# AQUATIC INVERTEBRATES AND HABITAT OF EAGLE CREEK: CHOUTEAU COUNTY, MONTANA
# Project TMDL-M23

August 22, 2002

A report to

The Montana Department of Environmental Quality
Helena, Montana

by

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## INTRODUCTION

Benthic assemblages are aptly applied to aquatic bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

Multimetric approaches to bioassessment use attributes of the assemblage in an integrated way to measure biotic integrity, defined by Karr and Dudley (1981) as "...the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitats within a region." The additive multimetric approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1996). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998a). The first element is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied must be done, to assist in the interpretation of metric outcomes.

This report summarizes data collected on August 22, 2002 from Eagle Creek, Chouteau County, Montana, by means of a multimetric method, an adaptation of the U.S. EPA's Rapid Bioassessment Protocols (RBP III) (Plafkin et al. 1989). Macroinvertebrates were collected at three sites, one located within the Montana Valley and Foothill Prairies ecoregion and two located in the Northwestern Great Plains ecoregion (Woods et al. 1999). The purpose of the study is to provide information that may be pertinent to the development of pollution control plans or Total Maximal Daily Loads as mandated by the Clean Water Act.

Metric selection for this study is based on the recommendations found in the standard operating procedures for macroinvertebrate sampling and analysis of the Montana Department of Environmental Quality (Montana DEQ) (Bukantis 1998). Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat parameters and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Assurance of the validity of association between habitat parameters and biotic metrics is particularly compelling in the Plains ecoregion, since impairment of the biotic health of streams in this region is generally the result of non-point sources. Agricultural activities, including cattle grazing and flow alteration, are predominant causes of stream degradation. The benthic assemblages of the Plains ecoregions and the performance of bioassessment metrics have not yet been examined thoroughly enough to determine whether or not the individual metrics or their integrated scores can discriminate impaired conditions from good biotic health. Thus, conclusions concerning bioassessment based upon these metrics must be regarded as tentative.

Habitat assessment enhances the interpretation of biological data (Barbour and Stribling 1991), because there is generally a direct response of the biological community to habitat degradation in the absence of water quality impairment. If biotic health appears more damaged than the habitat quality would predict, water pollution by quantities of organic materials, nutrients, metals, or other toxicants might be suspected. On the other hand, an "artificial" elevation of biotic condition in the presence of habitat degradation may be due to the paradoxical effect of mild nutrient or organic enrichment. Habitat assessment data is even more important in the Plains ecoregions, where the relationships between habitat variables and benthic community characteristics remain largely unknown.

**METHODS**

Aquatic macroinvertebrates were sampled by personnel of the Montana DEQ from three sites on Eagle Creek on August 22, 2002. Sampling site designations and locations are listed in Table 1a. The site selection and sampling method employed were those recommended in the Montana Department of Environmental Quality (DEQ) Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). The traveling-kick collection procedure was employed for all samples; duration and length are indicated in Table 1b.

**Table 1.** Sample designations and locations. Eagle Creek, August 22, 2002. Sites are listed in upstream-to-downstream order.

| Site | Station ID | Activity ID | Location description | Latitude/Longitude |
|---|---|---|---|---|
| 1 | M23EAGLC01 | 02-L411-M | Eagle Creek upper site on IX Ranch | 48°06'03"/109°46'08" |
| 2 | M23EAGLC02 | 02-L408-M | Eagle Creek downstream of Hwy 236 crossing | 47°56'24"/109°52'04" |
| 3 | M23EAGLC03 | 02-L410-M | Eagle Creek near mouth | 47°55'02"/110°03'11" |

**Table 1b.** Sample collection procedure, duration, and length. Eagle Creek, August 22, 2002.

| Site | Date | Collection Procedure | Duration | Length |
|---|---|---|---|---|
| 1 | 8-22-02 | KICK | 1 MINUTE | 12 FEET |
| 2 | 8-22-02 | KICK | 1 MINUTE | 10 FEET |
| 3 | 8-22-02 | KICK | 1:20 MINUTE | 10 FEET |

In addition to macroinvertebrate sample collection, habitat quality was visually evaluated at the three sites and reported by means of the habitat assessment protocols recommended by Bukantis (1998). Both riffle/run dominated and glide/pool dominated systems were encountered. Macroinvertebrate samples and associated habitat data were delivered to Rhithron Associates, Inc., Missoula, Montana for laboratory and data analyses.

In the laboratory, the RBP III sorting method was used to obtain subsamples of 300 (+/- 10%) organisms from each sample when possible. Organisms were identified to the lowest practical level.

*Assessment of Montana Valley and Foothill Prairies (MVFP) site*

To assess aquatic invertebrate communities from the MVFP Site 1 at upper Eagle Creek, a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman 1998a) was used. Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998a). The multimetric index used in this report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in western Montana ecoregions is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics comprising the bioassessment index used in this study were selected because, both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998a). In addition, they are relevant to the kinds of impacts that are present in the Lolo Creek watershed. They have been demonstrated to be more variable with anthropogenic disturbance than with natural environmental gradients (Bollman 1998a). Each of the six metrics developed and tested for western Montana ecoregions is described below.

1. **Ephemeroptera (mayfly) taxa richness.** The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.
2. **Plecoptera (stonefly) taxa richness.** Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.
3. **Trichoptera (caddisfly) taxa richness.** Caddisfly taxa richness has been shown to decline when sediment deposition affects their habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.
4. **Number of sensitive taxa.** Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998a).
5. **Percent filter feeders.** Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment

material, from the water column by means of a variety of adaptations, such as silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* spp. and *Parapsyche* spp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Here they are considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.

**6. Percent tolerant taxa.** Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery.

**Table 2.** Metrics and scoring criteria for bioassessment of streams of western Montana ecoregions (Bollman 1998a).

| | **Score** | | | |
|---|---|---|---|---|
| **Metric** | **3** | **2** | **1** | **0** |
| **Ephemeroptera taxa richness** | > 5 | 5 - 4 | 3 – 2 | < 2 |
| **Plecoptera taxa richness** | > 3 | 3 - 2 | 1 | 0 |
| **Trichoptera taxa richness** | > 4 | 4 - 3 | 2 | < 2 |
| **Sensitive taxa richness** | > 3 | 3 - 2 | 1 | 0 |
| **Percent filterers** | 0 – 5 | 5.01 - 10 | 10.01 – 25 | > 25 |
| **Percent tolerant taxa** | 0 – 5 | 5.01 - 10 | 10.01 – 35 | > 35 |

| **Table 3a.** Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis 1998). | |
|---|---|
| % Comparability to reference | Use support |
| >75 | Full support--standards not violated |
| 25-75 | Partial support--moderate impairment--standards violated |
| <25 | Non-support--severe impairment--standards violated |

| **Table3b.** Criteria for the assignment of impairment classifications (Plafkin et al. 1989). | |
|---|---|
| % Comparability to reference | Classification |
| > 83 | nonimpaired |
| 54-79 | slightly impaired |
| 21-50 | moderately impaired |
| <17 | severely impaired |

For Site 1, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman 1998b). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998a). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).
- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.

- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman 1998b).
- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman 1998b).

*Assessment of Plains sites*

For the two sites within the Plains ecoregion, community structure, function, and sensitivity to impact were characterized for each subsample using a battery of ten attributes, or metrics, recommended by Bukantis (1998). Actual metric values from each sample were compared to ecoregional reference values to obtain scores. The bioassessment metric battery and metric reference values are given in Table 4. Scores for all metrics were combined, and a total bioassessment score was expressed as a percentage of the maximum possible score. For all sites, the total bioassessment score was expressed in terms of use-support. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

**Table 4.** Provisional metrics and scoring criteria for the Montana Plains ecoregions. (Bukantis 1998).

| | **Score** | | | |
|---|---|---|---|---|
| **Metric** | **3** | **2** | **1** | **0** |
| Taxa richness | >24 | 24 - 18 | 18 – 12 | <12 |
| EPT richness | >8 | 8 – 6 | 5 – 3 | <3 |
| Biotic Index | <5 | 5 – 6 | 6 – 7 | >7 |
| % Dominant taxon | <30 | 30 – 45 | 45 – 60 | >60 |
| % Collectors | <60 | 60 – 80 | 80 – 95 | >95 |
| % EPT | >50 | 50 – 30 | 30 – 10 | <10 |
| Shannon H (log2) | >3.0 | 3.0 – 2.4 | 2.4 – 1.8 | <1.8 |
| % Scrapers + shredders | >30 | 30 – 15 | 15 – 3 | <3 |
| # Predator taxa | >5 | 4 – 5 | 3 – 4 | <3 |
| % Multivoltine | <40 | 40 – 60 | 60 – 80 | >80 |

## RESULTS

### Habitat Assessment

Table 5 shows the habitat parameters evaluated, parameter scores and overall habitat evaluations for the three sites studied. Figure 1 graphically compares total habitat assessment scores for the three sites.

The riffled habitat at Site 1 scored optimally. Benthic substrate here was perceived to be diverse, with little or no sediment deposition. Streambanks were judged moderately stable, with adequate vegetative cover. Riparian zone width was marginal on one side of the stream and sub-optimal on the other side.

Overall habitat conditions at Site 2 were also rated as optimal. Instream habitat parameters were judged to be essentially intact. Little or no sediment deposition was noted. Streambanks were perceived to be stable, with healthy vegetation protecting them from erosion. The riparian zone on both sides of the stream was moderately abbreviated, with cropland and grazed areas encroaching.

Near the mouth of Eagle Creek, Site 3 scored sub-optimally for habitat quality. Benthic substrate and available cover were judged to be sub-optimal. Car fords were noted. Flow conditions were perceived to be sub-optimal. Streambanks were judged to be fairly stable and were noted to be well vegetated. The riparian zone width on both sides of the stream was rated marginal.

**Figure 1.** Total habitat assessment scores for sites on Eagle Creek. August 22, 2002.

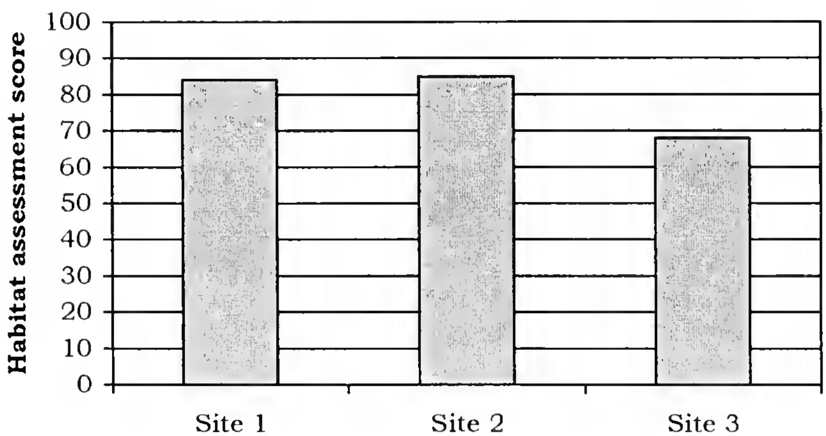


**Table 5**. Stream and riparian habitat assessment. Site 1 was assessed based upon criteria developed by Montana DEQ for streams with riffle/run prevalence, while the assessments for Sites 2 and 3 were based upon criteria developed for streams with glide/pool prevalence. Eagle Creek, August 22, 2002.

| Max. possible score | Parameter | Site 1 | Max. possible score | Parameter | Site 2 | Site 3 |
|---|---|---|---|---|---|---|
| 10 | Riffle development | 8 | 20 | Bottom substrate | 18 | 12 |
| 10 | Benthic substrate | 9 | 20 | Pool substrate char. | 18 | 17 |
| 20 | Embeddedness | 18 | 20 | Pool variability | 18 | 16 |
| 20 | Channel alteration | 16 | 20 | Channel alteration | 16 | 15 |
| 20 | Sediment deposition | 18 | 20 | Sediment deposition | 18 | 17 |
| 20 | Channel flow status | 18 | 20 | Channel sinuosity | 16 | 11 |
| 20 | Bank stability | 7 / 10 | 20 | Channel flow status | 18 | 12 |
| 20 | Bank vegetation | 8 / 10 | 20 | Bank vegetation | 10 / 8 | 6 / 6 |
| 20 | Vegetated zone | 5 / 8 | 20 | Bank stability | 10 / 10 | 8 / 8 |
| | | | 20 | Vegetated zone | 5 / 5 | 4 / 4 |
| 160 | Total | 135 | 200 | Total | 170 | 136 |
| | Percent of maximum | **84%** | | Percent of maximum | **85%** | **68%** |
| | CONDITION* | **OPTIMAL** | | CONDITION* | **OPTIMAL** | **SUB-OPTIMAL** |

* Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. (Plafkin et al. 1989.)

**Bioassessment**

Tables 6a and 6b itemize each contributing metric and show individual metric scores for each site. Figure 2 summarizes bioassessment scores for aquatic invertebrate communities sampled at the 3 sites in this study. Tables 3a and 3b above show criteria for use-support categories recommended by Montana DEQ (Bukantis 1998) and impairment classifications (Plafkin et al. 1989). Macroinvertebrate taxa lists, metric results and other information for each sample are given in the Appendix.

When the relevant bioassessment method is applied to these data, scores indicate slightly impaired biologic integrity and partial support of designated uses at Site 1. At Site 2, bioassessment suggests slight impairment of biotic health and full support of designated uses. Moderate impairment and partial support of uses is implied by bioassessment scores at Site 3.

**Table 6a.** Metric values, scores, and bioassessments for the MVFP site on upper Eagle Creek (Site 1). August 22, 2002. Revised bioassessment method (Bollman 1998a). Site location is given in Table 1.

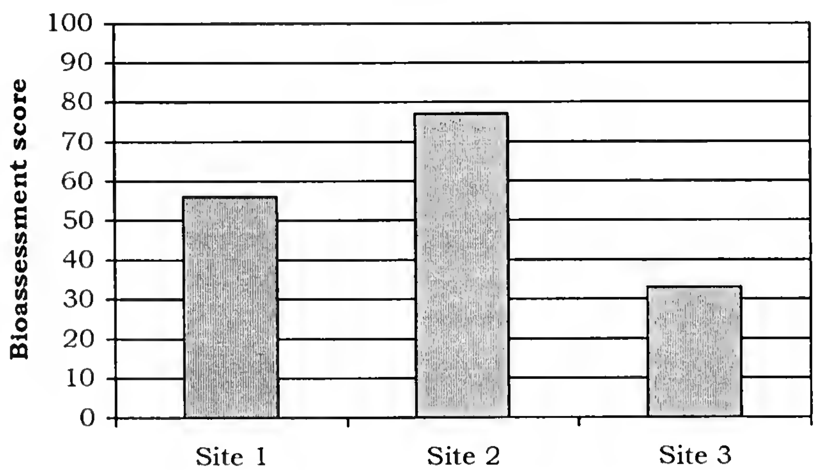
| | **SITE 1 Upper Eagle Creek** |
|---|---|
| **METRICS** | **METRIC VALUES** |
| **Ephemeroptera richness** | 3 |
| **Plecoptera richness** | 4 |
| **Trichoptera richness** | 5 |
| **Number of sensitive taxa** | 1 |
| **Percent filterers** | 8.21 |
| **Percent tolerant taxa** | 36.79 |
| | **METRIC SCORES** |
| **Ephemeroptera richness** | 1 |
| **Plecoptera richness** | 3 |
| **Trichoptera richness** | 3 |
| **Number of sensitive taxa** | 1 |
| **Percent filterers** | 2 |
| **Percent tolerant taxa** | 0 |
| **TOTAL SCORE (max.=18)** | 10 |
| **PERCENT OF MAX.** | **56%** |
| **Impairment classification*** | **SLI** |
| **USE SUPPORT †** | **PART** |

* Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.

† Use support designations: See Table 3a.

| **Table 6b.** Bioassessment metrics and scores two sites on Eagle Creek. August 22, 2002. Montana plains ecoregions reference (Bukantis 1998). | | |
|---|---|---|
| **VALUES** | **Site 2 Eagle Creek downstream** | **Site 3 Eagle Creek near mouth** |
| Taxa richness | 32 | 19 |
| EPT richness | 8 | 3 |
| Biotic Index | 5.79 | 6.81 |
| % dominant taxon | 21.77 | 57.98 |
| % collectors | 70.07 | 92.02 |
| % EPT | 38.44 | 11.35 |
| Shannon diversity | 3.65 | 1.70 |
| % Scrapers + shredders | 12.93 | 0.31 |
| # Predator taxa | 7 | 4 |
| % Multivoltine | 46.43 | 61.27 |
| **SCORES** | | |
| Taxa richness | 3 | 2 |
| EPT richness | 2 | 1 |
| Biotic Index | 2 | 1 |
| % dominant taxon | 3 | 1 |
| % collectors | 2 | 1 |
| % EPT | 2 | 1 |
| Shannon diversity | 3 | 0 |
| % Scrapers + shredders | 1 | 0 |
| # Predator taxa | 3 | 2 |
| % Multivoltine | 2 | 1 |
| **TOTAL SCORE** | 23 | 10 |
| **PERCENT MAXIMUM** | **77%** | **33%** |
| **IMPAIRMENT CLASSIFICATION[1]** | **SLI** | **MOD** |
| **USE SUPPORT[1]** | **FULL** | **PART** |
| [1]See Table 3b for impairment classification criteria and Table 3a for use support criteria. | | |

**Figure 2.** Total bioassessment scores compared among sites on Eagle Creek, August 22, 2002. The revised bioassessment method (Bollman 1998a) was used to determine scores for Site 1; Montana DEQ Plains ecoregions reference criteria (Bukantis 1998) were used to determine scores for Site 2 and Site 3. Scores are reported as the percent of maximum possible score.



### Aquatic invertebrate communities

Interpretations of biotic integrity in this report are made without reference to results of habitat assessments, or any other information about the sites or watersheds that may have accompanied the invertebrate samples. Interpretations are based entirely on: the taxonomic and functional composition of the sampled invertebrate assemblages; the sensitivities, tolerances, physiology, and habitus information for individual taxa gleaned from the writer's research; the published literature, and other expert sources; and on the performance of bioassessment metrics, described earlier in the report, which have been demonstrated to be useful tools for interpreting potential implications of benthic invertebrate assemblage composition.

At Site 1, the biotic index value (4.52) calculated for the entire assemblage was well within expectations for reference condition in the Plains ecoregions, but high for a foothill prairie stream. Additionally, the sample taken here yielded only 3 mayfly taxa. Physid and planorbid snails were collected, and 37% of animals collected were tolerant. These included the caddisfly *Oecetis* sp. These findings support a hypothesis of slight nutrient enrichment.

Eleven "clinger" taxa and 5 caddisfly taxa were collected, suggesting that fine sediment deposition did not substantially alter the availability of clean stony substrates. The chloroperlid stonefly *Sweltsa* sp. was abundant, implying that cobbles were loose and embeddedness was minimal. Three other stonefly taxa were also present at the site, suggesting that reach-scale habitat features, such as streambank stability and riparian function were essentially intact. At least 4 long-lived taxa were collected; it seems likely that dewatering or other life cycle interruptions have not recently affected this reach. The fauna of this reach of Eagle Creek has taxonomic and functional characteristics similar to foothill streams, justifying its assessment using the revised method described above. All feeding groups expected in such a stream were present in the sampled assemblage, in what appears to be appropriate proportions.

The benthic invertebrate assemblage takes on characteristics of Plains fauna at Site 2 on Eagle Creek. Cold water taxa such as *Pteronarcella* sp. and *Cricotopus nostococladius*, collected at Site 1, are replaced by a cool-to-warm water fauna, including the caddisfly *Helicopsyche borealis* and *Cheumatopsyche* sp. Water quality apparently remained slightly impaired by nutrient and/or organic enrichment at Site 2; only 3 mayfly taxa were collected in the sample, and the biotic index value (5.79) was somewhat elevated compared to the ecoregional reference.

Twelve "clinger" taxa and 5 caddisfly taxa were taken in the sample; this implies that clean hard substrates were not entirely obliterated by fine sediment deposition. Soft sediment habitat was apparently also available, however, since the burrowing mayfly *Ephemera simulans* was supported at the site. No stoneflies were present in the sample, but this is not unexpected for a Plains stream. The presence of the mayfly *Caenis* sp. suggests that macrophytes added complexity to overall habitat here. The functional composition of the assemblage did not lack any expected constituents.

Taxa richness has diminished at the mouth of Eagle Creek (Site 3). Where the upstream sites supported nearly 30 taxa each, the downstream site supported only 19. Only 1 mayfly taxon was taken in the sample, and the biotic index value (6.81) was substantially elevated over expectations for Plains reference condition. This may indicate that nutrient and/or organic enrichment affected assemblage composition. It may also indicate warmer water temperatures than expected.

Six "clinger" taxa and 2 caddisfly taxa were collected, suggesting that clean stony substrates were not abundantly available. Two "clinger" taxa dominated the sample, but these were midges in the Cricotopus Bicinctus Group and *Tanytarsus* sp., whose small size enables them to be prolific even when habitat space is limited. Fine sediment deposition appears to limit benthic colonization at this site. Macrophytes may contribute to habitat complexity here, however, since the mayfly *Caenis* sp. and immature coenagrionid damselflies were present. Functionally, the assemblage was skewed toward gatherers, with scrapers lacking; this lends strength to a hypotheses that sediment deposition or lack of stony substrates characterized this site. Long-lived taxa were not abundant at this site, suggesting that dewatering or other catastrophes may have limited life cycles here recently.

**CONCLUSIONS**

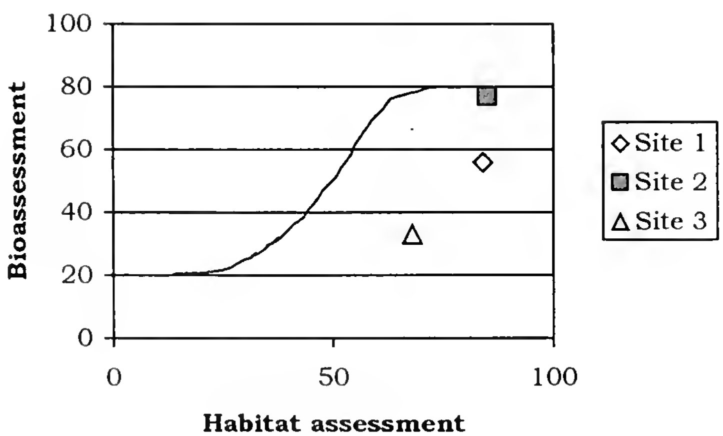
- Data generated for the assemblage collected at Site 1 suggests that water quality may have been slightly degraded by nutrient enrichment; habitat features were essentially undisturbed.

- At Site 2, water quality may have been slightly impaired by nutrient enrichment. Taxonomic and functional composition of the benthic assemblage suggests habitat complexity appropriate for the region.

- At Site 3, bioassessment metric performance suggests that water quality may be moderately impaired by nutrient enrichment and/or elevated temperatures. Taxonomic and functional composition of the benthic assemblage may indicate monotonous habitat, perhaps a consequence of fine sediment deposition.

- Figure 3 illustrates the relationship between habitat assessment scores and bioassessment scores for these 3 sites on Eagle Creek. The graph suggests that Sites 1 and 2 were relatively unimpaired by either habitat disturbances or water quality degradation. The symbol for Site 3, however, falls in a region of the graph where habitat assessment indicates good conditions; yet biologic integrity appears to be disrupted. This result suggests that poor water quality may be a strong limitation to benthic assemblage richness, function, and/or diversity.

**Figure 3.** Total bioassessment scores (MVFP and Plains ecoregions reference) plotted against habitat assessment scores for sites on Eagle Creek, August 22, 2003. The red line describes the hypothetical relationship expected when water quality is good and biotic health is determined predominantly by habitat quality (Barbour and Stribling 1991).



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