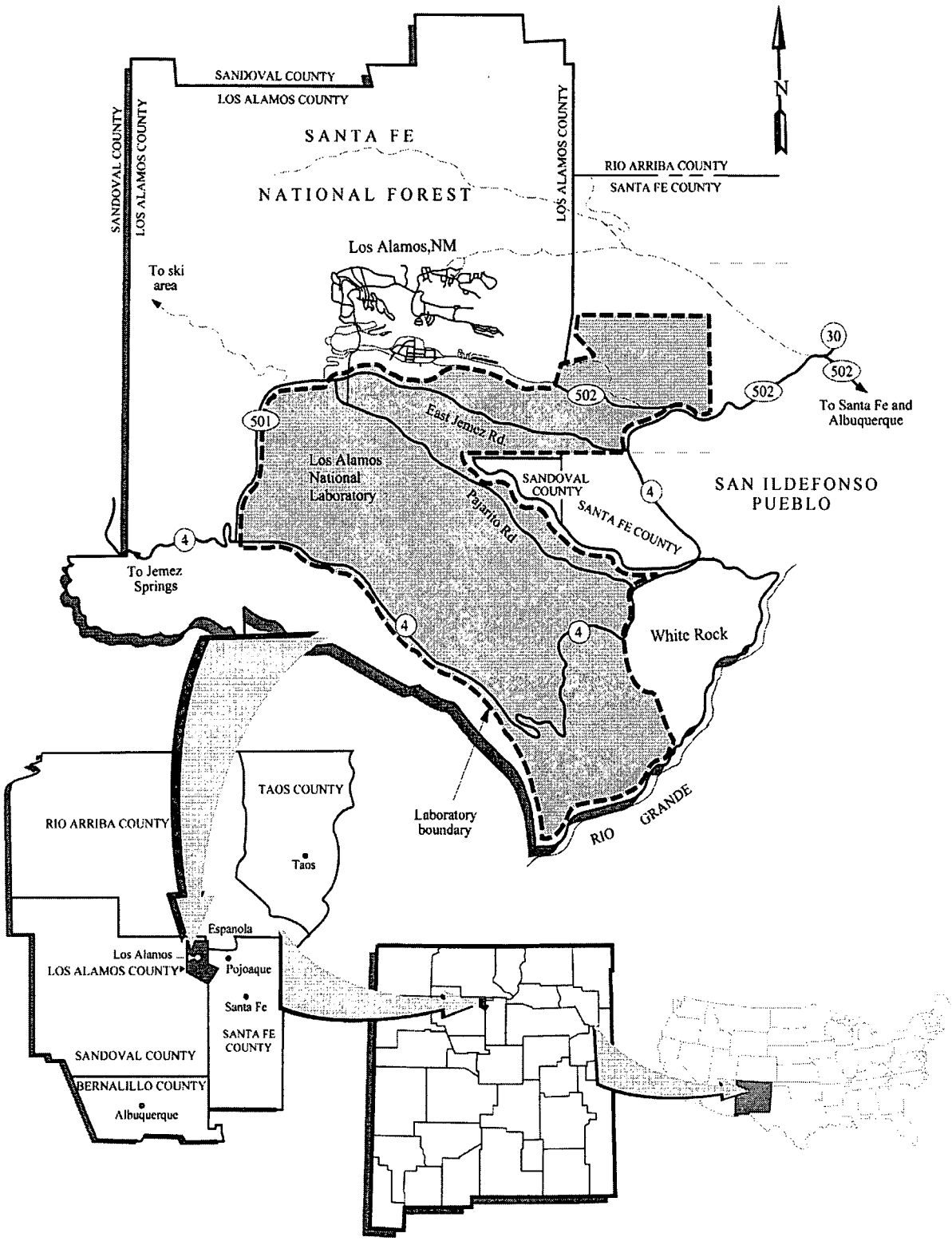


Figure 1. Location of the Los Alamos National Laboratory and Study Area (Source: LANL 1998a).

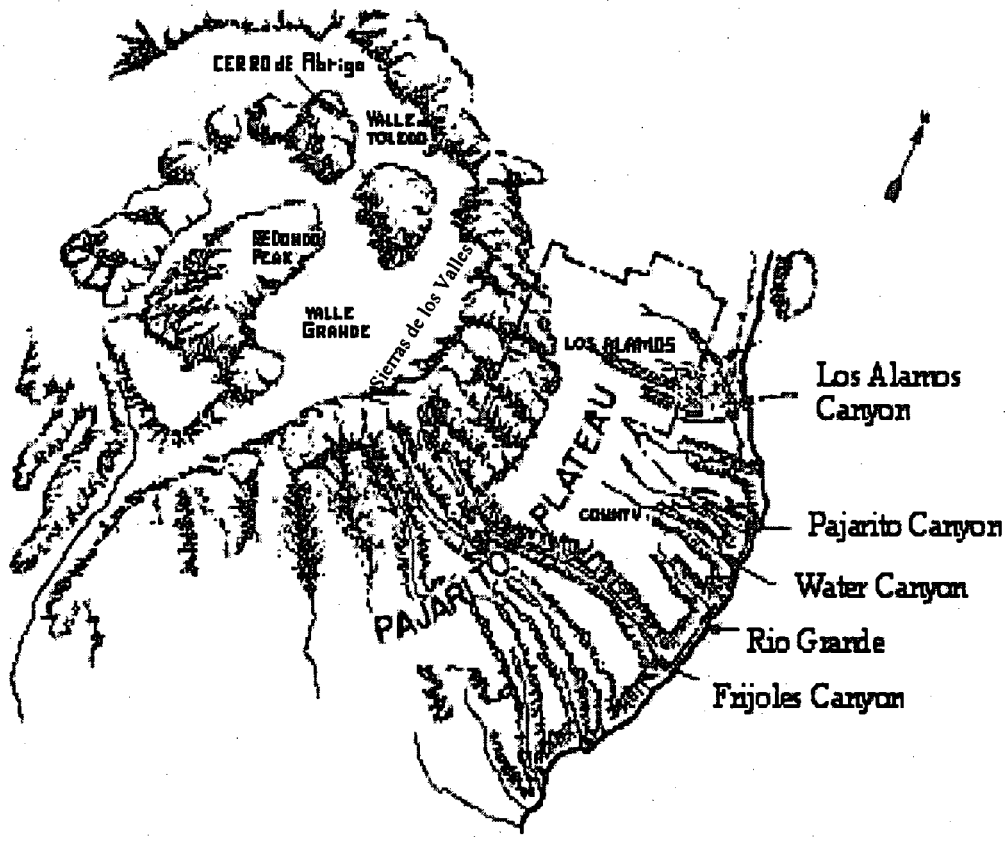


Figure 2. General Location of Several Physiographic Features of the East Jemez Mountains (Source: modified from Ferenbaugh *et al.* 1994).

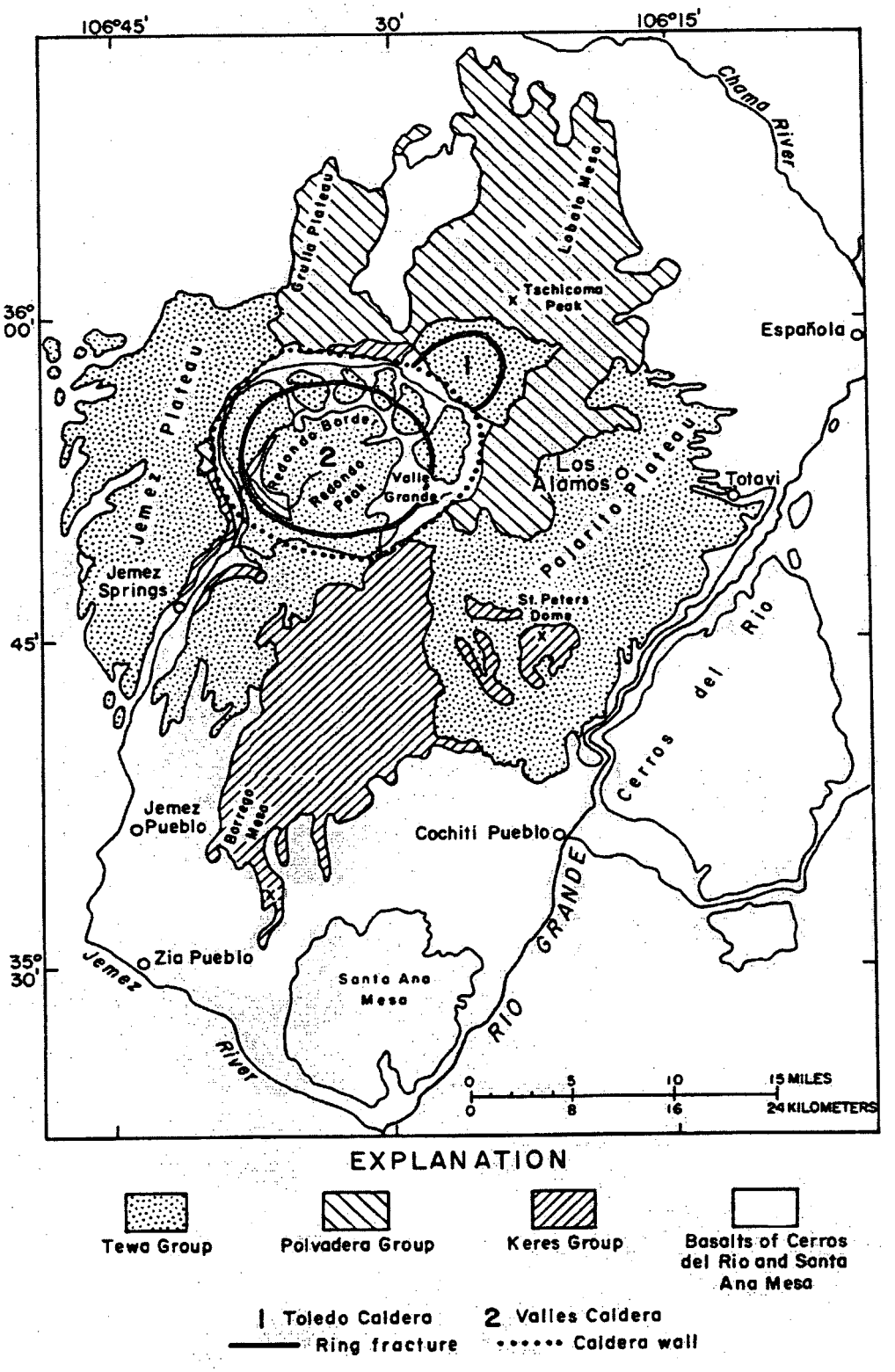


Figure 3. Surface Geology and Location of the Pajarito Plateau. (Copyright by the New Mexico Geological Society; Kudo 1974).

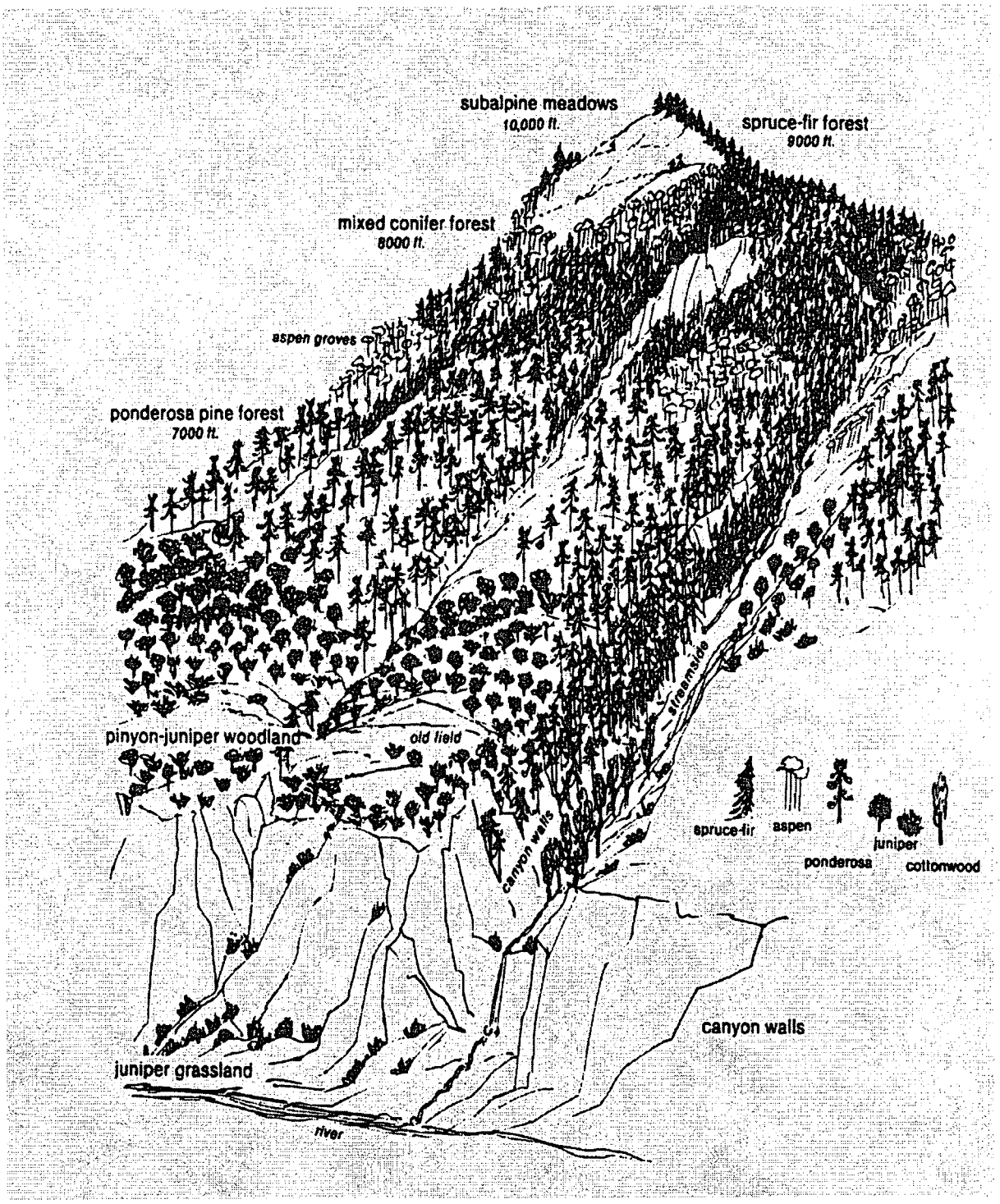


Figure 4. Depiction of Plant Communities of the Pajarito Plateau (Source: Travis 1992).

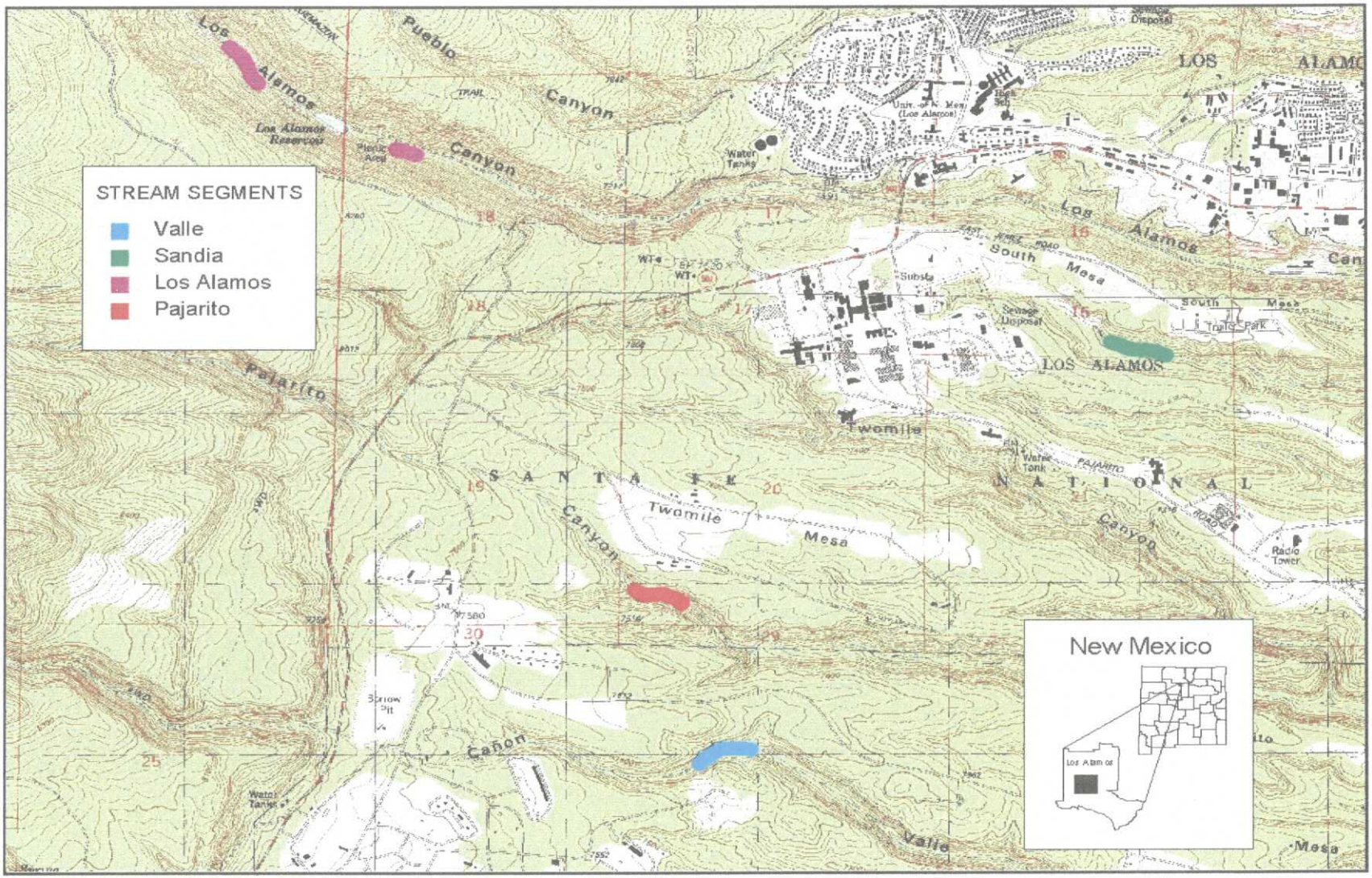


Figure 5. Location of Los Alamos, Sandia, Pajarito and Valle Canyon Stream Segments Studied

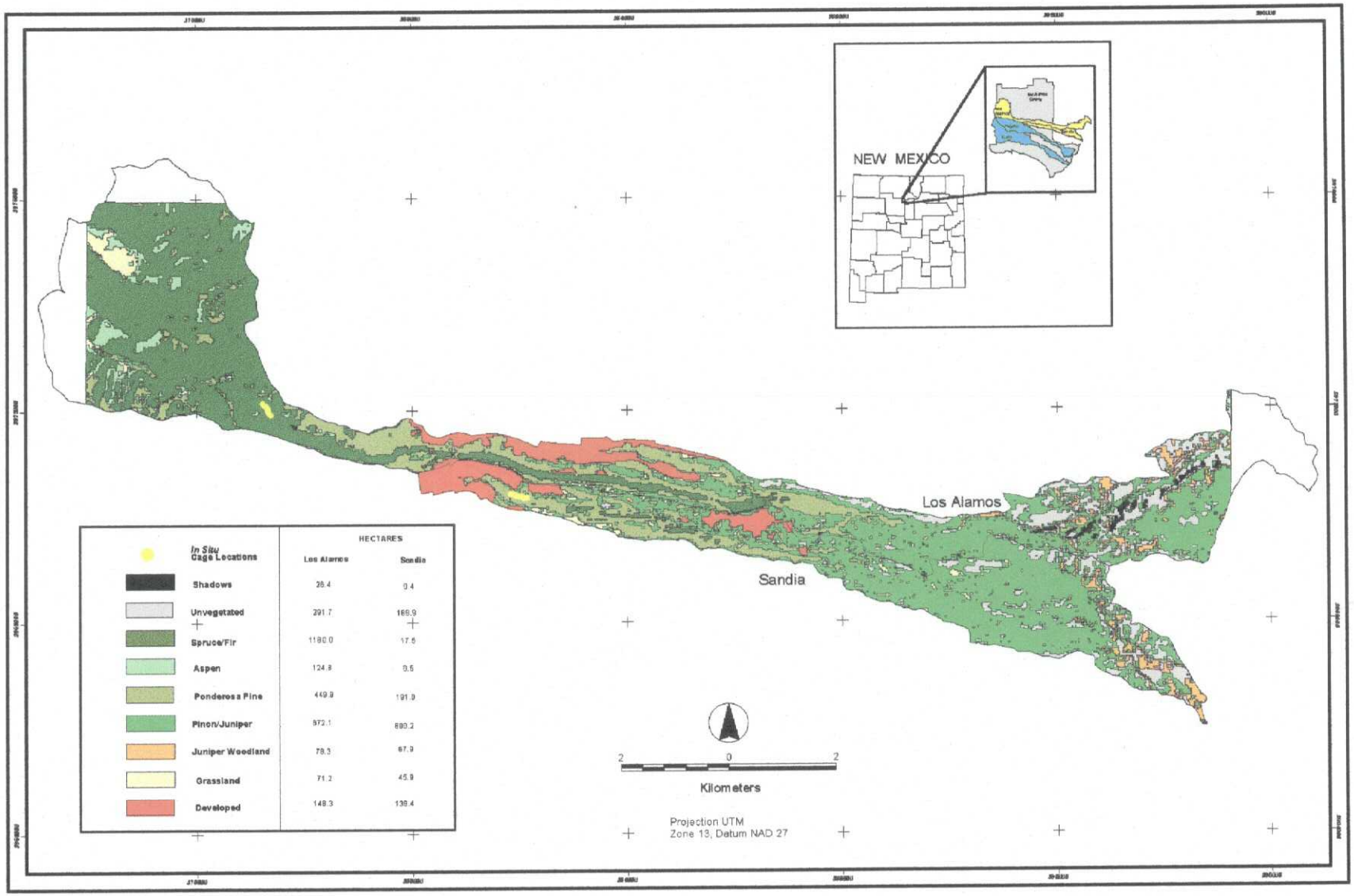


Figure 6. Land Cover of Los Alamos and Sandia Canyons (Source: Koch *et al.* 1997) and Cages Locations within Streams Studied.

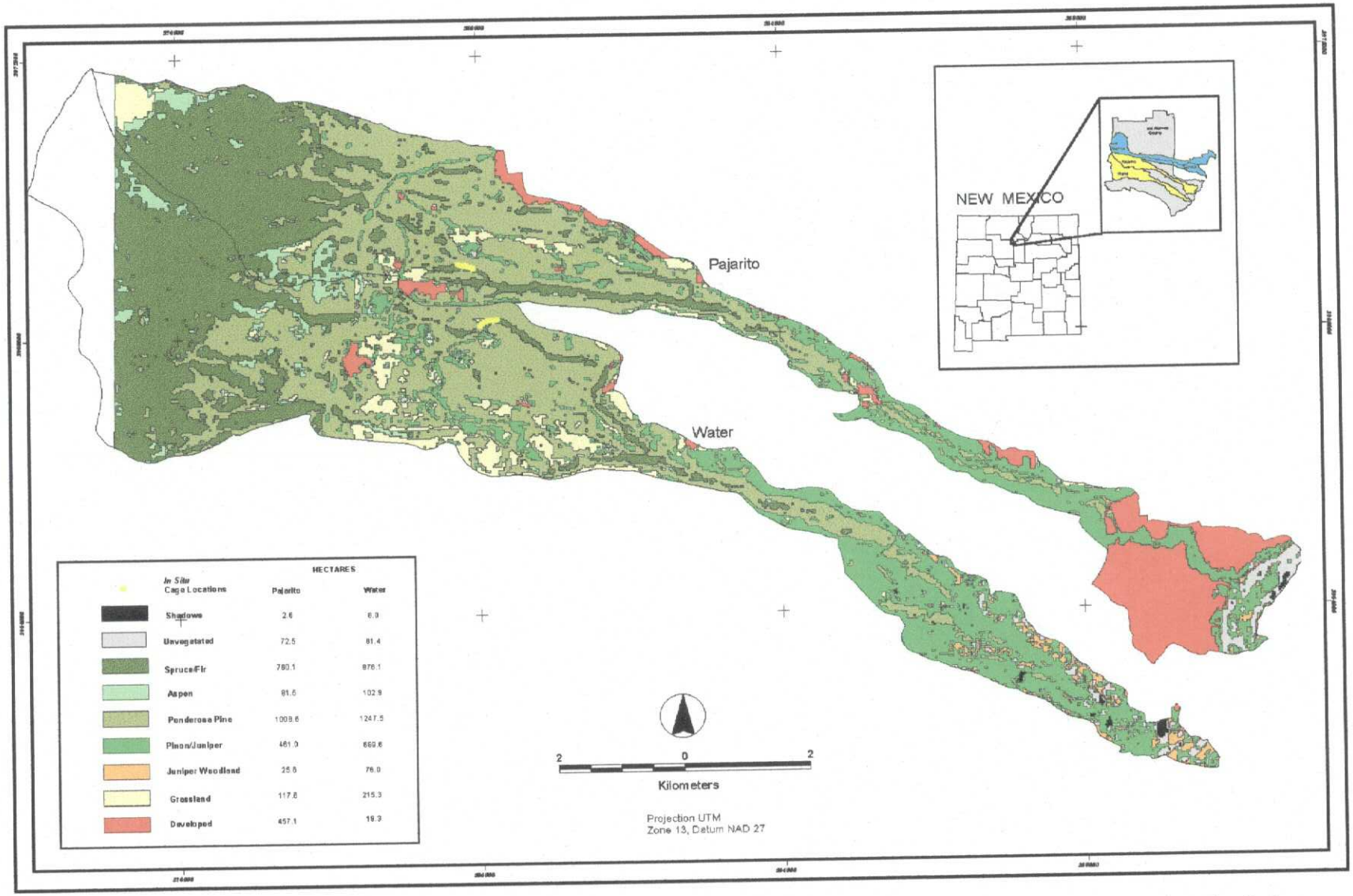


Figure 7. Land Cover of Pajarito and Valle Canyons (Source: Koch *et al*. 1997) and Cages Locations within Streams Studied.

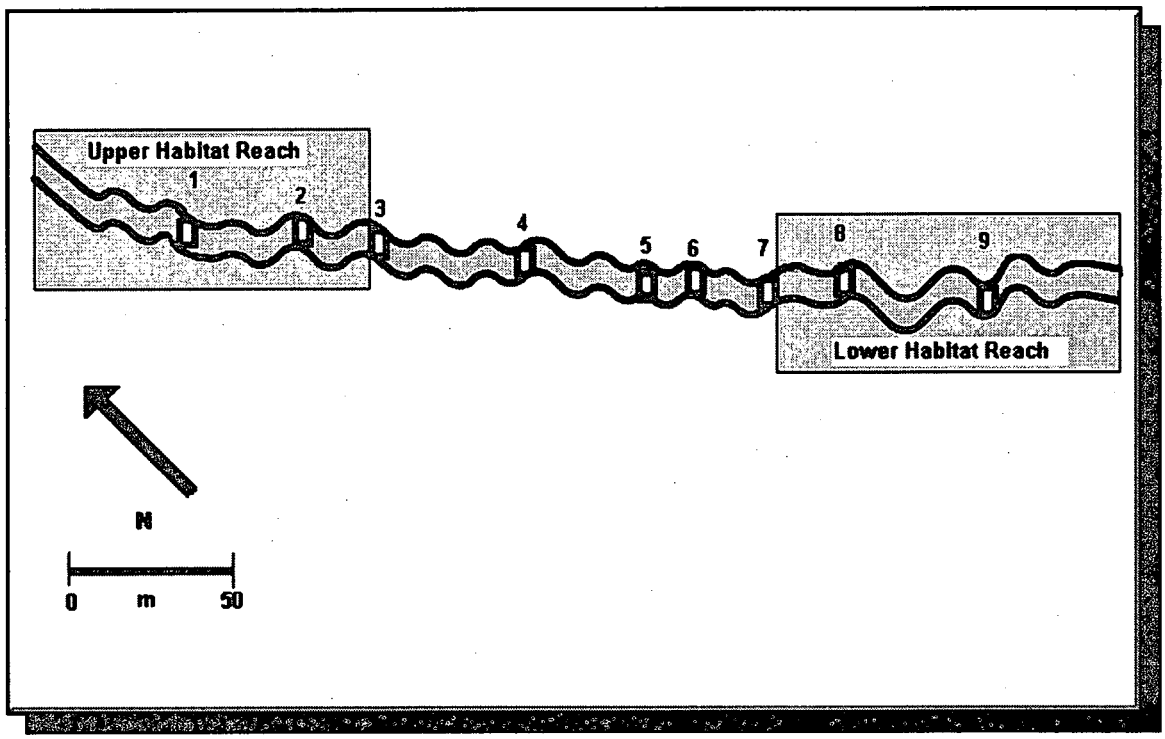


Figure 8. Depiction of Cage Locations and Habitat Evaluation Reaches in the Los Alamos Canyon Stream Segment.

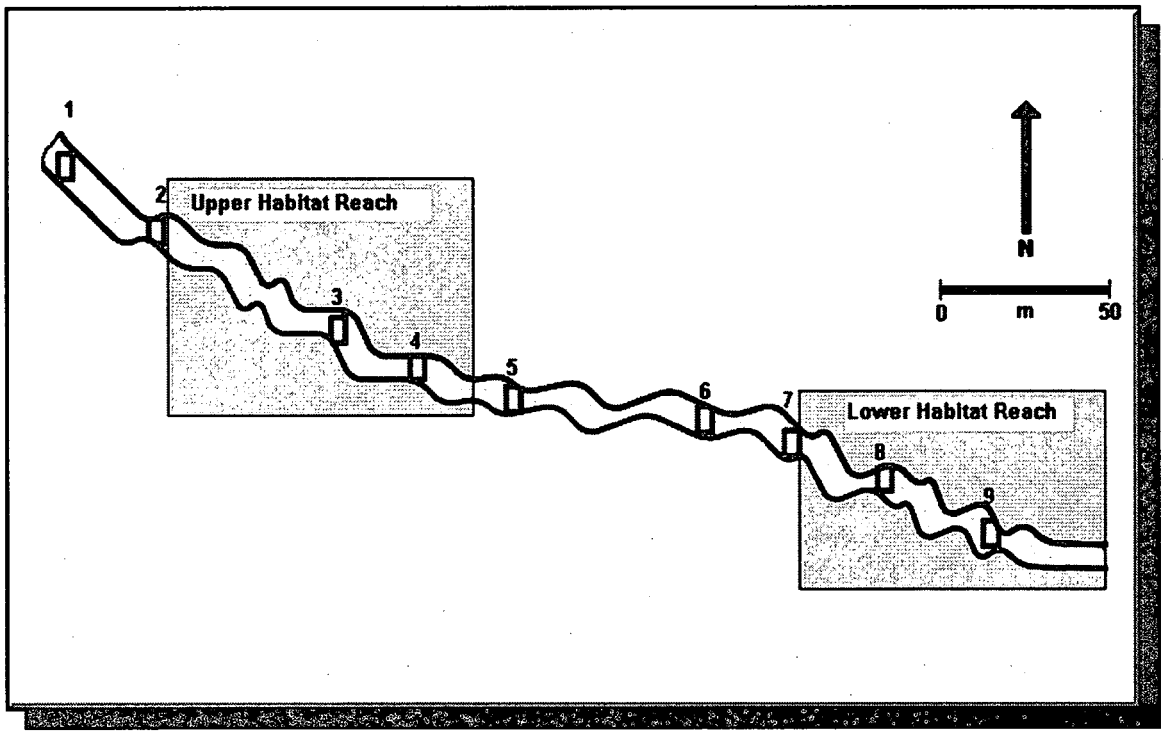


Figure 9. Depiction of Cage Locations and Habitat Evaluation Reaches in the Sandia Canyon Stream Segment.

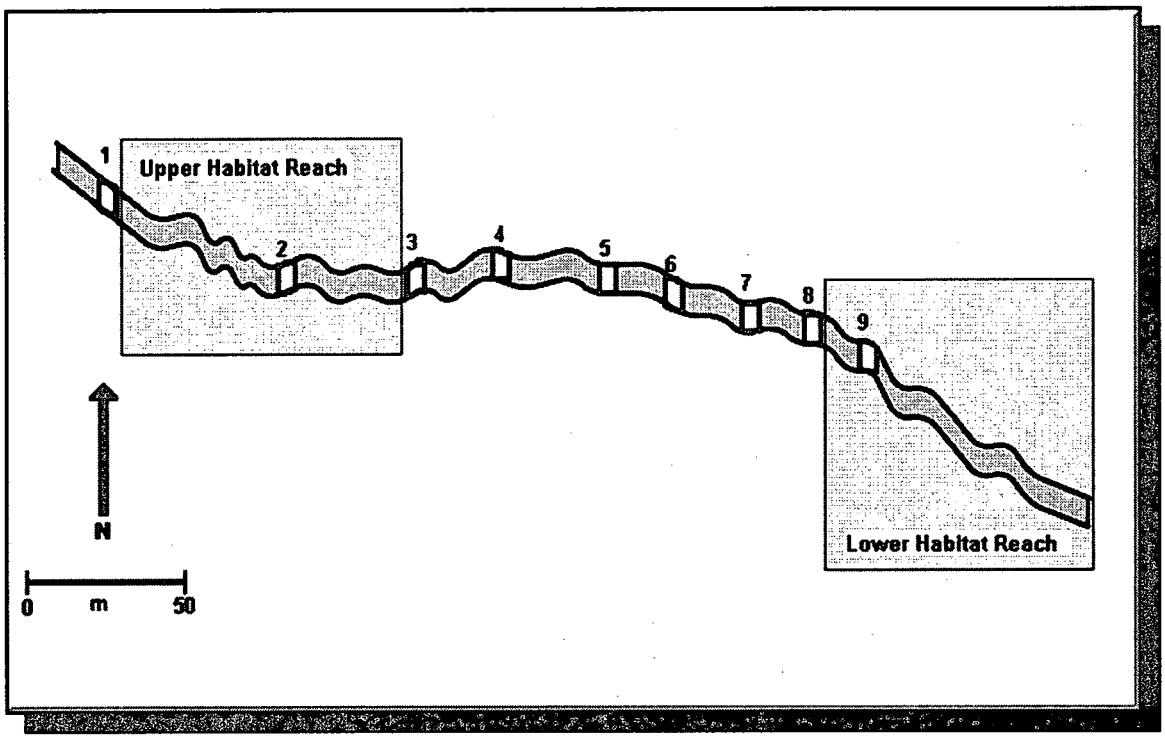


Figure 10. Depiction of Cage Locations and Habitat Evaluation Reaches in the Pajarito Canyon Stream Segment.

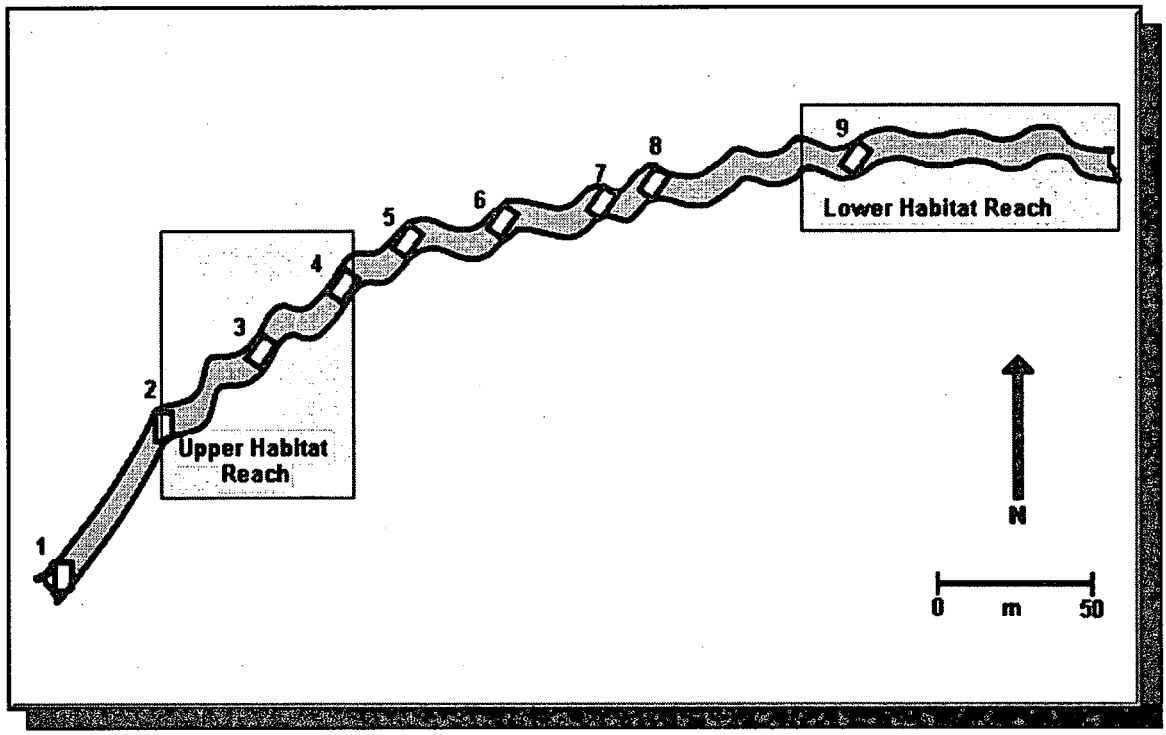
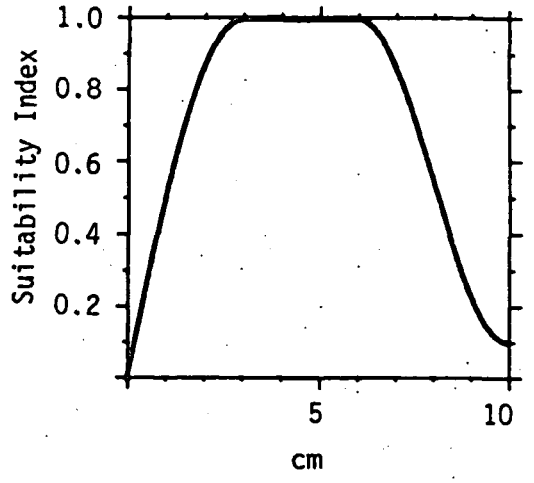


Figure 11. Depiction of Cage Locations and Habitat Evaluation Reaches in the Valle Canyon Stream Segment.

Figure 12. Example of a Suitability Index for Substrate (at right), and Habitat Variables (below) that are Components of the Brook Trout Habitat Suitability Index Model (Raleigh 1982).



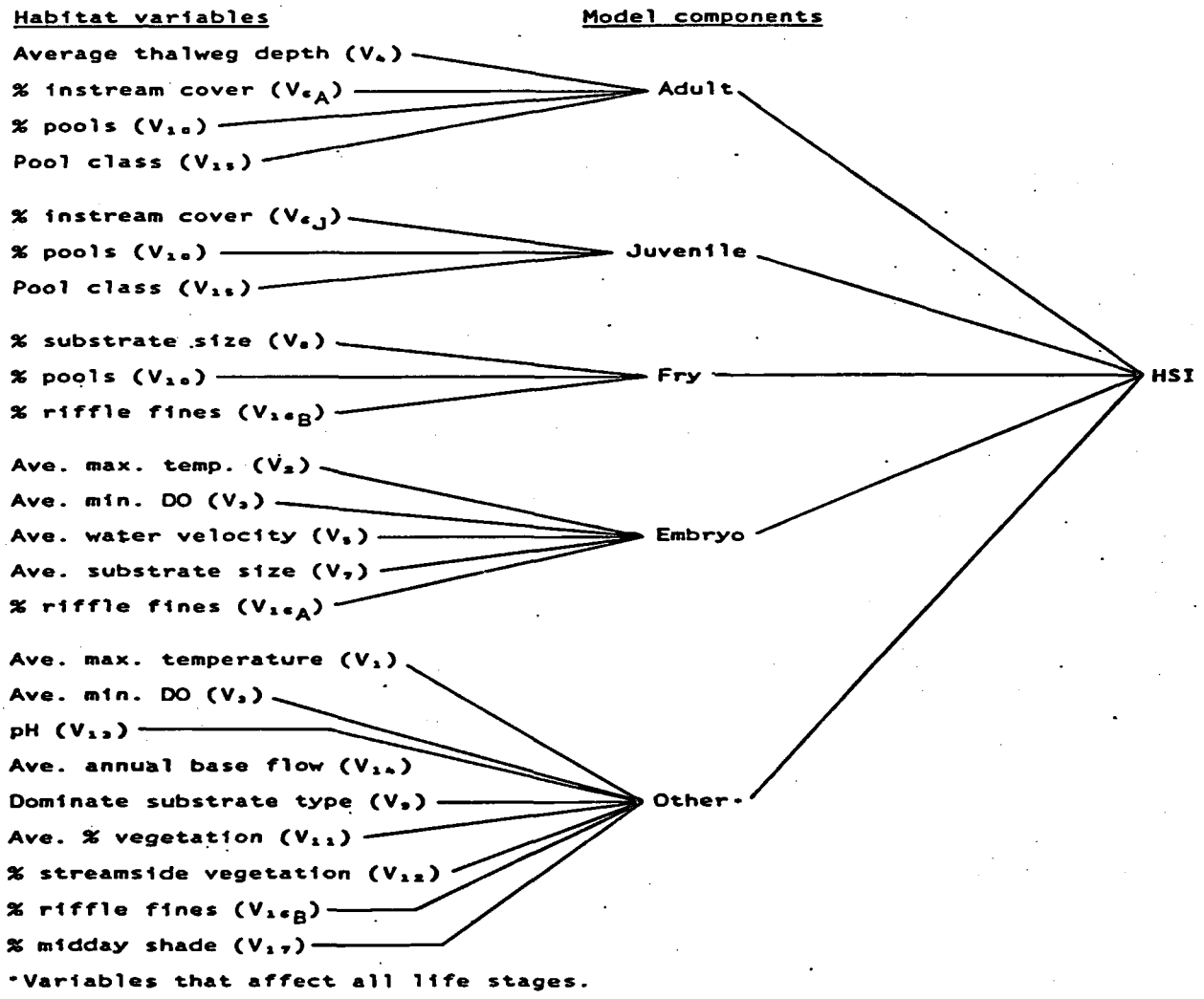


Figure 13. Habitat Variables That Are Components of the Longnose Dace Habitat Suitability Index Model (Edwards *et al.* 1983).

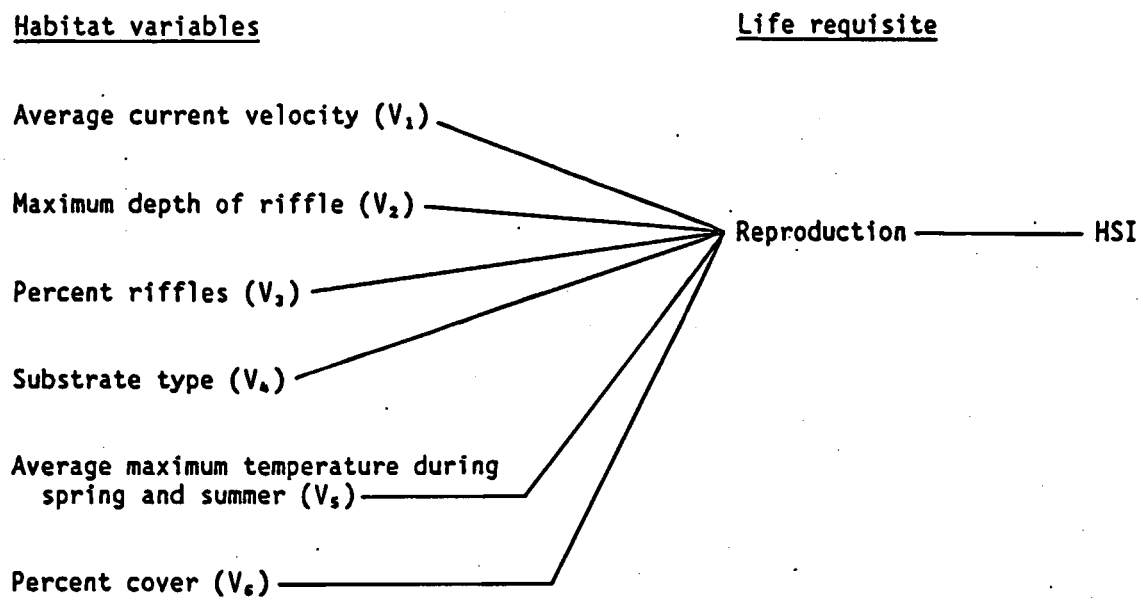


Figure 1. Habitat variables included in the riverine model for longnose dace.

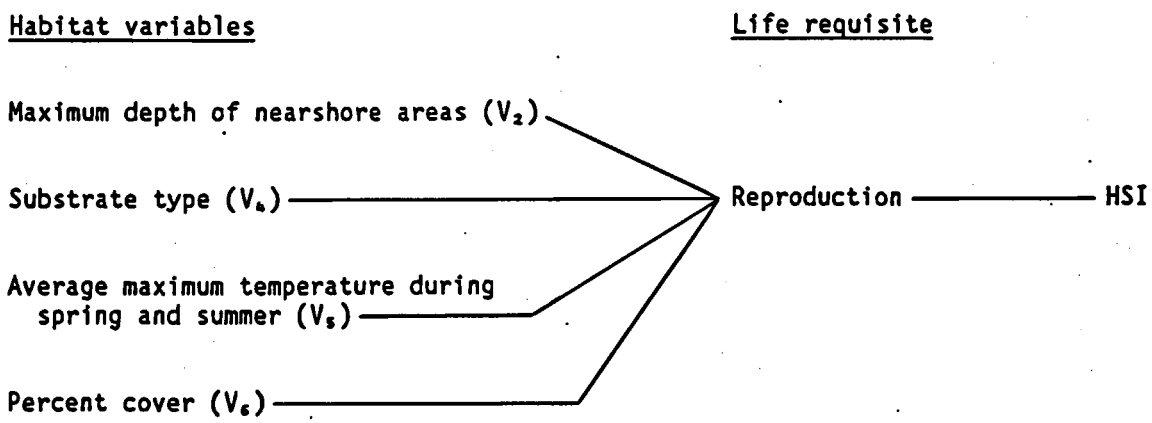


Figure 14. Stream Channel Geomorphological Classification Developed by Rosgen (1996) Used to Evaluate the Long-term Stability of a Stream.

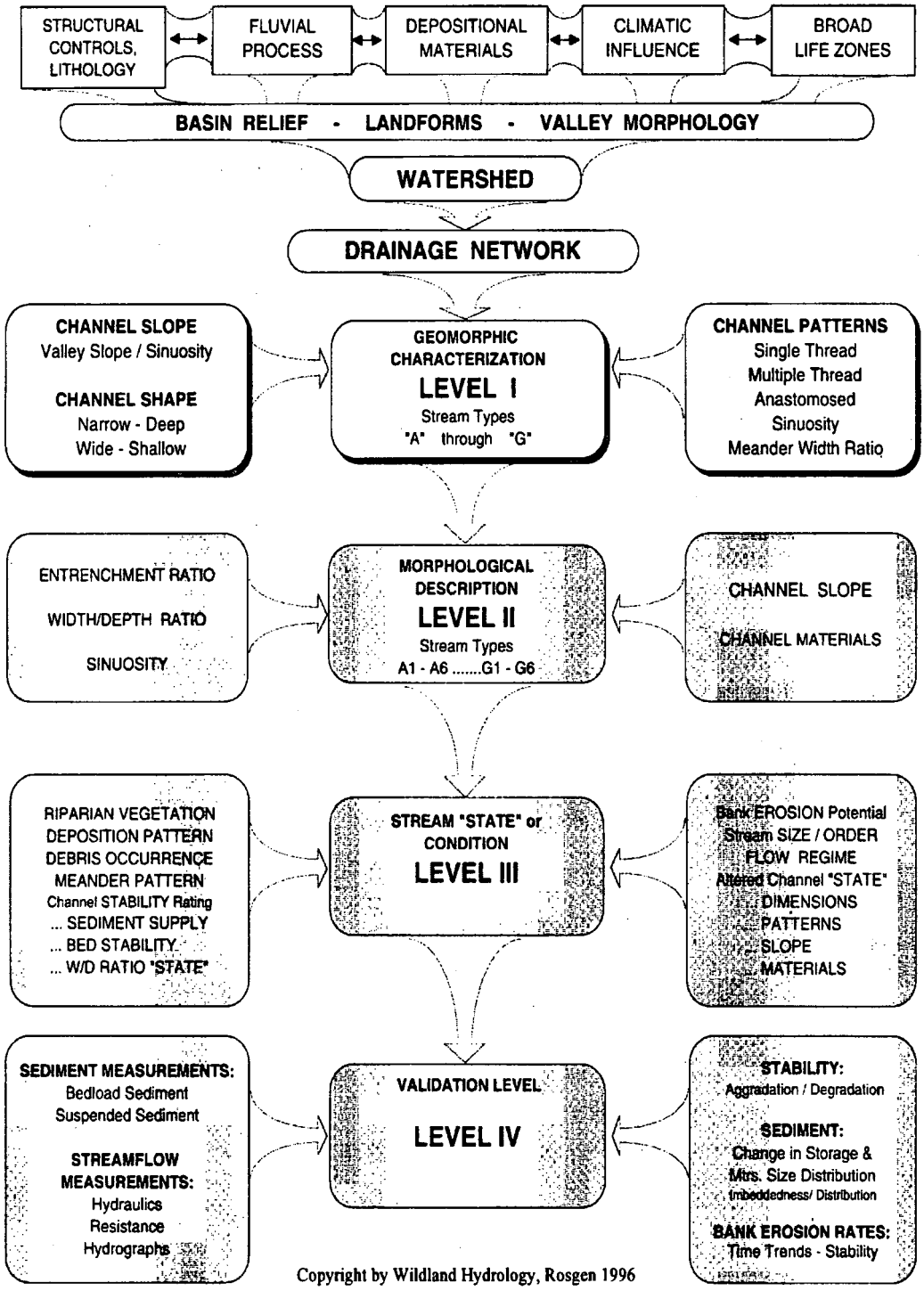


Figure 15. Rosgen (1996) Level II Stream Channel Morphological Classification.

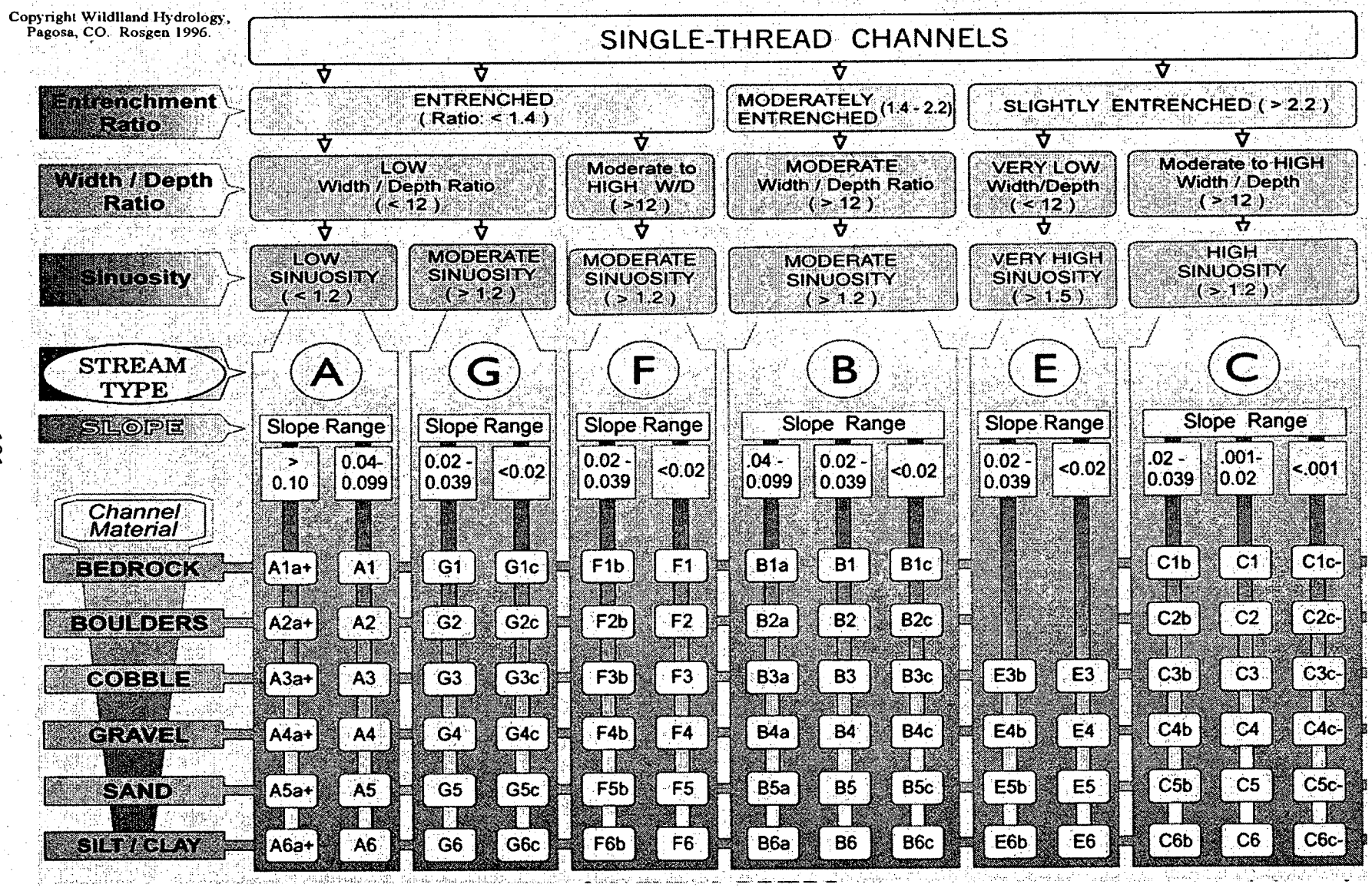


Figure 16. Rosgen (1996) Level III Stream Channel Classification.

CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

Reach Location_____ Date_____ Observers_____

Stream Type _____

		Category	EXCELLENT	
UPPER BANKS	1	Landform Slope	Bank Slope Gradient <30%	2
	2	Mass Wasting	No evidence of past or future mass wasting.	3
	3	Debris Jam Potential	Essentially absent from immediate channel area.	2
	4	Vegetative Bank Protection	90%+ plant density. Vigor and variety suggest a deep dense soil binding root mass.	3
LOWER BANKS	5	Channel Capacity	Ample for present plus some increases. Peak flows contained. W/D ratio <7.	1
	6	Bank Rock Content	65%+ with large angular boulders. 12"+ common.	2
	7	Obstructions to Flow	Rocks and logs firmly imbedded. Flow pattern without cutting or deposition. Stable bed.	2
	8	Cutting	Little or none. Infreq. raw banks less than 6".	4
	9	Deposition	Little or no enlargement of channel or pt. bars.	4
BOTTOM	10	Rock Angularity	Sharp edges and corners. Plane surfaces rough.	1
	11	Brightness	Surfaces dull, dark or stained. Gen. not bright.	1
	12	Consolidation of Particles	Assorted sizes tightly packed or overlapping.	2
	13	Bottom Size Distribution	No size change evident. Stable mater. 80-100%	4
	14	Scouring and Deposition	<5% of bottom affected by scour or deposition.	6
	15	Aquatic Vegetation	Abundant Growth moss-like, dark green perennial. In swift water too.	1
			TOTAL	

		Category	GOOD	
UPPER BANKS	1	Landform Slope	Bank Slope Gradient 30-40%	4
	2	Mass Wasting	Infrequent. Mostly healed over. Low future potential.	6
	3	Debris Jam Potential	Present, but mostly small twigs and limbs.	4
	4	Vegetative Bank Protection	70-90% density. Fewer species or less vigor suggest less dense or deep root mass.	6
LOWER BANKS	5	Channel Capacity	Adequate. Bank overflows rare. W/D ratio 8-15	2
	6	Bank Rock Content	40-65%. Mostly small boulders to cobbles 6-12"	4
	7	Obstructions to Flow	Some present causing erosive cross currents and minor pool. filling. Obstructions newer and less firm.	4
	8	Cutting	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12"	6
	9	Deposition	Some new bar increase, mostly from coarse gravel.	8
BOTTOM	10	Rock Angularity	Rounded corners and edges, surfaces smooth, flat.	2
	11	Brightness	Mostly dull, but may have <35% bright surfaces.	2
	12	Consolidation of Particles	Moderately packed with some overlapping.	4
	13	Bottom Size Distribution	Distribution shift light. Stable material 50-80%.	8
	14	Scouring and Deposition	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12
	15	Aquatic Vegetation	Common. Algae forms in low velocity and pool areas. Moss here too.	2
			TOTAL	

		Category	FAIR	
UPPER BANKS	1	Landform Slope	Bank slope gradient 40-60%	6
	2	Mass Wasting	Frequent or large, causing sediment nearly year long.	9
	3	Debris Jam Potential	Moderate to heavy amounts, mostly larger sizes.	6
	4	Vegetative Bank Protection	<50-70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9
LOWER BANKS	5	Channel Capacity	Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25.	3
	6	Bank Rock Content	20-40% with most in the 3-6" diameter class.	6
	7	Obstructions to Flow	Moder. frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6
	8	Cutting	Significant. Cuts 12-24" high. Root mat overhangs and sloughing evident	12
	9	Deposition	Moder. deposition of new gravel and course sand on old and some new bars.	12
BOTTOM	10	Rock Angularity	Corners and edges well rounded in two dimensions.	3
	11	Brightness	Mixture dull and bright, ie 35-65% mixture range.	3
	12	Consolidation of Particles	Mostly loose assortment with no apparent overlap.	6
	13	Bottom Size Distribution	Moder. change in sizes. Stable materials 20-50%	12
	14	Scouring and Deposition	30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools.	18
	15	Aquatic Vegetation	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3
			TOTAL	

Source: Rosgen 1996, Copyright Wildland Hydrology, Pagosa, CO

Figure 16. Rosgen (1996) Level III Stream Channel Classification ~ *Continued.*

CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

	Category		POOR	
UPPER BANKS	1	Landform Slope	Bank Slope Gradient 60%+	8
	2	Mass Wasting	Frequent or large causing sediment nearly year long or imminent danger of same.	12
	3	Debris Jam Potential	Moder. to heavy amounts, predom. larger sizes.	8
	4	Vegetative Bank Protection	<50% density, fewer species and less vigor indicate poor, discontinuous and shallow root mass.	12
LOWER BANKS	5	Channel Capacity	Inadequate. Overbank flows common. W/D ratio >25	4
	6	Bank Rock Content	<20% rock fragments of gravel sizes, 1-3" or less.	8
	7	Obstructions to Flow	Sediment traps full, channel migration occurring.	
	8	Cutting	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Extensive deposits of predom. fine particles. Accelerated bar development.	16
BOTTOM	10	Rock Angularity	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Predom. bright, 65%+ exposed or scoured surfaces.	4
	12	Consolidation of Particles	No packing evident. Loose assortment easily moved.	8
	13	Bottom Size Distribution	Marked distribution change. Stable materials 0-20%.	16
	14	Scouring and Deposition	More than 50% of the bottom in a state of flux or change nearly year long.	24
	15	Aquatic Vegetation	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	4
			TOTAL	

Stream Width _____ x avg. depth _____ x mean velocity _____ = Q _____ cfs

Gauge Ht _____ Reach Gradient _____ Stream Order _____ Sinuosity Ratio _____

Width $_{bf}$ _____ Depth $_{bf}$ _____ W/D Ratio _____ Discharge (Q_{bf}) _____

Drainage Area _____ Valley Gradient _____ Stream Length _____ Valley Length _____

Sinuosity _____ Entrenchment Ratio _____ Length Meander (Lm) _____ Belt Width _____

Sediment Supply
Extreme _____
Very High _____
High _____
Moderate _____
Low _____

Stream Bed Stability
Aggrading _____
Degrading _____
Stable _____

Width/Depth Ratio Condition
Normal _____
High _____
Very High _____

TOTAL SCORE for Reach E____ = G____ + F____ + P____ =

Remarks _____

Stream Type [ ]

Pfankuch Rating [ ]

from table Reach Condition [ ]

CONVERSION OF STABILITY RATING TO REACH CONDITION BY STREAM TYPE*

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
GOOD	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60
FAIR	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78
POOR	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+

Stream Type	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
GOOD	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
FAIR	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
POOR	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream Type	DA3	DA4	DA5	DA6	E3	E4	E5	E6
GOOD	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63
FAIR	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86
POOR	87+	87+	87+	87+	87+	97+	97+	87+

Stream Type	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6
GOOD	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
FAIR	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
POOR	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

**Generalized relations ... need additional Level IV data to expand data base for validation.*

Source: Rosgen 1996, Copyright by Wildland Hydrology, Pagosa, CO.

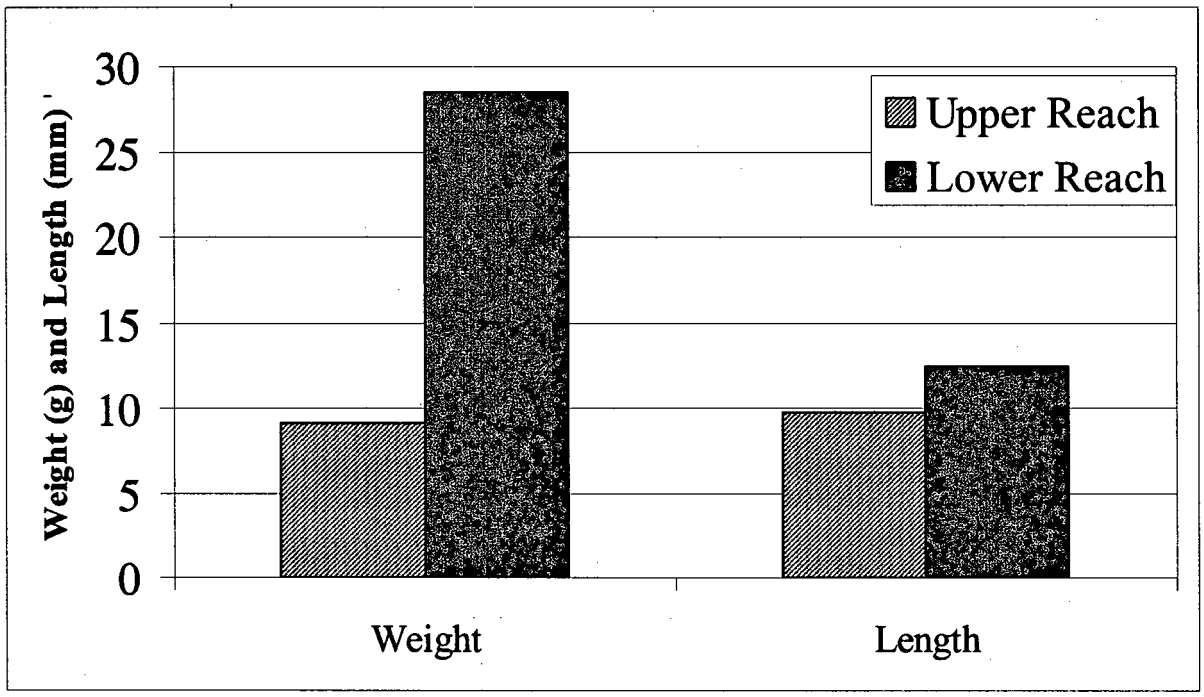


Figure 17. Mean Weight and Length of Trout Captured in Los Alamos Canyon During October 1997.

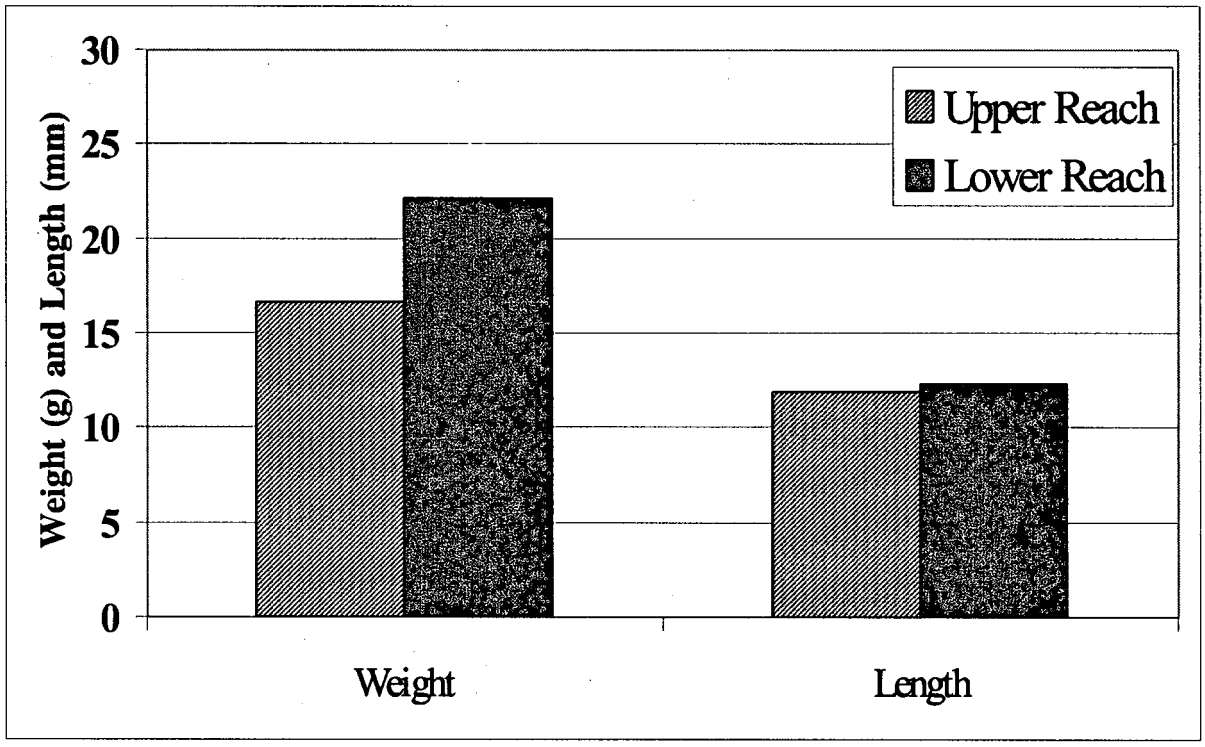


Figure 18. Mean Weight and Length of Trout Captured in Los Alamos Canyon during December 1998.

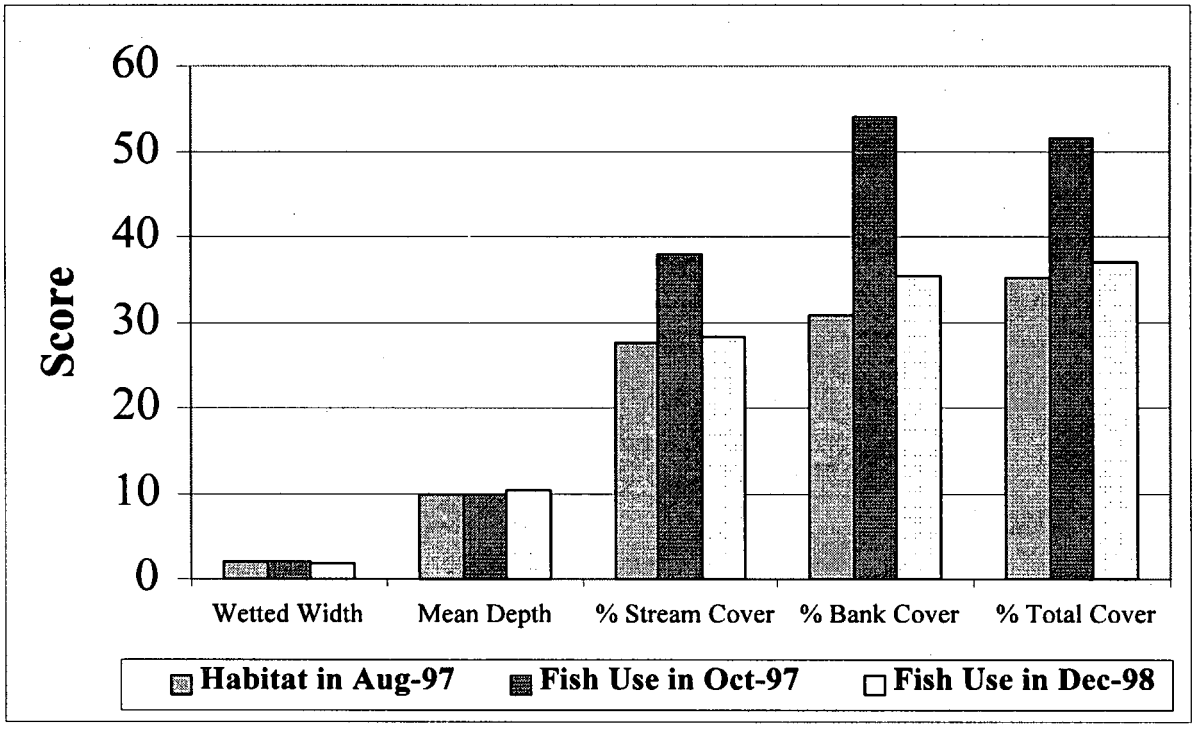


Figure 19. Comparative Values for Various Habitat Parameters Corresponding to Locations Where Fish were Captured (October 1997 and December 1998) Versus Randomized Habitat Quantification (August 1997) in Los Alamos Canyon.

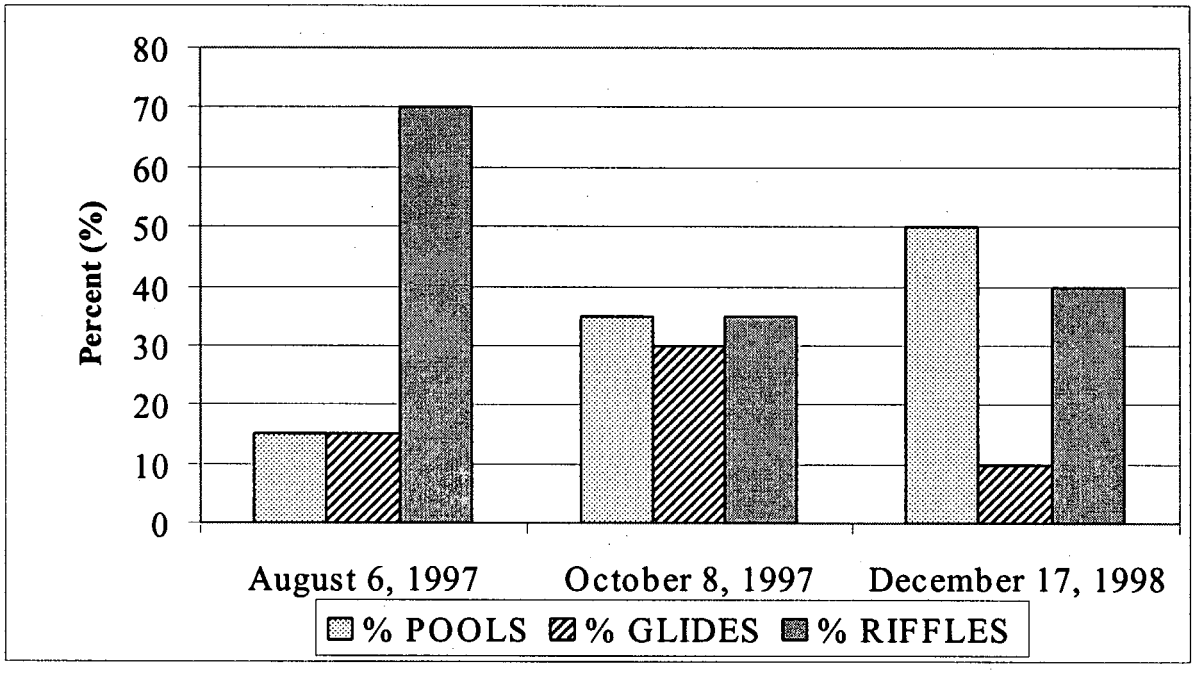


Figure 20. Comparative Habitat Type Percentages Corresponding to Locations Where Fish Were Captured (October 1997 and December 1998)Versus Randomized Habitat Quantification (August 1997) in Los Alamos Canyon.

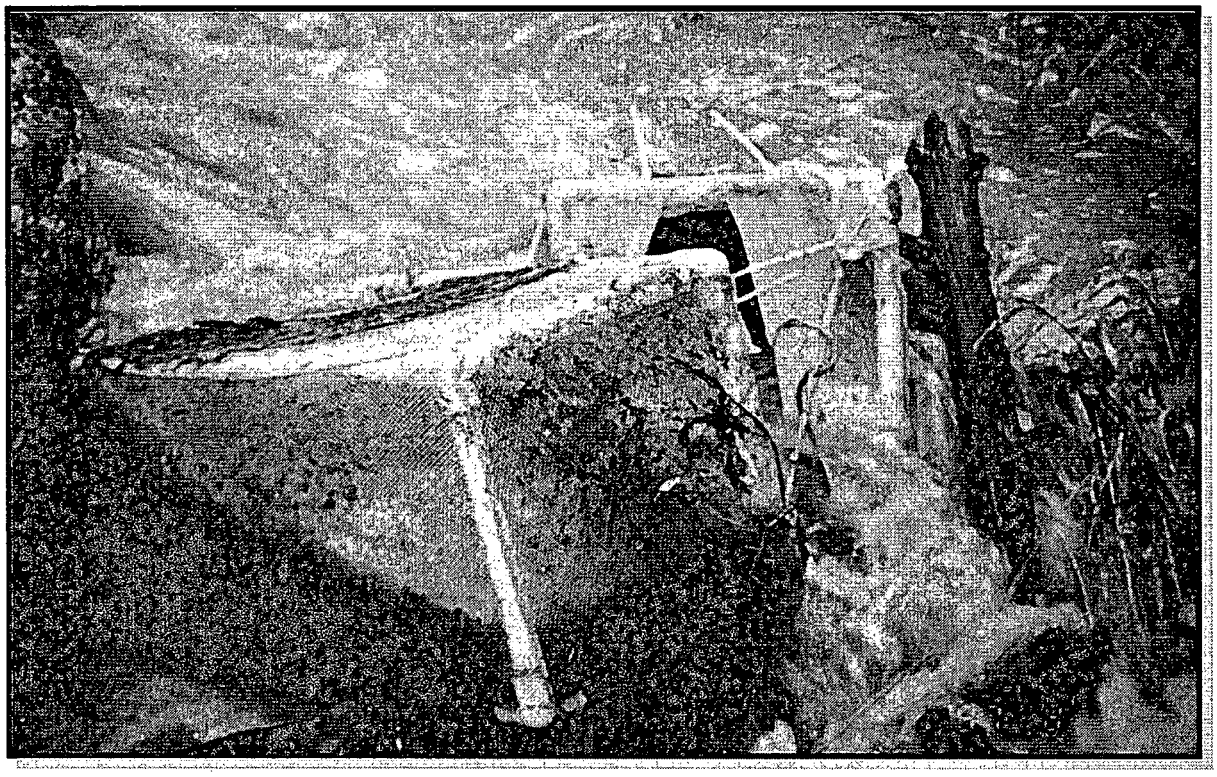


Figure 21. August Floods Affecting *In Situ,* Caged-Fish Bioassays in Sandia Canyon.

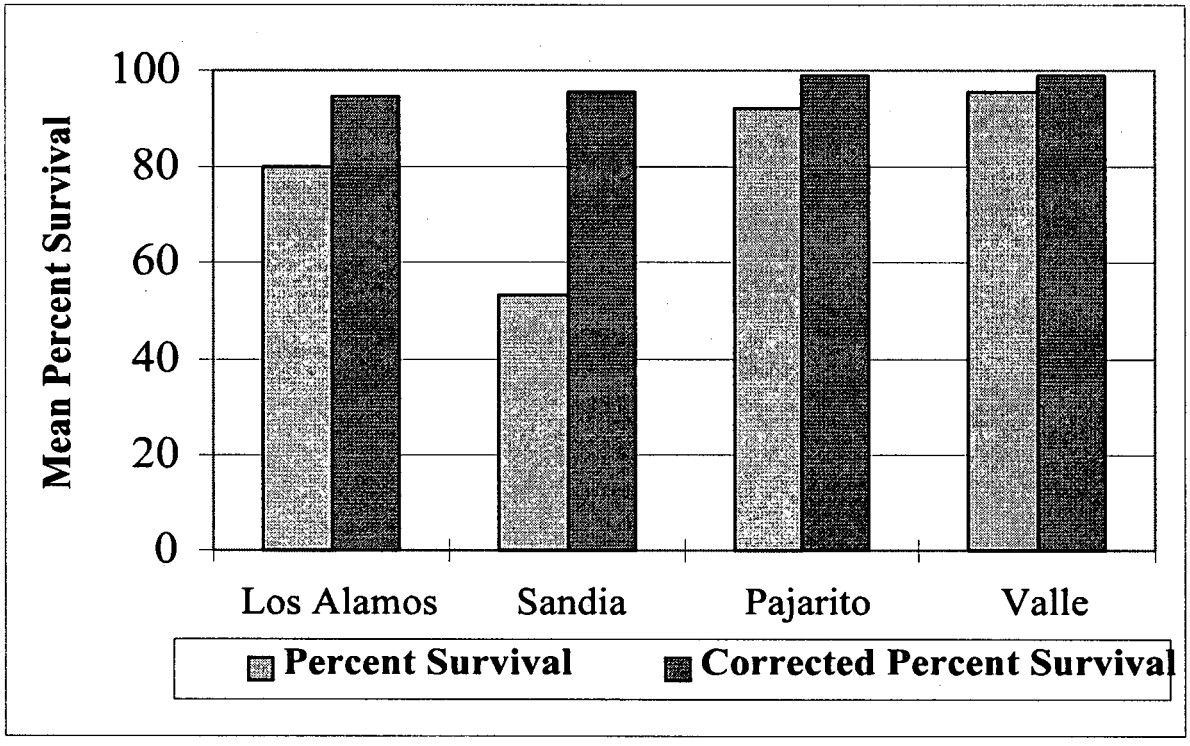


Figure 22. Percent Mortality During the 96-Hour, Caged-Fish Bioassay and Corrected for Mortality Attributed to Floods or Escaped Fish.

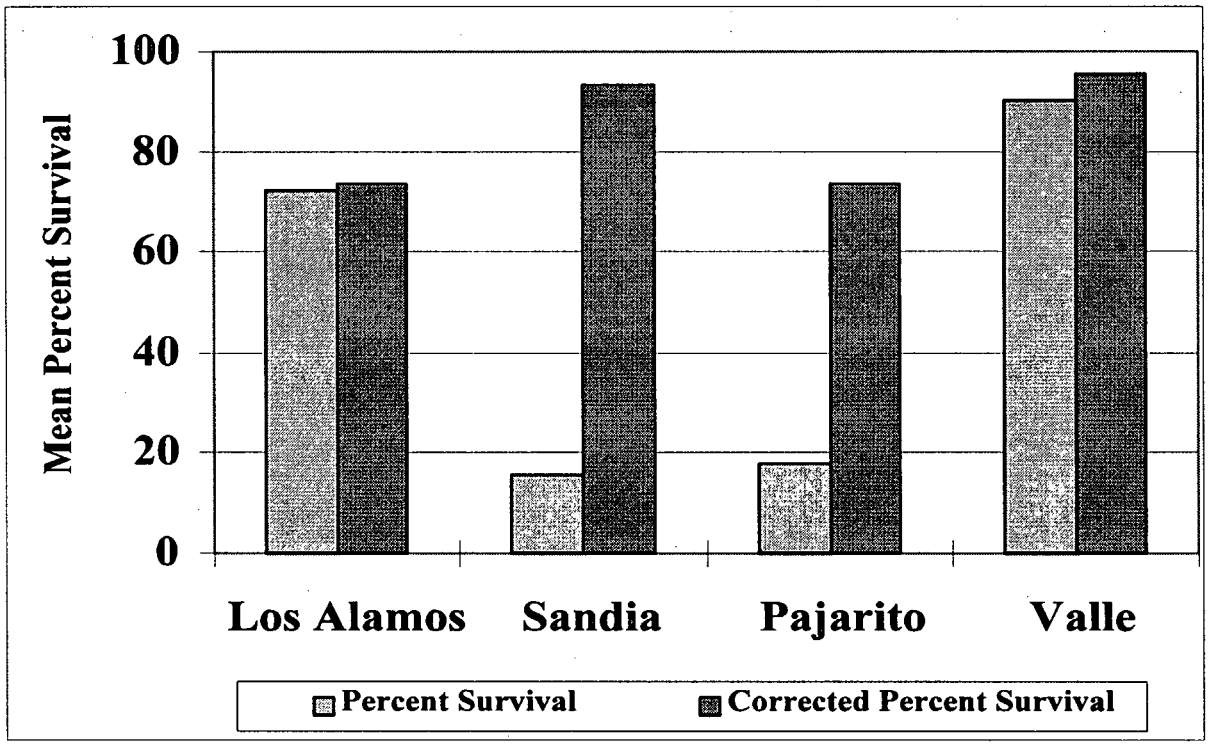


Figure 23. Percent Mortality During the 2-Month, Caged-Fish Bioassay and Corrected for Mortality Attributed to Floods, Vandalism, or Escaped Fish.

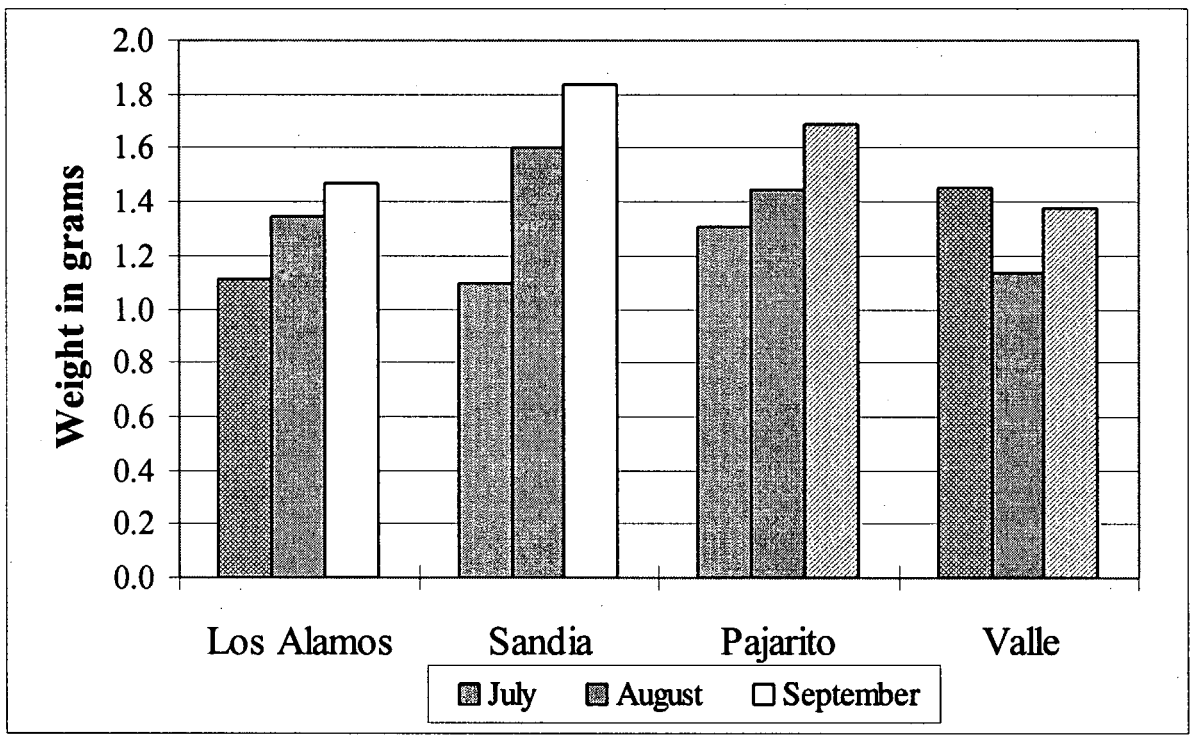


Figure 24. Average Weight Gain of Caged Fish During Two Months Exposure to Canyon Stream Segments.

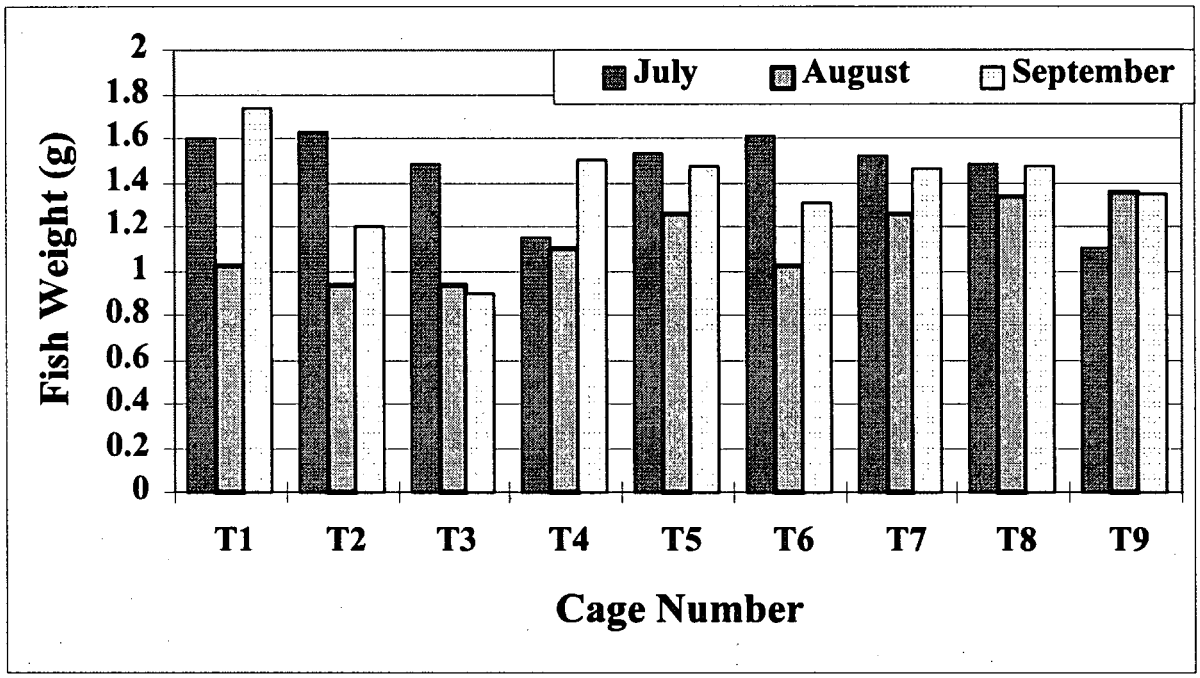


Figure 25. Average Weight Gain of Caged Fish, in Each Cage, During 2-Month Exposure to the Valle Canyon Stream Segment.

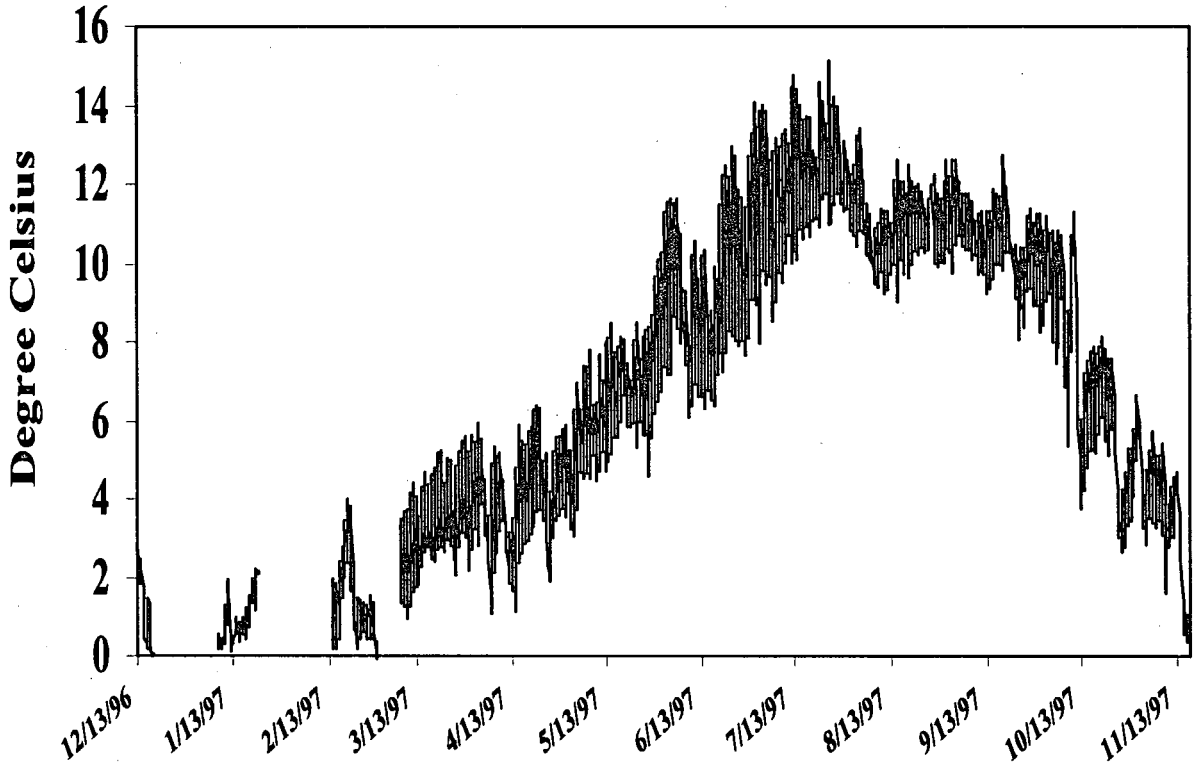


Figure 26. Water Temperature (°C) in the Los Alamos Canyon Stream Segment, 1996-1997.

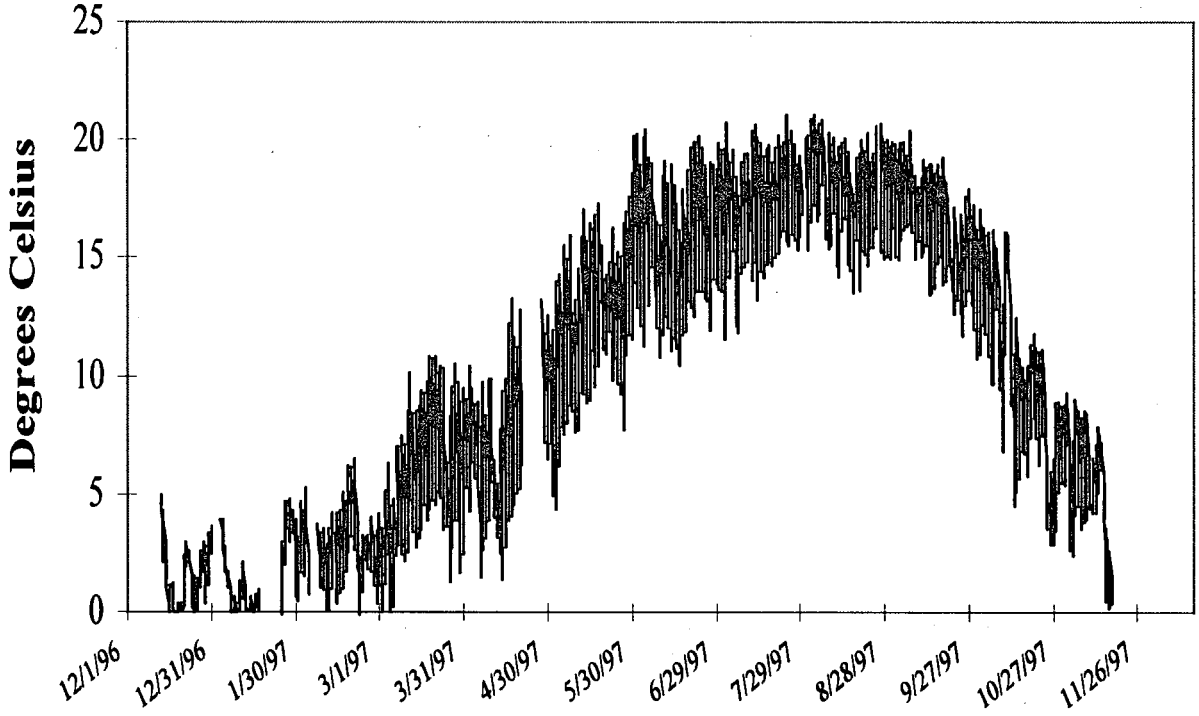


Figure 27. Water Temperature (°C) in the Sandia Canyon Stream Segment, 1996-1997.

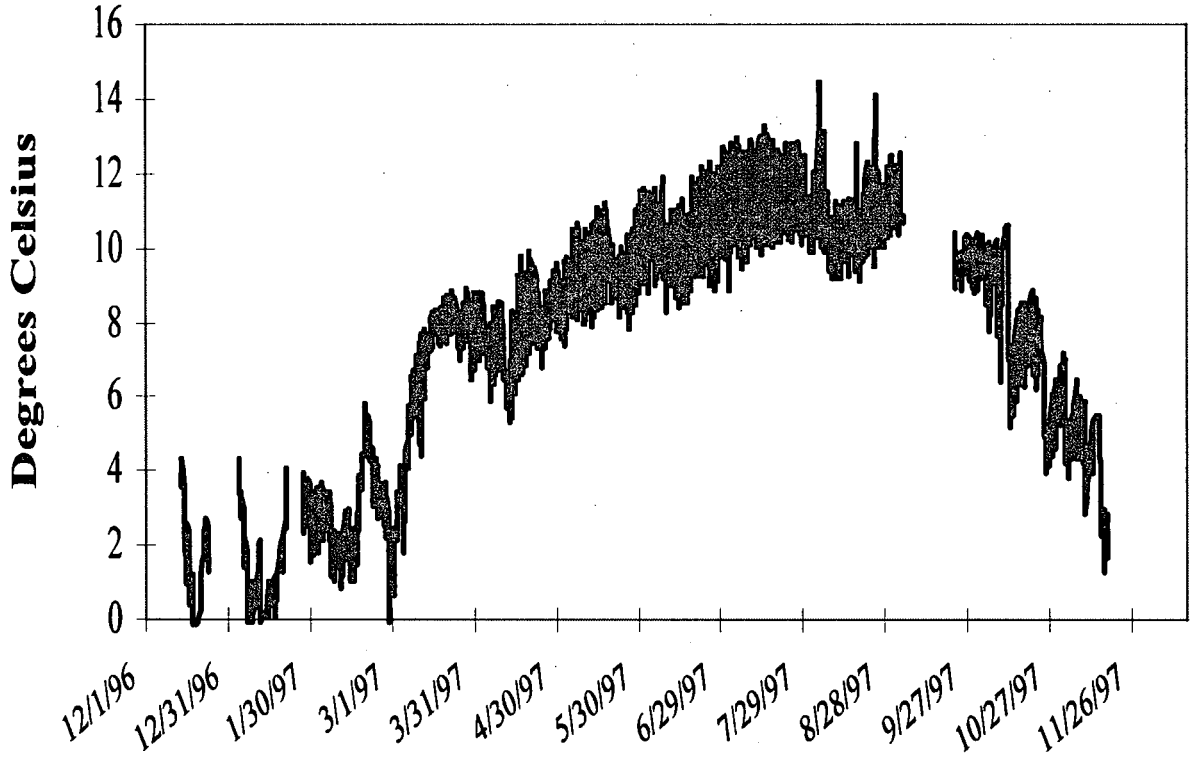


Figure 28. Water Temperature (°C) in the Pajarito Canyon Stream Segment, 1996-1997.

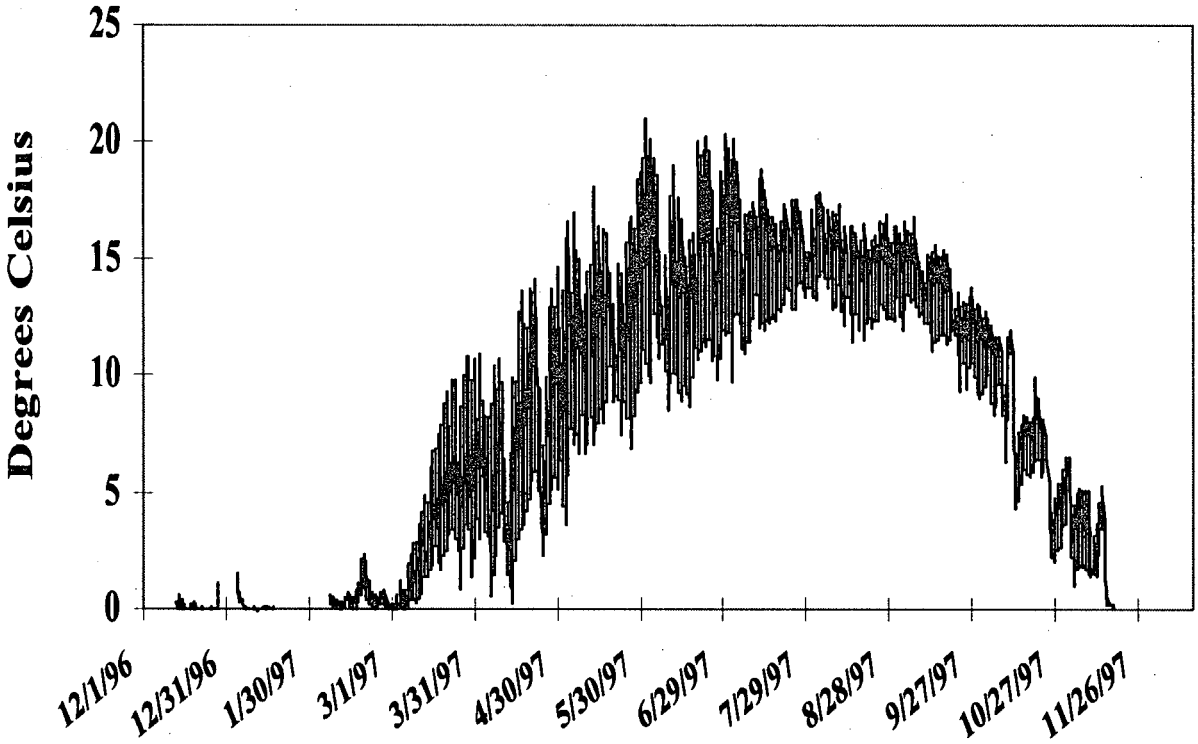


Figure 29. Water Temperature (°C) in the Valle Canyon Stream Segment, 1996-1997.

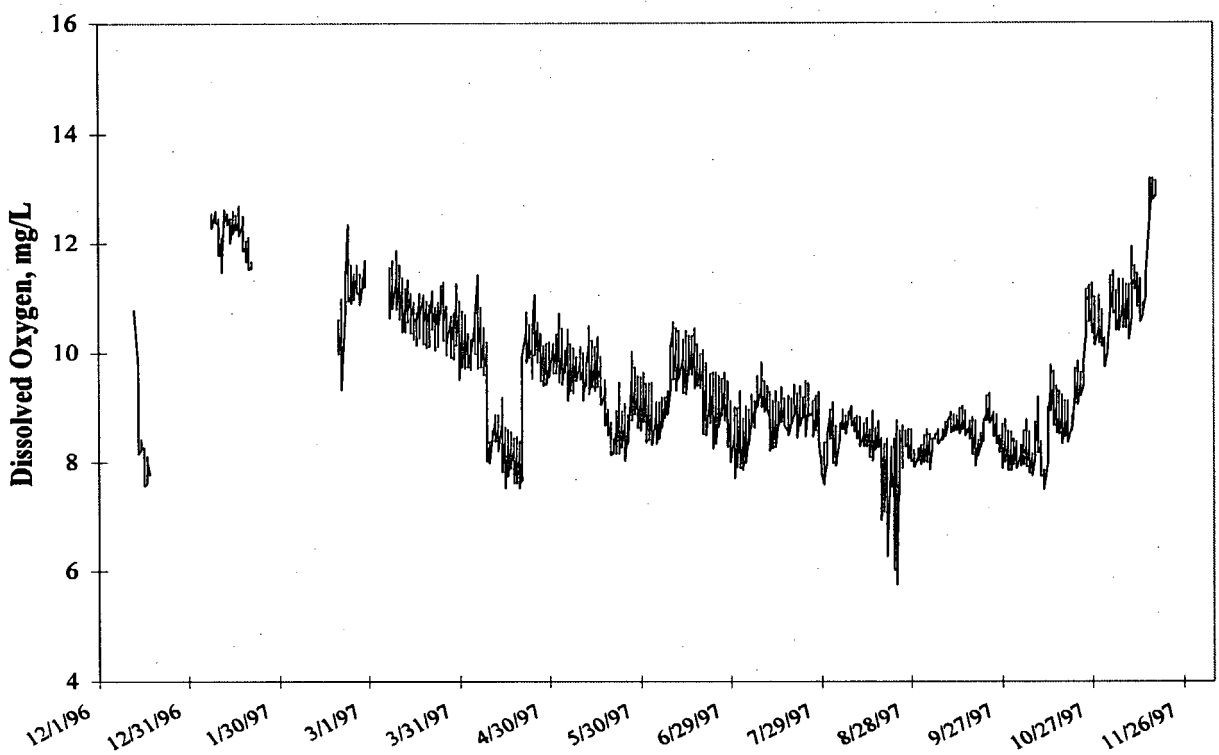


Figure 30. Dissolved Oxygen (mg/L) in the Los Alamos Canyon Stream Segment, 1996-1997.

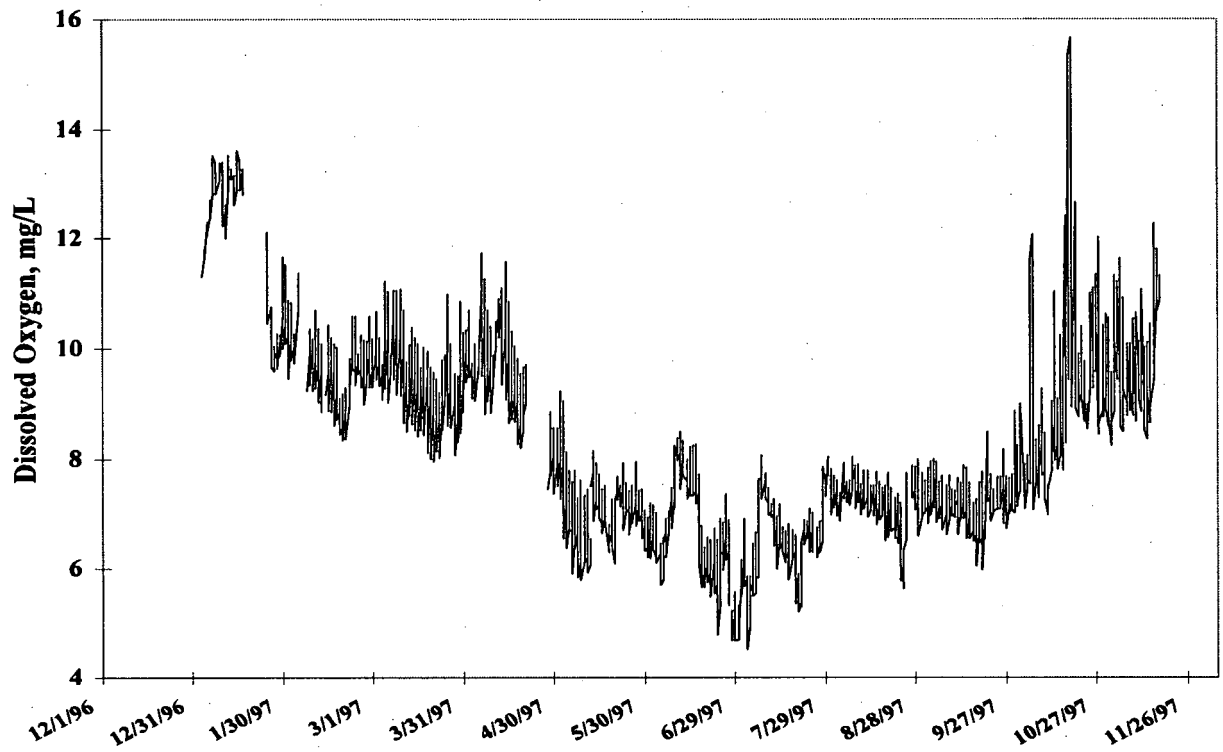


Figure 31. Dissolved Oxygen (mg/L) in the Sandia Canyon Stream Segment, 1996.1997.

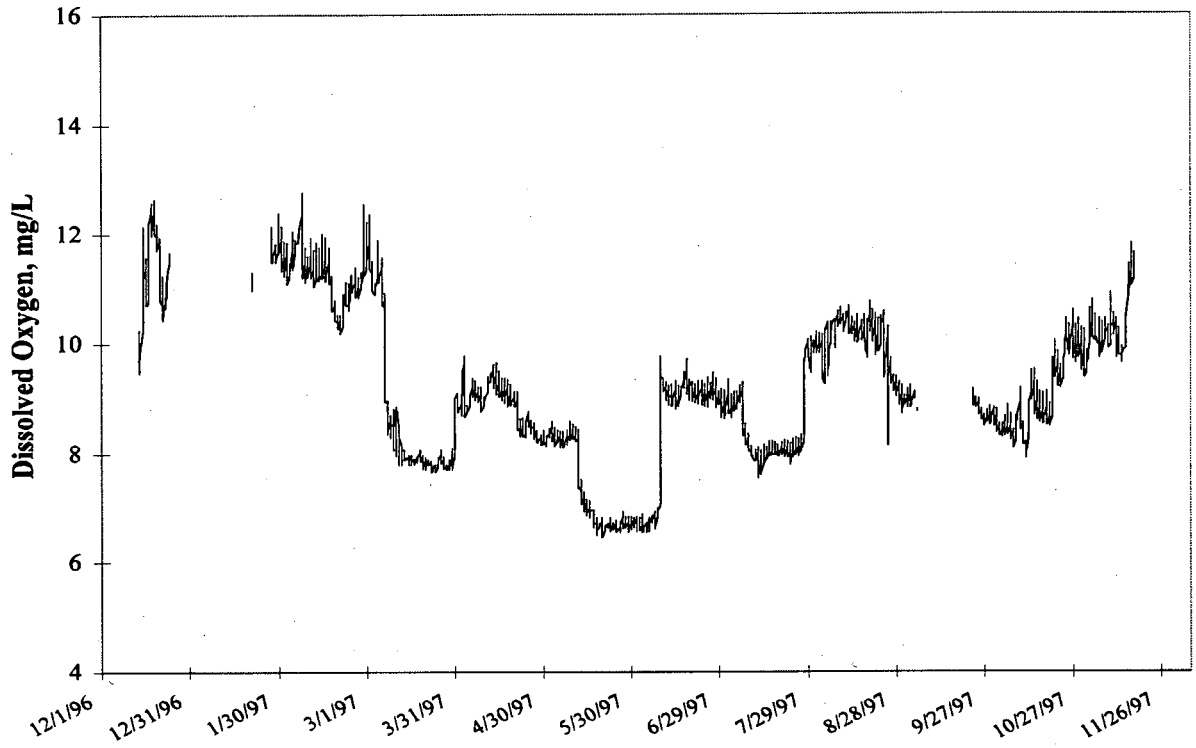


Figure 32. Dissolved Oxygen (mg/L) in the Pajarito Canyon Stream Segment, 1996-1997.

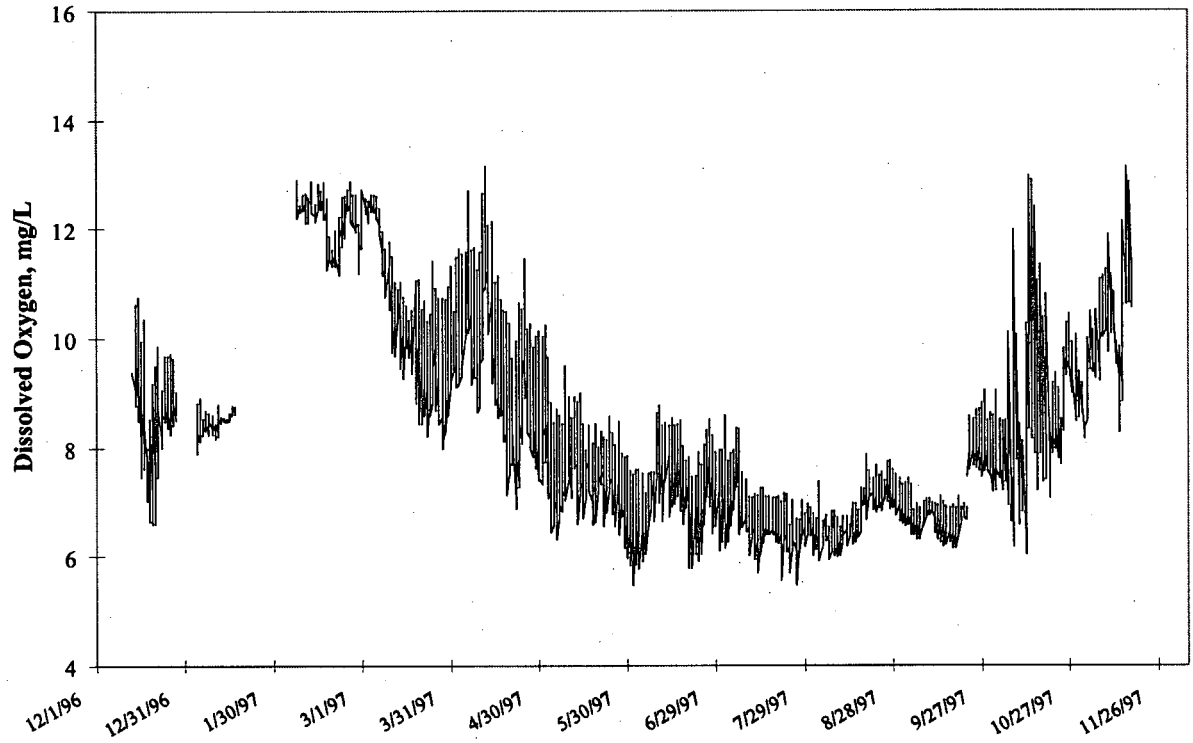


Figure 33. Dissolved Oxygen (mg/L) in the Valle Canyon Stream Segment, 1996-1997.

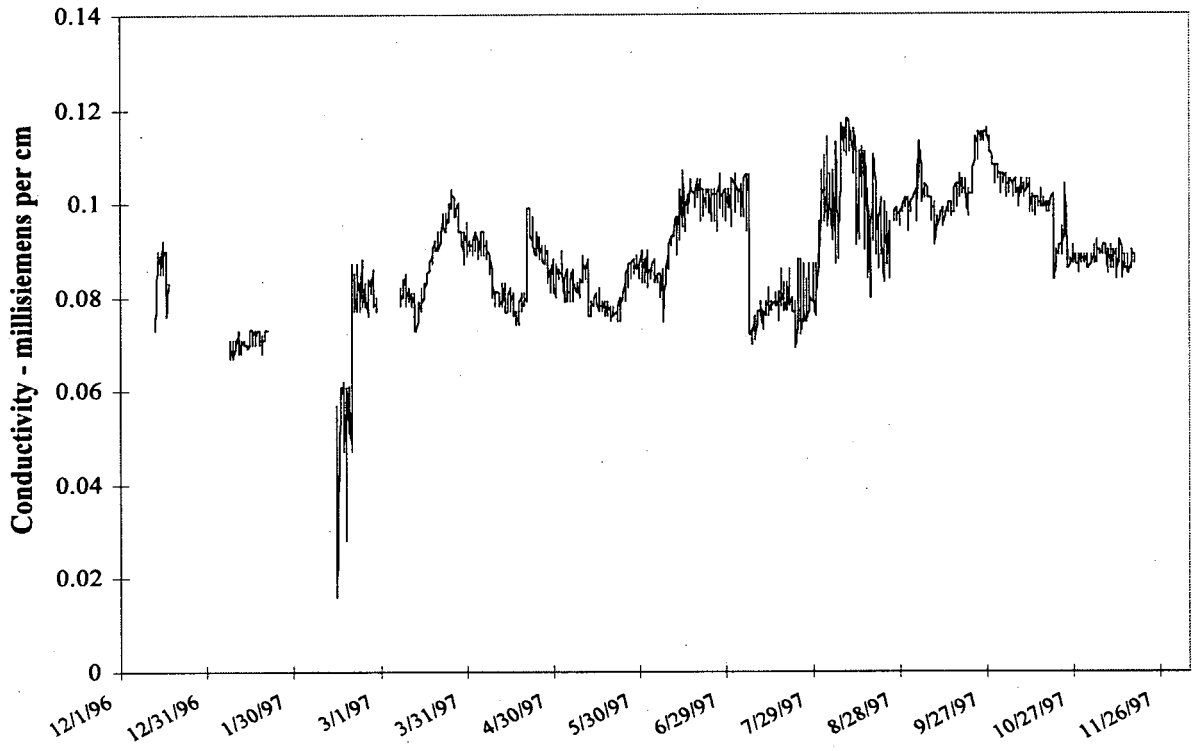


Figure 34. Conductivity (mS/cm) in the Los Alamos Canyon Stream Segment, 1996-1997.

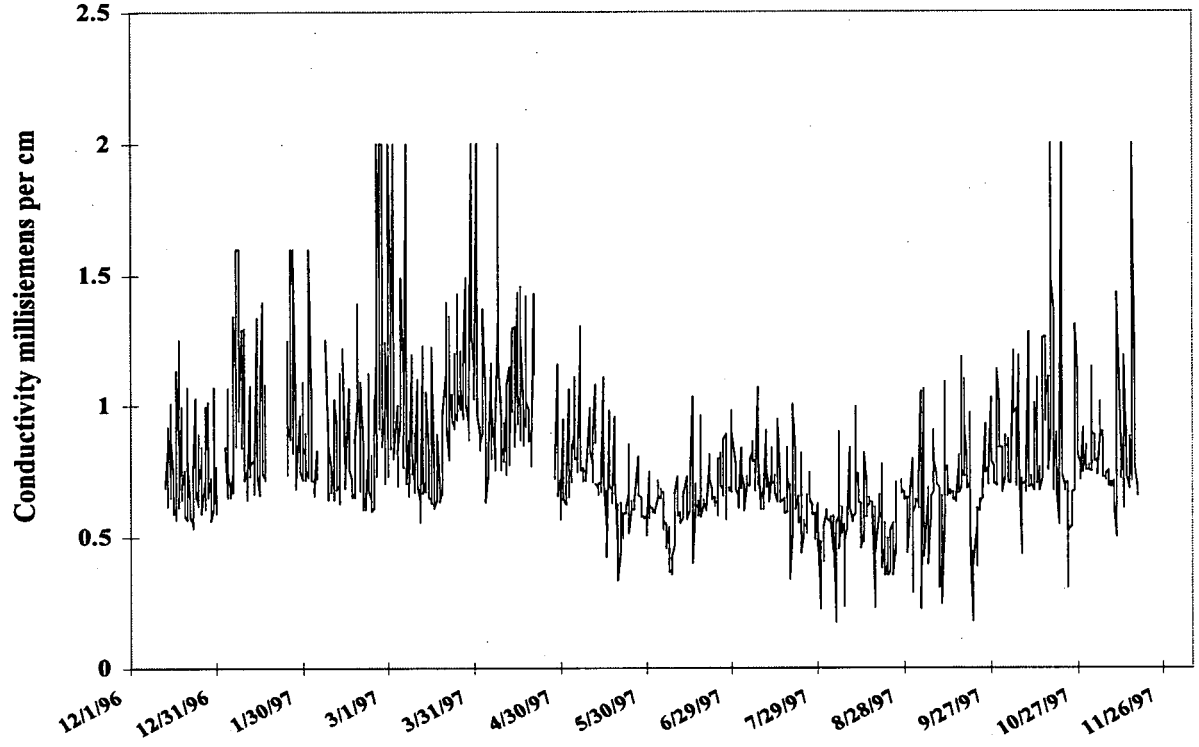


Figure 35. Conductivity (mS/cm) in the Sandia Canyon Stream Segment, 1996-1997.

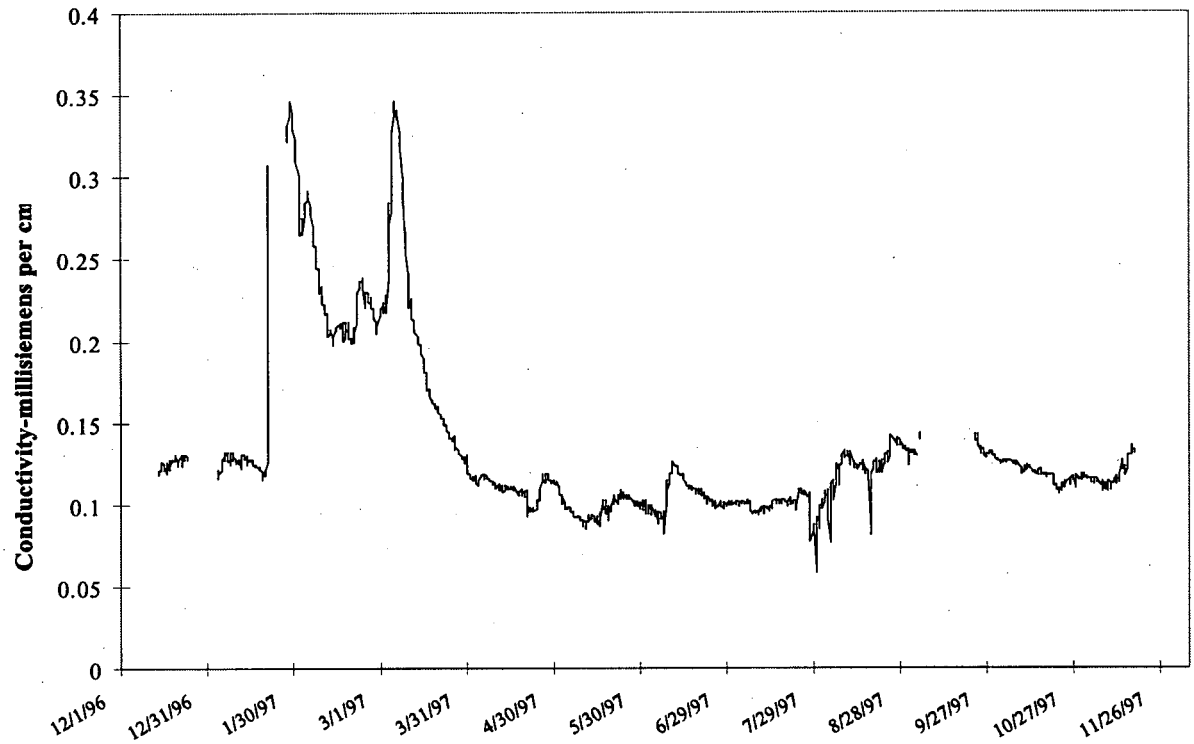


Figure 36. Conductivity (mS/cm) in the Pajarito Canyon Stream Segment, 1996-1997.

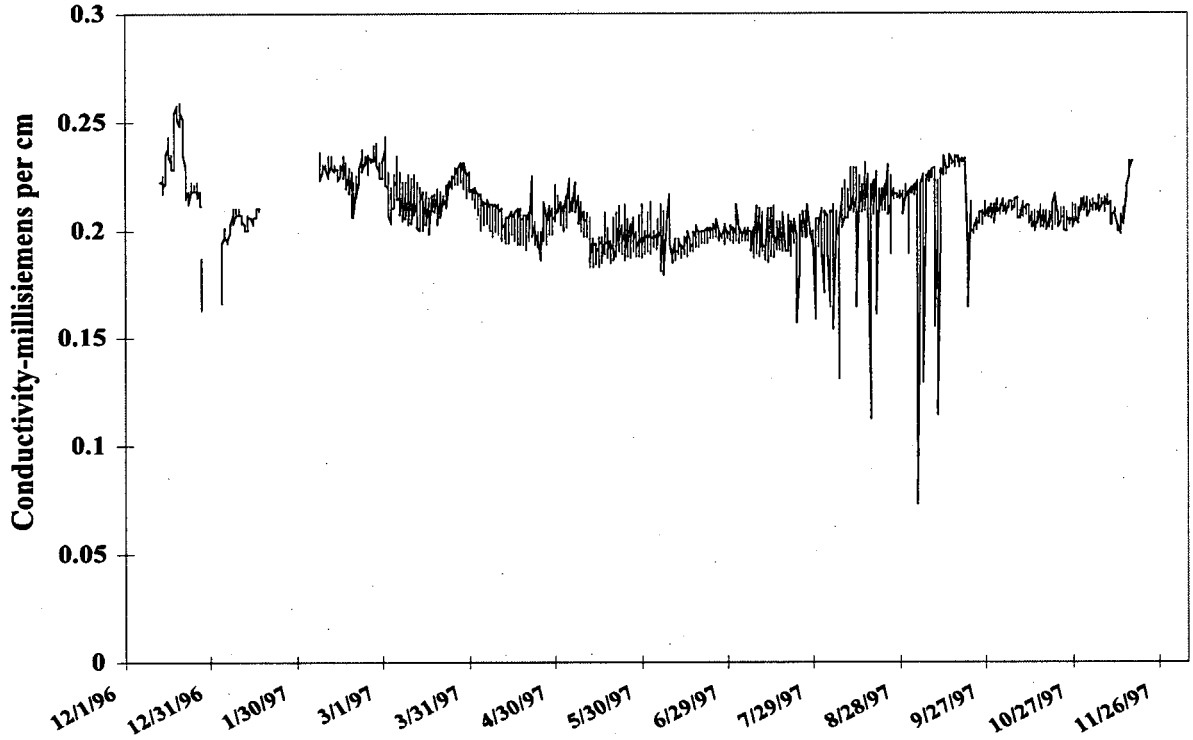


Figure 37. Conductivity (mS/cm) in the Valle Canyon Stream Segment, 1996-1997.

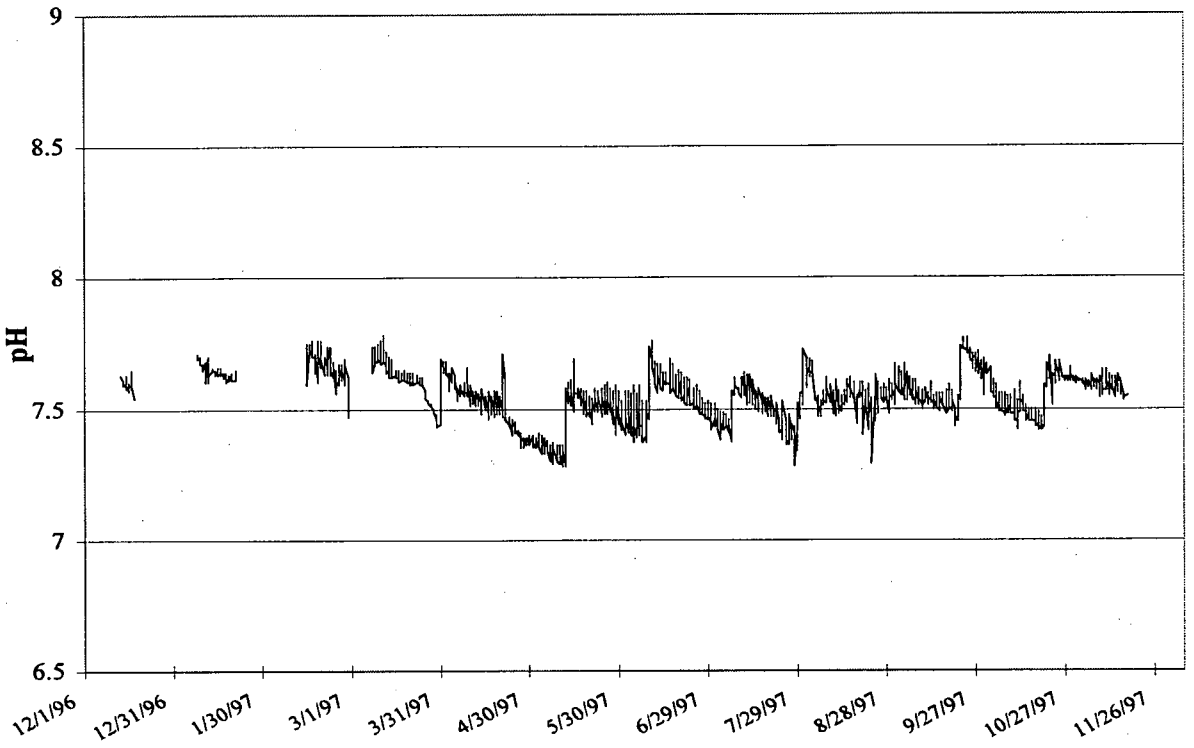


Figure 38. The pH in the Los Alamos Canyon Stream Segment, 1996-1997.

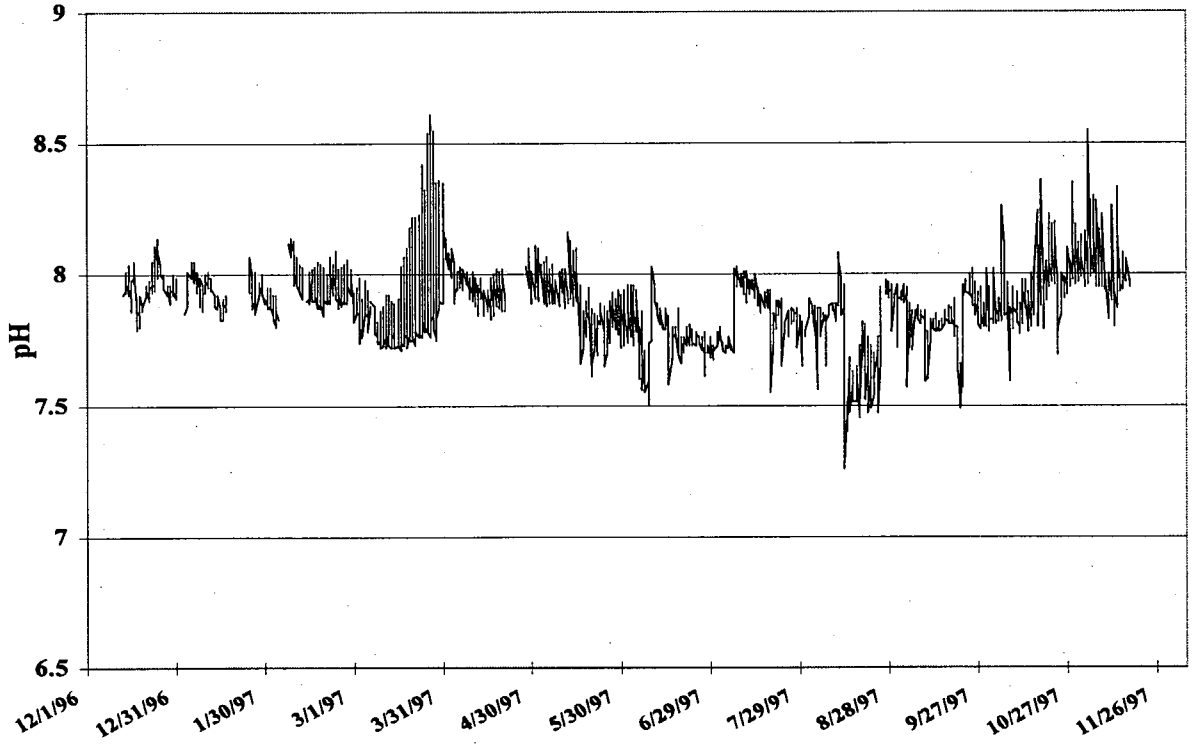


Figure 39. The pH in the Sandia Canyon Stream Segment, 1996-1997.

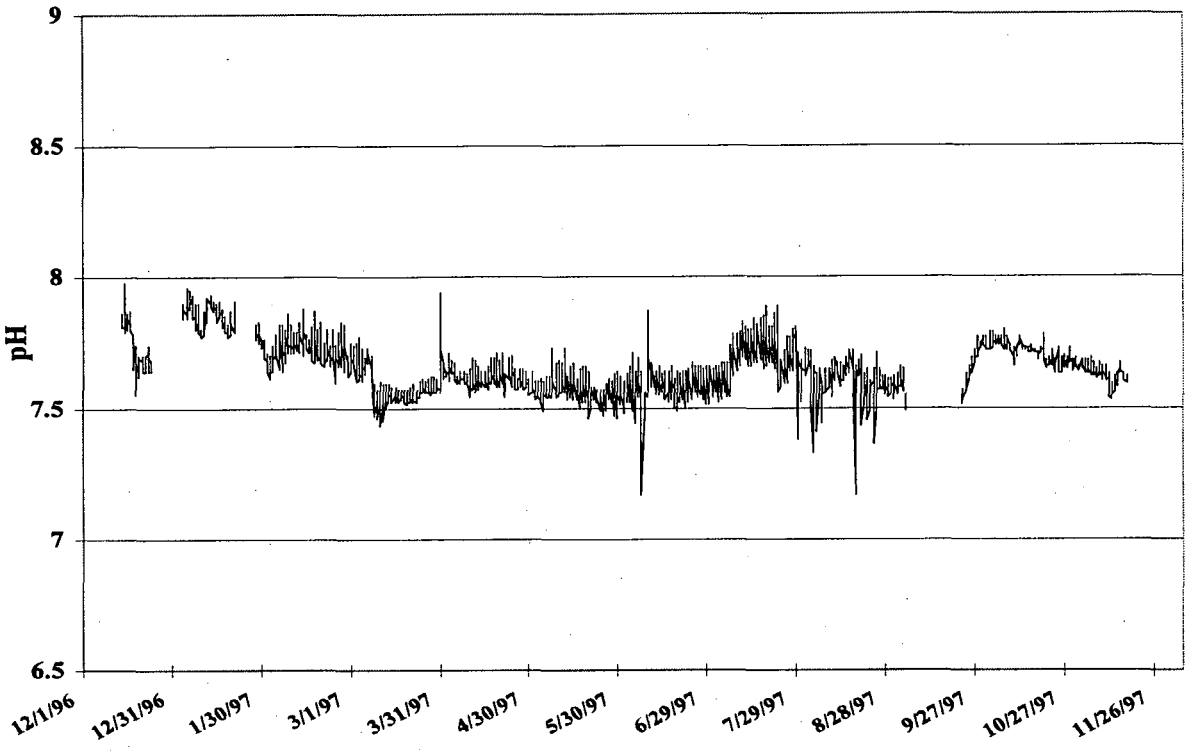


Figure 40. The pH in the Pajarito Canyon Stream Segment, 1996-1997.

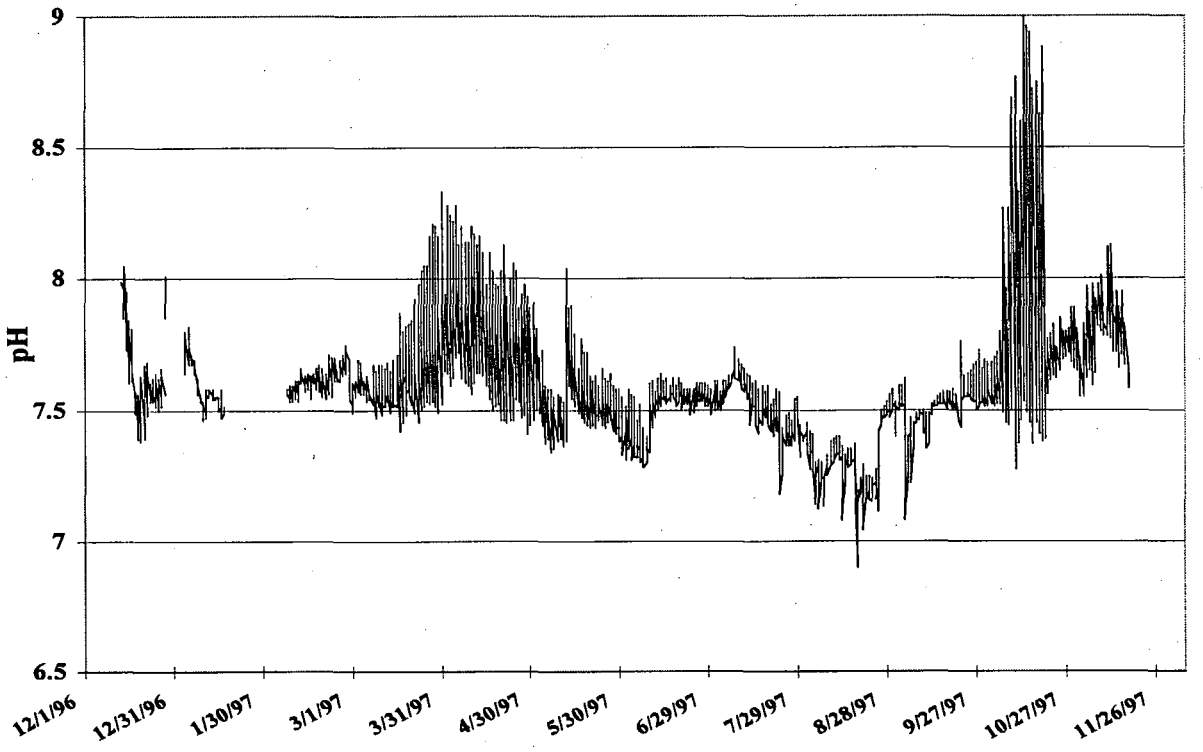
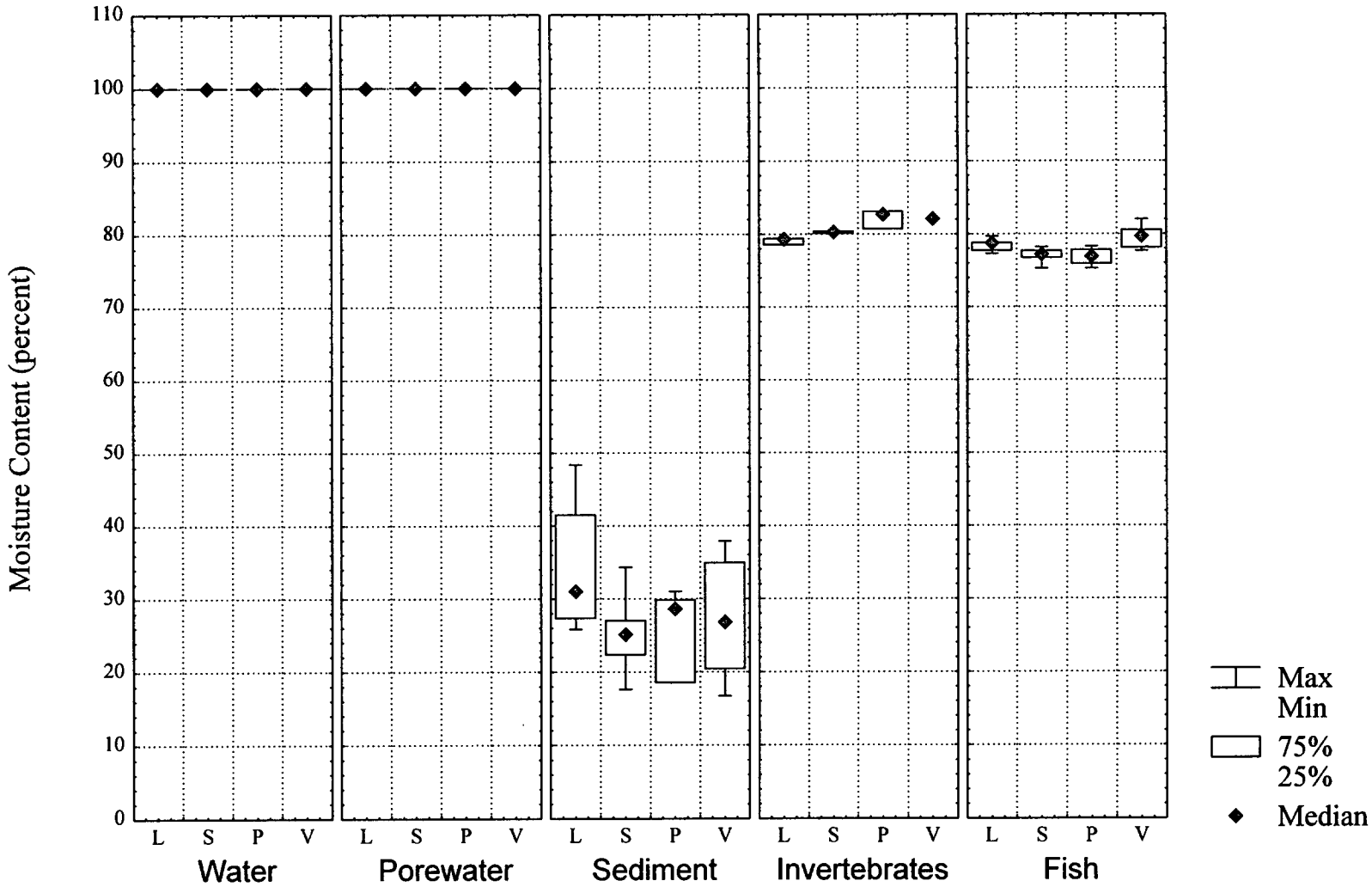


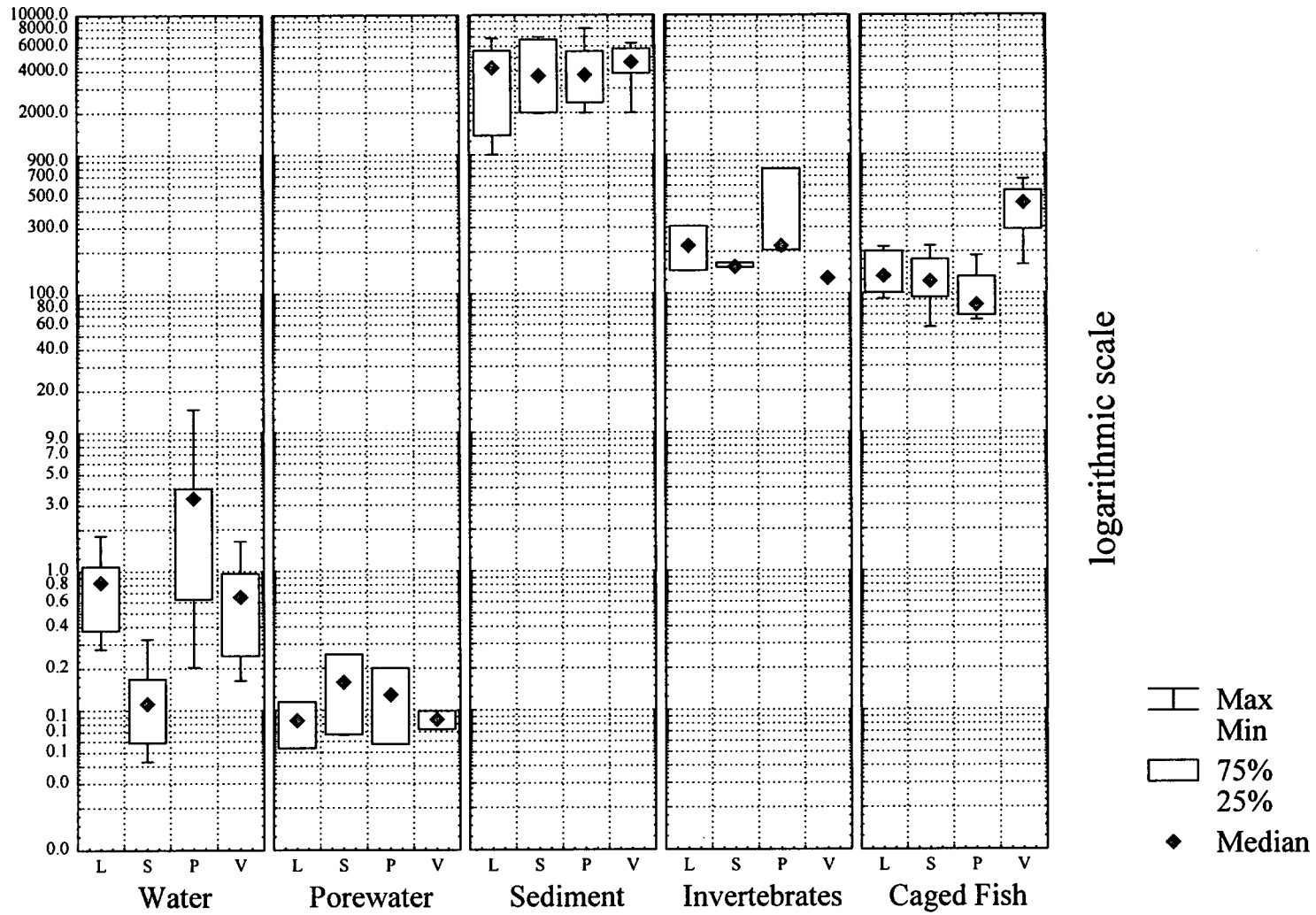
Figure 41. The pH in the Valle Canyon Stream Segment, 1996-1997.

Figure 42. Moisture Content of Environmental Samples.



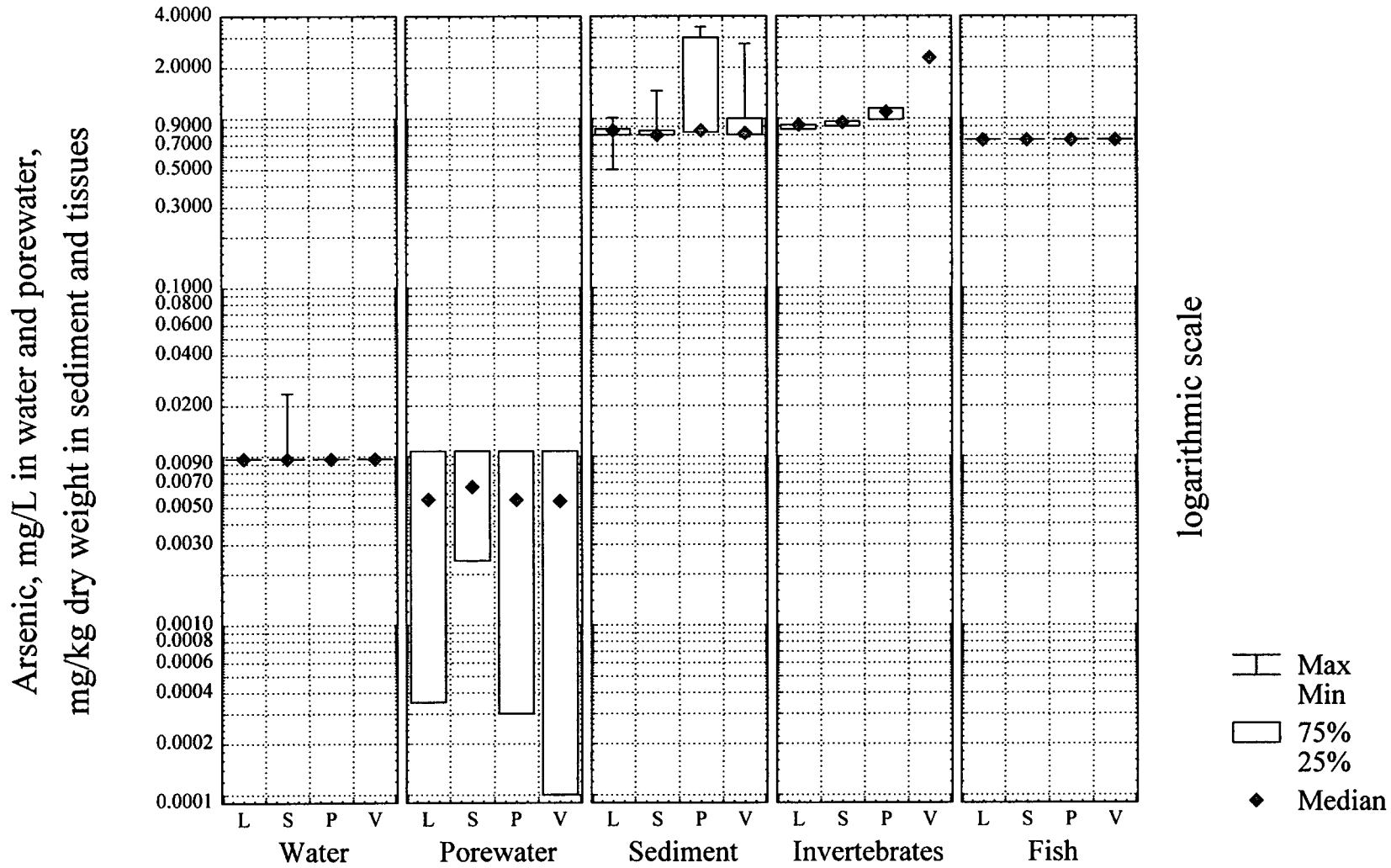
Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 43. Aluminum in Environmental Samples.



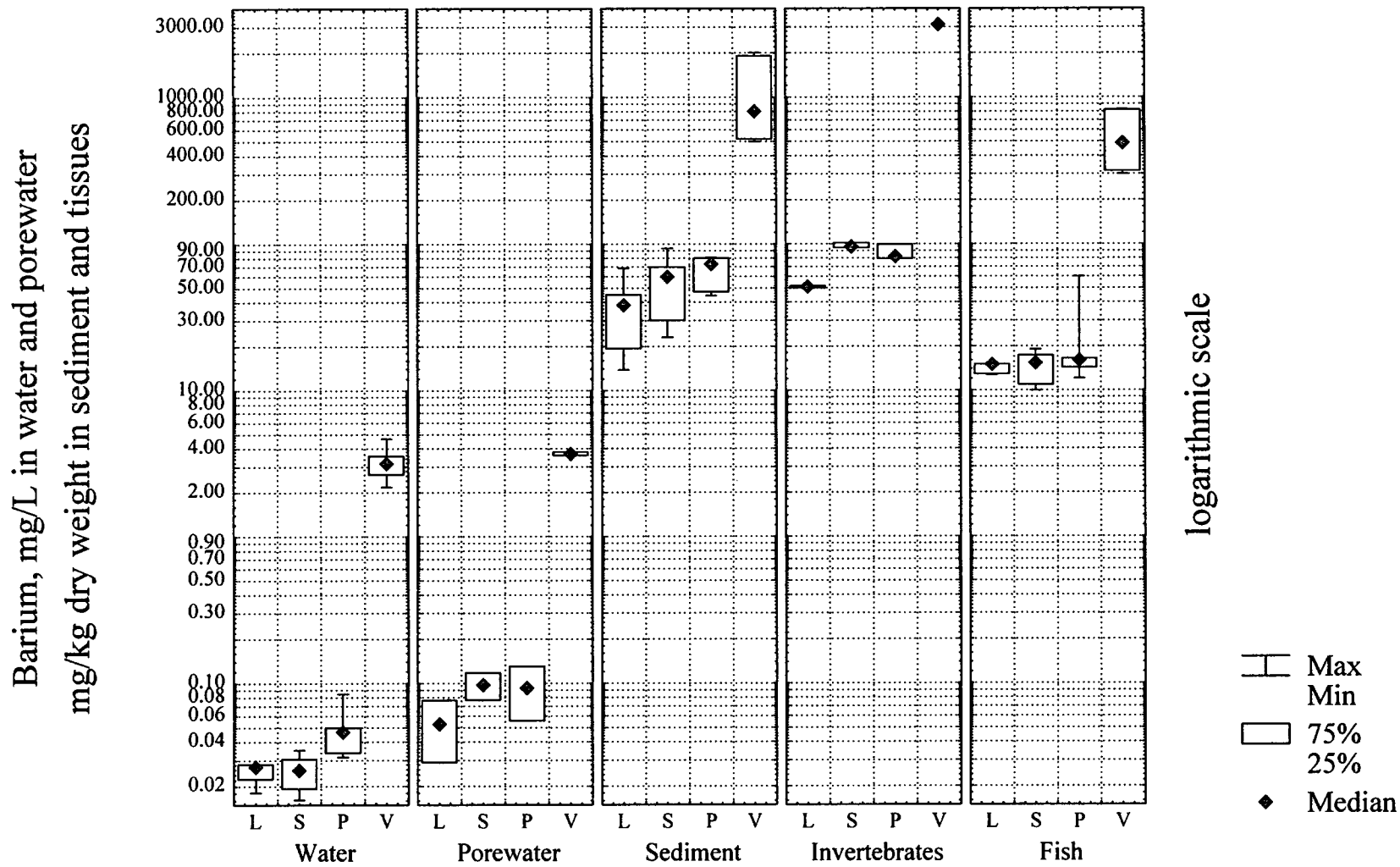
Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 44. Arsenic in Environmental Samples.



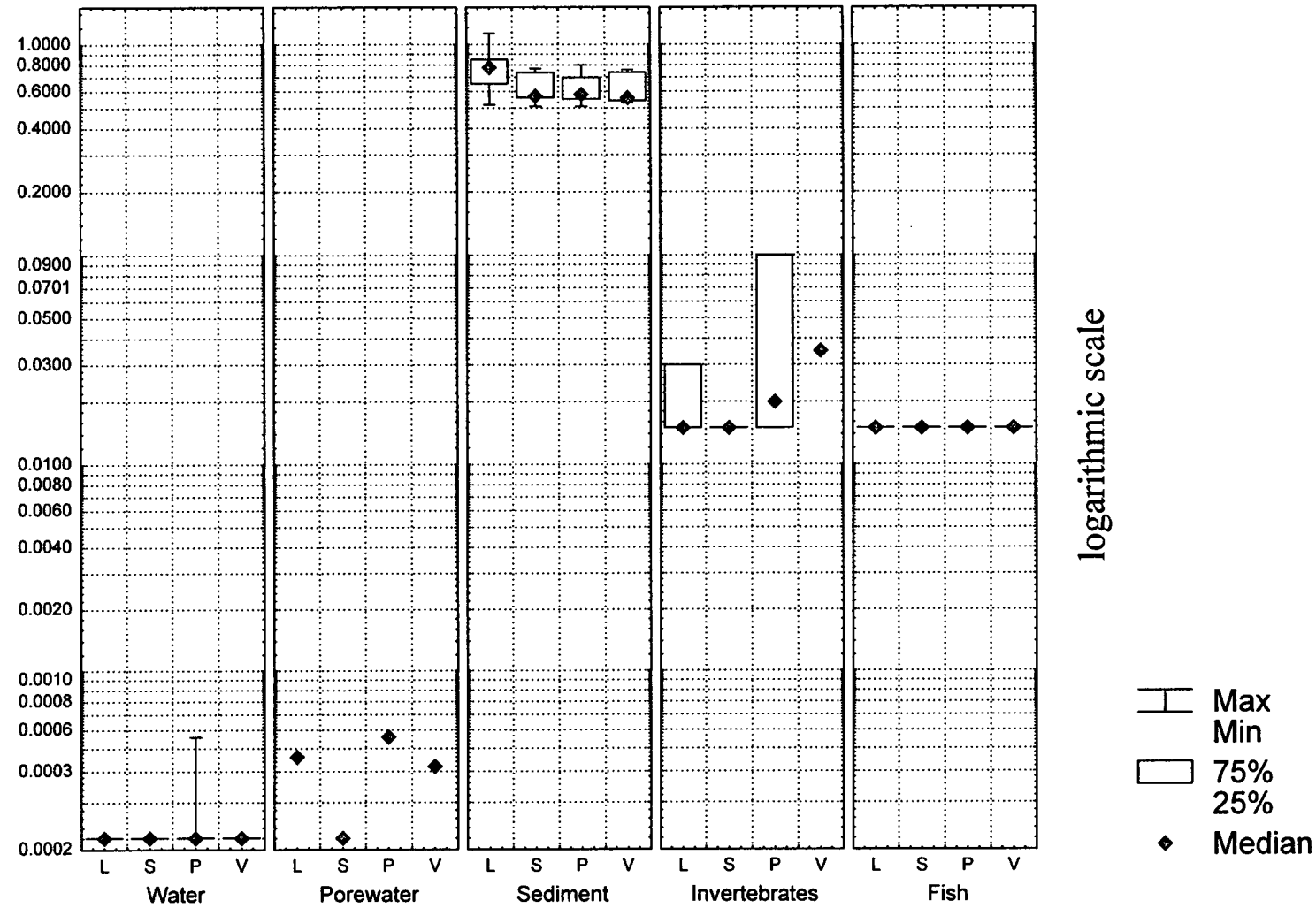
Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 45. Barium in Environmental Samples.



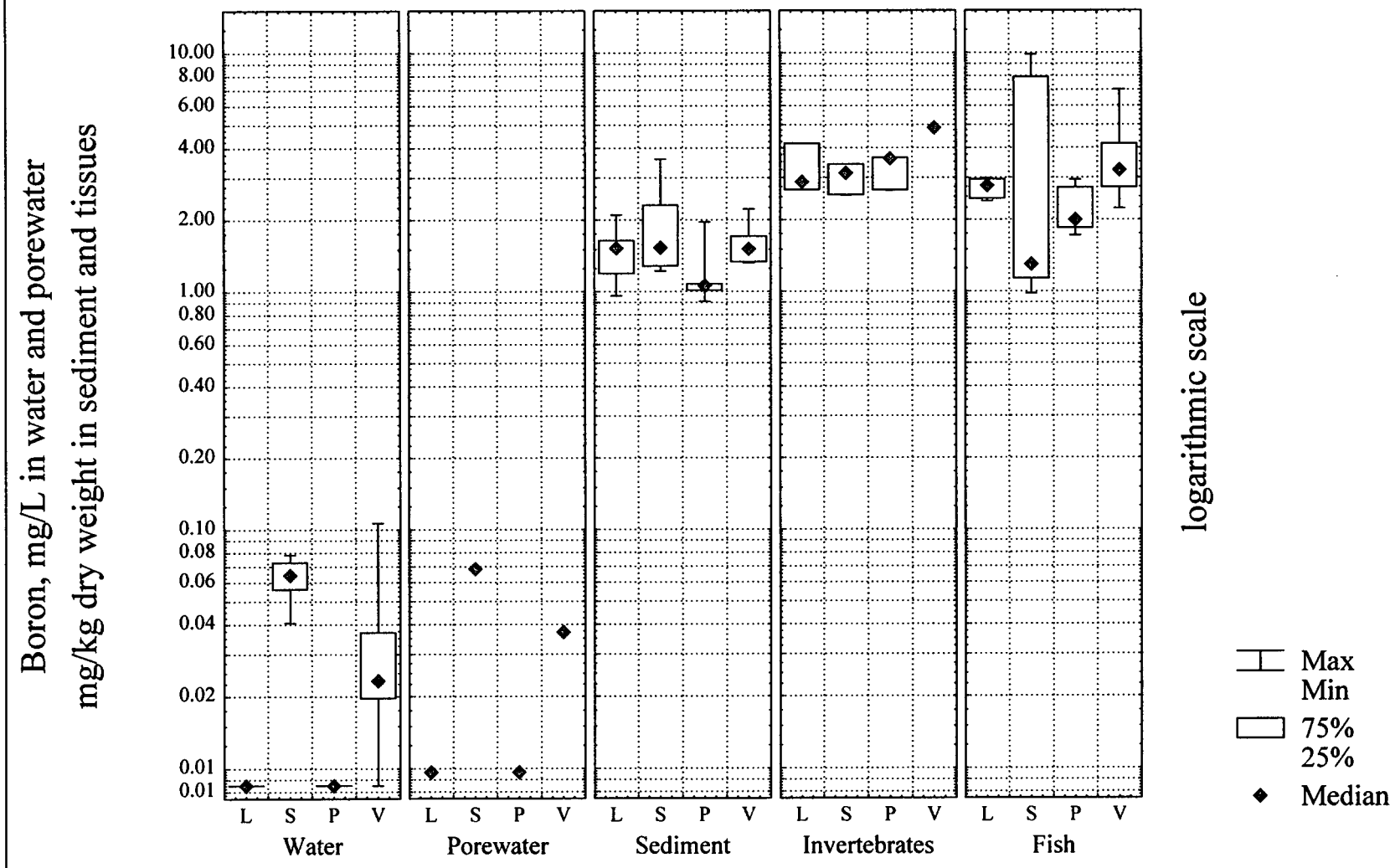
Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 46. Beryllium in Environmental Samples.



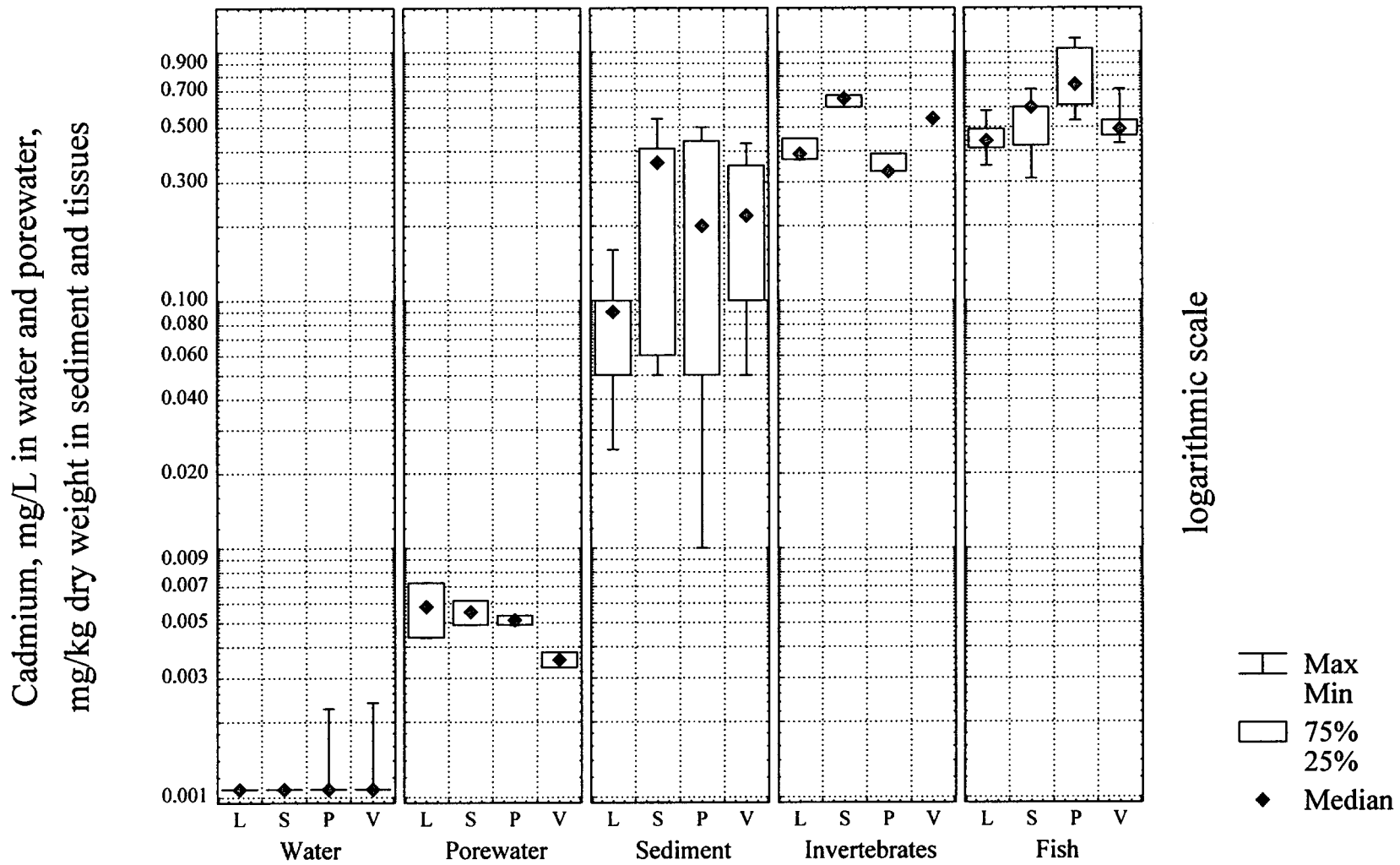
Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 47. Boron in Environmental Samples.



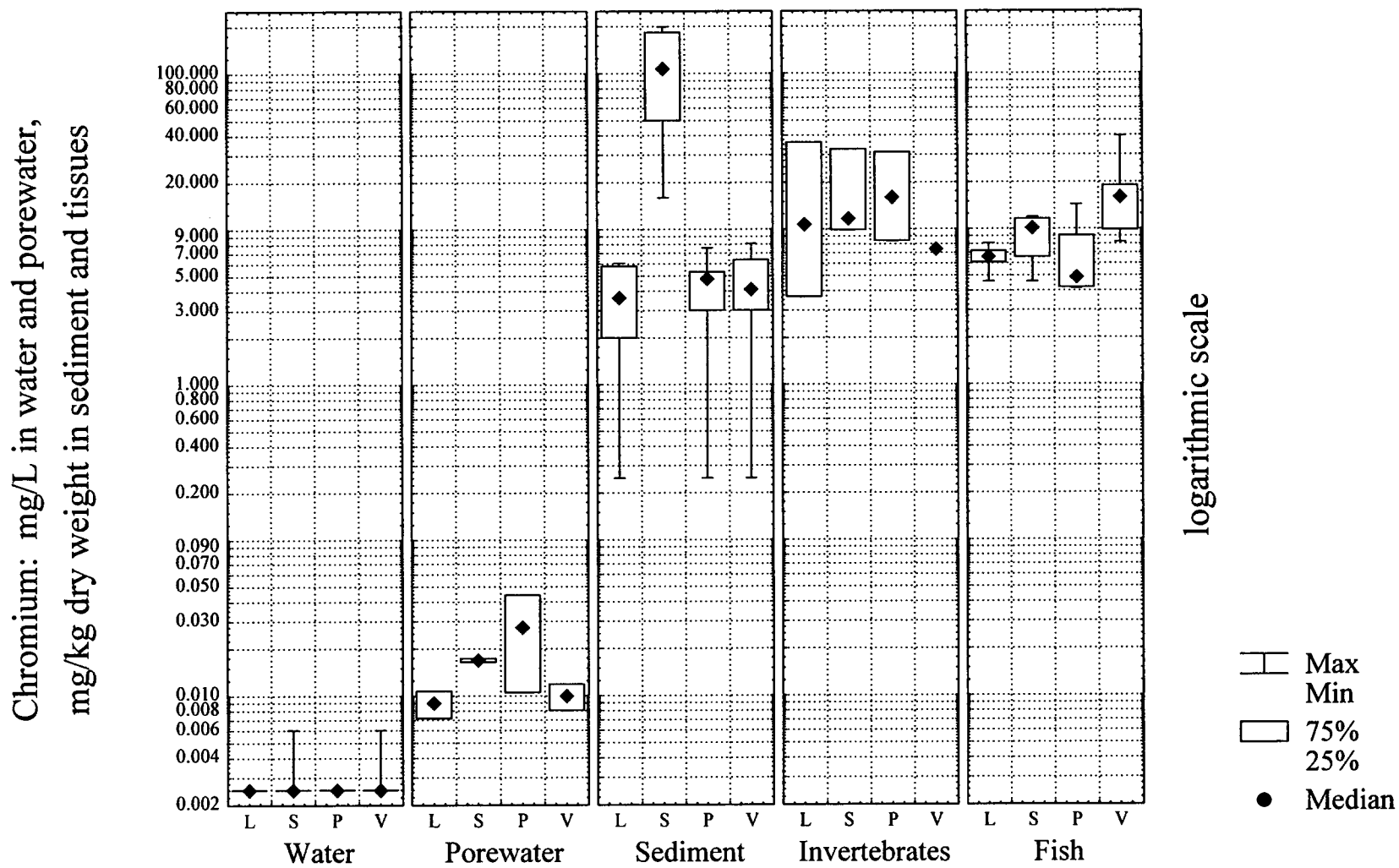
Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 48. Cadmium in Environmental Samples.



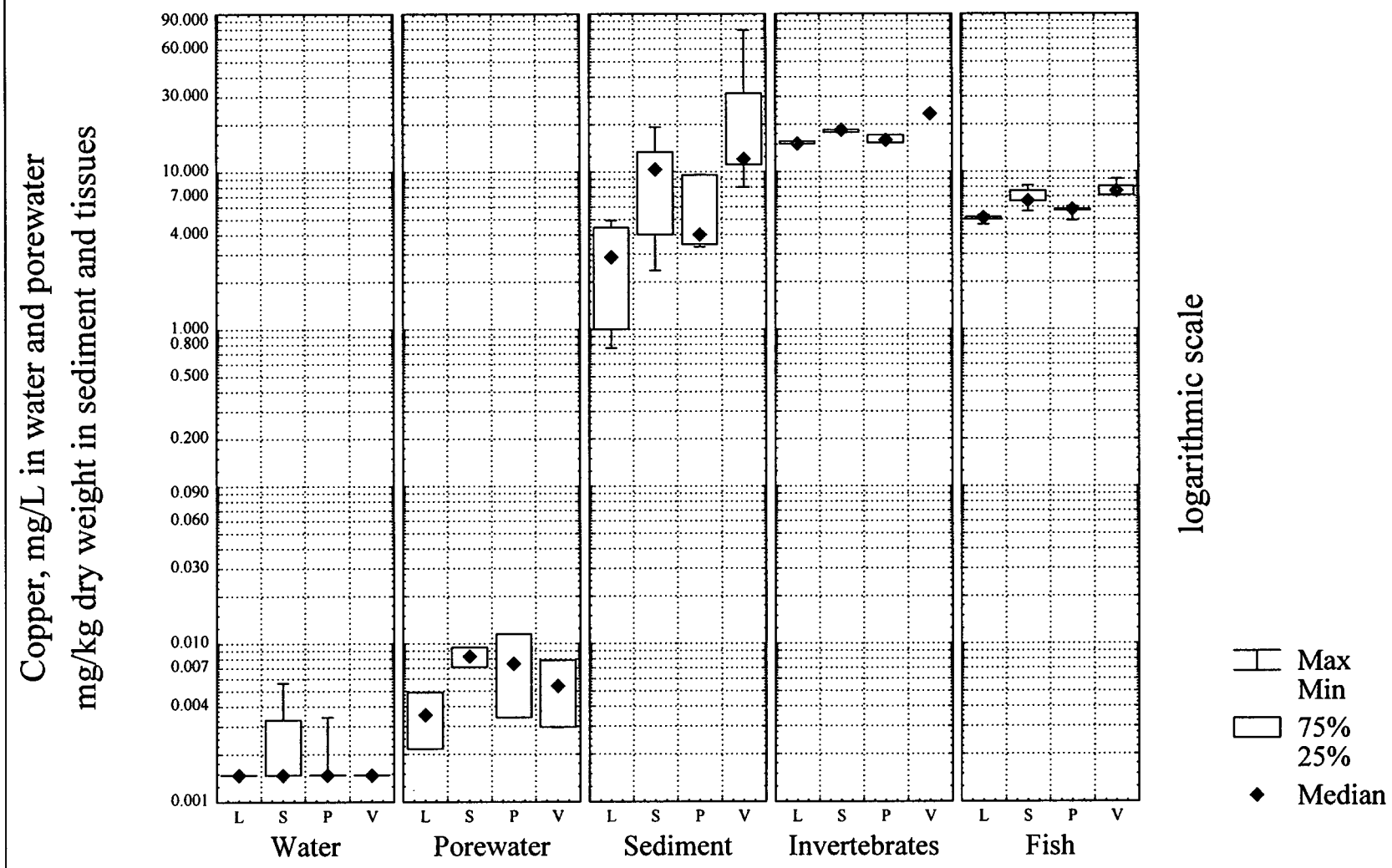
Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 49. Chromium in Environmental Samples.



Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 50. Copper in Environmental Samples.



Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 51. Iron in Environmental Samples

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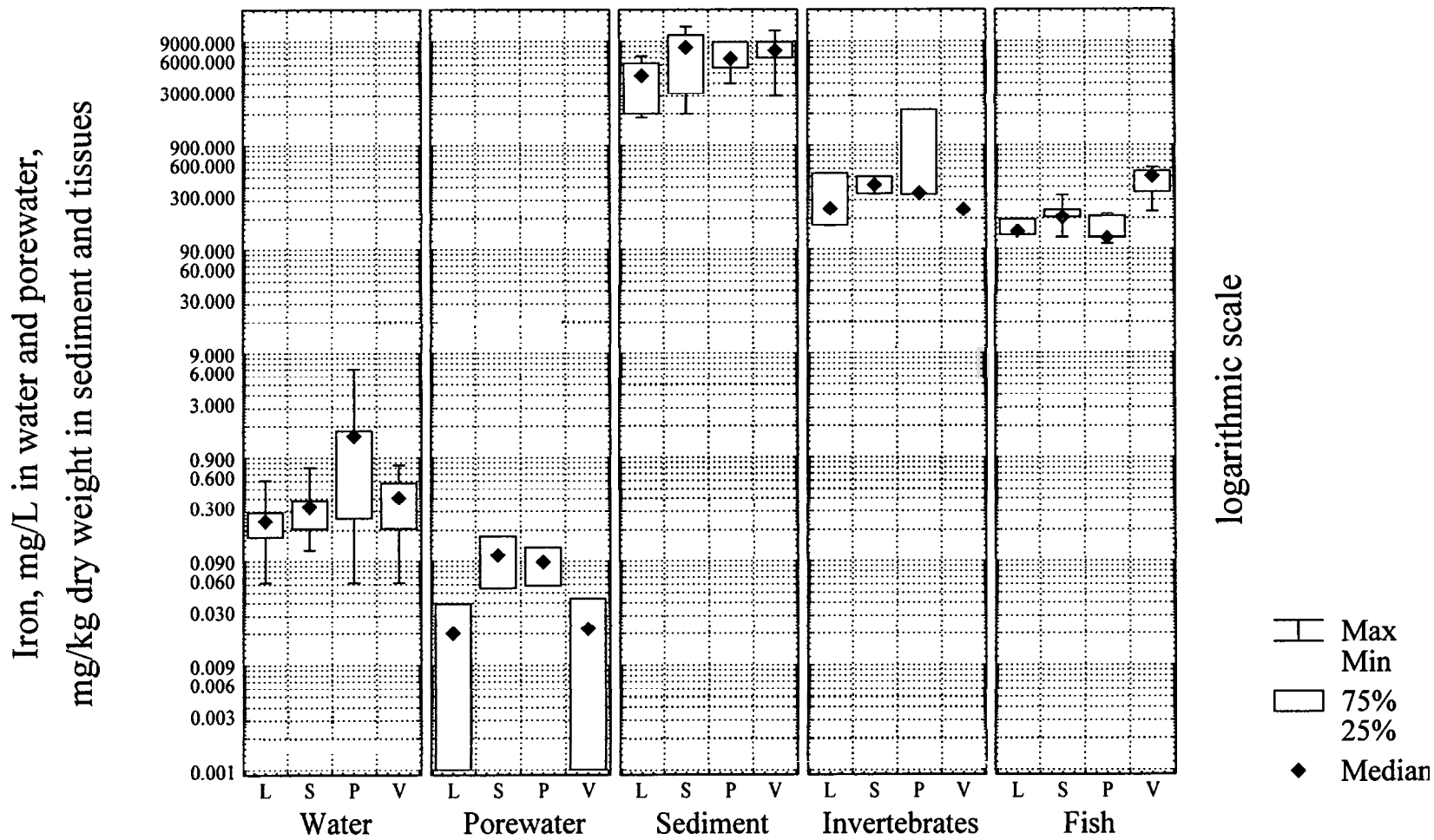
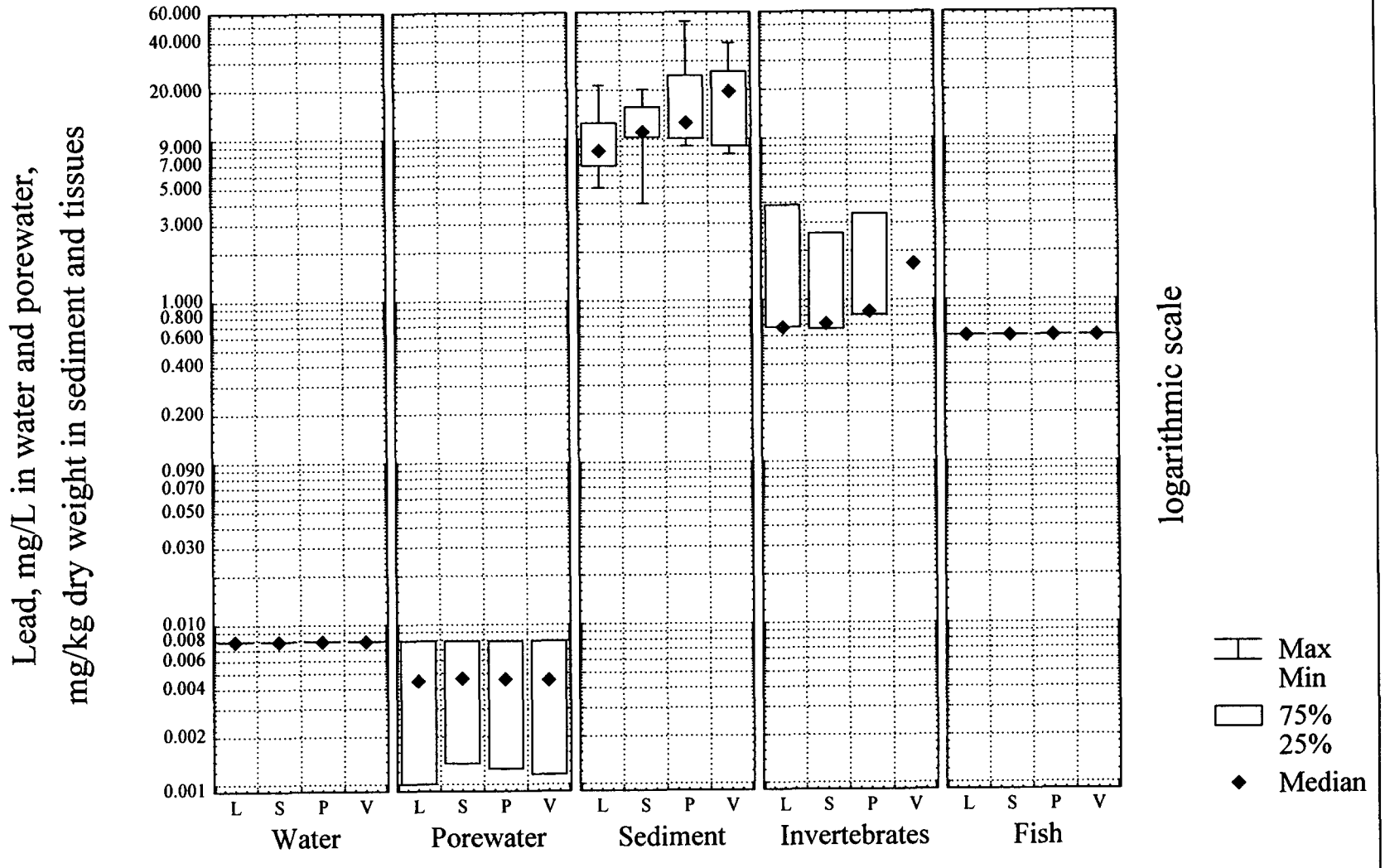


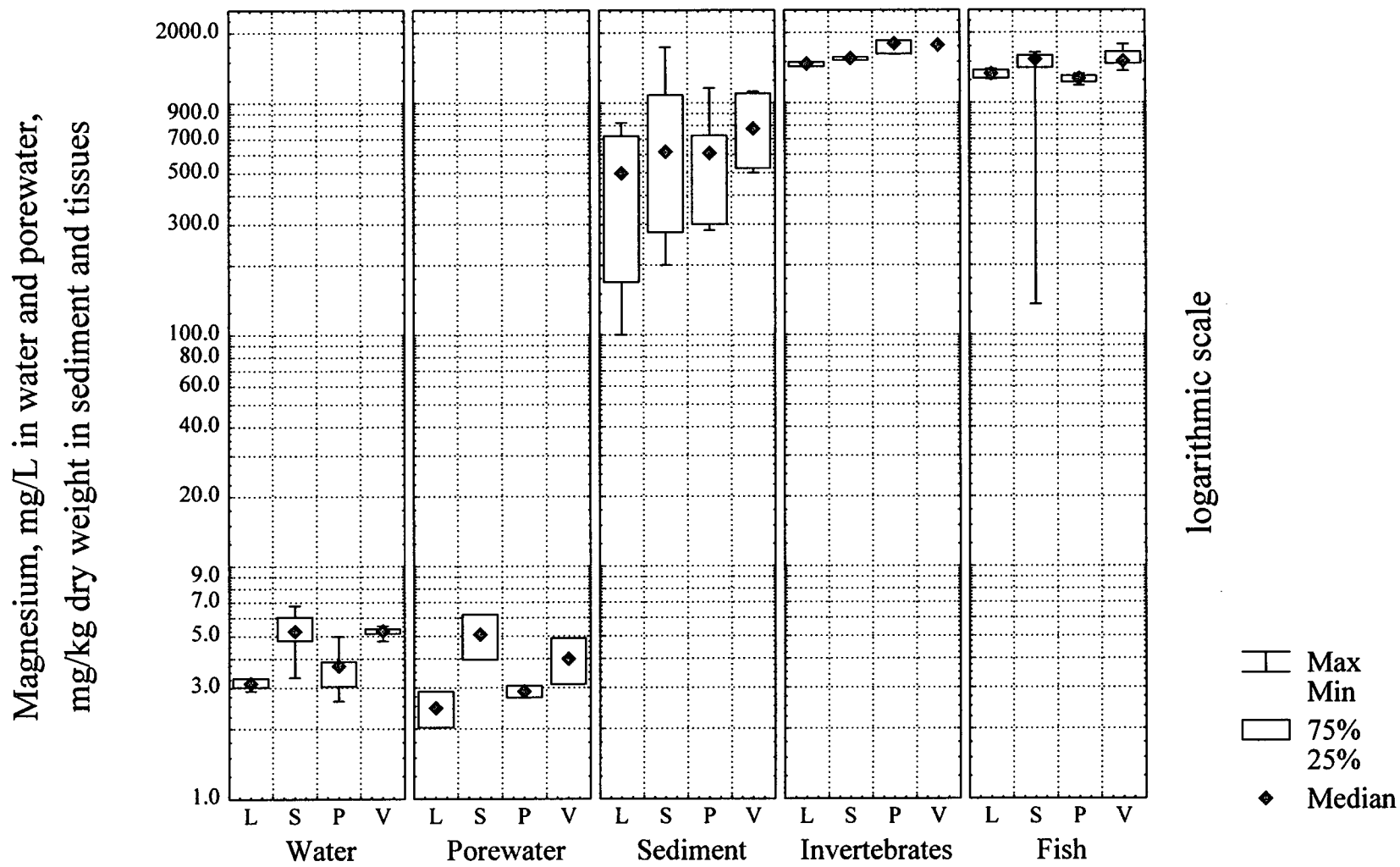
Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 52. Lead in Environmental Samples.



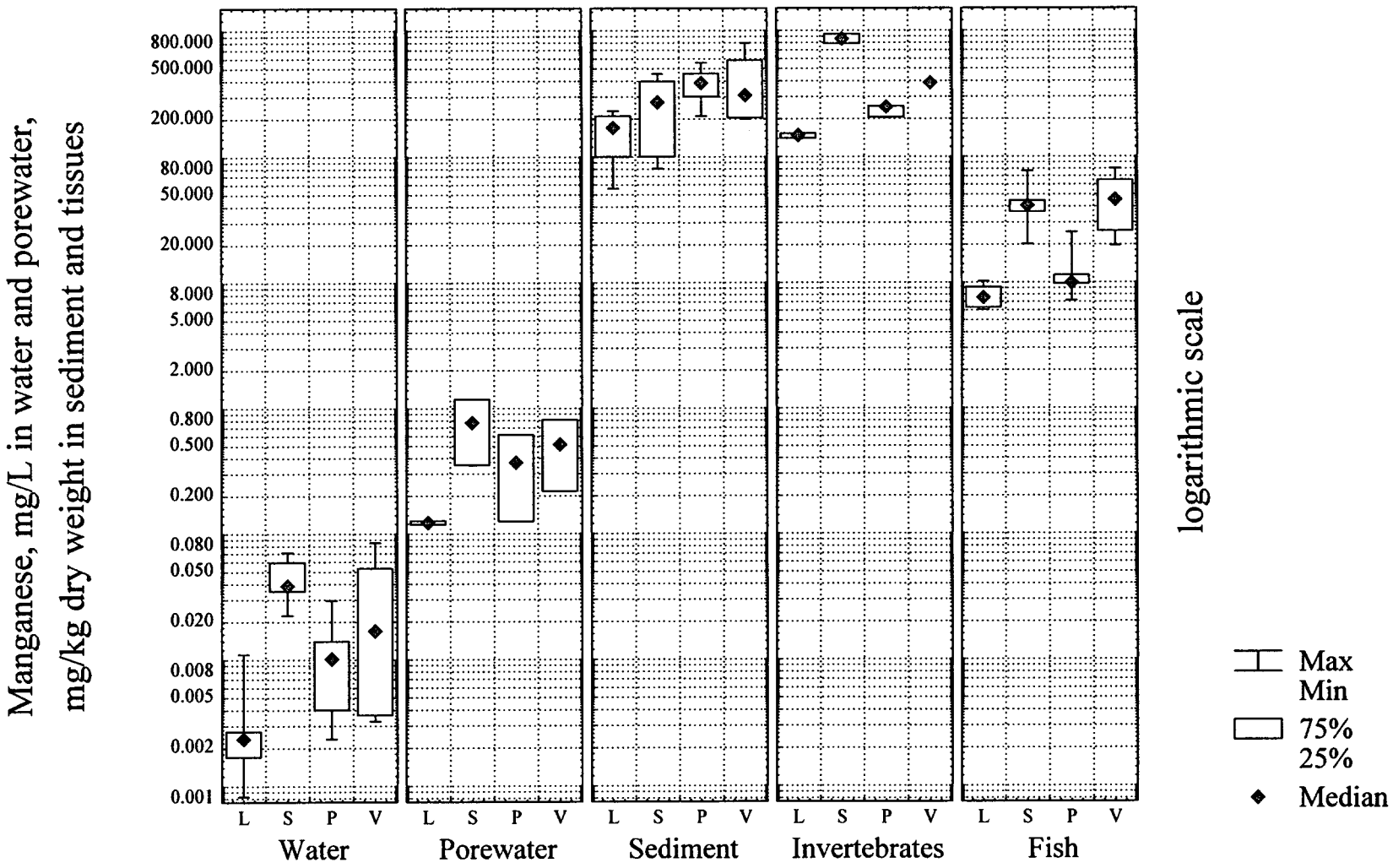
Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 53. Magnesium in Environmental Samples.



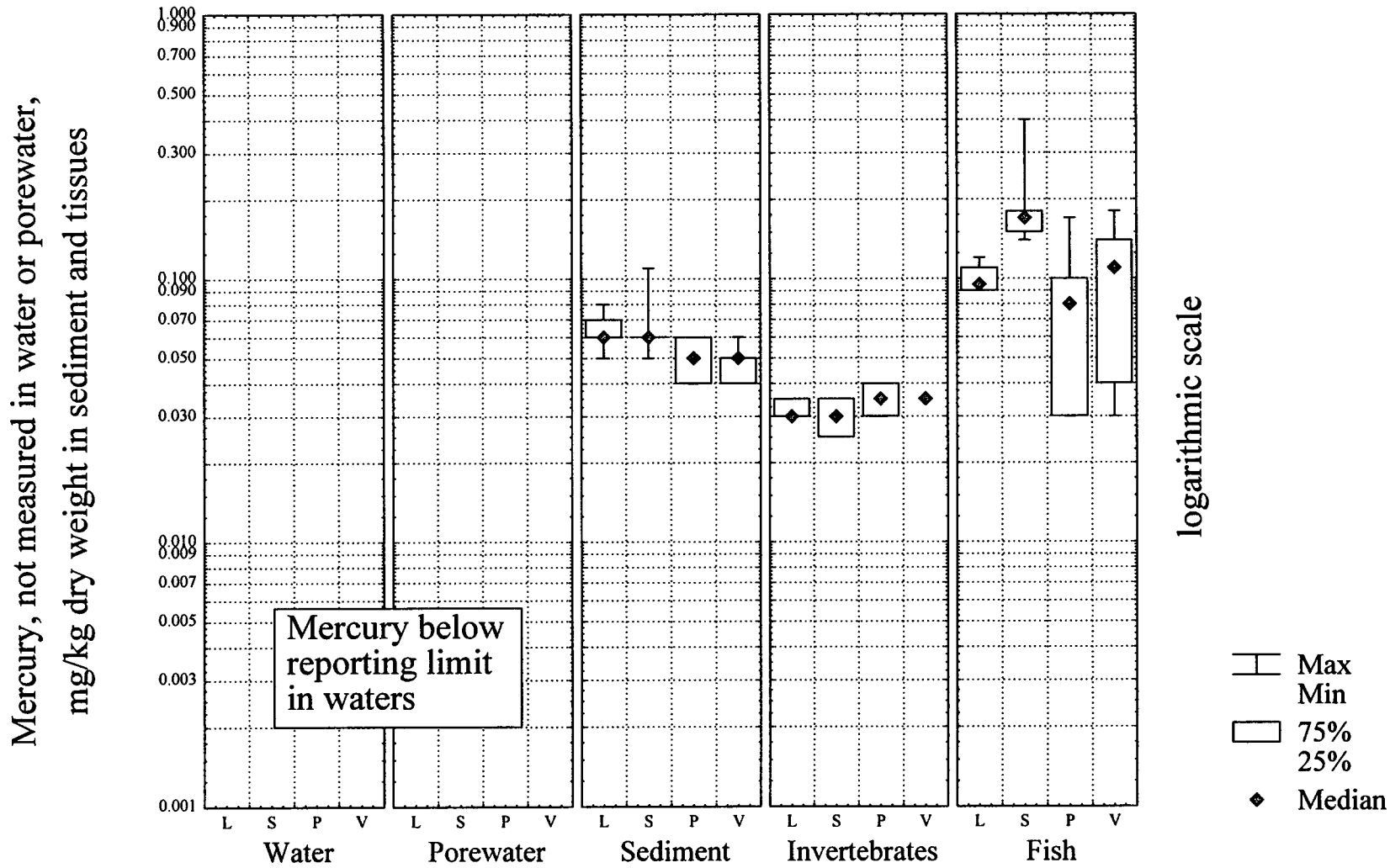
Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 54. Manganese in Environmental Samples.



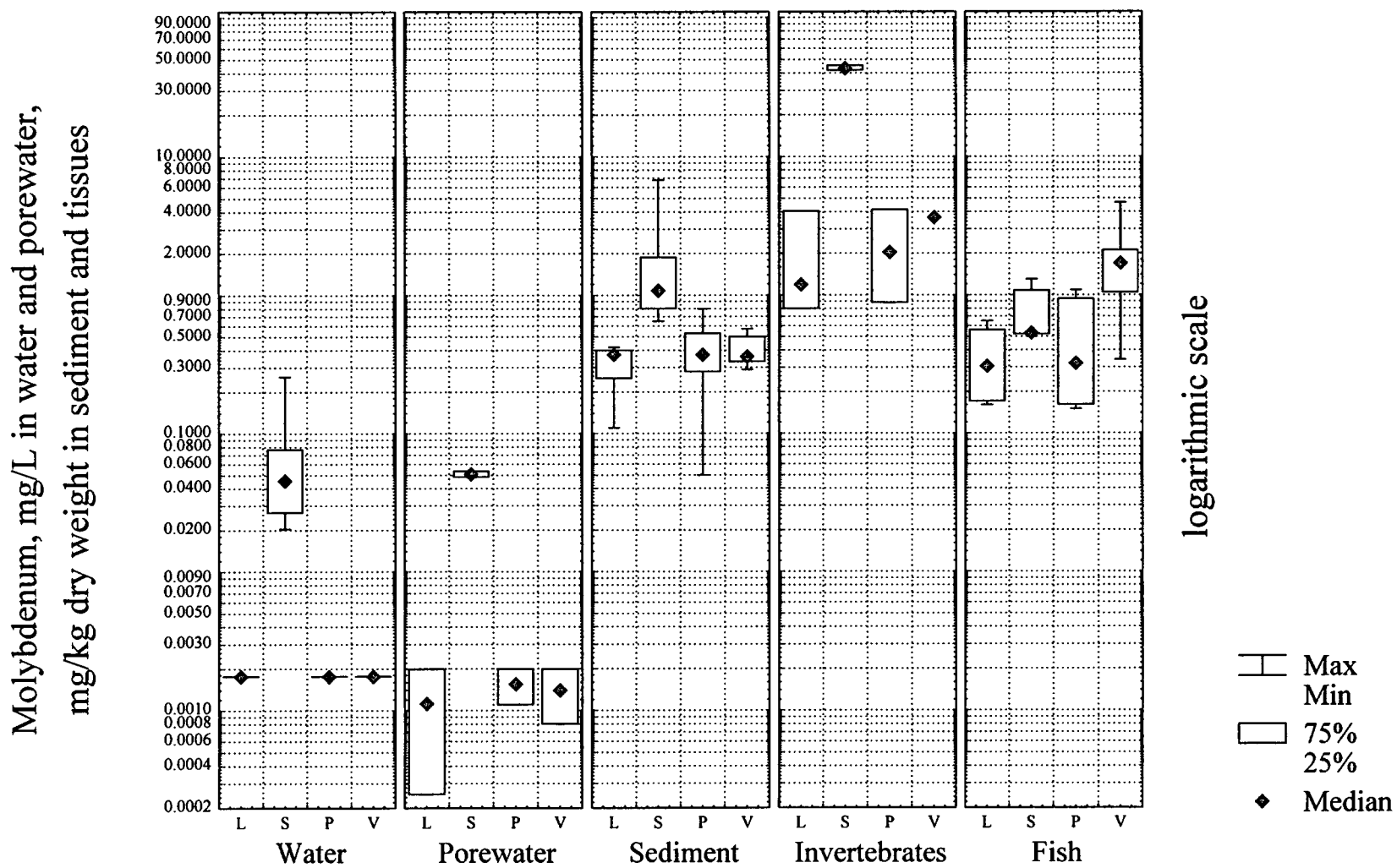
Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 55. Mercury in Environmental Samples.



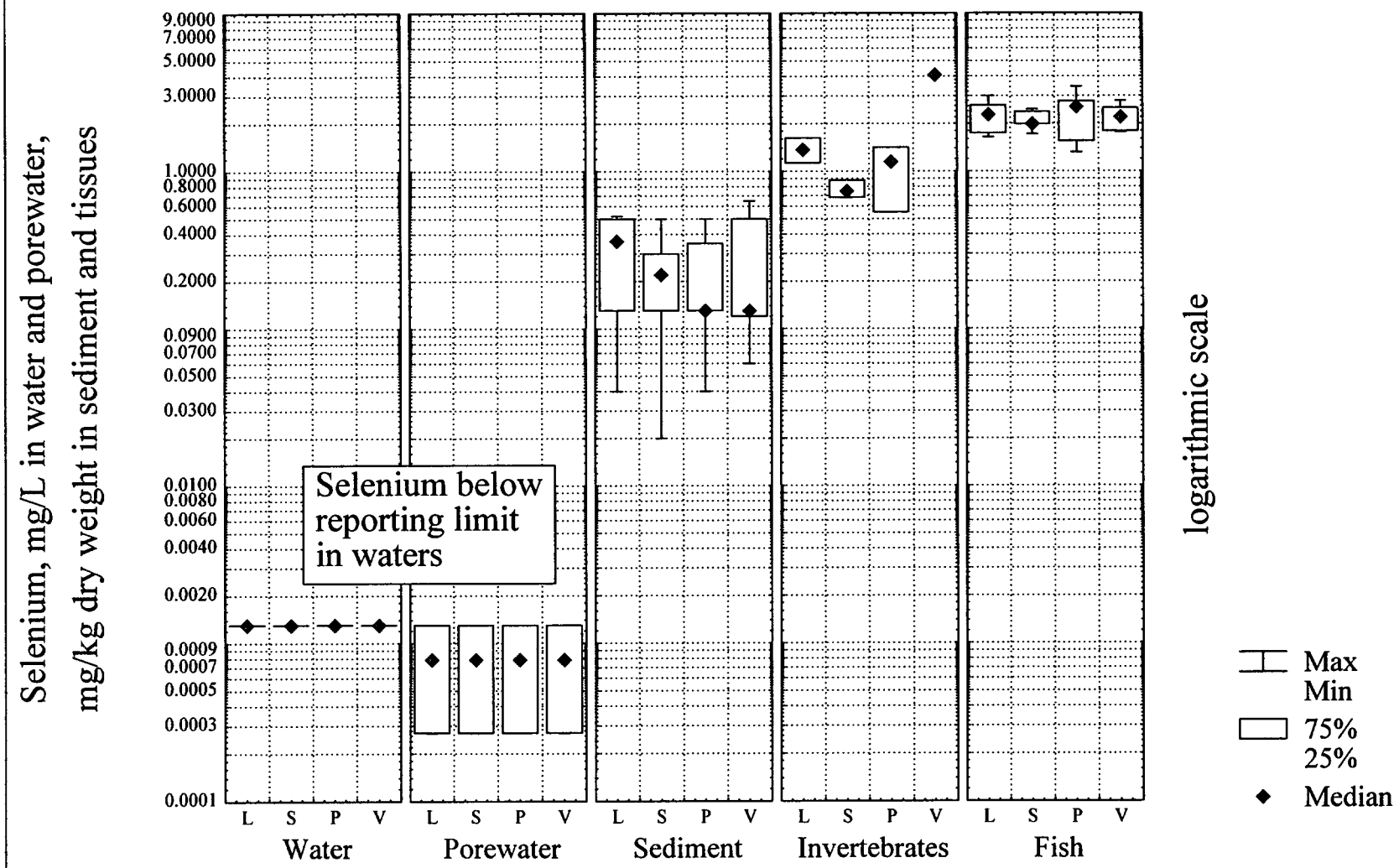
Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 56. Molybdenum in Environmental Samples.



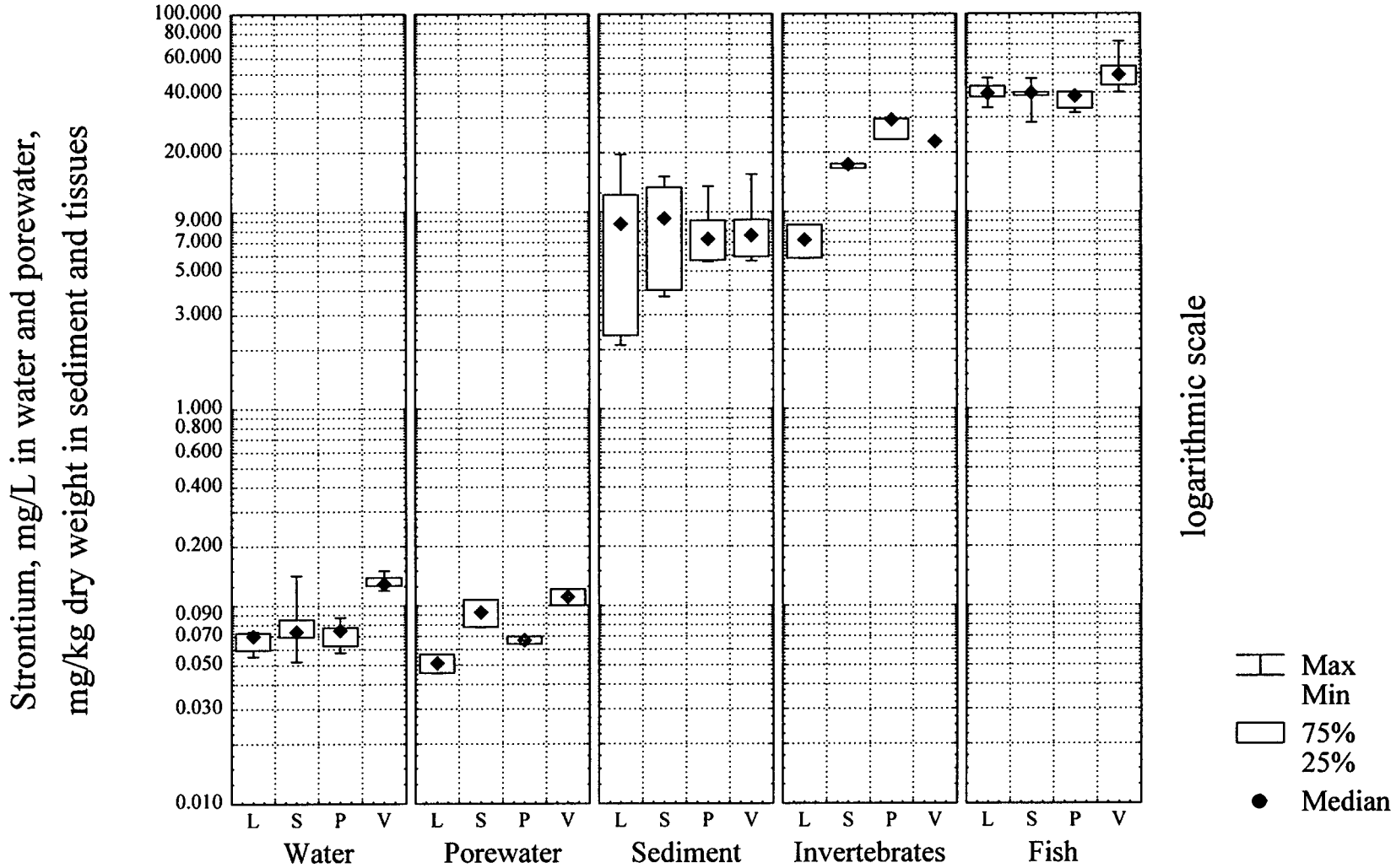
Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 57. Selenium in Environmental Samples.



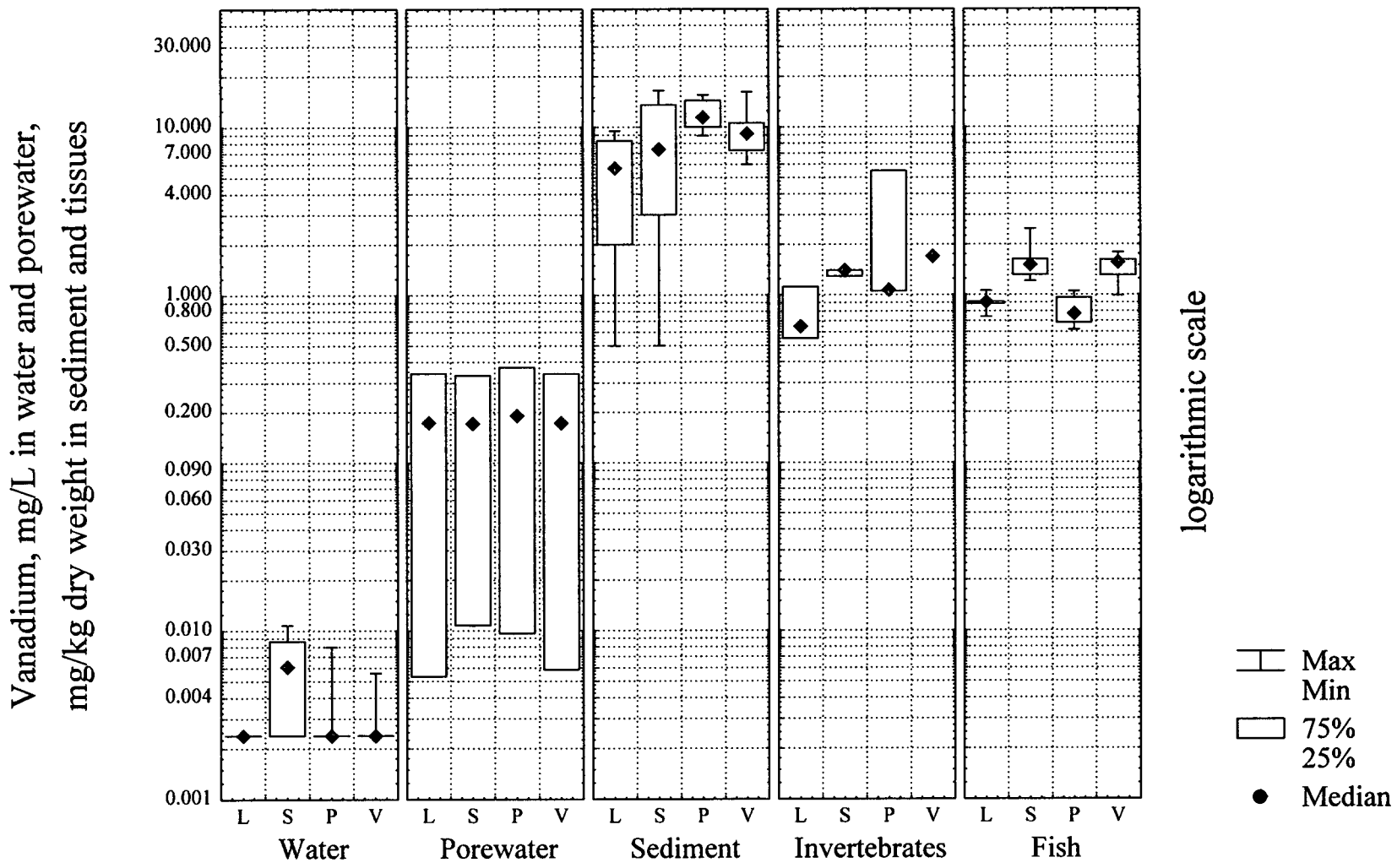
Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 58. Strontium in Environmental Samples.



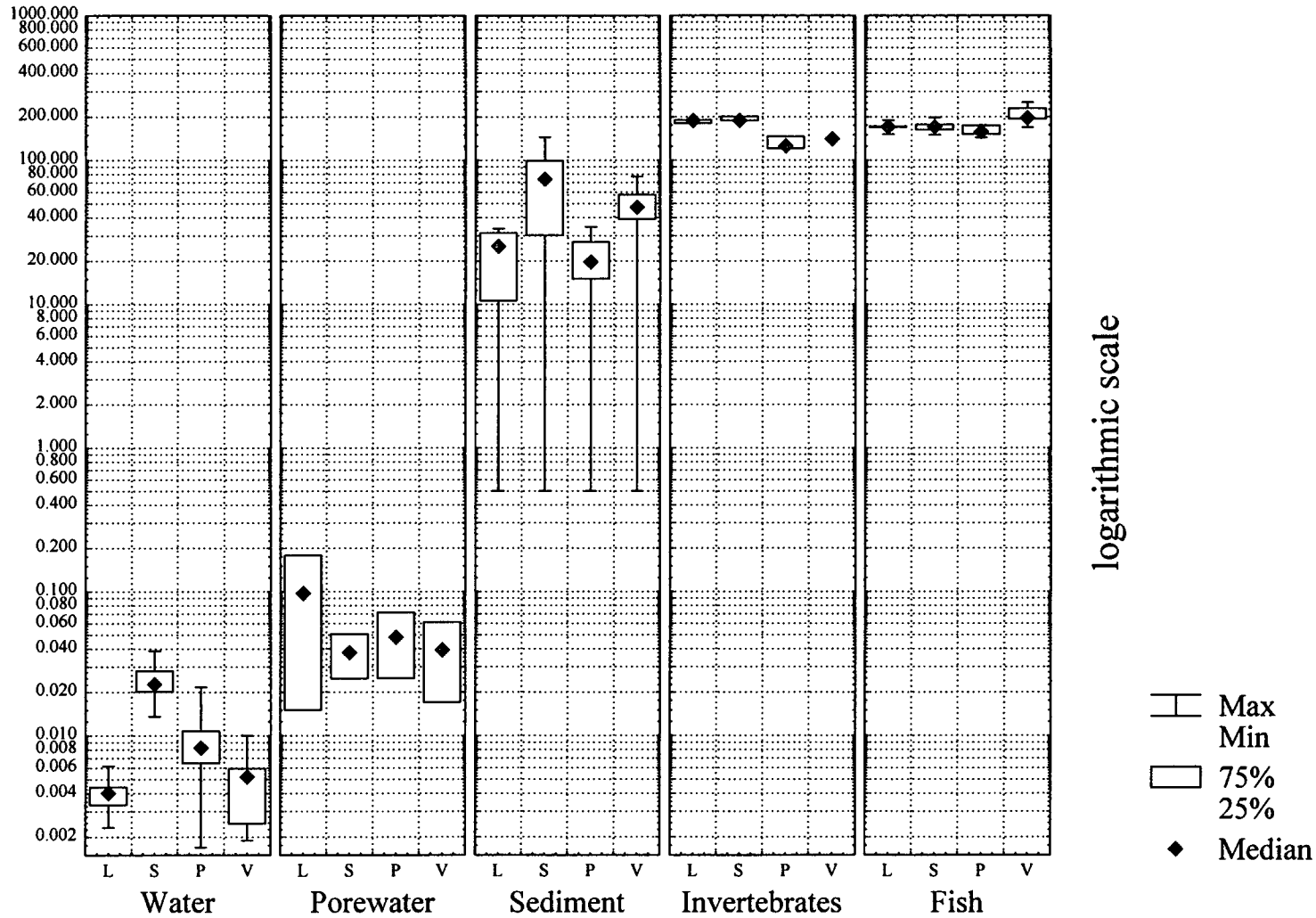
Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 59. Vanadium in Environmental Samples.

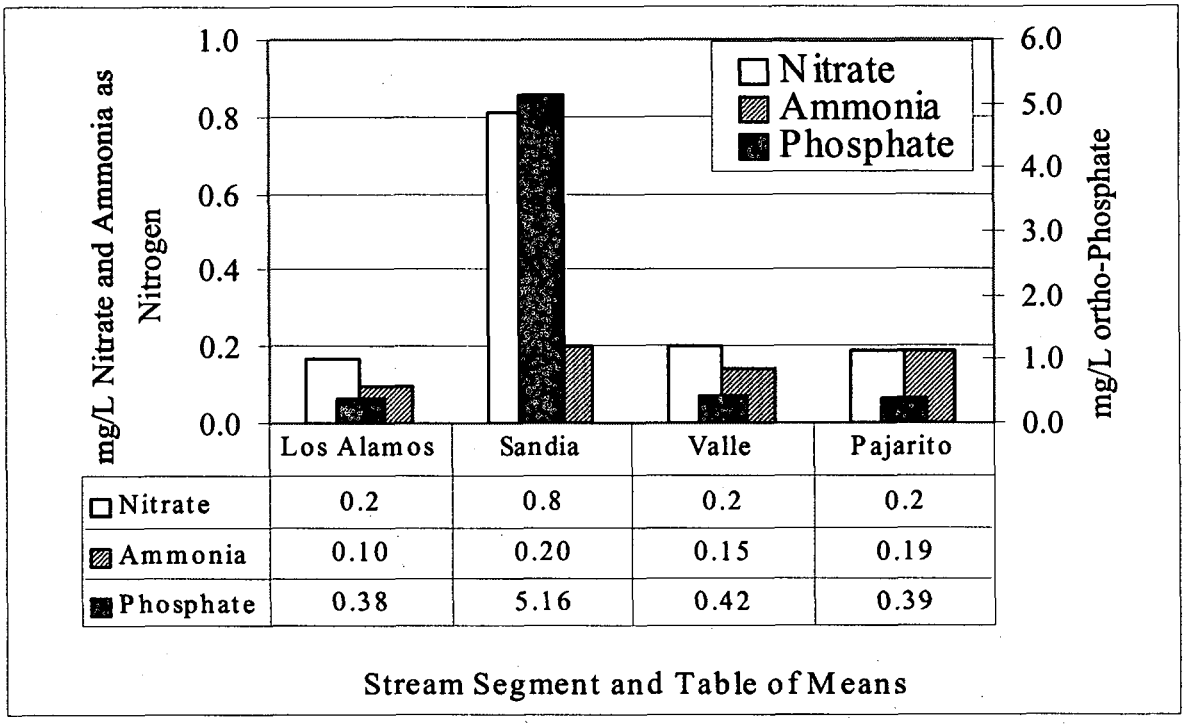


Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle

Figure 60. Zinc in Environmental Samples.

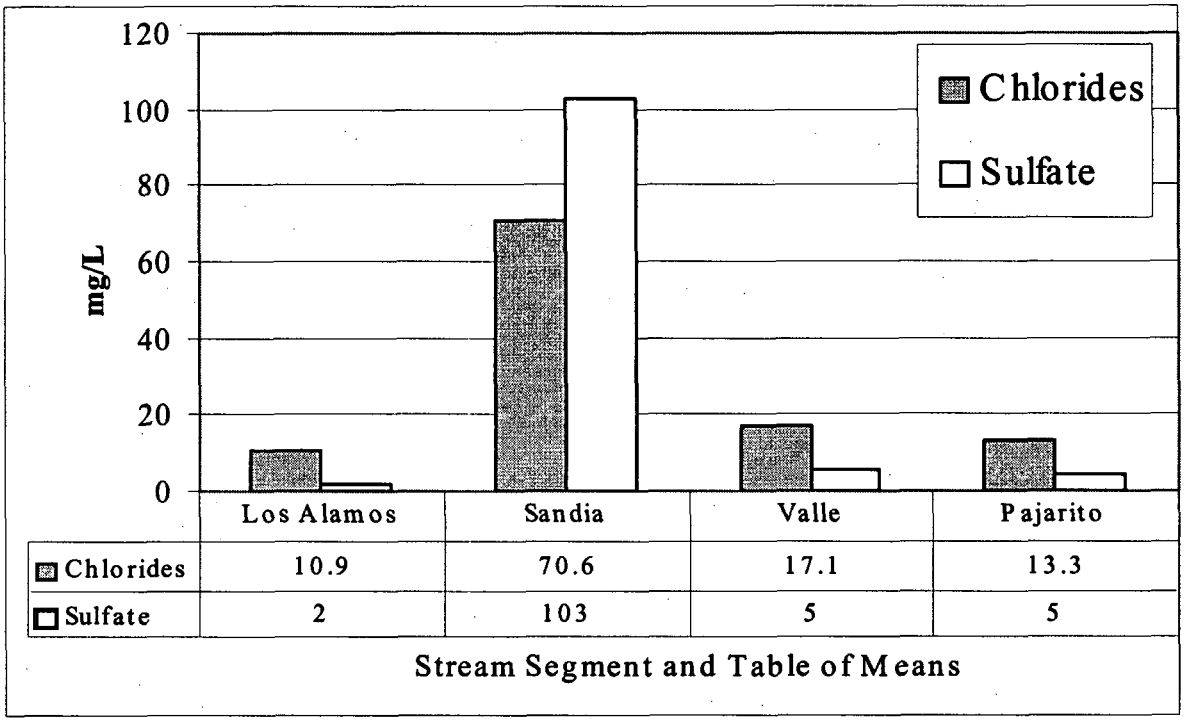


Canyon: L = Los Alamos S = Sandia P = Pajarito V = Valle



	Los Alamos	Sandia	Valle	Pajarito
Nitrate	0.2	0.8	0.2	0.2
Ammonia	0.10	0.20	0.15	0.19
Phosphate	0.38	5.16	0.42	0.39

Figure 61. Average Nutrient Content (Nitrate/Nitrite and Ammonia as Nitrogen, and Phosphorus as Ortho-Phosphate) of Canyon Stream Segments, 1997.



	Los Alamos	Sandia	Valle	Pajarito
Chlorides	10.9	70.6	17.1	13.3
Sulfate	2	103	5	5

Figure 62. Average Chloride and Sulfate Content of Canyon Stream Segments, 1997.

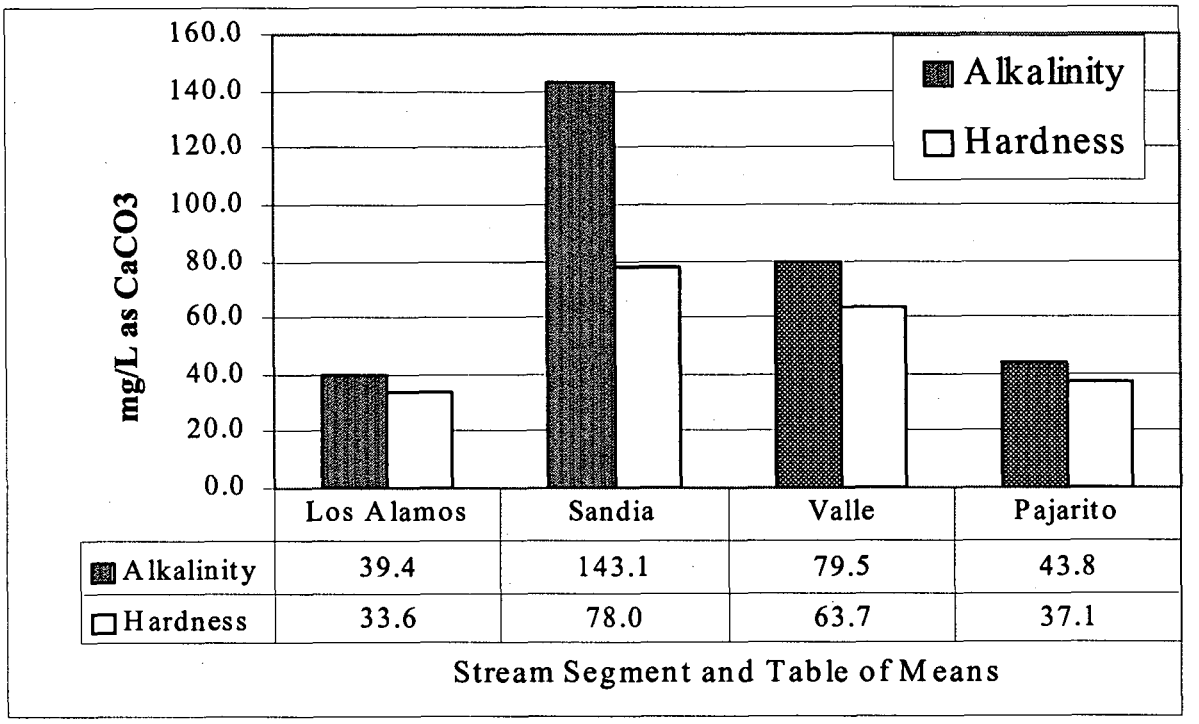


Figure 63. Average Alkalinity and Hardness (mg/L as $CaCO_3$) of Stream Segments, 1997.

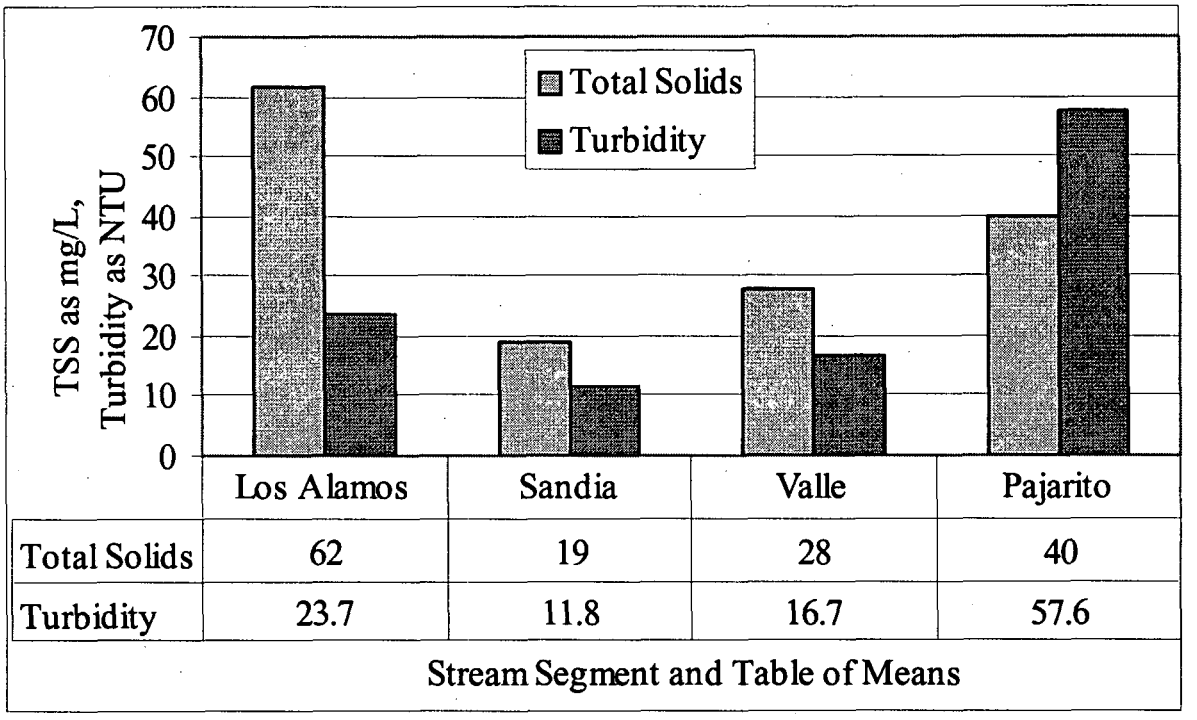


Figure 64. Average Turbidity (NTU) and Total Suspended Solids (mg/L) of Canyon Stream Segments, 1997.

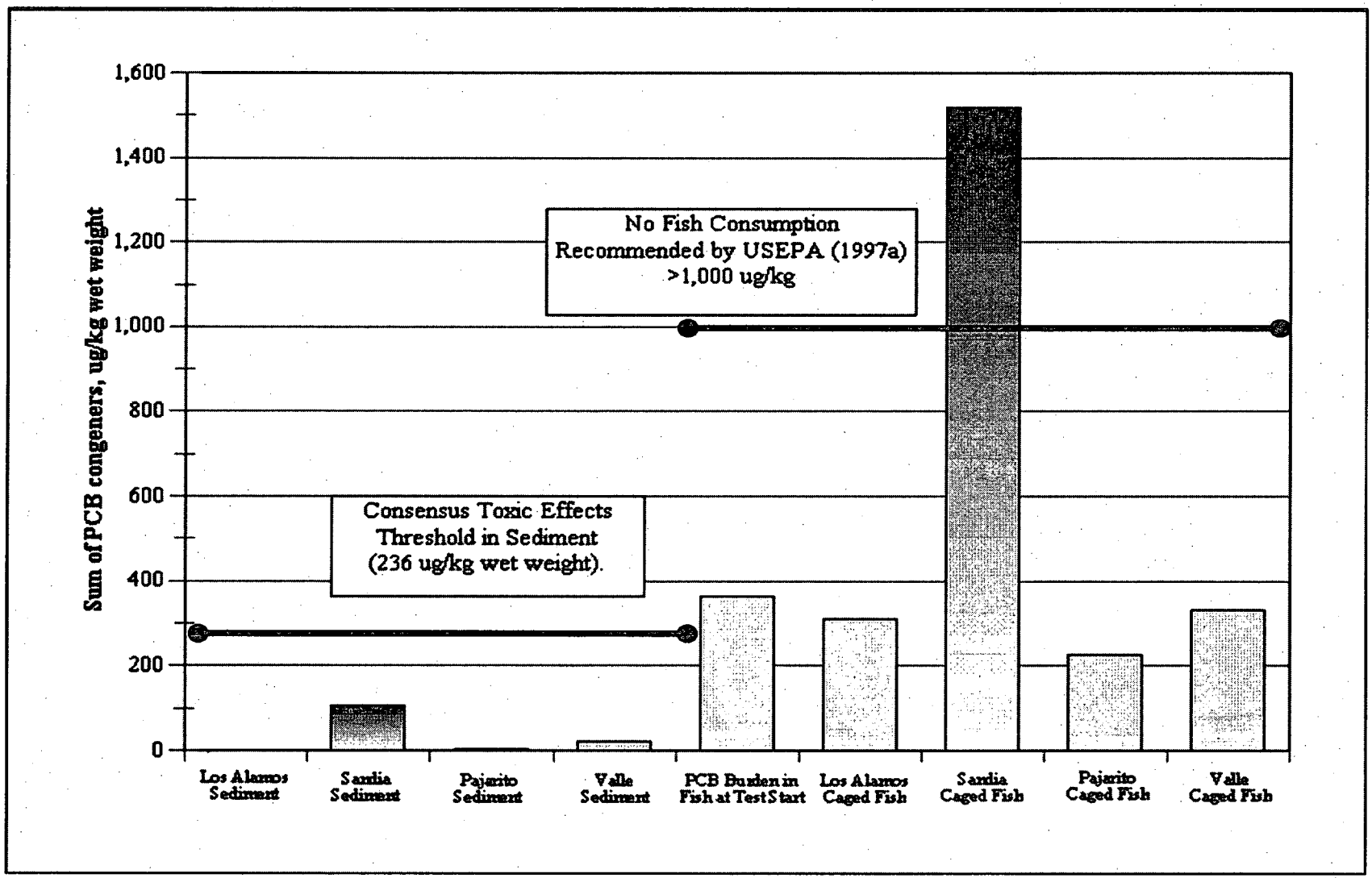
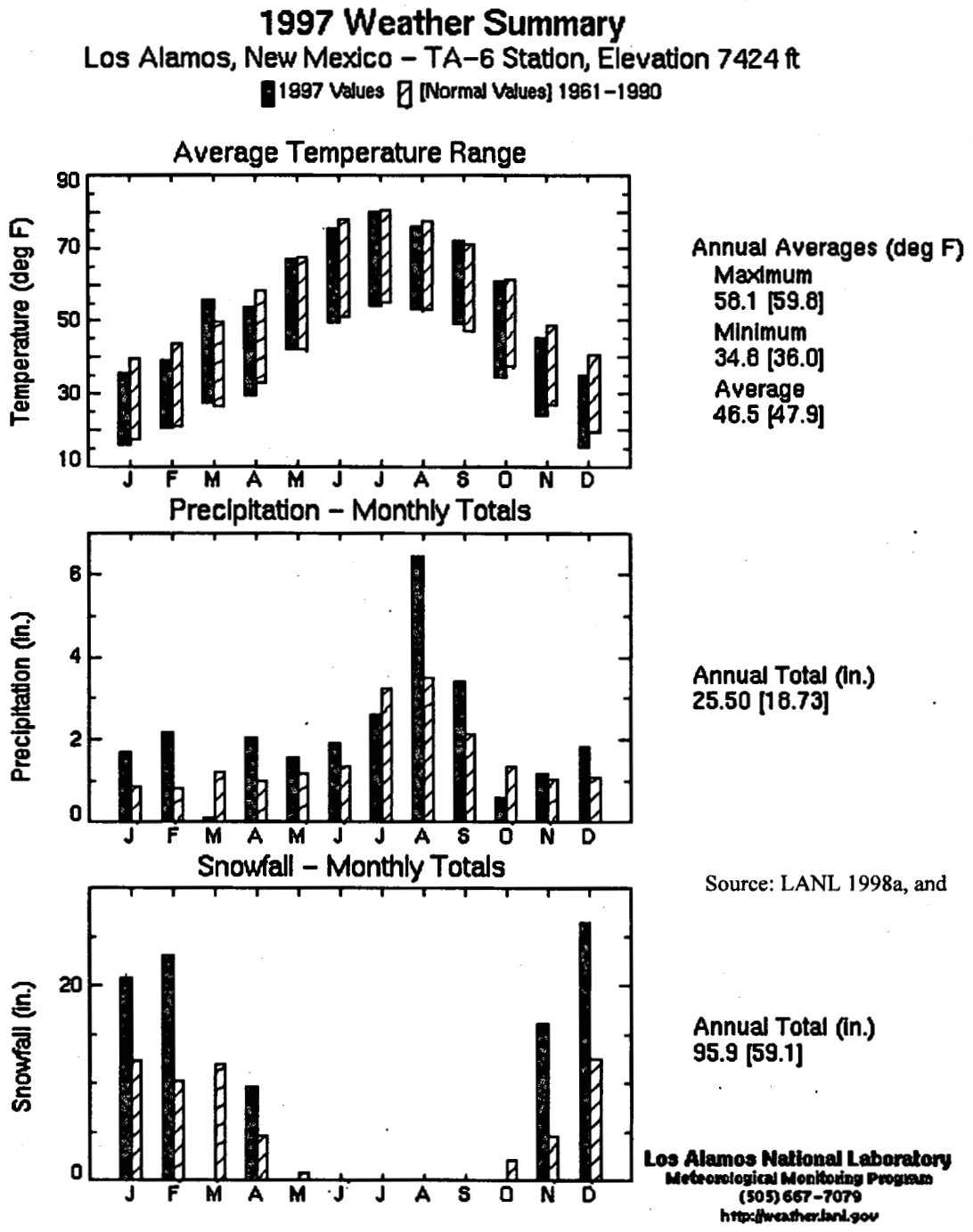


Figure 65. PCB congeners in Sediment and Caged Fish Collected for the Use Study Compared with Thresholds of Concern.



Source: LANL 1998a, and

Figure 66. Summary of Precipitation and Air Temperature (°F) in 1997 at Technical Area 6 of the Los Alamos National Laboratory. (This Weather Station was near to the Stream Segments Evaluated During the Use Study).

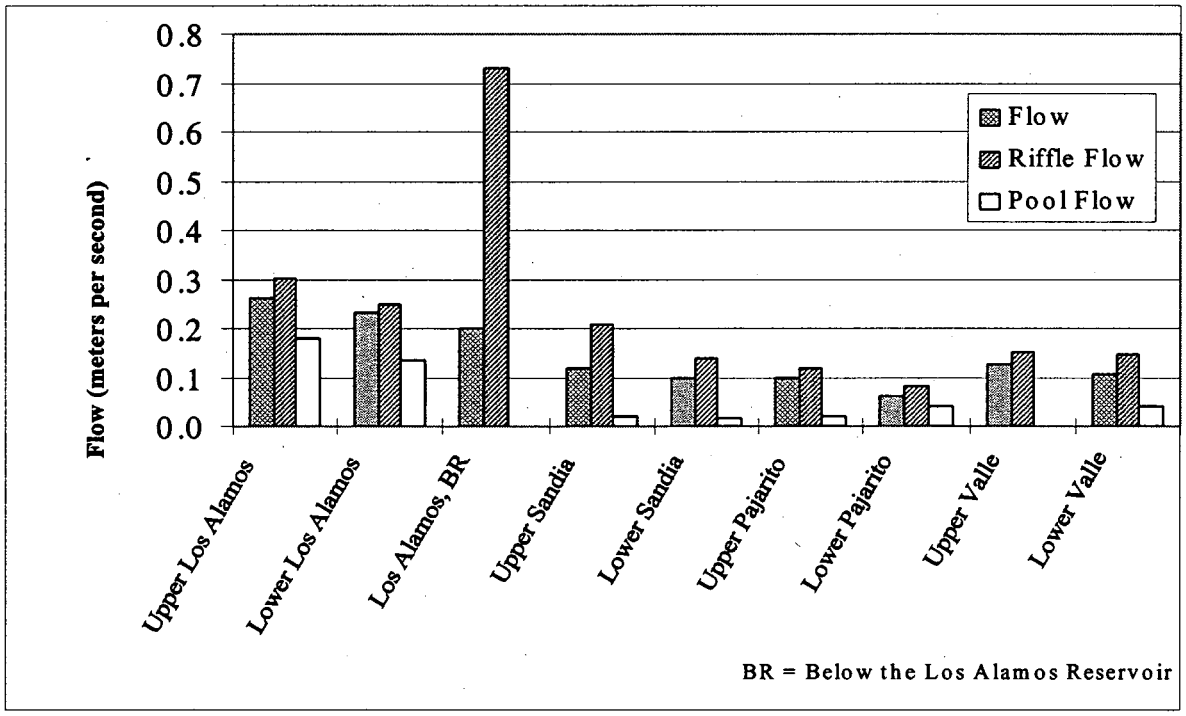


Figure 67. Average Stream Flow, Average Flow in Riffle Habitats, and Average Flow in Pool Habitats, Measured for Each Stream Reach in 1997.

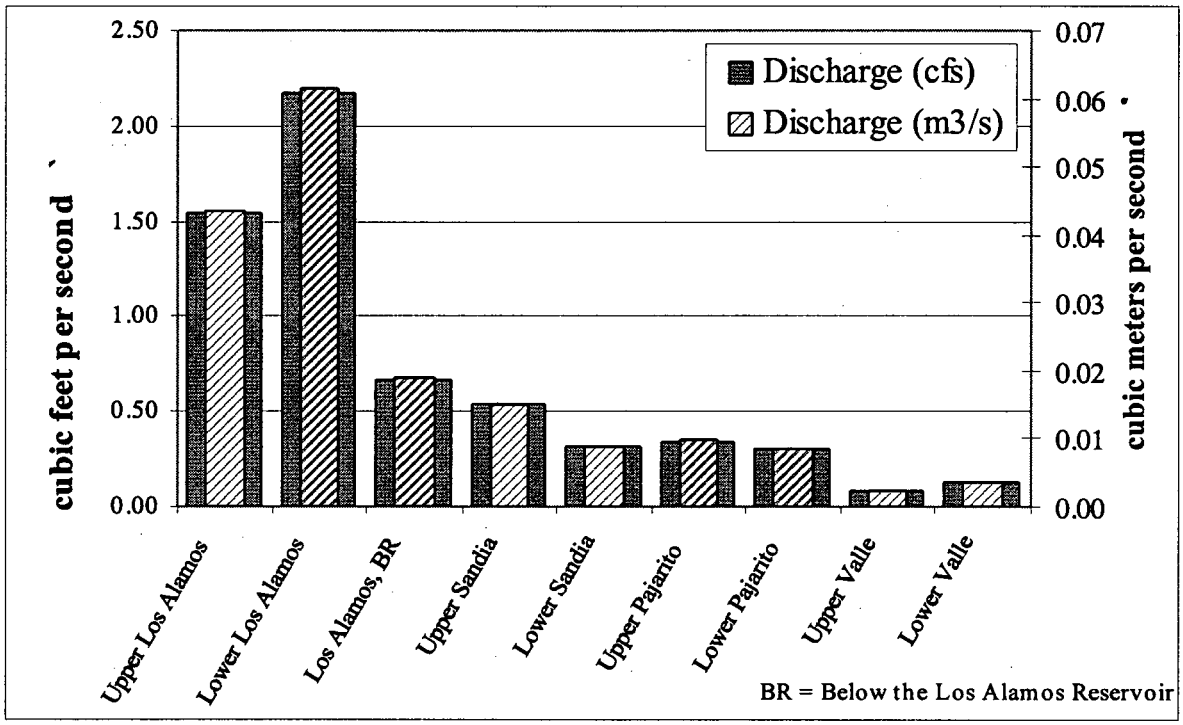


Figure 68. Average Stream Discharge (in cubic feet per second [cfs] and cubic meters per second [m3/s]) Measured for Each Stream Reach in 1997.

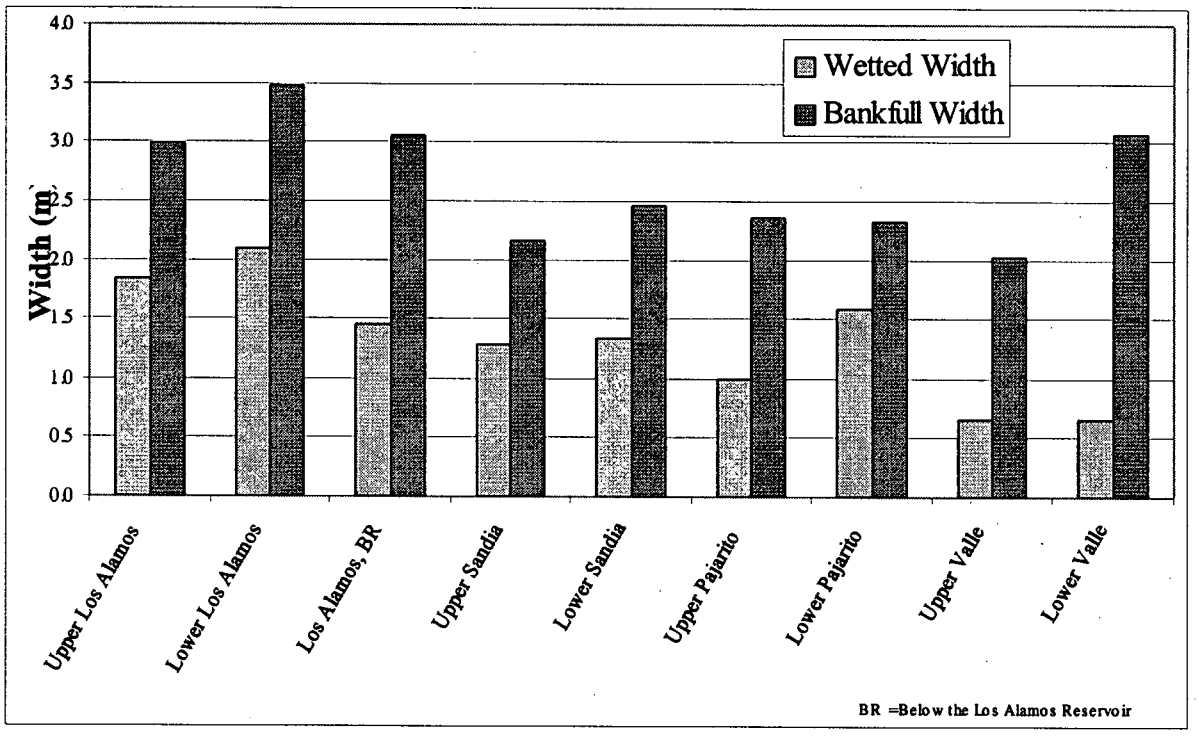


Figure 69. Average Wetted Width and Average Bankfull Width for Each Stream Reach.

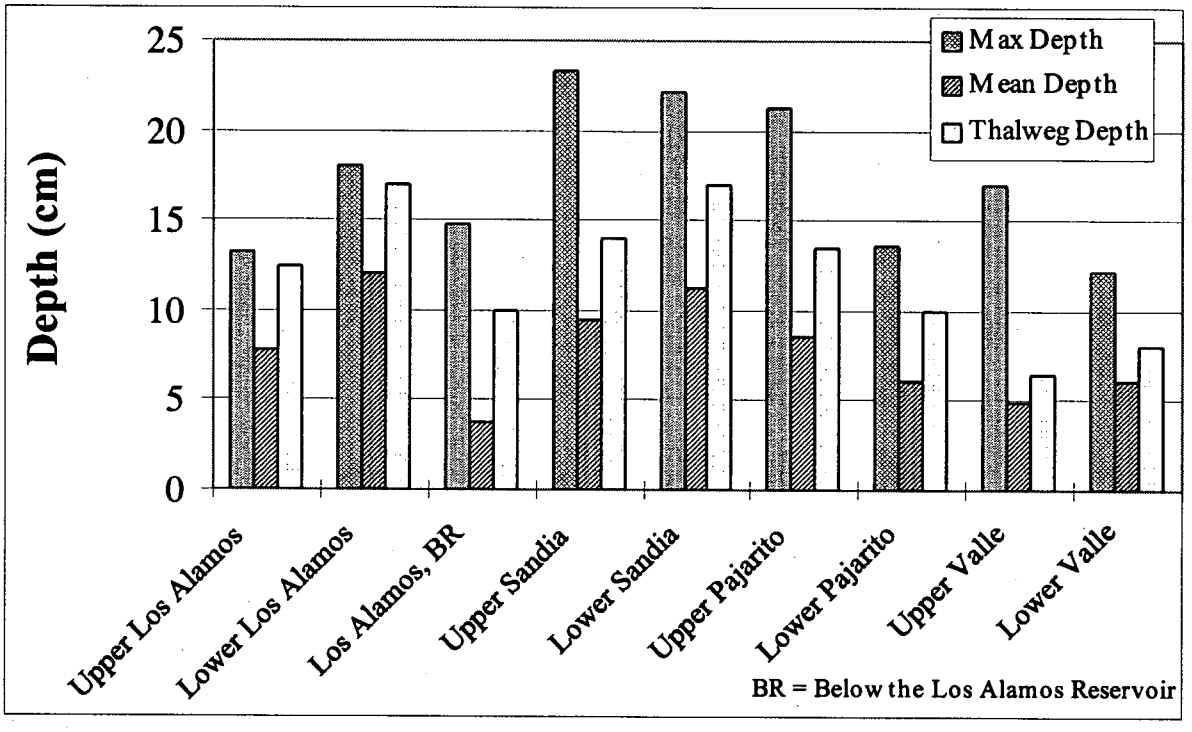


Figure 70. Mean, Maximum, and Thalweg Depth of Each Stream Reach Measured in 1997.

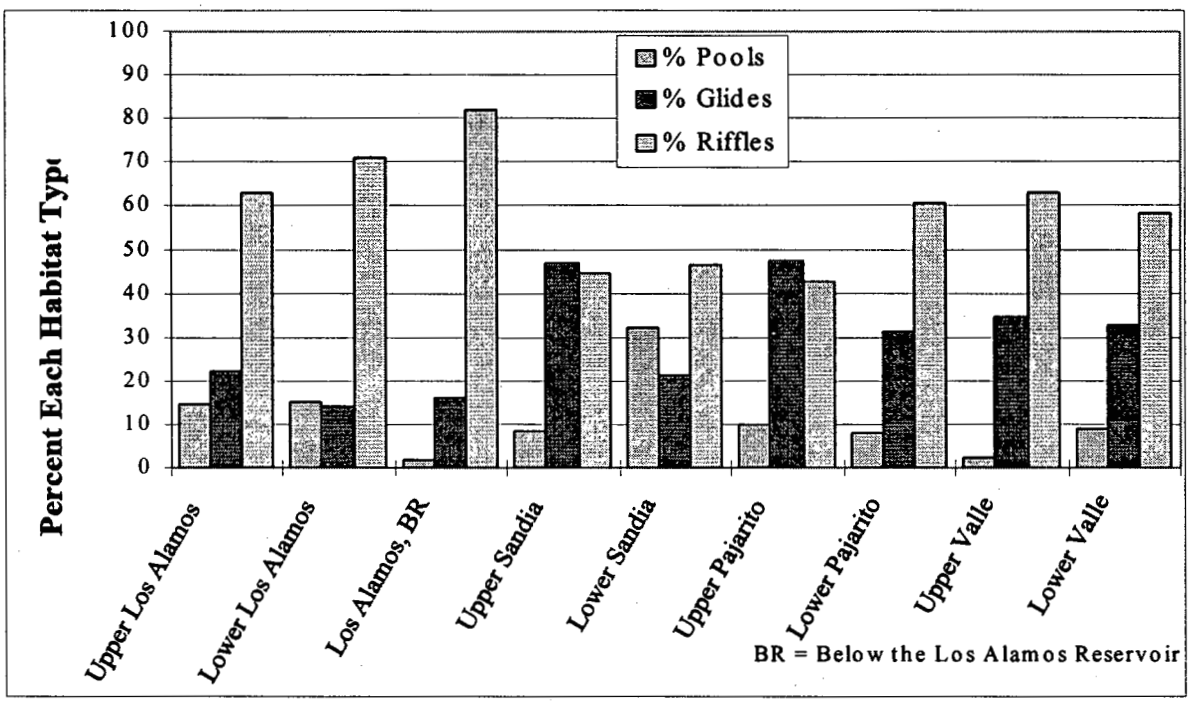


Figure 71. Percentage of Pools, Glides, and Riffles (expressed as a percentage of total wetted stream area) for Each Stream Reach Measured in 1997.

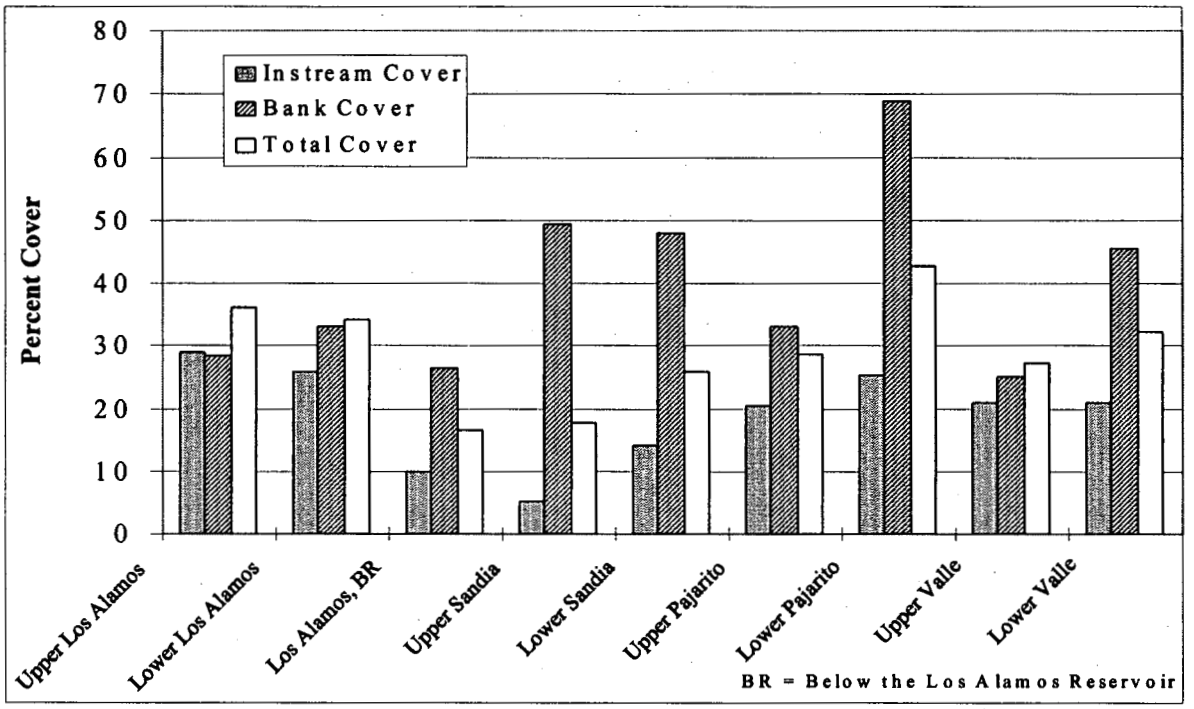


Figure 72. Percentage of Instream Cover, Bank Cover, and Total Cover (expressed as a percentage of the total wetted stream area) for Each Stream Reach in 1997.

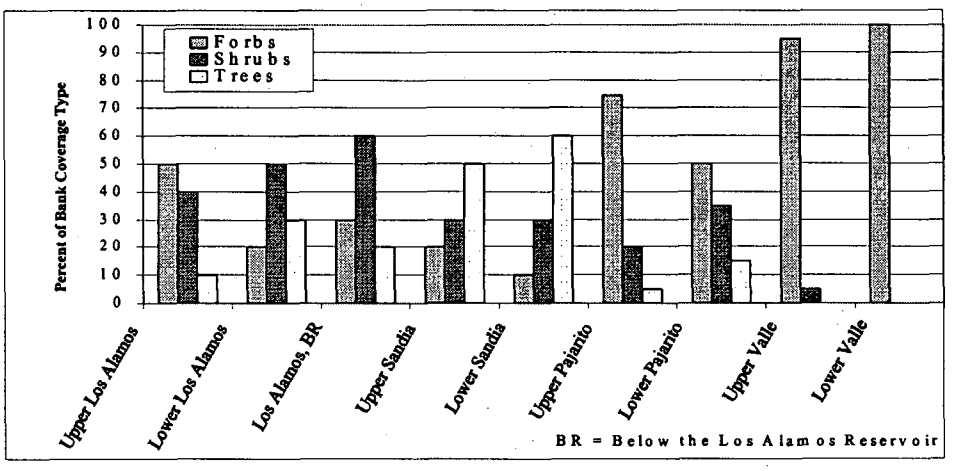


Figure 73. Percentage of Bank Cover Types (Forbs, Shrubs, or Trees) for Each Stream Reach Measured in 1997.

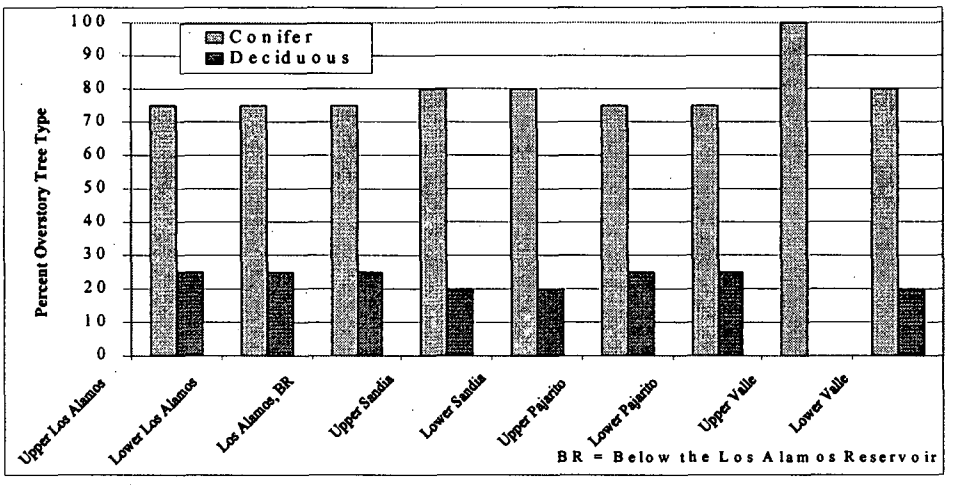


Figure 74. Percentage of Overstory Cover (expressed as a percentage of total riparian area) in the Form of Coniferous and Deciduous Trees for Each Stream Reach in 1997.

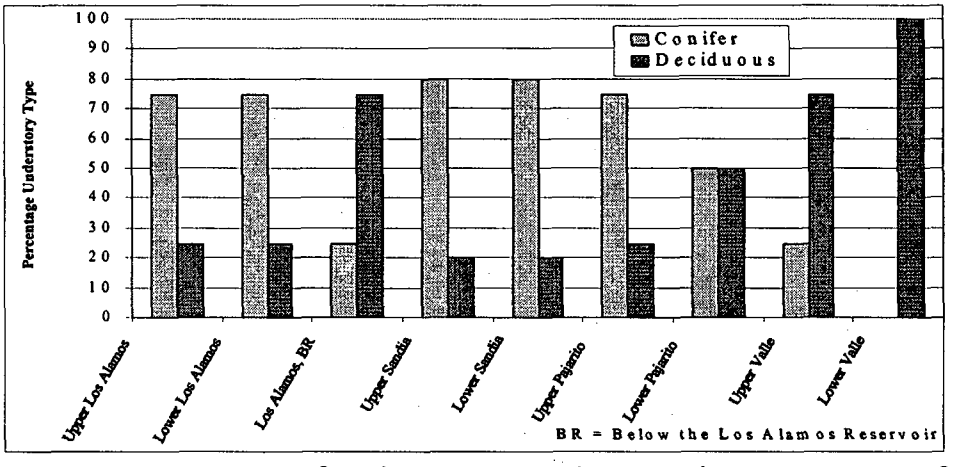


Figure 75. Percentage of Understory Cover (expressed as a percentage of total riparian area) in the Form of Coniferous and Deciduous Trees for Each Stream Reach in 1997.

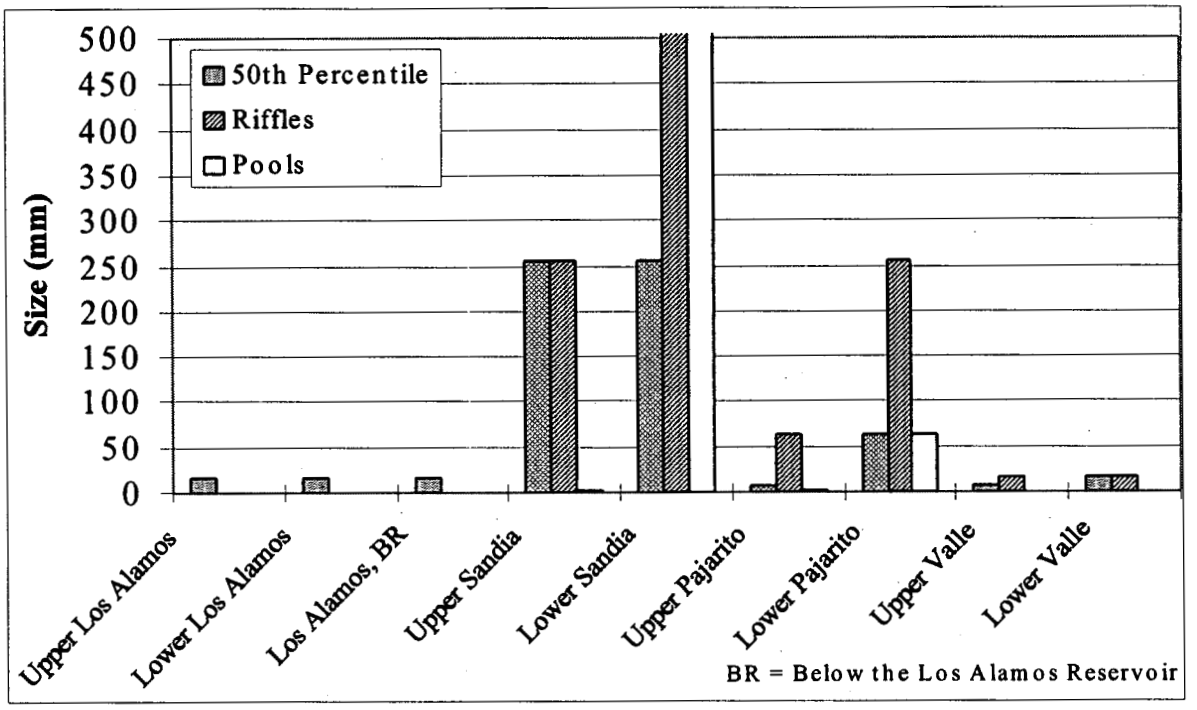


Figure 76. Stream Substrate Size Characteristics in Riffles, in Pools, and the 50th Percentile Distribution of Substrate Sizes for each Stream Reach Measured in 1997.

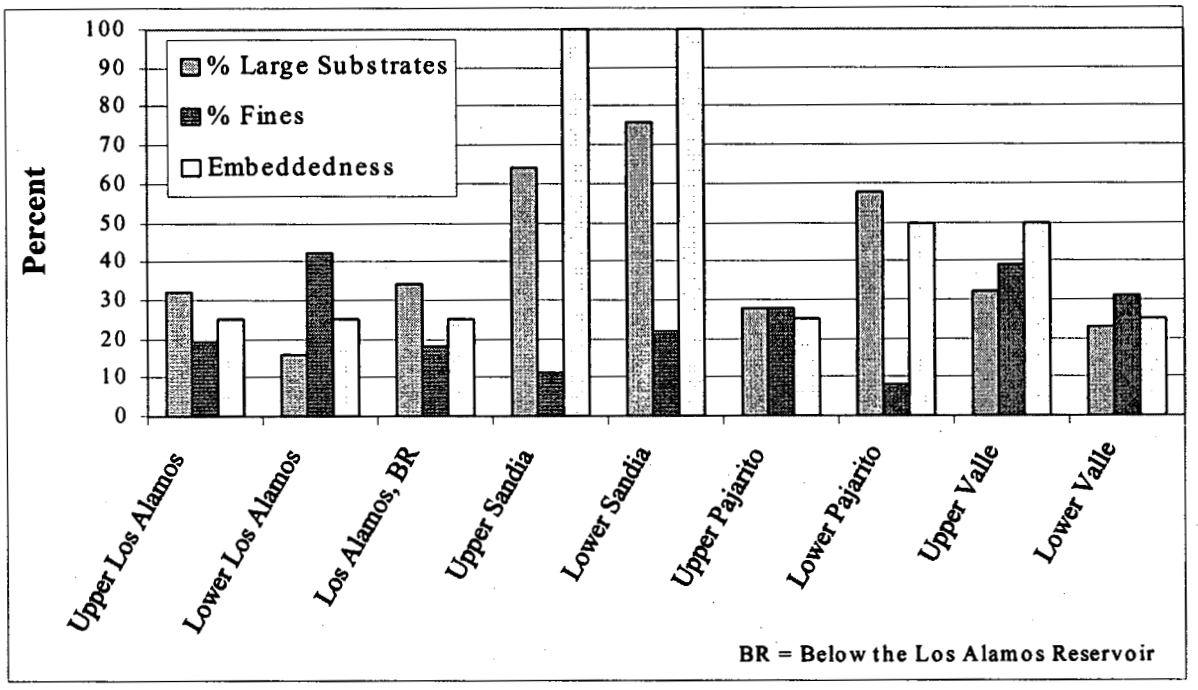
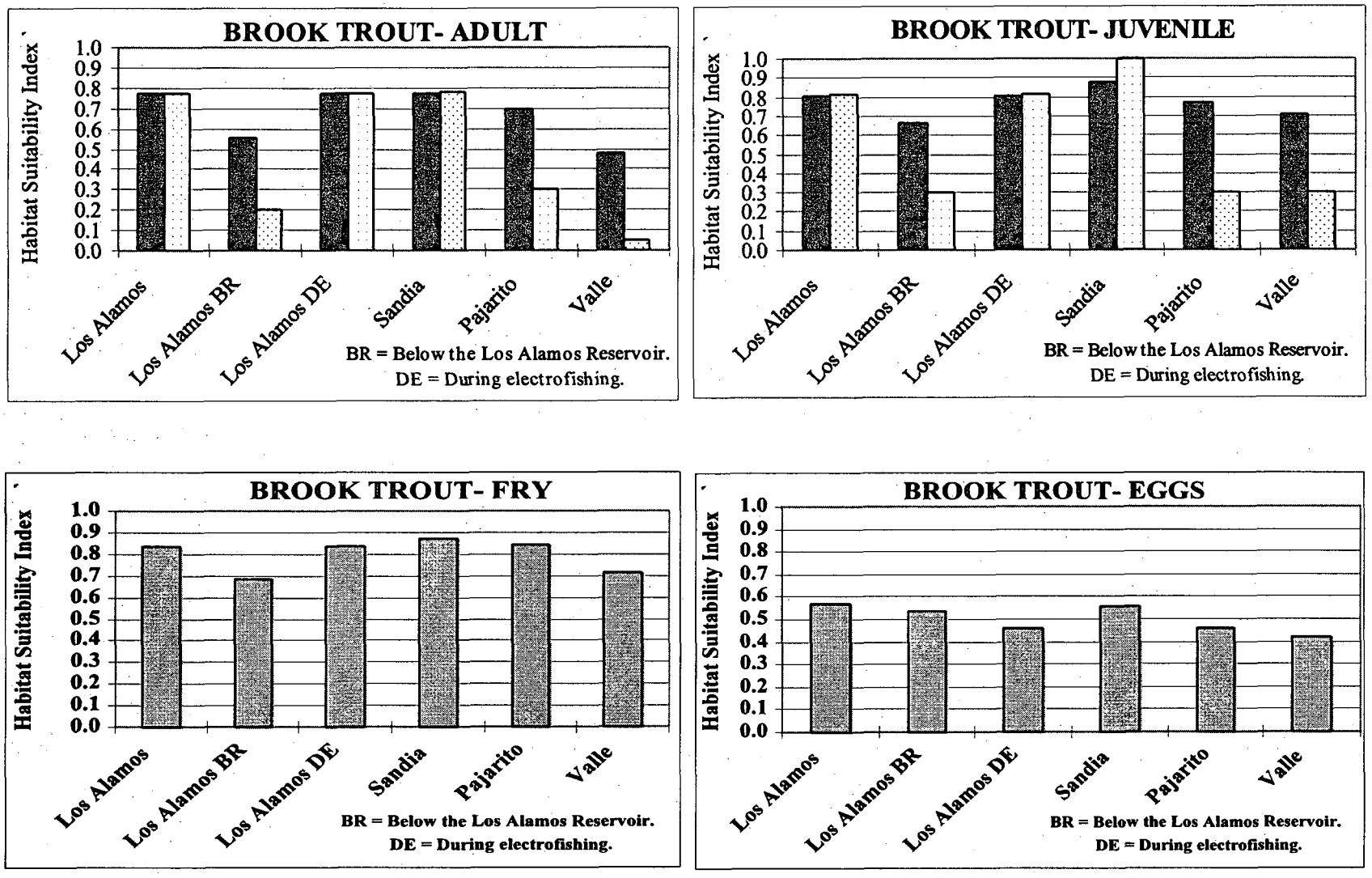
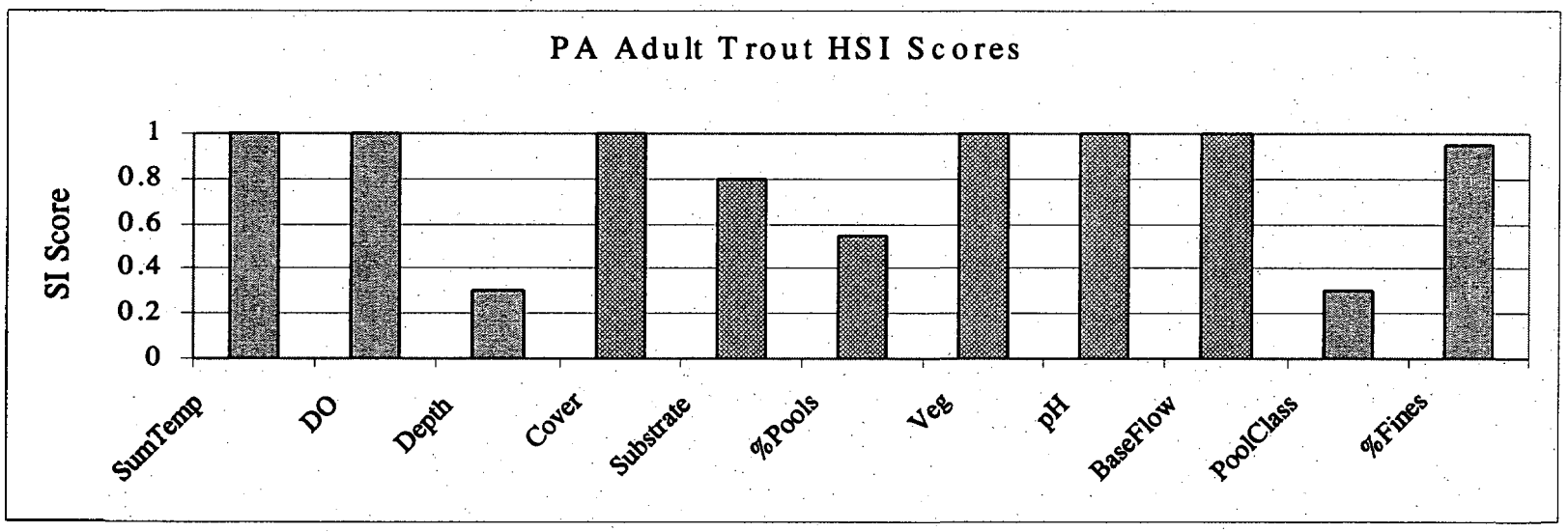


Figure 77. Stream Substrate Characteristics Expressed as Large and Fine Substrates as well as Percent Embeddedness of Large Substrates by Fines for Each Stream Reach.

Figure 78. Mean Habitat Suitability Index (HSI) Scores for Each Stream Segment for Adult, Juvenile, Fry, and Eggs of Brook Trout. For Illustrative Purposes, Adult and Juvenile Graphs Include Two Sets of Bars. Closed Bars Reflect the HSI Scores Before Water Depth and/or Pool Quality were Considered. Open Bars are the Final HSI Scores.





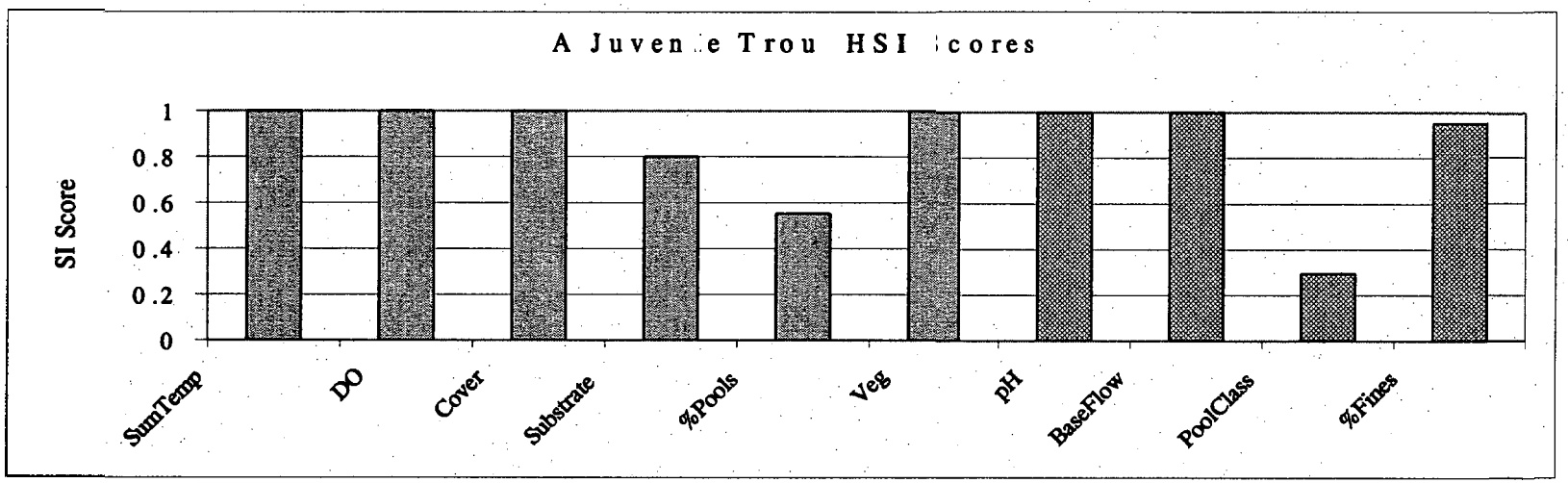


Figure 79. Mean Individual Habitat Suitability Scores (SI) for the Brook Trout HSI Model, Measured in Pajarito Canyon (PA) in 1997.

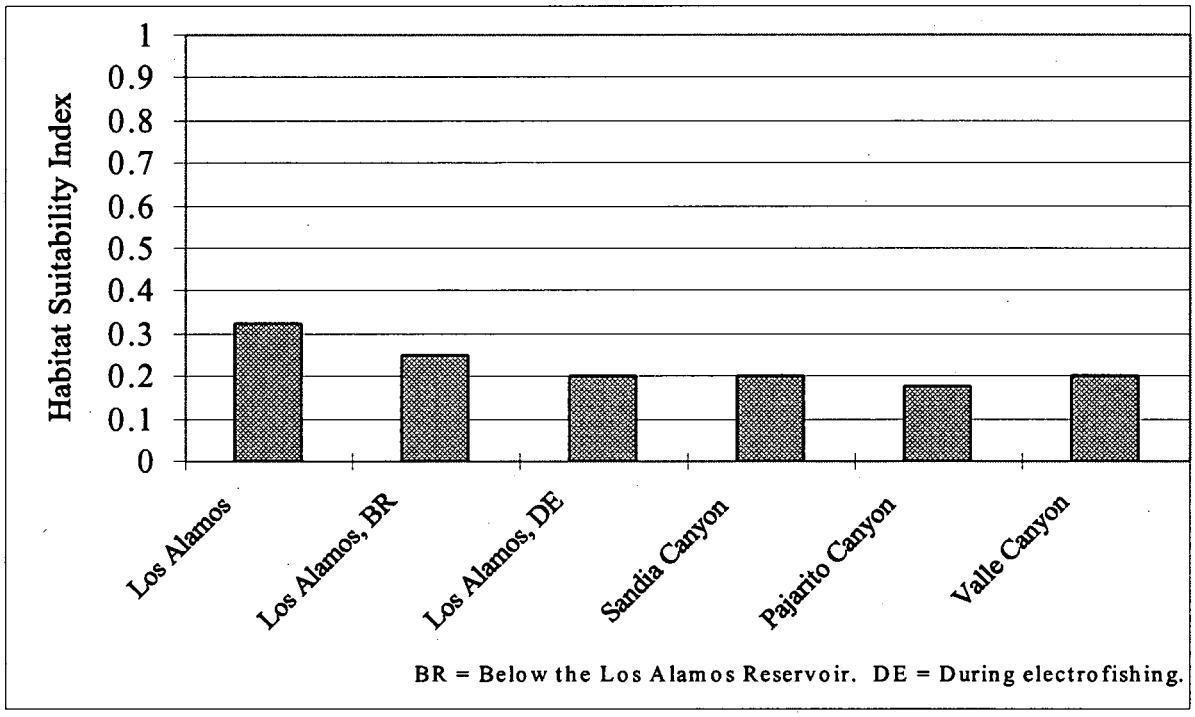


Figure 80. Overall Longnose Dace Habitat Suitability Index for Canyon Streams in 1997.

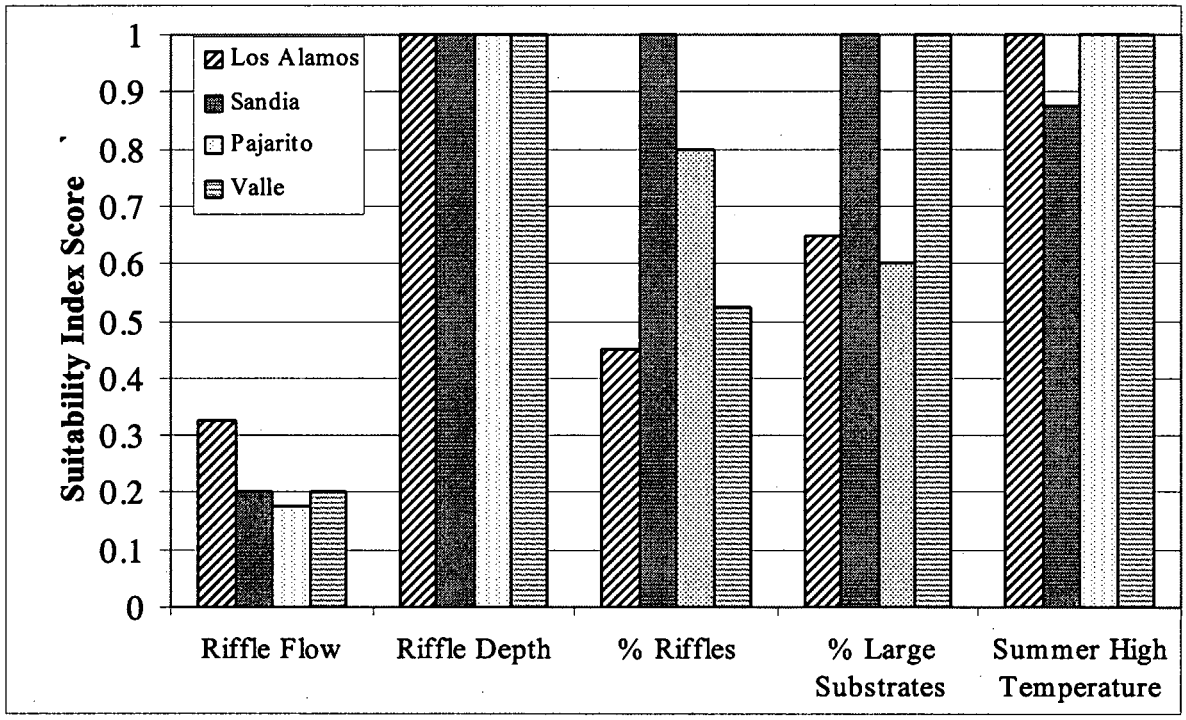


Figure 81. Mean Individual Habitat Parameter Scores for the Longnose Dace Suitability Index Model for Each Stream Reach Measured in 1997.

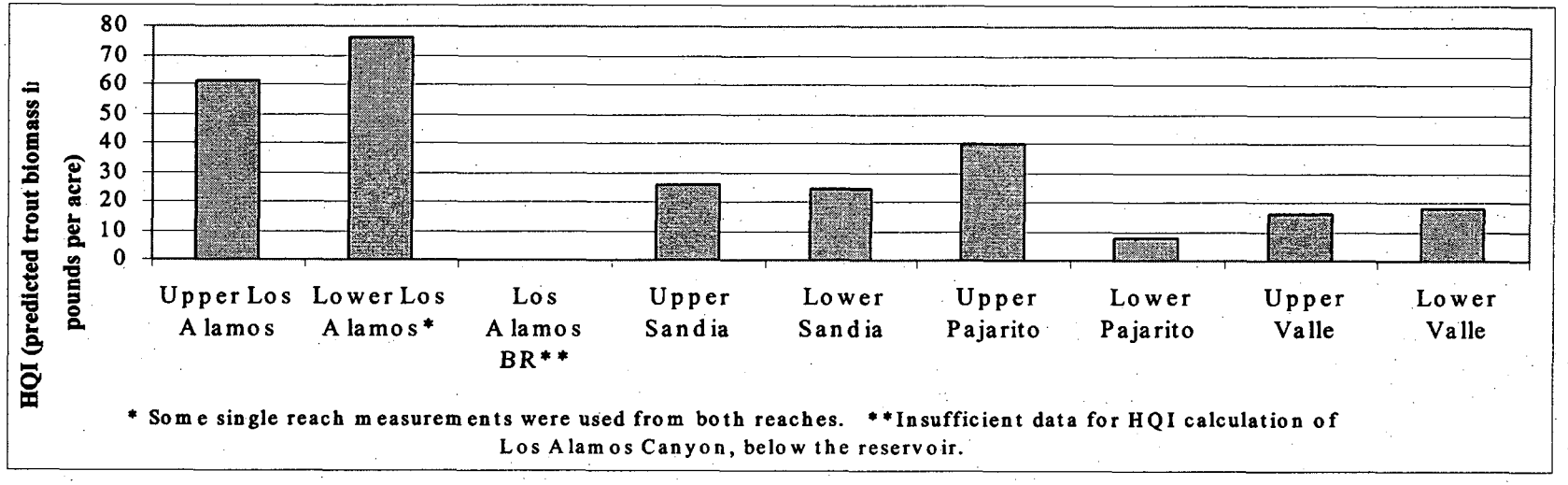


Figure 82. Predicted Trout Biomass (*i.e.*, Standing Crop Density) using the Habitat Quality Index (HQI) for Each Stream Reach.

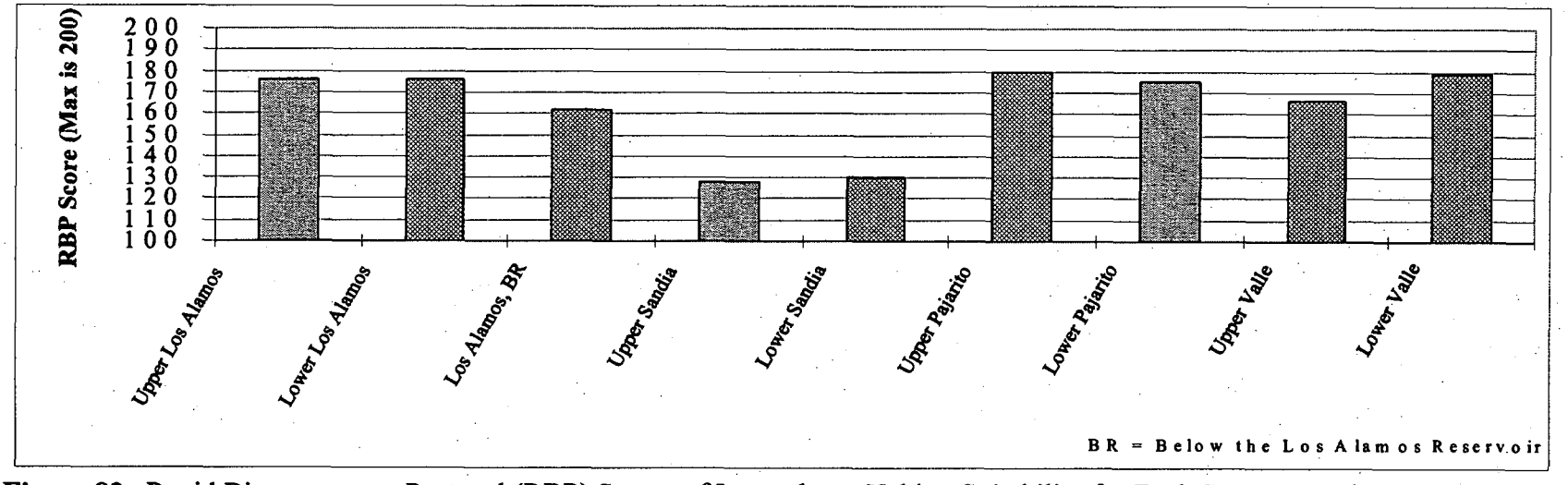


Figure 83. Rapid Bioassessment Protocol (RBP) Scores of Invertebrate Habitat Suitability for Each Stream Reach in 1997.

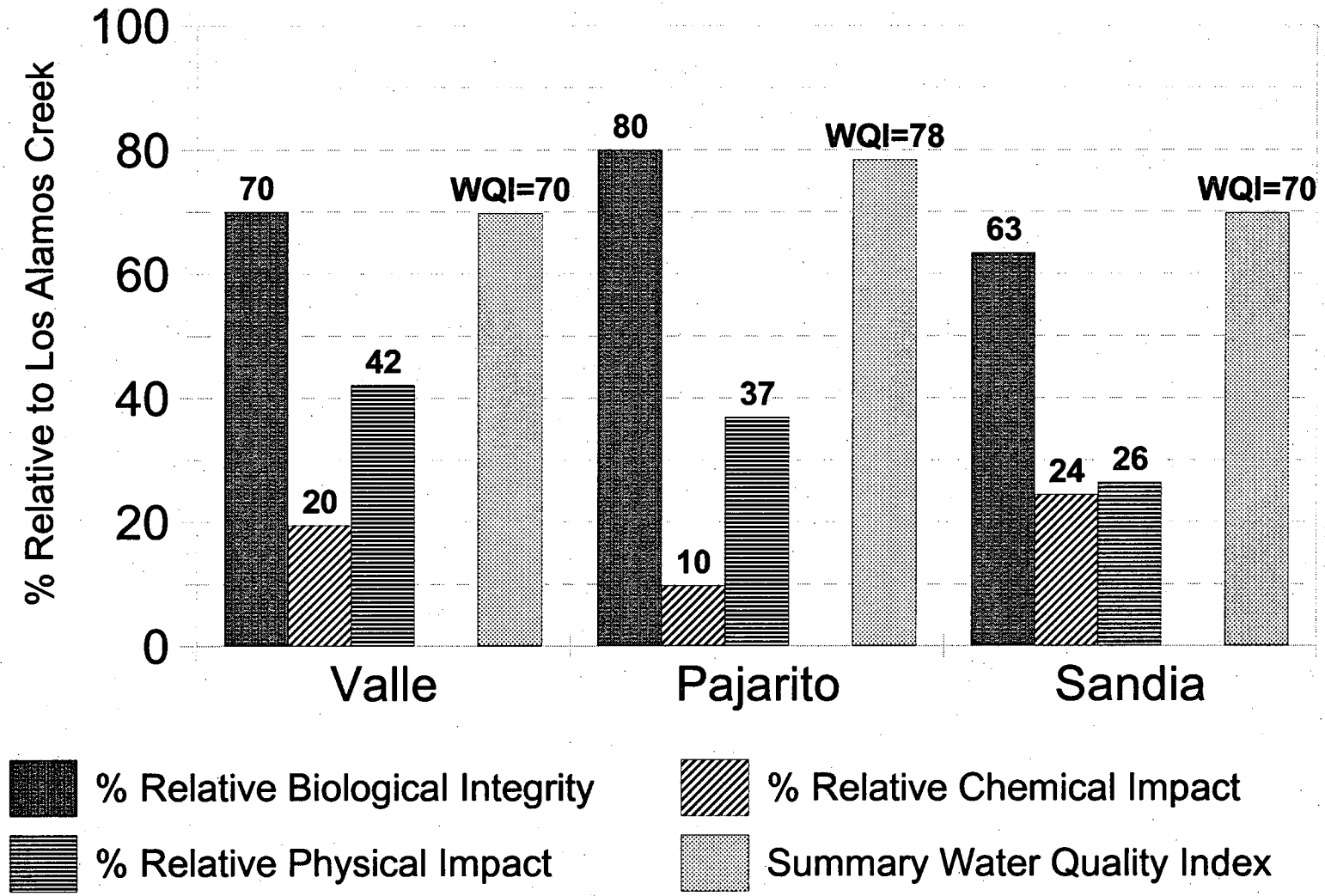


Figure 84. Relative Biological Integrity, the Percent Chemical and Physical Impact, and the Water Quality Index (WQI) for Valle, Pajarito, and Sandia Canyon Stream Segments Compared to Los Alamos Canyon Stream Segment as a Reference Site.