2 SITE DESCRIPTION AND BACKGROUND

The Bernalillo Bridge reach of the Middle Rio Grande spans 5.10 miles from New Mexico Highway 44 (agg/deg 298) to cross section CO-33 (agg/deg line 351) (Figure 1-1). The reach is generally straight with a sinuosity close to one and an average valley slope of 0.0010. This reach is characterized by a bimodal sediment size distribution, from medium sand to coarse gravel.

Historically, the middle Rio Grande was a relatively straight, braided channel (Baird 1996). In addition, the river bed was characterized by an aggradational trend, which might have started about 11,000 to 22,000 years ago (Sanchez et al. 1997). Increasing sedimentation of the river bed began after 1850 due to water shortage and increasing sediment input from tributaries and arroyos (Scurlock 1998). The aggradation of the river bed induced severe flooding, waterlogged lands and failing irrigation facilities (Scurlock 1998).

The Middle Rio Grande Conservancy District was organized in 1925 for the main purpose of improving drainage, irrigation and flood control in the middle valley (Woodson and Martin 1962). A floodway was constructed in the early 1930's to provide flood protection to the adjacent irrigated and urban areas (Woodson 1961). In addition, the Conservancy District built El Vado Dam on the Rio Chama in 1935, four diversion dams along the main stem, two canal headings and many miles of drainage and irrigation canals (Lagasse 1980).

Further aggradation and seepage induced deterioration of the floodway and suggested the need for regulation of flood flows, sediment retention and channel stabilization (Woodson and Martin 1962). The Corps of Engineers and the United States Bureau of Reclamation (USBR) together with other Federal, State and local agencies recommended a comprehensive plan of improvement for the Rio Grande in New Mexico in 1948 (Pemberton 1964). The plan consisted of constructing a system of reservoirs on the Rio Grande (Cochiti) and its tributaries (Abiquiu, Jemez, Galisteo) as well as the rehabilitation of the floodway constructed by the Rio Grande Conservancy District in 1935 (Woodson and Martin 1962).

Cochiti Dam, built in the Rio Grande, began impounding water and sediment in November 1973 (Lagasse 1980). Cochiti Dam was intended for flood and sediment control, preventing aggradation and inducing degradation of the main stem (Lagasse 1980). Additionally, other dams on the main tributaries (Jemez, Galisteo) and agricultural diversions (Angostura) in the main stem decrease the flow between Cochiti Dam and the Bernalillo Bridge reach.

Figure 2-1 shows a typical spring runoff hydrograph in the Middle Rio Grande. The Otowi stream gage station is located upstream of Cochiti Dam. Attenuation of the spring runoff peak between Otowi and the gages located downstream of the dam is evident in the hydrographs (Figure 2-1). Peak outflows from Cochiti can historically occur as much as 62 days after, or as much as 225 days prior to the peak inflows to the reservoir (Bullard and Lane 1993).

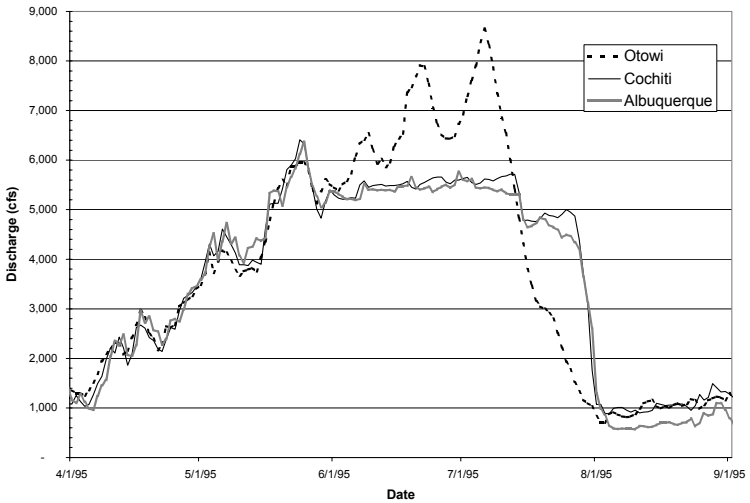

Figure 2-1 1995 Rio Grande spring runoff hydrograph

Cochiti dam also traps most of the sediment entering the reservoir from upstream. Figure 2-2 shows the change in annual suspended sediment yield from upstream of Cochiti dam to downstream. Tributary input and erosion of the channel bed and banks are the major sources of sediment to the middle Rio Grande downstream from Cochiti Dam. Increase of sediment yield between Cochiti Dam and Albuquerque gaging station is evident in Figure 2-2.

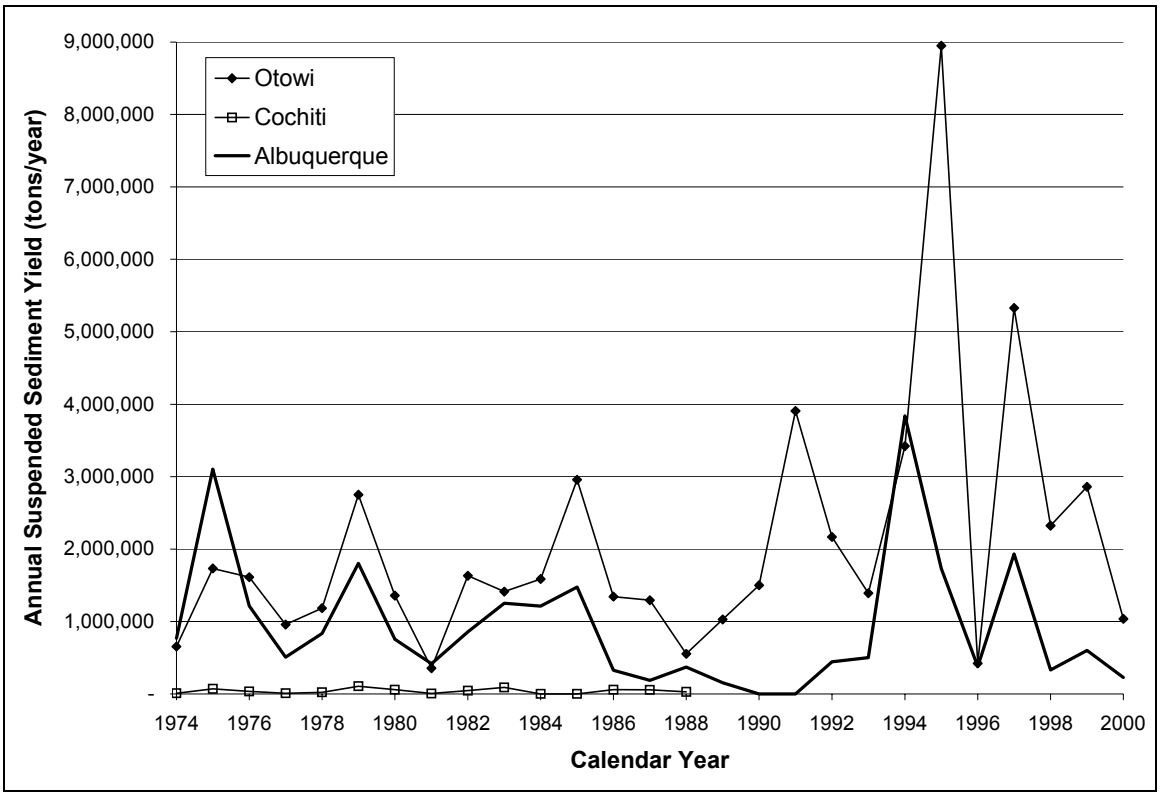

Figure 2-2 Annual suspended sediment yield in the Rio Grande in tons/year at Otowi Gage (upstream of Cochiti Dam), Cochiti Gage (just downstream of Cochiti dam) and Albuquerque Gage (downstream of Cochiti Gage) from 1974 to 2000. Cochiti gage record ends in 1988.

Two ephemeral tributaries, Arroyo Venada and Arroyo de la Barranca, join the study reach from the west. A third tributary, Arroyo de las Lomitas Negras, enters the river from the west just downstream of the study reach. Arroyo de la Barranca has a noticeable delta at the confluence with the main channel. The locations of these arroyos are indicated in the aerial photo in Figures 2-4 and 2-6.

2.1 SUBREACH DEFINITION

The Bernalillo Bridge reach was subdivided into three subreaches that exhibit similar channel characteristics, such as width, planform and slope to facilitate the geomorphic characterization. Subreach 1 is 1.79 miles long and spans from Highway NM-44 (Agg/Deg 298) to cross section Agg/Deg 316. Subreach 2 is 1.93 miles long and spans from cross section Agg/Deg 316 to cross section Agg/Deg 337. Subreach 3 is 1.38 miles long and spans from Agg/Deg 337 to Agg/Deg 351 (CO-33). The three subreaches are fairly straight, yielding an

average sinuosity of 1.10. Subreach 1 has vegetated bars lateral to the low flow channel. Subreach 2 has some vegetated bars within the low flow channel and subreach 3 does not exhibit vegetated islands. Subreach 1 exhibits a low flow single thread channel. Subreaches 2 and 3 show some short reaches with multiple channel patterns. Besides planform differences, the 1992 longitudinal profile reveals two slope breaks at cross sections Agg/deg 316 and Agg/deg 337. Only few cross sections were surveyed in the year 2001. Therefore, the same breaks in slopes are not noticeable in the 2001 longitudinal profile. The subreach definition is outlined in Table 2-1 and in Figures 2-3, 2-4, 2-5 and 2-6.

Table 2-1 Bernalillo Bridge reach subreach definition

	Agg/Deg Line		
	From	**To**	**Length (miles)**
Subreach 1	298	316	1.79
Subreach 2	316	337	1.93
Subreach 3	337	351	1.38

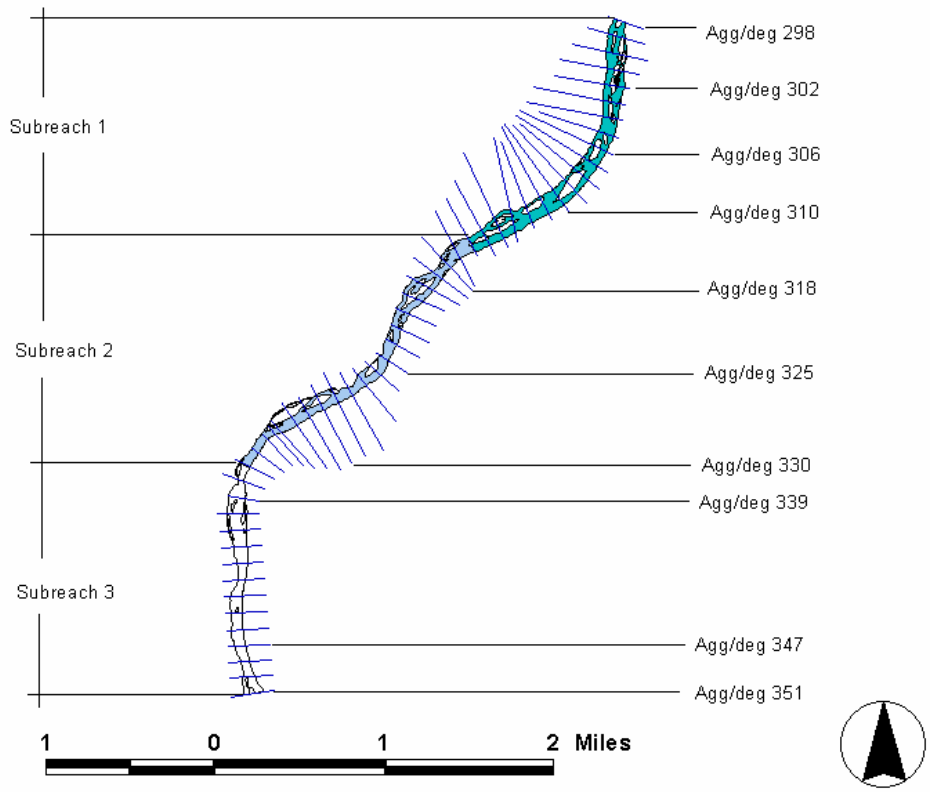

Figure 2-3 Bernalillo Bridge reach subreach definitions

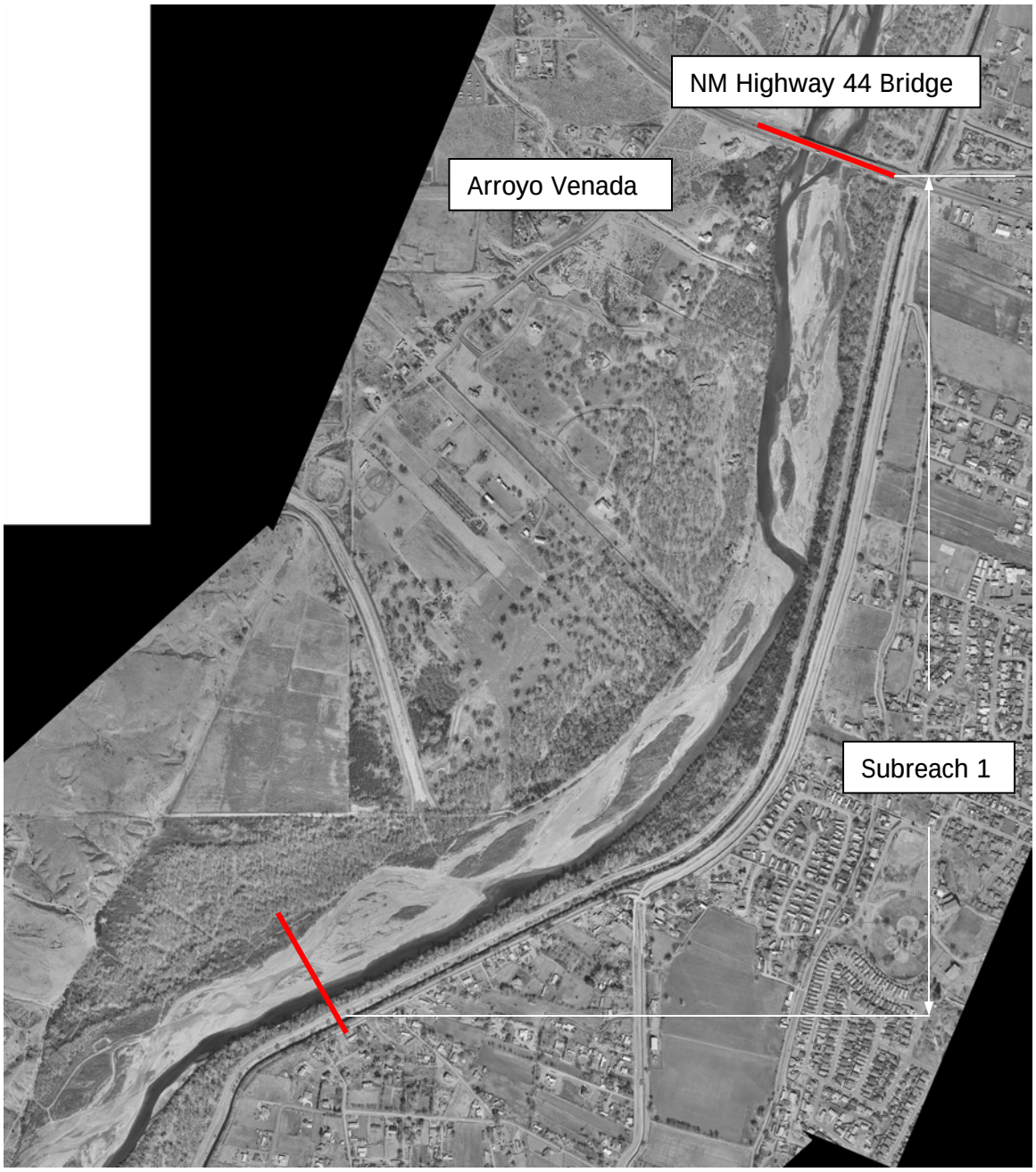

Figure 2-4 Aerial photo of subreach 1. Date of photography: Winter 2000

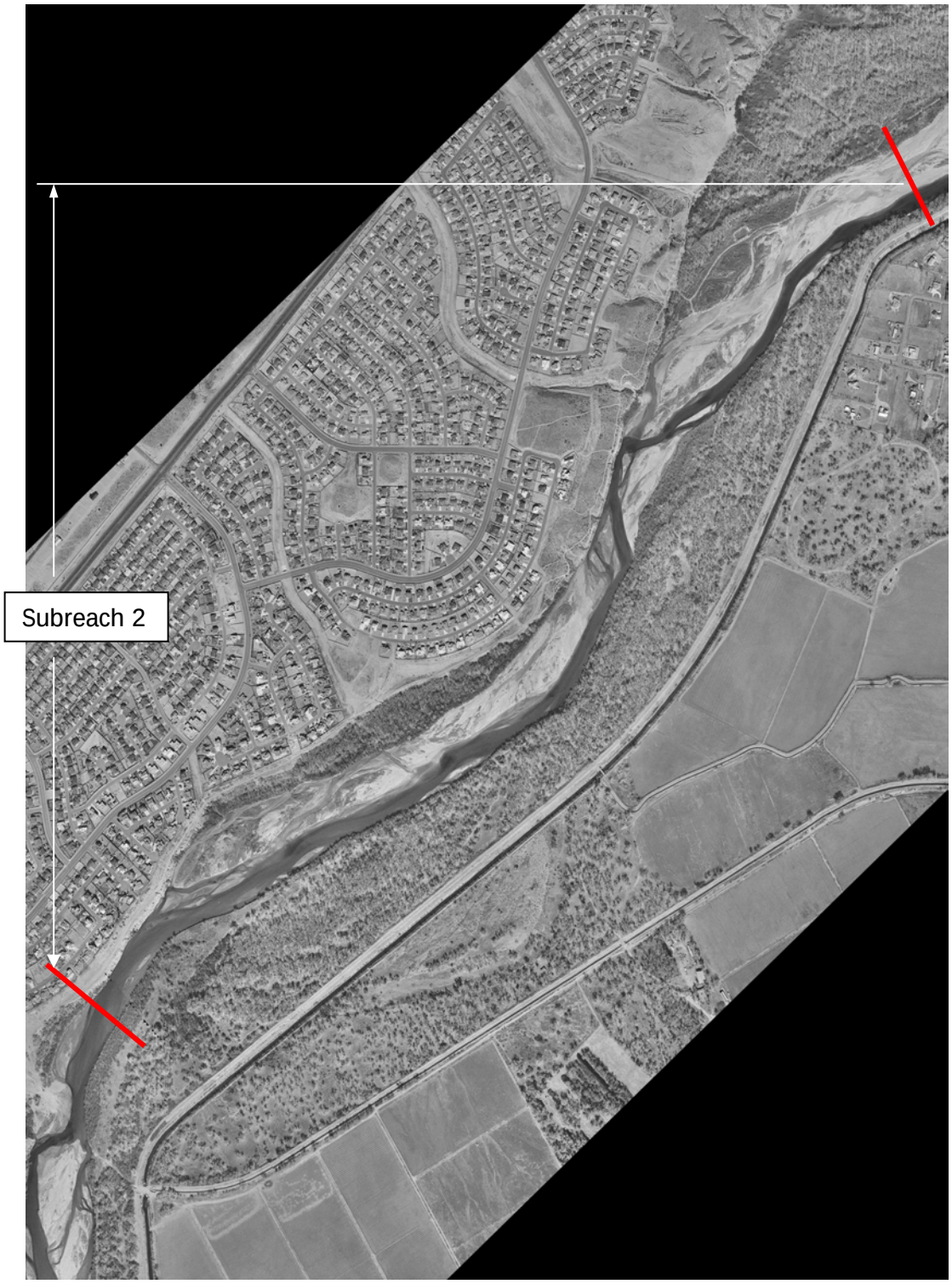

Figure 2-5 Aerial photo of subreach 2. Date of photography: Winter 2000

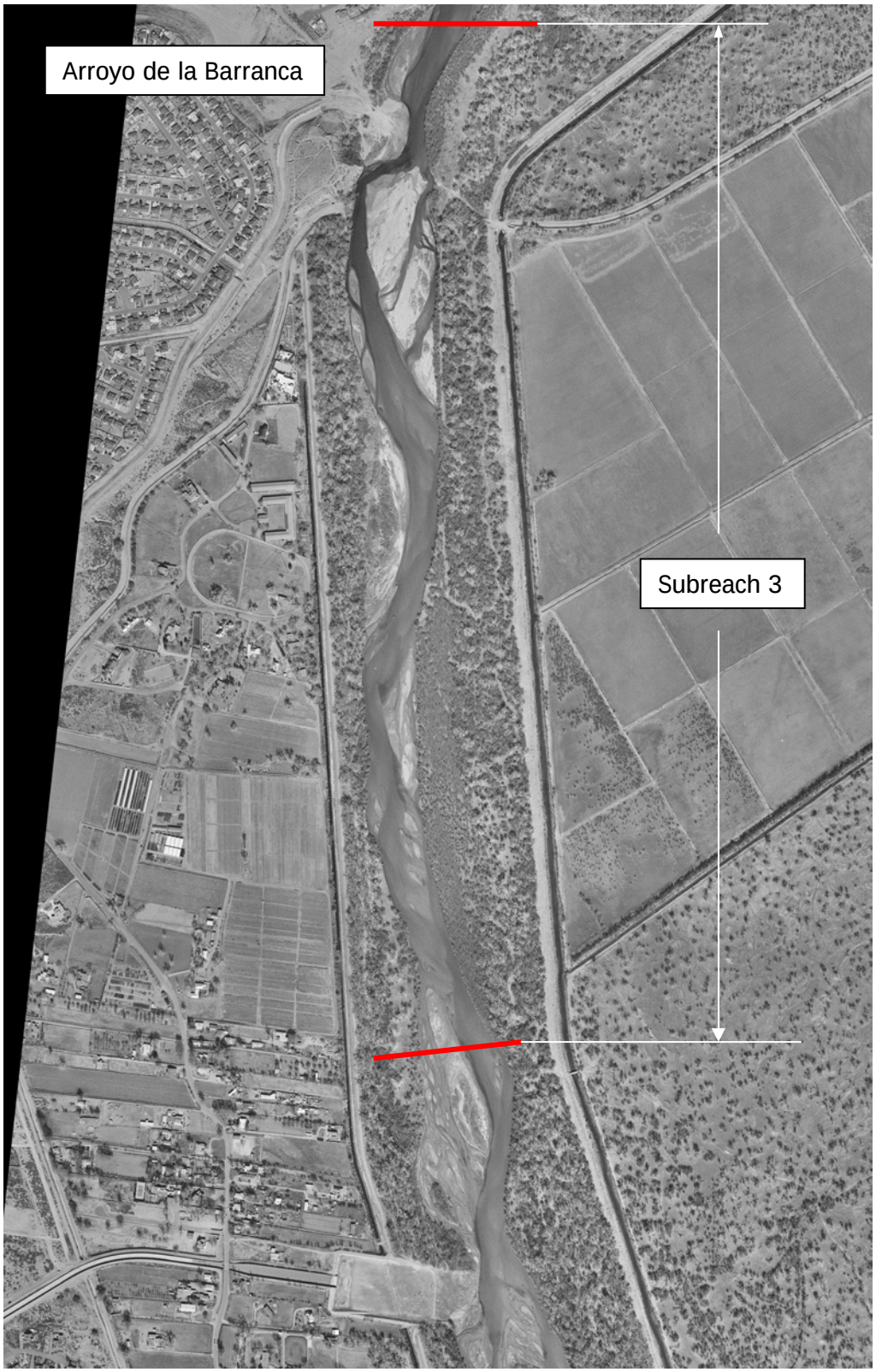

Figure 2-6 Aerial photo of subreach 3. Date of photography: Winter 2000

2.2 AVAILABLE DATA

There is one U.S. Geological Survey (USGS) gaging station (Rio Grande at Bernalillo) located in the Bernalillo reach, upstream of subreach 3 (Figure 1-1). In addition, there are two gaging stations upstream and downstream of the study reach. Rio Grande at San Felipe gaging station is located about 13 miles upstream from New Mexico Highway 44 and Rio Grande at Albuquerque gaging station is about 16.5 miles downstream from cross section CO-33. Table 2-2 summarizes the available water discharge and suspended sediment data from the USGS gages.

Table 2-2 Periods of record for discharge and continuous suspended sediment data collected by the USGS

Stations	***Mean Daily Discharge***	***Continuous Suspended Sediment Discharge***
	Period of Record	Period of Record
Rio Grande at San Felipe	1927-2001	----
Rio Grande near Bernalillo	1942-1968	1956-1969
Rio Grande at Albuquerque	1942-2001	1969-1989 1992-1999

Bed material particle size distribution data were collected at the USGS gaging stations at San Felipe, Bernalillo and Albuquerque. Table 2-3 summarizes the periods of record for the bed material data from the above-mentioned USGS gages. Additionally, bed material samples were collected at the CO-lines, BI-lines and BB-lines. BI-296 is about 0.16 miles upstream of the study reach. Table 2-4 lists the bed material surveyed dates at the CO-lines, BI-lines and BB-lines.

Table 2-3 Periods of record for bed material particle size distribution data collected by the USGS

Stations	***Bed Material Particle Size Distributions***
	Period of Record
Rio Grande at San Felipe	1970 - 1974
Rio Grande near Bernalillo	1961, 1966 - 1969
Rio Grande at Albuquerque	1969 - 2001

Table 2-4 Surveyed dates for bed material particle size distribution data at CO-lines and BI-lines collected by the US Bureau of Reclamation

Stations	***Bed Material Particle Size Distributions***
	Surveyed Date
CO-30	1971 - 1982, 1997
CO-31	1971 - 1982, 1992, 1995, 1997
CO-32	1971 1982, 1997
CO-33	1970 - 1982, 1992, 1995
BI-296	1990 - 1997
BB-301	2001
BB-307	2001
BB-318	2001
BB-327	2001
BB-340	2001
BB-345	2001

Reclamation's GIS and Remote Sensing group in Denver, CO digitized the aerial photos and topographic surveys of the study reach which are available for 1918, 1935, 1949, 1962, 1972, 1992 and 2001. Dates and scales of the aerial photos as well as the estimated mean daily discharges in the channel on the dates of the photos, according to USGS gaging stations, are summarized in Appendix A.

Aggradation/Degradation (agg/deg) line surveys, collected by the USBR, are available for 1962, 1972 and 1992. These cross section lines are photogrammetrically surveyed. The mean bed elevations were estimated by the USBR based on the water surface elevation, slope, channel roughness and discharge at the time of the survey. Agg/deg lines are approximately spaced every 500 feet apart.

There are three different sets of cross sections that have been field surveyed in this reach. The Cochiti (CO) range lines were field surveyed for the US Bureau of Reclamation. There are four lines located in this study reach (Figure 2-7). CO-30 is located 1.55 miles downstream from New Mexico Highway 44 (agg/deg 298) in subreach 1. CO-31 is located in subreach 2 and coincides with agg/deg 324. CO-32 is also located in subreach 2 and coincides with agg/deg 335. CO-33 is the last cross section in subreach 3 and corresponds to the agg/deg line 351. In addition to these four lines, there is one CO-line (CO-29) just upstream from the study reach. Table 2-5 summarizes the survey dates for the CO-Lines within the reach. CO-line plots and their corresponded agg/deg lines are included in Appendix B. There are a total of seven

Bernalillo Bridge (BB) lines along the study reach. There are two in subreach 1, three in subreach 2 and two in subreach 3. The CR-lines are downstream from the study reach. Table 2-5 lists the surveyed dates for these cross sections.

Reclamation's GIS and Remote Sensing group in Denver, CO digitized the aerial photos and topographic surveys of the study reach available for 1918, 1935, 1949, 1962, 1972, 1992 and 2001. Dates and scales of the photos as well as the estimated flow discharges in the channel during the date of the photos are summarized in Appendix A.

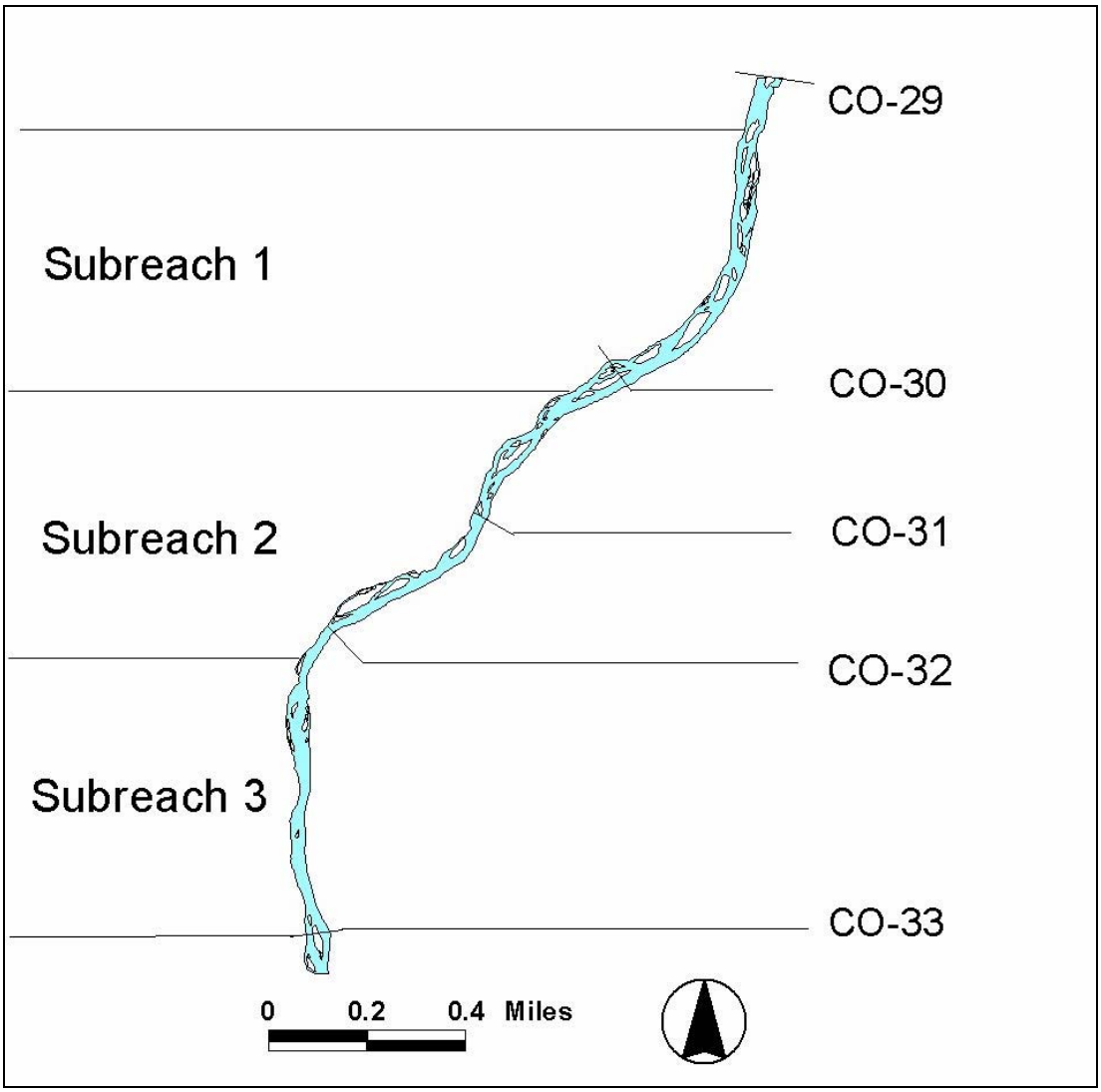

Figure 2-7 2001 River planform of the Bernalillo Bridge Reach indicating locations of CO-lines and subreaches

Table 2-5 Surveyed dates for BB and CR Lines collected by the US Bureau of Reclamation

Cross section	Dates
BB-301	13/04/01
BB-307	13/04/01
BB-318	13/04/01
BB-323	13/04/01
BB-327	13/04/01
BB-340	15/05/01
BB-345	15/05/01
CR-355	May-01
CR-361	May-01
CR-367	May-01

Table 2-6 Surveyed dates for the Cochiti range lines collected by the US Bureau of Reclamation

	Cross Section Number			
Date	CO-30	CO-31	CO-32	CO-33
May-71	x	x	x	x
Sep-71	x	x	x	x
Mar-72	x	x	x	x
Nov-72	x	x	x	x
May-73	x			
Jun-73		x	x	x
May-74	x	x	x	x
Sep-74	x		x	x
Nov-74	x	x	x	x
May-75	x	x	x	x
Jul-75	x	x	x	x
Nov-75	x	x	x	x
Apr-79	x	x	x	x
May-79			x	x
Jul-79		x	x	x
Jan-80	x	x	x	x
Oct-82	x	x	x	x
Nov-83	x	x	x	x
Nov-86	x	x	x	
Jul-92	x	x	x	x
Aug-95	x	x	x	x
Sep-98	x	x	x	x

2.3 CHANNEL FORMING DISCHARGE

Reclamation's Albuquerque office determined the channel forming discharge from discharge/frequency analysis in the Santa Ana Reach. The Bernalillo Bridge reach is the next downstream reach from the Santa Ana Restoration Project. The two year instantaneous peak discharge (Q_{2y}= 5,000 cfs) used as the channel forming discharge in the Santa Ana Geomorphic Analysis (Mosley and Boelman 1998) is also used in this work.

Figure 2-8 shows the annual maximum daily mean discharges recorded by the USGS at the San Felipe gaging station. Since 1958, there have been no flows recorded at San Felipe exceeding 10,000 cfs. Since flow regulation began at Abiquiu Dam on the Rio Chama in 1963

and on Cochiti Dam on the Rio Grande in 1973, the regulated two-year flow has decreased to 5,650 cfs (Bullard and Lane, 1993). Figure 2-9 shows annual peak flow histograms before and after 1963. Most of the flows are between 3,000 cfs and 7,000 cfs after 1963. Annual peak daily-mean discharge plots at Bernalillo and Albuquerque gages are included in Appendix C.

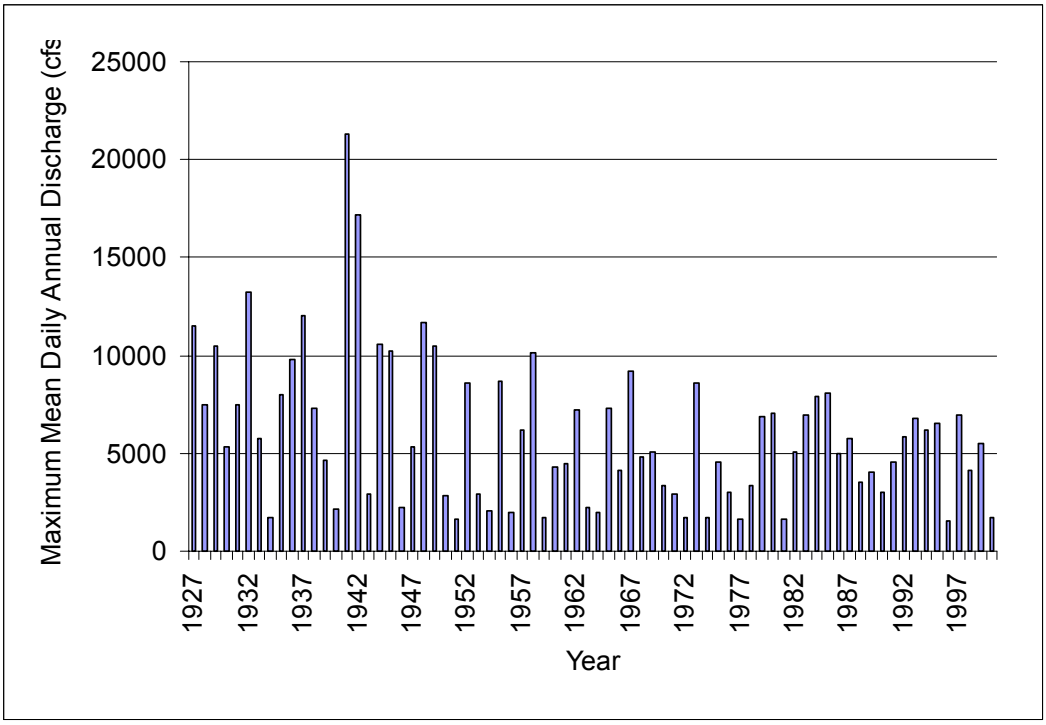

Figure 2-8 Maximum mean daily annual discharge in cfs on the Rio Grande at San Felipe (1927-2001)

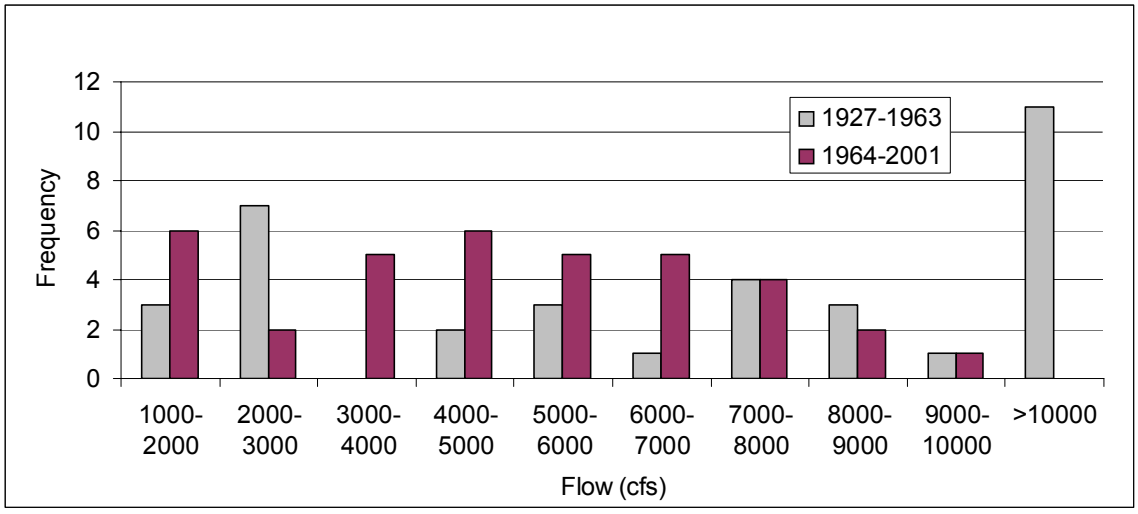

Figure 2-9 Maximum mean daily annual discharge histograms on the Rio Grande at San Felipe (1927 – 2001)

Besides flood regulation, climate changes seem to have a strong influence in the flow regime of the Rio Grande. Richard (2001) observed that the magnitude of the annual peak flows at Otowi and Cochiti gage declined with time since 1895, prior to the construction of main dams in the Rio Grande system. Cochiti gage data show a dry period from about 1942 to about 1978 (Richard 2001). Richard (2001) also determined that peak flows between 1943 and 1973 (pre-Cochiti dam) are not statistically different from those between 1974 and 1996 (post-Cochiti dam).

Molnár (2001) analyzed trends in precipitation and streamflow in the Rio Puerco, one of the largest tributary arroyos of the Rio Grande downstream from the Bernalillo Bridge reach. He concluded that statistically significant increasing trend in precipitation in the basin at the annual timescale occurred between 1948 and 1997. This increase is due to increases in non-summer precipitation, in particular in the frequency and intensity of moderate rainfall events (Molnár 2001). Molnár also concluded that there is a strong relationship between the long-term precipitation trends in the Rio Puerco Basin and the sea surface temperature anomalies in the Northern Pacific (Molnár 2001).

Also, annual maximum precipitation events seem to produce lower annual maximum runoff events in the last 50 years, most likely due to vegetation cover and hydraulic characteristics of the basin (Molnár 2001). Even though this type of analysis has not been performed in other sub-basins of the Rio Grande other than the Rio Puerco Basin, it is likely that the same trends occur in nearby areas along the Rio Grande.