Appendix B

WATERSHED ASSESSMENT AND NUMERIC TARGET DEVELOPMENT

B-1. INTRODUCTION

The Squaw Creek watershed assessment was conducted in part using the "reference" stream method (USEPA, 1999) in which the level of watershed disturbance, physical channel conditions, and biological health of other streams with similar characteristics to Squaw Creek were analyzed. This included bioassessment work done in 2000 and 2001 by staff from the Sierra Nevada Aquatic Research Laboratory (SNARL) that evaluated a variety of physical, chemical and biological parameters from study sites in the Squaw Creek watershed and several other streams in the Truckee River Hydrologic Unit.

A detailed discussion of the study design and sites selected for comparison to Squaw Creek is presented below (adapted from Herbst, 2002); however, it is important to define the terms used in this document. Reference streams are defined as those streams that have similar geomorphic characteristics and that exhibit the desired conditions found in relatively undisturbed watersheds. Reference streams/sites exhibit the target conditions to be achieved when restoring a degraded stream or watershed. Squaw Creek sites are referred to as "TMDL" sites, and sites located outside of the Squaw Creek watershed that exhibit the desired conditions associated with relatively undisturbed landscapes, are called "reference" sites. Two additional stream sites (Trout and Alder Creeks), which have relatively more disturbance in the their respective watersheds than the reference sites, were also studied to help establish sediment dose-response relationships. These sites are called "load exposure" sites and are identified in the discussions where applicable.

As such, results of the bioassessment were used to determine the level of impairment in Squaw Creek and establish appropriate numeric targets for tracking improvement in the watershed. Discussions of the methodology and results of the SNARL bioassessment (Herbst, 2002) are presented in the following sections.

B-2. STUDY DESIGN AND SAMPLING APPROACH

Reference stream sites were selected to reflect the potential range of ecological conditions found in stream habitats matched to the Squaw Creek watershed, but with minimal or reduced sediment impacts related to land use. Two load exposure streams external to the Squaw Creek watershed with moderate to high levels of sediment loading were also sampled to help place sediment effects in a broader context and develop a dose-response relation. Sampling was conducted to frame the natural background spatial and temporal variability of streams nearby and within the Squaw Creek watershed. This was accomplished by sampling stream sites over a 2-year period. In the first year (2000), surveys were conducted during late-season low flows (late August), and in the second year, surveys were conducted during mid-season moderate flows (early July 2001). This approach allowed the greatest extent of natural differences in stream invertebrate communities to be defined for watersheds that were subject to minimal land use slope erosion problems (reference sites) and provided an unbiased standard for evaluating the conditions in Squaw Creek. Quantitative description of biological communities at sites over a range of sediment loading exposures (reference and load exposure sites) permitted development of a dose-response linkage between sediment stress and biological signals.

B-2.1 SITE SELECTION

A variety of physical habitat features of streams can affect benthic invertebrate communities (Resh and Rosenberg 1984, in Herbst, 2002). In addition to natural erosion and sedimentation, size, gradient and elevation may contribute to shaping communities, as may land use impacts other than the suspected problem source. Site selection for bioassessment was thus guided by the need to account and control for varied environmental background influences.

Six TMDL sites were sampled in the Squaw Creek watershed from the upper to lower portions of the drainage basin. These sites were divided into three stream types based on location and geomorphology: (1) upper watershed tributaries (south and north tributaries at near 6800 feet above mean sea level (amsl), representing higher gradient 1^{st}-2^{nd} order streams); (2) low gradient mid-watershed streams (3 sites in the meadows, representing <2% slope 2^{nd}-4^{th} order channel types); and (3) lower watershed streams located near the bottom of drainages (below the terminal valley moraine, just above the Truckee River). Selection of reference and load exposure sites corresponding to each of the three Squaw Creek stream types was based on similarity with regard to the following criteria:

- stream order (±1)
- channel width (±100-300 cm)
- size/length of upstream watershed (some similar size, others ± 0.25-3X length)
- elevation (mostly within 6,000–7,000 ft zone)
- gradient (±2% in most cases)
- aspect (eastern orientation)
- geographic proximity (within 20 mile radius, and tributary to Truckee River)
- geologic and geomorphic setting

Most of the sites were selected to represent the low gradient meadow stream type so that a large sample size was available for analysis of conditions in this longest segment, referred to as the meadow reach, of the Squaw Creek drainage. Twenty-eight surveys were conducted over the 2000-2001 period at 22 separate locations (4 Squaw Creek sites and 2 reference sites were sampled in both years to examine temporal variation).

The sites were selected based on the sediment load regime predicted from maps generated by outputs from the Annual Agricultural NonPoint Source Model (AnnAGNPS, USDA, 2000) developed by the Desert Research Institute of the University of Nevada at Reno (DRI, 2001). The AnnAGNPS model generates sediment load predictions for different positions within watersheds based on the effects of a high run-off year on the upstream landscape (dependent on slopes, soils, vegetation cover, erodibility, land use, etc.). Streams conforming to the general physical selection criteria above were selected from these maps to form reference and load exposure streams/sites. Reference streams are those that are similar in characteristics to Squaw Creek, but with less disturbance and predicted load, and load exposure sites (Trout and Alder Creeks) are those that have relatively higher disturbance and predicted load that help establish relationships based on a wider range of potential sediment exposures. The selected sites are listed below in Table B-1.

Table B-1. Stream Survey Locations and Types

Watershed location/stream type	Squaw Creek TMDL Sites	Reference and Load Exposure Sites
Late Season Low-Flow Regime (late August 2000)		
Upper watershed, high gradient reach	Squaw Creek -south tributary Squaw Creek -north tributary	Pole Creek (reference)
Mid-watershed, low gradient reach	Squaw Creek meadows – lower Squaw Creek meadows – middle Squaw Creek meadows – upper	Little Truckee River/Perazzo Creek Confluence (reference) Cold Creek (reference) Sagehen Creek (reference) Prosser Creek (reference)
Lower watershed reach	Squaw Creek –below moraine	Bear Creek General Creek
Mid-Season Moderate-Flow Regime (early July 2001)		
Upper watershed, high gradient reach	Squaw Creek -South tributary Squaw Creek -North tributary	Lacey Creek (reference) Juniper Creek (reference)
Mid-watershed low gradient reach	Squaw Creek meadows – lower Squaw Creek meadows – middle	Little Truckee River/Coldstream Creek Confluence (reference) Sagehen Creek (reference) Perazzo Creek (reference) Independence Creek (reference) Martis Creek (reference) N. Prosser Creek (reference) Alder Creek (load exposure) Trout Creek (load exposure)
Lower watershed reach	Not repeated	Bear Creek (reference)

B-3. DATA ANALYSIS

Several physical and biological parameters were measured during the field sampling surveys and a correlation analysis was conducted on the data to help establish numeric targets and assess impairment in Squaw Creek. For each of the low-gradient stream sites, sediment-related measures were compared with predicted load from the modeling work and biologic metrics were compared with the sediment measures. The data used in the correlation analysis includes results from 17 surveys conducted at the low-gradient stream sites over the two-year sampling period: 10 surveys at reference stream sites, 2 surveys at load exposure stream sites, and 5 surveys at Squaw Creek TMDL stream sites.

Table B-2 shows the Pearson R-Value associated with each metric. The Pearson R-Value is a correlation coefficient consisting of a dimensionless index that ranges from -1.0 to 1.0 inclusive and reflects the extent of a linear relationship between two data sets. R-Values approaching the absolute value of 1 show close linear relationships between data sets. Metrics with an R-value greater than the absolute value of 0.5 (shown in bold italics) were considered to have good correlation and were suitable for setting the numeric targets for this TMDL.

Table B-2. Correlation Matrix for Sediment Dose and Biological Response Variables (R-values) For Low-Gradient Steam Sites

	Dist. Sed Load	*D-50*	*%Embed.*	*Turbidity*	*%F+S*	*%F*
Distributed Sed. Load	1.000					
D-50	***-0.596***	1.000				
% Embeddedness	0.190	-0.100	1.000			
Turbidity	0.120	-0.108	-0.202	1.000		
% F+S (fines and sand)	***0.675***	***-0.502***	0.304	0.081	1.000	
% F (fines)	***0.730***	***-0.509***	0.258	0.116	***0.757***	1.000
Total Richness	***-0.506***	0.428	0.088	-0.144	***-0.650***	-0.428
Biotic Index (mod.HBI)	***0.642***	***-0.608***	-0.353	0.387	***0.586***	0.472
Mean Taxa Richness	***-0.545***	0.454	0.071	-0.181	***-0.680***	-0.407
EPT Diversity	***-0.619***	***0.566***	0.317	-0.289	***-0.660***	-0.472
Density (#/m^2)	-0.206	-0.025	0.118	-0.184	-0.339	0.006
%Dominance	0.368	-0.436	0.083	-0.129	0.176	0.369
%Chironomidae	0.066	-0.280	-0.474	0.350	-0.017	-0.115
Chironomidae richness	-0.265	0.185	-0.304	0.215	-0.436	-0.302
EPT/Chironomidae	-0.251	0.352	0.416	-0.325	-0.237	-0.174
%EPT total	***-0.510***	***0.560***	0.359	-0.308	-0.356	-0.431
%EPT (w/o B,H)	-0.307	0.456	0.293	-0.222	-0.210	-0.344
No. Sensitive (0-2)	***-0.597***	***0.514***	0.310	-0.292	***-0.651***	-0.389
% Tolerant (7-10)	***0.632***	-0.422	-0.139	0.373	***0.649***	***0.541***
R-50 Dominance Index	-0.322	***0.541***	-0.094	0.067	-0.289	-0.407

Some metrics are indicative of conditions that overlap with other metrics (e.g., %F+S and %F, Total Richness and Mean Taxa Richness) and were screened out. For the sediment variables, D-50 particle size (D-50) and percent fines and sand (%F&S) showed good correlation with predicted load estimates and were selected as appropriate sediment related metrics. For the biologic metrics, biotic index, mean taxa richness, EPT diversity, percent EPT of total, number of sensitive taxa, percent tolerant taxa, and R-50 dominance index showed good correlation with the sediment metrics and were selected as appropriate targets. A summary of the biologic metrics chosen and their expected response to environmental stressors is presented in Table B-3.

Table B-3.
Macroinvertebrate Community Structure Metrics And Expected Response To Stress

Biological Metric	Metric Definition	Expected Response to Stress
Biotic Index	Composite measure of community tolerance to pollution (based on tolerance values and relative abundance)	Increase
Mean Taxa Richness (mean of samples)	Total number or richness of taxa found in a sample (reflecting resource variety)	Decrease
EPT Diversity Index (ephemeroptera, plecoptera, and trichoptera)	Number of taxa belonging to mayfly, stonefly, and caddisfly orders, usually regarded as intolerant of pollution	Decrease
% EPT	Percent of the organisms present belonging to one of the EPT orders	Decrease
No. of Sensitive Taxa (0-2)	Number of taxa with tolerance values of 0, 1, or 2 (scale of 10; least to most tolerant)	Decrease
% Tolerant Taxa (7-10)	Percent of organisms with tolerance values of 7-10 (scale of 10)	Increase
R-50 Index (pooled samples) [=diversity at 50% total count, and decreases as dominance increases]	Number of taxa required to reach 50 percent (half) of the ranked abundance of all organisms – an inverse dominance measure	Decrease

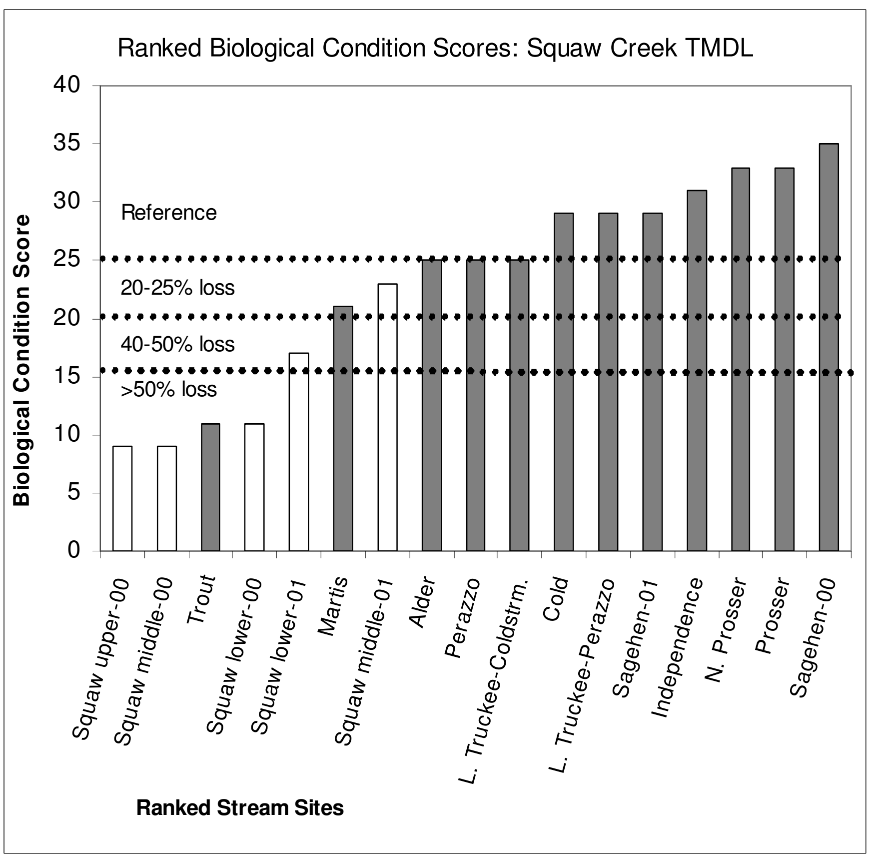
In order to reduce the complexity of information contained in the various metrics of invertebrate community structure, standard scores were assigned based on the distribution of values for each metric from all stream sites (low-, medium-, and high-gradient sites), and summed to produce a single biological condition score (USEPA, 1999b). The data analyzed in the standardized scoring procedure includes results from 28 stream surveys conducted over the two-year period: 16 surveys from reference stream sites, 2 surveys from load exposure stream sites, and 10 surveys from Squaw Creek stream sites. The scores assigned to the actual value for each metric comprising the biologic condition score are shown in Table B-4.

Table B-4. Biologic Condition Scoring For All Stream Sites

Metric	Metric Value Ranges		
Biotic Index	< 3.5	3.5 – 4.5	>4.5
Mean Taxa Richness	>50.0	40.0 – 50.0	<40.0
EPT Diversity Index	>20.0	15.0 – 20.0	<15.0
% EPT Taxa	>50%	35 – 50%	<35%
No. Sensitive Taxa	>18.0	12.0 – 18.0	<12.0
% Tolerant Taxa	<5%	5-10%	>10%
R-50 Index	>5.0	3.0 – 5.0	<3.0
Individual Scores Assigned to Metric Value Ranges	**5**	**3**	**1**

The composite biologic conditions score for each low-gradient stream site (10 reference stream sites, 2 load exposure stream sites, and 5 Squaw Creek stream sites) was plotted as follows on Figure B-1.

Figure B-1: Ranked Biological Condition Scores For Low-Gradient Stream Sites



Note that the reference sites, defined *a priori* according to the distributed sediment load model (Figure 3), conform to the threshold set for the biological reference condition (i.e. they score index values of 25 or greater) with the exception of Martis Creek). The other thresholds were set to express different levels of impairment relative to the mid-range of the reference condition (a value of 30).