9 Habitat Survey

by

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BACKGROUND AND INTRODUCTION

Aquatic habitat in the Salt River valley downstream of Smoot (Study Area Chapter, Figure 9-1) has been drastically altered since European settlement. Historical records indicate that before settlement, the valley was covered with grass and the stream lined with willows. Groves of cottonwoods were probably scattered on the valley floor and buffalo and beaver were abundant. Beaver ponds were probably common throughout the valley, particularly on the low gradient spring streams.

The first major impact to aquatic habitat probably resulted from the removal of large numbers of beaver from the watershed during the booming fur trade of the 1830s. Thousands of emigrants moved through the valley on the Lander cutoff of the Oregon and Mormon trails during the latter half of the 1800s. The flood of emigrants took their toll on game populations and bison were extirpated from the valley.

European settlement of the valley began about 1880 and the first irrigation canals were constructed prior to 1890. Agricultural practices have heavily impacted aquatic habitat in the valley ever since. The development of additional irrigation canals allowed agriculture to become the primary source of income. Natural stream flow patterns have been altered due to irrigation practices (Sando et al. 1985). Grazing has degraded stream banks and riparian areas and stands of willows have been removed from large sections of the river. Miller (1971) used two sets of aerial photos to estimate willow coverage along the Salt River in 1939 and 1964 and compared those estimates to an estimate based on a 1970 field survey. He documented an overall decrease in willow coverage along the Salt River. The flood plain between Smoot and Palisades Reservoir is now completely covered by crop fields and grazing pastures.

Since 1972, habitat management on the Salt River has focused on stream bank stabilization. Although some riparian areas have been fenced and a few willows planted, log and rock revetments have been the primary tools used to try to improve habitat and stabilize banks on the river. At least 8 miles of log and rock revetments have been installed, primarily on the outside bends of meanders, since 1972 (Erickson 1985, 1986). Although many of the revetments remain intact in the low gradient stretches of river between Afton and Highway 238 and below Etna Lane, most of those in the higher gradient stretch between the northern Highway 89 Bridge (south of Thayne) and Freedom Lane have been destroyed by high flow events or the treated channels have been abandoned (Figure 9-1). The river continues to cut new channels and abandon old in the highest gradient reach of the mainstem between the northern Highway 89 Bridge and Etna Lane.

Aquatic habitat is of primary concern to fisheries managers charged with managing the Salt River. One of the primary objectives of the original Jackson Regional Fisheries Management (FMJN) crew's 1994 proposal was to describe the distribution and quality of physical habitat features important to fish and to map habitat to facilitate documentation of future trends. A detailed survey protocol was utilized to describe the current habitat conditions in the four six mile study sections of the Salt River and a willow survey was also conducted in May 2000 to produce data that would be directly comparable to the willow survey of 1970 by Miller (Miller 1971).

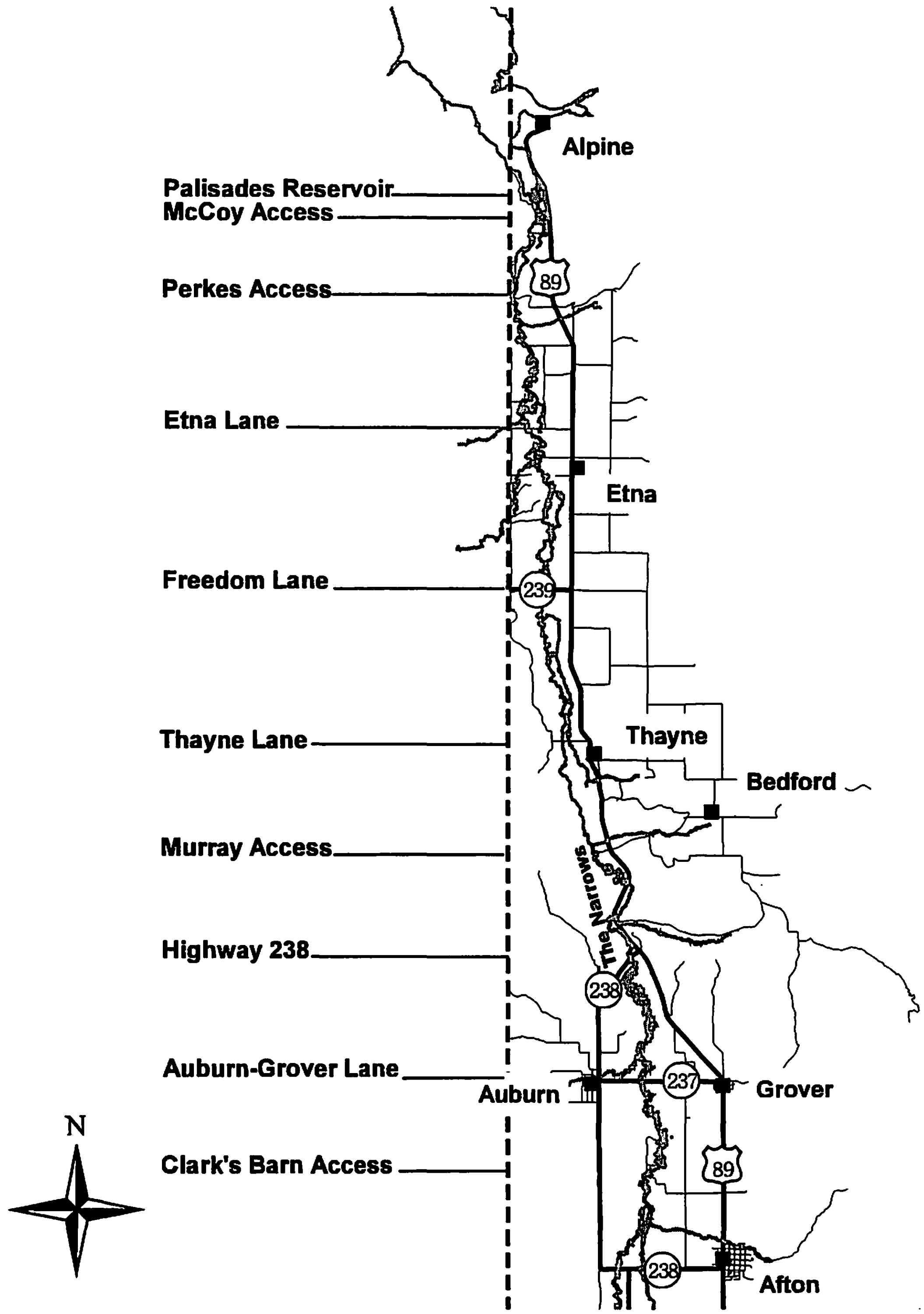


Figure 9-1. Mainstem Salt River from Afton, Wyoming to Palisades Reservoir. Locations noted on the left coincide with locations on Figure 9-2.

The habitat surveys were conducted so that data could be summarized for discrete reaches of river within the study sections and to facilitate comparisons of salmonid densities and species composition to available habitat within discrete stream reaches. Habitat conditions within each study reach will be compared and contrasted in this chapter and trends in willow abundance will be described.

Relationships between habitat and salmonid abundance will be presented in a future administrative report or peer reviewed manuscript.

STUDY AREA

The Salt River drainage lies in western Wyoming and eastern Idaho and is bordered by the Salt River Range to the east, the Gannett Hills to the south and the Caribou and Webster Ranges to the west. The watershed drains 830 mi^2, with elevations ranging from the 10,907 ft summit of Mt. Fitzpatrick in the Salt River Range to 5,620 ft Palisades Reservoir (Gipson et al. 2000). Major perennial tributaries include Strawberry, Willow, Swift, Dry and Cottonwood Creeks flowing from the Salt River Range, Crow and Stump Creeks Flowing from the Webster Range and Jackknife and Tincup Creeks flowing from the Caribou Range. Numerous spring creeks are also present on the valley floor. Although these creeks probably existed naturally, flows have been enhanced in the past century by irrigation returns (Isaak 2001). The mainstem Salt River is a fifth-order stream that arises from the southern Salt River Range and flows approximately 72 miles to its mouth at Palisades Reservoir. Along most of its course, the Salt River flows through the 35-mi long by 4-mi wide Star Valley. The mountain ranges to the east and west constrict the valley at The Narrows, separating it into an Upper and a Lower Valley.

In this study, we concentrated on the lower 48 mi of river, beginning west of Afton, WY, extending downstream to Palisades Reservoir (Figure 9-1). This 48-mi reach has a relatively low gradient throughout its course, dropping from 6,040 feet at the Clark's Barn Access Area to 5,620 feet at Palisades Reservoir. The gradient is lowest in the upper valley, with an average slope of 0.06% between the Clark's Barn Access area and Highway 238 (Figure 9-2). Riparian vegetation in this reach is composed primarily of willows, sedges and grasses. Depending on land use practices, it can range from dense willow coverage to homogenous grass stubble where heavy grazing has virtually eliminated all riparian vegetation.

Just downstream of the Highway 238 Bridge, gradient increases as the river enters The Narrows. The average slope is about 0.22% between Highway 238 and Etna Lane. The river is braided in this reach with numerous secondary channels, sloughs and oxbow lakes. Riparian vegetation in and just downstream of The Narrows is still dominated by willows, but Douglas fir, cottonwood and aspen are also present along the river. As the river emerges into the lower valley, trees become less abundant near the river and riparian vegetation is again composed of willows, sedges and grasses. Short reaches of highly braided channels are common between the Murray Access Area and Etna Lane (Figure 9-2).

Between Etna Lane and the Perkes Access Area, slope decreases to 0.10% and the river meanders extensively. The river becomes wider and shallower in the middle of this reach with very little willow coverage and extensive eroding banks. In the vicinity of the Perkes Access Area, slope increases and willow coverage becomes extensive. The slope averages 0.24% in the lower reach between the Perkes Access Area and Palisades Reservoir (Figure 9-2).

The majority of the Salt River flows through private land. The longest length of river flowing through public lands is in the uppermost 14 mi of river on the Bridger-Teton National forest. The river then enters the upper Star Valley and flows approximately 11 miles across private land to the Fairview

Canal (near Smoot, WY), where it is completely dewatered seasonally. The Salt River between Afton and Palisades Reservoir flows across 44.8 mi of private land, 1.5 mi of Bureau of Land Management land, 1.5 mi of state land and 0.2 mi of land owned by the WGFD (Gipson et al. 2000). Of the 44.8 privately owned river mi, 24.2 mi are permanent fishing easements administered by the Wyoming Game and Fish Department. The river from Afton to Palisades is floatable in canoes, small rafts, rowboats and drift boats. Although trespass on private lands above the high water line is illegal, floaters may transport their crafts over or around obstructions.

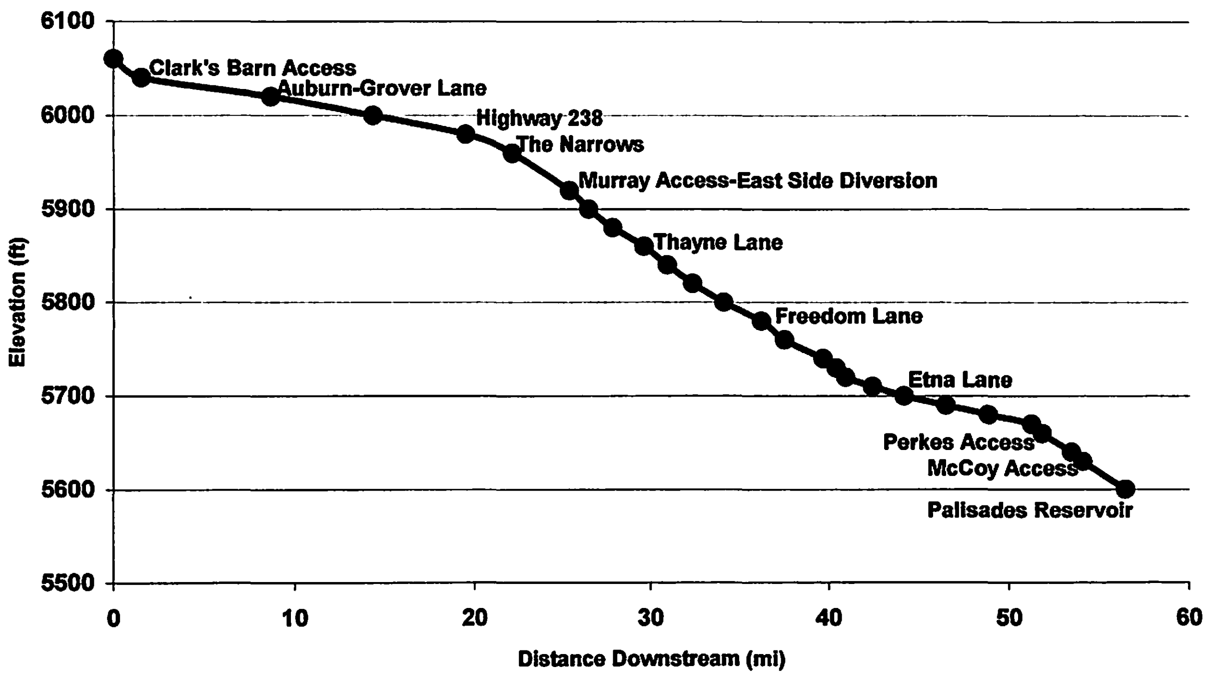


Figure 9-2. Gradient profile of the mainstem Salt River from Afton, Wyoming to Palisades Reservoir. Annotated locations coincide with those on Figure 9-1.

Across 47 years of record (1954-2000), the average annual discharge of the Salt River was 790 cfs at the Etna gauge (USGS gauge number 13027500). Average annual discharges ranged from a minimum of 362 cfs in 1977 to a maximum of 1,311 cfs in 1986. The first exceptionally high average annual discharge occurred in 1971 and similarly high averages have occurred in 1983, 1984, 1986 and 1997. Over the same period of record, the highest annual instantaneous peak discharge of the Salt River was 5,090 cfs, occurring on June 2, 1986. The lowest annual instantaneous peak discharge was 691 cfs, occurring on April 18, 1991. Annual peak discharges over the 47-yr period generally occurred between May and June.

Four study sites were carefully selected between Afton and Palisades Reservoir to represent the diversity of habitats present (Figure 9-3). From downstream to upstream the study sites were;

A. Etna Lane; Etna Lane Bridge to 6 mi downstream (6.0 mi total)
B. Thayne Lane; Thayne Lane Bridge to Freedom Lane Bridge (5.75 mi total)
C. Highway 238; from a point 0.67 mi downstream of the Highway 238 Bridge to a point 1.5 mi downstream of the Lower East Side Diversion Dam at the Murray Access Area (6.0 mi total)
D. Auburn-Grover Lane; Auburn-Grover Lane Bridge to 6 mi downstream (6.0 mi total)

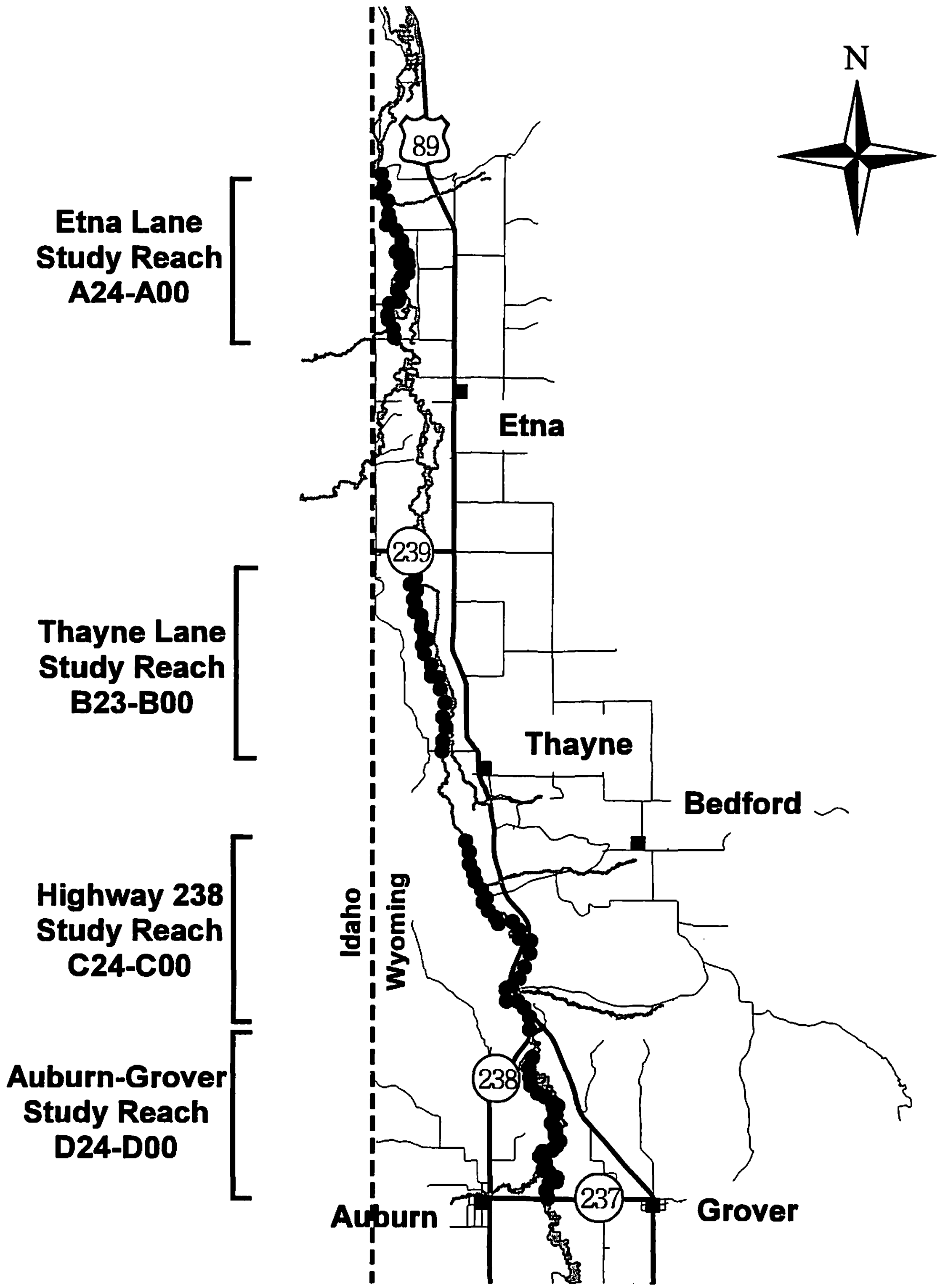


Figure 9-3. The mainstem Salt River and locations of the four 6-mi reaches sampled in this study.

Each of the study sites was walked with a tag line and staked and flagged at 0.25 mi intervals. At each 0.25 mi transect, photographs and GPS coordinates were taken for future reference. The 0.25 mi transects were labeled 24 to 0 (upstream to downstream) with a prefix corresponding to the study site; D24-D00 Auburn-Grover Lane, C24-C00 Highway 238, B23-B00 Thayne Lane, A24-A00 Etna Lane. All aquatic habitats within each of the reaches were surveyed. See the Study Area chapter of this report for a more detailed description of the valley, further descriptions of study reaches and UTM coordinates of each transect.

METHODS

Habitat Survey

The Oregon Department of Fish and Wildlife's Methods for Stream Habitat Surveys (Moore et al. 1998) was used to characterize aquatic habitat in the four 5.75-6.0 mi study reaches in mid to late September 1998 and 1999. This methodology was chosen because it was designed to provide quantitative information on habitat condition of streams for biologists and land managers to use to establish monitoring programs and to direct or focus habitat restoration efforts. This methodology was designed to be compatible with other stream habitat inventory and classification systems (i.e., Rosgen 1985, Frissell et al. 1986, Cupp 1989, Ralph 1989, USFS Region 6 Level II Inventory 1992, and Hawkins et al. 1993). The information is collected and analyzed based on a hierarchical system of regions, basins, streams, reaches, and habitat units. Since this survey was restricted to four segments of the mainstem Salt River, it was restricted to reach and habitat unit data.

Two field crews were comprised of two members each; an "Estimator" and a "Numerator". One crew conducted the survey in the low gradient study sections (Auburn-Grover Lane and Etna Lane) and the other conducted the survey in the higher gradient sections (Highway 238 and Thayne Lane). Each section of stream was broken into 0.25 mi reaches working in a downstream direction. The technique requires that new reaches be started at any significant change in valley type, channel form, adjacent landform, valley width index, vegetation or land use. Due to the homogeneity of variables within study sections, additional reach breaks were added only at tributary confluences. Each reach was then comprised of a variable number of consecutively numbered habitat units.

The Estimator completed a reach survey at the beginning of each new reach (every 0.25 mi or at a tributary confluence). The reach survey includes the following variables:

1. **Date.**
2. **Reach Number.**
3. **Habitat Unit Number.** The first habitat unit number within the reach.
4. **Channel Form.**
   - Constrained by bedrock
   - Constrained by hill slope
   - Constrained by alluvial fan
   - Unconstrained predominantly single channel
   - Unconstrained anastomosing (several complex, interconnecting channels)
   - Unconstrained braided
   - Constrained by terraces
   - Constrained by alternating terraces and hill slope
   - Constrained by land use

5. **Valley Form.**
   - Steep V-shaped valley or bedrock gorge
   - Moderate V-shaped valley
   - Open V-shaped valley
   - Constrained terraces
   - Multiple terraces
   - Wide-active flood plain
6. **Valley Width Index.** Ratio of the width of the active stream channel (bankfull channel) to the width of the valley floor. Synonymous with "entrenchment" based on Rosgen (1985).
7. **Streamside Vegetation.** Composition and size class of dominant and subdominant vegetation types in the riparian zone.
8. **Land Use.** Description of dominant and subdominant land use beyond the riparian zone.
9. **Water Temperature.**
10. **Stream Flow.** Gross description of the discharge condition at the time of the survey.

Dry	Puddled	Low Flow	Medium Flow
High Flow	Bankfull Flow	Flood Flow	

11. **Location.** Legal description of the location of the reach break and GPS coordinates.
12. **Photo.** Photograph showing the stream and riparian zone at each reach change.
13. **Reach Note.** Additional comments pertaining to habitat conditions within the reach.
14. **Sketch.** A sketch of the valley cross section.

While the Estimator conducted the reach survey, the Numerator conducted a riparian inventory at the reach break. The riparian inventory is designed to provide additional quantitative information on the species composition, abundance, and size distribution of riparian zone vegetation. Riparian inventory transects began at the margin of the active channel and extended into the riparian zone for 30 m perpendicular to the main axis of the stream. A 30 m transect was established on both banks at each reach break. Each 30 m transect was then broken into three 10 m long bands that were 5 m wide. Within each of the six 10 m bands, the numerator recorded the following information;

1. **Habitat Unit Number.** The first habitat unit number within the reach.
2. **Side.** Left or right side of the channel looking upstream.
3. **Zone.** Subdivision 1-3 of the 10 m transect.
4. **Surface.**

Floodplain	Low terrace	High terrace
Hill slope	Secondary channel	Tributary channel
Isolated pool	Wetland	Road bed
Railroad grade	Riprap	

5. **Slope.** Estimate of the percent slope of the stream bank surface using a clinometer.
6. **Percent Canopy Closure.**
7. **Percent Shrub Cover.**
8. **Percent Grass and Forb Cover.**
9. **Tree Group.** Conifer or hardwood.
10. **Count.** A tally of trees by diameter class.
11. **Riparian Notes.**

After completing the reach survey and riparian inventory, the two crew members began moving downstream characterizing the sequence of habitat units and estimating a number of variables respective to each unit. The Estimator recorded the following information for each individual habitat unit;

1. **Reach Number.** Used to link the habitat unit data to the reach data.
2. **Habitat Unit Number.** The first habitat unit number within the reach.

3. **Unit Type.**

Plunge pool	Straight scour pool	Lateral scour pool
Trench pool	Dammed pool	Beaver dam pool
Alcove	Backwater pool	Isolated pool
Glide	Glide with pockets	Riffle
Riffle with pockets	Rapid	Run
Step (6 types)	Special case units (4 types)	

4. **Channel Type.** A code used to order the sequence of multiple channels based on size and location.
5. **Percent Flow.** The relative amount of the total stream flow in the channel containing the unit.
6. **Unit Length.**
7. **Unit Width.**
8. **Unit Slope.** Estimate of the percent slope of the water surface using a clinometer.
9. **Channel Shade.** Measured perpendicular to the channel with the clinometer as the degrees above horizontal to the top of riparian vegetation or landforms.
10. **Active Channel Height.** Same as bankfull depth (Rosgen 1985).
11. **Active Channel Width.** Same as bankfull width (Rosgen 1985).
12. **Flood prone Height.**
13. **Flood prone Width.**
14. **Terrace Height.**
15. **Inter-Terrace Width.**
16. **Valley Width Index.** Ratio of the width of the active stream channel (bankfull channel) to the width of the valley floor. Synonymous with "entrenchment" based on Rosgen (1985).
17. **Notes.**

A few minor modifications were made to Moore et al. (1998) to adapt the methodology to the Salt River. Two channel types were added; run and glide with pockets. Runs are difficult areas to describe. They were generally characterized by swift flow, some surface turbulence and low habitat complexity. Runs were added to describe habitat that was intermediate between a glide and a rapid. Glides with pockets were added to characterize glide habitat as defined by Moore et al. (1998) that had sub-unit sized pools comprising at least 20% or more of the total unit area. A split channel type was also added to describe habitat units that were classified parallel to each other (i.e., half of the channel sometimes consisted of a run, while the other half was best classified as a riffle). Split channel types were only used if the survey members felt that it would be inappropriate to classify the entire cross section as a single, dominant habitat type.

The Estimator described the bounds of each habitat unit to the Numerator and reiterated the habitat unit number and unit type. The Numerator then collected the following additional information for each habitat unit;

1. **Habitat Unit Number.** To reference the Numerator's data to the Estimator's.
2. **Unit Type.** Corresponds to the sample type on the Estimator data sheet.
3. **Depth.**
4. **Depth a Pool Tail Crest.**
5. **Substrate.** Percent distribution by streambed area of six substrate size classes.

Silt and fine organic matter	Sand	Gravel
Cobble	Boulders	Bedrock

6. **Boulder Count.** Tally of boulders that protrude from the water surface.
7. **Percent Actively Eroding Bank.**
8. **Percent Undercut Bank.**
9. **Comments.** Bridge crossings, culvert crossings, channelized streambanks, debris jams, fence crossings, artificial habitat structures, potential barriers, and tributary junctions, etc.

10. **Other Notes.**

The Numerator also obtained a quantitative estimate of wood volume and distribution within the stream reach. All wood pieces of at least 15 cm diameter and 3 m length were tallied throughout the stream. The Estimator collected the following information pertaining to large woody debris;

1. **Habitat Unit Number.** To reference the wood data to the other survey data.
2. **Unit Type.** Corresponds to the sample type on the Estimator and Numerator data sheets.
3. **Debris Configuration.**
   Single Piece — Accumulation (2-4 pieces) — Jam (>4 pieces)
4. **Debris Type.**
   Natural — Cut end — Artificial
   Natural root wad — Root wad with cut end
5. **Debris Location.**
   Side of channel — Mid-channel — Island
   Full channel — Over channel
6. **Diameter Class.** Estimate of the diameter of each piece of large wood.
7. **Length Classes.** Tally of number of pieces within each of a number of length classes.
8. **Notes.**

The survey continued in a downstream direction with habitat units consecutively numbered within each study section. Each study section contained approximately 24 reaches and a variable number of habitat units. All data were entered into a DBase database and reports were used to summarize the data for each of the four study sections. Profiles were constructed to represent the distribution of habitat variables along the length of each study section.

Willow Survey

Miller (1971) used the two sets of aerial photos to determine the percent of willow cover on 17 one-half mile sections of the riverbank upstream from bridges and fishing access areas. The 17 sections were distributed from the McCoy Access Area above Palisades upstream to the Taylor easement below the Clark's Barn Access Area (Study Area Chapter, Figure 9-3). Percent willow cover on stream banks was estimated from aerial photos taken in 1939 and 1964. The percent willow cover on stream banks was determined by dividing the portion of the stream bank covered by willows by the total distance (0.5 mi). Miller calculated his June 19, 1970 estimates of willow cover by visiting the 17 sites and actually pacing the riverbank to estimate the percent willow coverage.

The field survey was repeated at the 17 sites in May 2000. Approximate UTM coordinates of the starting points and ending points for each site surveyed are listed in Table 9-1 to facilitate trend monitoring. If we could not determine which bank had been surveyed in previous years, both banks were surveyed and an average used. The 2000 estimates of willow coverage were compared to past estimates to determine if the loss of willows identified by Miller (1971) was continuing.

Table 9-1. UTM coordinates of the starting and ending points of the Salt River willow survey conducted in May 2000. Coordinates are listed as NAD 27 and Zone 12.

Easement Name	Direction Surveyed	Bank(s) Surveyed	Starting Point Meters E	Starting Point Meters N	Ending Point Meters E	Ending Point Meters N
Taylor	Downstream	West	502279	4733725	502482	4733887
West Burton	Upstream	West	502513	4733963	502943	4734333
South Burton	Upstream	West	502780	4734866	507720	4735098
Above AG Lane	Upstream	East & West	502254	4737282	502115	4737716
Narrows	Upstream	West	501751	4742600	501605	4742969
Hale	Upstream	East & West	500722	4744383	500929	4744607
Wakeman	Upstream	East & West	501543	4745620	501570	4746130
Murray	Upstream	East	500323	4747001	500174	4747380
Thayne	Upstream	East & West	498742	4751525	498632	4752213
Freedom	Upstream	East & West	497835	4758181	497520	4758662
Etna	Downstream	East & West	496880	4766064	497063	4765603
Miller 1[a]	Downstream	West	496995	4767445	497058	4767185
Miller 2[a]	Upstream	West	496828	4766150	496839	4766666
Wolfley	Upstream	East	497402	4768023	497537	4768274
Bateman	Upstream	East	497204	4768537	497203	4769023
LVPL Dam	Upstream	East	496842	4770034	496774	4770401
LVPL Plant	Upstream	East	497239	4773288	497267	4773849
McCoy	Upstream	East	497395	4774279	497513	4774701

[a]The exact location of the 1970 survey site at the Miller easement could not be determined. Two sites were surveyed in 2000 and an average willow coverage was used for comparisons to past estimates.

RESULTS

Habitat Survey

The habitat surveys delineated each of the four study sections into approximately 24 reaches. All reaches, including those within The Narrows, were bounded by a wide, active flood plain on a broad valley floor. The lowest valley width indexes (VWI) were in the Highway 238 study section (Table 2). The minimum VWI in this reach was 4.8 and the average was 19.5. The average VWI was identical in the Thayne Lane section. The VWIs in the Auburn-Grover Lane and Etna Lane sections were too high to be measured with a range finder, but always exceeded 20.

Channel morphology was unconstrained at all study sites. The cross sectional profile was single channel at all reaches at the low gradient study sites (Auburn-Grover Lane and Etna Lane). Channel structure was influenced by multiple or braided channels at 21% of the Highway 238 reaches and 42% of the Thayne Lane reaches. The river has downcut an average of 3.5-5.5 ft into the valley floor depending on the study section and does not appear to have abandoned its flood plain in any of the sections.

Habitat surveys were conducted from mid-late September in 1998 and 1999 at which time stream flows were generally moderate and water temperatures ranged from 46-58 F. Riparian vegetation at reaches within the Auburn-Grover and Etna Lane sections was composed primarily of grasses, herbs and forbs. The riparian vegetation at the Highway 238 and Thayne Lane sections was dominated by dense stands of willow, although grasses were more abundant in some reaches within the Thayne Lane section. The land beyond the riparian zone at the Auburn-Grover, Thayne Lane and Etna Lane sections was planted with agricultural crops or grazed by dairy cattle. Most of the land adjacent to the Highway 238 section was composed of dense stands of mature timber and agricultural use was very limited.

Table 9-2. Average values for habitat variables in four study sections of the Salt River in 1998 and 1999.

Variable	A-G Lane	Highway 238	Thayne Lane	Etna Lane
Habitat Units	310	337	644	143
Min. Valley Width Index	>20	4.8	8.0	>20
Total Area (acres)	84	69	71	87
% Area in 1^0 channel	80	80	68	91
Area of 1^0 channels (acres)[1]	67	55	48	79
Area of 2^0 channels (acres)[1]	17	14	23	8
Length of 1^0 channel (mi)[2]	6.44	6.25	6.36	6.06
Length of 2^0 channel (mi)[3]	2.49	3.07	5.89	1.63
Avg wetted width 1^0 (ft)[4]	83.7	72.2	62.2	107.4
Avg wetted width 2^0 (ft)[4]	56.2	36.8	33.2	4.5
Average depth of 1^0 channel (ft)	5.3	3.3	3.9	4.7
Average depth of 2^0 channel (ft)	3.2	2.1	1.9	2.0
Avg % eroding bank $1^0/2^0$ channels	30/30	4/3	17/13	12/6
Avg % eroding bank $1^0/2^0$ backwaters	2/0	1/0	7/8	7/0
Avg % undercut bank $1^0/2^0$ channels	9/7	6/12	14/7	3/1
Avg % undercut bank $1^0/2^0$ backwaters	3/2	4/0	11/8	<1/0
Avg % shade	5	29	16	7
Pieces of large wood	258	426	299	485

[1] Area is the sum of the surface area of all channel types in the primary (1^0) or secondary (2^0) channels. [2] Length is the sum of 00 and 01 channel types. [3] Backwaters and split channels (channel type 21) are excluded from estimate of total length. [4] Average wetted width was calculated as area/length.

The appropriate variables were calculated to determine the Rosgen stream type for each of the study sections (Table 3). The river is best described as a Rosgen C4 stream type; slightly entrenched, meandering, gravel-dominated, riffle/pool channel with a well-developed flood plain. Portions of the Thayne Lane study section are best classified as DA4 or D4; similar to the C4 channel, but with multiple, highly interconnected channel systems (Rosgen 1996).

Table 9-3. Variables calculated to determine Rosgen stream type.

Variable	Study Section AG Lane	Highway 238	Thayne Lane	Etna Lane
Dominant Channel Configuration	Single	Single	Multiple	Single
Valley Width Index (Entrenchment)	25.0	11.5	11.5	25.2
Width/Depth Ratio	25.0 (90 ft/3.6 ft)	19.5 (107 ft/5.5 ft)	27.5 (132 ft/4.8 ft)	22.7 (111 ft/4.9 ft)
Sinuosity[1]	2.25	1.69	1.69	2.06
Slope[2]	0.0006	0.0022	0.0021	0.0010
Rosgen Stream Type	C4	C4	D4/C4	C4

[1] Sinuosity was calculated as stream length divided by straight-line valley length using a USGS topographic map. [2] Slope was also calculated for each reach using a USGS topographic map.

Aquatic habitat complexity was estimated as the number of habitat units per 100 yds of stream. Complexity was highest at the Thayne Lane section (6.4 units/100 yds), followed by Highway 238 (3.2 units/100 yds), Auburn-Grover Lane (2.9 units/100 yds) and Etna Lane (1.4 units/100 yds).

Eroding banks within the primary channel ranged from 4% in the Highway 238 section to 30% in the Auburn-Grover Lane section. The Thayne Lane and Etna Lane sections were intermediate with 12% and 17% of the primary channel banks eroding, respectively. Large wood was most abundant in the Etna Lane study section; however, nearly all of the large wood within the Etna Lane and Auburn-Grover Lane sections was revetments. The large wood at the Highway 238 and Thayne Lane sections was usually conifers recruited from the surrounding hill slopes of The Narrows.

Instream habitat was in poorest condition within the Etna Lane section. Habitat complexity was low and glides and runs dominated primary channel habitat. Nine habitat types were identified in the primary channel (Table 9-4) and 7 were identified in secondary channels (Table 9-5). Only 3% of the primary channel area was comprised of riffles and 15% was pools. Approximately 30% of the primary channel substrate was silt and organic matter or sand and 66% was gravel or cobble (Table 9-6).

Table 9-4. Abundance of different habitat types within the primary channel in four study sections of the Salt River in 1998-1999.

	Primary Only							
	Auburn-Grover		**Highway 238**		**Thayne Lane**		**Etna Lane**	
Habitat Type	**# Units**	**% Area**	**# Units**	**% Area**	**# Units**	**% Area**	**# Units**	**% Area**
Pools	105	52	60	24	88	36	28	15
Lateral scour	(98)	(50)	(46)	(18)	(61)	(28)	(22)	(13)
Straight scour	(7)	(2)	(10)	(4)	(27)	(8)	(6)	(2)
Plunge			(2)	(<1)				
Dammed			(2)	(2)				
Subunit pools	40	11	35	4	71	5	20	6
Backwater	39	(11)	(33)	(3)	(64)	(5)	(20)	(6)
Isolated	1	(<1)	(2)	(<1)	(7)	(<1)		
Alcove			(1)	(<1)				
Glide	7	10	3	1	2	<1	15	33
Glide w/pockets	5	5	4	4			10	13
Run	31	12	71	40	79	43	21	28
Riffle	26	11	29	13	33	12	6	3
Riffle w/pockets			13	10				
Rapid			10	3	13	3	4	1
Step over cobble			1	<1				
Step over structure			2	<1	1	<1	1	<1
Total Units	**214**		**229**		**287**		**105**	

Habitat was also relatively poor within the Auburn-Grover Lane section. Although complexity was nearly twice Etna Lane, only 8 habitat types were identified in the primary channel (Table 9-4) and 6 in secondary channels (Table 9-5). Primary channel habitat was dominated by lateral scour pools interspersed with glides, runs and riffles (Table 9-4). Substrate was similar to the other low gradient section (Etna Lane); 28% silt and organic matter or sand and 71% gravel or cobble (Table 9-6).

Table 9-5. Abundance of different habitat types within the secondary channels in four study sections of the Salt River in 1998-1999.

	Secondary Only							
	Auburn-Grover		Highway 238		Thayne Lane		Etna Lane	
Habitat Type	**# Units**	**% Area**	**# Units**	**% Area**	**# Units**	**% Area**	**# Units**	**% Area**
Pools	46	45	47	19	103	23	9	11
Lateral scour	(45)	(45)	(2)	(2)	(77)	(19)	(9)	(11)
Straight scour	(1)	(<1)	(10)	(3)	(22)	(3)		
Plunge			(14)	(4)				
Dammed			(12)	(6)	(1)	(<1)		
Beaver dam			(9)	(4)	(3)	(1)		
Subunit pools	14	8	27	68	36	4	1	1
Backwater	(14)	(8)	(3)	(1)	(32)	(4)	(1)	(1)
Isolated			(23)	(25)	(4)	(<1)		
Alcove			(1)	(41)				
Glide	9	22	3	<1	56	24	8	40
Glide w/pockets			1	1			3	16
Run	9	12	4	4	40	12		
Riffle	18	13	15	5	96	23	12	15
Riffle w/pockets			5	3	6	1	2	3
Rapid			1	<1	4	<1		
Step over cobble			1	<1	1	<1		
Step over structure			1	<1	2	<1		
Step over beaver dam					6	<1		
Dry unit					3	<1	3	14
Dry channel					2	12		
Culvert crossing			3	<1	2	<1		
Total Units/Area	**96**	**17**	**108**	**14**	**357**	**23**	**38**	**8**

Habitat in the Highway 238 and Thayne Lane sections was in much better condition. Habitat complexity was extremely high at the Thayne Lane section (6.4 units/100 yds), due largely to secondary channels. Nine habitat types were identified in the primary channel (Table9- 4) and 17 were identified in secondary channels (Table 9-5). Nearly 25% of the habitat area occurred in secondary channels and more than half of the total number of habitat units were in secondary channels. More than 100 riffles were identified in secondary channels of the Thayne section, comprising nearly 25% of the area of secondary channels (Table 5). Complexity at Highway 238 (3.2 units/100 yds) was similar to the Auburn-Grover Lane section (2.9 units/100 yds), but consisted of a higher diversity of habitat types. Fifteen habitat types were identified in the primary channel of the Highway 238 section (Table 9-4) and 17 were identified in

Table 9-6. Substrate composition of different habitat types within the primary channels in four study sections of the Salt River in 1998-1999. S/0 = silt and organic matter, Grvl = gravel, Cobl = cobble, Bldr = boulders.

	Primary Only																			
	Auburn-Grover					**Highway 238**					**Thayne Lane**					**Etna Lane**				
Habitat Type	**S/O**	**Sand**	**Grvl**	**Cobl**	**Bldr**	**S/O**	**Sand**	**Grvl**	**Cobl**	**Bldr**	**S/O**	**Sand**	**Grvl**	**Cobl**	**Bldr**	**S/O**	**Sand**	**Grvl**	**Cobl**	**Bldr**
Pools	15	3	55	24	2	6	14	53	24	3	8	1	49	41	1	8	25	46	15	5
Lateral scour	16	3	55	24	2	6	11	55	25	4	7	1	51	40	1	8	27	45	15	5
Straight scour	8	4	50	33	5	2	15	58	22	1	9	1	42	47		8	12	56	21	4
Plunge						3	41	20	27	9										
Dammed						19	38	25	15	2										
Subunit Pools	91	4	2	<1	<1	52	19	19	8	1	65	2	20	13	<1	34	47	9	4	6
Backwater	92	5	3	<1	<1	46	20	22	9	1	65	2	20	13	<1	34	47	9	4	6
Isolated	100					90	9	1			94		4	2						
Alcove						90	10													
Glide	41	14	44	1		7	22	60	9	3			38	62		11	21	40	28	<1
Glide w/pockets	10	10	75	5		11	33	52	3	1						7	26	45	19	3
Run	5	4	73	18		1	8	49	37	5	5	<1	44	50	<1	5	13	37	38	7
Riffle	2	3	80	14		1	6	60	30	2	8	1	47	44		1	7	41	47	3
Riffle w/pockets						3	12	52	29	5										
Rapid						1	3	25	43	28	5	<1	33	61		1	5	32	41	22
Step over cobble						5		10	15	70										
Step over structure									40	60			25	55	20	14	14	38	29	5
Average for all Units	**23**	**5**	**54**	**17**	**1**	**5**	**11**	**50**	**29**	**4**	**10**	**1**	**44**	**45**	**<1**	**9**	**21**	**39**	**27**	**4**

secondary channels (Table 5). Silt and organic matter and sand were much less common in these two sections comprising only 16% and 11% of the substrate at Highway 238 and Thayne Lane, respectively. Gravel and cobble were more abundant, constituting 79% of the substrate at in the Highway 238 section and 89% in the Thayne Lane section (Table 6).

Secondary channels are most common in the Thayne Lane section where there are 5.89 mi of secondary channels constituting 23% of the channel area (Table 2). Total area of secondary channels is similar between the Highway 238 and Thayne Lane study sections and lowest in the Etna section. Secondary channels are rare within the Etna Lane section. Secondary channels are narrowest at the Highway 238 and Thayne Lane sections and widest at the Auburn-Grover section (Table 2).

Secondary channels within the Auburn-Grover Lane section are similar to those of the primary channel. Due to the high sinuosity in this section (Table 3), both are dominated by lateral scour pools. The remaining habitat in primary and secondary channels is composed of subunit pools, glides, runs and riffles although glides are more abundant than in the primary channel (Tables 4 and 5). Substrate composition of the secondary channel habitat types is also similar to the primary channel, although pools within secondary channels tend to contain more silt and organic matter (Tables 6 and 7).

Secondary channels within the Highway 238 section are dominated by subunit pools (Table 5). The pools were formed when the river cut off meanders forming isolated pools and alcoves in abandoned oxbows. Sediment in these areas is composed primarily of silt and organic matter (Table 7) deposited during flood flows. Secondary channels within the Etna Lane section are dominated by glides (Table 5). More than half of the substrate in the low gradient glide habitats is composed of silt and organic/matter (Table 7).

The most diverse habitat in the entire river is found within the secondary channels of the Thayne Lane section. Although only 32% of the total area of this section is within secondary channels (Table 2), they have more than half of the habitat units (Tables 4 and 5). Secondary channel habitat is composed primarily of pools, glides and riffles, reflecting the braiding of this section. Large channel cut offs are rare, resulting in few isolated pools and alcoves. Most subunit pools are backwaters within small flowing channels.

Longitudinal profiles of habitat attributes can be used to visually compare the distribution and abundance of habitat attributes through each section. Examples of these profiles are presented in Appendices A-E.

Undercut banks were generally attributable to overhanging willows and represent areas with good hiding cover for fish. The distribution of undercut banks is shown in Appendix A. Undercut banks are most abundant in the Thayne Lane Section, followed by the Highway 238 and Auburn-Grover sections. Undercut banks are almost completely lacking in the Etna Lane section.

Percent shade is also representative of the quantity of woody vegetation in the riparian zone. If tall riparian vegetation was lacking, shade measurements reflect the mountains to the east and west of the river. The mountains resulted in minimum shade values of about 5% in the Etna Lane, Thayne Lane and Auburn-Grover Lane sections and closer to 10% in the Highway 238 section. Percent shade values higher than these minimums indicate the height of riparian vegetation. Riparian vegetation is much more abundant in the Thayne Lane and Highway 238 sections than in the Etna Lane and Auburn-Grover Lane sections (Appendix B). The profiles can be used to identify potential problem areas. As sparse as riparian vegetation appears to be in the Auburn-Grover Lane section, the section from 5.0-6.0 mi below the upper end of the Auburn-Grover Lane section (Auburn-Grover Lane Bridge) appears significantly

Table 9-7. Substrate composition of different habitat types within the secondary channels in four study sections of the Salt River in 1998-1999. S/0 = silt and organic matter, Grvl = gravel, Cobl = cobble, Bldr = boulders.

	Secondary Only																			
	Auburn-Grover					Highway 238					Thayne Lane					Etna Lane				
Habitat Type	**S/O**	**Sand**	**Grvl**	**Cobl**	**Bldr**	**S/O**	**Sand**	**Grvl**	**Cobl**	**Bldr**	**S/O**	**Sand**	**Grvl**	**Cobl**	**Bldr**	**S/O**	**Sand**	**Grvl**	**Cobl**	**Bldr**
Pools	32	5	47	15	<1	63	12	20	4	1	38	<1	36	25	1	18	20	58	4	
Lateral scour	33	3	45	18	<1	28	24	42	5		36	<1	37	27		18	20	58	4	
Straight scour	20	5	45	30		49	19	31	1	<1	32	2	34	25	7					
Plunge							10	80	10											
Dammed						80	9	9	2	<1	100									
Beaver dam						84		3	7	6	89		11							
Subunit pools	83	1	8	8		99	<1	<1	<1	<1	77	1	16	5		90		10		
Backwater	83	1	8	8		81	7	3	4	4	76	2	17	6		90		10		
Isolated						87		3	5	5	100									
Alcove						100														
Glide	32	8	49	11		82	2	8	7	1	75	1	13	11		53	19	25	3	
Glide w/pockets						100										24	45	26	5	
Run	17	9	59	14		1	1	39	42	18	13	1	65	21	<1					
Riffle	10	5	68	17		10	12	59	18	<1	30	5	51	14		10	13	67	10	1
Riffle w/pockets						11	31	51	7		8	2	86	5		5	16	61	18	
Rapid											1		28	59	12					
Step over cobble									90	10	10	20	50	20						
Step over beaver dam											97		3							
Step over structure																				
Dry unit						3		83	14		91		9			28	9	62		
Dry channel											95			5						
Culvert crossing																				
Average for all Units	**32**	**5**	**47**	**15**	**<1**	**77**	**4**	**12**	**6**	**1**	**50**	**2**	**33**	**15**	**<1**	**34**	**21**	**41**	**4**	**<1**

lower than the most other reaches. There is also a short stretch from about 3.9-4.2 mi below the Auburn-Grover Bridge that is most likely lacking willows. Similarly, the reaches extending from about 1.8-3.0 and 5.5-6.0 mi from the upper end of the Thayne Lane section (Thayne Lane Bridge) probably have fewer willows than most other reaches of the Thayne Lane section.

Bank erosion was rare within the Highway 238 section and was most common in the downstream half of the Auburn-Grover study section (Appendix C). Bank erosion was most severe about 1.0-3.0 mi below the upper end of the Etna Lane section (Etna Lane Bridge). Bank erosion was very sporadic within the Thayne Lane section, but was very rare in the last mile of the section. Erosion in the Auburn-Grover Lane section appears to coincide with a large area lacking any log revetments in the primary channel; 3.0-6.0 mi below the Auburn-Grover Lane Bridge (Appendices C and D). Similar profiles demonstrate the distribution of fine sediments between and within the study sections (Appendix E). Silt, organic matter and sand are obviously most abundant in the Etna Lane section and least abundant in the Thayne Lane section.

Willow Survey

The 2000 willow coverage estimates are compared to past estimates in Table 9-8. In the 25-year period from 1939 to 1964 willow coverage in the valley declined from an average of about 77% to 49%. The loss was most severe in the upper and lower valleys of the Salt River where land is heavily grazed. Loss in the high gradient Narrows section was less severe. The percent willow coverage stabilized throughout the 6-year period between 1964 and 1970, and few willows were lost (Figure 9-4). During the 30-year period from 1970 to 2000, willow coverage on the banks of the Salt River increased from an average of 49% (1970) to an average of 57% (2000). The Narrows had the largest change in willow coverage during this period with a 15% increase.

The only site with an obvious loss of willows between 1970 and 2000 was Etna Lane (Table 8). Less significant losses were noted at the Murray and Bateman easements. As mentioned previously, the Etna Lane site was surveyed below the bridge in 2000. If the survey had been conducted above the bridge, as might have been done by Miller in 1970, willow coverage would most likely have increased because the banks upstream from the Etna Lane Bridge are fenced and heavily covered with willows.

Although the percent willow coverage in the Salt River valley has shown an overall increasing trend from 1964 (49%) to 2000 (57%), the 2000 average coverage was substantially lower than in 1939 (77%). Although few willows were lost in the Narrows section between 1939 and 2000, losses in the heavily agriculturalized valleys have been severe.

Table 9-8. Estimated percent coverage of stream banks of the Salt River by willows in 1939, 1964, 1970 and 2000. Easements are listed upstream to downstream.

	Survey Year			
Easement Name	1939	1964	1970	2000
Taylor	26	7	4	0
West Burton	44	7	3	0
South Burton	75	15	12	60
Above Auburn-Grover Lane	20	4	2	0
Upper Valley Average	**41**	**8**	**5**	**15**
Narrows	70	64	58	76
Hale	83	59	63	81
Wakeman	79	70	70	88
Murray	84	87	89	75
Thayne	72	38	42	73
Narrows Average	**78**	**64**	**64**	**79**
Freedom	78	46	42	45
Etna	43	38	40	4
Miller	62	34	37	47
Wolfley	53	10	2	0
Bateman	78	40	44	31
LVPL Dam	79	64	71	84
LVPL Plant	84	66	65	80
McCoy	84	67	72	81
Lower Valley Average	**70**	**46**	**47**	**47**
Average for All Sections	**77**	**49**	**49**	**57**

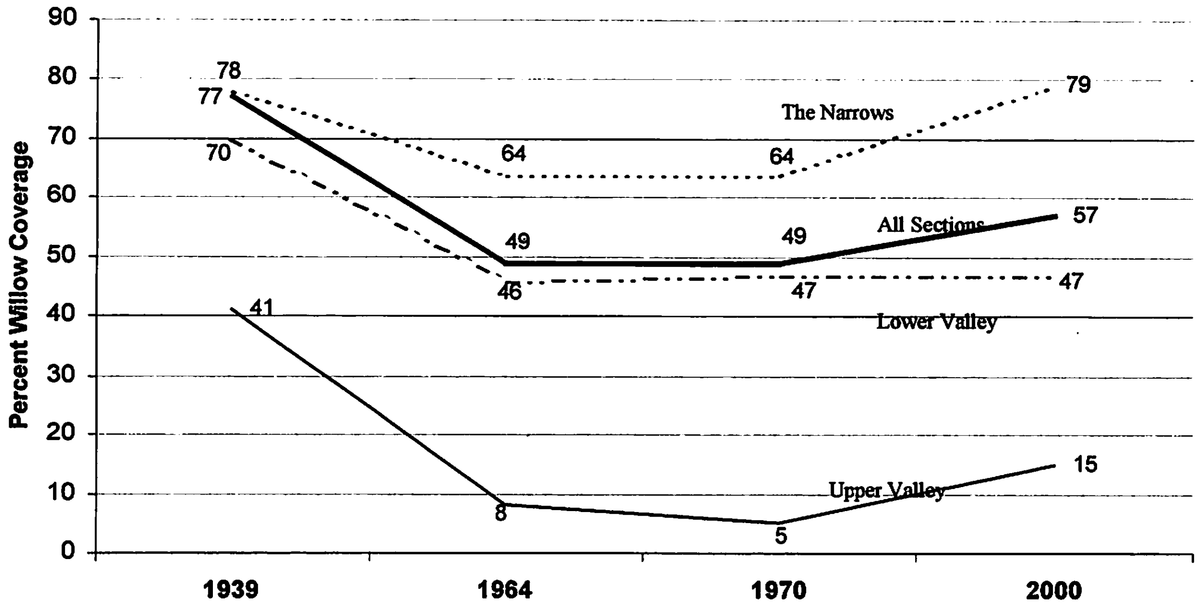


Figure 9-4. Trends in willow abundance at three sections of the Salt River and the average trend for all sections. Upper River is Clark's Barn to Auburn-Grover Lane. Narrows is Highway 238 to Thayne Lane. Lower Valley is Freedom Lane to the McCoy Access Area.

DISCUSSION

The quality of aquatic habitat in the mainstem Salt River varies from excellent (in The Narrows) to highly degraded in the upper and lower valleys. Characteristics of high quality habitat include complex habitat (large number of habitat units/mi and little glide habitat), lack of eroding banks, abundant undercut banks and shade. Habitat conditions and salmonid populations within each of the four study sections are summarized below from upstream to downstream.

Auburn-Grover Lane

This study section was selected to represent the low gradient habitat in the valley upstream of The Narrows. Although the section only extended downstream 6.0 mi from Auburn-Grover Lane, it is fairly representative of mainstem habitat conditions between Afton (Clark's Barn) and Highway 238 (Figure 9-1). This section has the lowest gradient and highest sinuosity in the Salt River study area. The river is generally composed of one or two channels. Approximately 20% of the total surface area of the stream is in secondary channel habitats. Habitat conditions in the secondary channels tend to be very similar to those in the primary channel, although the secondary channels have more glide habitat. There is heavy agricultural use on both banks throughout this section of river. Riparian vegetation alternates between stands of willows and areas completely lacking vegetation other than grasses and forbs.

Habitat quality is relatively poor in this section. Habitat complexity (units/100 yds) is intermediate when compared to the other study sections, but is composed of few habitat types. Lateral scour pools dominate the habitat. When compared to the other three study sections, the Auburn-Grover Lane section has the most eroding banks, the least shade and is intermediate in percent undercut banks.

As reflected by percent shade in the habitat inventory, willow coverage is the lowest of the four study sections. Willow coverage in the upper valley between Clark's Barn and Auburn-Grover Lane decreased from 41% in 1939 to 5% in 1970 and has since increased to only 15%.

Trout populations in this section of stream reflect the quality of the habitat. This section had the third highest trout abundance (858/mi) and few mountain whitefish (MWF) when compared to the Highway 238 and Thayne Lane sections. The trout population is composed of 66% brown trout (BNT) and 34% Snake River cutthroat (SRC) trout. The section has the third highest density of small (6.0-10.9 in) and large (>18.0 in) BNT. Average population estimates of small and large BNT were 478/mi and 27/mi, respectively.

The major habitat problems upstream of Highway 238 are the lack of fencing throughout this section, which results in heavy grazing of the stream banks. Riparian vegetation other than short grass is nonexistent in many reaches of this section.

Highway 238

This study section was selected to represent the high gradient habitat in The Narrows between Highway 238 and Thayne Lane (Figure 9-1). After leaving the upper valley, the river enters The Narrows immediately downstream of the Highway 238 Bridge. The river slope soon increases nearly fourfold, active channel height increases about 50% and sinuosity decreases about 25%. The riparian corridor is dominated by willows with stands of mature conifers beyond and agricultural use is limited to light grazing. Although the area of secondary channels is similar to the river upstream (20% of the total area), the secondary channels are very different. Rather than a second channel resembling the main channel, these channels are usually subunit pools in abandoned channels. The river continues to cut new channels forming isolated pools and alcoves that eventually fill with sediment. Evidence of this type of channel process is clearly visible west of Highway 89 between the Murray Access Area and the northern Highway 89 Bridge. Arching bands of willows along shallow depressions on the flat floodplain indicate past location of the primary channel.

Habitat quality is excellent in this section. Habitat complexity (units/100 yds) is intermediate compared to the other study sections, but is composed of a large number of habitat types. There are 15 different habitat types in the primary channel and 17 in secondary channels. Runs dominate the habitat in the primary channel, but pools and riffles are common. There are many types of pools and riffles commonly contain pocket water. When compared to the other study sections, the Highway 238 section has the fewest eroding banks, the most shade, and a relatively high percentage of undercut banks. The high shade values reflect the abundant willow coverage in The Narrows. Willow coverage in this section fell from 78% in 1939 to 64% in 1964, but has since recovered to 1939 levels.

As in the river upstream, the salmonid populations reflect the quality of the habitat. Although trout populations were highly variable between years, the Highway 238 section had the highest average trout abundance (1,671 per mile) and abundant MWF. The composition of the trout population is similar to the upper valley; 63% BNT and 37% SRC. However, this section has the highest density of small (6.0-10.9 in) BNT and the second highest density of large (>18 in) BNT. The average population estimates of small and large BNT were 845/mi and 38/mi, respectively.

The wild SRC population was also highest in this section (448/mi) and was composed of a large population of 6.0-10.9 in SRC (333/mi). Few age-0 SRC were found in the mainstem Salt River, supporting the idea that SRC enter the mainstem during the winter following emergence. Age-1 SRC were relatively abundant in the Highway 238 section as reflected in the estimate of 6.0-10.9 in SRC.

Willow Creek, entering the Salt River from the east at the southern Highway 89 Bridge, may be an important spawning tributary for SRC. Relatively large numbers of wild SRC, many of them small, were captured from the river below the Willow Creek confluence during population sampling.

The major habitat problems in The Narrows appear to be loss of channel sinuosity, high potential for development on the floodplain and fish losses to the East Side Diversion canal.

Thayne Lane

This study section was selected to represent the high gradient habitat downstream of The Narrows. Although the section only extended from the Thayne Lane Bridge to the Freedom Lane Bridge, a distance of 5.75 mi, it is fairly representative of mainstem habitat conditions between Thayne Lane and Etna Lane (Figure 9-1). The river emerges from The Narrows above the Thayne Lane Bridge, but maintains a slope, sinuosity and entrenchment very similar to the Highway 238 section. Average bankfull width increases and bankfull depth decreases resulting in a width/depth ratio of 27.4; the highest of the 4 study sections. The river becomes braided, with more than a dozen small secondary channels flowing through a single cross section of the active channel near the Flat Creek confluence. Approximately a third of the total area exists in secondary channels. The Rosgen channel type shifts between a C4 and a D4 or DA4 in the highly braided reaches. Bank erosion is 4 times higher than in The Narrows, but most silt, organic matter and sand is apparently transported through the section. Aggradation of the channel is evident, as gravel and cobble substrates appear to accumulate, becoming more common than in the other 4 study sections. Willows dominate riparian vegetation and adjacent land use is dominated by agriculture.

Although aggradation of the channel is common, fish habitat appears very good. Habitat complexity is twice as high as in the Narrows and is composed of a large number of habitat types. There are 9 habitat types in the primary channel and 16 in secondary channels. Runs continue to dominate the primary channel habitat, but pools and riffles are common and fine sediments are relatively rare. Riffle habitat is abundant in secondary channels. Eroding banks are relatively common as the channel braids and meanders, but undercut banks and shade are also abundant. Of the 17 willow survey sites, only the Freedom Lane site is located within the Thayne Lane study section. An estimated 45% of the banks in this half-mile section of stream were covered with willows. Although willow densities are lower than in The Narrows, they are much higher than in the upper or lower valleys.

The Thayne Lane section has the second highest average trout abundance (1,194 per mile) and abundant MWF. Trout populations are highly variable between years. The trout population is composed of 70% BNT and 30% SRC. The SRC population is intermediate when compared to the other 3 study sections. Large (>18.0 in) BNT were most common in this section; 49/mi. The density of small (6.0-10.9 in) BNT was second only to the Highway 238 section; 643/mi.

Much effort has been expended over the years to stabilize the channel in this reach with riprap and revetments, but the treated channels are soon abandoned. Few structures were found in the primary channel in 1998 and 1999 (Appendix C). A number of major channel changes occurred within this section between 1995 and 2000. The changes at one site were so severe that the direction of flow within the channel was reversed.

Although habitat in this section is highly unstable, it is also very complex and contains a large population of trout and MWF. The largest resident BNT in the river were typically captured in this section during population sampling. It has also been well documented (via fall electrofishing and conversations with local anglers) that large BNT congregate and spawn in the abundant riffle habitat within this section, particularly near the confluence of Flat Creek about 1.5 mi downstream of Thayne Lane. Abundant juvenile habitat is also present and age-0 and age-1 BNT are abundant. Some of the only age-0 SRC found in the mainstem were captured in this section.

There are many possible explanations for the types of habitat in this area. As the river leaves The Narrows above Thayne Lane, the valley floor opens up, but the river maintains its slope (Figure 9-2) and sinuosity. Aggradation of the channel is evident as nearly 90% of the substrate is the primary channel is composed of gravel and cobble and the volume of cobble is 1.5 times higher than in The Narrows. Aggradation results in a substantial increase in the width/depth ratio (Table 9-3). The aggradation may be attributable to the natural geology of the area. Gravel and cobble appear abundant in the soils. These materials were probably deposited when the river first cut its path through the 6.0 mi section of The Narrows. Since that time, the river may not have had the ability to transport these large sediments and as a result, the channel has become wider, shallower and highly braided.

Land use might also be responsible for the disturbance. Irrigation may have resulted in highly saturated soils that are less cohesive and more vulnerable to erosion. One of the largest areas of disturbance is at the Flat Creek confluence. Irrigation return flows have probably resulted in base flows within Flat Creek that are higher than those that occurred naturally. The augmented flows may be partially responsible for the areas of disturbance near its confluence with the Salt River. Regardless, the habitat within this section is unstable and likely to change unless a new channel is constructed within the active channel. The new channel would have to be designed to transport the large sediments through the reach. However, those sediments would probably cause a major disturbance when deposited in the low gradient stream below Etna Lane. Although highly aggraded and unstable, this area is home to a large population of salmonids and provides some of the most important spawning habitat on the mainstem Salt River. A Herculean effort might stabilize the river in this reach, but it would probably not benefit salmonids.

From the perspective of adjacent landowners, the major habitat problem between Thayne Lane and Etna Lane is undoubtedly channel instability. Landowners along this section of river struggle mightily to maintain their irrigation head gates and evidence of heavy equipment is commonplace in the stream channel. Installation of appropriate structures at the head gates might alleviate some of this disturbance. There is also potential for large losses of fish to unscreened diversions and suburban development of the floodplain. The best long-term habitat management may be maintenance of a wide, healthy riparian zone with dense willows. A large riparian corridor will be more likely to remain relatively stable as the channels shift within the active channel.

Etna Lane

This study section represents the low gradient habitat in the valley between Etna Lane and the Perkes Access Area. Habitat and salmonid data are not intended to represent conditions in the relatively high gradient section between Perkes and McCoy (Figure 9-1).

Downstream of the Etna Lane Bridge, river slope decreases to half that of the river above the bridge. The width/depth ratio decreases and sinuosity and entrenchment increase. The river becomes a single channel and the few secondary channels are dominated by glide habitats with substrates dominated by silt, organic matter and sand. Substrates larger than gravel are rare and entrenchment is highest in this section of stream. Aquatic habitat becomes homogenous with lateral scour pools in bends separated by very long glides or runs. Riffles are extremely rare. There is heavy agricultural use on both banks throughout this section of river. Riparian vegetation alternates between small stands of willows and large areas completely lacking vegetation other than grasses and forbs. Willow density (willows/1000 ft) is 55% lower than in the Thayne Lane section.

Habitat quality is very poor in this section. Habitat complexity is the lowest of the study sections and is dominated by glides and runs. Pool and riffle habitats are rare when compared to the other study sections and the substrate is composed of more silt, organics and sand and less gravel. Undercut banks and shade are rare and erosion is controlled largely by revetments (Appendix C). Willow coverage declined from 70% in 1939 to 46% in 1964 and has remained stable ever since.

This section has the lowest average trout abundance (719 per mile) and the fewest MWF of the four study sections. There is little variability in the trout population between years. Secondary channel habitat is very rare, so the population estimate conducted in the primary channel is probably representative of the true population. This was the only section in which wild SRC outnumbered wild BNT. The trout population is composed of 28% BNT and 72% SRC. The river between Etna Lane and the Perkes Access Area had the fewest large BNT (13/mi) and the fewest small BNT (148/mi).

The wild SRC population was high in this study section when compared to other study sections. The wild SRC population was highest at Highway 238 (448/mi), followed by Etna Lane (419/mi), Thayne Lane (331/mi) and AG Lane (186/mi). However, 80% of wild SRC in the Etna Lane section were small (6.0-10.9 in), compared to 71% at Thayne Lane, 74% at Highway 238 and 63% at AG Lane. The population of small, wild SRC was highest at Etna Lane (336/mi) and Highway 238 (333/mi), followed by Thayne Lane (236/mi) and Auburn-Grover Lane (118/mi). Although age-0 SRC are extremely rare in the mainstem river, a few were found in the Etna Lane section. It has been established that the composition of the trout population is dominated by BNT in the upper reaches of river, but SRC are more abundant than BNT in the lower river (Figures 9-25 through 9-27 in Trout Population Estimates chapter). The abundance of SRC in the lower river is due largely to small SRC.

This trend in SRC abundance might be attributed to BNT predation on SRC, competitive exclusion of SRC in areas where BNT are abundant, or the distribution of important SRC spawning tributaries. The Etna Lane and Highway 238 sections had the largest populations of small SRC. This suggests that the most important spawning tributaries might lie within the Etna Lane and Highway 238 study sections. Those might include Tincup and Jackknife Creeks and Laker Spring in the Etna Lane section and Willow Creek in the Highway 238 section. It also suggests that the contribution of wild SRC from Flat Creek (Thayne Lane section), Christensen Spring, Anderson Spring and mainstem Salt River near Fairview (Auburn-Grover Lane section) might be relatively small.

Although habitat is poor in the Salt River between Etna Lane and Perkes, this area supports an important fishery with a catch rate of 1.55 fish/hour; nearly twice that of the river above Thayne Lane (Table 9-4, Creel Survey and Stocking Evaluation chapter). Very little of the angling pressure in the lower river occurs between Thayne Lane and Etna Lane due to limited access, so the river below Etna Lane is largely responsible for this high catch rate (Figures 6-10 and 6-11, Creel Survey and Stocking Evaluation chapter). The catch rate is also attributable to the relative abundance of SRC, which are more easily caught than BNT, and surprisingly, to the poor quality of the habitat. Inexperienced boat anglers can effectively fish the wide, homogenous channel, encountering few problems from overhanging willows. More angling skill is required to effectively fish the narrow, willow-lined channels of the Highway 238 section from a boat.

Habitat management in this section should concentrate first on riparian management. Cattle grazing in the riparian zone must be controlled and willows re-established. Habitat could then be improved by utilizing instream structures to create additional pool and riffle habitats. Suburban development of the floodplain should be discouraged because the floods of the mid-1980s showed that flooding in the lower valley could easily destroy homes built on the floodplain.

Future Habitat Analyses

The 1998 and 1999 habitat surveys provided a detailed documentation of the habitat characteristics in the four representative study sections of the Salt River between Afton and Palisades Reservoir. Repeating a similar survey in the future will allow managers to document major changes in aquatic habitat over time. Although the habitat within individual units and short reaches of stream will undoubtedly change annually, summary information can be used to monitor conditions within reaches of stream. Biologists will be able to document any major changes in dimension, pattern and profile by repeating the survey in the future. We recommend that shorter reference reaches (Rosgen 1996) be established within each of the four study sections to more closely monitor changes in river morphology. These short reaches (generally two riffle-pool sequences) could be easily monitored on a more frequent basis than could the 6.0 mi study sections.

During the course of this project, habitat and population sampling were conducted using identical 0.25 mi intervals. This design will facilitate comparisons between trout abundance and available habitat within discrete reaches of the river. It would be very labor intensive to calculate actual trout population estimates for every reach of interest. However, we identified a strong relationship between single pass catch and multiple pass abundance estimates of trout (r^2=0.84, $P<0.0001$). We will summarize habitat variables for distinct sub-reaches within each study section and compare those to the numbers of trout captured during the first electrofishing pass within the reach. We hope to develop a data set that can be used to prioritize specific areas for habitat management efforts. These results will be presented in an administrative or peer reviewed manuscript in the future.

MANAGEMENT RECOMMENDATIONS

- Aquatic habitat management in poor quality areas must begin with riparian management. Fencing should be installed where necessary and grazing should be carefully managed to facilitate development of a wide, healthy, riparian zone with dense stands of willow. Even within the highly braided sections of stream and those losing sinuosity, the best long-term habitat management may be maintenance of a wide, healthy riparian zone with dense willows.

- Biologists should assist landowners by suggesting appropriate instream structures that could be installed to more effectively protect and supply head gates, thereby alleviating the regular channel disturbance now associated with the maintenance.

- Use of other instream structures should be judicious until a healthy riparian zone is established. Although structures can sometimes facilitate development of riparian vegetation, they must first be protected from excessive grazing if they are to succeed.

- Rosgen-type reference reaches should be established within each of the four study sections to more closely monitor changes in river morphology.

- As the human population in the valley continues to increase, potential for suburban development of the floodplain also increases. Such development should be strongly discouraged to allow development of a healthy riparian zone and because the floods of the mid-1980s showed that flooding in the lower valley could easily destroy homes built on the floodplain.

- More detailed analyses of existing data would help prioritize specific areas for habitat management efforts.

LITERATURE CITED

Cupp, C.E. 1989. Stream corridor classification for forested lands of Washington. Hosey and Assoc. Bellevue, WA. 46 pp.

Erickson, J.A. 1985. Lower Salt River-Habitat Improvement-Critical Area Treatment Project, LSR-4. Wyoming Game and Fish Department Administrative Report, Project No. 811-00-810. Cheyenne, WY.

Erickson, J. 1986. A bank stabilization and habitat restoration project for the Salt River. Wyoming Game and Fish Department Administrative Report, Project No. 811-00-810 (Critical Area Treatment Project). Cheyenne, WY.

Frissell, C.A., W.J. Liss, C.E. Warren, and M.D. Hurley. 1986. A hierarchical framework for stream habitat classification: viewing streams in a watershed context. Environ. Manage. 10: 199-214.

Gipson, R., R. Hudelson and J. Kiefling. 2000. Fisheries management plan for the lower Salt River basin. Wyoming Game and Fish Department. Cheyenne, WY.

Hawkins, C.P., J.L. Kershner, P.A. Bisson, M.D. Bryant, L.M. Decker, S.V. Gregory, D.A. McCullough, C.K. Overton, G.H. Reeves, R.J. Steedman, and M.K. Young. 1993. A hierarchical approach to classifying stream habitat features at the channel unit scale. Fisheries 18(6): 3-12.

Isaak, D.J. 2001. A landscape ecological view of trout populations across a Rocky Mountain watershed. MS Thesis, University of Wyoming, Laramie, Wyoming. 148 pp.

Miller, D.D. 1971. A programmed creel census and evaluation of the cutthroat trout fishery in the Salt River. Wyoming Game and Fish Commission Administrative Report. Project No. 01-00-010. Cheyenne, WY.

Moore, K., K. Jones and J. Dambacher. 1998. Aquatic Inventory Project: Methods for Stream Habitat Surveys. Oregon Department of Fish and Wildlife, Natural Production Program. Corvallis, OR.

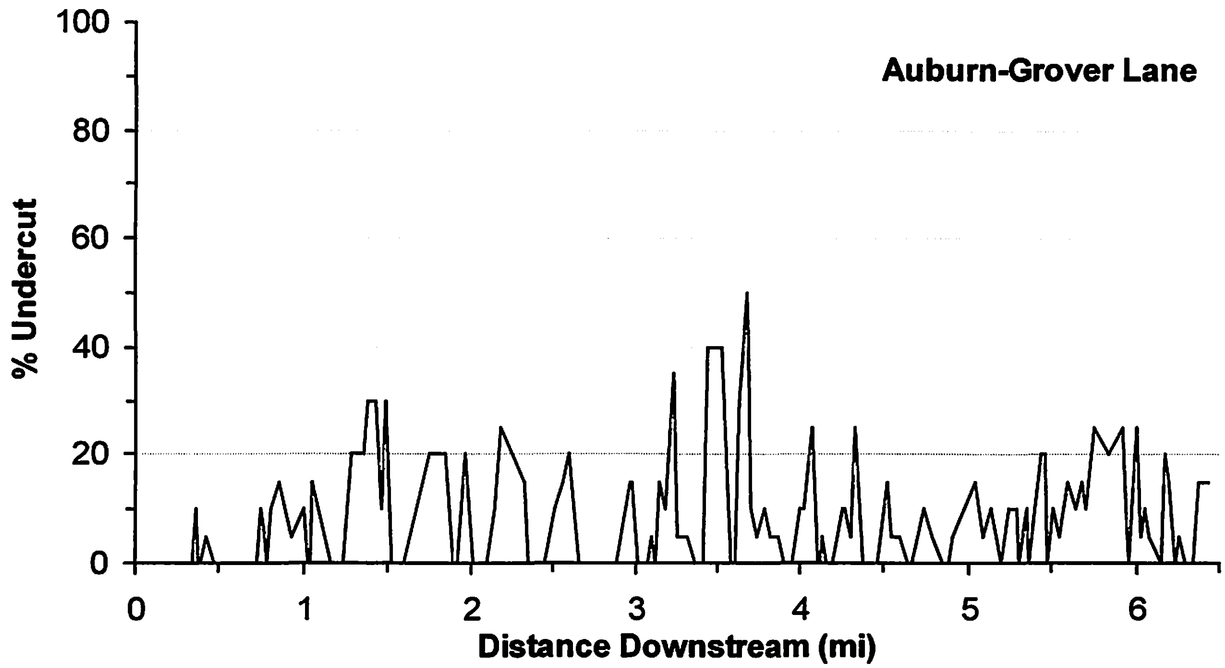
Ralph, S.C. 1989. Timber/Fish/Wildlife stream ambient monitoring field manual. Center for Streamside Studies, University of Washington. Seattle, WA.

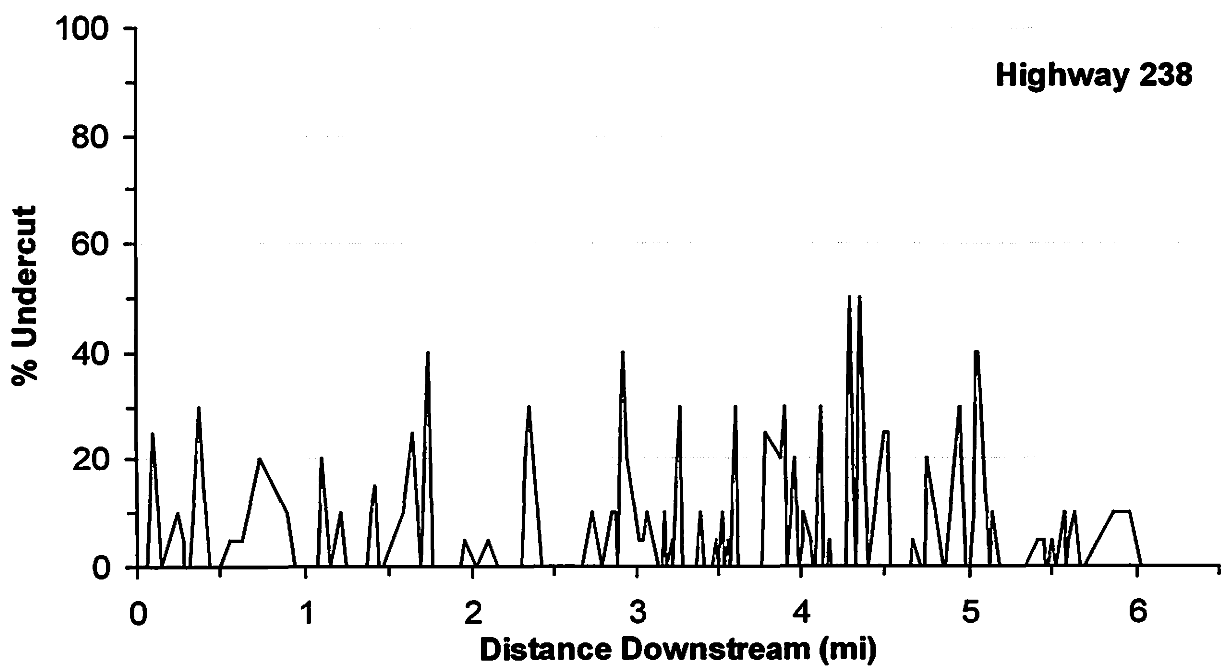
Rosgen, D.L. 1985. A stream classification system. Pages 95-100 *in* Riparian Ecosystems and Their Management; Reconciling Conflicting Uses. First North American Riparian Conference, April 16-18, 1985, Tucson, Arizona. USDA Forest Service. General Technical Report RM-120. Fort Collins, CO.

Rosgen, D.L. 1986. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO.

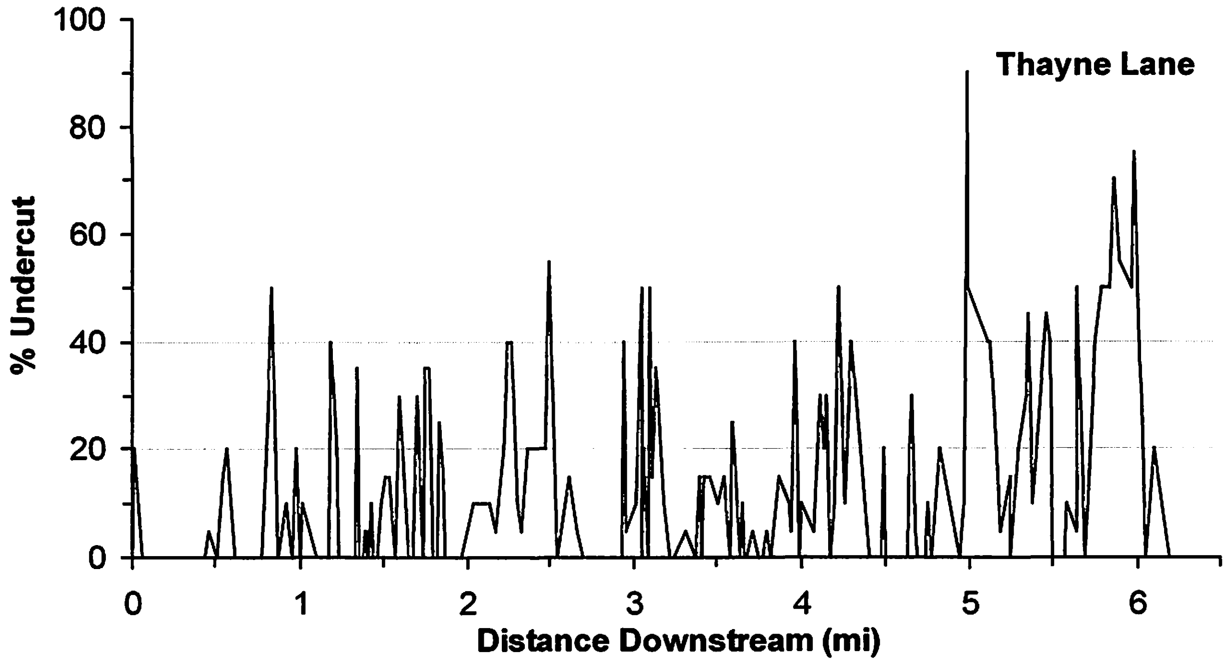
Sando, S.K., J. Borrelli and D.J. Brosz. 1985. Hydrologic impacts on the Salt River due to changes in irrigation systems. Prepared for the Wyoming Water Research Center, University of Wyoming, Laramie, WY. 73 pp.

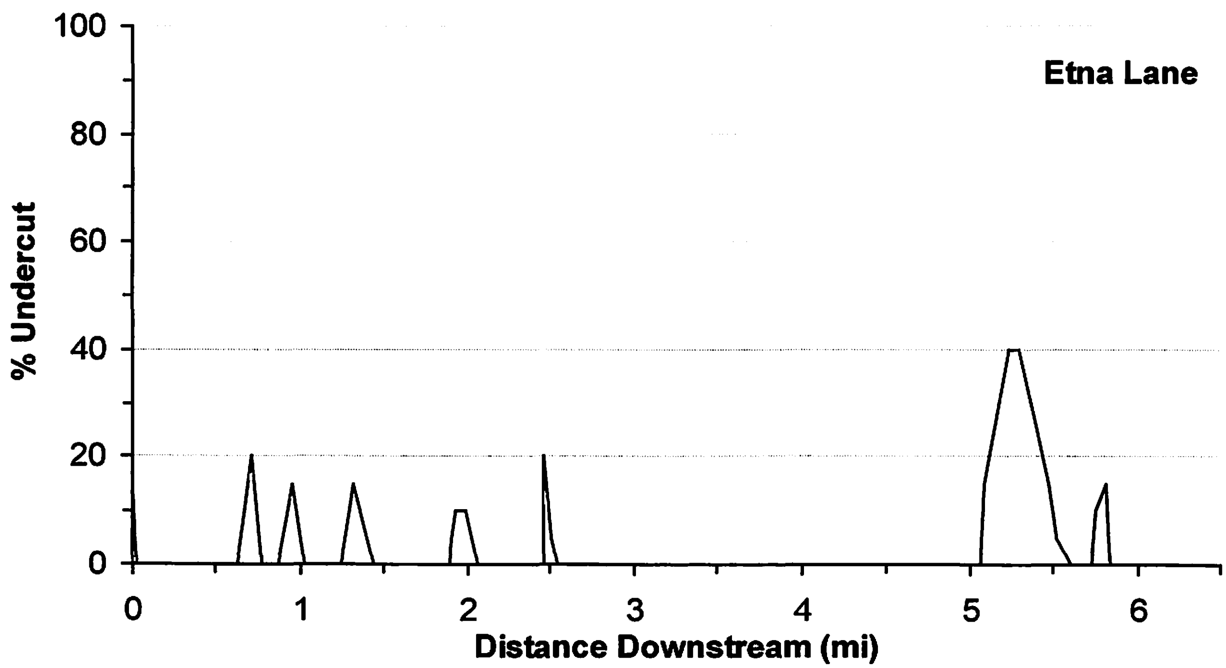
Appendix 9-A. Distribution of undercut banks in four sections of the Salt River in 1998-1999. Distribution is presented from the upstream end of the study section to the downstream end. Primary channel only with backwaters excluded.



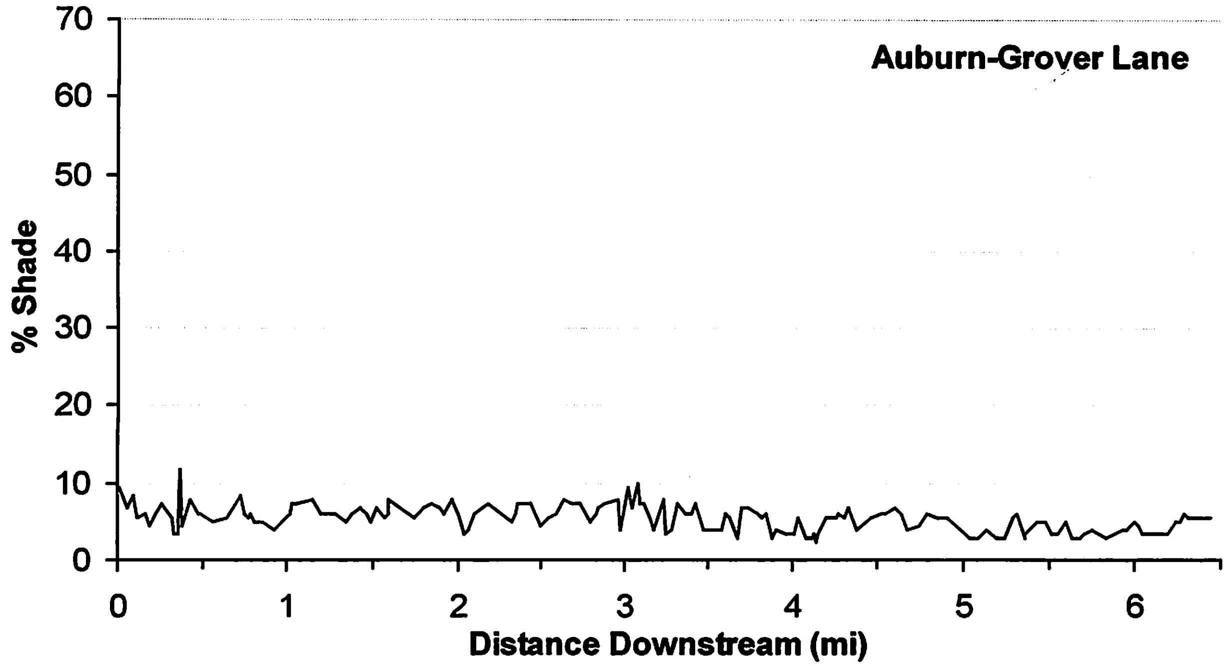


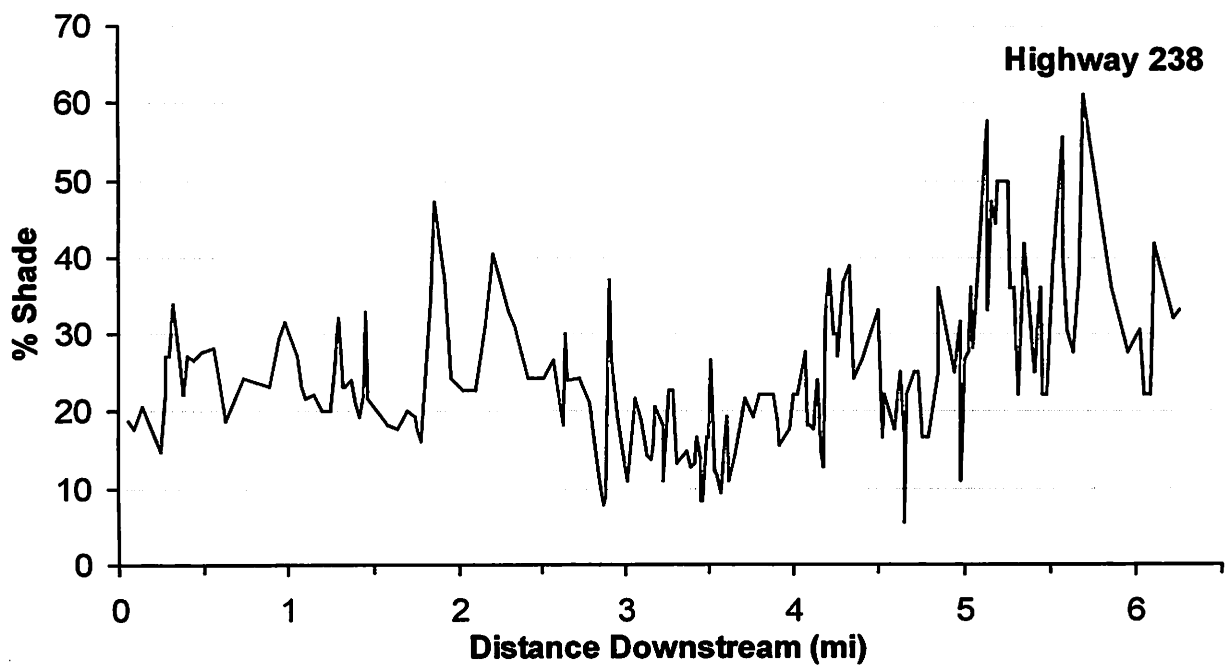
Appendix 9-A Continued



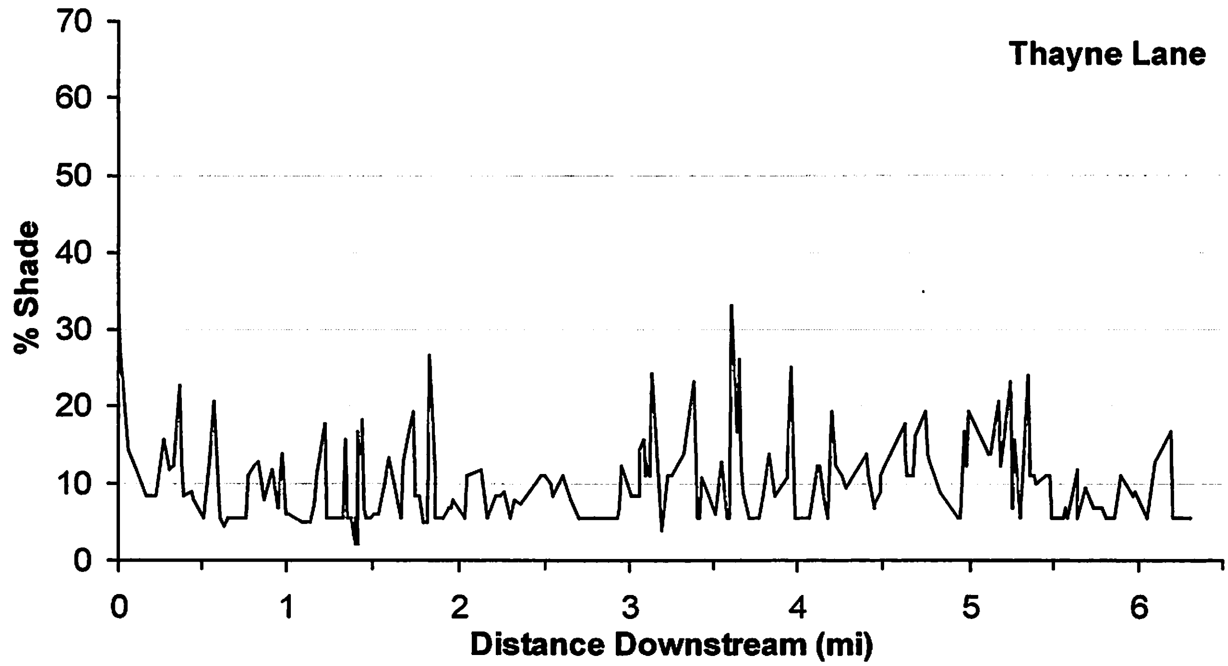


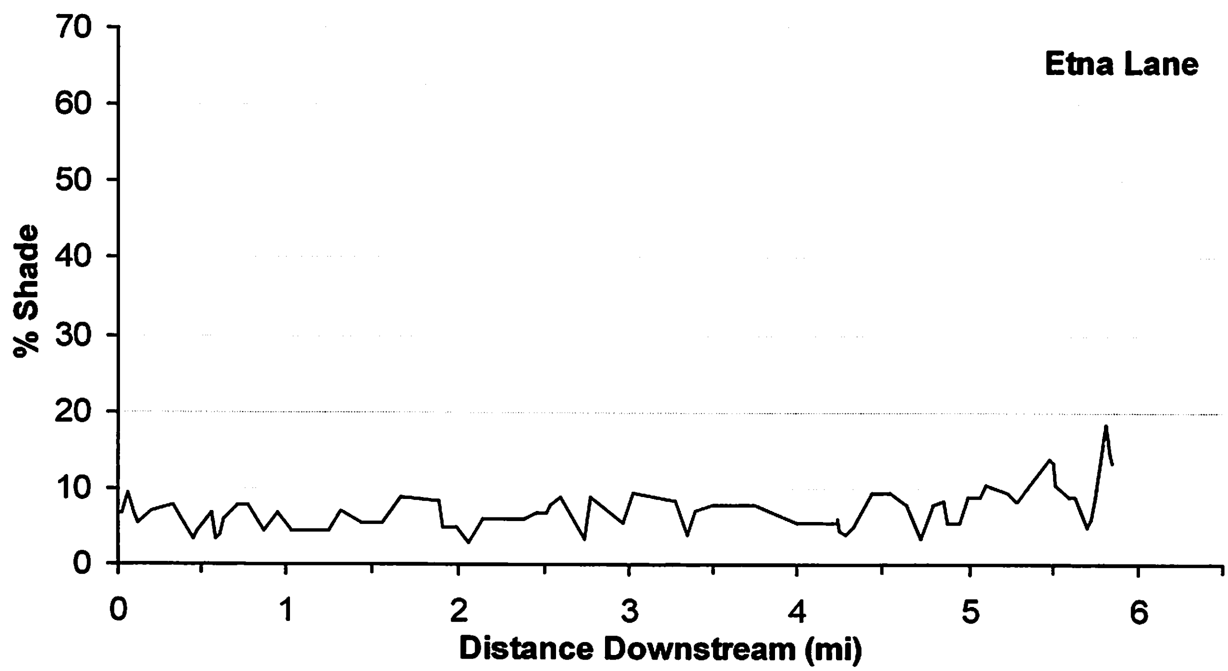
Appendix 9-B. Distribution of shade in four sections of the Salt River in 1998-1999. Distribution is presented from the upstream end of the study section to the downstream end. Primary channel only.



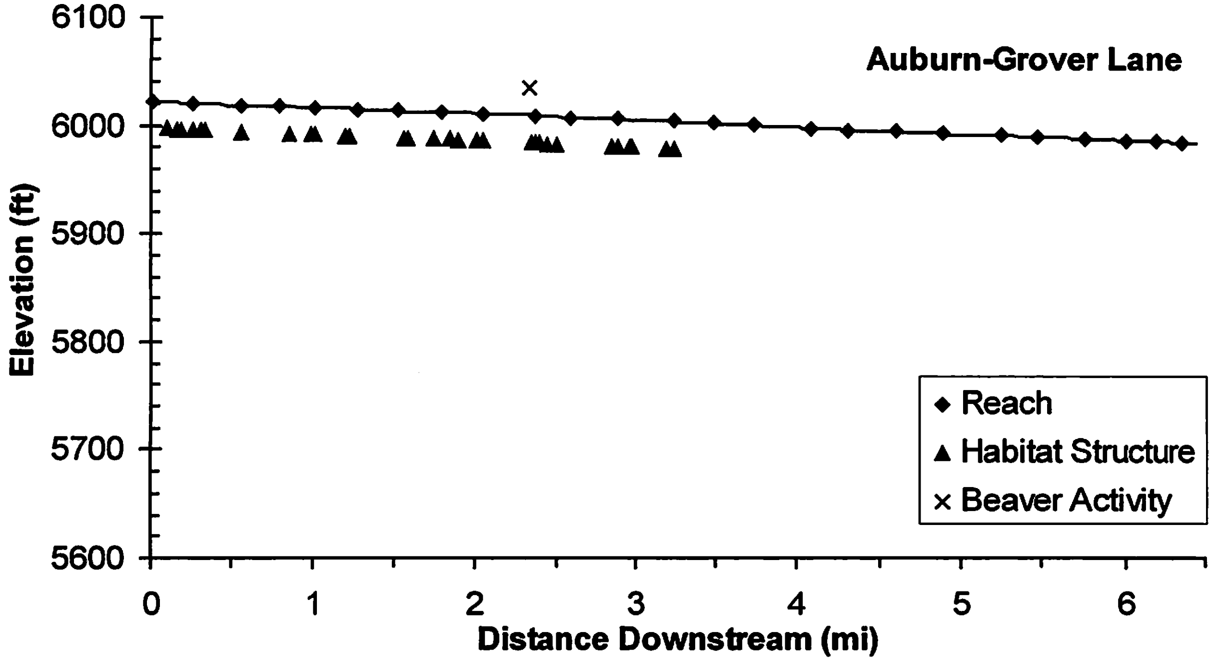


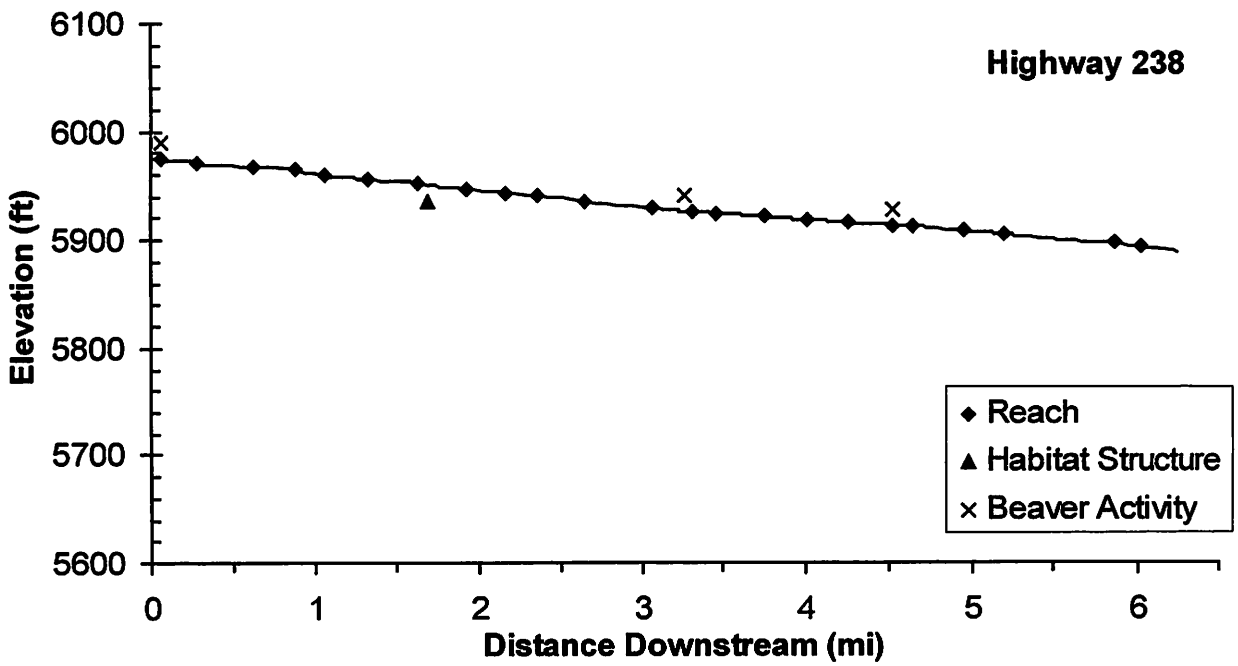
Appendix 9-B cont.



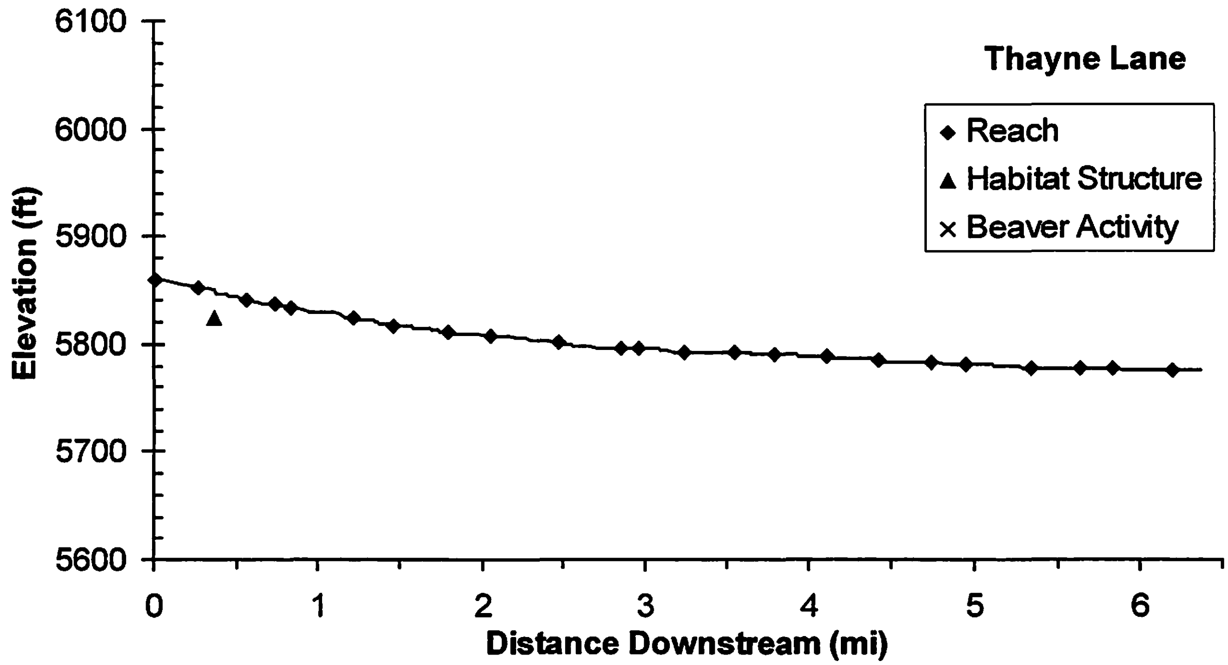


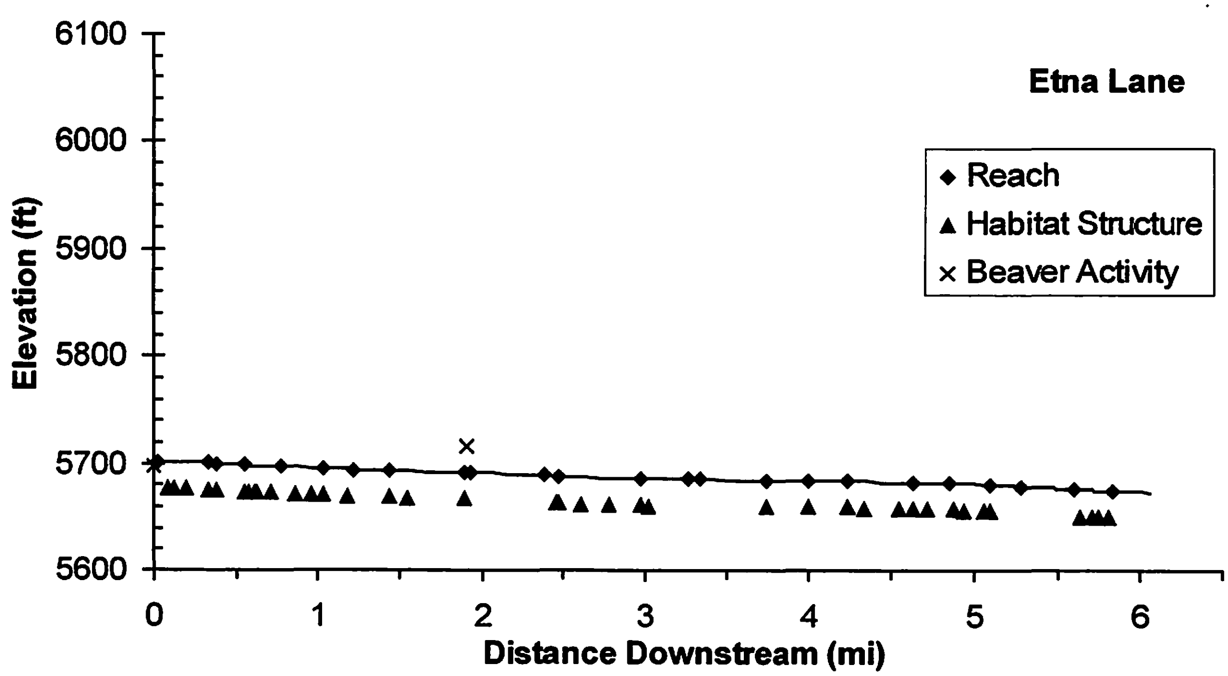
Appendix 9-C. Distribution of habitat structures and beaver activity within the primary channel of four sections of the Salt River in 1998-1999. Distribution is presented from the upstream end of the study section to the downstream end.



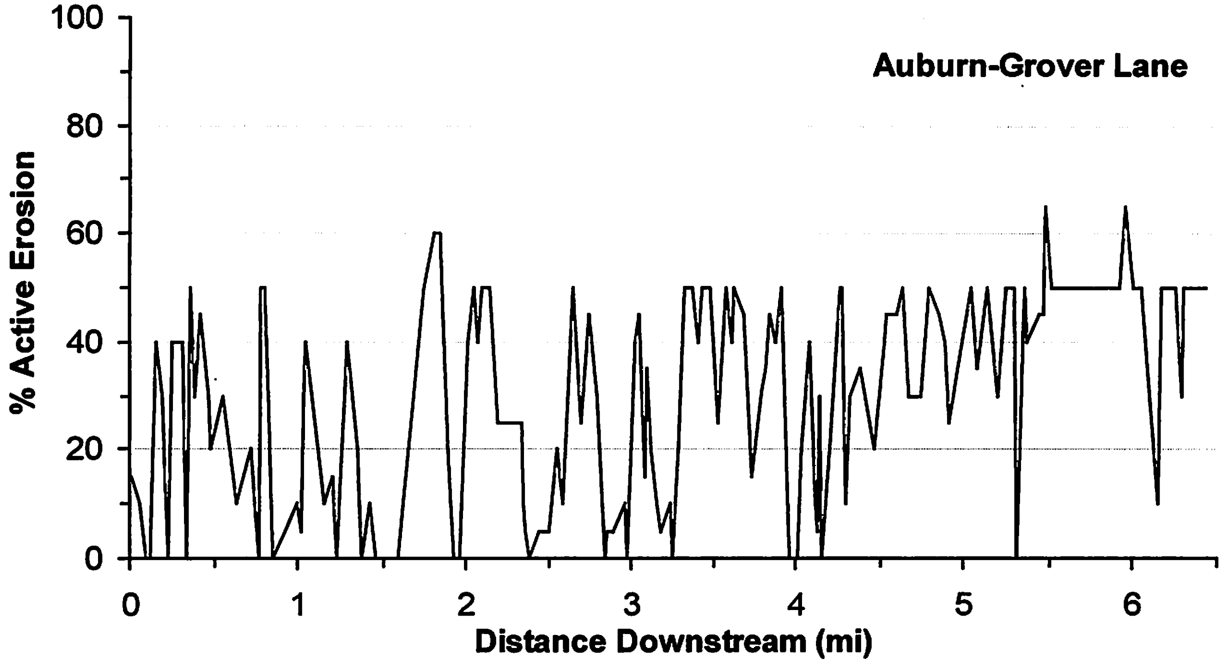


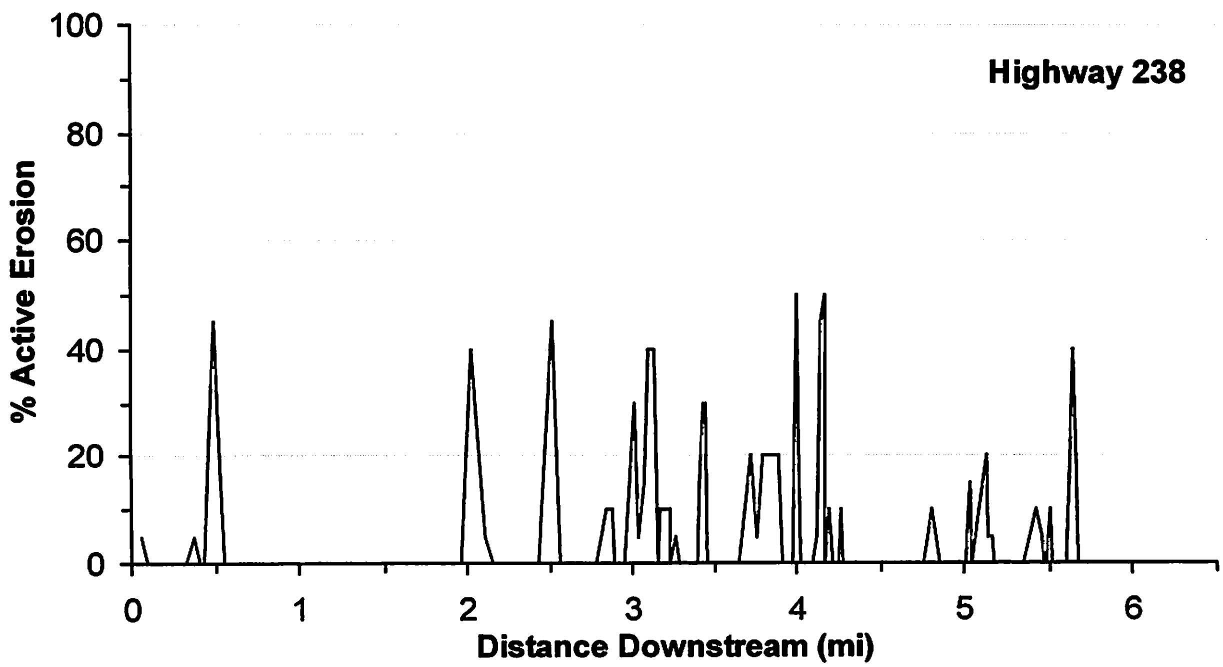
Appendix 9-C Continued

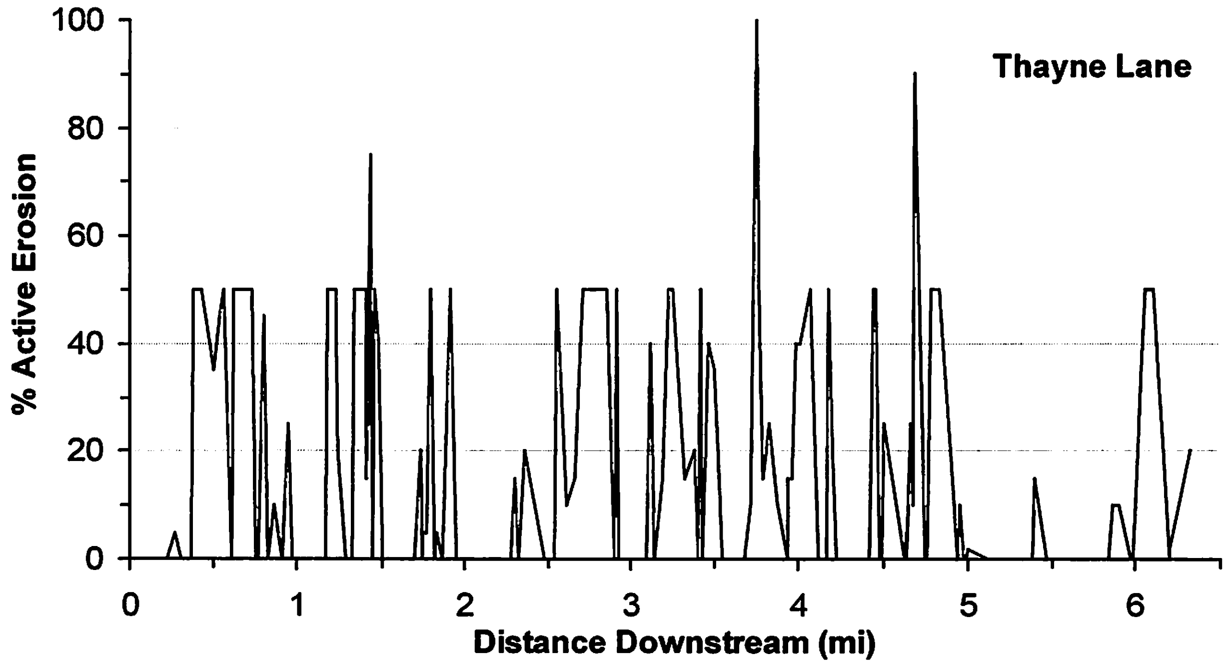


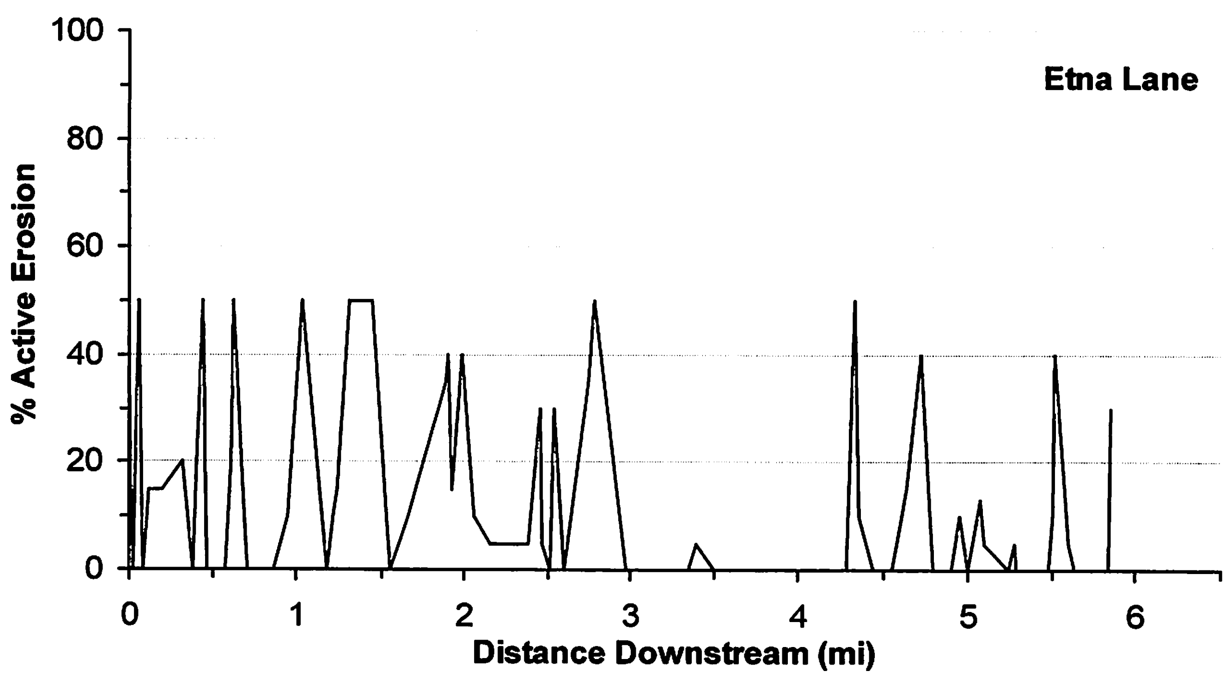


Appendix 9-D. Distribution of active erosion in four sections of the Salt River in 1998-1999. Distribution is presented from the upstream end of the study section to the downstream end. Primary channel only.

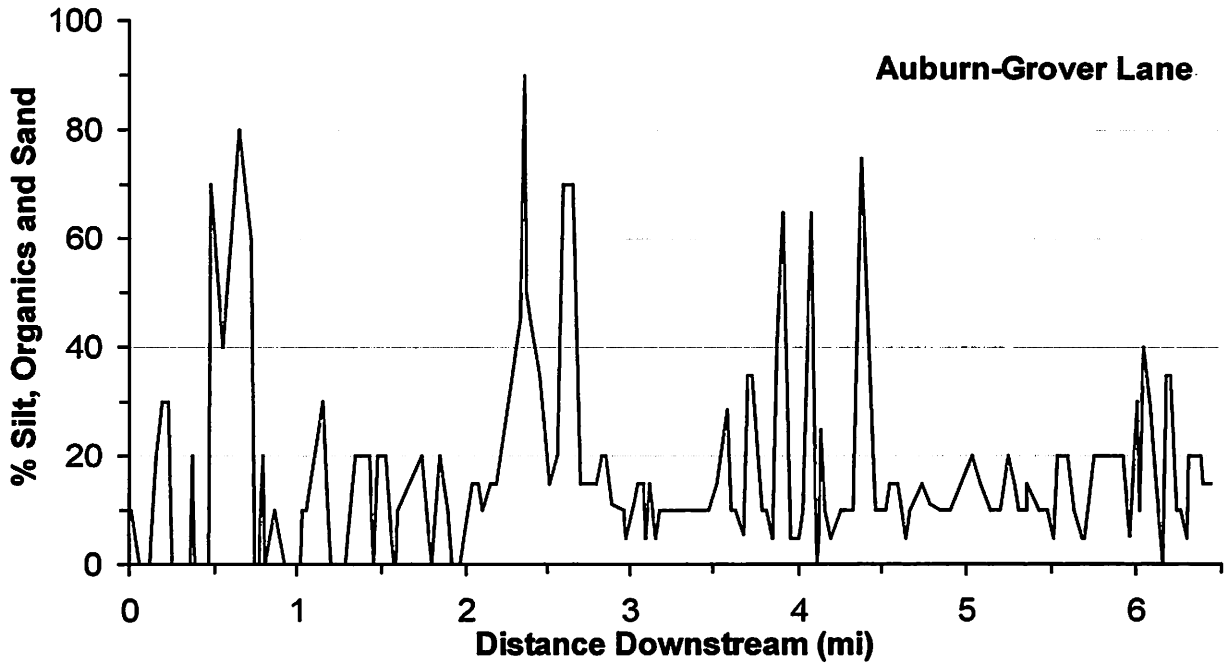


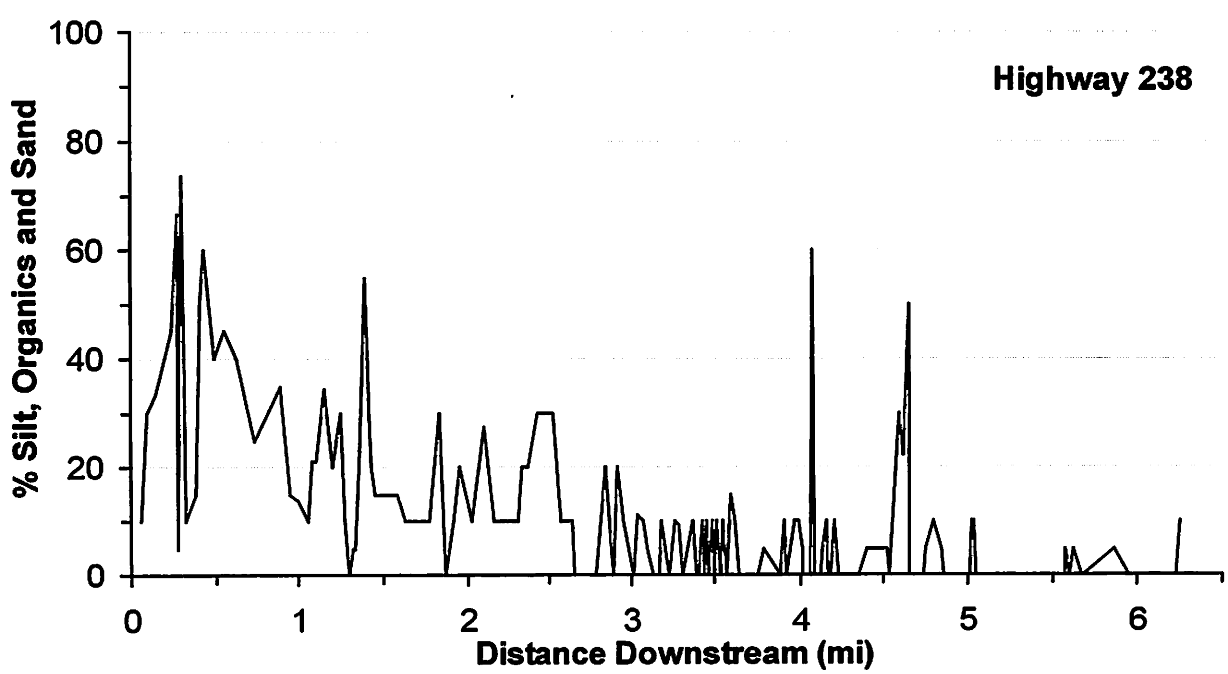


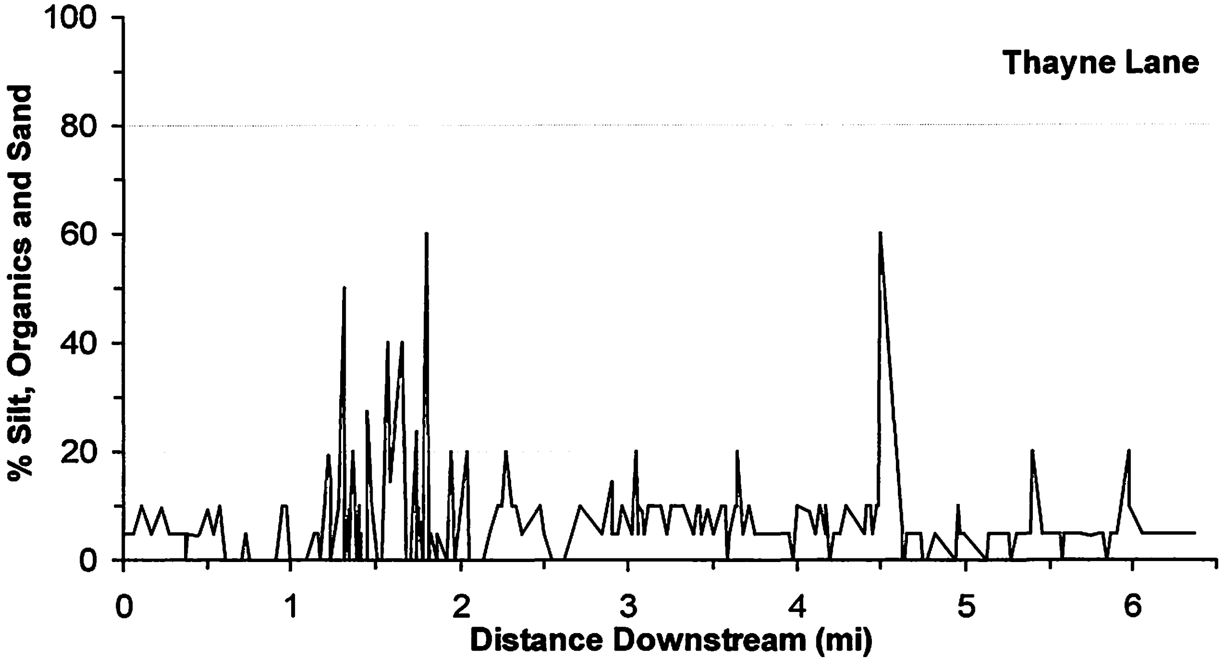

Thayne Lane
% Active Erosion
0
20
40
60
80
100
0
1
2
3
4
5
6
Distance Downstream (mi)

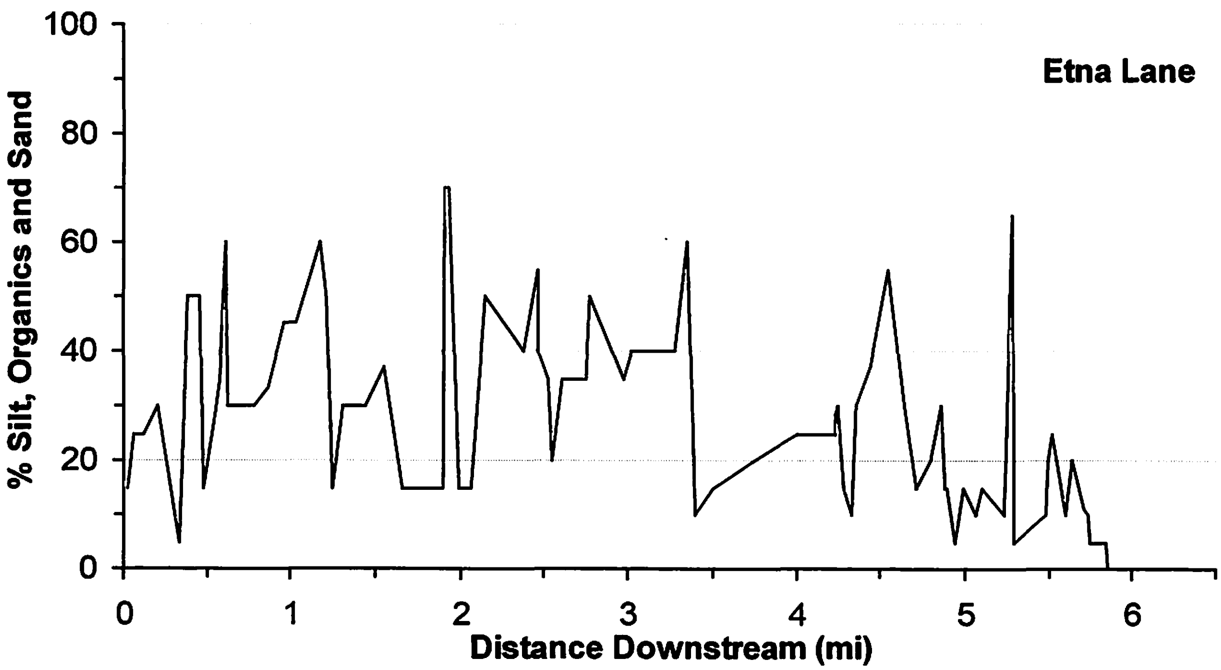

Etna Lane
% Active Erosion
0
20
40
60
80
100
0
1
2
3
4
5
6
Distance Downstream (mi)

Appendix 9-E. Distribution of fine sediments within the primary channel of four sections of the Salt River in 1998-1999. Distribution is presented from the upstream end of the study section to the downstream end. Backwaters are excluded.






Thayne Lane
% Silt, Organics and Sand
100
80
60
40
20
0
0
1
2
3
4
5
6
Distance Downstream (mi)


Etna Lane
% Silt, Organics and Sand
100
80
60
40
20
0
0
1
2
3
4
5
6
Distance Downstream (mi)