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Greenwood Creek Stream Survey:

Data Analysis and Recommendations

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May 15, 1996

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Prepared in Cooperation with

Greenwood Creek Watershed Project
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Executive Summary

Eighty Greenwood Creek mainstem samples of 30 meters, located along 16590 meters of stream, were evaluated in this study, a sample of 15%. Included in this sample were 85 pools, measured for sedimentation, and 40 sediment transport corridors (STC's), evaluated for size and source.

Channel pattern in the lower reaches, between sample sites #1-16, varied between straight, meandering and braided, becoming predominantly straight from site #17 and above, with the exception of a braided section from sites 34 to 37. High levels of unstable banks were found in the ranges of plots #16-20 and #38-43. Sample sites #12-17 show high percentages of unvegetated, squared and ramped banks and coincide with reaches of eroding banks.

The lower half of the creek showed significantly lower levels of large woody debris (LWD) per sample site, with the exception of large log jams that were located in and in between plots #1 to 4, with from 35-90 pieces per jam. In general, woody debris amounts increase upstream, with the exception to this trend occurring in the upper reaches of the stream between plots #62-71, where LWD drops off considerably.

Many sample sites along the entire length of Greenwood Creek had relatively few pools. 75% of the sites sampled had only one pool or less per 30 meters of stream reach, and 14% of these sites had no pools at all. This lack of pools may be linked to a lack of woody debris or boulders in many of the sites, or may be a function of the flow, the meander wavelength and the streambed materials.

A noticeable drop in fish numbers, from sites # 37-42, coincides with a large increase in collapsing banks, limited pools and almost no woody debris.

The mean pool filling by sediment was 25%. These values, compared to another study of North Coast watersheds, are relatively low, suggesting a creek in moderately good condition. The 85 pools measured, however, represent a significant baseline resource. Pool filling values were related inversely to cumulative pool size at a statistically significant level, with a stronger relationship for the upstream half of pools sampled. These data did not relate significantly to either direct sediment input locations or collapsing banks.

Sediment tranport corridors (STC's) were identified and found clustered in three reaches. The largest amounts of STC area were attributed to 1) collapsing banks along the stream course, 2) roads and 3) seeps and springs.

Specific restoration opportunites were found where multiple factors of restricted habitat, continuing sedimentation, and/or unstable streambanks coincided.

Principal areas for restoration were sample sites #12-13 (2310-2520 m), #34-37 (6930-7560 m), #40-44 (8190-9030 m) and #55-59 (11340-12180 m). Other restoration opportunites are STC's which connect to the mainstem of the channel, particularly roads, which are of interest to many parties both for their benefits and impact potential.

Further study in the Greenwood Creek watershed must consider water quality, fish habitat, watershed conditions, and increasing knowledge of the mainstem. A fisheries specialist should be consulted to design and implement population studies of salmonids. This report also recommends turbidity studies of tributaries, and road surveys, to increase knowledge of sedimentation sources and restoration opportunities in the watershed. The Greenwood Creek Watershed Project should maintain and expand its role as a central clearinghouse for existing information, future studies and data analysis.

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I. OVERVIEW AND METHODOLOGY

A. Project Goals and Survey Scope

In the spring of 1995, Forest, Soil & Water inc.(FSW) was contracted by the Greenwood Creek Watershed Project to design a mainstem study of the creek and train local workers to collect and enter data for analysis. The goals of this study were to:

1) Evaluate the health of the mainstem of Greenwood Creek, its ability to supply clean drinking water to the citizens of the Elk Community, and its ability to provide spawning and rearing habitat for resident and migratory salmonids;

2) Identify sediment source areas, problem erosion sites or areas with degraded salmonid habitat for erosion control projects or fish habitat restoration efforts; and

3) Establish a baseline database for Greenwood Creek to be used in further studies or future monitoring programs.

B. Methodology

Beginning at the Elk County Waters District wells at the 101 bridge, trained field crew from the Greenwood Watershed Project moved upstream, pulling a surveyor's tape and recording sample locations. The survey was designed to encompass 10-15% of the mainstem channel, evaluating 30 meter reaches of every 210 meters of stream length. Eighty sample sites were located along the creek at regular intervals, progressing upstream a total of 16,590 meters.

Upon arriving at a sample site, as measured upstream from the previous site, field crew first quietly looked for fish. Crew then filled out data sheets, conducted sediment probes in the pools and completed a detailed sketch map of each sample site. The sample area was measured and flagged at both the top and bottom of the plot, 0 and 30 meters respectively. Aluminum plot tags were placed on two bearing trees, at 10 m and 20 m transects within the 30 m plot. Photos were taken of the plot, looking both upstream and downstream. Figure 1 is a sample sketch map, made at site #6, and later imported into CorelDraw for standardized presentation. The accompanying document, Greenwood Creek Watershed Project Stream Survey (1996), gives sketch maps for all plots.

In between sample sites, crews looked for sediment source areas and recorded the quality and nature of tributaries entering the mainstem.

Most training took place in the field and the survey took approximately 6 weeks to complete. Protocols employed are described briefly below and in the respective analysis sections, and described in full in Appendix A.

C. Stream Survey Protocols

Stream survey methods used have been adapted from the Washington Forest Practice Board's Watershed Assessment Manual (1992), the California Department of Fish and Game's Salmonid Stream Habitat Restoration Manual (1991), and the Northwest Indian Fisheries Commission's Timber-Fish-Wildlife Stream Assessment Protocols (1994), with modification by FSW. V-wave protocols are based on research by Hilton and Lisle (1993), Knopp (1993) and the application system demonstrated in the WFPB manual (1992).

A field guide for stream survey methodology was written by FSW, to help standardize the data collection according to protocols, and was given to field crew during training and later, to use in collecting data and filling out data sheets. These protocols are attached as Appendix A.

1. Location: .Large cobble running creek, upstream from Commons Flat
2. Valley Morphology: constricted
3. Channel Morphology: riffle-pool-obstruction
4. Channel pattern: straight
5. Bank Morphology: ramped 75% squared 15% overhanging 15%
6. Bank condition: unvegetated 75% vegetated 30% wood or root wads 5% eroding actively contributing sediment 30%

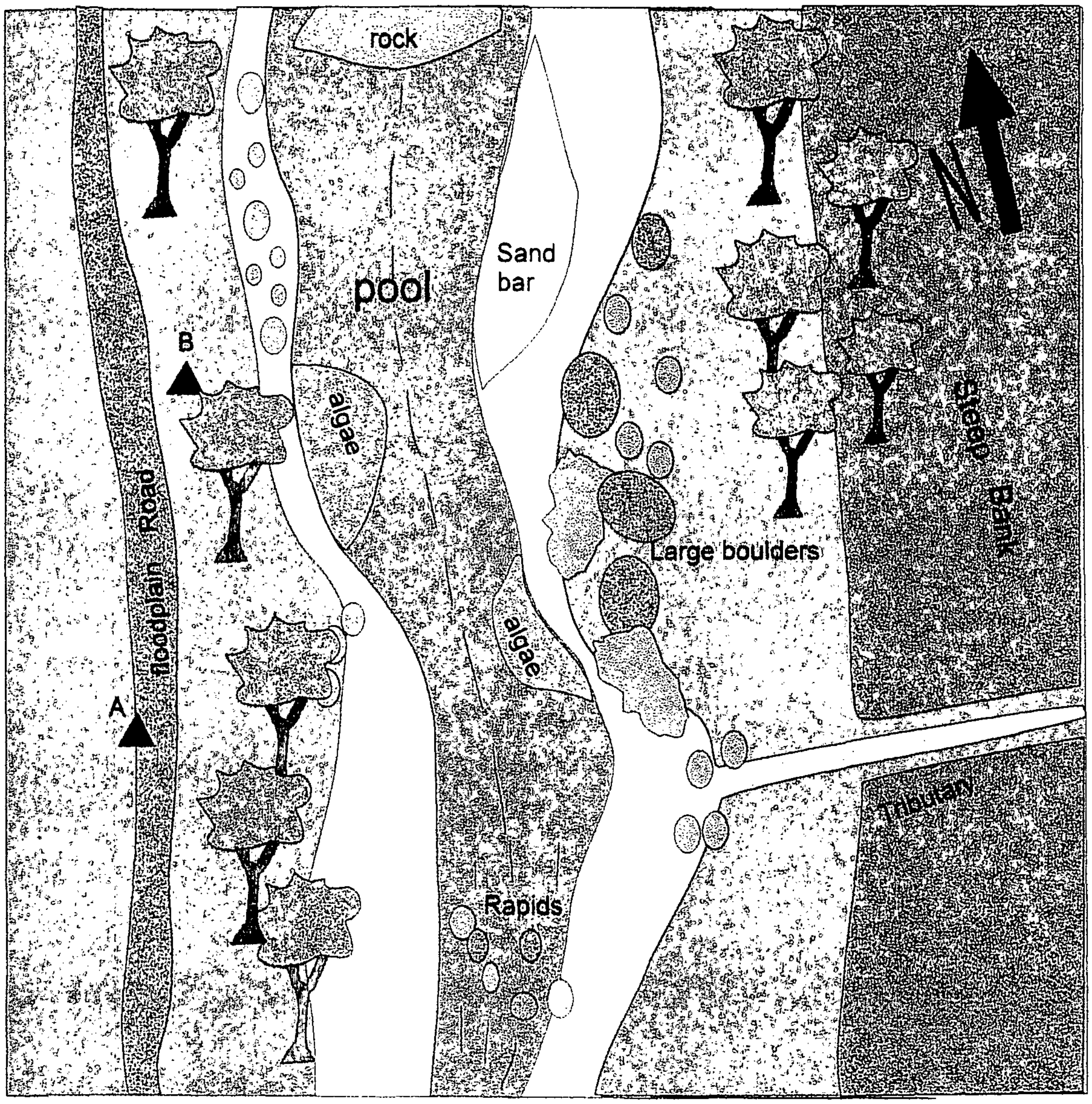


Figure 1.

Bearing 112* az

Transect A. Active channel location 9.7 ft Alternative channel locations ___
Edge of plain locations + 23 ft ,6. Total length of transect 29m

Transect B. Active channel location 5.0 ft. Alternative channel locations___
Edge of plain location + 22, -4.3. Total length of transect 26.3

Sample no. 6 meter location 1230 -1260 scribe's name Dave date 7/23/95

Site 6

II. DATA ANALYSIS

A. Valley and Stream Channel Morphology

The morphology of the stream and the valley it runs through contribute to stream dynamics and influence other factors, such as sediment deposition in the channel and erosion from banks. Data of valley morphology, stream channel morphology and channel pattern, have been collected in numeric, descriptive and sketch map form for every site and are summarized in Appendix B, Tables 1 and 2. These data serve as a baseline for future revisits to these sites.

The valley morphology at each stream sample was classified as either a broad floodplain, swale or constricted. In sample sites #1-5, measured from the Elk County Waters District wells at the 101 bridge upstream approximately 1000 meters, Greenwood Creek runs through a broad floodplain. Upstream from sample #5, the valley morphology narrows and the creek flows through a constricted channel for the remainder of the study reach. The only exception is site #34, next to Matt Evans' land, where the valley opens up and a braided channel flows through a wider floodplain.

Stream channel morphology was classified as either riffle, dune-riffle, riffle-pool-meandering, riffle-pool-obstruction, cascade or step-pool. Channel morphology in the lower reaches of Greenwood Creek, varied between riffle, riffle-pool-meander and riffle-pool-obstruction. Further upstream, above site #30, the channel was predominantly riffle-pool-obstruction in nature with a few sample sites noted as step-pools. Obstructions are either boulders or woody debris found in the channel, which alter channel morphology.

The channel pattern at each sample site was described as either straight, braided or meandering. Channel pattern in the lower reaches, between sample sites #1-16, varied between straight, meandering and braided, becoming predominantly straight from site #17 and above, with the exception of the reach from site 34 to 37.

In terms of restoration activity, instream work may be most effective in straight or meandering sections, riffle-pool-obstruction dominated reaches, and in constricted channels. As the valley widens, the effectiveness of in-channel structures may decline, because the stream may abandon its course and, with it, the structures. Readers should also note that braided channels, as at site #34, are often locations of significant aggradation and channel instability, so may be valid targets for channel restoration.

B. Bank Morphology and Bank Stability

Bank morphology was evaluated for each 30 meter sample reach, along both sides of the creek. Crews estimated the percent of bank that was ramped, squared or overhanging, with a sum total equal to 100%. Figure 2 shows Greenwood Creek bank morphology. Starting from the lower reaches of the creek in the broad floodplain, the banks tend to be highly ramped and/or squared. Moving upstream, from site banks get more overhanging and the distribution of bank conditions is more equally spread between the three types of morphologies (from site 50 and above).

Banks were also evaluated as to whether they were 1) vegetated, 2) unvegetated, 3) composed of wood or root wads and 4) actively eroding or collapsing. Figure 3 shows a running average of the distribution of bank conditions for sampled sites on Greenwood Creek. Note the higher percentages of actively eroding or collapsing banks in the upper reaches of the watershed above site #40, relative to stabilizing elements. Also note the marked peaks of collapsing banks in the vicinity of plots #16-20 and #38-43. These sites stand out as good stretches of the creek to revisit and assess for restoration and bank stabilization projects. Figure 4 shows the vegetated and unvegetated state of Greenwood Creek banks. Sample sites #12-17 show high percentages of unvegetated, squared and ramped banks and coincide with reaches of eroding banks. These sites should be revisited to evaluate potential for restoration and bank stabilization.

C. Large Woody Debris

The amount of large organic or woody debris (LWD) in a stream channel reflects both terrain and management. A thick overhead canopy provides fallen woody debris to the stream, and logging in the upper watershed can temporarily bring wood and slash down into the creek. A riparian zone that has been heavily cleared for timber or grazing purposes will have less long term recruitment of woody debris, may create less in-stream pools, and may provide less shelter for fish.

In evaluating streams for habitat potential it is important to note the role functional organic debris plays in forming pools and providing shade and shelter for juvenile fish (Murphy and Meehan,1991). LWD plays a major role in channel morphology, often altering the shape or location of a channel, and serves as a buffer which can hold back a sediment load or retain spawning gravel (Harmon, M. E. et al., 1986). The Regional Ecosystem Assessment Project of Region 6 of the U.S. Forest Service included pool frequency as a primary indicator of aquatic ecosystem quality. LWD adds complexity to the channel and increases the frequency and diversity of pool types. A primary reason for the loss of pools in forest streams is the loss of pool forming structures such as boulders and large wood (FEMAT, 1993).

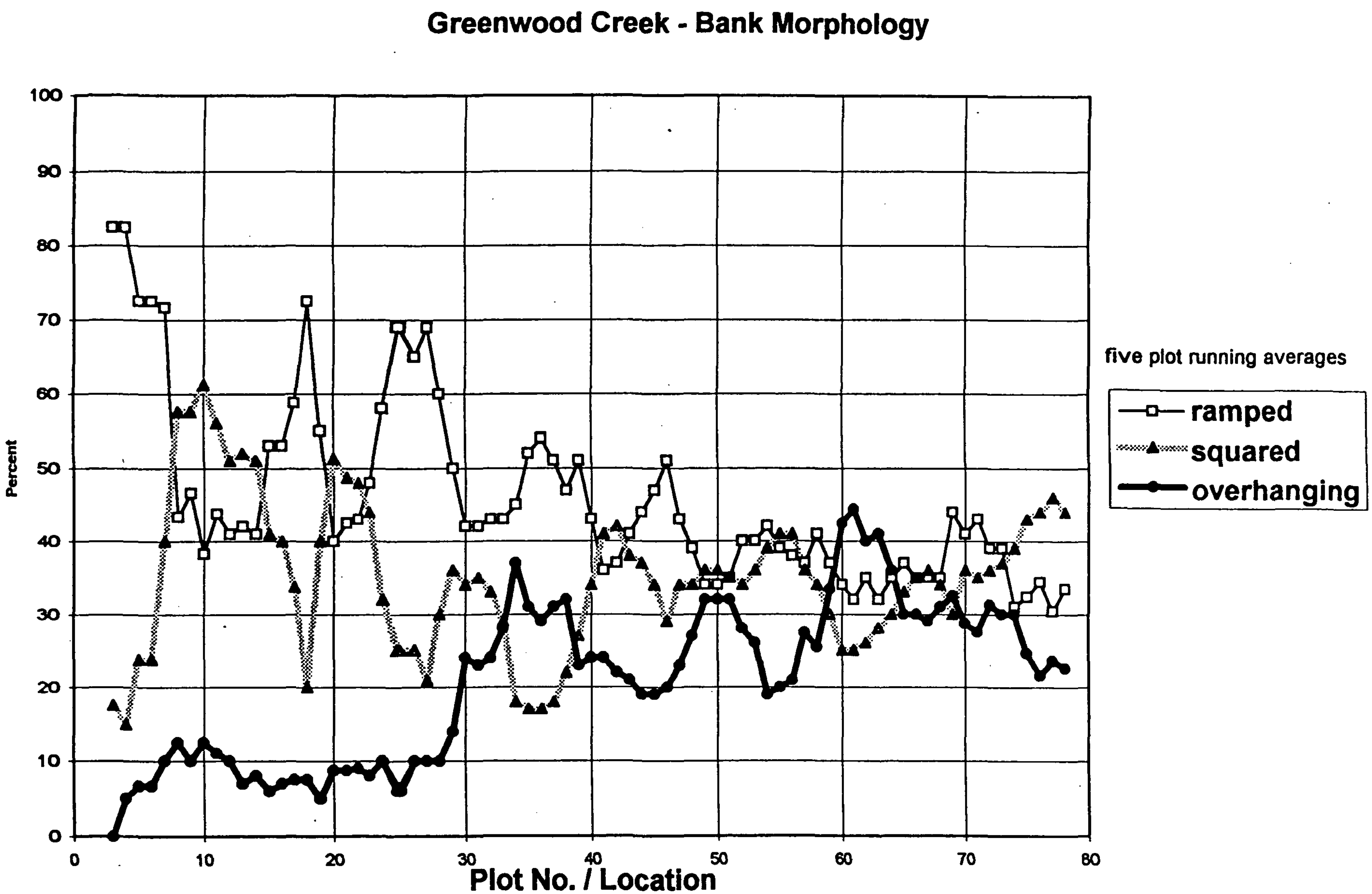

Greenwood Creek - Bank Morphology
Percent
Plot No. / Location
five plot running averages
ramped
squared
overhanging
0
10
20
30
40
50
60
70
80
90
100
0
10
20
30
40
50
60
70
80

Figure 2.

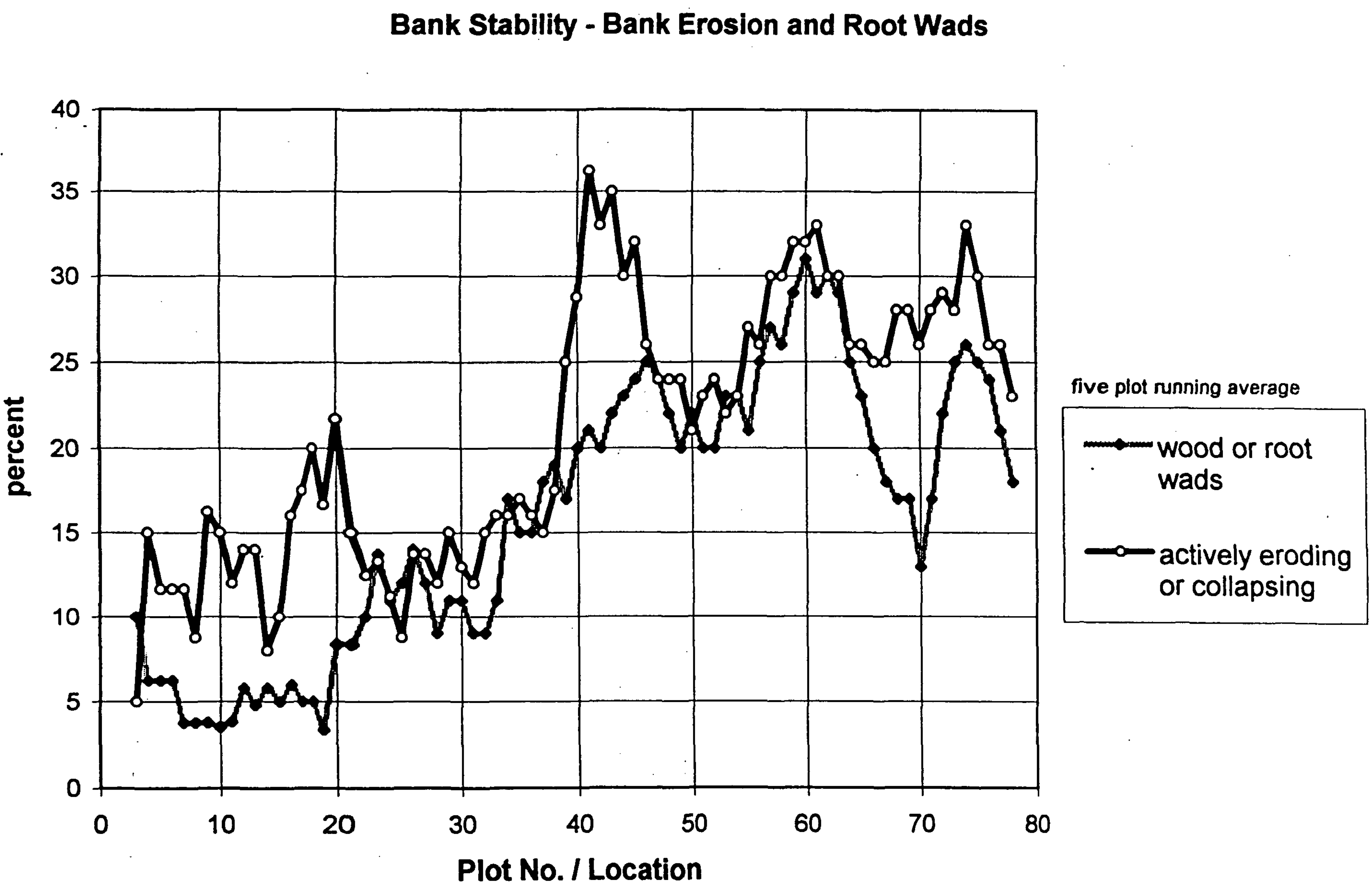

Bank Stability - Bank Erosion and Root Wads
40
35
30
25
20
15
10
5
0
percent
0
10
20
30
40
50
60
70
80
Plot No. / Location
five plot running average
wood or root wads
actively eroding or collapsing

Figure 3.

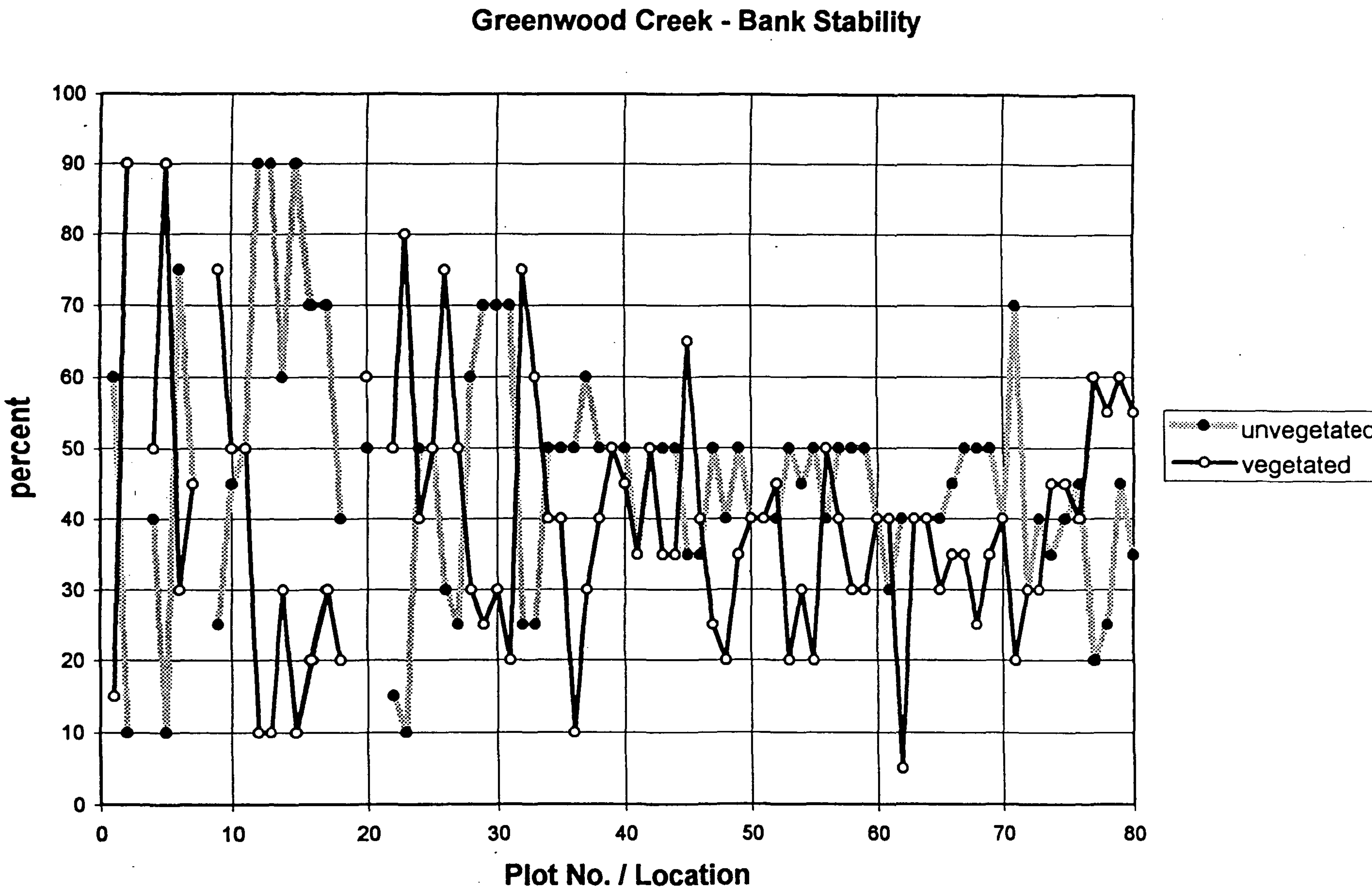

Greenwood Creek - Bank Stability
percent
Plot No. / Location
unvegetated
vegetated
0
10
20
30
40
50
60
70
80
90
100

Figure 4.

In this study, each log and rootwad found in or adjacent to the stream channel was classified according to size as well as functionality. *Small* organic debris measured 20-50 cm in diameter with *large* being greater than 50 cm in diameter. A *functional* piece was defined as being embedded into the banks or streambed or affecting the flow of water around it. *Non-functional* was defined as lying within 2 meters above the wetted channel and poised or ready to fall into the stream eventually (Shuett-Hames et al., 1994).

For the purpose of this study, Figure 5 shows the total number of *functional* woody debris elements found within sample sites on Greenwood Creek. Amount of woody debris per sample site ranged from zero to seventeen pieces per sample plot. 66% of sampled sites had 2 or less pieces of functional LWD, and 36% of the sites had none. Only 20% of the sampled sites showed a count of five or more functional woody debris elements. This may be due to high flows moving the LWD through the system, but, as discussed below, appears to suggest a clumpy distribution in log jams.

The lower half of the creek showed significantly lower levels of LWD per sample site, with the exception of large log jams that were located in and in between plots #1 to 4. In general, woody debris amounts increase upstream, with the exception to this trend occurring in the upper reaches of the stream between plots #62-71, where LWD drops off considerably. Lower reaches between sites #5-21 and the noted upper watershed sites #62-71 would be good stream reaches to look at for possible recruitment of LWD into the channel. This can be accomplished by widening the riparian buffer zone, falling logs into the channel, and the promotion of large, recruitment conifers and hardwoods in the riparian corridor. Recruitment trees would be marked for eventual falling (natural or assisted) into the stream.

D. Log Jams

In accordance with protocols established by the Timber-Fish-Wildlife Ambient Monitoring Program Manual (Shuett-Hames et al., 1994), a woody debris jam was defined as an accumulation of ten or more pieces of wood, either logs or rootwads, greater than 20 cm in diameter and touching other logs in the jam. Figure 6 shows the magnitude and locations of woody debris jams, all along Greenwood Creek. Some of these sample reaches show log jams with high numbers of woody debris elements. The region of sites #2-4 had log jams ranging from 35-90 pieces per jam. It is interesting to note that woody debris has washed down into log jams in the lower five sites, where the creek flows at a low stream gradient into a broad floodplain.

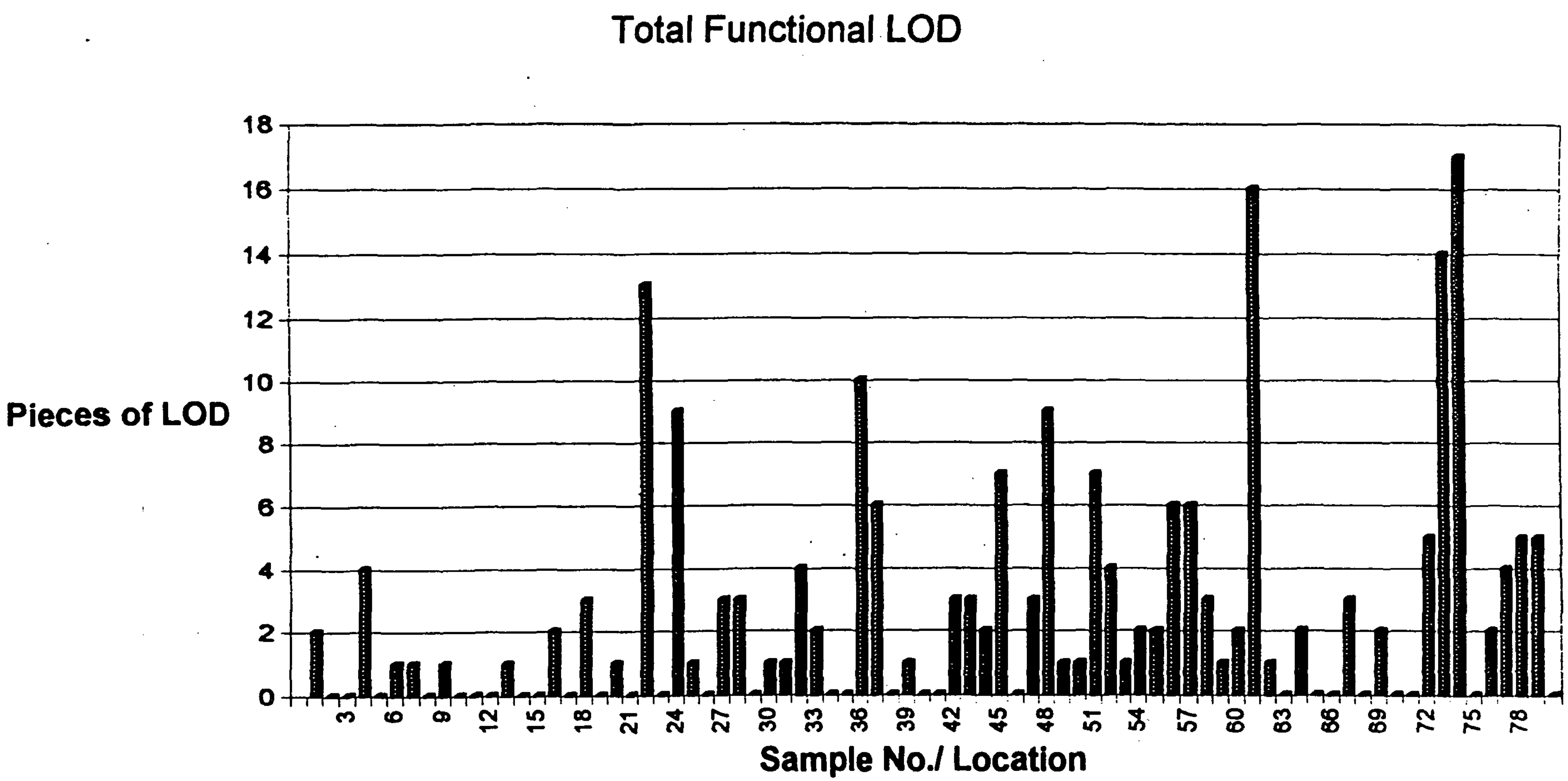

Total Functional LOD
Pieces of LOD
0
2
4
6
8
10
12
14
16
18
Sample No./ Location

Figure 5.

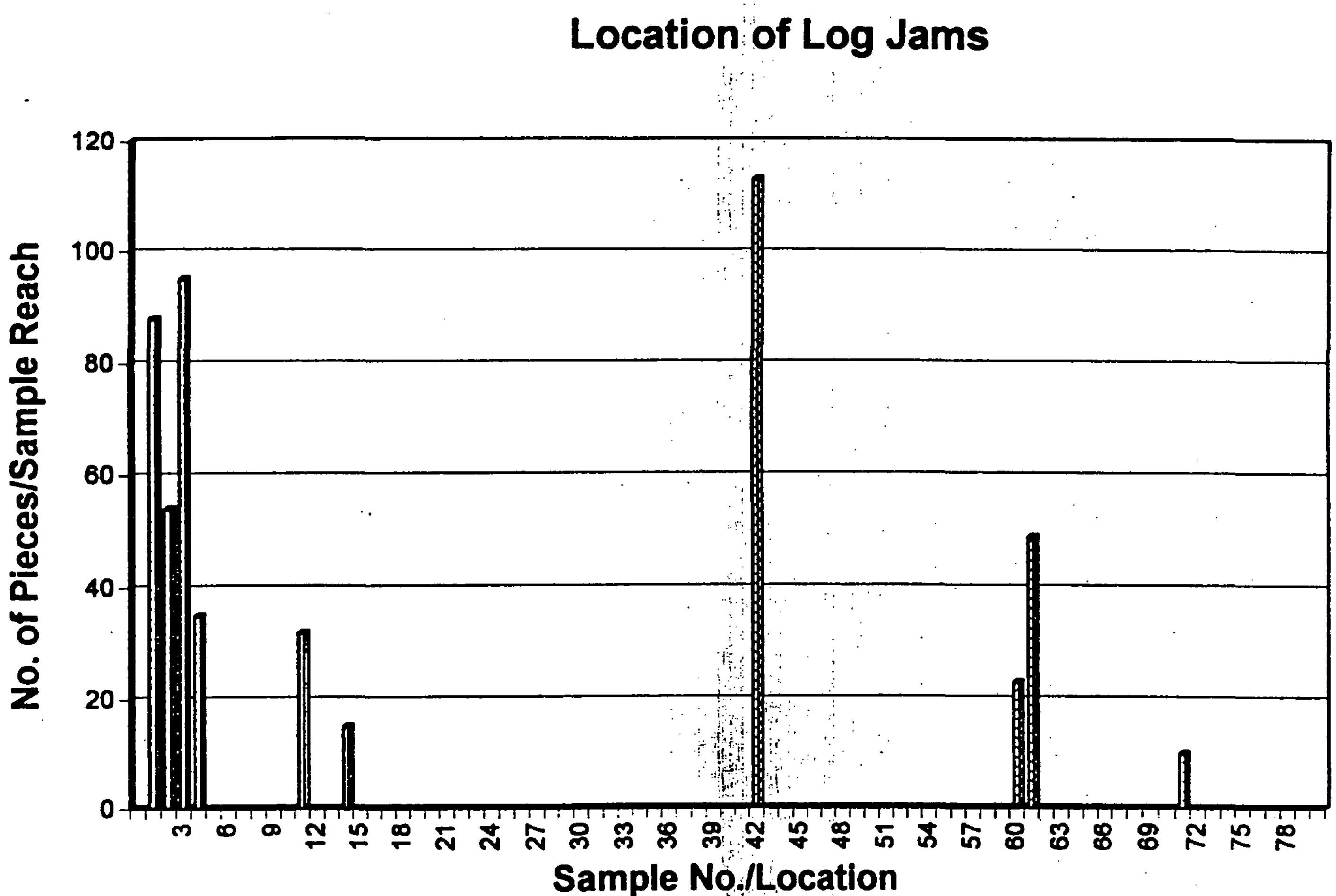
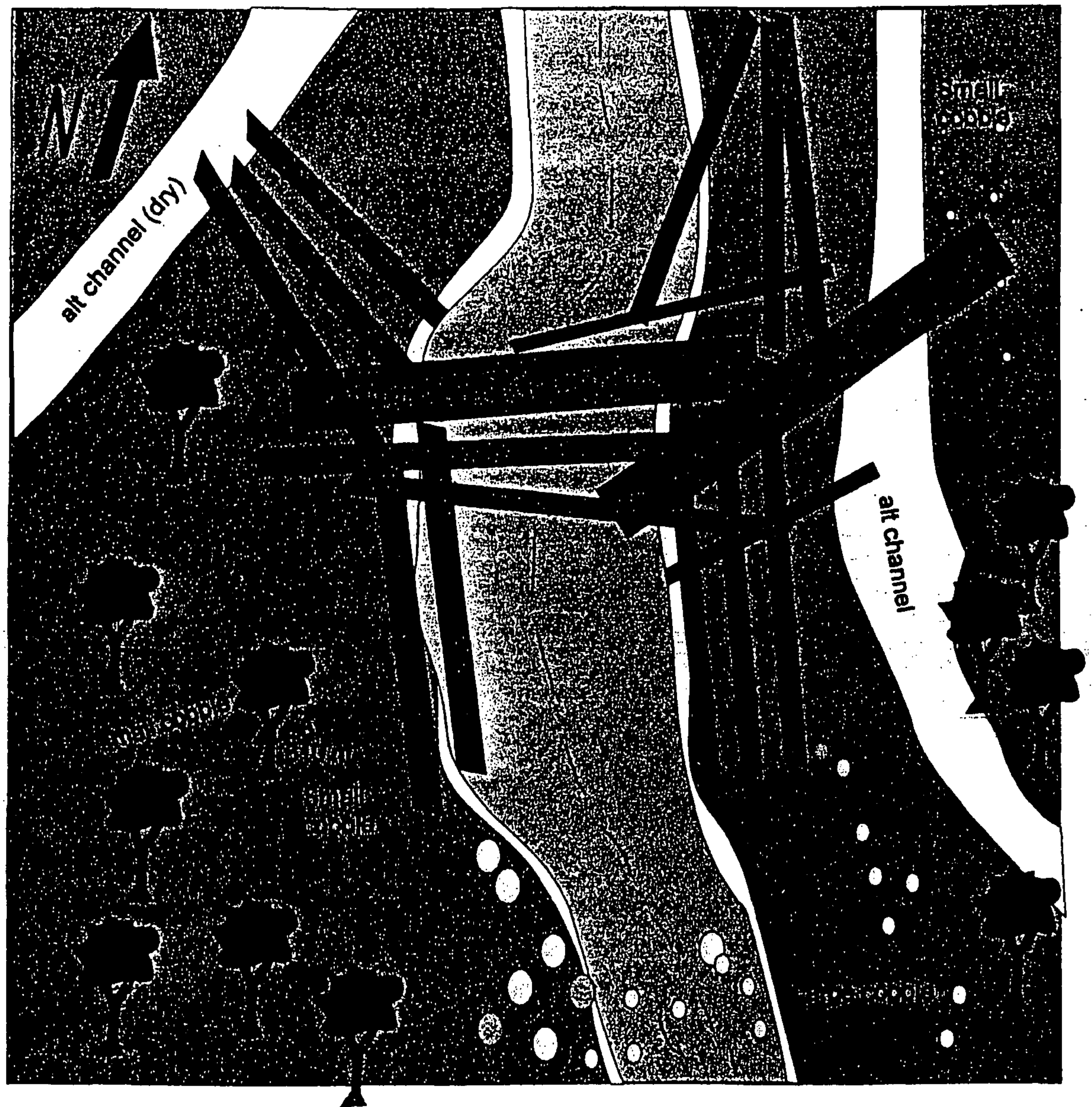

Location of Log Jams
No. of Pieces/Sample Reach
120
100
80
60
40
20
0
3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48 51 54 57 60 63 66 69 72 75 78
Sample No./Location

Figure 6.

Greenwood Creek Stream Survey 1995

1. Location:
2. Valley Morphology:
3. Channel Morphology:
4. Channel pattern:
5. Bank Morphology:
6. Bank condition:



Bearing 106* az

Transect A. Active channel location 41 ft Aletrnative channel locations 60 ft 271ft, -58ft
Edge of plain locations + 280 ft, -80 ft. Total length of transect 360 ft

Transect B. Active channel location 10 ft. Alternative channel locations 41 ft, 247 ft, -66 ft
Edge of plain location + 260 ft, -74 ft. Total length of transect 334 ft

Sample no. 3 meter location 600 - 630 scribe's nameDave date 7/21/95

Site 3

Log jams can affect instream habitat by restring fish passage or diverting erosive flows of water into banks. Jams also absorb much of the woody debris in a stream, so it is not available for forming habitat elsewhere. Restoration actions can include evaluation of jams for fish passage, flooding and erosion potential. Following Figure 6, please find a sketch of site 3, which includes a significant log jam.

E. Location and Number of Pools

Pools provide fish habitat and in times of low stream flow can provide pockets of water which allow the survival of aquatic organisms (Gordon et al., 1992). They also trap or hold sediment as it moves through the stream channel. Pools, being the result of local scour induced by structural elements in the channel, reflect the geomorphology of the streambed and the quantity of large woody debris moving into the channel from upstream sources or overhead canopy. Since woody debris increases the frequency and diversity of pool types, a primary reason for the loss of pools is the loss of pool forming structures such as boulders and large wood (Hamilton and Bergersen, 1984; FEMAT, 1993). Since the presence or absence of pools directly affects the habitat quality of a stream, it is important to identify streams which have a healthy number of pools per stream segment and those which do not.

Pools for this study were defined by the following criteria:

1) water slower than the mean velocity,
2) countervailing currents,
3) flat surface at low flow, and
4) maximum depth deeper than mean thalweg (continuous line of deepest depth).

Data collected on pools include the number, location and dimensions of each pool. At each sample site, two pools, if they occurred, were measured, sketched and probed with a rod to measure the depth of fine sediment trapped at the bottom of each pool. This data is later converted into a V-wave calculation which measures the percent of the pool filled with fine sediment.

Many sample sites along the entire length of Greenwood Creek had relatively few pools. 75% of the sites sampled had only one pool or less per 30 meters of stream reach, and 14% of these sites had no pools at all (Figure 7). This lack of pools may be linked to a lack of woody debris or boulders in many of the sites (Hamilton and Bergersen, 1984; FEMAT, 1993), or may be a function of the flow, the meander wavelength and the streambed materials (Leopold et al. 1964)--all directions for further research. After assessing what the 'right' number of pools are, and if they are restricted by woody debris recruitment, habitat restoration

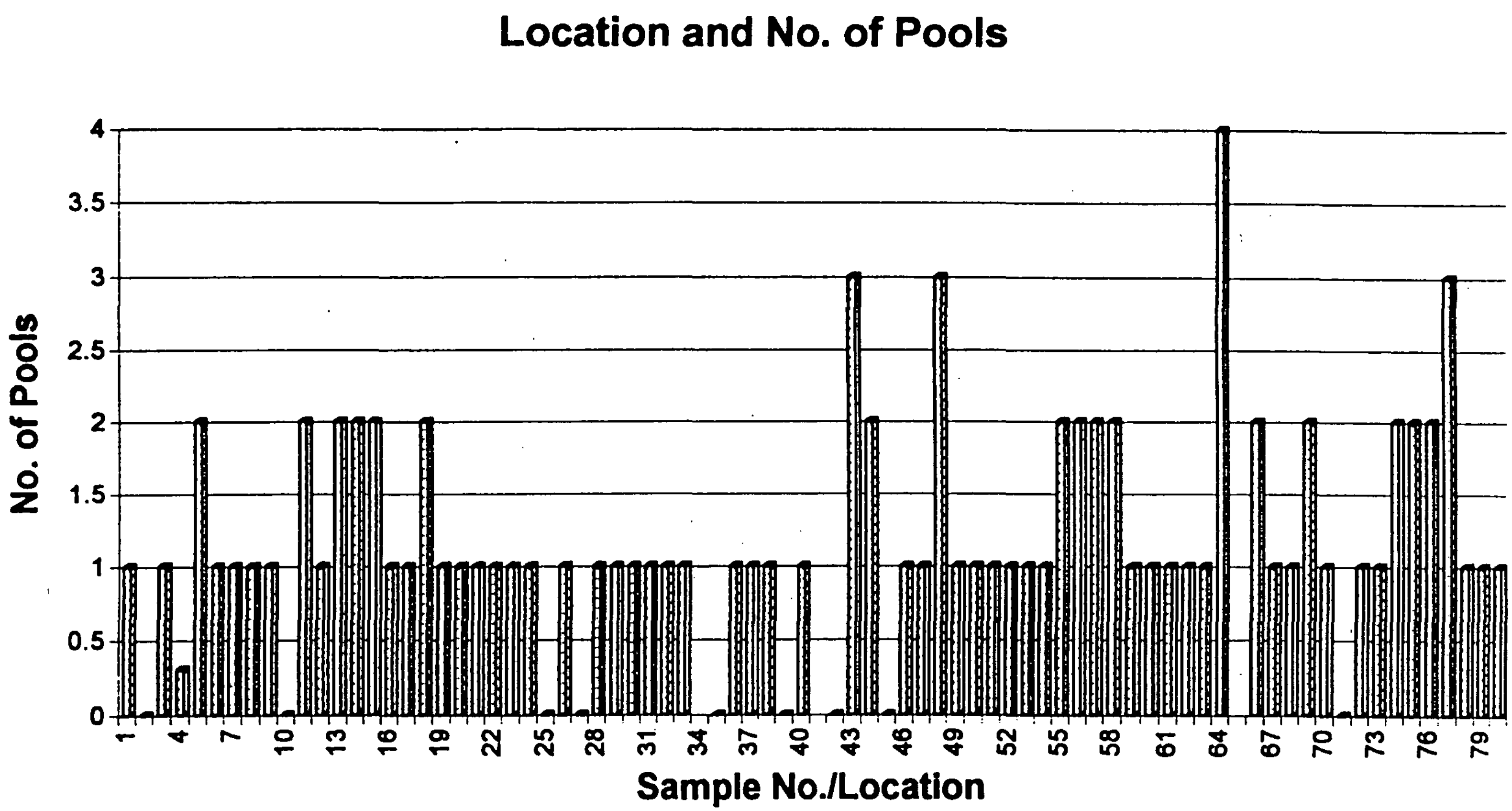

Location and No. of Pools
No. of Pools
0
0.5
1
1.5
2
2.5
3
3.5
4
Sample No./Location
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79

Figure 7.

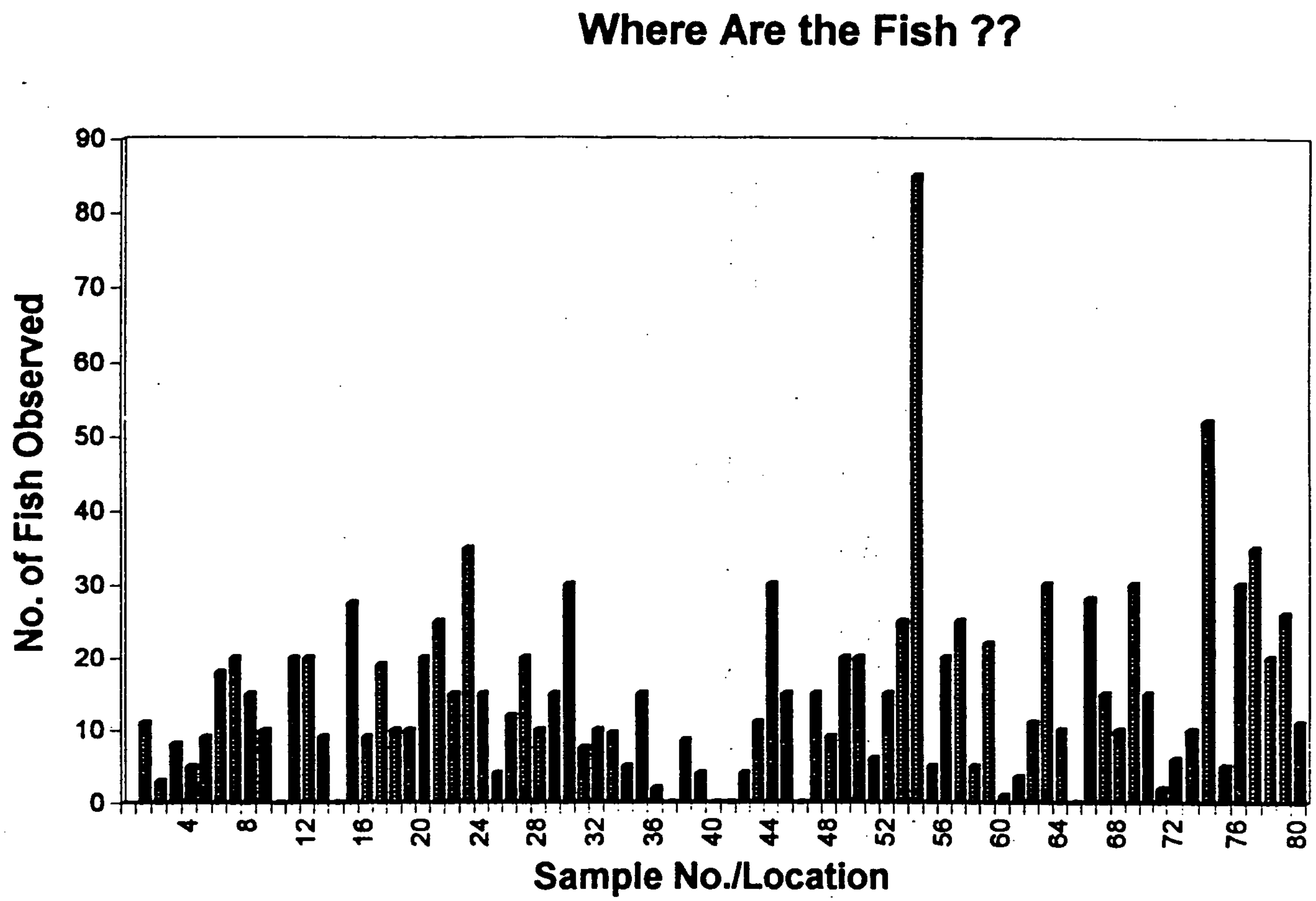

Where Are the Fish ??
No. of Fish Observed
0
10
20
30
40
50
60
70
80
90
4
8
12
16
20
24
28
32
36
40
44
48
52
56
60
64
68
72
76
80
Sample No./Location

Figure 8.

projects on Greenwood Creek may do well to focus on recruitment and stabilization of woody debris into the stream channel to create more pool formation to increase habitat potential for fish.

The first sites which should be evaluated are in the plot #34-45 area, which should be investigated both for causes of few pools and potential for pool creation.

F. Fish Sightings

Field crew first approached each sample site quietly, in order to observe the numbers and size ranges of fish present along the sample reach. These were recorded before any other evaluations were made. A table showing the numbers, size ranges and species of fish observed is found in Appendix B. Figure 8 shows the approximate number of fish observed during this study in sample plots within Greenwood Creek. Steelhead were the predominant species observed and estimates of their size ranged from1.5 to 7 inches.

A noticeable drop in fish numbers, from sites # 37-42, coincides with a large increase in collapsing banks, limited pools and almost no woody debris along that reach of the stream. This trend is best seen in Appendix B, Table 8.

Recommendations for future assessment of fish within Greenwood Creek are to get better population information using snorkel surveys, electrofishing or migrant trapping. This more intense measurement will better assess the number, species and habitats of Greenwood Creek's fish population. A fisheries specialist should be consulted on the direction and detail of survey goals and techniques.

Sediment in Pools: V-wave

Sediment moves into Greenwood Creek from adjacent banks and sideslopes of the stream and from the upper watershed via tributaries and sediment transport corridors (STC's). To assess relative sediment deposition levels within the stream, crews conducted a survey of pool filling by fine sediment. Sedimentation was measured with an FSW protocol, termed V-wave. This methodology can monitor increases or decreases in sediment levels in the stream over time and track the movement of sediment pulses moving downstream.

V-wave is a measurement of the relative amount a pool has become filled with fine sediment (please see protocol in Appendix A). These data are collected in the stream channel, probing the fine sediment in the pool to find the true bottom, felt as a layer which has greater resistance than the fine sediments. Only sediments and pool depths which are below the riffle crest, the lip elevation of the pool outlet, are counted. Points of the pool which have sediment above the riffle crest, but a bottom below it, are counted as full of sediment up to the riffle crest, only.

The term 'V-wave' refers to V*, a determination of volume presented by Hilton and Lisle (1993), and a contraction of 'weighted average'. Two pools per site, if present, were probed for pool and sediment depth in up to 48 evenly spaced points, and the weighted average of the sedimentation for those points is presented as V-wave. The weighting is by pool and sediment depth--deeper points count more than shallow points. A summary of V-wave measurements are presented in Appendix B, Table 5. A worked example, with accompanying pool cross-sections is shown in Appendix B, Table 6.

A histogram of the V-wave values is shown in Figure 9. Crews measured 85 pools. The mean pool filling (V_w in Hilton and Lisle) was 0.25, with a standard error of 0.01. The mode of the data, when grouped by five percent intervals, is also 0.25, or 25%.

The amount of pool filling is important for fish habitat, because sediment accumulates in the bottom of pools, reducing potential cover, and eliminates the deepest, coldest habitat. As sediment builds towards the surface of pools, it is able to absorb solar energy, re-reradiating heat into the stream. In addition, sediment covers habitat elements on the bottom of the stream and reduces the amount of countervailing current potential as the pool becomes smaller. The size and complexity of pools relates, therefore, directly to salmonid production (Bjornn and Reiser, 1991). DFG habitat surveys look specifically at subsurface habitat elements and bubble curtains (Flosi and Reynolds, 1991) both of which are limited by sedimentation in pool bottoms.

Hilton and Lisle's 1993 paper considers V* values of 10% and above to be moderate to high values, and notes the site specificity of these evaluations, putting forth V* as a useful monitoring tool. Coastal region comparative information is available in Knopp's 1993 report "Testing Indices of Cold Water Fish Habitat," which focused on the Franciscan Formation of the North Coast, and included Greenwood Creek as a sample site. It is important to note that Hilton and Lisle do not limit the use of V* to specific pool forming criteria or definitions; Knopp's study defined pools to have a maximum depth at least four times the riffle crest depth. Knopp found mean V* values for reaches in relatively undisturbed (index) watersheds to be 28% with historic management, and 17% with no history of management. Moderately disturbed watersheds had mean reach V* values of 37%; highly disturbed watersheds had mean reach V* values of 42% (Knopp, 1993). By these measures, the reach V* of Greenwood Creek is relatively low, suggesting a creek in moderately good condition. It is not clear, however, if values from Knopp, Hilton and Lisle, or this study may be robustly compared--each approach is designed for internal consistency.

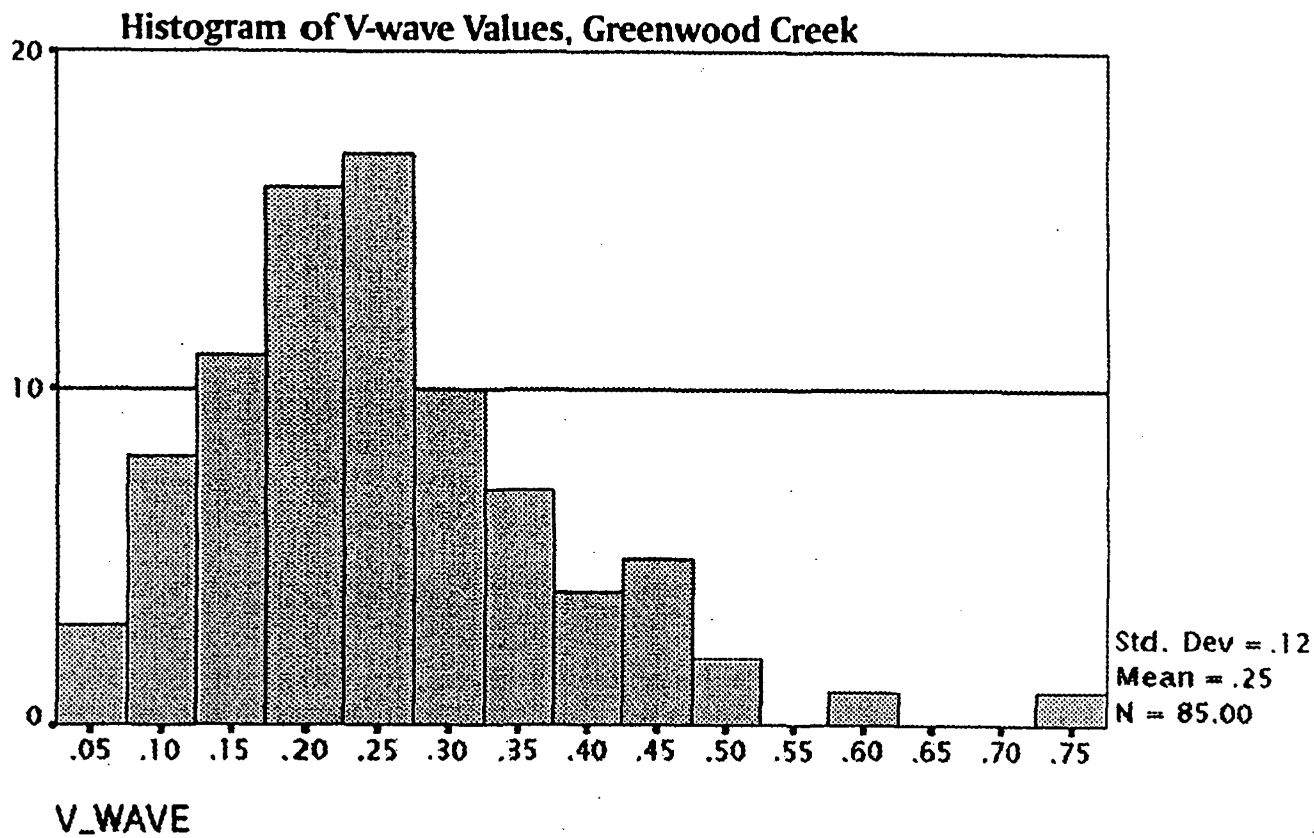

Histogram of V-wave Values, Greenwood Creek
20
10
0
.05
.10
.15
.20
.25
.30
.35
.40
.45
.50
.55
.60
.65
.70
.75
V_WAVE
Std. Dev = .12
Mean = .25
N = 85.00

Figure 9.

Results and Analysis
There are a few notable elements about the V-wave survey of Greenwood Creek (Figure 10). First, it shows a wide variation in pool filling, from 5.8% to 74.9%. Second, it shows wide and rapid variability of pool filling along the distance of the stream where pools were evaluated, with regular 10% and 20% differences from pool to pool among the sample set, as well as larger trends within the data set. Pools appear to go from low sedimentation levels at the 101 bridge to high levels at 5000 meters, then decline to about 15000 meters, and rise again to the upstream extent of the survey area. Third, there are places where STC's or bank collapse apparently relate directly to pool filling, though other sites of pool filling can not be traced to visible sources. Fourth, it appears that the relative size and location of the pool may strongly affect its relative sedimentation. And fifth, some pools have high sedimentation relative to the rest of the study pools and their sizes, so are good candidates for further study.

While, intuitively, it seems that location of the STC's would correlate directly with pool filling, comparison of the data show several instances where this works, and several where it does not. Figure 11 shows both mean V-wave values and cumulative STC volume by location. The data show that an infusion of sediment can elevate or maintain V-wave levels above 20%, in many cases. The data are not clear, however, because some V-wave averages are high without strong STC influence, and because some large STC's appear to have little affect on the V-wave measure. Similarly, unvegetated banks occasionally track with V-wave values, but not strongly enough for statistical strength.

Factors of V-Wave Prediction
Pool filling is a function of sediment input, stream morphology, slope and flow. Measurement of pool filling becomes dependent on selection criteria for pools, both by location and physical characteristics.

The measurements taken for the calculation of V-wave include total pool depth, which is accumulated for all points in the pool. Most pools had 48 points taken, spaced equidistantly on regular transects. Only very small pools had less than 48 points attempted, and only points with the pool bottom above the riffle crest were thrown out. Total pool depth, therefore, reflects the deepness of multiple points in pools, and is shown for all pools in the histogram in Figure 12. The histogram indicates a mode of cumulative pool depth in the 100-300 cm range and a mean of 900 cm.

Cumulative pool depth, as shown in Figures 13 and 14, correlates exponentially with V-wave, with correlation coefficients (adjusted R^2) of 0.198 for the whole data set, and 0.341 for sites 43 to 80. The significance of both of these values is >99.99%. In other words, it is statistically very certain that the cumulative depth of pools partially accounts for variation in V-wave measurements. The relationship is

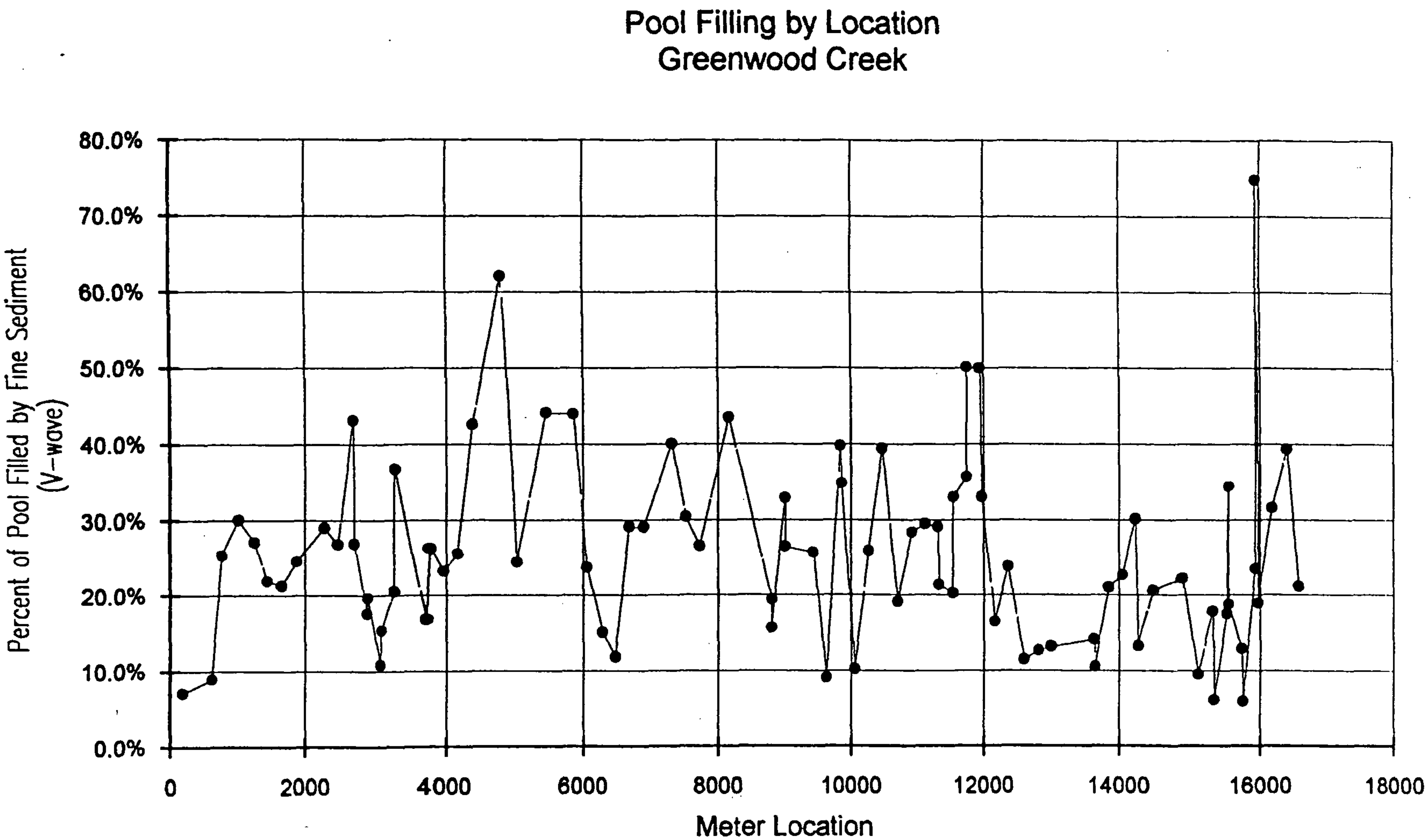

Pool Filling by Location
Greenwood Creek
Percent of Pool Filled by Fine Sediment (V-wave)
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
Meter Location

Figure 10.

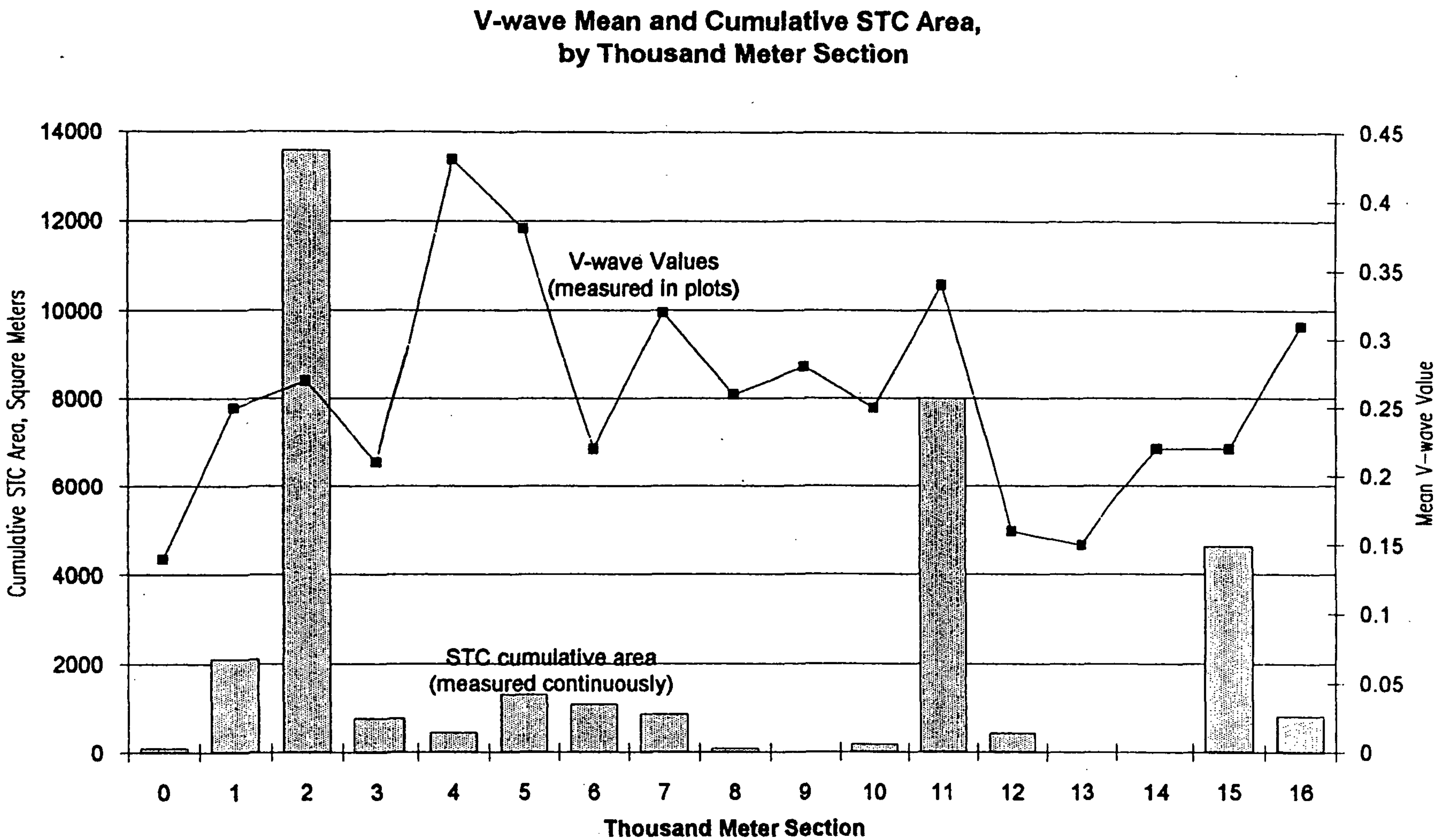

V-wave Mean and Cumulative STC Area,
by Thousand Meter Section
Cumulative STC Area, Square Meters
Mean V-wave Value
V-wave Values
(measured in plots)
STC cumulative area
(measured continuously)
14000
12000
10000
8000
6000
4000
2000
0
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Thousand Meter Section

Figure 11.

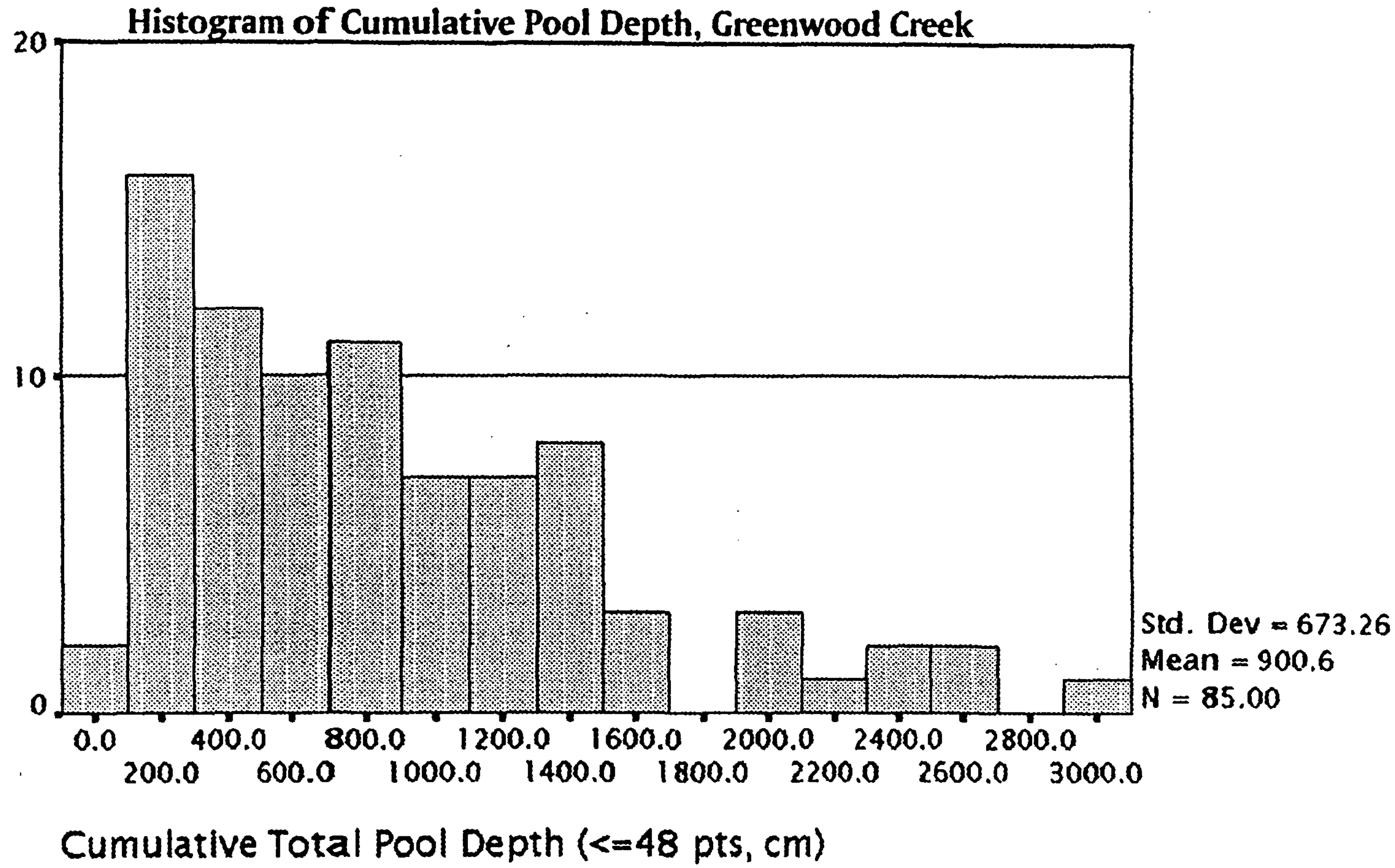

Histogram of Cumulative Pool Depth, Greenwood Creek
20
10
0
0.0
200.0
400.0
600.0
800.0
1000.0
1200.0
1400.0
1600.0
1800.0
2000.0
2200.0
2400.0
2600.0
2800.0
3000.0
Std. Dev = 673.26
Mean = 900.6
N = 85.00
Cumulative Total Pool Depth (<=48 pts, cm)

Figure 12.

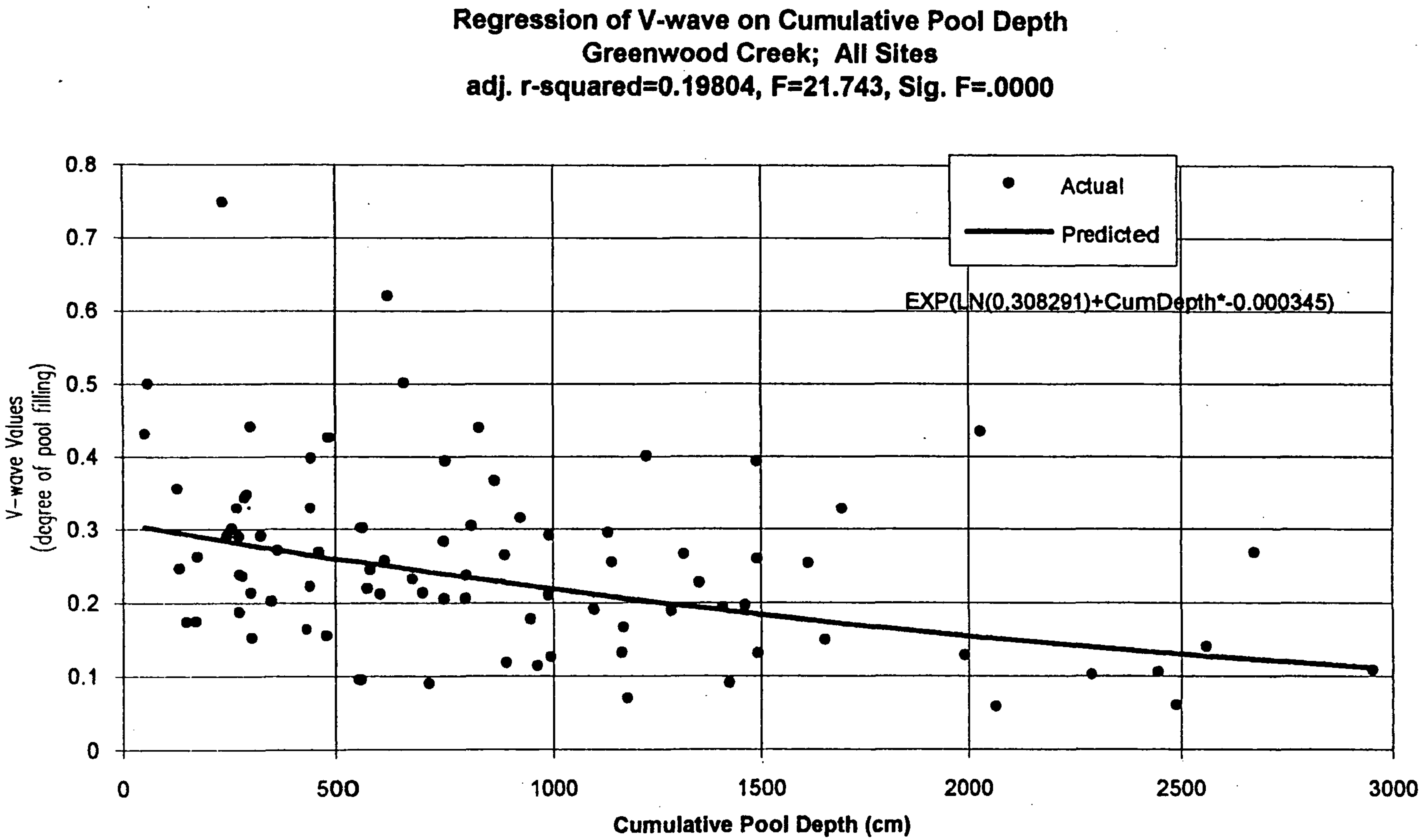

Regression of V-wave on Cumulative Pool Depth
Greenwood Creek; All Sites
adj. r-squared=0.19804, F=21.743, Sig. F=.0000
Actual
Predicted
EXP(LN(0.308291)+CumDepth*-0.000345)
V-wave Values
(degree of pool filling)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
500
1000
1500
2000
2500
3000
Cumulative Pool Depth (cm)

Figure 13.

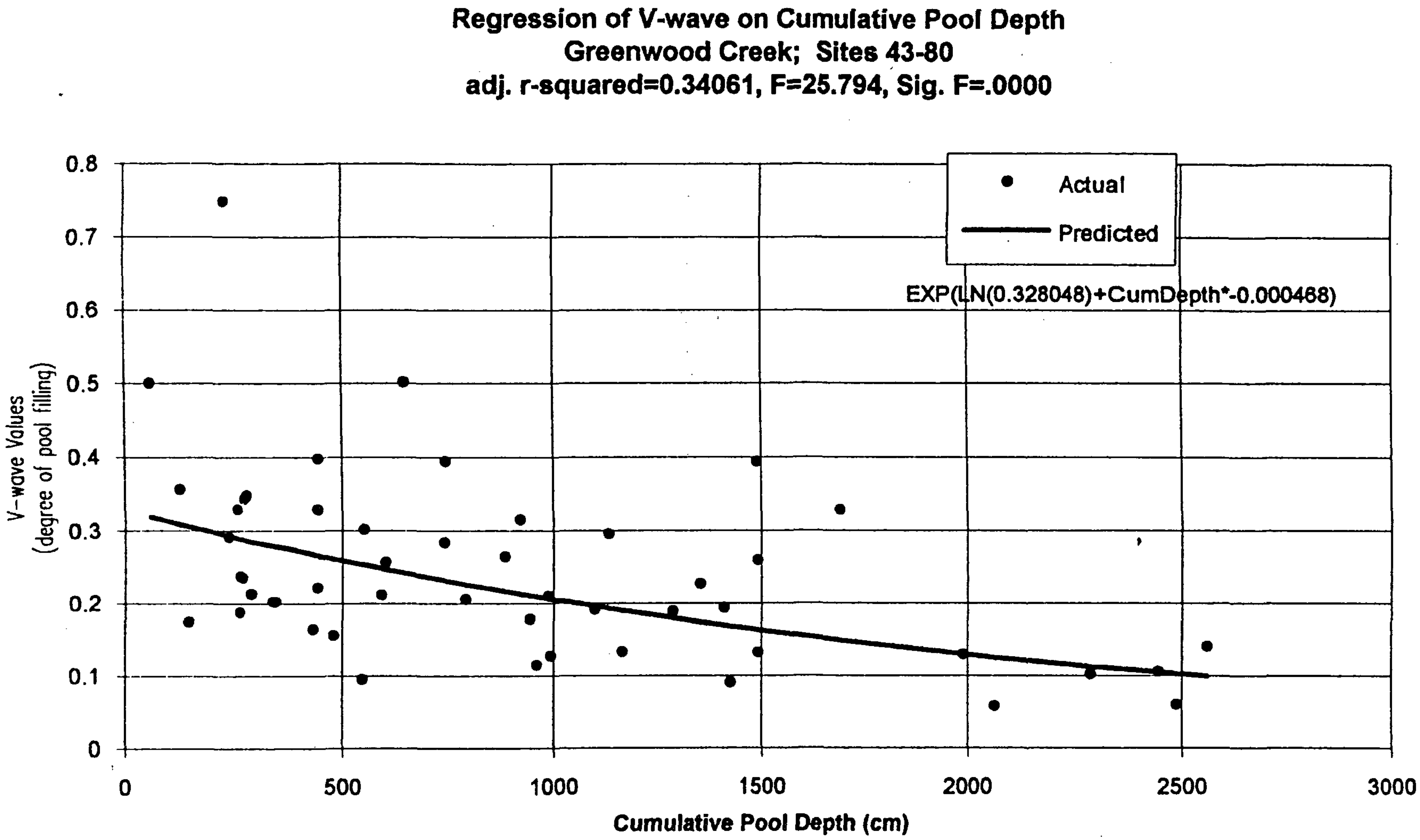

Regression of V-wave on Cumulative Pool Depth
Greenwood Creek; Sites 43-80
adj. r-squared=0.34061, F=25.794, Sig. F=.0000
Actual
Predicted
EXP(LN(0.328048)+CumDepth*-0.000468)
V-wave Values (degree of pool filling)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
500
1000
1500
2000
2500
3000
Cumulative Pool Depth (cm)

Figure 14.

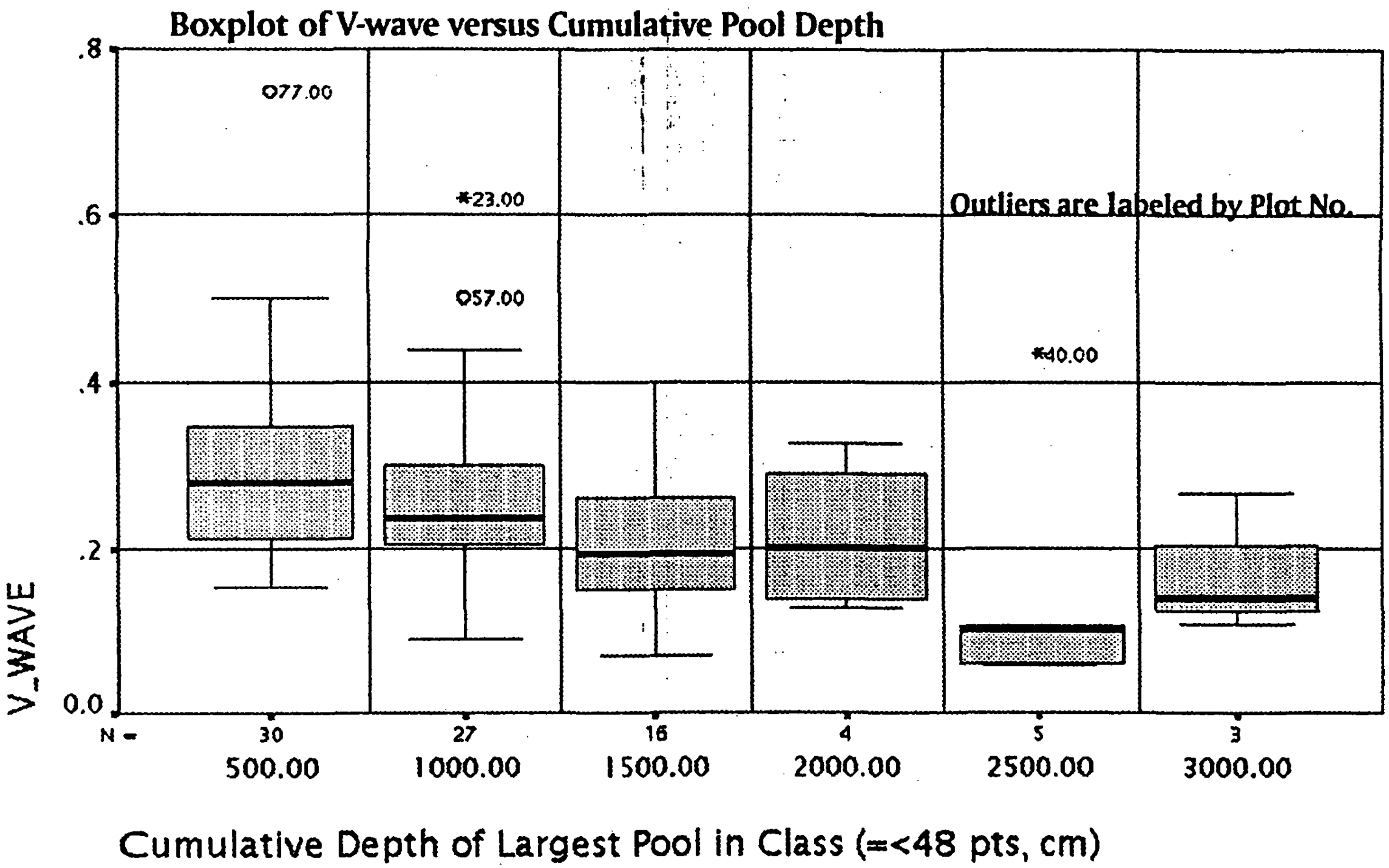

Boxplot of V-wave versus Cumulative Pool Depth
Outliers are labeled by Plot No.
O77.00
*23.00
O57.00
*40.00
.8
.6
.4
.2
0.0
V_WAVE
N =
30
27
16
4
5
3
500.00
1000.00
1500.00
2000.00
2500.00
3000.00
Cumulative Depth of Largest Pool in Class (=<48 pts, cm)

Figure 15.

inverse, and as pools have greater cumulative depth, they are less likely to contain residual sediment.

The relationship of cumulative depth to V-wave allows identification of pools which have uncharacteristically high amounts of sediment, so that researchers may go to the site and consider the reasons they are in that condition. As shown in the boxplot in Figure 15, pools can be sorted by cumulative depth category, and outliers and extremes for that category determined. An outlier is a pool which, when graphed, is beyond the 75th percentile by more than 1.5 times the range from the 25th percentile to the 75th percentile, and an extreme plots at more than 3.0 times that distance. Sites which meet these criteria are in plots 57 and 77, outliers, and 32 and 40, extremes.

Continuing Questions
The overview of the data suggests that sedimentation follows larger trends in the whole watershed and individual variation from pool to pool. Comparison with upslope sedimentation evaluations, and analysis of these data with respect to slope and stream characteristics may explain some of the broad-scale trends, as shown in Figure 10.

The role of cumulative depth respective to pool filling begs the question, "what are the other factors that fill pools?" We know, in this data set, that it is not STC area or unvegetated banks per 1000 m, though it may be either of these factors evaluated in a more site-specific context. It may also be tributary-derived sediment, slope of stream, thalweg placement, location on bar-unit (nearness to curves), distance to debris jams or knickpoints. This is a useful direction for further analysis of existing data and collection of data in the future.

The most interesting revelation from these data is the concept that pool filling can be controlled through pool depth. Anecdotally, deep pools, particularly deep, narrow pools, act as sluiceways, and keep themselves clean. Deep plunges following logs may also have a strong self-cleaning effect. The bottom line may be one for restoration: if one is building pools, build them deep.

H. Sediment Transport Corridors - STC's

Sediment Transport Corridors (STC's) are places where sediment enters the stream zone. They may be related to human activities or of natural causes. Roads, logging activities, utility right of ways, construction, and trails made by people, game, and cattle typically create STC's. Sometimes steep slopes or a high stream flow will cause banks to erode and an STC in the form of a landslide occurs. Tributaries are considered a separate category from STC's, although they do transport sediment. Figure 16 is a sample sketch of an STC created by a road failure into Greenwood Creek. The accompanying document, Greenwood Creek Watershed Project Stream Survey (1996), gives sketch maps for all STC's. A summary of STC dimensions and causes is presented in this report in Appendix B, Table 7.

Documenting the location and dimensions of STC's for a watercourse serves as a useful tool in evaluating sediment sources and planning for restoration work or road improvements. Field personnel recorded all STC's they encountered for the entire length of the sampled stream segments. These records include:

* location,
* effect on the stream (negligible, sediment deposition, or significant aggradation),
* written description,
* possible causes and sources,
* dimensions, and
* a sketch.

Location and Size of STC's

STC surface area was calculated from dimensions recorded in the field. In order to determine which STC's transport or produce the greatest relative amount of sediment, STC surface area was used as an indicator of magnitude. The surface area shows the degree to which bare soil is exposed to agents of transport. Surface area is also a function of persistence and ability of an STC to carry sediment over ground buffers to the stream channel.

Figure 17 shows the location and dimensions of STC's, as calculated in square meters, per sample plot. Figure 11, in the V-wave section, shows the cumulative STC area for each 1000 meter stretch of Greenwood Creek. The two diagrams show high values for sediment entry into the following regions on Greenwood Creek:

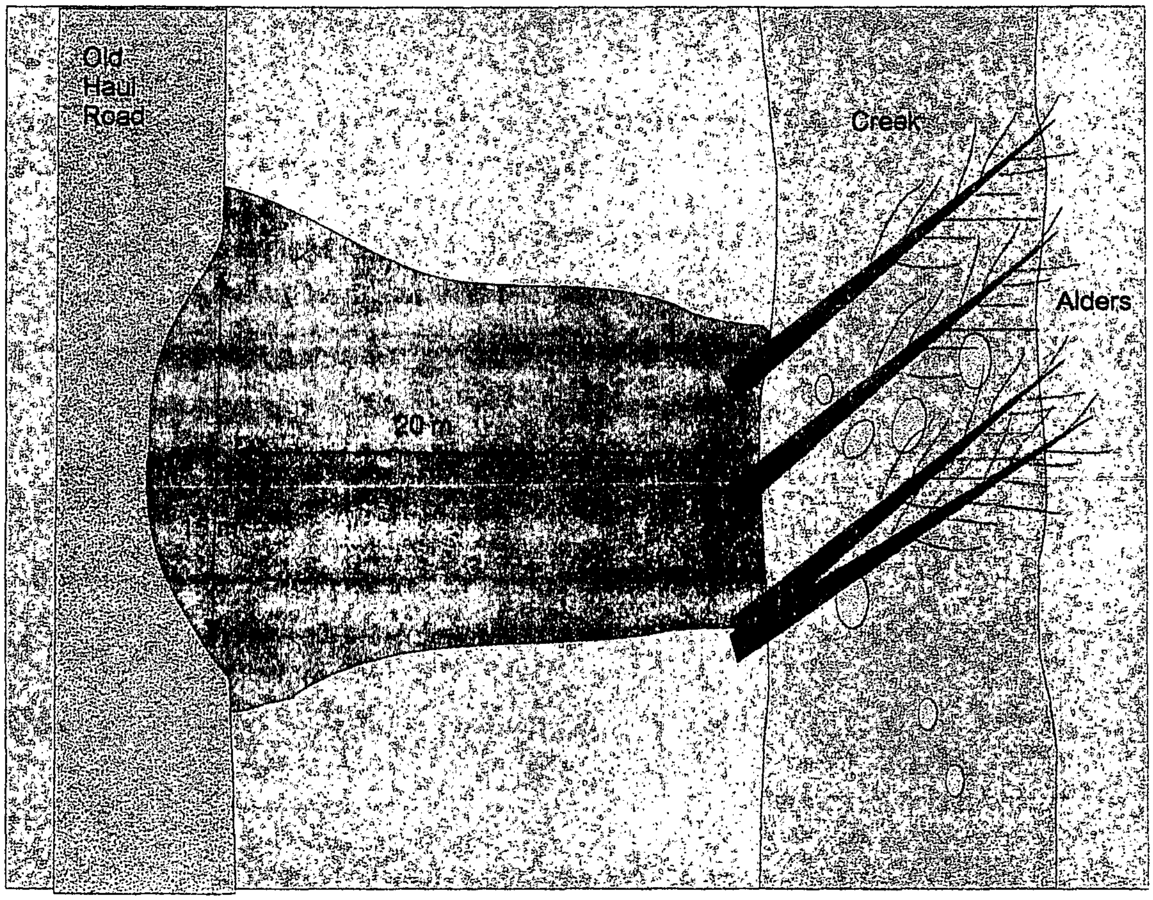
- Samples 8-13, at 1500-2700 m,
- Samples 55-57, at 11,100-11,800 m, and
- Samples 74-76, at 15,300-15,800 m.

STC Causes and Recommendations

Field crew were instructed to investigate STC's and follow them from the creek up to source areas. Most probable causes were noted, and are shown in Figure 18, which looks at a sum of STC area relative to cause. The largest amounts of STC area were attributed to 1) collapsing banks along the stream course, 2) roads and 3) seeps or springs. This breakdown is extremely important to consider when planning for water quality or fish habitat restoration. The reason for such high

Sediment Transport Corridor

Location of Stream entry Below the "Pigeon Hole"
Facing upstream, the STC drains in from the: Left
Width 15 m. Length 20 m. Depth ?
Describe the source and/ cause:
Failed road. Not proper draining.



sample no. above 9 meter location 1890 to 1910 scribe's name Jesse date 7/25/95

Site 9+

Figure 16.

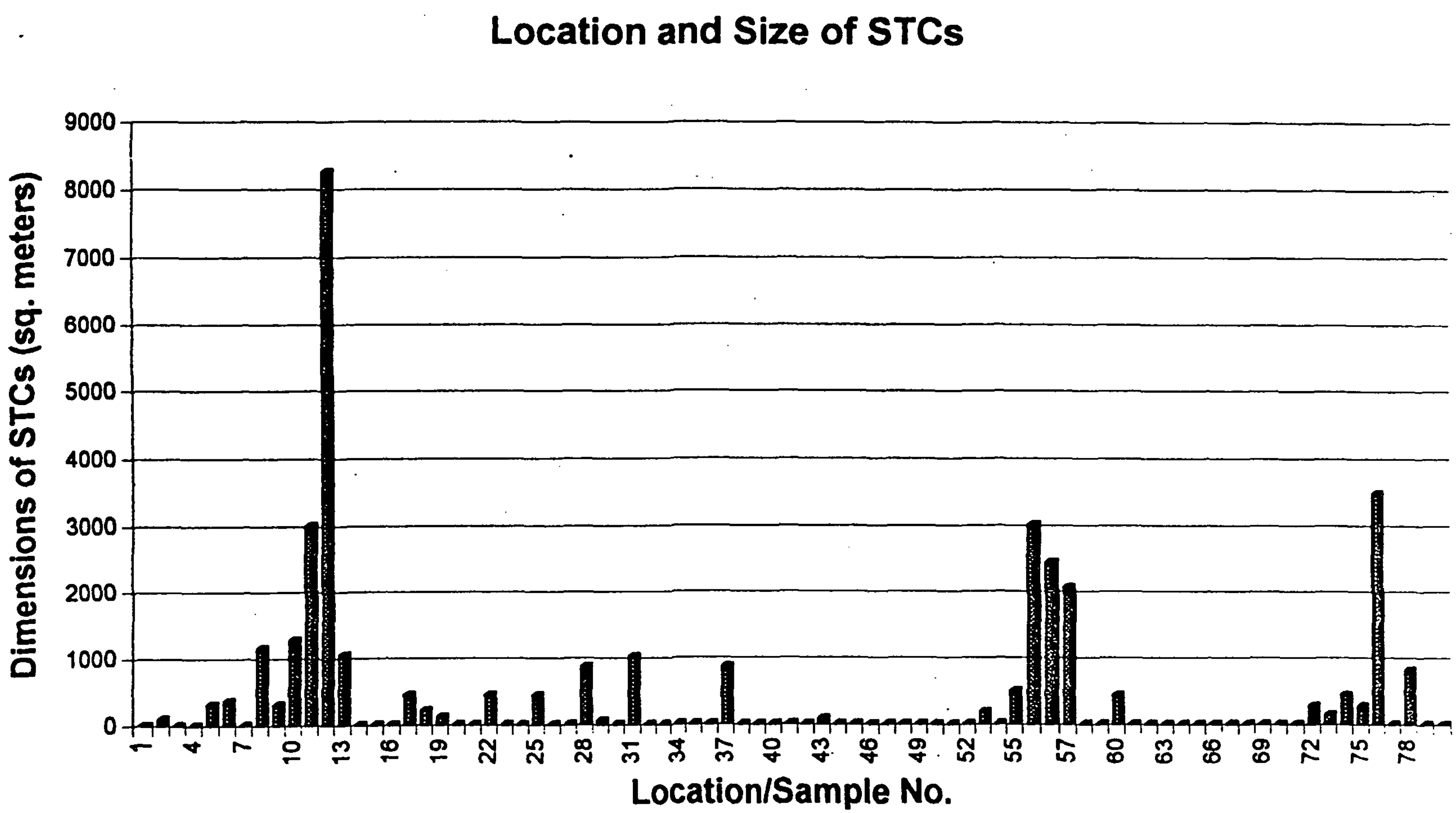

Location and Size of STCs
Dimensions of STCs (sq. meters)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1
4
7
10
13
16
19
22
25
28
31
34
37
40
43
46
49
52
55
57
60
63
66
69
72
75
78
Location/Sample No.

Figure 17.

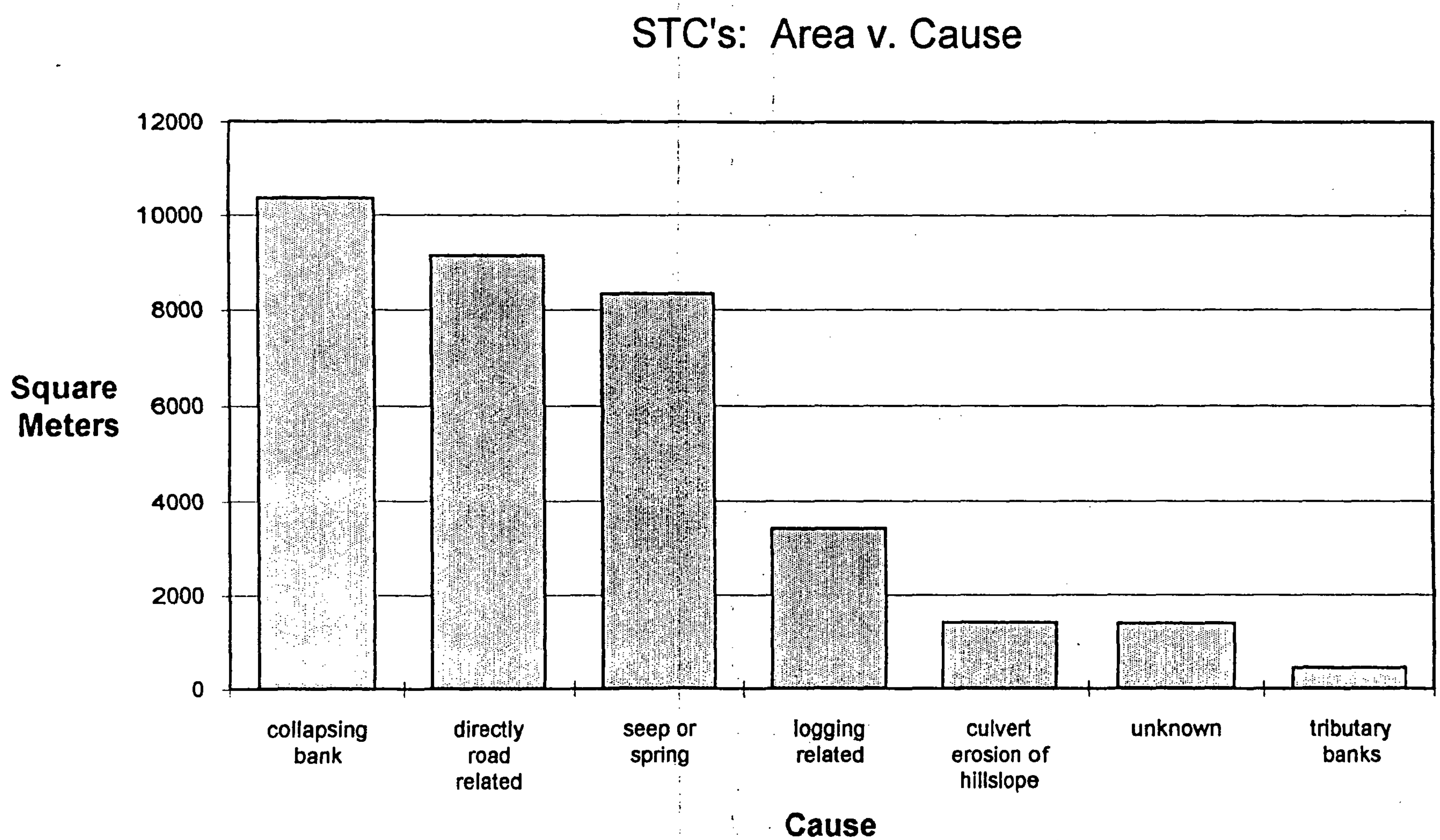

STC's: Area v. Cause
Square Meters
12000
10000
8000
6000
4000
2000
0
collapsing bank
directly road related
seep or spring
logging related
culvert erosion of hillslope
unknown
tributary banks
Cause

Figure 18.

percentages of collapsing banks, in particular, needs to be investigated. Road related STC's may be the source to reduce, because of the common interest in their repair--both road users and water users will benefit from reduced road erosion. Site specific, in-field, practical remedies need to be considered for every STC.

I. Tributaries

Data were gathered on all significant tributaries encountered by field crews. Like STC's, one goal of the data was to evaluate if any significant change occurred at the confluence with the mainstem. These data revealed little, apart from noting a few deltaic deposits. Sketch maps, as shown in Figure 19, were developed for each tributary as well.

Further information on tributaries and their contribution to the total sediment load of Greenwood Creek remains an important consideration to the total sediment budget, however. That information will need to be gathered either by specific analysis of the particle size, pool filling and STC's of the tributary system, analysis with airphotos, road surveys, and/or simultaneous turbidity analysis throughout the stream system during peak flows. Tributary watershed information may then be used along with the existing and future data on the mainstem of the stream.

The tributaries are an essential part of the watershed. This study has, to this pint, conducted a mainstem evaluation. Whole watershed analysis must address the tributaries and hillslopes, which contribute to the cumulative qualities of the mainstem.

Tributary

Location of Stream entry 1330 m.

Facing upstream, the STC drains in from the: Right.

Condition change apparent at confluence? Describe changes in sedimentation, water color, etc.

Channel goes up steep bank through second growth fir and redwood. The channel feeds in behind a large cobble bar and goes underground. Water feeds into stream about 10 m. down stream.

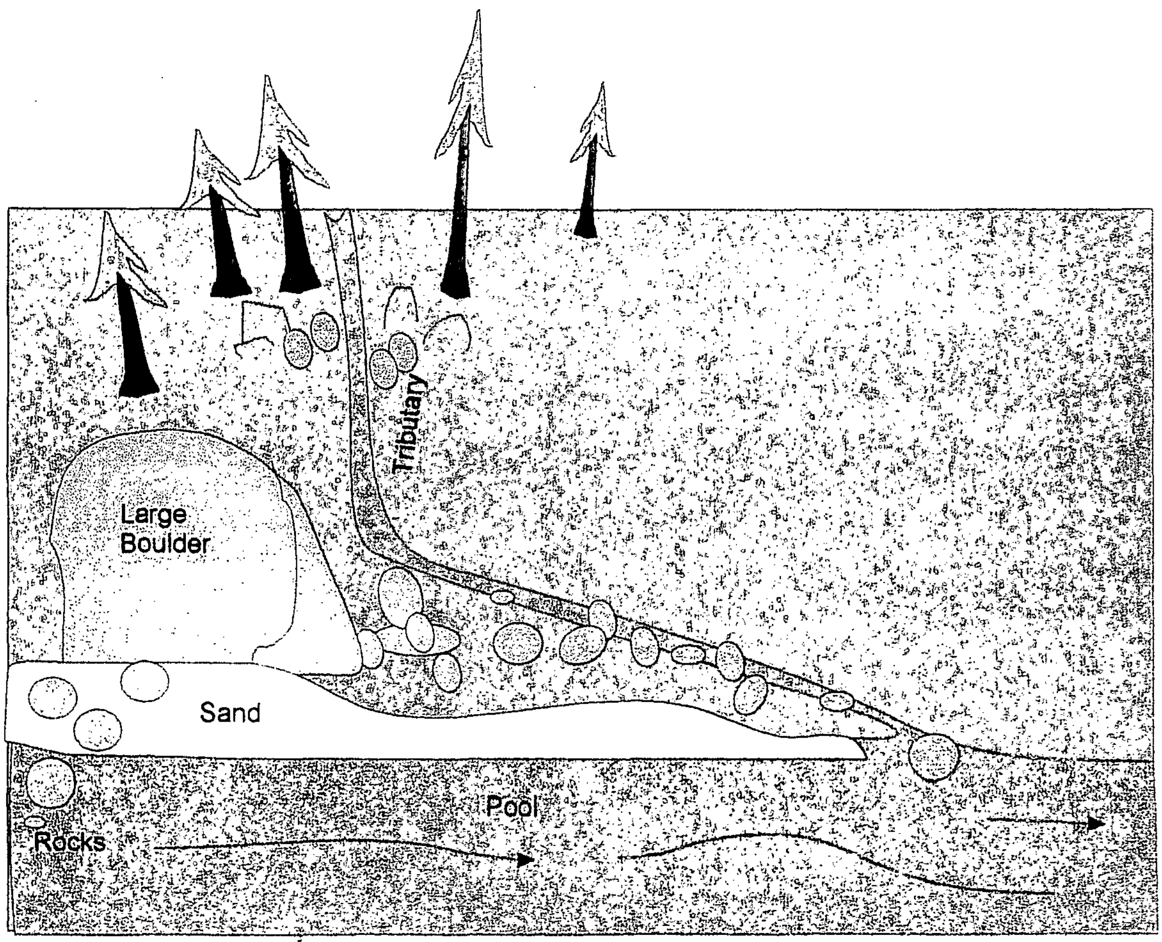


Figure 19.

sample no. 6+ meter location 1320 to 1330 scribe's name Dave date 7/23/95

Site 6+

III. RECOMMENDATIONS FOR RESTORATION AND FURTHER STUDY

Data Summary

Eighty Greenwood Creek mainstem samples of 30 meters, located along 16590 meters of stream, were evaluated in this study, a sample of 15%. Included in this sample were 85 pools, measured for sedimentation, and 40 sediment transport corridors (STC's), evaluated for size and source.

Channel pattern in the lower reaches, between sample sites #1-16, varied between straight, meandering and braided, becoming predominantly straight from site #17 and above. The exception is a braided section from sites 34 to 37.

High levels of unstable banks were found in the ranges of sites #16-20 and #38-43. Sample sites #12-17 show high percentages of unvegetated, squared and ramped banks and coincide with reaches of eroding banks.

The lower half of the creek showed significantly lower levels of large woody debris (LWD) per sample site, with the exception of large log jams that were located in and in between plots #1 to 4, with from 35-90 pieces per jam. In general, woody debris amounts increase upstream, with the exception to this trend occurring in the upper reaches of the stream between plots #62-71, where LWD drops off considerably.

Many sample sites along the entire length of Greenwood Creek had relatively few pools. 75% of the sites sampled had only one pool or less per 30 meters of stream reach, and 14% of these sites had no pools at all. This lack of pools may be linked to a lack of woody debris or boulders in many of the sites, or may be a function of the flow, the meander wavelength and the streambed materials.

A noticeable drop in fish numbers, from sites # 37-42, coincides with a large increase in collapsing banks, limited pools and almost no woody debris.

The mean pool filling (V_W in Hilton and Lisle) was 0.25, with a standard error of 0.01. Relative to Chris Knopp's 1993 study of North Coast watersheds, the pool filling values of Greenwood Creek are relatively low, suggesting a creek in moderately good condition. It is not clear, however, if values from Knopp, Hilton and Lisle, or this study may be reasonably compared. The 85 pools measured, however, represent a significant baseline resource.

Pool filling data (V-wave) related inversely to cumulative pool size at a significance >99.99%, with a stronger relationship for the upstream half of pools sampled. These data did not relate significantly to either STC location or collapsing banks. The relationship of cumulative depth to V-wave allows identification of pools which have uncharacteristically high amounts of sediment.

Those pools are in plots 57 and 77, which are outliers, and 32 and 40, which are extremes. The relationship of depth to sediment also suggests that when building pools, restorationists should emphasize depth.

STC's with significant contributing area were concentrated in several stream reaches:

- Samples 8-13, at 1500-2700 m,
- Samples 55-57, at 11,100-11,800 m, and
- Samples 74-76, at 15,300-15,800 m.

The largest amounts of STC area were attributed to 1) collapsing banks along the stream course, 2) roads and 3) seeps and springs.

Restoration Opportunities

There are several approaches to restoration. First, the GCWP should consider its goal or goals--water quality, fish habitat, stream stability or road utility--and how it wishes to spend scarce restoration funds. With this underlying decision, the GCWP has a variety of approaches to choose from, which are outlined below. All restoration projects will require further field reconnaissance and planning. In addition, no restoration project should be considered an end, but rather a management action within a strategy of inventory, management and monitoring.

- Comparison of the various factors of stream and bank condition is shown in Appendix B, Table 8. The data 'line up' to show key sites of concern. If restoration were to be commenced in the near future, these data suggest the following sites as zones of multiple concerns:

  * Sample #12-13 (2310-2520 m): High erosion from STC's, high sedimentation in pools, low LWD, scarce fish, nearby unstable banks and braided channel;

  * Sample #34-37 (6930-7560 m): Braided channel, few pools, low LWD, bare banks, scarce fish, and upstream from an extreme pool sedimentation site;

  * Sample #40-44 (8190-9030 m): Unstable and bare banks, few pools, low LWD, scarce fish, high pool sedimentation,an extreme sedimentation site, and a large log jam;

  * Sample #55-59 (11340-12180 m): Very high pool sedimentation throughout this area and many STC's. This is probably an area where STC's are contributing directly to stream sedimentation.

- Bare and unstable banks in the regions of samples #12-17 and #38-43 stand out as good stretches of the creek to revisit and assess for restoration and bank stabilization projects. Sites #12-17 should be revisited to evaluate potential for restoration and bank stabilization.

- Lower reaches between samples #5-21, and the upper watershed samples #62-71, would be good stream reaches to look at for possible recruitment of LWD into the channel. Restoration actions for log jams in the areas of samples #1 to 4 should include evaluation of jams for fish passage, flooding and erosion potential.

- Road related STC's may be the most economical and politically expedient source to restore, because both road users and water users will benefit from reduced road erosion. Site specific remedies need to be considered for every STC. In addition cost-sharing or in-kind donations may be available from road owners, co-owners or associations.

Continuing Study

Further study in the Greenwood Creek watershed must consider water quality, fish habitat, watershed conditions, and increasing knowledge of the mainstem. Some of these data are already collected and need assembly and analysis, such as turbidity data, from Elk County Water District, and GIS layers, from L-P Corporation. Other elements are in process, such as airphoto analysis by the Greenwood Creek Watershed Project. Creation and housing of a master data base and history of data analysis within the Watershed Project will help defray both cost and redundancy of sampling and analysis.

Water quality data would benefit from simultaneous turbidity sampling of creeks during storms. Combined with a rating curve to determine the actual amount of suspended sediment transport, these data would be useful in determining sediment sources in the watershed.

Road surveys in the watershed would identify clear sources of erosion. Landowners have stated that much of the erosion problem in the watershed may be traced to old railroad grades, unused roads and certain active roads which drain into tributaries. Location of these sites by survey and interview would identify future restoration sites that would benefit many parties at once.

Assessment of fish within Greenwood Creek will be useful to understand the potential for habitat restoration. Better population information may employ snorkel surveys, electrofishing or migrant trapping. This more intense measurement will better assess the number, species and habitats of Greenwood Creek's fish population. Specific direction and tools for fisheries research should be determined and detailed by a fisheries specialist.

The V-wave data tell a piece of a larger story, which probably includes tributary-derived sediment, slope of stream, thalweg placement, nearness to curves, distance to debris jams or geologic control points. This is a useful direction for further analysis of existing data and collection of data in the future. Further progression up the stream and analysis of watershed factors will also help isolate particular sedimentation sources.

A geomorphic evaluation of pool forming elements and structures may be conducted for the lower watershed, to see if the low number of pools found is valid for this stream system, or unreasonably low. After assessing what the 'right' number of pools are, and if they are restricted by woody debris recruitment, habitat restoration projects on Greenwood Creek may do well to focus on recruitment and stabilization of woody debris into the stream channel to create more pool formation to increase habitat potential for fish. The first sites which should be evaluated are in the sample #34-45 area, which should be investigated both for the reasons that there are few pools in this reach, and this reach's potential for pool creation.

Further information on tributaries and their contribution to the total sediment load of Greenwood Creek remains an important consideration to sedimentation analysis and control. The upper watershed and tributary information which may be gathered to best understand these relationships are particle size, pool filling, STC's, analysis with airphotos, road surveys, and/or simultaneous turbidity analysis throughout the stream system during peak flows. Tributary watershed information may then be used along with the existing and future data on the mainstem of the stream.

Whole watershed analysis must address the tributaries and hillslopes, sediment sources, precipitation rates, and land management activities. Ultimately it is the interaction of all these factors which cumulatively create the qualities of Greenwood Creek, including its characteristics of shape, water quality, and fish habitat.

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APPENDIX A

* * *

Field Guide for Stream Survey Methodology

Field Guide for Stream Survey Methodology

1. **Describe location:** Locations of samples should include obvious descriptions of the site that would help someone locate that spot again. (eg. broad open meadows, adjacent land owned by whom etc...)

2. **Valley Morphology:** Describe the valley morphology using the following terms:

Broad flood plain: An area with very low stream gradient and flat local topography, heavy sediment deposition and aggradation forming deltas and/or a braided channel. In a broad floodplain a channel can change its course quite easily.
Swale: A slight depression in the topography that confines the channel. The channel has a low gradient, is not deeply incised and can still change its course within the swale confines.
Constricted: A valley with steep sides, a deeply incised channel and little space for the stream to change its course.

3. **Channel Morphology:** This is an assessment of the channel morphology at the sample site. If the sample is anomalous compared to the overall stream morphology, you can note this on the data sheets. Choices include:

Riffle: A quickly moving stretch of water unbroken by meanders, obstruction pools or cascades.
Dune-riffle: A straight, sandy channel with little gradient and substantial deposits of fine sediment forming an undulating stream bottom with occasional pools and riffles.
Riffle-pool-meandering: A channel with riffles, pools and meanders that are not caused by large organic debris (LWD) or rock formations in the channel.
Riffle-pool-obstruction: A channel with riffles, pools and meanders that are caused by obstructions such as LWD or large boulder formations.
Cascade: A very steep channel with no pools and mostly white water.
Step-pool: A very steep channel consisting of small falls between frequent pools.

4. **Channel pattern:** The channel pattern is described in the following terms:

Straight: A single channel that flows generally in a straight line.
Braided: Multiple channels that flow in and out of each other.
Meandering: A single channel with many regularly spaced turns.

5. **Bank morphology:** This is an estimation of the percentage of the stream banks showing the following forms. Both banks together equal 100% and a visual grid, breaking the banks into smaller percentage areas, is used for standardization.

Ramped: Banks slope into the water at less than 90 degrees.
Squared: Banks rise vertically out of the water.

Overhanging: Banks extend over the water, with enough overhang to prevent you from seeing your boot toe under the bank.

6. **Bank condition:** An estimate of the bank condition, using percentages. These may total to over 100% if the categories overlap. Choices include:

Unvegetated cobble, gravel or sand
Vegetated
Wood or root wads
Collapsed
Bedrock/boulders
Actively contributing sediment.

7. **Pebble/Particle Count:** This is a measurement of 150 randomly selected mobile particles and the largest 30 particles in a single point bar or gravel bed. The objective of this measure is to determine what size materials the stream is capable of carrying, later to be used in determining stream energy, calculating Riffle Armor Stability Index and evaluating cumulative effects. With eyes closed, workers use their fingertip to select particles, from within the flowing water to the upper limit of the mobile material.. The size of the particle is recorded as its y-axis, or middle axis dimension. The thirty largest particles are identified by looking around the same bar and searching.

8. **Large Organic Debris (LWD):** Workers tally the number of large woody debris pieces in the bankfull channel for two size classes and categorize them as "functional" or "non-functional". The two size classes are from 20-50 cm and >50 cm in diameter. The size is determined by the *largest* diameter section of the wood. Functional is defined as embedded into the banks or bed or affecting the flow of water around it. Non-functional is defined as lying within 2 meters above the wetted channel or poised, ready to fall into the stream. If there is a debris jam of more than 10 pieces greater than 20 cm diameter, the jam is recorded separately on the debris jam form.

9. **Fish sighted:** When workers arrive at the sample site, they quietly walk the sample reach bank looking for fish before stepping in the water and beginning other evaluations. Number of fish, size and species are noted when possible.

10. **Number of pools in this plot:** Instream pools function to provide fish habitat, especially in hot weather, and to trap or hold sediment as it moves down through the stream channel. A basic question to ask when looking for pools in a channel, is "if you turned off the water, where would the pooled water remain?" Field crews are instructed to define pools with the following criteria:

- Water velocity slower than the mean velocity.
- Countervailing currents.
- Flat surface at low flow.
- Deeper than the mean thalweg depth. (deepest point of channel in cross-section).

11. **V-wave (V* proxy) :** Workers sample a maximum of two pools in each plot for relative volume of fine sands and sediments. Using a rod marked in centimeters, they

probe the pool in cross section, working from left to right, moving from downstream to upstream, conducting six transects of eight points each. The V points are not fixed to particular locations, though they should be spaced evenly through the length and width of the pool. Each point has two measurements, 1) the depth of the water without pushing the rod into the bed material and 2) the depth of the water after pushing the rod into the bed material until a resistant layer is reached. The rod should be jostled a few times to break through the sediment layers but should not be strenuously forced through heavy gravels or cobbles..

Workers record the downstream location of each pool, the maximum length and width of the pool and the maximum depth of the riffle crest (the lip over which the bathtub of the pool flows). After subtracting the riffle crest depth from each measurement, and excluding points which had sediment at a level higher than the riffle crest depth, the following values are determined to the nearest centimeter for each point. (Hilton and Lisle, 1993)

Vr: The residual pool depth. The depth of the water without pushing the rod into the bed material.

Vf + Vr: The total pool depth. The depth of the water after pushing the rod into the bed material until an armored layer is reached.

Vf: The fine sediment depth. Calculated as total pool depth minus residual pool depth, or:

$$Vf = (Vr + Vf) - Vr$$

V_{wave}: The weighted average of fines/total depth for all points measured. The weighting is relative to depth and sediment filling. In other words, the points are not first calculated then averaged, but first accumulated, then calculated for the whole pool. The calculation is:

$$V_{wave} = \frac{S\ Vf}{S\ Vr + Vf}$$

Site map: Field workers sketch a detailed map of the site on graph paper. This is done by first hanging flags known locations, segmenting the plot, then walking the site and the adjacent flood plain.

To develop the map and assure that workers see the whole site, two parallel transects are run perpendicular to the stream valley to measure floodplain width and locate alternate (overflow and abandoned) channels. One transect is at 10 m and one is at 20 m of the 0-30 m site. The bearing of the transects is recorded, and a bearing tree, which lies on the transect, is labeled with an aluminum tag. The transect bearing tree is designated at 0m for each cross-section with positive numbers on the right and negative numbers to the left, facing upstream. Each tag is marked with the sample number and transect letter, 'a' at 10m, and 'b', further upstream at 20m. Bearing trees are chosen for their visibility and proximity to the streambed so the same transects can be run in the future. From these transects, the mid-points of alternate channels and the floodplain width are measured and recorded. The edge of the floodplain is determined by the break in slope to upland forest, usually at the change in vegetation type.

Site sketch maps are later translated into CorelDraw, to standardize features and scale. Map features include:

*North arrow;
*Overall channel shape, including length and width of sample reach and thalweg;
*Position of transects A and B, across active channel and alternate channels;
*Dominant obstructions in or along channel (eg. boulders, LWD, bedrock projections);
*Associated vegetation in and out of channel;
*Pools should be drawn and numbered in correlation with data sheets; and
*Positions of gravel bars, sandy beaches and large overhanging banks.

STC's / Tributaries / Debris Jams

The following features are not surveyed within plots, but along the entire distance of the stream. They have separate forms, apart from plot data.

Sediment Transport Corridors (STC's): An STC is a visible corridor where sediment enters the stream channel. Workers look for STC's along the entire length of the survey section, not just within samples. STC data include its meter location, the direction from which it drains, and an evaluation of its effect on the stream--"virtually unnoticeable", "sediment deposition", or "significant deposition". The STC should be walked uphill to its sources, and its cause and source area recorded. The surface area of the STC is determined by measuring its width and length to the nearest 1/2 meter. The STC is sketched to show the connection between the stream, the STC, its causes and source area.

Tributaries: Each tributary is recorded by its location on the stream length and noting which bank it drains from. Effects on stream are also noted including any visible changes in water quality or sediment loading in the main channel. Values of "virtually unnoticeable", "sediment deposition", and "significant deposition" are assigned.

Debris jams: All debris jams that contain 10 or more pieces of wood greater than 20cm diameter are recorded on the Debris Jam form, along with the meter location of the jam. Where the jam is found relative to the stream channel is noted by assigning a Zone classification to the jam: Zone 1 = low flow channel, Zone 2 = bankfull channel and Zone 3 = flood channel.

APPENDIX B

* * *

Data Tables

Greenwood Creek Watershed Project Stream Survey 1995

SAMPLE LOCATIONS AND DESCRIPTIONS

Sample number	Location in meters	Location description
1	180 to 210	Log jam, rocky point bar, below Russell house
2	390 to 420	Cliff on right, cobbling island, start of flats
3	600 to 630	Two dry alternate channels, massive log jam
4	810 to 840	RXR tressle pilings at top of flats
5	1020 to 1050	Down stream from L.P crossing
6	1230 to 1260	Just upstream from Commons flat adjacent to steel bridge
7	1440 to 1470	Above Greenwood Commons
8	1650 to 1680	Top of plot has large washout
9	1860 to 1890	Below "Pidgeon Hole" by giant old redwood
10	2070 to 2100	Large rock, cobble riffle, cascade. 2nd growth redwood/fir
11	2280 to 2310	Up from cascade into widening floodplain - alder
12	2490 to 2520	Ecualyptis grove hole
13	2700 to 2730	Old RR Trestle Pool
14	2910 to 2940	Braided channel, large boulder, log jam at head of site
15	3120 to 3150	Log Bridge Hole
16	3330 to 3360	Above log bridge, large flat bouldering, granite substrate
17	3540 to 3570	Large, long shallow pool below cascade
18	3750 to 3780	Straight riffle pool, steep banks on either side
19	3960 to 3990	Just above gravelly spawning beds
20	4170 to 4200	Long slow pool channels in the sun
21	4380 to 4410	Straight pool-riffle with large old alder and 2nd growth fir and redwood
22	4590 to 4620	Large bolders below point bar
23	4800 to 4830	One large, shallow pool, alder on bank
24	5010 to 5040	Above soda spring, large rock split in middle
25	5220 to 5250	Just above big tributary on right, Alder, Redwood, Fir goove
26	5430 to 5460	Floodplain broadens, 2nd growth alder cover
27	5640 to 5670	Just up from Alder jam
28	5850 to 5880	Creek goes up to right, large redwood stump at left side of bank

Table 1.

Greenwood Creek Watershed Project Stream Survey 1995 Cont..

SAMPLE LOCATIONS AND DESCRIPTIONS

Sample number	Location in meters	Location description
29	6060 to 6090	Above large bolders, long bend, large cobble bar
30	6270 to 6300	Long wide pool
31	6480 to 6510	Sheer rock wall into pool on s. side of creek. Large boulders
32	6690 TO 6720	Broad cobble creek bed below redwood grove
33	6900 to 6930	Long shallow pool, next to old road
34	7110 to 7140	Braided channel, next to Mat Evan's land
35	7110 to 7140	Braided channel, large cobble island.
36	7320 to 7350	Large pool below log jam, rocks and alder
37	7530 to 7560	Fir trees down across and above stream channel
38	7740 to 7770	Just below lake tributary
39	7950 to 7980	Giant Alders, large log on left
40	8160 to 8190	Middle of 180 degree turn
41	8370 to 8400	Just above road crossing cr. overhanging root wads
42	8580 to 8610	Log jam inbetween A & B transects
43	8790 to 8820	Just above large log jam
44	9000 to 9030	Long pools, large pool forming. Fir log on right
45	9210 to 9240	Large 5" fir log on left, long shallow pool
46	9420 to 9450	Really long shallow pool. Alder shade
47	9630 to 9660	Creek bends into pool with two large boulders, one huge one
48	9840 to 9870	Log across creek and into boulders
49	10050 to 10080	Step bank on left of pool
50	10260 to 10290	Long pool, two large pool forming boulders
51	10470 to 10500	Undercut bank, small log jam, cobble bar
52	10680 to 10710	Very large redwood root wad, nice pool
53	10890 to 10920	Railroad trestle
54	11100 to 11130	Just above RR trestle bridge, long long pool
55	11310 to 11340	Cobble field in stream bed of large stones
56	11520 to 11550	Riparian many alders and sedge grass in river
57	11730 to 11760	Riparian w / willows and firs. Few redwoods, very rocky, little sand
58	11940 to 11970	Cobble gravel, bar, overhanging rock on right
59	12150 to 12180	Cobble creek bed. Redwoods to bank, make overhanging screen

Table 1.

Greenwood Creek Watershed Project Stream Survey 1995 Cont..

SAMPLE LOCATIONS AND DESCRIPTIONS

Sample number	Location in meters	Location description
60	12360 to 12390	Alders, redwoods, fir and oaks into creekbed
61	12570 to 12600	Center valley floor, low ridges, big pools
62	12780 to 12810	Barn Gulch meets Greenwood
63	12990 to 13020	Long pool above Barn Gultch trib., where a logging road crosses.
64	13200 to 13230	Large trib. on right facing up stream, lg. root wad overhang + water fall
65	13410 to 13440	Below large redwood log that bridges the creek
66	13620 to 13650	Two nice pools at old hunting and fishing cabin
67	13830 to 13860	Nice bouldery pool above first cabins
68	14040 to 14070	Very constricted, rock wall on right, long pool with boulders
69	14250 to 14280	Granite ledge on right facing up
70	14460 to 14490	Long shallow pool with skid trail on left facing above large trib.
71	14670 to 14700	Large rocks and boulders
72	14880 to 14910	Lots of fallen trees across creekbed
73	15090 to 15120	Two redwood logs going across channel, less than two meters above channel
74	15300 to 15330	Huge log jam on left facing up stream
75	15510 to 15540	Sunny spot with small alders, step pools
76	15720 to 15750	Two nice deep pools, pool #1 has a large boulder in middle
77	15930 to 15960	Above old dam, wide cobbly creekbed
78	16140 to 16170	Lower part of nice long pool, pretty wide pool
79	16350 to 16380	Nice pool with lg redwood root wad. Site below large STC.
80	16560 to 16590	Long narrow, shallow pool below large fir log across stream

Table 1.

Greenwood Creek Watershed Project Stream Survey 1995

CHANNEL AND BANK MORPHOLOGY

Sample	Valley	Channel	Channel	Bank Morphology- %			Bank Condition - %			
	Morphology	Morphology	Pattern	Ramp	Square	Overhung	Unvegetated	Vegetated	Root wads	Eroding/actively contributing soil
1	broad floodplain	riffle-pool-obstruction	meandering	75	25	0	60	15	20	10
2	broad floodplain	riffle	straight	85	15	0	10	90	5	
4	broad floodplain	riffle-pool-meandering	meandering	75	25	0	40	50	10	0
5	broad floodplain	riffle-pool	braided	95	5	0	10	90	5	
6	constricted	riffle-pool-obstruction	straight	73	13	13	75	30	5	30
7	constricted	pool-obstruction	straight	45	50	5	45	45	5	5
9	constricted	riffle-pool-obstruction	braided	0	90	10	25	75	0	0
10	constricted	riffle-pool-meandering	meandering	8	73	18	45	50	5	0
11		step-pool	meandering	83	13	4	50	50	5	60
12	constricted	step-pool	straight	20	65	15	90	10	4	0
13	constricted	riffle-pool-obstruction	straight	60	35	5	90	10	5	0
14	constricted	riffle-pool-obstruction	braided	30	65	5	60	30	10	10
15	constricted	step-pool	straight	15	80	5	90	10	0	0
16	constricted	riffle-pool-meandering	meandering	80	10	10	70	20	10	30
17	constricted	riffle-pool-obstruction	straight	80	15	5	70	30	0	10
18	constricted	riffle-pool-obstruction	straight	60	30	10	40	20	10	30
20	constricted	riffle-pool-meandering	braided	70	25	5	50	60	0	10
22	constricted	riffle-pool-obstruction	straight	20	60	20	15	50	15	25
23	constricted	riffle-pool-obstruction	straight	70	20	10	10	80	10	10
24	constricted	riffle-pool-meandering	braided	45	45	10	50	40	15	5
25	constricted	riffle-pool-obstruction	straight	95	5	0	50	50	15	
26	constricted	riffle-pool-obstruction	straight	60	30	10	30	75	0	5
27	constricted	riffle-pool-obstruction	straight	75	25	0	25	50	20	15
28	constricted	riffle-pool meandering	straight	50	20	30	60	30	20	30
29	constricted	cascade	straight	65	25	10	70	25	5	5
30	constricted	riffle-pool-obstruction	straight	50	50	0	70	30	0	5
31	constricted	riffle-pool-obstruction	straight	10	60	30	70	20	10	20
32	constricted	riffle-pool-obstruction	straight	35	15	50	25	75	20	5

Table 2.

Greenwood Creek Watershed Project Stream Survey 1995										
CHANNEL AND BANK MORPHOLOGY										
Sample	Valley	Channel	Channel	Bank Morphology - %			Bank Condition - %			
	Morphology	Morphology	Pattern	Ramp	Square	Overhung	Unvegetated	Vegetated	Root wads	Eroding/actively
33	constricted	step-pool	straight	50	25	25	25	60	10	25
34	broad floodplain	riffle-pool-obstruction	straight	70	15	15	50	40	5	20
35	constricted	riffle-pool-obstruction	straight	50	30	20	50	40	10	10
36	constricted	riffle-pool-meandering	braided	20	5	75	50	10	40	20
37	constricted	riffle-pool-meandering	braided	70	10	20	60	30	10	10
38	constricted	riffle-pool-obstruction	straight	60	25	15	50	40	10	20
39	constricted	riffle-pool-obstruction	straight	55	20	25	50	50	20	
40	constricted	riffle-pool-obstruction	straight	28	48	23	50	45	15	20
41	constricted	riffle-pool-obstruction	straight	40	30	30	35	35	30	50
42	constricted	riffle-pool-obstruction	straight	30	45	25	50	50	25	25
43	constricted	riffle-pool-obstruction	straight	25	60	15	50	35	15	50
44	constricted	riffle-pool-obstruction	straight	60	25	15	50	35	15	20
45	constricted	step-pool	straight	50	30	20	35	65	25	30
46	constricted	riffle-pool-obstructed	straight	55	25	20	35	40	35	25
47	constricted	riffle-pool-obstruction	braided	45	30	25	50	25	30	35
48	constricted	riffle-pool-obstruction	straight	45	35	20	40	20	20	20
49	constricted	riffle-pool-obstruction	straight	20	50	30	50	35	10	10
50	constricted	riffle-pool-meandering	meandering	30	30	40	40	40	15	30
51	constricted	riffle-pool-obstruction	straight	30	35	45	40	40	25	25
52	constricted	riffle-pool-obstruction	straight	45	30	25	40	45	40	20
53	constricted	riffle-pool-obstruction	straight	50	30	20	50	20	10	30
54	constricted	riffle-pool-obstruction	straight	45	45	10	45	30	10	15
55	constricted	riffle-pool-obstruction	meandering	30	40	30	50	20	30	20
56	constricted	riffle-pool-obstruction	straight	40	50	10	40	50	25	30
57	constricted	riffle-pool-obstruction	meandering	30	40	30	50	40	30	40
58	constricted	riffle-pool-obstruction	braided	45	30	25	50	30	30	25
59	constricted	riffle-pool-obstruction	meandering	39	20	41	50	30	20	35
60	constricted	riffle-pool-obstruction	straight	50	30	20	40	40	25	20
61	constricted	riffle-pool-obstruction	straight	20	30	50	30	40	40	40

Table 2.

Greenwood Creek Watershed Project Stream Survey 1995

CHANNEL AND BANK MORPHOLOGY

Sample	Valley	Channel	Channel	Bank Morphology			Bank Condition			
	Morphology	Morphology	Pattern	Rampe	Square	Overhangi	Unvegetated	Vegetated	Root wads	Eroding/actively
62	constricted	step-pool	straight	13	13	73	40	5	40	40
63	constricted	riffle-pool-obstruction	straight	35	30	35	40	40	20	30
64	constricted	step-pool	straight	55	25	20	40	40	25	20
65	constricted	riffle-pool-obstruction	straight	35	40	25	40	30	20	20
66	constricted	step-pool	braided	35	40	25	45	35	20	20
67	constricted	riffle-pool-obstruction	straight	25	30	45	50	35	30	40
68	constricted	riffle-pool-obstruction	straight	25	40	35	50	25	5	25
69	constricted	riffle-pool-obstruction	straight	55	30	15	50	35	15	20
70	constricted	riffle-pool-obstruction	straight	35	30	35	40	40	15	35
71	constricted	riffle-pool-obstruction	straight	80	20	0	70	20	20	20
72	constricted	riffle-pool-obstruction	straight	10	60	30	30	30	10	30
73	constricted	riffle-pool-obstruction	meandering	35	35	30	40	30	25	35
74	constricted	riffle-pool-obstruction	straight	35	35	30	35	45	40	25
75	constricted	step-pool	straight	35	35	30	40	45	30	30
76	constricted	riffle-pool-obstruction	straight	40	30	30	45	40	25	45
77	constricted	step-pool	straight	17	80	3	20	60	5	15
78	constricted	riffle-pool-obstruction	straight	45	40	15	25	55	20	15
79	constricted	riffle-pool-meandering	braided	15	45	40	45	60	25	25
80	constricted	riffle-pool-obstructed	straight	50	25	25	35	55	15	15
TOTAL PERCENT (average)				45	34	21	46	40	17	20

Table 2.

Greenwood Creek Watershed Project Stream Survey 1995

WOODY DEBRIS AND LOG JAMS

Sample number	LOD 20-50 Functional	LOD >50 Functional	Total Functional LOD	LOD 20-50 Non-functional	LOD >50 Non-functional	Jam Location	No. rootwads	No. logs 20-50 cm	No. logs >50 cm
1	2	0	2	0	0	180	1	14	7
2	0	0	0	1	0	190	1	16	19
3	0	0	0	0	0	280	1	14	15
4	4	0	4	0	0	540	1	19	5
5	0	0	0	0	0	555	1	20	8
6	1	0	1	0	0	620	0	50	18
7	0	1	1	2	0	805	3	21	3
8	0	0	0	0	0	863	0	19	10
9	1	0	1	0	2	2175	0	0	6
10	0	0	0	0	0	2338	0	32	6
11	0	0	0	0	2	2910	2	4	5
12	0	0	0	0	0	5630	4	8	4
13	0	1	1	0	0	6685	0	2	3
14	0	0	0	0	0	2236	0	0	3
15	0	0	0	0	0	2360	0	13	5
16	0	2	2	7	2	2401	0	11	3
17	0	0	0	0	0	2860	0	0	1
18	1	2	3	0	0	3104	0	5	5
19	0	0	0	0	0	3871	0	6	5
20	0	1	1	0	1	7345	0	20	3
21	0	0	0	0	0	7596	0	5	6
22	10	3	13	0	0	3652	1	14	3
23	0	0	0	0	0	5810	0	9	11
24	6	3	9	4	0	863	0	19	10
25	0	1	1	3	4	6729	0	2	0
26	0	0	0	0	0	7380	0	7	6
27	2	1	3	11	2	7870	0	10	3
28	2	1	3	4	0	8569	0	19	0
29	0	0	0	3	0	8595	0	20	3
30	0	1	1	1	0	8765	0	60	30
31	0	1	1	2	0	10495	0	5	5

Table 3.

Greenwood Creek Watershed Project Stream Survey 1995									
WOODY DEBRIS AND LOG JAMS									
Sample number	LOD 20-50 .Functional	LOD >50 Functional	Total Functional LOD	LOD 20-50 Non-functional	LOD >50 Non-functional	Jam Location	No. rootwads	No. logs 20-50 cm	No. logs >50 cm
32	4	0	4	2	2	10514	1	7	4
33	2	0	2	2	0	11158	3	4	3
34			0			12365	0	9	2
35	0	0	0	1	1	12575	2	9	2
36	5	5	10	10	0	12595	3	12	2
37	4	2	6	4	0	12615	4	20	8
38	0	0	0	0	0	13514	0	6	6
39	0	1	1	4	0	14829	0	5	5
40	0	0	0	0	0	16422	1	6	9
41			0						
42	2	1	3	20	2				
43	2	1	3	1	0				
44	1	1	2	2	0				
45	3	4	7	1	1				
46	0	0	0	3	3				
47	3	0	3	3	1				
48	8	1	9	0	0				
49	1	0	1	3	0				
50	1	0	1	3	1				
51	5	2	7	4	3				
52	1	3	4	3	0				
53	1	0	1	3	1				
54	2	0	2	0	0				
55	0	2	2	1	1				
56	0	6	6	17	1				
57	4	2	6	10	0				
58	3	0	3	3	0				
59	0	1	1	1	0				
60	1	1	2	8	1				

Table 3.

Greenwood Creek Watershed Project Stream Survey 1995					
WOODY DEBRIS AND LOG JAMS					
Sample number	LOD 20-50 .Functional	LOD >50 Functional	Total Functional LOD	LOD 20-50 Non-functional	LOD >50 Non-functional
61	7	9	16	15	5
62	1	0	1	0	0
63	0	0	0	3	0
64	2	0	2	0	0
65			0		
66	0	0	0	4	0
67	2	1	3	1	1
68	0	0	0	1	0
69	2	0	2	0	0
70	0	0	0	4	2
71	0	0	0	0	1
72	4	1	5	0	0
73	11	3	14	0	0
74	12	5	17	10	3
75	0	0	0	1	0
76	2	0	2	6	1
77	2	2	4	0	2
78	3	2	5	1	0
79	2	3	5	2	0
80	0	0	0	2	1

Table 3.

Table 4.

Greenwood Creek										
Fish Sighted - Numbers, Size and Species										
Sample	Fish	Number		Size		Species				
number	Sighted	min.	max.	min. in.	max. in.	trout	steelhead	stickleback	bullhead	suckerfish
1	yes	10	12	2	6				bullhead	suckerfish
2	yes	3	3	2	2		steelhead			
3	yes	8	8	1.5	5		steehlead			suckerfish
4	yes	5	5	1.5	2		steelhead	stickleback		
5	yes	9	9	2	4	trout				
6	yes	18	18	1.5	2.5		steelhead			
7	yes	20	20	1.5	6		steelhead		bullhead	
8	yes	15	15	2	5		steehlead			
9	yes	10	10	1.25	5		steelhead			
10	no									
11	yes	20	20	1.5	5		steelhead			
12	yes	20	20	1.5	6		steelhead			
13	yes	8	10	3	5					
14	yes	2	2	1.5	5					
15	yes	25	30	1.5	6		steelhead			
16	yes	8	10	1.5	5		steelhead			
17	yes	18	20	1.5	5		steelhead			
18	yes	10	10	1.5	6		steelhead			
19	yes	10	10	1.5	5					
20	yes	20	20	1.5	5		steelhead			
21	yes	30	30	1	3		steelhead			
22	yes	15	15	1.5	7		steelhead			
23	yes	35	35	1.5	3		steelhead			
24	yes	15	15	1.5	4		steelhead			
25	yes	4	4	1.5	2		steelhead			
26	yes	12	12	1.5	4		steelhead			
27	yes	20	20	1.5	4		steelhead			
28	yes	10	10	1.5	6		steelhead			
29	yes	15	15	1.5	6		steelhead			
30	yes	30	30	1.5	4		steelhead			
31	yes	5	10	1.5	4		steelhead			
32	yes	10	10	1.5	4		steelhead			
33	yes	9	10	1.5	4		steelhead			
34	no						steelhead			
35	yes	15	15	1.5	6		steelhead			
36	yes	2	2	1.5	2		steelhead			
37	yes	15	15	1.5	6					
38	yes	7	10	1.5	6		steelhead			
39	yes	4	4	1.5	2		steelhead			
40	yes	1	1	1.5	1.5		steelhead			
41	no									

Table 4.

Fish Sighted - Numbers, Size and Species Cont...										
Sample	Fish	Number		Size		Species				
number	Sighted	min.	max.	min. in.	max. in.	trout	steelhead	Sickleback	bullhead	suckerfish
42	yes	4	4	1.5	4		steelhead			
43	yes	10	12	1.5	4		steelhead			
44	yes	30	30	1.5	6		steelhead			
45	yes	15	15	1.5	4		steelhead			
46	yes	1	6	1.5	5					
47	yes	15	15	1.5	6		steelhead			
48	yes	9	9	1.5	3		steelhead			
49	yes	20	20	1.5	5		steelhead			
50	yes	20	20	1.5	6		steelhead			
51	yes	6	6	1.5	7		steelhead			
52	yes	15	15	1.5	7		steelhead			
53	yes	25	25	1.5	5		steelhead			
54	yes	80	90	1.5	7		steelhead			
55	yes	5	5	1	2		steelhead			
56	yes	20	20	2	5		steelhead			
57	yes	25	25	2	4		steelhead			
58	yes	5	5	2	4		steelhead			
59	yes	22	22	1.5	4		steelhead			
60	yes	1	1	3	3		steelhead			
61	yes	2	5	1.5	6		steelhead			
62	yes	11	11	1.5	4.5		steelhead			
63	yes	30	30	1.5	6		steelhead			
64	yes	10	10	1	4		steelhead			
65	no									
66	yes	28	28	2	7		steelhead			
67	yes	15	15	2	7		steelhead			
68	yes	10	10	2	6		steelhead			
69	yes	30	30	1.5	5		steelhead			
70	yes	15	15	1.5	3		steelhead			
71	yes	2	2	1.5	1.5		steelhead			
72	yes	6	6	2	2		steelhead			
73	yes	10	10	2	3		steehead			
74	yes	52	52	2	5		steelhead			
75	yes	5	5	2	4		steelhead			
76	yes	30	30	2	5		steelhead			
77	yes	35	35	2	5		steelhead			
78	yes	20	20	2	4		steelhead			
79	yes	26	26	2	6		steelhead			
80	yes	11	11	2	3		steelhead			
Average per Sample		**15.6**	**16.1**	**1.7**	**4.6**					

Sample No.	Pool No.	Pool location (m)	Sum of Pool Depth (cm)	V_wave	Sample No.	Pool No.	Pool location (m)	Sum of Pool Depth (cm)	V_wave	Sample No.	Pool No.	Pool location (m)	Sum of Pool Depth (cm)	V_wave
1	1	182	1179	7.0 %	31	1	6485	886	11.9 %	60	1	12365	273	23.8 %
3	1	625	705	8.9 %	32	1	6690	990	29.2 %	61	1	12601	960	11.5 %
4	1	770	1612	25.4 %	33	1	6910	323	29.1 %	62	1	12820	994	12.7 %
5	1	1020	256	30.1 %	36	1	7320	1226	40.0 %	63	1	13000	1492	13.2 %
6	1	1250	361	27.1 %	37	1	7530	805	30.4 %	66	1	13630	2558	14.1 %
7	1	1440	562	21.9 %	38	1	7740	1316	26.6 %	66	2	13650	2445	10.6 %
8	1	1650	691	21.3 %	40	1	8160	2028	43.5 %	67	1	13845	989	21.0 %
9	1	1880	134	24.6 %	43	1	8800	1409	19.4 %	68	1	14055	1353	22.7 %
11	1	2285	272	29.0 %	43	2	8805	481	15.6 %	69	1	14250	550	30.2 %
12	1	2480	2670	26.8 %	44	1	9005	1694	32.9 %	69	2	14285	1165	13.2 %
13	1	2705	51	43.1 %	44	2	9010	884	26.5 %	70	1	14490	791	20.6 %
13	2	2720	464	26.9 %	46	1	9425	602	25.7 %	72	1	14870	442	22.2 %
14	1	2910	171	17.5 %	47	1	9630	1424	9.1 %	73	1	15099	547	9.5 %
14	2	2920	1462	19.6 %	48	1	9845	445	39.8 %	74	1	15300	944	17.8 %
15	1	3120	2951	10.9 %	48	2	9855	290	34.8 %	74	2	15325	2486	6.1 %
15	1	3145	301	15.3 %	49	1	10060	2297	10.2 %	75	1	15510	149	17.4 %
16	1	3330	741	20.5 %	50	1	10270	1490	26.0 %	75	2	15535	285	34.4 %
17	1	3340	860	36.7 %	51	1	10470	744	39.4 %	75	3	15538	272	18.8 %
18	1	3750	1169	16.8 %	52	1	10700	1099	19.1 %	76	1	15725	1990	12.9 %
18	2	3790	175	26.3 %	53	1	10918	740	28.4 %	76	2	15751	2065	5.9 %
19	1	3960	667	23.2 %	54	1	11120	1133	29.6 %	77	1	15930	280	23.6 %
20	1	4170	1142	25.6 %	55	1	11315	244	29.1 %	77	2	15943	235	74.9 %
21	1	4390	486	42.6 %	55	2	11325	300	21.3 %	77	3	15963	1285	18.9 %
23	1	4800	609	62.1 %	56	1	11540	346	20.2 %	78	1	16170	921	31.6 %
24	1	5030	569	24.4 %	56	2	11545	443	33.0 %	79	1	16385	1489	39.4 %
26	1	5450	299	44.1 %	57	1	11740	129	35.7 %	80	1	16560	591	21.2 %
28	1	5860	823	44.0 %	57	2	11750	648	50.2 %					
29	1	6060	792	23.7 %	58	1	11947	60	50.0 %					
30	1	6290	1652	15.0 %	58	2	11965	267	33.0 %					
					59	1	12165	432	16.4 %					

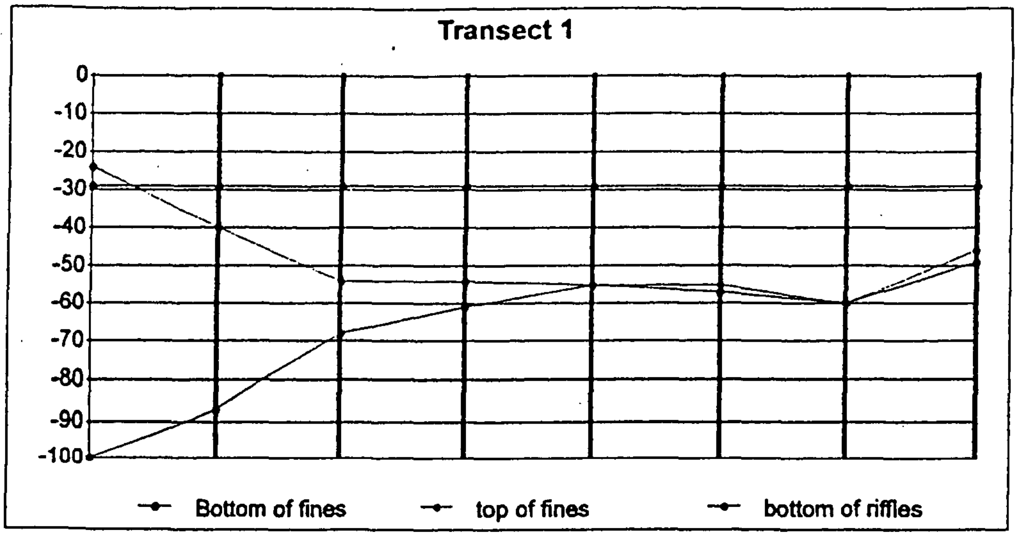
Table 5.

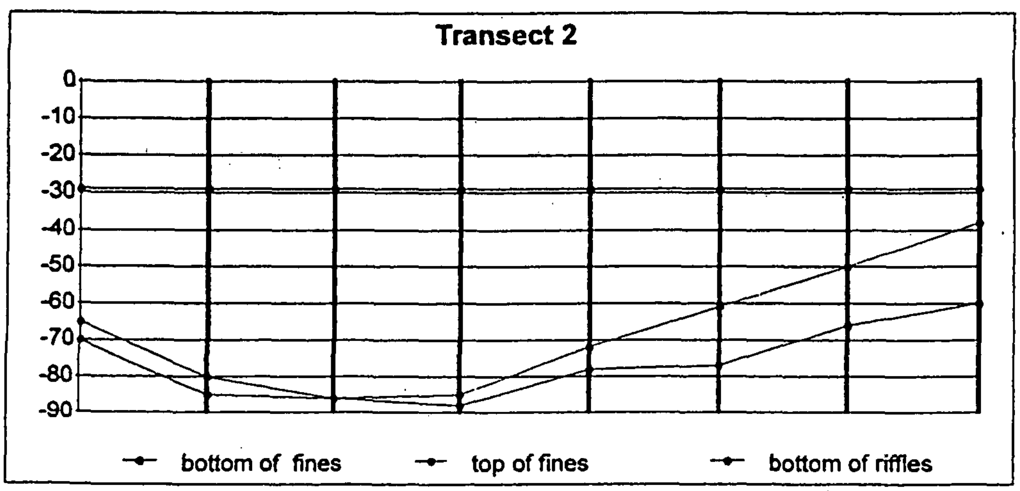
Sample #	Pool#	Pool locatior	cum_val	
4	1	770	1612	depth
V_wave			409	fines
25.37%				

bottom of fines	100	87	68	61	55	57	60	49	70	85	86	88	78	77	66	60	84	82
top of fines A	24	40	54	54	55	55	60	46	65	80	86	85	72	61	50	38	84	82
riffle crest	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
top of fines B	29	40	54	54	55	55	60	46	65	80	86	85	72	61	50	38	84	82
b-t=depth of fines	71	47	14	7	0	2	0	3	5	5	0	3	6	16	16	22	0	0
pool depth	71	58	39	32	26	28	31	20	41	56	57	59	49	48	37	31	55	53
fine depth	71	47	14	7	0	2	0	3	5	5	0	3	6	16	16	22	0	0
bottom of fines	84	72	72	66	68	88	65	59	50	29	32	38	36	24	74	61	71	61
top of fines A	75	68	70	53	52	35	65	57	46	29	32	35	30	21	53	59	68	59
riffle crest	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
top of fines B	75	68	70	53	52	35	65	57	46	29	32	35	30	29	53	59	68	59
b-t=depth of fines	9	4	2	13	16	53	0	2	4	0	0	3	6	0	21	2	3	2
pool depth	55	43	43	37	39	59	36	30	21	0	3	9	7	0	45	32	42	32
fine depth	9	4	2	13	16	53	0	2	4	0	0	3	6	0	21	2	3	2
bottom of fines	54	44	27	26	70	68	72	66	62	61	52	23						
top of fines A	47	41	24	20	63	65	72	66	61	46	36	23						
riffle crest	29	29	29	29	29	29	29	29	29	29	29	29						
top of fines B	47	41	29	29	63	65	72	66	61	46	36	29						
b-t=depth of fines	7	3	0	0	7	3	0	0	1	15	16	0						
pool depth	25	15	0	0	41	39	43	37	33	32	23	0						
fine depth	7	3	0	0	7	3	0	0	1	15	16	0						

Table 6.

Sample 4 Location 770 - 820 Longest length 50 m Widest width 10 m
Fish? Yes Number sighted 5 Size 1.5" - 2" Steelhead / Sickleback





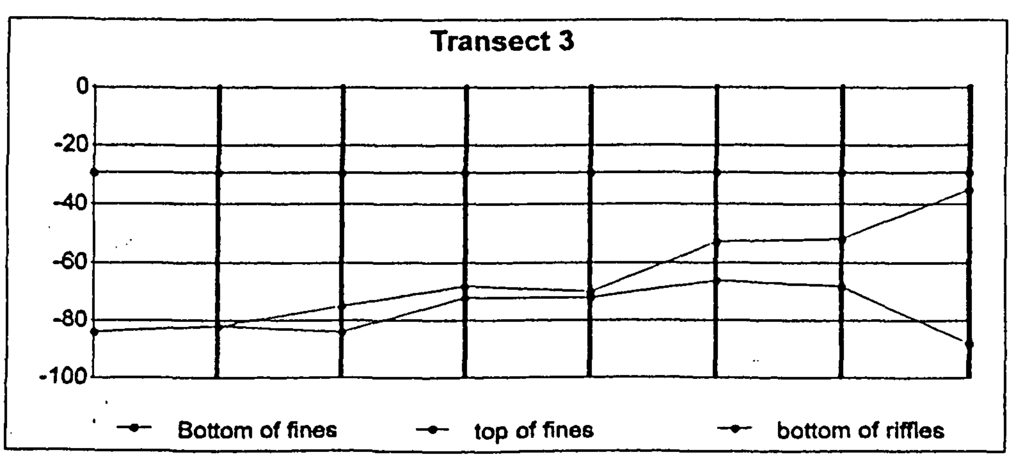
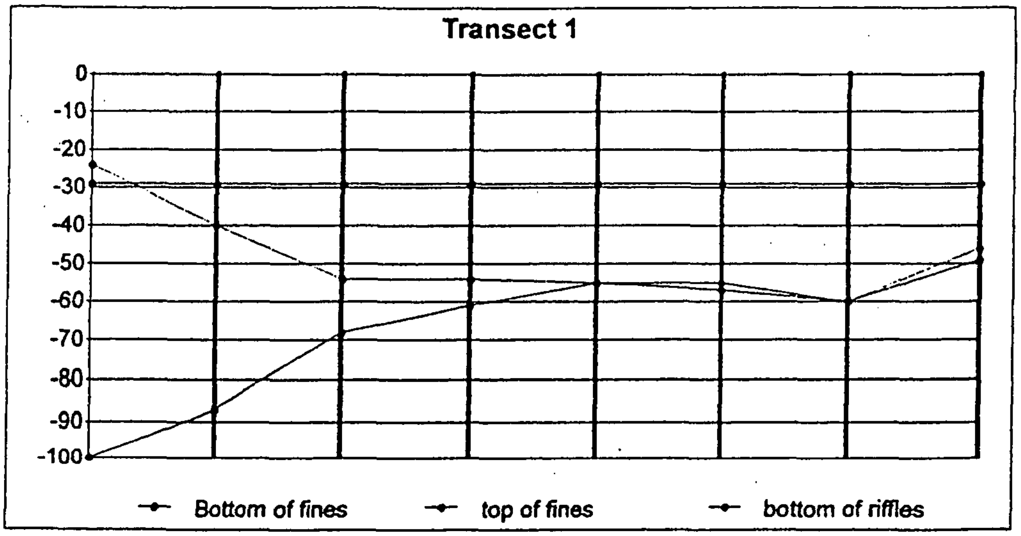
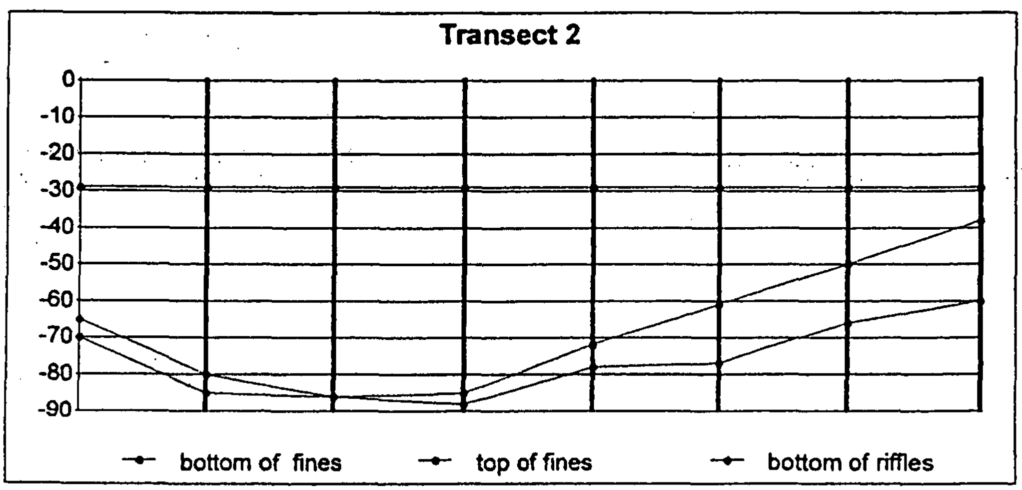


Table 6.

Site 4-pool 1

Sample 4 Location 770 - 820 Longest length 50 m Widest width 10 m
Fish? Yes Number sighted 5 Size 1.5" - 2" Steelhead / Sickleback





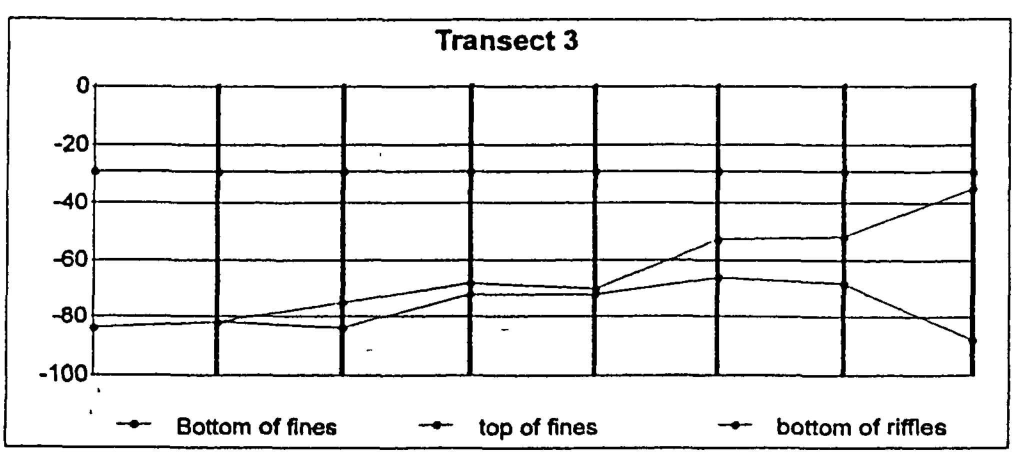


Table 6.

Summary - Sediment Transport Corridors

Greenwood Creek

STC location	STC Width	STC Length	STC sq. M	STC Source #1
510	9.45	9.45	89.3	seep
1198	14	22	308	road
1320	10	36	360	bank
1660	75	286	21450	culvert
1890	15	20	300	road
2155	50	25.4	1270	road
2300	50	60	3000	bank
2410	96	32	3072	seep
2654	74	70	5180	seep
2850	35	30	1050	road
3350	61			road
3673	16	28	448	trib
3780	42	5	210	road
3990	10.9	10	109.0	bank
4590	27	16.5	446	unknown
5330	21.5	20.2	434.3	road
5836	10.2	85	867	road
6195	9	5.8	52	bank
6490	20.5	50	1025	road
7135	8.5			unknown
7632	39.5	22	869	unknown
8839	7.6	10	76	unknown
9840	28			unknown
10951	15	11.7	175.5	bank
11400	29.5	17	502	bank
11650	100	30	3000	bank
11550	27			road
11735	61	40	2440	bank
11710				road
11800	68.5	30	2055	road
12441	29	15	435	road
15140	18	15.6	280.8	bank
15603	10	14	140	logging
15445	14	32	448	bank
15515	16	17.4	278.4	culvert
15720	20	10	200	road
15768	82	40	3280	logging
16244	23.5	15.5	364.3	road
16021	30.6	14.8	452.9	road
16422	83			road

Table 7.

m	plot no.	pattern	bank stability	bank veg	jams	LWD	pools	fish	V-wave	v-pools	STC
0	1			bare	large						
210	2				large	low	few	s			
420	3	braided			large	low		s			
630	4				small		few	s			
840	5	braided				low		s	high		
1050	6		unstable	bare		low		s			
1260	7					low		s			
1470	8	braided				low					sig.
1680	9					low					sig.
1890	10					low	few	s			sig.
2100	11		unstable		small	low					sig.
2310	12			bare		low			high		sig.
2520	13			bare		low		s			sig.
2730	14	braided		bare	small	low		s			
2940	15			bare		low					
3150	16		unstable	bare				s			
3360	17	braided	unstable	bare		low			high		
3570	18		unstable								
3780	19					low					
3990	20	braided	unstable	bare		low					
4200	21					low			high		
4410	22										
4620	23					low			high		
4830	24	braided									
5040	25			bare		low	few	s			
5250	26					low			high		
5460	27						few				
5670	28		unstable	bare					high		
5880	29			bare		low					
6090	30			bare		low					
6300	31		unstable	bare		low		s			
6510	32									extreme	
6720	33		unstable					s			
6930	34	braided	unstable	bare		low	few	s			
7140	35	braided		bare		low	few				
7350	36	braided		bare				s	high		

Table 8. - Summary of Areas of Concern - Greenwood Creek

m	plot no.	pattern	bank stability	bank veg	jams	LWD	pools	fish	V-wave	v-pools	STC
7560	37	braided		bare					high		
7770	38		unstable	bare		low		s			
7980	39			bare		low	few	s			
8190	40			bare		low		s	high	extreme	
8400	41		unstable			low	few	s			
8610	42			bare	large		few	s			
8820	43		unstable	bare							
9030	44			bare					high		
9240	45						few				
9450	46					low		s			
9660	47	braided		bare							
9870	48							s	high		
10080	49					low					
10290	50		unstable			low					
10500	51							s	high		
10710	52										
10920	53		unstable	bare		low					
11130	54										
11340	55			bare				s			sig.
11550	56								high		sig.
11760	57		unstable	bare					high	outlier	sig.
11970	58	braided		bare				s	high		
12180	59		unstable	bare		low			high		
12390	60				small			s			
12600	61				large			s			
12810	62					low					
13020	63		unstable			low					
13230	64										
13440	65					low	few	s			
13650	66	braided				low					
13860	67		unstable	bare							
14070	68		unstable	bare		low					
14280	69			bare					high		
14490	70		unstable			low					
14700	71			bare	small	low	few				
14910	72		unstable								

Table 8. - Summary of Areas of Concern - Greenwood Creek

m	plot no.	pattern	bank stability	bank veg	jams	LWD	pools	fish	V-wave	v-pools	STC
15120	73		unstable						low		
15330	74										sig.
15540	75					low		s	high		sig.
15750	76		unstable								sig.
15960 .	77		unstable						very high	outlier	
16170	78										
16380	79	braided							high		
16590	80					low			high		
		braided from EITHER pattern or gen. description	low indicates actively eroding is >= 10% more than stabilized by wood or rootwads	bare is >= 50% unvegetated	small is <40 pieces	low = less than 2 pieces/30 m	few is <1.0 pools /plot	scarce is min <10	high is >.30	extremes and outliers	sig. is >1000 m2/ 210 m

Table 8. - Summary of Areas of Concern - Greenwood Creek