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The Environmental Requirements and Pollution Tolerance of Aquatic Insects of the Regional Copper-Nickel Study Area

Minnesota Environmental Quality Board
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PRELIMINARY DRAFT REPORT, SUBJECT TO REVIEW

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INTRODUCTION TO THE REGIONAL COPPER-NICKEL STUDY

The Regional Copper-Nickel Environmental Impact Study is a comprehensive examination of the potential cumulative environmental, social, and economic impacts of copper-nickel mineral development in northeastern Minnesota. This study is being conducted for the Minnesota Legislature and state Executive Branch agencies, under the direction of the Minnesota Environmental Quality Board (MEQB) and with the funding, review, and concurrence of the Legislative Commission on Minnesota Resources.

A region along the surface contact of the Duluth Complex in St. Louis and Lake counties in northeastern Minnesota contains a major domestic resource of copper-nickel sulfide mineralization. This region has been explored by several mineral resource development companies for more than twenty years, and recently two firms, AMAX and International Nickel Company, have considered commercial operations. These exploration and mine planning activities indicate the potential establishment of a new mining and processing industry in Minnesota. In addition, these activities indicate the need for a comprehensive environmental, social, and economic analysis by the state in order to consider the cumulative regional implications of this new industry and to provide adequate information for future state policy review and development. In January, 1976, the MEQB organized and initiated the Regional Copper-Nickel Study.

The major objectives of the Regional Copper-Nickel Study are: 1) to characterize the region in its pre-copper-nickel development state; 2) to identify and describe the probable technologies which may be used to exploit the mineral resource and to convert it into salable commodities; 3) to identify and assess the impacts of primary copper-nickel development and secondary regional growth; 4) to conceptualize alternative degrees of regional copper-nickel development; and 5) to assess the cumulative environmental, social, and economic impacts of such hypothetical developments. The Regional Study is a scientific information gathering and analysis effort and will not present subjective social judgements on whether, where, when, or how copper-nickel development should or should not proceed. In addition, the Study will not make or propose state policy pertaining to copper-nickel development.

The Minnesota Environmental Quality Board is a state agency responsible for the implementation of the Minnesota Environmental Policy Act and promotes cooperation between state agencies on environmental matters. The Regional Copper-Nickel Study is an ad hoc effort of the MEQB and future regulatory and site specific environmental impact studies will most likely be the responsibility of the Minnesota Department of Natural Resources and the Minnesota Pollution Control Agency.

INTRODUCTION

Insects are an integral part of the aquatic ecosystem and are perhaps the most important class of aquatic invertebrates. Their position in the food web varies by species, but insects make up the majority of the primary consumers (herbivores) in the aquatic community.

The following literature review was prepared to provide information needed to predict possible impacts of mining operations upon aquatic insects of the Regional Copper-Nickel Study Area (Study Area). The first section contrasts the sensitivity of insects to common forms of pollution with that of other aquatic fauna (protozoans, fish, and non-insect invertebrates). The second section contrasts pollution tolerance of the major orders of insects of the first five functional groups. The third section provides details on the life history, habitat and pollution tolerance of the dominant Study Area species of the first five functional groups. This information was collected at the generic or species levels and is the most detailed of the three sections. An evaluation of the relative sensitivity of the functional groups to each type of environmental change is included in this section.

The first two sections of this report examine the effects of changes in water chemistry. Parameters include pH, alkalinity, hardness and organic effluents. The third section examines some of these parameters (primarily pH and organics), habitat preference, and time of emergence to determine the relative sensitivity of functional groups to environmental change. Habitat preference is important in those sections of a stream that may be physically altered by mining operations. For example, if a section of stream is channelized or impounded, the riffle areas and the pool-riffle interspersion will be destroyed, and those insects that can live only in the riffle areas will be eliminated.

Emergence is a particularly sensitive stage in the life history of aquatic insects. Also, because eggs are usually laid within a few days of emergence, the time of emergence correlates well with the time of embryonic development, another sensitive stage. One parameter which is examined is the number of species with spring-only emergence, since spring water conditions (alkalinity, hardness, metals, and pH) may be at high levels becasue of spring run-off conditions. In order to determine the sensitifity of species to these types of stress the data on sensitivity to pH, organics, and hardness because the greatest amount of data is available on these parameters and aquatic insects. These parameters are also likely to change if copper-nickel development proceeds.

METHODOLOGY

The pollution tolerance of aquatic insects relative to other aquatic fauna (pages 4-5) was assessed using information available from the literature, notably Hart (1971).

The relative tolerance of pollution of major orders of aquatic insects (pages 6-8)) was assessed using information available from Hart (1971). This assessment was then combined with information on the composition of functional groups I to V to give an indication of the pollution tolerance of each functional group. (See Regional Copper-Nickel Study 1978a, for explanation of functional groups.)

To produce a more comprehensive evaluation of the effects of stream changes resulting from mining operations upon functional groups I to V, life history and pollution tolerance information was compiled in Table 1 for the major genera and species present. The genera, which accounted for 80 percent of the organisms of each functional group during any sampling period were assessed.

Information about these genera was compiled on their life cycle (univoltine, hemivoltine or multivoltine), time of hatching, number of generations per year, time of emergence, temperature of emergence, bottom substrate, preferred current velocity, preferred water temperature, winter life stage, mechanisms for evasion of dessication (if present), TTolerance of organic pollution, functional group, and associated species. Information was unavailable for many of these categories for the majority of taxa. Information from three categories (time of emergence, preferred stream velocity and pollution tolerance) were put into tabular form, along with information on time of year larvae may be expected to be present and life history comments. In addition, water chemistry information from Hart (1971) was included for many species.

Figures 1-5 were prepared from Table 1, with the addition of stream order information by genus (from Regional Copper-Nickel Study 1978a). For stream order, the height of the bar represents frequency of occurrence at the most abundant period sampled. Values indicate whether a given genus was found at 0 percent, 1-25 percent, 26-50 percent, 51-75 percent, or 76-100 percent of the sampling stations at that stream order.

Using Figures 1-5, the number of taxa (genus or species) within several chosen parameters (time of emergence, riffle or pool habitat, tolerance to organic pollution and pH tolerance) were tabulated for each functional group. From this, generalizations and trends for each functional group were made (pages 8-13).

Three comments should be made on how information was organized to make these generalizations:

1. For each parameter examined, information is lacking for some percentage of the taxa present. Percentages of taxa within any parameter may be expressed either relative to all taxa for which information is known or relative to all taxa within the functional

group. Both approaches were applied and percentages calculated; both approaches are presented in the discussion section.

2. For this evaluation, "taxa" refers to either species or genus; evaluation was made at the species level whenever possible. No attempt was made to give the genus rank more "weight" in these evaluations, though each genus has one to several species.

3. Often, information available at the generic levels was applied to the species of the genus; an example of this is distribution within stream orders.

The data was examined for tolerance differences of taxa and functional groups with changes in stream order. No relationships of this type found.

POLLUTION TOLERANCE OF AQUATIC INSECTS RELATIVE TO OTHER AQUATIC FAUNA

In general, fish and insects appear to be the most sensitive aquatic organisms to the most common ofrms of pollution. In a comparison of the biota of several "undamaged" streams with the biota of "damaged" streams, Roback (1971, cited in Hart 1971) found that fish and insects were the most heavily affected. Contaminants in the damaged streams included industrial, strip mining and sewage effluents.

Roback defines an undamaged stream as "one which supports a diverse and balanced fauna and flora, with all trophic levels proportionally represented and no obvious population imbalance". He compiled information from 13 stations on undamaged streams and 10 on damaged streams. The mean number of species for all groups was depressed in the damaged streams; the decrease was greatest for fishes and insects, and less for protozoans and invertebrates other than insects. The percent relative abundance of these groups was also tabulated. Although all groups had fewer species in the damaged streams, the relative abundance of protozoans and non-insect invertebrates increased and the relative abundance of fish and insects decreased.

The similarity and sensitivity of fish and insects to pollution has been noted by other authors. Based primarily on a laboratory study of 20 aquatic insect species, Gaufin (1973) recommends that "to maintain a well-rounded, diversified population of cold water aquatic insects, maximum temperatures, minimum dissolved oxygen levels, and the pH range should not exceed the requirements of cold water fishes, such as trout and salmon". This includes a maximum summer temperature of 65^{o} and minimum dissolved oxygen level of 6.0 mg/l. Gaufin also states that a pH range of 6.0 to 8.5 should protect most cold water lotic insects. Bell (1971) makes a similar assessment; most aquatic insects are more tolerant than fish to low pH and thus a pH range of 6.5 to 9.0 should insure the survival of most fish and aquatic insect species.

Less information is available on the effects of other chemical pollutants. High alkalinity and hardness are tolerated by many insect and non-insect invertebrates (Hart 1971). Fish appear to be less sensitive to normal variability in water chemistry (i.e., unpolluted or undamaged streams) than other aquatic fauna (Hynes 1971).

A review of toxicology studies (Regional Copper-Nickel Study 1978b) indicates that fish and insects are very sensitive to copper and nickel, and that fish are much more sensitive to zinc, cadmium and lead than insects. Information is scarce for other groups but when available, indicates that invertebrates other than insects are often sensitive to these toxicants, and protozoan communities are often, but not always, tolerant.

POLLUTION TOLERANCE OF AQUATIC INSECTS BY ORDER

Plecoptera

Reviewing the tolerance of plecopterans to various chemical factors, Roback (cited in Hart 1971) found them sensitive to most parameters other than high pH. Parameters examined by Roback included low pH, alkalinity, dissolved oxygen and hardness.

Plecopterans are significant in two functional groups, comprising between one-half and one-third of Group I (shredders) and present (with one species) in Group V (scrapers). Other plecopteran species are members of the engulfing predators (Group VIII).

Ephemeroptera

Ephemeropterans are generally regarded as very sensitive to pollution. Roback suggests that organic pollution is the most commonly measured stress, and notes that individual species within the order may show greater tolerance.

Most of the taxa of two functional groups are ephemeropterans. Approximately two-thirds of Group III (collector-gathers) and three-fourths of Group V (scrapers) belong to this order.

Trichoptera

Net building trichopterans are generally tolerant of organic pollution, though not of toxic pollutants; in addition, many can tolerate high pH and hardness. Case-making trichopterans (about one-fourth of the order) are also tolerant of hard waters, but less tolerant of other pollution parameters.

Trichopterans are important in four functional groups, comprising almost three-fourths of Group IV (collector-filter-feeders), about half of both shredder groups (I and II) and about one-fifth of Group V (scrapers).

Diptera

Dipterans, especially chironomids, show a large degree of tolerance to extremes of pH, and tolerance of other chemical stresses.

Dipterans are represented in four of the five functional groups. They are absent in Group V (scrapers). Dipteran taxa account for about one-fourth of Group II (shredder) and almost one-sixth of the taxa in each of the other three groups.

Coleoptera

Members of Coleoptera show a wide degree of tolerance to extremes of pH and to hardness, high alkalinity and other chemical parameters. Coleopterans represent about one-ninth of Group III (collector-gathers).

General

Roback (cited in Hart 1971) collected data on insects present in damaged and undamaged streams, similar to the study presented earlier which contrasted insects to other aquatic fauna. Under damaged conditions, all orders were represented by fewer species. Odonata and Diptera increased in relative abundance; Coleoptera and Trichoptera remained the same; and Ephemeroptera and Plecoptera decreased in relative abundance. Plecoptera showed the most drastic reduction in relative abundance.

Conclusions

Roback's comparison of damaged and undamged streams indicates that Ephemeroptera and Pleoptera are the most sensitive of insect orders to various forms of pollution. A description of the pollution tolerance of each order supports this. Ephemeroptera and Plecoptera make up three-fourths of Group V (scrapers). Ephemeroptera makes up two-thirds of Group III (collector-gathers). Plecoptera makes up over one-third of Group I (shredders). These functional groups are, therefore, likely to be the most sensitive to these types of pollutional stresses.

SENSITIVITY OF FUNCTIONAL GROUPS TO ANTICIPATED CHANGES IN STREAM CONDITIONS DUE TO MINING OPERATIONS

Emergence

Spring and summer emergence is the most common; overall 57 percent of taxa are known to have at least some portion of their population emerge in the spring, and 77 percent in the summer. Taxa that have been observed to emerge only in the spring constitute 0 to 11 percent of each functional group. The mean value is 7 percent.

Habitat

Taxa known to be riffle-only account for 0 to 88 percent of each functional group. Except for Group II (shredders), the functional groups all show a strong tendency towards the riffle environment. Intolerance of pool conditions is then indicated.

Organics

Overall, more taxa are designated intolerant than facultative or tolerant. By functional group, 25 to 45 percent of taxa are designated intolerant (mean 38 percent); 7 to 41 percent are designated facultative (mean 26 percent); and 0 to 11 percent are designated tolerant (mean 3.6 percent). (The definitions of intolerant, facultative and tolerant were described in connection with the Table 1.

pH

Generally, few taxa are found at pH less than 6.0, and a number are found at pH values greater than 8.0; mean values for the functional groups are 6 percent and 21 percent, respectively. These are, however, expressed in percentages of total taxa. Unlike the parameters previously discussed, pH tolerance information is absent for almost two-thirds of the taxa.

SUMMARY OF POLLUTION TOLERANCE OF TAXA BY FUNCTIONAL GROUP

For Group I (shredders of dead plant material):

1) A high percentage of taxa are known to emerge in the spring (67 percent) though most of these emerge in other seasons as well. About 10 percent are believed to emerge only in the spring.

2) Three-fourths of the taxa are riffle-only organisms. The remaining taxa are pool-only or faculative.

3) Many of the taxa are known to be intolerant of organic pollution (39 percent); few are reported to be facultative (7 percent) and none tolerant. This group is probably the most sensitive of the functional groups to organic pollution.

4) Few taxa are found at pH less than six (3 percent) and none at pH greater than 8.0. By this data, Group I is more sensitive than the mean. (Data available on 21 percent of taxa.)

For Group II (shredders of live plants):

1) Less than half are reported to emerge in the spring, and none are reported to emerge only in the spring. Most of the group emerges in the summer months.

2) All taxa are reported to prefer or be tolerant of pool conditions.

3) Two-thirds of taxa are designated intolerant, one third facultative, and none tolerant of organic pollution. This is, however, based on information on two genera.

4) This group has the highest percent of taxa that are tolerant of high and low pH. With information on 71 percent of taxa, tolerance of pH less than 6.0 accounts for 28 percent of taxa, and pH greater than 8.0 accounts for 42 percent.

For Group III (collector-gathers):

1) Half of the taxa have life histories which include spring emergence, and three-fourths include summer emergence. Almost one-tenth of taxa emerge only in the spring.

2) Slightly over half of the taxa with known habitat preferences are riffle organisms, and slightly less than half are pool or pool-tolerant.

3) Tolerance of organic pollution follow the overall functional group pattern; the largest percentage intolerant, but many facultative and few tolerant.

4) A high percentage of taxa are found to tolerate the extremes of pH, relative to other groups: low pH, 10 percent; high pH, 21 percent. Information was avilable on 34 percent of the taxa.

For Group IV (collector-filter-fedders):

1) Almost all taxa include spring emergence, and about one-tenth emerge only in the spring.

2) None are known to be tolerant of pool conditions; with information on 88 percent of taxa.

3) An equal number of taxa are designated intolerant as facultative or tolerant of organic pollution.

4) None are known to be tolerant of low pH, but a high percentage (38 percent of total, 70 percent of known) may be tolerant of high pH levels.

For Group V (scrapers):

1) About one-third of taxa may emerge in the spring, and close to one-tenth of the taxa are spring-only emergers.

2) Information available places nine-tenths of the taxa into the riffle-only category, and one-tenth as pool-tolerant.

3) Roughly twice as many taxa are designated facultative as are designated intolerant to organic pollution, though none are designated tolerant.

4) None are known to tolerate pH less than 6.0, and few are known to tolerate high pH.

CONCLUSIONS

Sensitivity of Functional Groups to Changes in Stream Conditions

Spring Emergence

Group IV (collector-filter feeders) are probably the most sensitive to spring time stress: 94 percent of taxa emerge in the spring, and 11 percent emerge only in the spring. Group I (shredders) and Group III (collector-gathers) are the next most sensitive group, with over half of taxa emerging in the spring and 9 to 10 percent emerging only in the spring. Group II (shredders) and Group V (scrapers) will be the least affected, with less than half emerging in the spring, and 0 to 8 percent emerging only in the spring.

Riffle Specificity

Group IV (collector-filter-feeders) are found only in riffles and would be the most sensitive group to the elimination of riffle conditions. Most of Group V (scrapers) and Group I (shredders) are riffle specific; few taxa are believed to be tolerant to pool conditions. Group III (collector-gathers) would be more tolerant, as almost half of its members may be found in pools. Group II (shredders) is the most tolerant, with all taxa capable of living in pool conditions.

Sensitivity to Organic Pollution

Comparing the numbers of taxa of each functional group which are designated intolerant, facultative or tolerant, the following ranking (from least to most tolerant) was made: Group I (shredders); Group II (shredders); Group III (collector gathers); Group IV (collector-filter-feeders); Group V (scrapers). This ranges from GroupI, with 39 percent of taxa designated intolerant and 7 percent facultative to Group V (scrapers) with 25 percent designated intolerant and 41 percent designated facultative.

Tolerance of Extremes of pH

No members of Group IV and Group V are known to live in areas of pH less than 6.0; a few members of Group I, and a significant percentage of Group III and Group II are known to live in such conditions. No members of Group I are known to live in areas of pH greater than 8.0; a significant percentage of the taxa for which information is known of each of the other functional groups can tolerate such conditions.

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EXPLANATION OF TABLE 1
LIFE HISTORIES OF AQUATIC INSECTS

Column 1, Taxon. Family, genus and species names appear in phylogenetic order.

Column 2, Larvae present. Lists time of year larval forms are present, as has benn stated by a reference or inferred by hatching and emergence dates.

Column 3, Adult (Emergence). Lists time of emergence of adults, as has been stated by a reference (either as emergence dates or time of year adults are found). Times of year appearing in parenthesis referes to either (1) information on the generie level that has been generalized by information for one to several species, but not stated by any author as characteristic of the genus; or (2) information on the species level that has been generalized by one to several known emergence dates. In all cases, information from states or provineces adjacent to Minnesota was preferred over other information. In some cases, information from southern U.S. was used, particularly for the Chironomids; for several genera the entry (Su; all year) was used to reference that both summer and all year emergence has been recorded.

Column 4, Comments. Life history and habitat information is given.

Column 5, Habitat. Stream velocity, and occasionally substrate, are given. Running and rapidly flowing waters are denoted by riffle; lake and slow flowing waters are denoted by pool. The entry "riffle, pool" refers to species that have been reported in either condition or genera that have members found in either or both conditions.

Column 6, Water Chemsitry. All information from Hart, C.W. and Fuller, L.H. 1974. Pollution Ecology of Freshwater Invertibrates. New York: Academic Press.

Information to the generic level may be generalized from one to several species , and thus not represent the tolerance range of any single species.

Column 7, Pollution Tolerance. Three sources are used as indicators of pollution tollerance: W.C. Hilsenhoff (1977), use of arthropods to evaluate water quality of streams; P.A. Lewis (1974) Taxonomy and Ecology of Stenonuna mayflies (Heptogenudae:Ephemeroptera) and C.I. Weber, ed. (1973) Biological field and laboratory methdos for measuring the quality of surface waters and effluents.

Hilsenhoff (1977) evaluated the arthropod fauna of Wisconisn streams in relation to water quality, and assigned values to species and genera. Index values of 0 were assigned to species or genera collected only in unaltered streams of very high water quality and values of 5 assigned to species or genera known to occur in severely polluted or disturbed streams. Intermediate values were assigned to species or genera known to occur in streams iwth various degrees of disturbance or pollution.

Lewis (1974) and Weber (1973) classifly organisms as (I) intolerant, (F) faculative and (t) tolerant. Weber defines the catagories as follows:

Tolerant: Organisms frequently associated with gross organic contamination and are generally capable of thriving under anaerobic conditions; Faculative: Organisms having a wide range of tolerance and frequently are associated with moderate levels of organic contamination; Intolerant: Organisms that are not found associated with even moderate levels of organic contaminants and are generally intolerant of even moderate reductions in dissolved oxygen. Lewis'es definition is more quantitative, but is essentially the same.

Values appearing in parenthesis refer to information specific to one-to-several species, but not generalized by the studies' author to genera.

Abbreviations used: Sp = spring (March-May), Su = summer (June-August), Fa = fall (September-November), Wn - winter (December-February)

Hilsff. = Hilsenhoff

Table 1

ENVIRONMENTAL REQUIREMENTS, POLLUTION TOLERANCE, AND LIFE HISTORY DATA FOR THE DOMINANT AQUATIC INSECTS OF THE STUDY AREA

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TAXA	LIFE HISTORY LARVAE	ADULT (EMERGENCE)	COMMENTS	HABITAT
Plecoptera				
Amphinemura		Sp, su most common adults live 1-5 wks.	usually univoltine; eggs usually hatch in 2-3 wks; larvae usually develop over 1 year	use streams only
A. linda	July-Sept.	sp, su	univoltine	pool
A. delosa	April-July	sp, su	univoltine	
Shipsa				
S. rotunda		sp, su	univoltine	riffle
Leuctra		sp, su, fa		
L. ferruginea		May-Sept	univoltine	riffle, gravel
L. Tennius		May-Sept.	univoltine	riffle, gravel
Allocapnia		Nov-April		
A. Minima	su, fa	wn	univoltine; sp, su diapause	
A. pygmaea	su, fa	Dec-March	univoltine; sp, su diapause	riffle
Paracapnia				
P. angulata	su-sp	March-April	univoltine; no su diapause	
P. opis	su-sp	April-June	univoltine; no su diapause	
Taeniopteryx		March-April for family		
T. burkisi	all year	(April)	univoltine; larvae hatch in sp, diapause until fall	riffle
T. rivalis	all year	Jan-April	ünivoltine, larvae hatch in sp, diapause until fall	

PRELIMINARY DRAFT REPORT, SUBJECT TO REVIEW

TAXA	WATER CHEMISTRY pH	Alkalin	Hardness	SO_4	Temp	D.O.	POLLUTION TOLERANCE	REFERENCE
Plecoptera								
Amphinemura							Weber:I	22,23,31,42
A. linda							Hilsff:0	24,25,26,27
A. delosa							Hilsff:0	26,28
Shipsa								
S. rotunda							Hilsff:0	1,26
Leuctra								28
L. ferruginea							Hilsff:0	26,27,28
L. tennius							Hilsff:0	26,27,28
Allocapnia								22
A. minima								26,29,31,33
A. pygmaea								22,24,26,28
Paracapnia								26,28
P. angulata							Hilsff:0	26,27,28
P. opis								24,26,28
Taeniopteryx							(Hilsff:1)	26
T. burkisi								1,22,26
T. rivalis	6.0-6.8	2-20	70-82	45.1-45.2		10	Weber:I	22,26,33,42

TAXA	LIFE HISTORY LARVAE	ADULT (EMERGENCE)	COMMENTS	HABITAT
Hastaperta		sp, early su for family		
H. brevis	Oct-May	(May)	univoltine; hatching possibly delayed until fall	
Ephemeroptera			adults live a few days at most	
Siphlonurus				pool, silty
S. alternatus		June-July	univoltine	
S. marshalli		April-May	univoltine	
Arthroplea				
A. bipunctata	April-May	May	univoltine	pool
Eperorus sp.			probably univoltine; larvae present Sept-July, adults May-July for 1 species	streams
Heptagenia				
H. hebe	all year	June-Sept	univoltine	riffle
H. flavescens	all year	April-July	univoltine	riffle
Rhithrogena sp.		Feb-Sept.	larvae found all year, adults May-Aug for 4 Wisc. species	riffle, gravel
Stenacron				
S. candidum		April-June	univoltine	riffle, pool
S. interpunctatum	all year	June-Aug	univoltine	riffle, pool
S. minnetonka		May-July	univoltine	riffle, pool

PRELIMINARY DRAFT REPORT. SUBJECT TO REVIEW

PRELIMINARY DRAFT REPORT, SUBJECT TO REVIEW

TAXA	WATER CHEMISTRY pH	Alkalin	Hardness	SO_4	Temp	D.O.	POLLUTION TOLERANCE	REFERENCE
Hastaperta								26
H. brevis							Hilsff;0	24,26,27,28
Ephemeroptera								41
Siphlonurus							(Hilsff:2)	14,18
S. alternatus								10,32
S. marshalli	6.9	15	13	3.3		8		10,32
Arthroplea								
A. bipunctata								21,26
Eperorus sp.							(Hilsff:0)	18,21,27,32
Heptagenia								
H. hebe							Hilsff:0	1, 10, 21, 27, 32
H. flavescens							Hilsff:2	10,21,27,32
Rhithrogena sp.							(Hilsff:0)	18,21,32
Stenacron								
S. candidum								10,18
S. interpunctatum	5.6-8.4	5-205	13-705	<1.0-450.0		4-14	Lewis:I,5 Hilsff:3 Weber:I	10,18,21,27,33
S. minnetonka							Lewis:F	10,18,33

PRELIMINARY DRAFT REPORT, SUBJECT TO REVIEW

TAXA	LIFE HISTORY LARVAE	ADULT (EMERGENCE)	COMMENTS	HABITAT
Stenonema				
S. annexum		April-May	probably univoltine	riffle
S. exiguum	all year	June-Aug	probably univoltine	riffle, sandy
S. fuscum	all year	June-July	probably univoltine	riffle
S. pulchellum	all year	June-Aug	Probably univoltine	riffle
S. quinquespinum		(May)	probably univoltine	
S. rubrum	all year	June-July	probably univoltine	riffle
S. smithae		su	probably univoltine	riffle
S. terminatum	all year	May-July	probably univoltine	stream
S. tripunctatum	July-May	May-Aug	uniudtine and bivoltine	pool
S. femoratum		April-Aug	probably univoltine	
S. integrum	all year	June-Aug	probably univoltine	riffle
Baetis	most hatch in sp	su	hatching time may vary, resulting in cohorts of different sizes	riffle, pool, by species
B. brunneicolor		June-Aug		riffle
B. hageni		(April)		riffle
B. phyllis		(April-May)		
B. pygmaes		Sp, Su, Fa	emergence Aug-Sept in Michigan	riffle, pool
B. vagans		April-Aug		riffle

TAXA	WATER CHEMISTRY pH	Alkalin	Hardness	SO_4	Temp	D.O.	POLLUTION TOLERANCE	REFERENCE
Stenonema							Weber:I	
S. annexum								10,18,33
S. exiguum							Hilsff:3 Weber:I	18,21,27 34,41,42
S. fuscum							Hilsff:1 Lewis:I	1, 18,21,27
S. pulchellum	5.8-8.4	4-213	7-233	<1.0-72.8		3-11	Weber:I	32,33
S. quinquespinum							Lewis:F	18,33
S. rubrum							Hilsff:0 Lewis:F	10,21,27,32,33
S. smithae							Lewis:F Weber:I	33,42
S. terminatum							Hilsff:2 Lewis:I,F	10,21,27 33,42
S. tripunctatum	7.2-8.4	47-175	60-800	18.6-370.0		8-11	Weber:I Hilsff:1 Lewis:I,F	10,21,27
S. femoratum							Weber:I Weber:F,I	32,33,42 10,33
S. integrum							Hilsff:1	10,32,33
Baetis	5.6-8.5	5-312	16-1000	<10-5700		4-14		14,18
B. bruneicolor							Hilsff:3	10,27,32
B. hageni								1,10
B. phyllis								10
B. pygmaes							Hilsff:3	10,27,32
B. vagans							Hilsff:2 Weber:I	10,27,32

PRELIMINARY DRAFT REPORT. SUBJECT TO REVIEW

TAXA	LIFE HISTORY LARVAE	ADULT (EMERGENCE)	COMMENTS	HABITAT
B. flavistriga				riffle
B. frondalis		(May-July)		
Pseudocloeon	wn, sp	sp, su		riffle, pool
P. anoka		(June-Sept)		riffle
P. carolina		(Aug)		riffle
P. cingulatum		su		riffle
P. dubium		(June-Oct)		riffle
P. parvulum		(May-June)		riffle
Choroterpes				
C. basalis		July-Sept		riffle, pool
Paraleptophlebia		May-Nov	nymphs generally develop over full year	riffle
P. debilis		July-Oct		
P. mollis		June-Aug		riffle
P. volitans		sp-fa		
P. praepidita		sp,su	May-July emergence known	pool
P. guttata		sp, fa	July-August emergence known	
Ephemerella		sp, su	adults live 22-30 hrs. most species overwinter as larvae; rarely pool May-Sept emergence known	riffle

PRELIMINARY DRAFT REPORT. SUBJECT TO REVIEW

PRELIMINARY DRAFT REPORT. SUBJECT TO REVIEW

	WATER CHEMISTRY						POLLUTION	
TAXA	pH	Alkalin	Hardness	SO_4	Temp	D.O.	TOLERANCE	REFERENCE
B. flavistriga								1
B. frondalis							Hilsff:2	10
Pseudocloeon	6.6-8.4	30-97	20-216	3.5-235.0		6-12		18
P. anoka								32
P. carolina							Hilsff:2	1,12,27
P. cingulatum							Hilsff:2	1,13,27,30
P. dubium							Hilsff:2	1,10,27,30
P. parvulum							Hilsff:2	10,20
Choroterpes								
C. basalis	8.8-8.8	73-74	114-117	24.6-25.1		9-9		1,18
Paraleptophlebia	5.5-5.6	4-6	11-6	<1.0		3.5	(Hilsff:1)	18
P. debilis								18,32
P. mollis								1,32
P. volitans	6.6	20	21	3.6		7		18
P. praepidita	7.2	47	87	26.5		11		1,10,13,32
P. guttata	7.9	205	705	450.0		9		13,18
Ephemerella								18

TAXA	LIFE HISTORY LARVAE	ADULT (EMERGENCE)	COMMENTS	HABITAT
E. attenuata		(July)		
E. bicolor			June-July emergence suggested in literature	riffle
E. deficiens		June-Aug		
E. invaria		sp	May emergence known	riffle
E. needhami		May-July		
E. rotunda		May-July		riffle
E. serrata				
E. simplex		June-July		
E. sordida		June-Aug		
E. subvaria		April-June		riffle
E. temporalis		(June-July)		pool
E. versimilis				
E. minimella				
E. frisoni		(June)		
E. robusta				
Tricorythodes sp.		su	one western species multivoltine; many univoltine species over winter in egg stage	pool
Caenis sp.		su	June, July emergence known. Fall, winter broads reported	pool

PRELIMINARY DRAFT REPORT. SUBJECT TO REVIEW

PRELIMINARY DRAFT REPORT. SUBJECT TO REVIEW

TAXA	WATER CHEMISTRY pH	Alkalin	Hardness	SO_4	Temp	D.O.	POLLUTION TOLERANCE	REFERENCE
E. attenuata							Hilsff:0	13,18,27
E. bicolor	7.2	61	322	313.0		10	Hilsff:0	13,18,27
E. deficiens	6.8-8.0	20-97	13-124	3.5		6-12	Hilsff:0	4,27
E. invaria							Hilsff:0	1,10,27
E. needhami							Hilsff:1	7,10,27,32
E. rotunda								1,32
E. serrata								
E. simplex	6.9	22	15	2.7		7	Hilsff:1	3,10,27
E. sordida							Hilsff:0	4,13,27
E. subvaria							Hilsff:0	1,27,32
E. temporalis	6.8-8.4	5.97	6-216	2-135.0		4-11	Hilsff:4	1,10,13,27
E. versimilis								18
E. minimella								18
E. frisoni								4
E. robusta								18
Tricorythodes sp.	7.1-8.5	26-220	18-1800	1.3-450.0		5-14	(Hilsff:2)	1,10,14,18,32
Caenis sp.	5.4-8.5	3-220	6-705	<1.0-450.0		2-14	(Hilsff:4) Weber:F,I	18,32

PRELIMINARY DRAFT REPORT SUBJECT TO REVIEW

TAXA	LIFE HISTORY LARVAE	ADULT (EMERGENCE)	COMMENTS	HABITAT
Hexagenia				silt, stream
H. limbata	probably all year	su	probably univoltine; egg overwinters and survives in dry stream beds in Utah. July-Sept emergence known.	pool
Trichoptera			most species univoltine; some species emerge in winter	
Chimarra		sp, su		riffle
C. feria		(April-July)	has been found in streams tat go dry in Su, Fa	riffle
C. obscura		sp, su, fa		riffle
C. socia		(May)		riffle
C. aterrima		(April, May)	univoltine	riffle
Dolophiloides				
D. distinctus		wn		riffle, cold water
Lype				
L. diversa		May-Aug	univoltine	riffle, cold
Psychomyia				
P. flauida		May-Aug	univoltine	riffle, cold
Neureclipsis sp.		sp, su	univoltine; 1 species pollution tolerant	riffle

TAXA	WATER CHEMISTRY pH	Alkalin	Hardness	SO_4	Temp	D.O.	POLLUTION TOLERANCE	REFERENCE
Hexagenia								35
H. limbata	6.0-7.9	2-7	70-233	34.9-45.2		5-10	Hilsff:2 Weber:I	18,27,32
Trichoptera								21
Chimarra							Weber:I	26
C. feria	7.1	28	23	3.2		9	Hilsff:0	17,37
C. obscura	7.6-8.3	97-175	124-600	14.2-510.0		6-14	Hilsff:2	37
C. socia	6.3-8.7	9-124	4-800	7.3-25.0		8-10	Hilsff:0	37
C. aterrima	6.8-6.8	17-19	15-19	7.6-7.7		7-9	Hilsff:0	37,43
Dolophiloides								
D. distinctus							Hilsff:0	43,26
Lype								
L. diversa	7.2	47	87	26.5		11		17,26,43
Psychomyia								
P. flauida								26,43
Neureclipsis sp.	5.5-8.5	4-116	8-800	<1.0-72.8		6-14	(Hilsff:4) (Weber:I)	1,26,38

TAXA	LIFE HISTORY LARVAE	ADULT (EMERGENCE)	COMMENTS	HABITAT
Hydropsyche			Fa emergence suggests some species bivoltine	
H. betteni		April-Spet		riffle
H. cuanis		May-Aug		riffle
H. orris		April-Sept		riffle
H. simulans		April-Sept		
H. slossonae		May-Aug		riffle
H. bifida		May-Sept		
Agapetus sp.		sp, su	univoltine	riffle
Glossosoma sp.		sp, su	overwinters as pupae; emergence April-Su known	
Ptilostomis sp		(April-July	univoltine	pool
Grammotaulius sp.		su	probably univoltine; diapause of adult suggested for G. betteni; pool-ref 1	riffle, pool
Hydatophylax				
H. argus	su, fa, wn	sp	probably univoltine pool-ref 1	riffle, pool
Limnephilus sp.		sp, su fa	probably univoltine; one species has sp and fa emergences with su diapause	riffle, pool
Nemotaulius				
N. hostilis	su-sp	(June)	probably univoltine; larvae or prepupae overwinters pool-ref. 1	riffle

TAXA	WATER CHEMISTRY pH	Alkalin	Hardness	SO_4	Temp	D.O.	POLLUTION TOLERANCE	REFERENCE
Hydropsyche							(Hilsff:3)	16
H. betteni	5.9-8.5	10-113	154-2100	56.2-313.0		8-11		16,37
H. cuanis	8.7-8.8	73-74	114-117	24.6-25.1		9		1,37
H. orris	6.8-7.9	20-213	12-233	2.2-44.0		5-10	Weber:F	1,16,37
H. simulans	6.2-8.8	18-74	9-117	0.6-25.1		8-11	Weber:I	37
H. slossonae								1,16,37
H. bifida	7.5-8.8	61-205	114-2100	13.3-450.0		8-11	Weber:F	16,37
Agapetus sp.	7.3	39	66	25.0		8		1,26,37,43
Glossosoma sp.							(Hilsff:1)	26,37,43
Ptilostomis sp.	3.3-7.4	2-95	70-287	26.5-251.0		8-10		1,20,37
Gramotaulius sp.								1,15,26,43
Hydatophylax								
H. argus								1,15,20,26
Limnephilus sp.	6.4-8.5	9-97	6-164	2.4-24.0		9-12	(Hilsff:1)	15,20,26,43
Nemotaulius								
N. hostilis								15,20,26,43

TAXA	LIFE HISTORY LARVAE	ADULT (EMERGENCE)	COMMENTS	HABITAT
Neophylax	fa-sp; su diapause	su	univoltine; most emerge late su	riffle
N. nacatus			univoltine	riffle
Platycentropus sp.		probably su	probably univoltine	
Pycnopsyche	fa hatch	su, fa	probably univoltine	
P. guttifer			rarely lakes	riffle
P. scabripennis				riffle
Glyphopsyche				
G. irrorata		Sept-May	probably univoltine pool-ref.1	riffle
Pseudostenophylax sp.	fa-su	su	probably univoltine; overwinters as final instar larvae	riffle
Frenesia sp.		Oct-Nov.	probably univoltine; some (at least) hatch in sp.	riffle
Goera sp.		sp, su	probably univoltine; larvae probably overwinters	riffle
Lepidostoma sp.		probably sp, su	univoltine, pool-ref.1	riffle, pool
Trianodes				riffle, pool
T. marginata		June, July		
T. tarda		May-Sept.	possibly multivoltine	
T. injusta		June-July		
Diptera				

	WATER CHEMISTRY							
TAXA	pH	Alkalin	Hardness	SO_4	Temp	D.O.	POLLUTION TOLERANCE	REFERENCE
Neophylax								15,26,43
N. nacatus	7.2-7.5	39-47	66-87	25.0-26.5		8-11		15,26
Platycentropus sp.	7.3	39	66	25.0		8	(Hilsff:2)	15,20,26
Pycnopsyche	6.0-8.8	2-205	4-705	2.4-450.0		8-14		20,37
P. guttifer	7.2-7.3	36-61	66-332	25.0-313.0		8-11		15,20,26
P. scabripennis	6.7-7.2	36-47	87-287	26.5-251.0		10-11		15,20,26
Glyphopsyche								
G. irrorata								15,26,37,43
Pseudostenophylax sp.								15,20,26,43
Frenesia sp.								15,20,26,37
Goera sp.							(Hilsff:0)	15,26
Lepidostoma sp.	6.4-7.3	9-39	6-66	2.5-25.0		8-10	(Hilsff:2)	37,43
Trianodes	6.7-7.3	2-39	66-287	25.0-251.0			(Hilsff:1)	43
T. marginata								37
T. tarda								37
T. injusta	6.6-8.8	20-124	21-800	3.5-46.1		7-12		37
Diptera								

TAXA	LIFE HISTORY LARVAE	ADULT (EMERGENCE)	COMMENTS	HABITAT
Tipula sp.		sp, su, fa	univoltine and multivoltine emergence into fa somewhat rare.	riffle
Antocha sp.		(sp, su)		riffle
Dicranota sp.		(sp, su)	rarely pool	riffle
Limnephila sp.		(sp, su)		riffle
Hexatoma sp.		(sp, su)		riffle
Limonia sp.		(sp, su)	probably multivoltine	riffle
Pseudolimnophila sp.		(sp, su)		riffle, pool
Pedicia sp.		(sp, su)	rarely pool	riffle
Erioptera sp.		(sp, su)		riffle
Aedes sp.				
Prosimulium sp.	fa-sp	April-May	univoltine	riffle
Eusimulium sp.		sp, su	univoltine	riffle
Simulium sp.		May-Aug	some species multivoltine; diapause known; egg or larvae may overwinter	riffle
Cnephia sp.		April-June	univoltine	riffle
Chironomidae			most species multivoltine, adults found in all but coldest months	
Lasiodiamesa sp.				
Cricotopus sp.			riffle possibly	pool
Eukiefferiella sp.		(wn, sp)		riffle

TAXA	WATER CHEMISTRY pH	Alkalin	Hardness	SO_4	Temp	D.O.	POLLUTION TOLERANCE	REFERENCE
Tipula sp.	4.4-7.3	0-61	66-322	25.0-322.0		8-10	(Weber:I)	2,26
Antocha sp.	7.8-8.4	88-108	95-216	7.5-135.0		9-11		1,2
Dicranota sp.								2,26
Limnephila sp.								2,26
Hexatoma sp.							Weber:I	2,26
Limonia sp.								2,26
Pseudolimnophila sp.							(Weber:I)	2,26
Pedicia sp.								2,26
Erioptera sp.								2,26
Aedes sp.								
Prosimulium sp.							(Hilsff:0) (Weber:I)	1,26,29,40
Eusimulium sp.							(Hilsff:0,1)	1,26,40
Simulium sp.							(Hilsff:0-4) Weber:I	1,26,24,40
Cnephia sp.							(Weber:I)	1,26,40
Chironomidae								26
Lasiodiamesa sp.								
Cricotopus sp.	6.3-8.8	2-97	82-5000	25.0-135.0		6-11	(Hilsff:4) Weber:(T,F)I	6
Eukiefferiella sp.	6.0-8.7	20-88	82-110	25.0-45.1		6-10	(Hilsff:2)	6

TAXA	LIFE HISTORY LARVAE	ADULT (EMERGENCE)	COMMENTS	HABITAT
Parametreo cnemus sp.		(su)	rarely pool	riffle
Rheocricotopus sp.		(all year)		riffle
Heterotrissocladius sp.		(wn, sp, su)		riffle
Microscepta sp.		(su, fa)		riffle, pool
Zavrelia sp.		(su)		riffle
Chironomus sp.		(su; all year)	1 species known to be univoltine	riffle, pool
Dicrotendipes sp.		(su; all year)		pool
Endochironomus sp.		(su; all year)	pool-ref. 1	riffle, pool
Glyptotendipes sp.		(sp, su, fa; all year)	pool-ref. 1	riffle, pool
Polypedilum sp.		(su; all year)	riffle-ref.1	riffle, pool
Lepidoptera				
Nympula sp.		(su)	several species of order multivoltine; larvae is overwintering stage for some	
Coleoptera			larvae and adults aquatic for msot species	
Haliplidae		(su, fa)	some genera known to lay eggs in spring	pool
Hydraenidae			larvae more terrestrial than aquatic	pool
Elmidae			larval development over 2 years common; adults, larvae found at same time of year	riffle, pool
Macronychus sp.			adults and/or larvae found all months of year	
M. glabratus				riffle, pool

TAXA	WATER CHEMISTRY pH	Alkalin	Hardness	SO_4	Temp	D.O.	POLLUTION TOLERANCE	REFERENCE
Parametreo cnemus sp.								6
Rheocricotopus sp.							(Hilsff:1)	6
Heterotrissocladius sp.								
Microscepta sp.							(Hilsff:0) (Weber:F,I)	6
Zavrelia sp.	6.4	9	6	2.5		9		6
Chironomus sp.	3.0-8.4	0-220	18-600	0.7-370		1-13	Hilsff:5 Weber:T,F(I)	6,44
Dicrotendipes sp.	6.3-8.4	20-220	15-2100	0.6120.4		3-14	(Weber:T,F,I)	6
Endochironomus sp.	6.4-8.0	10-213	7-900	2.4-480.0		5-9	(Hilsff:2) (Weber:F,I)	1,6
Glyptotendipes sp.	6.6-8.5	20-180	21-900	3.2-480.0		6-14	(Hilsff:5) Weber:T(F,I)	1,6
Polypedilum sp.	3.8-8.8	0-220	6-2100	<1.0-315.0		6-14	(Hilsff:3) Weber:F,I(T)	1,6
Lepidoptera								
Nympula sp.							Weber:F (Hilsff:1)	8,41
Coleoptera								26
Haliplidae								26
Hydraenidae								26
Elmidae								26
Macronychus sp.								1,9
M. glabratus	5.5-8.3	4-130	8-705	<1.0-450.0		5-10	Hilsff:1 Weber:I	1

TAXA	LIFE HISTORY LARVAE	ADULT (EMERGENCE)	COMMENTS	HABITAT
Optioservuus		(sp-fa)	development to adult in 1 year common; egg laying may take place over several months in su. Adults and/or larvae found all months of year	riffle
O. fastiditus				
O. trivittatus				
O. ovalis				
Stenelmis			egg laying may take palce over several months in Su. Adults and/or larvae found all months of year	riffle
S. crenata				

TAXA	WATER CHEMISTRY pH	Alkalin	Hardness	SO_4	Temp	D.O.	POLLUTION TOLERANCE	REFERENCE
Optioservus							Weber:F	1,11
O. fastiditus	8.0-8.8	64-124	114-800	14.2-46.1		8-9	Hilsff:2	
O. trivittatus							Hilsff:0	
O. ovalis	7.2-8.2	47-122	87-800	13.3-46.1		9-11		
Stenelmis								1,9
S. crenata	5.5-8.8	4-113	11-705	<1.0-450.0		5-14	Hilsff:3 Weber:I	

Table 2. Life history, habitat preference, pollution tolerance and frequency of occurrence by stream order of the dominant invertebrate taxa of functional groups 1-5 in the Study Area.

	EMERGENCE				HABITAT						POLLUTION TOLLERANCE: ORGAN-ICS			POLLUTION TOLLERANCE: pH					POLLUTION TOLLERANCE: ALKAL-INITY			STREAM ORDER				
1. SHREDDERS (dead plants)	WINTER	SPRING	SUMMER	FALL	RIFFLE	POOL	MUD, SILT	SAND	GRAVEL	ROCK	TOLERANT	FACULATIVE	INTOLERANT	<5	5-6	6-7	7-8	>8	<50	50-100	>100	1	2	3	4	5
Amphinemura spp.																										
A. linda																										
A. delosa																										
Shipsa spp.																										
S. rotunda																										
Leuctra spp.																										
L. ferruginea																										
L. tennuis																										
Allocapnia spp.																										
A. minima																										
A. pygmaea																										
Paracapnia spp.																										
P. angulata																										
P. opis																										
Taeniopteryx spp.																										
T. burksi																										
T. nivalis																										
Grammotaulius spp.																										
Hydatophylax spp.																										
H. argus																										
Limnephilus spp.																										
Nemotaulius spp.																										
N. hostilis																										
Neophylax spp.																										
N. nacatus																										
Platycentropus spp.																										
Pycnopsyche spp.																										
P. guttifer																										
P. scabripennis																										
Glyphopsyche spp.																										
G. irrorata																										
Pseudostenophylax spp.																										
Frensia spp.																										
Goera spp.																										
Lepidostoma spp.																										
Tipula spp.																										
Pedicia spp.																										
Erioptera spp.																										
Endochironomus spp.																										

PRELIMINARY DRAFT REPORT, SUBJECT TO REVIEW

Table 2 cont'd

	EMERGENCE				HABITAT						POLLUTION TOLLERANCE: ORGANICS			POLLUTION TOLLERANCE: pH					POLLUTION TOLLERANCE: ALKALINITY			STREAM ORDER				
2. SHREDDERS (live plants)	WINTER	SPRING	SUMMER	FALL	RIFFLE	POOL	MUD, SILT	SAND	GRAVEL	ROCK	TOLERANT	FACULATIVE	INTOLERANT	<5	5-6	6-7	7-8	>8	<50	50-100	>100	1	2	3	4	5
Ptilistomis spp.																										
Triaenodes spp.																										
T. marginata																										
T. tarda																										
T. injusta																										
Cricotopus spp.																										
Polypedilum spp.																										
Nymphula spp.																										

PRELIMINARY DRAFT REPORT, SUBJECT TO REVIEW

Table 2 cont'd

	EMERGENCE				HABITAT						POLLUTION TOLLERANCE											STREAM ORDER				
											ORGAN-ICS			pH					ALKAL-INITY							
3. GATHERERS	WINTER	SPRING	SUMMER	FALL	RIFFLE	POOL	MUD, SILT	SAND	GRAVEL	ROCK	TOLERANT	FACULATIVE	INTOLERANT	<5	5-6	6-7	7-8	>8	<50	50-100	>100	1	2	3	4	5
E. deficiens																										
E. invaria																										
E. needhami																										
E. rotunda																										
E. serrata																										
E. simplex																										
E. sordida																										
E. subvaria																										
E. temporalis																										
E. versimilis																										
E. minimella																										
E. frisoni																										
E. robusta																										
Tricorythodes spp.																										
Caenis spp.																										
Hexagenia spp.																										
H. limbata																										
Antocha spp.																										
Lasiodiamesa spp.																										
Eukiefferiella spp.																										
Parametrecnemus spp.																										
Rheocricotopus spp.																										
Heterotrissocladius spp.																										
Microscepta spp.																										
Zevrelia spp.																										
Chironomus spp.																										
Dicrotendipes spp.																										
Glyptotendipes spp.																										
Macronychus spp.																										
M. glabratus																										
Optioservus spp.																										
O. fastiditus																										
O. trivittatus																										
O. ovalis																										
Stenelmis spp.																										
S. crenata																										

Table 2 cont'd

3. GATHERERS	EMERGENCE				HABITAT						POLLUTION TOLLERANCE: ORGAN-ICS			POLLUTION TOLLERANCE: pH					POLLUTION TOLLERANCE: ALKAL-INITY			STREAM ORDER				
	WINTER	SPRING	SUMMER	FALL	RIFFLE	POOL	MUD, SILT	SAND	GRAVEL	ROCK	TOLERANT	FACULATIVE	INTOLERANT	<5	5-6	6-7	7-8	>8	<50	50-100	>100	1	2	3	4	5
Siphlonurus spp.																										
S. alternatus																										
S. marshalli																										
Arthroplea spp.																										
A. bipunctata																										
Rhithrogena spp.																										
Stenacron spp.																										
S. candidum																										
S. interpunctatum																										
S. minnetonka																										
Stenonema spp.																										
S. annexum																										
S. exiguum																										
S. fuscum																										
S. pulchellum																										
S. quinquespinum																										
S. Rubrum																										
S. smithae																										
S. terminatum																										
S. tripunctatum																										
S. femoratum																										
S. integrum																										
Baetis gr. spp.																										
B. brunneicolor																										
B. hageni																										
B. phyllis																										
B. pygmaes																										
B. vagans																										
B. flavistriga																										
B. frondalis																										
Paraleptophlebia gr. spp																										
P. debilis																										
P. mollis																										
P. volitans																										
P. praepidita																										
P. guttata																										
Ephemerella spp.																										
E. attenuata																										
E. bicolor																										

PRELIMINARY DRAFT REPORT, SUBJECT TO REVIEW

Table 2 cont'd

											POLLUTION TOLLERANCE															
	EMERGENCE				HABITAT						ORGANICS			pH					ALKALINITY			STREAM ORDER				
4. FILTER-FEEDERS	WINTER	SPRING	SUMMER	FALL	RIFFLE	POOL	MUD, SILT	SAND	GRAVEL	ROCK	TOLERANT	FACULATIVE	INTOLERANT	<5	5-6	6-7	7-8	>8	<50	50-100	>100	1	2	3	4	5
Chimarra spp.																										
C. feria																										
C. obscura																										
C. socia																										
C. aterrima																										
Dolophiloides spp.																										
D. distinctus																										
Lype spp.																										
L. diversa																										
Psychomyia spp.																										
P. flavida																										
Neureclipsis spp.																										
Hydropsyche gr. spp																										
H. betteni																										
H. cuanis																										
H. orris																										
H. simulans																										
H. slossonae																										
H. bifida																										
Prosimulium spp.																										
Eusimilium spp.																										
Simulium spp.																										
Cnephia spp.																										

Table 2 cont'd

5. SCRAPERS	EMERGENCE				HABITAT						POLLUTION TOLLERANCE: ORGANICS			POLLUTION TOLLERANCE: pH					POLLUTION TOLLERANCE: ALKALINITY			STREAM ORDER				
	WINTER	SPRING	SUMMER	FALL	RIFFLE	POOL	MUD, SILT	SAND	GRAVEL	ROCK	TOLERANT	FACULATIVE	INTOLERANT	<5	5-6	6-7	7-8	>8	<50	50-100	>100	1	2	3	4	5
Hastaperla spp.																										
H. brevis																										
Epeorus spp.																										
Heptagenia spp.																										
H. Hebe																										
H. flavenscens																										
Pseudocloeon spp.																										
P. anoka																										
P. carolina																										
P. cingulatum																										
P. dubium																										
P. parvulum																										
Choroterpes spp.																										
C. basalis																										
Agapetus spp.																										
Glossosoma spp.																										

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