

Fish Habitat Surveys on the  
Wasatch-Cache National Forest  
During 1990 and 1994

by

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## INTRODUCTION

In 1994 fish habitat surveys were conducted on a number of streams along the North Slope of the Uinta Mountains. These surveys were conducted by fisheries staff from the Wasatch-Cache National Forest. Streams inventoried for habitat features on the Wasatch-Cache National Forest were the West Fork Bear River, above Whitney Reservoir; Mill Creek, a tributary to the Bear River; and the North Fork of Mill Creek. Fish surveys were also conducted in 1994, however those surveys were reported in Cowley 1994 and Cowley 1995. Some of the fish information will be repeated here as it deals with the stream on which habitat surveys were conducted. Also included in this report, is a fish habitat inventory conducted in 1990 on the Stillwater Fork, a tributary to the Bear River. All streams surveyed were located in Summit County, Utah.

## PROJECT AREA

### Mill Creek

Mill Creek is a first-forth order stream on the north slope of the Uinta Mountains on the Evanston Ranger District. This area surveyed has several sections of private inholdings intermixed with the National Forest System lands. The stream's headwaters begins on a private section of land in Utah (Township 2 North, Range 11 East, Section 33), then flows west and northwest alternating between public and private land until it leaves the National Forest completely at Township 2 North, Range 11 East, Section 7, northeast quarter. The stream eventually leaves Utah and empties into the Bear River in Wyoming. Within the area surveyed, Mill Creek flows on three sections of private land in Township 2 North, Range 11 East, Sections 19, 29, and 33. Management activities, in the area, include grazing, hunting, fishing, camping and hiking (Cowley 1995). Historically, heavy timber harvest or tie hacking occurred in the drainage (Peterson et al. 1980). Road 061 runs parallel to Mill Creek for the majority of the survey area.

### North Fork Mill Creek

North Fork Mill Creek drains a watershed area of 2,700 acres on the North Slope of the Uinta Mountains, in Summit County. The headwaters begin on private land at an elevation of 10,430 ft. in Township 2 North, Range 11 East, Section 21. The stream flows north and then west for approximately 5 miles until it reaches the confluence with Mill Creek, a tributary to the Bear River. The confluence with Mill Creek is located in Township 2 North, Range 11 East, Section 7 northeast quarter, elevation 8740 ft. North Fork Mill Creek flows on private land in Township 2 North, Range 11 East, Sections 5, 9, and 21. The North Slope road runs adjacent to the stream for approximately 2.5 miles. Historic Land uses include timber harvest or tie hacking (Peterson et al. 1980). Current management activities includes grazing, timber harvest, hunting, camping, and hiking.

### Stillwater Fork

Stillwater Fork is a tributary of the Bear River on the north slope of the Uinta Mountains, in Summit County. It is a first -third order stream that drains a watershed area of 24,750 acres. The stream begins at an elevation of 10,560 ft., just northeast of Mt. Agassiz and flows north and northwest for approximately 12.8 miles until it joins with the Hayden Fork in Township 2 North, Range 10 East, Section 32 (elevation 8,500 ft). The Hayden Fork and Stillwater Fork combine to form the Bear River. The Stillwater Fork of the Bear River is entirely on the Wasatch-Cache National Forest. Management activities that have or do occur in the drainage include timber harvest, grazing, hunting, camping, fishing, and hiking (Cowley 1995).

### West Fork Bear River

The West Fork of the Bear River, above Whitney Reservoir, is a 3rd order stream flowing north from the Uinta Mountains, in Summit County. It drains a watershed area of 26,750 acres. The headwaters are located in Township 1 North, Range 9 East, Section 28 at an approximate elevation of 9860 ft. It flows northward for 2.5 miles until emptying into Whitney Reservoir. From the outlet of Whitney Reservoir the West Fork flows north for another 1.8 miles until it leaves the National Forest at the northwest corner of Township 1 North, Range 9 East, Section 3 (elevation 8920 ft). Management activities in the area includes: hunting, fishing, camping, timber harvest and grazing (Cowley 1995). Only the section above the Whitney reservoir was surveyed.

## METHODS

The fish habitat inventories were conducted using a modified Hankins & Reeves survey originally developed in Region 6 (Oregon and Washington) of the United State Department of Agriculture, Forest Service (Stream Inventory Handbook, Region 6, 1990). The Region 6 methodology uses a series of estimated distances weighted and corrected using measured lengths and widths. For example a surveyor would measure only one of every 10 pools. All pools are estimated with the one that is measured being used to generate a correction factor. The 1990 Stillwater Fork survey uses a correction factor to assign a value to all estimated measurements. In the surveys conducted on the Wasatch-Cache National Forest (WC) in 1994 all measurements for all habitat units were measured. Therefore no correction factors were generated or needed.

The habitat inventories are conducted using one or two people. The surveyor starts at the mouth of the stream or when the mouth of the stream is off forest, the inventory may start at or near the forest boundary. The inventory consists of two phases, an office and a field phase.

The office phase is where the stream is divided up into reaches and general map characteristics are measured. A review of the existing available information is also made. A reach generally consists of a length of stream with similar slopes, topography and flows. The reach breaks occur where slopes change or where a major tributary enters the stream, causing differences in flows. These are preliminary reach breaks, which are checked and adjusted in the field. Migration barriers may also serve as a reach breaks where adfluvial or fluvial species may be located.

The field phase consists of measuring and defining a number of habitat characteristics. Each reach is divided up into discrete habitat units. Habitat units are broken up into the following habitat types: pool, riffle, run, glide, side channel, special cases (fall, chute, dam), dry channel, tributary, and culvert. They are distinguished using the Western Division of the American Fisheries Societies glossary of stream habitat terms (1983).

**Pool:** (a) A portion of the stream with reduced current velocity, often with water deeper than the surrounding areas, and which is frequently usable by fish for resting and cover. (b) A small body of standing water, e.g., in a marsh or on the flood plain.

**Riffle:** A shallow rapids where the water flows swiftly over completely or partially submerged obstructions to produce surface agitation, but standing waves are absent.

**Run:** An area of swiftly flowing water, without surface agitation or waves, which approximates uniform flow and in which the slope of the water surface is roughly parallel to the overall gradient of the stream reach.

**Glide:** A slow moving, relatively shallow type of run. Calm water flowing smoothly and gently, with moderately low velocities (10-20 cm/sec), and little or no surface turbulence.

**Side Channel:** Lateral channel with an axis of flow roughly parallel to the mainstem and which is fed by water from the mainstem; a braid of a river with flow appreciably lower than the main channel. Side channel habitat may exist either in well-defined secondary (overflow) channels, or in poorly defined watercourses flowing through partially submerged gravel bars and islands along the margins of the mainstem.

**Special Cases:**

1. **Fall:** (a) A free fall or precipitous descent of water. The plural, falls, may apply to a single waterfall or to a series of waterfalls. (b) A very fast white water cascade.
2. **Chute:** (a) A narrow, confined channel through which water flows rapidly; a rapid or quick descent in a stream, usually with a bedrock substrate. (b) A short straight channel which bypasses a long bend in a stream, and formed by the stream breaking through a narrow land area between two adjacent bends.

3. Dam: Water impounded upstream from a complete or nearly complete channel blockage, typically caused by a log jam, beaver dam, rockslide, or stream habitat improvement device (boulder berm, gabion, log sill, etc.).

Tributary: A stream feeding, joining, or flowing into a larger stream.

The following quantitative measurements are taken in each habitat unit: length, width, maximum depth, pieces of woody material (brush, small, large), and pool tail crest depth (Stream Inventory Handbook, Region 6, 1990). Woody material is defined as brush when the diameter is < 15 cm (6 in) and length is > 6.5 m (20 ft), small when the diameter is > 30 cm (12 in) and length is > 10 m (35 ft), and large when the diameter is > 50 cm (20 in) and length is > 10 m (35 ft). Woody material counts assist the biologist in assessing the pool formation potential of a system and instream cover. The pool tail crest is the restricting feature which ponds water in the pool. Typically this may be a gravel bar or some other form of obstruction. The depth of the pool tail crest is that portion of the pool tail crest which would be the last point allowing water to leave the pool if no additional water was entering the pool from upstream. This information is valuable in that it provides the biologist with a better understanding of the conservation pool that would remain during a low flow period.

Qualitative measurements are also taken of the instream habitat and the riparian vegetation. These include dominant-subdominant substrate classes, total stream cover rating, dominant-subdominant cover types, riparian class and dominant-subdominant riparian species (Stream Inventory Handbook, Region 6, 1990). Substrate classes are categorized as fines (sand, silt, and clay < 0.2 cm), gravel (0.2 cm – 6.4 cm), cobble (6.4 cm – 25.6 cm), small boulder (25.6 cm – 102.4 cm), large boulder (>102.4 cm) and bedrock. Total stream cover rating is broken up into four categories: 0 – 5%, 6 – 20%, 21 – 40%, and >40%. Stream cover ratings are taken by ocular estimate. Cover types include aquatic/emergent vegetation, depth > 1 meter, overhanging vegetation, substrate, turbulence, undercut banks, and woody material. Riparian class describes the successional stage of floodplain vegetation. Riparian classes are divided into grassland/forb, shrub/seedling, sapling/pole, small trees, large trees, and mature trees. Riparian species are divided into two categories: hardwoods and conifers. The riparian zone is split into two sections. The inner riparian zone is the vegetation on the immediate stream banks (0 – 15 ft). The outer riparian zone width for this survey was set at 100 feet. This is viewed as the area of potential influence on the stream.

### CALCULATIONS

The 1994 surveys (Mill Creek, North Fork Mill Creek and West Fork Bear River) were all based on the modified Hankins & Reeves survey originally developed in Region 6 (Oregon and Washington). The Region 6 methodology uses a series of estimated values which are weighted and corrected by using the measured values. No estimated values were used in the 1994 surveys. All habitat units were measured. The majority of calculations in this report are a standard sum, average, ratio or percentage of those measured values. The following calculations were weighted or corrected :

Average width adjusted by length =  $\sum (\text{individual unit width} \times \text{individual unit length}) / \sum \text{all unit lengths}$

Adjusted percent habitat include ½ of all glide habitat as pool habitat. The percent pool and riffle are then re-calculated on a scale of 100.

Adjusted % pool =  $(\% \text{ pool} + \frac{1}{2}(\% \text{ glide})) / (\% \text{ pool} + \frac{1}{2}(\% \text{ glide}) + \% \text{ riffle})$  In calculating the adjusted percent pool we added the percent pool and ½ of the percent glide and divided it by the percent pool, ½ the percent glide and the percent riffle. We used ½ the glide percent because it was assumed that glides were made up of 50% pool like habitat and 50% riffle like habitat.

Adjusted % riffle =  $\% \text{ riffle} / (\% \text{ pool} + \frac{1}{2}(\% \text{ glide}) + \% \text{ riffle})$

Pools per mile =  $(\text{number of pools}) / (\text{reach distance in meters} \times (1 \text{ mile} / 1609.34 \text{ m}))$

Woody material per mile =  $(\text{pieces of wood}) / (\text{reach distance in meters} \times (1 \text{ mile} / 1609.34 \text{ meters}))$

The 1990 Stillwater Fork survey used a procedure similar to the Hankins & Reeves methodology. Only a certain percentage of habitat units were measured, the rest were given estimated values. A total of 279 main channel habitat units were identified in the Stillwater Fork survey (Table 33). Of those units, 58 (21%) length and width measurements were taken, and 50 (18%) depth measurements were taken. Along with each measured value, an estimated value was also recorded to allow for comparison and the generation of a correction factor. By plotting the measured values on the x-axis (independent variable) and the corresponding estimated values on the y-axis (dependent variable), a best-fit straight line was generated. This regression line passed through the y-axis at the point (0,0), because a habitat unit estimated at zero meters should also measure zero meters. The slope of this line was then used to assign a measured value to all remaining estimated values. It is recognized that a certain amount of error is inherent in this procedure.

After this process, all calculations (with two exceptions) for the 1990 Stillwater survey were calculated in the same manner as the 1994 surveys. The two exceptions are adjusted habitat percentages and average depth adjusted by length. They were calculated in the following way:

Adjusted habitat percentages for the 1990 Stillwater Fork survey include ½ of all glide and trench habitat as pool habitat. The percent pool and riffle are then re-calculated on a scale of 100.

$$\text{Adjusted \% pool} = (\% \text{ pool} + \frac{1}{2}(\% \text{ glide}) + \frac{1}{2}(\% \text{ trench})) / (\% \text{ pool} + \frac{1}{2}(\% \text{ glide}) + \frac{1}{2}(\% \text{ trench}) + \% \text{ riffle})$$

$$\text{Adjusted \% riffle} = \% \text{ riffle} / (\% \text{ pool} + \frac{1}{2}(\% \text{ glide}) + \frac{1}{2}(\% \text{ trench}) + \% \text{ riffle})$$

Three depth measurements were taken across the measured habitat units in the 1990 Stillwater Fork survey. An average depth was then calculated by adding these three measurements and dividing by four, to account for zero at the banks. This average depth was then adjusted by length.

$$\text{Average depth adjusted by length} = \sum (\text{individual average depth} \times \text{individual length}) / \sum \text{all unit lengths}$$

## RESULTS

### Mill Creek

#### Reach 1

Reach one began at the private property fence line (GPS 521951 E 4530853 N), 98 feet above the confluence with North Fork Mill Creek, and continued upstream 1720 m (Table 3) to GPS 522172 E 4529679 N, elevation 8920 ft (Table 21). This reach had a sinuosity of 1.20 and an average gradient of 3.4% (Table 17). There were a total of 106 habitat units (Table 6) made up of 10% glide, 66% pool and 24% riffle by surface area (Table 7), and 21% glide, 35% pool and 44% riffle by length (Table 9). The adjusted percentages of habitat by surface area were 75% pool and 25% riffle (Table 8). The adjusted percentages by length were 51% pool and 49% riffle (Table 10). The reach was characterized by a relatively high sinuosity and high number of pools formed mostly by beaver dams. The pools in reach one had an average width of 12.1 m (Table 1), average length of 13.8 m (Table 4) and average maximum depth of 0.59 m (Table 2). The large size of these pools generated a pool: riffle ratio of 2.76 : 1 by surface area (Table 5). The pool: riffle ratio by length was 1 : 1.25 (Table 3). The number of pools per mile was 39 (Table 17), the highest value of the Mill Creek survey. The total length of side channel in reach one was 342.9 m. Each side channel averaged 22.9 m in length (Table 16). The total pieces of woody material per mile were 37, with 24 brush, 13 small, and 0 large (Table 14). The entire reach averaged 6.5 m in width (Table 1) and 0.39 m in maximum depth (Table 2). The riparian community consisted primarily of willow as both the dominant and subdominant species (Table 20). Both bed and bank substrates consisted of fines as dominant and cobble as subdominant (Table 18). The total stream cover rating was 6-20%, with the dominant cover type being depth > 1 m. The subdominant cover type was aquatic/emergent vegetation (Table 19). The maximum water temperature taken during this reach was 53° F (11.7° C) at 3:35 in the afternoon on September 12, 1994 (Table 15). The lower Mill Creek fish sampling section occurs in reach one. This site was sampled in both 1994 and 1999, with cutthroat trout and sculpin present (Figure 1).

#### Reach 2

Reach two was a relatively short reach continuing from GPS 522172 E 4529679 N, elevation 8920 ft up to GPS 522129 E 4529111 N, elevation 8990 ft (Table 21). The reach was 740 m long (Table 3) with a gradient of 3.9 % (Table 17). The channel was highly confined with a sinuosity of 1.13 (Table 17). The reach consisted of 33% glide, 9% pool and 57% riffle by length (Table 9) and 33% glide, 9% pool and 58% riffle by surface area (Table 7). The adjusted values of habitat by length were 31% pool and 69% riffle (Table 10). By surface area the adjusted percentages were 30% pool and 70% riffle (Table 8). The pool: riffle ratio by length was 1: 6.13 (Table 3) and 1: 6.52 by surface area (Table 5). The number of pools per mile was 26 (Table 17). The pieces of woody material per mile were 34 with 2 brush, 28 small and 4 large (Table 14). Widths and depths for all habitat units were fairly uniform with an average reach width of 3.4 m (Table 1) and average maximum depth of 0.40 m (Table 2). One side channel was present in reach two with a length of 16.5 m (Table 16). The dominant and subdominant bed substrate was cobble and small boulder, respectively. The dominant and subdominant bank substrate was gravel and fines, respectively (Table 18). The immediate riparian zone was classified as grassland/forbs with willow being both the dominant and subdominant species. The outer riparian zone consisted of willow as the dominant species and Douglas fir as subdominant (Table 20). The total stream cover value was 6 – 20%. Substrate was both the dominant and subdominant cover type (Table 19). No water temperatures were recorded in reach two.

### Reach 3

Reach three continued from GPS 522129 E 4529111 N, elevation 8,990 to the confluence with Plot Creek at GPS 522123 E 4528240 N, elevation 9,120 ft (Table 21). The reach was 1,095 m long (Table 3) with an average gradient of 4.6% (Table 17). The channel was moderately confined with a sinuosity of 1.13 (Table 17). The total of 60 habitat units (Table 6) was made up of 11% glide, 61% pool and 28% riffle by surface area (Table 7) and 21% glide, 30% pool and 49% riffle by length (Table 9). The adjusted percentages of habitat were 70% pool and 30% riffle by surface area (Table 8) and 45% pool and 55% riffle by length (Table 10). The reach had an average width of 5.7 m (Table 1) and average maximum depth of 0.46 m (Table 2). As in reach one, this area had a higher number of large pools relative to the rest of the stream. The pool: riffle ratio by surface area was 2.15 : 1 (Table 5). The ratio by length was 1: 1.62 (Table 3). The number of pools per mile was 32 (Table 17). The pieces of woody material per mile were 26 with 1 brush, 22 small, and 3 large (Table 14). The total length of side channel in reach three was 118 m. Each side channel averaged 29.5 m in length (Table 16). Both the bed and bank substrates consisted of fines as dominant and gravel as subdominant (Table 19). The inner riparian zone consisted of willow as both dominant and subdominant species. The outer riparian zone species included willow as dominant and lodgepole pine as subdominant (Table 20). Average total stream cover was 6 – 20%, with depth > 1 m as the dominant cover type and overhanging vegetation as subdominant (Table 19). The maximum temperature recorded in reach three was 42° F (5.6° C) at 2:10 in the afternoon on September 14, 1994 (Table 15).

### Reach 4

Reach four started at the confluence of Plot Creek (GPS 522123 E 4528240 N, elevation 9120 ft) and continued upstream to GPS 522724 E 4525433 N, elevation 9660 ft (Table 21). This was the longest reach of the 1994 Mill Creek survey with a length of 3449 m (Table 3). The channel was moderately confined with a sinuosity of 1.11 and average gradient of 5.2% (Table 17). Reach four had less slow water habitat than all other reaches, except six. The reach was made up of 11% glide, 9% pool and 81% riffle by surface area (Table 7) and 13% glide, 7% pool and 81% riffle by length (Table 9). The adjusted percentages of habitat resulted in 15% pool, 85% riffle by surface area (Table 8) and 14% pool, 86% riffle by length (Table 10). The lack of slow water habitat contributed to a pool: riffle ratio of 1: 9.29 by surface area (Table 5) and 1 : 12.38 by length (Table 2). The reach had an average width of 2.8 m (Table 1) and average maximum depth of 0.34 m (Table 2). The number of pools per mile was 23 (Table 17). The pieces of woody material per mile were 95 with 27 brush, 53 small, and 15 large (Table 14). The total length of side channel in reach four was 189.1 m. Each side channel averaged 23.6 m in length (Table 16). The dominant and subdominant bed substrate was cobble and gravel, respectively. The dominant and subdominant bank substrate was gravel and cobble, respectively (Table 18). Willows dominated the inner riparian zone. The outer riparian zone consisted of willows as the dominant species and lodgepole pine as subdominant (Table 20). The dominant cover type was substrate and the subdominant cover type was turbulence. Average total stream cover was 6 – 20% (Table 19). The maximum temperature taken in reach four was 49° F (9.4° C) at 3:15 in the afternoon on September 15, 1994 (Table 15). The majority of reach four, approximately 2534 m, is on private land (Township 2 North, Range 11 East, Sections 19 and 29). The remainder of reach four, approximately 915 m, lies on National Forest (Township 2 North, Range 11 East, Sections 18 and 30).

### Reach 5

Reach five began at GPS 522724 E 4525433 N, elevation 9660 ft and ended at GPS 522771 E 4525012 N, elevation 9700 ft (Table 21). The reach was 323 m long (Table 3) and had a total of 15 habitat units (Table 6). This reach opened into a meadow area with an average gradient of 2.9% and sinuosity of 1.17 (Table 17). Reach five was distinguished by the relatively low gradient and large pools resulting from a historic splash dam and beaver activity. This short reach consisted of 10% glide, 83% pool and 7% riffle by surface area (Table 7) and 29% glide, 42% pool and 29% riffle by length (Table 9). The adjusted percentages of habitat by surface area were 93% pool and 7% riffle by surface area (Table 8). The adjusted percentages, by length, were 66% pool and 34% riffle (Table 10). Due to these large pools the pool: riffle ratio by surface area was 12.41: 1 (Table 5), the highest ratio of the entire survey. The pool: riffle ratio by length was 1.47: 1 (Table 3). The average width for the reach was 5.5 m (Table 1). Average maximum depth was 0.35 m (Table 2). The number of pools per mile was 30 (Table 17). The pieces of woody material per mile was 10 with 10 brush, 0 small, and 0 large (Table 14). No side channels were located in reach five. Both the bed and bank substrates consisted of fines as dominant and gravel as subdominant (Table 18). The immediate and outer riparian zones were classified in grassland/forb condition with willow being the subdominant species (Table 20). The dominant and subdominant cover type was depth > 1 m. The total stream cover value was 0 – 5 % (Table 19). The maximum temperature taken in reach five was 43° F (6.1° C) at 11:25 a.m. on September 20, 1994 (Table 15). The upper Mill Creek fish sampling section occurs in reach five. This site was sampled in both 1994 and 1999 (Cowley 1995). Only cutthroat trout were collected within this section (Figure 2). All of reach five is on private land (Township 2 North, Range 11 East, Section 29).

## Reach 6

Reach six continued from GPS 522771 E 4525012 N, elevation 9700 ft upstream to GPS 522711 E 4524084 N elevation 9960 ft (Table 21). The reach was 1287 m long (Table 3) with a gradient of 8.1%, and a sinuosity of 1.14 (Table 17). Reach six was characterized by a highly confined channel and high gradient. Due to these characteristics, slow water habitat was greatly reduced. The reach was made up of 2% glide, 4% pool and 94% riffle by surface area (Table 7) and 2% glide, 3% pool and 95% riffle by length (Table 9). The adjusted values of habitat by surface area were 5% pool and 95% riffle (Table 8). The adjusted values by length were 4% pool and 96% riffle (Table 10). These were the lowest slow water percentages of the 1994 Mill Creek survey. The pool: riffle ratio was 1: 31.31 by length (Table 3) and 1: 24.81 by surface area (Table 5). The number of pools per mile was 20 (Table 17), also the lowest value of the survey. The pieces of woody material per mile were 43 with 16 brush, 16 small, and 11 large (Table 14). The total length of side channel in reach one was 38.7 m. Each side channel averaged 19.4 m in length (Table 16). Overall stream size became much smaller with an average reach width of 1.4 m (Table 1) and average maximum depth of 0.20 m (Table 2). The dominant and subdominant bed substrate was cobble and gravel respectively. Bank substrates included cobble as dominant and fines as subdominant (Table 18). The inner riparian zone was classified in grassland/forb condition. The outer riparian zone consisted of Douglas fir as both the dominant and subdominant species (Table 20). Total cover was estimated at 0 – 5%, with substrate as the dominant cover type and overhanging vegetation as subdominant (Table 19). The maximum temperature taken in reach six was 45° F (7.2° C) at 4:00 in the afternoon on September 20, 1994 (Table 15). Reach six begins and remains on private land (Township 2 North, Range 11 East, Section 29), until it enters the National Forest at the northern end of Township 2 North, Range 11 East, Section 32.

## North Fork Mill Creek

Due to the lateness of the season (September 21, 1994) only the first 1141 m (Table 25) of North Fork Mill Creek was surveyed. The survey began at the confluence with Mill Creek (GPS 521912 E 4530888 N, elevation 8745 ft) and continued upstream to GPS 522969 E 4531149 N, elevation 8950 ft (Table 27). The survey stopped before the end of reach one was reached. Approximately half of the section surveyed was adjacent to the North Slope road. The stream had an average width of 3.3 m and an average maximum depth of 0.29 m (Table 22). This section of the stream had a gradient of 5.7% and a sinuosity of 1.14 (Table 25). A sinuosity of 1.0 is a completely straight channel. Much of this section of stream has been channelized and straightened because of the North Slope Road. A total of 94 habitat units consisted of 33% glide, 8% pool and 59% riffle by surface area, and 34% glide, 8% pool and 58% riffle by length. The adjusted percentages of habitat were 29% pool, 71% riffle by surface area and 30% pool, 70% riffle by length (Table 23). The pool: riffle ratio was 1: 7.73 by surface area and 1: 7.02 by length (Table 23). This section of stream had a total of 424 m of side channel, with each side channel averaging 47 m in length. The number of pools per mile was 30 (Table 25). The pieces of woody material per mile were 150 with 11 brush, 111 small and 28 large (Table 24). The dominant and subdominant bed substrate was cobble and small boulder, respectively. The dominant and subdominant bank substrate was cobble and gravel, respectively (Table 26). The inner riparian zone consisted of willow as both the dominant and subdominant species. The outer riparian zone was

made up of willow as the dominant species and lodgepole pine as subdominant. The total stream cover was 6 – 20% with substrate as the dominant cover type and overhanging vegetation as subdominant (Table 26). Most of the material along the stream bank was embedded. The maximum water temperature during the survey was 50°F (10°C) at 3:22 in the afternoon on September 21, 1994 (Table 25). The lower North Fork Mill Creek fish sampling site occurs in reach one (within the section surveyed). The upper sampling site is located above the survey section in reach four (Cowley 1995). Only cutthroat and sculpin were captured in the North Fork of Mill Creek (Figures 3 and 4).

In 1998 the drainage of the North Slope Road was modified and the road width reduced to reduce sediment runoff and better protect aquatic values.

## Stillwater Fork

### Reach 1

Reach one started at the Mirror Lake Highway Bridge (GPS 514012 E 4524331 N) and went upstream to the confluence with Hayden Fork (GPS 513921 E 4523824 N), near the upper end of Stillwater campground (Table 43). The total reach distance was 504 m (Table 30) and had a sinuosity of 1.13 (Table 42). The stream was in a relatively flat, open valley with a map gradient of 1.1% and average field gradient of 1.5% (Table 42). This section had an average width of 12.0 m (Table 28) and an average depth of 0.22 m (Table 29). The total of 12 habitat units (Table 33) consisted of 24% glide, 76% riffle by length (Table 34) and 22% glide, 78% riffle by surface area (Table 35). No pools were found within this reach. However, the adjusted percentages, which include ½ of all glides and trenches as pool habitat, resulted in 12% pool and 88% riffle by surface area (Table 38). The adjusted percentages by length were 13% pool and 87% riffle (Table 37). A total of 74.9 m of side channel was present in the reach with each side channel averaging 12.5 m in length (Table 41). The average instream cover for reach one was 10% (Table 42). No water temperatures were recorded in reach one.

### Reach 2

Reach two continued from the confluence with Hayden Fork up to GPS 513890 E 4523248 N, elevation 8517 ft (Table 43). The reach was 633 m long (Table 30) with a sinuosity of 1.22 (Table 42). The map gradient was 1.0% and average field gradient was 2.3% (Table 42). As in reach one, no pools were found within this reach. It was made up of 32% glide and 68% riffle by surface area (Table 35) and 31% glide and 69% riffle by length (Table 34). The adjusted habitat percentages resulted in 19% pool and 81% riffle by surface area (Table 38). The adjusted percentages by length were 18% pool and 82% riffle (Table 37). Reach two had an average width of 6.8 m (Table 28) and an average depth of 0.24 m (Table 29). No side channels were located within the reach. The average instream cover was 7% (Table 42). The maximum temperature recorded in reach two was 58° F (14.4° C) at 2:10 in the afternoon of August 15, 1990 (Table 40). The lower Stillwater Fork fish sampling site is located within reach two, just above the Hayden Fork confluence and Stillwater campground. This site was sampled on August 15, 1994 (Cowley 1995) with cutthroat trout, brook trout, rainbow trout, mountain whitefish, mountain sucker, and sculpin present (Figure 5).

### Reach 3

Reach three went from GPS 513890 E 4523248 N, elevation 8517 ft up to GPS 514391 E 4522827 N, elev. 8545 ft (Table 43). The reach was 843 m long (Table 30) and with both field and map gradients of 1.0% (Table 42). The sinuosity value was 1.32 (Table 42). The reach consisted of 31% glide, 7% pool and 62% riffle by surface area (Table 35) and 40% glide, 7% pool and 53% riffle by length (Table 34). The adjusted percentages of habitat by surface area were 27% pool and 73% riffle (Table 38). The adjusted percentages by length were 33% pool and 67% riffle (Table 37). The pool: riffle ratio was 1: 9.02 by surface area (Table 32) and 1: 7.63 by length (Table 30). The low number of pools within the reach led to a value of 4 pools per mile (Table 42). The average instream cover was 9% (Table 42). Reach three had an average width of 7.7 m (Table 28) and an average depth of 0.21 m (Table 29). No side channels were identified within the reach. The maximum temperature recorded in reach three was 56° F (13.3° C) at 11:10 a.m. on August 16, 1990 (Table 40).

### Reach 4

Reach four continued from GPS 514391 E 4522827 N, elev. 8545 ft and went upstream to GPS 515753 E 4520469

N, elev. 8715 ft (Table 43). This reach was 3,158 m long (Table 30) and had a sinuosity of 1.20 (Table 42). The map gradient was 1.5% and the average field gradient was 1.9% (Table 42). The average width of this section was 7.4 m (Table 28). The average depth was 0.21 m (Table 29). The total of 98 habitat units (Table 33) consisted of 14% glide, 6% pool and 80% riffle by surface area (Table 35) and 17% glide, 7% pool and 76% riffle by length (Table 34). The adjusted percentages of habitat by surface area were 14% pool and 86% riffle (Table 38). The adjusted values by length were 17% pool and 83% riffle (Table 37). The pool: riffle ratio was 1: 12.93 by surface area (Table 32) and 1: 10.77 by length (Table 30). The number of pools per mile was 10 (Table 42). The average percent of instream cover through the reach was 14 % (Table 42), the highest value of the Stillwater survey. A total of 914.3 m of side channel was present in the reach, with an average length of 100.9 m per side channel (Table 41). The maximum temperature recorded in reach four was 61° F (16.1° C) at 3:13 in the afternoon on August 21, 1990 (Table 40).

### Reach 5

Reach five began at GPS 515753 E 4520469 N, elev. 8715 ft and went upstream to the Christmas Meadows Bridge at GPS 516188 E 4520090 N, elevation 8735 ft (Table 43). The reach was 629 meters long (Table 30) and consisted of 29 habitat units (Table 33). Reach five had an average width of 8.5 m (Table 28) and an average depth of 0.23 m (Table 29). The average field gradient was 3.6% and the map gradient was 1.0%. The sinuosity value was 1.22 (Table 42). Reach five had the only cascade habitat units of the Stillwater Fork survey. The composition of the reach was 4% cascade, 47% glide, 5% pool, and 43% riffle by surface area (Table 35). By length the reach consists of 6% cascade, 48% glide, 7% pool and 39% riffle (Table 34). The adjusted percentages of habitat by surface area were 40% pool and 60% riffle (Table 38). The adjusted percentages by length were 44% pool and 56% riffle (Table 37). The pool: riffle ratio was 1: 8.02 by surface area (Table 32) and 1: 5.49 by length (Table 30). The number of pools per mile was 10 (Table 42). A total of 81.0 m of side channel was present with an average side channel length of 40.5 m (Table 41). The percent of instream cover was 7% (Table 42). The maximum temperature recorded in reach five was 60° F (15.6° C) at 2:45 in the afternoon on August 28, 1990 (Table 40).

### Reach 6

Reach six continued from the Christmas meadows bridge (elevation 8735 ft) up to an unnamed tributary coming in at GPS 517018 E 4518046 N, elev. 8795 ft (Table 43). Reach six was the longest reach of the Stillwater survey with a length of 3,990 m (Table 30). This reach is characterized by numerous meanders through the Christmas meadows area. These meanders result in a relatively high sinuosity value of 1.44 (Table 42). The map and field gradients were 0.6% and 1.4%, respectively (Table 42). The stream becomes wider and deeper through this section with an average reach width of 11.4 m (Table 28) and an average depth of 0.58 m (Table 29). Reach six is the only reach in the Stillwater Fork survey with trench habitat. The trench habitat was described as a deep, pool-like channel. The total of 84 habitat units (Table 33) were made up of 18% glide, 14% pool, 23% riffle and 45% trench by surface area (Table 35). The composition by length was 21% glide, 16% pool, 26% riffle and 36% trench (Table 34). The adjusted percentages, which include ½ of all glides and trenches as pool habitat, produced the highest slow water percentages of the Stillwater Fork survey. The adjusted values by surface area were 66% pool and 34% riffle (Table 38). By length the adjusted values were 63% pool and 37% riffle (Table 37). The pool: riffle ratio was 1: 1.70 by surface area (Table 32) and 1: 1.61 by length (Table 30). The number of pools per mile was 10 (Table 42). The average instream cover of was 9% (Table 42). Reach six had 574.7 m of side channel with each side channel averaging 114.9 m in length (Table 41). The maximum temperature recorded in reach six was 62° F (16.7° C) at 3:05 in the afternoon on September 7, 1990 (Table 40).

### Reach 7

Reach seven continued from the tributary coming in at GPS 517018 E 4518046 N, elev. 8795 ft upstream to GPS 517199 E 4517469 N, elev. 8815 ft (Table 43). The reach was 713 m long (Table 30) with map and field gradients of 0.8% and 1.8% respectively, and a sinuosity of 1.45 (Table 42). The stream continued a meandering path in reach seven, which produced a sinuosity value of 1.45 (Table 42). The reach had an average width of 8.9 m (Table 28) and an average depth of 0.30 m (Table 29). A total of 13 habitat units (Table 33) consisted of 18% glide, 21% pool, and 61% riffle by surface area (Table 35) and 25% glide, 18% pool and 57% riffle by length (Table 34). The adjusted percentages of habitat by surface area were 33% pool and 67% riffle (Table 38). The adjusted percentages by length were 35% pool and 65% riffle (Table 37). The number of pools per mile was 11 (Table 42). The pool: riffle ratio was 1: 2.95 by surface area (Table 32) and 1: 3.14 by length (Table 30). The percent of instream cover was 10% (Table 42). No side channel habitat was found in reach seven. The maximum temperature recorded in reach seven was 46° F (7.8° C) at 11:00 a.m. on October 27, 1990 (Table 40).

## West Fork Bear River

The West Fork of the Bear River was divided into 5 stream reaches for the 1993-94 surveys. The stream below Whitney Reservoir was not surveyed. The survey above the reservoir started at the reservoir and went upstream. Much of this area was composed of willow, sagebrush and conifers.

### Reach 1

Reach one started at the reservoir and continued upstream 519 meters (Table 46) to GPS 506131 E 4518690 N, elevation 9330 ft (Table 64). This reach had an average width of 3.3 m (Table 44) and an average maximum depth of 0.41 m (Table 45). The gradient in this section was 3.6% and the sinuosity value was 1.10 (Table 60). The reach was characterized by a large number of beaver dams, which contributed to relatively high slow water percentages. Reach one consisted of 5% glide, 55% pool and 40% riffle by surface area (Table 50) and 6% glide, 41% pool and 53% riffle by length (Table 52). The adjusted percentages of habitat by surface area were 59% pool and 41% riffle (Table 51). The adjusted percentages by length were 45% pool and 55% riffle (Table 53). The number pools per mile was 37 (Table 60). The pool: riffle ratio by surface area was 1.37 : 1 (Table 48). The ratio by length was 1 : 1.31 (Table 46). The total length of side channel in reach one was 194.5 m. Each side channel averaged 32.4 m in length (Table 59). No woody material was found within this reach. The dominant and subdominant bed substrate was fines and gravel, respectively. The dominant and subdominant bank substrate was fines and small boulder, respectively (Table 61). The inner riparian zone was classified in shrub/seedling condition with willow as the dominant species and lodgepole pine as subdominant (Table 63). Total cover was estimated at 6 - 20% with turbulence being the dominant cover type and overhanging vegetation the subdominant (Table 62). The maximum temperature recorded in reach one was 60° F (15.6° C) at 2:00 in the afternoon on July 28, 1993 (Table 58). There was one ford within the reach that needed to be corrected to prevent additional sedimentation and silting in spawning areas. The upper West Fork of the Bear River fish sampling site is located at end of reach one (Figure 9). This site was sampled in 1994 with cutthroat, cutthroat/rainbow hybrid, and sculpin present (Cowley 1995).

### Reach 2

Reach two started where the conifers first reached the stream and went upstream 1,390 m (Table 46) to where a dry channel entered the stream at GPS 505978 E 4517534 N, elevation 9449 ft (Table 64). Water in this section ends 34 m below the reach break. In 1994 these 34 meters and an additional 495 meters at the beginning of reach three, were dry. Reach two, excluding the dry section had an average width of 1.8 m (Table 44) and average maximum depth of 0.24 m (Table 45). The pool : riffle ratio was 1 : 2.73 by surface area (Table 48) and 1 : 3.66 by length (Table 46). The reach had a gradient of 2.6% and sinuosity of 1.19 (Table 60). Reach two consisted of 48% glide habitat, 14% pool habitat, and 38% riffle habitat by surface area (Table 50). The composition by length was 50% glide, 11% pool, and 39% riffle (Table 52). The adjusted percentages of habitat by surface area were 50% pool and 50% riffle (Table 51). The adjusted percentages by length were 48% pool and 52% riffle (Table 53). The number of pools per mile was 31 (Table 60). Woody material consisted of 23 pieces per mile with 21 brush, 2 small and 0 large (Table 57). The total length of side channel in reach two was 8.4 m. Each side channel averaged 2.1 m in length (Table 59). Both the inner and outer riparian zones consisted of willow as the dominant species and Douglas fir as the subdominant species (Table 63). The bed substrate was made up of gravel as both dominant and subdominant. The bank substrate was gravel and cobble, respectively (Table 61). The total cover value was 0 - 5% with substrate being both the dominant and subdominant cover type (Table 62). The maximum temperature recorded in reach two was 62° F (16.7° C) at 3:50 in the afternoon on July 19, 1994 (Table 58).

### Reach 3

Reach three started at the dry tributary and went upstream 945 meters (Table 46) to GPS 506032 E 4516811 N, elevation 9600 ft (Table 64). The lower 495 meters of reach three were dry in 1994. Reach three, excluding the dry section, had an average width of 2.0 m (Table 44) and average maximum depth of 0.24 m (Table 45). The stream in this section was moderately confined and steeper with a sinuosity of 1.09 and gradient of 6.7% (Table 60). The pool : riffle ratio by surface area was 1 : 11.33 (Table 48). The ratio by length was 1 : 9.29 (Table 46). Reach three consisted of 38% glide, 5% pool, and 57% riffle by surface area (Table 50) and 35% glide, 6% pool and 59% riffle by length (Table 52). The adjusted percentages of habitat by both surface area and length were 29% pool and 71% riffle (Tables 51 and 53). The number of pools per mile was 12 (Table 60). Reach three had the lowest pools per mile and slow water percentages of all reaches. Woody material consisted of only 2 small pieces per mile (Table

57). No side channel habitat was found in reach three. The dominant bed substrate type was cobble with gravel being subdominant. Bank substrates were not identified (Table 61). The total cover rating was 0 - 5% with substrate and turbulence the dominant and subdominant cover types (Table 62). No riparian or water temperature information was recorded in reach three.

#### Reach 4

Reach four continued upstream from GPS 506032 E 4516811 N, elevation 9600 ft to GPS 506390 E 4516341 N elevation 9680 ft (Table 64). The total reach length was 575 m (Table 46), with an average width of 1.5 m (Table 44) and an average maximum depth of 0.23 m (Table 45). The reach had a gradient of 4.0% and sinuosity of 1.11 (Table 60). The pool: riffle ratio was 1 : 5.09 by surface area (Table 48) and 1 : 5.63 by length (Table 46). Reach four was made up of 50% glide habitat, 8% pool habitat and 42% riffle habitat by surface area (Table 50). The habitat composition by length was 56% glide, 7% pool, and 37% riffle (Table 52). The adjusted percentages of habitat by surface area were 44% pool and 56% riffle (Table 51). The adjusted percentages by length were 48% pool and 52% riffle (Table 53). The number of pools per mile was 22 (Table 60). No woody material was found within this reach. One side channel was present in reach four with a length of 12.6 m. The bed and bank substrates consisted of cobble as dominant and gravel as subdominant (Table 61). The riparian community consisted of willow as the dominant species and dogwood as the subdominant species (Table 63). Total cover was 0 - 5% with substrate and overhanging vegetation the dominant and subdominant cover types (Table 62). The maximum temperature recorded in reach four was 64° F (17.8° C) at 12:45 in the afternoon on July 21, 1994 (Table 58).

#### Reach 5

Reach five is the shortest of all reaches in the West Fork Bear River survey with a total length of 89 m (Table 46). It continued from GPS 506390 E 4516341 N, elevation 9680 ft upstream to GPS 506377 E 4516143 N, elevation 9730 ft (Table 64). The reach had a gradient of 8.3% and sinuosity of 1.09 (Table 60). The average width was 0.9 m (Table 44) and the average maximum depth was 0.15 m (Table 45). The pool: riffle ratio by surface area was 1 : 2.59 (Table 48). The ratio by length was 1 : 2.70 (Table 46). Reach five consisted of 5% glide, 26% pool, and 68% riffle by surface area (Table 50) and 5% glide, 25% pool and 70% riffle by length (Table 52). The adjusted percentages of habitat by surface area were 30% pool and 70% riffle (Table 51). The adjusted percentages by length were 29% pool and 71% riffle (Table 53). The number of pools per mile was 109 (Table 60). Woody material consisted of 635 pieces per mile with 36 brush, 363 small, and 236 large (Table 57). These are the largest pools per mile and woody material per mile values of all reaches. Even so, it should be remembered that this reach was only 89 meters long (Table 46) with an average width of 0.9 m (Table 44) and an average maximum depth of 0.2 m (Table 45). No side channel habitat was found in reach five. The dominant bed substrate was cobble with gravel being subdominant. The bank substrates consisted of fines as dominant and gravel as subdominant (Table 61). The inner riparian zone consisted of Douglas fir as both the dominant and subdominant species. The outer riparian zone was made up of Douglas fir as dominant and lodgepole pine as subdominant (Table 63). Reach five has approximately 0 -5% total cover with substrate and undercut banks the dominant and subdominant cover types (Table 62). The maximum temperature recorded in reach five was 50° F (10.0° C) at 11:30 in the morning on September 1, 1994 (Table 58).

FIGURE 1. LENGTH FREQUENCY DISTRIBUTION OF CUTTHROAT TROUT CAPTURED IN THE LOWER SECTION (REACH ONE) OF MILL CREEK, BEAR RIVER DRAINAGE, SUMMIT COUNTY, UTAH, IN 1994 AND 1999 (COWLEY 1995).

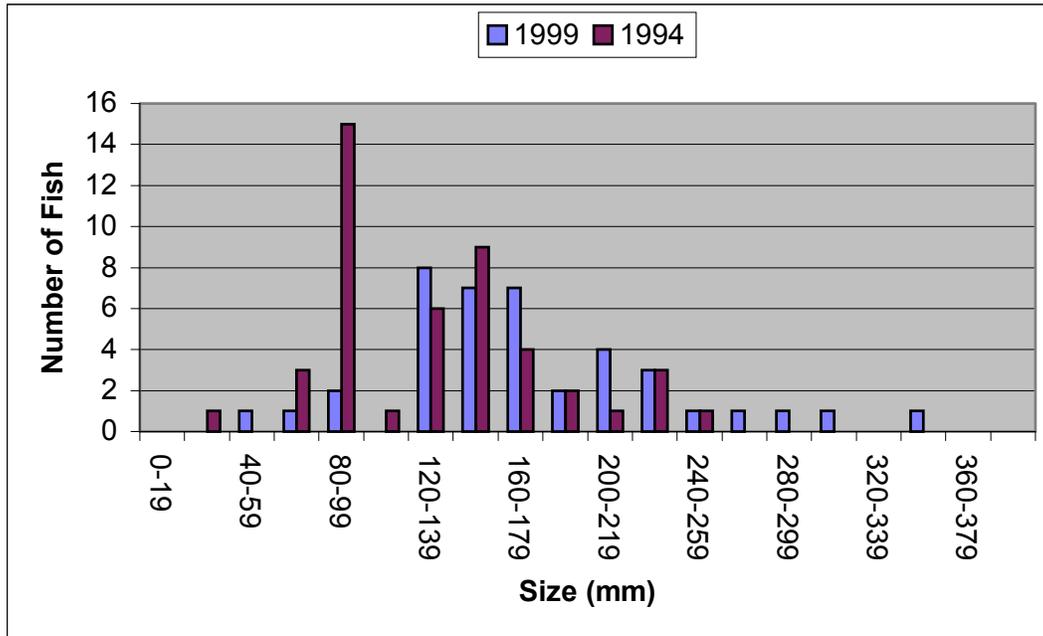


FIGURE 2. LENGTH FREQUENCY DISTRIBUTION OF CUTTHROAT TROUT CAPTURED IN THE UPPER SECTION (REACH FIVE) OF MILL CREEK, BEAR RIVER DRAINAGE, SUMMIT COUNTY, UTAH, IN 1994 AND 1999 (COWLEY 1995).

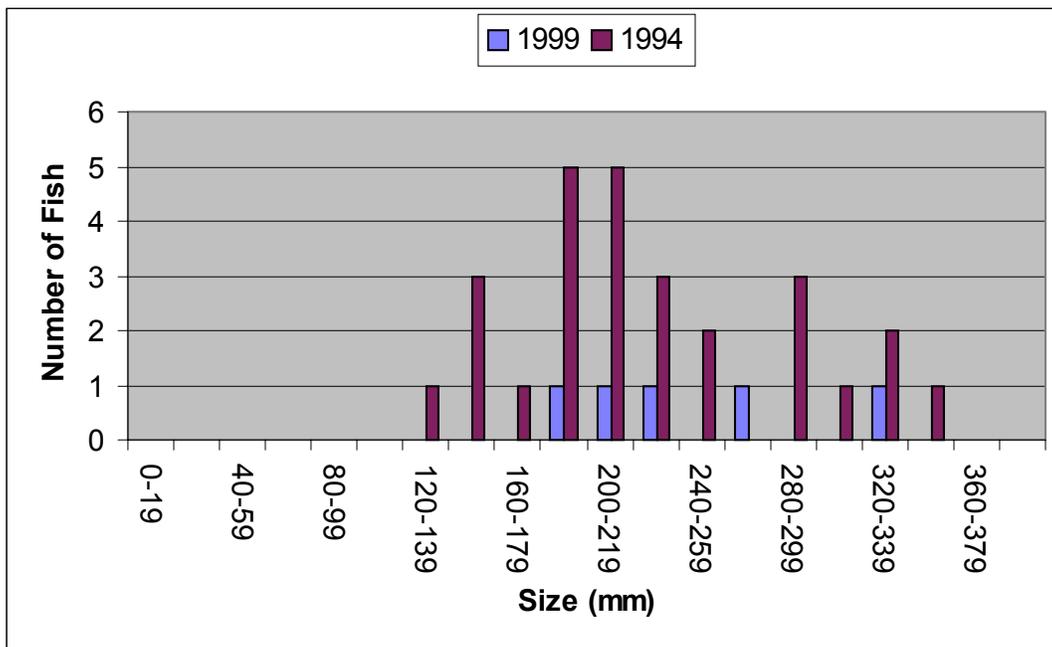


FIGURE 3. LENGTH FREQUENCY DISTRIBUTION OF CUTTHROAT TROUT CAPTURED IN THE LOWER SECTION (REACH ONE) OF NORTH FORK MILL CREEK, BEAR RIVER DRAINAGE, SUMMIT COUNTY, UTAH, IN 1994 (COWLEY 1995).

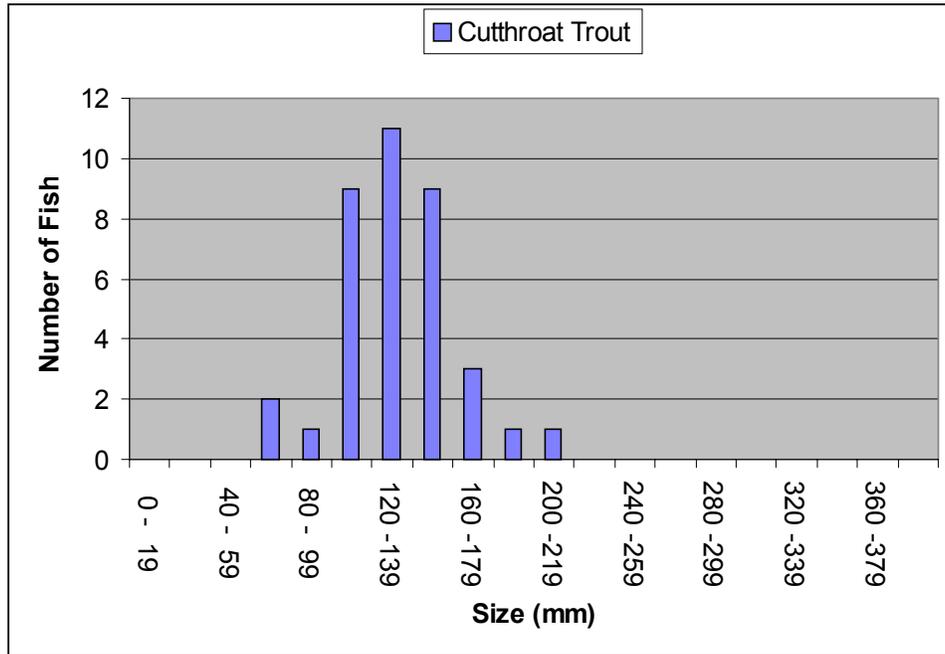


FIGURE 4. LENGTH FREQUENCY DISTRIBUTION OF CUTTHROAT TROUT CAPTURED IN THE UPPER SECTION (REACH FOUR) OF NORTH FORK MILL CREEK, BEAR RIVER DRAINAGE, SUMMIT COUNTY, UTAH, IN 1994 (COWLEY 1995).

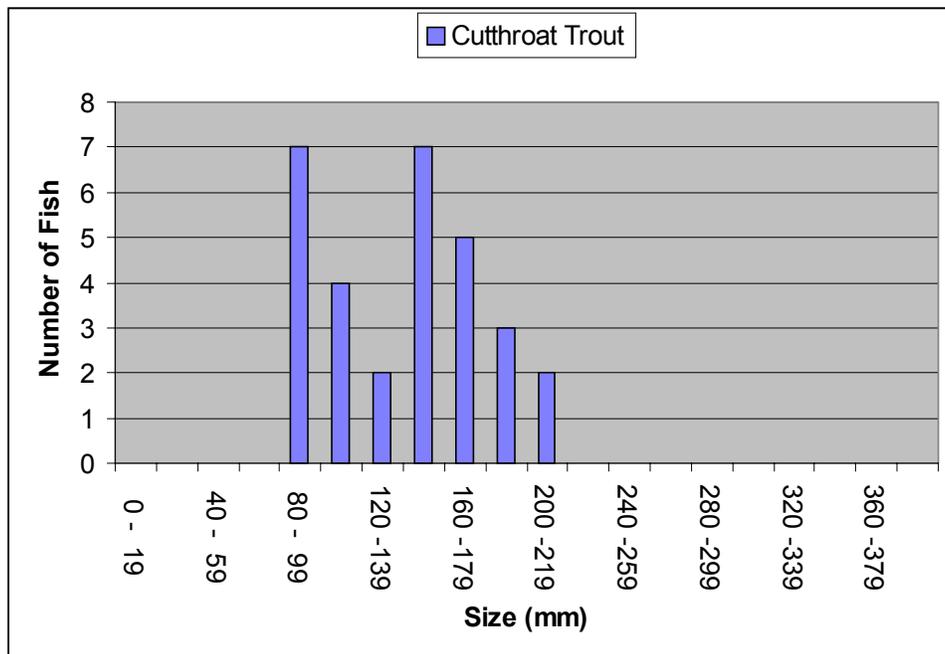


FIGURE 5. LENGTH FREQUENCY DISTRIBUTION OF BROOK TROUT, CUTTHROAT TROUT, RAINBOW TROUT, AND MOUNTAIN WHITEFISH CAPTURED IN THE LOWER SECTION OF STILLWATER FORK, BEAR RIVER DRAINAGE, SUMMIT COUNTY, UTAH, IN 1994 (COWLEY 1995).

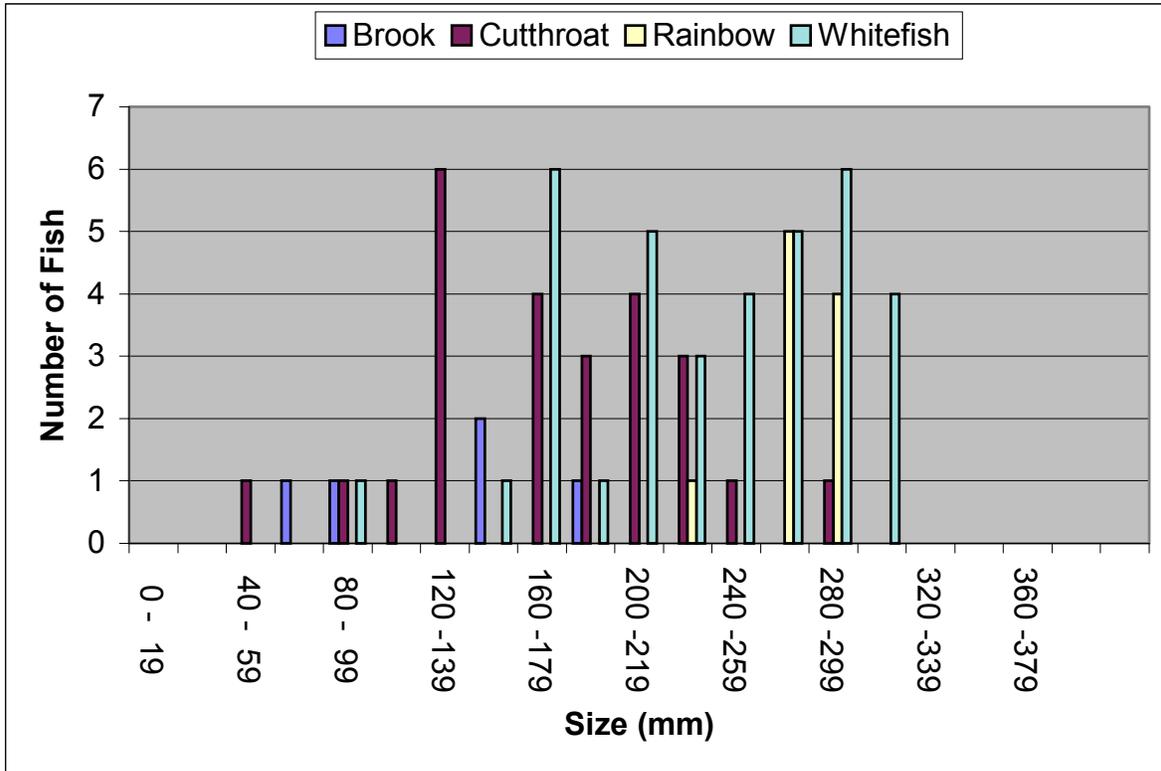


FIGURE 6. LENGTH FREQUENCY DISTRIBUTION OF CUTTHROAT TROUT CAPTURED IN THE MIDDLE SECTION OF STILLWATER FORK, BEAR RIVER DRAINAGE, SUMMIT COUNTY, UTAH, IN 1994 (COWLEY 1995).

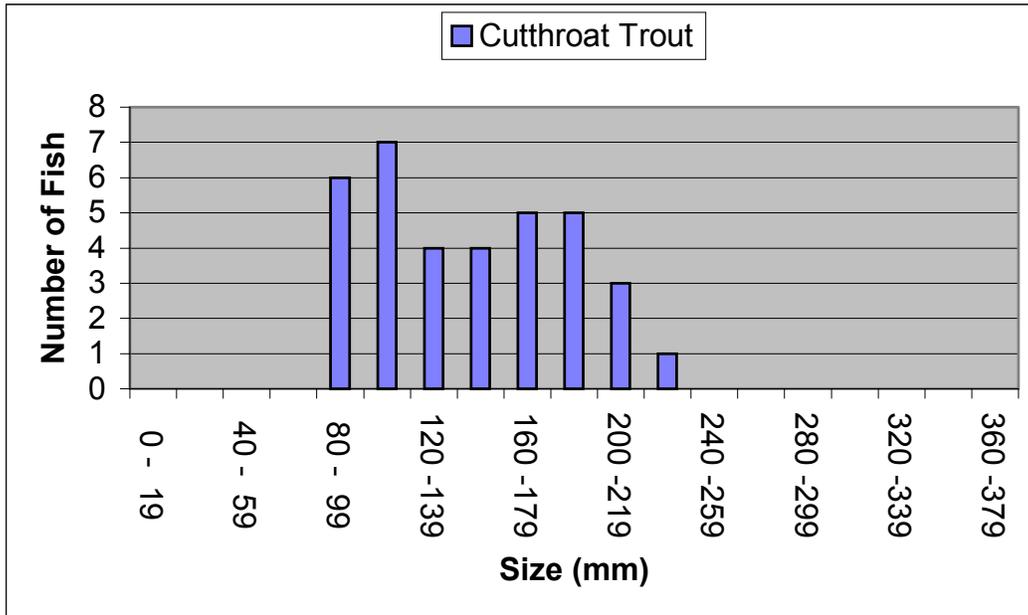


FIGURE 7. LENGTH FREQUENCY DISTRIBUTION OF CUTTHROAT TROUT CAPTURED IN THE UPPER SECTION OF STILLWATER FORK, BEAR RIVER DRAINAGE, SUMMIT COUNTY, UTAH, IN 1994 (COWLEY 1995).

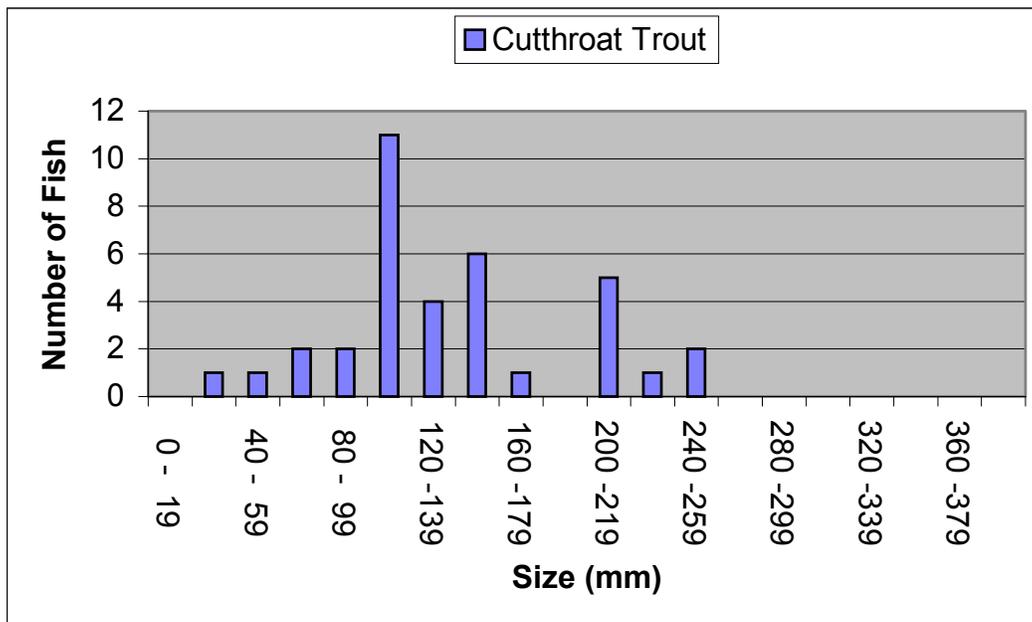


FIGURE 8. LENGTH FREQUENCY DISTRIBUTION OF CUTTHROAT TROUT CAPTURED IN THE LOWER SECTION OF WEST FORK BEAR RIVER, BEAR RIVER DRAINAGE, SUMMIT COUNTY, UTAH, IN 1994 (COWLEY 1995).

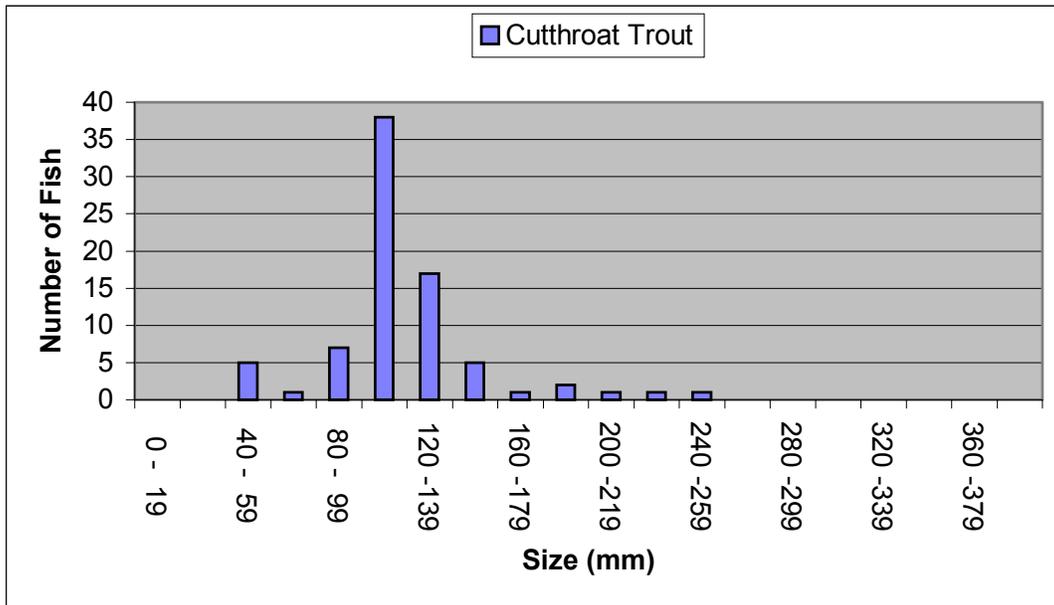


FIGURE 9. LENGTH FREQUENCY DISTRIBUTION OF CUTTHROAT TROUT CAPTURED IN THE UPPER SECTION (REACH ONE) OF WEST FORK BEAR RIVER, BEAR RIVER DRAINAGE, SUMMIT COUNTY, UTAH, IN 1994 (COWLEY 1995).

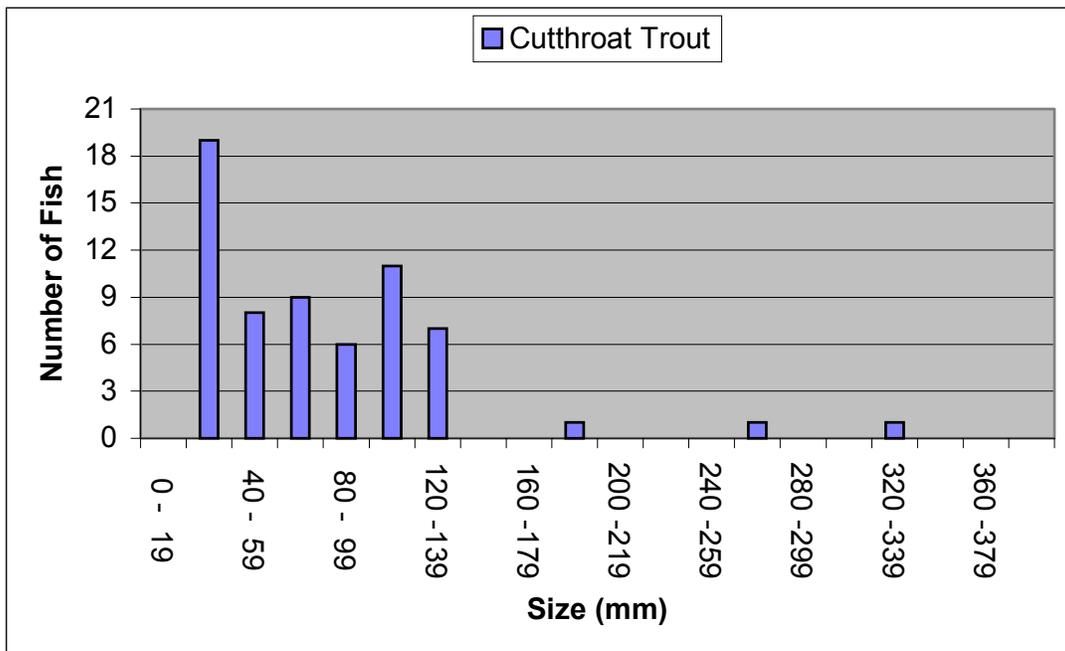


Table 1. Average width (m) adjusted by length in Mill Creek, Summit County, Utah, 1994.

<b>AVERAGE WIDTH (M)</b>				
<b>REACH</b>	GLIDE	POOL	RIFFLE	AVG <sup>(a)</sup>
<b>1</b>	3.2	12.1	3.5	6.5
<b>2</b>	3.4	3.2	3.5	3.4
<b>3</b>	2.9	11.6	3.3	5.7
<b>4</b>	2.4	3.7	2.8	2.8
<b>5</b>	2.0	10.9	1.3	5.5
<b>6</b>	1.4	1.8	1.4	1.4
<b>AVG</b>	2.8	9.7	2.7	3.8

(a) Average for reach and all habitat units.

Table 2. Average maximum depth (m) in Mill Creek, Summit County, Utah, 1994.

<b>AVERAGE MAXIMUM DEPTH (M)</b>				
<b>REACH</b>	GLIDE	POOL	RIFFLE	AVG <sup>(a)</sup>
<b>1</b>	0.36	0.59	0.22	0.39
<b>2</b>	0.37	0.51	0.31	0.40
<b>3</b>	0.38	0.68	0.33	0.46
<b>4</b>	0.31	0.43	0.28	0.34
<b>5</b>	0.28	0.64	0.13	0.35
<b>6</b>	0.19	0.25	0.15	0.20
<b>AVG</b>	0.31	0.52	0.24	0.36

(a) Average for reach and all habitat units.

Table 3. Total length (m) of habitat units in, Mill Creek, Summit County, Utah, 1994.

<b>TOTAL LENGTH (M)</b>					
<b>REACH</b>	GLIDE	POOL	RIFFLE	TOTAL	TOTAL <sup>(a)</sup>
<b>1</b>	340	578	722	1640	1720
<b>2</b>	246	69	423	737	740
<b>3</b>	227	322	522	1070	1095
<b>4</b>	428	224	2772	3424	3449
<b>5</b>	91	132	90	314	323
<b>6</b>	24	39	1221	1283	1287
<b>TOTAL</b>	1357	1364	5749	8469	8614

(a) Including special cases (falls, dams and culverts)

Table 4. Average habitat unit length in Mill Creek, Summit County, Utah, 1994.

<b>AVERAGE LENGTH (M)</b>			
<b>REACH</b>	GLIDE	POOL	RIFFLE
<b>1</b>	14.8	13.8	17.6
<b>2</b>	14.4	5.8	18.4
<b>3</b>	14.2	14.6	23.7
<b>4</b>	11.3	4.6	37.5
<b>5</b>	18.3	22.1	22.6
<b>6</b>	6.0	2.4	64.2
<b>AVG</b>	13.2	10.5	30.7

Table 5. Surface area (m<sup>2</sup>) of habitat units in Mill Creek, Summit County, Utah, 1994.

<b>SURFACE AREA (M<sup>2</sup>)</b>				
<b>REACH</b>	GLIDE	POOL	RIFFLE	TOTAL
<b>1</b>	1096	6984	2531	10611
<b>2</b>	833	225	1468	2526
<b>3</b>	659	3736	1739	6134
<b>4</b>	1036	835	7755	9626
<b>5</b>	182	1440	116	1738
<b>6</b>	35	70	1737	1842
<b>TOTAL</b>	3840	13291	15346	32478

Table 6. Count of habitat units in Mill Creek, Summit County, Utah, 1994.

<b>COUNT OF HABITAT UNITS</b>				
<b>REACH</b>	GLIDE	POOL	RIFFLE	TOTAL
<b>1</b>	23	42	41	106
<b>2</b>	17	12	23	52
<b>3</b>	16	22	22	60
<b>4</b>	38	50	74	162
<b>5</b>	5	6	4	15
<b>6</b>	4	16	19	39
<b>TOTAL</b>	103	148	183	434

Table 7. Percent of habitat by surface area (m<sup>2</sup>) in Mill Creek, Summit County, Utah, 1994.

<b>PERCENT OF HABITAT BY SURFACE AREA (M<sup>2</sup>)</b>				
<b>REACH</b>	<b>GLIDE</b>	<b>POOL</b>	<b>RIFFLE</b>	<b>TOTAL</b>
<b>1</b>	10%	66%	24%	100%
<b>2</b>	33%	9%	58%	100%
<b>3</b>	11%	61%	28%	100%
<b>4</b>	11%	9%	81%	100%
<b>5</b>	10%	83%	7%	100%
<b>6</b>	2%	4%	94%	100%
<b>AVG</b>	12%	41%	47%	100%

Table 8. Adjusted percent of habitat by surface area (m<sup>2</sup>) in Mill Creek, Summit County, Utah, 1994.

<b>ADJUSTED % OF HABITAT BY SURFACE AREA (M<sup>2</sup>)</b>			
<b>REACH</b>	<b>POOL<sup>(a)</sup></b>	<b>RIFFLE<sup>(b)</sup></b>	<b>TOTAL</b>
<b>1</b>	75%	25%	100%
<b>2</b>	30%	70%	100%
<b>3</b>	70%	30%	100%
<b>4</b>	15%	85%	100%
<b>5</b>	93%	7%	100%
<b>6</b>	5%	95%	100%
<b>AVG</b>	50%	50%	100%

(a) Adjusted % pool = (% pool + ½(% glide)) / (% pool + ½(% glide) + % riffle)

(b) Adjusted % riffle = % riffle / (% pool + ½(% glide) + % riffle)

Table 9. Percent of habitat by length (m) in Mill Creek, Summit County, Utah, 1994.

<b>PERCENT OF HABITAT BY LENGTH (M)</b>				
<b>REACH</b>	<b>GLIDE</b>	<b>POOL</b>	<b>RIFFLE</b>	<b>TOTAL</b>
<b>1</b>	21%	35%	44%	100%
<b>2</b>	33%	9%	57%	100%
<b>3</b>	21%	30%	49%	100%
<b>4</b>	13%	7%	81%	100%
<b>5</b>	29%	42%	29%	100%
<b>6</b>	2%	3%	95%	100%
<b>AVG</b>	16%	16%	68%	100%

Table 10. Adjusted percent of habitat by length (m) in Mill Creek, Summit County, Utah, 1994.

<b>ADJUSTED % OF HABITAT BY LENGTH (M)</b>			
<b>REACH</b>	<b>POOL<sup>(a)</sup></b>	<b>RIFFLE<sup>(b)</sup></b>	<b>TOTAL</b>
<b>1</b>	51%	49%	100%
<b>2</b>	31%	69%	100%
<b>3</b>	45%	55%	100%
<b>4</b>	14%	86%	100%
<b>5</b>	66%	34%	100%
<b>6</b>	4%	96%	100%
<b>AVG</b>	26%	74%	100%

(a) Adjusted % pool = (% pool + ½(% glide)) / (% pool + ½(% glide) + % riffle)

(b) Adjusted % riffle = % riffle / (% pool + ½(% glide) + % riffle)

Table 11. Percent of habitat by count in Mill Creek, Summit County, Utah, 1994.

<b>PERCENT OF HABITAT BY COUNT</b>				
<b>REACH</b>	<b>GLIDE</b>	<b>POOL</b>	<b>RIFFLE</b>	<b>TOTAL</b>
<b>1</b>	22%	40%	39%	100%
<b>2</b>	33%	23%	44%	100%
<b>3</b>	27%	37%	37%	100%
<b>4</b>	23%	31%	46%	100%
<b>5</b>	33%	40%	27%	100%
<b>6</b>	10%	41%	49%	100%
<b>AVG</b>	25%	35%	40%	100%

Table 12. Adjusted percent of habitat by count in Mill Creek, Summit County, Utah, 1994.

<b>ADJUSTED % OF HABITAT BY COUNT</b>			
<b>REACH</b>	<b>POOL<sup>(a)</sup></b>	<b>RIFFLE<sup>(b)</sup></b>	<b>TOTAL</b>
<b>1</b>	57%	43%	100%
<b>2</b>	47%	53%	100%
<b>3</b>	58%	42%	100%
<b>4</b>	48%	52%	100%
<b>5</b>	68%	32%	100%
<b>6</b>	49%	51%	100%
<b>AVG</b>	53%	47%	100%

(a) Adjusted % pool = (% pool + ½(% glide)) / (% pool + ½(% glide) + % riffle)

(b) Adjusted % riffle = % riffle / (% pool + ½(% glide) + % riffle)

Table 13. Woody material counts in Mill Creek, Summit County, Utah, 1994.

<b>WOODY MATERIAL COUNTS</b>				
<b>REACH</b>	<b>BRUSH<sup>(a)</sup></b>	<b>SMALL<sup>(b)</sup></b>	<b>LARGE<sup>(c)</sup></b>	<b>TOTAL</b>
1	26	14	0	40
2	1	13	2	16
3	1	15	2	18
4	57	113	33	203
5	2	0	0	2
6	13	13	9	35
<b>TOTAL</b>	100	168	46	314

- (a) Brush = Diameter > 15cm (6 in), length > 6.5 m (20 ft)
- (b) Small = Diameter > 30 cm (12 in), length > 10 m (35 ft)
- (c) Large = Diameter > 50cm (20 in), length > 10 m (35 ft)

Table 14. Woody material per mile in Mill Creek, Summit County, Utah, 1994.

<b>WOODY MATERIAL PER MILE</b>				
<b>REACH</b>	<b>BRUSH<sup>(a)</sup></b>	<b>SMALL<sup>(b)</sup></b>	<b>LARGE<sup>(c)</sup></b>	<b>TOTAL</b>
1	24	13	0	37
2	2	28	4	34
3	1	22	3	26
4	27	53	15	95
5	10	0	0	10
6	16	16	11	43
<b>TOTAL</b>	19	31	9	59

- (a) Brush = Diameter > 15cm (6 in), length > 6.5 m (20 ft)
- (b) Small = Diameter > 30 cm (12 in), length > 10 m (35 ft)
- (c) Large = Diameter > 50cm (20 in), length > 10 m (35 ft)

Table 15. Maximum water temperatures recorded in Mill Creek, Summit County, Utah, 1994.

<b>MAXIMUM TEMPERATURES</b>				
<b>REACH</b>	<b>°F</b>	<b>°C</b>	<b>TIME</b>	<b>DATE</b>
1	53	11.7	1535	12-Sep-94
2	--	--	--	--
3	42	5.6	1410	14-Sep-94
4	49	9.4	1515	15-Sep-94
5	43	6.1	1125	20-Sep-94
6	45	7.2	1600	20-Sep-94
<b>AVG</b>	46	7.8		

-- Measurement not taken.

Table 16. Side channel lengths in Mill Creek, Summit County, Utah, 1994.

<b>SIDE CHANNEL LENGTHS (M)</b>		
<b>REACH</b>	<b>TOTAL</b>	<b>AVERAGE</b>
1	342.9	22.9
2	16.5	16.5
3	118.0	29.5
4	189.1	23.6
5	0	0.0
6	38.7	19.4
<b>TOTAL</b>	705.2	23.5

Table 17. Pools per mile, sinuosity and gradient in Mill Creek, Summit County, Utah, 1994.

<b>REACH</b>	<b>POOLS PER MILE</b>	<b>SINUOSITY</b>	<b>MAP GRADIENT (%)</b>
1	39	1.20	3.4
2	26	1.13	3.9
3	32	1.17	4.6
4	23	1.11	5.2
5	30	1.17	2.9
6	20	1.14	8.1
<b>AVG</b>	28	1.14	4.7

Table 18. Visual estimate of dominant (DOM) and subdominant (S-DOM) substrate class by size<sup>(a)</sup> for bed and bank substrate in Mill Creek, Summit County, Utah, 1994.

REACH	BED SUBSTRATE		BANK SUBSTRATE	
	DOM	S-DOM	DOM	S-DOM
1	SA	CO	SA	CO
2	CO	SB	GR	SA
3	SA	GR	SA	GR
4	CO	GR	GR	CO
5	SA	GR	SA	GR
6	CO	GR	CO	SA
<b>AVG</b>	CO	GR	SA	GR

(a) Substrate

Class	Size
SA = Sand, Silt, Clay	< 0.2 cm
GR = Gravel	0.2 cm – 6.4 cm
CO = Cobble	6.4 cm – 25.6 cm
SB = Small Boulder	25.6 cm – 102.4 cm
LB = Large Boulder	> 102.4 cm

Table 19. Visual estimate of total stream cover rating<sup>(a)</sup> and dominant (DOM) and subdominant (S-DOM) cover types<sup>(b)</sup> in Mill Creek, Summit County, Utah, 1994.

TOTAL STREAM COVER			
REACH	RATING	DOM	S-DOM
1	2	D	A
2	2	S	S
3	2	D	H
4	2	S	T
5	1	D	D
6	1	S	H
<b>AVG</b>	2	D	H

(a) Rating  
 1 = 0 – 5% cover  
 2 = 6 – 20% cover  
 3 = 21 – 40% cover  
 4 = > 40% cover

(b) Cover Types  
 A = Aquatic/Emergent Vegetation  
 D = Depth > 1 meter  
 H = Overhanging vegetation  
 S = Substrate  
 T = Turbulence

Table 20. Visual estimate of riparian zone class<sup>(a)</sup> and dominant (DOM) and subdominant (S-DOM) riparian species<sup>(b)</sup> in Mill Creek, Summit County, Utah, 1994.

REACH	RIPARIAN VEGETATION					
	INNER RIPARIAN ZONE (0-15 FT)			OUTER RIPARIAN ZONE (15-100 FT)		
	CLASS	DOM	S-DOM	CLASS	DOM	S-DOM
1	GF	HW	HW	SS	HW	--
2	GF	HW	HW	SS	HW	CD
3	GF	HW	HW	SS	HW	CL
4	GF	HW	HW	SS	HW	CL
5	GF	--	HW	GF	--	HW
6	GF	--	--	SS	CD	CD
<b>AVG</b>	GF	HW	HW	SS	HW	CD

(a) Riparian Zone Class  
 GF = Grassland/Forb  
 SS = Shrub/Seedling  
 SP = Sapling/Pole

(b) Riparian Species  
 HW = Willow  
 CD = Douglas Fir  
 CL = Lodgepole pine  
 -- Species not identified

Table 21. GPS coordinates and elevations of reach breaks in Mill Creek, Summit County, Utah, 1994.

REACH	GPS (E)	GPS (N)	Elevation (FT)
1 begins	521951	4530853	8750
2 begins	522172	4529679	8920
3 begins	522129	4529111	8990
4 begins	522123	4528240	9120
5 begins	522724	4525433	9660
6 begins	522771	4525012	9700
6 ends	522711	4524084	9960

Table 22. Average width adjusted by length, average maximum depth, and average length of habitat units in the first 1,141 meters of North Fork Mill Creek, Summit County, Utah, 1994.

<b>VARIABLE</b>	<b>GLIDE</b>	<b>POOL</b>	<b>RIFFLE</b>	<b>AVG<sup>(a)</sup></b>
<b>AVERAGE WIDTH (M)</b>	3.2	3.1	3.4	3.3
<b>AVERAGE MAXIMUM DEPTH (M)</b>	0.30	0.38	0.23	0.29
<b>AVERAGE LENGTH (M)</b>	12.6	4.4	14.9	NA

(a) Average of all habitat units.

Table 23. Total length (m) of habitat units, surface area (m<sup>2</sup>), count of habitat units, percent of habitat by length (m), adjusted percent of habitat by length (m), percent of habitat by surface area (m<sup>2</sup>), adjusted percent of habitat by surface area (m<sup>2</sup>), percent of habitat by count, and adjusted percent of habitat by count in the first 1,141 meters of North Fork Mill Creek, Summit County, Utah, 1994.

<b>VARIABLE</b>	<b>GLIDE</b>	<b>POOL</b>	<b>RIFFLE</b>	<b>TOTAL</b>
<b>TOTAL LENGTH (M)</b>	377	91	639	1107
<b>SURFACE AREA (M<sup>2</sup>)</b>	1188	279	2156	3624
<b>COUNT OF HABITAT UNITS</b>	30	21	43	94
<b>PERCENT OF HABITAT BY LENGTH (M)</b>	34%	8%	58%	100%
<b>ADJUSTED % OF HABITAT BY LENGTH (M)</b>		30% <sup>(a)</sup>	70% <sup>(b)</sup>	100%
<b>PERCENT OF HABITAT BY SURFACE AREA (M<sup>2</sup>)</b>	33%	8%	59%	100%
<b>ADJUSTED % OF HABITAT BY SURFACE AREA (M<sup>2</sup>)</b>		29% <sup>(a)</sup>	71% <sup>(b)</sup>	100%
<b>PERCENT OF HABITAT BY COUNT</b>	32%	22%	46%	100%
<b>ADJUSTED % OF HABITAT BY COUNT</b>		46% <sup>(a)</sup>	54% <sup>(b)</sup>	100%

(a) Adjusted % pool = (% pool + ½(% glide)) / (% pool + ½(% glide) + % riffle)

(b) Adjusted % riffle = % riffle / (% pool + ½(% glide) + % riffle)

Table 24. Woody material counts and woody material per mile in the first 1,141 meters of North Fork Mill Creek, Summit County, Utah, 1994.

<b>VARIABLE</b>	<b>BRUSH<sup>(a)</sup></b>	<b>SMALL<sup>(b)</sup></b>	<b>LARGE<sup>(c)</sup></b>	<b>TOTAL</b>
<b>WOODY MATERIAL COUNTS</b>	8	79	20	107
<b>WOODY MATERIAL PER MILE</b>	11	111	28	150

(a) Brush = Diameter > 15cm (6 in), length > 6.5 m (20 ft)

(b) Small = Diameter > 30 cm (12 in), length > 10 m (35 ft)

(c) Large = Diameter > 50cm (20 in), length > 10 m (35 ft)

Table 25. Total length<sup>(a)</sup> (m), total side channel length (m), average side channel length, pools per mile, sinuosity, map gradient, and maximum temperature in the first 1,141 meters of North Fork Mill Creek, Summit County, Utah, 1994.

<b>VARIABLE</b>	
<b>TOTAL LENGTH<sup>(a)</sup> (M)</b>	1141
<b>TOTAL SIDE CHANNEL LENGTH (M)</b>	424
<b>AVERAGE LENGTH SIDE CHANNEL (M)</b>	47
<b>POOLS PER MILE</b>	30
<b>SINUOSITY</b>	1.14
<b>MAP GRADIENT (%)</b>	5.7
<b>MAXIMUM WATER TEMPERATURE</b>	50°F (10°C) at 1522 on September 21, 1994

(a) Including special cases (falls, dams and culverts)

Table 26. Visual estimate of dominant (DOM) and subdominant (S-DOM) substrate class by size<sup>(a)</sup> for bed and bank substrate, riparian class<sup>(b)</sup>, dominant (DOM) and subdominant (S-DOM) riparian species<sup>(b)</sup>, total stream cover rating<sup>(c)</sup> and dominant (DOM) and subdominant (S-DOM) cover types<sup>(c)</sup> in the first 1,141 meters of North Fork Mill Creek, Summit County, Utah, 1994.

<b>VARIABLE</b>	<b>DOM</b>	<b>S-DOM</b>
<b>BED SUBSTRATE</b>	CO	SB
<b>BANK SUBSTRATE</b>	CO	GR
<b>INNER RIPARIAN ZONE</b>	(GF) HW	(GF) HW
<b>OUTER RIPARIAN ZONE</b>	(SS) HW	(SS) CL
<b>COVER TYPES</b>	(2) S	(2) H

(a) <b>Substrate</b>	(b) <b>Riparian (Class) Species</b>	(c) <b>Cover (Rating) Type</b>
<b>Class</b> <b>Size</b>	(GF) = Grassland/Forb	(2) = 6 – 20% cover
GR = Gravel                      0.2 cm – 6.4 cm	(SS) = Shrub/Seedling	S = Substrate
CO = Cobble                      6.4 cm – 25.6 cm	HW = Willow	H = Overhanging Vegetation
SB = Small Boulder              25.6 cm – 102.4 cm	CL = Loddgepole pine	

Table 27. GPS coordinates and elevations of reach breaks in North Fork Mill Creek, Summit County, Utah, 1994.

<b>REACH</b>	<b>GPS (E)</b>	<b>GPS (N)</b>	<b>Elevation (FT)</b>
<b>1 begins</b>	521912	4530888	8745
<b>Survey ends<sup>(a)</sup></b>	522969	4531149	8950
<b>2 begins</b>	523682	4531720	9100
<b>3 begins</b>	525241	4530291	9600
<b>4 begins</b>	525364	4529491	9640
<b>4 ends</b>	525124	4528097	9965

(a) Survey ends before the end of reach one.

Table 28. Average width (m) adjusted by length in Stillwater Fork, Summit County, Utah, 1990.

<b>AVERAGE WIDTH (M)</b>							
<b>REACH</b>	<b>CASCADE</b>	<b>GLIDE</b>	<b>POOL</b>	<b>RIFFLE</b>	<b>TRENCH</b>	<b>AVG<sup>(a)</sup></b>	
<b>1</b>	0.0	11.1	0.0	12.3	0.0	12.0	
<b>2</b>	0.0	7.1	0.0	6.7	0.0	6.8	
<b>3</b>	0.0	6.1	7.5	8.9	0.0	7.7	
<b>4</b>	0.0	5.9	6.5	7.8	0.0	7.4	
<b>5</b>	6.1	8.5	6.5	9.4	0.0	8.5	
<b>6</b>	0.0	9.5	9.6	10.1	14.2	11.4	
<b>7</b>	0.0	6.5	10.2	9.5	0.0	8.9	
<b>AVG</b>	6.1	7.8	8.8	8.8	14.2	9.3	

(a) Average for reach and all habitat units.

Table 29. Average depth adjusted by length in Stillwater Fork, Summit County, Utah, 1990.

<b>AVERAGE DEPTH (M)</b>						
<b>REACH</b>	CASCADE	GLIDE	POOL	RIFFLE	TRENCH	AVG <sup>(a)</sup>
1	0.00	0.28	0.00	0.20	0.00	0.22
2	0.00	0.26	0.00	0.23	0.00	0.24
3	0.00	0.20	0.39	0.19	0.00	0.21
4	0.00	0.24	0.42	0.19	0.00	0.21
5	0.18	0.25	0.52	0.17	0.00	0.23
6	0.00	0.30	0.57	0.22	1.01	0.58
7	0.00	0.31	0.46	0.24	0.00	0.30
<b>AVG</b>	0.18	0.27	0.51	0.20	1.01	0.36

(a) Average for reach and all habitat units.

Table 30. Total length (m) of habitat units in, Stillwater Fork, Summit County, Utah, 1990.

<b>TOTAL LENGTH (M)</b>						
<b>REACH</b>	CASCADE	GLIDE	POOL	RIFFLE	TRENCH	TOTAL <sup>(a)</sup>
1	0	119	0	385	0	504
2	0	196	0	437	0	633
3	0	334	59	450	0	843
4	0	533	223	2402	0	3158
5	38	299	45	247	0	629
6	0	853	644	1039	1453	3990
7	0	175	130	408	0	713
<b>TOTAL</b>	38	2509	1101	5369	1453	10470

(a) Represents total reach lengths. No special cases were considered in the Stillwater Fork survey.

Table 31. Average habitat unit length (m) in Stillwater Fork, Summit County, Utah, 1990.

<b>AVERAGE LENGTH (M)</b>						
<b>REACH</b>	CASCADE	GLIDE	POOL	RIFFLE	TRENCH	
1	0.0	19.8	0.0	64.2	0.0	
2	0.0	21.7	0.0	43.7	0.0	
3	0.0	33.4	29.5	37.5	0.0	
4	0.0	16.2	11.1	53.4	0.0	
5	12.7	23.0	11.2	27.5	0.0	
6	0.0	35.6	24.8	32.5	726.4	
7	0.0	43.8	26.0	102.0	0.0	
<b>AVG</b>	12.7	25.3	19.3	45.5	726.4	

Table 32. Surface area (m<sup>2</sup>) of habitat units in Stillwater Fork, Summit County, Utah, 1990.

<b>SURFACE AREA (M<sup>2</sup>)</b>						
<b>REACH</b>	CASCADE	GLIDE	POOL	RIFFLE	TRENCH	TOTAL
1	0	1314	0	4759	0	6073
2	0	1394	0	2930	0	4324
3	0	2024	442	3988	0	6454
4	0	3164	1440	18624	0	23228
5	232	2526	290	2325	0	5373
6	0	8083	6215	10542	20604	45444
7	0	1132	1319	3887	0	6338
<b>TOTAL</b>	232	19637	9706	47055	20604	97233

Table 33. Count of habitat units in Stillwater Fork, Summit County, Utah, 1990.

<b>COUNT OF HABITAT UNITS</b>						
<b>REACH</b>	CASCADE	GLIDE	POOL	RIFFLE	TRENCH	TOTAL
1	0	6	0	6	0	12
2	0	9	0	10	0	19
3	0	10	2	12	0	24
4	0	33	20	45	0	98
5	3	13	4	9	0	29
6	0	24	26	32	2	84
7	0	4	5	4	0	13
<b>TOTAL</b>	3	99	57	118	2	279

Table 34. Percent of habitat by length (m), Stillwater Fork, Summit County, Utah, 1990.

<b>PERCENT OF HABITAT BY LENGTH (M)</b>						
<b>REACH</b>	CASCADE	GLIDE	POOL	RIFFLE	TRENCH	TOTAL
1	0%	24%	0%	76%	0%	100%
2	0%	31%	0%	69%	0%	100%
3	0%	40%	7%	53%	0%	100%
4	0%	17%	7%	76%	0%	100%
5	6%	48%	7%	39%	0%	100%
6	0%	21%	16%	26%	36%	100%
7	0%	25%	18%	57%	0%	100%
<b>AVG</b>	0%	24%	11%	51%	14%	100%

Table 35. Percent of habitat by surface area (m<sup>2</sup>) in Stillwater Fork, Summit County, Utah, 1990.

<b>PERCENT OF HABITAT BY SURFACE AREA (M<sup>2</sup>)</b>						
<b>REACH</b>	CASCADE	GLIDE	POOL	RIFFLE	TRENCH	TOTAL
1	0%	22%	0%	78%	0%	100%
2	0%	32%	0%	68%	0%	100%
3	0%	31%	7%	62%	0%	100%
4	0%	14%	6%	80%	0%	100%
5	4%	47%	5%	43%	0%	100%
6	0%	18%	14%	23%	45%	100%
7	0%	18%	21%	61%	0%	100%
<b>AVG</b>	0%	20%	10%	48%	21%	100%

Table 36. Percent of habitat by count in Stillwater Fork, Summit County, Utah, 1990.

<b>PERCENT OF HABITAT BY COUNT</b>						
<b>REACH</b>	CASCADE	GLIDE	POOL	RIFFLE	TRENCH	TOTAL
1	0%	50%	0%	50%	0%	100%
2	0%	47%	0%	53%	0%	100%
3	0%	42%	8%	50%	0%	100%
4	0%	34%	20%	46%	0%	100%
5	10%	45%	14%	31%	0%	100%
6	0%	29%	31%	38%	2%	100%
7	0%	31%	38%	31%	0%	100%
<b>AVG</b>	1%	35%	20%	42%	1%	100%

Table 37. Adjusted percent of habitat by length (m) in Stillwater Fork, Summit County, Utah, 1990.

<b>ADJUSTED % OF HABITAT BY LENGTH (M)</b>			
<b>REACH</b>	<b>POOL<sup>(a)</sup></b>	<b>RIFFLE<sup>(b)</sup></b>	<b>TOTAL</b>
1	13%	87%	100%
2	18%	82%	100%
3	33%	67%	100%
4	17%	83%	100%
5	44%	56%	100%
6	63%	37%	100%
7	35%	65%	100%
<b>AVG</b>	<b>36%</b>	<b>64%</b>	<b>100%</b>

(a) Adjusted % pool = (% pool + ½(% glide) + ½(% trench)) / (% pool + ½(% glide) + ½(% trench) + % riffle)

(b) Adjusted % riffle = % riffle / (% pool + ½(% glide) + ½(% trench) + % riffle)

Table 39. Adjusted percent of habitat by count in Stillwater Fork, Summit County, Utah, 1990.

<b>ADJUSTED % OF HABITAT BY COUNT</b>			
<b>REACH</b>	<b>POOL<sup>(a)</sup></b>	<b>RIFFLE<sup>(b)</sup></b>	<b>TOTAL</b>
1	33%	67%	100%
2	31%	69%	100%
3	37%	63%	100%
4	45%	55%	100%
5	54%	46%	100%
6	55%	45%	100%
7	64%	36%	100%
<b>AVG</b>	<b>48%</b>	<b>52%</b>	<b>100%</b>

(a) Adjusted % pool = (% pool + ½(% glide) + ½(% trench)) / (% pool + ½(% glide) + ½(% trench) + % riffle)

(b) Adjusted % riffle = % riffle / (% pool + ½(% glide) + ½(% trench) + % riffle)

Table 41. Side channel lengths in Stillwater Fork, Summit County, Utah, 1990.

<b>SIDE CHANNEL LENGTHS (M)</b>		
<b>REACH</b>	<b>TOTAL</b>	<b>AVERAGE</b>
1	74.9	12.5
2	0.0	0.0
3	0.0	0.0
4	914.3	100.9
5	81.0	40.5
6	574.7	114.9
7	0.0	0.0
<b>TOTAL</b>	<b>1644.9</b>	<b>67.2</b>

Table 38. Adjusted percent of habitat by surface area (m<sup>2</sup>) in Stillwater Fork, Summit County, Utah, 1990.

<b>ADJUSTED % OF HABITAT BY SURFACE AREA (M<sup>2</sup>)</b>			
<b>REACH</b>	<b>POOL<sup>(a)</sup></b>	<b>RIFFLE<sup>(b)</sup></b>	<b>TOTAL</b>
1	12%	88%	100%
2	19%	81%	100%
3	27%	73%	100%
4	14%	86%	100%
5	40%	60%	100%
6	66%	34%	100%
7	33%	67%	100%
<b>AVG</b>	<b>39%</b>	<b>61%</b>	<b>100%</b>

(a) Adjusted % pool = (% pool + ½(% glide) + ½(% trench)) / (% pool + ½(% glide) + ½(% trench) + % riffle)

(b) Adjusted % riffle = % riffle / (% pool + ½(% glide) + ½(% trench) + % riffle)

Table 40. Maximum water temperatures recorded in Stillwater Fork, Summit County, Utah, 1990.

<b>+MAXIMUM TEMPERATURES</b>				
<b>REACH</b>	<b>°F</b>	<b>°C</b>	<b>TIME</b>	<b>DATE</b>
1	--	--	--	--
2	58	14.4	1410	15-Aug-90
3	56	13.3	1110	16-Aug-90
4	61	16.1	1513	21-Aug-90
5	60	15.6	1445	28-Aug-90
6	62	16.7	1505	07-Sep-90
7	46	7.8	1100	27-Oct-90
<b>AVG</b>	<b>57</b>	<b>14</b>		

-- Measurement not taken

Table 42. Pools per mile, sinuosity, gradient, and percent instream cover in Stillwater Fork, Summit County, Utah, 1990.

REACH	POOLS PER MILE	SINUOSITY	GRADIENT (%)		INSTREAM COVER (%)
			MAP	FIELD	
1	0	1.13	1.1	1.5	10
2	0	1.22	1.0	2.3	7
3	4	1.32	1.0	1.0	9
4	10	1.20	1.5	1.9	14
5	10	1.22	1.0	3.6	7
6	10	1.44	0.6	1.4	9
7	11	1.45	0.8	1.8	10
AVG	9	1.30	1.0	1.9	11

Table 43. GPS coordinates and elevations of reach breaks in Stillwater Fork, Summit County, Utah, 1994.

REACH	GPS (E)	GPS (N)	Elevation (FT)
1 begins	514012	4524331	8485
2 begins	513921	4523824	8505
3 begins	513890	4523248	8517
4 begins	514391	4522827	8545
5 begins	515753	4520469	8715
6 begins	516188	4520090	8735
7 begins	517018	4518046	8795
7 ends	517199	4517469	8815

Table 44. Average width (m) adjusted by length in West Fork Bear River, Summit County, Utah, 1994.

REACH	AVERAGE WIDTH (M)			
	GLIDE	POOL	RIFFLE	AVG <sup>(a)</sup>
1	2.7	4.5	2.5	3.3
2	1.8	2.3	1.8	1.8
3	2.1	1.6	2.0	2.0
4	1.3	1.8	1.7	1.5
5	1.1	1.0	0.9	0.9
AVG	1.7	3.2	1.9	2.0

(a) Average for reach and all habitat units.

Table 45. Average maximum depth (m) in West Fork Bear River, Summit County, Utah, 1994.

REACH	AVERAGE MAXIMUM DEPTH (M)			
	GLIDE	POOL	RIFFLE	AVG <sup>(a)</sup>
1	0.35	0.69	0.22	0.41
2	0.26	0.35	0.28	0.24
3	0.17	0.37	0.16	0.24
4	0.23	0.29	0.19	0.23
5	0.12	0.20	0.07	0.15
AVG	0.25	0.38	0.17	0.26

(a) Average for reach and all habitat units.

Table 46. Total length (m) of habitat units in West Fork Bear River, Summit County, Utah, 1994.

REACH	TOTAL LENGTH (M)				
	GLIDE	POOL	RIFFLE	TOTAL	TOTAL <sup>(a)</sup>
1	32	211	276	519	519
2	672	145	530	1347	1390
3	155	28	260	443	945
4	322	38	214	575	575
5	4	23	62	89	89
TOTAL	1186	445	1342	2972	3518

(a) Including special cases and dry channel.

Table 47. Average habitat unit length (m) in West Fork Bear River, Summit County, Utah, 1994.

REACH	AVERAGE LENGTH (M)		
	GLIDE	POOL	RIFFLE
1	6.4	17.6	17.3
2	14.6	5.4	12.1
3	38.9	4.0	37.1
4	17.9	4.8	15.3
5	4.3	1.7	8.8
AVG	16.0	6.6	15.3

Table 48. Surface area (m<sup>2</sup>) of habitat units in West Fork Bear River, Summit County, Utah, 1994.

<b>SURFACE AREA (M<sup>2</sup>)</b>				
<b>REACH</b>	<b>GLIDE</b>	<b>POOL</b>	<b>RIFFLE</b>	<b>TOTAL</b>
<b>1</b>	87	946	693	1726
<b>2</b>	1183	340	929	2452
<b>3</b>	334	45	510	889
<b>4</b>	422	70	356	848
<b>5</b>	5	22	57	83
<b>TOTAL</b>	2030	1423	2544	5997

Table 49. Count of habitat units in West Fork Bear River, Summit County, Utah, 1994.

<b>COUNT OF HABITAT UNITS</b>				
<b>REACH</b>	<b>GLIDE</b>	<b>POOL</b>	<b>RIFFLE</b>	<b>TOTAL</b>
<b>1</b>	5	12	16	33
<b>2</b>	46	27	44	117
<b>3</b>	4	7	7	18
<b>4</b>	18	8	14	40
<b>5</b>	1	6	7	14
<b>TOTAL</b>	74	60	88	222

Table 50. Percent of habitat by surface area (m<sup>2</sup>) in West Fork Bear River, Summit County, Utah, 1994.

<b>PERCENT OF HABITAT BY SURFACE AREA (M<sup>2</sup>)</b>				
<b>REACH</b>	<b>GLIDE</b>	<b>POOL</b>	<b>RIFFLE</b>	<b>TOTAL</b>
<b>1</b>	5%	55%	40%	100%
<b>2</b>	48%	14%	38%	100%
<b>3</b>	38%	5%	57%	100%
<b>4</b>	50%	8%	42%	100%
<b>5</b>	5%	26%	68%	100%
<b>AVG</b>	34%	24%	42%	100%

Table 51. Adjusted percent of habitat by surface area (m<sup>2</sup>) in West Fork Bear River, Summit County, Utah, 1994.

<b>ADJUSTED % OF HABITAT BY SURFACE AREA (M<sup>2</sup>)</b>			
<b>REACH</b>	<b>POOL<sup>(a)</sup></b>	<b>RIFFLE<sup>(b)</sup></b>	<b>TOTAL</b>
<b>1</b>	59%	41%	100%
<b>2</b>	50%	50%	100%
<b>3</b>	29%	71%	100%
<b>4</b>	44%	56%	100%
<b>5</b>	30%	70%	100%
<b>AVG</b>	49%	51%	100%

- (a) Adjusted % pool = (% pool + ½(% glide)) / (% pool + ½(% glide) + % riffle)  
 (b) Adjusted % riffle = % riffle / (% pool + ½(% glide) + % riffle)

Table 52. Percent of habitat by length (m) in West Fork Bear River, Summit County, Utah, 1994.

<b>PERCENT OF HABITAT BY LENGTH (M)</b>				
<b>REACH</b>	<b>GLIDE</b>	<b>POOL</b>	<b>RIFFLE</b>	<b>TOTAL</b>
<b>1</b>	6%	41%	53%	100%
<b>2</b>	50%	11%	39%	100%
<b>3</b>	35%	6%	59%	100%
<b>4</b>	56%	7%	37%	100%
<b>5</b>	5%	25%	70%	100%
<b>AVG</b>	40%	15%	45%	100%

Table 53. Adjusted percent of habitat by length (m) in West Fork Bear River, Summit County, Utah, 1994.

<b>ADJUSTED % OF HABITAT BY LENGTH (M)</b>			
<b>REACH</b>	<b>POOL<sup>(a)</sup></b>	<b>RIFFLE<sup>(b)</sup></b>	<b>TOTAL</b>
<b>1</b>	45%	55%	100%
<b>2</b>	48%	52%	100%
<b>3</b>	29%	71%	100%
<b>4</b>	48%	52%	100%
<b>5</b>	29%	71%	100%
<b>AVG</b>	44%	56%	100%

- (a) Adjusted % pool = (% pool + ½(% glide)) / (% pool + ½(% glide) + % riffle)  
 (b) Adjusted % riffle = % riffle / (% pool + ½(% glide) + % riffle)

Table 54. Percent of habitat by count in West Fork Bear River, Summit County, Utah, 1994.

<b>PERCENT OF HABITAT BY COUNT</b>				
<b>REACH</b>	<b>GLIDE</b>	<b>POOL</b>	<b>RIFFLE</b>	<b>TOTAL</b>
<b>1</b>	15%	36%	48%	100%
<b>2</b>	39%	23%	38%	100%
<b>3</b>	22%	39%	39%	100%
<b>4</b>	45%	20%	35%	100%
<b>5</b>	7%	43%	50%	100%
<b>AVG</b>	33%	27%	40%	100%

Table 55. Adjusted percent of habitat by count in West Fork Bear River, Summit County, Utah, 1994.

<b>ADJUSTED % OF HABITAT BY COUNT</b>			
<b>REACH</b>	<b>POOL<sup>(a)</sup></b>	<b>RIFFLE<sup>(b)</sup></b>	<b>TOTAL</b>
<b>1</b>	48%	52%	100%
<b>2</b>	53%	47%	100%
<b>3</b>	56%	44%	100%
<b>4</b>	55%	45%	100%
<b>5</b>	48%	52%	100%
<b>AVG</b>	52%	48%	100%

- (a) Adjusted % pool = (% pool + ½(% glide)) / (% pool + ½(% glide) + % riffle)  
 (b) Adjusted % riffle = % riffle / (% pool + ½(% glide) + % riffle)

Table 56. Woody material counts in West Fork Bear River, Summit County, Utah, 1994.

<b>WOODY MATERIAL COUNTS</b>				
<b>REACH</b>	<b>BRUSH<sup>(a)</sup></b>	<b>SMALL<sup>(b)</sup></b>	<b>LARGE<sup>(c)</sup></b>	<b>TOTAL</b>
<b>1</b>	0	0	0	0
<b>2</b>	18	2	0	20
<b>3</b>	0	1	0	1
<b>4</b>	0	0	0	0
<b>5</b>	2	20	13	35
<b>TOTAL</b>	20	23	13	56

- (a) Brush = Diameter > 15cm (6 in), length > 6.5 m (20 ft)  
 (b) Small = Diameter > 30 cm (12 in), length > 10 m (35 ft)  
 (c) Large = Diameter > 50cm (20 in), length > 10 m (35 ft)

Table 57. Woody material per mile in West Fork Bear River, Summit County, Utah, 1994.

<b>WOODY MATERIAL PER MILE</b>				
<b>REACH</b>	<b>BRUSH<sup>(a)</sup></b>	<b>SMALL<sup>(b)</sup></b>	<b>LARGE<sup>(c)</sup></b>	<b>TOTAL</b>
<b>1</b>	0	0	0	0
<b>2</b>	21	2	0	23
<b>3</b>	0	2	0	2
<b>4</b>	0	0	0	0
<b>5</b>	36	363	236	635
<b>TOTAL</b>	9	11	6	26

- (a) Brush = Diameter > 15cm (6 in), length > 6.5 m (20 ft)  
 (b) Small = Diameter > 30 cm (12 in), length > 10 m (35 ft)  
 (c) Large = Diameter > 50cm (20 in), length > 10 m (35 ft)

Table 58. Maximum water temperatures recorded in West Fork Bear River, Summit County, Utah, 1994.

<b>MAXIMUM TEMPERATURES</b>				
<b>REACH</b>	<b>°F</b>	<b>°C</b>	<b>TIME</b>	<b>DATE</b>
<b>1</b>	60	15.6	1400	28-Jul-93
<b>2</b>	62	16.7	1550	19-Jul-94
<b>3</b>	--	--	--	--
<b>4</b>	64	17.8	1245	21-Jul-94
<b>5</b>	50	10	1130	01-Sep-94
<b>AVG</b>	59	15		

-- Measurement not taken.

Table 59. Side channel lengths in West Fork Bear River, Summit County, Utah, 1994.

<b>SIDE CHANNEL LENGTHS (M)</b>		
<b>REACH</b>	<b>TOTAL</b>	<b>AVERAGE</b>
<b>1</b>	194.5	32.4
<b>2</b>	8.4	2.1
<b>3</b>	0.0	0.0
<b>4</b>	12.6	12.6
<b>5</b>	0.0	0.0
<b>TOTAL</b>	215.8	18.0

Table 60. Pools per mile, sinuosity and gradient in West Fork Bear River, Summit County, Utah, 1994.

<b>REACH</b>	<b>POOLS PER MILE</b>	<b>SINUOSITY</b>	<b>MAP GRADIENT (%)</b>
<b>1</b>	37	1.10	3.6
<b>2</b>	31	1.19	2.6
<b>3</b>	12	1.09	6.7
<b>4</b>	22	1.11	4.0
<b>5</b>	109	1.09	8.3
<b>AVG</b>	27	1.13	4.2

Table 61. Visual estimate of dominant (DOM) and subdominant (S-DOM) substrate class by size<sup>(a)</sup> for bed and bank substrate in West Fork Bear River, Summit County, Utah, 1994.

REACH	BED SUBSTRATE		BANK SUBSTRATE	
	DOM	S-DOM	DOM	S-DOM
1	SA	GR	SA	SB
2	GR	GR	GR	CO
3	CO	GR	--	--
4	CO	GR	CO	GR
5	CO	GR	SA	GR
<b>AVG</b>	CO	GR	SA	CO

(a) **Substrate**

Class	Size
SA = Sand, Silt, Clay	< 0.2 cm
GR = Gravel	0.2 cm – 6.4 cm
CO = Cobble	6.4 cm – 25.6 cm
SB = Small Boulder	25.6 cm – 102.4 cm
--	Substrate not identified

Table 62. Visual estimate of total stream cover rating<sup>(a)</sup> and dominant (DOM) and subdominant (S-DOM) cover types<sup>(b)</sup> in West Fork Bear River, Summit County, Utah, 1994.

REACH	TOTAL STREAM COVER		
	RATING	DOM	S-DOM
1	2	T	H
2	1	S	S
3	1	S	T
4	1	S	H
5	1	S	U
<b>AVG</b>	1	S	H

(a) **Rating**

1 = 0 – 5% cover  
 2 = 6 – 20% cover  
 3 = 21 – 40% cover  
 4 = > 40% cover

(b) **Cover Types**

H = Overhanging vegetation  
 S = Substrate  
 T = Turbulence  
 U = Undercut banks

Table 63. Visual estimate of riparian zone class<sup>(a)</sup> and dominant (DOM) and subdominant (S-DOM) riparian species<sup>(b)</sup> in West Fork Bear River, Summit County, Utah, 1994.

RIPARIAN VEGETATION						
REACH	INNER RIPARIAN ZONE (0-15 FT)			OUTER RIPARIAN ZONE (15-100 FT)		
	CLASS	DOM	S-DOM	CLASS	DOM	S-DOM
1	SS	HW	CL	--	--	--
2	SS	HW	CD	SS	HW	CD
3	--	--	--	--	--	--
4	GF	HW	HD	GF	HW	HD
5	GF	CD	CD	GF	CD	CL
<b>AVG</b>	SS	HW	CD	SS	HW	CD

(a) **Riparian Zone Class**

GF = Grassland/Forb  
 SS = Shrub/Seedling  
 SP = Sapling/Pole

(b) **Riparian Species**

HW = Willow  
 CD = Douglas Fir  
 CL = Lodgepole pine  
 HD = Dogwood  
 -- = Class or Species not identified

Table 64. GPS coordinates and elevations of reach breaks in West Fork Bear River, Summit County, Utah, 1994.

REACH	GPS (E)	GPS (N)	Elevation (FT)
1 begins	506008	4519336	9250
2 begins	506131	4518690	9330
3 begins	505978	4517534	9440
4 begins	506032	4516811	9600
5 begins	506390	4516341	9680
5 ends	506377	4516143	9730

## DISCUSSION

### Mill Creek

The existing habitat conditions in Mill Creek have most likely been influenced by historic activities in the drainage. The Standard Timber Company's tie hacking operation was located in the Mill Creek Fork of the Bear River during 1912 and 1913. The following seven sections were logged during this period: Sections 31 and 33 of Township 3 North, Range 11 E, and Sections 3,9,5,17, and 19 of Township 2 North Range 11 E (Peterson et al. 1980, p. 134). In 1912 alone, some 200,000 ties were cut and floated down stream. Significant alterations were made to the stream channel in order to increase the ability to run the ties down the system. "Mill Creek's bed broadened at certain points into meadows where rotting ties and timber from earlier years attested to the need for improvements. As a result, stretches amounting to about one-third of a mile were cribbed on either side and the channel grubbed and cleaned" (Peterson et al. 1980, p. 135). The scouring and channelization of the streambed, along with the logging activity of this period has certainly impacted stream habitat conditions. Critical impacts to fish would be reduction of slow water habitat, removal of pool forming structure and loss of woody material. The loss of woody material decreases pool formation potential and instream cover.

The Inland Native Fish Strategy Environmental Assessment (USDA Forest Service 1995) establishes interim riparian management objectives. The objective for pool frequency states that streams with an average wetted width of 10 ft (3.05 m) should have 96 pools per mile, and streams with an average wetted width of 20 ft. (6.10 m) should have 56 pools per mile. All reaches in the Mill Fork survey fall short of these objectives. Reaches two, four and six had wetted widths of 3.4 m, 2.8 m and 1.4 m, respectively (Table 1). According to the interim objectives these three reaches should have approximately 96 pools per mile. The pools per mile values (Table 17) for reaches two, four and six were 26, 24 and 20, respectively, well below the objective value of 96. The average wetted widths of reaches one, three and five were 6.5 m, 5.7 m and 5.5 m, respectively (Table 1). The interim objectives state that these streams should have approximately 56 pools per mile. The actual pools per mile values (Table 2) of reaches one, three and five were 41, 33 and 31, respectively, all below the objective value.

It should be recognized that one objective value is difficult to apply to individual and unique streams. Although the pools per mile values for Mill Creek were low, the slow water percentages were not necessarily below optimal range. This report has included habitat percentages calculated by surface area, length and count. It is the belief of these researchers, that in the final analysis, percentage by surface area is the most valuable, and gives the most accurate view of stream conditions. For example, the stream with adjusted percentage of habitat by surface area in Mill Creek was 50% pool and 50% riffle (Table 8). Hickman and Raleigh (1982) identified the optimal range of percent pools for cutthroat trout to be 35% – 65%. A value of 50 % pools by surface area suggests that the stream, as a whole, provides an optimal balance of pool and riffle habitat. By length the stream wide average for adjusted habitat percentage drops to 26% pool and 74% riffle (Table 10). The adjusted percentage by count was 53% pool and 47% riffle (Table 12). Although useful in comparisons, percentages by length and count do not necessarily reflect accurate stream conditions.

Habitat percentages varied greatly among reaches. Reaches two, four and six had 30%, 15%, and 5% pools, respectively (Table 8). Although low in percent pools, these reaches with more riffle habitat provide important spawning areas and macro-invertebrate production. Reaches one, three and five all have very high percent pools by surface area, 75%, 70% and 93%, respectively (Table 8). The pools in these reaches are quite large in relation to the rest of the stream (Tables 1,2 and 4). The large pools in these reaches provide critical holding and wintering habitat. It is important to look at the stream as a whole and not just individual sub-sample. As mentioned above, all reaches in the Mill Creek survey combine to produce a habitat percentage of 50% pool and 50% riffle (Table 8), which is within the optimal range established by Hickman and Raleigh (1982).

The interim riparian management objectives (USDA Forest Service 1995) state that the value for large woody debris (> 12 inch diameter and > 35 feet in length) in forested systems should be greater than 20 pieces per mile. These size requirements would include both the small and large pieces counted in the Mill Creek survey (Tables 13 and 14). The combined values for small and large pieces per mile were 13, 32,25,68,0, and 27 for reaches 1 - 6, respectively (Table 14). Stream reaches one and five were below the minimum objective value of 20 pieces per mile. Reaches 3 and 6 were just slightly above the minimum objective value. Reach 4, which had a relatively low percent pools value (Table 8), had the highest value of large woody debris per mile at 68. Reach 5, which had the highest percent pools of the entire survey, had 0 pieces of large woody debris. This would indicate that large wood is not

playing a significant role in pool formation. Other factors, such as beaver dams, are contributing to the current amount of slow water habitat in Mill Creek. Without beaver activity the number of pools per mile and percentage of pools would drop significantly

Hickman and Raleigh (1982) identified the optimal maximum temperature range during the warmest part of the year as 12- 15°C (54 –59°F). Maximum temperatures measured in Mill Creek ranged from 53° F (11.7° C) to 42° F (5.6° C) (Table 15). The average maximum temperature was 46° F (7.8° C), slightly below the optimal range. These temperatures were taken between September 12 and September 20. Earlier in the summer water temperatures were slightly warmer. On August 10, 1994 (Cowley 1995), the water temperature at the lower fish-sampling site in reach one was 56° F (13.3° C). On the same date, the water temperature at the upper fish-sampling site in reach five was 54° F (12.2° C). Both these temperatures taken on August 10, 1994 are within the optimal range of 12- 15°C (54 – 59°F).

Mill Creek is of significant importance to the native cutthroat trout covered by the Bonneville Conservation agreement. Cutthroat trout are the only native trout in the Bear River drainage, and are listed as “sensitive” by the Regional Forester (Chase 1999). The Mill Creek Drainage contains one of the meta-populations of native cutthroat trout on the Wasatch-Cache National Forest. As Cutthroat trout are the only trout present in the stream, they experience no competition from non-native trout species. This enhances the importance to protect and monitor stream habitat conditions within the Mill Creek watershed.

In 1981 a macroinvertebrate analysis was conducted from a sample taken in the main stem of Mill Creek. The species composition of macroinvertebrates found indicated that the aquatic ecosystem was in “fairly good condition” (Mangum 1981). The results also indicated a moderate amount of sedimentation and excessive organic enrichment. There were 34 taxa present, indicating that impacts on the stream had not reached a severe magnitude as of the sampling date. It appeared that the macroinvertebrates found could support a resident fish population, even during winter months when instream nutrients become critical (Mangum 1981).

#### North Fork Mill Creek

Since only the first 1,141 m of stream were surveyed in the North Fork of Mill Creek, it is difficult to look at the stream as a whole. This first section of stream had fairly low slow water percentages. The composition was 30% pool, 70% riffle by length, and 29% pool, 71% riffle by surface area (Table 23). This section is below the optimal range of 35% - 65% pools established by Hickman and Raleigh (1982). Even so, the increased riffle habitat may facilitate spawning and macro-invertebrate production. A survey of remaining reaches would be useful in assessing the overall habitat percentages in the North Fork of Mill Creek.

The North Fork of Mill Creek is within the area affected by historic tie hacking activity. As described in the Mill Creek discussion, the following seven sections were logged during this period: Sections 31 and 33 of Township 3 North, Range 11 East, and Sections 3,9,5,17, and 19 of Township 2 North Range 11 East (Peterson et al. 1980, p. 134). The logging of Sections 5 and 9 in Township 2 North Range 11 East would have directly influenced the North Fork Mill Creek watershed. Direct effects to the stream could have been reduced slow water habitat and lack of woody material. The interim riparian management objectives (USDA Forest Service 1995) state that the value for large woody debris (> 12 inch diameter and > 35 feet in length) in forested systems should be greater than 20 pieces per mile. The small and the large pieces of woody material counted in the North Fork Mill Creek survey meet these size criteria. Despite its history, this section of stream had a combined total of 139 small and large pieces of wood per mile (Table 24). This value is well above the minimum objective of 20 pieces per mile. With an apparently sufficient supply of large woody material, the percentage of slow water habitat is still quite low. As in Mill Creek, this would indicate that large wood is not playing a significant role in pool formation. The North Slope road parallels the stream for approximately half of the section surveyed. The construction of this road has straightened and channelized the stream, which has most likely reduced slow water habitat. Above the surveyed area, the road parallels the stream for approximately two more miles.

In 1996 roadwork was done the section of the North Slope Road that parallels North Fork Mill Creek. The work included narrowing the road surface, increasing the number and locations of the drainage ditches and placing rock and erosion matting in area’s most vulnerable to erosion.

#### Stillwater Fork

The Stillwater Fork of the Bear River provides important habitat for the native cutthroat trout covered by the Bonneville Conservation Agreement. Three sections of the Stillwater Fork were sampled for fish in 1994. The lower sampling section was within the habitat survey at the beginning of reach two, just above the Stillwater campground. In 1994 cutthroat trout, brook trout, rainbow trout, mountain whitefish, mountain sucker and sculpin were captured (Cowley 1995). Since this lower section receives moderate fishing pressure, fish stocking occurs to supplement native cutthroat trout populations. The middle and upper sections were upstream of the 1990 survey area. The middle section was just above the confluence with the west basin stream. The upper section started where the trail is adjacent to a bedrock slide. Only cutthroat trout were captured in the middle and upper sections (Cowley 1995). The upper Stillwater Fork drainage receives light fishing pressure and provides critical habitat to native cutthroat trout.

Fish stocking was halted in 2001 in accordance with the State of Utah's fish stocking policy (Utah Division of Wildlife Resources (1997).

#### West Fork Bear River

The West Fork of the Bear River Drainage has and continues to provide important conservation areas for Bonneville cutthroat trout. One theory is that the fish in the Bear River Drainage are remnant populations stemming from Lake Bonneville. A second theory suggests that when Lake Bonneville drained north into the Snake River, Yellowstone cutthroat migrated up the Bear River to inhabit the main stem and its tributaries. In light of recent mitochondria DNA analysis the latter theory appears to be more correct. It should be remembered that this is still a theory pending additional investigation. In 1993 and 1994 a habitat survey was conducted on the West Fork of the Bear River above Whitney Reservoir. Cutthroat trout were found upstream to where the stream splits into three smaller tributaries. A portion of the stream had dried up during the survey. The upper part of the drainage consisted of a series of riffles and small pools. The portion of the stream from the reservoir upstream to the first conifers (approximately 1/4 of a mile) consisted of a number of beaver ponds and shallow riffles. Cutthroat trout appear to be coming out of the reservoir and moving upstream to spawn during the spring. Young-of-the-year cutthroat trout were seen throughout the stream.

### **PROJECT OPPORTUNITIES**

#### Mill Creek

Habitat conditions within Mill Creek were good, but could be improved. There are opportunities to increase the water quality of the Mill Creek watershed. Road 061 parallels the stream through the majority of the sections surveyed. Improved water drainage structures along this road would help prevent surface erosion and sediment loading into the stream (Cowley 1995).

Much of the Mill Creek Survey section is on private land. Development of these private areas could lead to additional impacts on the system. Opportunities to limit and monitor activities that would directly impact stream habitat would be greatly increased if the private areas could be included in the National Forest System lands. Opportunities for basin-wide watershed restoration projects would also be increased. The possibility of incorporating the private sections of land into National Forest System lands should be explored.

#### North Fork Mill Creek

The opportunity to improve water quality and reduce sedimentation into the stream from the North Slope road was identified in 1995. Work on this project was completed in 1998, when water drainage structures were improved and installed. In order to further reduce sedimentation and improve water quality, the North Slope road would need to be re-routed higher on the hillside, away from the stream.

#### Stillwater Fork

No pool habitat was identified in reaches one or two during the 1990 Stillwater survey. The opportunity exists to create slow water habitat through restoration projects. There is also an opportunity to increase water quality in Stillwater Fork by improving the trail adjacent to the stream. This trail crosses the stream in several wetland areas with no boardwalks or bridges to help reduce trampling and sedimentation (Cowley 1995). Improved crossings would help reduce impacts to the stream.

#### West Fork Bear River

The opportunity exists to improve water quality in the West Fork Bear River by improving road crossings and culverts. Installation of water bars would help reduce sediment run-off into the stream. Reach one contained a ford that needs to be corrected to prevent additional sedimentation and silting in spawning areas. In 2001 brook trout were also seen above the reservoir for the first time. Additional survey work will take place in 2002.

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## Appendix A

Information sheet for Mill Creek a tributary of the Bear River, Wasatch-Cache National Forest. Survey completed summer 1994.

Date surveyed: September 8 - September 20, 1994.

County: Summit, Utah

Survey Length: 6,696 m

Reach 1: 1,720 m (Forest Boundary, 98 ft above confluence with North Fork, GPS 521951 E 4530853 N, to GPS 522172 E 4529679 N, elev. 8920)

Reach 2: 740 m (GPS 522172 E 4529679 N, elev. 8920 ft. to GPS 522129 E 4529111 N, elev. 8990 ft.)

Reach 3: 1,095 m (GPS 522129 E 4529111 N, elev. 8990 ft. to confluence with Plot Creek, GPS 522123 E 4528240 N, elev. 9120 ft.)

Reach 4: 3,449 m (Confluence with Plot Creek to GPS 522724 E 4525433 N, elev. 9660 ft.)

Reach 5: 323 m (GPS 522724 E 4525433 N, elev. 9660 ft. to GPS 522771 E 4525012 N, elev. 9700 ft.)

Reach 6: 1,287 m (GPS 522771 E 4525012 N, elev. 9700 ft. to GPS 522711 E 4524084 N, elev. 9960 ft.)

Climate: Mountainous climate with wide ranging temperatures (-24° C to 35° C). Mean annual precipitation is 64 cm, two-thirds of which is received as snow. The stream does not freeze over in winter, but anchor ice forms on the streambed when the air temperature falls below -18° C (Pearson and Kramer, 1972).

Elevation: Headwaters: 10,460 ft.  
Forest Boundary: 8750 ft.

Riparian Vegetation: Riparian vegetation includes grasses/forbs, willow, lodgepole pine, Douglas fir.

Fish Species: Cutthroat trout (*Oncorhynchus clarki*)  
Mottled Sculpin (*Cottus bairdi*)

Distribution: Reach 1: Cutthroat trout, sculpin  
Reach 2: Cutthroat trout  
Reach 3: Cutthroat trout  
Reach 4: Cutthroat trout  
Reach 5: Cutthroat trout  
Reach 6: Cutthroat trout

Management: Grazing, hunting, fishing, camping and hiking (Cowley 1995).

## Appendix B

Information sheet for North Fork Mill Creek, a tributary of the Bear River, Wasatch-Cache National Forest. Survey completed summer 1994.

Date surveyed:	September 21, 1994.
County:	Summit, Utah
Survey Length:	1,141 m
Reach 1:	Survey ends 1,141 m into reach one (Confluence with Mill Creek upstream 1,141 m.)
Climate:	Mountainous climate with wide ranging temperatures (-24° C to 35° C). Mean annual precipitation is 64 cm, two-thirds of which is received as snow. The stream does not freeze over in winter, but anchor ice forms on the streambed when the air temperature falls below -18° C (Pearson and Kramer, 1972).
Elevation:	Headwaters: 10,430 ft. Confluence with Mill Creek: 8740 ft.
Riparian Vegetation:	Riparian vegetation includes grasses/forbs, willow, lodgepole pine, Douglas fir.
Fish Species:	Cutthroat trout ( <i>Oncorhynchus clarki</i> ) Mottled Sculpin ( <i>Cottus bairdi</i> )
Distribution:	Reach 1: Cutthroat trout and sculpin Reach 2: Cutthroat trout Reach 3: Cutthroat trout Reach 4: Cutthroat trout
Management:	Grazing, timber harvest, hunting, fishing, camping, and hiking (Cowley 1995).

## Appendix C

Information sheet for Stillwater Fork, a tributary of the Bear River, Wasatch-Cache National Forest. Survey completed summer 1990.

Date surveyed: August 14 – October 27, 1990.

County: Summit, Utah

Survey Length: 10470 m

Reach 1: 504 m (Mirror Lake Highway crossing to the confluence with Hayden Fork)  
Reach 2: 633 m (Confluence with Hayden Fork to Penn. bridge GPS 513890 E 4523248 N, elev. 8517 ft)  
Reach 3: 843 m (GPS 513890 E 4523248 N, elev. 8517 ft to GPS 514391 E 4522827 N, elev. 8545 ft)  
Reach 4: 3,158 m (GPS 514391 E 4522827 N, elev. 8545 ft to GPS 515753 E 4520469 N, elev. 8715 ft)  
Reach 5: 629 m (GPS 515753 E 4520469 N, elev. 8715 ft to Christmas Meadows bridge, elev. 8735 ft)  
Reach 6: 3,990 m (Christmas Meadows bridge, elev. 8735 ft to tributary at GPS 517018 E 4518046 N, elev. 8795 ft)  
Reach 7: 713 m (Tributary at GPS 517018 E 4518046 N, elev. 8795 ft to GPS 517199 E 4517469 N, elev. 8815 ft)

Climate: Mountainous climate with wide ranging temperatures (-24° C to 35° C). Mean annual precipitation is 64 cm, two-thirds of which is received as snow. The stream does not freeze over in winter, but anchor ice forms on the streambed when the air temperature falls below -18° C (Pearson and Kramer, 1972).

Elevation: Headwaters: 10,560 ft.  
Confluence with Hayden Fork: 8500 ft.

Riparian Vegetation: Riparian vegetation includes willow and sedges.

Fish Species: Cutthroat trout (*Oncorhynchus clarki*)  
Brook trout (*Salvelinus fontinalis*)  
Mountain Whitefish (*Prosopium williamsoni*)  
Mountain Sucker (*Castostomus platyrhynchus*)  
Mottled Sculpin (*Cottus bairdi*)  
Rainbow trout (*Oncorhynchus mykiss*)

Management: Grazing, timber harvest, hunting, fishing, camping and hiking (Cowley 1995).

## Appendix D

Information sheet for West Fork of the Bear River, Wasatch-Cache National Forest. Survey completed summer 1994.

Date surveyed: July 28, 1993. July 19 – September 1, 1994

County: Summit, Utah

Survey Length: 3,519 m

Reach 1: 519 m (Inlet of Whitney Reservoir to GPS 506131 E 4518690 N, elev. 9330 ft)  
Reach 2: 1,390 m (GPS 506131 E 4518690 N, elev. 9330 ft to GPS 505978 E 4517534 N, elev. 9,440 ft)  
Reach 3: 945 m (GPS 505978 E 4517534 N, elev. 9,440 ft to GPS 506032 E 4516811 N, elev. 9600 ft)  
Reach 4: 575 m (GPS 506032 E 4516811 N, elev. 9600 ft to GPS 506390 E 4516341 N, elev. 9680 ft)  
Reach 5: 89 m (GPS 506390 E 4516341 N, elev. 9680 ft to GPS 506377 E 4516143 N, elev 9730 ft)

Climate: Mountainous climate with wide ranging temperatures.  
Mean annual precipitation is ... cm, two-thirds of which is received as snow. The stream does not freeze over in winter, but anchor ice forms on the streambed when the air temperature falls below -18° C (Pearson and Kramer, 1972).

Elevation: Headwaters: 9860 ft.  
Forest Boundary: 8920 ft.

Riparian Vegetation: Riparian vegetation includes grasses/forbs and shrubs/seedlings. Species include willow, lodgepole pine, Douglas-fir and dogwood.

Fish Species: Cutthroat trout (*Oncorhynchus clarki*)  
Mottled Sculpin (*Cottus bairdi*)

Distribution: Reach 1: Cutthroat trout  
Reach 2: Cutthroat trout  
Reach 3: Cutthroat trout  
Reach 4: Cutthroat trout  
Reach 5: Cutthroat trout

Management: Hunting, fishing, camping, timber harvest and grazing (Cowley 1995).