Section 2.0 - Environmental Impacts

2.1 Introduction to Environmental Impacts

This section provides an overview of the natural environment of the Alamosa River watershed. The existing watershed condition is described according to the following resource categories:

- Channel of the Alamosa River and major tributaries
- Surface water quantity
- Surface water quality
- Groundwater
- Terrace Reservoir
- Sediments
- Riparian habitat (vegetative communities)
- Biological resources (wildlife resources)
- Agricultural uses
- Recreational uses

The description of the existing conditions in the watershed by resource categories is followed by a categorization of the Alamosa River into segments, a GIS mapping summary, and bibliography of previous studies.

Climate, key watershed structures, and land ownership are discussed below as an introduction to the affected environment.

2.1.1 Climate

In Capulin, in the lower watershed, the average low temperature in the coldest month, January, is 2˚F and the average high temperature in the warmest month, July, is 81˚F (Weather, 2004). In Platoro, the closest weather station to the upper watershed, the average minimum temperature in the coldest month, January, is –7˚F and the average maximum temperature in the warmest month, July, is 70˚F (WRCC, 2004a). Annual precipitation varies greatly across the watershed as shown in **Figure 2–1** . The San Juan Mountains receive an average of 55 inches of precipitation and the valley receives about 7 inches annually. The City of Alamosa receives about 30 inches of snowfall per year (NWS, 2004).

2.1.2 Key Structures in the Watershed

Terrace Reservoir divides the Alamosa into upper and lower watersheds. There are few manmade structures in the upper watershed because most of the area is located within the Rio Grande National Forest, and steep slopes would prevent development. Forest roads and trails have been constructed for access to the upper watershed. Structures in the lower watershed are primarily related to agriculture. Canal headgates and diversion structures are located at regular intervals to allow for regulated irrigation. A photo inventory of these structures is included as an electronic appendix to this report.

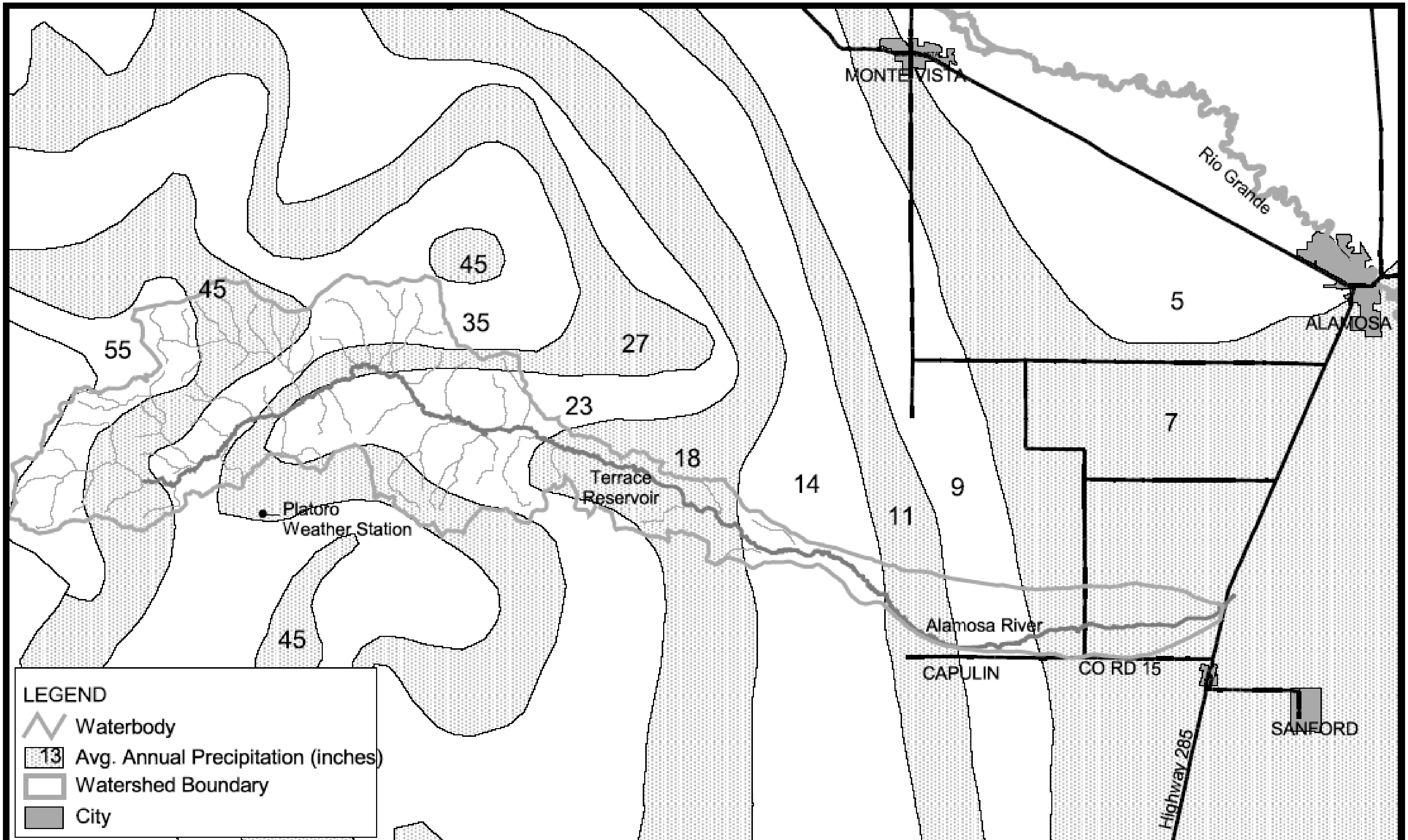

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Figure 2-1.

Average annual precipitation in Alamosa River watershed

2.1.3 Land Ownership

The Alamosa Watershed is located in Rio Grande and Conejos Counties. Land ownership is primarily federal and private. Most of the watershed upstream of Terrace Reservoir is in the Rio Grande National Forest. Another portion is part of the Bureau of Land Management's San Luis Resource Area. The land in the valley below Terrace Reservoir is primarily privately owned and is used for agricultural purposes. **Figure 2–2** shows the distribution of land ownership in the watershed between federal, state and private lands.

2.1.4 Segments

The Alamosa River was divided into segments and subwatersheds based on physical homogeneity. The segment endpoints were chosen as locations that are identifiable in the field and on maps. Generally, the segments are broken at major changes in slope, confluences with major tributaries, or man–made structures. In the upper watershed, dividing segments using major tributaries aids in discussion of major sources of water quality problems and sediments. The Alamosa River was divided into 12 segments. Wightman Fork of the Alamosa River was broken into 4 segments. Treasure Creek was considered a segment of its own. The segments are referred to throughout this report.

Table 2-1 summarizes some general characteristics of each segment/subwatershed. These segments are shown in plan view in **Figure 2–3**. The profiles of the Alamosa River and major tributaries are shown in **Figure 2–4**. The outline of each subwatershed is shown on USGS quad map background in **Appendix F**.

Table 2-1. Alamosa River Segment and Subwatershed Characteristics

Number	Description	Length (miles)	Area (mi^2)	Upstream Elevation (ft MSL)	Downstream Elevation (ft MSL)	Average Slope
1	County Road 10 to Point of last diversion	7.4	13.0	7,721	7,580	0.4%
2	Gunbarrel Road to County Road 10	5.3	10.3	7,931	7,721	0.8%
3	Terrace Main Canal to Gunbarrel Road	5.6	3.9	8,173	7,931	0.8%
4	Terrace to Main Canal to Terrace Outlet	5.6	10.3	8,560	8,173	1.3%
5	Terrace Reservoir	2.7	2.7	8,560	8,560	0.0%
6	French Creek to Terrace Reservoir Inlet	4.1	6.8	8,726	8,560	0.8%
7	Beaver Creek to French Creek	2.3	11.3	8,930	8,726	1.7%
8	Fern Creek to Beaver Creek	4.2	17.2	9,054	8,930	0.6%
9	Jasper Creek to Fern Creek	1.8	12.5	9,116	9,054	0.7%
10	Wightman Fork to Jasper Creek	3.2	6.3	9,377	9,116	1.5%
11	Iron Creek to Wightman Fork	4.9	12.7	9,891	9,377	2.0%
12	Treasure Creek to Iron Creek	2.9	11.5	10,426	9,891	3.5%
T1	Treasure Creek	5.7	13.6	13,300	10,426	9.5%
W1–4	Wightman Fork of Alamosa River	6.2	15.9	11,468	9,377	6.4%

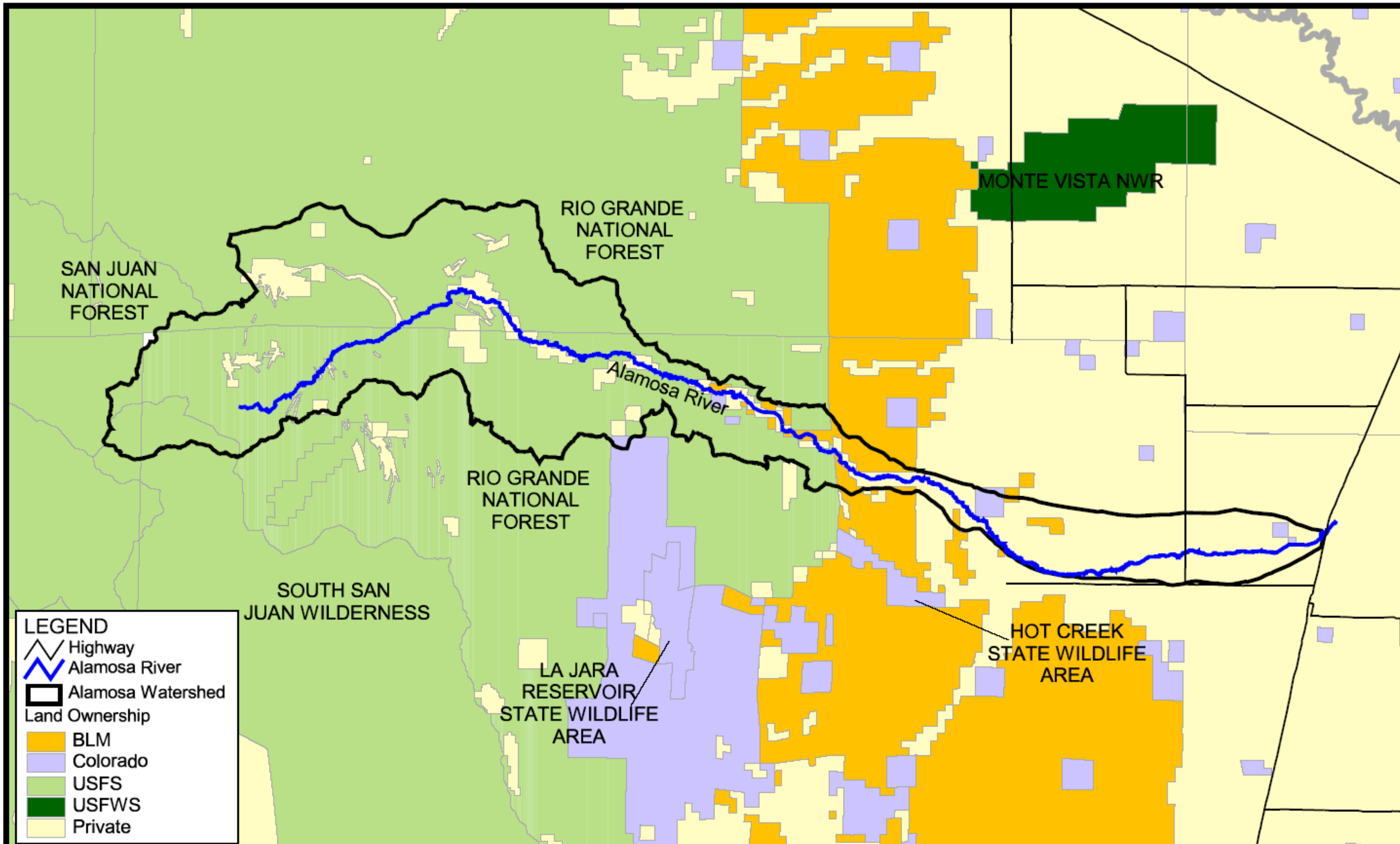

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Figure 2-2.

Land Ownership in the Alamosa River Watershed

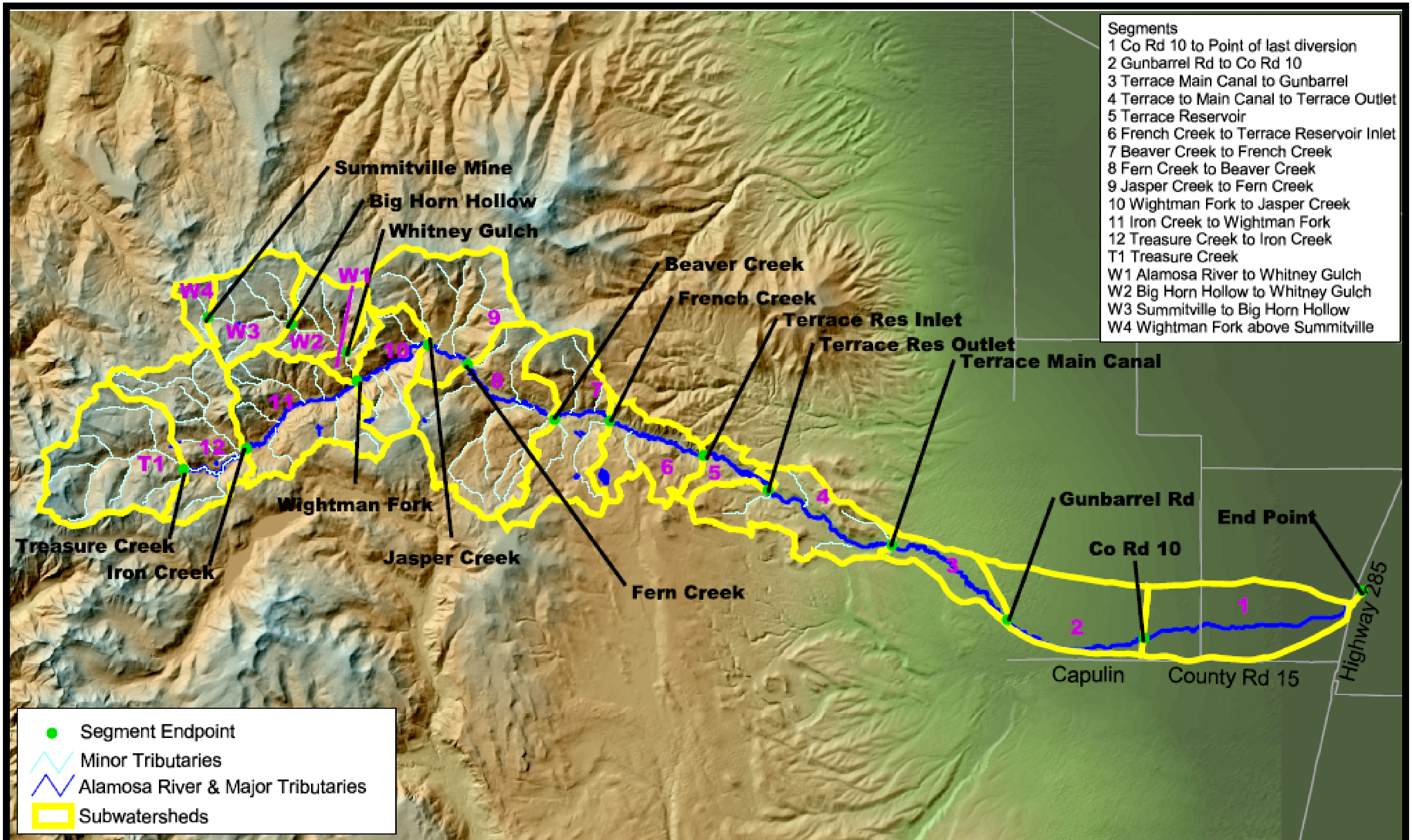

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Figure 2-3.

Alamosa River Segments and Subwatersheds

Figure 2-4. Alamosa River Profile and Segments

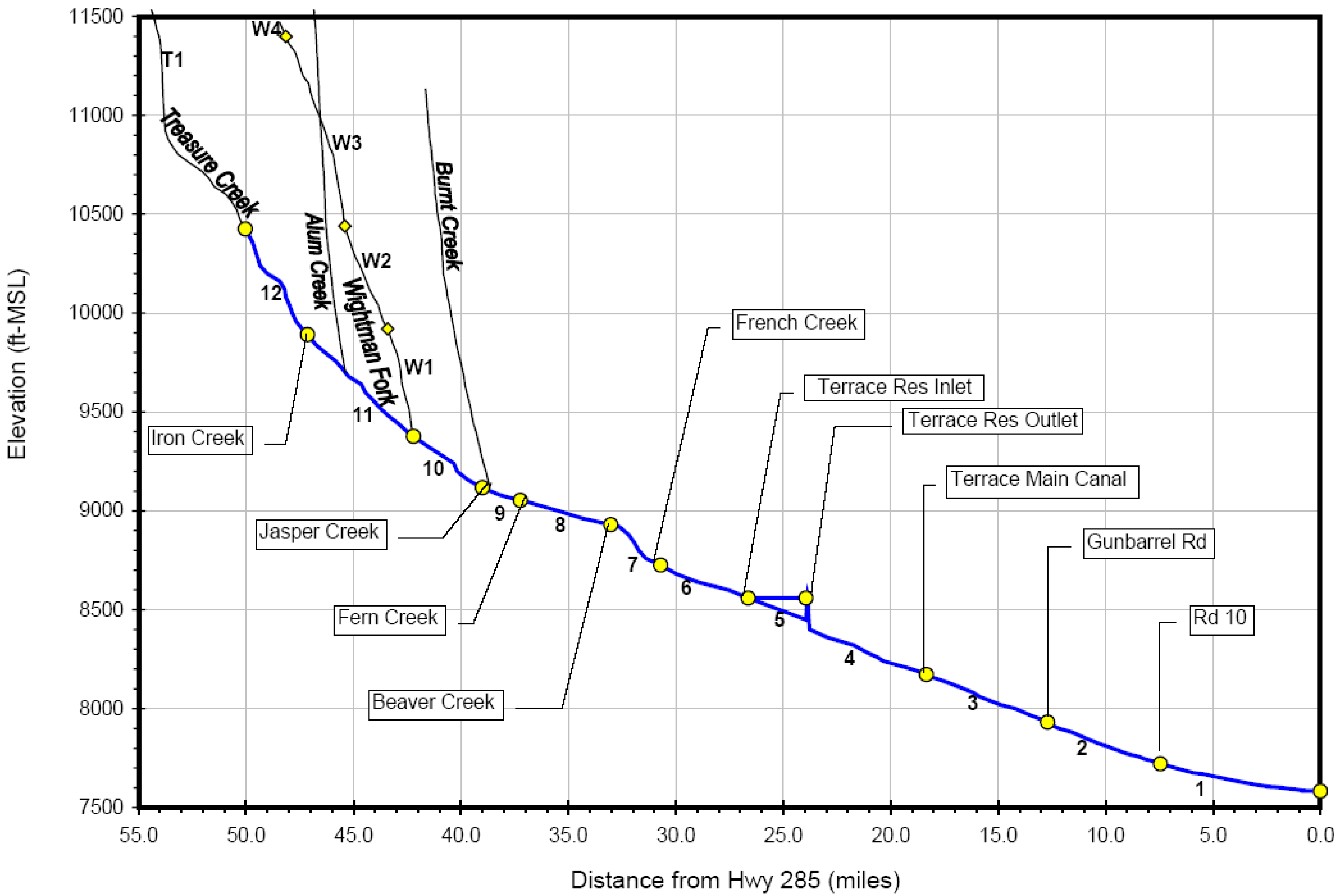

Table 2-2. Wightman Fork Alamosa River Segment and Subwatershed Characteristics

Number	Description	Length (miles)	Area (mi^2)	Upstream Elevation (ft MSL)	Downstream Elevation (ft MSL)	Average Slope
W1	Alamosa River to Whitney Gulch	1.2	5.4	9,920	9,377	8.5%
W2	Big Horn Hollow to Whitney Gulch	2.0	1.5	10,440	9,920	5.0%
W3	Summitville to Big Horn Hollow	2.8	7.2	11,400	10,440	6.6%
W4	Wightman Fork above Summitville	0.3	1.7	11,468	11,400	4.7%

The Master Plan segments do not coincide exactly with the CDPHE segments because the Master Plan evaluates other resource areas in addition to water quality. **Table 2-3** compares the CDPHE and Master Plan segments. The CDPHE segments are also depicted on a map in the water quality section of the affected environment (**Figure 2–53**).

Table 2-3. Comparison of CDPHE and Master Plan Segments for the Alamosa River

CDPHE Segment	Master Plan Segment
1) Tributaries in the South San Juan Wilderness	T1) Treasure Creek
2) Alamosa River from source to Alum Creek	12) Alamosa River from Treasure Creek to Iron Creek
3a) Alamosa River from Alum creek to Wightman Fork	11) Alamosa River from Iron Creek to Wightman Fork
3b) Alamosa River from Wightman Fork to Fern Creek	10) Alamosa River from Wightman Fork to Jasper Creek 9) Alamosa River from Jasper Creek to Fern Creek
3c) Alamosa River from Fern Creek to Ranger Creek	8) Alamosa River from Fern Creek to Beaver Creek
3d) Alamosa River from Ranger Creek to Terrace Reservoir	7) Alamosa River from Beaver Creek to French Creek 6) Alamosa River from French Creek to Terrace Reservoir Inlet
4a) Mainstem of Alum Creek, Bitter Creek, Burn Creek, and Iron Creek from source to confluence with Alamosa River with the exception of 4b	
4b) Mainstem of Iron Creek from its source to immediately above the confluence with Tributary G	
5) Mainstem of Wightman Fork from source to west line of S30, T37N, R4E to the confluence with Alamosa River	W4) Wightman Fork above Summitville
6) Mainstem of Wightman Fork from the west line of S30, 37N, R4E to the confluence with Alamosa River	W3) Wightman Fork from Big Horn Hollow to Summitville W2) Wightman Fork from Whitney Gulch to Big Horn Hollow W1) Wightman Fork from Alamosa River to Whitney Gulch
7) Jasper Creek	
8) Terrace Reservoir	5) Terrace Reservoir
9) Alamosa River from outlet of Terrace Reservoir to Gunbarrel Road	4) Alamosa River from Terrace Main Canal to Terrace Outlet 3) Alamosa River from Terrace Main Canal to Gunbarrel Road
10) Alamosa River from Gunbarrel Road to point of final diversion	2) Alamosa River from Gunbarrel Road to County Road 10 1) Alamosa River from County Road 10 to point of last diversion

Note: Segment endpoints do not always coincide so that correlation between segments is not always exact.

2.2 Channel of Alamosa River and Major Tributaries

In developing a solution for a particular river problem, it is important to evaluate the entire river system and its environment. The river, its floodplain, and the entire watershed are interrelated. Changes to one aspect affect all others. The stream's slope, width/depth ratio, channel sinuosity, entrenchment ratio, sediment types, sediment loading, hydrology, and channel hydraulics are all related and have an impact on how the stream functions. The preceding list of attributes can be divided into three major categories: sediment loading, slope, and discharge. All of these factors are influenced by the surrounding environment, and changes to that environment affect the river and its state of equilibrium. Natural conditions and human induced disturbances play important roles in the stream's function. Often the characterization of the existing system lends itself to an understanding of the nature of the system's instability.

In the same manner, numerous researchers (Leopold, et al., 1964; Schumm, et al., 1987; Rosgen, 1996) have identified a series of strong relationships between stream and channel variables. For example, as stream discharge decreases (i.e., below an irrigation diversion), the ability of the channel to transport its sediment load also decreases, which in turn affects the channel slope. Maintaining the balance between sediment loading, slope, and discharge in the development of stable channel geometry is an important consideration.

The Alamosa River headwaters lie in rugged mountainous terrain where tributaries transporting high sediment loads flow through steep canyons. The slope flattens considerably at the confluence with French Creek, about 4 miles upstream of the Terrace Reservoir inflow. Downstream through the reservoir, past the Terrace Main Canal ant to County Road 10, the slope is similar. With flatter slopes, the river is unable to convey the same sediment load that it could in the steep canyons. Due to the decreased stream power, the sediment load drops out, creating a large alluvial fan (**Figure 2–5**). Coarse sediments such as boulders and cobbles drop out first. As the slope flattens, progressively finer grained sediments are deposited. Under natural conditions, the alluvial fan segment of the Alamosa River would continually aggrade, become choked with sediment, and shift across the fan area. The natural "pre–disturbed" condition of the Alamosa River was a highly avulsive environment.

Agro Engineering, Inc. conducted a bankline analysis of Reach 2 from County Road 10 to Gunbarrel Road in 2003 (Agro Engineering, 2003). Historical aerial photos were used by Agro Engineering, Inc. to show the channel plan changes between the years 1941 and 1998. The report identifies areas of channel straightening and bank erosion in this reach. Many of the conclusions on the Alamosa River channel changes and reactions were based on the bankline analysis of this section of river. Unfortunately, little other historical channel geometry information is available for the river above and below Terrace Reservoir to quantify channel changes over time.

During a site visit in July 2004, Lidstone & Associates measured cross sections, slopes, and bed material to characterize the river channel in each reach from Wightman Fork to Highway 285. The information collected during the site visit was used to classify the Alamosa River upstream of Terrace Reservoir, where relatively little data exists, and compare to previous channel classifications between Terrace Reservoir and Highway 285. **Table 2-4** summarizes the channel geometry information gathered in the site visit. Sediment information is discussed in **Section 2.7**.

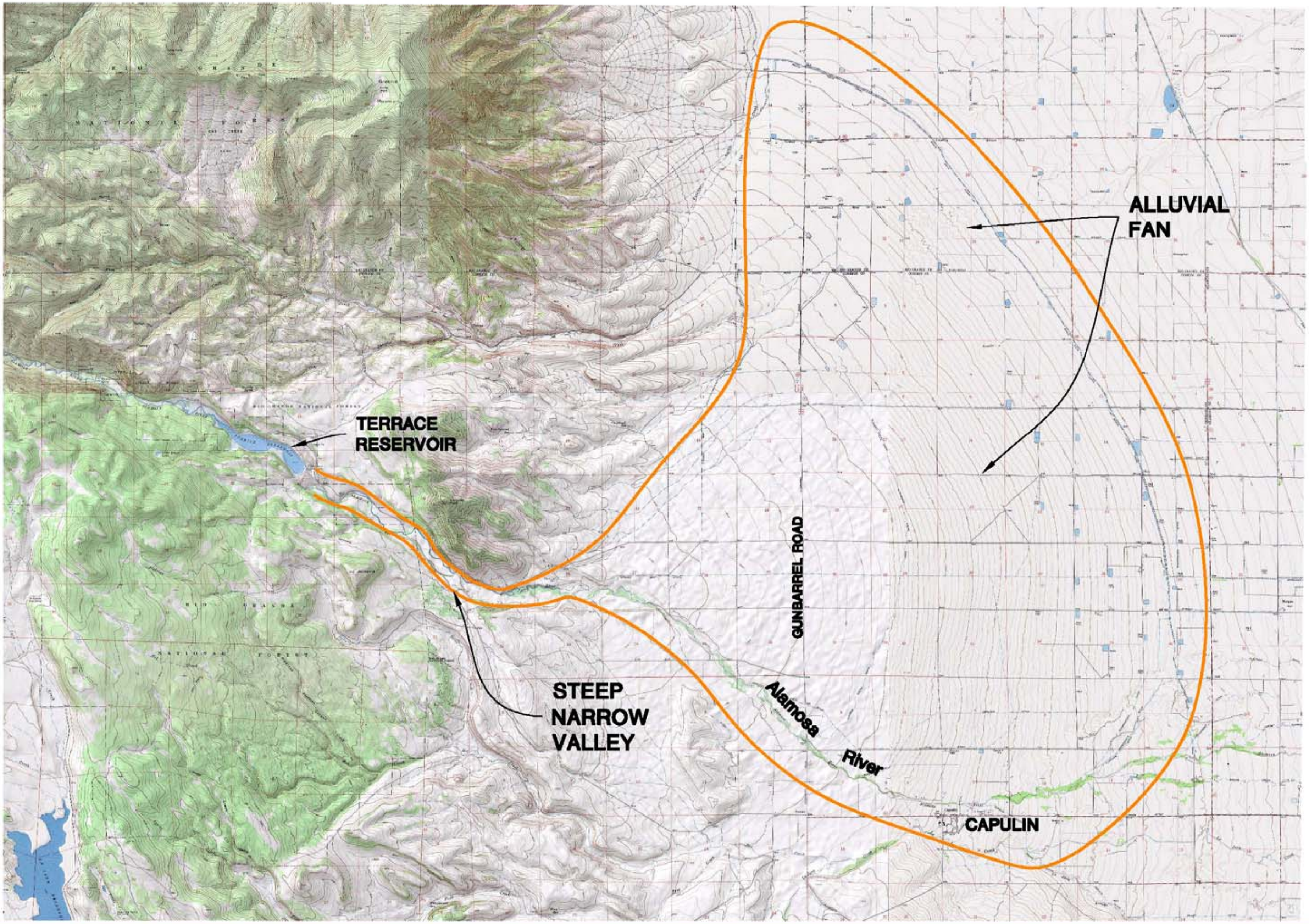

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Figure 2-5. Alluvial Fan

Table 2-4. Alamosa River Channel Geometry Data

Location	Location Description	Reach	Width (ft)	Depth (ft)	Ratio	Slope (ft/ft)
1	Upstream of County Road 15	1	40	3.5	11.4	0.0064
2	Below Ortiz Ditch	2	85	4.0	21.3	0.0033
3	Downstream of San Jose Ditches	2	65	4.0	16.3	0.0108
4	Upstream of Rodriquez Bridge	3	58	4.0	14.5	0.0599
5	Downstream of Terrace Main Canal	3	98	3.5	28.0	0.0082
6	Downstream of Gomez Bridge	4	58	5.5	10.5	0.0045
7	Upstream of campground	6	72	4.0	18.0	0.0108
8	Near Lieutenant Creek	7	57	4.0	14.3	0.0199
9	Upstream of steep reach	8	78	7.0	11.1	0.0037
10	Downstream of Wightman Fork	10	40	2.3	17.4	0.0080
11	Upstream of Alum Creek	11	45	4.0	11.3	0.0105

Source: July 2004 Field Measurements

Stream classifications for the river upstream of Terrace Reservoir were performed using the principles described in David Rosgen's report "Applied River Morphology." Rosgen described the river between Terrace Reservoir and Highway 285 according to his classification scheme in 1999 based on field observations. Field checks were conducted during the July 2004 site visit to evaluate the Rosgen stream classifications. No changes were made to Mr. Rosgen's 1999 classifications based on the data collected during the site visit. The Alamosa River stream classifications are shown in **Figure 2–6**. **Figure 2–7** depicts the Rosgen stream classification methodology.

The following sections describe channel characteristics on a reach by reach basis. The 2–year flowrate is discussed in each reach compared to the appropriated irrigation diversions in that reach. The 2–year flowrate is considered the channel forming flow and is important when analyzing channel stability and future changes. The 2–year flowrate is a peak flow with a 50 percent probability of occurring in any given year. This comparison is meant to show the potential that diverted flow can have on channel forming characteristics.

2.2.1 Upper Watershed (Reaches T1, 12, and 11)

The upper Alamosa River originates at the continental divide. Treasure Creek's headwaters are at elevation 13,300 feet with a slope of 9.5% and sinuosity of approximately 1.1. Many of the channels in the upper watershed are characterized by steep narrow valleys consisting of highly weathered and erodible material. Natural processes including landslides and debris flows occur in these upper tributaries (the high sediment loading from the upper watershed tributaries will be described in more detail in **Section 2.7**).

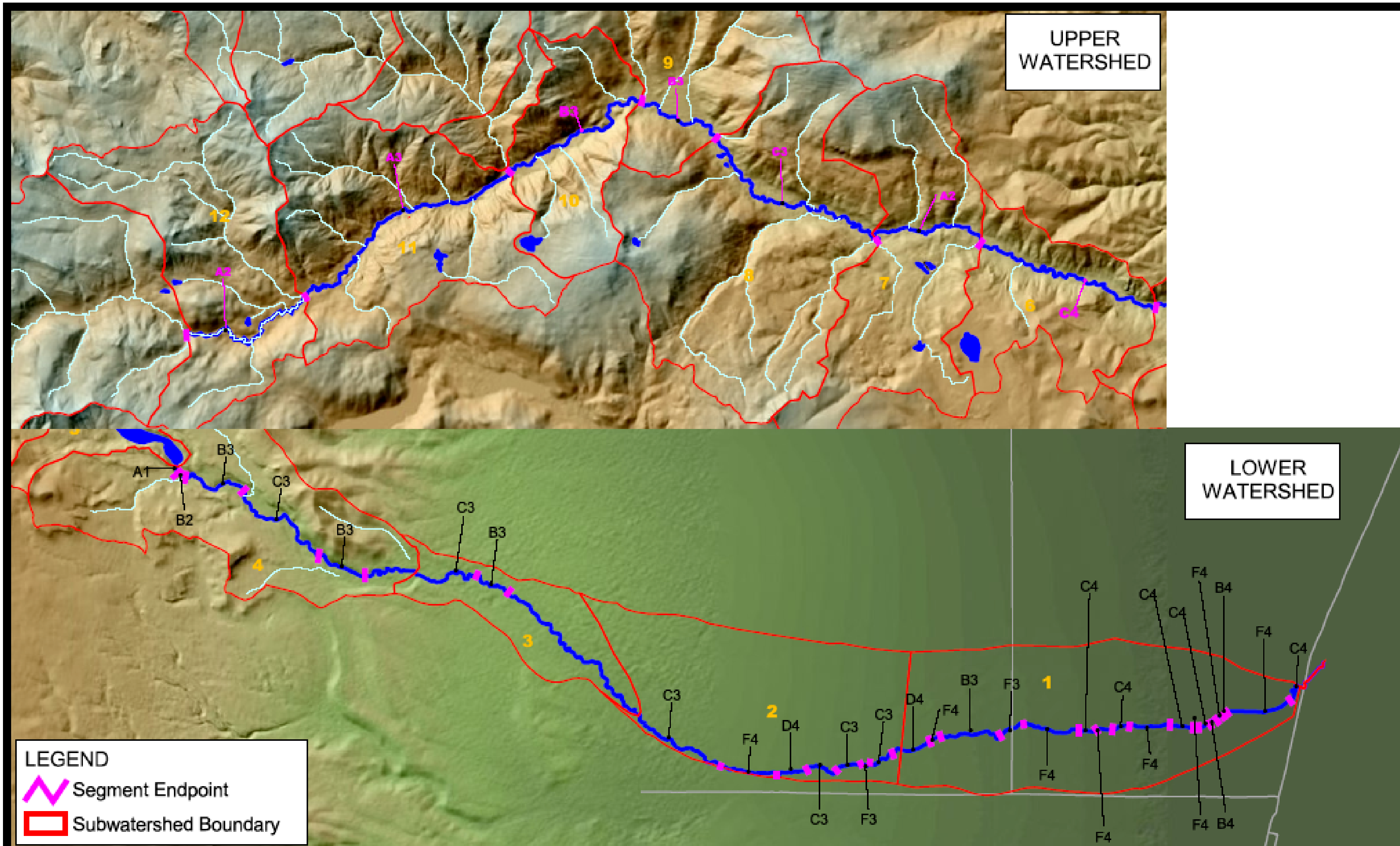

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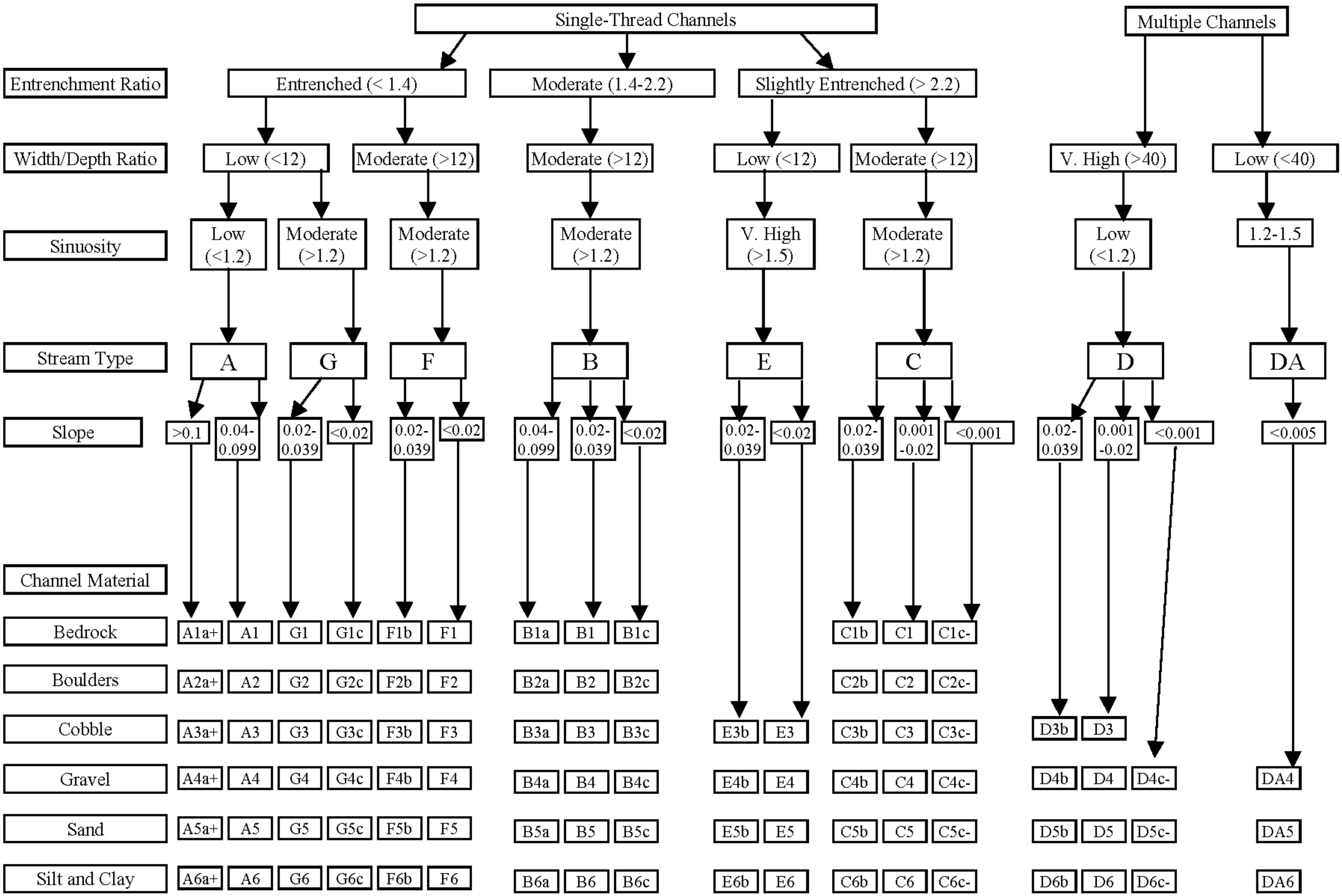
Figure 2-6.
Preliminary Stream Classification

Figure 2-7. Rosgen Stream Classification Methodology



2.2.2 Wightman to Beaver Creek (Reaches 10, 9, and 8)

Below Wightman Fork, the Alamosa River begins to meander within the confines of a 100–foot wide valley. The channel sinuosity of this reach is 1.3, and the stream has an average slope of 0.9%. Burnt Creek is a major tributary that enters this reach. The USGS quadrangle shows a 3,000–foot by 4,000–foot alluvial fan where Burnt Creek enters the Alamosa River. The large fan indicates a high sediment load carried by Burnt Creek, as shown in **Figure 2–8**. The alluvial fan may also restrict the extent of Alamosa River meandering in this area.

Figure 2–8. Photo of Burnt Creek and Sediment Load

2.2.3 Beaver Creek to French Creek (Reach 7)

This reach of the Alamosa River is very straight and confined by steep valley walls. The USGS quadrangle contours indicate a large landslide coming from the southern side of the valley. The apparent landslide is confining the channel and has created a steepened channel slope. The channel sinuosity is 1.0 and the average slope is 1.7%, which is more than twice as steep as the upstream and downstream channels.

2.2.4 French Creek to Terrace Reservoir (Reach 6)

This reach is similar to the Wightman Fork to Beaver Creek reach. The river meanders within a 100–foot wide valley. The channel sinuosity of this reach is 1.3, and the stream has an average slope of 0.8%. Sediment begins to drop out as the channel enters the reservoir resulting in local channel aggradation. When Terrace Reservoir was drained in 2003, the channel re–entrenchened into deposited sediments as the backwater condition was removed, as shown in **Figure 2–9**. When the reservoir is full this reach will once again aggrade as backwater condition flows allow sediment to drop out.

Figure 2–9. Photo of Sediment Influences by the Backwater of Terrace Reservoir

2.2.5 Terrace Reservoir (Reach 5)

Terrace Reservoir is an irrigation storage reservoir built in 1912 with a maximum capacity of about 15,200 acre–feet (Reinhardt, 2004). Terrace Reservoir serves as a sediment catch, reducing the amount of sediment being carried by the river to the downstream alluvial fan area. **Figure 2–10** shows a bar forming in Terrace Reservoir as sediment drops out.

Figure 2–10. Photo of Sediment Deposition in Terrace Reservoir

Terrace Reservoir has created new geomorphic conditions upstream and downstream of the reservoir. The decreased sediment load downstream of Terrace Reservoir has slowed the natural evolutionary process in which the channel in the alluvial fan becomes choked with sediment, and it avulses across the fan. Under the altered conditions, channel aggradation upstream of the reservoir is caused by the deposition of sediment as the river enters the reservoir. Degradation may occur downstream of Terrace Reservoir as flows exit the reservoir, due to the "hungry water" effect. "Hungry water" occurs because the river has the capacity to carry a given sediment load but is not carrying this load because the sediment has dropped out in the reservoir. However, it was very difficult to verify this degradation below the reservoir during the site visit.

Available rating curves for gages on the Alamosa River were obtained to determine if the channel has aggraded or degraded over the period of record. There are two long–term gages on the Alamosa River which were used to determine historical changes. Long–term rating tables dating back to 1934 were obtained from the USGS and Colorado Division of Water Resources (CDWR) for the stream gages upstream and downstream of Terrace Reservoir. The rating curves upstream of the reservoir show the channel being relatively stable between 1934 and 1954 with slight degradation between 1954 and 2002 (**Figure 2–11**). This slight degradation indicates the gage may be far enough upstream (7,000 feet) to avoid being affected by the reservoir backwater conditions. Usually reservoir backwater conditions would cause aggradation due to settling of suspended sediment. The rating table downstream of the reservoir does not show the degradation expected below a reservoir (**Figure 2–12**). Usually the clear water from a reservoir outlet causes the stream to pick up sediment causing degradation, unless the channel is made of rock. The downstream rating table indicates channel aggradation between 1934 and 1956 and relatively stable conditions from 1956 to 1988. The channel bed aggradation suggests the river has picked up its sediment load by the time it reaches the gaging station which is located approximately 2,500 feet downstream of Terrace Reservoir.

Figure 2–11. Rating Curve Above Terrace Reservoir

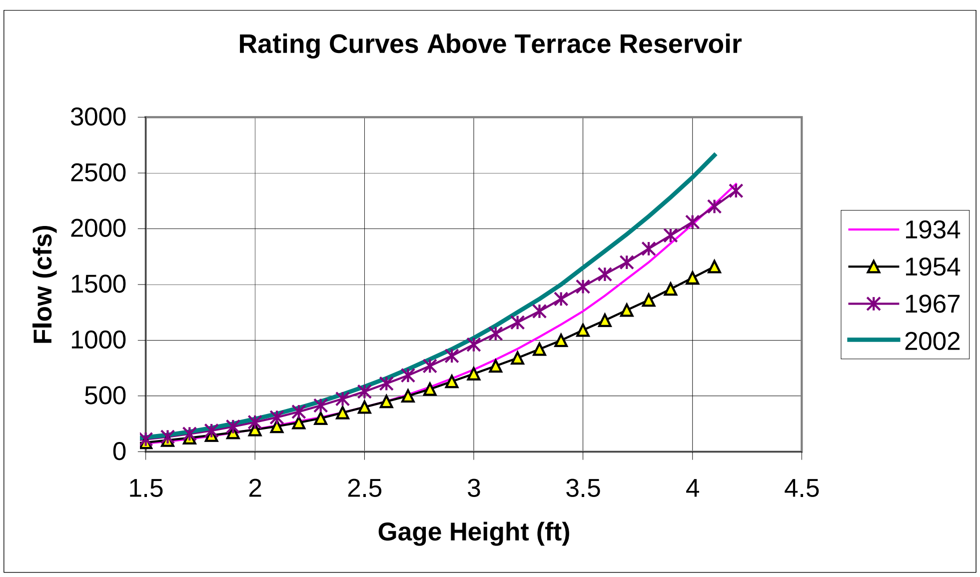
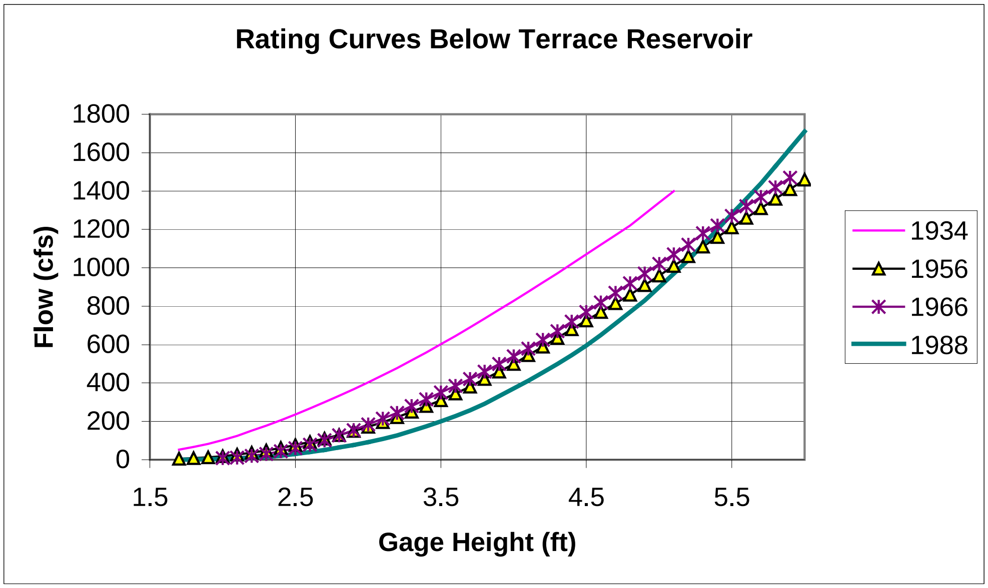


Figure 2–12. Rating Curve Below Terrace Reservoir



2.2.6 Terrace Reservoir to Terrace Main Canal (Reach 4)

This reach of the Alamosa River is confined by steep valley walls. The floodplain through this reach is 150 feet wide. The channel meanders across the entire valley. The channel sinuosity of this reach is 1.3, and there is an average channel slope of 0.8%. This reach marks the beginning of irrigation diversions. There are two ditches within this reach, which have an appropriation to divert a total of 147.02 cfs, or 19 percent of the two–year event, which is 761 cfs.

Irrigation diversions have a significant impact on the amount of water in the Alamosa River channel, which in turn impacts river channel characteristics and the ability of the channel to convey its sediment load. As discussed in **Section 2.3**, 36 ditches divert water from the Alamosa River. During the irrigation season, there is typically not enough water to fill all irrigation water rights (Vandiver, 2003).

As flows are reduced downstream of each irrigation headgate, sediment typically drops out, resulting in bed aggradation. Less flow translates to reduced stream power and decreased ability to convey sediment. This aggradation creates an unstable channel reach with widening and meandering expected for some distance until the channel adjusts to the new flow. If the diversion includes a dam, such as the Terrace Main Canal, deposition would also be expected upstream of the diversion due to the flattened slope and artificial grade control.

Analysis of the photo logs between Terrace Reservoir and Highway 285 (Agro Engineering, 2003, Black Creek Hydrology, 2002, and Rosgen, 1999) shows the channel changes at many of the diversion structures. Many photos, such as the following two (**Figure 2–13** and **Figure 2–14**), show unstable channels with eroded banks, and bed aggradation at the diversion structures. Adjustment in the Alamosa River channel geometry becomes more pronounced as more water is diverted from the river in the downstream reaches.

Figure 2–13. Photo Above Irrigation Diversion (photo by Alan Miller)

Figure 2–14. Photo Below Irrigation Diversion (photo by Alan Miller)

2.2.7 Terrace Main Canal to Gunbarrel (Reach 3)

Below the Terrace Main Canal, the floodplain widens into the alluvial fan physiographic landform. Channel aggradation and avulsion would typically occur here under natural conditions. However, channel confinement and river training to accommodate the irrigation diversions have impacted the river in this reach. There are four ditches in this reach that have the appropriations to divert 167.73 cfs, or 22 percent of the two–year event. The channel sinuosity and slope, 1.3 and 0.8%, respectively, are the same as in the reach immediately upstream.

This reach experiences significant bank erosion as the channel attempts to adjust to the reduced flows downstream of Terrace Main Canal and Valdez irrigation diversions. A pilot stabilization project was built in January 2000 to determine the effectiveness of rock vanes, j–hooks, and riffles to minimize bank erosion, improve channel conveyance, and decrease the downstream sediment loading. Seven monitoring cross sections were surveyed in a 2,000–foot river reach immediately upstream of the El Viejo Diversion in May, 2000. These cross sections had an average top width of 74 feet, average depth of 1.8 feet, and average width/depth ratio of 41 (Black Creek Hydrology, 2003). These dimensions are used for stream classification, such as the Rosgen classification shown in **Figure 2–7**. There is not enough information available yet to determine the effectiveness of the stabilization measures.

2.2.8 Gunbarrel to County Road 10 (Reach 2)

Between Gunbarrel and County Road 10 there are 18 ditches which have an appropriation to divert 456.12 cfs, which is 60 percent of the two–year event. This reach is characterized by channel straightening activities, which took place in the early 1970's (CWCB, 2000) to provide flood relief from Gunbarrel Road to Highway 285. Straightening of the channel increased the bed slope, which increased velocities. Increasing velocities had the desired affect of conveying more water through the reach at a shallower depth. However, the higher velocities and corresponding increased stream power resulted in increased bed and bank erosion. The channel straightening allowed the river to flush sediment through the straightened reach. Downstream of the straightening, as meandering resumes, sediment deposition occurs due to the flatter channel slope. While flooding was all but eliminated this reach now has erosion and channel instability problems.

The channel sinuosity of this reach is straighter than the previous two reaches at 1.2, but the average channel slope is the same at 0.8%. The extensive irrigation diversions and removal of channel flushing flows results in significant channel aggradation in the area. However, this has been counteracted by the channel straightening. The slope appears to have adjusted to match the upstream undisturbed slope, suggesting the channel is in the stage of channel evolution where channel aggradation typically occurs. The photo log and description of the area show aggradation through much of this reach. **Figure 2–15** shows significant aggradation. As the channel adjusts, the channel bed will continue to aggrade, the banks will erode, and eventually a meandering channel will form.

Figure 2–15. Photo Near Capulin at Straightened Channel Section (photo by Alan Miller)

2.2.9 County Road 10 to Highway 285 (Reach 1)

Between County Road 10 and Highway 285 there are 13 ditches that have an appropriation to divert 568 cfs, which is 75 percent of the two–year event. Extensive channel straightening has also taken place in this reach, decreasing the channel sinuosity to 1.1. The average channel slope is 0.4 percent, indicating the channel is approaching the fringe or distal margin of the alluvial fan. Deposition of fined grained sediment would be expected as the river comes to the fringes of the alluvial fan and enters more of a classic river floodplain environment. Deposition in this reach has been exacerbated by the diversion of flow from the Alamosa River for irrigation.

2.2.10 Floodplain Mapping

Floodplain mapping was prepared for the reach of the Alamosa River from Gunbarrel Road to County Road 10 in 2002. The analysis was performed by MWH using the cross section data provided by Black Creek Hydrology in HEC–RAS hydraulic modeling software format. The 100–year flood boundary upstream of Highway 371 is shown in **Figure 2–16** and downstream of Highway 371 is shown in **Figure 2–17**. Because the lower reaches of the Alamosa River are located on an alluvial fan that is "tilted" downward to the south, high flows can exceed the elevation of the drainage divide between the Alamosa River watershed and the La Jara Creek watershed. In this case "breakouts" from the Alamosa River can occur. Breakout locations are on the south bank at County Road 8 in Capulin, further downstream near the St. Joseph Cemetery, and just upstream of County Road 10.

CWCB mapped the floodplain downstream of County Line Road using approximate methods with similar results to the HEC–RAS modeling (as shown in the figures). Both analyses show that structures in Capulin, particularly north of Highway 15 are in the floodplain.

There is no available floodplain mapping for the rest of the watershed.

2.2.11 Summary of Channel Issues

The Alamosa River has its headwaters in steep mountainous terrain of highly erodible volcanic material providing a high sediment load to the Alamosa River. The river exits the confined valley near the Terrace Main Canal and flows onto an alluvial fan. Under natural/undisturbed conditions sediment loads would drop out as the river enters the alluvial fan area. The deposition of this coarse sediment load would choke off the river channel causing it to avulse to a new location. Terrace Reservoir, irrigation diversions, and channel straightening have had a significant impact on the Alamosa River characteristics, helping stabilize and negatively altering the river channel. The river system appears to be adjusting to changes in both water and sediment discharge.

The following key issues were identified as affecting the Alamosa River geomorphology:

- The upper watershed produces naturally high sediment loads
- Terrace Reservoir, irrigation diversions, and channel straightening impact the river's geomorphology

Structures located within Alamosa River floodplain are a flood hazard, especially in Capulin

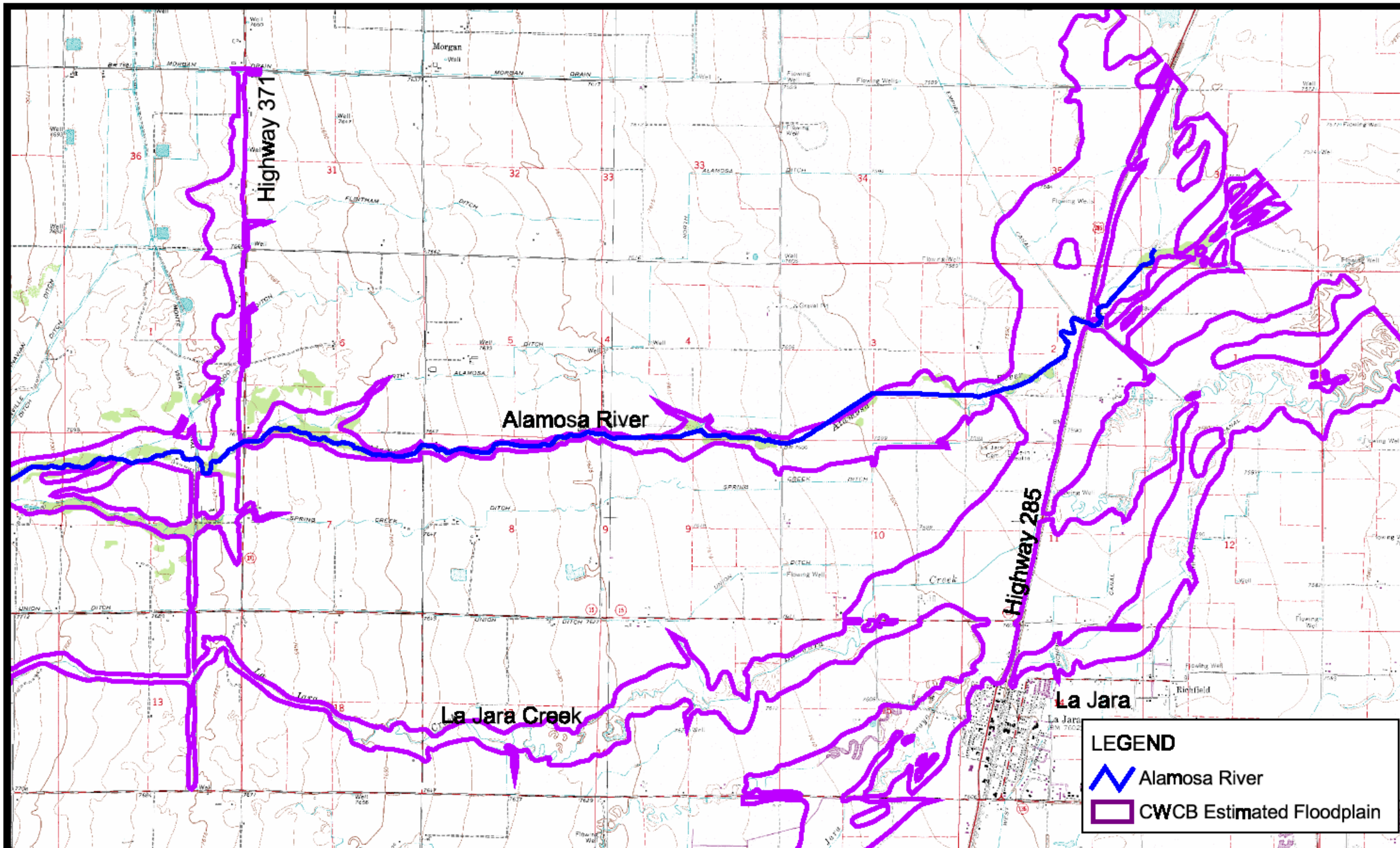


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Figure 2-16.

100-year Flood Boundary Upstream of Highway 371

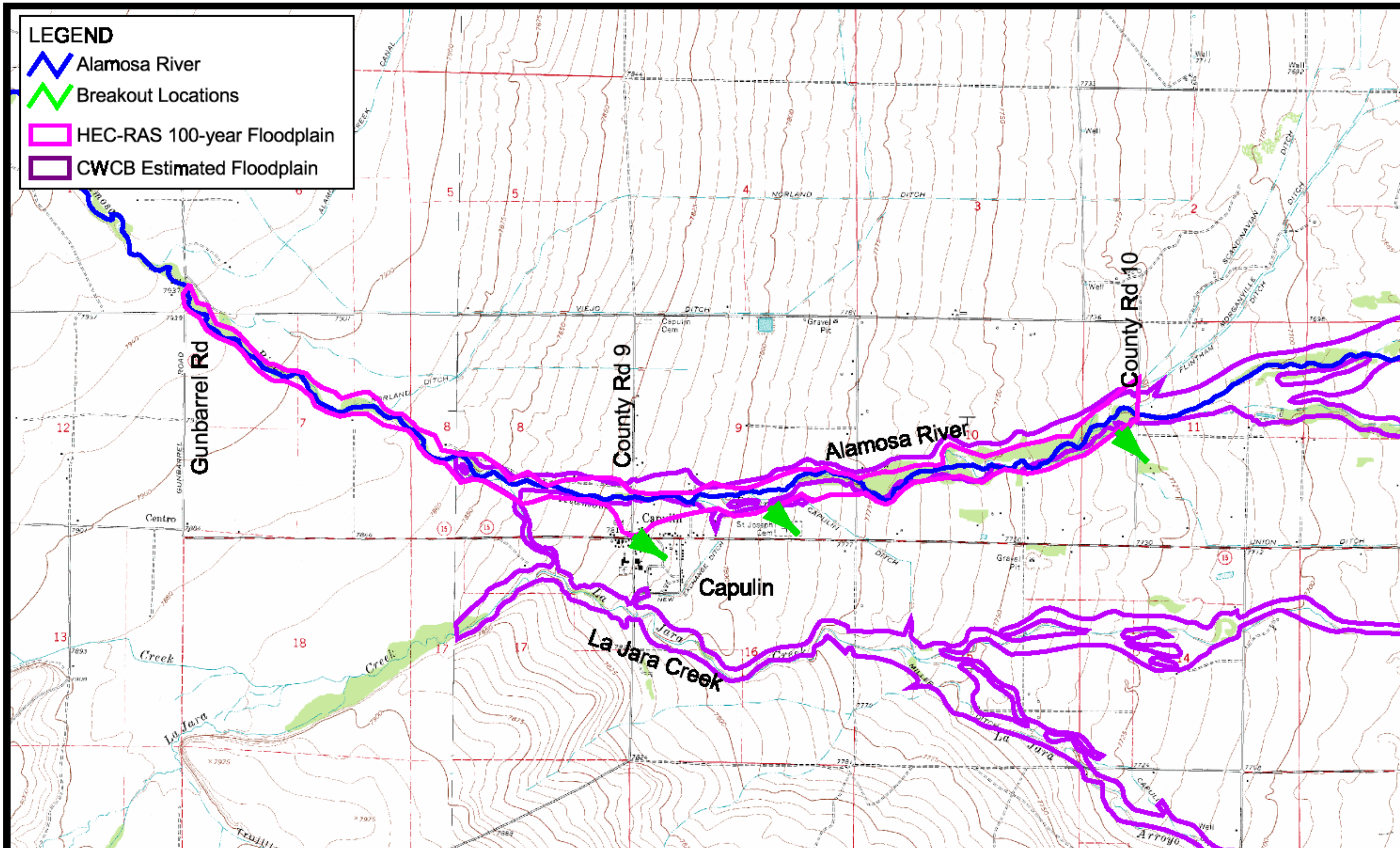

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Figure 2-17.

100-year Flood Boundary Downstream of Highway 371

2.3 Surface Water Quantity

The upper elevations of the watershed receive a significant snowpack that provides the majority of streamflow in the Alamosa River. The main tributaries are Treasure Creek, Iron Creek, Bitter Creek, Alum Creek, and Wightman Fork. There are many smaller tributaries as well. The mainstem of the Alamosa River flows to the east for approximately 50 miles until it is normally totally diverted at ditch headgates just east of US Highway 285 about 10 miles west of the Rio Grande. Terrace Reservoir is the only reservoir on the mainstem of the river, located approximately 14 miles downstream of Wightman Fork.

Terrace Reservoir is discussed in detail in **Section 2.6.** Briefly, the reservoir is owned by Terrace Irrigation Company and stores runoff during winter months and releases water in priority during the irrigation season for agricultural use. When called, senior downstream water rights are passed through the reservoir without attenuation. Water from storage is released to the Alamosa River during the irrigation season and is diverted from the river downstream of the Below Terrace Reservoir streamgage.

Water in the Alamosa River is primarily used to support agricultural activity in the San Luis Valley. Thirty–six ditches divert water from the river to irrigate farmland and pastures and to water livestock. The Alamosa River is over–appropriated. During the irrigation season, there usually is insufficient water to fill all irrigation water rights and storage limits in Terrace Reservoir are rarely exceeded (Vandiver, 2003). In addition to agriculture, water quantity is crucial for maintaining other use classifications of the stream segments, which include recreation, water supply, and cold water aquatic habitat. The use classifications established by the Colorado Department of Public Health and Environment (CDPHE) for segments of the Alamosa Basin are shown in **Appendix B**.

This section provides background information to aid the discussion of what future water utilization patterns are realistic for the Alamosa River. Topics discussed include:

- Streamflow
- Terrace Reservoir Levels
- Flood Frequency
- Flood Events
- Water Rights and Usage
- Rio Grande Compact

2.3.1 Streamflow

There are only two active stream gages on the Alamosa River. The two active gages are located about 1 mile above and about 0.5 mile below Terrace Reservoir. Stream gages higher in the upper basin were used temporarily between 1995 and 2000 as part of the Summitville Superfund project. All of the gage locations are shown in **Figure 2–18**. Location and drainage area information for each gage is summarized in **Table 2-5**. No streamflow data is available for the lower Alamosa River. Streamflow patterns are discussed below from upstream to downstream.

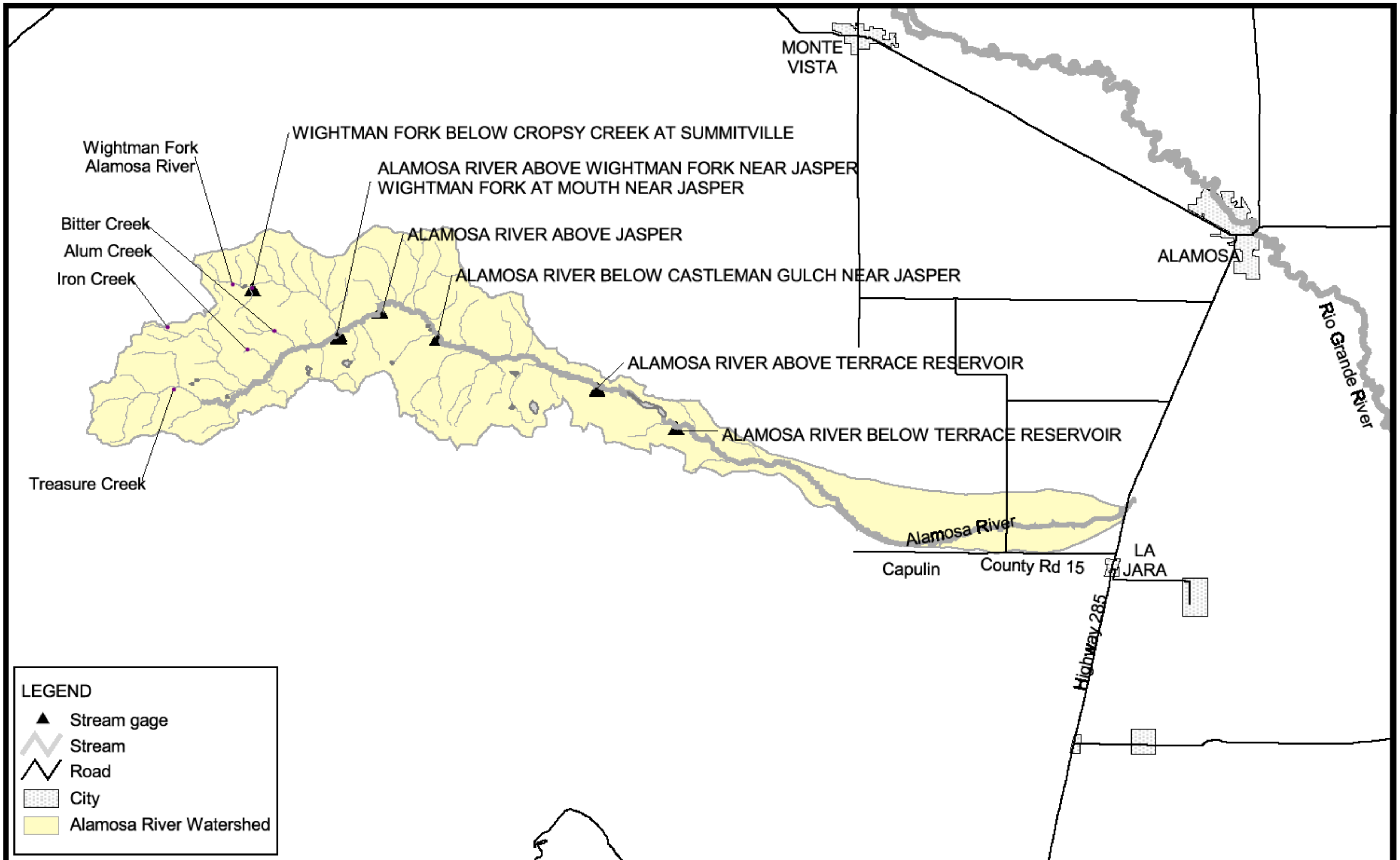

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Figure 2-18.

Alamosa Basin Stream Gage Locations

Streamflow data for Wightman Fork are available for 1995 to 2000. **Figure 2–19** shows the mean monthly streamflow for the period of record at two gages on Wightman Fork. The two gages are located approximately 4.5 miles apart. The "Wightman Fork below Cropsy Creek" gage has a drainage area of 4.4 square miles and the "Wightman Fork at Mouth" gage has a drainage area of 16.1 square miles. These data are seasonal due to icing that prevents measurements during the winter. Peak streamflow generally occurs in May and June. Peak streamflow at the "Wightman Fork below Cropsy Creek" gage varied from about 15 cfs to 60 cfs over the period of record. Peak streamflow at the "Wightman Fork at Mouth" gage varied from about 30 to 100 cfs.

Streamflow data are available for three temporary gages on the upper Alamosa River, and one permanent gage. Mean monthly streamflow for each gage is shown in **Figure 2–20**. Peak streamflow generally occurs in May or June. Peak streamflow at the most downstream temporary gage, "Alamosa River below Castleman Gulch," varied from about 250 cfs to 500 cfs over the period of record.

Table 2-5. Alamosa Basin Stream Gage Information

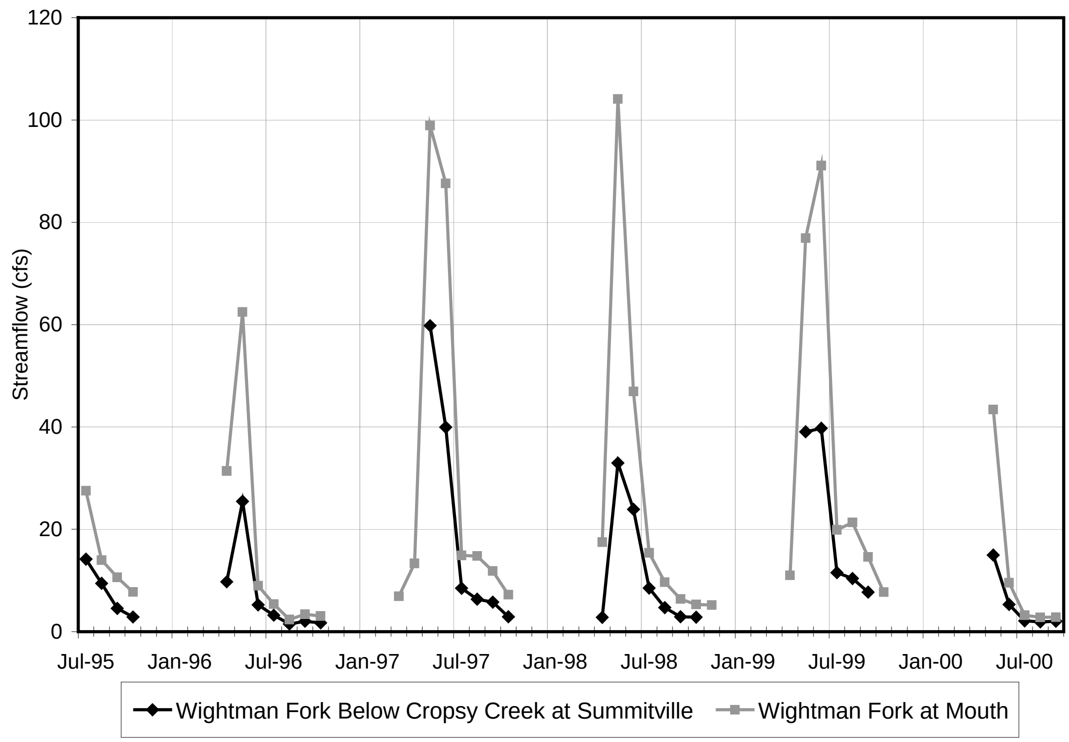
Gage Name	Drainage Area (sq. mi)	Elevation (feet msl)	Distance from Upstream Gage (miles)	Period of Record
Wightman Fork below Cropsy Creek at Summitville	4.4	11,100	N/A	1995–00
Wightman Fork at Mouth near Jasper	16.1	9,500	4.5	1995–00
Alamosa River above Wightman Fork near Jasper	37.8	9,500	N/A	1995–00
Alamosa River above Jasper	58.1	9,200	2.3	1995–99
Alamosa River below Castleman Gulch near Jasper	76.3	9,000	3.5	1995–00
Alamosa River above Terrace Reservoir	107.0	8,600	8.2	1914–present
Alamosa River below Terrace Reservoir	116.0	8,400	4.2	1923–present

Long term streamflow data on the Alamosa River are available for the "Above Terrace Reservoir" and "Below Terrace Reservoir" gages, beginning in 1914 and 1923, respectively. Drainage areas are 107 square miles at the "Above Terrace Reservoir" site and 116 square miles at the "Below Terrace Reservoir" site. Streamflow records from the "Above Terrace Reservoir" gage are indicative of what streamflow may have been like prior to construction of the reservoir.

Annual flow in the Alamosa River varies greatly. **Figure 2–21** displays historical annual average flow at the "Above Terrace Reservoir" and "Below Terrace Reservoir" gages. The averages at the Above Terrace and Below Terrace gages are 119 cfs (86,000 acre–feet/year) and 109 cfs (79,000 acre–feet/year) respectively, for the available periods of record. However, it is common to have average flow exceeding 150 cfs (109,000 acre–feet/year) or less than 60 cfs (43,000 acre–feet/year) at each gage. For the period of 1972 to 2002, when data are available for both gages, the long–term average flows are 107.4 cfs (77,700 acre–feet/year) and 104.7 cfs (75,800 acre–feet per year) respectively. The difference in average annual flows at the two gages is due to unmeasured losses from the reservoir. Unmeasured losses could include evaporation, leakage not recorded at the "Below Terrace Reservoir" gage, carryover storage, and changes in gage calibration. A discussion of evaporative losses from Terrace Reservoir is included in **Section 2.3.3**.

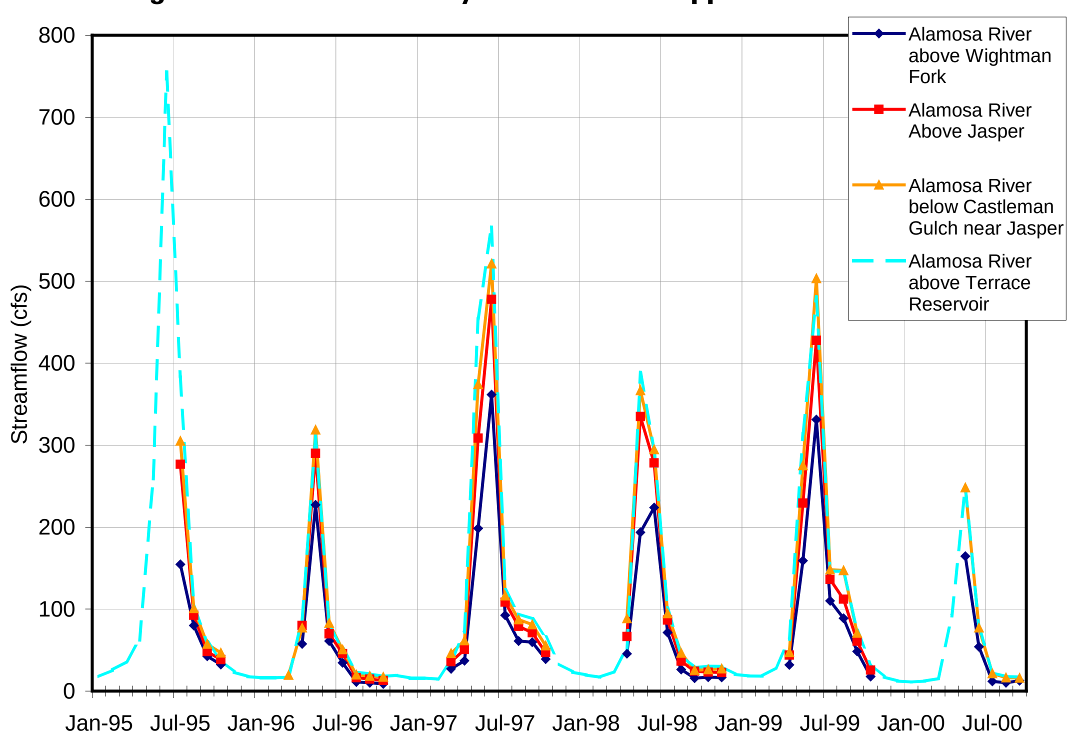
The seasonal variation in streamflow at each gage is depicted in **Figure 2–22**. The maximum flow at each gage typically occurs in June. An average of less than 50 cfs occurs from September through March. Flow is smaller at the "Below Terrace Reservoir" gage than the "Above Terrace Reservoir" gage from November through June due to water storage. Flow is greater at the "Below Terrace Reservoir" gage the rest of the year due to irrigation releases from the reservoir.

Figure 2–19. Mean Monthly Streamflow in Wightman Fork



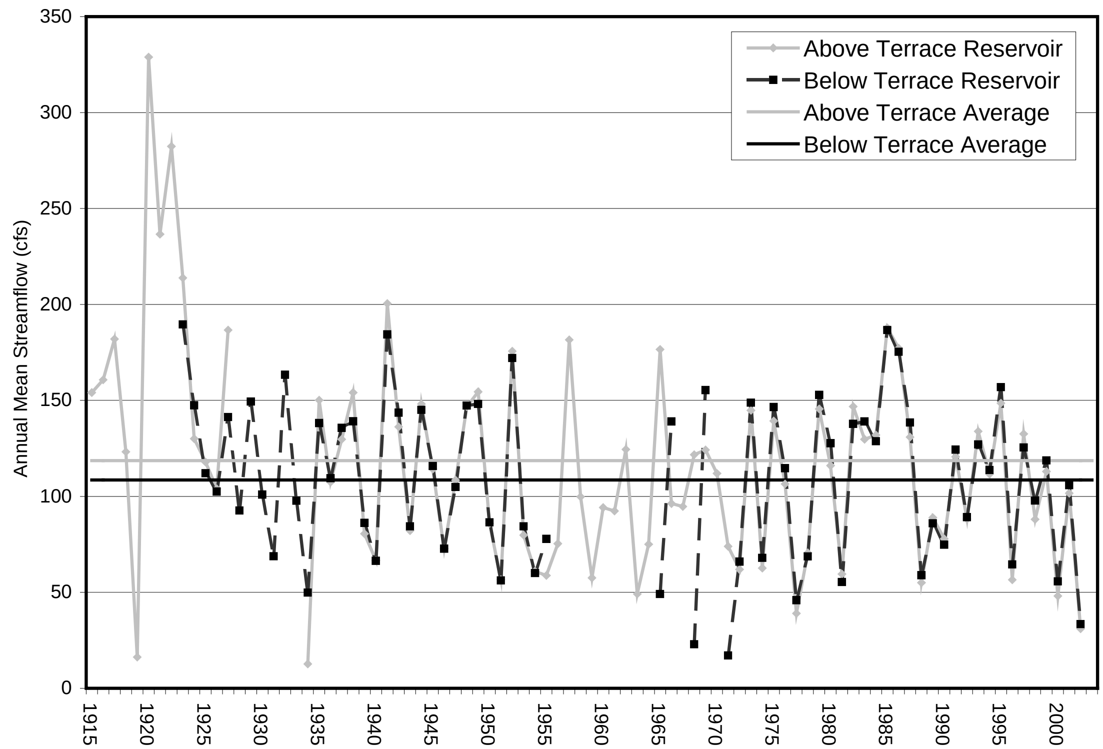
Source: USGS and CDWR Gage Data

Figure 2–20. Mean Monthly Streamflow in Upper Alamosa River



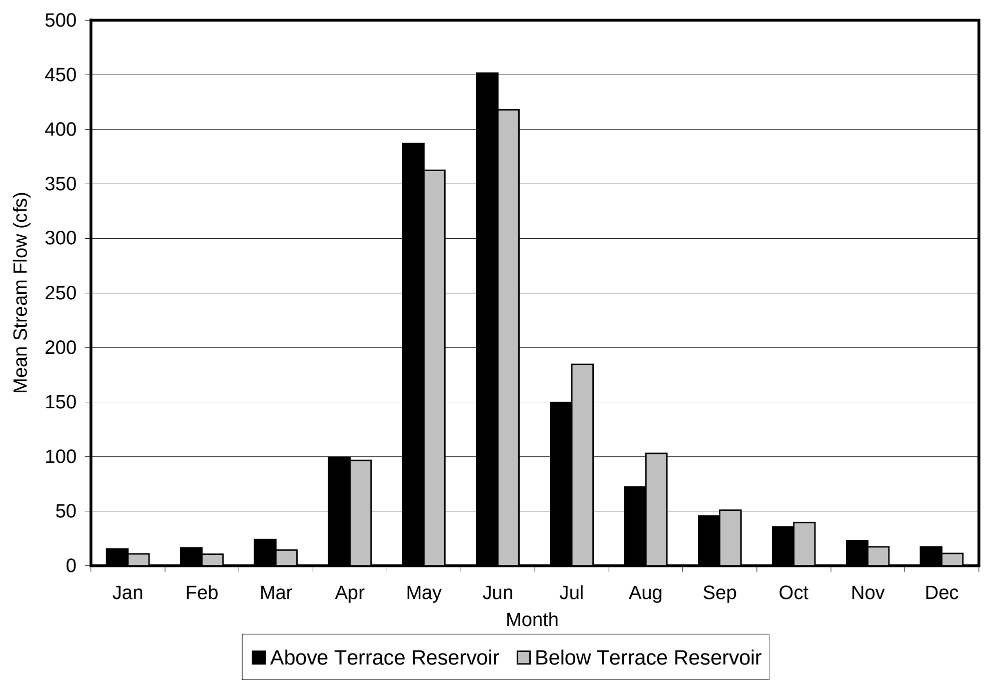
Source: USGS and CDWR Gage Data

Figure 2–21. Historical Flow – Alamosa River Near Terrace Reservoir



Source: USGS Gage Data and CDWR Data (Above Terrace 1914–2002, Below Terrace 1923–2002)

Figure 2–22. Mean Monthly Flow for Alamosa River near Terrace Reservoir



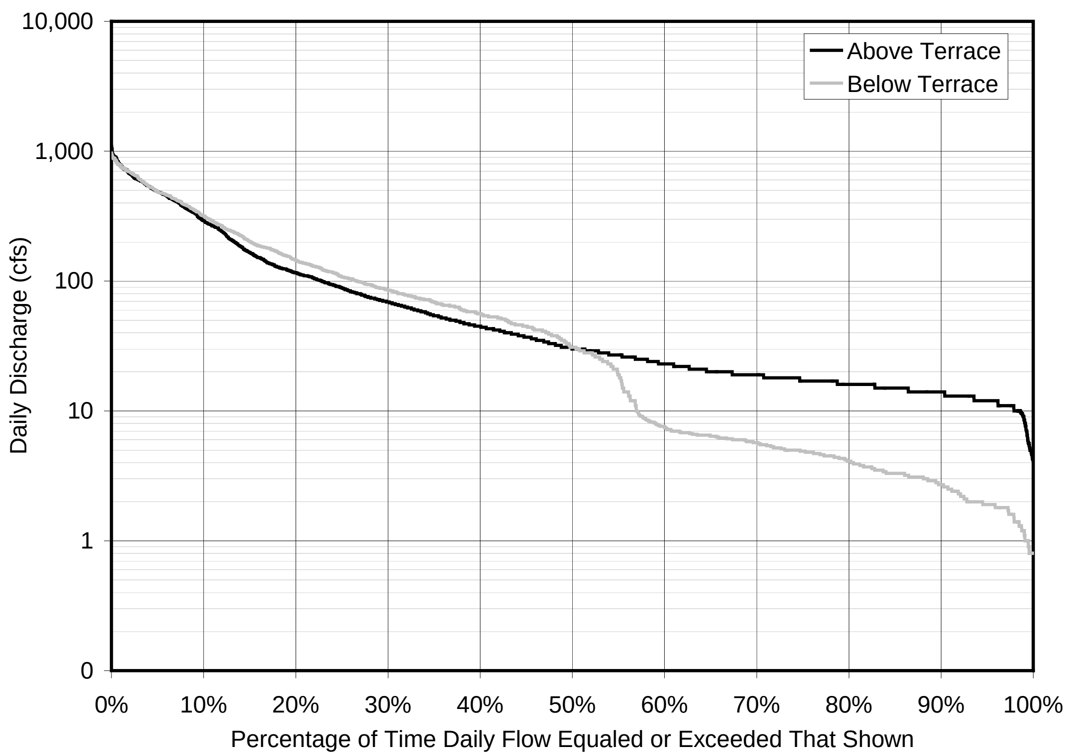
Source: USGS Gage Data and CDWR Data (Above Terrace 1914–2002, Below Terrace 1923–2002)

Figure 2–23 shows the flow duration curves for the Above Terrace Reservoir and Below Terrace Reservoir gages for water years 1982 to 2002. There is a pronounced dip in the discharge at the Below

Terrace Reservoir gage once the percentage exceedence is greater than 55 percent. The drop off is due to the dam being closed for most of the winter.

No streamflow measurements exist for the Alamosa River downstream of the Below Terrace Reservoir gage. The amount of flow in this reach varies by season. It is heavily impacted by agricultural diversions and surface water loss to the groundwater basin. Downstream of the Terrace Main Canal diversion structure the river is characterized as a losing stream due to lack of inflow and extensive groundwater recharge. Except during flooding, the Terrace Irrigation Company only releases the amount of direct streamflow requested by downstream irrigators and storage water requested by Terrace Irrigation Company shareholders. Each day's direct flow, equal to flow at the Above Terrace Reservoir gage, is used according to the seniority of irrigators placing calls. Therefore, the Alamosa River is generally dry downstream of the last irrigator. When the Terrace Gates are closed during the winter, approximately 3 to 8 cfs usually passes the Below Terrace Reservoir gage due to a seep through the foundation of the left abutment of Terrace Dam. Historically, large amounts of water, up to 30 cfs or more, have leaked through the valves of the dam creating flow in the reach downstream of Terrace Reservoir. A valve was repaired in February of 2004, reducing the leakage to less than 1 cfs. Under normal conditions, the flow downstream of the reservoir typically dissipates upstream of Gunbarrel Road. During most of the year, releases of at least 10 cfs must be made for flow to reach Capulin (Vandiver, 2002). Under high flow conditions, the river ends at the Lowland and Head Overflow ditch headgates just east of Highway 285.

Figure 2–23. Flow Duration Curve for Alamosa River (October 1981 to September 2002)



Source: CDWR Gage Data

2.3.2 Tributary Average Flow Estimate

An analysis was performed to estimate the amount of streamflow in upper reaches of the watershed where gage data are not available. This analysis is used in **Section 2.4.9** where contaminant loads from various tributaries are estimated. The approach relied on isohyetals obtained from CDWR and subwatersheds delineated in GIS. The watershed was divided into polygons with equal precipitation in each subwatershed (shown in **Figure 2–24**). The area of each polygon was used to determine the weighted average precipitation in that subwatershed. The average amount of precipitation per year tributary to the Above Terrace Reservoir streamgage was then calculated. This was converted to a flowrate that was compared to the average measured flowrate at the Above Terrace Reservoir gage. The ratio of flow rate to precipitation was 0.41, and is referred to as the runoff coefficient. The runoff coefficient represents the fraction of precipitation that is converted to streamflow. The runoff coefficient was applied to all of the subwatersheds to estimate streamflow in the upper tributaries.

Figure 2–24 shows the subwatersheds and isohyetals used in the analysis. One subwatershed was delineated for each major tributary. The depth of precipitation in the watershed upstream of Terrace Reservoir varies from 18 to 55 inches in an average year. **Table 2-6** summarizes the annual average streamflow calculated for the tributaries. Estimated monthly flow in the tributaries is included in **Appendix C**, based on the monthly distribution of flow at the Above Terrace Reservoir gage (as shown in **Figure 2–22**).

Table 2-6. Tributary Average Flow Estimates

Watershed Name	Drainage Area (acres)	Estimated Streamflow (acre–feet/year)	Estimated Streamflow (cfs)
ALAMOSA RIVER ABOVE WIGHTMAN FORK			
Upper Treasure Creek	7,791	13,700	19
Lower Treasure Creek	7,711	8,618	12
Alum Creek	1,436	1,736	2
Iron Creek	4,346	7,113	10
Bitter Creek	1,970	2,667	4
Asiatic Creek	950	1,280	2
Total	**24,202**	**35,114**	**48**
WIGHTMAN FORK AT MOUTH			
Wightman Fork	6,469	10,146	14
Sawmill Creek	763	1,186	2
Big Horn Hollow	1,305	1,985	3
Whitney Gulch	878	1,214	2
Palmer Gulch	740	1,126	2
Silver Creek	1,148	958	1
Total	**11,304**	**16,615**	**23**
ALAMOSA RIVER BELOW CASTLEMAN GULCH			
Downstream of Wightman	4,914	4,266	6
Jasper Creek	2,441	2,869	4
Spring Creek	2,294	2,595	4
Burnt Creek	1,658	1,918	3
Downstream of Spring	1,904	1,521	2
Castlman Gulch	1,437	1,118	2
Fern Creek	471	415	1
Total	**15,120**	**14,701**	**20**
Total with Upstream Contributions	**50,626**	**66,430**	**92**
ALAMOSA RIVER ABOVE TERRACE RESERVOIR			
Downstream of California	4,744	3,243	4
California Gulch	3,647	3,118	4
Beaver Creek	2,573	1,966	3
Rhodes Gulch Canyon	2,332	1,911	3
French Creek	2,146	1,759	2
Lieutenant Creek	1,390	1,095	2
Ranger Creek	1,025	843	1
Total	**17,858**	**13,934**	**19**
Total with Upstream Contributions	**68,483**	**80,364**	**111**

Note: Streamflow listed corresponds to subwatersheds shown in Figure 2–24.

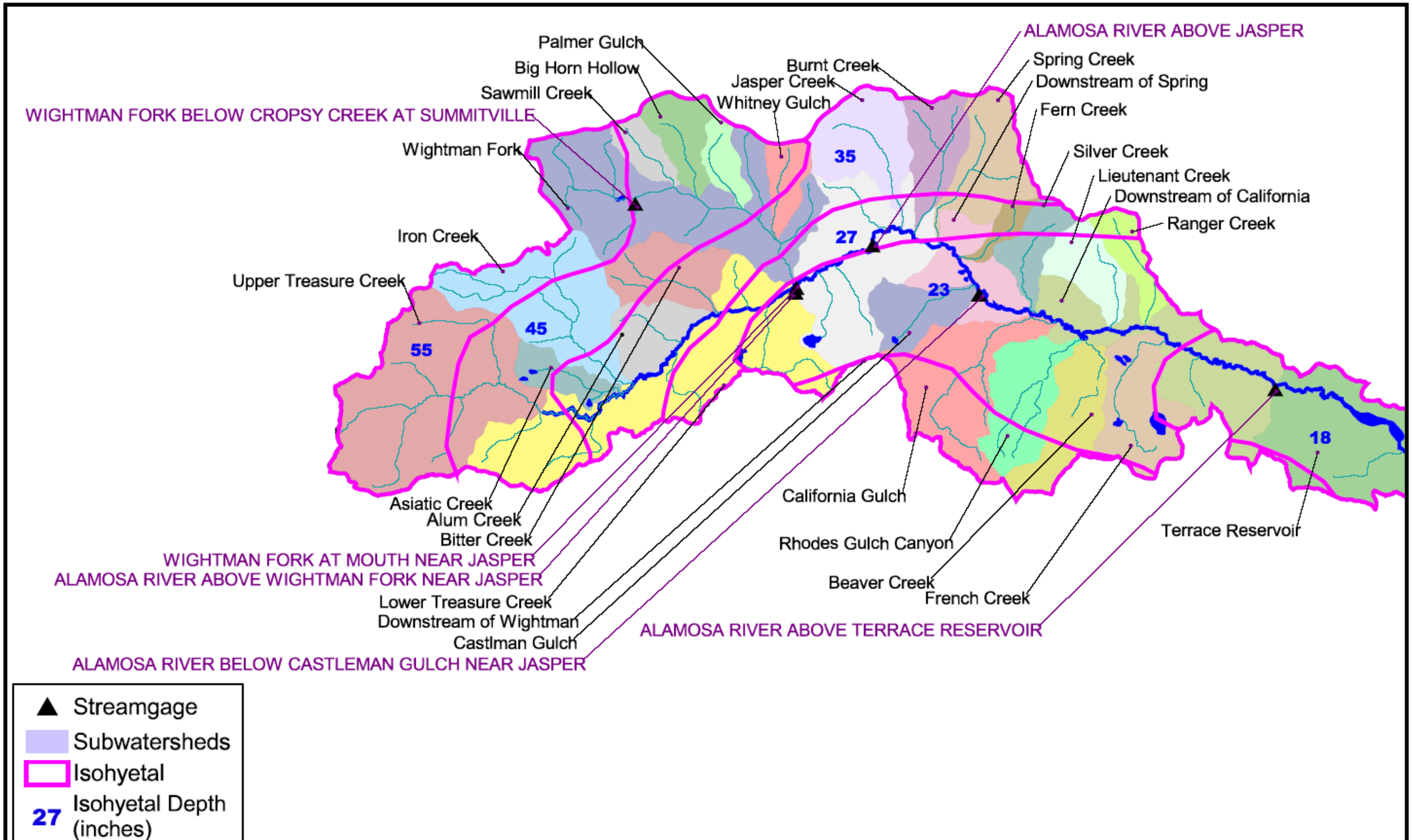


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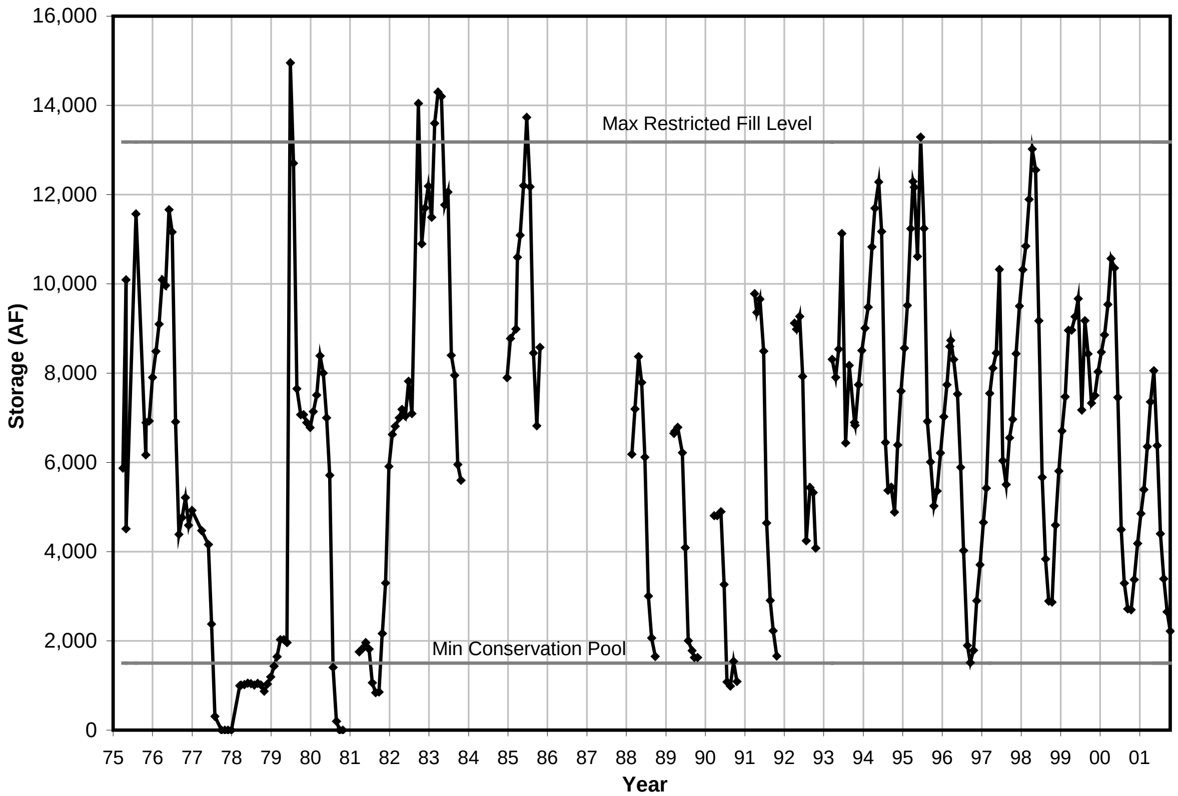
Figure 2-24.
Subwatersheds and Precipitation Isohyetals for Runoff Estimates

2.3.3 Terrace Reservoir Levels

Section 2.6 describes the Terrace Reservoir facility and operations. This section summarizes historical hydrologic data available for the reservoir.

Terrace Reservoir currently has a maximum restricted fill level of 8,564 feet above mean sea level (msl) with a total storage capacity of about 13,000 acre–feet (Miller, 2004). The fill level is restricted due to the limited spillway capacity of 8,928 cfs (see more discussion in **Section 2.6**). The spillway crest elevation is 8,571 feet (msl), at which the storage volume is about 15,000 acre–feet (Miller, 2004). **Figure 2–25** depicts the historic water storage in Terrace Reservoir. Reservoir storage follows an annual cycle, usually reaching a maximum storage level in June and then draining down to a minimum in the fall. Since 1975, Terrace Reservoir has reached the restricted level 6 times and used its spillway three times, in 1979, 1984, and 1985 (McCann, 2004). The fact that the reservoir only fills in well–above average precipitation years is evidence of the over–appropriated nature of the Alamosa River basin.

Figure 2–25. Terrace Reservoir Historic Water Storage



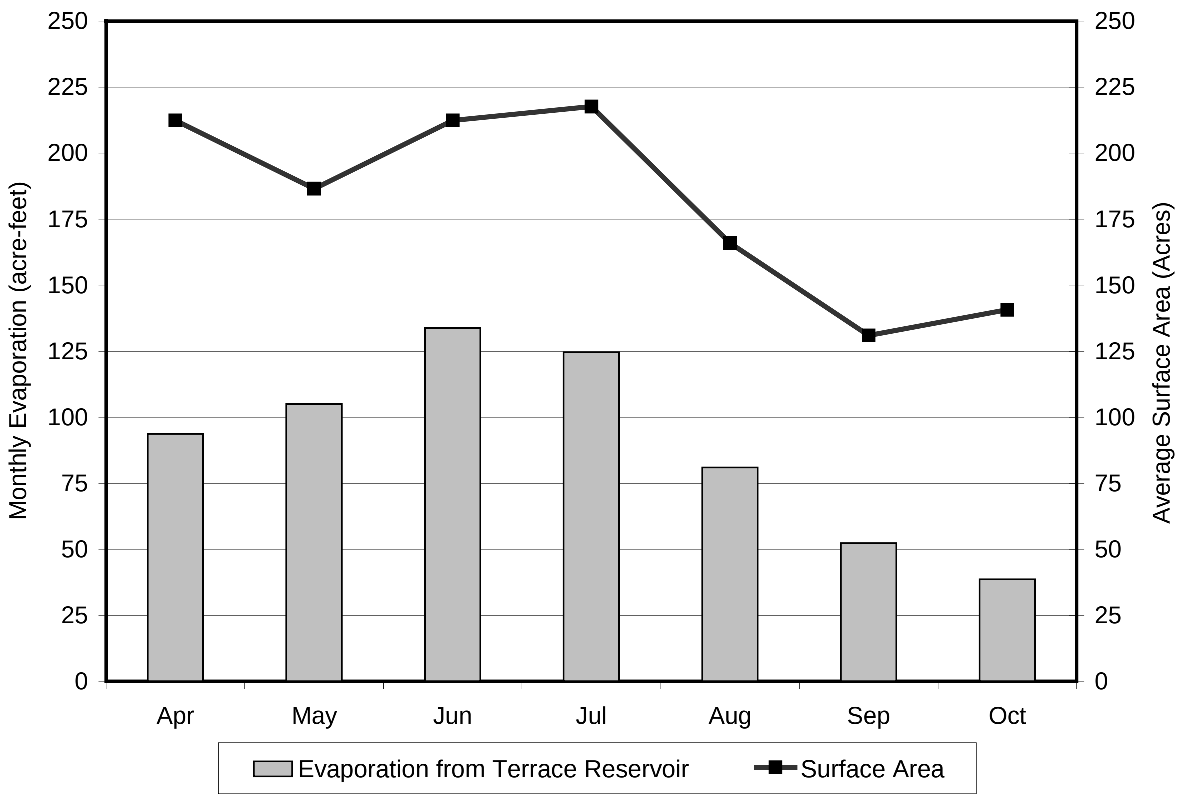
Note: The gaps in the chart represent periods where data is not available.

Source: Vandiver, 2002 and Miller 2004

A minimum conservation pool of 1,500 acre–feet is maintained in Terrace Reservoir. The conservation pool has been drained several times when the reservoir was emptied for repairs including in 1977, 1981, and 2003.

Terrace Reservoir loses approximately 600 acre–feet of water each year to evaporation. This estimate is based on the average monthly surface area of the reservoir, and an evaporation rate equal to 75 percent of the monthly pan evaporation rate at the Alamosa weather station. Evaporation is likely overestimated because Terrace Reservoir is at higher elevation and probably experiences less wind than the Alamosa station. The surface area of the reservoir fluctuates based on the depth of the reservoir. The pan evaporation rate varies according to climactic conditions. Evaporation is minimal during the winter when ice covers the reservoir and there are no measurements of pan evaporation available. **Figure 2–26** shows how evaporation and the surface area of Terrace Reservoir vary by month.

Figure 2–26. Average Monthly Surface Area and Evaporation from Terrace Reservoir

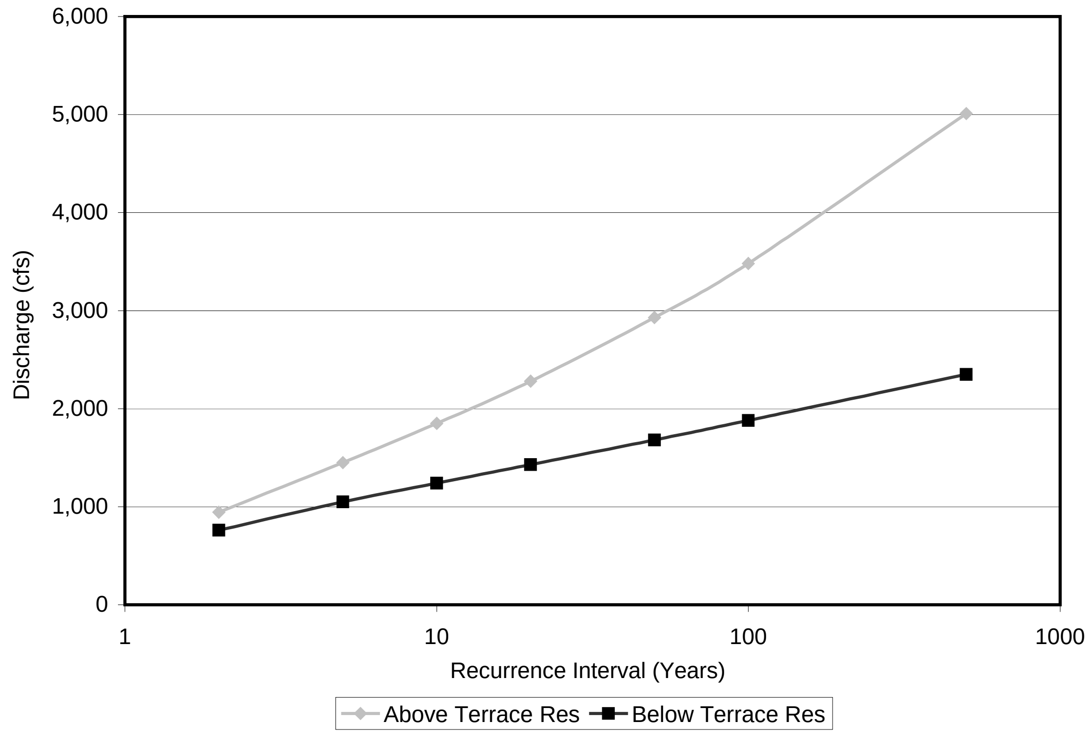


Source: WRCC, 2004b

2.3.4 Flood Frequency

Flood frequency data based on historical annual peak flow data for the Above and Below Terrace Reservoir gages are shown in **Figure 2–27** and **Table 2-7**. The flood frequency analysis consisted of fitting all available peak flow data to a log–Pearson distribution. The largest recorded flow at the Above Terrace Reservoir gage was 5,200 cfs in 1911. The 100–year flood event is 3,480 cfs at the Above Terrace Reservoir gage and 1,880 cfs at the Below Terrace Reservoir gage. The two–year flood event is approximately 940 cfs at the Above Terrace Reservoir gage and 760 cfs at the Below Terrace Reservoir gage. The State Engineer's Office determined the Probable Maximum Flood inflow to Terrace Reservoir is 26,900 cfs (VSCC, 2003).

Figure 2–27. Alamosa River Flood Frequency Curve



Source: Provided by CWCB in 2002

Table 2-7. Alamosa River Flood Frequency Data

Recurrence Interval (Years)	Discharge (cfs)	
	Alamosa River Above Terrace Reservoir	Alamosa River Below Terrace Reservoir
2	943	761
5	1,450	1,050
10	1,850	1,240
20	2,280	1,430
50	2,930	1,680
100	3,480	1,880
500	5,010	2,350

Source: CWCB, 2001

2.3.5 Flood Events

Flood events have caused damage to towns and agricultural lands in the Alamosa River watershed. Damage from high flows can be compounded by ice reducing channel capacity. In January of 1970, higher than average flows combined with below average temperatures caused ice jams leading to flooding near Capulin. In September of 1970, while Terrace Reservoir was drained and the valves were open, a discharge of 1190 cfs below Terrace Reservoir again caused damage in the vicinity of Capulin and deposited silt in the channel, further reducing capacity (Witte, date unknown). Conejos County sought and received money from the Office of Emergency Preparedness to take necessary precautionary measures. A contractor conducted channel straightening, deepening, and levee construction in 1971 to improve flood protection (Vandiver, 2004).

In 1985, high water destroyed the bridge crossing at Country Road 10 northeast of Capulin and washed out at least two irrigation headgates. In late June–early July of 1995, heavy precipitation lead to flooding in the agricultural areas east of Highway 285. Farm fields were submerged, irrigation ditches were filled with sediment, and roads and bridges were damaged (CCSCD, 1997).

Additional discussion of channel capacity and floodplain mapping is included in **Section 2.2**.

2.3.6 Water Rights and Usage

Colorado uses a system of water allocation known as the prior appropriation doctrine. Under the doctrine, the first appropriator of water has a senior right to that water that must be satisfied before any junior rights can receive water. The CDWR maintains a list of water rights on each stream in order of priority.

The first 90 priority water rights on the Alamosa River were adjudicated in 1888, although appropriation dates go back to 1870. The water right holders with the first 10 priority numbers in the Alamosa River watershed are shown in **Table 2-8**. Some priority numbers are skipped due to transfers and abandonment of historic rights. Other priority numbers are skipped for water rights assigned on either La Jara Creek or Hot Creek. The duplicate priority numbers are water rights having the same appropriation date. Many of the water right holders shown have additional water rights with lower priority. These additional rights are shown in the "total water rights appropriated to holder" column. This number includes all water rights assigned to the holder after the original appropriation date.

Table 2-8. Senior Water Rights in the Alamosa Watershed

Water Right Holder	Priority Number	Water Right for Priority Number Shown (cfs unless noted)	Total Water Right Appropriated to Holder (cfs unless noted)
Alamosa Creek Canal	1	4.8	78.70
El Viejo	1	14.4	14.4
Terrace Main Canal	2	2	142.02
Alamosa Creek Canal	3	2.85	78.70
Terrace Main Canal	8	5.2	142.02
Valdez	9	14	71.63
Capulin Ditch	10	31.37	31.37
Gabino Gallegos	11	15	35
Jasper Aug Plan	11	11.75 acre–feet	11.75 acre–feet
Terrace Reservoir	11	44.75 acre–feet	17,215.75 acre–feet

Source: CWRD, 2004

The complete list of current water right holders, their priority, and amount is shown in **Appendix D**. There are 85 total entries in the table but only 44 distinct water right holders. The total adjudicated flow is 1,354 cfs, accounting for recent abandonments and neglecting water rights based on volume. There is an additional adjudicated storage volume of 19,191 acre–feet, the majority (17,216 acre–feet) of which is appropriated to Terrace Reservoir. The diversion points of these major water right holders are shown in **Figure 2–104** (in **Section 2.11**).

Most of the water rights are reserved for agricultural uses. However, the USFS holds in stream rights in the Rio Grande National Forest. The instream flows were decreed in 2000 in order to protect and improve habitat, stream channels, aesthetic value, recreation, and soil conservation and to provide for range uses and fire protection (VSCC, 2003). Instream flows granted to USFS vary by month based on historical streamflow and are summarized in **Table 2-9**.

Table 2-9. USFS Appropriated Flows on Alamosa River for Rio Grande National Forest (cfs)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
20.6	23.5	29.7	68.9	178.2	134.8	56.4	43.3	27.0	23.4	19.2	22.0

Source: VSCC, 2003

Comparison of the total current water rights on the Alamosa River (1,354 cfs not including volumetric water rights) with the flow–duration curve in **Figure 2–23** shows that flows to accommodate all requests occur less than 1 percent of the time. The demands on the river are actually greater than the calculated 5–year flood discharge below Terrace Reservoir (shown **Figure 2–27**). There are 113 water right priority numbers but there is rarely enough water to fulfill half of the rights. **Table 2-10** shows the most junior priority number that is expected to be fulfilled in a given month based on average flow (ignoring volumetric water rights). Since most of the water rights are for irrigation, only the months of April to September are shown. In the highest flow month, June, only the 58 most senior water rights would come into priority based on historical average flows.

Table 2-10. Priority Numbers Expected to be Fulfilled in a Given Month

Month	Average Flow at Below Terrace Reservoir Gage (cfs)	Last Priority Number Fulfilled by Average Flow
April	97	14
May	363	45
June	418	58
July	185	27
August	103	15
September	51	9

Source: CWRD, 2004

Abandoned Water Rights

Several water rights have recently been abandoned on the Alamosa River after being placed on an abandonment list by the Division Engineer. The Division Engineer recommends that a water right be abandoned when the right has not been diverted for at least the last 10 years that water was available for the right to be in priority. The abandoned water rights were very junior and did not come into priority on a regular basis. The recently abandoned water rights are listed in **Table 2-11**. The most senior abandonment from the list is for priority number 77. According to the Division Engineer, the abandoned rights have little to no historical use and would provide little water to be transferred to other uses (Vandiver, 2002).

Table 2-11. Summary of Water Rights Abandonments Since April 1997

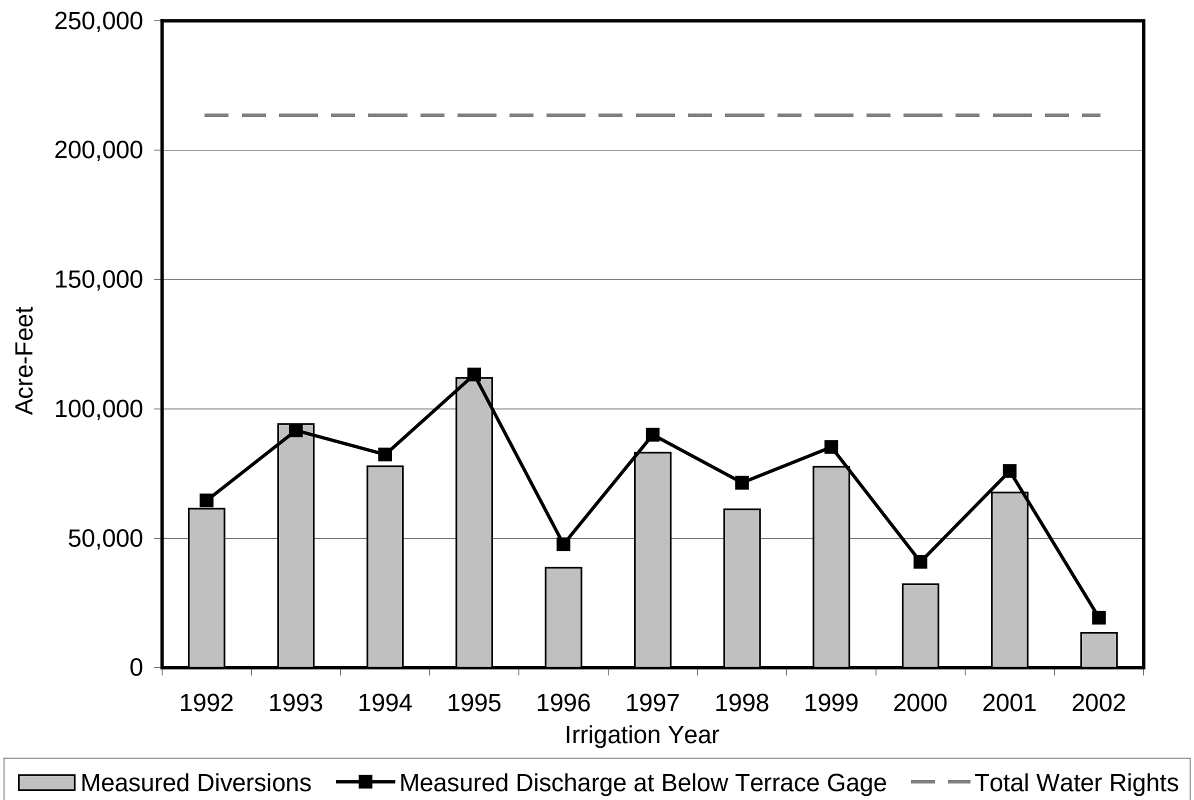
ID #	Water Right Name	Priority Number	Previous Adjudicated Flow (cfs)	Abandoned Amount (cfs)	New Adjudicated Flow (cfs)
571	North Alamosa Ditch	77	27.39	12.56	14.83
505	Alamosa Spring Creek Ditch	80	26.22	26.22	0
503	Alamosa Creek Canal	85	166.05	140	26.05
604	Valdez Ditch	90	72.63	15	57.63
601	Terrace Main Canal	112	300	209	91
Total			**590.76**	**402.78**	**187.98**

Source: CWRD, 2004

Water Usage

Although there are many claims on the water in the Alamosa River, actual water usage is limited by the water available in a given year. **Figure 2–28** shows how water usage varies from year to year according to water availability. Water usage data was obtained from the CDWR, but may not include all users. The figure shows that in some cases, return flows to the river allow the same water to be used more than once. However, in the unusually dry years of 1996 and 2002, discharge from Terrace Reservoir exceeded total ditch diversion. In these years, there was much less flood irrigation along the river corridor, and groundwater infiltration exceeded any available return flows. The data used to generate **Figure 2–28** is included in **Appendix D**.

Figure 2–28. Diversions compared with Streamflow



Notes: "Total water rights" only includes those 40 users for which diversion data exists. Water rights are generally adjudicated in cfs and were converted to acre–feet using the average number of days used over the 10 year period. This figure is only an estimate. Irrigation Year is from November to October and is referred to by the year ending in October

Source: Colorado State Engineer gage data and diversion data from Hydrobase

Figure 2–29 compares average water usage per water right holder to the appropriated water right. Water usage was converted from the original water usage data in acre–feet to cfs using the reported number of days used. This produces an estimate of the average water usage rate on days that the water right was used for comparison purposes; however, day to day water usage rates can vary. The data used to generate **Figure 2–29** is included in **Appendix D**. The water right holders shown in the figure only use a portion of their total water rights because there is not usually water available to use their entire right.

The Alamosa River is located within the Rio Grande Basin as shown in **Figure 2–31**. The Rio Grande Compact (Compact) of 1938 apportions water between Colorado, New Mexico, and Texas. The Compact requires minimum deliveries of water from the Rio Grande basin at the New Mexico state line based on an annual volumetric delivery schedule. The volume of water that must be delivered to the state line in a given year depends on the volume of flow measured at the following 4 index stream gages within the Rio Grande and Conejos basins:

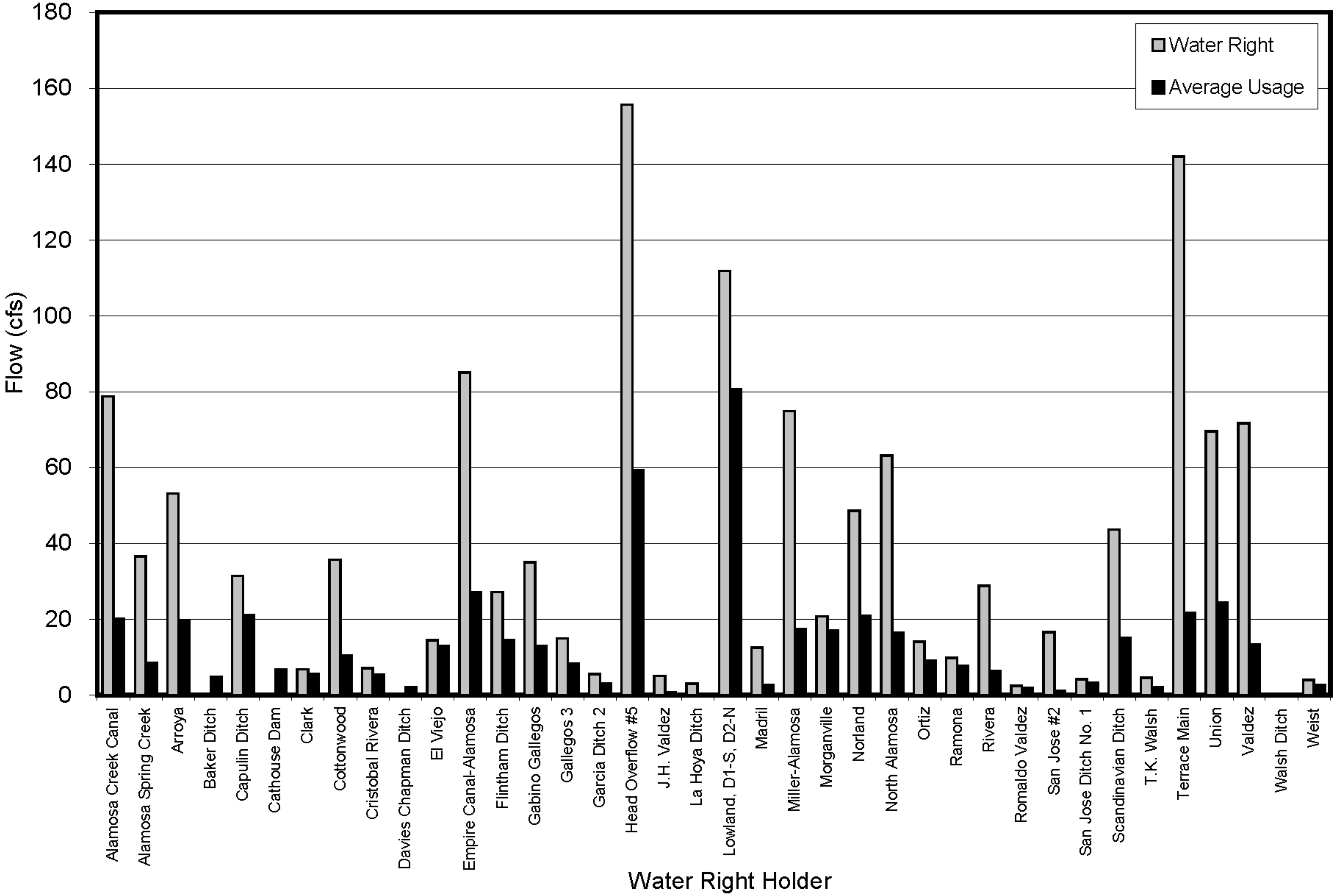
- Rio Grande near Del Norte
- Conejos near Mogote
- Los Pinos near Ortiz
- San Antonio near Ortiz (Vandiver, 2000)

In any given year Colorado is required to deliver between 25 and 70 percent of the water generated in the Rio Grande and Conejos River basins. The delivery schedules are summarized in **Figure 2–30**.

Administering the Compact to meet water demands within Colorado and obligations at its border has historically been difficult. Between 1927 and 1967 Colorado under–delivered water accruing a debit of approximately 940,000 acre–feet, leading Texas and New Mexico to bring a Supreme Court action against Colorado. Since 1968, the State Engineer has administered the Compact as a two–river system with delivery requirements for both the Conejos and Rio Grande and has met the required deliveries to New Mexico. The current administration enforces the prior appropriation doctrine in order to meet the Compact's requirements, curtailing junior water right users when necessary.

The Alamosa River's role in the Rio Grande Compact has been debated. The Colorado Supreme Court ruled the following in 1983, "Our independent evaluation of the legislative history, coupled with the water court's finding that at the time of the compact the streams contributed little water to the mainstem, leads us to conclude that the drafters did not intend to include the normal surface flows of Alamosa Creek, La Jara Creek, and Trinchera Creek under Article III compact administration, and therefore, that the state engineer does not have the authority to apply the tributary rule to these creeks (Case Number 80SA288, December 5, 1983)." The complete decision is included as **Appendix G**.

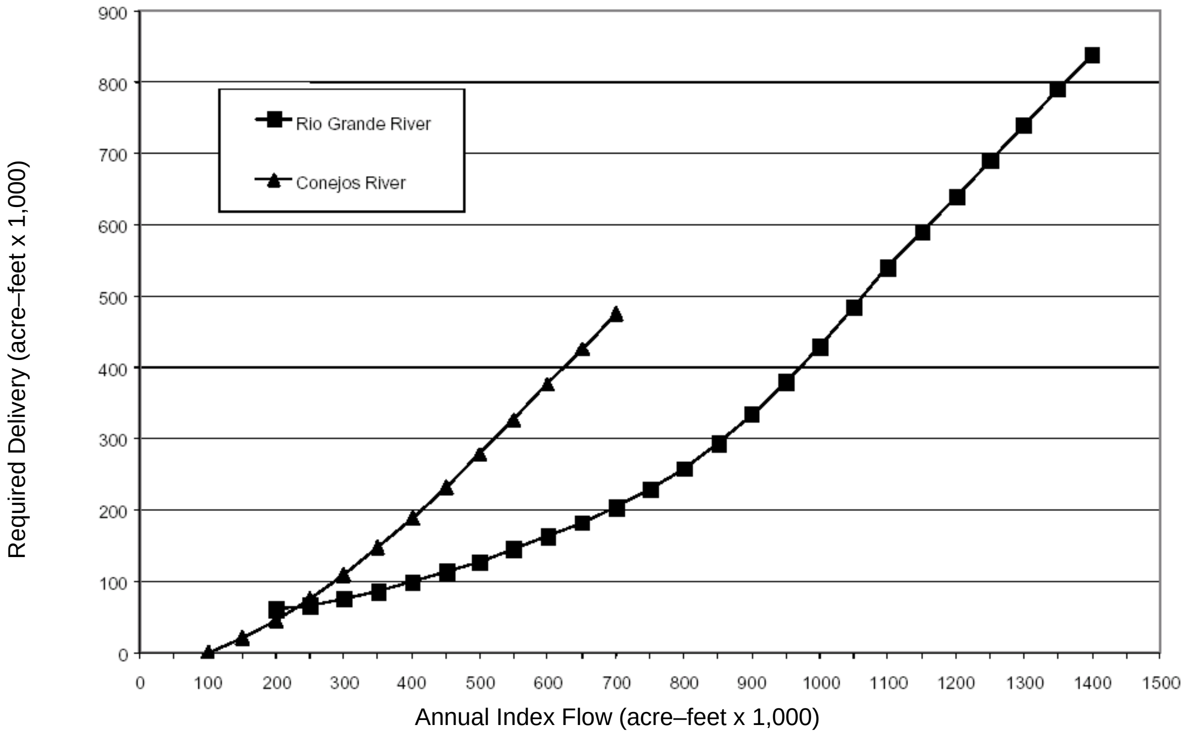
Figure 2-29. Average Water Usage for Irrigation Years 1992 to 2002 compared to Water Right



Note: Annual usage in cfs was computed from acre-feet per year using days used per year which was then averaged over 10 years, it is only an estimate.

Source: Colorado State Engineer diversion data from Hydrobase and water rights from CWRD, 2004.

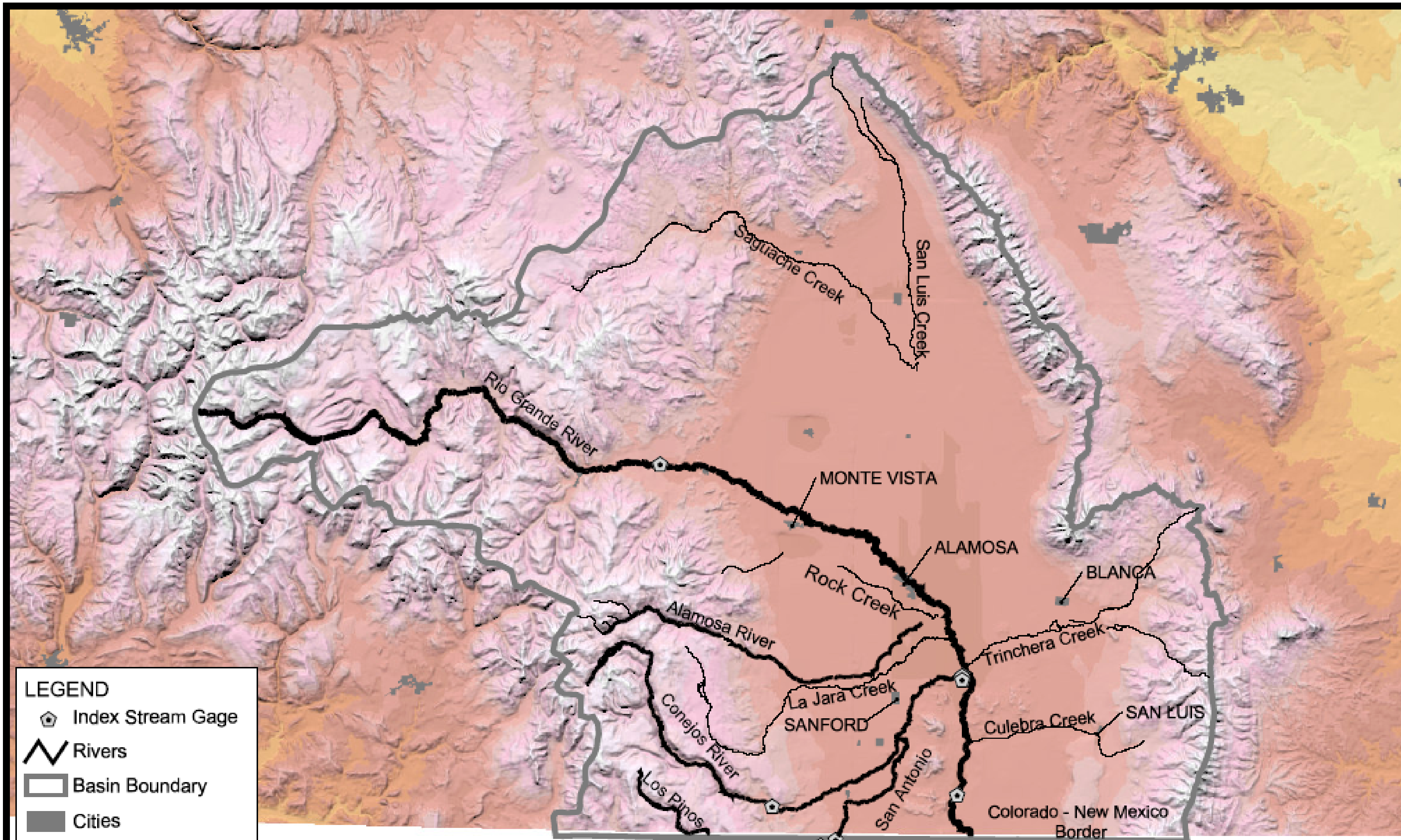
Figure 2–30. Rio Grande Compact Delivery Requirements Verses Annual Index Flows



From Vandiver, 2000

The Division Engineer has administered the Compact under the assumption that normal surface flows in the Alamosa River are not tributary to the Rio Grande (and thus are not subject to Compact limitations), but that groundwater and flood flows could be tributary to the Rio Grande. The Division Engineer defines normal surface flows as those up to that level which is required to satisfy all existing water rights in the Alamosa River basin (Vandiver 2004). At times of high flow, the Rio Grande delivery schedule requires an increase in obligation that is higher than the increase in flow coming into the system at Del Norte, and the Division Engineer feels that the framers of the Compact recognized that flood and groundwater flows from non–Compact tributaries would contribute to the flow at Lobatos gage (Vandiver 2002). It has been the policy of the State Engineer that groundwater tributary to and floodwater that accrues to the Rio Grande is not to be diminished.

There is currently a strong difference of opinion in the watershed regarding the fate of Alamosa River flood flows. Local landowners contend that flood flows dissipate in the fields and wetlands east of Highway 285, while the Division Engineer contends that flood flows have historically made it to the Rio Grande channel. The Division Engineer's current policy is to not permit any storage or other retention/depletion of flood flows in the Alamosa River watershed above that which has occurred historically, under the assumption that this would adversely affect the ability to make Compact deliveries at the state line. In addition, the Division Engineer has not permitted over–diversion or new appropriations (for water not historically used) that could reduce wet–year flows in the lower Alamosa River basin. This policy would effectively prevent any new projects designed to capture unused runoff in very wet years.



10 0 10 20 Miles

1:1150000

Alamosa River Watershed
Restoration Master Plan

MWH in association with Agro Engineering,
Lidstone and Associates, and SWCA

Figure 2-31.
Rio Grande Basin in Colorado