ITEM 4-1
Sediment and Water Yield Assumptions

ACTIVITY, PRACTICE OR EFFECT TO BE MEASURED	REPORTING PERIOD	VARIABILITY (+/-) WHICH WOULD INITIATE FURTHER EVALUATION
Validation of sediment and water yield assumptions used in plan.	Annual	30 % variability from sediment yields used in the model.

Introduction: The objective of this monitoring item is to determine whether the sediment and water yield coefficients used in the Forest Plan reflect current values. The sediment and water yield assumptions in the Lolo Forest Plan are based on numerical coefficients representing average annual values of precipitation, evapotranspiration, runoff, runoff timing, erosion, sediment delivery efficiency, and channel stability. These coefficients were derived from a number of sources; long-term records compiled by the National Weather Service, US Geological Survey, Soil Conservation Service, documented research and scientific studies performed by universities and Federal and state agencies, and Forest watershed inventory and monitoring data.

Evaluation: Based on over a decade of monitoring data, there is a discrepancy of more than 30 percent between the baseline sediment and water yield values projected by the Forest Plan and actual measured data.

Recommendation: Steps should be taken to develop appropriate local coefficients for sediment and water yield for the next Forest Plan revision. Annual monitoring data are in the forest watershed database. These data will be used as the basis for any watershed coefficients needed in the upcoming Forest Plan revision. This monitoring item has served its purpose; further reporting was discontinued in 1998.

ITEM 4-2
Water Quality Statutes Compliance

ACTIVITY, PRACTICE OR EFFECT TO BE MEASURED	REPORTING PERIOD	VARIABILITY (+/-) WHICH WOULD INITIATE FURTHER EVALUATION
Monitor for compliance with existing State and Federal water quality statutes.	Annual	Activities not meeting State and Federal water quality standards or leading to long-term degradation of aquatic environment.

Introduction: The analysis and methods supporting this item tier from previous years analyses and follow the framework within the current year Forest Water Monitoring Plan. The Forest Water Monitoring Plan is constantly evolving due to a constant effort to improve and update watershed monitoring methodology, techniques, and efficiency. The objective of this item is to provide information related to compliance with state and federal water quality statutes as well as to evaluate watershed response to land management activities in an effort to improve forest management. The primary reasons for modifying the annual Forest Water Monitoring Plan are due to:

- updates in technology
- results of current research studies abroad and at times contracted by the forest
- lessons learned in efficiency and methodology from the previous year
- current policy direction and budget levels

Consequently, annual monitoring reports have changed significantly over the years. The streams studied have changed as well. Each report contains pertinent information and should be referenced for thorough review and additional information. The 1997 report provides a substantial background information on water quality standards, stream dynamics, and complete explanations of current monitoring methodology. Earlier reports, as well as the 1997 report, explain the suspended sediment sampling procedure thoroughly. Following is a brief summary of what has been covered since the Forest began annual monitoring reports.

1964-65 - Flow and turbidity monitoring at Cinnamon Bear Creek.
1968-74 - Water quality monitoring: chemical and physical properties.
1975-85 - Extensive gaged flow, suspended sediment, analysis, and report.
1986-91 - Flow, suspended sediment, minimal bedload, and cross-section analysis.
1992- Extensive suspended sediment analysis and report, Upper Lolo area.
1993-94 – Flow and suspended sediment.
1995 - Flow, temperature, and suspended sediment analysis.
1996 - Water quality standards, suspended sediment, temperature, and initiation of measured stream dynamics.
1997 - Water quality standards, suspended sediment, temperature, and measured stream dynamics.
1998 – Watershed restoration effectiveness, substrate mobility, and measured stream dynamics.

Methods: Suspended sediment and stream discharge monitoring techniques follow standard USGS methodology (Edwards and Gleason, 1988). Channel morphological data collection and evaluation involves state-of-the-art techniques present in latest scientific reports and textbooks (1997 Monitoring Report, Leopold, 1994; Rosgen, 1996; Kappasser, 1995; Decker, 1993; Heede, 1980).

Results and Evaluations: As in previous years, this section summarizes pertinent results of analysis performed on data collected by hydrologic crews over the field season.

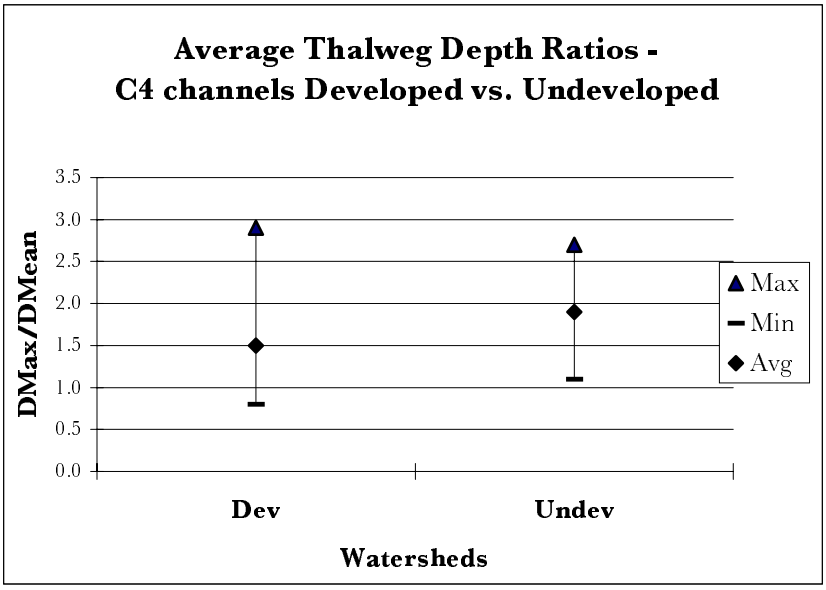
Stream Cross-Section Analysis

Thalweg Depths: Tracking stream morphological responses to perturbations is important in assessment of the overall stream condition. An effective method to monitor stream response is in the width/depth ratio. Because the two values are inversely proportional to each other (as width increases, depth decreases and visa versa), the measurement of depth, both bankfull (mean depth) and maximum depth may be used for assessment purposes. Several measurements are taken on a reach surrounding one monitoring cross-section. The measured reach length is 30-40 bankfull widths and the stream type is the same throughout.

Although new sites were added to the database in 1999, except for C4 channel types, there are not enough samples to establish trends or test statistical significance for the majority of stream types.

The graph below displays the differences in thalweg depth ratios (Dmax/Dmean) for developed and undeveloped watersheds for C4 channel types. These data support the hypothesis that average thalweg depths will be deeper in undeveloped watersheds, and the range of variation will be greater in developed watersheds than undeveloped watersheds.

Using a two-tailed t-test, the data show that there are significant differences between developed and undeveloped watersheds (P = 0.0207). While the difference is significant, the existing 13 and 7 samples (undeveloped and developed, respectively) is not sufficient (alpha = 90 percent confidence interval, delta = 0.2). In order to have enough data for this desired level of confidence, we would need at least 18 samples in each data set (beta = 0.3).



Substrate Mobility Analysis

Stream Bed Mobility: As higher proportions of a streambed become mobile, the stream becomes more unstable. Therefore, it is informative to quantify how much of a streambed is mobilized. This is accomplished by comparing the size of particles moving at peak flows (bar samples) to the material sizes making up the streambed (distribution obtained from the pebble count procedure).

Riffle Stability Index (RSI) measurements, and bar sampling were continued in 1999. Again, there is insufficient data to establish trends. The table below displays the results of the bar sampling. Refer to the 1998 monitoring report for additional information.

Three of the four developed watersheds are mobilizing larger proportions of the stream bed. More data are needed to verify if there is a larger trend on the forest, but this data set is larger than last year's and is showing the same results.

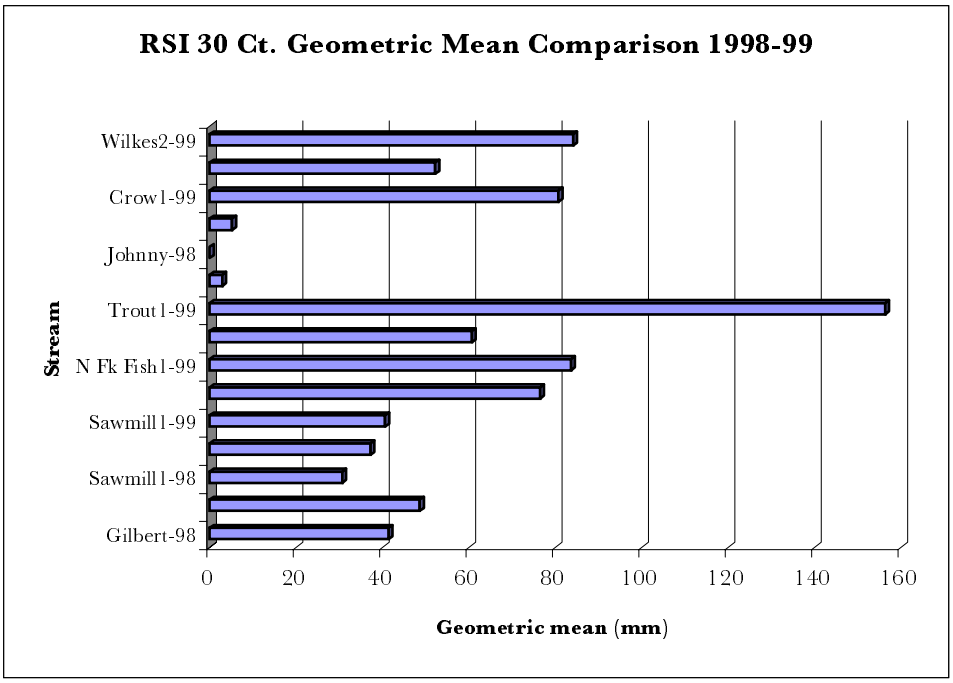
E5 channel types are dominated by sand which mobilizes almost entirely at peak flows. As suspected, these data confirm this. Because most of the sand is mobilized, and there are not significant differences in sizes between sand channel types, this method does not provide a good comparison for management implications in E5 channels. As a result, channel morphology and depositional trends analyzed by photo points should be the primary methods for monitoring sand dominated channel types on the forest.

Paired Watersheds	*1998* **Stream Bar D84 vs. Bed Size Comparison**	*1999* **Stream Bar D84 vs.** Bed Size Comparison
Sawmill (C4-UD)*	Bar D84 is 35mm = Bed D54	Bar D84 is 52mm = Bed D75
Gilbert (C4-D)	Bar D84 is 35mm = Bed D68	Bar D84 is 22mm = Bed D52
N.Fk. Fish (C4-UD)	Bar D84 is 71mm = Bed D62	Bar D84 is 58mm = Bed D59
Trout (C4-D)	Bar D84 is 81 mm = Bed D48	Bar D84 is 50 mm = Bed D61
Johnny (E5-UD)	Bar D84 is 1mm = Bed D1	Bar D84 is 1.8mm = Bed D78
Dick (E5-D)	Bar D84 is 1mm = Bed D2	Bar D84 is 1.3mm = Bed D51
Wilkes (C4 - UD)	Bar D84 is 82mm = Bed D73	Bar D84 is 42mm = Bed D72
Crow (C4-D)	No Data Gathered	Bar D84 is 33mm = Bed D58
S.Fk. Little Joe (C4-D)	No Data Gathered	Bar D84 is 56mm = Bed D78

**Stream Type, UD = Undeveloped Watershed and D = Developed.*

A simpler procedure for determining particle mobility is the RSI - a method that collects the 30 largest mobile particles on a specific location on the stream bar. This method helps substantiate there are several ways data can be collected and there is consistency among the trends indicated by separate monitoring methods. That is, the developed watersheds appear to be mobilizing larger stream substrates than undeveloped watersheds.

The following chart summarizes the 1999 RSI data. The trend indicated is that all the RSIs are larger in 1999 than in 1998. Wilkes and Crow Creeks are moving similar size particles; Trout Creek is moving much larger particles than the N.Fk. of Fish Creek, and Gilbert Creek is moving slightly larger particles than Sawmill Creek. No trend is evident between bar samples and RSIs. Dick Creek, the paired stream to Johnny Creek, was not sampled.



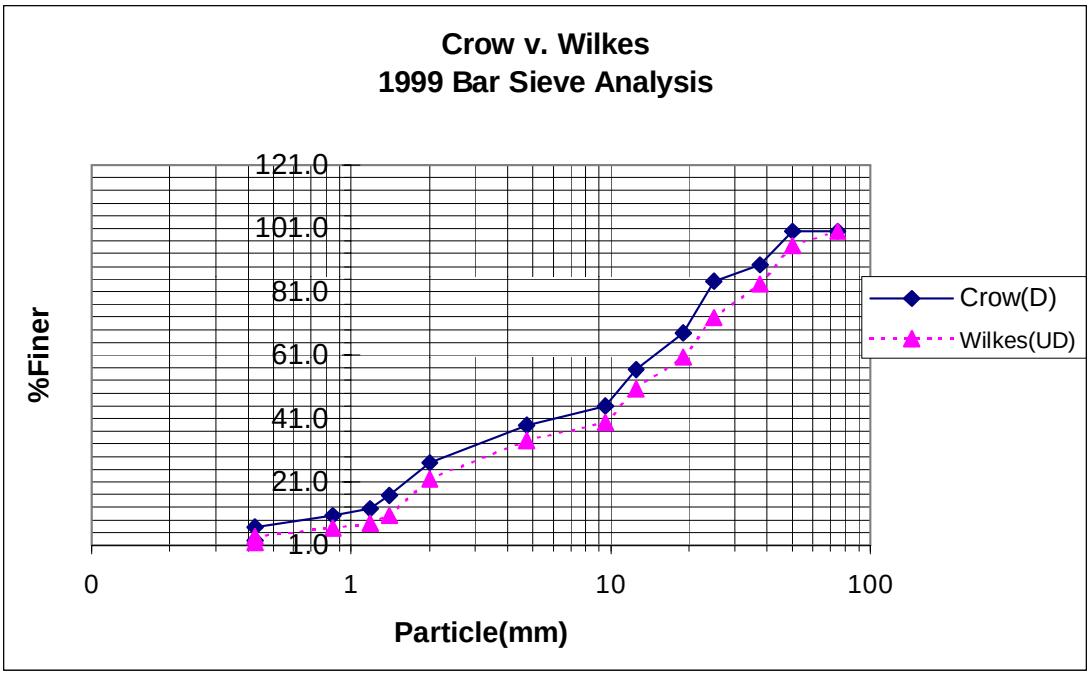
Stream Bar Distributions: Since bedload is not typically measured at bankfull flows, a field procedure is used to determine the particle size distribution of bedload being transported at the bankfull stage. Core samples are obtained from specific locations on depositional features such as point and central bars. The material obtained from the core sample is then sieved and weighed in order to establish the particle size distribution from the bars. The location sampled is half-way between the bankfull stage and the channel thalweg on the downstream side of the bar feature (Rosgen, 1996).

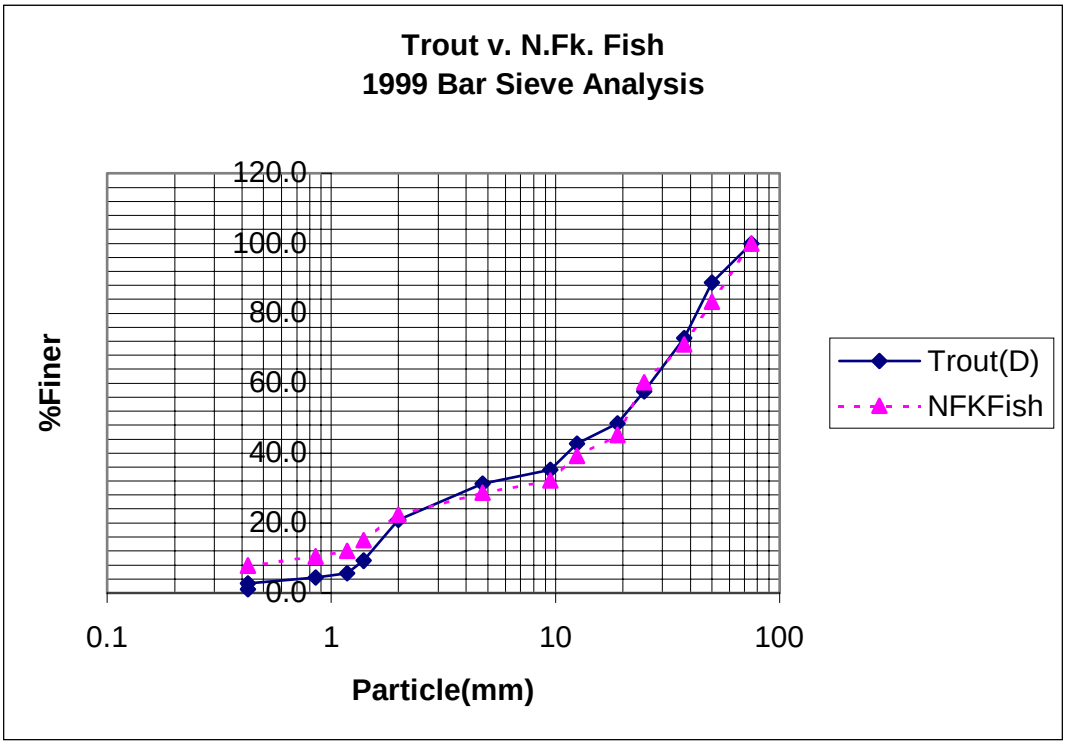
Of the paired streams set up on the Lolo for long-term watershed and fisheries monitoring, bar sieve samples were collected on four pairs: Crow/Wilkes, Gilbert/Sawmill, Dick/Johnny, and Trout/N.Fk.Fish.

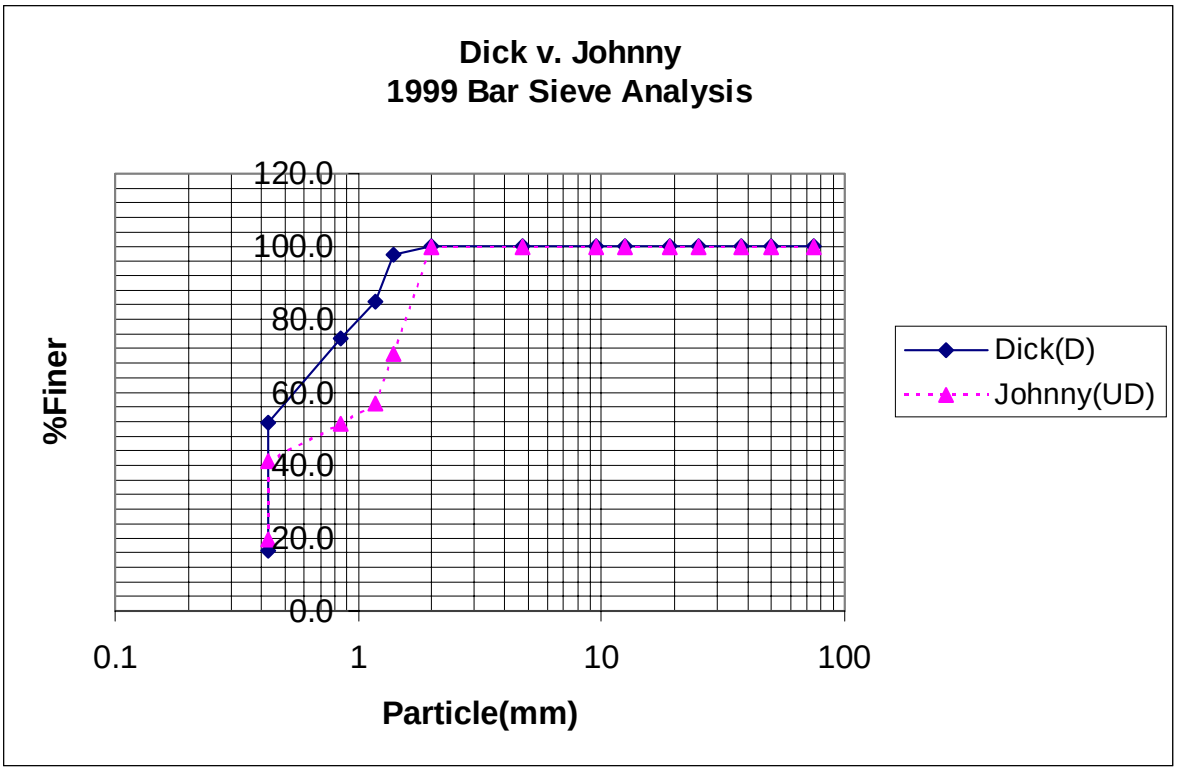
The hypothesis of this analysis is that lower gradient streams in developed watersheds will have higher representations of finer sized substrates and all stream types will have larger size substrates in transport at bankfull flows as compared to a reference stream.

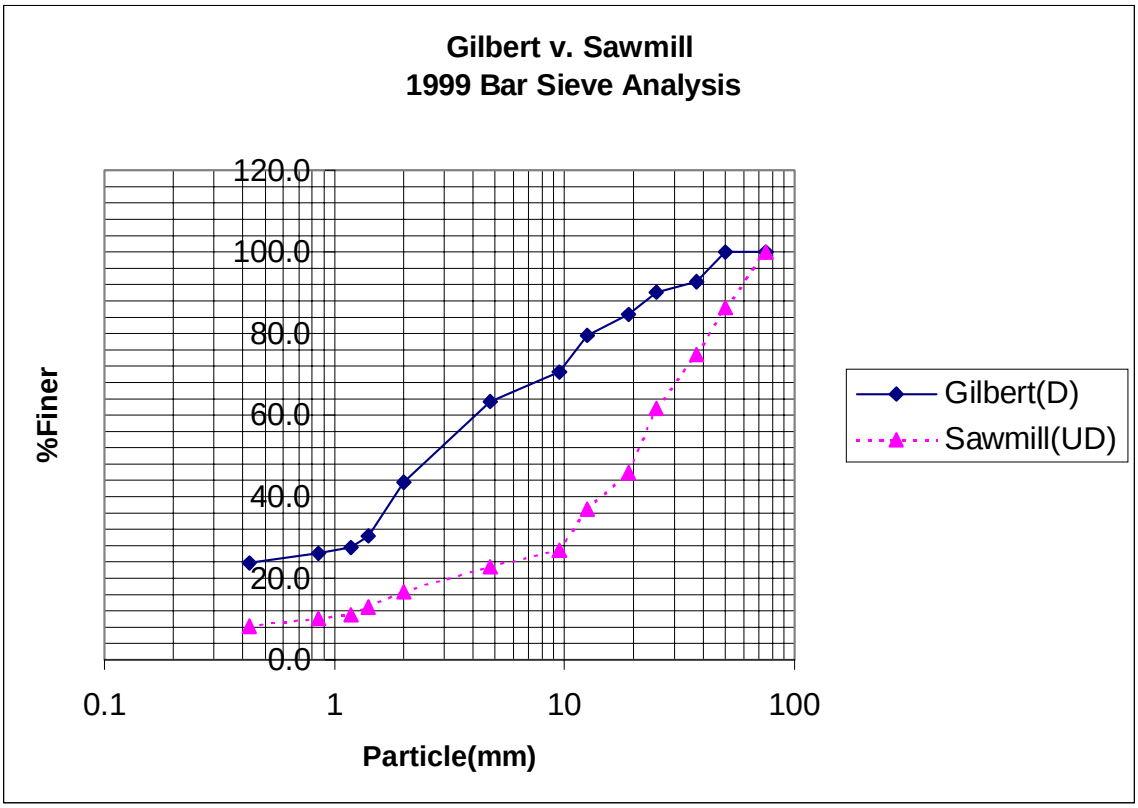
As with the mobility analysis, Dick and Johnny Creeks (E5 channel types or sand dominated) do not show contrast as all the particles are close to the same size and distribution. Other methods will be used to assess these types of streams.

Although there are not enough data to establish a trend, the sieve analysis results suggest that developed watersheds have bar distributions that are shifted to the left for each of the paired watersheds. (As plots shift to the left on the cumulative distribution charts, substrate sizes are smaller.) Therefore, the data indicate that developed watersheds are shifting to smaller substrate sizes. Trout/N. Fk. Fish and Crow/ Wilkes Creeks have similar distributions, although the developed watersheds are not shifted far to the left. There is a large shift in the Gilbert/Sawmill Creek pair.


Crow v. Wilkes
1999 Bar Sieve Analysis
%Finer
121.0
101.0
81.0
61.0
41.0
21.0
1.0
0
1
10
100
Particle(mm)
Crow(D)
Wilkes(UD)


Trout v. N.Fk. Fish
1999 Bar Sieve Analysis
%Finer
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0.1
1
10
100
Particle(mm)
Trout(D)
NFKFish





Temperature Analysis

Temperature data is collected on various streams throughout the forest to study ranges of stream temperature variability in connection with the bull trout recovery effort.

In 1999, Stowaway Temperature Data Recorders were placed in the following streams:

Tamarack Creek - 4 sites
Henry Creek – 1 site
Cottonwood Creek - 1 site
N.Fk. Cottonwood Creek - 1 site
Howard Creek – 3 sites
Tepee Creek (Howard Creek trib.) – 1 site

Water temperature is of interest specifically because it is a component of bull trout riparian management objectives; cooler water being preferable. The recording instruments allow daily maximum temperature to be determined and the period of time maximum temperatures are in certain ranges.

Howard Creek, a tributary of Lolo Creek, had the warmest temperatures recorded in 1999. In Howard Creek Meadows, upstream from the confluence with Tepee Creek, daily maximum water temperature was 20°C for nine days between mid-July and mid-August. Daily maximum temperatures then declined a degree or so through the end of August and then rapidly dropped around 10°C for early September. This rapid drop was noted at all temperature monitoring sites. Tepee Creek contributed water that had a maximum daily temperature between 15° and 17°C for the period of mid-July through the end of August. The lack of riparian vegetation in the meadows where the upper Howard and Tepee Creeks' recorders were located contributed to these warm temperatures. At the mouth of Howard Creek five miles downstream, the forest canopy shade allowed the stream to cool such that the maximum daily temperature was between 13° and 14°C throughout the monitoring period.

Cottonwood Creek, a tributary to the Blackfoot River, had the coolest water recorded during the summer of 1999. The highest daily maximum temperature was 11°C for several days near the end of July.

For the other stations monitored, daily maximum water temperatures were between 15° and 17°C for several days during the first half of August.

Recommendations: The data represented here were collected on streams associated with Lolo Ecosystem Management Areas (EMAs), and paired watershed study areas. Data were collected in response reaches (lower gradient sections), where possible.

In every method of analysis, as in the two previous monitoring reports, there are multiple indications that forest management is contributing to negative stream conditions as compared to reference conditions. It will be important for our future monitoring program to expand and verify the data presented. It is our goal to develop thresholds on management intensity and location from additional monitoring of the channel parameters and techniques presented.

Monitoring on the forest is an evolving process, building on what is learned from previous years' analyses. Some of the key points that we have learned are:

1) There appears to be a strong trend in the sediment analysis indicating that there are differences in developed and undeveloped watersheds. In developed watersheds the sediment data indicates our management may be leading to stream instability and poorer habitat conditions. Every sediment analysis method denotes this. However, more data is needed to substantiate this trend.

2) The thalweg depth analysis needs to be expanded because there not enough data for various stream types to make relative comparisons. In the largest data set, there appears to be a trend developing in the thalweg depth analysis. Thalweg depths in C4 channel types are deeper in undeveloped watersheds than in developed watersheds. Deeper thalweg depths usually are associated with better habitat, better stream stability, and more efficient transport of flow and sediment.

3) Sinuosity analysis is very beneficial in trend comparisons provided that past aerial photos are available. This analysis strongly supports that management activities have had negative effects on sensitive streams in areas where stream pattern has been altered. A reference stream and a stream not impacted by large scale riparian activities show virtually no changes in stream pattern (1998 Monitoring Report).

4) Although the scope of our data collection is fairly limited (data collected on approximately 20 streams), our ability to analyze the data in a timely manner is taxed. We must continually strive to find ways to fund and prioritize this type of monitoring. This information is providing necessary feedback concerning our forest management and will provide important guidance for future decisions.

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ITEM 4-3
Soil Productivity

ACTIVITY, PRACTICE OR EFFECT TO BE MEASURED	REPORTING PERIOD	VARIABILITY (+/-) WHICH WOULD INITIATE FURTHER EVALUATION
Monitor the effect of soil disturbance/displacement on land productivity.	Annual	Movement or compaction of soils reducing productivity more than 20 percent.

Introduction: The objective of this monitoring item is to determine whether changes in soil bulk density and organic matter or amount of soil movement, reduces basic soil productivity more than 20 percent.

Methods: Several procedures are used to monitor soil productivity. Range allotments are monitored annually to assess the amount of soil compaction in sensitive areas caused by grazing. Compaction on roads and skid trails is assessed during annual Forest Plan monitoring field reviews of timber sales. The potential for organic matter and nutrient recycling is assessed on these sites from the amount of woody debris left on site after timber harvest activities. The amount of soil movement is inferred by evaluating the potential for tractor harvest to cause soil displacement on units where slopes are greater than 35 percent. These units are individually reviewed and approved to assure meeting soil productivity standards.

Results: In 1999, one request was received to tractor harvest on slopes greater than 35 percent. Only a portion of the unit had a slope greater than 35 percent. The unit was evaluated based on soil type, particularly soil texture and rock content, moisture condition, length of skid, distance to drainage way, and potential mitigating measures to be applied. In this instance, tractor harvest was able to proceed without a risk of causing unacceptable soil displacement.

Across the forest in 1999, 11 active timber sales had contract requirements for woody debris retention. Of those sales, 46 of 48 units were found to have sufficient amounts of woody debris remaining after harvest and post-sale slash treatment. After burning, two units were determined to be below standards for coarse woody debris. Units that were monitored by timber sale administrators in 1999 met woody debris requirements 96 percent of the time.

One timber sale was reviewed during the 1999 Forest Plan Monitoring Trips (Dry Camp Timber Sale and Ecosystem Management Burn). On this project, fire was used to expose mineral soil for site preparation of ponderosa pine, rejuvenate shrubs, increase forage and reduce fuels. The project resulted in a natural pattern and structure of "…snags, fire-killed dead [trees] and coarse woody debris." These findings were documented in Forest Supervisor memo 1920 "Annual Forest Plan Project Monitoring Field Trips, FY 99", dated January 31, 2000.
Cattle grazing has been a chronic source of soil compaction, especially in sensitive riparian sites. The 1997 Monitoring Report identified three allotments with compaction problems from grazing riparian areas, the South Fork/East Fork Lolo Allotment, the Little Thompson Allotment, and the Hinchwood/Clark Allotment. The Hinchwood/Clark Allotment was closed and the National Forest boundary fence has been fairly successful in keeping cattle from trespassing on NF lands. Riparian fencing and close administration of the Little Thompson Allotment have been effective in excluding cattle from streamside areas. In the South Fork/East Fork Allotment, aggressive herding methods are used to keep cattle away from streamsides. Most of the riparian areas sensitive to compaction in this allotment are along Lost Park and East Fork Lolo Creeks on NF land. In 1998, a portable electric fence was installed to exclude cattle from a particularly

sensitive location along Lost Park Creek. Monitoring during 1998 revealed localized impacts to two other sensitive areas, one along another reach of Lost Park Creek and one along East Fork Lolo Creek. Additional portable electric fencing was installed to exclude these locations in 1999 but for other reasons cattle were not turned out on this pasture in 1999.

Evaluation: Certain practices have problems meeting soil productivity standards. Soil compaction from livestock grazing in riparian areas continues to be one of them although notable improvements have been made in the last three years. Organic matter, in the form of coarse woody debris retained in harvest units, was found to be sufficient in 96 percent of the harvest units requiring such retention in 1999.

The coarse woody debris requirement arose when many silviculture prescriptions combined clear cutting and tractor piling site preparation. Prescriptions have evolved away from clear cutting and tractor piling to partial cutting followed by under burning. Currently, many treated stands are of small diameter and the coarse woody material retained is of smaller diameter (4.5 to 5.5 inches) than was envisioned when this monitoring item was developed. Small diameter material is often fully or partially consumed in slash treatment following harvest.

Recommendation: The forest silviculturist, wildlife biologist, and soil scientist need to review the intent and approachs currently used to insure sufficient coarse woody debris retention following timber harvest and suggest modifications or improvements.

Continue to monitor and work to improve management practices so all range allotments meet Forest Plan Standards.