Regional Relationships for Bankfull Stage in Natural Channels of the Arid Southwest

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INTRODUCTION

The concept of “channel maintenance” or bankfull flows suggests that natural stream channels are created and maintained by moderate, frequent flow events. These events were defined by Dunne and Leopold (1978): “The bankfull stage corresponds to the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels.” In the field bankfull stage defines the boundary between the active channel which carries the systems sediment and floodplain features which dissipate energies of higher flows. A number of inventory, assessment, and design strategies have been developed utilizing the bankfull stage concept (Rosgen, 1996). To utilize these strategies, consistent, accurate identification of bankfull stage in the field is important tool for managers, land-owner, and stream practitioners.

Studies suggest that these channel maintenance flows are moderate, frequent events with recurrence intervals between 1 and 2 years. Relationships between channel cross-sectional area at bankfull stage and drainage area have been developed for various regions of the United States (Figure1). Howeve, little ork had been completed in stream channels of the arid southwest. Over the past 6 years, surveys of bankfull stage have been conducted in sites in Arizona, New Mexico, Utah, and the Navajo Nation This paper assesses this data to produce an integrated understanding of the relationships of bankfull stage in the natural stream channels of the arid southwest. Data used was developed with support from Arizona Department of Environmental Quality, USFS Rocky Mountain Experiment Station, New Mexico Environment Department, Navajo Nation Environmental Protection Agency and during a variety of projects completed by Natural Channel Design, Inc.

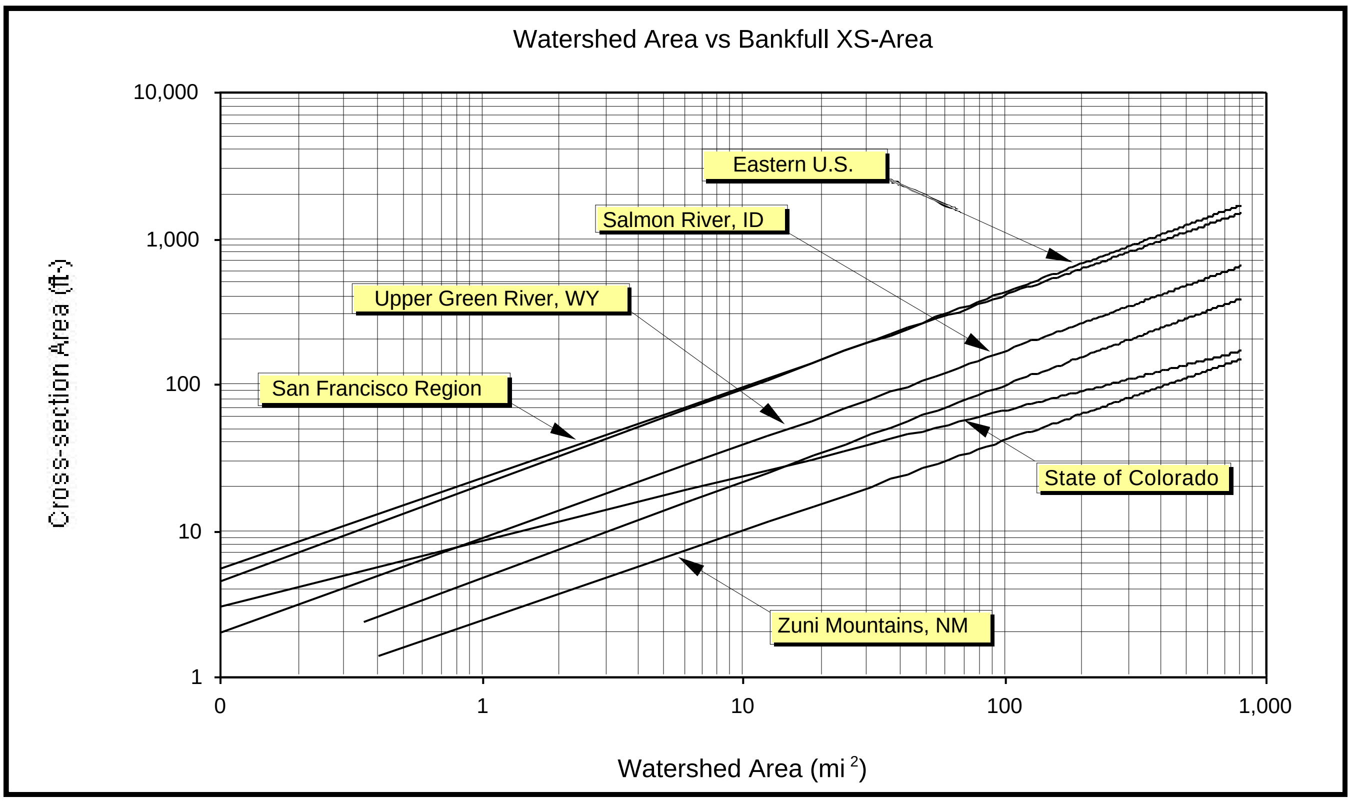


FIGURE 1. REGIONAL CURVES FOR VARIOUS REGIONS OF THE UNITED STATES.
(Leopold, et. al, 1964; Emmett, 1975; Jackson, 1994)

Bankfull Stage in the Arid Southwest

Identifying bankfull stage can be extraordinarily challenging in the arid southwest (Figure 2). Bankfull stage is defined as the point of incipient flooding or the elevation where flows overtop the active channel and spread across an adjacent floodplain. The term “bankfull” brings to mind the top of a bank, perhaps the most prominent bank. This is generally not the case in the southwest. Broad, level floodplains adjacent to well-defined active channels exist but are very unusual. Perhaps this is a consequence of the “flashy” hydrology common in the arid southwest or a remnant of channel evolution through the intensive “gullying” period of channel incision at the turn of the past century. Regardless, bankfull stage is rarely identified with the top of a bank in this region. However, there are consistent indicators that are associated with bankfull stage.

There are generally “too many” potential indicators than not enough. Multiple bar features of different sizes at different elevations are an example. Remember, bankfull features are built by the stream processes and therefore must be depositional. Point bars that form at the inside of meander bends provide the most consistent indicator of bankfull stage. These features represents the floodplain which is defined as a level feature adjacent to and created by a stream in the current climate and overtopped by

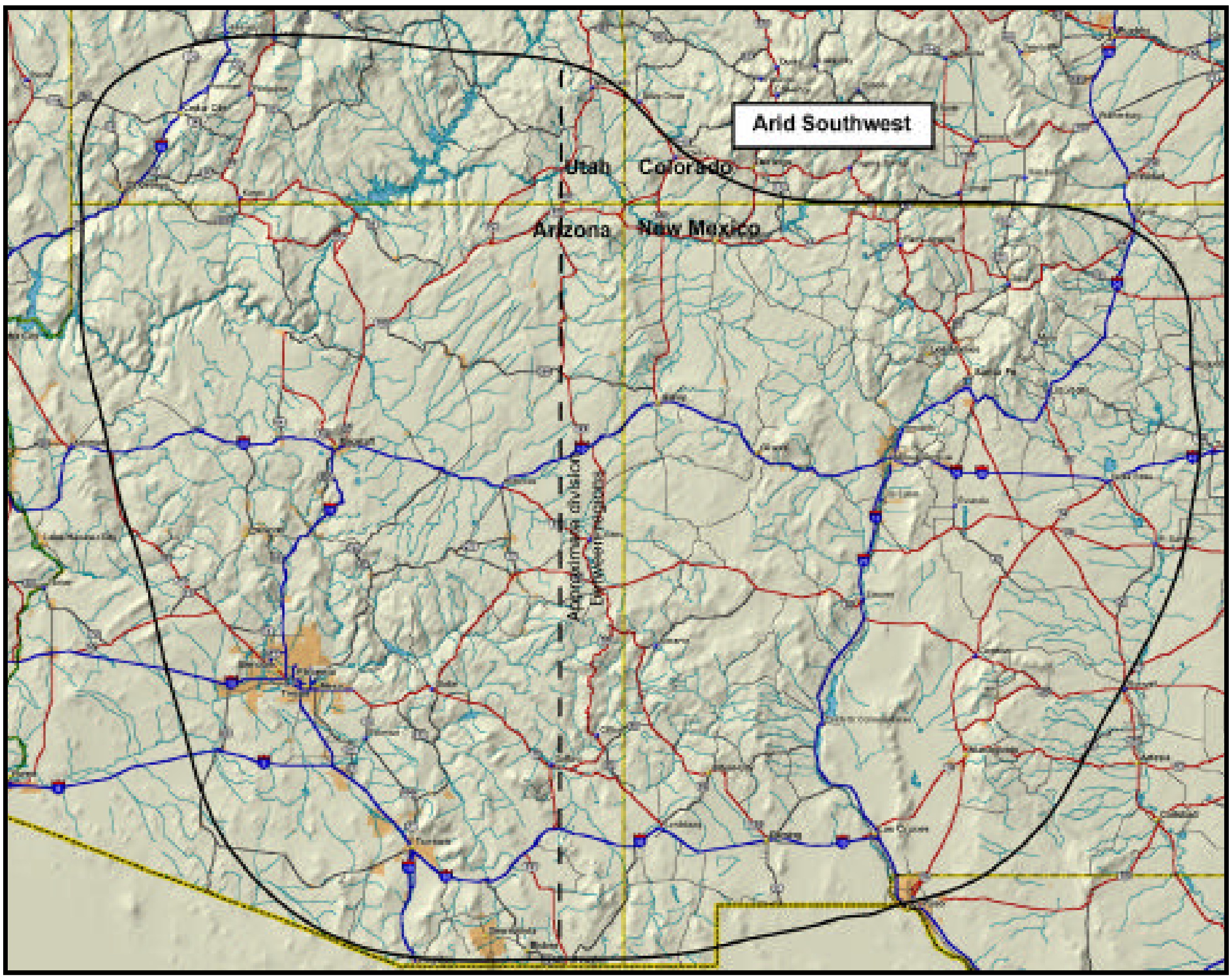


Figure 2. Map of Arizona & New Mexico Hydro-physiographic Provinces (boundaries approximate)

Figure 3. Whiskey Creek in the Chuska Mountains. Bankfull stage lies at the slope break along the well vegetated point bar on the inside of the meander. On the outside of the meander bankfull lies at the lower change in slope rather than at the top of bank.

Figure 4. Black Creek at Ft. Defiance. Bankfull stage lies along the change in slope on the point bar along the far bank and along a similar slope change on the near bank. The broad flat feature being colonized by cottonwood and willow on the right of the photo lies about 1 ft above bankfull.

Figure 5. Chilchinbito Wash. Straight channels do not form obvious point bars. However, there are numerous depositional levels along the channel. Bankfull stage lies at a consistent slope break along the base of the tamarish bushes. In this case little Vegetation grows in the channel below bankfull but that is not necessarily the case.

Figure 6. Moenave Wash. Ephemeral, sand bed channels can be very challenging. Bankfull stage lies along the change in slope on the point bar on the far shore. It also corresponds with a vegetation line. It does not match the vegetation on the outside of the meander along the near shore however. Beware of cut-banks especially on the outside of meanders that appear to indicate bankfull stage. They are erosional rather than depositional in nature and not reliable indicators.

moderate, frequent flow events. With the exception of small channels that lie high in the region's higher elevations (Figure 3) broad floodplains are uncommon. More commonly meanders will form a series of small point bars along the channel. These are often associated with broader features that lie at a higher elevation (Figure 4). Many channels are relatively straight with few meanders. In these channels, features are not only exceptionally subtle but occur at a variety of elevations (Figure 5). Careful attention to consistent elevations is the key to accurate identification in these cases. Due to the subtle nature of these features they must be plotted relative to the channel profile to be accurately evaluated. Cross-referencing with the local curve values or a number of other sites helps confirm the selection. Finally, ephemeral, sand channels can provide some of the most frustrating challenges to bankfull identification. Again look for point bars and other depositional features at consistent elevations (Figure 6). Broad valley floors are almost always above bankfull. Look for evidence of upland vegetation on features at all sites. Those that will not be happy being inundated every year will not be growing at floodplain elevation. See the protocols for bankfull determinations for the study sites in this project in Appendix 2.

There is no single, absolute and definitive line for bankfull stage. Instead, the strategy is to build a case for identification of bankfull based on physical evidence at the site. For example, the best evidence of bankfull stage is a series of features are depositional, containing similar substrate and vegetation components, and lying at a consistent elevation. Cross-sections taken at two or more riffle sections that have similar bankfull cross-sectional areas are further evidence. Test the cross-sectional area to see if it is consistent with regional values. Survey several sites within the vicinity and look for similar relationships of cross-sectional area and watershed area. These are all evidence of bankfull stage. Collect as much evidence as you can before making a determination and be ready to defend it.

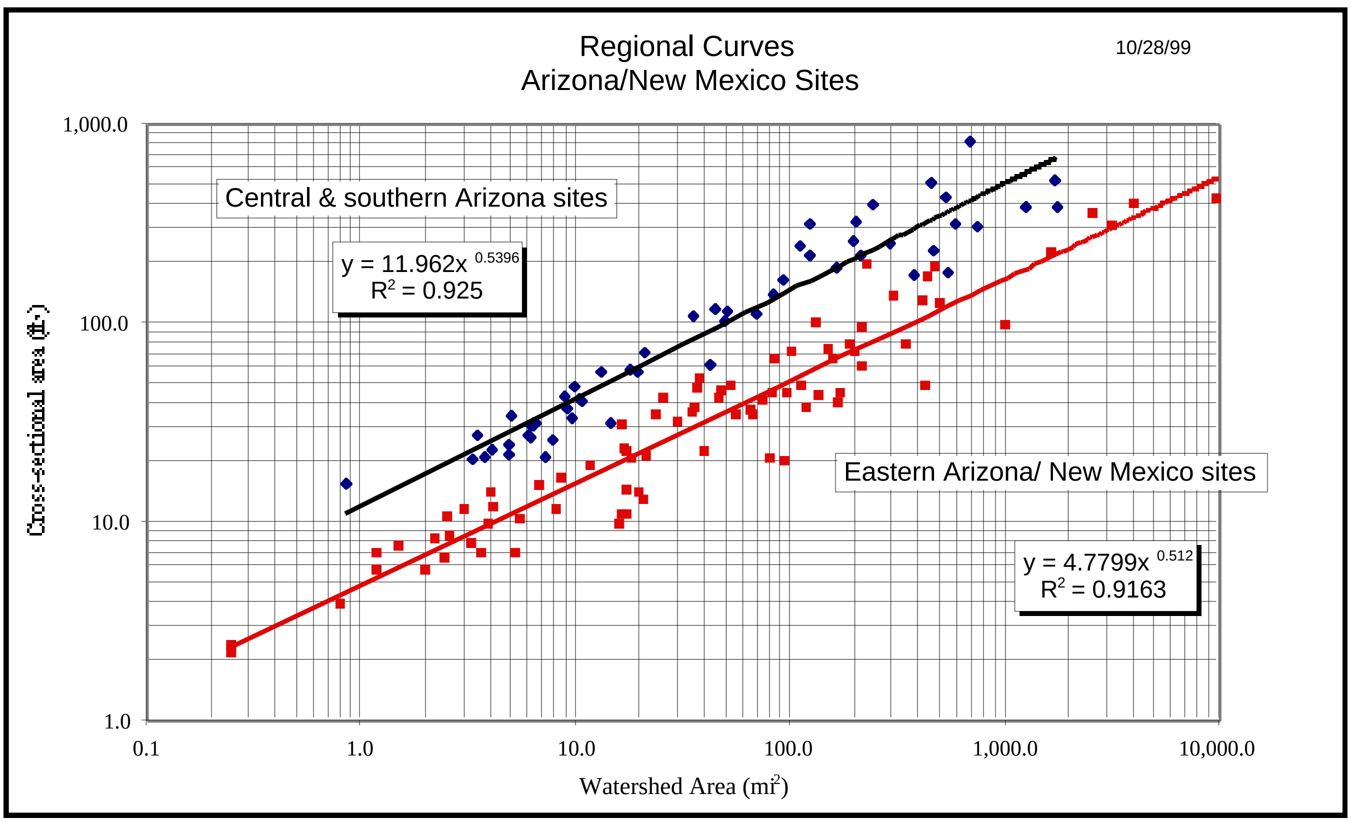


FIGURE 7. INTEGRATED REGIONAL CURVES FOR ARIZONA AND NEW MEXICO HYDRO-PHYSIOGRAPHIC PROVINCES.

Data collected and analyzed have provided similar conclusions: 1) alluvial evidence of bankfull stage exists and can be identified, 2) bankfull events are moderate, frequent events with recurrence intervals of less than 2 years, and 3) strong relationships could be established between bankfull cross-sectional area and watershed area.

The data suggested that the stream channels in Eastern Arizona and New Mexico differ from channels in central and southern Arizona as represented by the relationship between watershed area and cross-sectional area at bankfull stage (Figure 7). These regional relationships are presented in the next section. On the other hand, data from stream channels in southern Utah tended to fall along the New Mexico line or between the two. Given the wide variation in climate, topography, geology, and elevations within the region, a local calibration curve is recommended to establish the bankfull characteristics of a watershed or subwatershed. A series of examples of local calibration curves are included in a following section.

EXCEPTIONS TO THE REGIONAL DATA

While the relationships presented here characterize the physical functions of a wide variety of stream sizes and types, data from both studies produced inconsistent results from two distinct classes of streams.

1) The first was ephemeral sand bed stream channels in the most arid portions of the region. These were generally located in southwestern Arizona and the southern and southeastern sub-regions of New Mexico. These channel beds were mobilized by a wide range of flows and bankfull features were not consistently evident.

2) The second class were very large stream systems which serve to transport water and sediment from a variety of sub-watersheds. Examples of these systems are the main stem of the Gila, Salt, Verde, Little Colorado and San Pedro Rivers in Arizona.

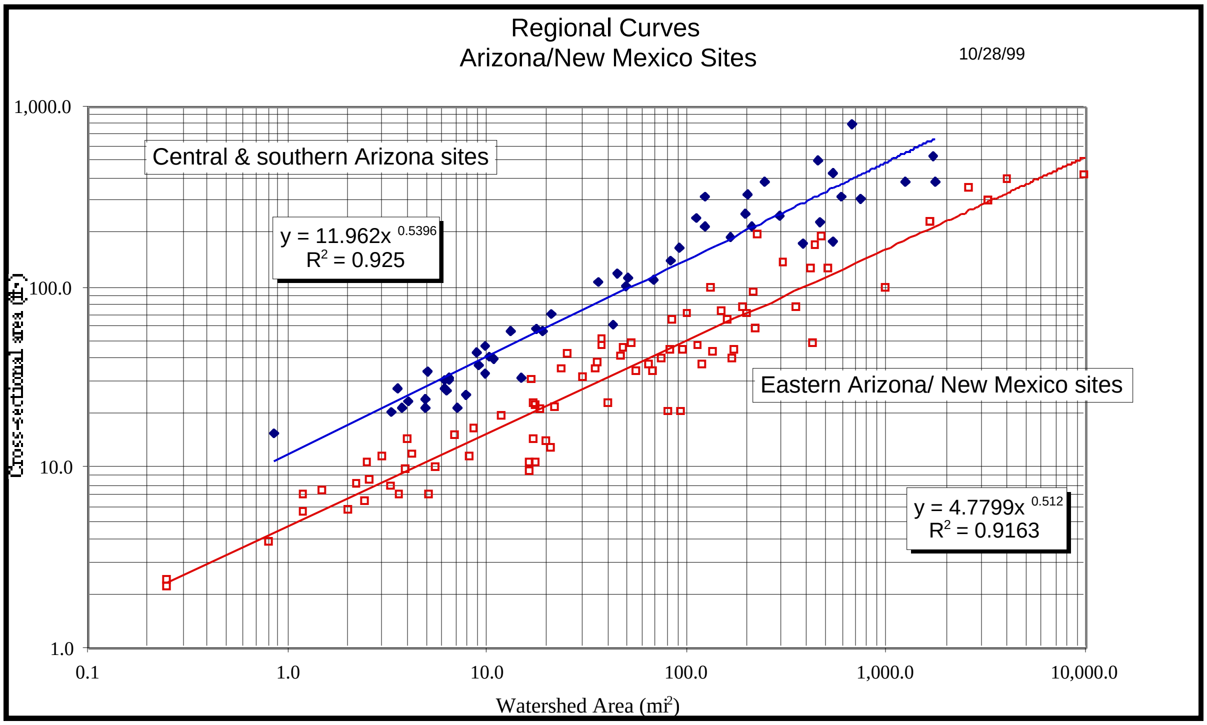
While bankfull features were consistently evident in these channels, they were not represented by the regional curves presented here. This may be due to the size and complexity of their watersheds and/or to the greater distance from precipitation sources in their sub-watersheds. Additional work needs to be done to more fully understand these systems.

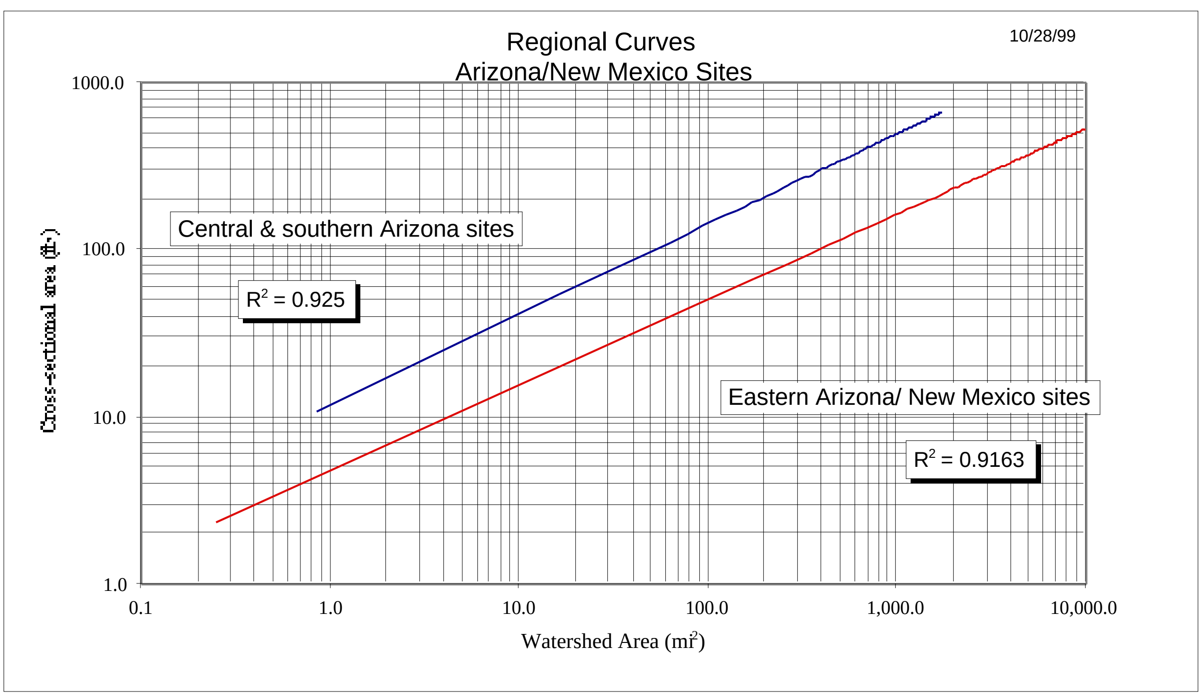
REGIONAL RELATIONSHIPS

The following graphs present a variety of regional relationships for bankfull stage in the arid Southwest.

BANKFULL CROSS-SECTIONAL AREA VS. WATERSHED AREA

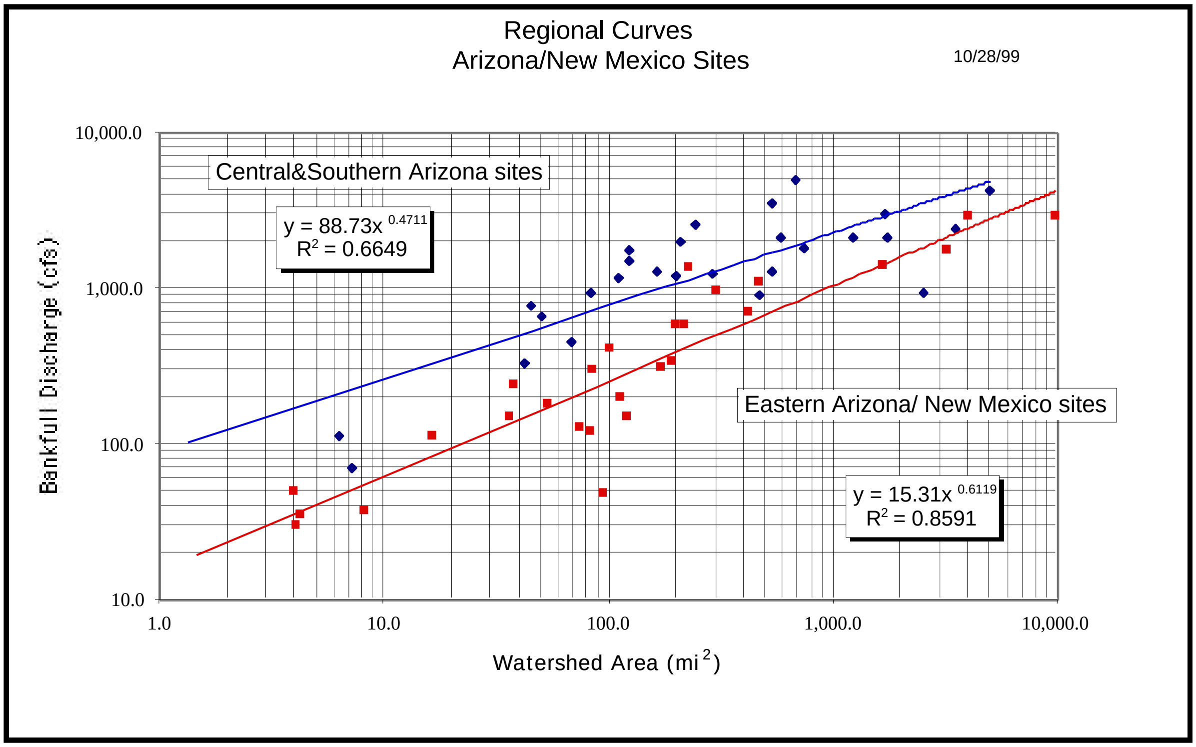
Figure 7a. includes data points. Note that while the data sets form distinct trendlines, overlap exists. The scatter evident makes the local calibration curves necessary.
Figure 7b. presents regional relationships Southern Arizona and Eastern Arizona/New Mexico regions.

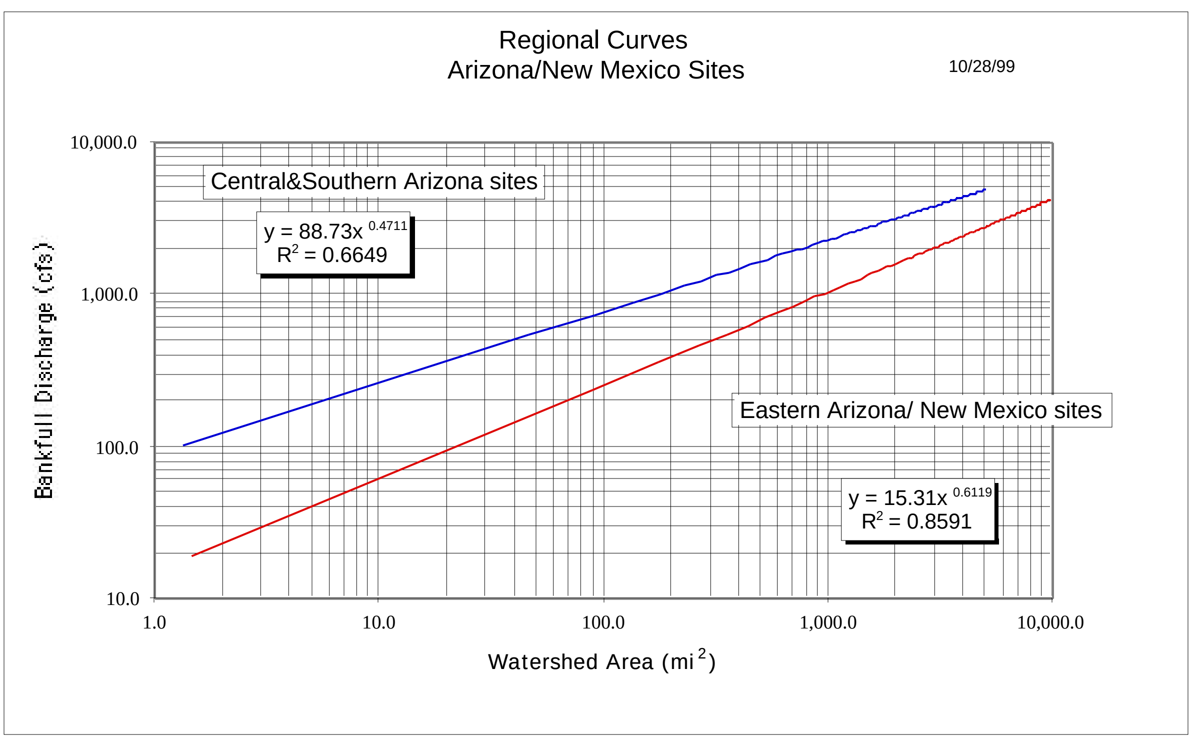




BANKFULL DISCHARGE VS. WATERSHED AREA

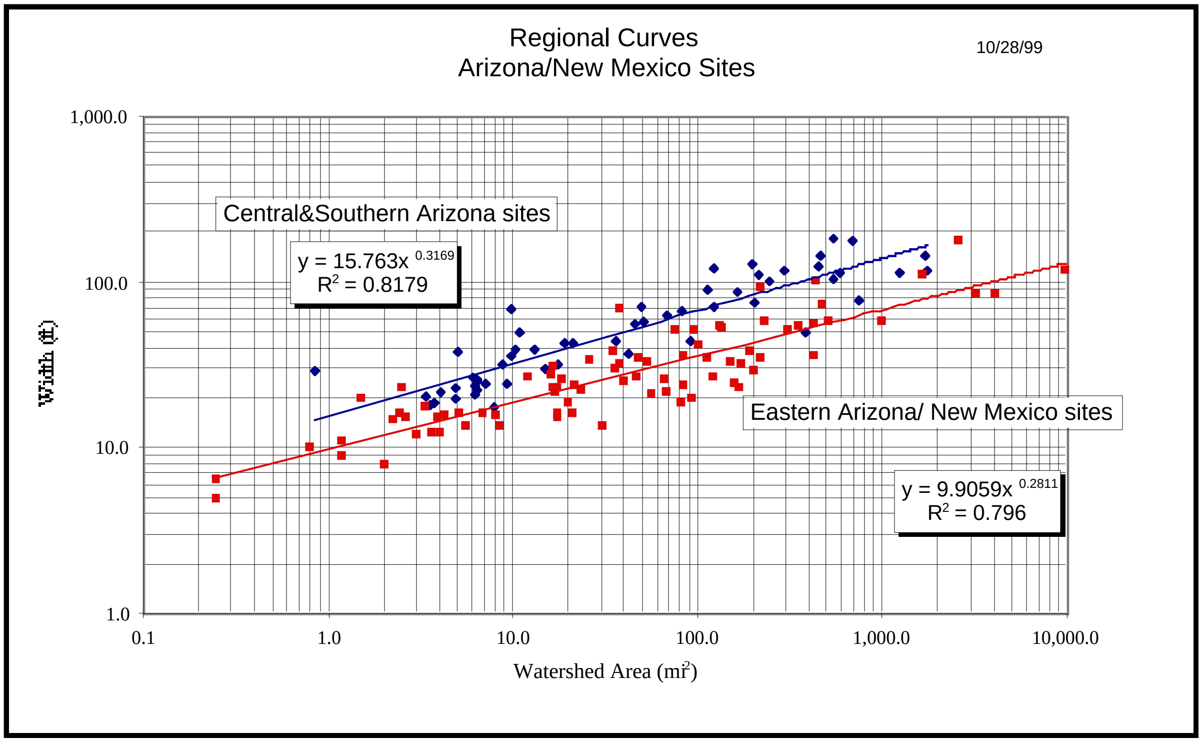
Figure 8a & b. The relationship for bankfull discharge is considerably weaker than the cross-sectional area relationship.

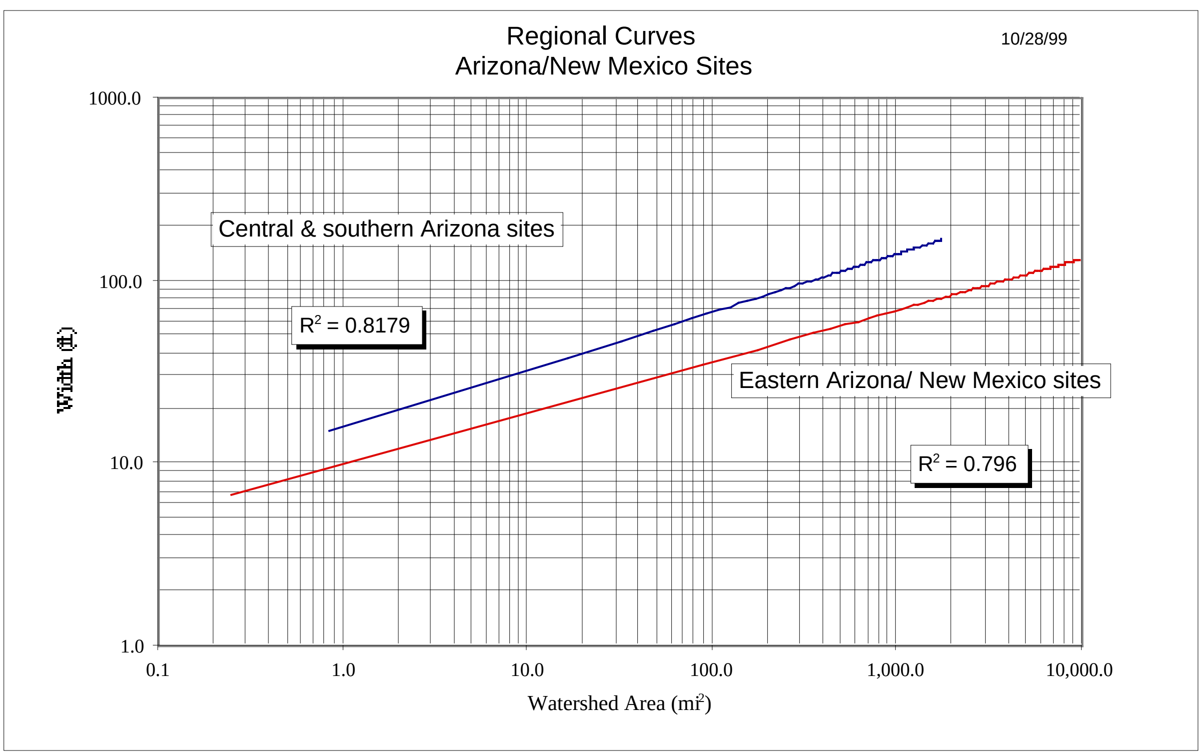




BANKFULL CHANNEL WIDTH VS. WATERSHED AREA

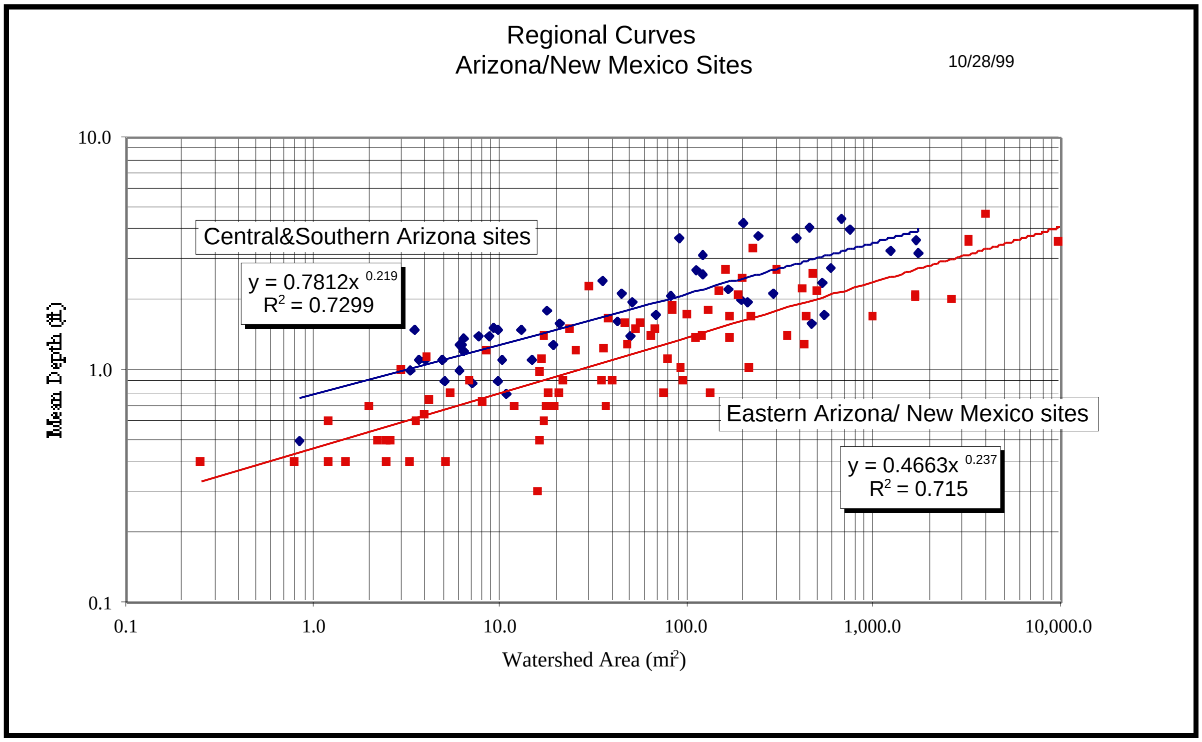
Figures 9a & b. The channel width relationship may exhibit greater scatter due to the variety of channel shapes and width/depth ratios.

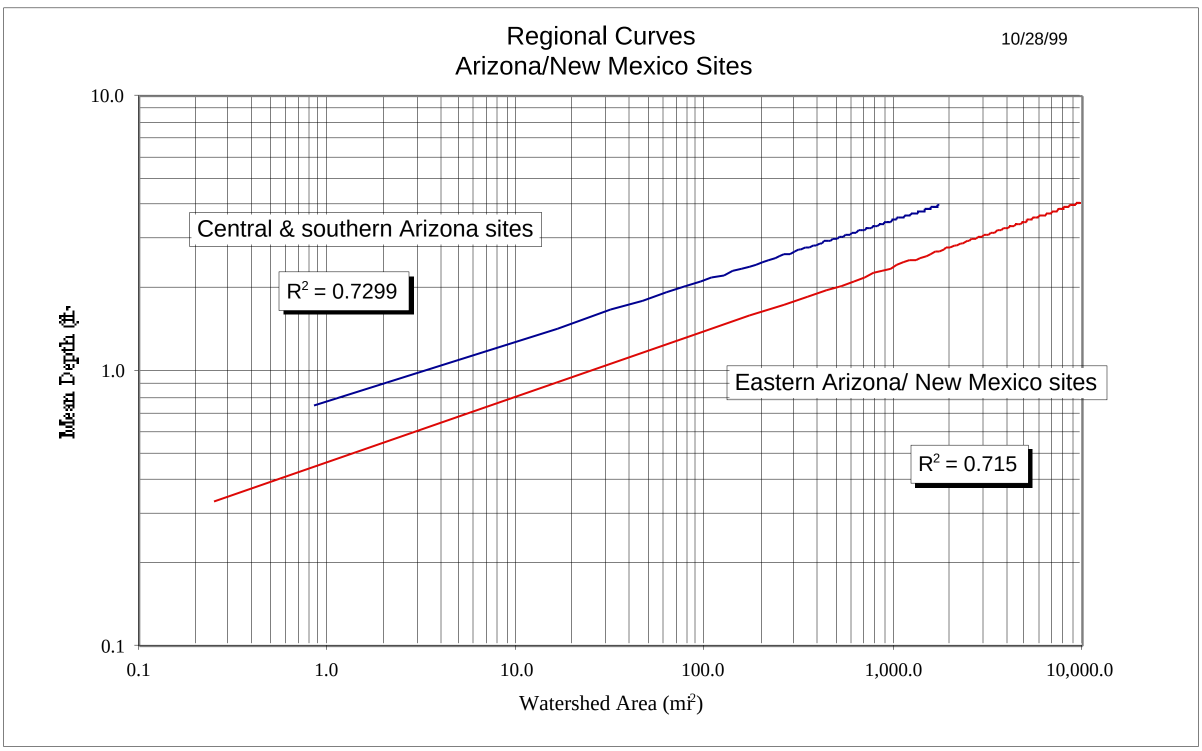




MEAN DEPTH OF BANKFULL CHANNEL VS. WATERSHED AREA

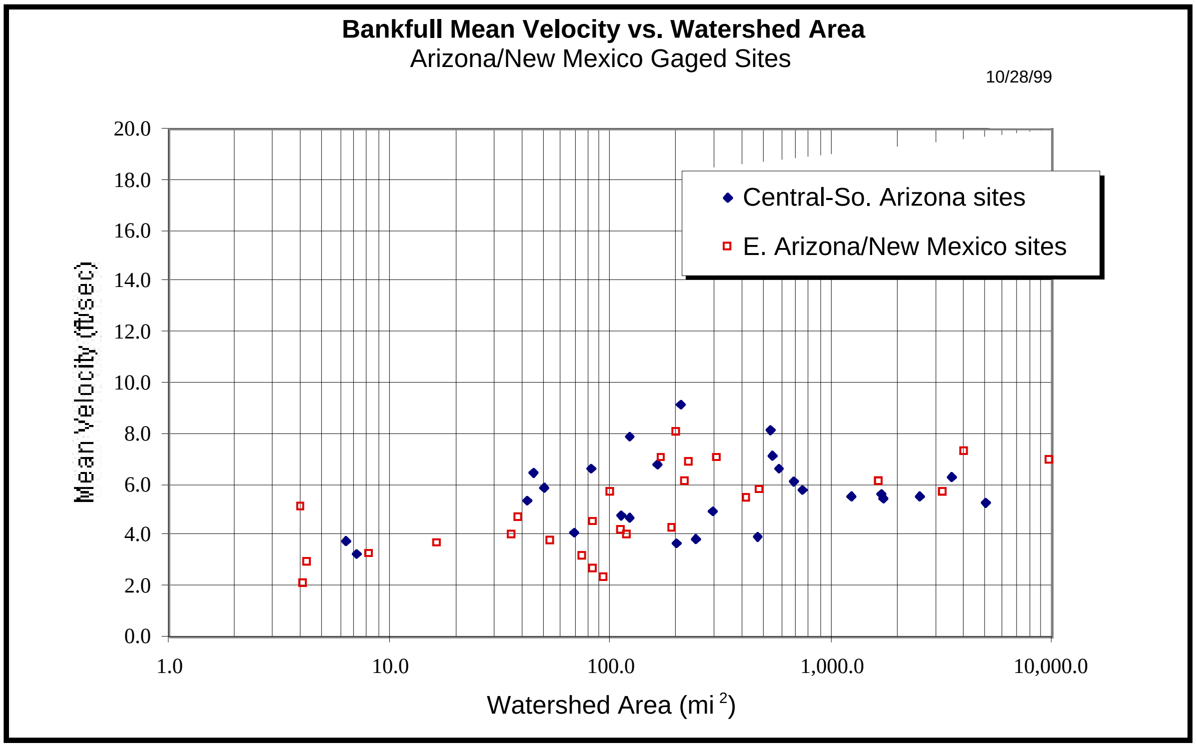
Figures 10a & b. The mean depth relationship may exhibit greater scatter due to the variety of channel shapes and width/depth ratios.

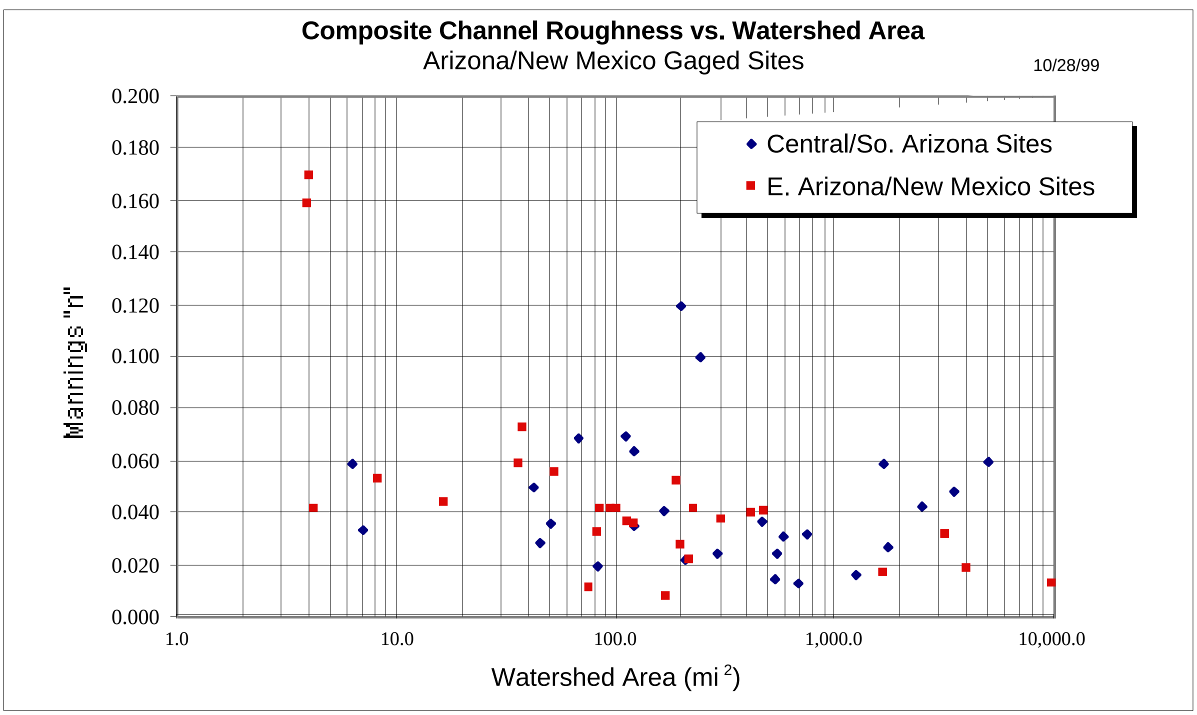




MEAN VELOCITY AND COMPOSITE CHANNEL ROUGHNESS VS. WATERSHED AREA

Figures 11 & 12. Mean velocity and Manning's n values were calculated at gaged sites in both studies. As with the original studies, bankfull mean velocity values range from 3 to 6 feet per second for watershed less than 100 square miles and from 4 to 8 feet per second for larger watersheds (Figure 11). This consistency provides a useful tool for estimating bankfull discharges at ungaged stream sites. Manning's n values are commonly between 0.02 and 0.06 with a significant number of outliers (Figure 12). It is important to note that a large number of sites had Manning's values greater than 0.03, a value commonly used in natural channels.





MANNING'S N VALUES BY REGION

Figure 13. This graph illustrates the range of roughness values for study sites. While 0.03 (a frequently used value) was most common in the Arizona region, 0.04 was more common for New Mexico sites. 30% of the sites had roughness values less than 0.03 and almost 50% had values greater of 0.04 and above. The broad range of these values suggest caution when assuming a roughness value for natural channels.

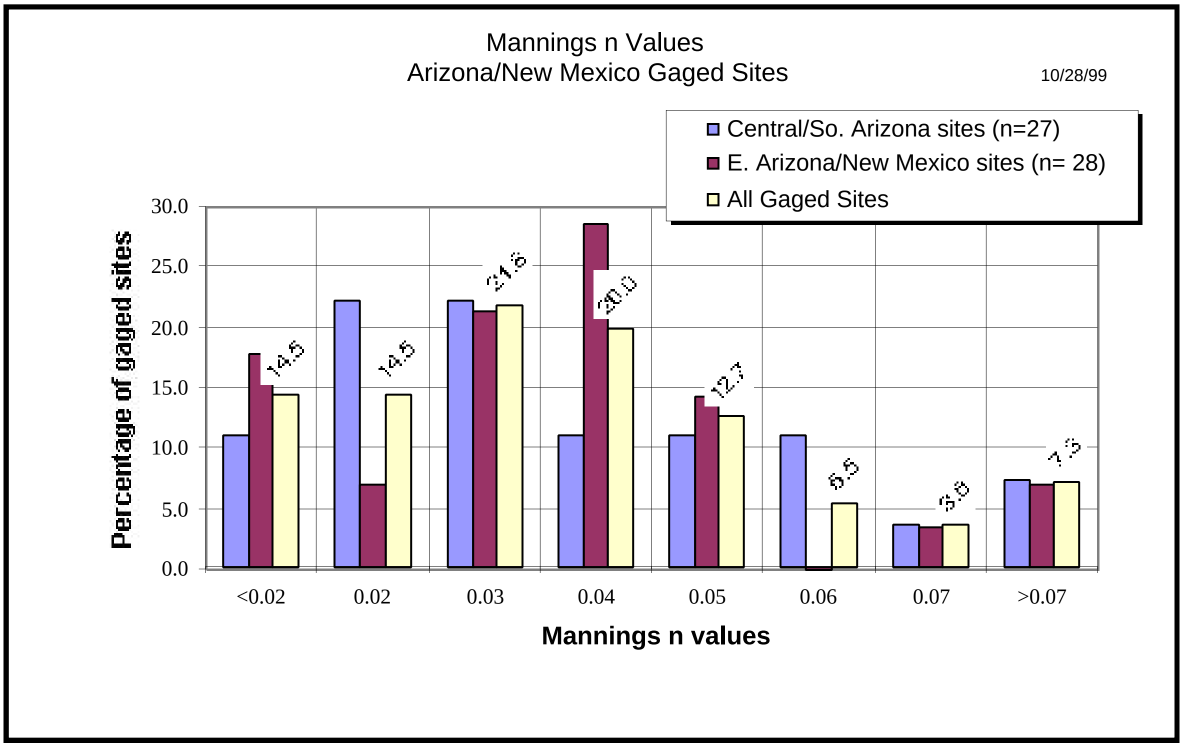


Table 1.
Composite channel roughness as a percentage of study sites

Manning's n Values	AZ Sites # of Sites	AZ Sites %	NM Sites # of Sites	NM Sites %	All Sites Sites	All Sites %
0.010 - 0.019	5	17.9	3	11.1	8	14.5
0.020 - 0.029	2	7.1	6	22.2	8	14.5
0.030 - 0.039	6	21.4	6	22.2	12	21.8
0.040 - 0.049	8	28.6	3	22.2	11	20.0
0.050 - 0.059	4	14.3	3	11.1	7	12.7
0.060 - 0.069	0	0	3	11.1	3	5.5
0.070 - 0.079	1	3.6	1	3.7	2	3.6
>0.100	2	7.1	2	7.4	4	7.3
	28		27		55	

Manning's n values by Rosgen Stream Type

Figure 14. This graph presents channel roughness values by stream type. The graph suggests that the more entrenched channel types (A, B, F) produce greater channel roughness even at bankfull stage. There is considerable range in some of the stream types and few data points in others. Roughness values in this region are similar to those presented in Rosgen, 1996 (page 8-3) but the values appear to be somewhat higher for AZ/NM sites.

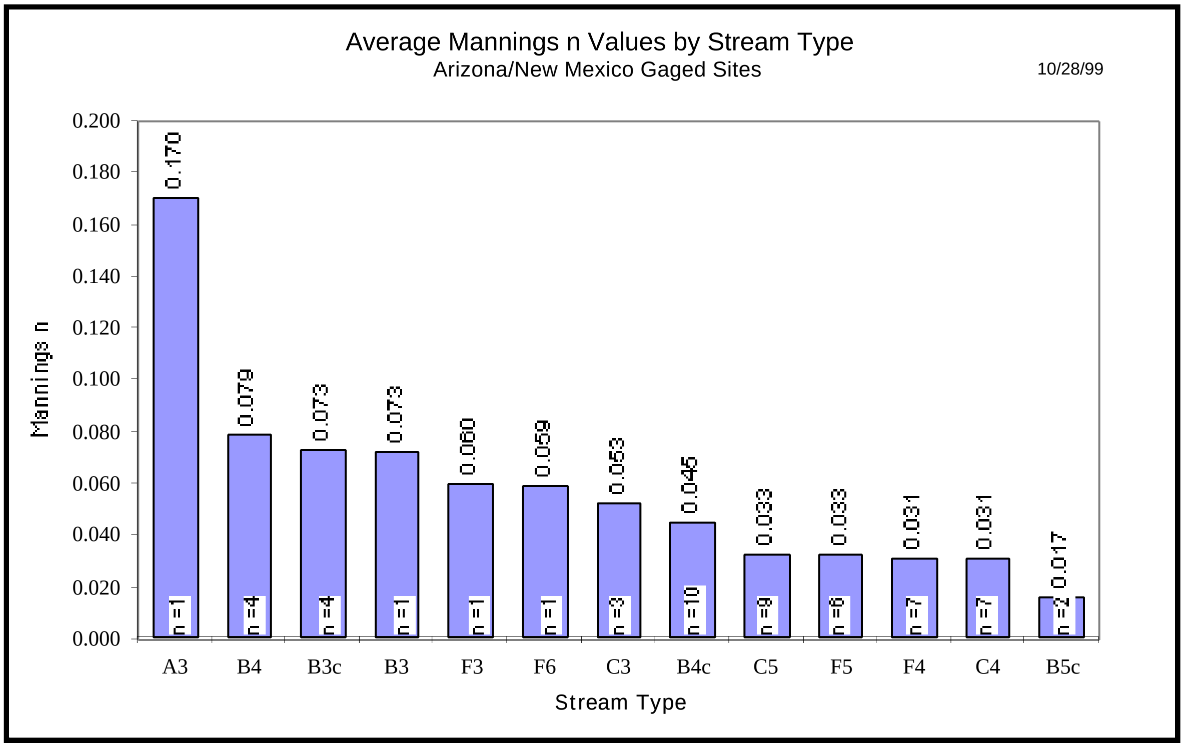


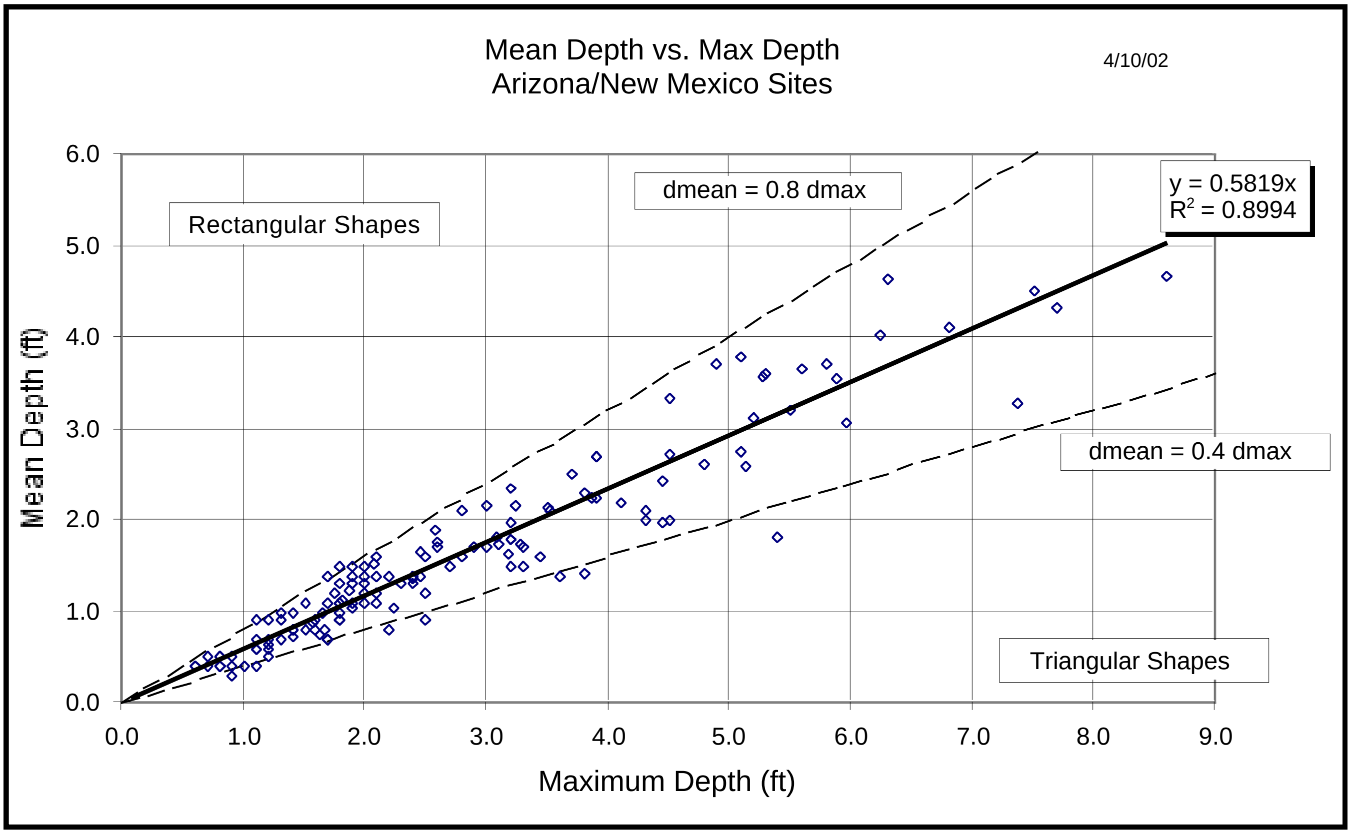
Table 3. Composite channel roughness by Stream Type

Stream Type	Manning's n values Avg.	Range	No. of sites
A3	0.170	0.17	1
B4	0.079	0.044-0.159	4
B3c	0.073	0.056-0.100	4
B3	0.073	0.073	1
F3	0.060	0.06	1
F6	0.059	0.059	1
C3	0.053	0.042-0.064	2
B4c	0.045	0.012-0.059	10
C5	0.033	0.012-0.042	9
F5	0.033	0.015-0.043	6
F4	0.031	0.013-0.055	7
C4	0.031	0.009-0.041	7
B5c	0.017	0.016-0.017	2

The relationship between Mean Depth and Maximum Depth

Figures 15. Estimating cross-sectional area is an important field tool. Width can be easily measured but mean depth is a calculated value (Area/width = mean depth) and cannot be measured. However, maximum depth is easily measured. The graphs below suggest that the relationship between mean depth and maximum depth in riffle sections is similar in the Arizona, New Mexico, and Navajo Nation studies. This relationship provides a useful function for field work.

Mean depth ~ 0.6 * Maximum depth (for riffle sections only)



Estimating Bankfull stage:

1. Identify bankfull stage using standard protocols.

2. Measure bankfull width and maximum depth.

3. Depending on the general shape of the channel choose an appropriate ratio. (0.6 for most channels, lower values for triangular shapes and higher values for more rectangular shapes. Ratio values should be between 0.4 and 0.8)

4. Multiply maximum depth by the chosen ratio to estimate mean depth.

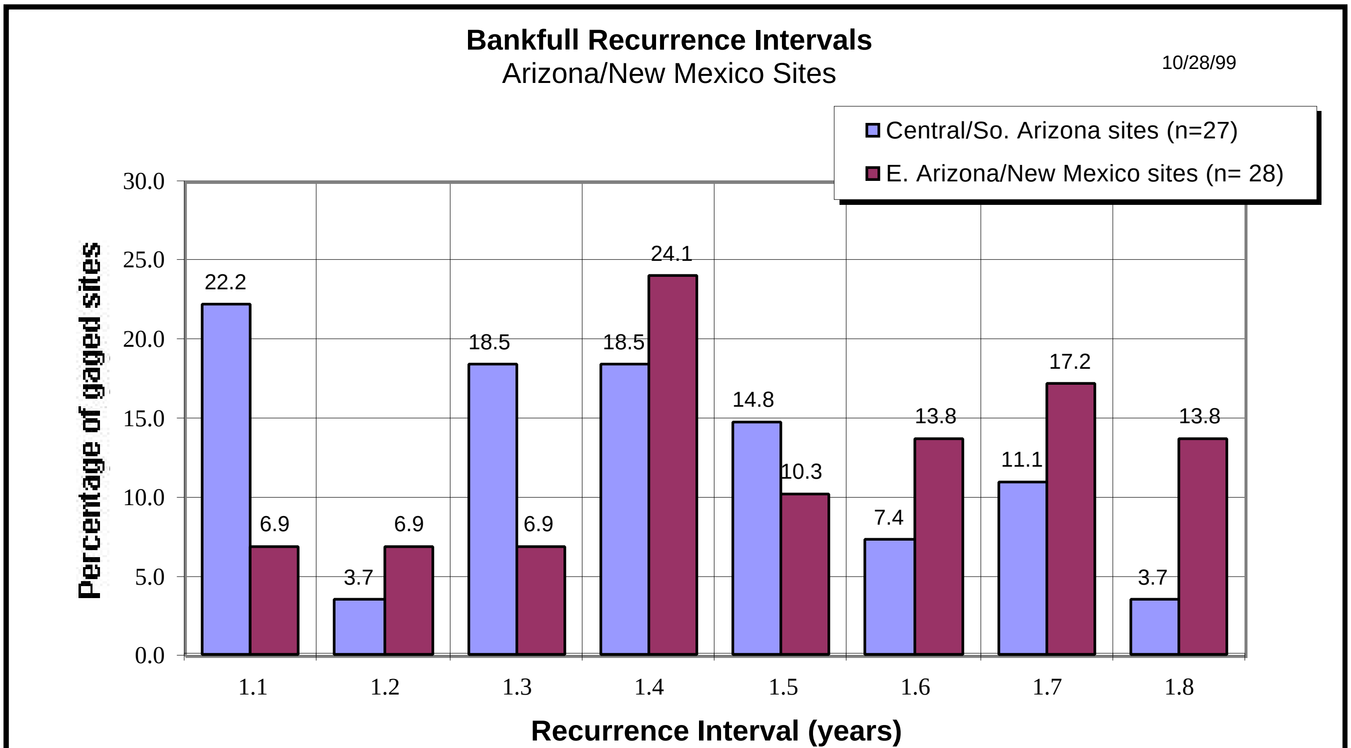
5. Mulitply mean depth by width to estimate cross-sectional area.

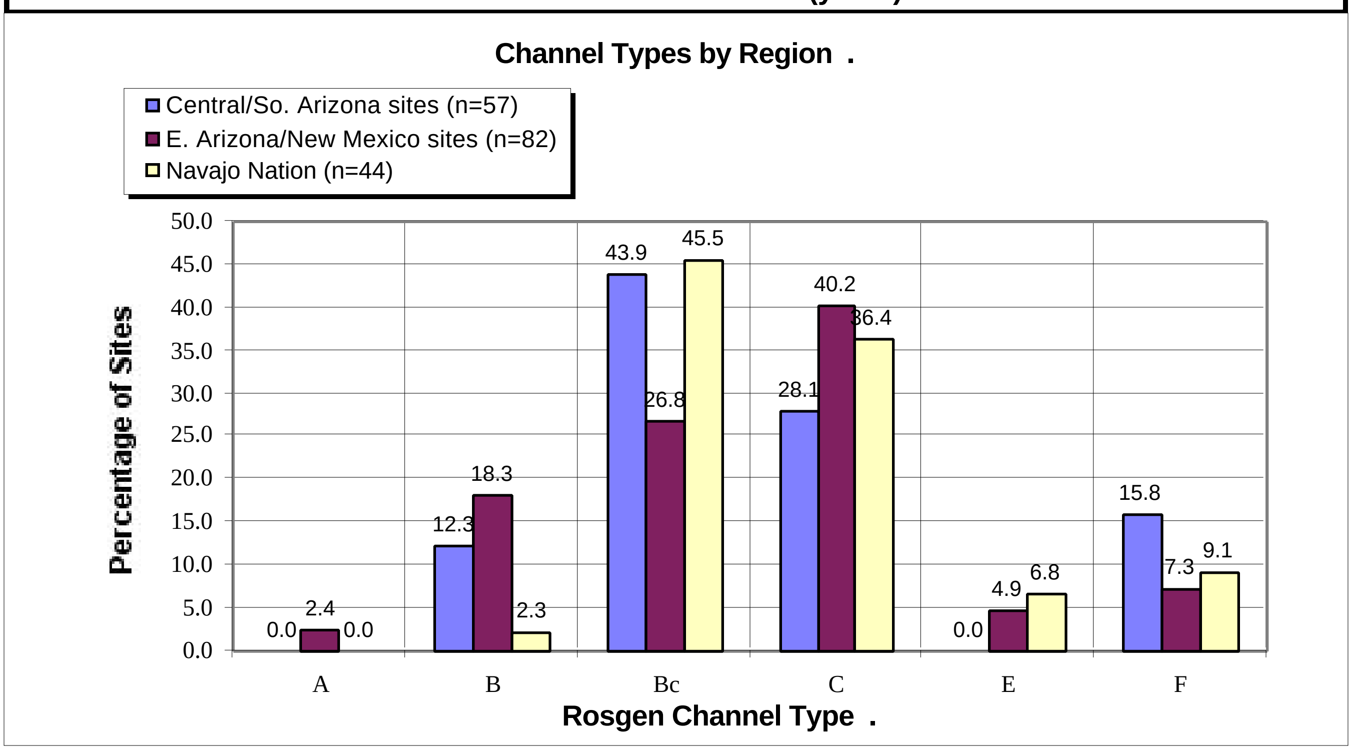
RECURRENCE INTERVALS FOR BANKFULL DISCHARGE

Figure 16. The figures demonstrate that recurrence intervals fall between 1.0 and 1.8 years for all sites. However, the Arizona sites tend to have lower values than New Mexico sites. The majority of the very frequent flows (RI=1 year) are found in the more arid portions of the study area.

Rosgen Stream Types

Figure 17. "C" type channels were common in both provinces, however, low gradient "Bc" channels were also numerous, especially in the Arizona province.





Local Calibration Curves

The identification of relationships that represent larger geographic areas reduces confusion over which curve is appropriate for individual sites, but the increase in variability reduces the precision and accuracy of the curve for specific sites. This paper proposes that these new regional curves be used in conjunction with site specific “local calibration curves”. A local calibration curve is created by surveying bankfull stage at a set of sites within in a sub-region or watershed (see Table 1 for procedures). Bankfull channel geometry data from these surveys are plotted on the Cross-sectional Area vs. Watershed Area regional curves. Given the strength and consistency of the slope of the Arizona and New Mexico regional curves, it is reasonable to assume that this same slope will represent smaller geographical units as well. Therefore, the data from local calibration sites can be used to determine an offset for the regional data. For example if local calibration sites consistently plot below one of the regional curves, the local calibration curve would be constructed with the same slope as the regional curves but below the regional line. A series of examples of local calibration curves are presented below. Figure 18 is location map for the local calibration curve sites.

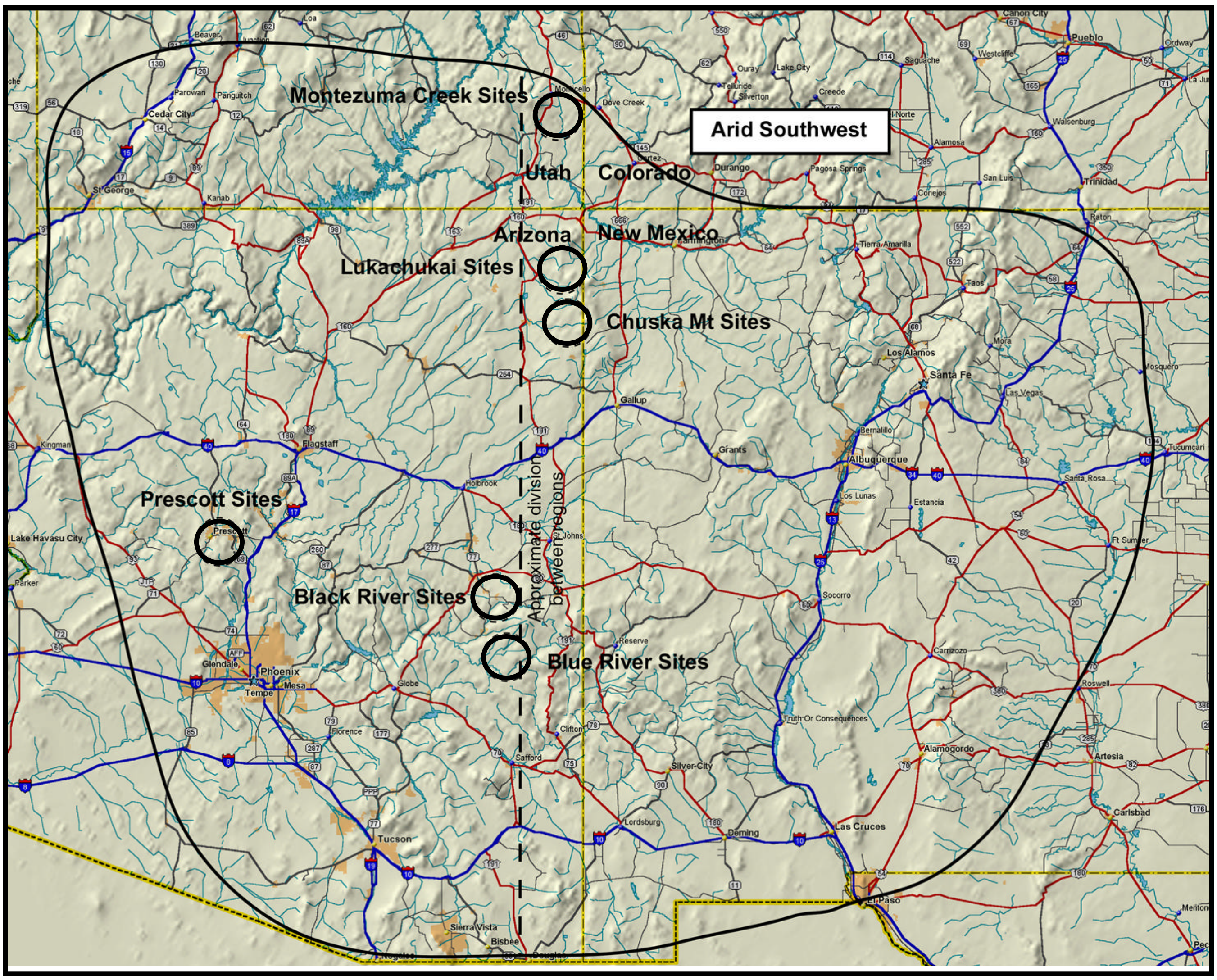


Figure 18. Location Map of examples of Local Calibration Curves in the Arid Southwest (boundaries approximate)

Table 2. Local Calibration Curve Procedures

1) Choose a minimum of five sites to collect data. The sites should include a range of watershed areas and stable, recognizable bankfull features.

2) Conduct bankfull surveys including identification of bankfull stage, longitudinal profile, cross-section survey, and pebble count. Establish bankfull channel and floodplain geometry (watershed area, cross-sectional area, width, mean depth, max. depth, width/depth ratio, entrenchment ratio, slope, sinuosity, and mean particle size of channel material (d50).

3) Create a table of channel/floodplain geometry values and plot cross-sectional area and watershed area values on the regional curve.

4) Assess the data. Use the relative position of the local data to the regional curve to characterize the local regime. Is the local data present acceptable scatter or are additional site surveys needed? Does local data plot nearer the Arizona or New Mexico curves? Does the local data consistently lie above or below one of these curves?

Given the consistency and strength of the regional curves, it is reasonable to expect that local curves will have slopes similar to the regional data but may lie above, below, or along one of the curves. Each watershed should be treated as a unique entity until field data suggests otherwise.

Figure 19 is a plot of data from stable channel sites near Prescott, AZ. As expected, the points consistently cluster along the Central/Southern Arizona curve.

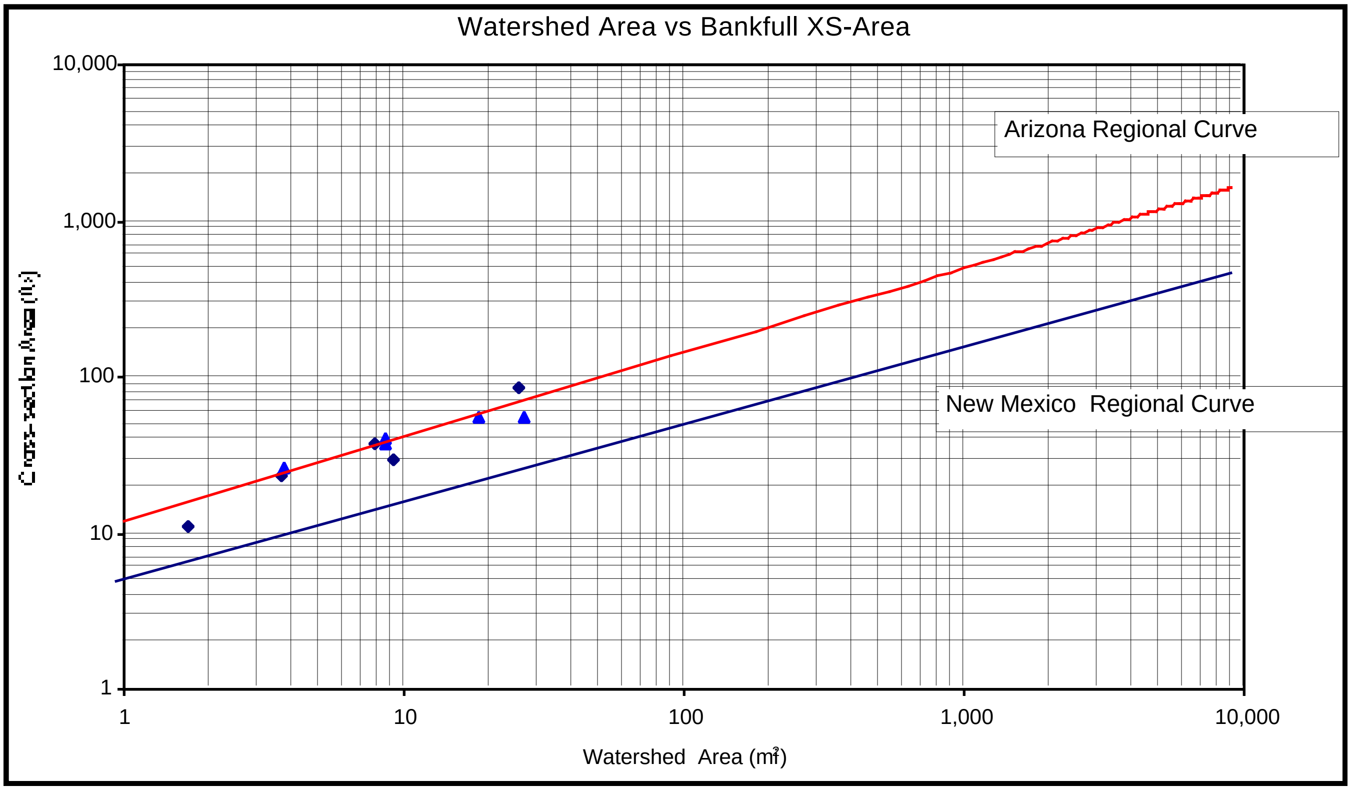


Figure 19. Local Calibration Curve for Prescott, AZ Sites (Natural Channel Design, Flagstaff, AZ)

Figure 20 presents channel data from a set of stable stream sites in the Blue and Black River watersheds in eastern Arizona. While all points fall around the Eastern Arizona/New Mexico curve, data from the Black River sites plots consistently belowthe curve and the Blue River points fall above the regional curve. This suggests there are subtle but consistent differences between these adjacent watersheds. The dotted lines represent local calibration curves for the Blue and Black Rivers.

Several sites located on the Navajo Nation along the AZ/NM border are plotted on Figures 21 and 22. These basins drain the western slopes of the Chuska Mountains and flowto the San Juan River. Although they are adjacent, the very different topography and geology of the watersheds are reflected in the calibration curves. The northern sites in the Lukachukai basin plot along the Arizona curve while the more southern Chuska Mountains sites lie on or below the New Mexico regional curve. The

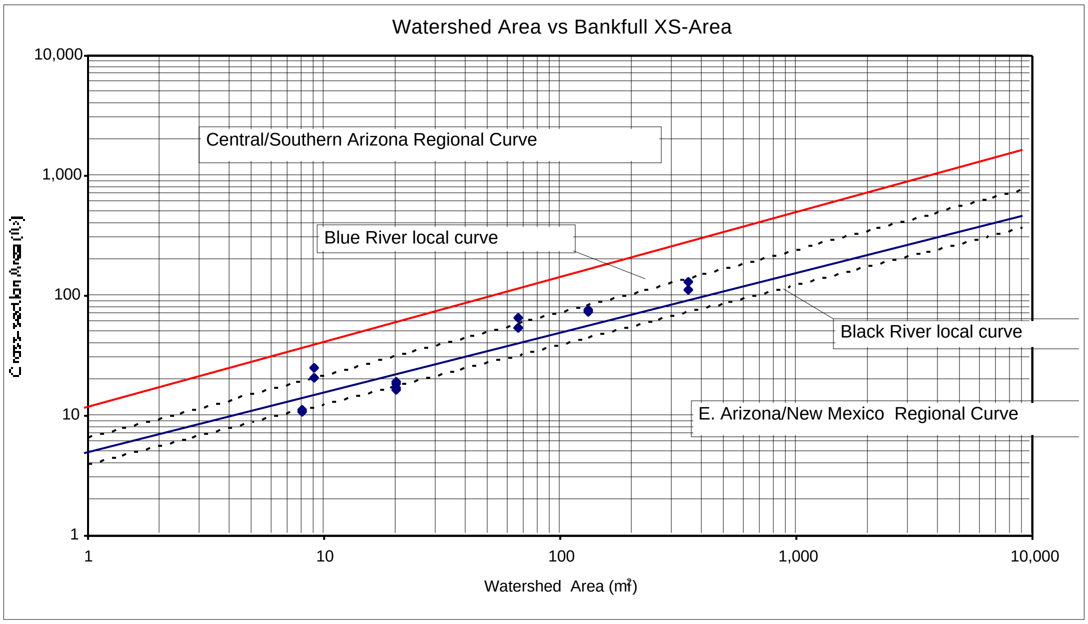


Figure 20. Local Calibration Curve for Blue and Black River Sites

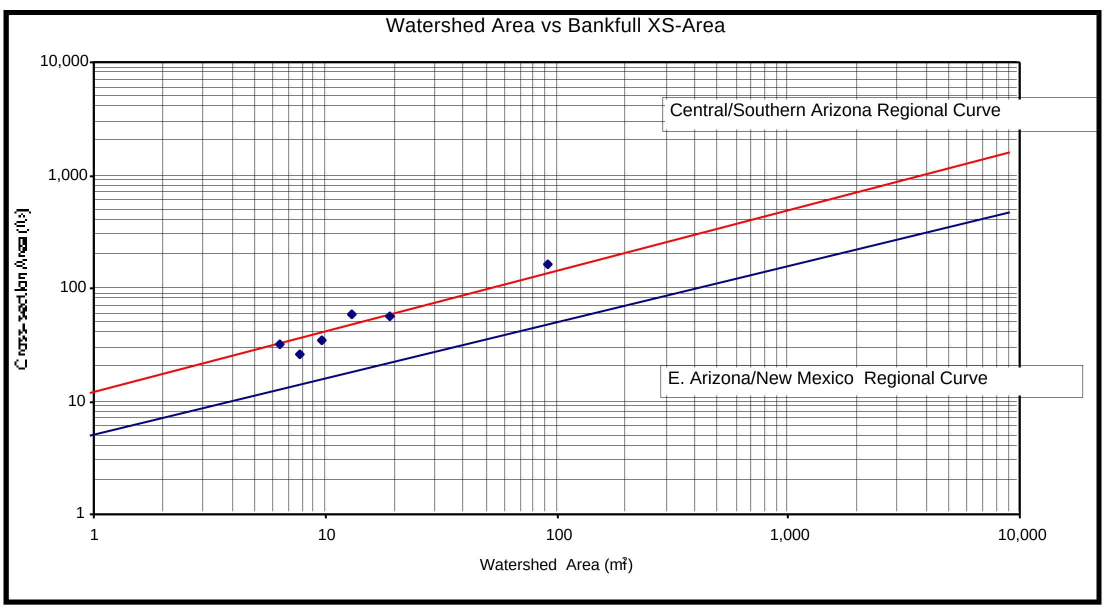


Figure 21. Lukachukai Creek Basin Sites

Lukachukai basin sites lie outside the current Arizona Province. Additional work on the Navajo Nation will integrate this portion of the state. Note the 4 largest sites on the Chuska Mountains curve lie in Canyon del Muerto below the impoundments of Tsaile and Wheatfields Reservoirs. The shift in the values of these points suggests the potential impacts of the altered hydrology. The dashed line represents the shifted New Mexico line to create the local Canyon del Muerto calibration curve.

Figure 23 demonstrates the use of a calibration curve outside of the AZ/NM region. These sites are located in the Montezuma Creek basin near Monticello in southeastern Utah. This data plots consistently below the New Mexico curve and suggests similar bankfull stream processes to the Canyon del Muerto sites.

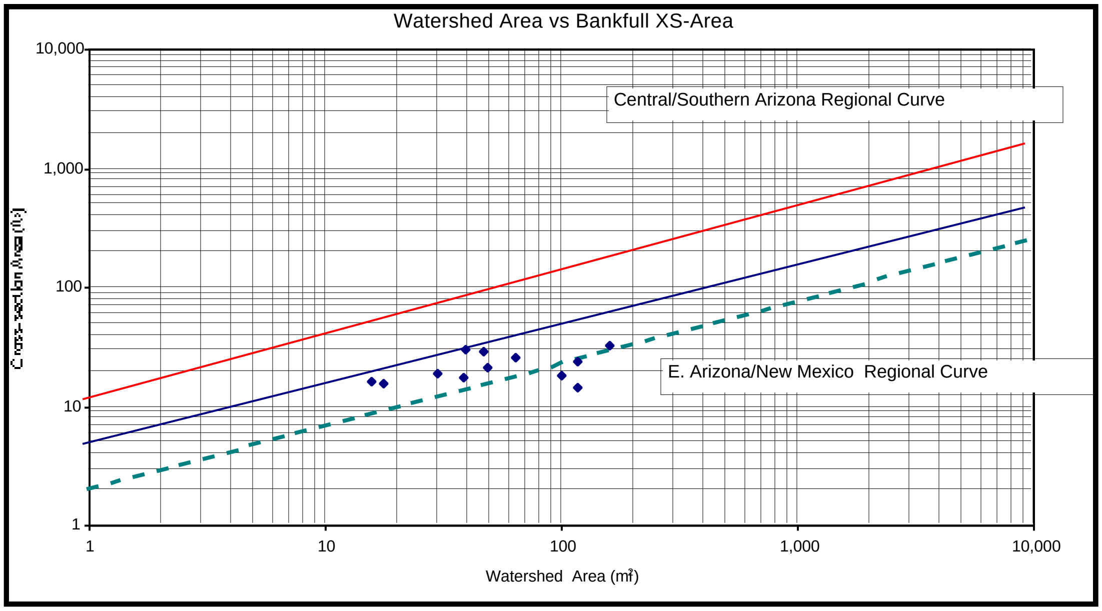


Figure 22. Local Calibration Curve for Chuska Mountains Sites

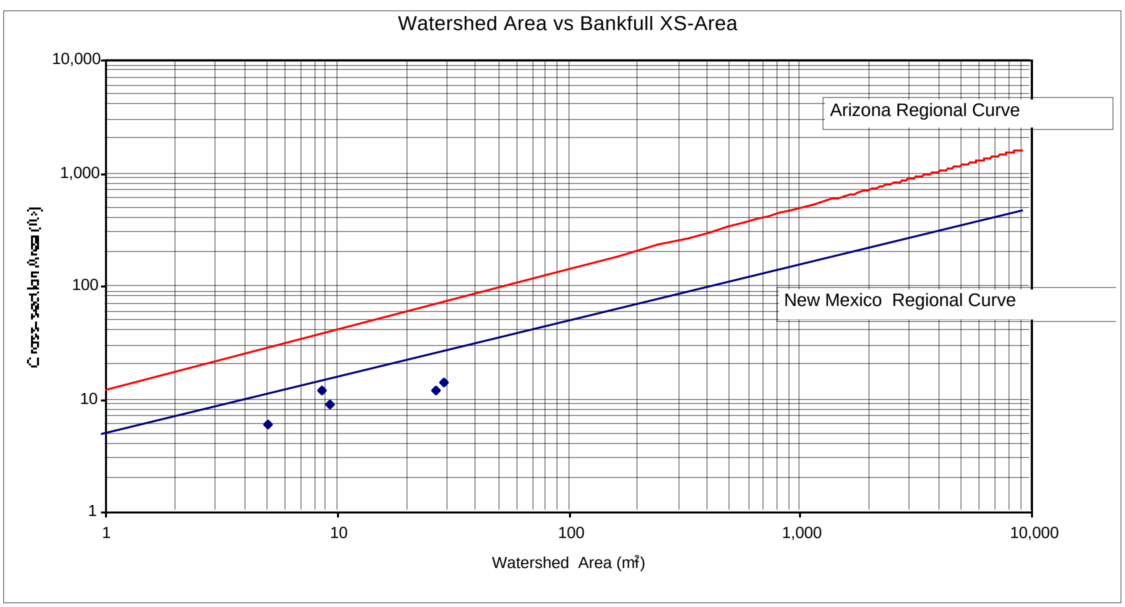


Figure 23. Local Calibration Curve for Montizuma Creek Basin Sites
(Natural Channel Design, Flagstaff, AZ)

Conclusions:

The integration of the Arizona and New Mexico studies produces a more accurate and unified picture of the bankfull processes in the two states. Creating two hydro-physiographic provinces across the two states creates a useful tool to the practitioner for field identification of bankfull stage for inventory, assessment, and design. The strength of the correlation coefficients, consistency of the trendline slopes, and number of data points in each curve provides added confidence in the validity of the relationships. Local Calibration curves can further refine these relationships for watersheds or sub-regions.

In general the data and analyses support the hypothesis that bankfull processes are active in the stream channels of Arizona and New Mexico. While the provinces exhibit distinct relationships, the recurrence intervals for bankfull stage are similar to those in other regions.

The relationships presented here characterize the physical functions of a wide variety of stream sizes and types. However, data from both studies produced inconsistent results from two distinct classes of streams. The first was ephemeral sand bed stream channels in the most arid portions of the study area. These were generally located in southwestern Arizona and the southern and southeastern sub-regions of New Mexico. These channel beds were mobilized by a wide range of flows and bankfull features were not consistently evident. The second class were very large stream systems which serve to transport water and sediment from a variety of sub-watersheds. Examples of these systems are the main stem of the Gila, Salt, Verde, Little Colorado and San Pedro Rivers in Arizona. While bankfull features were consistently evident in these channels, they were not represented by the regional curves presented here. This may be due to the size and complexity of their watersheds and/or to the greater distance from precipitation sources in their sub-watersheds. Additional research needs to be conducted to more fully understand these systems.

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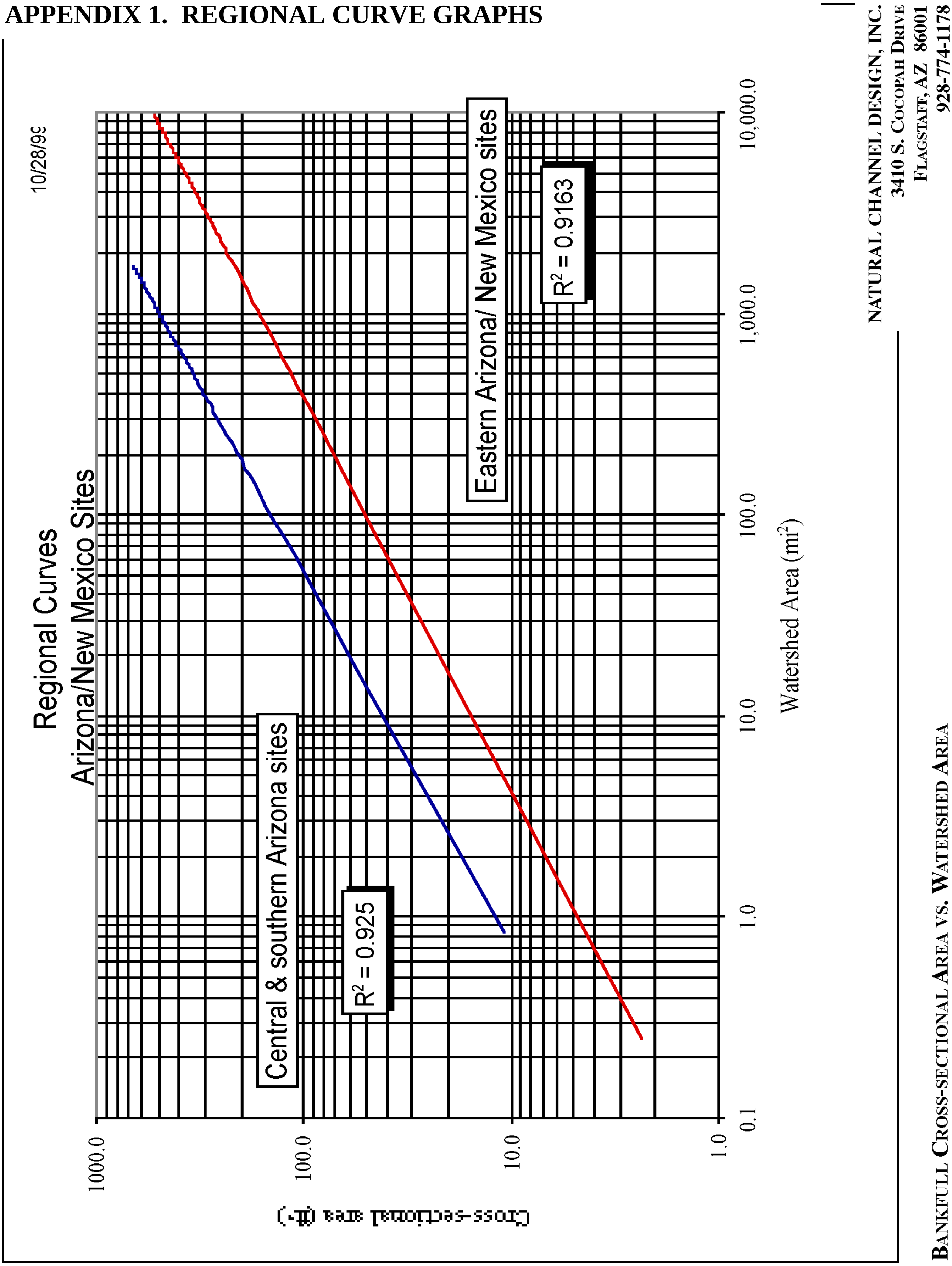
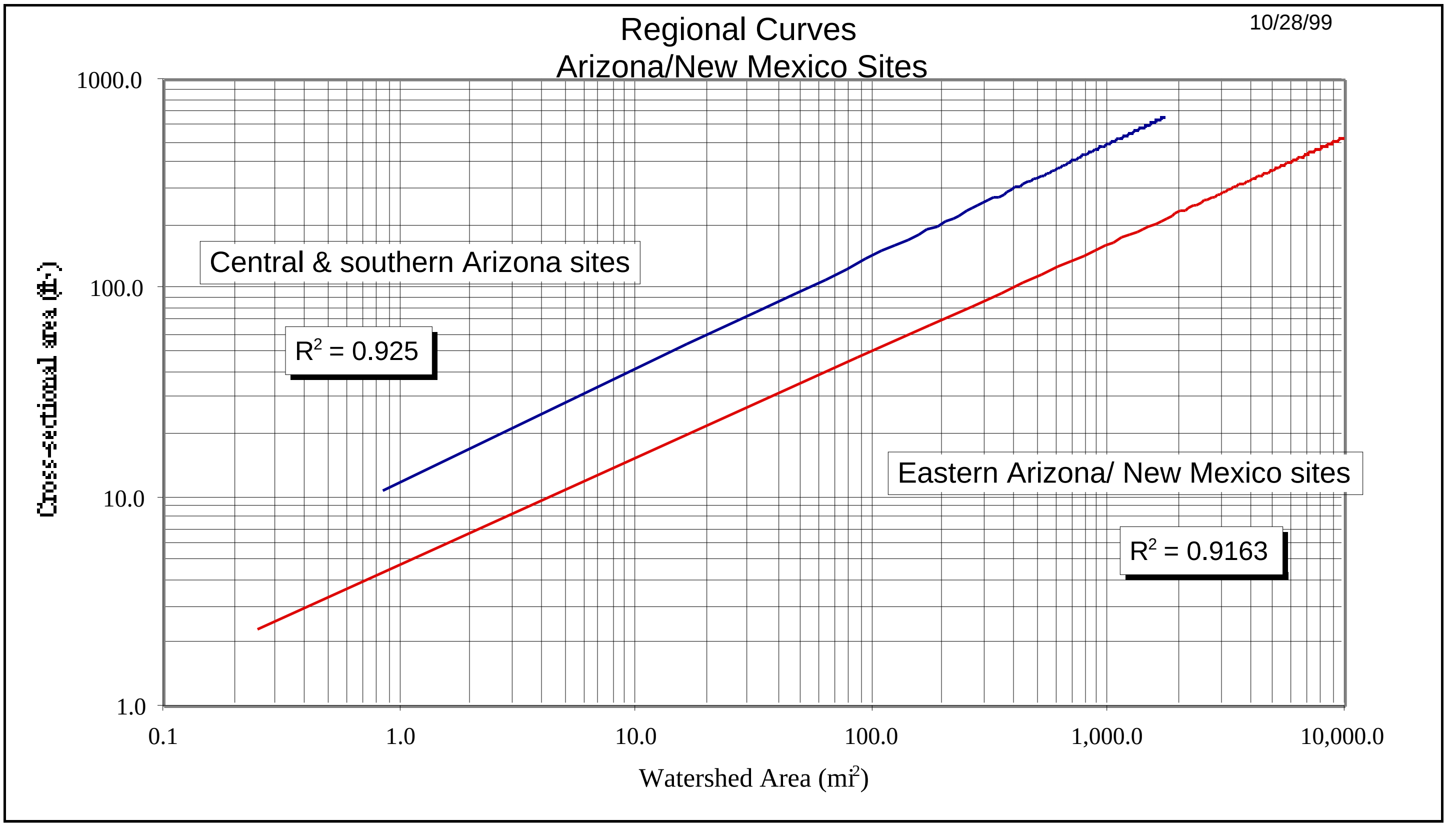
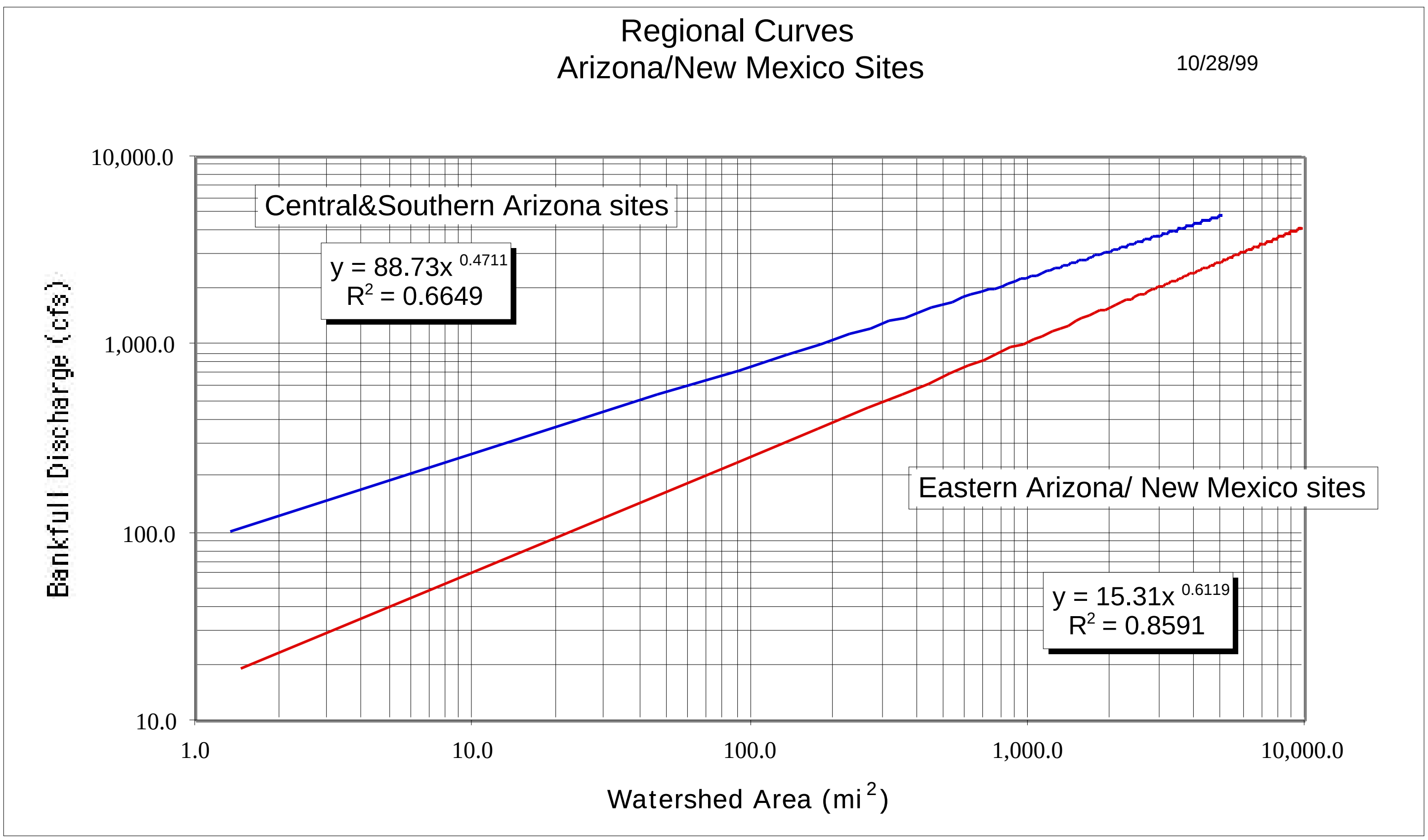
APPENDIX 1. REGIONAL CURVE GRAPHS



BANKFULL CROSS-SECTIONAL AREA VS. WATERSHED AREA



BANKFULL DISCHARGE VS. WATERSHED AREA



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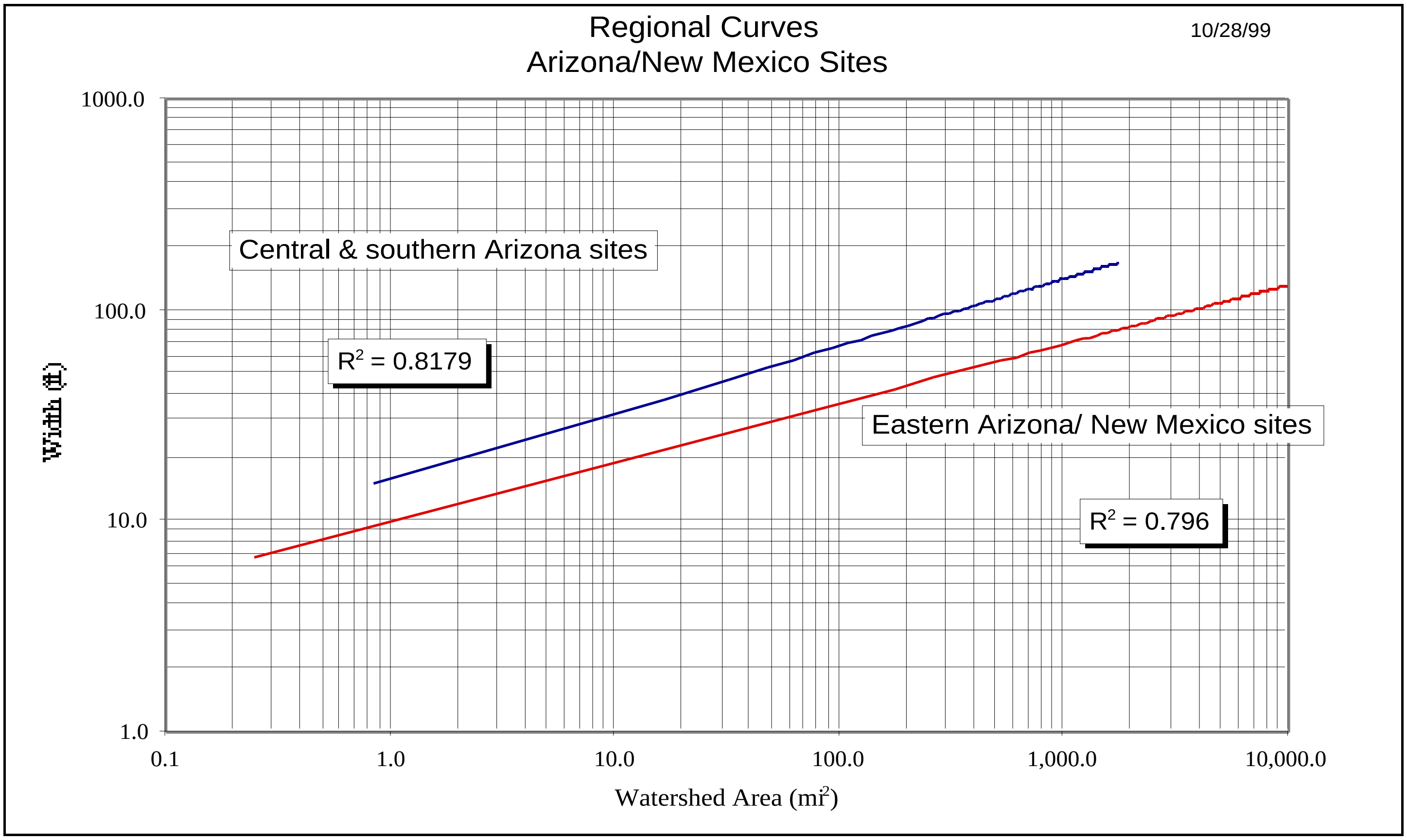
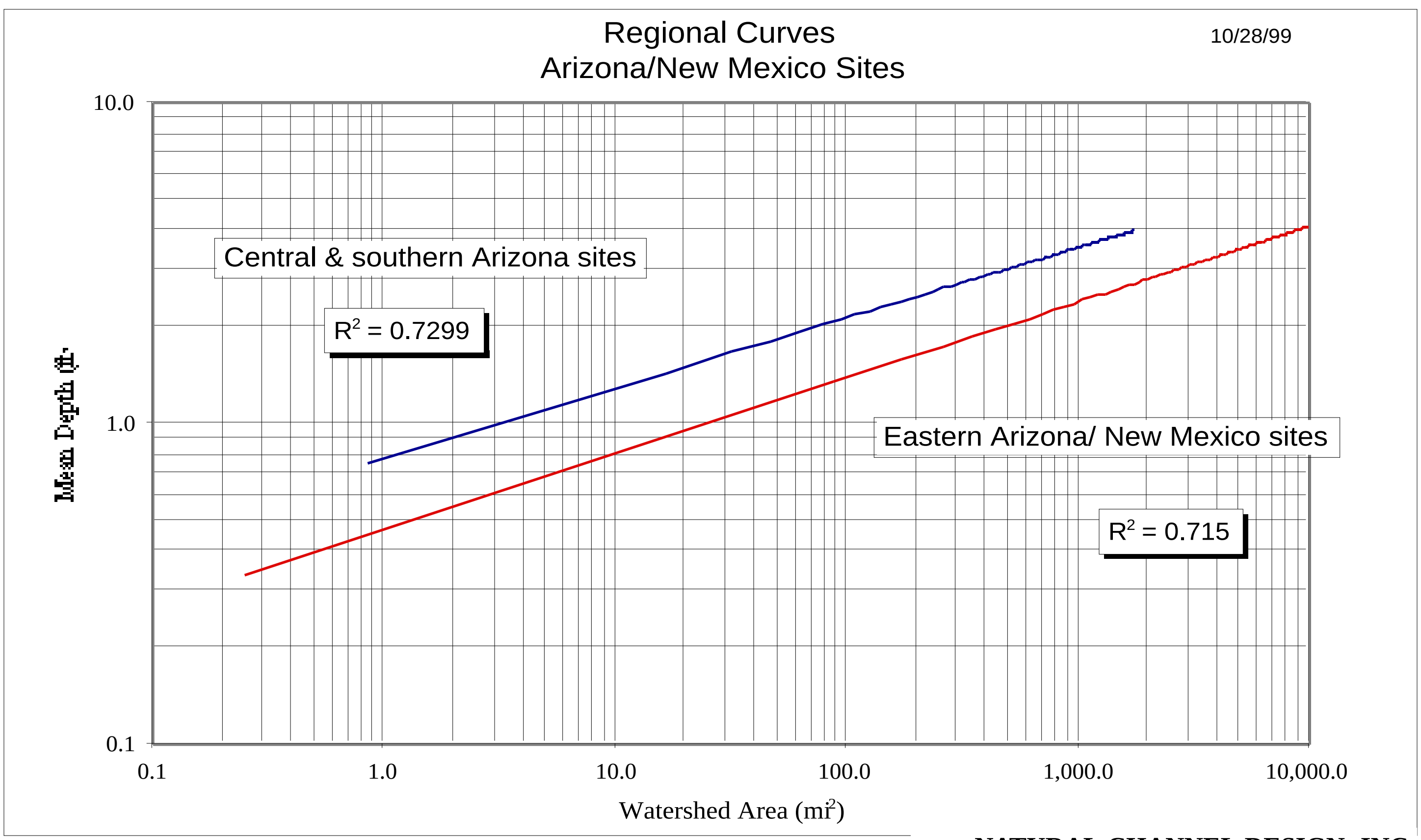
BANKFULL CHANNEL WIDTH VS. WATERSHED AREA



BANKFULL CHANNEL WIDTH VS. WATERSHED AREA



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APPENDIX 2. FIELD PROTOCOLS FOR DETERMINING BANKFULL STAGE

Bankfull stage can be difficult to successfully identify in the field. There are generally too many indicators (many of which are remnants of other flow events) rather than too few. The approach is adapted from the procedure described by Dunne and Leopold (1978). The procedure consists of 1) identification of bankfull stage indicators along the channel, 2) surveying a longitudinal profile along the channel, 3) plotting the relative positions of the thalweg, watersurface and bankfull stage on the profile, 4) surveying one or more cross-sections along the channel reach in representative riffle sections, and 5) determining the elevation of bankfull stage at each cross-section, and 6) analyzing cross-sections to determine bankfull channel geometries.

A reminder: The natural tendency is to overestimate the d50 particle, overestimate channel slope, and to underestimate bankfull stage.

BANKFUL INDICATORS:

- Deposition features which represent the floodplain. These include point bars and short, alternating lateral bars with consistent elevations along the reach;
- Consistent changes in slope along the bank especially when the slope flattens;
- Changes in particle size. Commonly smaller particles are found on the floodplain than in the channel or banks, but special circumstances can produce the opposite; and
- Consistent vegetation indicators. Outside of a few high, snowmelt streams, vegetation is best used as a secondary indicator to verify an estimate. Consistent lines of bacharis or other riparian vegetation has sometimes coincided with bankfull. Generally riparian vegetation grows well below bankfull stage.

FIELD PROCEDURES:

- Draw a simple site sketch that describes the reach and its features.
- Choose a representative reach of channel with a length equal to 20 bankfull channel widths (2 meanders). Mark depositional surfaces and other indicators along the reach that may represent bankfull stage. Describe the location, vegetation, and particle distribution for each bankfull indicator.
- Survey the longitudinal profile of the reach including thalweg, watersurface, potential bankfull indicators, and pertinent alluvial or vegetation features. The thalweg represents the central thread of water flow or the deepest part of the channel.
- Choose one or more representative cross-sections located in riffle sections to survey. Generally the top of a riffle section represents the most consistent cross-section.
- Survey the cross-sections and record the data. Carry the surveys well above the active channel to include floodprone width (channel width at an elevation 2 times maximum bankfull depth.)
- Estimate channel sinuosity.
- Characterize bed and bank material using Wolman pebble count.
- Measure channel pattern (meander width, meander length, radius of curvature).
- Take documenting photographs of the channel cross-section.

ANALYSES

- Graph the profile and connect the thalweg and watersurface survey points. Draw a smooth line through the potential bankfull indicators. The thalweg (from riffle to riffle), watersurface and bankfull stage should have similar slopes.
- Plot the cross-section data and transfer bankfull stage from the longitudinal profile to individual cross-sections. Calculate cross-sectional areas, widths, mean depth, floodprone width, entrenchment ratio, and width/depth ratios.
- Compare cross-sectional areas for all surveys. There should be general agreement (~+/-10%) between these values for all cross-sections unless there is an abrupt change in slope or channel shape through the reach.
- Compare bankfull cross-sectional areas with regional data. If there is not general agreement, justify the discrepancy or reanalyze the bankfull stage line in the profile.
- Classify stream according to Rosgen Natural Channel Classification System
- Plot cross-sectional area data on cross-sectional area vs. watershed area regional curves.

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Appendix 3: Arizona Province Sites:

Bankfull Data

Site Name	Watershed Area	X-section Area	Width	Mean Depth	Max Depth	Velocity	Mannings N	Discharge	Recurrence Interval	Stream Flow
	(mi2)	(ft2)	(ft)	(ft)	(ft)	(fps)	__	(cfs)	(fears)	__
Agua Fria River near Mayer, AZ	585.0	317.5	115.2	2.8	5.1	6.6	0.031	2100.0	1.1	Perennial
Altar Wash near Three Points, AZ	463.0	229.2	143.6	1.6	3.5	3.9	0.037	900.0	1.1	Ephemeral
Aravaipa at upper gage	380.0	175.0	50.0	3.7	5.8					Perennial
Aravaipa Creek near Mammoth, AZ	537.0	181.6	105.7	1.7	3.3	7.2	0.025	1300.0	1.1	Perennial
Bear Canyon Campground	3.5	27.6	18.5	1.5	1.9					Ephemeral
Bray Cr. Above Control Rd.	4.0	23.2	22.0	1.1	1.8					Ephemeral
Campaign Creek	17.6	58.9	32.0	1.8	3.2					Ephemeral
Canada del Oro near Oracle Jct., AZ	42.3	61.7	37.7	1.6	3.2	5.4	0.050	330.0	1.8	Perennial
Catalina State Park	6.1	30.6	24.0	1.3	1.8					Ephemeral
Cave Cr. Above campground	10.7	40.8	50.0	0.8	1.4					Perennial
Cherry Creek near Globe, AZ	200.0	328.0	76.0	4.3	7.7	3.7	0.120	1200.0	1.6	Perennial
Cienega Creek below Stevenson Canyon	196.0	256.3	128.0	2.0	4.3				1.5	Perennial
Cienega Creek near Pantano, AZ	289.0	251.6	116.8	2.2	3.0	4.9	0.025	1240.0		Ephemeral
Clover Wash (near Deer Cr.)	5.0	34.6	38.0	0.9	1.8					Ephemeral
Creek at mm 233 Beeline Hwy.	6.2	27.1	21.0	1.3	2.0					Ephemeral
Davidson Canyon	50.5	113.5	57.7	2.0	3.2	5.9	0.036	665.0	1.3	Ephemeral
Devore Wash off Hwy. 88	6.0	27.2	27.0	1.0	1.8					Ephemeral
Dry Beaver Creek near Rimrock, AZ	122.0	317.0	123.0	2.6	5.1	4.7	0.064	1500.0	1.4	Intermittent
Dude Cr. Below Dry Dude	4.8	21.8	20.0	1.1	2.1					Ephemeral
East Verde River	10.2	41.5	39.0	1.1	1.7					Perennial
East Verde River near Pine, AZ	6.3	30.5	25.2	1.2	1.8	3.8	0.059	115.0	1.4	Perennial
Ephemeral wash nr Luckachukai	9.7	33.7	36.0	0.9	1.6					Ephemeral
Lizard Wash below Luckachukai	19.0	57.3	43.0	1.3	2.4					Ephemeral
Luckachukai (ab. Lower Crossing)	7.7	25.7	18.0	1.4	2.1					Perennial
Luckachukai (Upper Crossing	6.4	32.0	26.0	1.2	2.5					Perennial
Luckachukai Wash below School	13.0	57.6	39.0	1.5	3.3					Perennial
Luckachukai Wash Gage	91.0	165.4	44.5	3.7	4.9					Perennial
Near A+ Road Jct. With Hwy. 188	0.8	15.6	29.0	0.5	0.7					Ephemeral
New River near Rock Springs, Az	68.3	111.0	63.4	1.8	2.6	4.1	0.069	460.0	1.3	Intermittent
Pantano Wash above Dam	450.0	510.0	125.0	4.1	6.8					Perennial
Pine Creek	8.8	43.3	32.0	1.4	1.9					Perennial
RackenSack Canyon	3.7	21.5	19.0	1.1	1.8					Ephemeral
Red Tank Draw near Rimrock, AZ	49.4	101.7	72.0	1.4	3.8	0.0	0.000	0.0		Intermittent
Rincon Creek near Tucson, AZ	44.8	119.1	55.6	2.1	3.5	6.5	0.029	768.0	1.7	Perennial
Rye Creek near Gisela, AZ	122.0	220.0	70.5	3.1	5.2	7.9	0.035	1738.0	1.4	Perennial
Sabino Creek near Tucson, AZ	35.5	108.2	44.8	2.4	4.4	0.0	0.000	0.0		Perennial
San Pedro River at Charleston, AZ	1234.0	381.4	116.5	3.3	7.4	5.5	0.016	2100.0	1.1	Perennial
San Pedro River near Palominas, AZ	741.0	310.0	77.1	4.0	6.2	5.8	0.032	1800.0	1.1	Perennial
San Pedro River near Tombstone, AZ	1730.0	384.0	119.9	3.2	5.5	5.5	0.027	2100.0	1.1	Perennial
San Pedro River Tributary near Bisbee, AZ	7.1	21.4	24.4	0.9	1.6	3.3	0.034	70.0	1.1	Ephemeral
Sand Wash nr Gisela	3.3	20.6	20.7	1.0	1.3					Ephemeral
Santa Cruz River near Continental, AZ	1682.0	528.3	145.0	3.6	5.6	5.7	0.059	2986.0	1.6	Ephemeral
Santa Cruz River near Lochiel, AZ	82.2	141.8	67.3	2.1	3.5	6.6	0.020	937.0	1.5	Perennial
Santa Cruz River near Nogales, AZ	533.0	431.6	182.5	2.4	3.2	8.2	0.015	3517.0	1.7	Intermittent
Seven Springs Wash	9.7	48.0	70.0	1.5	2.7					Perennial
Sonoita Creek near Patagonia, AZ	209.0	218.9	110.8	2.0	4.4	9.1	0.022	2000.0	1.5	Perennial
Sycamore Creek near Ft. McDowell, AZ	164.0	191.3	89.1	2.3	3.9	6.8	0.041	1300.0	1.5	Perennial
Tonto Creek abv Gun Ck nr Roosevelt, AZ	675.0	813.9	179.9	4.5	7.5	6.1	0.013	5000.0	1.3	Perennial
Trib to Dry Beaver Cr. (Hog Canyon)	4.9	24.4	23.0	1.1	1.9					Ephemeral
Turkey Cr. Near Aravaipa confluence	21.0	70.7	43.0	1.6	2.5					Ephemeral
Verde River near Camp Verde, AZ	5009.0	799.0	171.0	4.7	8.6	5.3	0.060	4225.0	1.3	Perennial
Verde River near Clarkdale, AZ	3503.0	380.5	123.7	3.1	6.0	6.3	0.048	2400.0	1.3	Perennial
Verde River near Pauldin, AZ	2507.0	171.3	92.4	1.8	5.4	5.5	0.043	947.0	1.7	Perennial
Walnut Gulch Flume 10	6.4	31.4	22.8	1.4	1.7	0.0	0.000	0.0		Ephemeral
Walnut Gulch Flume 9	9.1	37.1	24.3	1.5	2.1	0.0	0.000	0.0		Ephemeral
Weber Cr.	14.6	31.9	30.0	1.1	1.7					Ephemeral
West Clear Creek near Camp Verde, Az	241.0	391.0	102.0	3.8	5.1	3.9	0.100	2576.0	1.4	Perennial
Wet Beaver Creek near Rimrock, AZ	111.0	245.0	90.0	2.7	4.5	4.8	0.070	1185.0	1.4	Perennial

Appendix 3: Arizona Province Sites:

Delineative Criteria for Channel Classification

Gage Name	W/D	ER	Slope	Sinuosity	Bed Material	Channel Type	RI
Agua Fria River near Mayer, AZ	41.8	1.5	0.005	1.1	Fine Sand	B5	1.1
Altar Wash near Three Points, AZ	89.9	2.1	0.005	1.1	Very Fine Sand	C5	1.1
Aravaipa at upper gage	14.1	4.0	0.007	1.1	Very Coarse Sand	C5	
Aravaipa Creek near Mammoth, AZ	61.5	1.8	0.007	1.0	Coarse Gravel	B4c	1.1
Bear Canyon Campground	12.4	1.5	0.014	1.1	Very Fine Gravel	B4c	
Bray Cr. Above Control Rd.	20.9	1.4	0.021	1.2	Very Coarse Gravel	B4	
Campaign Creek	17.4	2.2	0.014	1.1	Very Fine Gravel	C4	
Canada del Oro near Oracle Jct., AZ	23.0	1.5	0.018	1.1	Coarse Gravel	B4c	1.8
Catalina State Park	18.8	2.0	0.009	1.1	Medium Gravel	B4c	
Cave Cr. Above campground	61.4	1.3	0.012	1.1	Very Coarse Gravel	F4	
Cherry Creek near Globe, AZ	17.6	1.8	0.013	1.4	Very Coarse Gravel	B4c	1.6
Cienega Creek below Stevenson Canyon	63.9	1.2	0.012	1.2	Silt/Clay	F6	1.5
Cienega Creek near Pantano, AZ	54.2	1.9	0.003	1.1	Very Fine Gravel	B4c	
Clover Wash (near Deer Cr.)	41.8	1.3	0.011	1.1	Coarse Gravel	F4	
Creek at mm 233 Beeline Hwy.	16.3	1.4	0.023	1.2	Small Cobble	B3	
Davidson Canyon	29.3	1.7	0.009	1.1	Coarse Sand	B5c	1.3
Devore Wash off Hwy. 88	26.8	1.1	0.026	1.1	Very Fine Gravel	F5b	
Dry Beaver Creek near Rimrock, AZ	47.6	2.1	0.012	1.1	Small Cobbles	B3c	1.4
Dude Cr. Below Dry Dude	18.3	1.7	0.027	1.1	Small Cobble	B3	
East Verde River	35.5	1.5	0.016	1.3	Very Coarse Gravel	B4c	
East Verde River near Pine, AZ	20.8	1.5	0.018	1.0	Very Coarse Gravels	B4c	1.4
Ephemeral wash nr Luckachukai	38.5	1.2	0.008	1.3	Very Fine Gravel	F4	
Lizard Wash below Luckachukai	32.3	2.3	0.015	1.2	Coarse Sand	C5	
Luckachukai (ab. Lower Crossing)	12.6	3.3	0.021	1.1	Medium Gravel	C4b	
Luckachukai (Upper Crossing	21.1	2.2	0.007	1.1	Medium Gravel	C4	
Luckachukai Wash below School	26.4	2.3	0.015	1.3	Silt/Clay	C6	
Luckachukai Wash Gage	12.0	1.6	0.005	1.2	Medium Sand	B6	
Near A+ Road Jct. With Hwy. 188	58.0	1.4	0.086	1.0	Fine Gravel	B5a	
New River near Rock Springs, Az	36.2	1.5	0.017	1.1	Small Cobble	B3c	1.3
Pantano Wash above Dam	30.6	2.4	0.007	1.1	Medium Sand	C5	
Pine Creek	22.8	1.2	0.021	1.1	Small Cobble	F3b	
RackenSack Canyon	17.3	2.2	0.029	1.1	Coarse Gravel	C4b	
Red Tank Draw near Rimrock, AZ	51.0	1.5	0.010	1.2	Small Cobble	B3c	
Rincon Creek near Tucson, AZ	26.0	1.9	0.006	1.1	Very Coarse Sand	B5c	1.7
Rye Creek near Gisela, AZ	22.6	2.6	0.008	1.2	Coarse Gravel	C4	1.4
Sabino Creek near Tucson, AZ	18.5	2.6	0.018	1.2	Very Coarse Gravel	C4	
San Pedro River at Charleston, AZ	35.6	1.8	0.001	1.1	Medium Sand	B5c	1.1
San Pedro River near Palominas, AZ	19.1	3.1	0.003	1.1	Medium Sand	C5	1.1
San Pedro River near Tombstone, AZ	37.4	2.0	0.002	1.1	Medium Sand	B4c	1.1
San Pedro River Tributary near Bisbee, AZ	27.8	1.5	0.007	1.1	Medium Gravel	B4c	1.1
Sand Wash nr Gisela	20.8	2.9	0.032	1.1	Very Coarse Sand	C5b	
Santa Cruz River near Continental, AZ	39.8	1.2	0.009	1.1	Silt/Clay	F6	1.6
Santa Cruz River near Lochiel, AZ	31.9	1.7	0.003	1.1	Medium Gravel	B4c	1.5
Santa Cruz River near Nogales, AZ	77.2	1.1	0.002	1.1	Coarse Sand	F5	1.7
Seven Springs Wash	21.4	2.2	0.010	1.1	Medium Gravel	C4	
Sonoita Creek near Patagonia, AZ	56.1	1.7	0.007	1.1	Fine Gravel	B4c	1.5
Sycamore Creek near Ft. McDowell, AZ	37.8	1.4	0.012	1.1	Coarse Gravel	B4c	1.5
Tonto Creek above Gun Ck near Roosevelt, AZ	39.8	1.4	0.000	1.1	Coarse Gravel	F4	1.3
Trib to Dry Beaver Cr. (Hog Canyon)	21.7	1.6	0.031	1.1	Very Coarse Gravel	B4	
Turkey Cr. Near Aravaipa confluence	26.2	1.5	0.008	1.1	Fine Gravel	B4c	
Verde River near Camp Verde, AZ	36.6	1.5	0.006	1.0	Small Cobbles	B3c	1.3
Verde River near Clarkdale, AZ	40.2	1.7	0.009	1.5	Very Coarse Gravel	B4c	1.3
Verde River near Pauldin, AZ	49.8	1.5	0.016	1.1	Medium Sand	B5c	1.7
Walnut Gulch Flume 10	16.6	2.7	0.012	1.0	Coarse Sand	C5	
Walnut Gulch Flume 9	15.9	2.1	0.005	1.0	Very Fine Gravel	C4	
Weber Cr.	28.2	2.5	0.021	1.2	Very Coarse Gravel	C4b	
West Clear Creek near Camp Verde, Az	29.0	1.5	0.013	1.2	Small Cobbles	B3c	1.4
Wet Beaver Creek near Rimrock, AZ	28.0	1.6	0.014	1.1	Large Cobbles	B3c	1.4

Appendix 4: New Mexico Province Sites:

Bankfull Data

Site Name	Watershed Area (mi2)	X-section Area (ft2)	Width (ft)	Mean Depth (ft)	Max Depth (ft)	Velocity (fps)	Mannings N	Discharge (cfs)	Recurrence Interval (fears)	Stream Flow
Apache #2-East of Picture Tank	2.5	6.6	16.0	0.4	0.8					Ephemeral
Apache Creek	135.0	43.5	53.0	0.8	1.6					Intermittent
Apache Creek trib (Red Steer Canyon)	2.2	8.2	15.0	0.5	0.9					Ephemeral
Blue River near Clifton,AZ	506.0	125.2	57.8	2.2	3.3					Perennial
Bluewater Creek ab Bluewater Dam, NM	75.0	40.3	50.9	0.8	1.7	3.2	0.012	129.0	1.7	Perennial
Bluewater Creek above FS campground	67.3	34.0	22.0	1.5	3.2					Perennial
Bluewater Creek trib.	3.0	11.4	12.0	1.0	1.4					Ephemeral
CarrizoCreek	439.0	169.6	101.0	1.7	3.3					Perennial
Cieniguilla Creek at Gage	56.0	34.4	21.0	1.6	2.8					Perennial
Cieniquilla Creek blw Angel fire	17.5	22.4	15.5	1.4	2.0					Perennial
Cimarron River blw Miami Lane	150.7	73.0	33.0	2.2	4.1					Perennial
Coal Mine Campground	5.2	7.0	16.0	0.4	0.9					Perennial
Copperas Canyon nr Pinos Altos, NM	4.0	9.8	15.2	0.6	1.2	5.1	0.159	50.0	1.0	Ephemeral
Cottonwood Gulch	18.3	21.0	26.0	0.8	2.2					Perennial
Crownpoint#1 below Hwy.9 Bridge	40.0	22.7	25.0	0.9	2.5					Ephemeral
Deep Cr. At E. Fork White R.	8.5	16.6	13.5	1.2	2.0					Perennial
Dry Canyon	11.9	19.3	27.0	0.7	1.2					Ephemeral
Duck Creek nr Cliff, NM	228.0	196.0	58.9	3.3	4.5	6.9	0.042	1350.0	1.1	Ephemeral
E Red Canyon	20.9	13.0	16.0	0.8	1.5					Ephemeral
Eagle Creek Below South Fork nr Alto, NM	8.1	11.6	15.8	0.7	1.4	3.3	0.054	38.0	1.4	Perennial
Eagle Creek Trib #1	0.3	2.2	5.0	0.4	1.1					Intermittent
E. Fork Gila River/Grapevine Campground	1000.0	98.4	58.0	1.7	3.0					Perennial
Embudo Creek at Dixon, NM	305.0	137.7	51.1	2.7	3.9	7.1	0.038	976.0	1.8	Perennial
Frye Creek near Thatcher, AZ	4.0	14.2	12.5	1.1	1.8	2.1	0.170	30.0	1.7	Perennial
FS 547 Road - Cibola	0.3	2.4	6.5	0.4	0.7					Ephemeral
Gallinas Creek nr Montezuma, NM	84.0	65.6	36.0	1.8	3.1	4.5	0.042	297.0	1.4	Perennial
Gila River at Bird Area	2600.0	351.0	178.0	2.0	4.5					Perennial
Gila River below Blue Ck near Virden, NM	3203.0	303.2	85.0	3.6	5.3	5.7	0.032	1738.0	1.2	Perennial
Gila River blw Blue Creek nr Virden, NM	3202.0	303.2	85.0	3.6	5.3	5.7	0.032	1738.0	1.2	Perennial
Gila River near Clifton, AZ	4010.0	397.7	85.9	4.6	6.3	7.3	0.019	2900.0	1.3	Perennial
Hunter Wash	48.0	46.0	35.0	1.3	1.9					Ephemeral
Hwy 44, MP121	2.5	10.6	23.0	0.5	0.8					Ephemeral
Hwy 44, MP123	1.5	7.6	20.0	0.4	0.6					Ephemeral
Hwy. 12 outside Reserve	37.2	47.5	69.0	0.7	1.7					Ephemeral
Hwy. 32 below Apache Cr. (Largo Canyon)	23.5	34.8	22.5	1.5	2.0					Intermittent
Jct. 209 and 180	0.8	3.9	10.0	0.4	0.8					Ephemeral
Jemez River ab Rio Guadalupe, NM	220.0	59.6	35.0	1.7	2.9					Perennial
Jemez River nr Jemez, NM	470.0	190.0	72.9	2.6	4.8	5.8	0.041	1100.0	1.6	Perennial
Jewett Gap	2.0	5.8	8.0	0.7	1.3					Perennial
La Jara Arroyo, NM	96.0	44.5	52.0	0.9	1.2					Perennial
Mail Hollow nr Luna, NM	4.2	11.8	15.8	0.8	1.6	3.0	0.042	35.0	1.5	Ephemeral
Middle Fork Ponil Creek	65.0	36.9	26.0	1.4	2.2					Perennial
Mimbres River at Mimbres, NM	216.0	94.5	92.0	1.0	2.2	6.2	0.022	582.0	1.5	Perennial
Morgan Creek	17.6	10.8	16.0	0.7	1.1					Ephemeral
Mt. Taylor #1	1.2	7.0	11.0	0.4	1.0					Ephemeral
N Fork Palomas	16.1	9.7	28.0	0.3	0.9					Ephemeral
Pecos River at Pecos, NM	189.0	78.6	38.0	2.1	2.8	4.3	0.053	340.0	1.3	Perennial
Pine Canyon - Cibola	5.5	10.2	13.5	0.8	1.4					Ephemeral
Ponil Creek above Gage	168.0	40.1	23.0	1.7	2.6					Perennial
Ponil Creek nr Cimarron, NM	171.0	44.7	32.3	1.4	2.4	7.1	0.009	316.0	1.7	Perennial
Rayado Creek ab. Miami Lane	160.0	66.0	24.5	2.7	3.9					Perennial
Red River nr Questa, NM	113.0	48.1	35.1	1.4	2.4	4.2	0.037	202.0	1.6	Perennial
Rio Bonito	80.3	20.6	19.0	1.1	1.5					Perennial
Rio Brazos @ County Rd. 573	132.3	99.8	54.0	1.8	3.2					Perennial
Rio Grande blw Taos Jct. Bridge, NM	9730.0	413.8	116.7	3.6	5.9	7.0	0.013	2900.0	1.8	Perennial
Rio Grande del Rancho nr Talpa, NM	83.0	44.7	23.6	1.9	2.6	2.7	0.033	120.0	1.7	Perennial

Appendix 4: New Mexico Province Sites:

Bankfull Data (cont)

Site Name	Watershed Area (mi2)	X-section Area (ft2)	Width (ft)	Mean Depth (ft)	Max Depth (ft)	Velocity (fps)	Mannings N __	Discharge (cfs)	Recurrence Interval (fears)	Stream Flow __
Rio Hondo nr Valdez, NM	36.0	37.9	30.6	1.2	1.9	4.0	0.059	152.0	1.8	Perennial
Rio Lucero nr Arroyo Seco, NM	16.6	30.5	31.2	1.0	1.7	3.7	0.044	113.0	1.7	Perennial
Rio Mora nr Terrero, NM	53.2	48.4	33.0	1.5	1.8	3.8	0.055	182.0	1.4	Perennial
Rio Ojo Caliente at La Madera, NM	419.0	128.0	57.0	2.3	3.9	5.5	0.040	700.0	1.4	Perennial
Rio Pueblo nr Penasco, NM	101.0	71.9	41.4	1.7	3.1	5.7	0.042	411.0	1.6	Perennial
Rio Ruidoso at Hollywood, NM	120.0	37.3	26.7	1.4	2.5	4.1	0.036	152.0	1.4	Perennial
Rio Santa Barbara nr Penasco, NM	38.0	52.0	31.7	1.7	2.5	4.7	0.073	245.0	1.8	Perennial
Rock Creek above E. Fork White	21.6	21.5	24.0	0.9	1.8					Perennial
Saliz Cr. Blw Wet and Dry Leggett	17.0	23.0	22.0	1.1	2.0					Ephemeral
San Antonio Creek	46.6	42.0	27.0	1.6	2.1					Perennial
San Francisco nr Reserve (gage site)	350.0	77.3	54.0	1.4	3.6					Perennial
San Francisco River above Luna, NM	30.0	31.7	13.5	2.3	3.8					Perennial
San Francisco River nr Glenwood, NM	1653.0	227.8	110.8	2.1	4.3	6.1	0.017	1400.0	1.4	Perennial
Sandy Wash at Catron Billboard	3.3	7.8	18.0	0.4	0.6					Ephemeral
Santa Fe above Cochiti Reservoir, NM	200.0	72.4	29.0	2.5	3.7	8.1	0.028	585.0	1.5	Perennial
Sixteen Springs Canyon	19.9	13.9	19.0	0.7	1.7					Ephemeral
Tajique Campground	17.3	14.6	23.0	0.6	1.2					Perennial
Trib to Copperas Canyon #1	1.2	5.8	9.0	0.6	1.1					Ephemeral
Trib to Largo Cr.-Apache NF	3.6	7.0	12.3	0.6	1.1					Ephemeral
Trib to Trout Creek on hwy 15	2.6	8.5	15.5	0.5	0.8					Intermittent
Tularosa River ab Aragon, NM	94.0	20.4	19.8	1.0	1.9	2.4	0.041	48.0	1.6	Perennial
Tularosa River below Canyon	426.0	48.3	36.5	1.3	2.3					Ephemeral
V1 Canyon	6.8	15.0	16.0	0.9	1.3					Ephemeral
Water Canyon	16.4	10.8	23.0	0.5	1.2					Ephemeral
White Oaks Draw	25.6	42.3	34.0	1.2	2.1					Ephemeral
Whitewater Creek at Catwalk	35.0	35.7	38.0	0.9	1.1					Ephemeral

Appendix 4: New Mexico Province Site Data:

Delineative Criteria for Channel Classification

Gage Name	W/D	ER	Slope	Sinuosity	Bed Material	Channel Type	RI
Apache #2-East of Picture Tank	38.9	1.7	0.005	1.1	gravel	B4c	
Apache Creek	64.6	1.7	0.008	1.2	Sand	B5c	
Apache Creek trib (Red Steer Canyon)	27.4	1.6	0.024	1.2	Gravel	B4	
Blue River near Clifton,AZ	26.7	2.0	0.002	1.3	Medium Gravel	C4	
Bluewater Creek ab Bluewater Dam, NM	64.3	2.2	0.001	1.4	Fine Sand	C5	1.7
Bluewater Creek above FS campground	14.3	2.6	0.007	1.2	sand	C5	
Bluewater Creek trib.	12.6	2.8	0.021	1.1	Gravel	C4b	
CarrizoCreek	60.2	1.7	0.006	1.3	Very Coarse Gravel	B4c	
Cieniguilla Creek at Gage	12.8	5.2	0.004	1.8	Silt	E6	
Cieniquilla Creek blw Angel fire	10.7	3.9	0.004	1.6	sand	E5	
Cimarron River blw Miami Lane	14.9	3.0	0.002	1.2	sand	C5	
Coal Mine Campground	36.6	1.8	0.038	1.2	Sand	B5	
Copperas Canyon nr Pinos Altos, NM	23.6	1.4	0.026	1.1	Med Gravel	B4	1.0
Cottonwood Gulch	32.2	1.9	0.025	1.1	Cobble	B3	
Crownpoint#1 below Hwy.9 Bridge	27.6	2.5	0.002	1.2	Silt	C6	
Deep Cr. At E. Fork White R.	11.0	1.7	0.034	1.1	Very Coarse Gravel	B4	
Dry Canyon	37.8	1.7	0.029	1.2	Gravel	B4	
Duck Creek nr Cliff, NM	17.7	1.2	0.008	1.1	sand	F5	1.1
E Red Canyon	19.8	2.9	0.018	1.1	Gravel	C4	
Eagle Creek Below South Fork nr Alto, NM	21.5	1.9	0.022	1.1	Coarse Gravel	B4	1.4
Eagle Creek Trib #1	11.3	2.6	0.127	1.1	Gravel	A4a+	
East Fork Gila river at Grapevine Campground	34.2	1.6	0.005	1.2	Gravel	B4	
Embudo Creek at Dixon, NM	19.0	2.7	0.010	1.2	Gravel	C4	1.8
Frye Creek near Thatcher, AZ	11.1	3.1	0.100	1.1	Large Cobble	A3	1.7
FS 547 Road - Cibola	17.8	1.9	0.031	1.3	Sand	B5	
Gallinas Creek nr Montezuma, NM	19.7	1.9	0.008	1.2	Gravel	B4c	1.4
Gila River at Bird Area	90.2	2.0	0.004	1.2	Gravel	B4c	
Gila River below Blue Ck near Virden, NM	23.8	3.9	0.003	1.1	Medium Sand	C5	1.2
Gila River blw Blue Creek nr Virden, NM	23.8	3.9	0.003	1.1	Med Sand	C5	1.2
Gila River near Clifton, AZ	18.6	3.0	0.001	1.1	Medium Sand	C5	1.3
Hunter Wash	26.8	1.6	0.005	1.1	Silt	B6c	
Hwy 44, MP121	50.0	1.2	0.009	1.2	sand	F5	
Hwy 44, MP123	53.0	1.4	0.009	1.1	sand	F5	
Hwy. 12 outside Reserve	100.2	1.5	0.015	1.2	Gravel	B4c	
Hwy. 32 below Apache Cr. (Largo Canyon)	14.6	1.7	0.013	1.1	gravel	B4c	
Jct. 209 and 180	25.8	1.6	0.029	1.1	Gravel	B4	
Jemez River ab Rio Guadalupe, NM	20.5	4.3	0.005	1.2	Gravel	C4	
Jemez River nr Jemez, NM	27.9	2.3	0.008	1.2	Coarse Gravel	C4	1.6
Jewett Gap	11.1	3.4	0.037	1.1	Cobble	E3b	
La Jara Arroyo, NM	60.8	1.9	0.009	1.1	sand	B5c	
Mail Hollow nr Luna, NM	21.2	2.9	0.010	1.3	Coarse Sand	C5	1.5
Middle Fork Ponil Creek	18.3	2.7	0.013	1.3	GRAVEL	C4	
Mimbres River at Mimbres, NM	89.6	2.1	0.009	1.1	V Coarse Gravel	C4	1.5
Morgan Creek	23.8	1.9	0.011	1.1	Gravel	B4c	
Mt. Taylor #1	26.3	2.7	0.086	1.1	gravel	C4a	
N Fork Palomas	81.1	2.7	0.014	1.1	Fine gravel	C4	
Pecos River at Pecos, NM	18.4	1.6	0.009	1.1	Cobble	B3c	1.3
Pine Canyon - Cibola	17.9	3.0	0.005	1.2	Gravel	C4	
Ponil Creek above Gage	13.2	2.3	0.003	1.2	Fine gravel	C5	
Ponil Creek nr Cimarron, NM	23.4	2.2	0.001	1.1	Gravel	C4	1.7
Rayado Creek ab. Miami Lane	9.1	2.7	0.006	1.3	gravel	C4	
Red River nr Questa, NM	25.6	2.2	0.007	1.4	Gravel	C4	1.6
Rio Bonito	19.6	2.3	0.006	1.2	Gravel	C4	
Rio Brazos @ County Rd. 573	29.2	3.7	0.015	1.1	cobble	C3	
Rio Grande blw Taos Jct. Bridge, NM	32.9	1.7	0.001	1.0	Gravel	B4c	1.8
Rio Grande del Rancho nr Talpa, NM	12.5	2.6	0.002	1.1	Gravel	C4	1.7
Rio Hondo nr Valdez, NM	24.7	1.8	0.019	1.1	Large Gravel	B4	1.8
Rio Lucero nr Arroyo Seco, NM	31.8	1.6	0.013	1.1	Coarse Gravel	B4	1.7
Rio Mora nr Terrero, NM	22.5	1.2	0.012	1.2	Gravel	F4	1.4

Appendix 4: New Mexico Province Site Data:

Delineative Criteria for Channel Classification (cont)

Gage Name	W/D	ER	Slope	Sinuosity	Bed Material	Channel Type	RI
Rio Ojo Caliente at La Madera, NM	25.4	1.9	0.008	1.1	Fine Gravel	B4c	1.4
Rio Pueblo nr Penasco, NM	23.8	5.2	0.013	1.1	Small cobble	C3	1.6
Rio Ruidoso at Hollywood, NM	19.1	1.6	0.007	1.1	Coarse Gravel	B4c	1.4
Rio Santa Barbara nr Penasco, NM	19.2	2.3	0.028	1.1	Small cobble	B3	1.8
Rock Creek above E. Fork White	26.8	1.2	0.045	1.1	Very Coarse Gravel	B4a	
Saliz Cr. Blw Wet and Dry Leggett	20.9	2.0	0.016	1.2	gravel	B4c	
San Antonio Creek	17.4	2.0	0.014	1.1	Cobble	B3c	
San Francisco nr Reserve (gage site)	37.7	2.6	0.005	1.2	Sand	C5	
San Francisco River above Luna, NM	5.8	6.7	0.012	1.1	Cobble	E3	
San Francisco River nr Glenwood, NM	53.9	1.9	0.002	1.3	Med Sand	B5c	1.4
Sandy Wash at Catron Billboard	41.3	2.1	0.015	1.2	Sand	C5	
Santa Fe above Cochiti Reservoir, NM	11.6	1.9	0.007	1.3	Gravel	B4c	1.5
Sixteen Springs Canyon	26.0	1.5	0.015	1.1	Gravel	B4c	
Tajique Campground	36.4	1.6	0.006	1.1	Small Gravel	B4c	
Trib to Copperas Canyon #1	14.1	2.4	0.038	1.2	Gravel	C4b	
Trib to Largo Cr.-Apache NF	21.6	1.8	0.010	1.1	sand	B5c	
Trib to Trout Creek on hwy 15	28.2	1.2	0.010	1.1	Gravel	F4	
Tularosa River ab Aragon, NM	19.2	2.6	0.004	1.1	Sand	C5	1.6
Tularosa River below Canyon	27.6	1.7	0.004	1.2	Sand	B5c	
V1 Canyon	17.0	2.3	0.024	1.1	gravel	C5b	
Water Canyon	49.0	1.6	0.025	1.1	gravel	B4	
White Oaks Draw	27.3	3.2	0.022	1.1	gravel	C4b	
Whitewater Creek at Catwalk	40.5	1.1	0.020	1.1	Gravel	F4	

Appendix 5: Navajo Nation Sites:

Bankfull Channel Data

Site Name	Watershed Area (mi2)	X-section Area (ft2)	Width (ft)	Mean Depth (ft)	Max Depth (ft)	Stream Flow
Asaayi Creek @ Gage	14.6	19.10	16.0	1.2	2.1	Perennial
Begashibito wash	82.0	129.60	56.0	2.3	2.6	Ephemeral
Black Creek BEHI Site	500.0	74.50	56.0	1.3	2.9	Perennial
Black Creek nr Fort Defiance	158.0	50.10	42.0	1.2	2.0	Perennial
Black Creek nr Houck	625.5	79.60	37.0	2.2	4.8	Perennial
Black Falls	8.9	47.40	45.0	1.1	1.4	Ephemeral
Black Rock Canyon	35.7	24.00	26.0	0.9	1.3	Ephemeral
Chilchinbito Creek Below Highway Bridge	43.5	60.80	42.0	1.4	2.1	Intermittent
Chinle Creek nr Mexican Water, AZ	3650.0	244.50	63.0	3.9	6.6	Perennial
Chinle Wash near Chinle	639.0	70.40	120.0	0.6	0.8	Intermittent
Chinle Wash nr White House Ruins	368.0	46.70	25.0	1.9	2.4	Perennial
Cutfoot Wash	8.1	16.20	18.0	0.9	1.3	Intermittent
East Dinnebito Wash above hwy 41	45.0	55.80	26.7	2.1	3.0	Ephemeral
Fish Wash	29.0	25.00	21.0	1.1	2.0	Ephemeral
Five-mile wash	58.0	72.90	57.0	1.3	1.8	Ephemeral
Ganado	206.0	52.90	36.0	1.4	2.3	Perennial
Kah Bihghi Valley, Cove Wash	30.0	46.40	44.0	1.1	1.9	Ephemeral
Kinlichi Wash	131.2	51.50	32.0	2.5	1.6	Perennial
Laguna Creek @ Dinnehotso	414.0	64.00	32.0	2.0	3.1	Perennial
Landmark Wash	41.7	53.80	56.0	1.0	1.3	Ephemeral
Lizard Wash (‘01)	9.5	21.10	16.0	1.3	1.6	Ephemeral
Lizard Wash (‘98)	19.0	39.50	32.0	1.2	2.0	Ephemeral
Lukachukai @ Gage	91.0	89.90	54.3	1.7	3.1	Perennial
Moenave Wash	8.3	26.60	28.0	1.0	1.2	Ephemeral
Moenkopi Wash Above Tuba City	1038.0	127.90	44.0	2.9	4.3	Perennial
Moenkopi Wash nr Moenkopi, AZ	1629.0	123.50	55.0	2.2	3.3	Perennial
Naschiti Wash	8.6	23.30	30.0	0.8	1.9	Ephemeral
Nazlini	52.2	41.90	48.0	0.9	1.7	Perennial
Oraibi Wash	203.0	124.10	55.0	2.3	4.0	Ephemeral
Parrish Creek blw Cutfoot	31.5	44.00	56.0	0.8	1.1	Ephemeral
Parrish Wash ab Cutfoot	23.5	30.00	54.0	0.5	0.8	Ephemeral
Polaka Trib near Blue Gap	5.4	18.00	24.5	0.8	1.3	Ephemeral
Sanostee	39.0	47.80	42.0	1.1	2.0	Ephemeral
Sourwater Canyon	18.8	19.60	18.0	1.1	1.7	Ephemeral
Tappan Wash	103.0	52.00	30.0	1.7	2.8	Ephemeral
Tocito Wash	52.0	47.70	22.0	2.2	2.5	Ephemeral
Tsaile Creek	47.0	29.20	20.0	1.5	3.2	Perennial
Tsaile Creek Gage	36.7	25.70	16.0	1.6	3.4	Perennial
Tsegi Canyon	80.0	50.20	54.0	0.9	1.3	Ephemeral
Western Trib	1.2	21.70	18.0	1.2	1.7	Ephemeral
Wheatfield Creek	49.0	50.40	29.0	1.7	3.5	Perennial

Appendix 5: Navajo Nation Sites:

Delineative Criteria for Channel Classification

Gage Name	W/D	ER	Slope	Sinuosity	Bed Material	Channel Type
AgAsaayi Creek @ Gage	13.4	4.1	0.015	1.1	Gravel	E4
Begashibito wash	24.2	2	0.004	1.4	Sand	B5c
Black Creek BEHI Site	42.1	1.6	0.001	1.3	Sand	B5c
Black Creek nr Fort Defiance	35.2	4	0.003	1.2	Sand	C5
Black Creek nr Houck	17.2	3.5	0.005	1.3	Gravel	C4
Black Falls	42.7	2.2	0.004	1.1	Sand	C5
Black Rock Canyon	28.2	1.9	0.004	1.2	Sand	B5c
Chilchinbito Creek Below Highway Bridge	29	1.5	0.004	1.1	Sand	B5c
Chinle Creek nr Mexican Water, AZ	16.2	3.2	0.001	1.3	Silt/Clay	C6
Chinle Wash near Chinle	204.5	1.5	0.003	1.2	Sand	F5
Chinle Wash nr White House Ruins	13.4	1.5	0.004	1.2	Gravel	B4c
Cutfoot Wash	20	1.8	0.003	1.2	Sand	B5c
East Dinnebito Wash above hwy 41	12.8	1.6	0.004	1.4	Sand	B5c
Fish Wash	17.7	3.1	0.003	1.1	Sand	C5
Five-mile wash	44.5	1	0.004	1.2	Sand	F5
Ganado	25.6	1.5	0.002	1.1	Sand	B5c
Kah Bihghi Valley, Cove Wash	41.8	5.3	0.006	1.3	Sand	C5
Kinlichi Wash	19.9	1.6	0.003	1.2	Sand	B5c
Laguna Creek @ Dinnehotso	16	1.9	0.004	1.3	Silt/Clay	B6c
Landmark Wash	58.3	1.6	0.007	1.1	Sand	B5c
Lizard Wash (‘01)	12.1	2.5	0.018	1.2	Sand	C5
Lizard Wash (‘98)	26	2.3	0.015	1.2	Sand	C5
Lukachukai @ Gage	32.8	2.5	0.012	1.2	Gravel	C4
Moenave Wash	29.5	2	0.007	1.3	Sand	B5c
Moenkopi Wash Above Tuba City	15.1	2	0.002	1.2	Sand	B5c
Moenkopi Wash nr Moenkopi, AZ	24.5	1.8	0.002	1.3	Silt/Clay	B6c
Naschiti Wash	38.7	1.7	0.013	1.2	Gravel	B4
Nazlini	54.9	1.6	0.008	1.3	Sand	B5c
Oraibi Wash	24.4	3.6	0.003	1.4	Silt/Clay	C6
Parrish Creek blw Cutfoot	74.1	1.8	0.003	1.1	Sand	B5c
Parrish Wash ab Cutfoot	107.1	1.3	0.002	1.3	Sand	F5
Polaka Trib near Blue Gap	29.8	1.4	0.009	1.4	Sand	B5c
Sanostee	36.9	1.4	0.011	1.3	Sand	F5
Sourwater Canyon	16.5	2.9	0.005	1.3	Sand	C5
Tappan Wash	17.3	2.9	0.007	1	Gravel	C4
Tocito Wash	10.1	2	0.005	1.3	Sand	B5c
Tsaile Creek	13.7	4.4	0.01	1.3	Sand	C5
Tsaile Creek Gage	9.9	12.5	0.005	1.4	Gravel	E4
Tsegi Canyon	58.1	1.6	0.003	1.4	Sand	C5
Western Trib	14.9	4.9	0.013	1.2	Sand	C5
Wheatfield Creek	16.7	2.8	0.08	1.2	Gravel	C4
Wheatfields Creek @ Gage	19.5	2	0.015	1.1	Gravel	C4
Whiskey Creek	17.6	7	0.08	1.2	Gravel	C4
Whiskey Creek @ Gage	9.3	5.4	0.017	1.3	Gravel	E4