A Comparison of Stream Physical Habitat Measurements With Benthic Macroinvertebrate Occurrence from North Canyon Creek, Nevada (July-October, 2000)

Final Draft

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INTRODUCTION

Aquatic invertebrates or benthic macroinvertebrates, can be used as biological indicators of stream habitat conditions. The term bioassessment is used when the biota are utilized to assess the relative condition of a habitat. Benthic macroinvertebrates are invertebrates that inhabit the bottom substrate of freshwater habitats for at least part of their life-cycle and are one of the most promising groups of aquatic organisms being used in bioassessment (Rosenberg and Resh 1993). The advantages of using benthic macroinvertebrates for bioassessment are well documented (Plafkin et al. 1989; Rosenberg and Resh 1993; Wisseman 1996; Karr and Chu 1999) and include:

- Macroinvertebrates are common and abundant in most aquatic habitats.
- The sessile nature of aquatic macroinvertebrates allows effective spatial analysis of disturbance.
- Relatively long life-cycles (often more than one year) allow for temporal monitoring for disturbance.
- Adequate taxonomic keys exist for most groups allowing for generic determinations.
- Benthic macroinvertebrates communities are a direct measure of biotic integrity of the aquatic system.

Benthic macroinvertebrate taxa vary in their response to different physical and chemical parameters. Taxa that respond negatively to habitat disturbance (e.g., toxic and organic pollution) are considered sensitive (or intolerant) to habitat degradation while taxa that occur over a broad range of disturbances are considered tolerant. Historically the sensitivity of benthic macroinvertebrates to disturbance was used to monitor organic pollution (Cairns and Pratt 1993). More recent trends are to establish baseline and reference conditions of the benthic macroinvertebrate community to investigate changes over time and to assess the response of the communities to organic pollution and other types of man-induced disturbance.

Tahoe Regional Planning Agency (TRPA), as part of a pilot study to determine efficiency of the USFS Region 6 Stream Inventory monitoring methodology, collected benthic macroinvertebrate samples along with physical habitat measurements from North Canyon Creek, Carson City, Nevada. The goal of the study was to determine, if any, what physical habitat measurements were associated with various benthic macroinvertebrate community indices or values.

STUDY AREA

North Canyon Creek is a small-scale stream located on the east side of Lake Tahoe, Nevada, primarily within the administrative boundaries of Lake Tahoe Nevada State Park. The stream measures 5.5 miles long (3.3 miles from its mouth at and confluence with Slaughterhouse Canyon Creek to Secret Harbor Creek fork), is perennial, and fed primarily by snowmelt and spring water. The stream ranges in elevation from approximately 7,650 feet (at Secret Harbor Creek fork) to about 6,400 feet (at confluence to Slaughterhouse Creek), above sea level. The creek bisected a variety of geomorphic conditions and thus vegetation types. Vegetation types included quaking aspen, coniferous and deciduous riparian, and wet meadow.

During the Comstock silver mining era (circa 1870 through 1910), the North Canyon watershed was significantly altered. The watershed was clear-cut and grazed, and the flow regime of the creek was altered to accommodate log flumes. Remnants of North Canyon Creek alterations exist today; Spooner Lake was a meadow and small tributary to North Canyon

Creek that was dammed and there is evidence that North Canyon Creek historically was isolated from Secret Harbor Creek (State of Nevada, Nevada Tahoe Resource Team Report Records, Carson City, NV). At the time of the survey in August of 2000, North Canyon Creek was dry approximately 400 feet below the Secret Harbor Creek fork. North Canyon Creek was surveyed from the mouth (where it joins Slaughterhouse Creek) up to this point, for a total length of 3.3 map miles (Figure 1).

METHODS

Habitat Sampling

The lower 3.3 map miles of North Canyon Creek were sampled for benthic macroinvertebrates. Habitats were classified as either pool habitat (slow moving, relatively deep water) or riffle (relatively swift moving and shallow). No attempt was made to determine the underlying cause of habitat form (i.e., pool created from beaver dam). Physical habitat parameter data were systematically collected at every 5th riffle or pool habitat type and estimated at all other habitat units. Physical habitat parameters were collected according to the USFS Region 6 Stream Inventory Level I and II Field Protocol (http://www.fs.fed.us/r6/water/fhr/training/ index.htm) and included the following:

- Habitat Length – Wetted length of habitat unit at thalweg.
- Habitat Width – Average wetted width of stream.
- Maximum Depth – Measured maximum depth for each habitat unit to the nearest 0.1 ft.
- Average Depth – Estimated average depth in riffles only.
- Pool Tail Crest Depth – Maximum measured depth to the nearest 0.1 foot of the pool tail crest.
- Small Woody Debris - Number of small size pieces of woody debris affecting bankfull water flow; Diameter > 6 to 12 inches, at 20 feet from large end.
- Medium Woody Debris – Number of medium size pieces of woody debris affecting bankfull flow; Diameter >12 to 20 inches at 35 ft from large end.
- Large Woody Debris – Number of large size pieces of woody debris affecting bankfull flow; Diameter > 20 inches at 35 feet from large end.
- Bankfull Width – Width of stream at bankfull condition.
- Depth Bankfull Right – Bankfull depth taken at right of bankfull width.
- Depth Bankfull Middle – Bankfull depth taken at middle of bankfull width.
- Depth Bankfull Left – Bankfull depth taken at left of bankfull width.
- Maximum Bankfull Depth – Maximum bankfull depth at thalweg.
- Flood Prone Depth – 2 times maximum bankfull depth.
- Flood Prone Width- Flood prone width.
- Temperature – Temperature in degrees Fahrenheit at measured habitat units only.
- Bank Stability – Total length of unstable or eroded bank within habitat unit.
- Length of overhanging vegetation – length in feet of overhanging vegetation within habitat unit.

Benthic Macroinvertebrate Field Collection

Benthic macroinvertebrate (BMI) samples were systematically collected at every measured riffle habitat unit (i.e., every 5th riffle). Three kick samples were collected using a 500 micron d-frame net across a randomly selected perpendicular cross section of the stream habitat unit. The collection net was positioned at right, middle, and left of wetted width of stream. With the collection net positioned downstream, the stream bottom (approximately 3 inches deep) was agitated by foot for one minute after which the three samples were combined into a deep-walled white sorting tray. After samples were combined into the sorting tray, two people, equipped with appropriately sized forceps, sorted through the contents in search and collection of BMIs for a total of 30 minutes (60 person minutes). BMI samples were immediately preserved in ethanol after field collection. All BMI samples (and habitat parameters) were collected between July 20 and October 9, 2000 and stored at room temperature until taxonomic processing in October 2002. Prior to laboratory processing in October 2002, BMI samples were transferred to smaller containers (3 ml vials) filled with ethanol.

Taxonomic Determination
Specimens were determined to the lowest practical taxonomic level with the aid of a stereomicroscope (8-50X magnification) or when necessary a compound microscope (40-1000X magnification). Macroinvertebrates were keyed to the lowest practical level (generally genus) based on specimen condition and maturity using the following taxonomic keys: Usinger 1956; Cook 1974; Wiederholm 1983; Stewart and Stark 1988; Pennak 1989; Merritt and Cummins 1996; Wiggens 1996; Kathman and Brinkhurst 1998; Larson et al. 2000. Within each sample, discrete taxa were enumerated, placed in a vial containing 70% ethanol, and labeled with the sample date, sample I.D., taxa name, and taxa determiners initials.

Analysis
Metrics are numerical measures, which attempt to describe the macroinvertebrate community sampled. Although primarily used with a Rapid Bioassessment Protocol it was predetermined that selected metrics would be useful in evaluating the North Canyon Creek samples. Primary metrics include Richness Measures, Composition Measures, Tolerance/Intolerance Measures, and Functional Feeding Group Measures. The following is a brief description of metrics calculated for North Canyon Creek samples, which have proven to be useful in the Pacific Northwest (Fore et al. 1996; Karr and Chu 1999) and northern California (Harrington et al. 1999).

Taxa Richness
The total number of distinct taxa in a sample. Reflects health of the community through measurement of the variety of taxa present. Generally increases with increasing water quality, habitat diversity, and/or habitat quality (Plafkin et al. 1989).

EPT Richness
The total number of Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) taxa present, species that are generally sensitive to disturbance. EPT richness is expected to decrease with increased human induced disturbance.

Sensitive EPT Index (%)
A composition measure that measures the proportion of a sample composed of Ephemeroptera, Plecoptera and Trichoptera taxa that have been assigned a tolerance value of 0 to 3. Expected to decrease with degraded habitat.

Percent Dominant Taxon
A Tolerance/Intolerance measure. Percent contribution of the most numerous taxon present in a sample. A community dominated by relatively few taxa would indicate environmental stress (Plafkin et al. 1989). Expected to increase with stress.

Tolerance Value
A tolerance/Intolerance measure. A biotic index that evaluates tolerance of benthic macroinvertebrates to organic enrichment. Taxa tolerant of organic enrichment are also generally tolerant of warm water, fine sediment, and heavy filamentous algal growth (Wisseman

1996). Scale is 0 through 10. 0 being highly intolerant and 10 being highly tolerant of organic enrichment. The tolerance value is calculated as:

$$TV=SUM(n_i t_i)/N$$

where n_i is the number of individuals in a taxon, t_i is the tolerance value for that taxon, and N is the total number of individuals in the sample. Value expected to increase with stressed environment. Tolerance values are from California Department of Fish and Game (2000) listed values.

Shannon's Diversity Index (H)
A diversity index is a mathematical measure of taxa diversity in a community. Shannon's index accounts for both abundance and evenness of the taxa present. The proportion of taxa *i* relative to the total number of taxa (p_i) is calculated, and then multiplied by the natural log of this proportion ($\ln p_i$). The resulting product is summed across taxa, and multiplied by -1:

$$H=-SUM p_i \ln p_i$$

Diversity is expected to decrease with increased disturbance.

RESULTS and DISCUSSION

Several taxa considered intolerant (i.e., cool adapted, fine sediment and winter scour/resorting intolerant) were present in the samples. These included: mayflies (Ephemeroptera) - *Cinygma*, (early instar *Drunella* may be *D. spinifera* which is considered intolerant however taxonomic characters were inconclusive); stoneflies (Plecoptera) - *Moselia infuscata, Zapada frigida, Doroneuria baumanni*, and *Yoraperla;* caddisflies (Trichoptera) - *Cryptochia, Yphria californica, Rhyacophila grandis* group, and *Rhyacophila vofixa* group; and true flies (Diptera) – *Glutops* (Wisseman 1996). A majority of the samples (63%) had at least two intolerant taxa present per sample.

The majority of samples with < 2 intolerant taxon present were collected in late August (Reach # 3, between sample locations MR 55 and MR 90, Figure 1) and dominated by the ubiquitous scud *Hyalella azteca* (Amphipoda). Physical habitat parameters shared by these sample sites were average wetted stream width of two to three feet and the highest recorded late afternoon temperatures (59° F. to 62° F.) of any of the sample sites. This section of stream was also bisected in four locations by steel and wood planks used to bridge winter cross-country ski trails, which appeared to aggravate stream bank instability and may explain the relative high frequency of occurrence of *H. azteca*. Additionally, all-track tractor treads were observed bisecting the stream between MR50 and MR65 sample site, resulting in obvious increase in suspended sediment, and may have contributed to the increased frequency of *H. azteca* observations. Higher temperature in this reach also may have attributed to lower median vegetative cover compared to vegetation cover observed on reaches above and below Spooner Meadow. The high numbers of *Hyalella* may be a seasonal occurrence, or a response to higher temperatures and/or decreased stream width. Amphipods, such as *Hyalella*, in general are strongly thigmotactic (touching or grouping together) and react negatively to light (Pennak 1989). Consequently, they are often collected during daylight in vegetation or in debris or small diameter gravels, which is consistent with observations of streambed substrate and debris where most *H. azteca* were collected.

Of the remaining three sites with only one intolerant taxon, MR5 had only 12 field picked invertebrates; MR50 also had between two and three feet of wetted stream width (2.4 ft.) but lacked *Hyalella* in the sample; and MR125 was dominated by lumbriculid (Oligochaeta) worms and planarians (Turbellaria). In sample MR125 only 81 specimens were enumerated in the lab compared to 160 recorded from the field picking (Table 1). Many of the missing specimens were planarians (probably *Polycelis coronata*) and lumbriculids, which are composed of soft tissue and were badly deteriorated.

Several interesting fly larvae were present in the samples. Among these were three genera of the non-biting midge (Chironomidae) subfamily Prodiamesinae. These were *Monodiamesa, Odontomesa,* and *Prodiamesa.* The primary author had previously seen only *Monodiamesa* and *Odontomesa* from "headwater" type streams in coastal California (Humboldt and Marin counties). Also collected was *Diplocladius* (subfamily Orthocladiinae), a new genus to the author. Three of these genera exhibit a strong "beard" of setae associated with the mouthparts (visible with a stereomicroscope). Monakov (1972) reported an interesting feeding method by larval *Odontomesa fulva* in Asia. *O. fulva* larva swallow water and forces it back out by strong contractions of the intestine, food particles are then filtered out by a "beard". A similar feeding strategy may be suggested by the setal "beard" present in the taxa mentioned above. Also new to the primary author was *Protanypus* (subfamily Diamesinae), which is known to inhabit oligotrophic lakes (Wiederholm 1983) and considered lentic-profundal by Merritt and Cummins (1996). Finding *Protanypus* may be unique because it was found in the upper reaches of a small stream (lotic) ecosystem was Wiederholm (1983) and Merritt and Cummins (1996) report them to be associated with lentic water bodies.

Two cranefly (Tipulidae) larvae were also new to the primary author. These were *Ulomorpha* and a species keyed to *Limnophila* genus but were ultimately keyed to the Tipulidae family level. These were also recently found in samples from a coastal Humboldt County headwater stream (of Eel River). Also present in the Humboldt Co. samples were *Monodiamesa* and *Odontomesa*. The dominant taxon in the Humboldt County samples was the scud *Gammarus* (Amphipoda), formerly named *Anisogammarus.* Several other taxa were common to samples from both sites. Also of interest were similar predatory stonefly genera in the family Perlodidae from both the Tahoe and Humboldt sites. *Calliperla luctuosa* is a perlodid stonefly found in headwater streams on the coast while an *Isoperla* resembling *Calliperla* was present in many of the North Canyon Creek samples. Headwater streams such as North Canyon (and those in Humboldt County) appeared to have unique invertebrate fauna, which also may have provided refuge for species that cannot survive in disturbed habitats downstream of Lake Tahoe. Consequently, wise conservation of North Canyon Creek appears to be in order for the preservation of species diversity and unique BMI's in Nevada.

The relationship between benthic macroinvertebrate community structure and the physical habitat parameters measured was not directly evident from the data as analyzed. Some bias may have been introduced by picking benthic macroinvertebrate sample in the field, although field investigators felt confident that sufficient time was allocated to collect the majority of visible

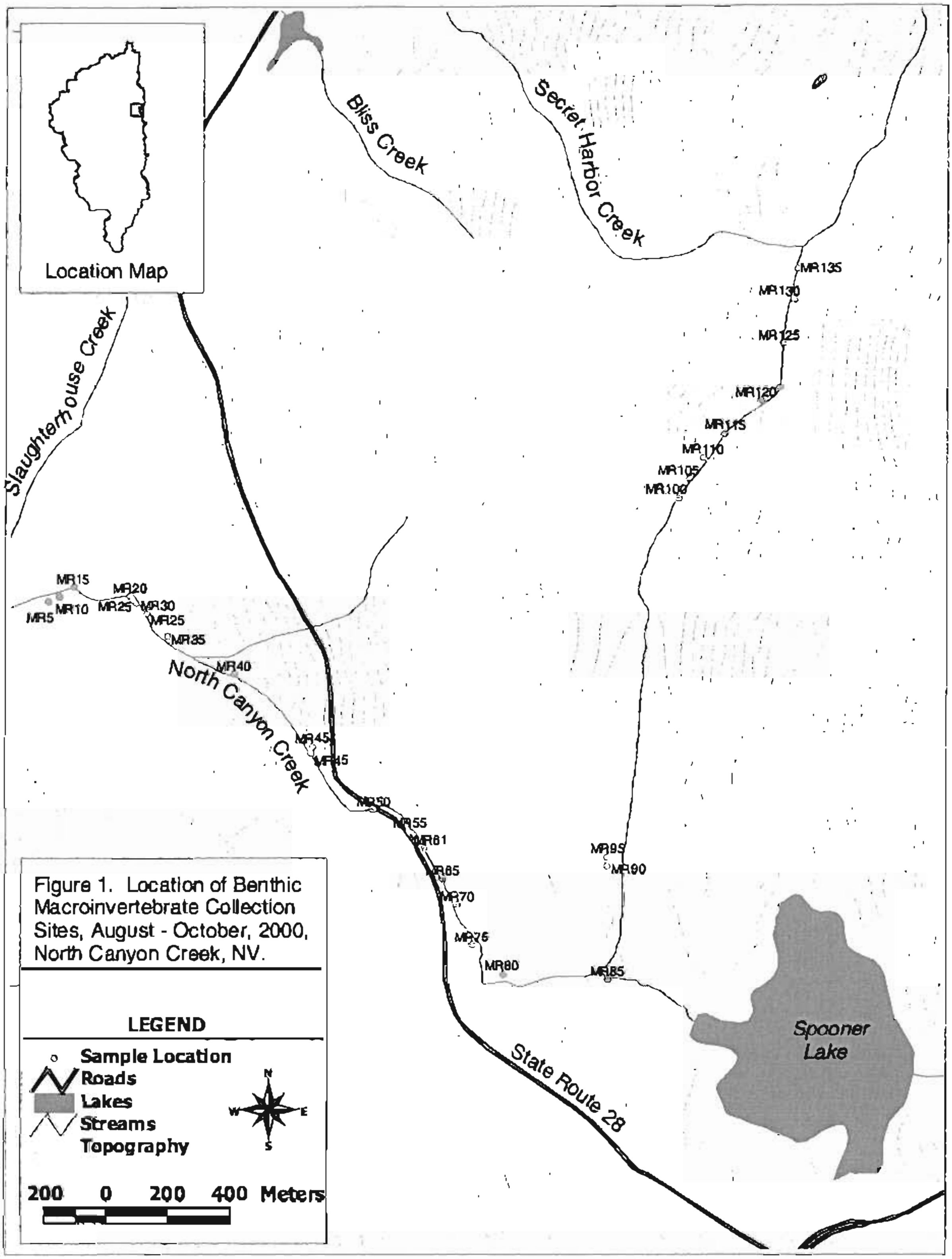

Figure 1. Location of Benthic Macroinvertebrate Collection Sites, August - October, 2000, North Canyon Creek, NV.

bugs. Laboratory sorting and picking of bug provides addition tools, such as a stereomicroscope, to ensure all bug size classes and total number of bugs are represented in the sample. The quantitative analysis of species indices and quality metrics was confounded by the long-term storage of BMI samples and subsequent handling of the samples. Two years of room temperature storage deteriorated some invertebrate tissues to a malleable condition, making species unidentifiable (i.e., worms) and especially vulnerable to further degradation when handled for shipping. Consequently, although Rapid Bioassessment Protocol metrics were calculated and reported (Table 1), interpretation should be made cautiously and understood to be biased towards species that are more tolerant to deterioration (i.e., species with exoskeletons).

Table 1. Summary of benthic macroinvertebrate metrics calculated for North Canyon Creek samples, July 20 through October 9, 2000.

Sample Location	Taxa Richness	EPT Taxa Richness	Sensitive EPT Taxa (%)	% Dominant Taxon	Tolerance Value	Shannon's Diversity Index	Total Lab Specimen Count	Total Field Specimen Count	Variance From Field Count (Degraded)
MR5	6	3	33.33	16.67	4.33	1.79	6	12	-6
MR10	4	2	17.65	58.82	4.00	1.07	17	28	-11
MR15	16	4	40.00	33.33	3.00	2.36	30	39	-9
MR20	20	7	27.91	13.95	3.95	2.80	43	49	-6
MR25	18	7	38.71	25.81	3.13	2.50	62	88	-26
MR30	24	14	62.50	30.00	2.54	2.51	120	150	-30
MR35	17	13	64.29	16.07	2.48	2.60	56	85	-29
MR40	3	2	85.71	71.43	1.43	0.80	7	22	-15
MR45	18	13	56.76	31.08	2.42	2.27	74	85	-11
MR50	13	8	44.23	28.85	3.47	2.10	104	145	-41
MR55	18	6	13.27	29.59	5.02	2.29	98	104	-6
MR61	15	4	2.28	82.65	7.15	0.84	219	221	-2
MR65	15	2	3.20	68.00	6.62	1.30	125	123	2
MR70	23	5	5.05	57.58	6.59	1.86	99	107	-8
MR75	22	5	9.17	54.13	5.79	1.84	218	226	-8
MR80	19	7	17.24	54.48	5.86	1.72	145	153	-8
MR85	9	4	5.31	89.37	7.35	0.52	207	238	-31
MR90	10	2	31.58	26.32	3.32	2.13	19	20	-1
MR95	17	10	71.15	32.69	2.31	2.35	52	57	-5
MR100	15	9	74.07	41.98	2.56	1.88	81	140	-59
MR105	18	6	38.46	20.00	4.37	2.45	65	74	-9
MR110	24	11	53.33	26.67	2.73	2.65	60	100	-40
MR115	21	10	71.82	40.91	1.76	2.09	110	202	-92
MR120	15	6	57.58	28.79	2.48	2.25	66	92	-26
MR125	14	1	4.94	51.85	4.38	1.57	81	160	-79
MR130	17	7	54.79	30.14	2.96	2.13	73	128	-55
MR135	18	6	35.90	12.82	3.74	2.66	39	64	-25
Mean	**15.89**	**6.44**	**37.79**	**39.78**	**3.92**	**1.98**	**84.30**	**107.85**	**-23.56**
Std. Dev.	**5.55**	**3.63**	**25.27**	**21.01**	**1.68**	**0.61**	**59.04**	**64.58**	**24.14**
Maximum	**24**	**14**	**85.71**	**89.37**	**7.35**	**2.8**	**219**	**238**	**-92**
Minimum	**3**	**1**	**2.28**	**12.82**	**1.43**	**0.52**	**6**	**12**	**2**

Following sample processing it was determined the field sampling method (field picking of macroinvertebrates) and degraded shape of specimens in several of the samples (making them non-keyable/uncountable) would bias the analytical intent of the Sensitive EPT Index, Percent Dominant Taxon, Tolerance Value, and Shannon's Diversity Index metrics because missing or degraded taxa would not be represented in the metric. Taxa Richness, EPT Taxa Richness, and the field Invertebrate Count were graphed individually against each physical habitat parameter measured. Each graph was visually inspected for suggested trends between the biological community and physical habitat measures. Visual inspection of individual graphs of physical and biological data suggested that physical habitat did not explain variation among macroinvertebrate samples collected. The mean laboratory invertebrate count/field invertebrate count for all subsamples was 75%. The primary reasons for discrepancies were poor storage of some of the subsamples and the inclusion of terrestrial and non-benthic invertebrates in the subsamples. Samples containing large numbers of soft-bodied invertebrates (worms and flatworms) were greatly affected. Without being fixed in formalin, two years of alcohol storage caused severe deterioration and made taxonomic determination and enumeration problematic. The arthropods (insects, mites and scuds) were generally in better shape due to sclerotized exoskeletons however in at least one subsample it was decided that using body parts for taxonomic determination was dubious at best.

A standardized protocol such as the California Stream Bioassessment Procedure for Wadeable Streams (1999) and USFS Region 6 Stream Inventory Level I and II Field Protocol (http://www.fs.fed.us/r6/water/fhr/ training/ index.htm) may be helpful in future investigation of the relationship of physical habit parameters and the biological community in North Canyon Creek.

Due to the inconclusive nature of this project as a result if degraded BMI samples, it is recommended that an additional field investigation on North Canyon Creek, as well as other Nevada streams within the Lake Tahoe basin, be conducted to establish baseline biological integrity conditions. Additionally, future programs on state lands in Lake Tahoe should considering including this type of approach to monitor stream habitat conditions over time.

LITERATURE CITED

Cairns, J. Jr. and J.R. Pratt. 1993. A History of Biological Monitoring Using Benthic Macroinvertebrates. pp. 10-27 *in* Rosenberg, D.M and V.H. Resh (eds.) Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman and Hall, New York.

California Department of Fish and Game. 1999. California Stream Bioassessment Procedure.Water Pollution Control Laboratory. Rancho Cordova, California. California Department of Fish and Game. 2000. ABAL Taxa List. Water Pollution Control Laboratory. Rancho Cordova, California.

Cook, D.R. 1974. Water mite genera and subgenera. Memoirs of the American Entomological Institute. 21:860 pp.

Fore, L.S., J.R. Karr and R.W. Wisseman. 1996. Assessing invertebrate responses to human activities: evaluating alternative approaches. Journal North American Benthological Society. 15(2):212-231.

Harrington, J.M., P. Ode and A. Montalvo. 1999. Russian River Index of Biological Integrity (RRIBI) for First to Third Order Streams. California Department of Fish and Game. Water Pollution Control Laboratory. Rancho Cordova, California.

Larson, D.J, Y. Alarie, and R.E. Roughley. 2000. Predaceous Diving Beetles (Coleoptera:Dytiscidae) of the Nearctic Region, With Emphasis on the Fauna of Canada and Alaska. National Research Council of Canada, Ottawa.

Ode, P. 2003. List of Californian macroinvertebrate taxa and standard taxonomic effort. Cal. Dept. Fish and Game. http://www.dfg.ca.gov/cabw/CAMLnetSTE.PDF. 45 pp.

Karr, J.R. and E.W. Chu. 1999. Restoring Life in Running Waters. Island Press, Washington, D.C.

Kathman, R.D. and R.O. Brinkhurst. 1998. Guide to the Freshwater Oligochaetes of North America. Aquatic Resource Center, College Grove, Tennessee.

Merritt, R.W. and K.W. Cummins (eds.) 1996. An Introduction to the Aquatic Insects of North America. Kendall/Hunt, Dubuque, Iowa.

Monakov, A.V. 1972. Review of studies on feeding of aquatic invertebrates conducted at the Institute of Biology of Inland Waters , Academy of Science, U.S.S.R. Journal Fisheries Research Board Canada. 29:363-383.

Pennak, R.W. 1989. Fresh Water Invertebrates of the United States (3rd ed.). John Wiley and Sons, Inc., New York.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers. Benthic Macroinvertebrates and Fish. EPA 440-4-89-001. Office of Water Regulation and Standards, U.S. Environmental Protection Agency, Washington, D.C.

Rosenberg, D.M. and V.H. Resh. 1993. Introduction to Freshwater Biomonitoring and Benthic Macroinvertebrates. pp. 1-9 *in* D.M. Rosenberg and V.H. Resh (eds.). Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman and Hall, New York.

Stewart, K.W. and B.P. Stark. 1988. Nymphs of North American Stonefly Genera (Plecoptera). University of Texas Press, Denton.

Usinger, R.L. (ed.) 1956. Aquatic Insects of California. University of California Press, Berkeley.

Wiederholm, T. (ed.). 1983. Chironomidae of the holarctic region. Part 1. Larvae. Entomologica Scandinavica Supplement 19:1-457.

Wiggens, G.B. 1996. Larvae of the North American Caddisfly Genera (Trichoptera). University of Toronto Press, Canada.

Wisseman, R.W. 1996. Benthic Invertebrate Biomonitoring and Bioassessment in Western Montane Streams. Aquatic Biology Associates, Inc., Corvallis, Oregon.

Appendix 1: Frequency of benthic macroinvertebrate taxa detected in North Canyon Creek, Nevada, associated feeding group and sensitivity, August through November 2000

Taxa	Frequency of Occurrence	Feeding Group[a]	Tolerance[b]
ARTHROPODA			
INSECTA			
Coleoptera			
Dytiscidae			
Agabus	1	P	8
Hydrovatus	1	P	5
Sanfilippodytes	9	P	5
Elmidae			
Cleptelmis	58	CG	4
Lara	6	SH	4
Narpus	10	CG	4
Optioservus	38	SC	4
Hydraenidae			
Hydraena	2	SC	5
Octhebius	16	SC	5
Hydrophilidae			
Ametor	2	CG	5
Cymbiodyta	1	CG	5
Laccobius	2	MH	5
Diptera			
Ceratopogonidae			
Bezzia/Palpomyia	5	P	6
Chironomidae			
Chironominae			
Chironomini			
Microtendipes rydalensis grp.	1	C	6
Polypedilum	2	OM	6
Tanytarsini			
Microspectra	48	CG	7
Rheotanytarsus	4	CF	6
Diamesinae			
Pagastia	74	CG	1
Pseudodiamesa	10	CG	6
Protanypus	1	CG	6
Orthocladiinae			
Brillia	4	SH	5
Cricotopus	6	CG	7
Diplocladius	5	CG/CF?	
Eukiefferiella	3	OM	8
Parametriocnemus	1	CG	5
Paraphaenocladius	2	CG	4

Taxa	Frequency of Occurrence	Feeding Group[a]	Tolerance[b]
Prodiamesinae			
Monodiamesa	5	CG	7
Odontomesa	1	CG/CF?	4
Prodiamesa	1	CG/CF?	3
Tanypodinae			
Brundiniella	5	P	6
Conchapelopia	1	P	6
Macropelopia	17	P	6
Natarsia	1	P	8
Thienemannimyia group	1	P	6
Zavrelimyia	4	P	8
Dixidae			
Dixa	3	CG	2
Meringodixa	4	CG	2
Empididae	1	P	6
Trichoclinocera	1	P	6
Pelecorhynchidae			
Glutops	8	P	3
Psychodidae			
Pericoma/Telmatoscopus	1	CG	4
Ptychopteridae			
Ptychoptera	28	CG	7
Simuliidae			
Prosimulium	2	CF	3
Simulium	63	CF	6
Tipulidae	2	P	3
Dicranota	8	P	3
Limnophila	16	P	3
Limonia	1	SH	6
Pedicia	1	P	6
Tipula	4	OM	4
Ulomorpha	4	P	3
Brachycera (pupa)	3		6
Ephemeroptera			
Baetidae			
Baetis	18	CG	5
Diphetor	1	CG	5
Ephemerellidae			
Drunella	18	P	0
Serratella	2	CG	2
Heptageniidae			
Cinygma	12	SC	2
Ironodes	9	SC	3
Leptophlebiidae			
Paraleptophlebia	78	CG	4

Taxa	Frequency of Occurrence	Feeding Group[a]	Tolerance[b]
Megaloptera			
Sialidae			
Sialis	16	P	4
Plecoptera			
Chloroperlidae			
Sweltsa	15	P	1
Leuctridae			
Moselia	109	SH	0
Nemouridae			
Malenka	67	SH	2
Soyedina	13	SH	2
Zapada cinctipes	90	SH	2
Zapada frigida	1	SH	2
Peltoperlidae			
Yoraperla	167	SH	1
Perlidae			
Doroneuria	11	P	1
Hesperoperla	10	P	2
Perlodidae			
Isoperla	25	P	2
Kogotus	9	P	2
Trichoptera			
Hydropsychidae			
Hydropsyche	1	CF	4
Parapsyche	36	P	0
Limnephilidae	1		4
Cryptochia	1	SH	0
Psychoglypha	1	SH	2
Phryganeidae			
Yphria	11	P	1
Rhyacophilidae			
Rhyacophila	1	P	0
Rhyacophila betteni group	1	P	1
Rhyacophila brunnea group	6	P	1
Rhyacophila grandis group	12	P	1
Rhyacophila vofixa group	49	P	0
Chelicerata			
ARACHNOIDEA			
Acarina			
Arrenuridae			
Arrenurus	1	P	5
Hygrobatidae			
Hygrobates	1	P	8
Lebertiidae			
Lebertia	1	P	8

Taxa	Frequency of Occurrence	Feeding Group[a]	Tolerance[b]
Sperchontidae			
Sperchon	4	P	8
Crustacea			
MALACOSTRACA			
Amphipoda			
Hyalellidae			
Hyalella azteca	721	CG	8
Ostracoda	2	CG	8
MOLLUSCA			
BIVALVIA			
Pelecypoda			
Sphaeriidae			
Pisidium	26	CF	8
ANNELIDA			
OLIGOCHAETA	3	CG	5
Tubificida			
Enchytraeidae	8	CG	5
Tubificidae (hair chaetae)	1	CG	5
Tubificidae (no hair chaetae)	15	CG	5
Lumbriculida			
Lumbriculidae	91	CG	5
Megadrili	46	CG	5
PLATYHELMINTHES			
TURBELLARIA			
Tricladida			
Planariidae	63	OM	4
NEMATOMORPHA			
GORDIOIDEA			
Gordiidae			
Gordius	1	PA	N/E
NEMATODA	3	P	5

[a] Functional feeding group codes according to Ode (2003).

P = Predator
PA = Parasite
CG = Collector-gatherer
CF = Collector filterer
MH = Macrophyte herbivore
PH = Peircer herbivore
SC = Scarper
SH = Shredder
OM = Omnivore
XY = Xylophage (wood eater)

[b] California Tolerance Value – Based on Hilsenhoff Biotic Index, a pollution sensitivity scale from 0 to 10, with 0 = highly intolerant or sensitive to organic pollution, and 10 = highly tolerant to organic pollution (see Ode 2003 for details).