety of wildlife species, many of which are dependent on the perennial water and adjacent riparian habitat provided by the creek. A total of seven native fish, eight amphibian, 47 reptile, 237 bird, and 46 mammal species have been reported in the canyon; of these 305 species, 20 receive federal or state protection (Appendix 3).

No group of animals is as susceptible to changes in water quantity and quality as the fishes. For this reason, biological resource analysis is based on flows needed to maintain the native fish population. Three of the seven species of fish in Aravaipa are protected by federal and state regulations. The loach minnow (*Tiaroga cobitis*) and spikedace (*Meda fulgida*) are Federally Threatened, while the Gila roundtail chub (*Gila robusta grahami*) is a Federal Category 2 Candidate species. All three are listed as Group 3 Threatened by the State of Arizona.

In 1980-81, the USFWS financed a study of flows in Aravaipa Creek (Turner and Tafanelli, 1983) required for the Federally Threatened *Meda* and *Tiaroga*. They concluded that ... "a discharge of 20 cfs provided the most available habitat for adult *Meda* and *Tiaroga*." Habitat ... "rapidly decreases at discharges less than 10 cfs for both species. A minimum discharge of 13 cfs at

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BLM's East Aravaipa gaging station would be an acceptable minimum flow for adult Meda and Tiaroga during low-flow periods in the summer and fall."

The USFWS study (Appendix 4) discusses yearlong flow requirements for the two species of fish. While it concludes that scouring flows during winter probably are necessary to clean silt and sand from cobble sites used for spawning, no recommendations were made for these flows.

The BLM study by ASU (Minckley 1981) analyzes 21 years of monthly average flows from the USGS gaging. It also discusses the relationship between flows and fish and riparian habitat.

Dr. Minckley commented on some ecological principles to consider for instream flow. He believes that high winter and summer flows are necessary to clean gravel, scour pools, and recharge the riparian zone. Based on his 25 years of experience in Aravaipa, a stable flow of 15 cfs would probably be disasterous. He recommended that flows vary in a pattern following the natural, unregulated flow regime. His estimation for the low flow for April-May-June should be approximately 10 cfs, and a similar low flow in the October-November period. The difference between 10 and 15 cfs for these months should be added to winter and summer months. He pointed out a deficiency acknowledged in the USFWS report: The flow recommendations were for adult fishes only; there are no data for the needs of egg or fry.

Generally, the population of the seven species of native fish vary in absolute numbers and in proportion with each other. The environmental factors that allow seven species to coexist in a relatively small stream are created at least in part by a complex pattern of discharge amounts. Complex environments allow species diversity to increase as no single species can specialize for all the conditions present. No other stream in Arizona supports more than five native fish species. Aravaipa Creek is unique in its diversity.

Based on this input, fisheries needs in Aravaipa would best be accommodated with a varying flow regime while maintaining a 15 cfs average as follows:

Month	J	F	M	A	M	J	J	A	S	O	N	D
cfs	20	25	20	10	10	10	15	20	10	10	10	20

Recreational Considerations

The water of Aravaipa Creek and its tributaries is extremely important to the recreational experiences of visitors to Aravaipa Canyon. Nearly every recreational opportunity found in Aravaipa Canyon is enhanced by or focused on the water of Aravaipa Creek. The presence of a perennial stream in a desert setting attracts many people from Arizona and throughout the world, not only for hiking, wading and swimming activities, but for birdwatching and viewing other wildlife that the water of Aravaipa Creek supports directly or by providing riparian habitat.

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These conclusions are based upon verbal comments by visitors to Aravaipa rangers and other BLM employees, written comments on visitor register sheets at the wilderness trailheads, letters and articles. Comments received during the preparation of the Aravaipa Canyon Wilderness Management Plan also recognized the importance of maintaining necessary and adequate streamflow in Aravaipa Creek.

An Aravaipa Canyon Wilderness (ACW) recreation visitor survey was conducted by the University of Arizona during a 12-month period in 1987-88 to obtain information about visitor preference regarding a variety of factors that affect experience in the wilderness. A total of 665 responses (83% response rate) were received and evaluated. Data from that survey has been used to prepare A Preliminary Analysis of the Significance of Water to Recreational Visitors at Aravaipa Canyon Wilderness, Arizona, a copy of which is attached as Appendix 5.

The analysis showed that water and water-related recreational activities in Aravaipa Canyon Wilderness are highly valued by people visiting the area. Of 13 Aravaipa Canyon elements listed, water was ranked most frequently as the most important element in the canyon. Water was ranked among the top five of those Aravaipa Canyon elements by 82% of the respondents. Other elements ranking highly included peace and quiet, solitude and wildlife.

Two activities, hiking in the creek and swimming, were highly rated by visitors. The survey showed that 95% of the respondents liked or strongly liked hiking in the creek. Considering a more common assumption that people would rather hike with dry feet, that response is significant with respect to the importance of Aravaipa Creek to ACW visitors. About 78% responded that they would like or strongly like to swim during future wilderness visits.

Analysis of data from the survey also indicates that visitors are sensitive to changes in Aravaipa Creek streamflow. Approximately 88% of the respondents found streamflow at preferable levels. Further analysis of the data showed that visitors to the wilderness prefer some streamflow levels over others. Through that analysis, it was possible to determine at what streamflow volumes respondents were more likely to indicate that they saw less water than they prefer, as much water as they prefer or more water than they prefer.

The researchers postulated that declines in streamflow increased the likelihood that respondents would report they found less water than they preferred. Since visitors appear to be highly satisfied with current flows, declines to less than those experienced are likely to cause dissatisfaction. The availability of swimming and other water-related activities is decreased as deep pools and swimming holes disappear at low flows. The aesthetic character of the canyon is also changed, with dying vegetation and stagnant pools increasing due to lessened flow.

Many Aravaipa Canyon Wilderness visitors have been to the canyon before. The recreation visitor survey showed that over 51% of the respondents had previously visited ACW. These repeat visitors are more likely to be accustomed to average flows and thus more likely to be dissatisfied with flows that vary from the natural flow regime. If flows were to decline below the requested

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quantities some visitors might seek other locations with water-related qualities they desire. The attraction of Aravaipa Canyon for recreation could be diminished.

Without a sufficient flow of water in Aravaipa Creek, the uncommon, and in some cases, unique recreation opportunities present in Aravaipa Canyon would not exist. The chances of seeing a rare bird or viewing desert bighorn sheep in the canyon are greatly improved by the presence of a perennial stream and the vegetation and habitat it supports. Other recreational activities possible in a desert wilderness setting are made more enjoyable by the flowing stream. In the opinion of many visitors, the water of Aravaipa Creek and its tributaries is the single most important element of Aravaipa Canyon Wilderness.

Aravaipa Canyon is a wilderness area and must be managed to maintain its wilderness character, including natural conditions and outstanding opportunities for primitive recreation. The maintenance of the natural ecosystem requires flows to follow their natural cycles. Adequate flows are also necessary to perpetuate recreational opportunities and the aesthetic attraction of Aravaipa Canyon. For this reason, a range of flows that would satisfy visitor expectations without varying from the natural flow pattern is requested.

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SUMMARY AND CONCLUSION

An application for an instream flow water right in Aravaipa Creek was filed by the BLM on June 1, 1981. This request for 15 cfs was based on a "best guess" of the minimum needs for the recreational and wildlife uses. Since that time, three studies of particular concern were conducted in the canyon. Minckley (1981) summarized the physical and biological characteristics of the creek, and included USGS statistics on flow data for a 21-year period, with monthly averages. Turner and Tafanelli (1983) evaluated the instream flow requirements of native fishes in Aravaipa Creek. These reports, coupled with recent discussions with Minckley, resulted in a recommendation for varying monthly flow amounts, while maintaining an average flow request of 15 cfs over the year.

Moore and Brickler (1988) analyzed visitor satisfaction at Aravaipa Canyon Wilderness, and attempted to correlate this with stream discharge. They found that visitors were sensitive to changes in streamflow, and suggest that below average flows would result in some visitor dissatisfaction.

Seven years of flow data from BLM's West Aravaipa gaging station and 21 years of flow data from the USGS station downstream (Minckley, 1981) were compared for streamflow trends. The long-term monthly flows of the creek vary on a seasonal basis. In most months, flows are higher than the 15 cfs requested in the original application; for three months flows are lower. The USGS data for April-June suggest that there may be insufficient flow during those months to support the original 15 cfs request during these months; the 7-year BLM average indicates otherwise.

High flows are needed to scour silt to produce sites for fish egg-laying. They also tend to wash out mats of aquatic vegetation, making a more pleasant recreational experience for hikers. To account for the seasonal fluctuations in flows, BLM proposes to modify the original application according to the 21-year average. The monthly requests for flow follow the natural flow pattern of the creek, as established by the West End gage. Flows were also selected not to exceed average flows occurring at the USGS gage downstream. Figure 2 compares these three flow patterns.

Although recent studies indicate that flows greater than 15 cfs would be beneficial for some periods, we have attempted to reconcile all beneficial uses while staying within the 15 cfs average of our 1981 application. Overall, the instream flow request accounts for less than half of the average monthly flow measured at the West End gage.

Month	J	F	M	A	M	J	J	A	S	O	N	D
Instream Flow Nomination	20	25	20	10	10	9	10	20	11	15	10	20

The instream flow requested above, which averages to the 15 cfs in the original application, is compared to USGS and GLM averages in Figures 2a and 2b.

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Figure 2a.

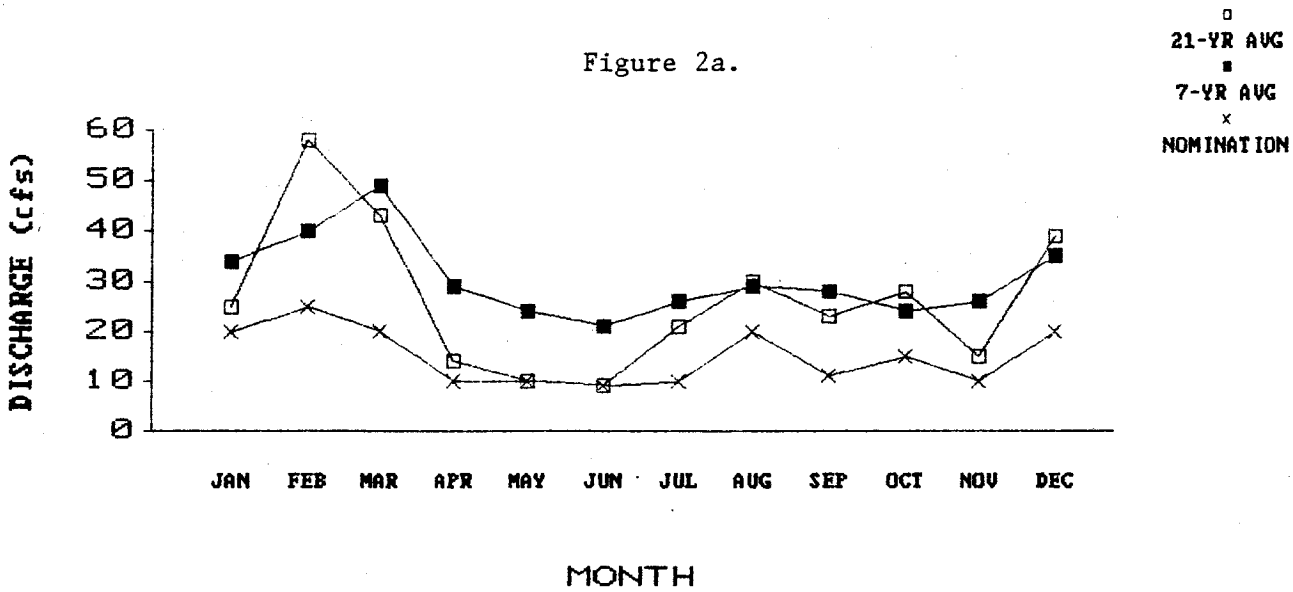
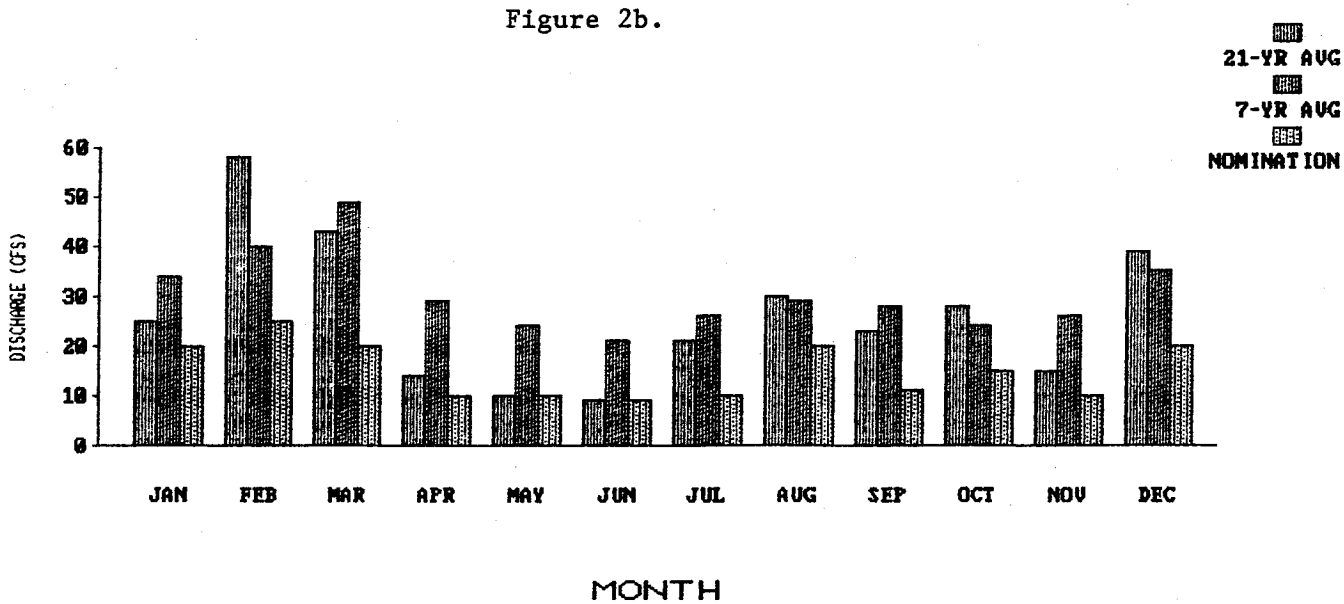


Figure 2. Comparison of Instream Flow Request with USGS and BLM monthly streamflow averages.

Figure 2b.



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Subject to valid existing rights, the BLM regards this flow regime as a valid representation of current instream, non-consumptive uses in Aravaipa Creek. As such, this regime represents the minimum amounts of flow needed to maintain and preserve the character of water-dependent values in the Aravaipa Canyon Wilderness. Any diversions of stream flow from Aravaipa Creek which would result in a net depletion of streamflow at the east entrance to the area will diminish the water dependent values within the wilderness. Therefore, these flows are not considered average monthly flows, but, rather, average daily flows. In other words, we cannot tolerate some days of 30 cfs and some of 0 cfs even though they average to 15 cfs.

This flow regime results in a 10,840 acre-feet per year request, compared to the 10,860 acre-feet per year calculated at the 15 cfs per month rate of flow. BLM will continue to measure flow through the canyon, and will use the West End gage to monitor flows granted through this application.

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APPENDIX 1
Monthly/Semi-monthly Streamflow Measurements
at East and West Aravaipa Streamgaging Stations

East Aravaipa		West Aravaipa		East Aravaipa		West Aravaipa	
Date	CFS	Date	CFS	Date	CFS	Date	CFS
	1979				1981		
03/14/79	33.2			03/10/81	23.1	03/13/81	32.9
03/20/79	31.2					04/16/81	23.2
04/02/79	36.7			06/02/81	16.8	06/04/81	10.2
04/23/79	34.3			07/08/81	14.1		
						07/17/81	34.3
05/10/79	28.1					09/09/81	17.4
05/30/79	29.4			10/23/81	14.6		
06/13/79	29.5					10/28/81	13.6
06/27/79	33.0					11/23/81	16.3
07/11/79	23.0			12/24/81	16.1		
07/18/79	20.9						
08/16/79	29.8			12/31/81	15.5		
10/23/79	24.0						
	1980				1982		
06/20/80	21.6			01/15/82	20.5		
06/26/80	18.6			01/29/82	17.3	01/27/82	24.5
07/15/80	21.4			02/24/82	18.8		
07/17/80	13.5			03/02/82	17.5	03/05/82	23.8
				03/12/82	16.7		
07/22/80	20.3					04/09/82	23.8
~~07/29/80~~	~~24.3~~			~~04/27/82~~	~~12.3~~		
08/06/80	26.0			05/13/82	16.0		
				05/24/82	10.8		
10/24/80	14.7						
		12/12/80	28.0	06/04/82	11.9		
				06/09/82	9.2		
12/19/80	21.3						
				07/06/82	6.8	07/09/82	7.8
				07/20/82	10.8		
				08/03/82	17.3		
						08/31/82	17.8
				09/22/82	7.8		
						09/29/82	16.1
				10/09/82	12.6		
				10/19/82	10.2	10/16/82	14.3
						10/31/82	16.6
				11/05/82	9.2		
						11/13/82	15.6
				12/02/82	14.9		
				12/18/82	9.9		

East Aravaipa		West Aravaipa		East Aravaipa		West Aravaipa	
Date	CFS	Date	CFS	Date	CFS	Date	CFS
	1983				1984		
01/04/83	16.5			01/10/84	31.0		
01/22/83	10.1	01/24/83	23.4	01/22/84	33.1		
02/11/83	21.2			02/27/84	37.9		
02/15/83	26.2	02/18/83	32.3	04/03/84	27.5		
02/28/83	17.2			04/17/84	36.3		
		03/10/83	38.3	04/30/84	30.7		
		04/02/83	43.9			05/02/84	37.1
04/08/83	26.7	04/12/83	43.9	05/14/84	33.1		
		04/17/83	44.3				
04/29/83	17.0			06/11/84	30.1	06/15/84	31.6
				06/22/84	25.3		
		05/01/83	27.4	07/04/84	26.7		
05/16/83	16.6	05/15/83	27.4	07/16/84	26.7	07/15/84	41.5
		05/29/83	22.3				
				08/04/84	34.4		
06/04/83	18.5					08/10/84	43.4
06/17/83	17.9	06/13/83	21.9	08/24/84	66.8		
06/29/83	10.0	06/30/83	11.1	09/13/84	37.0		
						09/19/84	34.2
07/12/83	20.8						
		07/18/83	19.9	10/01/84	30.7		
07/22/83	27.5					10/06/84	31.2
		07/30/83	32.4	10/16/84	29.3		
						10/21/84	30.7
08/09/83	21.9			11/02/84	30.4	11/04/84	31.4
08/29/83	25.2	08/28/83	23.0	11/16/84	27.9		
09/14/83	20.7			11/20/84	30.0		
		09/25/83	28.5	12/10/84	29.2	12/05/84	34.4
				12/22/84	47.0	12/19/84	46.2
10/18/83	40.0						
11/17/83	33.4						
11/22/83	28.7						
11/25/83	30.5						
12/07/83	43.7						
12/12/83	34.6						

East Aravaipa		West Aravaipa		East Aravaipa		West Aravaipa	
Date	CFS	Date	CFS	Date	CFS	Date	CFS
	1987				1988		
01/05/87	25.6	01/04/87	25.1	01/04/88	22.7		
01/11/87	26.5					01/10/88	23.0
		01/19/87	25.8	01/19/88	24.8	01/23/88	27.8
		01/31/87	45.6	02/01/88	20.6		
						02/07/88	34.2
02/01/87	25.9			02/15/88	21.3		
		02/13/87	26.9	02/28/88	21.8	02/28/88	22.9
02/20/87	25.9						
03/02/87	30.6	03/01/87	94.7				
03/16/87	30.5	03/14/87	40.7			03/13/88	22.2
03/30/87	23.6	03/29/87	28.6			03/20/88	22.3
				04/04/88	19.6	04/03/88	19.9
04/13/87	26.2	04/11/87	26.4	04/19/88	19.8	04/17/88	20.9
04/27/87	23.6					04/29/88	23.2
		05/03/87	24.7				
05/11/87	21.8			05/04/88	18.0		
		05/17/87	23.1			05/15/88	20.0
05/25/87	23.5	05/29/87	21.1				
06/08/87	22.5						
		06/14/87	21.4				
06/22/87	21.0						
		06/28/87	20.6				
07/06/87	20.2						
		07/12/87	19.0				
07/20/87	21.7						
		07/26/87	18.9				
08/03/87	25.0						
		08/09/87	22.3				
08/17/87	22.7						
		08/23/87	21.9				
08/31/87	21.6						
		09/07/87	21.9				
09/14/87	21.8						
		09/20/87	19.6				
09/28/87	21.6						
		10/04/87	20.1				
10/12/87	21.6						
		10/18/87	23.3				
10/28/87	23.2						
		11/02/87	26.5				
11/10/87	22.2						
11/23/87	21.3						
12/07/87	22.0	12/06/87	23.7				
12/21/87	24.1	12/20/87	44.2				

East Aravaipa		West Aravaipa		East Aravaipa		West Aravaipa	
Date	CFS	Date	CFS	Date	CFS	Date	CFS
	1985				1986		
		01/16/85	39.2	01/13/86	28.3	01/12/86	27.4
02/12/85	62.4	02/14/85	65.7	01/27/86	27.1	01/25/86	26.3
02/26/85	52.6			02/11/86	29.3		
				02/24/86	27.7	02/21/86	34.2
		03/01/85	71.0				
03/11/42.4				03/10/86	24.3	03/09/86	26.9
		03/16/85	58.1			03/23/86	55.2
03/22/85	42.1			04/08/86	29.4	04/06/86	30.5
		03/31/85	45.2	04/20/86	27.6	04/20/86	28.2
04/08/85	37.8			05/04/86	26.0	05/04/86	27.2
		04/14/85	44.4	05/19/86	25.7		
04/22/85	40.2			06/02/86	25.8	06/01/86	23.0
		04/30/85	39.5	06/16/86	24.9	06/15/86	21.9
						06/29/86	22.9
05/06/85	37.7						
		05/12/85	37.5	07/21/86	22.9	07/20/86	21.2
05/20/85	36.4			07/29/86	31.3		
				08/04/86	24.0	08/03/86	23.7
06/03/85	35.1			08/18/86	29.4		
		06/09/85	33.0			08/23/86	23.9
06/17/85	31.3	06/23/85	28.5				
06/30/85	29.2			09/01/86	30.6		
						09/07/86	25.5
07/15/85	29.5					09/21/86	23.9
08/12/85	35.8			09/29/86	24.5		
08/26/85	31.8	08/25/85	27.7				
						10/15/86	24.6
09/09/85	27.6			10/13/86	35.8		
		09/14/85	28.2	10/27/86	24.8	10/25/86	26.7
09/23/85	29.2			11/10/86	25.6	11/09/86	27.6
		09/29/85	43.4	11/24/86	28.1	11/23/86	25.6
10/07/85	28.2			12/01/86	23.8		
		10/13/85	35.2	12/08/86	48.4		
10/21/85	29.3					12/11/86	38.6
				12/15/86	26.7		
11/04/85	29.9	11/02/85	29.6	12/22/86	26.8		
11/18/85	28.7	11/17/85	30.0	12/29/86	25.8		
12/02/85	31.6	12/01/85	55.5				
12/16/85	28.8						
		12/21/85	31.4				
12/30/85	26.4						

APPENDIX 2

Streamflow Tabulation Data for BLM West Aravaipa Gaging Station, 1981-1988

STATION: West Aravaipa

STREAMFLOW TABULATION

WY: 1981

Month:							December			January		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1										1.24	33.5	
2										1.24	33.5	
3										1.24	33.5	
4										1.23	32.2	
5										1.25	34.8	
6										1.25	34.8	
7										1.26	36.0	
8										1.26	36.0	
9										1.26	36.0	
10										1.26	36.0	
11										1.25	34.8	
12							1.19E	27.7		1.25	34.8	
13							1.24	33.5		1.24	33.5	
14							1.22	31.0		1.24	33.5	
15							1.23	32.2		1.24	33.5	
16							1.24	33.5		1.23	32.2	
17							1.24	33.5		1.23	32.2	
18							1.24	33.5		1.23	32.2	
19							1.24	33.5		1.24	33.5	
20							1.24	33.5		1.24	33.5	
21							1.24	33.5		1.22	31.0	
22							1.24	33.5		1.22	31.0	
23							1.24	33.5		1.23	32.2	
24							1.23	32.2		1.21	29.8	
25							1.23	32.2		1.21	29.8	
26							1.24	33.5		1.22	31.0	
27							1.23	32.2		1.22	31.0	
28							1.24	33.5		1.22	31.0	
29							1.24	33.5		1.23	32.2	
30							1.24	33.5		1.22	31.0	
31							1.25	34.8		1.21	29.8	
TAL								657.8	1304.7		1019.8	2022.7
VE.								32.8	65.2		32.8	65.2

STATION: W. Aravaipa

STREAMFLOW TABULATION

WY: 1981

Month:	February			March			April			May		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	1.21	29.8		1.20	28.5		1.08	19.4		1.13	22.9	
2	1.21	29.8		1.58	110.8		1.10	20.5		1.08	19.4	
3	1.22	31.0		1.76	204.0		1.15	24.5		1.06	18.3	
4	1.21	29.8		1.82	248.0		1.14	23.7		1.03	16.6	
5	1.21	29.8		1.56	103.6		1.14	23.7		1.03	16.6	
6	1.22	31.0		2.02	---		1.13	22.9		1.03	16.6	
7	1.22	31.0		1.66	146.0		1.14	23.7		1.02	16.1	
8	1.22	31.0		1.39	55.8		1.14	23.7		1.02	16.1	
9	1.67	31.0		1.32	44.3		1.15	24.5		1.02	16.1	
10	1.52	89.2		1.26	36.0		1.15	24.5		1.00	15.0	
11	1.26	36.0		1.19	27.7		1.14	23.7		.99	14.6	
12	1.23	32.2		1.20	28.5		1.15	24.5		.95	13.1	
13	1.22	31.0		1.22	31.0		1.15	24.5		.93	12.3	
14	1.21	29.8		1.20	28.5		1.14	23.7		.94	12.7	
15	1.21	29.8		1.17	26.1		1.13	22.9		.93	12.3	
16	1.21	29.8		1.17	26.1		1.18	26.9		.97	13.9	
17	1.21	29.8		1.17	26.1		1.13	22.9		.98	14.2	
18	1.21	29.8		1.16	25.3		1.10	20.5		.99	14.6	
19	1.21	29.8		1.16	25.3		1.09	20.0		.99	14.6	
20	1.21	29.8		1.18	26.9		1.08	19.4		.99	14.6	
21	1.20	28.5		1.17	26.1		1.08	19.4		.99	14.6	
22	1.20	28.5		1.16	25.3		1.08	19.4		.99	14.6	
23	1.20	28.5		1.16	25.3		1.07	18.8		.98	14.2	
24	1.20	28.5		1.15	24.5		1.06	18.3		.98	14.2	
25	1.20	28.5		1.15	24.5		1.01	15.6		.98	14.2	
26	1.22	31.0		1.15	24.5		.99	14.6		.96	13.5	
27	1.20	28.5		1.12	22.1		.99	14.6		.96	13.5	
28	1.21	29.8		1.09	20.0		.99	14.6		.96	13.5	
29				1.10	20.5		.98	14.2		.95	13.1	
30				1.12	22.1		1.01	15.6		.94	12.7	
31				1.08	19.4		1.06	18.3				
		1023.02	2029.1		1502.8	2981.0		643.5	1276.3		448.7	889.9
		36.5	72.4		50.0	99.3		20.7	41.1		14.9	29.6

STATION: W. Aravaipa

STREAMFLOW TABULATION

WY: 1981

Month:	June			July			August			September		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	.93	12.3		.93	12.3		1.22	31.0		.95	13.1	
2	.92	12.0		.91	11.6		1.11	21.3		.96	13.5	
3	.87	10.6		.90	11.2		1.10	20.5		.96	13.5	
4	.86	10.3		.90	11.2		1.10	20.5		.99	14.6	
5	.84	9.8		.90	11.2		1.09	20.0		1.00	15.0	
	.84	9.8		.90	11.2		1.11	21.3		1.20	28.5	
7	.89	11.0		.91	11.6		1.08	19.4		1.04	17.2	
	.92	12.0		1.29	39.7		1.01	15.6		1.03	16.6	
	.92	12.0		.94	12.7		1.02	16.1		1.03	16.6	
	.88	12.0		.94	12.7		--- LOST DATA ---			1.02	16.1	
	.87	10.8		1.21	29.8					1.01	15.6	
	.87	10.6		1.33	46.0					1.00	15.0	
	.88	10.8		1.10	20.5					1.00	15.0	
	.90	11.2		1.07	18.8					1.00	15.0	
	.88	10.8		1.09	20.0					1.00	15.0	
	.88	10.8		1.09	20.0					1.00	15.0	
	.89	11.0		1.12	22.1					1.36	50.9	
	.90	11.2		1.10	20.5					1.05	17.8	
	.91	11.6		1.08	19.4					1.04	17.2	
	.92	12.0		1.13	22.9					1.01	15.6	
	.92	12.0		1.10	20.5					1.01	15.6	
	.91	11.6		1.32	44.3		.87E	10.6		1.24	33.5	
	.86	10.3		1.14	23.7		.89	11.0		1.27	37.2	
	.85	10.0		1.13	22.9		.95	13.1		1.04	17.2	
	.82	9.30		1.31	42.6		.96	13.5		1.02	16.1	
	.88	10.8		1.14	23.7		.89	11.0		1.02	16.1	
	.90	11.2		1.15	24.5		.88	10.8		1.02	16.1	
	.90	11.2		1.13	22.9		.94	12.7		1.03	16.6	
	.91	11.6		1.10	20.5		.94	12.7		.96	13.5	
	.93	12.3		1.35	49.2		.94	12.7		.95	13.1	
				1.49	79.6		.94	12.7				
		332.0	658.0		760.0	1508.0		307.0	608.0		552.0	1095.0
		11.0	22.0		25.0	49.0		16.1	32.0		18.3	36.4

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STATION: W. Aravaipa

STREAMFLOW TABULATION

WY: 1982

Month:	October			November			December			January		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	.97	13.9		.97	13.9		1.05	17.8		1.03	16.6	
2	1.26	36.0		.98	14.2		1.04	17.2		1.22	31.0	
3	1.19	27.7		.99	14.6		1.03	16.6		1.36	50.9	
4	1.08	19.4		.98	14.2		1.03	16.6		1.18	26.9	
5	1.08	19.4		.96	13.5		1.01	15.6		1.14	23.7	
6	1.07	18.8		.88	10.8		1.02	16.1		1.38	54.2	
7	1.06	18.3		.89	11.0		1.02	16.1		2.06	--	
8	1.06	18.3		.92	12.0		1.02	16.1		1.36	50.9	
9	1.05	17.8		.98	14.2		1.03	16.6		1.27	37.2	
10	1.04	17.2		.98	14.2		1.03	16.6		1.22	31.0	
11	1.03	16.6		.99	14.6		1.04	17.2		1.21	29.8	
12	1.02	16.1		1.01	15.6		1.04	17.2		1.97	--	
13	1.02	16.1		1.01	15.6		1.04	17.2		-- LOST DATA --		
14	1.00	15.0		1.01	15.6		1.04	17.2				
15	1.00	15.0		1.01	15.6		1.05	17.8				
16	1.01	15.6		1.00	15.0		1.04	17.2				
17	1.01	15.6		.99	14.6		1.04	17.2				
18	.99	14.6		.97	13.9		1.03	16.6				
19	.99	14.6		.99	14.6		1.04	17.2				
20	.98	14.2		1.00	15.0		1.03	16.6				
21	.96	13.5		1.01	15.6		1.03	16.6				
22	.96	13.5		1.02	16.1		1.03	16.6				
23	.96	13.5		1.02	16.1		1.03	16.6				
24	.96	13.5		1.02	16.1		1.03	16.6				
25	.96	13.5		1.02	16.1		1.03	16.6				
26	.95	13.1		1.04	17.2		1.03	16.6				
27	.95	13.1		1.04	17.2		1.03	16.6		1.14E	23.7	
28	.96	13.5		1.04	17.2		1.02	16.1		1.13	22.9	
29	.96	13.9		1.39	55.8		1.03	16.6		1.16	25.3	
30	.97			1.19	27.7		1.03	16.6		1.18	26.9	
31							1.03	16.6		1.16	25.9	
TAL		495.0	981.4		498.0	987.3		519.0	1029.0		476.0	944.1
E.		16.4	33.0		17.0	33.0		17.0	33.1		32.0	62.9

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STATION: W. Aravaipa

STREAMFLOW TABULATION

WY: 1982

Month:	February			March			April			May		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	1.15	24.5		1.15	24.5		1.11	21.3		1.05	17.8	
2	1.14	23.7		1.14	23.7		1.12	22.1		1.05	17.8	
3	1.13	22.9		1.14	23.7		1.14	23.7		1.05	17.8	
4	1.12	22.1		1.14	23.7		1.14	23.7		1.19	27.7	
5	1.11	21.3		1.13	22.9		1.15	24.5		1.14	23.7	
6	1.11	21.3		1.13	22.9		1.15	24.5		1.08	19.4	
7	1.11	21.3		1.12	22.1		1.15	24.5		1.06	18.3	
8	1.12	22.1		1.12	22.1		1.14	23.7		1.04	17.2	
9	1.13	22.9		1.12	22.1		1.13	22.9		1.04	17.2	
10	1.14	23.7		1.11	21.3		1.14	23.7		1.04	17.2	
11	1.76	20.4		1.11	21.3		1.14	23.7		1.02	16.1	
12	1.48	77.1		1.13	22.9		1.13	22.9		1.03	16.6	
13	1.30	41.0		1.69	160.0		1.10	20.5		1.03	16.6	
14	1.23	32.2		1.38	77.1		1.10	20.5		1.01	15.6	
15	1.20	28.5		1.45	69.8		1.08	19.4		1.01	15.6	
16	1.19	27.7		1.28	38.5		1.09	20.0		1.01	15.6	
17	1.18	26.9		1.21	29.8		1.09	20.0		.99	14.6	
18	1.34	47.6		1.30	41.0		1.10	20.5		.99	14.6	
19	1.32	44.3		1.40	57.5		1.10	20.5		.98	14.2	
20	1.26	36.0		1.30	41.0		1.08	19.4		.95	13.1	
21	1.23	32.2		1.21	29.8		1.08	19.4		.93	12.3	
22	1.21	29.8		1.18	26.9		1.08	19.4		.92	12.0	
23	1.18	26.9		1.14	23.7		1.08	19.4		.90	11.2	
24	1.17	26.1		1.09	20.0		1.08	19.4		.89	11.0	
25	1.23	32.2		1.08	19.4		1.08	18.8		.89	11.0	
26	1.19	27.7		1.12	22.1		1.07	18.3		.88	10.8	
27	1.17	26.1		1.20	28.5		1.06	18.3		.89	11.0	
28	1.16	25.3		1.08	19.4		1.06	18.3		.90	11.2	
29				1.12	22.1		1.06	18.3		.92	12.0	
30				1.12	22.1		1.06	17.8		.92	12.0	
31				1.10	20.5					.92	12.0	
TAL		834.0	1654.0		1042.4	2068.0		629.4	1248.4		473.2	939.0
VE.		30.0	59.0		34.0	67.0		21.0	42.0		15.2	30.2

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STATION: W. Aravaipa **STREAMFLOW TABULATION** WY: 1982

Month:	June			July			August			September		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	.90	11.2		.80	8.8		.98	14.2		1.05	17.8	
2	.90	11.2		.79	8.6		.90	11.2		1.05	17.8	
3	.89	11.0		.79	8.6		.90	11.2		1.06	18.3	
4	.90	11.2		.79	8.6		.89	11.0		1.06	18.3	
5	.90	11.2		.79	8.6		.89	11.0		1.06	18.3	
6	.89	11.0		.76	8.2		.90	11.2		1.06	18.3	
7	.88	10.8		.78	8.5		.88	10.8		1.06	18.3	
8	.84	9.8		.74	7.9		.88	10.8		1.08	19.4	
9	.81	9.1		.74	7.9		.89	11.0		1.06	18.3	
10	.80	8.8		.73	7.7		.88	10.8		1.54	96.4	
11	.79	8.6		.76	8.1		1.07	18.8		1.41	60.0	
12	.78	8.5		.76	8.1		1.66	146.0		1.62	127.4	
13	.82	9.3		.76	8.1		-- LOST DATA --			1.12	22.1	
14	.85	10.3		.75	8.0					1.04	17.2	
15	.85	10.0		.72	7.6					1.02	16.1	
16	.85	10.0		.71	7.4					1.02	16.1	
17	.83	9.5		.75	8.0					1.02	16.1	
18	.78	8.5		.89	11.0					1.00	15.0	
19	.77	8.3		.82	9.3					.93	12.3	
20	.78	8.5		.80	8.8					.92	12.0	
21	.83	9.5		.81	9.0					.98	14.2	
22	.84	9.8		.81	9.0					.92	12.0	
23	.83	9.6		.81	9.0					.90	11.2	
24	.83	9.6		.81	9.0					.90	11.2	
25	.83	9.6		.82	9.3					.98	14.2	
26	.83	9.6		.82	9.3					.99	14.6	
27	.82	9.3		.82	9.3					.99	14.6	
28	.80	8.8		.81	9.0					1.00	15.0	
29	.81	9.1		.82	9.3					1.01	15.6	
30	.82	9.3		.80	8.8					1.01	15.6	
31				1.22	31.0		1.05E	17.8				
TAL		291.0	577.1		290.0	575.0		296.0	587.1		714.0	1416.2
VE.		9.7	19.2		9.3	19.0		23.0	45.1		24.0	47.2
ak							4.94			4.83		

USAV-00005825

STATION: W. Aravaipa

STREAMFLOW TABULATION

WY: 1983

Month:	October			November			December			January		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	1.01	15.6		1.03	16.6		1.79	22.4		1.14	23.7	
2	1.01	15.6		1.03	16.6		1.21	29.8		1.14	23.7	
3	1.00	15.0		1.02	16.1		1.13	22.9		1.14	23.7	
4	.99	14.6		1.01	15.6		1.11	21.3		1.14	23.7	
5	.99	14.6		.99	14.6		1.10	20.5		1.13	22.9.	
6	.99	14.6		1.01	15.6		1.09	20.0		1.13	22.9	
7	.98	14.2		1.03	16.6		1.08	19.4		1.13	22.9	
	.98	14.2		1.03	16.6		1.07	18.8		1.13	22.9	
	.99	14.6		1.04	17.2		1.08	19.4		1.12	22.1	
0	.98	14.2		1.05	17.8		1.35	49.2		1.12	22.1	
1	.97	13.9		1.11	21.3		1.36	50.9		1.11	21.3	
2	.94	12.7		1.02	16.1		1.19	27.7		1.10	20.5	
3	.91	11.6		1.01	15.6		1.15	24.5		1.10	20.5	
4	.94	12.7		1.01	15.6		1.15	24.5		1.10	20.5	
5	.93	12.3		1.01	15.6		1.15	24.5		1.10	20.5	
6	.96	13.5		1.03	16.6		1.15	24.5		1.10	20.5	
7	.98	14.2		1.14	23.7		1.14	23.7		1.17	26.1	
8	.98	14.2		1.20	28.5		1.14	23.7		1.12	22.1	
9	.99	14.6		1.08	19.4		1.14	23.7		1.11	21.3	
0	.99	14.6		1.06	18.3		1.14	23.7		1.25	34.8	
	.99	14.6		1.06	18.3		1.13	22.9		1.17	26.1	
	1.00	15.0		1.05	17.8		1.14	23.7		1.14	23.7	
	1.00	15.0		1.04	17.2		1.22	31.0		1.13	22.9	
	.99	14.6		1.05	17.8		1.29	39.7		1.13	22.9	
	1.00	15.0		1.06	18.3		1.17	26.1		1.13	22.9	
	1.00	15.0		1.08	19.4		1.14	23.7		1.12	22.1	
	1.00	15.0		1.07	18.8		1.13	22.9		1.11	21.3	
	1.01	15.6		1.08	19.4		1.12	22.1		1.26	36.0	
	1.01	15.6		1.08	19.4		1.13	22.9		1.56	104.0	
	1.01	15.6		1.16	25.3		1.14	23.7		- LOST	DATA -	
	1.02	16.1					1.14	23.7				
		449.0	891.0		546.0	1083.0		798.0	1582.0		761.0	1509.4
		14.4	29.0		18.1	36.0		26.0	51.0		26.2	52.0

USAV-00005826

STATION: W. Aravaipa

Month: February

STREAMFLOW TABULATION

WY: 1983

	February			March			April			May		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	--LOST	DATA--		1.18	26.9		1.36	50.4		1.16	25.3	
2				1.19	27.7		1.32	44.3		1.21	29.8	
3				1.25	34.8		1.34	47.6		1.18	26.9	
4				1.92	--		1.32	44.3		1.21	29.8	
5				2.66	--		1.30	41.0		1.17	26.1	
6				2.00	--		1.29	39.7		1.06	18.3	
7				1.63	132.00		1.31	42.6		1.13	22.9	
8				1.45	69.8		1.30	41.0		1.17	26.1	
9				1.33	46.0		1.30	41.0		1.16	25.3	
10				1.29	39.7		1.31	42.6		1.14	23.7	
11				1.29	39.7		1.29	39.7		1.15	24.5	
12				1.28	38.5		1.33	46.0		1.15	24.5	
13				1.29	39.7		1.35	49.2		1.16	25.3	
14				1.30	41.0		1.30	41.0		1.17	26.1	
15				1.30	41.0		1.30	41.0		1.20	28.5	
16				1.32	44.3		1.31	42.6		1.20	28.5	
17				1.31	42.6		1.31	42.6		1.15	24.5	
18	1.24E	33.5		1.75	198.0		1.32	44.3		1.14	23.7	
19	1.21	29.8		4.11	--		1.32	44.3		1.11	21.3	
20	1.19	27.7		3.27	--		1.31	42.6		1.15	24.5	
21	1.20	28.5		2.33	--		1.28	38.5		1.15	24.5	
22	1.19	27.7		2.75	--		1.27	37.2		1.12	22.1	
23	1.19	27.7		2.18	--		1.24	33.5		1.06	18.3	
24	1.19	27.7		3.01	--		1.22	31.0		1.06	18.3	
25	1.19	27.7		1.99	--		1.23	32.2		1.12	22.1	
26	1.19	27.7		2.32	--		1.22	31.0		1.06	18.3	
27	1.18	26.9		1.84	266.0		1.22	31.0		1.05	17.8	
28	1.18	26.9		1.61	122.7		1.21	29.5		1.02	16.1	
29				1.51	85.6		1.22	31.0		1.11	21.3	
30				1.47	74.6		1.15	24.5		1.15	24.5	
31				1.46	72.2					1.16	25.3	
		311.8	618.5		1482.8	2942.0		1188.0	2356.4		734.2	1456.3
		28.3	56.2		74.1	147.0		39.6	78.5		23.7	47.0
				8.35								

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USAV-00005827

STATION: W. Aravaipa

STREAMFLOW TABULATION

WY: 1983

Month:	June			July			August			September			
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	
	1.19	27.7											
	1.16	25.3											
5	1.15	24.5											
6	1.14	23.7											
	1.08	19.4											
	1.16	25.3											
	1.14	23.7											7
	1.12	22.1											8
	1.14	23.7											9
	1.13	22.9											1
	1.19	27.7		--LOST DATA--			--LOST DATA--			--LOST DATA--			1
	1.14	23.7											1.
	1.10	20.5											1
	1.01												1
	1.03	16.6											15
	1.09	20.0											16
	1.00	15.0											17
	1.03	16.6											18
	1.06	18.3											19
	1.10	20.5											20
	1.12	22.1											21
	1.09	20.0											22
	1.08	19.4											23
	1.13	22.9											24
	1.14	23.7											25
	1.11	21.3											26
	1.05	17.8											27
	.88	10.8											28
	.86	10.3											29
	.88E	10.8											30
													31
		611.9	1213.7										
		20.4	40.4										

USAV-00005828

STATION: W. Aravaipa **STREAMFLOW TABULATION** WY: 1984

Month:	February			March			April			May		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1										1.61E	34.7	
2										1.60	33.6	
3										1.60	33.6	
4										1.59	32.8	
5										1.59	32.8	
6										1.59E	32.8	
7										1.59E	32.8	
										158E	32.8	
										158	32.0	
10	--LOST	DATA--		--LOST	DATA--		--LOST	DATA--		158	32.0	
11										1.57	31.2	
12										1.57	31.2	
13										1.56	30.4	
14										1.55	29.6	
15										1.58	32.0	
16										1.59	32.8	
17										1.58	32.0	
18										1.57	31.2	
19										1.57	31.2	
20										1.57	31.2	
21										1.57	31.2	
22										1.57	31.2	
23										1.57	31.2	
24										1.57	31.2	
25										1.57	31.2	
26										1.57	31.2	
27										1.57	31.2	
28										1.57	31.2	
29										1.57	31.2	
30										1.57	31.2	
31										1.57	31.2	
											985.1	1862.9
											31.7	62.1

USAV-00005829

STATION: W. Aravaipa

STREAMFLOW TABULATION

WY: 1984

Month:	June			July			August			September		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	1.56	30.4		1.51	26.4		1.63	37.0		1.65	39.3	
2	1.55	29.6		1.62	35.9		1.53	28.0		1.77	54.8	
3	1.56	30.4		1.62	35.9		1.52	27.2		1.62	35.9	
4	1.55	29.6		1.40	19.6		1.52	27.2		1.61	34.7	
5	1.56	30.4		1.36	18.0		1.88	74.2		1.58	32.0	
	1.56	30.4		1.43	21.4		1.67	41.6		1.58	32.0	
	1.56	30.4		1.45	22.6		1.73	49.2		1.58	32.0	
	1.56	30.4		1.40	19.6		1.76	53.4		1.58	32.0	
	1.55	29.6		1.38	18.8		1.68	42.8		1.57	31.2	
	1.55	29.6		1.70	45.0		1.69	43.9		1.73	49.2	
	1.54	28.8		1.57	31.2		2.09	127.0		2.12	137.0	
	1.54	28.8		1.57	31.2		1.93	84.6		1.83	64.7	
	1.54	28.8		1.65	39.3		1.79	57.6		1.66	40.5	
	1.54	28.8		1.71	46.4		1.91	80.2		1.63	37.0	
	1.54	28.8		1.66	40.5		1.83	64.7		1.58	32.0	
	1.55	29.6		1.77	54.8		1.73	49.2		--LOST	DATA--	
	1.55	29.6		1.91	80.2		1.96	91.2				
	1.55	29.6		2.18	158.0		1.85	68.5				
	1.55	29.6		2.00	100.0		2.48	--				
	1.55	29.6		1.80	59.0		1.93	84.6				
	1.55	29.6		2.63	--		1.57	31.2				
	1.54	28.8		1.88	74.2		1.60	33.6				
	1.54	28.8		1.97	93.4		1.87	72.3				
	1.54	28.8		1.70	45.0		1.78	56.2				
	1.63	37.0		1.55	29.6		1.59	32.8				
	1.62	35.9		1.57	31.2		1.65	39.3		1.67	41.6	
	1.60	33.6		1.56	30.4		1.53	28.0		1.66	40.5	
	1.56	30.4		1.58	32.0		1.65	39.3		1.64	38.2	
	1.53	28.0		1.90	78.0		1.55	29.6		1.61	34.7	
	1.51	26.3		1.68	42.8		1.55	29.6		1.60	33.6	
				1.56	30.4		1.62	35.9		1.61	34.7	
		900.0	1785.1		1320.0	2618.2		1560.0	3094.2		907.8	1800.6
		30.0	59.5		44.0	87.2		52.0	103.1		43.2	85.7

2.91

USAV-00005830

STATION: West Aravaipa

STREAMFLOW TABULATION

WY: 85

North:	October			November			December			January		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	1.61E	34.7		1.56	30.4		1.62	35.9		1.86	70.4	
2	1.61E	34.7		1.57	31.2		1.57	31.2		1.76	53.4	
3	1.61E	34.7		1.58	32.0		1.61	34.7		1.70	45.0	
4	1.60E	33.6		1.57	31.2		1.70	45.0		1.65	39.3	
5	1.59E	32.8		1.57	31.2		1.64	38.2		1.65	39.3	
6	1.57E	31.2		1.58	32.0		1.66	40.5		1.65	39.3	
7	1.55	29.6		1.59	32.8		1.69	43.9		1.65	39.3	
8	1.54	28.8		1.62	35.9		1.62E	35.9		2.23	177.9	
	1.52	27.2		1.61	34.7					2.30	208.0	
0	1.50	25.6		1.61	34.7					1.93	84.6	
1	1.49	25.0		1.58	32.0					1.76	53.4	
2	1.51	26.4		1.51	26.4					1.70	45.0	
3	1.53	28.0		1.50	25.6		LOST	DATA		1.64	38.2	
4	1.52	27.2		1.49	25.0					1.62	35.9	
5	1.52	27.2		1.48	24.4					1.63	37.0	
6	1.51	26.4		1.49	25.0					1.59	32.8	
7	1.51	26.4		1.49	25.0					1.59	32.8	
8	1.52	27.2		1.48	24.4					1.58	32.0	
9	1.53	28.0		1.48	24.4					1.57	31.2	
0	1.55	29.6		1.47	23.8		1.91	80.2		1.56	30.4	
1	1.56	30.4		1.47	23.8		2.12	137.0		1.55	29.6	
2	1.56	30.4		1.50	25.6		1.83	64.7		1.54	28.8	
3	1.53	28.0		1.54	28.8		1.73	49.2		1.57	31.2	
	1.52	27.2		1.47	23.8		1.72	47.8		1.81	60.9	
	1.53	28.0		1.65	39.3		1.64	38.2		1.68	42.8	
	1.56	30.4		1.80	59.0		1.66	40.5		2.21	169.3	
	1.56	30.4		1.64	38.2		2.45	-		2.64	-	
	1.53	28.0		1.64	38.2		3.33	-		2.31	-	
	1.52	27.2		1.63	37.0		2.93	-		2.04	112.0	
	1.54	28.8		1.62	35.9		2.20	165.0		2.66	-	
	1.55	29.6					1.95	89.0		2.32	-	
		902.7	1790.5		931.7	1848.0		1017.0	2017.2		1640.0	3253.0
		29.1	57.7		31.1	61.6		60.0	119.0		60.7	120.4
							6.79			7.28		

USAV-00005831

STATION: West Aravaipa

STREAMFLOW TABULATION

WY: 1985

Month:	February			March			April			May		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	2.03	109.0		1.86	70.4		1.70	45.0		1.69	43.9	
2	1.95	89.0		1.85	68.5		1.71	46.4		1.69	43.9	
3	2.00	100.0		1.83	64.7		1.73	49.2		1.69	43.9	
4	2.23	177.9		1.82	62.8		1.70	45.0		1.69	43.9	
5	2.48	–		1.79	57.6		1.70	45.0		1.69	43.9	
6	2.45	–		1.79	57.6		1.70	45.0		1.67	41.6	
7	↑	↑		1.78	56.2		1.70	45.0		1.67	41.6	
8				1.78	56.2		1.71	46.4		1.66	40.5	
9				1.77	54.8		1.71	46.4		1.65	39.3	
10	LOST	DATA		1.76	53.4		1.71	46.4		1.64	38.2	
11				1.76	53.4		1.71	46.4		1.64	38.2	
12				1.78	56.2		1.72	47.8		1.63	37.0	
13	↓	↓		1.76	53.4		1.72	47.8		1.64	38.2	
14	1.83E	64.7		1.75	52.0		1.71	46.4		1.63	37.0	
15	1.82	62.8		1.83	64.7		1.71	46.4		1.64	38.2	
16	1.76	53.4		1.82	62.8		1.70	45.0		1.63	37.0	
17	1.74	50.6		1.78	56.2		1.70	45.0		1.62	35.9	
18	1.74	50.6		1.77	54.8		1.71	46.4		1.62	35.9	
19	1.76	53.4		1.77	54.8		1.68	42.8		1.62	35.9	
20	1.75	52.0		1.76	53.4		1.67	41.6		1.62	35.9	
21	1.74	50.6		1.74	50.6		1.69	43.9		1.62	35.9	
22	1.76	53.4		1.75	52.0		1.69	43.9		1.63	37.0	
23	1.85	68.5		1.73	49.2		1.69	43.9		1.62	35.9	
24	1.82	62.8		1.72	47.8		1.68	42.8		1.62	35.9	
25	1.78	56.2		1.72	47.8		1.68	42.8		1.61	34.7	
26	1.78	56.2		1.72	47.8		1.71	46.4		1.61	34.7	
27	1.78	56.2		1.69	43.9		1.74	50.6		1.61	34.7	
28	1.90	78.0		1.67	41.6		1.72	47.8		1.61	34.7	
29				1.72	47.8		1.68	42.8		1.61	34.7	
30				1.71	46.4		1.68	42.8		1.62	35.9	
31				1.70	45.0					1.62	35.9	
		1345.3	2667.0		1683.8	3339.8		1363.1	2703.7		1179.9	2340.3
		71.0	140.3		54.3	107.7		45.4	90.1		38.0	75.4

STATION: West Aravaipa

STREAMFLOW TABULATION

WY: 1985

Month:	June			July			August			September		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	1.61	34.7		1.51	26.4		1.63	37.0		1.47	23.8	
2	1.62	35.9		1.51	26.4		1.73	49.2		1.47	23.8	
3	1.62	35.9		1.50	25.6		1.72	47.8		1.48	24.4	
4	1.63	37.0		1.50	25.6		1.63	37.0		1.49	25.0	
5	1.63	37.0		1.49	25.0		↑	↑		1.48	24.4	
6	1.62	35.9		1.48	24.4					1.49	25.0	
7	1.62	35.9		1.48	24.4		LOST	DATA		1.51	26.4	
	1.62	35.9		1.47	23.8		↓	↓		1.50	25.6	
	1.62	35.9		1.45	22.6		1.47E	23.8		1.51	26.4	
0	1.61	34.7		1.45	22.6		1.46	23.2		1.51	26.4	
1	1.61	34.7		1.45	22.6		1.71	46.4		1.53	28.0	
2	1.61E	34.7		1.48	24.4		1.50	25.6		1.53	28.0	
3	↑	↑		1.46	23.2		1.49	25.0		1.51	26.4	
4				1.46	23.2		1.49	25.0		1.50	25.6	
5				1.45	22.6		1.49	25.0		1.51	26.4	
6	LOST	DATA		1.46	23.2		1.49	25.0		1.50	25.6	
7				1.46	23.2		1.49	25.0		1.50	25.6	
8				1.47	23.8		1.51	26.4		1.66	40.5	
9				1.48	24.4		1.56	30.4		1.56	30.4	
0				1.50	25.6		1.77	54.8		1.52	27.2	
				1.49	25.0		1.59	32.8		1.50	25.6	
				1.54	28.8		1.53	28.0		1.50	25.6	
	1.52E	27.2		1.51	26.4		1.51	26.4		1.50	25.6	
	1.52	27.2		1.50	25.6		1.50	25.6		1.50	25.6	
	1.52	27.2		1.49	25.0		1.54	28.8		1.49	25.0	
	1.52	27.2		1.49	25.0		1.56	30.4		1.50	25.6	
	1.52	27.2		1.50	25.6		1.54	28.8		1.52	25.6	
	1.52	27.2		1.51	26.4		1.50	25.6		1.68	42.8	
	1.52	27.2		1.50	25.6		1.49	25.0		1.66	40.5	
	1.52	27.2		1.49	25.0		1.48	24.4		1.61	34.7	
				1.94	86.8		1.47	23.8				
		645.8	1280.9		828.2	1642.7		826.2	1638.7		881.5	1748.4
		32.2	64.0		26.7	52.9		30.6	60.6		29.3	58.2

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USAV-00005833

STATION: West Aravaipa

STREAMFLOW TABULATION

WY: 1986

Month:	October			November			December			January		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	1.71	46.4		1.55	29.6		1.78	56.2		1.54	28.8	
2	1.62	35.9		1.55	29.6		1.67	41.6		1.54	28.8	
3	1.62	35.9		1.55	29.6		1.62	35.9		1.55	29.6	
4	1.62	35.9		1.54	28.8		1.61	34.7		1.56	30.4	
5	1.61	34.7		1.54	28.8		1.60	33.6		1.57	31.2	
6	1.61	34.7		1.53	28.0		1.59	32.8		1.56	30.4	
7	1.62	35.9		1.52	27.2		1.59	32.8		1.55	29.6	
8	1.61	34.7		1.50	25.6		1.59	32.8		1.55	29.6	
9	1.64	38.2		1.49	25.0		1.60	33.6		1.53	28.0	
10	1.74	50.6		1.49	25.0		1.61	34.7		1.53	28.0	
11	1.83	64.7		1.48	24.4		1.62	35.9		1.53	28.0	
12	1.63	37.0		1.54	28.8		1.64	38.2		1.52	27.2	
13	1.61	34.7		1.52	27.2		1.62	35.9		1.52	27.2	
14	1.59	32.8		1.51	26.4		1.63	37.0		1.51	26.4	
15	1.57	31.2		1.52	27.2		1.62	35.9		1.51	26.4	
16	1.60	33.6		1.54	28.8		1.61	34.7		1.50	25.6	
17	1.68	42.8		1.55	29.6		1.60	33.6		1.49	25.0	
18	1.60	33.6		1.55	29.6		1.59	32.8		1.48	24.4	
19	1.57	31.2		1.56	30.4		1.59	32.8		1.47	23.8	
20	1.56	30.4		1.57	31.2		1.57	31.2		1.47	23.8	
21	1.54	28.8		1.58	32.0		1.57	31.2		1.48	24.4	
22	1.54	28.8		1.57	31.2		1.56	30.4		1.49	25.0	
23	1.55	29.6		1.57	31.2		1.55	29.6		1.50	25.6	
24	1.55	29.6		1.58	32.0		1.53	28.0		1.51	26.4	
25	1.55	29.6		1.80	59.0		1.53	28.0		1.51	26.4	
26	1.56	30.4		2.26	190.8		1.52	27.2		1.51	26.4	
27	1.57	31.2		1.84	66.6		1.52	27.2		1.51	26.4	
28	1.57	31.2		1.66	40.5		1.52	27.2		1.52	27.2	
29	1.58	32.0		1.61	34.7		1.53	28.0		1.51	26.4	
30	1.58	32.0		2.12	137.0		1.53	28.0		1.51	26.4	
31	1.57	31.2					1.53	28.0		1.52	27.2	
TAL		1089.3	2160.6		1215.8	2411.5		1049.5	2081.6		840.0	1666.1
/E.		35.1	69.6		40.5	80.3		33.8	67.1		27.0	53.7

STATION: West Aravaipa

STREAMFLOW TABULATION

WY: 1986

Month:	February			March			April			May		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	1.62	35.9		1.57	31.2		1.23	36.3		1.16	27.1	
2	1.60	33.6		1.57	31.2		1.23	36.3		1.15	26.4	
3	1.54	28.8		1.56	30.4		1.22	34.2		1.15	26.4	
4	1.58	32.0		1.56	30.4		1.21	32.1		1.14	25.6	
5	1.58	32.0		1.55	29.6		1.21	32.1		1.15	26.4	
6	1.57	31.2		1.55	29.6		1.19	29.3		1.15	26.4	
7	1.66	40.5		1.53	28.0		1.20	30.0		1.15	26.4	
8	1.66	40.5		1.53	28.0		1.18	28.6		1.15	26.4	
9	2.45	-		1.52	27.2		1.18	28.6		1.14	25.6	
10	1.94	86.8		1.54	28.8		1.18	28.6		1.13	24.9	
11	1.74	50.6		2.44	-		1.17	27.8		1.12	24.2	
12	1.67	41.6		2.61	-		1.16	27.1		1.11	23.5	
13	1.64	38.2		2.51	-		1.16	27.1		1.11	23.5	
14	1.63	37.0		3.44	-		1.16	27.1		1.10	22.7	
15	1.62	35.9		2.40	-		1.16	27.1		1.10	22.7	
16	1.99	97.3		1.87	72.3		1.16	27.1		1.09	22.4	
17	1.86	70.4		3.03	-		1.15	26.4		1.09	22.4	
18	1.69	43.9		3.03E	-		1.16	27.1		1.09	22.4	
19	1.64	38.2		2.64E	-		1.16	27.1		1.08	22.1	
20	1.62	35.9					1.16	27.1		1.07	21.7	
21	1.60	33.6					1.16	27.1		1.07	21.7	
22	1.58	32.0		LOST	DATA		1.17	27.8		1.08	22.1	
23	1.58	32.0					1.17	27.8		1.08	22.1	
24	1.58	32.0		1.31	55.0		1.17	27.8		1.07	21.7	
25	1.57	31.2		1.28	46.8		1.17	27.8		1.07	21.7	
26	1.58	32.0		1.27	44.7		1.17	27.8		1.07	21.7	
27	1.57	31.2		1.24	38.4		1.17	27.8		1.07	21.7	
28	1.57	31.2		1.24	38.4		1.16	27.1		1.07	21.7	
29				1.24	38.4		1.16	27.1		1.06	21.4	
30				1.24	38.4		1.16	27.1		1.07	21.7	
31				1.24	38.4					1.08	22.1	
TAL		1106.0	2194.0		705.2	1399.0		862.3	1710.3		728.8	1445.5
/E.		40.9	81.2		37.1	74.0		28.7	57.0		23.5	46.6

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USAV-00005835

STATION: West Aravaipa

STREAMFLOW TABULATION

WY: 1986

Month:	June			July			August			September		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	1.07	21.7		1.07	21.7		1.05	21.0			1.57E	241.4
2	1.06	21.4		1.07	21.7		1.13	24.9			↑	↑
3	1.05	21.0		1.10	22.7		1.14	25.6				
4	1.05	21.0		1.13	24.9		1.09	22.4			LOST	DATA
5	1.05	21.0		1.11	23.5		1.08	22.1				
6	1.04	20.7		1.09	22.4		1.10	22.7			↓	↓
7	1.04	20.7		1.09	22.4		1.13	24.9			1.11E	23.5
8	1.05	21.0		1.12	24.2		1.10	22.7			1.13	24.9
9	1.05	21.0		1.12	24.2		1.11	23.5			1.16	27.1
10	1.06	21.4		1.07	21.7		1.12	24.2			1.15	26.4
11	1.06	21.4		1.06	21.4		1.11	23.5			1.15	26.4
12	1.05	21.0		1.04	20.7		1.12	24.2			1.15	26.4
13	1.05	21.0		1.04	20.7		1.09	22.4			1.14	25.6
14	1.05	21.0		↑	↑		1.27	44.7			1.14	25.6
15	1.05	21.0					1.16	27.1			1.15	26.4
16	1.05	21.0					1.12	24.2			1.13	24.9
17	1.06	21.4		LOST	DATA		1.17	27.8			1.11	23.5
18	1.06	21.4					1.11	23.5			1.11	23.5
19	1.04	20.7		↓	↓		1.09	22.4			1.11	23.5
20	1.04	20.7		1.05E	21.0		1.08	22.1			1.10	22.7
21	1.03	20.3		1.08	22.1		1.08	22.1			1.10	22.7
22	1.04	20.7		1.15E	26.4		1.09	22.4			1.10	22.7
23	1.05	21.0		1.57E	241.4		1.08	22.1			1.20	30.0
24	1.06	21.4		1.13	24.9		1.12	24.2			1.90	-
25	1.05	21.0		1.09	22.4		1.12	24.2			1.26	42.6
26	1.05	21.0		1.07	21.7		1.10	22.7			1.16	27.1
27	1.05	21.0		1.06	21.4		1.32	59.0			1.14	25.6
28	1.05	21.0		1.06	21.4		1.14	25.6			1.13	24.9
29	1.06	21.4		1.06	21.4		1.41E	98.2			1.12	24.2
30	1.06	21.4		1.05	21.0		1.22	34.2			1.11	23.5
31				1.05	21.0		1.10	22.7				
TAL		631.7	1252.9		778.35	1543.7		873.5	1732.5		835.2	1656.6
/E.		21.0	41.7		31.13	61.7		28.2	55.8		34.8	69.0

USAV-00005836

STATION: West Aravaipa **STREAMFLOW TABULATION** WY: 1987

Month:	October			November			December			January		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	1.10	22.7		1.11	23.5		1.10	22.75		1.15	26.4	
2	1.09	22.4		1.19	29.3		1.09	22.4		1.14	25.6	
3	1.10	22.7		1.16	27.1		1.09	22.4		1.13	24.9	
4	1.10	22.7		1.13	24.9		1.10	22.75		1.13	24.9	
5	1.12	24.2		1.11	23.5		1.10	22.75		1.19	29.3	
6	1.12	24.2		1.10	22.7		1.33	65.7		1.15	26.4	
7	1.13	24.9		1.16	27.1		2.36	--		1.15	26.4	
8	1.13	24.9		1.11	23.5		2.42	--		1.14	25.6	
9	1.14	25.6		1.10	22.7		1.47	141.4		1.13	24.9	
10	1.23	36.3		1.11	23.5		1.30	51.0		1.13	24.9	
11	1.37E	79.0		1.10	22.7		1.24	38.4		1.13	24.9	
12	2.89	--		1.11	23.5		1.22	34.2		1.12	24.2	
13	1.99	--		1.10	22.7		1.19	29.3		1.13	24.9	
14	1.32	60.8		1.11	23.5		1.19	29.3		1.12	24.2	
15	1.23	36.3		1.12	24.2		1.19	29.3		1.13	24.9	
16	1.19	29.3		1.14	25.6		1.19	29.3		1.16	27.1	
17	1.18	28.6		1.14	25.6		1.27	44.7		1.16	27.1	
18	1.17	27.8		1.14	25.6		1.27	44.7		1.14	25.6	
19	1.16	27.1		1.21	32.1		1.23	36.3		1.14	25.6	
20	1.16	27.1		1.17	27.8		1.21	32.1		1.14	25.6	
21	1.15	26.4		1.17	27.8		1.19E	29.3		1.13	24.9	
22	1.15	26.4		1.16	27.1		1.19E	29.3		1.12	24.2	
23	1.14	25.6		1.15	26.4		1.18E	28.6		1.12	24.2	
24	1.14	25.6		1.14	25.6		1.18	28.6		1.11	23.5	
25	1.14	25.6		1.13	24.9		1.17	27.8		1.10	22.7	
26	1.14	25.6		1.13	24.9		1.17	27.8		1.10	22.7	
27	1.13	24.9		1.12	24.2		1.16	27.1		1.10	22.7	
28	1.13	24.9		1.11	23.5		1.16	27.1		1.09	22.4	
29	1.12	24.2		1.11	23.5		1.16	27.1		1.09	22.4	
30	1.11	23.5		1.10	22.7		1.15	26.4		1.23	36.3	
31	1.11	23.5								1.28	46.8	
TAL		843.0	1672.0		757.0	1501.5		1271.0	2521.0		806.3	1599.2
VE.		29.0	58.0		25.2	50.0		45.3	90.0		26.0	51.5
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USAV-00005837

STATION: W.Aravaipa

STREAMFLOW TABULATION

WY: 1987

Month:	February			March			April			May		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	1.17	27.8		1.57	241.4		1.18	28.6		1.14	25.6	
2	1.13	24.9		1.47	141.4		1.18	28.6		1.13	24.9	
3	1.13	24.9		1.38	83.0		1.17	27.8		1.12	24.2	
4	1.12	24.2		1.39	87.0		1.26	42.6		1.11	23.5	
5	1.12	24.2		1.51	174.2		1.28	46.8		1.10	22.75	
6	1.11	23.5		1.44	119.8		1.32	59.0		1.10	22.75	
7	1.09	22.4		1.37	79.0		1.27	44.7		1.08	22.1	
	1.11	23.5		1.28	46.8		1.20	30.0		1.07	21.7	
	1.12	24.2		1.25	40.5		1.18	28.6		1.08	22.1	
0	1.13	24.9		1.92			1.17	27.8		1.07	21.7	
1	1.14	25.6		1.77			1.14	25.6		1.07	21.7	
2	1.14	25.6		1.46	134.2		1.13	24.9		1.08	22.1	
3	1.15	26.4		1.32	59.0		1.13	24.9		1.08	22.1	
4	1.15	26.4		1.25	40.5		1.11	23.5		1.08	22.1	
5	1.15	26.4		1.30	51.0		1.10	22.7		1.10	22.7	
6	1.16	27.1		1.63			1.09	22.4		1.10	22.7	
7	1.15	26.4		1.51			1.09	22.4		1.08	22.1	
8	1.14	25.6		1.34	67.0		1.09	22.4		1.09	22.4	
9	1.14	25.6		1.27	44.7		1.10	22.7		1.09	22.4	
0	1.14	25.6		1.22	34.2		1.11	23.5		1.12	24.2	
	1.13	24.9		1.20	30.0		1.10	22.7		1.11	23.5	
	1.12	24.2		1.23	36.3		1.11	23.5		1.10	22.7	
	1.15	26.4		1.21	32.1		1.11	23.5		1.09	22.4	
	1.78			1.19	29.3		1.12	24.2		1.06	21.4	
	2.14			1.18	28.6		1.13	24.9		1.07	21.7	
	1.82			1.19	29.3		1.14	25.6		1.06	21.4	
	1.63			1.17	27.8		1.14	25.6		1.06	21.4	
	1.54	207.8		1.18	28.6		1.15	26.4		1.04	20.7	
				1.18	28.6		1.14	25.6		1.04	20.7	
				1.18	28.6		1.14	25.6		1.04	20.7	
				1.18	28.6					1.04	20.7	
		789.0	1565.0		2018.0	4003.0		847.2	1680.4		693.2	1374.9
		33.0	65.2		74.7	148.2		28.2	56.0		22.4	44.8

USAV-00005838

STATION: W. Aravaipa

STREAMFLOW TABULATION

WY: 1987

Month:	June			July			August			September		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	1.04	20.7		1.00	19.3		1.06	27.1		1.04	20.7	
2	1.04	20.7		1.00	19.3		1.05	26.4		1.04	20.7	
3	1.04	20.7		0.99	19.1		1.05	26.4		1.04	20.7	
4	1.04	20.7		0.99	19.1		1.17	27.8		1.07	21.7	
5	1.04	20.7		0.99	19.1		1.07E	27.8		1.07	21.7	
6	1.16	27.1		0.99	19.1		1.11E	23.5		1.06	21.4	
7	1.22	34.2		0.99	19.1		1.08	22.1		1.04	21.7	
8	1.10	22.7		0.98	19.0		1.07	21.7		1.03	20.3	
9	1.09	22.4		0.97	18.8		1.06	21.4		1.02	20.0	
10	1.07	21.7		0.96	18.7		1.10	22.7		1.01	19.6	
11	1.07	21.7		0.95	18.5		1.15E	26.4		1.01	19.6	
12	1.06	21.4		0.95	18.5		1.08	22.1		1.00	19.3	
13	1.06	21.4		0.95	18.5		1.06	21.4		1.00	19.3	
14	1.05	21.0		0.98	19.0		1.05	21.0		1.00	19.3	
15	1.04	20.7		0.97	18.8		1.04	20.7		1.00	19.3	
16	1.03	20.3		0.99	19.1		1.03	20.3		0.99	19.1	
17	1.01	19.6		0.97	18.8		1.03	20.3		0.99	19.1	
18	1.01	19.6		0.95	18.5		1.02	20.0		1.01	19.6	
19	1.01	19.6		0.95	18.5		1.02	20.0		1.00	19.3	
20	1.02	20.0		0.95	18.5		1.03	20.3		0.99	19.1	
21	1.02	20.0		0.94	18.4		1.10E	22.7		1.00	19.3	
22	1.01	19.6		0.94	18.4		1.06	21.4		1.01	19.6	
23	1.01	19.6		0.93	18.2		1.06	21.4		1.04	20.7	
24	1.00	19.3		0.94	18.4		1.07	21.7		1.04	20.7	
25	1.01	19.6		0.97	18.8		1.08	22.1		1.04	20.7	
26	1.01	19.6		0.94	18.4		1.06	21.4		1.03	20.3	
27	1.00	19.3		0.94	18.4		1.06	21.4		1.03	20.3	
28	1.01	19.6		1.00	19.3		1.06	21.4		1.03	20.3	
29	1.01	19.6		1.01	23.5		1.06	21.4		1.03	20.3	
30	1.01	19.6		1.19	29.3		1.06	21.4		1.14	25.6	
31				1.10	22.7		1.05	21.0				
TAL		632.7	1254.9		601.0	1192.0		696.7	1381.9		609.3	1208.5
E.		21.1	41.8		19.4	38.4		22.4	44.5		20.3	40.2

AK 3.5

USAV-00005839

STATION: West Aravaipa

STREAMFLOW TABULATION

WY: 1988

Month:	October			November			December			January		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	1.04	20.7		1.29E	48.9		1.12	24.2		1.06	21.4	
2	1.02	20.0		1.19E	29.3		1.11	23.5		1.06	21.4	
3	1.00	19.3		1.14	25.6		1.11	23.5		1.07	21.7	
4	1.00	19.3		1.13	24.9		1.13	24.9		1.08	22.1	
5	1.00	19.3		1.12	24.2		1.12	24.2		1.08	22.1	
6	1.01	19.6		1.12	24.2		1.12	24.2		1.09	22.4	
7	1.00	19.3		1.12	24.2		1.12	24.2		1.09	22.4	
8	1.02	20.0		1.11	23.5		1.13	24.9		1.09	22.4	
9	1.03	20.3		1.11	23.5		1.12	24.2		1.10	22.7	
10	1.03	20.3		1.10	22.7		1.12	24.2		1.10	22.7	
11	1.03	20.3		1.11	23.5		1.12	24.2		1.11	23.5	
12	1.04	20.7		1.11	23.5		1.12	24.2		1.12	24.2	
13	1.08	22.1		1.11	23.5		1.13	24.9		1.13	24.9	
14	1.09	22.4		1.12	24.2		1.12	24.2		1.14	25.6	
15	1.09	22.4		1.12	24.2		1.12	24.2		1.14	25.6	
16	1.09	22.4		1.13	24.9		1.11	23.5		1.14	25.6	
17	1.10	22.7		1.13	24.9		1.19	29.3		1.15	26.4	
18	1.10	22.7		1.13	24.9		1.39	87.0		1.64	–	
19	1.10	22.7		1.13	24.9		1.23	36.3		1.49	155.8	
20	1.09	22.4		1.13	24.9		1.21	32.1		1.30	51.0	
21	1.10	22.7		1.13	24.9		1.13	24.9		1.24	38.4	
22	1.11	23.5		1.13	24.9		1.08	22.1		1.20	30.0	
23	1.13	24.9		1.14	25.6		1.08	22.1		1.18	28.6	
24	1.12	24.2		1.14	25.6		1.14	25.6		1.15	26.4	
25	1.12	24.2		1.13	24.9		1.12	24.2		1.14	25.6	
26	1.11	23.5		1.13	24.9		1.10	22.7		1.14	25.6	
27	1.11	23.5		1.12	24.2		1.08	22.1		1.13	24.9	
28	1.11	23.5		1.12	24.2		1.07	21.7		1.14	25.6	
29	1.11	23.5		1.12	24.2		1.07	21.7		1.13	24.9	
30	1.11	23.5		1.12	24.2		1.07	21.7		1.14	25.6	
31	1.13	24.9					1.06	21.4		1.14	25.6	
		680.8	1350.3		762.0	1511.4		822.1	1630.6		895.1	1775.4
		21.9	43.5		25.4	50.3		26.5	52.6		30.0	59.1

STATION: West Aravaipa

STREAMFLOW TABULATION

WY: 1988

Month:	February			March			April			May		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	1.13	24.9		1.09	22.4		1.03	20.3				
2	1.13	24.9		1.09	22.4		1.03	20.3				
3	1.14	25.6		1.08	22.1		1.01	19.6				
4	1.14	25.6		1.07	21.7		1.01	19.6				
5	1.50	163.0		1.07	21.7		1.00	19.3				
6	1.39	87.0		1.07	21.7		.99	19.1				
7	1.21	32.4		1.08	22.1		1.00	19.3				
8	1.16	27.1		1.08	22.1		1.00	19.3				
9	1.13	24.9		1.08	22.1		.99	19.1				
10	1.12	24.2		1.08	22.1		.98	19.0				
11	1.10	22.7		1.08	22.1		.99	19.1				
12	1.09	22.4		1.08	22.1		.99	19.1				
13	1.09	22.4		1.08	22.1		.99	19.1				
14	1.08	22.1		1.08	22.1		1.04	20.7				
15	1.08	22.1		1.08	22.1		1.02	20.0				
16	1.09	22.4		1.08	22.1		1.07	21.7				
17	1.09	22.4		1.08	22.1		1.05	21.0				
18	1.09	22.4		1.08	22.1		1.05	21.0				
19	1.10	22.7		1.08	22.1		1.04	20.7				
20	1.11	23.5		1.08	22.1		1.03	20.3				
21	1.12	24.2		1.08	22.1		1.06	21.4				
22	1.12	24.2		1.07	21.7		1.14	25.6				
23	1.12	24.2		1.07	21.7		1.11	23.5				
24	1.12	24.2		1.06	21.4		1.08	22.1				
25	1.12	24.2		1.06	21.4		1.07	21.7				
26	1.12	24.2		1.06	21.4		1.06	21.4				
27	1.10	22.7		1.06	21.4		1.06	21.4				
28	1.10	22.7		1.05	21.0		1.09	22.4				
29	1.09	22.4		1.05	21.0		1.10	22.7				
30				1.04	20.7		1.08	22.1				
31				1.03	20.3							
	397.7	1780.6			675.8	1340.4		621.9	1233.5			
	0.9	51.4			21.8	43.3		20.7	41.1			

USAV-00005841

Station Name: West Aravaipa

Elevation: 2650

		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	AVG/ TOTAL
1980	Avg. CFS													
	Total AF													
	Peak Depth													
1981	Avg. CFS			1 32.8	32.8	36.5	50.0*	20.7	14.9	11.0	25.0	16.1	18.3	
	Total AF			1304.7	2022.7	2029.1	2981.0	1276.3	889.9	658.0	1508.0	608.0	1095.0	
	Peak Depth											5.41		
1982	Avg. CFS	16.4	17.0	17.0	3 32.0*	30.0	34.0	21.0	15.2	9.7	9.3	23.0	24.0	
	Total AF	981.4	987.3	1029.0	944.1	1654.0	2068.0	1248.4	939.0	577.1	575.0	587.1	1416.2	
	Peak Depth				5.05							4.94	4.83	
1983	Avg. CFS	14.4	18.1	26.0	5 26.2	6 28.3	74.1*	39.6	23.7	20.4	–	–	–	
	Total AF	891.0	1803.0	1582.0	1509.4	618.5	2942.8	2356.4	1456.3	1213.7				
	Peak Depth						8.35							
1984	Avg. CFS	–	–	–	–	–	–	–	31.7	30.0	44.0*	52.0	43.2	
	Total AF								1862.9	1785.1	2618.2	3094.2	1800.6	
	Peak Depth													
1985	Avg. CFS	29.1	31.1	1 60.0*	60.7	2 71.0*	54.3	45.4	38.0	1 32.2	26.7	1 30.6	29.3	
	Total AF	1790.5	1848.0	2017.2	3253.0	266 .0	3339.8	2703.7	2340.3	1280.9	1642.7	1638.7	1758.4	
	Peak Depth			6.79	7.28						6.20			
1986	Avg. CFS	35.1	40.5	33.8	27.0	40.9*	9 37.1*	28.7	23.5	21.0	2 31.3	28.2	34.8*	
	Total AF	2160.6	2411.5	2081.6	1666.1	2194.2	1399.0	1710.3	1445.5	1252.9	1543.7	1732.5	1656.6	
	Peak Depth						6.22							
1987	Avg. CFS	29,0*	25.2	45.3*	26.0	33.0*	74.7*	28.4	22.4	21.1	19.4	22.4	20.3	
	Total AF	1672.2	1501.5	2521.0	1599.2	1565.0	4003.0	1680.4	1374.9	1254.9	1192.0	1381.9	1208.5	
	Peak Depth	5.14	5.57											
1988	Avg. CFS	21.9	25.4	26.5	30.0*	30.9	21.8	20.7						
	Total AF	13 .3	1511.4	1630.6	1775.4	178 .7	1340.4	1233.5						
	Peak Depth													

*CFS Missing

Days Lost

[illegible] 17,7-10,8-11,9-4, 10-[illegible]

USAV-00005842

APPENDIX 3

List of Threatened and Endangered Species Occuring at Aravaipa Canyon

Species	State	Federal
FISH		
Loach Minnow *Tiaroga cobitis*	Listed Group 3	Listed Threatened
Spikedace *Meda fulgida*	Listed Group 3	Listed Threatened
Gila Roundtail Chub *Gila robusta grahami*	Listed Group 3	Candidate Category 2
REPTILES		
Desert Tortoise *Gopherus agassizii*	Listed Group 3	Candidate Cagegory 2
Gila Monster *Heloderma suspectum*		Candidate Category 2
BIRDS		
Osprey *Pandion haliaetus carolinensis*	Listed Group 3	
Bald Eagle ~~*Haliaetus leucocephalus*~~	Listed ~~Group 2~~ Subspecies *H.l. leucocephalus*	Listed ~~Endangered~~
Black Hawk *Buteogallus a. anthracinus*	Listed Group 3	
Swainson's Hawk *Buteo swainsoni*		Candidate Category 2
Ferruginous Hawk *Buteo regalis*		Candidate Category 2
Peregrine Falcon *Falco peregrinus*	Listed Group 3	Listed Endangered
Crested Caracara *Polyborus plancus auduboni*	Listed Group 4	
Western Yellow-billed Cuckoo *Coccyzus americanus occidentalis*		Candidate Category 2

Northern Beardless Tyrannulet *Camptostoma imberbe ridgewayi*	Listed Group 3
Buff-breasted Flycatcher *Empidonax fulvifrons pygmaeus*	Listed Group 3
Rose-throated Becard *Pachyramphus aglaiae richmondi*	Listed Group 3
American Redstart *Setophaga ruticilla*	Listed Group 3
Snowy Egret *Egretta thula brewsteri*	Listed Group 4
Black-crowned Night Heron *Nycticorax n. noactle*	Listed Group 4

MAMMALS

Desert Bighorn Sheep *Ovis canadensis mexicanus*	Listed Group 3

APPENDIX 4

EVALUATION OF THE INSTREAM FLOW REQUIREMENTS OF THE NATIVE FISHES OF ARAVAIPA CREEK, ARIZONA BY THE INCREMENTAL METHODOLOGY

Submitted to the

U.S. Fish and Wildlife Service
Office of Biological Services
P.O. Box 1306
Albuquerque, New Mexico 87103

by

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JUL 1983

June 22, 1983

USAV-00005845

ABSTRACT

A study of the instream flow requirements of the native fishes of Aravaipa Creek in southeast-central Arizona was done in 1980-1981 using the Incremental Methodology. An IFG4 hydraulic simulation of the changes in physical habitat was completed for a typical stream reach located about 3/4 mile upstream from the eastern boundary of Aravaipa Canyon Primitive Area. For this simulation, field measurements of stream parameters (e.g. water depth and velocity, bottom substrate) were made at discharges of 11.1, 16.5 and 24.4 ft.^{3}/sec. and used to simulate stream conditions for discharges from 5 to 40 ft.^{3}/sec.

Probability-of-use curves were developed for two endemic, riffle-dwelling cyprinids, Meda fulgida and Tiaroga cobitis, from frequency-of-capture data on water depths and velocities which were collected by electrofishing in Aravaipa Creek and the Gila River, New Mexico during the summer and fall. This analysis revealed that adult Meda were most commonly collected at water velocities of 1.3 to 2.7 ft./sec. and were rarely found in areas with velocities less than 0.6 ft./sec. or greater than 3.0 ft./sec. Meda apparently preferred water depths of 0.60 to 0.75 feet and were not collected at depths less than 0.2 feet or greater than 1.2 feet. Although adult Tiaroga were collected at velocities from 0 to 3.6 ft./sec., they preferred a velocity of about 2.0 ft./sec. Adult Tiaroga were collected at depths of 0.1 to 1.0 feet, but were found most commonly at 0.4 to 0.6 feet. Adult Meda apparently preferred bottom substrates of sand and gravel, whereas adult Tiaroga preferred areas with gravel and cobble substrate.

Based on changes in Weighted Usable Area (WUA) at the study site, a discharge of 20 ft.^{3}/sec. provided the most available habitat for adult Meda and Tiaroga. WUA decreased rapidly at discharges less than 10 ft.^{3}/sec. for both species. A minimum discharge of 13 ft.^{3}/sec. at the BLM's East Aravaipa gaging station would be an acceptable minimum flow for adult Meda and Tiaroga during low-flow periods in the summer and fall. Stream flow dropped below this recommended minimum discharge during much of the summer of the 1982 water year. Thus, any additional water removals from the drainage upstream from the Aravaipa Canyon Primitive Area would reduce preferred habitats for adult Meda and Tiaroga in Aravaipa Creek during low-water years.

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ACKNOWLEDGEMENTS

We would like to recognize the efforts of the following students and employees for their assistance with fieldwork in Aravaipa Creek and the Gila River: J. Anderson, K. Britt, G. Desmare, M. Burrough, J. Gebler, B. Tibbetts, T. Thompson and R. Wilson. Personnel of the BLM office in Safford, Arizona provided useful suggestions, the use of helicopter and pilot, and streamflow records for Aravaipa Creek. John Luepke and other employees of Defenders of Wildlife provided considerable assistance and allowed us free access to the guest house at the George Whittell Wildlife Preserve and our instream flow study site.

T. Hardin completed the computer analysis in a professional and timely fashion. D. Hoppe (USFWS) and Dr. D. Weigmann reviewed the draft manuscript and provided helpful editorial suggestions. Members of the Cooperative Instream Flow Service Group (CIFSG) in Fort Collins, Colorado, especially Ken Bovee, gave expert advice and provided the computer analysis of our habitat data for Meda and Tiaroga. K. Spence typed the manuscript and the final report with her typical patience and professional competence.

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INTRODUCTION

Background

Funds for this study were made available to the senior author in 1980 after a Phase II Instream Flow Study of Arizona streams by the Arizona Game and Fish Department (AGFD) was terminated by a joint agreement between the U.S. Fish and Wildlife Service and AGFD. At the time the Arizona Phase II study was terminated with AGFD, New Mexico State University (NMSU) had just completed a Phase II Instream Flow Study of three New Mexico rivers (Turner et al. 1980). Because the two graduate students who had performed the New Mexico Phase II Study were still available, the senior author agreed to use the remaining unspent Arizona Phase II funds ($13,125.00 of $35,000.00 initially allocated to AGFD) for instream flow work on Arizona waters. This research was authorized as a modification to the original New Mexico instream flow study with the New Mexico Department of Game and Fish continuing as an administrative coordinator of the contract.

Selection of Study Sites

The streams originally selected for instream flow studies by AGFD included Aravaipa Creek, Black River at Buffalo Crossing in the Apache-Sitgreaves National Forest, and West Clear Creek, a tributary of the Verde River. All previous surveying work at the original AGFD study sites on the three streams had been destroyed by severe floods during the 1979 water year. Thus, our instream flow study in Arizona was essentially starting over as far as fieldwork was concerned. After an on-site evaluation of Aravaipa Creek in February 1980, we decided to retain this stream as a study site. At this time, Aravaipa Creek was

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considered a high priority stream by the AGFD because it was one of very few Arizona streams which still supported an essentially unmodified representation of the native Gila River ichthyofauna (Minckley 1973). In addition, the Safford District Office of the Bureau of Land Management (Safford-BLM) was managing the Aravaipa Canyon as a Primitive Area and had just completed the Aravaipa Canyon Wilderness Final Environmental Statement.

We had been advised by AGFD personnel to eliminate West Clear Creek as a potential study site, but were not given any specific recommendations on alternative study sites. During 1980, we contacted the Tucson and Pinetop offices of the AGFD, Safford District Office of the BLM, and the Apache-Sitgreaves National Forest about potential study sites in eastern Arizona. The BLM at Safford was especially helpful and provided a helicopter and pilot for an aerial reconnaisance of several potential study sites in their district including: Bonita Creek, Eagle Creek and the Gila River. We made on-site evaluations of Eagle Creek upstream from the water pumping station and of the following streams on the Apache-Sitgreaves National Forest: Black River at Buffalo Crossing, West and East Forks of the Black River, Blue River and Campbell Blue Creek. Because of the lack of any impending changes in the instream flow regime of these streams and limited funding, we decided to concentrate our efforts on Aravaipa Creek; the poor accessibility of the Gila River "box" upstream from Safford and the highly modified nature of the ichthyofauna at this potential site were the main reasons for eliminating the Gila River from potential consideration.

During the process of our selection of instream flow study streams in 1980, the senior author was contacted by the Phoenix District Office

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of the BLM and Dr. Randy McNatt, U.S. Fish and Wildlife Service (USFWS) about doing an instream flow study on the Burro Creek drainage in west-central Arizona. After preparation of a cooperative agreement between BLM and USFWS, a contract was awarded to the senior author to conduct an instream flow study of the Burro Creek drainage using the CIFSG's Incremental Methodology (Turner and Tafanelli 1983).

Aravaipa Creek

With the exception of the incision of the channel in sections not protected by bedrock and the elimination of cienegas in the floodplain above the canyon portion, Aravaipa Creek has apparently retained much of its original physical character and almost all of its native flora and fauna (Minckley 1981). Although temporary diversion dams of mounded sand and gravel are used to irrigate several hundred acres above the USGS gaging station near Mammoth, Arizona (USGS 1981), man's impact on Aravaipa Creek and its flora and fauna is minor when compared to other streams of the Sonoran desert (Minckley 1981). In particular, introduced fishes have remained rare and the native ichthyofauna is still composed of five cyprinids: spikedace (*Meda fulgida*), loach minnow (*Tiaroga cobitis*), roundtail chub (*Gila robusta grahami*), longfin dace (*Agosia chrysogaster*), speckled dace (*Rhinichthys osculus*); and two catostomids: Sonora sucker (*Catostomus insignis*) and desert sucker (*Catostomus* or *Pantosteus clarki*). Although all of these fishes of the Gila River drainage have experienced reductions in their distribution in Arizona because of reservoir construction and regular dessication in many of the originally permanent reaches (Minckley 1973), the status of *Meda fulgida* and *Tiaroga cobitis* have been most seriously impacted.

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Listing packages for these two species are currently being prepared by the USFWS and both species are being considered for "threatened" status under the existing guidelines of the Endangered Species Act of 1973; Aravaipa Creek is being considered as potential "critical habitat" for both fishes (Dr. Jim Johnson, USFWS, pers. comm.). In addition, the portion of Aravaipa Creek managed by the BLM will probably be officially designated as the Aravaipa Canyon Wilderness Area during 1983 by the U.S. Congress and become the first BLM-managed area to receive wilderness status.

I will not attempt to summarize most aspects of the excellent report on the physical, chemical and biological aspects of Aravaipa Creek (Minckley 1981) which was based on studies started in 1964 and intensified in 1976-1978 by Dr. W.L. Minckley and his colleagues. Minckley's (1981) report provides a thorough review of the available literature on the history, geology and hydrology of the Aravaipa Creek drainage and summarizes the results of an intensive survey of its flora and fauna in relation to their physical and chemical environment.

Minckley (1981) reviewed the discharge patterns in Aravaipa Creek based on USGS data for gaging stations located near the mouth of the drainage. He found that streamflow at the downstream gaging station generally reached its highest levels in the winter (December-March) and summer (July-September) with lowest discharges during April-June in most years. Winter discharge minima exceeded summer minima by 2-3 times and the frequency distribution of the mean daily discharges at the gaging station near Mammoth, Arizona exhibited a strong bimodality at 5 and 10 $ft.^3/sec.$ Minckley (1981) considered the 5 $ft.^3/sec.$ discharge as the base flow of the aquifer in the summer (less irrigation uses); the

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higher mode was attributed to either periods when no irrigation was being practiced or when local spates (small floods) were occurring in the drainage because of localized thunderstorms. Discharges at the downstream USGS gaging station were less than 20 ft.^{3}/sec. about 90% of the time. This relatively low discharge provided "adequate stability for development and maintenance of a diverse biota"; flooding of more than 100 ft.^{3}/sec. occurred less than 3% of the time and had no long-lasting detrimental impacts on the native flora and fauna (Minckley 1981).

Since Minckley's (1981) review of the discharge patterns for the downstream gage, several significant events from a hydrological standpoint have occurred. The maximum discharge since 1931 occurred on December 18, 1978, when a flood peaked at 16,200 ft.^{3}/sec. at the downstream gage (USGS 1981). Although the impact of this flood was still evident in the floodplain, the stream and its aquatic biota had apparently recovered from any adverse impacts by the spring of 1980.

Of more significance to this study was the establishment in 1980 of two new BLM gaging stations near the upstream (East Aravaipa) and downstream (West Aravaipa) boundaries of the current wilderness area. The upper gaging station (East Aravaipa) now provides a daily record of the discharge entering the canyon and should allow careful monitoring of streamflow conditions. Although the East Aravaipa gaging station only provides complete data for the 1981 and 1982 water years, the discharge records indicate a relatively stable discharge pattern for the upper part of the drainage (Appendix A). Mean daily discharge for the East Aravaipa gage during the 1981 water year was 18.7 ft.^{3}/sec. (range of 13.7 to 30.9 ft.^{3}/sec.) compared to a provisional mean of 20.4 ft.^{3}/sec. (range of 6.0 to 276 ft.^{3}/sec.) at the USGS gaging station near Mammoth,

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Arizona (Appendix A). Discharge at the East Aravaipa gage was slightly lower during the 1982 water year with a mean daily discharge of 14.7 $ft.^3$/sec. (range 7.3–34.3) $ft.^3$/sec.; mean monthly discharge ranged from 10.2–11.0 $ft.^3$/sec. during June, July, October and November of 1982 (Appendix A). Although the East Aravaipa gaging station has only been operational since August 1, 1980, a comparison of the streamflow records with the USGS gage near the mouth of the creek indicates considerable differences in the variability and magnitude of discharge between the upper and lower parts of the drainage. Insufficient data exists to make a thorough comparison in seasonal discharge patterns at this time, but monitoring the discharge at BLM's East Aravaipa gage should provide the best indicator of instream flow conditions both above the canyon and in the Aravaipa Canyon Primitive Area.

Because of the previously discussed reasons, our instream flow study of Aravaipa Creek concentrated on the instream flow requirements, particularly the physical habitat requirements, of the spikedace and loach minnow. We chose Meda and Tiaroga because we considered these species the most sensitive to instream flows and because we could obtain more reliable information on their habitat requirements than for other native fishes of Aravaipa Creek.

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MATERIALS AND METHODS

Study Site (T.6S., R.19E., NE¼, Sec. 19)

The instream flow study site was selected after either walking or driving along the flowing portions of Aravaipa Creek upstream from the mouth of Turkey Creek. The study site, located about 3/4 mile upstream from Turkey Creek, was a 358-foot reach (T.6S., R.19E., NE¼, Sec. 19) of the creek in the George Whittell Wildlife Preserve which is owned and managed by the Defenders of Wildlife. Preliminary electrofishing efforts on May 14, 1980 at the proposed site, prior to surveying and placement of transects, yielded all seven of the native fishes found in Aravaipa Creek (Minckley 1973). We found both adult and juvenile roundtail chub in the small pool at the downstream portion (Transect 1) of the study site. Adult spikedace and adult loach minnows were found in the run and riffle habitat types characterized by Transects 2-6. Although other native fishes were also observed at the study site, no attempts were made to quantify our fish collections. Our sampling efforts for fish were specifically designed to obtain quantitative data on the physical habitats used by spikedace, loach minnow and roundtail chub in and adjacent to the study site.

Except for the pool at Transect 1 where depths reached nearly 2 feet, water depths throughout the study site rarely exceeded 1.1 ft. Bottom substrate was dominated by sand and gravel at all transects, but small amounts of cobble were present at Transects 2-4 and 6. Channel width at the time of field measurements ranged from 16 to 26 ft. except for the run at Transect 2 which was only 10 to 14 ft. wide. Mean column velocities generally ranged from 1.0 to 3.0 ft./sec. in the middle of the

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stream channel except for Transect 2 and for our measurements at the highest discharge (24.4 $ft.^3$/sec. on March 4, 1981). Maximum mean column velocity during our field measurements was 4.6 ft./sec. at Transect 2.

The south bank of the creek at the study site was at the southern edge of the floodplain and was heavily wooded with deciduous species of the Mixed Broadleaf Community which includes cottonwood (Populus fremontii), willow (Salix spp.), sycamore (Platanus wrightii), velvet ash (Fraxinus pennsylvanica velutina), box elder (Acer negundo) and walnut (Juglans major) (Minckley 1981). Water cress (Rorippa Nasturtium-aquaticum) was present along the shallower margins of the study site during the summer of 1981, but was not apparent during May 14-15, 1980, presumably because of a series of floods in January, February and March of 1980 (USGS 1981). The north bank at the study site was considerably less steep and was less heavily vegetated by woody riparian species than the south bank.

Field Methods

Hydraulic Simulation. Techniques for placement of transects and collection of physical data on water depths, velocities and bottom substrate followed Bovee and Milhous (1978). Mean column water velocity was measured for each vertical during each sampling period with a pygmy flow meter which was attached to a top-setting wading rod. The wading rod was also used at each vertical to determine water depth to the nearest 0.1 foot.

The initial surveying and placement of the stakes for the transects and bench marks were accomplished on May 14-16, 1980. Because of obvious streambed movements over the winter, we took three additional sets of

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field measurements at the study site on March 4, July 21 and August 26, 1981.

Collection of Habitat Data on Fish. Most fish were collected by dip nets after being immobilized by DC current produced by a Smith-Root, Inc., Type VI or Type VII (backpack) Electrofisher. Sufficient amperage was used to produce galvanonarcosis and special attempts were made to minimize sampling bias by following the recommendations given by Bovee and Cochnauer (1977). Electrofishing efforts generally proceeded either upstream or laterally to the current in stream sections suspected of supporting populations of the target species. In areas which were considered likely habitat for loach minnows, a small seine (1/4- or 3/16-inch mesh) was held in place a few feet downstream and then the area immediately upstream was electrofished. Because adult *Tiaroga* were carried along the bottom downstream to the seine by the current, it was necessary to either carefully note their original location when shocked or sample discrete sections with homogenous habitat characteristics.

The original location of each target species was marked by dropping color-coded markers at the site where the fish was first observed. The markers consisted of 3-inch sections of 1/2-inch wooden dowel rods which had been painted various colors and tied by nylon twine to a 3-inch piece of iron rebar. The twine was carefully rolled around the dowel rod and the weight of the rebar caused it to unroll immediately after being dropped. Because we only had sufficient color combinations to identify six different fish groups, it was possible to mark the locations for adults and juveniles of only three species. During most sampling runs, a single person was responsible for dropping the location markers which were carried in the various compartments of a carpenter's apron.

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In Aravaipa Creek, we restricted the placement of location markers to spikedace, loach minnows and roundtail chubs. Fish habitat data from Aravaipa Creek were only collected from between the first upstream and first downstream stream crossings immediately above and below the instream flow study site. Although we concentrated our sampling efforts on spikedace and loach minnows in the Gila River in New Mexico, some habitat data was obtained for roundtail chubs, Sonora suckers and desert suckers; all of our sampling was done downstream from the Highway 180 bridge.

After a sampling run was completed, the crew would determine water depth and mean column water velocity with a top-setting wading rod and a pygmy flow meter at the site of the iron rebar anchor of the location marker. Bottom substrate within a 6-inch radius of the iron rebar was categorized to the nearest 10% into categories of the Modified Wentworth Particle Size Scale described by Bovee and Cochnauer (1977). When present, instream cover within 1 foot of a location marker and the presence of overhead cover (e.g. riparian vegetation) was noted.

Data Analysis

Hydraulic Simulation. The IFG4 analysis was done by Tim Hardin, a former CIFSG employee, using the computer facilities at Oregon State University in Corvallis, Oregon. The CIFSG computer programs used in this analysis were described by Milhous et al. (1981). Because of streambed movements between our March 4 and August 26, 1981, sampling dates, it was necessary to eliminate the data from the two upstream transects and make the IFG4 simulation with only four transects. The computer output includes the input data used in the computer analysis

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and contains a plot of the bottom profile across each transect. Mr. Hardin made some minor adjustments in the input data to improve the IFG4 simulation; both the unmodified and adjusted input data are provided in the computer output.

Probability-of-use Curves. The habitat data that was collected from Aravaipa Creek and the Gila River, New Mexico was sent to the CIFSG in Fort Collins, Colorado for preliminary evaluation. Our data was coded into the computer and analyzed by a CIFSG computer program designed to evaluate probability-of-use data. The input data and computer output of this analysis is contained in the following appendices: Appendix B for Sonora sucker, desert sucker and roundtail chub; Appendix C for spikedace; and Appendix D for loach minnow. A written summary of this computer analysis by Ken Bovee, CIFSG, is contained in Appendix E.

We prepared probability-of-use curves for water velocity and water depth from the computer-drawn marginals for spikedace and loach minnow. For comparative purposes, probability-of-use curves were also prepared by frequency analysis (Bovee and Cochnauer 1977) of the raw habitat data for velocity and depth. For our analysis, the probability-of-use weighting factors were taken directly from the frequency-of-capture data which were clustered in different increments to produce weighting factors which had the least variance between adjacent clusters (Bovee and Cochauer 1977). The frequency-of-capture data from Aravaipa Creek and the Gila River were summarized separately, but were combined when preparing the probability-of-use curves. In a few cases, it was necessary to sum the frequency data from adjacent increments to reduce the variance of the larger increments which were used in the frequency analysis of either velocity or depth. When this was done, the weighting factors were given

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the same value in both adjacent increments. In two cases where a school of spikedace had been collected together and assigned a single depth and velocity value, the school was counted as only a single observation in the frequency analysis. This method avoided excessive weighting of data which may have been influenced by schooling behavior associated with electrofishing efforts. Because the actual availability of different velocities and depths was unknown for most areas where fish habitat data was collected, we did not attempt to develop true habitat preference curves.

Weighted Usable Area

The weighted usable area (WUA) for all fish species was determined by using the CIFSG's HABTAT program (Milhous et al. 1981) with the IFG4 hydraulic simulation of the instream flow study site. For adult *Meda* and *Tiaroga*, the different sets of weighting factors developed from the computer-drawn curves and from our frequency analysis of the habitat data were both used in separate HABTAT runs to evaluate the impact of varying the probability-of-use weighting factors on weighted usable area over a range of discharges. The weighting factors used for the HABTAT analysis for Sonora sucker, desert sucker and roundtail chub were taken directly from the probability-of-use curves developed for these species in Burro and Francis creeks; the analysis of WUA for these three species was done mainly to evaluate how WUA varied for species which had substantially different probability-of-use curves from those of *Meda* and *Tiaroga*.

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RESULTS AND DISCUSSION

Hydraulic Simulation

Hydraulic information was obtained for the Aravaipa Creek instream flow site at the following discharges (based on our estimate for transect 3): 14.7 ft.^{3}/sec. on May 15, 1980; 24.4 ft.^{3}/sec. on March 4, 1981; 16.5 ft.^{3}/sec. on July 21, 1981; and 11.1 ft.^{3}sec. on August 26, 1981. Our estimates at the instream flow station were consistently 2.5-3.1 ft.^{3}/sec. less than measured during 1981 at the BLM gaging station located downstream near the upstream boundary of the wilderness area. Thus, 3 ft.^{3}/sec. was added to our recommended instream flow values so that the BLM gaging station (East Aravaipa) could be used to monitor streamflow.

Because of extensive streambed movements between May 15, 1980 and March 4, 1981, we eliminated the measurements on May 15, 1980 from our hydraulic simulation; this was not a serious problem because the flow on July 21, 1981 was quite comparable. Although mean daily flow at the East Aravaipa gaging station only varied from 14.0 to 30.9 ft.^{3}/sec. between our March 4 and August 26 sampling dates in 1981, there was sufficient streambed changes at 2 of our 6 transects to cause problems with the assumption of no streambed movement which is required for the IFG4 hydraulic simulation. Thus, we were forced to eliminate transects 5 and 6 from our simulation.

Based on field observations, the sand and gravel substrates which predominate in the stream channel upstream from the primitive area move quite readily during even short periods of increased flow associated with afternoon thunderstorms. Based on this observation, it is

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desirable to make field measurements within a 2-4 week period when discharge varies by only about 10 ft.^{3}/sec. in order to minimize streambed movement. In hindsight, the BLM streamflow records indicate that these criteria were best met from May 1-13, 1981.

The IFG4 simulation was based on three sets of data with a range of 11.1 to 24.4 ft.^{3}/sec. Using the accepted CIFSG guidelines for IFG4 simulation at 0.4 times the lowest flow to 2.5 times the highest flow (Milhous et al. 1981), our simulation of the instream flow site on Aravaipa Creek should have been acceptable within a range of flows from 4.4 to 61.0 ft.^{3}/sec. Because flows seldom exceed 40 ft.^{3}/sec. above the canyon except during floods, weighted usable area was only simulated over the range from 5 to 40 ft.^{3}/sec.

Although streambed movement was a problem in this study, the IFG4 simulation was considered preferable to a Water Surface Profile (WSP) simulation because it allowed evaluation over a wider range of flow conditions. After reviewing our results in Aravaipa Creek, it appears that a single set of hydraulic measurements taken at 12-15 ft.^{3}/sec. and a WSP simulation would have provided a sufficient range of simulated flows to adequately evaluate habitat conditions for Meda and Tiaroga.

Habitat Preferences of Key Species

Probability-of-use data were collected for spikedace and loach minnow on June 18-19, 1981, from the Gila River, New Mexico, and on July 19, August 27-28, and November 8-10, 1981, from Aravaipa Creek, Arizona (Appendices C and D). Limited data on Sonora and desert suckers were obtained on March 5-6, 1981, from the Gila River, New Mexico (Appendix B). However, the probability-of-use curves used for both suckers and the roundtail chub were developed from data collected from Burro and

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Francis creeks, Arizona during the spring and summer of 1981 (Turner and Tafanelli 1983).

Spikedace. Probability-of-use data on *Meda fulgida* were obtained for 54 adults from the Gila River and 140 adults from Aravaipa Creek; data on juvenile spikedace were restricted to 7 fish collected on August 27-28, 1981 in Aravaipa Creek (Appendix C).

The probability-of-use curve derived from the computer-drawn marginal prepared by the CIFSG (Appendix C, Figure 1) indicated a probability-of-use for spikedace of 1.00 for velocities between 1.6 and 2.0 ft./sec.; probability-of-use dropped to 0.10 as velocity decreased to 0.4 ft./sec. and increased to 3.0 ft./sec. (Table 1). However, our analysis of the velocity data (Table 2) indicated that the probability-of-use curve for velocity should be more plateau-like with a probability-of-use of nearly 1.0 for velocities of 1.3 to 2.7 ft./sec. (Figure 1). Very few *Meda* were collected at velocities either less than 0.6 or greater than 3.0 ft./sec (Table 2). The probability-of-use weighting factors (Table 3) which were used for the alternate computer analysis of available habitat (Run 2) were determined directly from our analysis of data on capture frequencies at different mean column velocities. Our best estimate of the velocity preferences for spikedace is represented by the smoothed curve drawn for these probability-of-use factors (Figure 1). If a probability-of-use curve had been drawn for capture data from the Gila River, probabilities-of-use would have been slightly greater at mean column velocities less than 1.7 ft./sec. and lower at velocities greater than 1.9 ft./sec. However, the limited habitat data collected for *Meda* from the Gila River had little impact on the probability-of-use curve developed from the combined data (Figure 1, Table 3). Except for one

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Table 1. Probability-of-use weighting factors for water velocity and depth used to determine weighted usable area for adult spikedace and loach minnow in Aravaipa Creek, Arizona. These factors were based on computer-drawn marginals prepared by CIFSG.

Species	Velocity (ft./sec.)	Probability-of-use	Depth (feet)	Probability-of-use
Spikedace (*Meda fulgida*)	0.0	0.0	0.00	0.00
	0.4	0.1	0.15	0.00
	1.0	0.6	0.30	0.40
	1.6	1.0	0.45	0.60
	2.0	1.0	0.60	1.00
	2.4	0.6	0.75	1.00
	3.2	0.0	0.90	0.45
	100.0	0.0	1.05	0.10
			1.20	0.00
Loach Minnow (*Tiaroga cobitis*)	0.0	0.2	0.00	0.00
	0.8	0.6	0.10	0.00
	1.3	1.0	0.24	0.38
	1.7	1.0	0.30	0.65
	2.4	0.7	0.36	0.85
	3.2	0.2	0.40	1.00
	4.0	0.0	0.50	1.00
	100.0	0.0	0.58	0.80
			0.72	0.20
			0.85	0.05
			1.00	0.00
			100.00	0.00

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Table 2. Frequency-of-capture data for loach minnow and spikedace collected at different water velocities in Aravaipa Creek, Arizona and the Gila River, New Mexico.

Velocity (ft./sec.)	Loach Minnow			Spikedace		
	Aravaipa Creek	Gila River	Total	Aravaipa Creek	Gila River	Total
0.0	--	1	1	--	--	--
0.1	--	3	3	--	1	1
0.2	1	5	6	--	--	--
0.3	--	6	6	--	--	--
0.4	2	4	6	--	1	1
0.5	--	7	7	--	--	--
0.6	1	4	5	--	2[a]	2[a]
0.7	4	5	9	1	1	2
0.8	1	2	3	1	2	3
0.9	2	3	5	1	2	3
1.0	1	4	5	6	1	7
1.1	9	7	16	1	--	1
1.2	5	5	10	1	--	1
1.3	5	--	5	7	5	12
1.4	2	2	4	6	3	9
1.5	10	3	13	4	1	5
1.6	8	4	12	6	1	7
1.7	7	1	8	6	5	11
1.8	10	--	10	6[b]	2	8[b]
1.9	10	5	15	4	1	5
2.0	9	4	13	12	1	13
2.1	12	5	17	7	2	9
2.2	8	2	10	10	2	12
2.3	3	2	5	9	--	9
2.4	11	2	13	4	1	5
2.5	4	1	5	7	4	11
2.6	3	3	6	7	1	8
2.7	3	--	3	5	1	6
2.8	4	6	10	3	--	3
2.9	4	1	5	2	--	2
3.0	--	1	1	1	--	1
3.1	--	1	1	--	--	--
3.2	--	6	6	--	--	--
3.3	1	--	1	--	--	--
3.4	--	3	3	--	--	-
3.5	--	3	3	1	--	1
3.6	--	2	2	--	--	--

[a]A school of 15 spikedace which were first observed at a location with this velocity was counted as a single observation.

[b]A school of 23 spikedace which were first observed at a location with this velocity was counted as a single observation.

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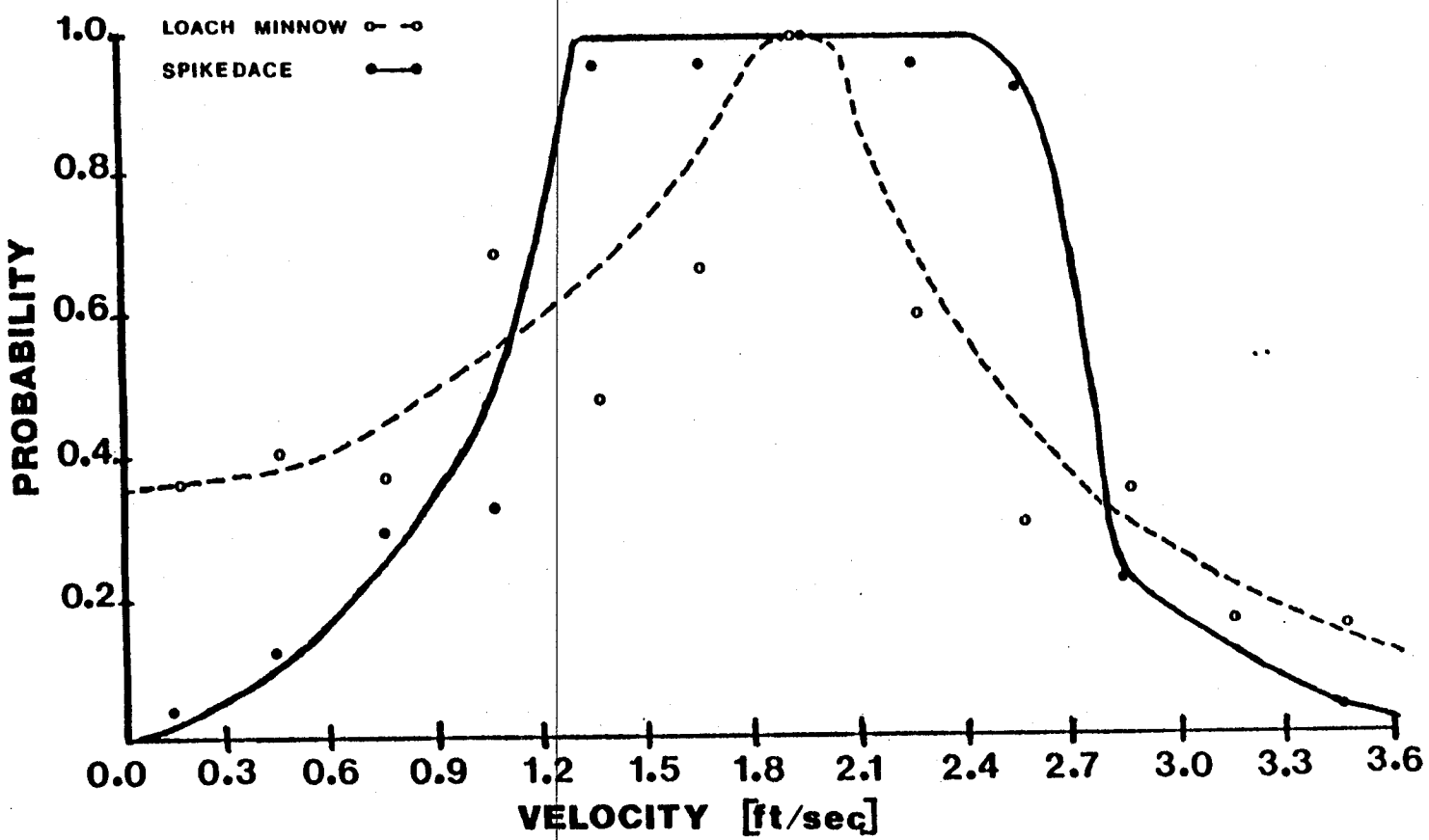

Figure 1. Probability-of-use curves for water velocity for loach minnow (--) and spikedace (—). Probability points for loach minnow (∘) and spikedace (·) were based on frequency-of-capture data for fish collected in Aravaipa Creek, Arizona and the Gila River, New Mexico.

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Table 3. Probability-of-use weighting factors for velocity and depth for spikedace and loach minnow developed by frequency analysis of capture data from Aravaipa Creek, Arizona and Gila River, New Mexico.

Velocity (ft./sec.)	Probability-of-use		Depth (feet)	Probability-of-use	
	Meda	Tiaroga		Meda	Tiaroga
0.0	0.00	0.20	0.00	0.00	0.00
0.2	0.04	0.36	0.15	0.00	0.06
0.5	0.12	0.40	0.25	0.06	0.29
0.8	0.30	0.40	0.35	0.17	0.61
1.1	0.33	0.60	0.45	0.23	0.87
1.4	0.96	0.60	0.55	1.00	1.00
1.7	1.00	0.70	0.65	0.79	0.58
2.0	1.00	1.00	0.75	0.35	0.17
2.3	0.96	0.62	0.85	0.35	0.06
2.6	0.93	0.34	0.95	0.15	0.01
2.9	0.22	0.34	1.05	0.09	0.01
3.2	0.04	0.18	1.15	0.06	0.00
3.5	0.04	0.18	1.25	0.02	0.00
4.0	0.00	0.00	1.50	0.00	0.00
10.0	0.00	0.00	10.00	0.00	0.00

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fish collected at a mean column velocity of 0.1 ft./sec. from the Gila River, adult spikedace were not collected at velocities less than 0.4 ft./sec. Mean column velocities at capture locations ranged from 0.85 to 3.0 ft./sec. in Aravaipa Creek, but ranged from 0.1 to 2.7 ft./sec. in the Gila River (Appendix C).

The computer-drawn marginal for probability-of-use for depth of adult spikedace (Appendix C, Figure 2) indicated that probability-of-use was 1.00 for water depths of 0.60 to 0.75 ft. and then dropped to 0.00 when depths either decreased to 0.15 ft. or increased to 1.20 ft. (Table 1). Our analysis of the frequency-of-capture data for depth (Table 4) indicated more restrictive depth preferences for adult spikedace with a strong preference for depths of 0.5 to 0.6 ft. (Figure 2). The probability-of-use weighting factors which we determined from our frequency analysis (Table 3) were lower at depths from 0.20 to 0.45 ft. and from 0.60 to 1.05 ft. than the weighting factors generated from the computer-drawn marginal (Table 1). Both sets of weighting factors were used in separate computer runs (HABTAT program) to evaluate the sensitivity of the habitat analysis to modifications in the probability-of-use curves.

Depths of capture for adult spikedace were slightly greater in Aravaipa Creek (mean of 0.65 ft., range of 0.3 to 1.2 ft.) than in the Gila River (mean of 0.52 ft., range of 0.2 to 0.8 ft.) (Table 4). Probability-of-use weighting factors (Table 3) would have been 0.04-0.15 greater at depths from 0.6 to 1.1 ft. if the data for spikedace from the Gila River had been eliminated from our analysis.

The axes of the depth-velocity scattergram (Appendix C, Figure 3), are quite skewed and indicate that there is a high degree of correlation

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Table 4. Frequency-of-capture data for loach minnow and spikedace collected at different depths in Aravaipa Creek, Arizona and the Gila River, New Mexico.

Depth (feet)	Loach Minnow			Spikedace		
	Aravaipa Creek	Gila River	Total	Aravaipa Creek	Gila River	Total
0.10	--	1	1	--	--	--
0.15	--	3	3	--	--	--
0.20	2	7	9	--	1	1
0.25	2	9	11	--	2	2
0.30	19	17	36	4	--	4
0.35	4	2	6	2	2	4
0.40	35	9	44	6	2	8
0.45	8	8	16	2	1	3
0.50	31	22	53	22	14	36
0.55	9	7	16	8	3	11
0.60	20	13	33	24	9	33
0.65	3	4	7	3	1	4
0.70	6	4	10	12	2	14
0.75	--	2	2	1	--	1
0.80	1	3	4	15[a]	2	17
0.85	--	--	--	--	--	--
0.90	--	1	1	5	--	5
0.95	--	--	--	2	--	2
1.00	1	--	1	3	--	3
1.05	--	--	--	1	--	1
1.10	--	--	--	1	--	1
1.15	--	--	--	3	--	2
1.20	--	--	--	1[b]	--	1

[a] A school of 15 spikedace which were first observed at a location with this depth and captured later was counted as only a single observation in the frequency analysis.

[b] A school of 23 spikedace which were first observed at a location with this depth and captured later was counted as only a single observation in the frequency analysis.

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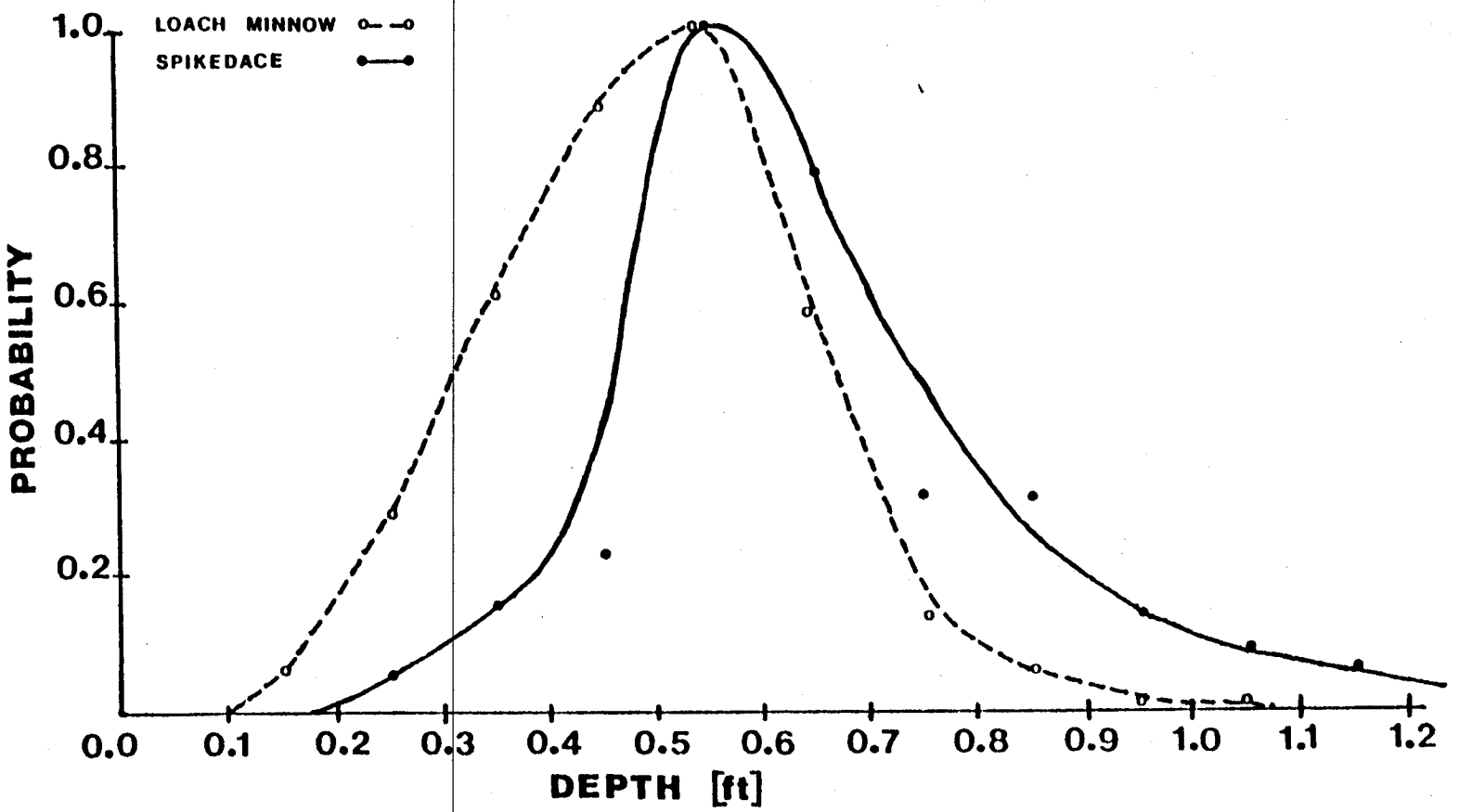

Figure 2. Probability-of-use curves for water depth for loach minnow (--) and spikedace (—). Probability points for loach minnow (∘) and spikedace (·) were based on frequency-of-capture data for fish collected in Aravaipa Creek, Arizona and the Gila River, New Mexico.

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between depth and velocity in the two streams. This "environmental bias" in our data causes our curves for Meda and Tiaroga to really describe the range of tolerances for a restricted range of environmental conditions where both suitable velocity and depth occur together rather than the fish's actual preferences for these parameters (Ken Bovee, CIFSG, pers. comm.). Because we did not have time to collect the PHABSIM type data needed to simulate the availability of microhabitats at each site where habitat preference data was obtained, it was impossible to correct for the environmental bias in our preference data. The summary of habitat data by Ken Bovee indicated that our curves "are as good as most curves on FISHFIL," but the curves on Meda and Tiaroga should not be used on streams that are much different from where we collected the habitat data (Appendix E).

The CIFSG was unable to get computer-drawn preference curves for substrate for Meda and Tiaroga. A good deal of their difficulties probably resulted from the differences in how substrate information was recorded between our June sample from the Gila River and later collections of habitat preference data from Aravaipa Creek. Our data on adult Meda indicate an apparent preference for substrates containing smaller gravel sizes and sand (Appendix C, Figures 4 and 5).

Although we did not observe spawning activities, observations on habitat preferences in Arizona waters are quite consistent with observations made by the senior author in the Gila River and its tributaries in New Mexico. The following information refers to habitat preferences in Arizona waters:

> Meda fulgida appears to prefer moving water less than a meter in depth during most of the year, concentrating near the downstream ends of riffles, or in eddies. In larger habitats, such as in the

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Salt River Canyon, spikedace have been taken only below the mouths of creeks, and as young along the margins of large pools over muddy bottoms. In spring, the fish often frequents fairly shallow areas, especially over sand and finer gravels in places of swift, relatively laminar flow (Minckley 1973).

Spawning habitat in Aravaipa Creek was described as shallow sand-bottomed areas with moderate water velocities (Barber et al. 1970). The presence of shallow riffles (less than 1 ft.) with sand and fine gravel substrate and relatively moderate, laminar flows coincided with large aggregations of adult spikedace prior to 1979 in the East Fork of the Gila River just upstream from its confluence with the West Fork. However, the elimination of this habitat type and its replacement by narrower, more rapidly-flowing runs by floods in 1978 has resulted in Meda becoming uncommon in the lower portions of the East Fork in recent years. In the Gila River downstream from Cliff, New Mexico, spikedace have been observed to patrol the edges of rapidly-flowing runs within a relatively narrow range of water depths and velocities. They also utilized eddies on the downstream portions of runs and shallower (less than 1 ft.) riffles with moderate flows where braided channels provided a variety of habitat types.

Loach minnow. Habitat preference data were collected for 141 adults in Aravaipa Creek and 112 adults in the Gila River. Comparable data for 14 juveniles was collected from Aravaipa Creek on August 27, 1981.

In contrast to our data on spikedace, adult loach minnows appear to have a strong preference for a cobble and gravel substrates and avoid substrates dominated by sand and finer gravel (Appendix D, Figures 4 and 5). The apparent requirement for cobble and large gravel substrates is probably related to the tendency for Tiaroga to maintain a relatively

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stationary position on the bottom in flowing water. An irregular bottom caused by the presence of cobble and larger gravels should create microhabitats near the bottom with low velocities. These microhabitats should allow Tiaroga to maintain a stationary position with less energy expenditure.

The presence of cobble substrate appears to be necessary for spawning and satisfactory egg incubation in the Gila River and its tributaries in New Mexico; fertilized eggs were only found attached to the underside of flattened cobble (average dimensions of 5.3 x 7.1 inches) (Britt 1982). This cobble substrate apparently must provide a protected location, which lacks periphytic growth because of the shading caused by the cobble. Thus, it appears important that the cobble is not imbedded in finer substrate particles which may eliminate shaded cavities for egg deposition.

In New Mexico, spawning sites were typically found along the head and margins of riffles and runs at depths of 1.2 to 29.9 inches with a mean of 5.1 inches (Britt 1982; Appendix D); bottom velocities taken with a pygmy meter immediately downstream from the cobble spawning site (after the cobble was carefully repositioned) averaged 0.6 ft./sec. Eggs of loach minnows were also found attached to the underneath sides of cobble in Aravaipa Creek in May of 1980, but the size of the cobble was considerably smaller; the reduced abundance of larger unimbedded cobble in Aravaipa Creek was probably a factor in the use of smaller spawning substrate.

Minckley (1973) indicates that Tiaroga is "restricted to gravelly riffles" and is "most often taken in association with beds of filamentous algae such as Pithophora or Cladophora, either in the main channels of shallow swift reaches, or along the margins of more torrential rapids"

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of small to moderately-large creeks and rivers. Because algal beds are typically absent in the Gila River and its larger tributaries in New Mexico, Tiaroga does not seem to require the presence of aquatic vegetation. However, it has been collected from submerged beds of vascular macrophytes in New Mexico streams when this type of vegetation was present. Beds of submerged algae or macrophytes may serve the same purpose as cobble substrate, which is to reduce bottom water velocities. In the absence of cobble, the availability of submerged vegetation may become a more important habitat feature; however, it is unknown whether submerged vegetation can provide suitable sites for attachment of the loach minnow's adhesive eggs.

Collections of young-of-the-year loach minnows in New Mexico streams prior to 1981 indicate that juveniles have greater preferences for smaller substrate sizes (e.g. sand), shallower depths and slower velocities than adult Tiaroga. Although our observations prior to this study were not quantified, juvenile loach minnows have been commonly encountered near the edges of riffles and runs and in shallow (less than 6 inches) portions of braided riffles which have been created by temporary diversion structures or dropping water after high winter and spring flows. The 14 juvenile Tiaroga which were captured in Aravaipa Creek in 1981 were at depths of 4.0 to 8.4 inches and at mean column velocities of 0.9 to 2.5 ft./sec. (Appendix D).

Adult loach minnows have a somewhat wider range of tolerance for water velocity than adult spikedace, especially for lower mean column velocities (Tables 1-3, Figure 1). When the computer-drawn marginal (Appendix D, Figure 1) was used as a guide, probability-of-use was 1.00 between 1.3 and 1.7 ft./sec. and dropped linearly to a probability of

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0.20 at 0.0 and 3.2 ft./sec. (Table 1). When our capture frequencies were compared, it was obvious that Tiaroga preferred slower mean column velocities in the Gila River than in Aravaipa Creek (Table 2). In the Gila River, probability-of-use was essentially 1.0 at velocities of 0.1-1.2 ft./sec. and decreased to about 0.5 at 1.3-3.6 ft./sec. In contrast, loach minnows preferred velocities of 1.5-2.4 ft./sec. in Aravaipa Creek with progressively lower probabilities-of-use at velocities less than 1.5 ft./sec. and greater than 2.4 ft./sec. The major differences in velocity preferences between streams could have been caused by one or more of the following factors: loach minnows were collected only in early June in the Gila River and habitat preferences may have still been influenced by spawning activities which continue into June in the Gila River (Britt 1982); water transparency was lower in the Gila River than in Aravaipa Creek in the summer and fall when Tiaroga were collected; the presence of more and larger cobble substrate in the Gila River may have influenced the use of slower velocities and shallower water; and considerably more water with slower velocities was available for Tiaroga use in the Gila River than in Aravaipa Creek which had a higher proportion of runs and rapidly-flowing riffles in a single well-established channel in the areas where we collected habitat data.

The use of slower velocities by Tiaroga in the Gila River suggested a higher preference for this type of water than indicated by the capture data in Aravaipa Creek (Table 4). Thus, the frequency-of-capture data for both streams were combined to produce more generalized probability-of-use weighting factors (Table 3) for use in the computer analysis. The combination of capture data resulted in the probability-of-use factors being considerably greater at mean column velocities less

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than 1.3 ft./sec. and slightly greater at velocities greater than 2.8 ft./sec. than would have occurred if only capture data from Aravaipa Creek were used. The weighting factors which we developed by frequency analysis (Table 3) indicated lower probability-of-use values for Tiaroga between 1.0 and 2.0 ft./sec. than predicted by the computer-drawn marginal (Table 1; Appendix D, Figure 1).

Although adult Tiaroga apparently have a wider range of tolerance for velocity than Meda, the probability-of-use curve for mean column velocity has a much sharper peak for Tiaroga than the plateau-like curve for Meda (Figure 1). Our habitat data for the loach minnow indicate greater preferences for higher velocities in streams where cobble substrate provides the preferred microhabitats on the bottom. In the Gila River, adult loach minnows were not collected at mean column velocities of 2.5-3.6 ft./sec. unless cobble substrate was present (Appendix D). Adult Tiaroga were rarely collected at velocities greater than 2.0 ft./sec. in Aravaipa Creek (Table 2) unless very coarse gravel or cobble was present.

Adult loach minnows preferred slightly shallower water than adult spikedace in our streams (Figure 2). Based on the computer-drawn marginal (Appendix D, Figure 2), probability-of-use was 1.00 at a depth of 0.4-0.5 feet and dropped rapidly to 0.20 when depth increased to 0.7 ft. (Table 1). When the frequency-of-capture data were analyzed (Table 4), we found that the probability-of-use peaked at 0.50-0.55 ft. (Table 3, Figure 1). When the capture data were compared between streams, the preferences appeared similar at depths greater than 0.25 ft., but loach minnows used water less than 0.3 ft. more in the Gila River than in Aravaipa Creek (Table 4).

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Although adult Tiaroga were not collected at depths greater than 1.0 ft. during 1981 (Appendix D), they must occasionally occur at greater depths during spawning because Britt (1982) found eggs in water as deep as 29.9 inches. This may indicate either sampling bias or environmental bias in our data collection in 1981; however, the preferred depths for the species was probably accurately described for the summer and fall. It is likely that habitat preferences may be somewhat different during winter and spring and during the spawning period.

Other species. Because of time limitations and our belief that Meda and Tiaroga were more sensitive to changes in instream flow, we collected little data on habitat preferences on other species in Aravaipa Creek. Although habitat data were obtained for 62 roundtail chub from Aravaipa Creek, the probability-of-use curves which were prepared from data collected in Burro and Francis creeks (Turner and Tafanelli 1983) for roundtail chub (Gila robusta robusta), Sonora sucker (Catostomus insignis) and desert sucker (Catostomus clarki) (Table 5) were used to estimate how available habitat (weighted usable area) for these species would be influenced by changing discharge in Aravaipa Creek. Changes in weighted usable area for these three species should be considered less reliable than for Meda and Tiaroga for the following reasons: roundtail chub from Aravaipa Creek belong to a different subspecies (Gila robusta grahami) which is generally found in smaller tributaries and at higher elevations than Gila r. robusta which occurs in Burro Creek (Minckley 1973); Catostomus clarki may differ genetically between Aravaipa and Burro creeks (Minckley 1973); stream habitat conditions in upper parts of Aravaipa Creek and where we collected habitat data in the Burro Creek drainage were quite different, thus our probability-of-use

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Table 5. Probability-of-use weighting factors for water velocity and depth used to estimate weighted usable area for roundtail chub, Sonora sucker and desert sucker. These weighting factors were based on habitat data collected in Burro Creek, Arizona for the size ranges indicated for each species.

	Velocity (ft./sec.)	Probability-of-use	Depth (feet)	Probability-of-use
Roundtail chub (3-7 inches, TL)	0.00	1.00	0.00	0.00
	0.30	1.00	0.08	0.00
	0.50	0.50	0.15	0.30
	0.70	0.25	0.20	0.40
	1.30	0.15	0.30	0.80
	2.00	0.10	0.40	0.90
	2.50	0.00	0.50	0.97
	100.00	0.00	0.60	1.00
			100.00	1.00
Sonora sucker (5-12 inches, TL)	0.00	0.90	0.00	0.00
	0.05	0.96	0.10	0.00
	0.20	1.00	0.30	0.15
	0.40	0.95	0.50	0.30
	0.50	0.34	0.60	0.50
	0.60	0.25	0.64	0.85
	1.00	0.12	0.80	0.98
	1.60	0.09	0.90	1.00
	2.00	0.07	100.00	1.00
	100.00	0.00		
Desert sucker (3-9 inches, TL)	0.00	0.85	0.00	0.00
	0.20	0.95	0.09	0.00
	0.30	1.00	0.30	0.30
	0.60	0.70	0.50	0.65
	0.80	0.34	0.80	0.93
	1.30	0.15	1.00	1.00
	2.00	0.07	100.00	1.00
	100.00	0.00		

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curves were probably influenced by environmental bias which reduce their comparability between different types of streams; and sampling biases associated with collecting fish by electrofishing probably has a greater impact on probability-of-use curves for both suckers and roundtail chub than for Meda and Tiaroga.

Because of the limited amount of pool habitat available in the sections of Aravaipa Creek that we sampled, we only collected roundtail chub at depths of 0.4 to 1.5 feet. Although this data should be considered biased because we seldom sampled water over 1.5 feet in Aravaipa Creek, our data on depth preferences of roundtail chub compared well with the probability-of-use curve prepared with data from Burro and Francis creeks (Table 5). In contrast, our data suggested higher preferences for mean column water velocities greater than 0.5 ft./sec. in Aravaipa Creek than in the Burro Creek drainage. When instream cover was absent, roundtail chub were collected in similar numbers at mean column velocities from 0.75 to 2.5 ft./sec.; when instream cover (e.g. undercut banks, submerged logs) was present, roundtail chub were collected more commonly at velocities less than 1.0 ft./sec. These data were considered to be biased because relatively few pools or areas with lower water velocities were sampled in Aravaipa Creek except at the shallow margins of riffles and runs where depth probably limited the likelihood of roundtail chub being collected. Our data do suggest a strong preference for instream cover for Gila robusta grahami in Aravaipa Creek during the daytime when water transparencies were high.

Because of previously discussed reasons, estimates of weighted usable area (WUA) for both suckers and the roundtail chub in Aravaipa Creek should only be used for comparative purposes to the more reliable

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WUA values obtained for Meda and Tiaroga. A more complete discussion of habitat preferences of both suckers and roundtail chub was given by Turner and Tafanelli (1983).

Weighted Usable Area Versus Discharge

Spikedace. When the weighting factors developed from the computer-drawn preference curves were used (Run 1), weighted usable area (WUA) was greatest for adult spikedace at discharges of 20-25 $ft.^3$/sec., but varied relatively little at flows of 10 to 40 ft^3/sec. (Table 6). The use of our alternate probability-of-use factors (Table 3) caused a 30-70% reduction in WUA, but WUA still peaked at 20 $ft.^3$/sec. (Run 2, Table 6). In both computer runs, WUA varied by less than 25% as discharge was simulated over a range from 10 to 40 ft^3/sec. WUA decreased rapidly for both computer runs when discharge was reduced from 10 to 5 $ft.^3$/sec. (Table 6). For Run 2, WUA decreased from 4400 to 900 $ft.^2$ per 1000 feet of stream when discharge dropped from 10 to 5 $ft.^3$/sec. Although the use of different probability-of-use weighting factors changed the absolute amount of WUA, the peak in WUA for adult spikedace still occurred at 20 $ft.^3$/sec.

Loach minnow. WUA for adult Tiaroga peaked at 15-20 $ft.^3$/sec. for both computer runs, but was relatively similar at discharges of 10 to 25 $ft.^3$/sec. (Table 6). Although WUA decreased by 45% for adult loach minnows when discharge was reduced from 10 to 5 $ft.^3$/sec. (Run 2), the magnitude of this decrease was not as great as noted for adult spikedace. As noted with spikedace, WUA was 30 to 45% less for Tiaroga in Run 2 than estimated in Run 1 for the same discharges (Table 6). WUA was greater for adult Tiaroga than adult Meda at all flows from 5 to 35 $ft.^3$/sec.

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Table 6. Weighted usable area and percentage of gross area for spikedace and loach minnow at the Aravaipa Creek, Arizona Study Site which was located on Defenders of Wildlife property upstream from the Aravaipa Canyon Wilderness Area.

Discharge (ft.^{3}/sec.)	Area in Square Feet (x1000) per 1000 Feet of Stream				
	Gross Area	Weighted Usable Area			
		Spikedace		Loach Minnow	
		Run 1[a]	Run 2[b]	Run 1[a]	Run 2[b]
5	14.4	2.5 (18)[c]	0.9 (6)[c]	5.5 (38)	3.0 (21)
7	15.5	3.9 (25)	1.9 (12)	6.9 (41)	4.4 (28)
10	16.7	5.6 (34)	4.4 (26)	7.9 (47)	5.5 (33)
12	17.2	6.3 (36)	4.6 (27)	8.1 (47)	5.7 (33)
15	19.0	6.7 (35)	4.8 (25)	8.3 (44)	5.9 (31)
20	20.4	7.1 (35)	5.6 (27)	8.5 (41)	5.7 (28)
25	21.3	7.1 (34)	5.1 (24)	8.1 (38)	5.6 (26)
30	22.0	6.7 (30)	4.8 (22)	7.4 (34)	5.1 (23)
35	26.1	6.0 (23)	4.3 (16)	6.3 (24)	4.4 (17)
40	27.8	5.6 (20)	4.5 (16)	5.5 (19)	4.1 (15)

[a]Probability-of-use weighting factors for Run 1 were based on computer-drawn preference curves prepared by the CIFSG from our capture data (Table 1).

[b]Probability-of-use weighting factors for Run 2 were based on preference curves prepared by frequency analysis from our capture data (Table 3).

[c]Number in parentheses is the percentage of the gross area.

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Other Species. WUA varied by less than 10% for both Sonora and desert suckers over the range of discharge from 7 to 25 $ft.^3$/sec. and then increased slowly with increasing discharge up to 40 $ft.^3$/sec. (Table 7). In contrast to both suckers where WUA was lowest at 5 $ft.^3$/sec., WUA for roundtail chub was greater at 5-12 $ft.^3$/sec. than at higher discharges. The relative insensitivity of WUA to varying discharge for both suckers and roundtail chub was related to their preference for low water velocities and tolerance for shallow depths (Table 5).

Instream Flow Recommendations for Aravaipa Creek

Because of their apparent tolerance of a wide range of discharges and low-flow conditions, WUA values for both suckers and the roundtail chub were not as useful as WUA values for *Meda* and *Tiaroga* in making instream flow recommendations for Aravaipa Creek above the Aravaipa Canyon Primitive Area. The current distribution of the spikedace and loach minnow is more restricted than for the other native cyprinids and catostomids of Aravaipa Creek and the upper portions of the Gila River drainage. In addition, proposed water developments on the Gila and San Francisco rivers may have serious impacts on the status of native fishes, especially the spikedace. Listing packages for both *Meda* and *Tiaroga* are currently being prepared by the Office of Endangered Species, U.S. Fish and Wildlife Service. Both species are likely to be recommended for "threatened" status and Aravaipa Creek is being considered as "critical habitat" for both species (Jim Johnson, USFWS, pers. comm.).

Based on changes in WUA, it appears that a discharge of 20 $ft.^3$/sec. at our instream flow study site would provide the most usable habitat

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Table 7. Weighted usable area and percentage of gross area for roundtail chub, Sonora sucker and desert sucker at the Aravaipa Creek Study Site which was located on Defenders of Wildlife property upstream from the Aravaipa Canyon Wilderness Area.

Discharge (ft.^{3}/sec.)	Area in Square Feet (x1000) per 1000 Feet of Stream			
		Weighted Usable Area		
	Gross Area	Roundtail Chub	Sonora Sucker	Desert Sucker
5	14.4	3.0 (21)[a]	0.8 (6)[a]	1.6 (11)[a]
7	15.5	3.2 (20)	1.0 (6)	1.8 (12)
10	16.7	3.2 (19)	1.0 (6)	1.9 (12)
12	17.2	3.1 (18)	1.1 (7)	2.0 (12)
15	19.0	2.8 (15)	1.0 (6)	2.0 (11)
20	20.4	2.2 (11)	1.0 (5)	1.9 (9)
25	21.3	2.3 (11)	1.1 (5)	1.9 (9)
30	22.0	2.2 (10)	1.2 (6)	2.0 (9)
35	26.1	2.1 (8)	1.4 (5)	2.1 (8)
40	27.8	2.6 (9)	1.5 (5)	2.4 (9)

[a]Number in parentheses is the percentage of the gross area.

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for adult spikedace and loach minnow in Aravaipa Creek during the summer and fall. A minimum flow of 10 ft.^{3}/sec. would not result in much reduction in usable habitat, but lower flows would have more detrimental impacts, especially for Meda. Streamflow data for the BLM gaging station upstream from the wilderness area (East Aravaipa) indicates that June and July are low-flow periods and flows of 7.5-13.6 ft.^{3}/sec. occurred in those months in 1982, discharge was less than 10 ft.^{3}/sec. on 18 days. When using the BLM gaging station (East Aravaipa) for monitoring purposes, 3 ft.^{3}/sec. should be added to our flow recommendations. Thus, an optimum flow of about 23 ft.^{3}/sec. would be desirable during the late spring through early fall; below about 13 ft.^{3}/sec., the amount of WUA would decrease rapidly for Meda and Tiaroga.

Although we did not include substrate preferences in our analysis of weighted usable area, it appears that cobble substrate which is not imbedded in the bottom by accumulations of fines and gravel is an important habitat requirement of adult loach minnows and may be an absolute requirement for successful spawning and egg incubation. This information indicates that the control of soil erosion and accumulations of silt and sand in the streambed is desirable. It appears that the substrate-cleaning effects of scouring flows which occur during the winter may be a desirable part of the annual flow regime in Aravaipa Creek.

Any additional water withdrawals from Aravaipa Creek above the primitive area by either surface diversions during low-flow periods or groundwater pumping in low-water years should be opposed. A nonconsumptive water right which guaranteed a minimum flow of 13 ft.^{3}/sec. at BLM's East Aravaipa gaging station should be obtained for Aravaipa

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Creek upstream from the primitive area. It may be desirable to purchase sufficient water rights from private land owners who currently irrigate limited amounts of agricultural land upstream from the primitive area to insure instream flows do not drop below 13 ft.^{3}/sec. during summer and early fall low-flow periods.

Recommendations for Additional Study

Based on our IFG4 simulation, a range of simulated discharges from 5 to 40 ft.^{3}/sec. provided sufficient data for making instream flow recommendations in Aravaipa Creek for adult Meda and Tiaroga. However, it would be worthwhile to compare our IFG4 simulation to a WSP simulation using the hydraulic information that we collected on May 15, 1980 at a discharge of 14.7 ft.^{3}/sec. Likewise, it would be desirable to include substrate preferences for both adult Meda and Tiaroga into an analysis (using the WSP simulation) of available habitat using the CIFSG's HABTAT program. It might be possible to obtain acceptable probability-of-use curves for substrate by either eliminating the data we collected from the Gila River from the data set or by combining the various gravel sizes (e.g. course, medium, pea) into a single coding for all gravel size for the analysis of dominant particle size (see Bovee's comments in Appendix E). However, it may be desirable to wait until more extensive habitat data for Meda and Tiaroga from the Gila and San Francisco River drainages in New Mexico are analyzed before including substrate preferences in the HABTAT analysis. The main problems with our habitat data are the restricted range of substrates available in Aravaipa Creek and our inability to determine the actual availability of different substrates, velocities and depths in the specific stream sections where we

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obtained habitat data on Meda and Tiaroga. Because of the latter problem, we were restricted to developing probability-of-use curves with our data and could not determine actual preference curves for the habitat parameters.

It would be worthwhile for future investigators to prepare habitat preference curves for other life stages of Meda and Tiaroga. In particular, preference curves for spawning, egg incubation and fry may be quite valuable in future instream flow studies. It appears that the spawning requirements for Tiaroga are quite restricted and future studies should concentrate on substrate size and degree of imbeddedness. Because eggs are attached to the underside of cobble substrates, it will require tedious and careful fieldwork to document the actual habitat preferences. The fieldwork will require the researchers to check potential spawning sites by removing each possible substrate (e.g. cobble) from the bottom and examining the underneath side for eggs. An alternative approach would be studies in a laboratory stream where substrate sizes and degree of imbeddedness can be controlled. In either case, the disturbance created by checking the substrate for eggs may alter either the degree of imbeddedness or the behavior of potential spawners.

Considerations for Desert Streams

Hydraulic Simulation. The methodology (e.g. WSP or IFG4) chosen to simulate the hydraulic conditions in desert streams should be determined after a review of annual streamflow regime, streambed morphology and accessibility of study sites. If the accessibility of the study sites during higher flow periods is poor (e.g. Burro and Francis creeks) because of road conditions and stream fords, it is desirable to either plan fieldwork during low-flow periods or make arrangements for reaching

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the study sites by helicopter. When low-flow conditions are likely to be the limiting aspect for fishes or higher flows are uncontrollable because of no upstream dams, it is not necessary to simulate hydraulic conditions at higher flows. Thus, a WSP simulation may be quite adequate for simulating the hydraulic conditions that occur over a restricted range of discharges about the median flow during low-flow periods.

A WSP simulation would also be desirable when the stability of the streambed and predictability of storm events are low. The sand and finer gravel substrates in the Arizona streams we studied were easily moved by relatively minor increases in discharge. Thus, the potential for simulating a wide range of flows by an IFG4 simulation is relatively low unless the field measurements can be made during a relatively short time interval when discharge can be expected to decrease in a predictable fashion. The first set of field measurements should be made at the upper end of the expected range in discharges and successive field measurements should be taken when discharge decreases by 20-30% from the previously measured discharge. If streambed movement is excessive between the first and second set of field measurements, the first set of measurements can be eliminated from the data set for the IFG4 simulation and an additional set of field measurements can be taken as flow continues to drop.

In the case of lower elevation (less than 4,000 feet) Arizona streams where there is a wintertime peak in streamflow, it appears that the optimum time to take a set of field measurements for IFG4 simulation is from mid-March through mid-June. At higher elevation streams in Arizona and New Mexico which are influenced by snowmelt runoff, it would

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be desirable to wait until the snowmelt runoff has started to decrease (i.e. April-June, depending on elevation and snowpack) before beginning any fieldwork. Field measurements made during the months of July-September are subject to rapid hour-to-hour or day-to-day changes in discharge because of the unpredictability of summer thunderstorms.

Our WSP simulations in Burro and Francis creeks were complicated because of the relatively high gradient and presence of large boulders in the riffle sections. When gradient is high enough to cause stairstep-type drops in the riffles, it becomes very difficult to adequately calibrate a WSP simulation (Tim Hardin, pers. comm.). Likewise, the occurrence of braided flow through boulder-strewn riffles (e.g. Burro and Francis creeks) during low-flow periods causes problems with WSP simulation.

Sampling Bias Associated with Fish Capture. These comments are based on fish captured during spring, summer and fall sampling trips to Aravaipa, Burro and Francis creeks, Arizona, and the Gila River downstream from the Highway 180 bridge in New Mexico. Electrofishing was used to capture all fish, but the sampling bias associated with this method was quite variable between species. Large boulders, cobble and algal mats prohibited the use of seines in Burro Creek. Although seines could have been used more easily in Aravaipa Creek, the exact location of each fish could not be determined by seining unless the seine hauls were made only in water where the bottom could be observed. Visual observations were used mainly for deeper pools and also worked quite well in slow-moving water for those species that could be readily identified with just a brief sighting. Visual observations were useful as a supplement to electrofishing data, but did not provide satisfactory

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data in either rapidly-flowing riffles and runs or areas where instream cover (e.g. logs, undercut banks, boulders, cobble) concealed the fish until they were either shocked or flushed from cover. Visual observations of the movements of fish in relation to electrofishing efforts provided much of the basis for the following discussion of sampling bias.

Because the loach minnow is a small (less than 3½ inches, TL), sedentary bottom dweller that apparently remains in place in shallow flowing water (often near cobble substrate), electrofishing was an effective method for obtaining data on habitat preferences. This species did not appear to be disturbed and apparently stayed relatively stationary as the electrofishing crew approached. When shocked, individuals usually simply rolled over in place and either began rolling downstream along the bottom or became lodged in crevices between gravel and cobble. Their original location was relatively easy to establish and they were usually captured quickly by either dip nets or a seine set a few feet downstream after being shocked.

The spikedace is a small (less than 3½ inches, TL) fish that usually stays in the lower half of the water column in flowing water. It prefers moving water less than 1.5 feet in depth and is often found in small schools near the edge of runs and in shallow riffles with sand and gravel substrate. It was more affected by the approach of the electrofishing crew and sometimes would flee; however, they were relatively easy to identify in the water and could usually be captured within a few feet of where they were first seen. With some care the species could be shocked without undue effects on their behavior and a reasonably good determination made of their original location.

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The desert sucker and Sonora sucker are both basically bottom dwellers that are relatively mobile, but often use boulders, debris, undercut banks and overhanging vegetation as shelter. These two species were much more affected by the approach of the electrofishing crew than Meda and Tiaroga and would often flee making it difficult or even impossible to determine their original position. Sometimes the fish would flee before they could be identified only to be herded a short distance ahead (5-10 feet) and shocked as a group, outside of their original microhabitat. In small, shallow pools this was even more of a problem than in boulder-strewn riffles and runs. More turbid water made fleeing and herding less of a problem but made seeing the fish more difficult.

The roundtail chub is a relatively mobile mid-water species that was highly sensitive to disturbances such as the approach of an electrofishing crew. They would usually flee for cover if available or swim rapidly away from the area; thus, it was often difficult to determine the original location of roundtail chubs. This was virtually impossible in shallow pools unless the observers either approached very carefully and slowly or could first observe their behavior from out of the stream from a distance of at least 15-20 feet.

If electrofishing were rated on a scale of 1-10 (poor to excellent) as the only method for obtaining unbiased data on habitat preferences, we would give the following ratings for the species we studied: loach minnow, 9.5; spikedace, 8.0; Sonora sucker and desert sucker, 3.5-4.0; and roundtail chub, 1.0. The presence of cover and intermediate water transparencies which permit observation of fish, but reduce water clarity could be expected to decrease sampling bias associated with

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electrofishing for the latter three species by reducing their tendency to flee from the sampling crew.

Because of the difficulties encountered in obtaining unbiased habitat on desert suckers, Sonora suckers and roundtail chubs in Burro and Francis creeks, an alternative method of collecting data on habitat preferences would be desirable for supplementing visual observation and capture data by electrofishing. Although Burro Creek consisted of a variety of substrates, velocities, and depths, these differences in habitat features often occurred within a few feet of each other in a mosaic along any given stretch of run or riffle habitat. The fish moved freely between these microhabitats, especially when pursued by a sampling crew. Thus it was difficult to obtain unbiased estimates of their habitat preferences in shallow, moving waters by sampling with backpack electrofishing gear. Although this sampling bias was noted by visual observations and considered when preparing the probability-of-use curves, the difficulty in quantifying observations made during electrofishing efforts make it desirable to develop a more quantifiable approach to characterizing habitat preferences for fishes like suckers and chubs in small, clear desert streams.

Since suckers and roundtail chub use a larger area within a short time interval than less mobile species like the loach minnow, it would seem reasonable to characterize their habitat preferences by characterizing the habitat parameters within a larger cell. For the latter three species, it might be better to evaluate a large cell (of 10-30 square feet, in either a rectangular or circular configuration) and then determine the relative abundance of each species in that cell. This could be

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then compared with ratios for other cells of similar size, but with different substrate-velocity-depth characteristics.

This approach could be facilitated by selecting sections of stream that differ significantly in velocity, substrate, and depth characteristics. These areas should be characterized by using conventional instream flow methods by placing transects and verticals as close together as is practically possible at the boundaries of stream sections with more homogeneous habitat parameters. After areas that are quantifiably different have been located, block off as small a stream section of a particular habitat type that can be effectively blocked by seines without affecting the relative abundance of different fishes in that section and then thoroughly sample each section by repeated electrofishing passes (i.e. depletion sampling). Record the relative number of each species as well as the relative number of juveniles versus adults. If habitat preferences differ between species or between juveniles and adults of a species, the relative numbers collected in different types of habitats should show significant differences and could be used to supplement habitat data collected by visual observations and electrofishing. It would be desirable to conduct this sampling either with permanent instream flow study reaches or in reaches which could be characterized by WSP simulation in order to know the relative availability of different combinations of habitat types available for use by the fish species. In either case, the blocking off of sections for fish sampling would have to be based on the observed differences in habitat parameters at the time of sampling.

It would be desirable to set the block seines both at night and during the day to determine diurnal differences in habitat preferences;

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the actual collection of fish could be done during the daytime. Although difficulties in assuring an effective blockage of fish movements is recognized, we feel this approach may be useful when determining the habitat preferences of species which cannot be observed easily or modify their location in the stream because of sampling efforts. It would also be desirable to evaluate potential seasonal differences in habitat preferences by sampling throughout the year. In particular, the habitat needs of a species may differ greatly between winter and summer, depending on the magnitude of the seasonal or diurnal shifts in water temperature and flow. Likewise, the presence of other aquatic organisms (e.g. fishes, invertebrate prey species) which affect the behavior of the species in question by either competition, predation or serving as a food source could have substantial impacts on the habitat preferences of fishes and should be considered when analyzing data on habitat preferences between different areas or waters.

General Recommendations

When considering the initiation of an instream flow study using the Incremental Methodology, the researcher should carefully read Bovee (1982) for recommended procedures. The need for close contact with CIFSG personnel throughout an instream flow study becomes increasingly important if the researcher has only limited familiarity with the methodology. The development and modification of the Incremental Methodology in the last few years has resulted in the availability of a versatile and valuable tool which can provide a rational and sophisticated approach to instream flow analysis. However, the ability to use this methodology properly is largely dependent on the user becoming thoroughly familiar with the methodology through short courses and direct contact with personnel who are

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intimately knowledgeable of the intracacies and pitfalls associated with the method. Unless the researcher has considerable experience with the methodology in similar streams, we recommend involving a member of the CIFSG in the early phases of all instream flow studies. This involvement may require the on-site presence of a knowledgeable person to assist in scoping, site selection and placement of transects (especially if a WSP simulation is desirable) for types of streams which have not been evaluated previously with the Incremental Methodology (e.g. desert streams with unpredictable flow regimes).

In the case of undammed streams with unstable substrates and either unpredictable or poorly documented flow patterns, it is important to make the field measurements over as short a time interval as possible for an IFG4 hydraulic simulation. As stated previously, a 2- to 4-week period when discharge can be expected to decrease (e.g. near end of snowmelt runoff or rainy season) is a good time to make measurements; this is especially true if it is difficult to reach the stream on short notice or if the instream flow study team either cannot be maintained intact or be available when the streamflow conditions require fieldwork. For an IFG4 simulation of Burro Creek with a desirable range of discharges (e.g. 5 to 25 $ft.^3/sec.$), the necessary field measurements could have been taken only in the latter half of March and again in late April during the 1981 water year. For undammed desert streams, it would always be good insurance to take the appropriate field measurements for a WSP simulation at a discharge near the median flow during low-water periods.

When collecting habitat data to develop probability-of-use or habitat preference curves, the researcher should typically discuss the most

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desirable methods with individuals who have personal sampling experience with the target species in the waters to be sampled. Prior to data collection, the recommendations and methods in Bovee (1981) should be reviewed to minimize sampling and environmental biases when collecting habitat data; this may require obtaining the data with innovative methods tailored to the particular species and streams. Consultations with CIFSG personnel and other experts should be mandatory. If electrofishing or other active sampling methods are used to collect data on habitat preferences, the researcher should provide space on the data forms to describe and rank the degree of avoidance and behaviorial modification associated with the collection of each fish or group of fishes; a coded ranking or descriptive system may be helpful. Data forms should also provide space to record water temperature and transparency, cover, associated species and general comments.

Our experience with sampling in clear desert streams suggests that it would be a good idea to periodically utilize a pre-positioned, stationary observer who can watch the reaction of the fish to the approach of the sampling team. When possible, direct observations of fish movements in areas where a grid system can be set up in advance probably offers the best opportunity to obtain unbiased data on fish habitat preferences. This approach may require the use of binoculars, polaroid glasses and elevated platforms, but should always be included with other methods for obtaining habitat data when feasible. As discussed earlier, it is obvious that habitat preferences of the same species will vary from one type of stream to another because of differences in the types and combinations of physical habitat parameters (e.g. substrate, cover, water depth) and probably because of the presence

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or abundance of other aquatic and semi-aquatic species. Likewise, seasonal and diurnal differences in habitat preferences are probably significant in most streams and should be evaluated whenever appropriate and economically feasible. For some of the smaller fishes (e.g. cyprinids) and for fry and juveniles of larger fishes it appears that habitat preference data may be obtained by the use of observations in laboratory streams or specifically modified reaches of natural streams.

In all cases, it would be highly desirable to document the actual availability of different combinations of habitat parameters for the specific areas where the habitat preference data are collected. When feasible, the inclusion of sufficient field measurements to allow either an IFG4 or WSP simulation of the sampling sites would be appropriate; a grid map which describes habitat parameters such as instream cover, streambank conditions, and aquatic and riparian vegetation should be included. In some cases, it may be practical and necessary to sample a range of relatively homogenous stream sections (e.g. equivalent to specific cells in a hydraulic simulation) to augment other habitat preference data. The ability to effectively segregate these cells may be difficult with block seines, but some habitats and fishes may lend themselves to this approach. Although many of the previous recommendations are difficult to put into effect and often time-consuming, the availability of meaningful habitat preference curves are critical to the use of the Incremental Methodology. Our experience with modifying the probability-of-use curves for adult Meda and Tiaroga indicate the major impact of even relatively minor changes in the weighting factors on the predicted weighted usable area at various discharges.

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APPENDIX A

Discharge records for the 1978-1981 water years for the USGS gaging station on Aravaipa Creek near Mammoth, Arizona and for the BLM gaging stations on Aravaipa Creek from 1980-1982

STREAMFLOW DATA SUMMARY

Station Name East Aravaipa

Elevation 3,110

		OCT.	NOV.	DEC.	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	AVERAGE
1980	Avg. CFS											23.1	20.4	
	Avg. AF											45.8	40.5	
	Total AF											1421.0	1215.9	
	Peak Flow		08-24 68CFS											
1981	Avg. CFS	16.7	16.5	17.0	21.4	24.3	22.6	21.3	16.7	15.2	19.5	16.1	16.6	18.7
	Avg. AF	33.0	32.8	35.0	42.5	48.2	44.8	42.1	33.1	30.0	38.6	32.0	32.9	37.0
	Total AF	1023.5	983.0	1083.8	1318.2	1349.2	1389.2	1262.9	1026.6	901.3	1197.4	991.7	988.2	13,515.0
	Peak Flow		07-11 114CFS											
1982	Avg. CFS	15.3	14.6	15.9	20.3	17.9	16.1	13.8	14.2	11.0	10.4	17.4	12.1	14.7
	Avg. AF	30.4	29.0	31.6	40.3	35.6	31.9	26.7	27.6	21.3	20.1	33.7	23.4	29.2
	Total AF	941.0	870.4	978.7	1249.8	955.7	988.0	800.1	854.5	639.7	623.1	1043.4	702.6	10,647.0
	Peak Flow		08-13 92CFS											
1983	Avg. CFS	11.0	10.2	14.8										
	Avg. AF	21.8	19.5	29.4										
	Total AF	674.4	605.4	912.6										
	Peak Flow													
1984	Avg. CFS													
	Avg. AF													
	Total AF													
	Peak Flow													
1985	Avg. CFS													
	Avg. AF													
	Total AF													
	Peak Flow													
1986	Avg. CFS													
	Avg. AF													
	Total AF													
	Peak Flow													
1987	Avg. CFS													
	Avg. AF													
	Total AF													
	Peak Flow													

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STATION: [illegible] STREAMFLOW TABULATION WY: [illegible]

Month: [illegible] August [illegible]

	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
							.99	23.1		.88	[illegible]	
							.99	23.1		.89	23.1	
							[illegible]	23.5		.86	23.2	
							[illegible]	[illegible]		.84	21.5	
							[illegible]	20.7		.83	[illegible]	
							[illegible]	[illegible]		.83	[illegible]	
							.92	24.1		.86	22.3	
							.92	24.1		.88	22.7	
7							.93	24.5		.86	22.3	
							1.12	30.0		.80	20.5	
							1.00	26.4		.77	19.7	
2							.83	21.4		.77	19.7	
3							.89	23.2		.76	19.4	
4							1.00	26.4		.77	19.7	
5							.83	21.4		.84	21.7	
6							.80	20.5		.81	20.8	
7							.78	19.9		.83	21.4	
8							.79	20.2		.80	20.5	
9							.80	20.5		.79	20.2	
10							.82	21.1		.78	19.9	
11							.83	21.4		.77	19.7	
12							.83	21.4		.75	19.1	
13							.92	24.1		.66	16.5	
14							.94	24.8		.67	16.7	
15							.89	22.9		.77	19.7	
16							.84	21.7		.78	19.9	
17							.86	22.3		.76	19.4	
18							.85	22.0		.77	19.7	
19							.83	21.4		.76	19.4	
20							.83	21.4		.76	19.4	
							.87	22.5				
TOTAL								716.4	1421.0		612.0	[illegible]
AVE.								23.1	45.8		20.4	[illegible]

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STATION: [illegible] STREAMFLOW TABULATION WY: [illegible]

Month: October			November			December			February		
Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
.75	19.1		.69	17.4		.63	15.7		.79	[illegible]	
.74	18.8		.62	17.1		.60	14.8		.77	19.9	
.75	19.1		.67	16.8		.60	14.8		.79	19.9	
.73	18.5		.67	16.8		.59	14.5		.79	[illegible]	
.69	17.4		.67	16.8		.59	14.2		.79	20.2	
.69	17.4		.67	16.8		.59	14.5		.80	20.5	
.68	17.1		.67	16.8		.61	15.1		.81	[illegible]	
.66	16.5		.67	16.8		.66	16.5		.80	20.5	
.65	16.2		.65	16.2		.68	17.1		.81	20.8	
.66	16.5		.60	14.8		.69	17.4		.81	20.8	
.67	16.8		.60	14.8		.69	17.4		.83	21.4	
.70	17.7		.64	16.0		.71	18.0		.83	21.4	
.67	16.8		.62	16.5		.72	18.5		.82	21.1	
.65	16.2		.66	16.5		.72	18.3		.82	21.1	
.66	16.5		.67	16.8		.72	18.3		.82	21.1	
.67	16.8		.67	16.8		.72	18.3		.83	21.4	
.67	16.8		.67	16.8		.72	18.3		.83	21.4	
.66	16.5		.68	17.1		.73	18.5		.83	21.4	
.66	16.5		.68	17.1		.73	18.5		.84	[illegible]	
.65	16.2		.67	16.8		.73	18.5		.84	21.7	
.65	16.2		.67	16.8		.73	18.5		.85	22.0	
.64	16.0		.67	16.8		.74	18.8		[illegible]	[illegible]	
.60	14.8		.67	16.8		.73	18.5		[illegible]	22.0	
.60	14.8		.66	16.5		.73	18.5		[illegible]	22.3	
.62	15.4		.65	16.2		.74	18.8		.86	22.3	
.64	16.0		.65	16.2		.74	18.8		.85	22.0	
.67	16.8		.65	16.2		.75	19.1		.88	22.8	
.64	16.0		.65	16.2		.76	19.4		.88	22.8	
.60	14.8		.65	16.2		.76	19.4		.88	22.8	
.65	16.2		.65	16.2		.77	19.7		.88	22.8	
.61	17.1					.77	19.7		.88	22.8	
TAL [illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]
TE. 6.7	61.5			16.5	32.9	17.6	35.0			[illegible]	[illegible]

USAV-00005905

STATION: [illegible]

STREAMFLOW TABULATION

WY: [illegible]

Month: [illegible] | [illegible] | [illegible] | [illegible]

Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
.84	23.1		.93	24.4	45.4	.69	19.4	34.5	[illegible]	[illegible]	[illegible]
.90	23.5		.96	25.4	50.4	.77	19.7	39.1	.76	19.4	[illegible]
.90	23.5		1.02	27.2	54.0	.84	21.7	43.1	.71	18.0	[illegible]
.90	23.5		1.01	26.9	53.4	.84	21.7	43.1	.67	16.8	[illegible]
.92	24.1		.96	25.3	50.2	.84	21.7	43.1	.67	16.8	[illegible]
.92	24.1		1.14	30.9	61.3	.84	21.7	43.1	.66	[illegible]	[illegible]
.91	23.8		1.03	27.3	54.1	.84	21.7	43.1	.66	16.5	32.7
.91	23.8		.93	24.4	48.4	.84	21.7	43.1	.66	16.5	
1.05	27.9		.90	23.5	46.6	.84	21.7	43.1	.66	16.5	[illegible]
1.06	28.2		.90	23.5	46.6	.84	21.7	43.1	.67	16.8	
.93	24.4		.89	23.1	45.8	.84	21.7	43.1	.66	16.5	
.92	24.1		.89	23.2	46.0	.85	22.8	45.2	.63	15.7	31.1
.92	24.1		.88	22.8	45.2	.84	21.7	43.1	.57	14.0	27.8
.92	24.1		.86	22.3	44.2	.84	21.7	43.1	.57	14.0	
.92	24.1		.85	22.8	45.2	.83	21.4	42.3	.58	14.2	
.92	24.1		.84	21.7	43.1	.83	21.4	42.3	.58	14.2	28.3
.92	24.1		.83	21.4	42.3	.85	22.8	45.2	[illegible]	16.0	
.92	24.1		.82	21.1	41.9	.84	21.7	43.1	.65	16.2	33.1
.92	24.1		.82	21.1	41.9	.84	21.7	43.1	.66	16.5	
.92	24.1		.83	21.4	42.3	.85	22.8	45.2	.67	16.8	
.92	24.1		.82	21.1	41.9	.84	21.7	43.1	.67	16.8	
.92	24.1		.82	21.1	41.9	.85	22.8	45.2	.68	17.1	
.92	24.1		.83	21.4	42.3	.85	22.8	45.2	.68	17.1	
.92	24.1		.82	21.1	41.9	.83	21.4	42.3	.67	16.8	
.92	24.1		.72	21.1	41.9	.71	18.0	35.7	.67	16.8	
.93	24.4		.82	21.1	41.9	.70	17.7	35.1	.67	16.8	
.92	24.1		.77	19.7	39.1	.71	18.0	35.7	.68	17.1	
.93	24.4		.73	18.5	36.7	.82	21.1	41.9	.67	16.8	
			.76	19.4	38.5	.83	21.4	42.3	.67	16.8	
			.73	18.5	36.7	.85	22.8	42.3	.67	16.8	
			.69	17.4	34.5				.66	16.5	
Tot	1620.2	1249.2		700.4	1359.2		625.1	1262.9		517.8	[illegible]
	24.3	49.2		22.6	44.8		21.27	42.09		16.7	[illegible]

USAV-00005906

STATION: Avawatz

STREAMFLOW TABULATION

WY: [illegible]

Month: June

	June			July			August			September		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
	.66	16.5	32.7	.66	17.1	33.9	.66	16.5		.64	16.0	
	.63	15.7	31.1	.66	16.5	32.7	.63	15.7		.63	16.0	
	.60	14.8	29.4	.65	16.2	32.1	.69	17.4		.65	16.2	
	.58	14.2	28.2	.65	16.2	32.1	.69	17.1		.66	16.5	
	.56	13.7	27.2	.64	16.0	31.7	.69	17.4		.69	17.4	
	.57	14.0	27.8	.63	15.7	31.1	.72	18.3		.79	20.2	
	.65	16.2	32.1	.65	16.2	32.1	.69	17.1		.67	16.7	
	.65	16.2	32.1	.65	16.2	32.1	.56	13.7		.67	16.7	
	.62	15.4	30.5	.64	16.0	31.7	.62	15.4		.65	16.2	
1	.57	14.0		.64	16.0	31.7	.81	20.8		.65	16.2	
1	.57	14.0	27.8	.92	25.9	51.4	.64	16.0		.64	16.0	
2	.58	14.2	28.2	.97	25.7	51.0	.62	15.4		.63	15.7	
3	.60	14.8	29.4	.76	19.4	38.5	.64	16.0		.63	15.7	
4	.62	15.4	30.5	.76	19.4	38.5	.81	20.8		.63	15.7	
5	.62	15.4	30.5	.75	19.1	37.9	.65	16.2		.62	15.4	
6	.62	15.4	30.5	.76	19.4	38.5	.65	16.2		.63	15.7	
7	.62	15.4	30.5	.81	20.8	41.3	.65	16.2		.70	18.5	
8	.64	16.0	31.7	.77	19.7	39.1	.64	16.0		.67	16.5	
9	.64	16.0	31.7	.74	18.8	37.3	.64	16.0		.66	16.5	
10	.64	16.0	31.7	.80	20.5	40.7	.62	15.4		.65	16.2	
11	.63	15.7	31.1	.76	19.4	38.5	.58	14.2		.65	16.2	
12	.62	15.4	30.5	.72	18.3	36.3	.57	14.0		.74	18.3	
13	.56	13.7	27.2	.71	18.0	35.7	.61	15.1		.71	18.0	
14	.53	12.3	25.4	.69	17.4	34.5	.63	15.7		.69	17.4	
15	.54	13.1	26.0	.79	20.0	39.7	.61	15.1		.66	16.5	
16	.63	15.7	31.1	.78	19.9	39.5	.58	14.2		.65	16.2	
17	.63	15.7	31.1	.83	21.2	42.1	.59	14.5		.65	16.2	
18	.63	15.7	31.1	.84	21.7	43.0	.63	15.7		.63	15.7	
19	.66	16.5	32.7	.81	20.9	41.5	.62	15.4		.57	14.0	
20	.67	16.8	33.3	1.07	28.7	56.9	.62	15.4		.57	14.0	
21				1.03	27.4	54.3	.63	15.7				
TOTAL		1454.6	1901.3		1003.7	1977.4		520.0	391.7		[illegible]	[illegible]
AVE.		15.2	30.0		19.5	38.6		16.0	33.0		16.6	[illegible]

USAV-00005907

STATION: [illegible]

Month: Oct

STREAMFLOW TABULATION

WY: [illegible]

	Oct Stage	Oct CFS	Oct AF	Nov Stage	Nov CFS	Nov AF	Dec Stage	Dec CFS	Dec AF	Jan Stage	Jan CFS	Jan AF
1	.67	16.8		.60	14.8		.63	15.7		.65	16.2	
2	.87	22.5		.60	14.8		.63	15.7		.9[illegible]	[illegible]	
3	.80	20.4		.60	14.8		.63	15.7		.72	19.3	
4	.63	15.7		.59	14.5		.63	15.7		.71	19.0	
5	.63	15.7		.57	14.0		.62	15.4		.71	19.0	
6	.64	16.0		.53	12.9		.62	15.4		.95	22.0	
7	.62	15.4		.53	12.9		.63	15.7		1.05	27.9	
8	.61	15.1		.55	13.4		.63	15.7		.92	21.1	
9	.61	15.1		.59	14.5		.63	15.7		.81	20.9	
10	.60	14.8		.59	14.5		.64	15.9		.81	20.8	
11	.60	14.8		.60	14.8		.64	16.0		.81	20.2	
12	.60	14.8		.60	14.8		.64	16.0		1.26	34.3	
13	.59	14.5		.60	14.8		.64	16.0		1.23	33.5	
14	.59	14.5		.60	14.8		.64	16.0		.91	20.9	
15	.59	14.5		.60	14.8		.64	16.0		.80	20.5	
16	.60	14.8		.60	14.8		.64	16.0		.80	20.5	
17	.60	14.8		.59	14.5		.64	16.0		.79	19.9	
18	.60	14.8		.57	14.0		.64	16.0		.77	19.7	
19	.60	14.8		.59	14.5		.64	16.0		.77	19.7	
20	.59	14.5		.60	14.8		.65	16.2		.76	19.4	
21	.59	14.5		.60	14.8		.65	16.2		.76	19.4	
22	.59	14.5		.60	14.8		.65	16.2		.76	19.4	
23	.59	14.5		.60	14.8		.65	16.2		.76	19.4	
24	.59	14.5		.60	14.8		.65e	16.2	Data Estimated	.75	18.8	
25	.59	14.5		.61	15.1		.65e	16.2	W. Ann Elect. Chippewa Flowage	.74	18.8	
26	.59	14.5		.61	15.1		.65e	16.2		.72	18.3	
27	.59	14.5		.61	15.1		.64e	16.0		.70	17.7	
28	.59	14.5		.61	15.1		.64e	16.0		.70	17.7	
29	.60	14.8		.64	16.0		.64e	16.0		.69	17.4	
30	.60	14.8		.64	16.0		.63e	15.7		.67	16.8	
31	.60	14.8					.63	15.7		.67	16.8	
TOTAL	—	474.4	941.0		438.8	870.4		492.4	976.7		[illegible]	1237.2
AVE		15.3	30.4		14.6	29.0		15.9	31.6		[illegible]	40.3

USAV-00005908

STATION: [illegible] STREAMFLOW TABULATION WY: 72

Month: Feb				May			Apr			Mar		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	.67	16.9		.70	17.7		.63	15.7		.54	12.1	
2	.66	16.5		.70	17.7		.64	16.0		.56	13.7	
3	[illegible]	16.5		.70	17.7		[illegible]	16.0		.56	13.7	
4	[illegible]	16.5		.69	17.4		.63	15.7		.71	17.9	
5	.66	16.5		.69	17.4		.63	15.7		.55	13.4	
6	.66	16.5		.68	17.1		.62	15.7		.53	12.8	
7	.67	16.8		.68	17.1		.62	15.4		.59	14.5	
8	.68	17.1		.67	16.8		.61	15.1		.63	15.7	
9	.68	17.1		.66	16.5		.61	15.1		.64	16.0	
10	.68	17.1		.66	16.5		.59	14.5		.64	16.0	
11	.71	18.0		.66	16.5		.59	14.5		.64	16.0	
12	.73	18.5		.66	16.5		.58	14.2		.65	16.2	
13	.71	18.0		.74	18.8		.49	11.5		.65	16.2	
14	.69	17.4		.71	18.0		.50	12.0		.65	16.2	
15	.69	17.4		.71	18.0		.46	10.9		.65	16.2	
16	.71	18.0		.68	17.1		.51	12.3		.63	15.7	
17	.71	18.0		.69	17.4		.54	13.1		.62	15.4	
18	.76	19.4		.69	17.4		.56	13.7		.62	15.4	
19	.75	19.1		.69	17.4		.55	13.4		.59	14.5	
20	.74	18.8		.68	17.1		.56	13.7		.58	14.2	
21	.74	18.8		.67	16.8		.56	13.7		.55	13.4	
22	.75	19.1		.66	16.5		.55	13.4		.53	12.8	
23	.74	18.8		.60	14.8		.54	13.1		.51	12.3	
24	.74	18.8		.51	12.3		.53	12.8		.51	12.3	
25	.72	18.3		.50	12.0		.53	12.8		.50	12.0	
26	.72	18.3		.52	12.6		.52	12.6		.50	12.0	
27	.70	17.7		.56	13.7		.52	12.6		.51	12.3	
28	.70	17.7		.49	11.7		.52	12.6		.52	12.6	
29				.53	12.8		.53	12.8		.55	13.4	
30				.57	14.0		.54	13.1		.54	13.1	
31				.60	14.8					.53	12.8	
Tot.		502.0	995.7		448.1	889.0		413.5	820.1		441.6	876.2
Avg.		17.9	35.6		16.1	31.9		13.8	26.7		14.2	28.6

USAV-00005909

STATION: E Avawatz

STREAMFLOW TABULATION

WY: 72

Month:	June			July			Aug			Sept		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	.53	12.8		.41	9.6		.72	18.5		.54	12.[illegible]	
2	.52	12.6		.41	9.6		.69	17.4		.55	13.[illegible]	
3	.50	12.0		.39	8.8		.69	17.4		.52	12.6	
4	.50	12.0		.40	9.3		.72	18.3		.52	12.6	
5	.54	13.1		.38	8.6		.74	18.8		.51	12.3	
6	.53	12.8		.33	7.3		.70	17.7		.50	12.0	
7	.53	12.8		.38	8.6		.68	17.1		.50	12.0	
8	.52	12.6		.34	7.6		.69	17.4		.51	12.3	
9	.45	10.6		.33	7.3		.68	17.1		.47	11.2	
10	.44	10.4		.37	8.3		.66	16.5		.74	18.8	
11	.44	10.4		.43	10.1		.75	19.2		.71	18.1	
12	.43	10.1		.42	9.8		.89	23.1		.88	22.7	
13	.43	10.1		.43	10.1		1.20	32.7		.58	14.2	
14	.47	11.2		.43	10.1		.67	16.8		.52	12.8	
15	.47	11.2		.38	8.6		.65	16.2		.52	12.6	
16	.48	11.5		.40	9.3		.62	15.4		.49	11.7	
17	.48	11.5		.46	10.9		.79	20.1		.49	11.7	
18	.44	10.4		.55	13.3		.64	16.0		.44	10.4	
19	.40	9.3		.43	10.1		.65	16.2		.38	8.6	
20	.42	9.8		.45	10.6		.68	17.0		.37	8.3	
21	.44	10.4		.48	11.5		.67	16.8		.44	10.4	
22	.46	10.9		.47	11.2		.64	16.0		.36	8.1	
23	.46	10.9		.46	10.9		.73	18.6		.37	8.3	
24	.45	10.6		.47	11.2		.67	16.7		.38	8.6	
25	.44	10.4		.47	11.2		.63	15.7		.45	10.6	
26	.44	10.4		.46	10.9		.61	15.1		.46	10.9	
27	.42	9.8		.46	10.9		.61	15.1		.46	10.9	
28	.42	9.8		.46	10.9		.59	14.5		.47	11.2	
29	.44	10.4		.46	10.9		.58	14.2		.47	11.2	
30	.42	9.8		.44	10.4		.58	14.2		.48	11.5	
31				.90	23.6		.55	13.4				
TOTAL		330.6	639.7		322.0	623.1		539.2	1043.4		3[illegible].3	[illegible]
AVE.		11.0	21.3		10.4	20.1		17.4	33.7		12.1	23.[illegible]

USAV-00005910

STATION: [illegible]

STREAMFLOW TABULATION

WY: [illegible]

Month: Oct | Nov | [illegible] | [illegible]

Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
.49	11.7		.46	10.9		[illegible]	[illegible]		[illegible]	16.2	
.49	11.7		.46	10.9		.60	14.2		.66	16.5	
.49	11.7		.42	9.8		[illegible]	[illegible]		[illegible]	[illegible]	
.51	12.3		.40	9.3		.55	13.4		.66	16.5	
.51	12.3		.40	9.3		.54	13.1				
.51	12.3		.39	8.9		.55	13.4				
.51	12.3		.39	8.9		.54	13.1				
.53	12.8		.39	8.9		.55	13.4				
.51	12.3		.42	9.8		.56	13.7				
.51	12.3		.42	9.8		.57	14.0				
.48	11.5		.41	9.6		.59	14.5				
.46	10.9		.41	9.6		.58	14.2				
.43	10.1		.42	9.8		.58	14.2				
.45	10.6		.42	9.8		.57	14.0				
.45	10.6		.44	10.4		.56	13.7				
.46	10.9		.44	10.4		.58	14.2				
.45	10.6		.44	10.4		.58	14.2				
.44	10.4		.45	10.6		.59	14.5				
.43	10.1		.44	10.4		.59	14.5				
.43	10.1		.44	10.4		.58	14.2				
.43	10.1		.45	10.6		.60	14.8				
.43	10.1		.45	10.6		.60	14.8				
.42	9.8		.44	10.4		.64	15.9				
.43	10.1		.45	10.6		.77	19.8				
.43	10.1		.45	10.6		.64	16.0				
.43	10.1		.46	10.9		.63	15.7				
.44	10.4		.45	10.6		.63	15.7				
.45	10.6		.46	10.9		.65	16.2				
.44	10.4		.45	10.6		.65	16.2				
.44	10.4		.48	11.5		.65	16.2				
.44	10.4					.65	16.2				
	340.0	674.4		305.2	605.4		460	912.6			
	11.0	21.8		10.2	19.5		14.8	29.4			

USAV-00005911

STREAMFLOW DATA SUMMARY

Station Name West Aravaipa

Elevation 2,630

		OCT.	NOV.	DEC.	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	AVERAGE
1980	Avg. CFS													
	Avg. AF													
	Total AF													
	Peak Flow													
1981	Avg. CFS			28.1	28.6	29.9	35.5	21.8	20.1	17.6	27.4	23.8	18.9	
	Avg. AF			55.7	56.7	57.6	70.3	43.2	39.9	34.1	54.4	47.2	37.4	
	Total AF			1114.9	1757.2	1611.8	2180.8	1294.9	1237.1	1022.7	1686.3	1462.8	1122.5	
	Peak Flow	07-11 Estimated CFS 600 and 08-10 Estimated CFS 690												
1982	Avg. CFS	19.7	17.0	21.9	40.6*	32.7	30.8	21.6	17.2	11.5	10.9	28.1**	22.2	22.6
	Avg. AF	39.1	33.7	43.4	80.6	64.9	61.2	42.9	34.3	22.8	21.7	55.7	44.0	44.7
	Total AF	1211.7	1009.8	1345.0	2338.3	1817.9	1897.9	1286.5	1062.0	684.3	672.2	1058.4	1321.6	15,704.9
	Peak Flow	08-12 Estimate CFS 835												
1983	Avg. CFS													
	Avg. AF													
	Total AF													
	Peak Flow													
1984	Avg. CFS													
	Avg. AF													
	Total AF													
	Peak Flow													
1985	Avg. CFS													
	Avg. AF													
	Total AF													
	Peak Flow													
1986	Avg. CFS													
	Avg. AF													
	Total AF													
	Peak Flow													
1987	Avg. CFS													
	Avg. AF													
	Total AF													
	Peak Flow													

Missing Data - * 2 days, **12 days

USAV-00005912

STATION: West Avenue

STREAMFLOW TABULATION

WY: 1971

Month: December

Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
									1.59	28.8	57.1
									1.59	28.8	57.1
									1.59	28.8	57.1
									1.58	28.0	55.5
									1.60	29.6	58.7
									1.60	29.6	58.7
									1.61	30.5	60.5
									1.61	30.5	60.5
									1.61	30.5	60.5
									1.61	30.5	60.5
									1.60	29.6	58.7
						1.58	28.0	55.5	1.60	29.6	59.7
						1.58	28.0	55.5	1.59	28.8	57.1
						1.57	27.2	54.0	1.59	28.8	57.1
						1.58	28.0	55.5	1.59	28.8	57.1
						1.59	28.0	55.5	1.59	28.0	55.5
						1.59	28.0	55.5	1.58	27.2	55.5
						1.59	28.0	55.5	1.57	27.2	54.0
						1.59	28.0	55.5	1.59	28.8	57.1
						1.58	28.0	55.5	1.59	28.8	57
						1.59	28.0	55.5	1.59	28.0	55.5
						1.59	28.8	57.1	1.58	27.2	55.5
						1.59	28.8	57.1	1.59	28.8	57.1
						1.58	28.0	55.5	1.57	27.2	54.0
						1.58	28.0	55.5	1.57	27.2	54.0
						1.59	28.8	57.1	1.57	27.2	54.0
						1.58	28.0	55.5	1.57	27.2	54.0
						1.58	28.0	55.5	1.57	27.2	54.0
						1.58	28.0	55.5	1.58	28.0	55.5
						1.58	28.0	55.5	1.57	27.2	54.0
						1.59	28.8	57.1	1.57	27.2	54.0
TOTAL							562.4	1114.9		486.0	[illegible]

USAV-00005913

STATION: W. Arauaiga — STREAMFLOW TABULATION — WY: 1991

Month:	February			March			April			May		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1	1.57	27.2	54.0	1.54	24.9	49.4	1.42	18.7	37.5	1.49	21.2	42.1
2	1.57	27.2	54.0	1.92	50.5	100.2	1.49	20.0	40.3		27.6	54.7
3	1.57	28.0	55.5	2.00	70.9	140.6	1.53	24.1	47.8	1.52	23.3	46.2
4	1.57	27.2	54.0	2.02	80.1	158.9	1.53	24.1	47.8	1.50	21.7	43.0
5	1.57	27.2	54.0	1.86	54.7	108.5	1.53	24.1	47.8	1.49	20.3	40.3
6	1.58	28.0	55.5	2.40	123.3	244.6	1.52	23.3	46.2	1.48	20.3	-
7	1.58	28.0	55.5	2.04	74.9	148.6	1.53	24.1	47.8	1.48	20.3	
8	1.58	28.0	55.5	1.77	45.3	89.9	1.53	24.1	47.8	1.48	20.3	40.3
9	2.14	87.7	174.0	1.69	37.5	74.4	1.54	24.9	49.4	1.48	20.3	40.3
10	1.88	56.8	112.7	1.63	32.2	63.9	1.54	24.9	49.4	1.48	20.3	40.3
11	1.61	30.5	60.5	1.56	26.4	52.4	1.53	24.1	47.8	1.47	19.6	38.9
12	1.57	27.2	54.0	1.57	27.2	54.0	1.54	24.9	49.4	1.46	18.9	37.5
13	1.56	26.4	52.4	1.59	28.81	57.1	1.54	24.9	49.4	1.42	16.2	32.1
14	1.57	27.2	54.0	1.57	27.2	54.0	1.53	24.1	47.8	1.41	15.5	30.7
15	1.56	26.4	52.4	1.54	24.9	49.4	1.52	23.3	46.2	1.42	16.2	-
16	1.56	26.4	52.4	1.54	24.9	49.4	1.60	29.25	58.2	1.41	15.5	30.7
17	1.56	26.4	52.4	1.54	24.9	49.4	1.51	22.5	44.6	1.46	18.9	37.5
18	1.56	26.4	52.4	1.53	24.1	47.8	1.49	21.0	41.7	1.47	19.6	38.1
19	1.56	26.4	52.4	1.53	24.1	47.8	1.49	21.0	41.7	1.49	20.3	-
20	1.55	25.6	50.8	1.55	25.7	51.0	1.49	21.0	41.7	1.48	20.3	-
21	1.55	25.6	50.8	1.54	24.9	49.4	1.49	21.0	41.7	1.49	21.0	-
22	1.55	25.6	50.8	1.53	24.1	47.8	1.49	21.0	41.7	1.49	21.0	41.7
23	1.55	25.6	50.8	1.53	24.1	47.8	1.49	21.0	41.7	1.49	21.0	41.7
24	1.55	25.6	50.8	1.52	23.3	46.2	1.49	20.3	40.3	1.49	21.0	41.7
25	1.54	24.9	49.4	1.53	24.1	47.8	1.43	16.9	33.5	1.49	21.0	41.7
26	1.55	25.6	50.8	1.53	24.1	47.8	1.42	16.2	32.1	1.49	21.0	41.7
27	1.53	24.1	47.8	1.50	21.7	43.0	1.42	16.2	32.1	1.48	20.3	40.3
28	1.54	24.9	49.4	1.47	19.6	38.9	1.42	16.2	32.1	1.48	20.3	-
29				1.49	20.3	40.3	1.42	16.2	32.1	1.48	20.3	-
30				1.50	21.7	43.0	1.45	18.2	36.3	1.48	20.3	-
31				1.46	18.9	37.5				1.47	19.6	38.9
Total		[illegible]	[illegible]		[illegible]	[illegible]		1658	1294.0		1625.1	1237.1

USAV-00005914

STATION: [illegible]

STREAMFLOW TABULATION

WY: [illegible]

Month: June | July | August | Sept

	June Stage	June CFS	June AF	July Stage	July CFS	July AF	August Stage	August CFS	August AF	Sept Stage	Sept CFS	Sept AF
	1.47	18.6	38.9	1.49	21.0	41.7	1.66	34.5	68.4	1.41	15.5	
	1.46	18.9	37.5	1.48	20.3	40.3	1.54	24.9	49.4	1.41	15.5	
	1.42	16.2	32.1	1.46	18.9	37.5	1.53	24.1	47.8	1.40	14.8	
	1.40	14.8	29.4	1.46	18.9	37.5	1.53	24.1	47.8	1.43	16.9	
	1.32	13.6	27.0	1.46	18.9	37.5	1.52	23.3	46.2	1.44	17.3	
	1.32	13.6	27.0	1.46	18.9	37.5	1.54	24.9	49.4	1.63	[illegible]	
	1.43	16.9	33.5	1.47	19.6	38.9	1.53	23.3	46.2	1.45	18.3	
	1.46	18.9	37.5	1.71	39.2	77.8	1.45	18.3	36.3	1.43	16.9	
	1.46	18.9	37.5	1.44	17.6	34.9	1.46	18.9		1.42	16.2	
0	1.42	16.2	32.1	1.44	17.6	34.9	1.99c	66.9		1.42	16.2	
1	1.41	15.5	30.7	1.74	42.3	83.9	1.56c	26.4		1.41	15.5	
2	1.41	15.5	30.7	1.80	48.3	95.8	1.55c	25.6		1.40	14.8	
3	1.42	16.2	32.1	1.54	24.9	49.4	1.56c	26.3		1.40	14.8	
4	1.44	17.6	34.9	1.51	22.5	44.6	1.73c	41.3		1.40	14.8	
5	1.43	16.9	32.1	1.53	23.9	47.4	1.59c	28.8		1.39	14.2	
6	1.43	16.9	32.1	1.50	21.7	43.0	1.58c	28.0		1.39	14.2	
7	1.44	17.6	34.9	1.52	24.3	48.2	1.56c	26.4		1.82	50.2	
18	1.45	18.3	36.3	1.51	22.5	44.6	1.54c	24.9		1.47	19.6	
19	1.46	18.9	37.5	1.49	21.0	41.7	1.53c	24.1		1.45	18.3	
20	1.47	19.6	38.9	1.54	24.9	49.4	1.46c	18.9		1.42	16.2	
21	1.47	19.6	38.9	1.51	22.5	44.6	1.41c	15.5		1.42	16.2	
22	1.46	18.9	37.5	1.76	43.8	86.9	1.41	15.5		1.79	47.1	
23	1.41	15.5	30.7	1.55	25.7	51.0	1.43	16.9		1.75	43.3	
24	1.40	14.8	29.4	1.55	25.7	51.0	1.48	20.3		1.49	21.0	
25	1.37	13.0	25.8	1.75	43.2	85.7	1.48	20.3		1.46	18.9	
26	1.43	16.9	32.1	1.56	26.4	52.4	1.40	14.8		1.46	18.9	
27	1.46	18.9	37.5	1.57	27.6	54.7	1.38	13.6		1.46	18.9	
28	1.46	18.9	37.5	1.55	25.7	51.0	1.44	17.6		1.47	19.6	
29	1.47	19.6	38.7	1.52	23.8	41.2	1.43	16.9		1.40	14.8	
30	1.49	21.0	41.7	1.79	46.9	93.0	1.42	16.2		1.38	13.6	
31				1.83	52.10	103.2	1.41	15.5				
TALL		1517.7	1[illegible]		[illegible]	1686.9		737.0	1462.9		565.9	[illegible]

USAV-00005915

STATION: J. Arauaiga

STREAMFLOW TABULATION

WY: 92

Month: February			March			April			May		
	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
	1.52	23.3		1.54	24.9		1.50	21.7		1.46	18.9	
2	1.51	22.5		1.53	24.1		1.52	23.3		1.46	18.9	
3	1.49	21.0		1.51	22.5		1.53	24.1		1.46	18.9	
4	1.48	20.3		1.51	22.5		1.53	24.1		1.64	33.0	
5	1.46	18.9		1.50	21.7		1.53	24.1		1.56	26.4	
6	1.46	18.9		1.50	21.7		1.53	24.1		1.50	21.7	
7	1.45	18.2		1.48	20.3		1.54	24.9		1.47	19.6	
8	1.46	18.9		1.47	19.6		1.53	24.1		1.47	19.6	
9	1.46	18.9		1.45	18.3		1.53	24.1		1.46	18.9	
10	1.47	19.6		1.44	17.6		1.53	24.1		1.46	18.9	
11	2.26	103.7		1.43	16.9		1.53	24.1		1.46	18.9	
12	1.94	63.0		1.44	17.6		1.52	23.3		1.46	18.9	
13	1.74	42.3		2.04	75.0		1.49	21.0		1.45	18.2	
14	1.67	35.8		1.88	56.8		1.49	21.0		1.45	18.2	
15	1.63	32.2		1.94	63.8		1.48	20.3		1.45	18.2	
16	1.62	31.4		1.76	44.3		1.49	21.0		1.45	18.2	
17	1.60	29.6		1.69	36.6		1.49	21.0		1.45	18.2	
18	1.78	46.2		1.79	47.3		1.49	21.0		1.44	17.6	
19	1.77	45.3		1.86	54.7		1.49	21.0		1.43	16.9	
20	1.71	39.4		1.75	43.3		1.48	20.3		1.41	15.5	
21	1.67	35.8		1.65	34.0		1.48	20.3		1.39	14.2	
22	1.65	34.0		1.61	30.5		1.48	20.3		1.38	13.6	
23	1.61	30.5		1.58	28.0		1.48	20.3		1.36	12.4	
24	1.60	29.6		1.52	23.3		1.48	20.3		1.35	11.8	
25	1.65	34.0		1.51	22.5		1.47	19.6		1.35	11.8	
26	1.60	29.6		1.54	24.9		1.47	19.6		1.34	11.2	
27	1.57	27.2		1.62	31.4		1.46	18.9		1.35	11.8	
28	1.56	26.4		1.50	21.7		1.46	18.9		1.36	12.4	
29				1.54	24.9		1.46	18.9		1.39	14.2	
30				1.53	24.1		1.46	18.9		1.39	14.2	
31				1.50	21.7					1.39	14.2	
Sum		916.5	1817.9		954.5	1897.2		648.6	1286.5		435.4	[illegible]

USAV-00005916

STATION: W. Avawatz

STREAMFLOW TABULATION

WY: 82

Month: June | July | August | September

Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF	Stage	CFS	AF
1.38	13.6		1.33	10.6		1.57	27.5		1.45	18.2	
1.38	13.6		1.33	10.6		1.49	21.0		1.45	18.3	
1.37	13.0		1.33	10.6		1.48	20.3		1.46	18.9	
1.37	13.0		1.32	10.0		1.47	19.6		1.45	18.3	
1.37	13.0		1.32	10.0		1.48	20.3		1.44	17.6	
1.39	13.6		1.28	7.9		1.49	21.0		1.44	17.6	
1.38	13.6		1.31	9.4		1.47	19.6		1.44	17.6	
1.38	13.6		1.28	7.9		1.47	19.6		1.46	18.9	
1.33	10.6		1.27	7.5		1.48	20.3		1.44	17.6	
1.31	9.4		1.27	7.5		1.47	19.6		2.21	96.9	
1.30	8.8		1.30	8.8		1.76	45.0		1.82	50.0	
1.29	8.4		1.30	8.8		2.15 e	140.5		2.07	78.8	
1.29	8.4		1.30	8.8					1.56	26.4	
1.32	10.0		1.29	8.4					1.48	20.3	
1.36	12.4		1.26	7.0					1.46	18.9	
1.36	12.4		1.26	7.0		Lost	Data		1.45	18.3	
1.36	12.4		1.29	8.4					1.45	18.3	
1.34	11.2		1.41	15.7					1.43	16.0	
1.29	8.4		1.34	11.2					1.35	11.8	
1.30	8.8		1.32	10.0					1.34	11.2	
1.35	11.8		1.33	10.6					1.45	18.3	
1.36	12.4		1.34	11.2					1.33	10.6	
1.36	12.4		1.33	10.6					1.31	9.4	
1.36	12.4		1.33	10.6					1.31	9.4	
1.34	11.2		1.34	11.2		1.50 e	21.7		1.38	13.6	
1.34	11.2		1.34	11.2		1.49 e	21.0		1.39	14.2	
1.34	11.2		1.34	11.2		1.49 e	21.0		1.39	14.2	
1.33	10.6		1.33	10.6		1.47 e	19.6		1.40	14.8	
1.35	11.8		1.34	11.2		1.46 e	18.9		1.41	15.5	
1.35	11.8		1.33	10.6		1.46 e	19.9		1.41	15.5	
			1.75	43.2		1.45 e	18.2				
	345.0	684.3		332.9	672.2		533.2	1057.4		666.3	1321.4
	1.2	2.9		10.0	21.7		10	45.5		2.3	

USAV-00005917

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY

PROCESS DATE IS 07-19-82

STATION NUMBER 09473000 ARAVAIPA CREEK NEAR MAMMOTH, ARIZ.

LATITUDE 325037 LONGITUDE 1103707 DRAINAGE AREA 501.00 DATUM 2950.00 STREAM SOURCE AGENCY USGS STATE 04 COUNTY 021

PROVISIONAL DATA

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1980 TO SEPTEMBER 1981

MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	17	18	20	20	19	22	15	39	18	12	25	6.0
2	17	19	16	20	19	68	16	20	18	11	19	6.0
3	17	19	17	19	19	172	20	20	10	10	15	6.5
4	17	19	17	19	16	161	20	20	9.2	10	15	7.1
5	17	19	16	20	18	67	19	19	8.8	9.6	15	12
6	17	19	16	20	18	226	16	18	6.5	8.0	15	20
7	17	20	16	21	16	127	16	18	7.7	10	19	16
8	15	20	17	20	16	56	20	17	8.0	49	13	13
9	13	20	19	19	135	35	20	16	8.0	7.0	7.1	12
10	12	17	20	19	103	27	20	15	6.0	6.5	179	10
11	12	16	20	20	93	28	20	16	7.7	66	28	10
12	15	16	20	22	27	22	20	14	7.7	67	16	10
13	20	19	22	22	25	22	21	11	7.7	19	14	12
14	21	19	21	21	22	20	20	11	8.0	12	14	9.2
15	23	20	21	20	21	19	18	10	7.7	9.6	20	8.6
16	23	21	21	21	21	18	20	10	8.0	13	14	8.0
17	23	21	21	20	21	19	25	10	7.7	13	8.0	66
18	22	21	21	20	21	17	22	13	7.7	13	8.0	13
19	21	21	21	20	21	17	16	13	7.7	11	8.0	10
20	20	21	21	20	20	17	16	10	8.0	13	8.0	7.0
21	19	21	20	19	20	17	16	15	8.0	15	8.0	6.5
22	19	21	20	19	20	17	18	15	9.2	37	8.0	32
23	17	21	20	19	21	17	18	15	9.2	15	6.0	59
24	16	21	20	19	20	17	16	15	7.7	16	6.0	15
25	15	21	20	19	21	16	14	15	7.7	34	6.0	12
26	17	21	19	19	22	16	12	16	7.0	20	6.0	12
27	18	20	19	19	18	16	12	15	7.7	18	6.0	12
28	18	20	20	19	20	16	12	15	9.2	16	6.0	10
29	16	20	19	19	---	16	12	15	10	16	6.0	8.0
30	13	20	19	19	---	16	12	16	10	52	6.0	6.8
31	17	---	19	19	---	16	---	17	---	57	6.0	---
TOTAL	550	560	600	612	777	1397	553	507	261.0	447.1	580.1	828.5
MEAN	17.7	19.7	19.4	19.7	27.8	45.1	17.6	16.2	8.70	20.8	17.0	10.2
MAX	30	21	22	22	135	226	25	39	14	67	179	59
MIN	12	16	16	19	18	16	12	10	7.0	6.5	6.0	6.0
AC-FT	1090	1110	1190	1210	1540	2770	1040	998	518	1260	1170	1640

CAL YR 1980 TOTAL 13960.0 MEAN 37.9 MAX 996 MIN 10 AC-FT 27690

WTR YR 1981 TOTAL 7034.7 MEAN 20.8 MAX 226 MIN 6.0 AC-FT 14750

USAV-00005918

[illegible] RIVER BASIN

[illegible] NEAR [illegible], [illegible]

LOCATION. Lat [illegible], long [illegible], in [illegible] S., R. [illegible] E., [illegible] County, [illegible] (1) [illegible] from mouth and 9 mi (14 km) north of [illegible]

DRAINAGE AREA. [illegible] mi² ([illegible] km²)

[illegible] OF RECORD. [illegible] to December 1942 (published as "[illegible]"), May 1951 to current year. [illegible] to December 1942, published in WSP [illegible].

REVISED RECORDS. WSP [illegible]: 1948, 1957.

GAGE. Water stage recorder. Altitude of gage is 2,350 ft (716 m), from topographic map. May 1951 to December 1[illegible] at [illegible] (0.5 km) downstream at different datum.

REMARKS. Records fair. Diversions for irrigation of several hundred acres above station.

AVERAGE DISCHARGE. 25 years, 30.7 ft³/s (0.869 m³/s), 22,240 acre-ft/yr (27.4 hm³/yr); median of yearly mean discharges, 22 ft³/s (0.62 m³/s), 15,900 acre-ft/yr (20 hm³/yr).

EXTREMES FOR PERIOD OF RECORD. Maximum discharge since at least 1951, 16,200 ft³/s (459 m³/s) Dec. 18, 1958, gage height, 13.71 ft (4.179 m), from profile past gage, from rating curve extended above 1,400 ft³/s (37 m³/s) on basis of slope-area measurement of peak flow; minimum, 0.5 ft³/s (0.014 m³/s) Aug. 30, 1940.

EXTREMES OUTSIDE PERIOD OF RECORD. A discharge of 20,000 ft³/s (566 m³/s) occurred Aug. 2, 1919, at site of former gaging station [illegible] (13 km) downstream, operated April 1906 to September 1921, gage height, 6.3 ft (1.92 m), from floodmark, site and datum then in use, from rating curve extended above 5,100 ft³/s (144 m³/s) on basis of velocity area study.

EXTREMES FOR CURRENT YEAR. Maximum discharge, 2,400 ft³/s (69.7 m³/s) Feb. 15, 1715 hours, gage height, 5.26 ft (1.603 m), no peak above base of 2,500 ft³/s (71 m³/s); minimum daily, 10 ft³/s (0.28 m³/s) June 19-20, 22, Aug. 21-23.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1979 TO SEPTEMBER 1980
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	22	25	25	26	36	50	37	25	16	19	23	15
2	24	25	25	26	36	56	39	25	19	18	22	15
3	23	25	27	26	32	55	37	25	16	17	20	15
4	23	25	26	26	36	129	37	25	17	16	26	15
5	25	25	26	26	29	52	37	25	16	15	61	14
6	25	25	26	26	29	46	32	25	16	14	26	14
7	25	25	26	26	27	78	27	25	19	17	25	56
8	25	29	26	26	31	46	27	24	19	16	25	36
9	25	30	26	26	34	37	26	24	19	15	21	29
10	25	28	26	28	31	36	26	23	19	15	46	21
11	25	27	26	29	31	261	26	21	18	15	56	18
12	25	26	26	29	30	159	26	21	16	16	26	17
13	25	26	26	27	109	68	25	19	17	17	25	16
14	25	27	26	26	395	45	26	19	17	17	125	16
15	25	27	26	26	656	41	26	17	17	17	47	16
16	25	27	27	26	677	37	25	17	17	18	36	21
17	25	26	27	26	651	32	25	18	16	16	25	21
18	25	26	27	161	353	32	25	19	12	17	23	21
19	25	26	27	210	315	30	25	19	16	16	26	17
20	25	27	27	169	1083	30	25	21	16	21	15	20
21	50	27	52	61	200	33	25	21	11	16	18	19
22	35	28	50	60	120	35	25	22	16	16	18	18
23	25	29	28	47	100	30	25	22	15	26	18	15
24	25	30	27	40	100	30	25	21	17	27	15	13
25	25	29	27	37	80	33	25	21	15	25	25	16
26	25	30	26	35	60	33	25	21	12	21	15	20
27	25	29	31	33	55	36	25	20	12	25	15	20
28	25	31	27	32	50	36	25	20	16	21	15	19
29	25	31	27	33	50	34	25	20	16	20	15	18
30	25	27	27	40	---	34	25	18	16	23	15	17
31	25	---	27	39	---	38	---	16	---	24	15	---
TOTAL	832	822	861	1411	5090	1700	829	650	490	560	616	524
MEAN	25.9	27.4	27.8	45.5	176	54.8	27.6	21.2	15.6	18.2	20.5	17.5
MAX	50	31	33	210	656	263	39	25	19	27	125	56
MIN	22	25	25	26	27	32	25	16	10	12	18	13
AC-FT	1590	1630	1710	2800	10100	3370	1640	1300	924	1120	1220	1040

CAL YR 1979 TOTAL 20917 MEAN 57.3 MAX 1390 MIN 15 AC-FT 41490
WTR YR 1980 TOTAL 14605 MEAN 39.9 MAX 656 MIN 10 AC-FT 28970

USAV-00005919

[illegible]

LOCATION.--Lat [illegible], long [illegible], in [illegible] (0.5 mi) upstream from [illegible] mi (1.1 km) north of [illegible].

DRAINAGE AREA.--[illegible] mi² ([illegible] km²).

PERIOD OF RECORD.--May 1931 to December 1942 (published as [illegible]); [illegible] 1941 to December 1942, published in WSP 1311.

REVISED RECORDS.--WSP [illegible]: 1948, 1967.

GAGE.--Water stage recorder. Altitude of gage is [illegible] (0.5 mi) downstream at different datum.

REMARKS.--Records fair. Diversions for irrigation of several [illegible].

AVERAGE DISCHARGE.--[illegible] years, 30.3 ft³/s ([illegible] m³/s), 21,950 acre-ft/yr ([illegible] hm³/yr), median of yearly mean discharges, [illegible] ft³/s ([illegible] m³/s), 15,[illegible] acre-ft/yr ([illegible] hm³/yr).

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge since at least [illegible] ([illegible] m³), from profile past gage, from rating curve extended above [illegible] ft³/s ([illegible] m³/s) on basis of slope-area measurement of peak flow; minimum, 0.3 ft³/s ([illegible] m³/s) Aug. [illegible], 1956.

EXTREMES OUTSIDE PERIOD OF RECORD.--A discharge of [illegible] ft³/s [illegible] at site at former gaging station [illegible] (1.0 mi) downstream, operated April 1931 to September [illegible]; [illegible] mi, from [illegible]; rate and datum [illegible] use, from rating curve extended above [illegible] ft³/s [illegible].

EXTREMES FOR CURRENT YEAR.--Maximum discharge [illegible], from rating [illegible] flow [illegible] ft³/s or [illegible] of slope-area measurement of peak flow; and peak discharges some days [illegible].

Date	Time	Discharge (ft³/s)	Discharge (m³/s)	Gage height (ft)	Gage height (m)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nov. 28	a2500	[illegible]	139	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Dec. 28	a[illegible]	b10,200	450	c13.71	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Minimum daily, [illegible] ft³/s ([illegible] m³/s) [illegible].
a Maximum.
b From high-water mark in gage well.
c From profile past gage.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1978 TO SEPTEMBER 1979
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	9.5	24	26	20	556	45	41	42	30	24	16	18
2	9.0	23	25	20	372	51	55	40	30	25	16	18
3	9.0	20	23	20	244	46	62	38	31	23	22	18
4	12	23	22	20	193	41	50	35	41	22	20	16
5	12	22	22	20	478	41	49	35	36	22	20	16
6	12	22	20	200	215	41	47	36	36	21	27	18
7	12	19	24	124	157	41	45	38	38	23	31	25
8	11	14	22	38	126	41	46	38	33	17	25	27
9	12	17	21	28	113	39	45	45	29	16	24	25
10	12	18	21	28	122	35	71	31	26	16	23	24
11	12	18	21	28	119	34	70	31	25	18	20	20
12	10	19	22	28	116	34	42	38	25	18	155	25
13	6.2	18	22	28	108	37	48	31	24	20	47	25
14	5.8	22	22	28	104	36	47	31	17	25	28	27
15	9.5	24	22	28	190	37	46	30	22	25	36	27
16	10	20	22	28	157	34	45	33	24	24	40	27
17	8.5	20	24	481	101	38	45	35	23	24	28	23
18	9.5	18	6400	1390	86	42	45	44	21	19	26	22
19	18	18	4000	373	74	36	44	50	19	22	23	22
20	12	18	2000	353	67	35	43	45	18	25	22	27
21	190	18	1000	257	64	39	44	40	18	23	22	26
22	69	17	503	224	100	114	44	43	18	23	22	26
23	118	17	100	199	59	103	43	68	18	27	21	26
24	83	1100	59	166	49	91	42	181	16	26	20	26
25	65	900	50	543	45	81	40	68	21	23	20	27
26	46	100	40	832	45	69	38	56	25	22	20	15
27	45	62	40	468	42	60	38	49	25	23	18	16
28	33	49	38	279	42	60	38	45	25	23	18	16
29	33	39	38	254	---	128	40	38	25	24	18	24
30	31	33	38	195	---	103	41	35	24	24	18	26
31	27	---	38	182	---	70	---	31	---	23	18	---
TOTAL	962.0	2734	14685	7134	3745	1759	1414	1388	754	699	872	671
MEAN	31.0	91.1	474	230	134	56.6	47.1	44.8	25.1	22.5	28.1	22.4
MAX	190	1100	6400	1390	552	128	71	181	41	28	155	27
MIN	5.8	17	21	20	42	35	38	30	17	16	16	15
AC-FT	1910	5420	29130	14150	7430	3490	2800	2750	1500	1390	1730	1330

CAL YR 1978 TOTAL 32111.0 MEAN 88.0 MAX 6400 MIN 3.7 AC-FT 63690
WTR YR 1979 TOTAL 36813.0 MEAN 101 MAX 6400 MIN 5.8 AC-FT 73020

USAV-00005920

GILA RIVER BASIN

[illegible] ARIZONA CANAL NEAR SHEFFORD, AZ

LOCATION.--Lat 32°50'[illegible], long 110°[illegible], [illegible] S., R 1[illegible] E., Pinal County, Hydrologic Unit 15[illegible], on right bank 6.[illegible] km (10 mi) upstream from mouth and 9 mi (14 km) north of Shefford.

DRAINAGE AREA.--[illegible] mi² ([illegible] km²).

PERIOD OF RECORD.--May 1931 to December 1942 (published as "near Kilgore"), May 1966 to current year. Monthly discharge only July 1931 to December 1942, published in WSP [illegible].

REVISED RECORDS.--WSP [illegible]: 1968: [illegible] mi².

GAGE.--Water stage recorder. Altitude of gage is 2,350 ft (716 m), from topographic map. May 1931 to December 1942 at site 0.3 mi (0.5 km) downstream at different datum.

REMARKS.--Records fair except those above 100 ft³/s (2.8 m³/s), which are poor. Diversions for irrigation of several hundred acres above station.

AVERAGE DISCHARGE.--23 years, 27.2 ft³/s (0.770 m³/s), 19,710 acre-ft/yr (24.3 hm³/yr); median of yearly mean discharges, 20 ft³/s (0.57 m³/s), 14,500 acre-ft/yr (18 hm³/yr).

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge since at least 1931, 10,500 ft³/s (297 m³/s) Dec. 19, 1967, gage height, 11.[illegible] ft (3.615 m), in gage well, 14.25 ft (4.34 m), from profile past gage, from rating curve extended above 450 ft³/s (12.[illegible] m³/s) on basis of slope-area measurement at gage height 12.5 ft (3.81 m), from profile past gage; minimum, 0.3 ft³/s (0.008 m³/s) Aug. 27, 1940.

EXTREMES OUTSIDE PERIOD OF RECORD.--A discharge of 20,000 ft³/s (566 m³/s) occurred Aug. 2, 1919, at site of former gaging station 6 mi (10 km) downstream, operated April 1919 to September 1921, gage height, 6.3 ft (1.92 m), from flood-mark, site and datum then in use, from rating curve extended above 5,100 ft³/s (140 m³/s) on basis of velocity-area study.

EXTREMES FOR CURRENT YEAR.--Maximum discharge (*) and peak discharges above base of 2,500 ft³/s (71 m³/s).

Date	Time	Discharge (ft³/s)	Discharge (m³/s)	Gage height (ft)	Gage height (m)
Dec. 2	2230	3,600	96.3	a5.5	1.68
Aug. 1	0415	*5,100	144	a6.4	1.95

Minimum daily, 1.2 ft³/s (0.034 m³/s) Dec. 4.
a From high water mark in gage well.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1977 TO SEPTEMBER 1978
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	5.7	2.3	6.0	10	5e	910	32	13	7.2	9.5	190	18
2	5.0	2.2	6.0	9.0	2e	1600	25	28	6.0	6.0	190	19
3	4.1	2.3	6.3	9.5	1e	1070	26	25	6.0	6.0	53	17
4	1.2	3.7	6.0	9.1	1e	329	19	19	5.0	6.5	91	16
5	6.0	3.6	8.5	8.6	1e	210	16	18	5.3	6.0	75	118
6	37	55	8.7	8.2	15	635	11	27	5.1	5.7	42	18
7	52	21	6.0	8.0	5e	267	10	20	6.0	7.0	38	16
8	16	10	8.7	7.5	2e	171	12	19	6.0	7.0	35	14
9	17	12	6.0	7.0	15	136	16	18	6.0	7.1	193	13
10	11	12	6.3	9.0	15	122	15	19	5.2	6.5	26	12
11	9.0	11	7.0	11	10e	115	12	17	5.1	13	16	17
12	8.0	12	8.3	9.5	6e	116	12	15	5.0	15	13	16
13	7.7	11	8.0	8.6	10e	129	11	12	8.0	19	11	8.7
14	7.7	11	8.2	8.2	275	120	12	8.0	7.0	13	11	11
15	6.3	10	8.0	8e0	23e	85	17	6.0	6.0	7.2	11	11
16	6.5	8.0	8.7	175	215	65	17	5.3	6.2	5.0	11	11
17	5.0	9.1	8.0	100	143	55	13	5.0	6.0	15	11	6.0
18	5.0	9.2	8.0	30	120	51	11	4.7	7.1	25	11	9.0
19	5.7	9.6	8.0	20	8e	46	13	4.7	7.2	13	10	9.2
20	5.5	9.4	8.7	15	72	40	13	4.8	7.0	7.4	27	9.0
21	6.0	9.5	8.0	12	6e	40	11	4.7	8.0	6.0	10	9.2
22	6.1	10	8.0	10	37	35	9.0	13	8.5	21	11	9.0
23	6.3	9.5	8.0	10	33	30	10	9.3	8.7	26	10	9.2
24	6.0	8.0	8.7	10	5e	30	12	7.0	9.5	18	10	9.2
25	5.6	8.0	8.0	10	2e	32	12	9.1	9.5	30	13	8.0
26	6.6	7.0	8.0	10	27	31	15	10	9.0	19	12	8.5
27	2.0	7.0	9.0	10	5e	28	16	10	7e	11	10	8.0
28	2.1	8.1	25	13	10e	20	17	11	8?	9.7	10	7.1
29	3.6	8.1	30	10	---	25	16	13	23	9.1	10	7.0
30	5.0	8.3	12	10	---	29	16	12	12	32	1e	9.2
31	2.0	---	12	20	---	27	---	10	---	11	10	---
TOTAL	264.2	315.0	325.5	1263.0	2170	7020	452.0	410.0	303.0	530.5	1156	393.5
MEAN	8.52	10.5	10.5	39.5	77.5	227	15.1	13.2	12.1	17.1	37.0	13.1
MAX	52	55	30	600	30e	1600	32	28	30	30	190	118
MIN	1.2	2.2	7.0	7.0	1e	27	9.0	9.2	5.0	5.0	10	7.2
AC-FT	524	625	646	2510	430e	13920	897	815	722	1050	2300	781

CAL YR 1977 TOTAL 3750.00 MEAN 10.3 MAX 15[illegible] MIN .90 AC-FT 7440
WTR YR 1978 TOTAL 14035.50 MEAN 38.3 MAX 1600 MIN 1.2 AC-FT 29030

USAV-00005921

APPENDIX B

Habitat data for Sonora sucker, desert sucker and roundtail chub collected from the Gila River, New Mexico and Aravaipa Creek, Arizona

INSTREAM FLOW FISH DATA

SPECIES: Catostomus insignis

Stream: Gila River
Station: Just downstream from bridge at Red Rock
Collector: NMSU-Tafanelli,Britt
Date: 3/5/81
Meter: Pygmy

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	SUBSTRATE	AREA DESCRIPTION/COVER
Adult	1.7	0.125	Sand,mud	Undercut bank, flow at R.edge

Stream: Gila River
Station: Cliff, N.M.
Collector: NMSU-Tafanelli,Britt
Date: 3/6/81
Meter: Pygmy

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	SUBSTRATE	AREA DESCRIPTION/COVER
Adult	1.1	0	Mud,sand,gravel	Near boulder
Adult	1.7	0	Mud,sand,gravel	Amongst boulders,tumbleweeds
Adult	1.35	0	Mud,sand,gravel	Under boulder
Adult	1.5	0	Mud,sand,gravel	Under boulder
Adult	2.1	0	Mud,sand	Boulder,tumbleweed
Adult	2.0	0	Mud,sand	Near boulders
Adult	1.4	0	Mud,sand	Large boulders
Adult	1.4	0	Mud,sand	Large boulders
Adult	1.4	0	Mud,sand	Large boulders
Adult	1.4	0	Mud,sand	Large boulders
Adult	0.45	0	Cobble	Behind large rock-algae
Adult	0.85	0	Mud,cobble	-----
Adult	1.5	0.7	Sand,cobble	Edge of deep pool
Adult	2.8	1.775	Gravel,sand	Snag,pool
Adult	2.8	1.775	Gravel,sand	Snag,pool
Adult	2.8	1.775	Gravel,sand	Snag,pool
Adult	2.8	1.775	Gravel,sand	Snag,pool
Adult	2.4	0.175	Gravel,sand	Snag,pool
Adult	2.4	0.175	Gravel,sand	Snag,pool
Adult	2.4	0.925	Gravel,sand	Snag,pool
Adult	2.4	0.925	Gravel,sand	Snag.pool
Adult	2.0	0.65	Gravel,sand	Snag,pool

USAV-00005923

INSTREAM FLOW FISH DATA

SPECIES: Catostomus insignis

Stream: Gila River
Station: Just downstream from bridge at Red Rock

Collector: NMSU-Tafanelli, Britt Meter: Pygmy
Date: 3/5/81

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	SUBSTRATE	AREA DESCRIPTION/COVER
Juvenile	1.45	0.275	Mud,sand	At side of river
Juvenile	1.4	? algal mat	Mud,sand	At side of river
Juvenile	2.4	? algal mat	------	At side of river near brush
Juvenile	1.4	0.3	Sand,mud	At side of river near brush
Juvenile	1.7	0.125	Sand,mud	Undercut bank,flow at R.edge
Juvenile	1.7	0.125	Sand,mud	Undercut bank,flow at R.edge
Juvenile	1.7	0.125	Sand,mud	Undercut bank,flow at R.edge
Juvenile	1.7	0.125	Sand,mud	Undercut bank,flow at R.edge
Juvenile	1.7	0.125	Sand,mud	Undercut bank,flow at R.edge
Juvenile	0.95	0	Sand,mud,vegetation	Veg. bed at river side
Juvenile	0.95	0	Sand,mud,vegetation	Veg. bed at river side
Juvenile	1.1	0	Sand,mud,vegetation	Veg. bed at river side
Juvenile	1.4	0	Sand,mud,vegetation	Veg. bed at river side
Juvenile	1.1	0	Sand,mud,vegetation	Veg. bed at river side
Juvenile	1.1	0	Sand,mud,vegetation	Veg. bed at river side

Stream: Gila River
Station: Cliff, N.M.

Collector: NMSU- Tafanelli, Britt Meter: Pygmy
Date: 3/6/81

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	SUBSTRATE	AREA DESCRIPTION/COVER
Juvenile	0.75	0	Mud,sand,gravel	Back water
Juvenile	0.5	0.675	Cobble	Algae
Juvenile	0.85	0	Mud,algae	-----
Juvenile	0.6	0	Cobble,sand	Algal mat
Juvenile	1.0	0.25	Sand,cobble	Some algae

USAV-00005924

INSTREAM FLOW FISH DATA

SPECIES: Catostomus clarki

Stream: Gila River
Station: Just downstream of bridge at Red Rock

Collector: NMSU-Tafanelli, Britt, and Tibbetts
Date: 3/5/81

Meter: Pygmy

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	SUBSTRATE	AREA DESCRIPTION/COVER
Juvenile	0.9	? Veg.	Cobble	Riffle created by diversion
Juvenile	0.9	? Veg.	Cobble	" " " "
Juvenile	0.9	? Veg.	Cobble	" " " "
Juvenile	0.9	? Veg.	Cobble	" " " "
Juvenile	1.1	1.525	Cobble	" " " "
Juvenile	1.1	1.225	Cobble	" " " "
Juvenile	0.6	0.5	Cobble	" " " "
Juvenile	0.7	2.5	Cobble	" " " "
Juvenile	0.4	0.075	Cobble	" " " "
Juvenile	0.4	0.075	Cobble	" " " "
Juvenile	0.9	2.4	Cobble	" " " "
Juvenile	0.7	3.074	Cobble	" " " "
Juvenile	0.7	0.15	Cobble	" " " "
Juvenile	0.7	1.425	Cobble	" " " "
Juvenile	0.8	3.15	Cobble	" " " "
Juvenile	0.7	2.825	Cobble	" " " "
Juvenile	0.8	3.225	Cobble	" " " "
Juvenile	0.7	1.325	Cobble	" " " "
Juvenile	0.7	2.0	Cobble	" " " "
Juvenile	0.6	3.175	Cobble	" " " "
Juvenile	0.6	1.15	Cobble	" " " "
Juvenile	0.6	0.625	Cobble	" " " "
Juvenile	0.6	1.475	Cobble	" " " "
Juvenile	0.6	0.15	Cobble	" " " "
Juvenile	0.7	1.775	Cobble	" " " "
Juvenile	0.6	2.825	Cobble	" " " "
Juvenile	0.6	3.225	Cobble	" " " "
Juvenile	0.5	2.325	Cobble	" " " "
Juvenile	0.4	2.7	Cobble	" " " "
Juvenile	0.7	1.4	Cobble	" " " "
Juvenile	0.7	1.85	Cobble	" " " "
Juvenile	0.6	2.0	Cobble	" " " "
Juvenile	0.7	2.0	Cobble	" " " "
Juvenile	0.7	3.48	Cobble	" " " "
Juvenile	0.5	0.95	Cobble	" " " "
Juvenile	0.5	0.95	Cobble	" " " "
Juvenile	0.6	1.05	Cobble	" " " "
Juvenile	0.4	1.75	Cobble	" " " "
Juvenile	0.4	1.0	Cobble	" " " "
Juvenile	0.4	1.775	Cobble	" " " "
Juvenile	0.3	1.35	Cobble	" " " "
Juvenile	0.2	2.375	Cobble	" " " "
Juvenile	0.4	1.925	Cobble	Riffle, usually behind cobble
Juvenile	0.4	1.925	Cobble	" " " "
Juvenile	0.4	1.925	Cobble	" " " "

USAV-00005925

INSTREAM FLOW FISH DATA

SPECIES: Catostomus clarki

Stream: Gila River
Station: Just downstream of bridge at Red Rock

Collector: NMSU-Tafanelli, Britt and Tibbetts
Date: 3/5/81

Meter: Pygmy

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	SUBSTRATE	AREA DESCRIPTION/COVER
Juvenile	0.4	1.925	Cobble	Riffle, filamentous algae mats
Juvenile	0.3	2.05	Cobble	" " " "
Juvenile	0.6	1.15	Cobble	" " " "
Juvenile	0.6	1.15	Cobble	" " " "
Juvenile	0.5	2.3	Cobble	" " " "
Juvenile	0.4	1.75	Cobble	" " " "
Juvenile	0.7	1.15	Cobble	" " " "
Juvenile	1.4	0.65	Veg., mud, sand	Deep run, filamentous algae
Juvenile	1.1	0	Veg., mud, sand	" " " "
Juvenile	1.5	? algae mat	Mud, sand	Algal mat, side of river
Juvenile	1.3	? algae mat	Mud, sand	Side of river
Juvenile	?	0.225	Mud, sand	" " "
Juvenile	?	0.225	Mud, sand	" " "
Juvenile	1.9	0.075	Mud, sand	" " "
Juvenile	0.9	0.025	Mud, sand	" " "
Juvenile	1.0	0.9	Cobble, algal mat	" " "
Juvenile	1.0	0.9	Cobble, algal mat	" " "
Juvenile	1.0	0.8	Cobble, gravel, algae	" " "
Juvenile	0.9	0.975	Cobble, gravel, algae	" " "
Juvenile	0.9	1.15	Cobble, gravel, algae	" " "
Juvenile	0.8	0.525	Cobble, gravel, algae	" " "
Juvenile	1.2	0.55	Algal mat, mud, sand	" " "
Juvenile	1.3	0.5	Algal mat, mud, sand	" " "
Juvenile	0.95	? brush	Sand, debris	" " "
Juvenile	0.9	2.825	Sand, mud, algae	" " "
Juvenile	1.0	1.275	Mud, sand	" " "
Juvenile	1.5	1.05	Sand, mud	Run
Juvenile	0.9	0.25	Cobble, sand	Side of river
Juvenile	0.8	0.25	Cobble, sand	" " "
Juvenile	0.8	0.25	Cobble, sand	" " "
Juvenile	0.8	0.25	Cobble, sand	" " "
Juvenile	0.8	0.25	Cobble, sand	" " "

USAV-00005926

INSTREAM FLOW FISH DATA

SPECIES: Catostomus clarki

Stream: Gila River
Station: Cliff, N.M.

Collector: NMSU-Tafanelli, Britt, and Tibbetts
Date: 3/6/81

Meter: Pygmy

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	SUBSTRATE	AREA DESCRIPTION/COVER
Juvenile	0.9	0	Cobble, sand	Vascular vegetation
Juvenile	0.8	0.675	Cobble	-----
Juvenile	0.7	1.625	Cobble	-----
Juvenile	0.7	1.625	Cobble	-----
Juvenile	0.7	0.55	Cobble	-----
Juvenile	0.6	0.75	Cobble	-----
Juvenile	1.1	2.325	Cobble	-----
Juvenile	1.1	2.575	Cobble	-----
Juvenile	0.7	0	Mud, sand	Vascular plants
Juvenile	0.7	1.4	Cobble	-----
Juvenile	0.8	2.57	Cobble	-----
Juvenile	0.9	2.275	Cobble	-----
Juvenile	0.65	1.575	Cobble	-----
Juvenile	0.7	0.9	Cobble	-----
Juvenile	0.8	3.45	Cobble	-----
Juvenile	0.6	1.575	Cobble	-----
Juvenile	0.7	1.025	Cobble, sand	-----
Juvenile	0.85	1.075	Cobble, sand	Behind boulder
Juvenile	0.85	1.075	Cobble, sand	Behind boulder
Juvenile	0.85	1.075	Cobble, sand	Behind boulder
Juvenile	0.85	1.075	Cobble, sand	Behind boulder
Adult	2.8	1.775	Cobble, sand	Snag, pool behind
Adult	2.8	1.775	Cobble, sand	Snag, pool behind
Adult	2.3	0.45	Cobble, sand	-----

USAV-00005927

INSTREAM FLOW FISH DATA

SPECIES: Gila robusta

Stream: Aravaipa Creek
Station:

Collector: NMSU-Wilson, Tafanelli, Meter: Pygmy
Date: 2-29-81 Gebler

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.7	2.525	25G;75S/25OB	
Adult	0.9	3.575	25G;75S/25OB	
Adult	1.0	4.375	50C;50G/50OB	
Adult	0.5	2.075	25G;75S/25OB	
Adult	0.4	2.8	50C;50S/25OB	
Adult	0.4	2.25	25G;75S/OBR	
Adult	0.6	1.5	100S	
Adult	0.75	2.5	50C;50G/25OB	

*Substrate Code: BR bedrock; B boulder; C cobble; LC large cobble; SC: small cobble; G gravel; VCG very course gravel; CG course gravel; MG medium gravel; PG: pea gravel; and S sand

USAV-00005928

APPENDIX C

CIFSG computer analysis of habitat data on spikedace collected from Aravaipa Creek and the Gila River, New Mexico

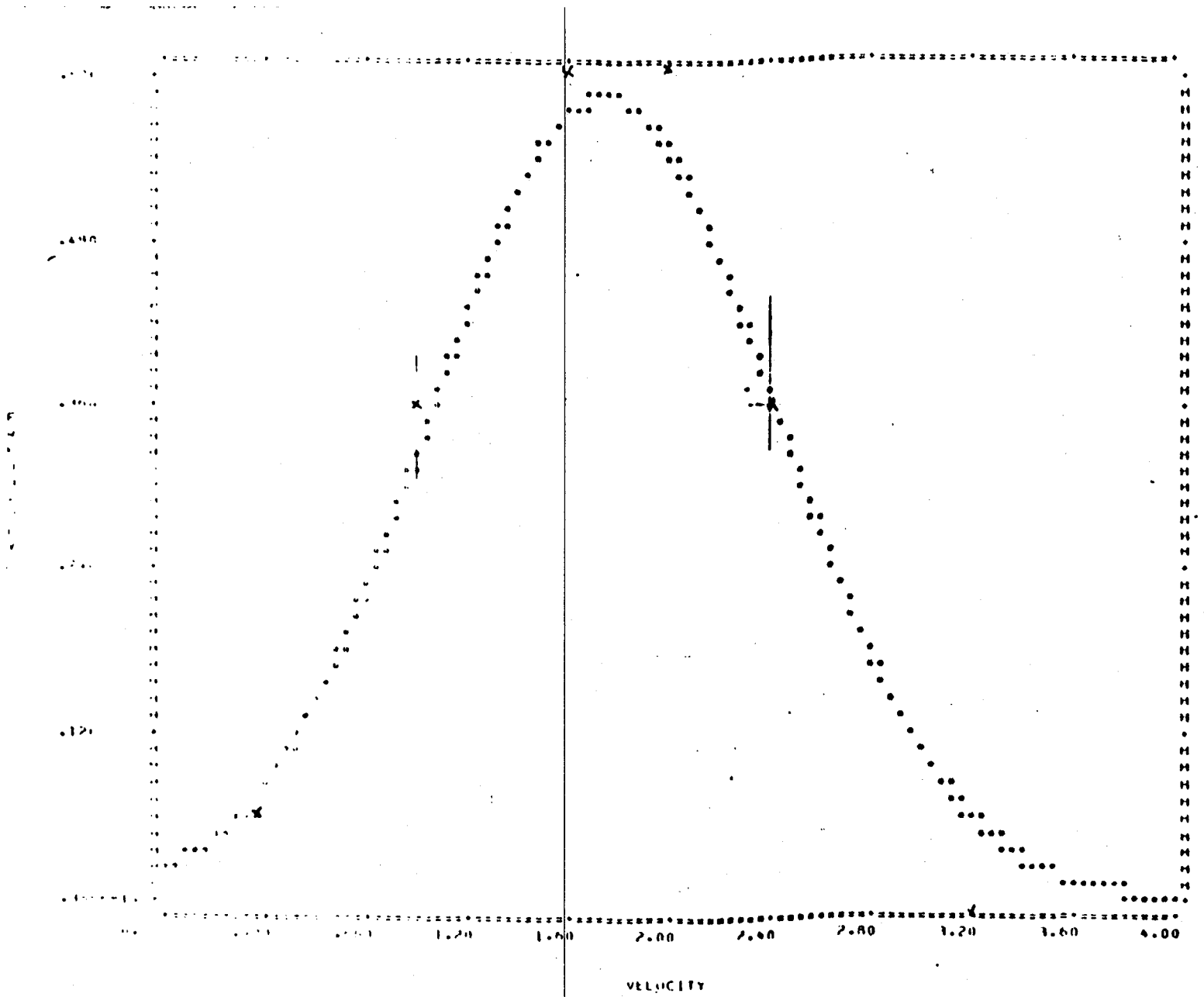


Figure 1. Marginal for adult spikedace for velocity based on fish collected in Aravaipa Creek, Arizona and Gila River, New Mexico in 1981.

USAV-00005930

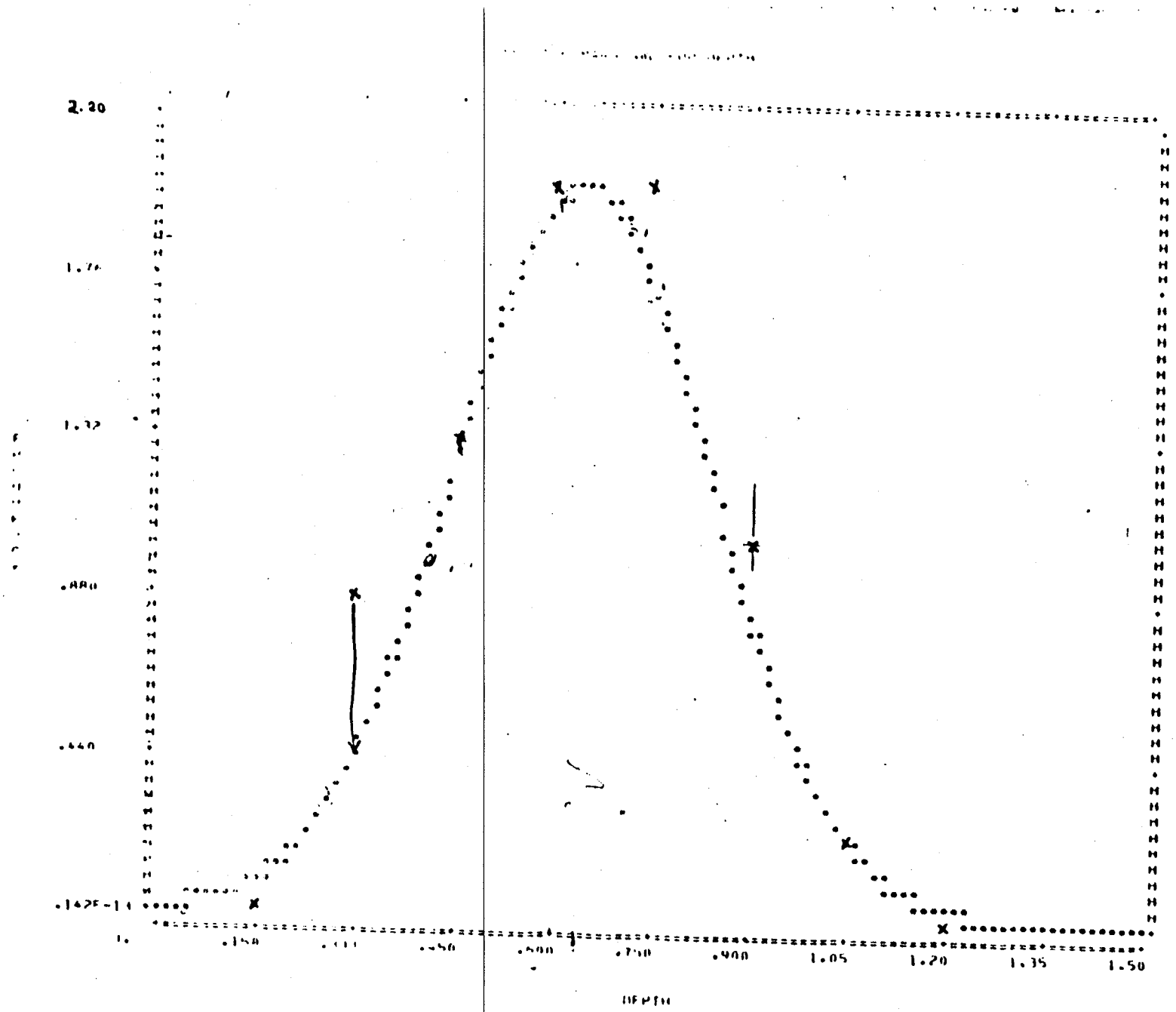


Figure 2. Marginal for adult spikedace for depth based on fish collected in Aravaipa Creek, Arizona and Gila River, New Mexico in 1981.

USAV-00005931

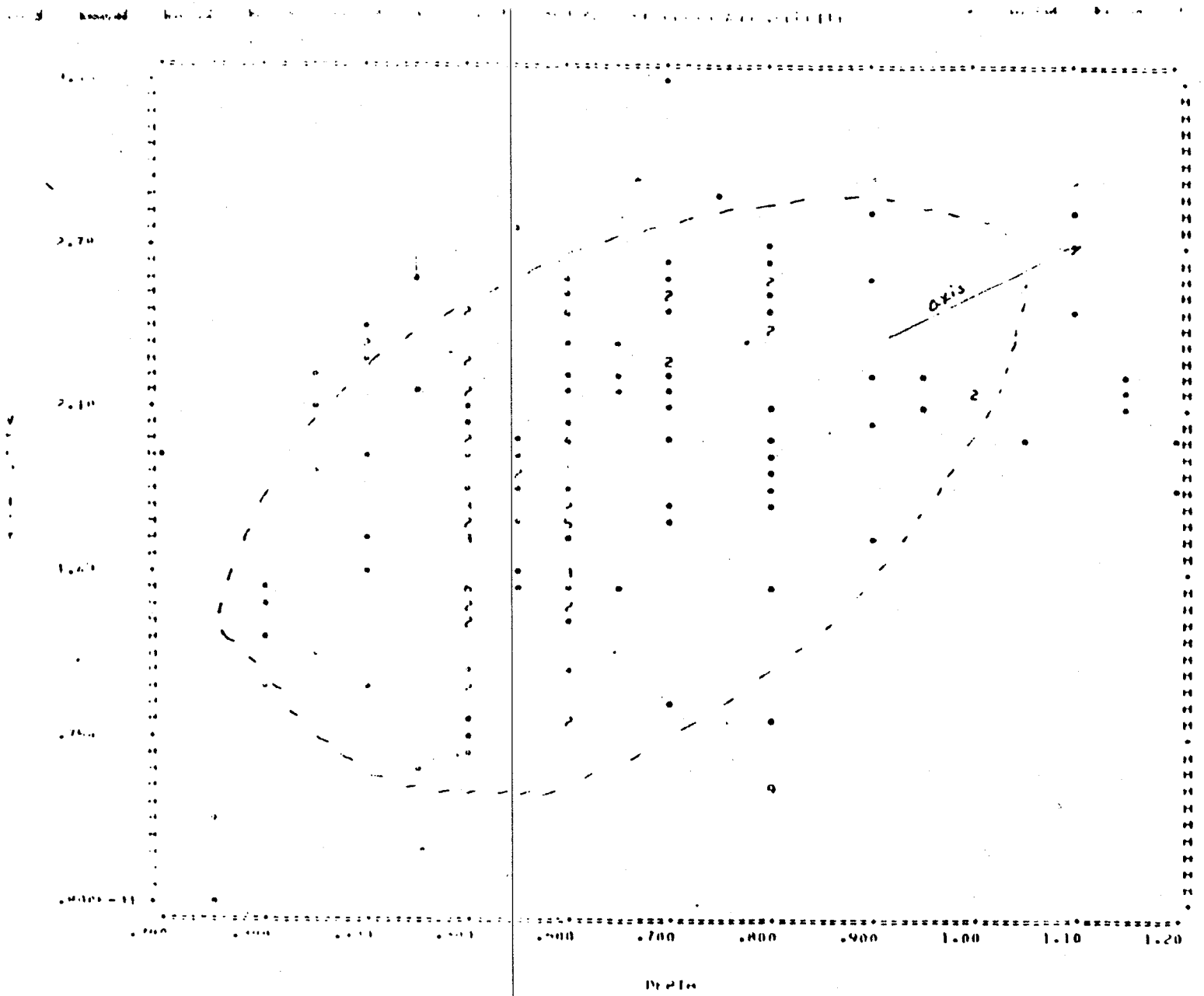


Figure 3. Scattergram for adult spikedace: depth and velocity based on fish collected in Aravaipa Creek, Arizona and Gila River, New Mexico in 1981.

USAV-00005932

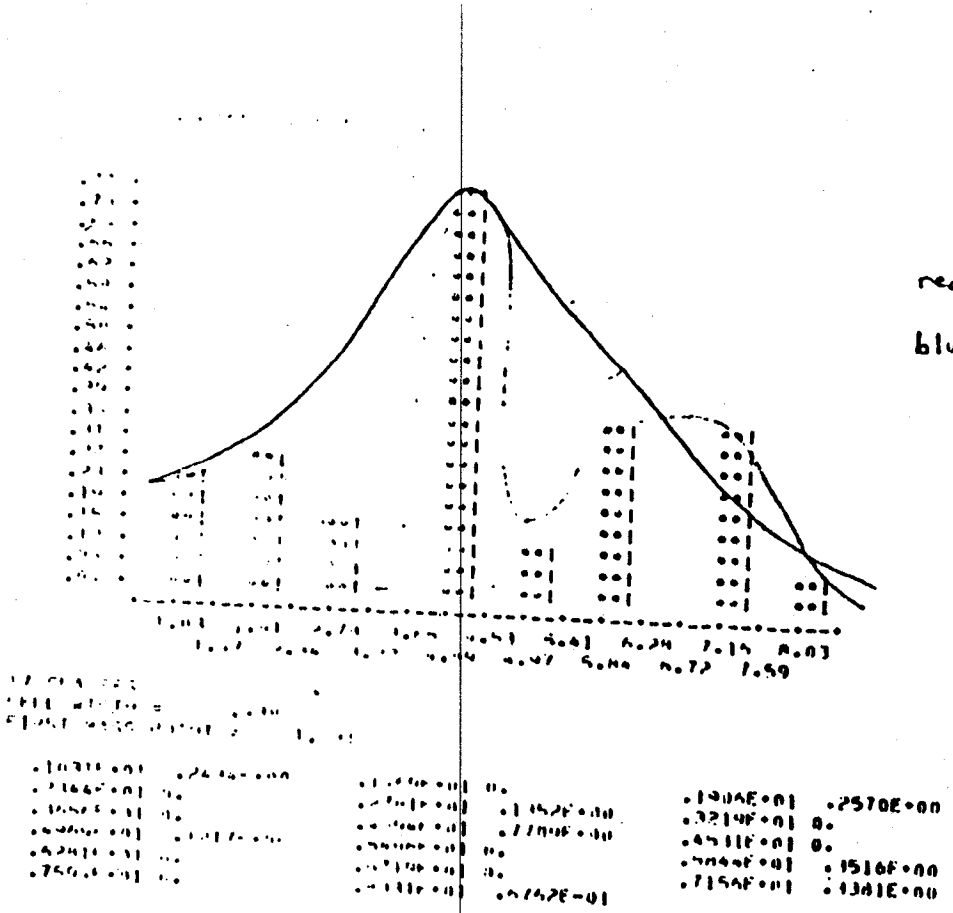


Figure 4. Adult spikedace histogram for dominant particle size based on fish collected in Aravaipa Creek, Arizona and Gila River, New Mexico in 1981.

USAV-00005933

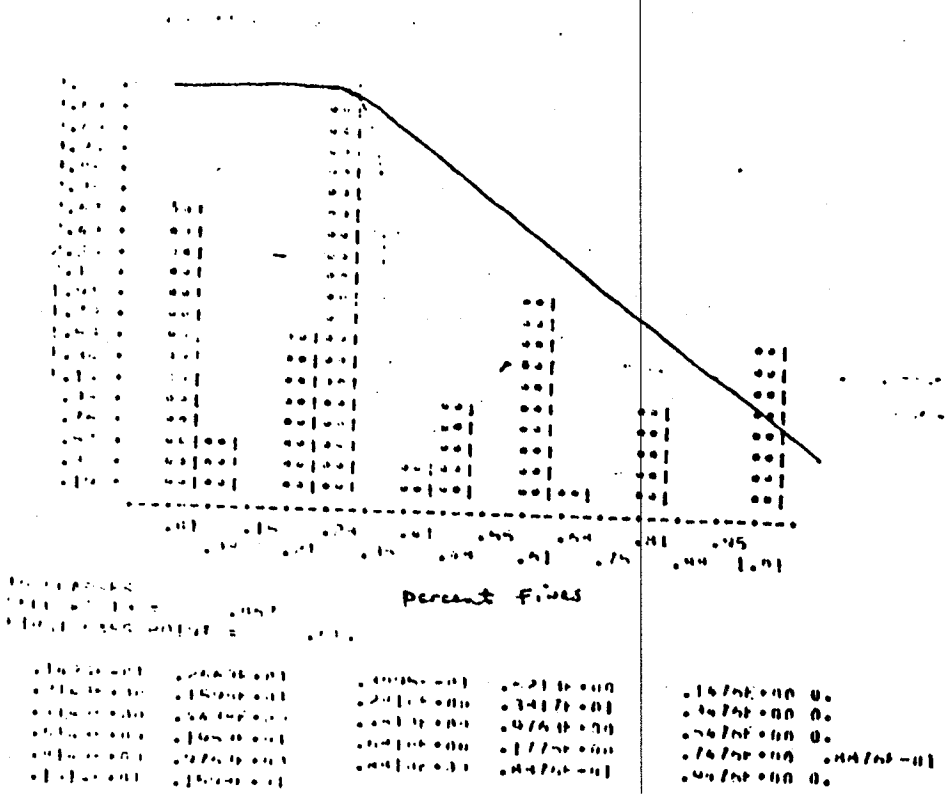


Figure 5. Adult spikedace histogram for percent fines based on fish collected in Aravaipa Creek, Arizona and Gila River, New Mexico in 1981.

USAV-00005934

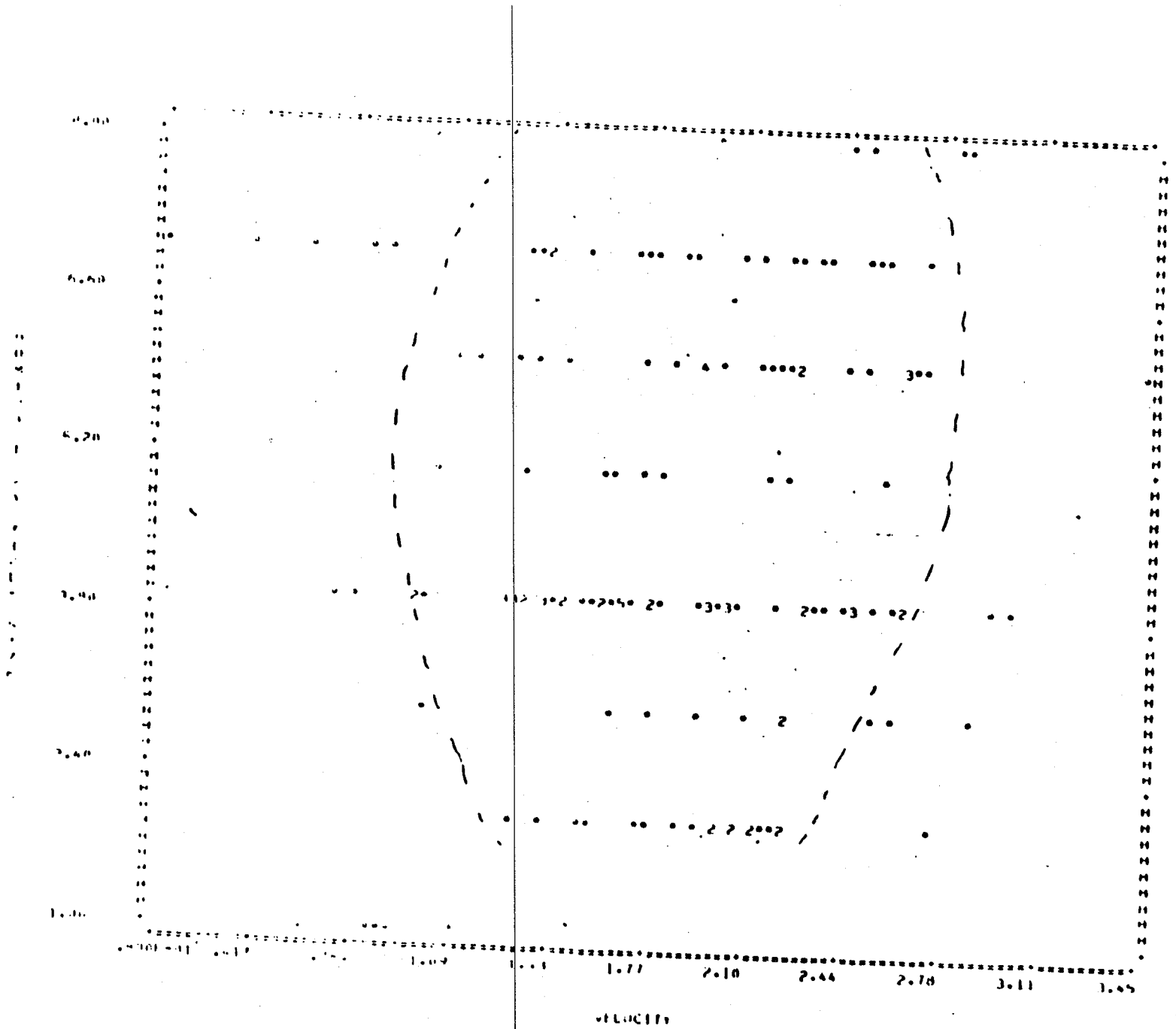


Figure 6. Scattergram for adult spikedace velocity and dominant particle size based on fish collected

USAV-00005935

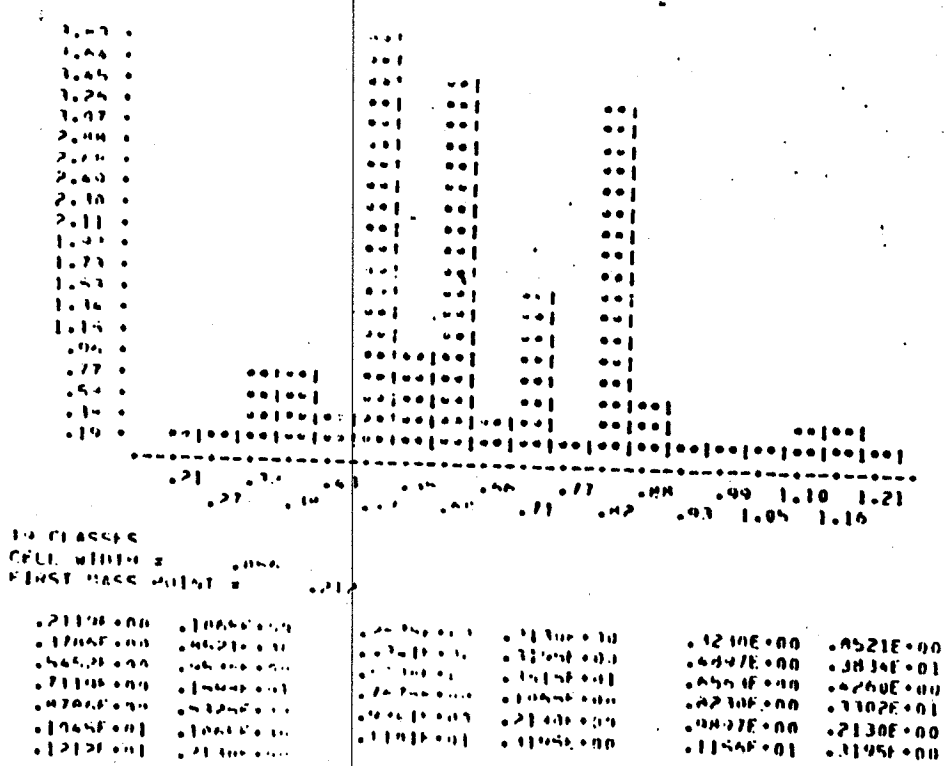


Figure 7. Adult spikedace histogram for depth based on fish collected in Aravaipa Creek, Arizona a
Gila River, New Mexico in 1981.

USAV-00005936

INSTREAM FLOW FISH DATA

SPECIES: Meda fulgida

Stream: Aravaipa Creek
Station: below 1st road crossing above lf station

Collector: NMSU-Thompson, Anderson Meter: Pygmy
Date: 11-10-92

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.5	0.975	40MG;60S	open channel; no overhead veg run area
Adult	0.6	1.625	40MG;60S	open channel; no overhead veg run area
Adult	0.65	2.25	100PG	open channel along rock wall; beginning of run-pool area
Adult	0.8	2.65	10VCG;90PG	open channel along rock wall; beginning of run-pool area
Adult	0.6	1.95	100PG	open channel along rock wall; beginning of run-pool area
Adult	0.8	1.75	100PG	open channel along rock wall; beginning of run-pool area
Adult	0.9	2.25	40PG;60S	open channel along rock wall; run-pool area
Adult	1.2	2.0	40PG;60S	open channel along rock wall; run-pool area
Adult	1.0	2.15	40PG;60S	open channel along rock wall; run-pool area
Adult	1.15	2.175	40PG;60S	open channel along rock wall; run-pool area
Adult	1.05	2.0	40PG;60S	open channel along rock wall; run-pool area
Adult	1.15	2.075	40PG;60S	open channel along rock wall; run-pool area
Adult	0.95	2.1	10MG;80PG;10S	open channel along rock wall; run-pool area
Adult	1.1	2.525	10MG;80PG;10S	open channel along rock wall; run-pool area
Adult	0.9	1.55	40PG;60S	open channel along rock wall; run-pool area
Adult	1.1	2.75	100PG	open channel along rock wall; run-pool area
Adult	0.5	2.2	30CG;30MG;20PG;20S	open channel; no overhead veg run area near edge
Adult	0.55	2.0	30CG;30MG;20PG;20S	open channel; no overhead veg run area near edge
Adult	1.15	2.25	20MG;80PG	open channel along rock wall; run-pool area
Adult	0.95	2.25	20MG;80PG	open channel along rock wall; run-pool area

*Substrate Code: BR= bedrock; B= boulder; LC= large cobble; SC= small cobble; G= gravel; VCG= very course gravel; CG= course gravel; MG= medium gravel; PG= pea gravel; and S= sand

USAV-00005937

INSTREAM FLOW FISH DATA

SPECIES: Meda fulgida

Stream: Aravaipa Creek
Station: above instream flow station

Collector: NMSU-Thompson, Anderson Meter: Pygmy
Date: 11-9-81

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.7	2.625	20CG;60S	open channel; no overhead veg run area near bank
Adult	0.7	2.575	20VCG;80S	open channel; no overhead veg run area near bank
Adult	0.65	2.15	500PG;50S	open channel; no overhead veg run area near bank
Adult	0.7	2.075	20PG;80S	open channel; no overhead veg run area near bank
Adult	0.45	2.2	50PG;50S	open channel; no overhead veg run area near bank
Adult	0.55	2.825	10B;40VCG;30PG;20S	open channel; no overhead veg mid-riffle
Adult	0.5	1.975	10VCG;30PG;60S	open channel; no overhead veg edge of run area
Adult	0.5	2.3	10VCG;30PG;60S	open channel; no overhead veg edge of run area
Adult	0.55	1.625	10VCG;30PG;60S	open channel; no overhead veg edge of run area
Adult	0.6	1.43	10VCG;30PG;60S	open channel; no overhead veg edge of run area
Adult	0.5	1.375	10VCG;30PG;60S	open channel; no overhead veg edge of run area
Adult	0.6	1.275	10VCG;30PG;60S	open channel; no overhead veg edge of run area

Stream:
Station: below 1st road crossing above IF station

Collector:
Date: 11-10-81

Meter:

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.8	2.45	10B;40CG;20PG;30S	open channel; no overhead veg run area
Adult	0.8	2.5	10B;40CG;20PG;30S	open channel; no overhead veg run area
Adult	0.8	2.4	10B;40CG;20PG;30S	open channel; no overhead veg run area
Adult	0.8	2.075	10B;40CG;20PG;30S	open channel; no overhead veg run area

*Substrate Code: BR: bedrock; B: boulder; LC: large cobble; SC: small cobble; G: gravel; VCG: very course gravel; CG: course gravel; MG: medium gravel; PG: pea gravel; and S: sand

USAV-00005938

INSTREAM FLOW FISH DATA

SPECIES: Meda fulgida

Stream: Aravaipa Creek
Station: above Instream flow station

Collector: NMSU-Thompson, Anderson Meter: Pygmy
Date: 11-9-81

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	1.1	2.875	50MG;25PG;25S	near undercut bank @ head of pool; overhanging vegetation
Adult	0.5	1.35	10SC;10VCG;40PG;40S	open channel near shore; no overhanging vegetation
Adult	0.8	1.725	20SC;20LC;40VCG;20S	deep riffle @ head of pool; open channel; overhead veg.
Adult	0.8	2.625	20SC;20LC;40VCG;20S	deep riffle @ head of pool; open channel; overhead veg.
Adult	0.8	1.375	50LC;50S	deep riffle @ head of pool; open channel; overhead veg.
Adult	0.6	0.8	50LC;50S	deep riffle @ head of pool; open channel; overhead veg.
Adult	0.5	1.025	50VCG;10MG;40S	open channel; no overhead veg riffle @ edge
Adult	0.4	2.275	20LC;60CG;20S	open channel; no overhead veg
Adult	0.4	2.35	20LC;60CG;20S	open channel; no overhead veg
Adult	0.5	1.725	40PG;60S	next to bank; overhanging veg
Adult	0.55	1.85	40PG;60S	next to bank; overhanging veg
Adult	0.55	1.375	40PG;60S	next to bank; overhanging veg
Adult	0.4	1.525	10LC;30MG;60S	open channel; no overhead veg
Adult	0.4	1.925	20MG;80PG	open channel; no overhead veg riffle-run area
Adult	0.5	2.3	60CG;20PG;20S	open channel; no overhead veg riffle-run area
Adult	0.6	2.05	40CG;40MG;20S	along undercut bank
Adult	0.6	1.0	10B;20VCG;20CG;50S	open channel; no overhead veg run area
Adult	0.65	2.35	10CG;10MG;80S	open channel; no overhead veg run area
Adult	0.5	1.65	10CG;10MG;80S	open channel; no overhead veg run area
Adult	0.6	1.25	10CG;10MG;80S	open channel; no overhead veg run area
Adult	0.55	1.75	10CG;10MG;80S	open channel; no overhead veg run area
Adult	0.6	1.7	10CG;10MG;80S	open channel; no overhead veg run area near bank
Adult	0.75	3.0	20CG;80S	open channel; no overhead veg run area near bank

*Substrate Code: BR- bedrock; B- boulder; LC- large cobble; SC- small cobble; G- gravel; VCG- very course gravel; CG- course gravel; MG- medium gravel; PG- pea gravel; and S- sand

USAV-00005939

INSTREAM FLOW FISH DATA

SPECIES: Meda fulgida

Stream: Aravalpa Creek
Station: 1st stream crossing below IF station

Collector: NMSU-Thompson, Anderson **Meter:** Pygmy
Date: 11-8-81

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.5	1.275	10SC;40CG;25PG;25S	open channel; no overhead veg
Adult	0.5	1.525	50VCG;25PG;25S	open channel; no overhead veg
Adult	0.55	1.875	10LC;25VCG;25MG;40S	open channel; no overhead veg
Adult	0.7	2.5	10SC;50VCG;20CG;20MG	open channel; no overhead veg
Adult	0.6	1.95	10SC;50VCG;20CG;20MG	open channel; no overhead veg

Stream:
Station: rock wall below road crossing

Collector:
Date:

Meter:

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.6	2.375	80VCG;20PG	open channel; no overhead veg
Adult	0.35	1.075	10SC;40MG;25PG;25S	open channel; no overhead veg
Adult	0.3	1.15	10SC;40MG;25PG;25S	open channel; no overhead veg
Adult	0.7	1.975	60VCG;20MG;20PG	open channel; no overhead veg
Adult	0.6	1.95	30SC;10MG;60S	open channel; no overhead veg
Adult	0.7	2.7	20SC;50VCG;20PG;10S	open channel; no overhead veg
Adult	0.8	1.8	10VCG;40MG;50S	open channel; no overhead veg
Adult	0.7	2.225	20SC;60VCG;20PG	open channel; no overhead veg
Adult	0.5	1.925	40SC;40VCG;10MG;10PG	open channel; no overhead veg
Adult	0.6	1.45	40SC;40VCG;10MG;10PG	open channel; no overhead veg
Adult	0.6	2.225	70VCG;20CG;10PG	open channel; no overhead veg
Adult	0.5	2.525	10VCG;80MG;10PG	open channel; no overhead veg
Adult	0.6	2.625	10SC;30VCG;30CG;30MG	open channel; no overhead veg
Adult	0.6	2.175	40SC;40VCG;20PG	open channel; no overhead veg
Adult	0.7	2.175	30VCG;40PG;30S	open channel; no overhead veg
Adult	0.6	1.725	40VCG;40MG;20S	open channel; no overhead veg
Adult	0.6	1.625	40VCG;40MG;20S	open channel; willow high overhead
Adult	0.5	2.0	10SC;40CG;30PG;20S	open channel; no overhead veg

*Substrate Code: BR= bedrock; B- boulder; LC= large cobble; SC= small cobble; G= gravel; VCG= very course gravel; CG= course gravel; MG= medium gravel; PG= pea gravel; and S= sand

USAV-00005940

INSTREAM FLOW FISH DATA

SPECIES: *Meda fulgida*

Stream: Aravaipa Creek
Station: approx. 100m below instream flow station
Collector: NMSU-Thompson, Anderson, Tibbetts
Date: 8-27-81
Meter: Pygmy

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Juvenile	0.8	1.8	10LC;10SC;20VCG;40CG;20S	Instream cover present
Juvenile	0.8	1.6	10LC;10SC;20VCG;40CG;20S	Instream cover present
Juvenile	0.9	2.475	10LC;10SC;20VCG;40CG;20S	Instream cover present
Juvenile	1.0	1.675	10LC;10SC;20VCG;40CG;20S	Instream cover present
Juvenile	1.0	2.95	10LC;10SC;20VCG;40CG;20S	Instream cover present
Adult	0.8	2.7	10LC;10SC;20VCG;40CG;20S	Instream cover present
Adult	0.7	3.45	20SC;50VCG;30CG	cover present as cobble
Adult	0.7	2.575	10VCG;60MG;30PG	cover present as cobble
Adult	0.6	1.575	20CG;40PG;40S	small cut right bank; grass
Adult	0.5	0.7	20CG;40PG;40S	small cut right bank; grass
Adult	0.35	1.8	10VCG;30MG;60S	no cover

Stream:
Station: Instream flow station
Collector: NMSU-Thompson, Anderson, Tibbetts
Date: 8-28-81
Meter: Price AA

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.8	2.43	10SC;40VCG;30CG;20MG	open canopy;undercut right bank
Adult	1.0	2.14	10SC;40VCG;30CG;20MG	open canopy;undercut right bank
Adult	0.6	----	10SC;30VCG;40CG;15PG;5S	open canopy; no cover
Adult	0.5	2.19	10SC;30VCG;40CG;15PG;5S	open canopy; no cover
Adult	0.55	1.63	10SC;30VCG;40CG;15PG;5S	open canopy; no cover
Adult	0.7	2.28	10SC;30VCG;40CG;15PG;5S	open canopy; no cover
Adult	0.7	2.28	10SC;30VCG;40CG;15PG;5S	open canopy; no cover
Adult	0.9	2.67	10SC;30VCG;40CG;15PG;5S	open canopy; no cover
Adult	0.8	1.95	30SC;40VCG;30CG	open canopy; cut right bank
Adults (23)	1.2	1.76	25MG;25PG;50S	undercut left bank; overhanging rip.veg.; instream roots

*Substrate Code: BR= bedrock; B= boulder; LC= large cobble; SC= small cobble; G= gravel; VCG= very course gravel; CG= course gravel; MG= medium gravel; PG= pea gravel; and S= sand

USAV-00005941

INSTREAM FLOW FISH DATA

SPECIES: Meda fulgida

Stream: Aravaipa Creek
Station: Instream flow station
Collector: NMSU-Wilson, Tafanelli, Gebler **Meter:** Pygmy
Date: 7-29-81

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.8	2.6	25G;75S/25BR	-----
Adult	0.6	0.85	100S	-----
Adult	0.3	1.375	50G;50S;/90BR	-----

Stream:
Station: 1st road crossing below instream flow sta.
Collector: NMSU-Thompson, Anderson, Tibbetts **Meter:** Pygmy
Date: 8-27-81

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.6	1.975	10VCG;90S	overhanging vegetation
Adult	0.3	0.95	10VCG;45MG;45S	shaded by vegetation
Adult	0.6	2.6	50CG;50S	cover in water
Adult	0.5	1.675	20MG;80S	cover in water
Adult	0.5	1.275	50PG;50S	cover in water
Adult	0.5	1.525	30PG;70S	cover in water
Adult	0.4	0.95	20VCG;50MG;30PG	velocity measured behind cobble
Adult	0.3	1.3	50CG;50S	velocity measured behind cobble
Adult	0.5	1.325	5VCG;25MG;70S	-----
Adult	0.5	1.6	10VCG;10CG;80S	-----

Stream:
Station: approx. 100m below instream flow station
Collector:
Date: 8-27-81
Meter:

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.6	2.5	30LC;20CG;30MG;20S	overhead tree; shaded
Adult	0.45	2.65	10SC;20VCG;50CG;20S	open canopy
Adult	0.4	2.45	10SC;20VCG;50CG;20S	open canopy
Adult	0.6	1.3	10VCG;40CG;20MG;30S	instream cover on right bank
Adult	0.9	2.05	10VCG;40CG;20MG;30S	instream cover on right bank
Adult	0.8	1.925	10VCG;40CG;20MG;30S	instream cover on right bank
Juvenile	0.9	2.925	10VCG;40CG;20MG;30S	instream cover on right bank
Juvenile	0.7	1.6	10VCG;40CG;20MG;30S	instream cover on right bank; slight overhanging rip.veg.
Juvenile	1.0	2.9	10LC;10SC;20VCG;40CG;20S	instream cover present

*Substrate Code: BR= bedrock; B= boulder; LC= large cobble; SC= small cobble; G= gravel; VCG= very course gravel; CG= course gravel; MG= medium gravel; PG= pea gravel; and S= sand

USAV-00005942

INSTREAM FLOW FISH DATA

SPECIES: Meda fulviga

Stream: Gila River
Station: 1 mile upstream from Moonhull Canyon

Collector: Taffanelli, Britt, and Desmare
Date: 6/18/81
6/19/81

Meter: Pygmy

LIFE STAGE	DEPTH	VELOCITY (ft/s)	SUBSTRATE	AREA DESCRIPTION/COVER
Adult	0.65	1.325	Cobble,gravel,sand	-----
Adult	0.5	1.725	Cobble,gravel,sand	-----
Adult	0.7	1.7	Cobble,gravel,sand	-----
Adult	0.6	1.775	Cobble,gravel,sand	-----
Adult	0.55	2.675	-----	-----
Adult	0.6	2.6	-----	-----
Adult	0.55	2.2	-----	-----
Adult	0.5	2.525	Cobble,gravel,sand	-----
Adult	0.35	2.075	Cobble,gravel,sand	-----
Adult	0.4	2.375	Cobble,gravel,sand	-----
Adult	0.5	1.35	Cobble,gravel,sand	-----
Adult	0.5	2.125	Cobble,gravel,sand	-----
Adult	0.5	0.85	Cobble,gravel,sand	-----
Adult	0.45	0.6	Cobble,gravel,sand	-----
Adult	0.5	2.025	Gravel,sand	-----
Adult	0.6	2.475	Gravel,sand	-----
Adult	0.6	2.475	Gravel,sand	-----
Adult	0.6	2.475	Gravel,sand	-----
Adult	0.5	1.25	Gravel,sand	-----
Adult	0.5	1.25	Gravel,sand	-----
Adult	0.55	1.45	Gravel,sand	-----
Adult	0.5	1.75	Gravel,sand	-----
Adult	0.6	1.65	Gravel,sand	-----
Adult	0.6	1.65	Gravel,sand	-----
Adult	0.6	1.65	Gravel,sand	-----
Adult	0.5	1.325	Gravel,sand	-----
Adult	0.5	1.325	Gravel,sand	-----
Adult	0.5	0.75	Gravel,sand	-----
Adult	0.5	1.55	Gravel,sand	-----
Adult	0.5	0.975	Gravel,sand	-----
Adult	0.7	0.9	Sand	-----
Adult	0.8	0.7	Sand	-----
Adult	0.8	0.825	Sand	-----
Adult	0.6	0.575	Sand	-----
Adult	0.8	0.575	Sand	-----
Adult	0.8	0.575	Sand	-----
Adult	0.8	0.575	Sand	-----
Adult	0.8	0.575	Sand	-----
Adult	0.6	0.575	Sand	-----
Adult	0.8	0.575	Sand	-----
Adult	0.8	0.575	Sand	-----
Adult	0.8	0.575	Sand	-----
Adult	0.8	0.575	Sand	-----
Adult	0.8	0.575	Sand	-----
Adult	0.9	0.575	Sand	-----

USAV-00005943

INSTREAM FLOW FISH DATA

SPECIES: Meda fulgida

Stream: Gila River
Station: 1.5 mile downstream of U.S.180 bridge near Cliff,N.M.

Collector: Taffanelli, Britt, and Desmare
Date: 6/18/81
6/19/81

Meter: Pygmy

LIFE STAGE	DEPTH	VELOCITY	SUBSTRATE	AREA DESCRIPTION/COVER
Adult	0.6	0.575	Sand	-----
Adult	0.8	0.575	Sand	-----
Adult	0.8	0.575	Sand	-----
Adult	0.35	2.225	Cobble,gravel	-----
Adult	0.2	1.9	Cobble,gravel	-----
Adult	0.25	0.4	Cobble,gravel	Behind rock
Adult	0.4	1.4	Cobble,gravel	-----
Adult	0.25	0.075	Cobble,gravel	-----
Adult	0.6	1.45	Gravel,sand,cobble	Behind boulder

USAV-00005944

APPENDIX D

CIFSG computer analysis of habitat data on loach minnows collected from Aravaipa Creek and the Gila River, New Mexico

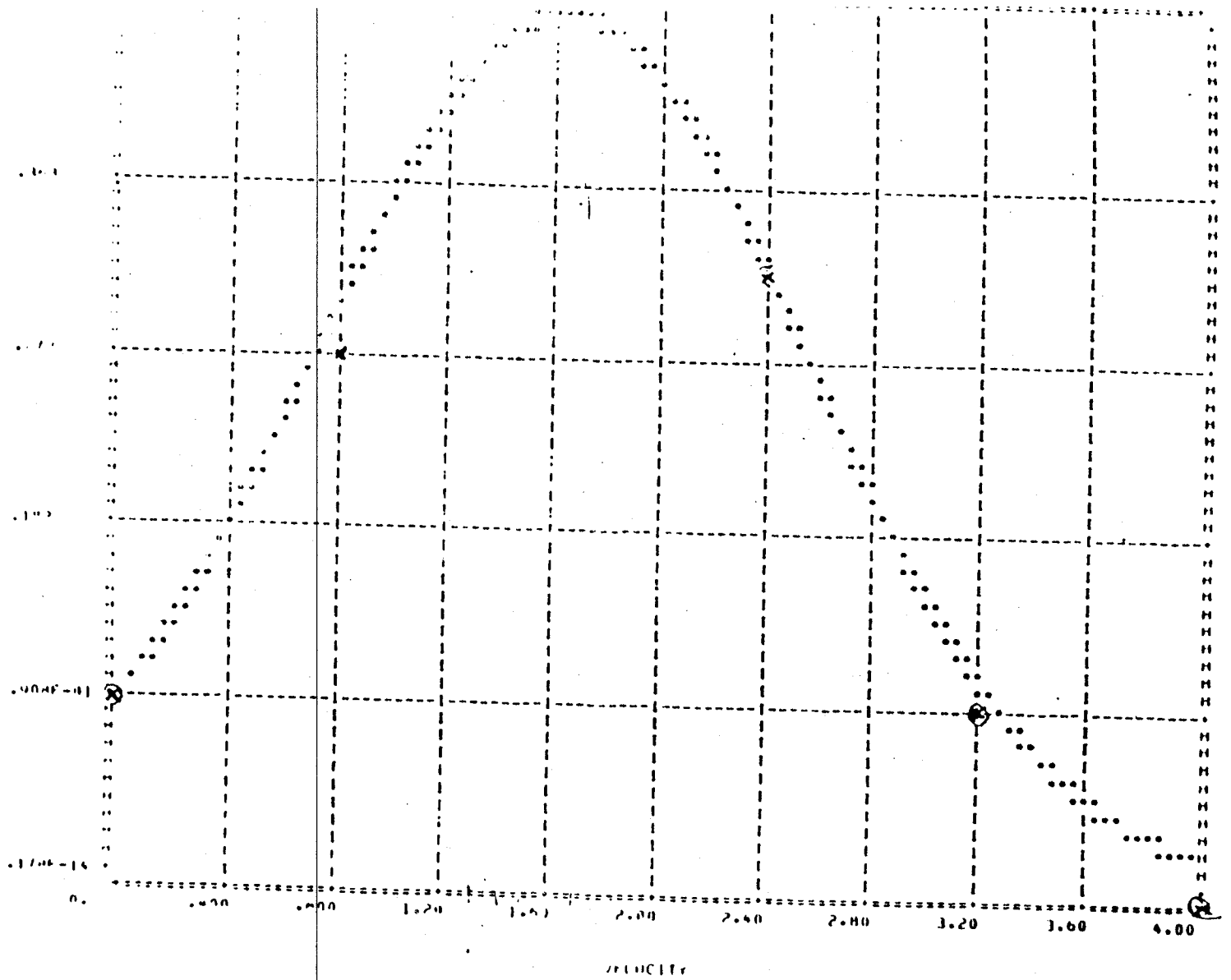


Figure 1. Marginal for adult loach minnow for velocity based on fish collected in Aravaipa Creek, Arizona and Gila River, New Mexico in 1981.

USAV-00005946

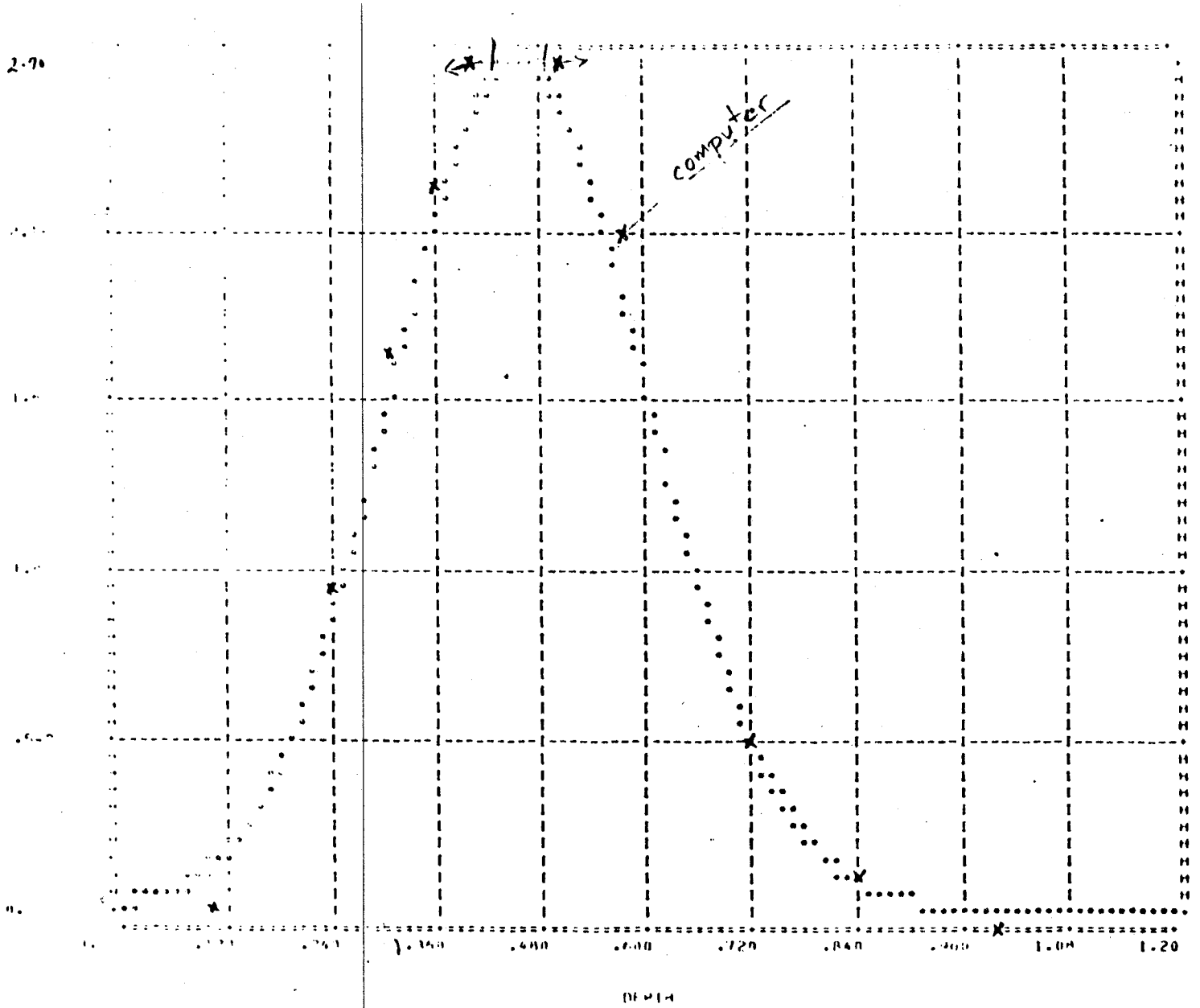


Figure 2. Marginal for adult loach minnow for depth based on fish collected in Aravaipa Creek, Arizona and Gila River, New Mexico in 1981.

USAV-00005947

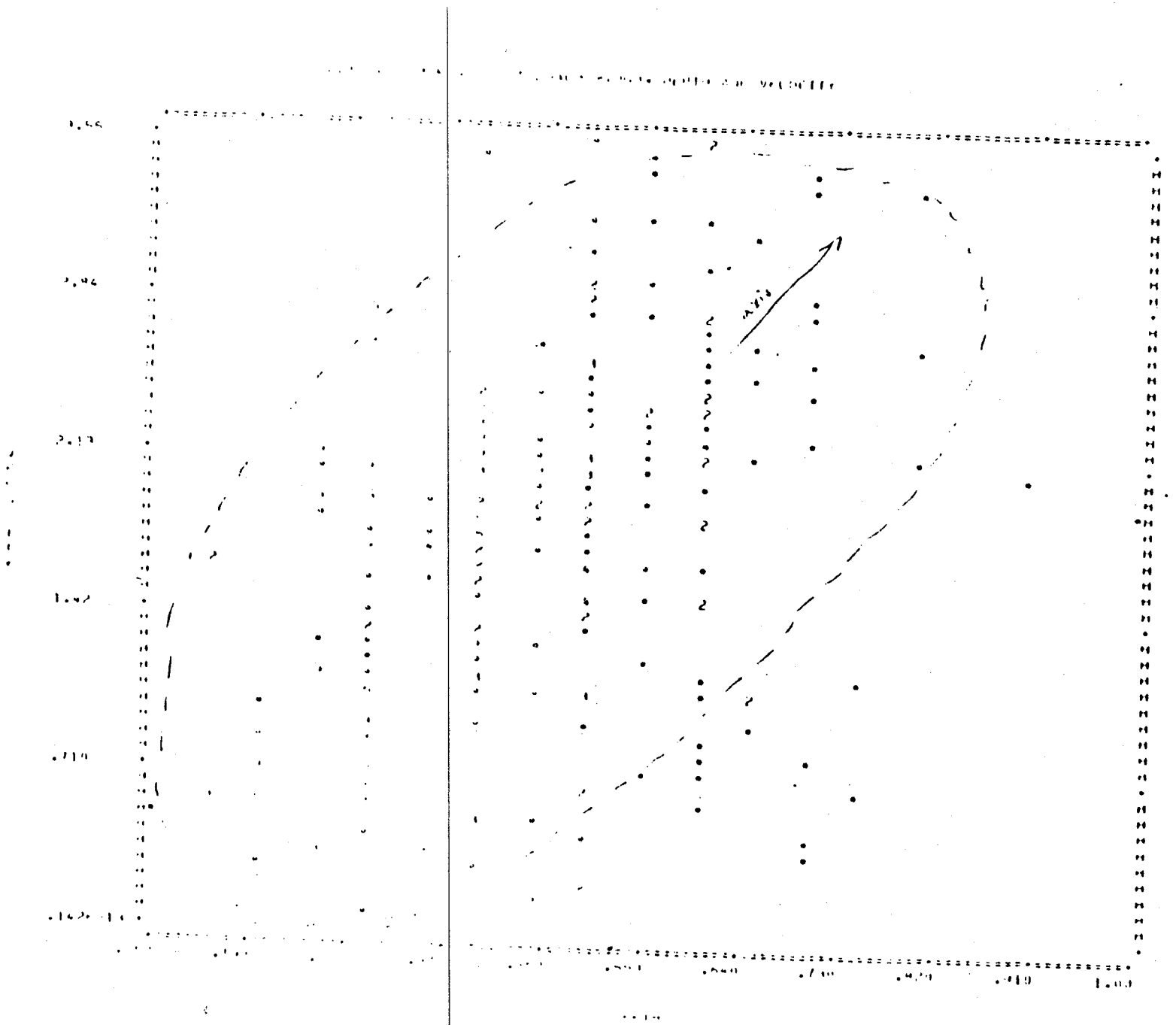


Figure 3. Scattergram for adult loach minnow: depth and velocity based on fish collected in Aravaipa Creek, Arizona and Gila River, New Mexico in 1981.

USAV-00005948

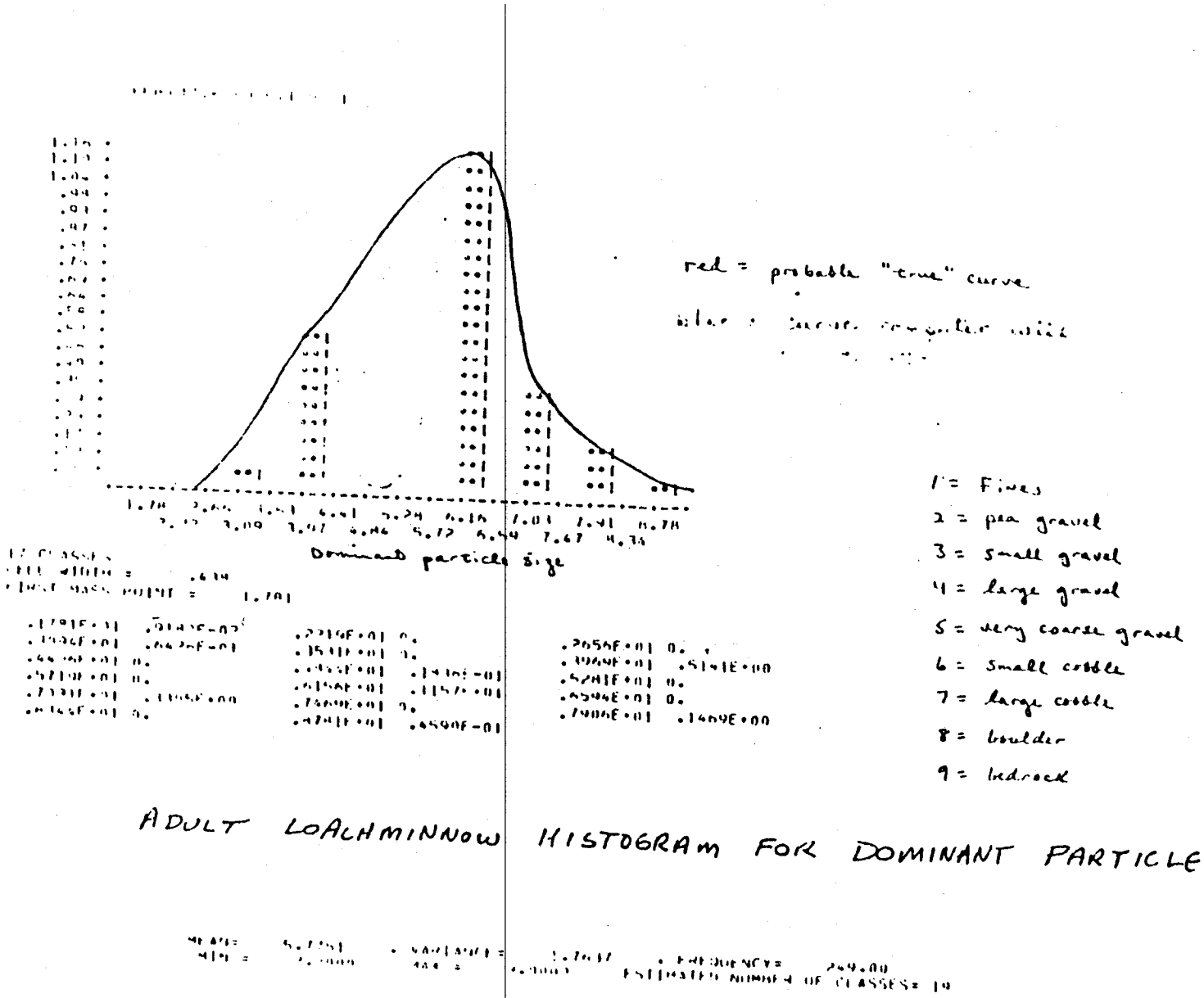


Figure 4. Adult loach minnow histogram for dominant particle size based on fish collected in Aravaipa Creek, Arizona and Gila River, New Mexico in 1981.

USAV-00005949

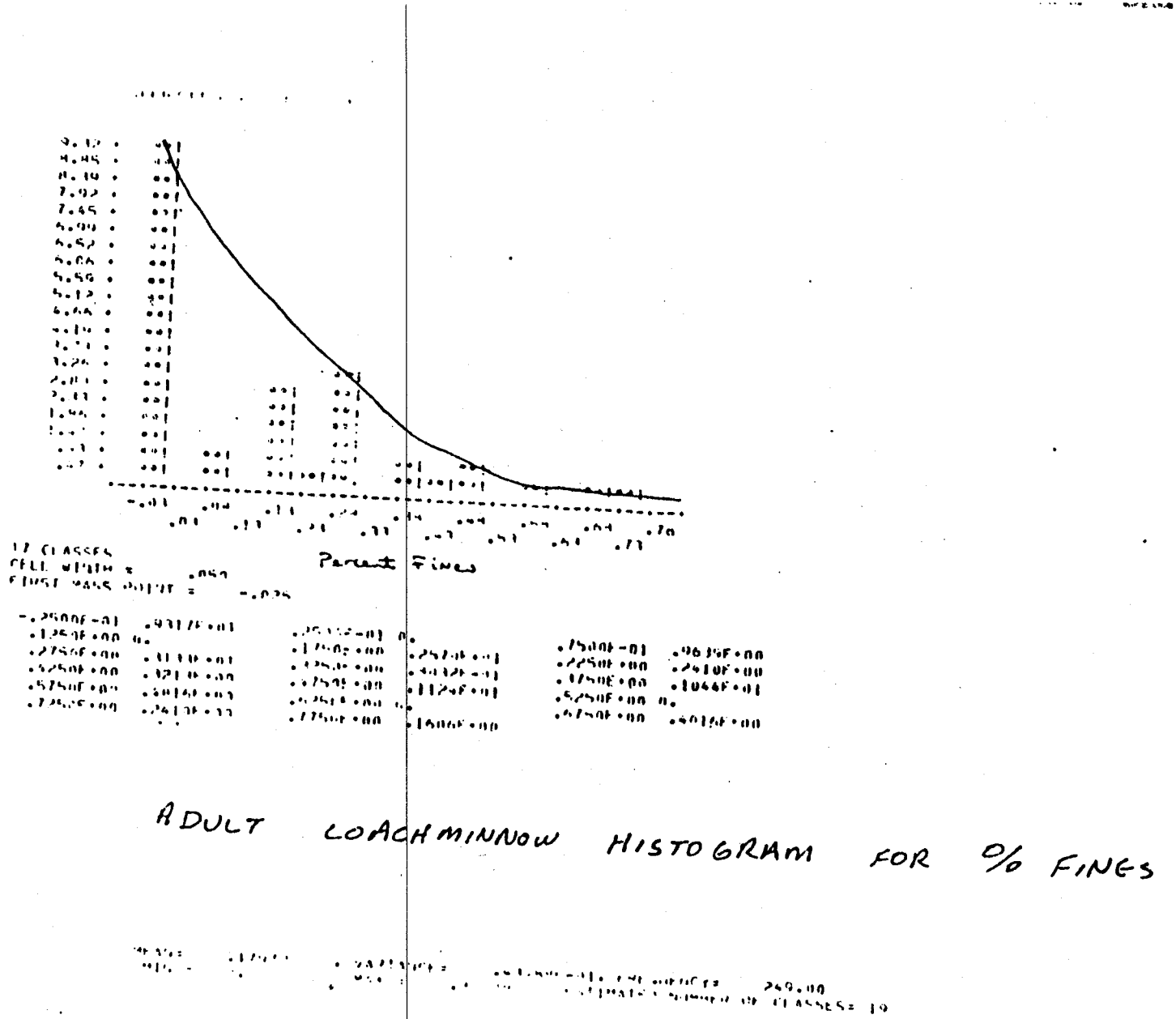


Figure 5. Adult loach minnow histogram for percent fines based on fish collected in Aravaipa Creek, Arizona and Gila River, New Mexico in 1981.

USAV-00005950

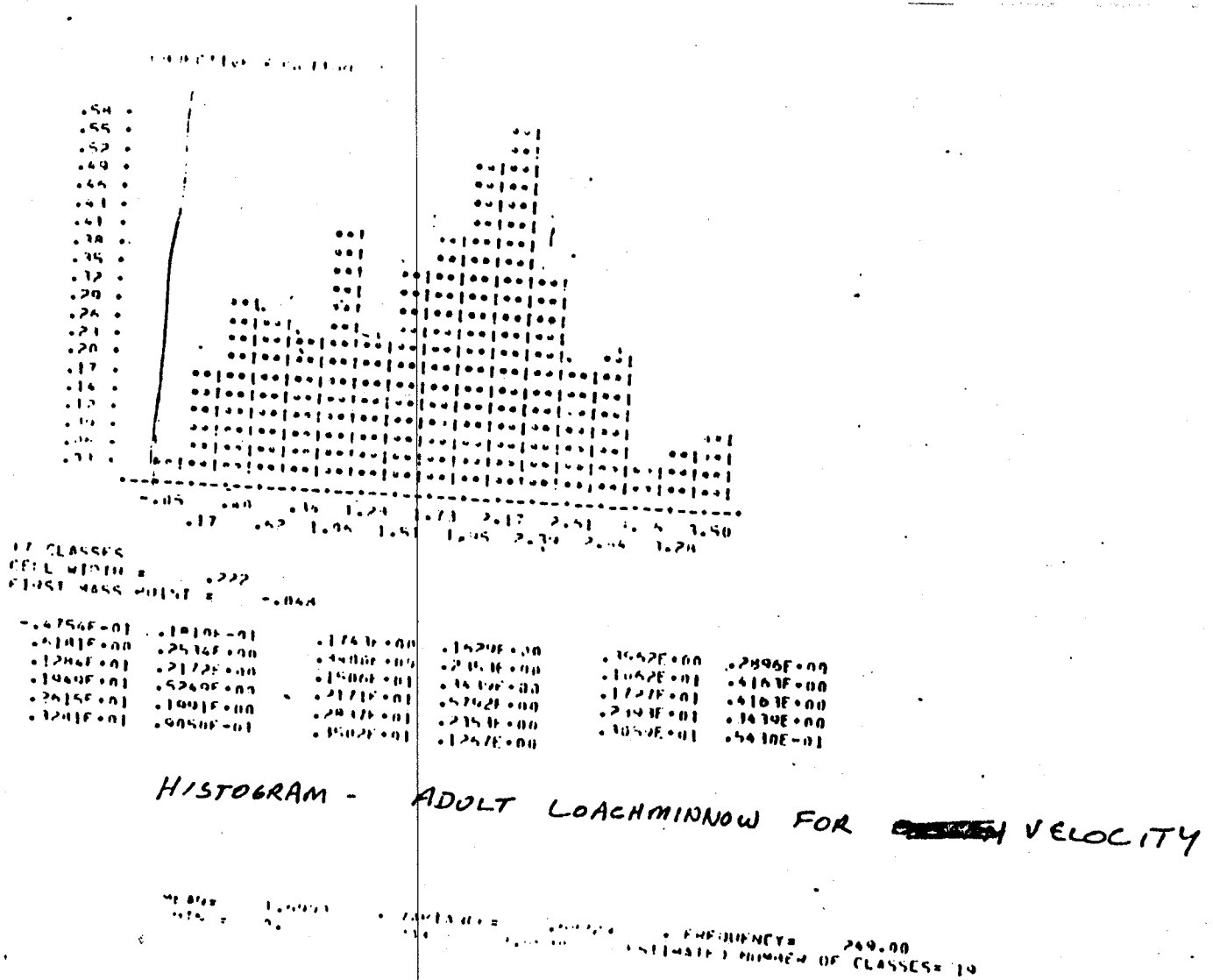


Figure 6. Adult loach minnow histogram for velocity based on fish collected in Aravaipa Creek, Arizona and Gila River, New Mexico in 1981.

USAV-00005951

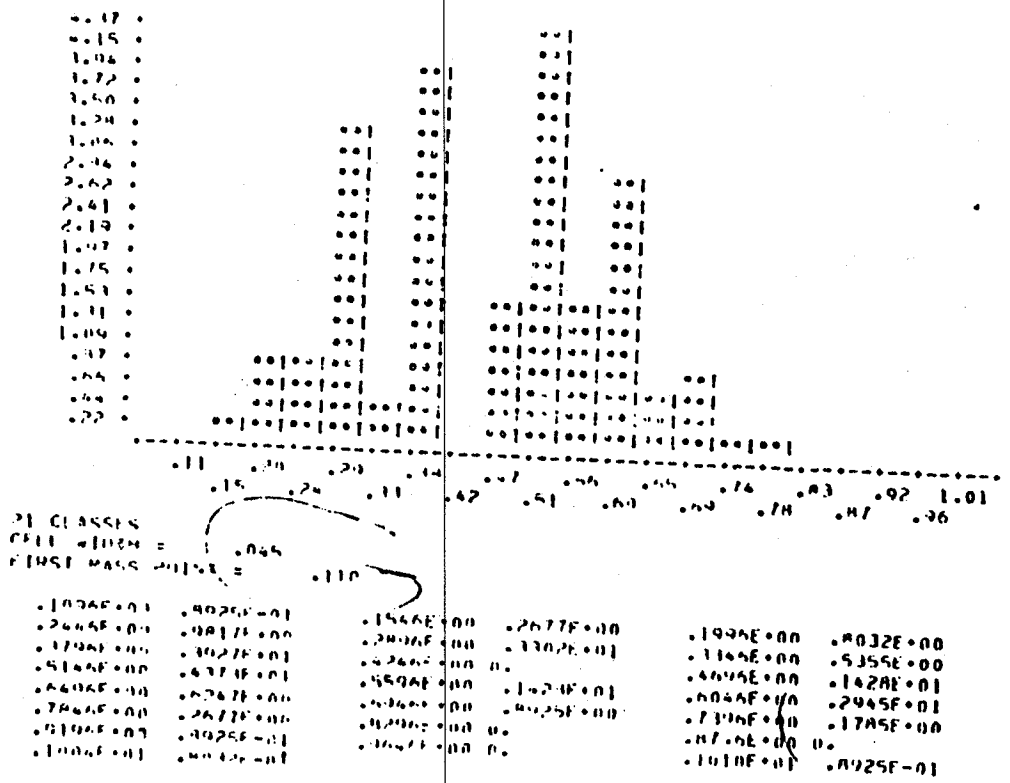
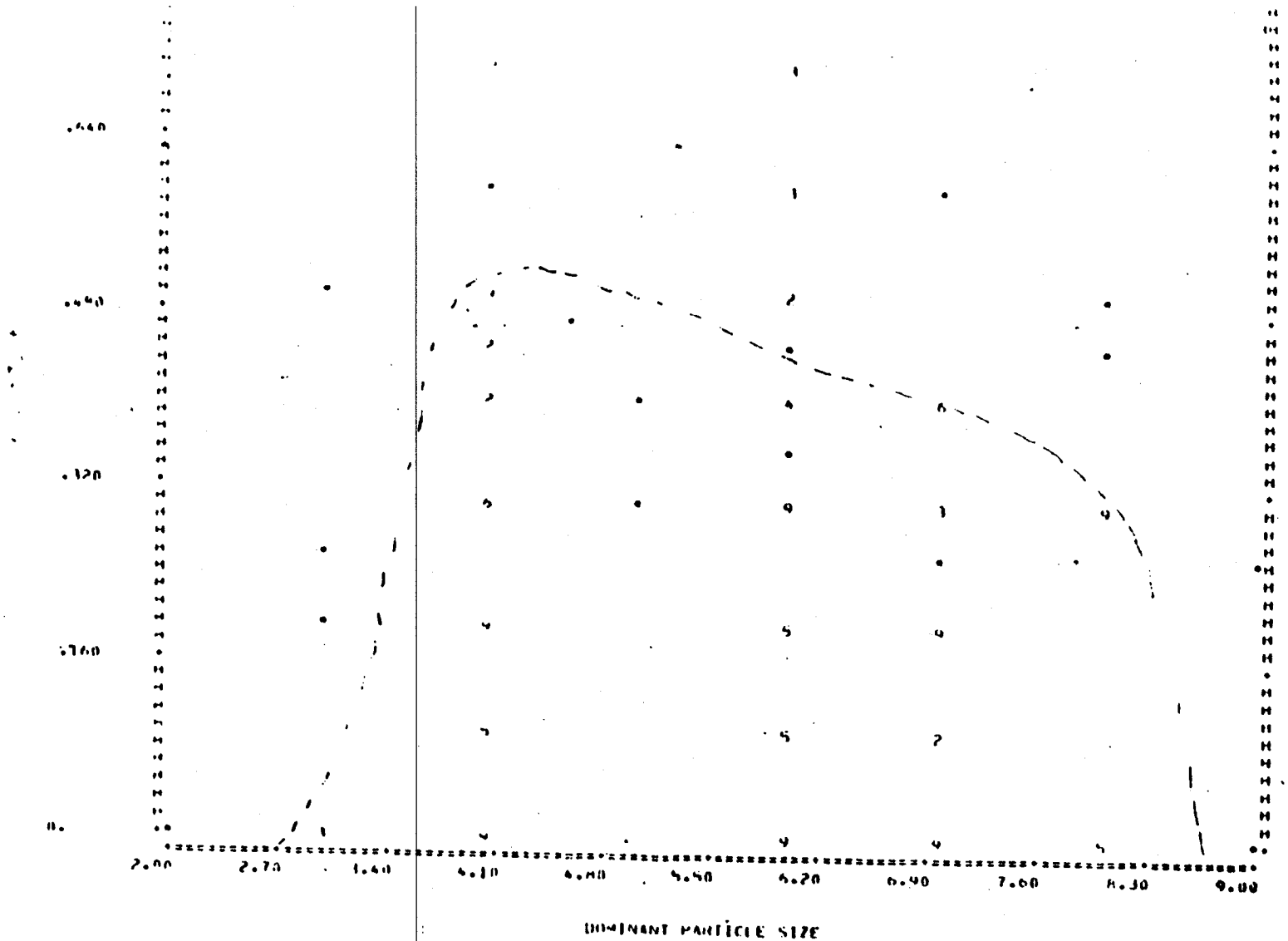


Figure 7. Adult loach minnow histogram for depth based on fish collected in Aravaipa Creek, Arizona and Gila River, New Mexico in 1981.

USAV-00005952



SCATTERGRAM FOR ADULT. LOACHMINNOW: DOMINANT PARTICLE SIZE AND % FINES

R SQUARED = .826

Figure 8. Scattergram for adult loach minnow: dominant particle size and percent fines based on fish collected in Aravaipa Creek, Arizona and Gila River, New Mexico in 1981.

USAV-00005953

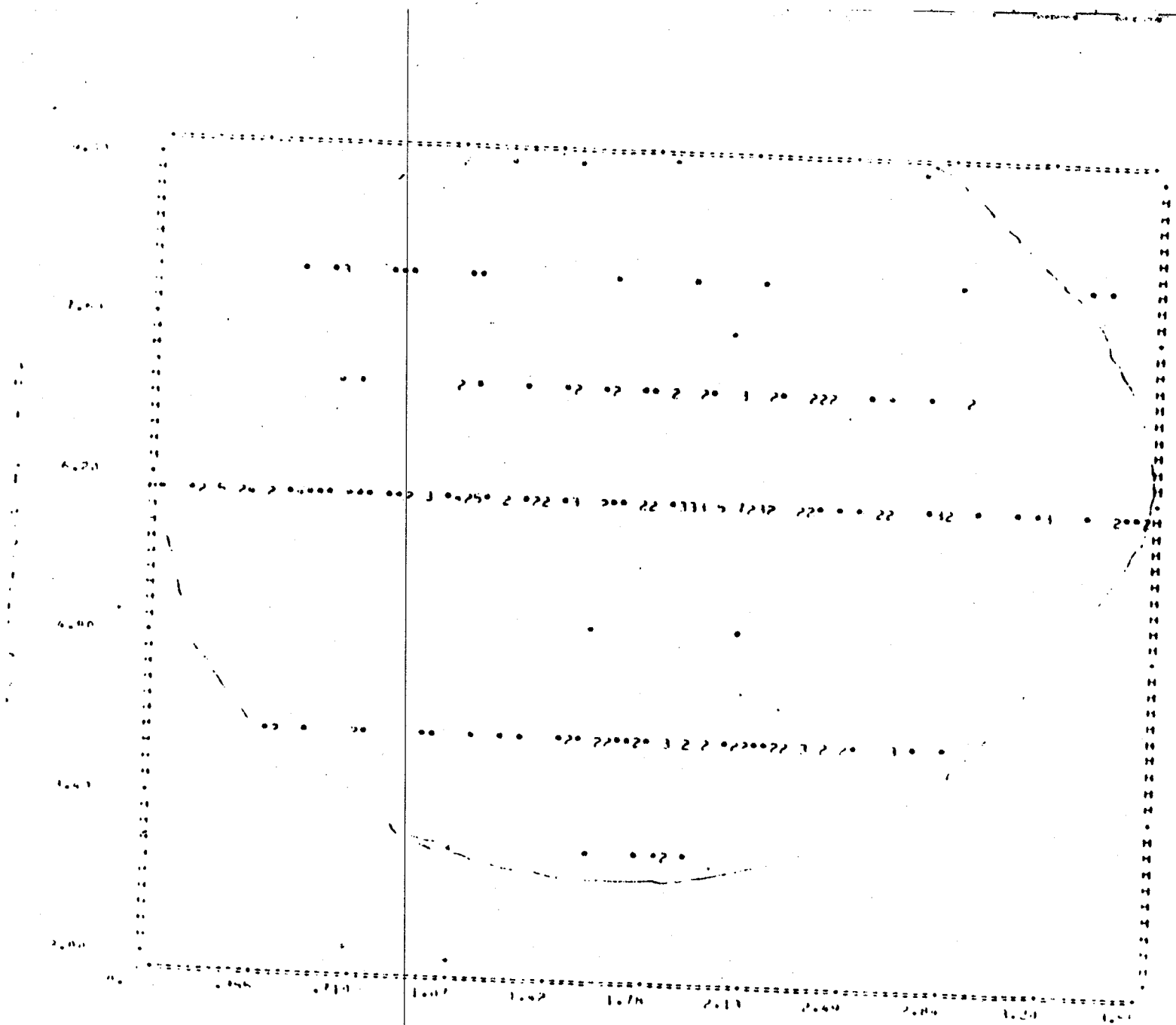


Figure 9. Scattergram for adult loach minnow: velocity and dominant particle size based on fish collected in Aravaipa Creek, Arizona and Gila River, New Mexico in 1981.

USAV-00005954

INSTREAM FLOW FISH DATA

SPECIES: *Etheostoma cobitis*

Stream: Aravaipa Creek
Station: upstream from instream flow station

Collector: NMSU-Thompson, Anderson **Meter:** Pygmy
Date: 11-9-81

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.6	1.1	10SC;30MG;60S	open channel; no overhead vegetation; run area
Adult	0.5	1.75	30SC;10MG;60S	open channel; no overhead vegetation; riffle & edge
Adult	0.3	1.775	30LC;30VCG;20MG;20S	open channel; no overhead vegetation; riffle & edge
Adult	0.6	2.175	10SC;40VCG;20PG;30S	open channel; no overhead vegetation; mid-riffle
Adult	0.45	2.075	10SC;10CG;40PG;40S	open channel; no overhead vegetation; mid-riffle
Adult	0.5	0.65	10LC;10CG;40MG;40S	open channel; no overhead vegetation; run area
Adult	0.45	2.2	10SC;20VCG;40MG;30PG	open channel; no overhead vegetation; mid-run area

Stream:
Station: below 1st road crossing above IF station

Collector:
Date: 11-10-81

Meter:

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.6	1.625	40LC;40PG;20S	open channel; no overhead vegetation; run area
Adult	0.6	2.35	30LC;20SC;20PG;30S	open channel; no overhead vegetation; riffle
Adult	0.4	1.85	10LC;30VCG;30MG;30PG	open channel; no overhead vegetation; riffle
Adult	0.55	1.5	10SC;40VCG;40PG;10S	open channel; no overhead vegetation; riffle
Adult	0.4	2.2	10LC;60CG;20MG;10PG	open channel; no overhead vegetation; riffle
Adult	0.4	1.65	30SC;20VCG;20CG;30PG	open channel; no overhead vegetation; run area
Adult	0.5	2.9	10LC;30VCG;30MG;30PG	open channel; no overhead vegetation; riffle
Adult	1.0	1.925	20B;20VCG;10MG;50S	open channel; no overhead vegetation; riffle
Adult	0.5	1.6	40SC;40CG;10MG;10S	open channel; no overhead vegetation; run area
Adult	0.4	1.625	30LC;10SC;30MG;30PG	open channel near edge; run area

*Substrate Code: BR- Bedrock; B- boulder; LC- Large cobble; SC= small cobble; G= gravel; VCG- very course gravel; CG- course gravel; MG- medium gravel; PG- pea gravel; and S= sand

USAV-00005955

INSTREAM FLOW FISH DATA

SPECIES: *Tiaroga cobitis*

Stream: Aravaipa Creek
Station: Instream flow station going upstream

Collector: NMSU-Thompson, Anderson Meter: Pygmy
Date: 11-9-81

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.4	1.325	50SC;20MG;30S	open channel; no overhead vegetation; riffle & edge
Adult	0.6	2.375	10LC;40SC;20CG;20S	open channel; no overhead vegetation; mid-riffle
Adult	0.6	0.8	40SC;20VCG;10MG;30S	open channel; no overhead vegetation; riffle & edge
Adult	0.4	1.775	20SC;10VCG;40MG;10S	open channel; no overhead veg
Adult	0.45	2.0	10VCG;30CG;40PG;20S	open channel; no overhead veg
Adult	0.5	2.475	30VCG;30MG;40S	open channel; no overhead veg
Adult	0.3	1.175	10SC;30VCG;30MG;30S	open channel; no overhead veg
Adult	0.2	0.85	40SC;30MG;30PG	open channel; no overhead veg
Adult	0.5	1.975	20LC;30SC;25CG;25S	open channel; no overhead veg
Adult	0.5	2.475	10B;30LC;20SC;20MG;20SC	open channel; no overhead veg
Adult	0.5	1.5	20SC;20PG;50S	overhanging willow
Adult	0.3	0.7	30LC;30VCG;40S	overhanging willow
Adult	0.45	2.025	40SC;20VCG;20PG;20S	overhanging willow
Adult	0.3	1.05	40SC;30MG;30S	open channel; no overhead veg
Adult	0.45	2.15	20LC;30CG;10PG;40S	open channel; no overhead veg
Adult	0.45	1.3	20LC;30CG;10PG;40S	open channel; no overhead veg
Adult	0.6	2.55	10LC;30PG;60S	open channel; no overhead vegetation; run area
Adult	0.6	2.35	10SC;30MG;60S	open channel; no overhead vegetation; run area
Adult	0.5	2.125	10SC;90PG	open channel; no overhead vegetation; riffle-run area
Adult	0.35	1.9	40CG;60MG	open channel; no overhead vegetation; riffle-run area
Adult	0.4	1.55	40CG;60MG	open channel; no overhead vegetation; riffle-run area
Adult	0.55	2.35	30VCG;20MG;50S	open channel; no overhead vegetation; riffle-run area
Adult	0.6	2.15	40B;30PG;30S	open channel; no overhead vegetation; riffle-run area
Adult	0.55	1.725	10CG;10MG;80S	open channel; no overhead vegetation; run area
Adult	0.5	1.725	30LC;10SC;20VCG;40MG	open channel; no overhead vegetation; riffle

*Substrate Code: BR bedrock; B boulder; LC large cobble; SC small cobble; G gravel; VCG very course gravel; CG course gravel; MG medium gravel; PG pea gravel; and S sand

USAV-00005956

INSTREAM FLOW FISH DATA

SPECIES: Tiaroga cobitis

Stream: Aravaipa Creek
Station: rock wall below crossing

Collector: NMSU-Thompson, Anderson Meter: Pygmy
Date: 11-8-81

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.5	1.95	10LC;60VCG;30PG	cottonwood limbs, 40ft and up
Adult	0.5	2.375	20LC;40SC;20MG;20S	open channel; no overhead veg
Adult	0.5	1.375	60SC;20VCG;20PG	open channel; no overhead veg
Adult	0.5	1.6	50VCG;25CG;25PG	open channel; no overhead veg
Adult	0.5	1.45	10LC;40SC;25VCG;25CG	open channel; no overhead veg
Adult	0.5	1.825	50CG;25PG;25S	open channel; no overhead veg
Adult	0.55	2.9	10LC;40SC;30VCG;20S	open channel; no overhead veg
Adult	0.6	1.475	10LC;40SC;30VCG;20S	open channel; no overhead veg
Adult	0.6	2.775	20LC;30SC;10PG;40VCG	open channel; no overhead veg
Adult	0.6	2.4	20LC;30SC;10PG;40VCG	open channel; no overhead veg

Stream:
Station: Instream flow station going upstream

Collector:
Date: 11-9-81

Meter:

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.6	2.175	70VCG;20MG;10S	open channel near shore; no overhead vegetation; riffle
Adult	0.65	2.475	20VCG;40CG;20PG;20S	open channel 3ft from bank; no overhead veg.; riffle
Adult	0.5	2.35	20VCG;60MG;20PG	open channel; no overhead vegetation; riffle
Adult	0.45	1.95	10SC;20VCG;30MG;40PG	open channel; no overhead vegetation; riffle
Adult	0.7	2.525	30VCG;40CG;20PG;10S	open channel; no overhead vegetation; riffle
Adult	0.5	1.5	10LC;10SC;30MG;30PG	open channel near bank; no overhead vegetation; riffle
Adult	0.4	2.1	40SC;30CG;30PG	open channel; no overhead vegetation; riffle
Adult	0.4	2.025	40LC;10VCG;30MG;20S	open channel; no overhead vegetation; riffle
Adult	0.55	2.1	30LC;60CG;10PG	near watercress; riffle
Adult	0.4	2.075	20SC;40MG;40PG	open channel; no overhead vegetation; run area
Adult	0.4	1.9	20SC;40MG;40PG	open channel; no overhead vegetation; run area
Adult	0.4	1.35	20SC;10VCG;30MG;40S	open channel; no overhead vegetation; riffle & edge

*Substrate Code: BR- bedrock; B- boulder; LC- large cobble; SC- small cobble; G- gravel; VCG- very coarse gravel; CG- coarse gravel; MG- medium gravel; PG- pea gravel; and S- sand

USAV-00005957

INSTREAM FLOW FISH DATA

SPECIES: *Haroga cobitis*

Stream: Arasalpa Creek
Station: 1st road crossing below instream flow sta.
Collector: NMSU-Thompson, Anderson **Meter:** Pygmy
Date: 11-8-81

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.5	1.6	10SC;10VCG;80PG	1ft. from watercress; slight undercutting
Adult	0.4	1.575	90VCG;10MG;10PG	-----
Adult	0.35	1.525	60VCG;30PG;10S	open channel; no overhead veg
Adult	0.35	1.725	10SC;40MG;40PG;10S	open channel; no overhead veg
Adult	0.3	0.675	20SC;40VCG;20PG;20S	open channel; 1ft. from bank; overhead vegetation
Adult	0.5	1.45	40VCG;10MG;30PG;20S	open channel; 1ft. from bank; overhead vegetation
Adult	0.6	2.2	50VCG;20MG;30S	open channel; no overhead veg
Adult	0.7	3.325	10SC;50VCG;20CG;20MG	open channel; no overhead veg
Adult	0.4	2.425	30VCG;30CG;30PG;10S	open channel; overhanging branches
Adult	0.3	1.9	30VCG;30CG;30PG;10S	open channel; overhanging branches
Adult	0.2	0.2	30SC;35MG;35PG	open channel; no overhead veg
Adult	0.3	1.925	40MG;40PG;20S	open channel; no overhead veg
Adult	0.3	1.05	30LC;40PG;30S	open channel; no overhead veg
Adult	0.3	1.05	100PG	open channel; no overhead veg.; next to watercress

Stream:
Station: rock wall below crossing
Collector:
Date:
Meter:

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.7	2.4	10LC;40SC;30VCG;20S	open channel; no overhead veg
Adult	0.6	2.1	10LC;40SC;30VCG;20S	open channel; no overhead veg
Adult	0.35	1.925	100VCG	open channel; no overhead veg
Adult	0.4	1.85	25LC;25SC;40VCG;10S	open channel; no overhead veg
Adult	0.55	2.175	30SC;40VCG;10PG;20S	open channel; no overhead veg
Adult	0.55	2.9	30SC;40VCG;10PG;20S	open channel; no overhead veg
Adult	0.5	2.075	30SC;40VCG;10PG;20S	open channel; no overhead veg
Adult	0.5	0.95	80VCG;20S	open channel; no overhead veg
Adult	0.6	2.625	40SC;40VCG;20MG	open channel; no overhead veg
Adult	0.4	2.25	60VCG;30CG;10PG	open channel; no overhead veg
Adult	0.5	1.925	60VCG;20CG;20S	open channel; no overhead veg
Adult	0.3	2.65	10VCG;50MG;40PG	open channel; no overhead veg
Adult	0.4	2.1	10VCG;90PG	cottonwood limbs, 40ft and up
Adult	0.3	1.525	10CG;90PG	cottonwood limbs, 40ft and up

*Substrate Code: BR bedrock; B boulder; LC large cobble; SC small cobble; G gravel; VCG very coarse gravel; CG coarse gravel; MG medium gravel; PG pea gravel; and S sand

USAV-00005958

INSTREAM FLOW FISH DATA

SPECIES: Tiaroga cobitis

Stream: Aravaipa Creek
Station: 100m downstream from instream flow station
Collector: NMSU-Thompson, Tibbetts, Anderson
Date: 8-27-81
Meter: Pygmy

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Juvenile	0.35	2.525	10SC;60MG;30S	open canopy
Juvenile	0.35	1.3	20VCG;50CG;10SC;20S	open canopy
Juvenile	0.45	1.8	20VCG;50CG;10SC;20S	open canopy
Juvenile	0.6	2.5	40VCG;40MG;20PG	no instream cover;no rip.veg.
Juvenile	0.7	2.0	30VCG;50MG;20S	no instream cover;no rip.veg.

Stream:
Station: Instream flow station
Collector: NMSU-Gehler, Wilson, Tafanelli
Date: 7-29-81
Meter:

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.3	1.075	75S;25G/50BR	behind or near boulder
Adult	0.5	1.5	75S;25G/25BR	behind or near boulder
Adult	0.3	0.65	25B;75G/25BR	behind or near boulder
Adult	0.3	2.75	25G;75S/25BR	in shallow run
Adult	0.25	1.25	50C;50G/50BR	behind or near boulder
Adult	0.3	0.85	10B;45G;45S/50BR	behind or near boulder
Adult	0.4	1.075	75G;25S/25BR	behind or near boulder

Stream:
Station: 1st road crossing below IF Station
Collector: NMSU-Thompson, Anderson
Date: 11-8-81
Meter:

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.3	1.25	10SC;80MG;10S	open channel w/o cover
Adult	0.4	1.75	10SC;10VCG;30MG;30S	open channel w/o cover
Adult	0.4	1.15	20LC;40VCG;10CG; 20MG;10S	near stream edge; slight over hang of rip.veg.; 1.5ft. from watercress
Adult	0.45	1.95	10SC;20VCG;35MG;35S	open channel w/o cover
Adult	0.4	1.1	40VCG;20MG;20PG;20S	open channel w/o cover
Adult	0.5	0.425	40VCG;20MG;20PG;20S	open channel w/o cover
Adult	0.5	2.1	40VCG;20MG;20PG;20S	open channel w/o cover
Adult	0.5	2.25	10LC;30VCG;20MG;40S	open channel w/o cover
Adult	0.4	1.125	20SC;20VCG;30MG; 30PG	open channel w/o cover; 1.5ft from watercress

*Substrate Code: BR bedrock; B boulder; LC large cobble; SC small cobble; G gravel; VCG very coarse gravel; CG coarse gravel; MG medium gravel; PG pea gravel; and S sand

USAV-00005959

INSTREAM FLOW FISH DATA

SPECIES: Ilaroga cobitis

Stream: Aravalpa Creek
Station: 1st downstream crossing from Instream flow station

Collector: NMSU-Thompson, Tibbetts, Anderson
Date: 8-27-81
Meter: Pygmy

LIFE STAGE	DEPTH (ft)	VELOCITY (ft/s)	% SUBSTRATE*	AREA DESCRIPTION/COVER
Adult	0.4	1.125	30S;20CG;20VCG;30SC	no vegetative cover
Adult	0.25	1.825	10VCG;45S;45PG	instream-no cover; overhanging willow
Adult	0.3	0.375	10SC;45MG;45S	velocity measured behind cobble;high overhead willow
Adult	0.4	1.85	40VCG;30MG;30S	high overhead willow
Adult	0.4	1.55	70CG;30S	high overhead willow
Adult	0.3	0.575	40SC;10S;30VCG;20MG	velocity measured behind cobble;high overhead willow
Adult	0.4	1.675	10VCG;45MG;45S	underbank; some watercress
Adult	0.4	1.775	30VCG;30S;40CG	underbank; some watercress
Adult	0.4	1.725	50VCG;50MG	shaded by vegetation
Adult	0.4	2.35	10LC;40S;20VCG;30MG	-----
Adult	0.5	1.475	5VCG;25MG;70S	-----
Adult	0.4	1.5	40VCG;30MG;30S	-----
Adult	0.4	1.95	40LC;30VCG;30S	-----
Adult	0.5	1.075	20LC;40S;40CG	-----
Adult	0.55	1.9	10SC;50MG;40S	overhead tree; shaded
Adult	0.4	2.4	20VCG;10SC;50CG;20S	open canopy
Adult	0.8	2.625	20SC;30CG;40VCG;10PG	no overhanging riparian vegetation
Adult	0.6	2.0	40VCG;40MG;20S	no instream cover;no rip.veg.
Adult	0.65	2.65	40VCG;40MG;20S	no instream cover;no rip.veg.
Adult	0.6	2.25	30VCG;50MG;20S	no instream cover;no rip.veg.
Adult	0.7	2.75	30VCG;50MG;20S	no instream cover;no rip.veg.
Adult	0.7	2.85	30VCG;50MG;20S	no instream cover;no rip.veg.
Adult	0.6	2.675	30VCG;50MG;20PG	no instream cover;no rip.veg.
Adult	0.3	1.7	10VCG;30MG;60S	no cover
Juvenile	0.25	0.925	10LC;70CG;20S	no vegetative cover
Juvenile	0.3	1.55	10LC;40PG;10VCG;40S	no cover
Juvenile	0.3	1.4	10VCG;10MG;40PG;40S	no cover
Juvenile	0.3	1.2	10VCG;45MG;45S	overhanging willow
Juvenile	0.3	1.525	10VCG;10CG;40MG;40S	shaded
Juvenile	0.3	1.275	20CG;40S;40PG	overhanging willow
Juvenile	0.3	1.85	10VCG;45CG;25PG;20S	high overhead willow
Juvenile	0.4	1.475	50CG;25MG;25S	high overhead willow
Juvenile	0.45	2.125	10SC;60MG;30S	open canopy

* Substrate Code: BR- bedrock; B- boulder; LC- large cobble; SC- small cobble; G- gravel; VCG- very course gravel; CG- course gravel; MG- medium gravel; PG- pea gravel; S- sand

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INSTREAM FLOW FISH DATA

SPECIES: Tiaroga cobitis

Stream: Gila River
Station: 1 and 1/2 mile downstream of U.S.180 bridge at Cliff,N.M.

Collector: NMSU-Tafanelli, Britt, Meter: Pygmy
Date: 6/18/91 and Desmare

LIFE STAGE	DEPTH (ft)	VELOCITY(ft/s)	SUBSTRATE	AREA DESCRIPTION/COVER
Adult	0.4	0.9	Cobble	Behind rock
Adult	0.3	1.35	Cobble	Behind rock
Adult	0.4	0.5	Cobble	Behind rock
Adult	0.4	0.5	Cobble	Behind rock
Adult	0.4	0.5	Cobble	Behind rock
Adult	0.6	1.15	Cobble	Open
Adult	0.5	1.95	Cobble	Behind rock
Adult	0.35	0.375	Cobble	Behind rock, sand,cobble
Adult	0.5	0.2	Sand & cobble	Behind rock,sand,cobble
Adult	0.5	0.2	Sand & cobble	Behind rock,sand,cobble
Adult	0.5	0.2	Sand & cobble	Behind rock,sand,cobble
Adult	0.65	1.05	Sand & cobble	Behind rock
Adult	0.75	1.15	Cobble, boulder	Behind rock
Adult	0.55	1.6	Cobble	Behind rock
Adult	0.3	0.75	Cobble	Cobble
Adult	0.3	1.375	Cobble gravel	Cobble
Adult	0.2	0	Cobble	Cobble
Adult	0.3	0.95	Cobble	Cobble
Adult	0.3	0.95	Cobble	Cobble
Adult	0.3	0.95	Cobble	Cobble
Adult	0.5	2.575	Cobble	Cobble
Adult	0.5	2.575	Cobble	Cobble
Adult	0.3	0.45	Cobble gravel	Behind rock
Adult	0.4	0.1	Cobble,gravel,sand	Behind rock
Adult	0.3	0.1	Cobble,gravel,sand	Behind rock
Adult	0.2	0.55	Cobble,gravel	Cobble
Adult	0.25	0.475	Cobble	Cobble
Adult	0.2	0.225	Cobble	Behind rock
Adult	0.25	0.325	Cobble	Cobble
Adult	0.25	0.125	Cobble	Cobble
Adult	0.25	0.425	Cobble	Cobble
Adult	0.15	0.6	Cobble	Cobble
Adult	0.2	0.325	Cobble	Behind rock
Adult	0.4	2.025	Cobble,gravel	Cobble,gravel
Adult	0.5	1.2	Cobble,gravel	Behind rock
Adult	0.5	1.35	Cobble,gravel,bould.	Behind boulder
Adult	0.5	1.1	----	-----
Adult	0.7	1.4	Gravel-cobble,rock	Beside rock
Adult	0.3	1.0	Sand, gravel	-----
Adult	0.25	1.9	Cobble,gravel,sand	-----
Adult	0.5	2.1	Cobble	-----
Adult	0.[illegible]	[illegible]	Cobble,gravel	-----
Adult	0.[illegible]	[illegible]	Cobble,gravel	-----
Adult	0.5	[illegible]	Cobble,gravel	-----
Adult	0.5	[illegible]	Cobble,gravel	-----

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INSTREAM FLOW FISH DATA

SPECIES: Ictalurus cobitis

Stream: Gila River
Station: 1 and 1/2 mile downstream of U.S.180 bridge at Cliff,N.M

Collector: NMSU-Tafanelli, Britt, and Desmare
Meter: Pygmy
Date: 6/18/81

LIFE STAGE	DEPTH (FT)	VELOCITY (FT/S)	SUBSTRATE	AREA DESCRIPTION/COVER
Adult	0.55	3.175	Cobble,gravel	-----
Adult	0.6	2.8	Cobble,gravel	-----
Adult	0.5	3.2	-----	-----
Adult	0.3	2.275	Gravel	-----
Adult	0.3	2.275	Gravel	-----
Adult	0.55	3.425	Cobble,gravel	-----
Adult	0.65	3.15	Cobble,gravel	-----
Adult	0.5	3.575	Cobble,gravel	-----
Adult	0.55	3.45	Cobble,gravel	-----
Adult	0.55	2.245	Cobble,gravel	-----
Adult	0.5	2.55	Cobble,gravel	Beside boulder
Adult	0.4	2.175	Cobble,gravel	Behind boulder
Adult	0.25	2.025	Cobble,gravel	-----
Adult	0.45	1.675	Cobble,gravel	-----
Adult	0.45	2.625	Cobble,gravel	-----
Adult	0.4	3.475	Cobble,gravel	-----
Adult	0.4	1.575	Cobble,gravel	-----
Adult	0.3	1.075	Cobble,gravel	-----
Adult	0.25	2.125	Cobble	-----
Adult	0.3	2.025	Cobble,gravel	-----
Adult	0.45	0.125	Cobble,gravel,sand	Behind boulder
Adult	0.45	0.125	Cobble,gravel,sand	Behind boulder
Adult	0.5	2.925	Cobble,gravel	Behind rock
Adult	0.5	1.05	Cobble,gravel	Behind rock
Adult	0.3	1.125	Cobble,gravel	-----
Adult	0.5	2.075	Cobble,gravel	Beside rock
Adult	0.7	0.425	Gravel,sand	Behind rock
Adult	0.5	2.125	Gravel,sand	Behind boulder
Adult	0.6	1.475	Cobble,gravel	-----
Adult	0.1	0.525	Gravel,sand	-----
Adult	0.2	0.7	Gravel,sand	-----
Adult	0.2	0.7	Gravel,sand	-----
Adult	0.15	1.625	Gravel,sand	-----
Adult	0.15	1.625	Gravel,sand	-----
Adult	0.35	1.15	Cobble,gravel,sand	-----
Adult	0.25	1.15	Cobble,gravel,sand	-----
Adult	0.45	1.875	Cobble,gravel	-----
Adult	0.3	1.075	Cobble,gravel	-----
Adult	0.3	2.35	Cobble,gravel	-----
Adult	0.3	1.45	Cobble,gravel	-----
Adult	0.35	0.2	Cobble	Behind rock
Adult	[illegible]	1.175	Cobble	Behind submerged rock
Adult	[illegible]	[illegible]	Cobble	Behind submerged rock
Adult	[illegible]	[illegible]	Cobble	Behind submerged rock
Adult	0.3	[illegible]	Cobble	Between rocks

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INSTREAM FLOW FISH DATA

SPECIES: Ptaroga cobitis

Stream: Gila River
Station: 1 and 1/2 mile downstream of U.S.180 bridge.

Collector: NMSU-Taffenelli, Britt, and Desmare
Meter: Price AA
Date: 6/18/92

LIFE STAGE	DEPTH	VELOCITY (ft/s)	SUBSTRATE	AREA DESCRIPTION/COVER
Adult	0.45	1.1	Cobble	Behind rock fall
Adult	0.7	0.325	Cobble,sand	Cobble,sand
Adult	0.5	1.475	-----	-----
Adult	0.6	0.875	Gravel,boulder,cobbl	Behind boulder
Adult	0.9	2.075	Gravel,boulder,cobbl	Behind boulder
YOY	0.3	0.375	Sand or gravel	On edge of riffle

Stream: Gila River
Station: 1 mile upstream of Moonbull Canyon

Collector: NMSU-Taffenelli, Britt, and Desmare
Meter: Price AA
Date: 6/19/91

LIFE STAGE	DEPTH	VELOCITY (ft/s)	SUBSTRATE	AREA DESCRIPTION/COVER
Adult	0.6	2.2	Cobble,gravel,sand	-----
Adult	0.5	2.1	Cobble,gravel,sand	-----
Adult	0.5	2.775	Cobble,gravel,sand	-----
Adult	0.6	1.85	Cobble,gravel,sand	-----
Adult	0.55	1.225	Cobble,gravel,sand	-----
Adult	0.55	0.425	-----	-----
Adult	0.6	1.875	Cobble,gravel,sand	-----
Adult	0.45	2.375	Cobble,gravel,sand	-----
Adult	0.55	0.725	Gravel,sand	-----

Stream: Gila River
Station: 250 meters upstream of Ira Canyon

Collector: NMSU- Taffenelli, Britt, and Desmare
Meter: Price AA
Date: 6/19/91

LIFE STAGE	DEPTH	VELOCITY (ft/s)	SUBSTRATE	AREA DESCRIPTION/COVER
Adult	0.65	1.1	Rock,cobble,sand	Behind boulder
Adult	0.5	0.625	Rock,cobble,sand	Behind rock
Adult	0.75	0.65	Rock,cobble,sand	Behind boulder
Adult	0.7	0.9	Rock,cobble,sand	Behind boulder
Adult	0.45	0.475	Rock,cobble,sand	Behind rock
Adult	0.5	1.625	Rock,cobble,sand	Behind rock
Adult	0.6	0.6	Rock,cobble,sand	Behind rock
Adult	0.65	0.9	Rock,cobble,sand	Behind boulder

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APPENDIX E

Ken Bovee's summary of the CIFSG analysis of habitat data on spikedace and loach minnows collected from Aravaipa Creek and the Gila River, New Mexico

INSTREAM FLOW FISH DATA

SPECIES: *Tiaroga cobitis*

Stream: Gila River, East Fork
Station: Riffles within 1 KM stretch above confluence with main fork.

Collector: Britt (1992)-NMSU
Date: 6/1/79

Meter: Pygmy

LIFE STAGE	DEPTH (cm)	VELOCITY (cm/s)	COBBLE DIMENSIONS(cm)	NUMBER OF EGGS
Egg	3	1.5	-----	28
Egg	76	15.2	14.0 X 18.0	160
Egg	6	9.1	-----	74
Egg	76	15.2	11.5 X 13.5	30
Egg	15	16.0	19.5 X 21.5	80

Stream: Gila River
Station: Gila River 2 KM downstream of U.S.180 Bridge near Cliff, N.M.

Collector: Britt (1982)-NMSU
Date: 6/6/79

Meter: Pygmy

LIFE STAGE	DEPTH (cm)	VELOCITY (cm/s)	COBBLE DIMENSIONS(cm)	NUMBER OF EGGS
Egg	6	39.6	20.0 X 21.0	75
Egg	3	35.8	14.0 X 27.6	55
Egg	3	46.5	17.0 X 24.3	35
Egg	6	26.7	11.5 X 18.0	9
Egg	3	9.1	6.9 X 8.0	20
Egg	9	11.4	11.0 X 11.0	13
Egg	9	6.1	11.5 X 20.0	120
Egg	12	23.6	10.0 X 12.0	40
Egg	18	38.1	16.0 X 21.0	80
Egg	12	31.2	12.0 X 12.0	100

Stream: Gila River
Station: Gila River 2 KM downstream of U.S.180 Bridge near Cliff, N.M.

Collector: Britt (1982)-NMSU
Date: 5/13/80

Meter: Pygmy

LIFE STAGE	DEPTH (cm)	VELOCITY (cm/s)	COBBLE DIMENSIONS(cm)	NUMBER OF EGGS
Egg	12	-----	12.5 X 17.0	29
Egg	12	-----	12.5 X 19.0	66
Egg	14	-----	11.0 X 19.5	19
Egg	5	-----	17.0 X 19.0	100
Egg	5	-----	7.5 X 19.0	39
Egg	10	-----	19.0 X 22.0	11
Egg	15	-----	14.0 X 19.0	200

Britt, Kenneth B. 1982. The reproductive biology and aspects of life history of Tiaroga cobitis in southwestern New Mexico. M.S. Thesis, New Mexico State University, Las Cruces, New Mexico. 56pp.

USAV-00005965

memorandum

Drake Creekside One
2625 Redwing Road
Fort Collins, Colorado 80526

Jon Souder, FWS, Ecological Services
Albuquerque, NM

FILE: 1200.8a

Ken Bovee, Hydrologist, IFG

DATE: April 14, 1982

Analysis of Species Data

We have examined the data for Tiaroga cobitis, Meda fulgida, Catostomus clarki, and C. insignis as you requested in your memo of April 2, 1982. We ran the data through the multivariate statistical package developed by IFG, but unfortunately, we were unable to get a complete set of output. We did not have enough data on the suckers to get a good run.

I have enclosed three separate pieces of information for the loach minnow and spikedace: histograms, scattergrams, and marginal probability plots. The histograms are simple one-dimensional frequency plots of our data. The scatter grams are two-dimensional frequency plots. The marginals are curves derived by making a two-dimensional projection of the multivariate probability density functions. We got the multivariate to work but couldn't get it plotted out. The marginal is virtually the same as a preference curve, except you'll have to normalize it.

A few observations regarding these data:

1. Reviewing the histograms for the loach minnow and spikedace, you can see that the functions for depth and velocity are pretty well defined for both species. It's quite obvious that a curve fit to the histograms would be bell shaped. The depth histogram for the loach minnow and the velocity histogram for the spikedace have a couple of discontinuities that we try to avoid. The loach minnow depth plot has a hole in the middle of it at about .4 ft. The spike dace plot has an unexpected mode at about .5 fps. These discontinuities don't really hurt the curve fit too much, but may indicate that the entire range of environmental conditions was not sampled with proportional effort. The small interval used for the depth histograms may give the appearance of a discontinuity where none really exists. The extra bump on the velocity curve is probably due to sampling bias.

2. You can see from the dominant particle size and percent fines histograms that we really have a problem with substrate. I've drawn two curves on each histogram. The red curve is what I think the curve should look like and the blue line is what the computer is going to try to fit to the data. The problem is that large gravel is unrespresented as a dominant particle

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size, either because it is absent in this river or it always occurs in association with larger materials. Likewise, we seem to either have no fines, or about 30% fines in the matrix. This is possibly due to the way substrate information was recorded. Sometimes the percent fines were recorded, and sometimes not. You'll notice that you didn't get marginals plotted out for substrate of any kind. That's because whenever we tried to get the computer to fit the red lines, it blew up. I don't believe these blue lines for a minute. I believe we can eliminate the problem with dominant particle size by coalescing a couple of the gravel size classes and just have one code for gravel. (The codes used are recorded next to the substrate histogram for the loach minnow). Looking at the histograms for percent fines, it looks like the loach minnow prefers a clean substrate. The spike dace, on the other hand, is more tolerant of a sandy substrate. I feel that any substrate code you develop for PHABSIM should contain information on percent fines, especially if the loach minnow is one of your evaluation species. You might not need it for the spike dace.

3. The scattergrams really only show one thing of any importance. Notice that I've sketched an oval on each scattergram. This is the approximate shape of a bivariate function: depth-velocity; velocity-dominant particle size; or dominant particle size - percent fines. The axes of both depth-velocity scattergrams are really skewed. This means that there is a high degree of correlation between the two variables in this stream. Mike Prewitt has seen hundreds of these things, and he says this kind of correlation is a dead giveaway that there is a large environmental bias in the data. What you're seeing is not the fish's actual preferences, but its tolerances within a small range of environmental conditions. The only way to correct this is to have some measure of the availability of different microhabitats at the flows the fish were observed at. Basically, it means you need to collect PHABSIM type data for these sites and simulate the stream at the flows occurring during the fish observations. That's the bad news.

The good news is that the marginals we are sending you are as good or better than the trout curves people have blithely been using for years (especially your depth and velocity curves). The curves we have provided generally agree with Minckley's descriptions in Fishes of Arizona. As long as you stick to streams about the size of the one's these data came from, you should be all right. I wouldn't try to extrapolate to larger rivers, but Minckley says these species are pretty much restricted to small streams anyway. If corrections are made for environmental/sampling bias, it is probable that both the peaks and the tails of the curves

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will shift. This basically means that these curves are not transferrable to streams that are very much different from the ones the fish were observed in. Ultimately, the decision to use the curves in an analysis is up to the biologist responsible for the study. We can only help this decision by saying these curves are as good as most of the curves on FISHFIL.

If you have any questions regarding the data or our analysis, please call me at FTS 323-5320.

Ken Bovee

P.S. I'd like to keep your data in case we figure something out to correct the environmental biases. Will keep you posted.

USAV-00005968

APPENDIX 5

A PRELIMINARY ANALYSIS OF THE SIGNIFICANCE OF WATER TO RECREATIONAL VISITORS AT ARAVAIPA CANYON WILDERNESS, ARIZONA

A report to the Bureau of Land Management
Safford District Office
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Safford, AZ 85546

by

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and

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20 June 1988

ACKNOWLEDGEMENT

The authors wish to thank Dr. James W. Shockey for his technical assistance on this paper.

INTRODUCTION

Research on landscape preferences and use of natural resource areas for recreation has consistently found that people are strongly attracted to water. Pictures of landscapes with streams, lakes, or ponds are consistently preferred over pictures of landscapes without open water. Places with water, particularly in arid regions of the nation, are popular recreation sites. From an aesthetic point of view, water is a focal element in landscapes and is an integral part of the feeling of recreation places. It also is an important medium for many popular recreational activities: swimming, boating, fishing, etc.

Our research has demonstrated that people also highly value water and water related recreational activities in Aravaipa Canyon Wilderness. The results presented in this paper indicate that elimination or even a small diminutions of the flow of Aravaipa Creek could reduce the recreational attractiveness of the wilderness area.

The data base for this paper comes from a mail questionnaire survey of visitors to Aravaipa Canyon Wilderness in Arizona. From April 1987 to March 1988 questionnaires were mailed each month to a random sample of people who had reserved permits to visit Aravaipa Canyon during the previous month. The names and addresses of these individuals were obtained from permit records provided by the Bureau of Land Management (the agency responsible for managing the wilderness area). The sampling process provided

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a stratified random sample of an annual cross-section of wilderness visitors. Six hundred and sixty-five responses were received and coded, representing an 83% overall response rate. Except where indicated, results presented in this paper are derived from a weighted data set. We have weighted the data set to correct for minor statistical inequalities in selecting samples from each month of the sample period. The result of our weighting method is that each respondent has an equal probability of being included in our total sample.

The paper proceeds as follows. First, we discuss the importance of water for visitors—at its face value. Second, we look at the significance of water-based recreational activities. Third, a quantitative analysis is described that attempts to quantify visitor's preferences for stream flows in Aravaipa Canyon. Finally, we offer some concluding remarks.

RESULTS

The importance of water to visitors

The best indication of the importance of water to visitors at Aravaipa Canyon Wilderness comes from one question. We asked visitors to rank out of a list of thirteen elements, the five most important elements of Aravaipa Canyon. Approximately 82% of the respondents placed water among the top five elements (table 1). Peace and quiet, solitude, and wildlife were also ranked highly. Water was also ranked most frequently as the most important element of Aravaipa Canyon.

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The importance of water-based activities to visitors

Two water-based activities--hiking and swimming in Aravaipa Creek--were highly rated by respondents. Nearly all respondents (94.7%) reported liking or strongly liking hiking in the creek (table 2). This result is important in light of the fact that visitors must repeatedly cross the creek to traverse the wilderness area. If visitors were not pre-disposed to enjoy the water, they might report lower levels of enjoyment for this activity. Some respondents have commented that walking through the creek was difficult at times, but these comments were associated with visits during flood and near-flood stages. We cannot recall any respondents requesting diminution of the flow of Aravaipa Creek to make hiking easier. Some respondents, however, have suggested installation of bridges, etc. to facilitate river crossings. Seventy-eight percent of the respondents reported that they would like or strongly like swimming in Aravaipa Creek if they visited the wilderness in the near future (table 3). Although only 42% of respondents reported actually swimming in the creek during their most recent visit (table 4), a strong preference for contact with water at Aravaipa is apparent from the results.

Preferences for water quantity

A hint at visitors' preferences for water quantity is provided by table 5: approximately 88 percent of the respondents found streamflows at preferable levels. A more in-depth analysis indicates that some streamflows may be more preferable than

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others. Using multinomial logit models, we compared actual streamflows[1] to the responses in table 5. In this manner we were able to investigate at what streamflows respondents were more likely to indicate that they saw less water than they prefer, as much water as they prefer, and more water than they prefer.[2] At present, we do not feel that our models are sensitive enough to make an accurate prediction of the breakpoint between too low and just enough flows.[3] We can, however, state that small changes in streamflow may influence respondents' feelings about the amount of water they find in Aravaipa Canyon. Our results indicate that during our study period, single increment declines in streamflow (for example from 25 cubic feet per second [cfs] to 24 cfs) increased the likelihood that respondents would report that they found less water than they preferred. The respondents apparently were sensitive to small changes in streamflow.

CONCLUSIONS

Two conclusions are apparent from our analyses. First, water is a highly valued attribute of the recreational setting at Aravaipa Canyon Wilderness. Respondents ranked water highly compared to other attributes of the setting and demonstrated

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1 Streamflow data were provided by the Safford District Office of the Bureau of Land Management.

2 This analysis was conducted with unweighted data.

3 We are continuing to explore the relationship between streamflow and attitudes with more sophisticated statistical models.

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strong preferences for water-related activities. These results are not surprising considering the rarity and significance of open water in a desert setting. Based on our results and on personal experience, we could argue that water is the intrinsic attraction of Aravaipa Canyon Wilderness. Second, visitors appear to be sensitive to small changes in streamflow. Our preliminary analyses indicate that declines in streamflow increase the likelihood that respondents will find less water than they prefer. Many factors could explain this relationship, we offer two. At lower flows, the river bed may be less aesthetically pleasing. Stagnant pools and dying vegetation become more prevalent and noticeable. Also at low flows, deep pools and swimming holes may disappear, leading to less availability of sites for water related recreation.

It is important to note that our survey was conducted at a time when streamflows ranged between 17 and 250 cfs (approximately). Accordingly, our respondents were not subjected to the 15 cfs level proposed for the instream flow permit. Because visitors are highly satisfied with current streamflows, a decline to 15 cfs or lower is likely to lead to some dissatisfaction. Repeat visitors (people who are accustomed to higher streamflows) may be more affected than new visitors.[4] Dissatisfaction should continue for a time until visitors become accustomed to the new stream level. If some features of the

[4] 51.1% of our survey respondents have visited Aravaipa Canyon Wilderness one or more times during their lifetime.

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stream are eliminated by decreased flow (for example, pools for swimming), though, some recreational visitors could be permanently displaced from the area. At some point (which could be above, at, or below 15 cfs, but we cannot judge this from our data), Aravaipa Canyon could become relatively undesirable as a recreation site.

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TABLES

Table 1: Percentages of respondents rating elements of Aravaipa Canyon most important and within the five most important elements. N=546.

	Most Important Element	Within the Five Most Important Elements
Water	33.3%	81.8%
Peace and quiet	23.2	73.5
Solitude	16.4	67.1
Wildlife	8.7	65.9
Geology	6.9	47.1
Challenge	3.0	29.4
Vegetation	2.5	51.1
Ease of hiking	2.3	23.0
Good campsites	1.6	28.0
Shade	1.4	24.5
Safety from natural hazards	0.4	6.4
Archeology	0.2	7.0

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Table 2: Respondents' attitudes toward walking in Aravaipa Creek. N=665.

Strongly dislike	0.3%
Dislike	1.5
Neutral	3.5
Like	18.1
Strongly Like	76.6
	100.0

Table 3: Respondents' attitudes toward swimming in Aravaipa Creek. N=665.

Strongly dislike	1.2%
Dislike	1.9
Neutral	18.6
Like	31.5
Strongly Like	46.7
	100.0

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Table 4: Activities pursued by visitors in Aravaipa Canyon Wilderness. N=575.

Hiking	97.4%
Camping	57.9
Rock climbing	26.5
Hunting	1.0
Swimming	42.0
Backpacking	53.5
Horseback riding	2.1
Birdwatching	55.5
Observing wildlife other than birds	63.2
Relaxing	82.7
Photography	65.0

USAV-00005979

Table 5: Amount of water in the main canyon of Aravaipa Canyon Wilderness in relation to visitors' preferences. N=483.

Less than preferred	8.4%
At the preferred amount	87.9
More than preferred	3.7

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