Synoptic Review of River Invertebrate Data and Initial Development of a Monitoring Protocol for the Greater Yellowstone Network Inventory and Monitoring Program

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Executive Summary

The primary purpose of the National Park Service (NPS) Inventory and Monitoring Program is to assess and monitor the long-term ecological health of the nation's parks. The Greater Yellowstone Inventory and Monitoring Network (GRYN) is one of 32 multi-unit monitoring networks created to facilitate the sharing of data and resources between various NPS-administered facilities. The GRYN includes Bighorn Canyon National Recreation Area (BICA), Grand Teton National Park and the John D. Rockefeller, Jr. Memorial Parkway (collectively referred to as GRTE), and Yellowstone National Park (YELL). All of the streams and rivers in YELL and GRTE have been designated as Outstanding Natural Resource Waters (ONRW) by the Environmental Protection Agency (EPA). ONRWs are considered the highest quality waters of the United States and as such are accorded the highest level of protection. Despite this, a number of park streams are thought to be impaired to varying degrees.

Benthic macroinvertebrate assemblages have been identified as a high priority Vital Sign for assessment and monitoring of river and stream ecosystems in the GRYN (Jean *et al*. 2003). Benthic invertebrates were selected because previous research has found that these organisms are sensitive to a broad range of stressors and are thus good indicators of the biological integrity of stream ecosystems. The overall intent of this report is to aid the GRYN in developing a long-term monitoring program for its aquatic ecosystems. Specifically, this report includes 1) an assessment of the existing GRYN river macroinvertebrate data, including an analysis of the adequacy of existing reference site data for developing a bioassessment program; 2) an analysis of the various approaches that could be used to develop an aquatic bioassessment program in the GRYN; and 3) a detailed proposal outlining how the GRYN could implement a bioassessment program developed in cooperation with the Western Center for Monitoring and Assessment of Freshwater Ecosystems (WCMAFE).

We compiled data from 185 unique stream invertebrate samples collected in the three park units of the GRYN. These samples included a total of 66 distinct species and 172 distinct genera of aquatic insects, crustaceans, and mollusks. Differences in the level of taxonomic resolution both within and among data sets complicates determination of unique taxa and comparisons among samples. A commonly used method for maximizing the information content of invertebrate samples and for streamlining comparisons is the use of Operational Taxonomic Units (OTUs). Using this approach, we found that OTU taxa richness varied from a low of 5 taxa in Polecat Creek (GRTE) to a high of 36 taxa in Lava Creek (YELL), Amethyst Creek (YELL) and Arizona Creek (GRTE). However, incompatibilities between the various data sets greatly complicated the compilation, and illustrated the need for the GRYN to develop both a protocol for data recording and a database structure that are internally consistent and that facilitate direct comparisons with existing macroinvertebrate databases.

We tentatively identified 206 sites that could serve as the basis for a reference site network that could be used to establish biological benchmarks for evaluating the condition of other sites within YELL and GRTE. These sites are located both within the parks themselves (102 sites) as well as in the surrounding Greater Yellowstone Ecosystem (GYE, 104 sites). Using all available reference sites from the GYE will minimize the amount of additional sampling needed to establish a reference site network that would be applicable to YELL and GRTE. Use of sites outside of YELL and GRTE will also encourage interagency cooperation in the management of the GYE's aquatic resources. Based on the paucity of appropriate reference sites in and near BICA, and ecological differences between it and the rest of the GRYN, we recommend using existing assessment tools that have been developed for Wyoming streams to assess streams within the BICA.

Based on our analysis of the existing data and the mandated requirements of a GRYN bioassessment program, we recommend the following approach to the development of that program. First, the GRYN needs to develop an objective and defensible set of criteria for selecting reference condition stream sampling sites for a YELL/GRTE bioassessment tool. This set of criteria must take into account a number of factors, including fire, New Zealand mud snails, roads, historic land use within GRTE, current upstream land use outside of park boundaries, grazing by ungulates and heavy backcountry use. Second, the GRYN will need to use these criteria to filter the existing potential reference sites as well as to identify additional reference sites that can be sampled, if necessary, to provide adequate representation of all stream types that are to be assessed. Third, the GRYN will need to identify sites of special concern, where biological impairment is suspected. Fourth, the GRYN will need to develop a stratified random sampling protocol for selecting a set of streams in YELL/GRTE to assess with the YELL/GRTE bioassessment tool, as well as a set of streams in BICA to assess with the Wyoming bioassessment tool; these will be used to determine the average biological condition of streams in the GRYN. Fifth, the GRYN should select "sentinel sites" in all three park units for long-term monitoring of average biological condition. Before any of these steps are taken, however, it is essential that the GRYN develop consistent methods for data collection, taxa identification and database management. The WCMAFE has extensive experience in all aspects of bioassessment, and can work with GRYN personnel to ensure that these issues are dealt with efficiently.

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Acknowledgements

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Section I

Compilation of existing macroinvertebrate data

Overview

Aquatic invertebrate samples have already been collected for many stream and river locations within the GRYN. However, because these samples were collected by a number of different state and federal agencies (*i.e*. U. S. Geological Survey, U. S. Forest Service, Bureau of Land Management, state environmental agencies, and various universities) and over a period of years, a complete list of these data had not yet been compiled. Our first goal was to compile all available benthic invertebrate data for the three units of the GRYN. These data allowed us to address five questions:

1. What taxa have been collected within the GRYN?
2. To what extent are data collected by different agencies directly comparable?
3. What field collection method will maximize the number of existing samples that can be used in the development of a monitoring and assessment program?
4. Have enough reference quality streams and rivers been sampled within the GRYN to establish a robust reference site network?
5. Is there a need for additional reference site samples to develop robust tools that can be used to assess the ecological health of GRYN streams and rivers? If so, in what specific areas or "types" of stream are data needed?

In this section we will restrict the discussion to the first three questions. Questions four and five will be addressed in later sections. We were able to obtain invertebrate data for the three parks of the GRYN from a variety of sources. These sources included our laboratory at Utah State University, the Yellowstone Center for Resources, The Wyoming Department of Environmental Quality (WYDEQ), The Bridger-Teton National Forest, Robert Hall's laboratory at the University of Wyoming, the Bureau of Land Management's National Aquatic Monitoring Lab at Utah State University, the U.S. Geological Survey's National Water Quality Monitoring Program (NAWQA) and the Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP).

Overall, data were available from 185 invertebrate samples collected in park units of the GRYN. The samples were collected from 1992-2003, with the majority dating to 2000-2002, and represented 139 geographically distinct stream reaches on 72 streams and rivers (Figures 1 and 2). The number of reaches exceeded the number of streams because several of the streams were sampled by more than one agency, or by the same agency at multiple reaches. In a number of cases these reaches were in very close proximity, whereas in others they were fairly widely separated. Also, the number of samples exceeded the number of sites (reaches) because many sites were resampled, either in different seasons or in different years. At several sites, 2 samples were taken from different habitats and maintained separately.

In most cases, the entire sample was not identified; rather, subsamples of 300-500 organisms were enumerated and identified. Subsampling misses many rare organisms that actually occur at a site, but for bioassessment purposes can adequately characterize the assemblage at a site. These samples should provide a reasonably comprehensive list of the taxa present within the GRYN, with the likely exception of BICA (where relatively few data are available). Although we have not received all data that we requested, the data in hand are sufficient to address whether adequate data exist to develop a bioassessment program for the GRYN, and to identify significant gaps in those data.

Data set comparability

One of the issues that arose during our analysis concerned the lack of comparability of data sets assembled from different sources. Data set comparability is often a problem on several levels. The first and most often discussed has to do with the method by which the data were collected. Although for the purposes of simply compiling a taxa list for the GRYN, this issue is not directly germane, it is certainly a factor when data collected by different agencies are combined for the purpose of developing a bioassessment program. In general, for aquatic invertebrate data to be directly comparable, the data should have been collected in the same way. They should be collected during the same season, using a similar collection method, from similar habitats, with similar effort and using a similar net mesh size. The samples should also be subsampled in a similar way and organisms should be identified using similar techniques. The majority of the invertebrate data we compiled for the GRYN (154/185 samples) were collected using a similar set of field methods. These generally included taking multiple fixed area riffle samples using a 500 μm mesh Surber sampler or modified Surber sampler. In the majority of cases, 8 such riffle samples, representing 0.74 m^2 of stream benthos, were combined into a single composite sample for a given site. Nearly all samples were collected during the summer months (late June – early September). Therefore we strongly recommend that the GRYN continue to collect data using this general approach. Doing so will maximize the compatibility and comparability of newly collected GRYN invertebrate data with existing data. The WCMAFE developed a standard field collection protocol that describes these collection methods in more detail (Appendix VI).

Less often discussed, but just as critical, is the way invertebrate data are recorded in databases. We experienced substantial difficulties in attempting to compare and combine the data sets discussed here, even though they all ostensibly contain the same information. For example, some of the data sets listed only Latin binomial (genus and species) in a single database cell, others listed phylum, order, family, genus and species in separate cells. Yet others used taxa codes that required additional tables to translate into traditional taxonomic terminology. Some data sets consisted of only presence-absence data, others used informal abundance categories, and both raw numbers and densities were given in other data sets without any indication of the area sampled or the degree of subsampling. Some data sets listed only those taxa that were successfully identified to species, whereas others listed all organisms identified regardless of the level of taxonomic resolution achieved. These inconsistencies would be problematic even for a small number of taxa and sites, although in such a case it would be feasible to go through each data set and make the necessary adjustments by hand. In the case of the GRYN data, however, we are dealing with hundreds of samples and well over a hundred taxa, making correction by hand logistically impractical without a substantial commitment of time and resources. Most of the data were from two sources, our lab at Utah State University and the Yellowstone Center for Resources. Although the data from these two sources were collected in a comparable way, the two data sets were nevertheless not compatible in terms of how data were recorded. It is important to point out that these problems with data set incompatibility are not unique to the GRYN invertebrate data, and are in fact relatively common. The lesson to be learned here is that developing a database structure and a data recording protocol that are both internally consistent and generally comparable with other similar databases is absolutely essential, and should be a significant and early priority for the GRYN. Cooperation between GRYN database managers and WCMAFE staff should be a fundamental aspect of these developmental tasks.

Operational taxonomic units

There are several important taxonomic issues that also need to be addressed when dealing with macroinvertebrate data sets. First, some taxa cannot be identified to species using only larval characteristics, although often they can be identified to the genus level. Identification of other taxa such as chironomid midges may require significant additional effort; these taxa are often only identified to family or sub-family. Finally, some specimens may be damaged or immature and therefore lack key identification characteristics; such specimens may be identified to genus or family level depending on which characteristics are missing. One result of these identification issues is that a substantial and often overwhelming fraction of taxa in a sample may only be identified to the family or genus level. Similarly, one taxon can be correctly identified to several levels of taxonomic resolution (species, genus and family) in a single sample. Hence it is often difficult to determine how many unique taxa were present in a sample. If all levels of taxonomic resolution are considered ‘unique’ then ‘richness inflation’ occurs, which has the potential of obscuring differences in community structure among different water bodies. For example, consider a sample that contains 10 individuals identified as *Drunella grandis* (species), 8 individuals identified as *Drunella* sp. (genus), and 15 individuals identified as Ephemerellidae (family). It is possible that all 33 individuals are actually *Drunella grandis*, or alternatively that there are actually multiple emphemerellid taxa in the sample. If the issue were not addressed, then all subsequent analyses would assume that there were 3 unique taxa in this sample, an assumption which is likely to be incorrect.

Furthermore, analytical problems associated with such issues are often exacerbated when multiple samples are compared.

On the other hand, if one simply discards all taxa that were identified only to genus or to family, so as to ensure that each taxon is unique, a substantial amount of compositional information can be lost. Fortunately, a number of techniques exist for ensuring that the information content of a sample can be maximized while avoiding problems associated with 'richness inflation'. The most commonly used approach for multivariate assessment models is to develop a set of so-called "Operational Taxonomic Units" (OTU) that are used to represent unique taxa in a macroinvertebrate data set. Each OTU is linked with the taxonomic designation to which a given organism can be reliably identified. OTU designations not only increase the information content of a given invertebrate sample, but also increase the comparability of samples identified by different labs. We have developed an OTU table that incorporates the GRYN invertebrate data (Appendix IV). We have also developed a table (Appendix V) that links our OTU designations with the standardized Taxonomic Serial Numbers (TSN) assigned to aquatic invertebrate taxa in the Integrated Taxonomic Information System (ITIS). ITIS is the result of a federal multiagency program to develop an accessible, reliable and scientifically credible taxonomic database. Because most invertebrate labs are familiar with ITIS, the GRYN can request from whichever lab is contracted to do its invertebrate identification that TSN's be attached to its invertebrate data, ensuring seamless integration with data from other sources.

Summary of existing GRYN Invertebrate Data

Substantial data are available for YELL and to a lesser extent GRTE, but data for BICA are sparse (Table 1). Sampling locations are relatively well dispersed geographically in YELL and GRTE (Figure 1), although most samples were collected relatively near roads. There are so few samples from BICA that no geographic interpretation is appropriate (Figure 2). Detailed taxa lists for each park, at both the genus and species level, are given in Appendix II. Overall, 66 distinct species were identified throughout the GRYN (Table 2). Most taxa were

Table 1. Distribution of invertebrate samples among GRYN park units.

Park Unit	Samples	Sites	Streams	Source
YELL	114	91	49	USU, YCR, WYDEQ, Hall, NAWQA, EMAP
GRTE	62	41	19	USU, YCR, WYDEQ, Hall, NAWQA, BLM, USFS
BICA	9	7	4	USU, YCR, WYDEQ, NAWQA
Total	**185**	**139**	**72**	

#Samples: number of unique invertebrate samples. #Sites: number of geographically distinct sites from which samples were obtained. #Streams: number of unique streams on which sites were located (tributaries are treated as unique).
YELL = Yellowstone National Park, GRTE = Grand Teton National Park and the Rockefeller Parkway, BICA = Bighorn Canyon National Recreation Area. USU = C. P. Hawkins lab at Utah State University, YCR = National Park Service Yellowstone Center for Resources, WYDEQ = Wyoming Division of Environmental Quality, Hall = R.O. Hall lab at University of Wyoming, NAWQA = United States Geological Survey National Water Quality Assessment Program, EMAP = Environmental Protection Agency Environmental Monitoring and Assessment Program.

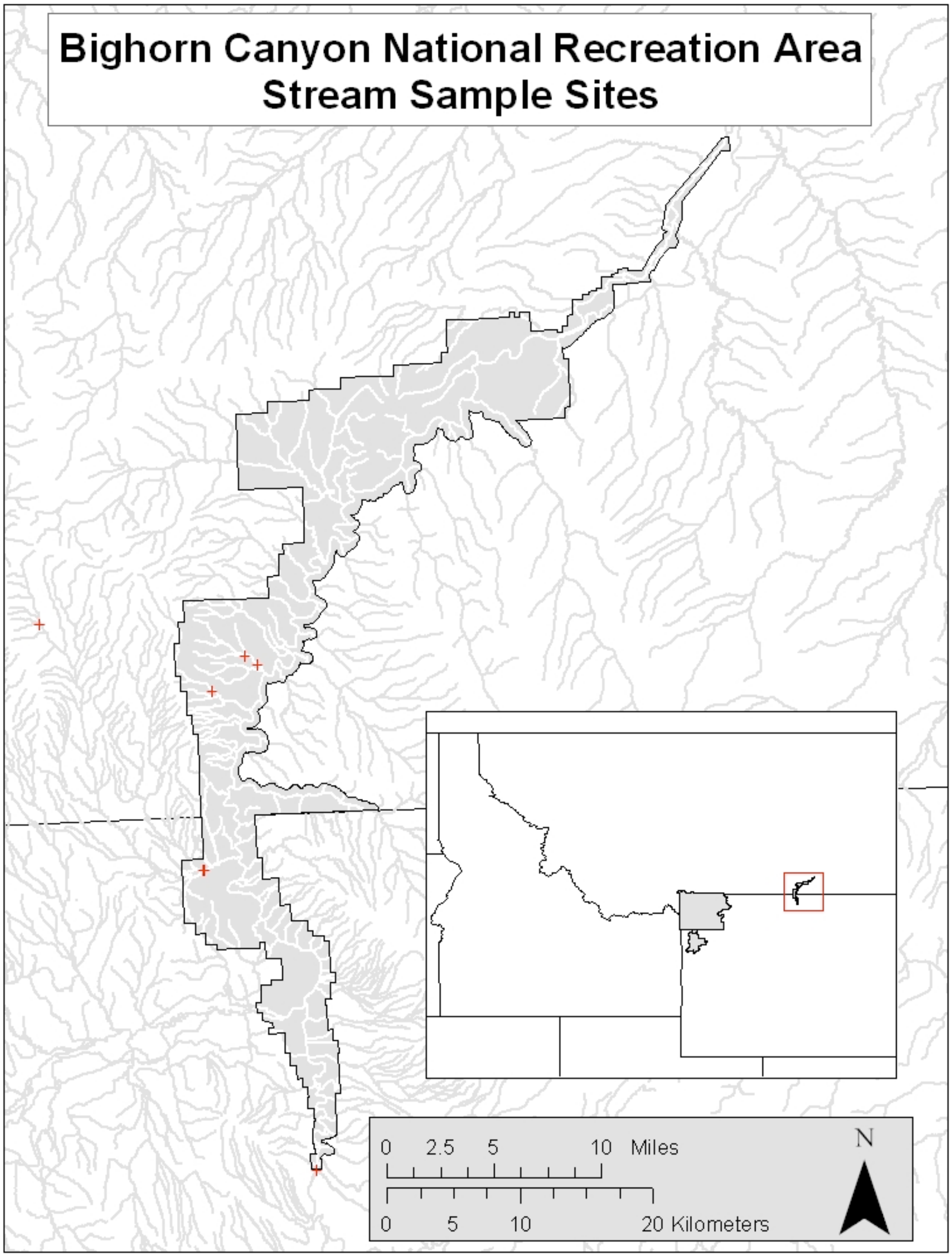

Figure 1. Location of stream macroinvertebrate samples from BICA

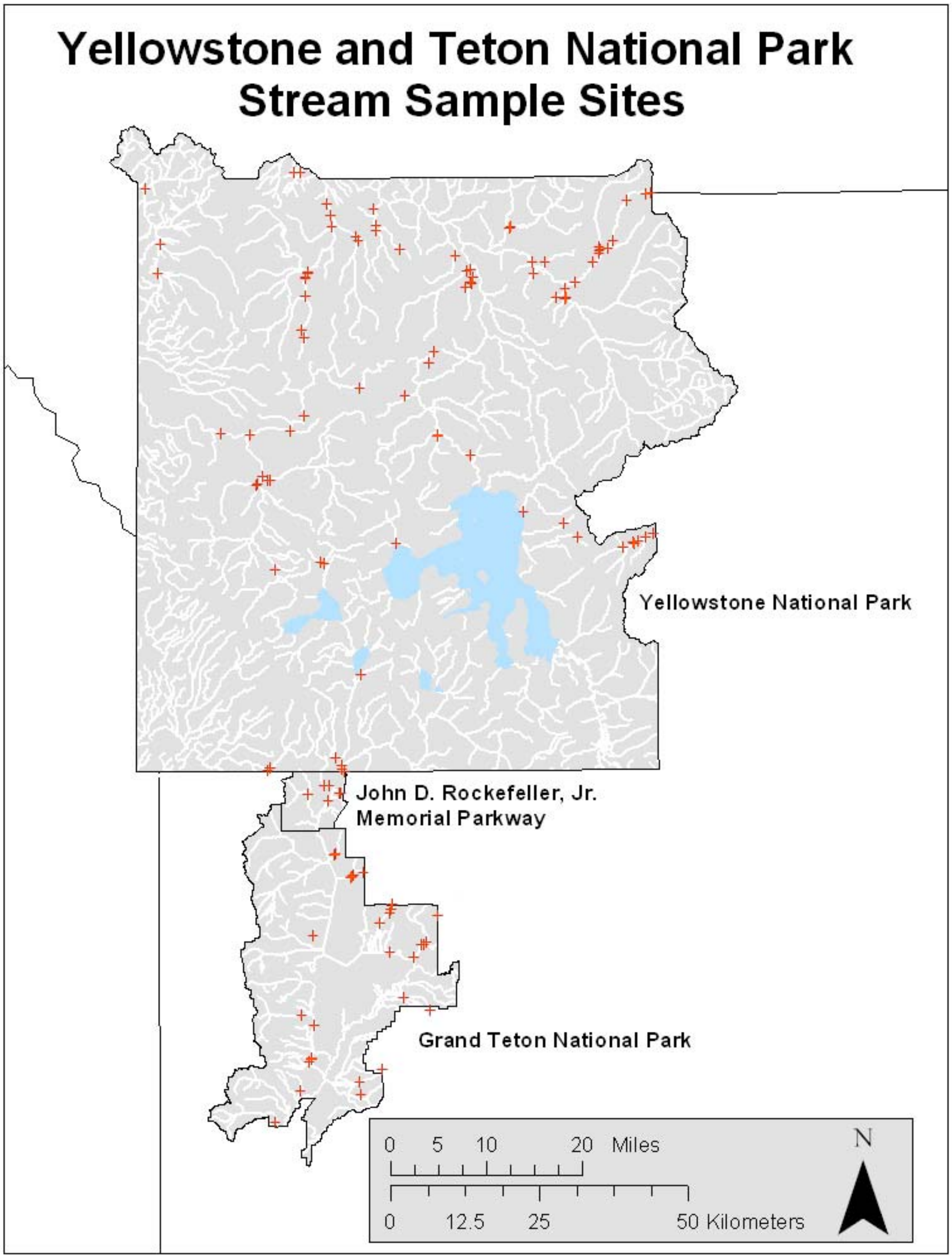

Figure 2. Location of stream macroinvertebrate samples from YELL and GRTE.

aquatic insects, although crustaceans and mollusks were also common. Because most taxa were not identified to species, this is a substantial underestimate of true species richness in the GRYN. An additional 172 distinct genera were also identified in the data set (Table 2). At the generic level, the bulk of aquatic insect diversity was represented by dipterans (true flies) and trichopterans (caddisflies), whereas at the species level, most of the diversity was represented by ephemeropterans (mayflies) and trichopterans. Given the limitations inherent in macroinvertebrate identification and taxonomy, it is difficult to estimate the true species diversity of streams in the GRYN; however, based on the available data, it is reasonable to say that GRYN streams are within the expected range for North American temperate streams (Vinson & Hawkins 2003).

Table 2. Summary of species-level and generic invertebrate richness in the GRYN

Taxon	Generic richness	Species richness
Coleoptera	15	1
Diptera	87	8
Ephemeroptera	11	21
Plecoptera	13	8
Trichoptera	32	23
Other	14	5
Total	172	66

To get a sense of how macroinvertebrate diversity varied across streams in the GRYN, we generated summary statistics for a subset of the compiled samples. Given the constraints imposed by the structure of the various data sets, we limited our analyses to 76 samples where the data were recorded in a consistent and easily manipulable format. To generate easily interpretable metrics, we relied on OTU taxa as the basis for comparison among streams. Within this framework, we found that invertebrate taxa richness exhibited a wide range of variability across the GRYN, which is not surprising given the substantial variation in topography, geothermal activity and climate (Table 3). OTU taxa richness varied from a low of 5 (Polecat Creek [GRTE]) to a high of 36 (Lava Creek and Amethyst Creek [YELL] and Arizona Creek [GRTE]) taxa. These metrics indicate that the GRYN spans the range of OTU richness found in western streams, as determined by comparison to the extensive data set we have compiled for the 13 western states.

To estimate how complete the data set we compiled was in terms of the actual richness of stream macroinvertebrates in the GRYN, we compared it with an unpublished aquatic invertebrate checklist prepared for YELL and GRTE (Duffy 1996). At the genus level, there is substantial overlap between Duffy's taxa list and ours for some taxa (*e.g.*, plecopterans), but little overlap for others (*e.g.*, odonates). In general, our compiled data set represents a significant fraction of the taxa from Duffy, but is far from complete, with the exception of chironomid midges, for which we have identified many more genera. As the primary sources of data for Duffy's list do not indicate when and where samples were collected, the data are not directly comparable; however, we can offer some likely explanations for the differences. First, many of the taxa in Duffy's list are found primarily in wetlands and lakes, whereas our data are exclusively from running waters. This difference in habitats sampled is the likely explanation for the relative paucity of coleopteran, odonate and hemipteran taxa in our data set relative to Duffy's. Second, many larval aquatic insects cannot be reliably identified to genus. For example, capniid stonefly larvae, when collected in the summer, are almost always very small, and cannot generally be identified beyond the family level. Finally, many of the chironomid midges in our compiled data set were identified to genus, which is still relatively uncommon, and probably accounts for the large number of identified chironomid genera that are not listed in Duffy 1996. Given these constraints, the compiled data set is a reasonable representation of the diversity of stream macroinvertebrates in YELL/GRTE.

Table 3. OTU-based biological metrics for 76 representative GRYN macroinvertebrate samples

Site Name	PARK	S	E	H'	D
Amethyst Creek	YELL	36	0.666	2.385	0.8311
Amphitheater Creek	YELL	20	0.716	2.145	0.8303
Antelope Creek trib	YELL	30	0.804	2.736	0.9154
Arizona Creek	GRTE	36	0.75	2.686	0.9051
Arnica Creek trib	YELL	27	0.764	2.519	0.8792
Aster Creek	YELL	26	0.81	2.641	0.8791
Aster Creek	YELL	26	0.648	2.111	0.8305
Blacktail Deer Creek	YELL	33	0.704	2.462	0.857
Canyon Creek	YELL	17	0.687	1.947	0.754
Cascade Creek	GRTE	23	0.704	2.209	0.8061
Chalcedony Creek	YELL	33	0.726	2.54	0.8611
Clear Creek	YELL	20	0.4	1.198	0.4222
Crayfish Creek	YELL	22	0.584	1.804	0.7241
Crayfish Creek	YELL	23	0.427	1.338	0.6049
Crooked Creek	BICA	18	0.809	2.339	0.8728
Crooked Creek	BICA	19	0.813	2.392	0.8691
Cub Creek	YELL	22	0.786	2.429	0.8857
DeLacy Creek	YELL	24	0.839	2.665	0.9134
Elk Antler Creek	YELL	14	0.573	1.512	0.6197
Falls River	YELL	25	0.72	2.317	0.8528
Falls River	YELL	27	0.688	2.266	0.8445
Firehole River, Upper	YELL	26	0.755	2.46	0.863
Firehole River, Upper	YELL	29	0.782	2.632	0.8961
Gallatin River	YELL	32	0.753	2.61	0.8877
Gardner River	YELL	29	0.764	2.574	0.854
Gibbon River, lower	YELL	16	0.868	2.408	0.8884
Gibbon River, lower	YELL	23	0.836	2.621	0.9038
Gibbon River, upper	YELL	28	0.795	2.648	0.899
Granite Creek	GRTE	23	0.71	2.228	0.8148
Grayling Creek	YELL	27	0.634	2.091	0.7596
Herron Creek	YELL	26	0.767	2.498	0.866
Joey Ramone Creek	GRTE	26	0.657	2.141	0.8036

Table 3. OTU-based biological metrics for 76 representative GRYN macroinvertebrate samples, cont.

Site Name	PARK	S	E	H’	D
Joey Ramone Creek	GRTE	28	0.735	2.45	0.853
Kathleen's Creek, tributary to Lamar Creek	YELL	19	0.857	2.525	0.8936
Kathleen's Creek, tributary to Lamar Creek	YELL	22	0.632	1.955	0.8043
Kelly Warm Spring (Nr Jackson)	GRTE	8	0.615	1.28	0.6504
Lamar River	YELL	22	0.776	2.398	0.8758
Landslide Creek	YELL	23	0.752	2.358	0.8377
Lava Creek	YELL	36	0.714	2.559	0.8576
Lewis River	YELL	23	0.801	2.512	0.8628
Lewis River	YELL	27	0.733	2.416	0.8538
Little Taggart Creek	GRTE	23	0.726	2.277	0.8578
Lost Creek	YELL	21	0.758	2.307	0.8449
Madison Creek	YELL	21	0.812	2.471	0.8648
Middle Creek	YELL	21	0.688	2.095	0.7896
Nez Perce Creek	YELL	16	0.657	1.822	0.7604
Nez Perce Creek	YELL	22	0.818	2.528	0.8953
Obsidian Creek	YELL	27	0.721	2.378	0.858
Otter Creek	YELL	12	0.577	1.434	0.581
Pacific Creek	GRTE	18	0.78	2.256	0.844
Pacific Creek	GRTE	21	0.803	2.446	0.8723
Pacific Creek	GRTE	21	0.852	2.594	0.8992
Pacific Creek	GRTE	24	0.641	2.037	0.7614
Pebble Creek	YELL	25	0.808	2.602	0.8926
Polecat Creek	GRTE	5	0.868	1.398	0.719
Polecat Creek	GRTE	8	0.256	0.532	0.2138
Polecat Creek	GRTE	11	0.632	1.516	0.6872
Polecat Creek	GRTE	20	0.779	2.332	0.8664
Rose Creek	YELL	30	0.588	1.999	0.7401
Sedge Creek	YELL	9	0.459	1.01	0.5551
Slough Creek	YELL	19	0.681	2.005	0.7936
Slough Creek	YELL	26	0.629	2.049	0.7577
Snake River	GRTE	22	0.567	1.752	0.6727
Snake River downstream from Jackson Dam	GRTE	9	0.768	1.687	0.7312
Snake River downstream from Jackson Dam	GRTE	13	0.826	2.12	0.8359
Solfatara Creek	YELL	23	0.658	2.064	0.8033
Solfatara Creek	YELL	31	0.718	2.464	0.8438
Specimen Creek	YELL	26	0.567	1.848	0.7676
Stephens Creek	YELL	27	0.794	2.617	0.8917
Sulphur Creek, South Fork	YELL	26	0.667	2.172	0.7839
Tower Creek	YELL	26	0.678	2.207	0.8271
Trout Lake Stream	YELL	22	0.713	2.205	0.8124
Upper Tributary to Middle Creek	YELL	25	0.651	2.096	0.7317
West Fork Pilgrim Creek	GRTE	27	0.739	2.434	0.8519
West Fork Pilgrim Creek	GRTE	28	0.652	2.173	0.7995
Yellowstone River	YELL	24	0.779	2.474	0.8753

Due to limitations in the comparability of the data sets, we calculated metrics only for 76 samples. S = total OTU richness. E = Pielou’s evenness, calculated as H’/lnS. H’ = Shannon’s diversity, calculated as $H = -\Sigma p_i \ln p_i$. D = Simpson’s diversity, calculated as $D = 1/\Sigma p_i^2$. In each case, p_i represents the proportion of organisms in a sample belonging to the *i*th taxon.

A comprehensive and geographically precise survey of the stream invertebrate taxa of the GRYN would require a considerable investment of additional effort. Even relatively depauperate streams may have hundreds of taxa; however, most of these taxa will be rare and an extensive sampling effort would be necessary to capture them. Such a survey is beyond the scope of this document. Fortunately, for bioassessment purposes, taxa that are relatively common are most suitable; hence data collected for bioassessment purposes do not need to provide a comprehensive taxa list for any stream. Should the GRYN decide to attempt a comprehensive survey of stream macroinvertebrate diversity, the WCMAFE would be able to assist in developing a rigorous protocol.

Section II

Development of an aquatic bioassessment program for the GRYN

Background

As part of the Natural Resource Inventory and Monitoring Program the National Park Service identified a need to monitor the condition of benthic invertebrate communities of the rivers and streams within the jurisdiction of the GRYN. In general, measuring the biological integrity of ecosystems involves quantifying the extent to which biological communities have been altered by anthropogenic stressors. Because historical biological data are unavailable for most sites, the extent of alteration must therefore be estimated by comparing the observed biota at a site with that found at minimally impaired sites (*i.e*. reference sites), which are used to estimate the expected biological condition of otherwise physically similar sites. Worldwide, a number of measures or indicators have been developed to quantify the departure from expected condition. These indicators are sometimes based on different conceptual models or emphasize different aspects of biological structure and hence have different strengths and weaknesses. However, the effectiveness of any indicator will greatly depend on the sampling design of the overall monitoring program.

Within the context of the Inventory and Monitoring program, a comprehensive monitoring and assessment program should consist of the following elements:

1. Clearly defined, quantifiable objectives;
2. A sample design that allows statistically rigorous inferences regarding the overall condition of ecosystems within GRYN in addition to the condition of individual sites;
3. Cost-effective sample collection and processing techniques;
4. Collection techniques that are not environmentally destructive;
5. Maximum compatibility with other state and federal agencies in the region;
6. A reliable data storage and retrieval system;
7. Development of analytical tools that are easily used by resource managers;
8. Outputs that are readily interpreted by managers, policy makers, and the general public;
9. Compatibility with other management questions.

Three phases of work will be necessary for the development of an effective benthic invertebrate monitoring and assessment program for the GRYN. The first phase involves the completion of two main tasks: (1) conducting a synoptic review that consists of compiling and comparing previously collected data on riverine invertebrates within the GRYN, and (2) reviewing the existing literature and developing recommendations regarding the most appropriate sampling designs, field collection techniques, laboratory procedures and data analysis methods for addressing key elements of a long-term monitoring program. Phase

2 will consist of refining monitoring protocols, selecting sites for additional collections, and collecting any additional data necessary to develop biological assessment tools for the GRYN. Phase 3 will involve sample processing, data analysis, development of user-friendly assessment tools, and training of GRYN personnel and personnel from other state and federal agencies on the use of these tools and the interpretation of assessment outputs. This report constitutes Phase I of the development of the GRYN benthic invertebrate inventory and monitoring program.

Specific objectives for a GRYN biological monitoring program

Based on our understanding of the overall goals of the GRYN Inventory and Monitoring Program, along with our knowledge of the capabilities and limitations of current aquatic bioassessment methods, we propose that 7 specific objectives be addressed when developing and implementing a GRYN monitoring program.

1) Identify and sample if necessary an appropriate set of reference sites for the 3 GRYN park units.

2) In cooperation with WCMAFE, use these reference site data to construct appropriate biological indicators for the GRYN.

Use these indicators to:

3) Determine the current overall biological condition of rivers and streams in each of the 3 GRYN park units.

4) Determine the biological condition of specific sites of concern.

5) Detect changes in the overall biological condition of streams and rivers in each of the 3 park units over time.

6) Detect changes in the biological condition of specific sites of concern over time.

7) Identify stressors that are likely responsible for degrading the biological condition of streams in each of the 3 park units.

Overview of Biological Assessment

The use of biological data to assess water quality is nearly 100 years old, going back at least as far as Kolkwitz and Marsson's classic work in Europe in the first decade of the 20th century, from which developed the Saprobien system of indicator organisms for organic pollution (see *e.g.*, Cairns & Pratt 1993). In North America, biologically-based approaches to measuring stream condition also have a long history (Patrick 1949). Over time, a wide variety of methods for relating measurements of the state of aquatic communities to the quality of running waters have been developed and implemented worldwide. Although these approaches have often differed substantially in methodology, they share a common reliance on the fundamental idea that biological communities respond sensitively to anthropogenic alterations in the quality of aquatic habitats. Put another way, the biological integrity of aquatic ecosystems is an expression of both direct effects on biota and the indirect effects of altering chemical and physical integrity, on which biota depend.. Moreover, biological communities integrate the effects of multiple stressors over time and therefore provide a broad measure of their aggregate impact.

Most modern biological assessments attempt to quantify the degree to which a given stream retains its expected biological integrity. Biological integrity, a term that first appeared in Section 101[a][2] of the 1972 Clean Water Act, has proven difficult to define precisely, although there has been general agreement that it refers to the “naturalness” of stream ecosystems. The most widely accepted definition, first expressed by Frey (1977) and popularized by Karr & Dudley (1981), is “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 of a region.” This definition provides the foundation for developing quantitative biological criteria based on conditions found at reference sites in a given region.

Historically, benthic macroinvertebrates have been the most commonly used taxa for biological assessments of streams. However, other groups, most commonly fish and benthic diatom (periphyton) assemblages, have also been used or considered for aquatic biological assessment programs. Each of these taxa has distinct advantages and disadvantages. Because fish are relatively long-lived and highly mobile, they can be good indicators of long term effects and large-scale habitat conditions. Conversely, however, the fish community in a particular reach may be more indicative of conditions at other sites (spawning or rearing habitat, for example) rather than of conditions in the reach of interest. Fish communities generally span several trophic levels (*e.g.*, herbivores, insectivores, piscivores); because higher trophic levels will tend to integrate and concentrate effects on lower trophic levels, fish community structure is generally reflective of overall ecosystem health. Fish are generally at the top of aquatic food webs, and are consumed by humans, which makes them important sources for assessing accumulation of toxicants. Furthermore, the life histories, distributions and habitat requirements of many fish species are generally well understood. Fish species are relatively easy to identify in the field, allowing trained technicians to record samples and subsequently release individuals unharmed. Finally, because designated aquatic life uses, as defined for many state water quality standards, are often defined in terms of fisheries (*e.g.*, coldwater fishery), assessing fish communities provides a direct evaluation of such water quality designations.

Benthic algae, in contrast, generally have short life cycles and rapid reproduction rates, making them more useful indicators of short term or chronically occurring impacts to stream ecosystems. As primary producers, they can be directly sensitive to chemical and physical impacts on water quality. Furthermore, they are sensitive to particular classes of toxicants (e.g. herbicides) at lower concentrations than are other organisms. While sampling techniques for benthic algae are relatively straightforward, reproducible, and inexpensive, laboratory preparation and identification of samples may not be. At present there are few commercial laboratories that provide these services, and there are relatively few trained diatom taxonomists working in resource management agencies. On the other hand, standard methods exist for characterizing aggregate functional metrics of periphyton communities (*e.g*., chlorophyll content, biomass). Although these aggregate metrics are known to respond to some impacts (*e.g*., significant eutrophication), it is not clear whether they are sensitive to others.

Benthic macroinvertebrates, as a group, exhibit a number of characteristics that suggest macroinvertebrate communities may be better and more useful indicators in general of the biological condition of streams than either fish or diatoms. Perhaps most important is that stream macroinvertebrates occupy every habitat and every trophic level but one. They are thus good indicators of both habitat-specific stress and of general habitat conditions. Furthermore, the life cycles of macroinvertebrates vary from several months to several years. They are therefore capable of responding to and integrating both short-term and long-term environmental impacts. Macroinvertebrates are well suited to assessing site specific impacts, because they are relatively sessile or have limited migration ability and are therefore good indicators of localized conditions. In addition, macroinvertebrates are abundant and diverse in nearly all streams, including those with limited or absent fish communities. This characteristic greatly expands the universe of streams that can be assessed with a single technique. Sampling for benthic macroinvertebrates is straightforward and inexpensive, requiring minimal training, few people, and inexpensive gear. Sampling can be accomplished with minimal impact on resident biota. The taxonomy of benthic macroinvertebrates is fairly well defined and a number of commercial labs specialize in sorting and identifying benthic macroinvertebrate samples. For all of these reasons, nearly all water quality programs worldwide that include bioassessment rely primarily on macroinvertebrate indicators to assess biological integrity.

Comparative Evaluation of Bioassessment Methods

Currently there are two main approaches to macroinvertebrate-based stream bioassessment. One, the multimetric approach, bases assessments on the value of an index that is derived by summing several different metrics that describe different aspects of an assemblage (e.g., Karr 1981, Barbour *et al.* 1999, Karr & Chu 1999, Barbour & Yoder 2000). The other approach, based on predictive modeling, measures biological condition as the degree to which assemblage taxonomic composition agrees with that expected to occur under reference conditions (Wright 1995, Reynoldson *et al*. 1997, Hawkins *et al*. 2000, Simpson & Norris 2000, Wright 2000, Hawkins & Carlisle 2001, Ostermiller & Hawkins 2004). Although a variety of predictive modeling methods exist, they are often collectively referred to as "RIVPACS models," after the original program (River InVertebrate Prediction And Classification System) developed in Great Britain in the 1980's (Moss *et al*. 1987). Both approaches in general use the same basic data (macroinvertebrate community composition) and both compare the macroinvertebrate community at a site of interest with that found in a presumably appropriate set of reference sites; however, they differ substantially in the criteria by which the appropriate set of reference sites is selected, in how the macroinvertebrate data are employed, and in how the comparison is made. Below we provide a comparative evaluation of the two approaches, followed by discussions of sampling design, reference site selection and field and laboratory methods for macroinvertebrate sampling.

As argued by Norris & Hawkins (2000), a useful biological indicator, or alternatively a useful bioassessment method, should satisfy the following 6 criteria:

It should:
1) quantify and simplify complex ecological phenomena
2) provide easily interpretable outputs
3) respond predictably to damage caused by humans while being insensitive to natural spatial or temporal variation
4) relate to an appropriate scale
5) relate to management goals
6) be scientifically defensible

In this section we compare multimetric and predictive modeling approaches in terms of how well they satisfy these criteria.

RIVPACS models attempt to quantify biological integrity based on the degree to which a site supports the biota that would be predicted to occur there in the absence of anthropogenic impairment. Essentially, the composition of biota is compared between an assessed site (hereafter called test sites) and that found at reference sites with similar physical and chemical characteristics. In the initial step, an empirical statistical model is created that relates the probability of detecting each taxon found at a set of reference sites to a set of generally invariant environmental characteristics, *i.e*., those that are unlikely to be altered by human activity. That set of characteristics is then used to match a given test site with its most similar set of reference sites, generating site-specific predictions of the probability of detecting each taxon. Taxa with a high probability of detection are expected to be observed under reference conditions. The robustness of a given model depends on the degree to which the network of reference sites used in model construction represents the range of natural variation in conditions in the region under consideration.

Essentially, predictive modeling is based on the idea that the community composition found at an unimpaired site will be identical to the composition predicted to occur. Anthropogenic stress is assumed to cause native taxa to be lost from the community (these taxa may or may not be replaced by other taxa). The result is that the taxonomic composition at impaired sites will differ from that expected in the absence of stress. Because all levels of biological organization ultimately arise from the taxonomic composition of the biota, measuring that composition provides a direct and fundamental indicator of biological degradation. Changes in the expected taxonomic composition should therefore be a sensitive indicator not only of disruption at the community level, but should also signal ongoing or impending changes in ecosystem processes (e.g., nutrient cycling) that are regulated by different taxa.

Given a set of expected taxa for a given site, a direct measure of biological degradation can be obtained by observing how many of those taxa are actually collected at the site. The comparison is expressed as the ratio of observed (O) to expected (E) taxa, a standardized measure of the extent to which the biota remains intact. O/E can vary in principle from 0 (none of the expected taxa were observed) to 1 (all of the expected taxa were observed). The greater the deviation away from 1, the greater the degradation that is inferred. In practice, streams are judged to be impaired if their O/E values fall outside of a range determined by the error inherent in predicting E and estimating O/E (Clarke *et al*. 1996, Hawkins *et al*. 2000, Simpson & Norris 2000). In addition to providing a measure of what proportion of taxa are present at a site, predictive models also allow identification of those taxa that are missing and thus most indicative of the biological degradation occurring at a site. Identification of these taxa can aid in diagnosing potential causes of impairment.

Predictive models satisfy all 6 of the criteria listed above. Their most powerful feature may be that assessments are based on a simple concept that can be easily understood by managers and policy makers, as well as the general public. Predictive modeling requires no assumptions about either the type or the intensity of anthropogenic impact, making the approach generalizable. Furthermore, the derivation of model outputs is scientifically defensible.

The multimetric approach to biological assessment is designed to quantify the concept of biological integrity by assigning values to a number of attributes (metrics) that are thought in combination to describe the state of the biological community at a site, and comparing them to the values expected to occur under reference conditions. Generally these metrics are selected from several categories that address different aspects of the macroinvertebrate community: richness, composition, tolerance, and feeding behavior or life history. Examples of commonly used metrics include total taxa richness, %EPT (% of taxa belonging to the insect orders Ephemeroptera, Plecoptera, and Trichoptera), and number of tolerant taxa. A measure of the overall biological integrity of the site is then obtained by combining the values of the individual metrics after rescaling each to a common range. The resulting combined score is often referred to as the Index of Biotic Integrity (IBI).

As in RIVPACS models, the expected values for each indicator are derived from sampling a set of unimpaired or minimally impaired reference sites. However, in contrast to predictive models, in multimetric methods the expected conditions are generally derived using an *a priori*, spatially discrete classification of reference sites. Often this classification is based on geographic criteria (*i.e.*, ecoregions *sensu* Omernik, see Hughes *et al*. 1986), but may be further stratified (by stream order, for example) to minimize the range of metric values expected at a site (Barbour *et al*. 1996, Barbour *et al*. 1999). The individual and combined values for each metric measured at a site of interest are then compared to the range of values observed at the appropriate set of reference sites. In practice, impairment is usually inferred if the observed IBI value at the site of interest falls below a defined threshold value, generally the 25% percentile of reference site values (Gibson *et al*. 1996, Barbour *et al*. 1999) or in some cases below a threshold determined by a dose-response relationship between the metric(s) and a gradient of perceived human alteration (Karr 1999, Karr & Chu 1999).

Because the value of any biological indicator will vary both spatially and temporally in response to naturally occurring environmental variation, a critical step in determining the value of that indicator expected at a test site is to identify an appropriate set of reference sites for that site. An appropriate set of reference sites can be defined as that set that minimizes naturally occurring variation in the indicator of interest and is sufficiently biologically similar to the test site that the indicator can be expected to vary within the same range of values (*e.g.*, Bailey *et al*. 2003). Such conditions ensure that deviations from the expected value of the indicator at a test site, as obtained by comparison with the range of values observed at a set of reference sites, truly represent impairment as opposed to natural variation. In the multimetric approach, test sites are matched with reference sites based on *a priori* assumptions about the determinants of biological similarity. Generally reference sites are classified on an ecoregional basis; a more refined classification based on habitat type is also often employed, although the parameters by which habitat type is defined are rarely explicitly defined. Test sites are then assigned to reference site groups based on their geographic location and some set of habitat parameters.

Although both multimetric and predictive modeling techniques have been successfully applied to the biological assessment of streams, we believe there are five main advantages to the predictive modeling approach: (1) intuitive outputs, (2) refined matching of test sites with reference sites, (3) no need to calibrate indicator values against stressors, (4) a history of rigorous evaluation, and (5) ability to integrate and compare assessments with those currently being conducted at a national scale. The main output of predictive model assessments is the ratio of observed to expected taxa (O/E). This measure describes the extent to which the natural capital of an ecosystem is intact and has the distinct advantage over IBI values in that it means the same thing everywhere. An O/E score of 0.5, for example, indicates that only 50% of the taxa that were expected at that site were actually collected. This result would suggest a fairly substantial degree of biological impairment. Threshold values, based on the statistical distribution of reference site O/E scores, and bands of impairment for assigning test sites to management classes, can be easily applied. In addition to O/E, a number of biotic indices, including those used in multimetric approaches, can be calculated. However, in predictive models these indices are weighted by the probability of occurrence of taxa at each site, which refines their use in assessments. Predictive model assessments explicitly acknowledge that sites vary continuously in their physical and biological attributes. They improve matching of test and reference sites by adjusting for this naturally occurring variation with statistical weighting and interpolation. The fact that no assumptions are made regarding either the specific stressors that are impacting the system or the direction or magnitude of the response expected by different measures of community structure when developing models ensures the models are robust in their ability to assess biological impairment caused by many forms of stress. Models can therefore be used with confidence when assessing the effect of a novel stressor, such as, for example, the current invasion of New Zealand mud snails into Yellowstone and other western streams. All aspects of predictive modeling have been subjected to rigorous evaluation, and sources of potential error are well understood (*e.g.*, Wright *et al*. 2000, Clarke papers, Hawkins et al. 2000, Ostermiller and Hawkins 2004). Finally, both the United States Geological Survey and the EPA are developing predictive models to assess streams sampled in conjunction with the National Water Quality Assessment program (NAWQA) and the recently launched National Streams Assessment program. As we discuss below, the Wyoming Department of Water Quality has recently developed a predictive model for assessing the biological quality of Wyoming streams.

Sampling design considerations

The choice of sampling design for each aspect of a bioassessment program depends on the specific goals that are to be achieved. The goals of the GRYN Inventory and Monitoring Program will require at least four distinct sampling designs at different stages in its development. During the initial stage of model development, an adequate reference site network must be acquired, which will probably require some additional sampling. Once an assessment tool has been developed, or as it is being developed, the GRYN will need to address conditions at specific sites of concern (for example at 303(d) listed sites) as well as determine the overall condition of stream ecosystems in the GRYN. Finally, the program will need to monitor trends over time both at sites of special concern and for the GRYN as a whole. Two general types of sampling design are needed for these four different components of program development and implementation: targeted and probabilistic sampling.

Development of a regional reference site network is most efficiently addressed by targeting a wide variety of site types for sampling. The aim here is to ensure that the biological heterogeneity within the region is captured so that all possible reference conditions are characterized. In general, site selection for a reference network entails an analysis and stratification of the distribution of stream “types,” as determined by several criteria. These criteria may include geographic location, along with physical criteria that relate directly to site characteristics. Examples of useful site characteristics for stratification include stream size, elevation, water chemistry or catchment geology, riparian vegetation (e.g., forested *vs*. meadow), and slope. We provide a preliminary assessment of the existing GRYN reference sites in the following section, along with general recommendations for further reference site sampling. Because we expect that the GRYN bioassessment program will use a number of existing reference sites from outside of park boundaries, we do not anticipate that substantial additional targeted sampling will be required; however, some stream types may be underrepresented. A specific plan for identifying additional reference sites will need to be developed in cooperation with GRYN biologists.

Targeted sampling is also needed to assess streams that are either known or suspected to be biologically impaired – *i.e.*, sites of special concern. Because all streams in YELL and GRTE are listed by the EPA as ONRW streams, the highest designation possible, any potentially impaired streams should be a focus of concern for the GRYN. These streams should be sampled in a targeted fashion to ascertain their current biological condition. We have identified several possible sites of special concern for YELL and GRTE (Table 4), along with likely stressors. This list is for illustrative purposes only, and should be considered neither exhaustive nor complete. A final list of sites of special concern should be generated with the assistance of park personnel who are familiar with land use patterns and water quality concerns within the parks. We have only listed 2 sites from BICA, a likely function of the general lack of available information regarding the status of aquatic resources in BICA. Due to the large amount of agriculture in the Bighorn basin outside BICA, we would expect that most of the streams might qualify as sites of special concern.

In contrast to targeted sampling, a probabilistic sampling design is essential to make inferences about overall conditions across the entire population of streams in a region, most of which will not be sampled (Overton & Stehman 1996, Larsen 1997, Olsen *et al.* 1999). A critical component of the GRYN Vital Signs mandate is to determine the overall status of stream and river ecosystems in the GRYN. Given the large number of potential sampling sites, it is logistically impractical to sample every one. Therefore, a subset of sites must be assessed, and the

Table 4. Potential sites of special concern in the GRYN

Site/Stream	Park	Potential or Known Stressors
Soda Butte Creek	YELL	Mine waste, road – 303d listed*
Reese Creek	YELL	Diversion, agriculture - 303d listed*
Lamar River below confluence	YELL	Mine waste, grazing, road
Stephens Creek	YELL	Grazing
Landslide Creek	YELL	Grazing
Madison River	YELL	NZMS**, road
Gibbon River	YELL	NZMS**, road, construction
Yellowstone River	YELL	Road, pollutants from lake
Nez Perce Creek	YELL	NZMS**
Crayfish Creek	YELL	NZMS**
Lewis River	YELL	NZMS**
Cascade Creek	YELL	Development
Lost Creek	YELL	Trail erosion, development
Trout Creek	YELL	Grazing
2 unnamed creeks in Grant Village	YELL	Development
Lower Firehole River	YELL	NZMS**, development, road
Upper Gardner River	YELL	Diversion
Polecat Creek	YELL/GRTE	NZMS**
Spread Creek	GRTE	Diversion, agriculture – 303d listed*
Ditch Creek	GRTE	Diversion
Snake River	GRTE	Development, channelization
Cottonwood Creek	GRTE	Development
Cascade Creek	GRTE	Heavy recreational use
Gros Ventre River	GRTE	Agriculture, development, diversion, gravel mining
Christian Creek	GRTE	Development
Buffalo Fork	GRTE	Agriculture, development
Granite Creek	GRTE	Diversion
Bighorn River	BICA	Agriculture, industrial development, impoundment
Shoshone River	BICA	Agriculture, industrial development

*303d listed refers to streams that have been listed by the states as impaired as required under the Federal Clean Water Act Section 303d. By definition, impaired waterbodies do not meet or are not expected to meet Surface Water Quality Standards (SWQS) despite the implementation of point and nonpoint source pollution controls. This means that other management measures will be needed to improve these streams. Streams cannot be removed from the Impaired Waterbodies List (303d List) until water quality standards are met. **NZMS: NewZealand mud snail (*Potamopyrgus antipodarum*)

biological condition determined at those sites used to infer the biological condition at sites that have not been sampled. For this inference to be statistically defensible, a probabilistic sampling design must be used to select the subset to be sampled. To ensure that a variety of stream types are included, we suggest that a “stratified random” sampling design be employed. In stratified random designs, the universe of interest (here, all stream reaches in the GRYN) is stratified according to relevant criteria, and then random samples are taken from within each of the strata. For the GRYN these criteria might include stream size, geothermal influence, geological strata, and elevation. The EPA, in designing the sampling protocol for the EMAP aquatic bioassessment program, spent considerable time and resources evaluating different possible approaches to regional sampling of reference sites. Their conclusion was that a stratified random sampling design was the most efficient and the most defensible approach (Ernst *et al.* 1995, Stevens & Olsen 2000, Fore 2003). The WCMAFE can cooperate with GRYN scientists to design an appropriate stratification scheme and develop an automated method for random site selection within those strata.

Monitoring temporal trends in aquatic ecosystems, a second critical mandate for the GRYN, may require a mixture of targeted and probabilistic sampling. Monitoring temporal trends requires repeated sampling at both sites of concern and across the GRYN as a whole. For sites of concern, repeat sampling could be conducted at every site every year or on a rotating schedule so that each site was sampled at frequent enough intervals to meet management needs. For example, annual sampling might be called for at a site during the early stages of restoration to assess management effectiveness, but less frequent sampling may be acceptable later as system recovery approaches reference condition. Repeat sampling to determine trends in the overall condition of GRYN streams could in principle be accomplished in one of several ways. The most obvious approach would be to repeat the stratified random site selection each year, either from the starting population, or from the subset that were sampled initially. The most significant advantage of doing so would be the maintenance of maximal inferential power, but this power comes at a cost. Because of natural variability in biological conditions between sites, such an approach could require a relatively high sampling effort if we wanted to detect relatively small changes in overall condition over time. An alternative approach would be to select a number of “sentinel sites” from the original set of sampled sites, and to resample those sites regularly. In this case the tradeoff works in the other direction. Because the sites are not selected in a strictly random fashion, overall inferential power is lost; however, because natural variability between sites is controlled for, there is increased sensitivity in detecting subtle changes in biological condition over time. Use of the sentinel site method would allow detection of a given size change earlier than with a repeated random sample. Given the GRYN mandate to monitor and detect trends in biological condition, we suggest that the GRYN consider use of sentinel sites. To ensure that specific stream types that might be more sensitive to, for example, climate change, are included in the set of sentinel sites, we recommend careful selection of sites to adequately represent the range of variability in stream ecosystems in the GRYN. The number of sites to be included as sentinel sites, and the frequency with which they are to be sampled will depend on the resources available. Clearly, if resources permit, a combination of sentinel sites and repeated stratified random sampling would allow the GRYN to take advantage of the strengths of each design and would be recommended.

Criteria for Reference Site Selection

A major task in developing any aquatic bioassessment system is identifying reference sites. The biological characteristics of reference sites serve to represent the “natural” condition of streams in a region, and are thus the standard against which the effects of human activity on stream ecosystems are evaluated. “Naturalness” here implies the absence of significant alteration by human activity. The use of multiple reference sites to represent the natural condition of regional streams has been referred to as the “Reference Condition Approach” (Reynoldson *et al*. 1997, Bailey *et al.* 1998, Reynoldson & Wright 2000, Bailey *et al*. 2004). Due to natural spatial and temporal variability, any given biological indicator measured at a set of undisturbed sites will take on a range of values. Even a single such site will vary over time as a result of natural disturbances and climatic influence. Hence the reference condition is generally defined by a distribution of biological indicator values, and it is this distribution against which values measured at test sites are evaluated. There are thus two important goals when developing a network of reference sites. First, the reference site network will ideally represent the natural biological potential of sites in the region under consideration, and second, the network should capture the full range of natural variability in that condition.

Operationally, the standards for what qualifies as the reference condition will vary depending on the extent of human alteration of stream ecosystems in a given area. In general, reference condition streams are defined somewhat loosely as those representing the best available conditions in a given region. Therefore, streams that are accepted as reference in one area may not be of sufficient quality to serve as reference streams in another area. Essentially, accepting a wider range of conditions as “reference” will have the effect of broadening the distribution of reference site indicator values and thus lowering the threshold values used to classify the condition of test sites. Conversely, being more restrictive in the level of human disturbance allowed at reference sites will constrain the distribution and raise threshold values. Often there is a trade-off between the level of human disturbance deemed acceptable and the number of potential reference streams available. In the GRYN, for example, the best available conditions in BICA probably would not qualify as reference condition for streams in a presumably more restrictive reference site distribution for YELL or GRTE. The bottom line is that criteria for reference site selection must be based on an assessment of the overall quality of streams that are available in a given area, and of the goals of the program. As we discuss in the next section, this disparity in the biological condition of potential reference sites between BICA and YELL/GRTE suggests that the best approach for the GRYN would be to develop separate assessment tools and perhaps different criteria for these two areas.

In general, criteria for reference site selection are based on a combination of site-specific and catchment-level factors (Bailey *et al*. 2004). Examples of site specific factors include elevated nutrient concentrations, riparian alteration associated with management, or evidence of disturbance by livestock. Examples of catchment-level factors include the degree of historical or current human alteration upstream of a site. Depending on the goals of the program, criteria may be relatively simple or quite complex. For example, Hawkins *et al*. (2000), in a study of the effects of logging on California stream biota, used a single criterion. They considered sites in catchments where less than 5% of the catchment had been logged as meeting the requirement for reference condition. Similarly, Bailey *et al.* (1998), working in an area with a single dominant disturbance (placer mining), used the presence or absence of current or historical mining in the catchment as the only criterion. On the other hand, a program developed for the Idaho Department of Environmental Quality used 9 criteria, ranging from riparian vegetation condition at the site to land use in the catchment (Jessup & Gerritsen 2000). Criteria for the EMAP Mid-Atlantic Highlands study were based on 6 factors, all of which were site-specific (5 were related to water chemistry, one to habitat quality – see Fore 2003). Often reference site selection relies to some degree on the knowledge and experience of local biologists or land managers with intimate knowledge of both current conditions and historical land use in their area. This is commonly termed Best Professional Judgement (BPJ). Although BPJ can be an invaluable tool in identifying potential reference sites, it is probably best used in conjunction with objective criteria (Fore 2003, Bailey *et al*. 2004). The WCMAFE can work with GRYN personnel to develop a set of criteria for reference site selection that will best address the goals of the GRYN bioassessment program. These criteria can be used both to filter the existing reference data set as well as to identify new reference sites for additional sampling as needed.

Reference Site Issues Specifically Relevant to the GRYN

There are a number of characteristics of the GRYN that must be taken into account in thinking about criteria for identifying reference sites. In each case, decisions will have to be made by the GRYN regarding how best to address them. Here we provide some guidance on each issue, with the understanding that final determinations will have to made by GRYN staff in consultation with WCMAFE and other sources. One key such issue for the GRYN is the disparity in overall biological condition between BICA and the YELL/GRTE area. BICA has a much different land-use history than YELL, and from much of the GRTE as well. It is very likely that the biological condition of the best available streams in the two areas differs substantially, which will make it challenging to develop a single set of criteria for reference sites that meets appropriate management goals in both areas. For example, a set of appropriately stringent criteria for YELL/GRTE would likely reject every potential reference site in BICA. Conversely, a set of criteria based on the best available conditions in BICA would lead to significant degradation of YELL/GRTE streams not being assessed as impaired. For this reason, as well as others discussed in the next section, we recommend that BICA be treated separately from YELL/GRTE when identifying reference sites and establishing reference baselines for use in assessments and monitoring.

Probably the most pervasive influence in YELL/GRTE relevant to reference site selection is fire. Although fire is a natural and essential component of many western ecosystems, it can be a significant source of disturbance to streams and rivers. Fire can cause substantial direct mortality of stream organisms, and significant long terms changes in riparian vegetation, sediment delivery and channel morphology often result. These effects can be exacerbated by firefighting activity when retardants are dropped in or near streams and when heavy equipment or fire lines pass through streams or riparian zones. These impacts in turn lead to relatively substantial changes in stream biota that may persist for years (Minshall *et al*. 2001a, 2001b). Fires are relatively frequent in YELL/GRTE, and have in some cases been severe. For example, the 1988 Yellowstone fires burned some 793,000 acres within the park itself, and another 400,000 throughout the GYE. In 2003, a more typical fire year, 77 fires burned 29,000 acres in Yellowstone. The question of whether fire-related disturbance should be considered natural for YELL/GRTE streams and whether fire-disturbed streams should be included in the reference site network is a decision that must be made by the GRYN; however, we can provide some guidance. It is our view that as fire is an essentially natural feature of western ecosystems it should be treated as such for the purposes of reference site selection. Nevertheless, it is appropriate to define a set of criteria for what constitutes "natural" fire-related disturbance. For example, the GRYN may want to exclude streams affected by human caused fires, and should exclude streams affected by retardant drops or firefighting activity. Whatever criteria are set, it will be necessary to include some measures of fire-related influence as predictor variables for the RIVPACS model (see Section IV for more discussion of predictor variables). Appropriate measures might include the percentage of the catchment that has burned, time since last fire, and some measure of fire intensity. WCMAFE staff can work with the GRYN to determine appropriate fire criteria and measures of fire effect.

A more recently identified influence on the biota of streams in YELL/GRTE is the invasive New Zealand mud snail (NZMS), *Potamopyrgus antipodarum*. The NZMS was first discovered in the Yellowstone area in 1994, and has since spread rapidly through the GYE and beyond. Although the original vector by which the snail was introduced is unknown, it is likely that it was transported to the GYE on fishing gear. It is now found in almost all warm geothermal streams in the GYE (R. O. Hall, pers. comm.), and a number of colder streams as well. A partial list of GRYN streams known to be invaded by NZMS includes the Snake River, the Lewis River, the Gibbon River, the Firehole River, the Little Firehole River, the Madison River, Polecat Creek, Crayfish Creek, Pelican Creek and Nez Perce Creek. Densities of NZMS in invaded streams vary widely, from less than 10/m^2 to over 500,000/m^2. Although the long-term effects of NZMS invasion are still under investigation, it is clear that at least in some streams with high densities of snails ecosystem structure and function have been drastically affected (Hall *et al*. 2003, Hall *et al*. in prep.). Streams where these ecosystem-level changes have occurred should be excluded from consideration as potential reference sites. By this criterion, the lower Firehole River, Polecat Creek, the lower Gibbon River and probably the upper Madison River should not be considered as potential reference sites. In other streams, for example the Snake River in YELL, NZMS populations are extremely patchy and probably do not yet represent a significant impact on overall ecosystem structure and function (R. O. Hall, pers. comm). There are two ways that the GRYN could address this issue. First, all stream samples that contain NZMS could be rejected as non-reference, and all unsampled potential reference sites known to harbor NZMS could be excluded from further consideration. Alternatively, the GRYN could set some threshold NZMS density below which sites would still be considered equivalent to reference. Because little is known about the effects of relatively low densities of snails, the first approach is more conservative; however, such an approach would eliminate most, if not all warm streams from the reference data set. Accordingly, some version of the second approach should probably be implemented. We recommend that the GRYN set a conservative threshold for acceptable NZMS density, for example 5% of total invertebrate biomass, above which sites would no longer qualify as reference.

Several other factors also need to be considered in defining reference criteria, although they are probably not as pervasive as fire and NZMS. The first of these is wild ungulates. The management of ungulates, and particularly elk in YELL, by the National Park Service has been a contentious issue over the years, and we will not review it here. However, there are clearly instances in which disturbance by wild ungulates, either through overgrazing of riparian vegetation, or trampling of stream banks, has had deleterious effects on aquatic communities, particularly in YELL. Examples of this phenomenon can be found at Trout Creek in the Hayden Valley and at a number of sites in the Lamar Valley. It is arguable whether or not such disturbance is “natural,” but from the perspective of aquatic resources, it is nonetheless disturbance and needs to be carefully considered in setting criteria for reference sites. A related issue for GRTE is historic and current (although much reduced) livestock grazing. Catchments that are currently grazed should probably not be considered reference for the purposes of the GRYN. The effects of historic grazing are more complex, however, and should be evaluated on a case-by-case basis. The negative impacts of roads and road crossings on stream ecosystems have been well documented (*e.g.*, Jones *et al.* 2000, Trombulak & Frissell 2000), and road effects on sites that might otherwise be in excellent condition need to be evaluated. In YELL/GRTE this is mostly an issue for larger streams and rivers, many of which have roads running alongside them. Roads run near at least portions of the Yellowstone River, Madison River, Gallatin River, Gardner River, Firehole River, Gibbon River, Lewis River, Snake River, Lamar River, Obsidian Creek, Soda Butte Creek and Antelope Creek, among others. In addition, there are a large number of road crossings in both YELL and GRTE. Heavy recreational use can also have a negative impact on streams through organic enrichment, loss of vegetation and compaction or erosion of soils. As in the case of NZMS, it is probably not realistic to eliminate all streams that are subject to some level of recreational use. Instead, some criteria should be set so that streams that are likely to have been adversely affected by recreational use are eliminated from the reference data set. These kinds of decisions are often based on subjective (BPJ) rather than strictly objective criteria, as our understanding of the relationship between nonmotorized recreational use and impact to stream ecosystems remains largely undeveloped. Finally, a number of streams, particularly in GRTE, may be affected by upstream land use that is outside park boundaries. A classic example is Soda Butte Creek, which has been significantly impaired by mine waste originating outside of YELL. Other streams that are probably impacted by outside activity include Buffalo Fork, Spread Creek, Ditch Creek and the Gros Ventre River. All of these potential factors should be considered in setting reference site criteria. The WCMAFE can work with GRYN staff to develop a set of criteria and methods that are appropriate for the development of a high quality YELL/GRTE reference site network.

Section III

Analysis of Existing Reference Site Data

Overview

There are at least 206 sites in the GRYN and surrounding areas, most identified as reference quality by the collecting agency, where invertebrates were collected in a compatible way and where at least some of the environmental characteristics commonly used in predictive models have been measured (Appendix III). For many sites in the database we assembled, no designation (reference vs. non-reference) was recorded, and some of these sites may also be reference quality based on either the professional judgement of biologists familiar with them or on map characteristics (*e.g.*, they are in wilderness areas or roadless areas). Therefore they have also been included in the list. Of these 206 potential reference sites, 102 are actually within one of the three park units (Table 5).

Table 5. Number of potential reference sites in different units within and near the GRYN.

Location	Sites
YELL	76
GRTE	26
BICA	1*
GYE (outside parks)	104**
TOTAL	207

*Although Crooked Creek has been designated as reference by some agencies, it does not appear to be of sufficient quality to be included in a list of reference sites for the GRYN as a whole. **Data were collected for the EMAP program in 2003 at a number of additional designated and potential reference sites in the GYE, but those data are not yet available. Therefore the total number of reference sites in the GYE outside of the parks is likely to be greater than 105.

Based on our analysis of the existing reference data and a consideration of the ecology and degree of human activity across the area, we recommend that a GRYN bioassessment program consist of two separate “sub-programs.” Because of their close proximity, as well as their similarity in ecology and water quality, the YELL and GRTE should be treated as a single unit. We also recommend that the GRYN make use of available reference data from the Greater Yellowstone Ecosystem (GYE) as a whole, rather than only those sites from within park boundaries. Because of its isolation, ecological dissimilarity, and distinct land use history, we feel that inclusion of BICA with YELL and GRTE is not appropriate. Because so few reference sites occur in and near BICA, we recommend that BICA streams be assessed with existing tools for the assessment of Wyoming streams that have been constructed for the Wyoming Division of Environmental Quality by the WCMAFE (predictive model) or TetraTech Inc. (multimetric). Taking this two-pronged approach will allow the GRYN to set stringent thresholds for both reference site quality and impairment in YELL/GRTE while assessing BICA streams within a more pragmatic framework.

Yellowstone and Grand Teton/Rockefeller Parkway

We identified 102 potential reference sites in YELL/GRTE (Table 5, Appendix III). Reynoldson & Wright (2000) suggest that 60-70 reference sites is the minimum number required to develop an adequate multivariate model, although models have been built using as few as 16 (Carlisle & Hawkins 1998). Therefore, 102 sites could in theory provide a reasonable reference site network. However, there are several reasons why this number is misleading in terms of the likely performance of the network. First, depending on how criteria for determining reference conditions in the GRYN are set, some of these potential reference sites will probably end up being rejected. For example, Polecat and Crayfish Creeks and the Madison and Firehole Rivers support large and expanding populations of New Zealand Mud Snails (NZMS), and may not be suitable. Furthermore, many of the existing potential reference sites are located in relatively close proximity to one another. A good example is Pacific Creek, where 5 potential reference sites are found within a couple of miles of each other. Samples taken within the same stream are not biologically independent of one another. Use of such samples does little to expand the range of natural variation in biological condition that the network is designed to represent, and can potentially bias assessments of some sites by overweighting expectations. Finally, it is clear that some stream types are underrepresented in this data set – most notably high elevation streams and geothermal streams. Taken together, these factors suggest that the existing potential reference site data in YELL/GRTE may not be adequate for the development of a bioassessment program. Although we may not need the 175-250 reference sites to adequately characterize a region the size of the GRYN that Reynoldson and Wright (2000) argue is desirable, we believe additional sites will be needed to achieve the high standards needed for the GRYN Program.

Operationally, there are two ways to add sites to the reference site network. First, the GRYN could embark on an accelerated program of reference site sampling to obtain sufficient additional sites within the parks. The alternative is to use existing reference site data from outside the park boundaries. Doing so would immediately and significantly expand the number of potential reference sites at no additional cost. For example, we identified at least 104 additional potential reference sites within the approximate traditional boundaries of the Greater Yellowstone Ecosystem (GYE). Adding these sites to the existing sites within park boundaries gives a total of at least 206 potential reference sites that could be used in the development of a GRYN bioassessment program (Figure 3, Appendix III). In addition to greatly expanding the pool of available sites, such an approach has other advantages. The GYE is considered to be the largest relatively intact ecosystem in the lower 48 states; as such, it is an area of critical importance, both ecologically and symbolically. Developing a single aquatic bioassessment model that could be applied throughout the GYE would greatly facilitate coordinated monitoring and management of aquatic resources in this ecologically important and unique area. Furthermore, such an approach would allow the GRYN to work cooperatively with other state and federal agencies in the region as mandated by the Vital Signs Program.

Even including available reference sites from the GYE as a whole may not provide adequate representation of the full range of natural variability in GRYN streams (or in GYE streams), and some additional sampling of reference sites is likely to be necessary. This sampling should be targeted at stream types and/or areas that are underrepresented in the list we have compiled. A comprehensive comparison of the distribution of sampled reference sites with the overall distribution of stream types in the GYE, or even in YELL/GRTE, is beyond the scope of this document, as it would require investing considerable resources to the compilation of a GIS-based database of all potential sites, both reference and non-reference, sampled and not sampled, throughout the region. Nevertheless, some general conclusions can be extracted from the available data.

From a purely geographic standpoint, there are several gaps that can be easily identified. Essentially, little or no sampling has been conducted in backcountry areas. In fact, the road network in YELL can be easily identified based simply on the distribution of sampling sites (Fig. 3). With some exceptions, backcountry sites will generally be of reference quality even given stringent criteria. We recommend therefore that supplemental reference site sampling be targeted to backcountry areas to the extent possible. This will also substantially increase scientific knowledge of important park resources. Five areas in particular should probably be emphasized: southeast YELL and the adjoining Teton Wilderness; southwest YELL, including the Pitchstone and Madison Plateaus; northeast YELL including the Absaroka Range and possibly the Mirror Plateau; northwest YELL including the Gallatin Range; and finally the Teton backcountry. In addition to improving the geographic distribution of reference sites, targeting these areas should expand the number of reference sites in two stream categories that appear to be underrepresented in the current data set: high altitude streams and geothermal streams that have not been invaded by NZMS.

Geothermal streams tend to have distinct water chemistry and thermal regimes and hence often support unique assemblages relative to nearby nongeothermal streams. This feature might suggest that geothermal streams in YELL/GRTE could not be successfully assessed using a bioassessment model that is largely based on data from nongeothermal streams. However, all that is required is that the range of geothermal influence on streams of interest be adequately represented in the reference site data set. This will require additional targeted sampling of geothermally influenced streams. Operationally, there are several ways to approach this. First, sites with more than some threshold density or number of geothermal sources upstream could be defined as “geothermal,” and sampled accordingly. An alternative to this categorical approach would be to include geothermal influence as a continuous variable, and to then select sites along a gradient of geothermal influence. This variable could either be defined by the number and proximity of upstream geothermal sources, or by a surrogate variable such as temperature or chloride concentration

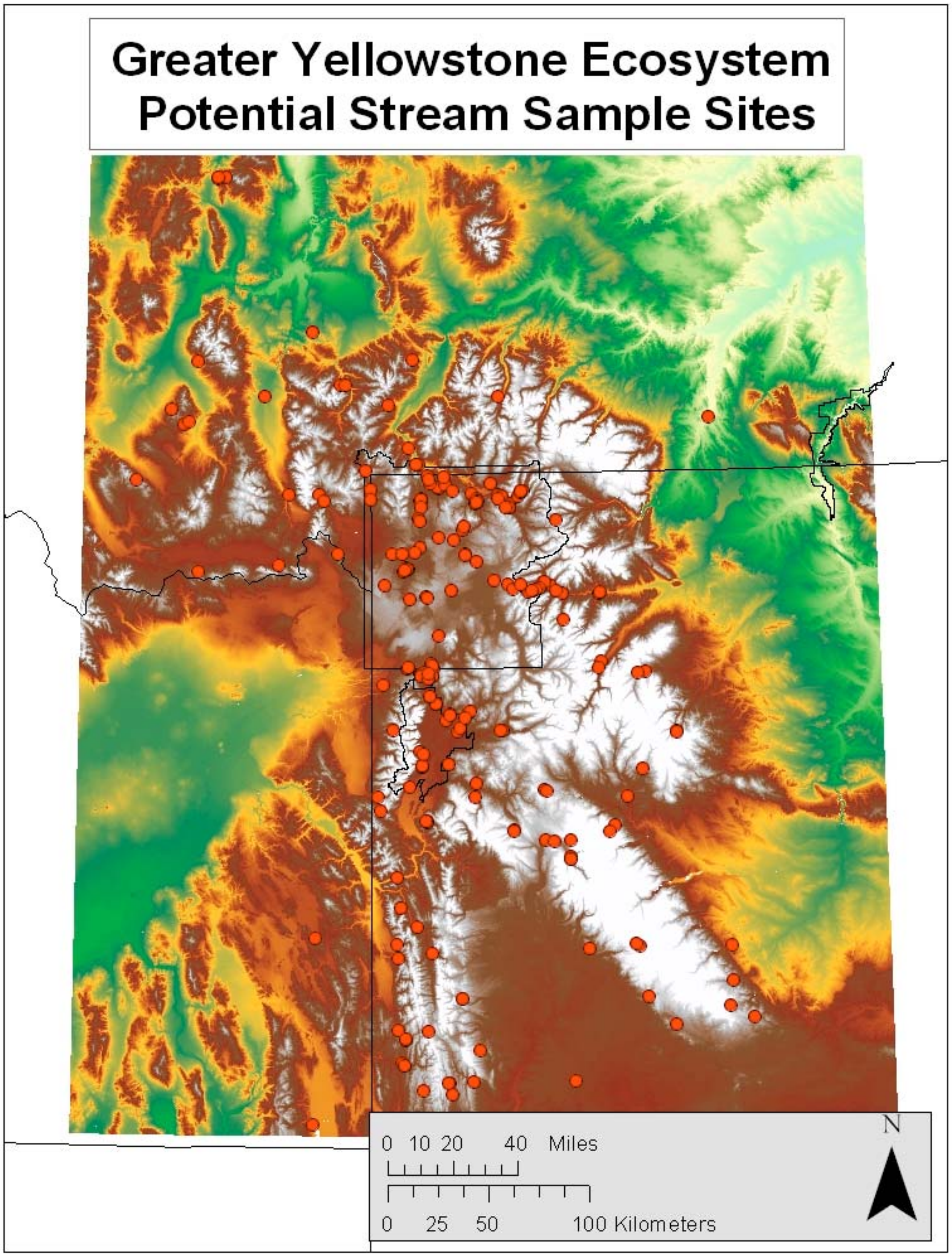

Figure 3. Locations of existing potential reference sites in the GYE.

Section IV

Development of a RIVPACS Model for the GRYN

Overview

Construction of a RIVPACS model involves 3 basic steps: (1) classification of the reference sites into biologically similar groups, (2) development of a statistical model to predict a new site's probability (P_g) of membership in each of the groups defined in (1), and (3) weighting of the frequencies of occurrence of taxa observed within each biotic group by the probabilities of a site's group membership (P_g) to estimate the site-specific probabilities (P_t) of detecting each of the taxa that were collected across all of the reference sites. These estimates of site-specific probabilities of detection are used to estimate E, the number of taxa expected at the site ($E = \sum P_t$). The statistical model is typically a discriminant functions model in which the predictor variables are environmental variables that are relatively invariant at a site (*e.g.*, latitude, elevation, stream slope, watershed area, catchment geology, longterm climatic conditions). Invariant variables are used to avoid predicting biota that would only occur if the habitat had been modified (*e.g.*, NO_3 concentration, stream temperature).

Assessments are based on comparisons of O, the number of taxa contributing to E that were collected, and are expressed as a ratio, O/E. Values of O/E near 1 imply reference quality conditions. Values < 1 imply biological degradation. In practice, the O/E value measured at an assessed site is compared against the distribution of O/E values derived from reference quality sites. This distribution typically has a mean of 1, but sampling and prediction error result in values for some reference sites falling above and below 1. More precise models will have a narrower range of reference site O/E scores. The precision of predictive models is typically expressed as the standard deviation of reference site O/E scores. Biological degradation is inferred if the O/E value for the site falls below (or above) a threshold value derived from the reference site O/E values. These threshold values have typically been set at the 10th and 90th percentiles, the 5th and 95th percentiles, or +/- 2 standard deviations of the reference site values. Choice of specific threshold values is typically based on considerations of both statistical and policy criteria.

The WCMAFE has developed web-based tools for running RIVPACS models. These tools are designed to allow users to employ region-specific models built by the WCMAFE to assess the biological condition of streams in a streamlined and user-friendly environment. Use of the tools is password protected to ensure the integrity of data. Once a model has been constructed by the WCMAFE, users enter two text-format data files and the model generates four output files. The two input files are a site-by-taxon occurrence matrix and a site-by-environmental predictor file. The four output files include (1) a test of whether the model can be appropriately applied to each assessed site (*i.e.*, are the environmental conditions at a given test site within the range of conditions represented by the set of reference sites used to construct the model), (2) a list of the O/E values estimated for each assessed site, (3) a site-by-taxon matrix containing the estimated probabilities of detection for each taxon at each site, and (4) a summary table that lists the mean probabilities of detection for all taxa collected at the assessed sites, the number of sites at which each taxon was expected (S_e), the number of sites at which each taxon was observed (S_o), and the ratio S_o/S_e, which measures the overall response of a taxon to whatever environmental alterations have occurred across the assessed sites. Values of $S_o/S_e < 1$ imply the taxon decreased in frequency of occurrence in response to environmental alterations (*i.e.*, sensitive taxa) and values > 1 imply the taxon increased in frequency of occurrence (*i.e.,* tolerant taxa).

Field collection techniques

RIVPACS models can be built and applied based on invertebrate data that are sampled by a variety of methods, but the methods must be consistent within the data set used to construct a given model. Ideally models would be based on as complete a sampling scheme as possible, which would require sampling over multiple seasons at each site. Although such sampling is possible and implemented in some programs (*e.g*., the United Kingdom), in many situations there are insufficient resources to undertake such an effort. Most applications of RIVPACS assessments (and IBI assessments) are based on samples taken at a single time, an approach we recommend that the GRYN follow. We also recommend that sampling target a single habitat (riffles or fastest water) rather than multiple habitats. Although sampling multiple habitats may generate a larger taxa list, environmental alterations at a site may result in changes in the proportion of habitat types at that site, which could potentially confound assessments. We also recommend that invertebrates be collected from eight 30-by-30 cm quadrats with a Surber-type sampler equipped with 500 μm mesh net to be consistent with most sampling protocols in the western United States. Samples should be pre-processed in the field to reduce the bulk of samples following the procedures described in our field protocols and samples sorted and identified in the laboratory.

Laboratory procedures

Laboratory processing of samples must be conducted following rigorous Quality Assurance (QA) procedures to minimize errors, and samples should be processed to meet the performance criteria required to generate reproducible assessments with acceptable error. In general, we recommend that 600 individuals be subsampled in the lab and that invertebrates be identified to the lowest practical level as described by the informal agreements among major taxonomy labs in the region. Unless the GYRN has reasons to use other laboratories, we recommend use of the BLM National Aquatic Monitoring Laboratory (The BugLab) to maintain as consistent a taxonomy as possible. Many of the existing reference site data in the GYE were developed and collated by the BugLab. However, if the GRYN wishes to include genus/species level identifications of chironomid midges, other labs may be more appropriate.

Other issues

There are a large number of potential environmental variables that might be useful as predictor variables in RIVPACS models. These environmental data include both local scale factors such as latitude, longitude, elevation, slope, substrate composition and water chemistry and larger scale GIS-derived data such as watershed area, geology, ecoregion, drainage density, and temperature and precipitation regime. Procedures for collecting the most frequently used local-scale data are described in our sampling protocols. Appropriate watershed-scale data for GRYN streams can be easily extracted by the WCMAFE or other suitably equipped GIS labs. These data have already been obtained for most of the potential reference sites listed in Appendix III.

Although they are potentially important for conservation purposes, rare taxa contribute little to biological assessments because they are so difficult to predict. In this sense, their inclusion in assessments tends to both increase errors and decrease the precision of assessments. For these reasons, we typically base assessments only on those taxa with estimated site-specific probabilities of detection > 0.5 (Hawkins *et al*. 2000, Simpson and Norris 2001). However, our software calculates O/E ratios based on both $P_t > 0$ and $P_t > 0.5$, and the user has the choice of which measure to use. WCMAFE staff can help the GRYN determine the appropriate probability of detection level.

Role of the WCMAFE

As the GRYN moves toward developing and implementing a bioassessment program, decisions will need to be made regarding who conducts field sampling, processes samples, and builds and runs bioassessment tools. The WCMAFE is interested in working with the GRYN in whatever capacity is most useful in realizing these goals. Our responsibilities could range from initial site selection, to sample collection and processing, to data analysis or we could mostly play an advisory role. We propose that these decisions be made once the GRYN staff have had a chance to read and consider this report. We can arrange a visit to the GRYN at a mutually suitable date to discuss any issues or questions that the GRYN staff may have regarding this report and our recommendations.

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Appendix I

Compilation of GRYN Stream Macroinvertebrate Samples

Compilation of GRYN Stream Macroinvertebrate Samples

Sample ID	Stream/Site Name	Park unit	Year collected	Latitude (DD)	Longitude (DD)	Collector	Sample Type	ID Lab
6279500	Big Horn River	BICA	1999	44.7586	-108.1815	NAWQA	Riffle	USGS
BCC10913	Crooked Creek	BICA	2003	44.9637	-108.2778	YCR	Riffle	Wisseman
CROOKED-1	Crooked Creek	BICA	1998	45.0433	-108.3853	BLM	Multiple	BUGLAB
EPA01:429	Crooked Creek	BICA	2001	45.1334	-108.4278	HAWKINS	Riffle	BUGLAB
EPA01:429	Crooked Creek	BICA	2001	45.1334	-108.4278	HAWKINS	Multiple	BUGLAB
WYDEQ15	Crooked Creek	BICA	2003	44.9634	108.2792	WYDEQ	Riffle	Wisseman
BLO10913	Layout Creek	BICA	2003	45.0848	-108.2650	YCR	Riffle	Wisseman
BTC10912	North Fork Trail Creek	BICA	2003	45.1014	-108.2210	YCR	Riffle	Wisseman
BTC20912	North Fork Trail Creek	BICA	2003	45.1076	-108.2329	YCR	Riffle	Wisseman
ECO-6	Arizona Creek	GRTE	2002	43.9765	-110.6427	HAWKINS	Riffle	BUGLAB
YNPWYO-041	Arizona Creek	GRTE	2001	43.9765	-110.6427	HAWKINS	Riffle	BUGLAB
GAZ10829	Arizona Creek	GRTE	2003	43.9723	-110.6462	YCR	Riffle	Wisseman
GAZ11021	Arizona Creek	GRTE	2003	43.9723	-110.6462	YCR	Riffle	Wisseman
GAZ20829	Arizona Creek	GRTE	2003	43.9742	-110.6441	YCR	Riffle	Wisseman
GAZ21017	Arizona Creek	GRTE	2003	43.9742	-110.6441	YCR	Riffle	Wisseman
HALL8	Bailey Creek	GRTE	2000	43.9794	-110.6214	HALL	Hyporheic	Hall
YNPWYO-043	Cascade Creek	GRTE	2001	43.7651	-110.7493	HAWKINS	Riffle	BUGLAB
GCT10904	Cottonwood Creek	GRTE	2003	43.6980	-110.7292	YCR	Riffle	Wisseman
GCT11022	Cottonwood Creek	GRTE	2003	43.6980	-110.7292	YCR	Riffle	Wisseman
GCT20904	Cottonwood Creek	GRTE	2003	43.6997	-110.7295	YCR	Riffle	Wisseman
GCT21022	Cottonwood Creek	GRTE	2003	43.6997	-110.7295	YCR	Riffle	Wisseman
GCT30904	Cottonwood Creek	GRTE	2003	43.7500	-110.7246	YCR	Riffle	Wisseman
GCT31022	Cottonwood Creek	GRTE	2003	43.7500	-110.7246	YCR	Riffle	Wisseman
GDT20905	Ditch Creek	GRTE	2003	43.6827	-110.5834	YCR	Riffle	Wisseman
GDT21018	Ditch Creek	GRTE	2003	43.6827	-110.5834	YCR	Riffle	Wisseman
HALL11	Ditch Creek	GRTE	2000	43.6631	-110.6311	HALL	Hyporheic	Hall
YNPWYO-044	Granite Creek	GRTE	2001	43.6033	-110.8058	HAWKINS	Riffle	BUGLAB
YNPWYO-032	Joey Ramone Creek	GRTE	2001	44.0991	-110.7348	HAWKINS	Riffle	BUGLAB
YNPWYO-032	Joey Ramone Creek	GRTE	2001	44.0991	-110.7348	HAWKINS	Multiple	BUGLAB
HT-27	Kelly Warm Spring (Nr Jackson)	GRTE	1998	43.6448	-110.6277	BUGLAB	Riffle	BUGLAB
YNPWYO-042	Little Taggart Creek	GRTE	2001	43.6950	-110.7339	HAWKINS	Riffle	BUGLAB
HALL9	Lizard Creek	GRTE	2000	44.0089	-110.6792	HALL	Hyporheic	Hall
GLZ10906	Lizard Creek	GRTE	2003	44.0067	-110.6809	YCR	Riffle	Wisseman
GLZ11025	Lizard Creek	GRTE	2003	44.0067	-110.6809	YCR	Riffle	Wisseman
GLZ20906	Lizard Creek	GRTE	2003	44.0069	-110.6808	YCR	Riffle	Wisseman
GLZ21025	Lizard Creek	GRTE	2003	44.0069	-110.6808	YCR	Riffle	Wisseman

HALL5	North Moran Creek	GRTE	2000	43.8856	-110.7253	HALL	Hyporheic	Hall
HALL12	Pacific Creek	GRTE	2000	43.8697	-110.4936	HALL	Hyporheic	Hall
PACIFIC-01	Pacific Creek	GRTE	2000	43.9278	-110.4519	BTNF	Riffle	BUGLAB
PACIFIC-01	Pacific Creek	GRTE	2000	43.9278	-110.4519	BTNF	Riffle	BUGLAB
YNPWYO-001	Pacific Creek	GRTE	2001	43.9426	-110.4318	HAWKINS	Riffle	BUGLAB
YNPWYO-001	Pacific Creek	GRTE	2001	43.9426	-110.4318	HAWKINS	Multiple	BUGLAB
GPC10903	Pacific Creek	GRTE	2003	43.8511	-110.5159	YCR	Riffle	Wisseman
GPC11016	Pacific Creek	GRTE	2003	43.8511	-110.5159	YCR	Riffle	Wisseman
GPC20830	Pacific Creek	GRTE	2003	43.8701	-110.4996	YCR	Riffle	Wisseman
GPC21016	Pacific Creek	GRTE	2003	43.8701	-110.4996	YCR	Riffle	Wisseman
GPC30830	Pacific Creek	GRTE	2003	43.9138	-110.4652	YCR	Riffle	Wisseman
GPC31016	Pacific Creek	GRTE	2003	43.9138	-110.4652	YCR	Riffle	Wisseman
HALL10	Pilgrim Creek	GRTE	2000	43.9192	-110.5653	HALL	Hyporheic	Hall
GPG10828	Pilgrim Creek	GRTE	2003	43.9041	-110.5867	YCR	Riffle	Wisseman
GPG11017	Pilgrim Creek	GRTE	2003	43.9041	-110.5867	YCR	Riffle	Wisseman
GPG20828	Pilgrim Creek	GRTE	2003	43.9239	-110.5633	YCR	Riffle	Wisseman
GPG21017	Pilgrim Creek	GRTE	2003	43.9239	-110.5633	YCR	Riffle	Wisseman
EPA01:547	Polecat Creek	GRTE	2001	44.1119	-110.7009	HAWKINS	Multiple	BUGLAB
EPA01:547	Polecat Creek	GRTE	2001	44.1119	-110.7009	HAWKINS	Riffle	BUGLAB
HALL4	Polecat Creek	GRTE	2001	44.1107	-110.6901	HALL	Macrophyte	HALL
GSN10829	Snake River	GRTE	2003	44.0991	-110.6667	YCR	Riffle	Wisseman
GSN11025	Snake River	GRTE	2003	44.0991	-110.6667	YCR	Riffle	Wisseman
YNP-112	Snake River	GRTE	2000	44.1314	-110.6592	HAWKINS	Riffle	BUGLAB
13010065	Snake River - Flagg Ranch	GRTE	1999	44.0892	-110.6939	NAWQA	Riffle	USGS
MRW3	Snake River - Flagg Ranch	GRTE	1993	44.1008	-110.6695	WYDEQ	Riffle	Wisseman
13013650	Snake River - Moose	GRTE	1999	??	??	NAWQA	Riffle	USGS
HT-31	Snake River - Jackson Dam	GRTE	1998	43.8596	-110.5651	BUGLAB	Riffle	BUGLAB
GSP10905	Spread Creek	GRTE	2003	43.7903	-110.5377	YCR	Riffle	Wisseman
GSP11021	Spread Creek	GRTE	2003	43.7903	-110.5377	YCR	Riffle	Wisseman
GSP20903	Spread Creek	GRTE	2003	43.7720	-110.4817	YCR	Riffle	Wisseman
GSP21021	Spread Creek	GRTE	2003	43.7720	-110.4817	YCR	Riffle	Wisseman
HALL6	Two Ocean Lake Creek	GRTE	2000	43.8750	-110.4892	HALL	Hyporheic	Hall
YNPWYO-002	W. Fk. Pilgrim Creek	GRTE	2001	43.9310	-110.5603	HAWKINS	Riffle	BUGLAB
YNPWYO-002	W. Fk. Pilgrim Creek	GRTE	2001	43.9310	-110.5603	HAWKINS	Multiple	BUGLAB
HALL7	Wilson Creek	GRTE	2000	43.6494	-110.7531	HALL	Hyporheic	Hall
YNP-070	Amethyst Creek	YELL	2000	44.8842	-110.2532	HAWKINS	Riffle	BUGLAB
YNP-072	Amphitheater Creek	YELL	2000	44.9194	-110.0941	HAWKINS	Riffle	BUGLAB
MRW58	Antelope Creek	YELL	1994	44.8694	-110.3836	WYDEQ	Riffle	Wisseman
YAT10814	Antelope Creek	YELL	2003	44.8895	-110.3854	YCR	Riffle	Wisseman

YAT11008	Antelope Creek	YELL	2003	44.8895	-110.3854	YCR	Riffle	Wisseman
YAT20813	Antelope Creek	YELL	2003	44.8786	-110.3813	YCR	Riffle	Wisseman
YAT21008	Antelope Creek	YELL	2003	44.8786	-110.3813	YCR	Riffle	Wisseman
YAT30814	Antelope Creek	YELL	2003	44.8699	-110.3856	YCR	Riffle	Wisseman
YAT31008	Antelope Creek	YELL	2003	44.8699	-110.3856	YCR	Riffle	Wisseman
YNP-009	Antelope Creek tributary	YELL	2000	44.8623	-110.3970	HAWKINS	Riffle	BUGLAB
YNPWYO-017	Antelope Creek tributary	YELL	2001	44.4770	-110.5465	HAWKINS	Riffle	BUGLAB
YNPWYO-038	Aster Creek	YELL	2001	44.2789	-110.6243	HAWKINS	Riffle	BUGLAB
YNPWYO-038	Aster Creek	YELL	2001	44.2789	-110.6243	HAWKINS	Multiple	BUGLAB
WWYP99-0533	Blacktail Deer Creek	YELL	2000	44.9815	-110.5923	EMAP	Riffle	
MRWI25	Blacktail Deer Creek	YELL	1994	44.9569	-110.5861	WYDEQ	Riffle	Wisseman
YNP-016	Blacktail Deer Creek	YELL	2000	44.9503	-110.5867	HAWKINS	Riffle	BUGLAB
WWYP99-0608	Blacktail Deer tributary	YELL	2001	44.9211	-110.5373	EMAP	Multiple	
WWYP99-0608	Blacktail Deer tributary	YELL	2001	44.9211	-110.5373	EMAP	Riffle	
YNPWYO-040	Canyon Creek	YELL	2001	44.6472	-110.7703	HAWKINS	Riffle	BUGLAB
YNP-117	Chalcedony Creek	YELL	2000	44.8473	-110.2054	HAWKINS	Riffle	BUGLAB
YNP-055	Clear Creek	YELL	2000	44.4850	-110.1648	HAWKINS	Riffle	BUGLAB
YNPWYO-036	Crayfish Creek	YELL	2001	44.1531	-110.6782	HAWKINS	Riffle	BUGLAB
YNPWYO-036	Crayfish Creek	YELL	2001	44.1531	-110.6782	HAWKINS	Multiple	BUGLAB
YNP-054	Cub Creek	YELL	2000	44.5051	-110.1938	HAWKINS	Riffle	BUGLAB
YNP-040	DeLacy Creek	YELL	2000	44.4477	-110.7005	HAWKINS	Riffle	BUGLAB
ECO-4	Elk Antler Creek	YELL	2002	44.6379	-110.4596	HAWKINS	Riffle	BUGLAB
YNP-075	Elk Antler Creek	YELL	2000	44.6379	-110.4596	HAWKINS	Riffle	BUGLAB
ECO-5	Falls River	YELL	2002	44.1388	-110.8152	HAWKINS	Riffle	BUGLAB
EPA01:548	Falls River	YELL	2001	44.1388	-110.8152	HAWKINS	Multiple	BUGLAB
EPA01:548	Falls River	YELL	2001	44.1388	-110.8152	HAWKINS	Riffle	BUGLAB
MRW42	Falls River	YELL	1993	44.1347	-110.8208	WYDEQ	Riffle	Wisseman
HALL1	Firehole River	YELL	2001	44.5657	-110.8426	HALL	Riffle	HALL
HALL2	Firehole River	YELL	2001	44.5679	-110.8401	HALL	Macrophyte	HALL
ECO-13	Firehole River, Upper	YELL	2002	44.4379	-110.8041	HAWKINS	Riffle	BUGLAB
YNP-037	Firehole River, Upper	YELL	2000	44.4379	-110.8041	HAWKINS	Riffle	BUGLAB
YNP-022	Gallatin River	YELL	2000	44.9287	-111.0467	HAWKINS	Riffle	BUGLAB
YGD10821	Gardner River	YELL	2003	44.9893	-110.6907	YCR	Riffle	Wisseman
YGD11113	Gardner River	YELL	2003	44.9893	-110.6907	YCR	Riffle	Wisseman
YGD20821	Gardner River	YELL	2003	44.9723	-110.6826	YCR	Riffle	Wisseman
YGD21107	Gardner River	YELL	2003	44.9723	-110.6826	YCR	Riffle	Wisseman
YGD30812	Gardner River	YELL	2003	44.8873	-110.7333	YCR	Riffle	Wisseman
YGD31106	Gardner River	YELL	2003	44.8873	-110.7333	YCR	Riffle	Wisseman
YNP-101	Gardner River	YELL	2000	44.9563	-110.6803	HAWKINS	Riffle	BUGLAB

HALL3	Gibbon River	YELL	2001	44.6413	-110.8556	HALL	Riffle	HALL
ECO-12	Gibbon River, lower	YELL	2002	44.6708	-110.7422	HAWKINS	Riffle	BUGLAB
YNP-102	Gibbon River, lower	YELL	2000	44.6708	-110.7422	HAWKINS	Riffle	BUGLAB
YNP-108	Gibbon River, upper	YELL	2000	44.7122	-110.6244	HAWKINS	Riffle	BUGLAB
YNP-025	Grayling Creek	YELL	2000	44.8852	-111.0525	HAWKINS	Riffle	BUGLAB
YNP-039	Herron Creek	YELL	2000	44.4494	-110.7081	HAWKINS	Riffle	BUGLAB
ECO-11	Unnamed Creek, Lamar trib	YELL	2002	44.8441	-110.1853	HAWKINS	Riffle	BUGLAB
YNP-113	Unnamed Creek, Lamar trib	YELL	2000	44.8441	-110.1853	HAWKINS	Riffle	BUGLAB
YNP-071	Lamar River	YELL	2000	44.8464	-110.1841	HAWKINS	Riffle	BUGLAB
MRWI24	Lamar River - lower	YELL	1994	44.9008	-110.2556	WYDEQ	Riffle	Wisseman
MRW41	Lamar River - upper	YELL	1994	44.8608	-110.1864	WYDEQ	Riffle	Wisseman
YNP-060	Landslide Creek	YELL	2000	45.0376	-110.7473	HAWKINS	Riffle	BUGLAB
MRW44	Lava Creek	YELL	1994	44.9356	-110.6242	WYDEQ	Riffle	Wisseman
YNP-005	Lava Creek	YELL	2000	44.9401	-110.6290	HAWKINS	Riffle	BUGLAB
YNPWYO-039	Lewis River	YELL	2001	44.1421	-110.6646	HAWKINS	Riffle	BUGLAB
YNPWYO-039	Lewis River	YELL	2001	44.1421	-110.6646	HAWKINS	Multiple	BUGLAB
YNP-106	Lost Creek	YELL	2000	44.9105	-110.4181	HAWKINS	Riffle	BUGLAB
YNP-103	Madison River	YELL	2000	44.6438	-110.9187	HAWKINS	Riffle	BUGLAB
ECO-8	Middle Creek	YELL	2002	44.4744	-110.0450	HAWKINS	Riffle	BUGLAB
MRW45	Middle Creek	YELL	1992	44.4778	-110.0356	WYDEQ	Riffle	Wisseman
YMC10819	Middle Creek	YELL	2003	44.4883	-110.0036	YCR	Riffle	Wisseman
YMC11009	Middle Creek	YELL	2003	44.4883	-110.0036	YCR	Riffle	Wisseman
YMC20819	Middle Creek	YELL	2003	44.4830	-110.0211	YCR	Riffle	Wisseman
YMC21009	Middle Creek	YELL	2003	44.4830	-110.0211	YCR	Riffle	Wisseman
YNP-057	Middle Creek	YELL	2000	44.4744	-110.0450	HAWKINS	Riffle	BUGLAB
YNP10822	Nez Perce Creek	YELL	2003	44.5793	-110.8308	YCR	Riffle	Wisseman
YNP11007	Nez Perce Creek	YELL	2003	44.5793	-110.8308	YCR	Riffle	Wisseman
YNP20822	Nez Perce Creek	YELL	2003	44.5729	-110.8184	YCR	Riffle	Wisseman
YNP21007	Nez Perce Creek	YELL	2003	44.5729	-110.8184	YCR	Riffle	Wisseman
YNPWYO-037	Nez Perce Creek	YELL	2001	44.5737	-110.8144	HAWKINS	Riffle	BUGLAB
YNPWYO-037	Nez Perce Creek	YELL	2001	44.5737	-110.8144	HAWKINS	Multiple	BUGLAB
MRW37	Obsidian Creek	YELL	1994	44.8794	-110.7367	WYDEQ	Riffle	Wisseman
YNP-058	Obsidian Creek	YELL	2000	44.8787	-110.7382	HAWKINS	Riffle	BUGLAB
YOB10806	Obsidian Creek	YELL	2003	44.8852	-110.7327	YCR	Riffle	Wisseman
YOB11107	Obsidian Creek	YELL	2003	44.8852	-110.7327	YCR	Riffle	Wisseman
YOB20807	Obsidian Creek	YELL	2003	44.8520	-110.7368	YCR	Riffle	Wisseman
YOB21106	Obsidian Creek	YELL	2003	44.8520	-110.7368	YCR	Riffle	Wisseman
YOB30807	Obsidian Creek	YELL	2003	44.7989	-110.7460	YCR	Riffle	Wisseman
YOB31112	Obsidian Creek	YELL	2003	44.7989	-110.7460	YCR	Riffle	Wisseman

YOB40813	Obsidian Creek	YELL	2003	44.7873	-110.7397	YCR	Riffle	Wisseman
YOB41112	Obsidian Creek	YELL	2003	44.7873	-110.7397	YCR	Riffle	Wisseman
YNP-109	Otter Creek	YELL	2000	44.7007	-110.5287	HAWKINS	Riffle	BUGLAB
MRW62	Pebble Creek	YELL	1997	44.9178	-110.1106	WYDEQ	Riffle	Wisseman
YNP-073	Pebble Creek	YELL	2000	44.9215	-110.1124	HAWKINS	Riffle	BUGLAB
YPB10816	Pebble Creek	YELL	2003	44.9137	-110.1117	YCR	Riffle	Wisseman
YPB20816	Pebble Creek	YELL	2003	44.9173	-110.1123	YCR	Riffle	Wisseman
YNP-012	Rose Creek	YELL	2000	44.8997	-110.2282	HAWKINS	Riffle	BUGLAB
YNP-053	Sedge Creek	YELL	2000	44.5230	-110.2789	HAWKINS	Riffle	BUGLAB
ECO-10	Slough Creek	YELL	2002	44.9523	-110.3034	HAWKINS	Riffle	BUGLAB
MRW38	Slough Creek	YELL	1994	44.9533	-110.2994	WYDEQ	Riffle	Wisseman
YNP-066	Slough Creek	YELL	2000	44.9523	-110.3034	HAWKINS	Riffle	BUGLAB
MRW39	Snake River - Yellowstone	YELL	1995	44.1367	-110.6642	WYDEQ	Riffle	Wisseman
YSB10816	Soda Butte Creek	YELL	2003	44.8690	-110.1655	YCR	Riffle	Wisseman
YSB11105	Soda Butte Creek	YELL	2003	44.8690	-110.1655	YCR	Riffle	Wisseman
YSB20820	Soda Butte Creek	YELL	2003	44.9323	-110.0823	YCR	Riffle	Wisseman
YSB30820	Soda Butte Creek	YELL	2003	45.0007	-110.0110	YCR	Riffle	Wisseman
6187915	Soda Butte Creek	YELL	1999	45.0030	-110.0019	NAWQA	Riffle	
MRWI30	Soda Butte Creek	YELL	1994	44.9928	-110.0519	WYDEQ	Riffle	Wisseman
EPA01:549	Solfatara Creek	YELL	2001	44.7487	-110.4757	HAWKINS	Multiple	BUGLAB
EPA01:549	Solfatara Creek	YELL	2001	44.7487	-110.4757	HAWKINS	Riffle	BUGLAB
YNP-019	Specimen Creek	YELL	2000	45.0127	-111.0785	HAWKINS	Riffle	BUGLAB
YNP-104	Stephens Creek	YELL	2000	45.0371	-110.7613	HAWKINS	Riffle	BUGLAB
YNP-110	Sulphur Creek, South Fork	YELL	2000	44.7663	-110.4658	HAWKINS	Riffle	BUGLAB
YNP-105	Tower Creek	YELL	2000	44.8874	-110.3957	HAWKINS	Riffle	BUGLAB
MRWI31	Trout Creek	YELL	2002	44.6414	-110.4575	WYDEQ	Riffle	Wisseman
YNP-011	Trout Lake Stream	YELL	2000	44.8987	-110.1251	HAWKINS	Riffle	BUGLAB
YUT10819	Unnamed Tributary to Middle Cr.	YELL	2003	44.4767	-110.0462	YCR	Riffle	Wisseman
YUT21009	Unnamed Tributary to Middle Cr.	YELL	2003	44.4767	-110.0462	YCR	Riffle	Wisseman
ECO-9	Upper Tributary to Middle Creek	YELL	2002	44.4691	-110.0685	HAWKINS	Riffle	BUGLAB
YNP-115	Upper Tributary to Middle Creek	YELL	2000	44.4691	-110.0685	HAWKINS	Riffle	BUGLAB
YNP-051	Yellowstone River	YELL	2000	44.6089	-110.3886	HAWKINS	Riffle	BUGLAB

Appendix II

Compilation of Unique Taxa Collected from GRYN Streams and Rivers

Compilation of Unique Taxa Collected from BICA Streams

Unique Species Collected from BICA Streams

Taxonomic Group	Species	Number of Observations
Diptera	*Cricotopus Bicinctus Group*	1
Diptera	*Tvetenia Bavarica Group*	3
Ephemeroptera	*Baetis tricaudatus*	4
Ephemeroptera	*Drunella doddsi*	1
Ephemeroptera	*Tricorythodes minutus*	1
Plecoptera	*Hesperoperla pacifica*	4
Plecoptera	*Zapada cinctipes*	3
Trichoptera	*Rhyacophila narvae*	1

Unique Genera Collected from BICA Streams

Taxonomic Group	Genus	Number of Observations
Coleoptera	Helichus	1
Coleoptera	Heterlimnius	3
Coleoptera	Narpus	2
Coleoptera	Optioservus	1
Coleoptera	Postelichus	2
Diptera	Antoch	1
Diptera	Apedilum	1
Diptera	Brillia	2
Diptera	Caloparyphus	2
Diptera	Chelifera	1
Diptera	Corynoneura	2
Diptera	Diamesa	1
Diptera	Dicranota	3
Diptera	Dicrotendipes	1
Diptera	Epoicocladius	1
Diptera	Eukiefferiella	4
Diptera	Heleniella	1
Diptera	Hemerodromia	1
Diptera	Limnophora	2
Diptera	Limnophyes	1
Diptera	Micropsectra	3
Diptera	Ormosia	1

Unique Genera Collected from BICA Streams, cont.

Taxonomic Group	Genus	Number of Observations
Diptera	Orthocladius	3
Diptera	Pagastia	1
Diptera	Parakiefferiella	1
Diptera	Paramerina	1
Diptera	Parametriocnemus	2
Diptera	Parorthocladius	1
Diptera	Prodiamesa	1
Diptera	Prosimulium	1
Diptera	Pseudosmittia	1
Diptera	Psilometriocnemus	1
Diptera	Rheocricotopus	1
Diptera	Rheotanytarsus	1
Diptera	Simulium	3
Diptera	Tanytarsus	2
Diptera	Tipula	3
Diptera	Zavrelimyia	1
Ephemeroptera	Acentrella	1
Ephemeroptera	Ameletus	1
Ephemeroptera	Cinygmula	2
Ephemeroptera	Epeorus	1
Ephemeroptera	Paraleptophlebia	1
Non Insect	Acari	2
Non Insect	Hyalella	1
Non Insect	Oligochaeta	4
Non Insect	Turbellaria	1
Odonata	Argia	1
Plecoptera	Isoperla	1
Plecoptera	Kogotus	1
Plecoptera	Malenka	2
Plecoptera	Sweltsa	1
Trichoptera	Hesperophylax	1
Trichoptera	Hydropsyche	3
Trichoptera	Hydroptila	2
Trichoptera	Neothremma	1
Trichoptera	Ochrotrichia	1

Compilation of Unique Taxa Collected from GRTE Streams

Unique Species Collected from GRTE Streams

Taxonomic Group	Species	Number of Observations
Coleoptera	*Cleptelmis addenda*	4
Diptera	*Cricotopus Bicinctus Group*	6
Diptera	*Cricotopus nostococladius*	16
Diptera	*Cricotopus Trifascia Group*	1
Diptera	*Eukiefferiella Devonica Group*	3
Diptera	*Potthastia Gaedii Group*	4
Diptera	*Potthastia Longimana Group*	3
Diptera	*Tvetenia Bavarica Group*	22
Diptera	*Tvetenia Vitracies Group*	2
Ephemeroptera	*Acentrella insignificans*	1
Ephemeroptera	*Acentrella turbida*	20
Ephemeroptera	*Attenella margarita*	2
Ephemeroptera	*Baetis tricaudatus*	26
Ephemeroptera	*Diphetor hageni*	19
Ephemeroptera	*Drunella coloradensis/flavilinea*	10
Ephemeroptera	*Drunella doddsi*	34
Ephemeroptera	*Drunella grandis*	20
Ephemeroptera	*Drunella spinifera*	4
Ephemeroptera	*Epeorus albertae*	4
Ephemeroptera	*Ephemerella inermis*	2
Ephemeroptera	*Paraleptophlebia bicornuta*	3
Ephemeroptera	*Serratella tibialis*	11
Ephemeroptera	*Timpanoga hecuba*	2
Non Insect	*Hyalella azteca*	
Non Insect	*Margatifera falcata*	
Plecoptera	*Claassenia sabulosa*	13
Plecoptera	*Hesperoperla pacifica*	19
Plecoptera	*Pteronarcella badia*	2
Plecoptera	*Pteronarcys californica*	4
Plecoptera	*Zapada cinctipes*	22
Plecoptera	*Zapada columbiana*	1
Plecoptera	*Zapada Oregonensis Group*	2
Trichoptera	*Amiocentrus aspilus*	15
Trichoptera	*Arctopsyche grandis*	13
Trichoptera	*Brachycentrus americanus*	27
Trichoptera	*Brachycentrus occidentalis*	7
Trichoptera	*Chyranda centralis*	2

Unique Species Collected from GRTE Streams, cont.

Taxonomic Group	Species	Number of Observations
Trichoptera	*Lepidostoma cascadense*	7
Trichoptera	*Lepidostoma Pluviale Group*	26
Trichoptera	*Parapsyche elsis*	2
Trichoptera	*Rhyacophila Betteni Group*	1
Trichoptera	*Rhyacophila brunnea*	2
Trichoptera	*Rhyacophila Coloradensis Group*	11
Trichoptera	*Rhyacophila narvae*	4

Unique Genera Collected from GRTE Streams

Taxonomic Group	Genus	Number of Observations
Coleoptera	Heterlimnius	10
Coleoptera	Lara	3
Coleoptera	Narpus	4
Coleoptera	Optioservus	25
Coleoptera	Oreodytes	2
Coleoptera	Zaitzevia	14
Diptera	Abiskomyia	1
Diptera	Agathon	5
Diptera	Antocha	6
Diptera	Apedilum	2
Diptera	Atherix	26
Diptera	Brillia	8
Diptera	Caloparyphus	1
Diptera	Cardiocladius	3
Diptera	Chaetocladius	5
Diptera	Chironomus	1
Diptera	Chelifera	6
Diptera	Cladotanytarsus	4
Diptera	Clinocera	8
Diptera	Corynoneura	6
Diptera	Diamesa	6
Diptera	Dicranota	15
Diptera	Dixa	1
Diptera	Glutops	1
Diptera	Heleniella	2
Diptera	Hexatoma	29

Unique Genera Collected from GRTE Streams, cont.

Taxonomic Group	Genus	Number of Observations
Diptera	Larsia	4
Diptera	Limnophila	1
Diptera	Limnophora	2
Diptera	Limnophyes	1
Diptera	Meringodixa	1
Diptera	Micropsectra	23
Diptera	Microtendipes	2
Diptera	Nanocladius	1
Diptera	Nostococladius	1
Diptera	Oreogeton	1
Diptera	Pagastia	4
Diptera	Paracladopelma	3
Diptera	Parakiefferiella	3
Diptera	Parametriocnemus	8
Diptera	Parorthocladius	1
Diptera	Pericoma	21
Diptera	Phaenopsectra	1
Diptera	Philorus	1
Diptera	Polypedilum	8
Diptera	Probezzia	3
Diptera	Prosimulium	1
Diptera	Psectrocladius	2
Diptera	Pseudochironomus	1
Diptera	Pseudodiamesa	1
Diptera	Pseudosmittia	2
Diptera	Ptychoptera	1
Diptera	Radotanypus	2
Diptera	Rhabdomastix	1
Diptera	Rheocricotopus	15
Diptera	Rheotanytarsus	9
Diptera	Simulium	33
Diptera	Stempellina	5
Diptera	Stempellinella	2
Diptera	Stictochironomus	3
Diptera	Stilocladius	1
Diptera	Sublettea	12
Diptera	Symposiocladius	1
Diptera	Synorthocladius	4
Diptera	Tanyderidae	1
Diptera	Tanytarsus	21

Unique Genera Collected from GRTE Streams, cont.

Taxonomic Group	Genus	Number of Observations
Diptera	Thienemanniella	1
Diptera	Tipula	8
Diptera	Wiedemannia	7
Diptera	Zavrelimyia	2
Ephemeroptera	Acentrella	10
Ephemeroptera	Ameletus	17
Ephemeroptera	Caenis	1
Ephemeroptera	Centroptilum	3
Ephemeroptera	Cinygma	2
Ephemeroptera	Cinygmula	30
Ephemeroptera	Rhithrogena	30
Ephemeroptera	Tricorythodes	2
Megaloptera	Sialis	2
Non Insect	Acari	30
Non Insect	Fossaria	1
Non Insect	Physella	3
Non Insect	Pisidium	3
Odonata	Argia	1
Odonata	Ophiogomphus	1
Plecoptera	Cultus	3
Plecoptera	Doroneuria	14
Plecoptera	Isoperla	13
Plecoptera	Kogotus	1
Plecoptera	Malenka	2
Plecoptera	Megarcys	6
Plecoptera	Paraperla	2
Plecoptera	Rickera	1
Plecoptera	Skwala	23
Plecoptera	Sweltsa	39
Trichoptera	Agraylea	3
Trichoptera	Agapetus	3
Trichoptera	Anagapetus	1
Trichoptera	Amphicosmoecus	1
Trichoptera	Apatania	32
Trichoptera	Arctopsyche	6
Trichoptera	Ceraclea	2
Trichoptera	Cheumatopsyche	6
Trichoptera	Dicosmoecus	4
Trichoptera	Ecclisomyia	2
Trichoptera	Glossosoma	29

Unique Genera Collected from GRTE Streams, cont.

Taxonomic Group	Genus	Number of Observations
Trichoptera	Helicopsyche	1
Trichoptera	Hydropsyche	26
Trichoptera	Hydroptila	5
Trichoptera	Micrasema	12
Trichoptera	Neophylax	1
Trichoptera	Neothremma	4
Trichoptera	Ochrotrichia	1
Trichoptera	Oecetis	2
Trichoptera	Oxyethira	1
Trichoptera	Protoptila	1
Trichoptera	Psychomyia	2

Compilation of Unique Taxa Collected from YELL Streams

Unique Species Collected from YELL Streams

Taxonomic Group	Species	Number of Observations
Coleoptera	*Cleptelmis addenda*	12
Diptera	*Cricotopus bicinctus group*	3
Diptera	*Cricotopus Nostococladius*	11
Diptera	*Eukiefferiella Devonica Group*	10
Ephemeroptera	*Acentrella insignificans*	4
Ephemeroptera	*Acentrella turbida*	1
Ephemeroptera	*Attenella margarita*	3
Ephemeroptera	*Baetis bicaudatus*	6
Ephemeroptera	*Baetis tricaudatus*	30
Ephemeroptera	*Caudatella heterocaudata*	1
Ephemeroptera	*Caudatella hystrix*	15
Ephemeroptera	*Diphetor hageni*	12
Ephemeroptera	*Drunella coloradensis/flavilinea*	42
Ephemeroptera	*Drunella doddsi*	58
Ephemeroptera	*Drunella grandis*	24
Ephemeroptera	*Drunella spinifera*	11
Ephemeroptera	*Epeorus albertae*	13
Ephemeroptera	*Epeorus grandis*	13
Ephemeroptera	*Epeorus longimanus*	8
Ephemeroptera	*Ephemerella inermis*	19
Ephemeroptera	*Ephemerella infrequens*	4
Ephemeroptera	*Serratella tibialis*	21
Ephemeroptera	*Timpanoga hecuba*	1
Ephemeroptera	*Tricorythodes minutus*	1
Non Insect	*Gammarus lacustris*	1
Non Insect	*Hyallela azteca*	3
Non Insect	*Margaritifera falcata*	3
Non Insect	*Potamopyrgus antipodarum*	6
Plecoptera	*Calineuria californica*	2
Plecoptera	*Claassenia sabulosa*	14
Plecoptera	*Hesperoperla pacifica*	34
Plecoptera	*Pteronarcys californica*	14
Plecoptera	*Zapada cinctipes*	15
Plecoptera	*Zapada columbiana*	8
Plecoptera	*Zapada Oregonensis Group*	16
Trichoptera	*Arctopsyche grandis*	9
Trichoptera	*Brachycentrus americanus*	18

Unique Species Collected from YELL Streams, cont.

Taxonomic Group	Species	Number of Observations
Trichoptera	*Brachycentrus occidentalis*	3
Trichoptera	*Chyranda centralis*	2
Trichoptera	*Dicosmoecus atripes*	5
Trichoptera	*Dicosmoecus gilvipes*	1
Trichoptera	*Helicopsyche borealis*	7
Trichoptera	*Lepidostoma cascadense*	1
Trichoptera	*Onocosmoecus unicolor*	1
Trichoptera	*Parapsyche elsis*	16
Trichoptera	*Rhyacophila Angelita Group*	5
Trichoptera	*Rhyacophila Betteni Group*	3
Trichoptera	*Rhyacophila brunnea*	2
Trichoptera	*Rhyacophila Brunnea/Vemna Group*	17
Trichoptera	*Rhyacophila Coloradensis Group*	5
Trichoptera	*Rhyacophila Hyalinata Group*	15
Trichoptera	*Rhyacophila Iranda Group*	7
Trichoptera	*Rhyacophila narvae*	6
Trichoptera	*Rhyacophila pellisa/valuma*	14
Trichoptera	*Rhyacophila Sibirica Group*	2
Trichoptera	*Rhyacophila verrula*	1

Unique Genera Collected from YELL Streams

Taxonomic Group	Genus	Number of Observations
Coleoptera	Agabus	2
Coleoptera	Ametor	1
Coleoptera	Brychius	2
Coleoptera	Deronectes	2
Coleoptera	Dytiscus	5
Coleoptera	Heterlimnius	38
Coleoptera	Hydraena	2
Coleoptera	Lara	4
Coleoptera	Microcylloepus	1
Coleoptera	Narpus	3
Coleoptera	Optioservus	46
Coleoptera	Oreodytes	4
Coleoptera	Zaitzevia	16
Diptera	Agathon	2

Unique Genera Collected from YELL Streams

Taxonomic Group	Genus	Number of Observations
Diptera	Antocha	32
Diptera	Atherix	20
Diptera	Boreoheptagyia	1
Diptera	Brillia	7
Diptera	Cardiocladius	3
Diptera	Chaetocladius	5
Diptera	Chelifera	17
Diptera	Chironomus	2
Diptera	Cladotanytarsus	8
Diptera	Clinocera	16
Diptera	Corynoneura	8
Diptera	Dasyhelea	1
Diptera	Deuterophlebia	8
Diptera	Diamesa	12
Diptera	Dicranota	16
Diptera	Dixa	6
Diptera	Epoicocladius	1
Diptera	Glutops	16
Diptera	Heleniella	2
Diptera	Hemerodromia	3
Diptera	Hesperoconopa	2
Diptera	Heterotrissocladius	1
Diptera	Hexatoma	37
Diptera	Hydrobaenus	6
Diptera	Limnophila	1
Diptera	Limonia	1
Diptera	Lopescladius	1
Diptera	Maruina	1
Diptera	Micropsectra	21
Diptera	Microtendipes	1
Diptera	Oreogeton	3
Diptera	Ormosia	1
Diptera	Pagastia	21
Diptera	Parakiefferiella	1
Diptera	Parametriocnemus	3
Diptera	Paraphaenocladius	4
Diptera	Pentaneura	2
Diptera	Pericoma	32
Diptera	Polypedilum	8
Diptera	Probezzia	14

Unique Genera Collected from YELL Streams

Taxonomic Group	Genus	Number of Observations
Diptera	Procladius	1
Diptera	Prosimulium	8
Diptera	Psectrocladius	1
Diptera	Pseudochironomus	2
Diptera	Pseudodiamesa	2
Diptera	Rhabdomastix	2
Diptera	Rheocricotopus	9
Diptera	Rheotanytarsus	9
Diptera	Simulium	57
Diptera	Stempellina	3
Diptera	Stempellinella	10
Diptera	Stictochironomus	4
Diptera	Sublettea	2
Diptera	Tanytarsus	6
Diptera	Thienemannimyia group	1
Diptera	Tipula	7
Diptera	Trichoclinocera	1
Diptera	Wiedemannis	5
Diptera	Zavrelimyia	2
Ephemeroptera	Ameletus	45
Ephemeroptera	Cinygma	2
Ephemeroptera	Cinygmula	53
Ephemeroptera	Paraleptophlebia	2
Ephemeroptera	Rhithrogena	30
Ephemeroptera	Siphlonurus	1
Lepidoptera	Petrophila	2
Lepidoptera	Petrophila	2
Megaloptera	Sialis	1
Non Insect	Acari	27
Non Insect	Nematoda	7
Non Insect	Oligochaeta	22
Non Insect	Physella	5
Non Insect	Pisidium	26
Non Insect	Turbellaria	15
Non Insect	Unionacea	1
Odonata	Argia	8
Odonata	Cordulegaster	1
Odonata	Ophiogomphus	4
Plecoptera	Cultus	1
Plecoptera	Doroneuria	23

Unique Genera Collected from YELL Streams

Taxonomic Group	Genus	Number of Observations
Plecoptera	Isoperla	10
Plecoptera	Kogotus	5
Plecoptera	Malenka	6
Plecoptera	Megarcys	30
Plecoptera	Paraperla	8
Plecoptera	Perlodidae	19
Plecoptera	Pteronarcella	6
Plecoptera	Skwala	6
Plecoptera	Sweltsa	63
Plecoptera	Yoraperla	3
Trichoptera	Agapetus	3
Trichoptera	Agraylea	3
Trichoptera	Amiocentrus	1
Trichoptera	Anagapetus	3
Trichoptera	Apatania	30
Trichoptera	Cheumatopsyche	2
Trichoptera	Chimarra	2
Trichoptera	Cryptochia	1
Trichoptera	Culoptila	3
Trichoptera	Dolophilodes	4
Trichoptera	Dolophilodes	7
Trichoptera	Ecclisomyia	3
Trichoptera	Glossosoma	57
Trichoptera	Hesperophylax	2
Trichoptera	Hydropsyche	14
Trichoptera	Hydroptila	19
Trichoptera	Leucotrichia	2
Trichoptera	Micrasema	43
Trichoptera	Neophylax	8
Trichoptera	Neothremma	15
Trichoptera	Ochrotrichia	2
Trichoptera	Oligophlebodes	12
Trichoptera	Oxythera	9
Trichoptera	Protoptila	6
Trichoptera	Psychoglypha	2
Trichoptera	Wormaldia	9

Appendix III

Potential Reference Sites in the Greater Yellowstone Ecosystem

Potential Reference Sites in the GRYN and Surrounding Area

Site ID	Stream Name	Data Source	Location	Latitude (DD)	Longitude (DD)
YNPWYO-041	Arizona Creek	Hawkins	GRTE	43.9765	-110.6427
GAZ10829	Arizona Creek	YCR	GRTE	43.9723	-110.6462
GAZ20829	Arizona Creek	YCR	GRTE	43.9742	-110.6441
YNPWYO-043	Cascade Creek	Hawkins	GRTE	43.7651	-110.7493
GCT10904	Cottonwood Creek	YCR	GRTE	43.6980	-110.7292
GCT20904	Cottonwood Creek	YCR	GRTE	43.6997	-110.7295
GCT30904	Cottonwood Creek	YCR	GRTE	43.7500	-110.7246
YNPWYO-032	Glade Creek tributary	Hawkins	GRTE	44.0991	-110.7348
YNPWYO-044	Granite Creek	Hawkins	GRTE	43.6033	-110.8058
YNPWYO-042	Little Taggart Creek	Hawkins	GRTE	43.6950	-110.7339
GLZ10906	Lizard Creek	YCR	GRTE	44.0067	-110.6809
GLZ20906	Lizard Creek	YCR	GRTE	44.0069	-110.6808
PACIFIC-01	Pacific Creek	BTNF	GRTE	43.9278	-110.4519
YNPWYO-001	Pacific Creek	Hawkins	GRTE	43.9426	-110.4318
GPC10903	Pacific Creek	YCR	GRTE	43.8511	-110.5159
GPC20830	Pacific Creek	YCR	GRTE	43.8701	-110.4996
GPC30830	Pacific Creek	YCR	GRTE	43.9138	-110.4652
GPG10828	Pilgrim Creek	YCR	GRTE	43.9041	-110.5867
GPG20828	Pilgrim Creek	YCR	GRTE	43.9239	-110.5633
EPA01:547	Polecat Creek	Hawkins	GRTE	44.1119	-110.7009
HALL4	Polecat Creek	Hall	GRTE	44.1107	-110.6901
GSN10829	Snake River	YCR	GRTE	44.0991	-110.6667
MRW3	Snake River	WYDEQ	GRTE	44.1008	-110.6695
YNP-112	Snake River	Hawkins	GRTE	44.1314	-110.6592
13010065	Snake River	NAWQA	GRTE	44.0892	-110.6939
YNPWYO-002	W. Fk. Pilgrim Creek	Hawkins	GRTE	43.9310	-110.5603
MRW58	Antelope Creek	WYDEQ	GYE	44.8694	-110.3836
MRW93	Beaver Creek	WYDEQ	GYE	42.5660	-108.7346
EPA01:436	Big Creek	Hawkins	GYE	45.3034	-110.9401
MRW9	Buffalo Fork River	WYDEQ	GYE	43.8547	-110.2383
YNPWYO-034	Buffalo Fork River	Hawkins	GYE	43.8557	-110.2504
MRW61	Cabin Creek	WYDEQ	GYE	44.1275	-109.6439
YNPMAD-005	Cabin Creek	Hawkins	GYE	44.8766	-111.3401
EPA01:546	Cache Creek	Hawkins	GYE	43.4555	-110.7097
MRW1	Cache Creek	WYDEQ	GYE	43.4524	-110.7036
MRW12	Cache Creek	WYDEQ	GYE	43.4508	-110.7008
EPA01:438	Cascade Creek	Hawkins	GYE	45.3903	-111.2404
YNPWYO-031	Cascade Creek	Hawkins	GYE	44.1137	-110.7243
MRW92	Castle Creek	WYDEQ	GYE	43.6768	-109.3779
CLEAR1	Clear Creek	BugLab	GYE	43.2932	-109.8308
CLEARCK-01	Clear Creek	BTNF	GYE	42.2951	-109.8197
YNPWYO-007	Clear Creek	Hawkins	GYE	43.4070	-110.1699
MRW18	Crow Creek	WYDEQ	GYE	44.5131	-109.9733
WWYP99-0537	Crow Creek	EMAP	GYE	44.5040	-110.1168
MRW10	Crystal Creek	WYDEQ	GYE	43.5583	-110.4056
MRW60	Deer Creek	WYDEQ	GYE	44.1606	-109.6208
YNPWYO-033	Ditch Creek	Hawkins	GYE	43.7043	-110.5668
WF&G-15	E. Fk. S. Fk. Wood River	WY F&G	GYE	43.8372	-109.1694
EPA01:556	East Torrey Creek	Hawkins	GYE	43.4010	-109.5874
EPA01:440	Elk Creek	Hawkins	GYE	45.6267	-111.4141
MRW31	Elk Fork Creek	WYDEQ	GYE	44.4578	-109.6325
MRW73	Elk Fork Creek	WYDEQ	GYE	44.4647	-109.6278
EPA01:541	Fontenelle Creek	Hawkins	GYE	42.2883	-110.5768
MRW59	Fontenelle Creek	WYDEQ	GYE	42.2878	-110.5747
MRW86	Fontenelle Creek	WYDEQ	GYE	42.2401	-110.5552

EPA01:432	Four Mile Creek	Hawkins	GYE	45.3407	-110.2464
EPA01:439	Gallatin River	Hawkins	GYE	45.3951	-111.2072
EPA01:164	Gravel Creek	Hawkins	GYE	42.9333	-111.3802
EPA01:545	Green River	Hawkins	GYE	43.3660	-109.9809
GRGRL1	Green River	BugLab	GYE	43.2830	-109.8317
MRW21	Greybull River	WYDEQ	GYE	44.1111	-109.3533
TETON-GR05	Greys River	BTNF	GYE	42.9833	-110.7667
MRW67	Grinnel Creek	WYDEQ	GYE	44.4950	-109.9331
HALLSCK-01	Halls Creek	BTNF	GYE	42.8996	-109.4399
MRW53	Hams Fork River	WYDEQ	GYE	42.2542	-110.7297
EPA01:543	Hobble Creek	Hawkins	GYE	42.3654	-110.8410
MRW15	Hobble Creek	WYDEQ	GYE	42.3650	-110.8453
INDI-1	Indian Creek	BLM - Dillon	GYE	45.4922	-112.1378
PFC:WY-25	Irish Canyon Creek	BugLab	GYE	42.6660	-109.3663
JAKECAN	Jake Canyon Creek	BLM - Dillon	GYE	44.9611	-112.5133
MRW22	La Barge Creek	WYDEQ	GYE	42.5211	-110.6989
EPA01:428	Lake Fork Rock Creek	Hawkins	GYE	45.2356	-108.9252
MRW68	Libby Creek	WYDEQ	GYE	44.4606	-109.8617
EPA01:538	Little Sandy Creek	Hawkins	GYE	42.5374	-109.2035
LRCORCRK	Lower Corral Creek	BLM - Dillon	GYE	44.5903	-111.6247
BOULDCK-01	M. Fk. Boulder Creek	BTNF	GYE	42.8877	-109.4202
MRW48	M. Fk. Popo Agie River	WYDEQ	GYE	42.7297	-108.8589
MRW71	M. Fk. Shoshone River	WYDEQ	GYE	44.4922	-109.9958
MRWI6	M. Fk. Shoshone River	WYDEQ	GYE	44.4928	-109.9933
YNPWYO-035	Mail Cabin Creek	Hawkins	GYE	43.4973	-110.9851
YNPID-001	Moose Creek	Hawkins	GYE	43.5637	-111.0031
MORMONCRK	Mormon Creek	BLM - Dillon	GYE	45.2128	-112.2181
MRW69	Mormon Creek	WYDEQ	GYE	44.4731	-109.8964
TETON-MC01	Murphy Creek	BTNF	GYE	43.0667	-110.8667
MUSKR-01	Muskrat Creek	BLM - Butte	GYE	46.3152	-111.9778
NFGAQ700	N. Fk. Popo Agie River	WY G&F	GYE	42.8855	-108.8606
EPA01:553	N. Fk. Shoshone River	Hawkins	GYE	44.5153	-109.9671
MRW70	N. Fk. Shoshone River	WYDEQ	GYE	44.5031	-110.9606
MRWI39	N. Fk. Smiths Fork River	WYDEQ	GYE	42.4872	-110.8358
WWYP99-0585	North Leigh Creek	EMAP	GYE	43.8590	-110.9091
MRW16	North Piney Creek	WYDEQ	GYE	42.6614	-110.4900
MRW6	North Piney Creek	WYDEQ	GYE	42.6617	-110.4906
NURSERY-1	Nursery Creek	BLM - Butte	GYE	46.3075	-112.0306
NURSERY-2	Nursery Creek	BLM - Butte	GYE	46.3147	-112.0308
EPA01:441	O'Dell Creek	Hawkins	GYE	45.3407	-111.7178
PAP0-1	Papoose Creek	BLM - Dillon	GYE	44.9025	-111.5611
PETERSONCK	Peterson Creek	BLM - Dillon	GYE	45.2219	-112.1881
EPA01:435	Pine Creek	Hawkins	GYE	45.5062	-110.7893
PFC:WY-27	Pine Grove Creek	BugLab	GYE	42.4326	-110.3856
MRW95	Pole Creek	WYDEQ	GYE	42.8808	-109.7181
PORC1	Porcupine Creek	BugLab	GYE	43.2828	-109.8317
PRICE-01	Price Creek	BLM - Dillon	GYE	44.5592	-112.1231
ROARFK1	Roaring Fork Creek	BugLab	GYE	43.3578	-109.9236
ROARFKC-01	Roaring Fork Creek	BTNF	GYE	43.3644	-109.8253
PFC:WY-28	Rock Creek	BugLab	GYE	42.2915	-110.4271
WWYP99-0501	Ruth Creek tributary	EMAP	GYE	44.3456	-109.8538
WF&G-14	S. Fk. Wood River	WY F&G	GYE	43.8450	-109.1708
MRW25	Salt River	WYDEQ	GYE	42.5250	-110.8819
YNPMAD-004	Shedhorn Creek	Hawkins	GYE	45.1150	-110.8134
TETON-SC01	Sheep Creek	BTNF	GYE	42.8667	-110.6750
MRW20	Silas Creek	WYDEQ	GYE	42.6161	-108.8789
YNPWYO-005	Slate Creek	Hawkins	GYE	43.6216	-110.4025
MRW5	Smiths Fork	WYDEQ	GYE	42.4772	-110.8336

MRWI32	Smiths Fork	WYDEQ	GYE	42.3794	-110.8553
YNPWYO-030	South Boone Creek	Hawkins	GYE	44.0591	-110.9687
URM-039	St. Charles Creek	Hawkins	GYE	42.1057	-111.3895
MRW28	Strawberry Creek	WYDEQ	GYE	42.9067	-110.8867
MRW19	Torrey Creek	WYDEQ	GYE	43.4278	-109.5583
TROUTCRK	Trout Creek	BLM - Dillon	GYE	45.2797	-112.2989
EPA01:162	Tygee Creek	Hawkins	GYE	44.6398	-111.2557
WWYP99-0594	Unnamed Creek	EMAP	GYE	44.7862	-109.8922
YNPWYO-006	Upper Gros Ventre River	Hawkins	GYE	43.4134	-110.1735
YNPMAD-003	W. Fk. Beaver Creek	Hawkins	GYE	44.9053	-111.3723
WWYP99-0603	Warhouse Creek	EMAP	GYE	44.1022	-109.3976
MRW111	Warm Springs Creek	WYDEQ	GYE	43.5858	-109.9677
MRW109	Warm Springs Creek	WYDEQ	GYE	43.5920	-109.9841
MRW49	Wiggins Fork	WYDEQ	GYE	43.5564	-109.4767
MRW26	Willow Creek	WYDEQ	GYE	42.8450	-110.8789
YNPWYO-008	Wolf Creek	Hawkins	GYE	43.2029	-110.8858
YNP-070	Amethyst Creek	Hawkins	YELL	44.8842	-110.2532
YNP-072	Amphitheater Creek	Hawkins	YELL	44.9194	-110.0941
YAT10814	Antelope Creek	YCR	YELL	44.8895	-110.3854
YAT20813	Antelope Creek	YCR	YELL	44.8786	-110.3813
YAT30814	Antelope Creek	YCR	YELL	44.8699	-110.3856
YNP-009	Antelope Creek tributary	Hawkins	YELL	44.8623	-110.3970
YNPWYO-017	Arnica Creek tributary	Hawkins	YELL	44.4770	-110.5465
YNPWYO-038	Aster Creek	Hawkins	YELL	44.2789	-110.6243
MRWI25	Blacktail Deer Creek	WYDEQ	YELL	44.9569	-110.5861
WWYP99-0533	Blacktail Deer Creek	EMAP	YELL	44.9815	-110.5923
YNP-016	Blacktail Deer Creek	Hawkins	YELL	44.9503	-110.5867
WWYP99-0608	Blacktail Deer Creek tributary	EMAP	YELL	44.9211	-110.5373
YNPWYO-040	Canyon Creek	Hawkins	YELL	44.6472	-110.7703
YNP-117	Chalcedony Creek	Hawkins	YELL	44.8473	-110.2054
YNP-055	Clear Creek	Hawkins	YELL	44.4850	-110.1648
YNPWYO-036	Crayfish Creek	Hawkins	YELL	44.1531	-110.6782
YNP-054	Cub Creek	Hawkins	YELL	44.5051	-110.1938
YNP-040	DeLacy Creek	Hawkins	YELL	44.4477	-110.7005
YNP-075	Elk Antler Creek	Hawkins	YELL	44.6379	-110.4596
EPA01:548	Falls River	Hawkins	YELL	44.1388	-110.8152
MRW42	Falls River	WYDEQ	YELL	44.1347	-110.8208
HALL1	Firehole River	Hall	YELL	44.5657	-110.8426
HALL2	Firehole River	Hall	YELL	44.5679	-110.8401
YNP-037	Firehole River	Hawkins	YELL	44.4379	-110.8041
YNP-022	Gallatin River	Hawkins	YELL	44.9287	-111.0467
YGD10821	Gardner River	YCR	YELL	44.9893	-110.6907
YGD20821	Gardner River	YCR	YELL	44.9723	-110.6826
YGD30812	Gardner River	YCR	YELL	44.8873	-110.7333
YNP-101	Gardner River	Hawkins	YELL	44.9563	-110.6803
HALL3	Gibbon River	Hall	YELL	44.6413	-110.8556
YNP-102	Gibbon River	Hawkins	YELL	44.6708	-110.7422
YNP-108	Gibbon River	Hawkins	YELL	44.7122	-110.6244
YNP-025	Grayling Creek	Hawkins	YELL	44.8852	-111.0525
YNP-039	Herron Creek	Hawkins	YELL	44.4494	-110.7081
MRW41	Lamar River	WYDEQ	YELL	44.8608	-110.1864
MRWI24	Lamar River	WYDEQ	YELL	44.9008	-110.2556
YNP-071	Lamar River	Hawkins	YELL	44.8464	-110.1841
YNP-060	Landslide Creek	Hawkins	YELL	45.0376	-110.7473
MRW44	Lava Creek	WYDEQ	YELL	44.9356	-110.6242
YNP-005	Lava Creek	Hawkins	YELL	44.9401	-110.6290
YNPWYO-039	Lewis River	Hawkins	YELL	44.1421	-110.6646
YNP-106	Lost Creek	Hawkins	YELL	44.9105	-110.4181

YNP-103	Madison River	Hawkins	YELL	44.6438	-110.9187
MRW45	Middle Creek	WYDEQ	YELL	44.4778	-110.0356
YMC10819	Middle Creek	YCR	YELL	44.4883	-110.0036
YMC20819	Middle Creek	YCR	YELL	44.4830	-110.0211
YNP-057	Middle Creek	Hawkins	YELL	44.4744	-110.0450
YUT10819	Middle Creek tributary	YCR	YELL	44.4767	-110.0462
YNP-115	Middle Creek upper tributary	Hawkins	YELL	44.4691	-110.0685
YNP10822	Nez Perce Creek	YCR	YELL	44.5793	-110.8308
YNP20822	Nez Perce Creek	YCR	YELL	44.5729	-110.8184
YNPWYO-037	Nez Perce Creek	Hawkins	YELL	44.5737	-110.8144
MRW37	Obsidian Creek	WYDEQ	YELL	44.8794	-110.7367
YNP-058	Obsidian Creek	Hawkins	YELL	44.8787	-110.7382
YOB10806	Obsidian Creek	YCR	YELL	44.8852	-110.7327
YOB20807	Obsidian Creek	YCR	YELL	44.8520	-110.7368
YOB30807	Obsidian Creek	YCR	YELL	44.7989	-110.7460
YOB40813	Obsidian Creek	YCR	YELL	44.7873	-110.7397
YNP-109	Otter Creek	Hawkins	YELL	44.7007	-110.5287
MRW62	Pebble Creek	WYDEQ	YELL	44.9178	-110.1106
YNP-073	Pebble Creek	Hawkins	YELL	44.9215	-110.1124
YPB10816	Pebble Creek	YCR	YELL	44.9137	-110.1117
YPB20816	Pebble Creek	YCR	YELL	44.9173	-110.1123
YNP-012	Rose Creek	Hawkins	YELL	44.8997	-110.2282
YNP-110	S. Fk. Sulphur Creek	Hawkins	YELL	44.7663	-110.4658
YNP-053	Sedge Creek	Hawkins	YELL	44.5230	-110.2789
MRW38	Slough Creek	WYDEQ	YELL	44.9533	-110.2994
YNP-066	Slough Creek	Hawkins	YELL	44.9523	-110.3034
MRW39	Snake River	WYDEQ	YELL	44.1367	-110.6642
EPA01:549	Solfatara Creek	Hawkins	YELL	44.7487	-110.4757
YNP-019	Specimen Creek	Hawkins	YELL	45.0127	-111.0785
YNP-104	Stephens Creek	Hawkins	YELL	45.0371	-110.7613
YNP-105	Tower Creek	Hawkins	YELL	44.8874	-110.3957
MRWI31	Trout Creek	WYDEQ	YELL	44.6414	-110.4575
YNP-011	Trout Lake Stream	Hawkins	YELL	44.8987	-110.1251
YNP-113	Unnamed Creek	Hawkins	YELL	44.8441	-110.1853
YNP-051	Yellowstone River	Hawkins	YELL	44.6089	-110.3886

Appendix IV

OTU Lookup Table for GRYN Streams

OTU Lookup Table for the GRYN

LAB ID CODE	OTU CODE	OTU NAME	OTU LEVEL	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
857	1	Erpobdellidae	Family	Annelida	Arhynchobdellida	Erpobdellidae	Erpobdella	punctata
1713	1	Erpobdellidae	Family	Annelida	Arhynchobdellida	Erpobdellidae	Mooreobdella	microstoma
729	1	Erpobdellidae	Family	Annelida	Arhynchobdellida	Erpobdellidae	Nephelopsis	obscura
12	1	Erpobdellidae	Family	Annelida	Arhynchobdellida	Erpobdellidae		
858	2	Haemopidae	Family	Annelida	Arhynchobdellida	Haemopidae	Haemopsis	marmorata
1720	3	Glossiphoniidae	Family	Annelida	Rhynchobdellida	Glossiphoniidae	Desserobdella	picta
859	3	Glossiphoniidae	Family	Annelida	Rhynchobdellida	Glossiphoniidae	Glossiphonia	complanata
1721	3	Glossiphoniidae	Family	Annelida	Rhynchobdellida	Glossiphoniidae	Helobdella	elongata
860	3	Glossiphoniidae	Family	Annelida	Rhynchobdellida	Glossiphoniidae	Helobdella	stagnalis
1602	3	Glossiphoniidae	Family	Annelida	Rhynchobdellida	Glossiphoniidae	Placobdella	montifera
15	3	Glossiphoniidae	Family	Annelida	Rhynchobdellida	Glossiphoniidae		
5	4	Branchiobdellida	Subclass	Annelida	Branchiobdellida			
662	5	Other_Oligochaeta	Subclass	Annelida	Haplotaxida	Naididae		
24	5	Other_Oligochaeta	Subclass	Annelida	Haplotaxida			
19	5	Other_Oligochaeta	Subclass	Annelida				
58	7	Trombidiformes	Order	Arthropoda	Trombidiformes			
101	8	Amphizoa	Genus	Arthropoda	Coleoptera	Amphizoidae	Amphizoa	
102	9	Carabidae	Family	Arthropoda	Coleoptera	Carabidae		
684	10	Curculionidae	Family	Arthropoda	Coleoptera	Curculionidae		
104	11	Helichus	Genus	Arthropoda	Coleoptera	Dryopidae	Helichus	
108	16	Agabus	Genus	Arthropoda	Coleoptera	Dytiscidae	Agabus	
906	19	Graphoderus	Genus	Arthropoda	Coleoptera	Dytiscidae	Graphoderus	
115	21	Hygrotus	Genus	Arthropoda	Coleoptera	Dytiscidae	Hygrotus	
117	23	Laccophilus	Genus	Arthropoda	Coleoptera	Dytiscidae	Laccophilus	
118	27	Oreodytes	Genus	Arthropoda	Coleoptera	Dytiscidae	Oreodytes	
119	28	Rhantus	Genus	Arthropoda	Coleoptera	Dytiscidae	Rhantus	
1538	30	Stictotarsus	Genus	Arthropoda	Coleoptera	Dytiscidae	Stictotarsus	
122	31	Ampumixis	Genus	Arthropoda	Coleoptera	Elmidae	Ampumixis	
1743	33	Cleptelmis	Genus	Arthropoda	Coleoptera	Elmidae	Cleptelmis	addenda
125	33	Cleptelmis	Genus	Arthropoda	Coleoptera	Elmidae	Cleptelmis	ornata

OTU Lookup Table for the GRYN

LAB ID CODE	OTU CODE	OTU NAME	OTU LEVEL	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
124	33	Cleptelmis	Genus	Arthropoda	Coleoptera	Elmidae	Cleptelmis	
126	34	Dubiraphia	Genus	Arthropoda	Coleoptera	Elmidae	Dubiraphia	
1751	34	Dubiraphia	Genus	Arthropoda	Coleoptera	Elmidae	Dubiraphia	quadrinotata
827	35	Heterelmis	Genus	Arthropoda	Coleoptera	Elmidae	Heterelmis	
129	35	Heterelmis	Genus	Arthropoda	Coleoptera	Elmidae	Heterlimnius	corpulentus
128	35	Heterelmis	Genus	Arthropoda	Coleoptera	Elmidae	Heterlimnius	
130	36	Lara	Genus	Arthropoda	Coleoptera	Elmidae	Lara	
1244	38	Macronychus	Genus	Arthropoda	Coleoptera	Elmidae	Macronychus	
132	39	Microcylloepus	Genus	Arthropoda	Coleoptera	Elmidae	Microcylloepus	similis
134	40	Narpus	Genus	Arthropoda	Coleoptera	Elmidae	Narpus	concolor
133	40	Narpus	Genus	Arthropoda	Coleoptera	Elmidae	Narpus	
1029	41	Neocylloepus	Genus	Arthropoda	Coleoptera	Elmidae	Neocylloepus	
1742	43	Optioservus	Genus	Arthropoda	Coleoptera	Elmidae	Optioservus	pecosensis
1076	43	Optioservus	Genus	Arthropoda	Coleoptera	Elmidae	Optioservus	quadrimaculatus
135	43	Optioservus	Genus	Arthropoda	Coleoptera	Elmidae	Optioservus	
140	44	Ordobrevia	Genus	Arthropoda	Coleoptera	Elmidae	Ordobrevia	
732	45	Oulimnius	Genus	Arthropoda	Coleoptera	Elmidae	Oulimnius	
1386	46	Rhizelmis	Genus	Arthropoda	Coleoptera	Elmidae	Rhizelmis	
143	47	Stenelmis	Genus	Arthropoda	Coleoptera	Elmidae	Stenelmis	
146	48	Zaitzevia	Genus	Arthropoda	Coleoptera	Elmidae	Zaitzevia	parvula
144	48	Zaitzevia	Genus	Arthropoda	Coleoptera	Elmidae	Zaitzevia	
147	49	Dineutus	Genus	Arthropoda	Coleoptera	Gyrinidae	Dineutus	
148	50	Gyrinus	Genus	Arthropoda	Coleoptera	Gyrinidae	Gyrinus	
150	51	Brychius	Genus	Arthropoda	Coleoptera	Haliplidae	Brychius	
151	52	Haliplus	Genus	Arthropoda	Coleoptera	Haliplidae	Haliplus	
152	53	Peltodytes	Genus	Arthropoda	Coleoptera	Haliplidae	Peltodytes	
160	54	Helophorus	Genus	Arthropoda	Coleoptera	Helophoridae	Helophorus	
1219	55	Hydraena	Genus	Arthropoda	Coleoptera	Hydraenidae	Hydraena	
1221	57	Ochthebius	Genus	Arthropoda	Coleoptera	Hydraenidae	Ochthebius	
154	58	Ametor	Genus	Arthropoda	Coleoptera	Hydrophilidae	Ametor	

OTU Lookup Table for the GRYN

LAB ID CODE	OTU CODE	OTU NAME	OTU LEVEL	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
155	59	Berosus	Genus	Arthropoda	Coleoptera	Hydrophilidae	Berosus	
161	65	Hydrobius	Genus	Arthropoda	Coleoptera	Hydrophilidae	Hydrobius	
165	67	Paracymus	Genus	Arthropoda	Coleoptera	Hydrophilidae	Paracymus	
166	69	Tropisternus	Genus	Arthropoda	Coleoptera	Hydrophilidae	Tropisternus	
901	70	Lampyridae	Family	Arthropoda	Coleoptera	Lampyridae		
670	71	Acneus	Genus	Arthropoda	Coleoptera	Psephenidae	Acneus	
169	72	Eubrianax	Genus	Arthropoda	Coleoptera	Psephenidae	Eubrianax	
170	73	Psephenus	Genus	Arthropoda	Coleoptera	Psephenidae	Psephenus	
1046	76	Scirtidae	Family	Arthropoda	Coleoptera	Scirtidae	Elodes	
895	77	Staphylinidae	Family	Arthropoda	Coleoptera	Staphylinidae		
175	78	Atherix	Genus	Arthropoda	Diptera	Athericidae	Atherix	
177	79	Blephariceridae	Family	Arthropoda	Diptera	Blephariceridae	Agathon	
178	79	Blephariceridae	Family	Arthropoda	Diptera	Blephariceridae	Bibiocephala	
685	79	Blephariceridae	Family	Arthropoda	Diptera	Blephariceridae	Blepharicera	
763	79	Blephariceridae	Family	Arthropoda	Diptera	Blephariceridae	Philorus	
176	79	Blephariceridae	Family	Arthropoda	Diptera	Blephariceridae		
748	80	Ceratopogoninae	Subfamily	Arthropoda	Diptera	Ceratopogonidae	Bezzia	
933	80	Ceratopogoninae	Subfamily	Arthropoda	Diptera	Ceratopogonidae	Culicoides	
851	80	Ceratopogoninae	Subfamily	Arthropoda	Diptera	Ceratopogonidae	Dasyhelea	
908	80	Ceratopogoninae	Subfamily	Arthropoda	Diptera	Ceratopogonidae	Probezzia	
671	81	Forcipomyiinae	Subfamily	Arthropoda	Diptera	Ceratopogonidae	Atrichopogon	
750	81	Forcipomyiinae	Subfamily	Arthropoda	Diptera	Ceratopogonidae	Forcipomyia	
1757	88	Chironomus	Genus	Arthropoda	Diptera	Chironomidae	Chironomus	
1758	89	Cladopelma	Genus	Arthropoda	Diptera	Chironomidae	Cladopelma	
1093	90	Cryptochironomus	Genus	Arthropoda	Diptera	Chironomidae	Cryptochironomus	
1759	91	Cryptotendipes	Genus	Arthropoda	Diptera	Chironomidae	Cryptotendipes	
1094	93	Demicryptochironomus	Genus	Arthropoda	Diptera	Chironomidae	Demicryptochironomus	
1294	94	Dicrotendipes	Genus	Arthropoda	Diptera	Chironomidae	Dicrotendipes	
1812	96	Endochironomus	Genus	Arthropoda	Diptera	Chironomidae	Endochironomus	
1766	98	Gillotia	Genus	Arthropoda	Diptera	Chironomidae	Gillotia	

OTU Lookup Table for the GRYN

LAB ID CODE	OTU CODE	OTU NAME	OTU LEVEL	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
1308	99	Glyptotendipes	Genus	Arthropoda	Diptera	Chironomidae	Glyptotendipes	
1807	101	Harnischia	Genus	Arthropoda	Diptera	Chironomidae	Harnischia	
1095	102	Lauterborniella	Genus	Arthropoda	Diptera	Chironomidae	Lauterborniella	
1297	104	Microtendipes	Genus	Arthropoda	Diptera	Chironomidae	Microtendipes	
1753	107	Parachironomus	Genus	Arthropoda	Diptera	Chironomidae	Parachironomus	
1694	108	Paracladopelma	Genus	Arthropoda	Diptera	Chironomidae	Paracladopelma	
1681	109	Paralauterborniella	Genus	Arthropoda	Diptera	Chironomidae	Paralauterborniella	
1810	109	Paralauterborniella	Genus	Arthropoda	Diptera	Chironomidae	Paralauterborniella	
1102	110	Paratendipes	Genus	Arthropoda	Diptera	Chironomidae	Paratendipes	
1103	111	Phaenopsectra	Genus	Arthropoda	Diptera	Chironomidae	Phaenopsectra	
1301	112	Polypedilum	Genus	Arthropoda	Diptera	Chironomidae	Polypedilum	
1106	113	Robackia	Genus	Arthropoda	Diptera	Chironomidae	Robackia	
1809	116	Stenochironomus	Genus	Arthropoda	Diptera	Chironomidae	Stenochironomus	
1698	117	Stictochironomus	Genus	Arthropoda	Diptera	Chironomidae	Stictochironomus	
1687	119	Tribelos	Genus	Arthropoda	Diptera	Chironomidae	Tribelos	
1692	120	Xenochironomus	Genus	Arthropoda	Diptera	Chironomidae	Xenochironomus	
1104	122	Pseudochironomus	Genus	Arthropoda	Diptera	Chironomidae	Pseudochironomus	
1750	123	Acricotopus	Genus	Arthropoda	Diptera	Chironomidae	Acricotopus	
1685	124	Cladotanytarsus	Genus	Arthropoda	Diptera	Chironomidae	Cladotanytarsus	
1684	125	Constempellina	Genus	Arthropoda	Diptera	Chironomidae	Constempellina	brevicosta
1672	126	Micropsectra	Genus	Arthropoda	Diptera	Chironomidae	Micropsectra	
1763	127	Nimbocera	Genus	Arthropoda	Diptera	Chironomidae	Nimbocera	
1101	128	Paratanytarsus	Genus	Arthropoda	Diptera	Chironomidae	Paratanytarsus	
1105	129	Rheotanytarsus	Genus	Arthropoda	Diptera	Chironomidae	Rheotanytarsus	
1107	130	Stempellina	Genus	Arthropoda	Diptera	Chironomidae	Stempellina	
1109	132	Sublettea	Genus	Arthropoda	Diptera	Chironomidae	Sublettea	
1306	133	Tanytarsus	Genus	Arthropoda	Diptera	Chironomidae	Tanytarsus	
1693	134	Zavrelia	Genus	Arthropoda	Diptera	Chironomidae	Zavrelia	pentatoma
1013	136	Boreoheptagyia	Genus	Arthropoda	Diptera	Chironomidae	Boreoheptagyia	
1111	137	Diamesa	Genus	Arthropoda	Diptera	Chironomidae	Diamesa	

OTU Lookup Table for the GRYN

LAB ID CODE	OTU CODE	OTU NAME	OTU LEVEL	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
1112	138	Pagastia	Genus	Arthropoda	Diptera	Chironomidae	Pagastia	
1673	139	Potthastia	Genus	Arthropoda	Diptera	Chironomidae	Potthastia	
1115	140	Pseudodiamesa	Genus	Arthropoda	Diptera	Chironomidae	Pseudodiamesa	
1689	141	Pseudokiefferella	Genus	Arthropoda	Diptera	Chironomidae	Pseudokiefferella	parva
825	142	Syndiamesa	Genus	Arthropoda	Diptera	Chironomidae	Syndiamesa	
1695	144	Antillocladius	Genus	Arthropoda	Diptera	Chironomidae	Antillocladius	
1117	145	Brillia	Genus	Arthropoda	Diptera	Chironomidae	Brillia	
1761	146	Bryophaenocladius	Genus	Arthropoda	Diptera	Chironomidae	Bryophaenocladius	
823	148	Cardiocladius	Genus	Arthropoda	Diptera	Chironomidae	Cardiocladius	
1688	149	Chaetocladius	Genus	Arthropoda	Diptera	Chironomidae	Chaetocladius	
1118	150	Corynoneura	Genus	Arthropoda	Diptera	Chironomidae	Corynoneura	
1122	151	Cricotopus_trifascia_group	Species-group	Arthropoda	Diptera	Chironomidae	Cricotopus	trifascia group
1119	152	Cricotopus_bicinctus_group	Species-group	Arthropoda	Diptera	Chironomidae	Cricotopus	bicinctus group
1146	153	Cricotopus_Nostocladius	Subgenus	Arthropoda	Diptera	Chironomidae	Cricotopus (Nostocladius)	
863	154	Other_Cricotopus_Orthocladius	Genus-group	Arthropoda	Diptera	Chironomidae	Cricotopus	
1669	154	Other_Cricotopus_Orthocladius	Genus-group	Arthropoda	Diptera	Chironomidae	Cricotopus/Orthocladius	
1147	155	Orthocladius_Symposiocladius	Subgenus	Arthropoda	Diptera	Chironomidae	Orthocladius	
1162	155	Orthocladius_Symposiocladius	Subgenus	Arthropoda	Diptera	Chironomidae	Orthocladius (Symposiocladius)	lignicola
1123	156	Diplocladius	Genus	Arthropoda	Diptera	Chironomidae	Diplocladius	
1814	157	Doncricotopus	Genus	Arthropoda	Diptera	Chironomidae	Doncricotopus	
1806	158	Epoicocladius	Genus	Arthropoda	Diptera	Chironomidae	Epoicocladius	
1670	159	Eukiefferiella	Genus	Arthropoda	Diptera	Chironomidae	Eukiefferiella	
1691	161	Georthocladius	Genus	Arthropoda	Diptera	Chironomidae	Georthocladius	
1135	163	Heleniella	Genus	Arthropoda	Diptera	Chironomidae	Heleniella	
1697	165	Heterotrissocladius	Genus	Arthropoda	Diptera	Chironomidae	Heterotrissocladius	
1137	166	Hydrobaenus	Genus	Arthropoda	Diptera	Chironomidae	Hydrobaenus	
1140	167	Krenosmittia	Genus	Arthropoda	Diptera	Chironomidae	Krenosmittia	
1141	168	Limnophyes	Genus	Arthropoda	Diptera	Chironomidae	Limnophyes	
1142	169	Lopescladius	Genus	Arthropoda	Diptera	Chironomidae	Lopescladius	
1143	170	Metriocnemus	Genus	Arthropoda	Diptera	Chironomidae	Metriocnemus	

OTU Lookup Table for the GRYN

LAB ID CODE	OTU CODE	OTU NAME	OTU LEVEL	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
1676	171	Nanocladius	Genus	Arthropoda	Diptera	Chironomidae	Nanocladius	
1148	172	Parachaetocladius	Genus	Arthropoda	Diptera	Chironomidae	Parachaetocladius	
1683	174	Parakiefferiella	Genus	Arthropoda	Diptera	Chironomidae	Parakiefferiella	
1150	176	Parametriocnemus	Genus	Arthropoda	Diptera	Chironomidae	Parametriocnemus	
1151	177	Paraphaenocladius	Genus	Arthropoda	Diptera	Chironomidae	Paraphaenocladius	
1153	178	Parorthocladius	Genus	Arthropoda	Diptera	Chironomidae	Parorthocladius	
1303	179	Procladius	Genus	Arthropoda	Diptera	Chironomidae	Procladius	
1298	180	Psectrocladius	Genus	Arthropoda	Diptera	Chironomidae	Psectrocladius	
1156	181	Pseudorthocladius	Genus	Arthropoda	Diptera	Chironomidae	Pseudorthocladius	
1678	183	Psilometriocnemus	Genus	Arthropoda	Diptera	Chironomidae	Psilometriocnemus	tnannulatus
1158	184	Rheocricotopus	Genus	Arthropoda	Diptera	Chironomidae	Rheocricotopus	
1159	185	Rheosmittia	Genus	Arthropoda	Diptera	Chironomidae	Rheosmittia	
1160	187	Stilocladius	Genus	Arthropoda	Diptera	Chironomidae	Stilocladius	
1163	189	Synorthocladius	Genus	Arthropoda	Diptera	Chironomidae	Synorthocladius	
1164	191	Thienemanniella	Genus	Arthropoda	Diptera	Chironomidae	Thienemanniella	
1700	193	Trissocladius	Genus	Arthropoda	Diptera	Chironomidae	Trissocladius	
1674	194	Tvetenia	Genus	Arthropoda	Diptera	Chironomidae	Tvetenia	
1166	196	Boreochlus	Genus	Arthropoda	Diptera	Chironomidae	Boreochlus	
1167	198	Monodiamesa	Genus	Arthropoda	Diptera	Chironomidae	Monodiamesa	
1168	199	Odontomesa	Genus	Arthropoda	Diptera	Chironomidae	Odontomesa	
1169	200	Prodiamesa	Genus	Arthropoda	Diptera	Chironomidae	Prodiamesa	
1686	202	Alotanypus	Genus	Arthropoda	Diptera	Chironomidae	Alotanypus	
1754	203	Apsectrotanypus	Genus	Arthropoda	Diptera	Chironomidae	Apsectrotanypus	
1813	203	Apsectrotanypus	Genus	Arthropoda	Diptera	Chironomidae	Apsectrotanypus	
1171	205	Brundiniella	Genus	Arthropoda	Diptera	Chironomidae	Brundiniella	
1173	206	Macropelopia	Genus	Arthropoda	Diptera	Chironomidae	Macropelopia	
1765	206	Macropelopia	Genus	Arthropoda	Diptera	Chironomidae	Macropelopia	
1760	208	Radotanypus	Genus	Arthropoda	Diptera	Chironomidae	Radotanypus	
1815	209	Natarsia	Genus	Arthropoda	Diptera	Chironomidae	Natarsia	
1170	210	Ablabesmyia	Genus	Arthropoda	Diptera	Chironomidae	Ablabesmyia	

OTU Lookup Table for the GRYN

LAB ID CODE	OTU CODE	OTU NAME	OTU LEVEL	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
1699	211	Krenopelopia	Genus	Arthropoda	Diptera	Chironomidae	Krenopelopia	
1764	212	Labrundinia	Genus	Arthropoda	Diptera	Chironomidae	Labrundinia	
1808	212	Labrundinia	Genus	Arthropoda	Diptera	Chironomidae	Labrundinia	
1172	213	Larsia	Genus	Arthropoda	Diptera	Chironomidae	Larsia	
1174	214	Nilotanypus	Genus	Arthropoda	Diptera	Chironomidae	Nilotanypus	
1175	215	Zavrelimyia_Paramerina	Genus_group	Arthropoda	Diptera	Chironomidae	Paramerina	
1696	215	Zavrelimyia_Paramerina	Genus_group	Arthropoda	Diptera	Chironomidae	Zavrelimyia	
824	216	Pentaneura	Genus	Arthropoda	Diptera	Chironomidae	Pentaneura	
1176	217	Thienemannimyia	Genus	Arthropoda	Diptera	Chironomidae	Thienemannimyia group	
1680	218	Djalmabatista	Genus	Arthropoda	Diptera	Chironomidae	Djalmabatista	pulcher
1756	220	Tanypus	Genus	Arthropoda	Diptera	Chironomidae	Tanypus	
191	221	Culicidae	Family	Arthropoda	Diptera	Culicidae	Anopheles	
189	221	Culicidae	Family	Arthropoda	Diptera	Culicidae		
817	222	Deuterophlebia	Genus	Arthropoda	Diptera	Deuterophlebiidae	Deuterophlebia	coloradensis
196	222	Deuterophlebia	Genus	Arthropoda	Diptera	Deuterophlebiidae	Deuterophlebia	
198	223	Dixa	Genus	Arthropoda	Diptera	Dixidae	Dixa	
665	224	Dixella	Genus	Arthropoda	Diptera	Dixidae	Dixella	
673	225	Meringodixa	Genus	Arthropoda	Diptera	Dixidae	Meringodixa	
199	226	Dolichopodidae	Family	Arthropoda	Diptera	Dolichopodidae		
201	227	Chelifera_Metachela	genus	Arthropoda	Diptera	Empididae	Chelifera	
202	228	Clinocera	genus	Arthropoda	Diptera	Empididae	Clinocera	
203	229	Hemerodromia	genus	Arthropoda	Diptera	Empididae	Hemerodromia	
204	231	Oreogeton	genus	Arthropoda	Diptera	Empididae	Oreogeton	
206	234	Wiedemannia	genus	Arthropoda	Diptera	Empididae	Wiedemannia	
207	235	Ephydridae	Family	Arthropoda	Diptera	Ephydridae		
210	236	Muscidae	Family	Arthropoda	Diptera	Muscidae		
213	237	Glutops	Genus	Arthropoda	Diptera	Pelecorhynchidae	Glutops	
215	239	Maruina	Genus	Arthropoda	Diptera	Psychodidae	Maruina	
216	240	Pericoma_Telmatoscopus	Genus_group	Arthropoda	Diptera	Psychodidae	Pericoma	
217	241	Psychoda	Genus	Arthropoda	Diptera	Psychodidae	Psychoda	

OTU Lookup Table for the GRYN

LAB ID CODE	OTU CODE	OTU NAME	OTU LEVEL	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
672	242	Ptychopteridae	Family	Arthropoda	Diptera	Ptychopteridae	Ptychoptera	
218	242	Ptychopteridae	Family	Arthropoda	Diptera	Ptychopteridae		
674	243	Sciomyzidae	Family	Arthropoda	Diptera	Sciomyzidae		
222	244	Simuliidae	Family	Arthropoda	Diptera	Simuliidae	Prosimulium	
223	244	Simuliidae	Family	Arthropoda	Diptera	Simuliidae	Simulium	
221	244	Simuliidae	Family	Arthropoda	Diptera	Simuliidae		
706	245	Caloparyphus_Euparyphus	Genus-group	Arthropoda	Diptera	Stratiomyidae	Caloparyphus	
226	245	Caloparyphus_Euparyphus	Genus-group	Arthropoda	Diptera	Stratiomyidae	Euparyphus	
782	248	Stratiomys	Genus	Arthropoda	Diptera	Stratiomyidae	Stratiomys	
233	249	Tabanidae	Family	Arthropoda	Diptera	Tabanidae	Tabanus	
231	249	Tabanidae	Family	Arthropoda	Diptera	Tabanidae		
708	250	Tanyderidae	Family	Arthropoda	Diptera	Tanyderidae		
689	251	Thaumaleidae	Family	Arthropoda	Diptera	Thaumaleidae		
728	251	Thaumaleidae	Family	Arthropoda	Diptera	Thaumaleidae	Thaumalea	
235	252	Antocha	Genus	Arthropoda	Diptera	Tipulidae	Antocha	
237	254	Dicranota	Genus	Arthropoda	Diptera	Tipulidae	Dicranota	
238	255	Helius	Genus	Arthropoda	Diptera	Tipulidae	Helius	
240	256	Hesperoconopa	Genus	Arthropoda	Diptera	Tipulidae	Hesperoconopa	
241	257	Hexatoma	Genus	Arthropoda	Diptera	Tipulidae	Hexatoma	
243	259	Limnophila	Genus	Arthropoda	Diptera	Tipulidae	Limnophila	
244	260	Limonia	Genus	Arthropoda	Diptera	Tipulidae	Limonia	
720	261	Molophilus	Genus	Arthropoda	Diptera	Tipulidae	Molophilus	
716	262	Ormosia	Genus	Arthropoda	Diptera	Tipulidae	Ormosia	
245	263	Pedicia	Genus	Arthropoda	Diptera	Tipulidae	Pedicia	
667	264	Rhabdomastix	Genus	Arthropoda	Diptera	Tipulidae	Rhabdomastix	
247	265	Tipula	Genus	Arthropoda	Diptera	Tipulidae	Tipula	
303	266	Ameletus	Genus	Arthropoda	Ephemeroptera	Ameletidae	Ameletus	
907	268	Acentrella	Genus	Arthropoda	Ephemeroptera	Baetidae	Acentrella	
1750	269	Acerpenna	Genus	Arthropoda	Ephemeroptera	Baetidae	Acerpenna	pygmaea
1719	269	Acerpenna	Genus	Arthropoda	Ephemeroptera	Baetidae	Acerpenna	

OTU Lookup Table for the GRYN

LAB ID CODE	OTU CODE	OTU NAME	OTU LEVEL	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
250	271	Baetis	Genus	Arthropoda	Ephemeroptera	Baetidae	Baetis	
723	272	Baetodes	Genus	Arthropoda	Ephemeroptera	Baetidae	Baetodes	
251	273	Callibaetis	Genus	Arthropoda	Ephemeroptera	Baetidae	Callibaetis	
1712	274	Camelobaetidius	Genus	Arthropoda	Ephemeroptera	Baetidae	Camelobaetidius	musseri
1714	274	Camelobaetidius	Genus	Arthropoda	Ephemeroptera	Baetidae	Camelobaetidius	similis
784	274	Camelobaetidius	Genus	Arthropoda	Ephemeroptera	Baetidae	Camelobaetidius	
252	275	Centroptilum	Genus	Arthropoda	Ephemeroptera	Baetidae	Centroptilum	
834	277	Diphetor	Genus	Arthropoda	Ephemeroptera	Baetidae	Diphetor	hageni
1407	278	Fallceon	Genus	Arthropoda	Ephemeroptera	Baetidae	Fallceon	quilleri
1718	280	Plauditus	Genus	Arthropoda	Ephemeroptera	Baetidae	Plauditus	
1646	282	Psuedocloeon	Genus	Arthropoda	Ephemeroptera	Baetidae	Psuedocloeon	apachae
1647	282	Psuedocloeon	Genus	Arthropoda	Ephemeroptera	Baetidae	Psuedocloeon	
258	283	Baetisca	Genus	Arthropoda	Ephemeroptera	Baetiscidae	Baetisca	
1599	284	Amercaenis	Genus	Arthropoda	Ephemeroptera	Caenidae	Amercaenis	
260	285	Brachycercus	Genus	Arthropoda	Ephemeroptera	Caenidae	Brachycercus	
261	286	Caenis	Genus	Arthropoda	Ephemeroptera	Caenidae	Caenis	
1803	287	Cercobrachys	Genus	Arthropoda	Ephemeroptera	Caenidae	Cercobrachys	
1220	288	Attenella	Genus	Arthropoda	Ephemeroptera	Ephemerellidae	Attenella	delantala
263	288	Attenella	Genus	Arthropoda	Ephemeroptera	Ephemerellidae	Attenella	
1071	289	Caudatella	Genus	Arthropoda	Ephemeroptera	Ephemerellidae	Caudatella	heterocaudata
1033	289	Caudatella	Genus	Arthropoda	Ephemeroptera	Ephemerellidae	Caudatella	hystrix
264	289	Caudatella	Genus	Arthropoda	Ephemeroptera	Ephemerellidae	Caudatella	
835	290	Drunella_coloradensis_flavilinea	Species-group	Arthropoda	Ephemeroptera	Ephemerellidae	Drunella	coloradensis
1180	290	Drunella_coloradensis_flavilinea	Species-group	Arthropoda	Ephemeroptera	Ephemerellidae	Drunella	coloradensis/flavilinea
267	291	Drunella_doddsi	Species	Arthropoda	Ephemeroptera	Ephemerellidae	Drunella	doddsi
970	292	Drunella_grandis	Species	Arthropoda	Ephemeroptera	Ephemerellidae	Drunella	grandis
1181	293	Drunella_pelosa	Species	Arthropoda	Ephemeroptera	Ephemerellidae	Drunella	pelosa
836	294	Drunella_spinifera	Species	Arthropoda	Ephemeroptera	Ephemerellidae	Drunella	spinifera
1224	295	Ephemerella_aurivillii	Species	Arthropoda	Ephemeroptera	Ephemerellidae	Ephemerella	aurivillii
778	296	Other_Ephemerella	Genus	Arthropoda	Ephemeroptera	Ephemerellidae	Ephemerella	inermis

OTU Lookup Table for the GRYN

LAB ID CODE	OTU CODE	OTU NAME	OTU LEVEL	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
268	296	Other_Ephemerella	Genus	Arthropoda	Ephemeroptera	Ephemerellidae	Ephemerella	
943	298	Serratella	Genus	Arthropoda	Ephemeroptera	Ephemerellidae	Serratella	tibialis
271	298	Serratella	Genus	Arthropoda	Ephemeroptera	Ephemerellidae	Serratella	
1031	299	Timpanoga_hecuba	Species	Arthropoda	Ephemeroptera	Ephemerellidae	Timpanoga	hecuba
1415	300	Ephemera	Genus	Arthropoda	Ephemeroptera	Ephemeridae	Ephemera	simulans
275	301	Hexagenia	Genus	Arthropoda	Ephemeroptera	Ephemeridae	Hexagenia	
279	302	Cinygmula	Genus	Arthropoda	Ephemeroptera	Heptageniidae	Cinygmula	
280	303	Epeorus	Genus	Arthropoda	Ephemeroptera	Heptageniidae	Epeorus	
281	304	Heptagenia	Genus	Arthropoda	Ephemeroptera	Heptageniidae	Heptagenia	
282	305	Ironodes	Genus	Arthropoda	Ephemeroptera	Heptageniidae	Ironodes	
283	306	Leucrocuta	Genus	Arthropoda	Ephemeroptera	Heptageniidae	Leucrocuta	
285	308	Rhithrogena	Genus	Arthropoda	Ephemeroptera	Heptageniidae	Rhithrogena	
764	309	Stenacron	Genus	Arthropoda	Ephemeroptera	Heptageniidae	Stenacron	
286	310	Stenonema	Genus	Arthropoda	Ephemeroptera	Heptageniidae	Stenonema	
296	311	Isonychia	Genus	Arthropoda	Ephemeroptera	Isonychiidae	Isonychia	
1539	312	Asioplax	Genus	Arthropoda	Ephemeroptera	Leptohyphidae	Asioplax	
306	314	Leptohyphes	Genus	Arthropoda	Ephemeroptera	Leptohyphidae	Leptohyphes	
307	316	Tricorythodes	Genus	Arthropoda	Ephemeroptera	Leptohyphidae	Tricorythodes	
288	318	Choroterpes	Genus	Arthropoda	Ephemeroptera	Leptophlebiidae	Choroterpes	
291	319	Leptophlebia	Genus	Arthropoda	Ephemeroptera	Leptophlebiidae	Leptophlebia	
292	321	Paraleptophlebia	Genus	Arthropoda	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	
287	321	Paraleptophlebia	Genus	Arthropoda	Ephemeroptera	Leptophlebiidae		
1027	322	Thraulodes	Genus	Arthropoda	Ephemeroptera	Leptophlebiidae	Thraulodes	
293	323	Traverella	Genus	Arthropoda	Ephemeroptera	Leptophlebiidae	Traverella	
297	324	Oligoneuridae	Family	Arthropoda	Ephemeroptera	Oligoneuriidae	Lachlania	
1600	324	Oligoneuridae	Family	Arthropoda	Ephemeroptera	Oligoneuriidae	Homoeoneuria	ammophila
299	325	Ephoron	Genus	Arthropoda	Ephemeroptera	Polymitarcyidae	Ephoron	
1598	327	Anthopotamus	Genus	Arthropoda	Ephemeroptera	Potamanthidae	Anthopotamus	myops
304	328	Siphlonuridae	Family	Arthropoda	Ephemeroptera	Siphlonuridae	Siphlonurus	
302	328	Siphlonuridae	Family	Arthropoda	Ephemeroptera	Siphlonuridae		

OTU Lookup Table for the GRYN

LAB ID CODE	OTU CODE	OTU NAME	OTU LEVEL	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
310	329	Belostomatidae	Family	Arthropoda	Hemiptera	Belostomatidae	Abedus	
311	329	Belostomatidae	Family	Arthropoda	Hemiptera	Belostomatidae	Belostoma	
309	329	Belostomatidae	Family	Arthropoda	Hemiptera	Belostomatidae		
323	330	Corixidae	Family	Arthropoda	Hemiptera	Corixidae	Trichocorixa	
314	330	Corixidae	Family	Arthropoda	Hemiptera	Corixidae		
325	331	Gelastocoris	Genus	Arthropoda	Hemiptera	Gelastocoridae	Gelastocoris	
925	332	Gerridae	Family	Arthropoda	Hemiptera	Gerridae	Aquarius	
326	332	Gerridae	Family	Arthropoda	Hemiptera	Gerridae		
333	333	Naucoridae	Family	Arthropoda	Hemiptera	Naucoridae	Ambrysus	
332	333	Naucoridae	Family	Arthropoda	Hemiptera	Naucoridae		
1364	334	Ranatra	Genus	Arthropoda	Hemiptera	Nepidae	Ranatra	
1367	334	Ranatra	Genus	Arthropoda	Hemiptera	Nepidae	Ranatra	fusca
335	335	Notonectidae	Family	Arthropoda	Hemiptera	Notonectidae		
338	337	Veliidae	Family	Arthropoda	Hemiptera	Veliidae		
340	337	Veliidae	Family	Arthropoda	Hemiptera	Veliidae	Microvelia	
341	337	Veliidae	Family	Arthropoda	Hemiptera	Veliidae	Rhagovelia	
350	338	Lepidoptera	Genus	Arthropoda	Lepidoptera	Pyralidae	Petrophila	
344	338	Lepidoptera		Arthropoda	Lepidoptera			
1236	339	Corydalus	Genus	Arthropoda	Megaloptera	Corydalidae	Corydalus	cognata
724	339	Corydalus	Genus	Arthropoda	Megaloptera	Corydalidae	Corydalus	
887	341	Neohermes	Genus	Arthropoda	Megaloptera	Corydalidae	Neohermes	
1186	342	Orohermes	Genus	Arthropoda	Megaloptera	Corydalidae	Orohermes	crepusculus
1032	343	Sialis	Genus	Arthropoda	Megaloptera	Sialidae	Sialis	occidens
359	343	Sialis	Genus	Arthropoda	Megaloptera	Sialidae	Sialis	
355	344	Corydalidae	Family	Arthropoda	Megaloptera	Corydalidae		
365	345	Aeshna	Genus	Arthropoda	Odonata	Aeshnidae	Aeshna	
1557	347	Oplonaeschna	Genus	Arthropoda	Odonata	Aeshnidae	Oplonaeschna	armata
369	347	Oplonaeschna	Genus	Arthropoda	Odonata	Aeshnidae	Oplonaeschna	
372	348	Calopterygidae	Family	Arthropoda	Odonata	Calopterygidae	Calopteryx	
1319	348	Calopterygidae	Family	Arthropoda	Odonata	Calopterygidae	Hetaerina	americana

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LAB ID CODE	OTU CODE	OTU NAME	OTU LEVEL	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
373	348	Calopterygidae	Family	Arthropoda	Odonata	Calopterygidae	Hetaerina	
371	348	Calopterygidae	Family	Arthropoda	Odonata	Calopterygidae		
1541	349	Argia	Family	Arthropoda	Odonata	Coenagrionidae	Argia	emma
376	349	Argia	Family	Arthropoda	Odonata	Coenagrionidae	Argia	
374	350	Other_Coenagrionidae	Family	Arthropoda	Odonata	Coenagrionidae		
1187	351	Cordulegastridae	Family	Arthropoda	Odonata	Cordulegastridae	Cordulegaster	dorsalis
382	351	Cordulegastridae	Family	Arthropoda	Odonata	Cordulegastridae	Cordulegaster	
1582	353	Gomphidae	Family	Arthropoda	Odonata	Gomphidae	Arigomphus	cornutus
1559	353	Gomphidae	Family	Arthropoda	Odonata	Gomphidae	Erpetogomphus	lampropeltis
386	353	Gomphidae	Family	Arthropoda	Odonata	Gomphidae	Erpetogomphus	
387	353	Gomphidae	Family	Arthropoda	Odonata	Gomphidae	Gomphus	
390	353	Gomphidae	Family	Arthropoda	Odonata	Gomphidae	Ophiogomphus	
1533	353	Gomphidae	Family	Arthropoda	Odonata	Gomphidae	Progomphus	borealis
385	353	Gomphidae	Family	Arthropoda	Odonata	Gomphidae		
394	354	Archilestes	Genus	Arthropoda	Odonata	Lestidae	Archilestes	
1558	356	Libellulidae	Family	Arthropoda	Odonata	Libellulidae	Brechmorhoga	mendax
396	356	Libellulidae	Family	Arthropoda	Odonata	Libellulidae		
404	358	Capniidae	Family	Arthropoda	Plecoptera	Capniidae		
415	359	Chloroperlidae	Family	Arthropoda	Plecoptera	Chloroperlidae	Kathroperla	
416	359	Chloroperlidae	Family	Arthropoda	Plecoptera	Chloroperlidae	Paraperla	
418	359	Chloroperlidae	Family	Arthropoda	Plecoptera	Chloroperlidae	Suwallia	
419	359	Chloroperlidae	Family	Arthropoda	Plecoptera	Chloroperlidae	Sweltsa	
666	359	Chloroperlidae	Family	Arthropoda	Plecoptera	Chloroperlidae	Triznaka	
412	359	Chloroperlidae	Family	Arthropoda	Plecoptera	Chloroperlidae		
424	360	Leuctridae	Family	Arthropoda	Plecoptera	Leuctridae	Moselia	
420	360	Leuctridae	Family	Arthropoda	Plecoptera	Leuctridae		
430	361	Amphinemura	Genus	Arthropoda	Plecoptera	Nemouridae	Amphinemura	
431	362	Malenka	Genus	Arthropoda	Plecoptera	Nemouridae	Malenka	
434	364	Podmosta	Genus	Arthropoda	Plecoptera	Nemouridae	Podmosta	
909	367	Zapada	Genus	Arthropoda	Plecoptera	Nemouridae	Zapada	cinctipes

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LAB ID CODE	OTU CODE	OTU NAME	OTU LEVEL	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
439	367	Zapada	Genus	Arthropoda	Plecoptera	Nemouridae	Zapada	
441	369	Soliperla	genus	Arthropoda	Plecoptera	Peltoperlidae	Soliperla	
443	370	Yoraperla	genus	Arthropoda	Plecoptera	Peltoperlidae	Yoraperla	
1000	371	Acroneuria	genus	Arthropoda	Plecoptera	Perlidae	Acroneuria	abnormis
445	371	Acroneuria	genus	Arthropoda	Plecoptera	Perlidae	Acroneuria	
837	372	Calineuria	Genus	Arthropoda	Plecoptera	Perlidae	Calineuria	californica
798	373	Claassenia_sabulosa	Species	Arthropoda	Plecoptera	Perlidae	Claassenia	sabulosa
450	374	Doroneuria	Genus	Arthropoda	Plecoptera	Perlidae	Doroneuria	
838	375	Hesperoperla	Genus	Arthropoda	Plecoptera	Perlidae	Hesperoperla	pacifica
1741	376	Perlesta	Genus	Arthropoda	Plecoptera	Perlidae	Perlesta	decipiens
457	377	Cultus	Genus	Arthropoda	Plecoptera	Perlodidae	Cultus	
460	378	Isogenoides	Genus	Arthropoda	Plecoptera	Perlodidae	Isogenoides	
462	379	Isoperla	Genus	Arthropoda	Plecoptera	Perlodidae	Isoperla	
463	380	Kogotus	Genus	Arthropoda	Plecoptera	Perlodidae	Kogotus	
464	381	Megarcys	Family	Arthropoda	Plecoptera	Perlodidae	Megarcys	
466	382	Perlinodes	Genus	Arthropoda	Plecoptera	Perlodidae	Perlinodes	
469	383	Skwala	Genus	Arthropoda	Plecoptera	Perlodidae	Skwala	
465	384	Oroperla	Genus	Arthropoda	Plecoptera	Perlodidae	Oroperla	
467	385	Pictetiella	Genus	Arthropoda	Plecoptera	Perlodidae	Pictetiella	
468	386	Setvena	Genus	Arthropoda	Plecoptera	Perlodidae	Setvena	
800	391	Pteronarcella	Genus	Arthropoda	Plecoptera	Pteronarcyidae	Pteronarcella	badia
472	391	Pteronarcella	Genus	Arthropoda	Plecoptera	Pteronarcyidae	Pteronarcella	
799	392	Pteronarcys	Genus	Arthropoda	Plecoptera	Pteronarcyidae	Pteronarcys	californica
1267	392	Pteronarcys	Genus	Arthropoda	Plecoptera	Pteronarcyidae	Pteronarcys	princeps
473	392	Pteronarcys	Genus	Arthropoda	Plecoptera	Pteronarcyidae	Pteronarcys	
474	393	Taeniopterygidae	Family	Arthropoda	Plecoptera	Taeniopterygidae		
545	394	Allomyia	Genus	Arthropoda	Trichoptera	Apataniidae	Allomyia	
531	395	Apatania	Genus	Arthropoda	Trichoptera	Apataniidae	Apatania	
552	396	Pedomoecus	Genus	Arthropoda	Trichoptera	Apataniidae	Pedomoecus	
482	397	Amiocentrus	Genus	Arthropoda	Trichoptera	Brachycentridae	Amiocentrus	

OTU Lookup Table for the GRYN

LAB ID CODE	OTU CODE	OTU NAME	OTU LEVEL	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
809	398	Brachycentrus	Genus	Arthropoda	Trichoptera	Brachycentridae	Brachycentrus	americanus
483	398	Brachycentrus	Genus	Arthropoda	Trichoptera	Brachycentridae	Brachycentrus	
484	399	Micrasema	Genus	Arthropoda	Trichoptera	Brachycentridae	Micrasema	
486	400	Heteroplectron	Genus	Arthropoda	Trichoptera	Calamoceratidae	Heteroplectron	
1565	401	Phylloicus	Genus	Arthropoda	Trichoptera	Calamoceratidae	Phylloicus	
488	402	Agapetus	Genus	Arthropoda	Trichoptera	Glossosomatidae	Agapetus	
489	403	Anagapetus	Genus	Arthropoda	Trichoptera	Glossosomatidae	Anagapetus	
491	404	Glossosoma	Genus	Arthropoda	Trichoptera	Glossosomatidae	Glossosoma	
493	405	Helicopsychidae	Family	Arthropoda	Trichoptera	Helicopsychidae		
494	405	Helicopsychidae	Family	Arthropoda	Trichoptera	Helicopsychidae	Helicopsyche	
1239	406	Atopsyche	Genus	Arthropoda	Trichoptera	Hydrobiosidae	Atopsyche	
496	407	Arctopsyche	Genus	Arthropoda	Trichoptera	Hydropsychidae	Arctopsyche	
497	408	Cheumatopsyche	Genus	Arthropoda	Trichoptera	Hydropsychidae	Cheumatopsyche	
499	409	Hydropsyche	Genus	Arthropoda	Trichoptera	Hydropsychidae	Hydropsyche	
502	410	Parapsyche	Genus	Arthropoda	Trichoptera	Hydropsychidae	Parapsyche	
503	411	Potamyia	Genus	Arthropoda	Trichoptera	Hydropsychidae	Potamyia	
504	412	Smicridea	Genus	Arthropoda	Trichoptera	Hydropsychidae	Smicridea	
507	413	Agraylea	Genus	Arthropoda	Trichoptera	Hydroptilidae	Agraylea	
509	414	Hydroptila	Genus	Arthropoda	Trichoptera	Hydroptilidae	Hydroptila	
510	415	Ithytrichia	Genus	Arthropoda	Trichoptera	Hydroptilidae	Ithytrichia	
511	416	Leucotrichia	Genus	Arthropoda	Trichoptera	Hydroptilidae	Leucotrichia	
512	417	Mayatrichia	Genus	Arthropoda	Trichoptera	Hydroptilidae	Mayatrichia	
513	419	Neotrichia	Genus	Arthropoda	Trichoptera	Hydroptilidae	Neotrichia	
515	423	Oxyethira	Genus	Arthropoda	Trichoptera	Hydroptilidae	Oxyethira	
516	424	Palaeagapetus	Genus	Arthropoda	Trichoptera	Hydroptilidae	Palaeagapetus	
1344	427	Lepidostomatidae	Family	Arthropoda	Trichoptera	Lepidostomatidae	Lepidostoma	Subgenus neodinarthrum
1361	427	Lepidostomatidae	Family	Arthropoda	Trichoptera	Lepidostomatidae	Lepidostoma	unicolor group
519	427	Lepidostomatidae	Family	Arthropoda	Trichoptera	Lepidostomatidae	Lepidostoma	
518	427	Lepidostomatidae	Family	Arthropoda	Trichoptera	Lepidostomatidae		
521	428	Ceraclea	Genus	Arthropoda	Trichoptera	Leptoceridae	Ceraclea	

OTU Lookup Table for the GRYN

LAB ID CODE	OTU CODE	OTU NAME	OTU LEVEL	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
522	430	Nectopsyche	Genus	Arthropoda	Trichoptera	Leptoceridae	Nectopsyche	
525	431	Oecetis	Genus	Arthropoda	Trichoptera	Leptoceridae	Oecetis	
999	432	Ylodes	Genus	Arthropoda	Trichoptera	Leptoceridae	Ylodes	
529	433	Allocosmoecus	Genus	Arthropoda	Trichoptera	Limnephilidae	Allocosmoecus	
533	434	Chyranda	Genus	Arthropoda	Trichoptera	Limnephilidae	Chyranda	
535	435	Cryptochia	Genus	Arthropoda	Trichoptera	Limnephilidae	Cryptochia	
1279	436	Dicosmoecus	Genus	Arthropoda	Trichoptera	Limnephilidae	Dicosmoecus	atripes
536	436	Dicosmoecus	Genus	Arthropoda	Trichoptera	Limnephilidae	Dicosmoecus	
538	437	Ecclisomyia	Genus	Arthropoda	Trichoptera	Limnephilidae	Ecclisomyia	
542	438	Hesperophylax	Genus	Arthropoda	Trichoptera	Limnephilidae	Hesperophylax	
530	440	Amphicosmoecus	Genus	Arthropoda	Trichoptera	Limnephilidae	Amphicosmoecus	
722	441	Ecclisocosmoecus	Genus	Arthropoda	Trichoptera	Limnephilidae	Ecclisocosmoecus	
551	442	Onocosmoecus	Genus	Arthropoda	Trichoptera	Limnephilidae	Onocosmoecus	
555	443	Psychoglypha	Genus	Arthropoda	Trichoptera	Limnephilidae	Psychoglypha	
680	444	Marilia	Genus	Arthropoda	Trichoptera	Odontoceridae	Marilia	
566	448	Chimarra	Genus	Arthropoda	Trichoptera	Philopotamidae	Chimarra	
567	449	Dolophilodes	Genus	Arthropoda	Trichoptera	Philopotamidae	Dolophilodes	
568	450	Wormaldia	Genus	Arthropoda	Trichoptera	Philopotamidae	Wormaldia	
569	451	Phryganeidae	Family	Arthropoda	Trichoptera	Phryganeidae		
578	452	Polycentropus	Genus	Arthropoda	Trichoptera	Polycentropodidae	Polycentropus	
573	453	Other_Polycentropodidae	Family	Arthropoda	Trichoptera	Polycentropodidae		
581	454	Psychomyia	Genus	Arthropoda	Trichoptera	Psychomyiidae	Psychomyia	
582	455	Tinodes	Genus	Arthropoda	Trichoptera	Psychomyiidae	Tinodes	
1205	456	Himalopsyche_phryganea	Species	Arthropoda	Trichoptera	Rhyacophilidae	Himalopsyche	phryganea
1215	457	Rhyacophila_alberta_group	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	alberta
1707	457	Rhyacophila_alberta_group	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	alberta group
1207	458	Rhyacophila_angelita_group	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	angelita
1706	458	Rhyacophila_angelita_group	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	angelita group
1213	460	Rhyacophila_betteni_group	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	betteni
1668	460	Rhyacophila_betteni_group	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	betteni group

OTU Lookup Table for the GRYN

LAB ID CODE	OTU CODE	OTU NAME	OTU LEVEL	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
1274	462	Rhyacophila_brunnea_vemna_groups	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	brunnea
1667	462	Rhyacophila_brunnea_vemna_groups	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	brunnea group
1206	462	Rhyacophila_brunnea_vemna_groups	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	brunnea/vemna groups
808	463	Rhyacophila_coloradensis_group	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	coloradensis
1710	463	Rhyacophila_coloradensis_group	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	coloradensis group
1717	464	Rhyacophila_glaciera	Species	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	glaciera
1665	466	Rhyacophila_harmstoni	Species	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	harmstoni
1214	467	Rhyacophila_hyalinata_group	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	hyalinata
1708	467	Rhyacophila_hyalinata_group	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	hyalinata group
1709	472	Rhyacophila_sibirica_group	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	sibirica group
1716	473	Rhyacophila_tucula	Species	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	tucula
1501	474	Rhyacophila_vaccua	Species	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	vaccua
1502	476	Rhyacophilla_pellisa_valuma	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	valuma
1208	477	Rhyacophila_verrula_group	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	verrula
1715	477	Rhyacophila_verrula_group	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	verrula group
1505	478	Rhyacophila_vofixa_group	Species-group	Arthropoda	Trichoptera	Rhyacophilidae	Rhyacophila	vofixa group
587	479	Gumaga	Genus	Arthropoda	Trichoptera	Sericostomatidae	Gumaga	
549	481	Neophylax	Genus	Arthropoda	Trichoptera	Uenoidae	Neophylax	
589	482	Neothremma	Genus	Arthropoda	Trichoptera	Uenoidae	Neothremma	
550	483	Oligophlebodes	Genus	Arthropoda	Trichoptera	Uenoidae	Oligophlebodes	
819	488	Gammarus	Genus	Arthropoda	Amphipoda	Gammaridae	Gammarus	lacustris
929	489	Hyalella	Genus	Arthropoda	Amphipoda	Hyalellidae	Hyalella	azteca
1030	490	Astacidae	Family	Arthropoda	Decapoda	Astacidae	Pacifastacus	leniusculus
81	490	Astacidae	Family	Arthropoda	Decapoda	Astacidae	Pacifastacus	
1331	492	Cambaridae	Family	Arthropoda	Decapoda	Cambaridae	Orconectes	virilis
1330	492	Cambaridae	Family	Arthropoda	Decapoda	Cambaridae	Orconectes	
82	492	Cambaridae	Family	Arthropoda	Decapoda	Cambaridae		
84	493	Asellidae	Family	Arthropoda	Isopoda	Asellidae		
87	493	Asellidae	Family	Arthropoda	Isopoda	Asellidae	Caecidotea	

OTU Lookup Table for the GRYN

LAB ID CODE	OTU CODE	OTU NAME	OTU LEVEL	PHYLUM	ORDER	FAMILY	GENUS	SPECIES
1618	494	Copepoda	Subclass	Arthropoda				
90	495	OSTRACODA	Class	Arthropoda	Podocopida			
639	496	Margaritiferidae	Family	Mollusca	Unionida	Margaritiferidae	Margaritifera	
1217	496	Margaritiferidae	Family	Mollusca	Unionida	Margaritiferidae	Margaritifera	falcata
1575	496	Margaritiferidae	Family	Mollusca	Unionida	Margaritiferidae	Margaritifera	margaritifera
641	497	Unionidae	Family	Mollusca	Unionida	Unionidae	Anodonta	
647	499	Pisidiidae	Family	Mollusca	Veneroida	Pisidiidae	Pisidium	
646	499	Pisidiidae	Family	Mollusca	Veneroida	Pisidiidae		
599	500	Ferrissia	Family	Mollusca	Basommatophora	Ancylidae	Ferrissia	
854	500	Ferrissia	Family	Mollusca	Basommatophora	Ancylidae	Ferrissia	rivularis
604	503	Other_Lymnaeidae	Family	Mollusca	Basommatophora	Lymnaeidae		
627	504	Physa_Physella	Family	Mollusca	Basommatophora	Physidae	Physella	
629	505	Planorbidae	Family	Mollusca	Basommatophora	Planorbidae	Gyraulus	
628	505	Planorbidae	Family	Mollusca	Basommatophora	Planorbidae		
616	506	Valvata	Genus	Mollusca	Heterostropha	Valvatidae	Valvata	
1369	507	Potamopyrgus_antipodarum	Family	Mollusca	Neotaenioglossa	Hydrobiidae	Potamopyrgus	antipodarum
633	508	Other_Hydrobiidae	Family	Mollusca	Neotaenioglossa	Hydrobiidae		
636	509	JUGA	Genus	Mollusca	Neotaenioglossa	Pleuroceridae	Juga	
652	510	Nematoda	Phylum	Nemata				
719	511	Nematomorpha	Phylum	Nematomorpha				
655	513	Turbellaria		Platyhelminthes				

Appendix V

GRYN OTU – ITIS TSN Conversion Lookup Table

OTU – ITIS TSN Conversion Lookup Table for the GRYN

BugLab Code	TSN	Name	TaxaLevel	OTUCode	OTUName	OTULevel
5	69168	Branchiobdellida	ORDER	4	Branchiobdellida	Subclass
12	69438	Erpobdellidae	FAMILY	1	Erpobdellidae	Family
15	69357	Glossiphoniidae	FAMILY	3	Glossiphoniidae	Family
19	68422	Oligochaeta	CLASS	5	Other_Oligochaeta	Subclass
24	68498	Haplotaxida	ORDER	5	Other_Oligochaeta	Subclass
58	82769	Trombidiformes	ORDER	7	Trombidiformes	Order
81	97325	Pacifastacus	GENUS	490	Astacidae	Family
82	97336	Cambaridae	FAMILY	492	Cambaridae	Family
84	92657	Asellidae	FAMILY	493	Asellidae	Family
87	92686	Caecidotea	GENUS	493	Asellidae	Family
90	609939	Podocopida	ORDER	495	OSTRACODA	Class
101	111953	Amphizoa	GENUS	8	Amphizoa	Genus
102	109234	Carabidae	FAMILY	9	Carabidae	Family
104	114006	Helichus	GENUS	11	Helichus	Genus
108	111966	Agabus	GENUS	16	Agabus	Genus
115	112200	Hygrotus	GENUS	21	Hygrotus	Genus
117	112278	Laccophilus	GENUS	23	Laccophilus	Genus
118	112314	Oreodytes	GENUS	27	Oreodytes	Genus
119	112086	Rhantus	GENUS	28	Rhantus	Genus
122	114196	Ampumixis	GENUS	31	Ampumixis	Genus
124	114164	Cleptelmis	GENUS	33	Cleptelmis	Genus
125	114165	ornata	SPECIES	33	Cleptelmis	Genus
126	114126	Dubiraphia	GENUS	34	Dubiraphia	Genus
128	114167	Heterlimnius	GENUS	35	Heterelmis	Genus
129	114169	corpulentus	SPECIES	35	Heterelmis	Genus
130	114137	Lara	GENUS	36	Lara	Genus
132	114160	similis	SPECIES	39	Microcylloepus	Genus
133	114142	Narpus	GENUS	40	Narpus	Genus
134	114144	concolor	SPECIES	40	Narpus	Genus
135	114177	Optioservus	GENUS	43	Optioservus	Gneus
140	114235	Ordobrevia	GENUS	44	Ordobrevia	Gneus
143	114095	Stenelmis	GENUS	47	Stenelmis	Gneus
144	114205	Zaitzevia	GENUS	48	Zaitzevia	Gneus
146	114206	parvula	SPECIES	48	Zaitzevia	Gneus
147	112711	Dineutus	GENUS	49	Dineutus	Gneus
148	112654	Gyrinus	GENUS	50	Gyrinus	Gneus
150	111947	Brychius	GENUS	51	Brychius	Gneus
151	111858	Haliplus	GENUS	52	Haliplus	Gneus
152	111923	Peltodytes	GENUS	53	Peltodytes	Gneus
154	112890	Ametor	GENUS	58	Ametor	Gneus

OTU – ITIS TSN Conversion Lookup Table for the GRYN

BugLab Code	TSN	Name	TaxaLevel	OTUCode	OTUName	OTULevel
155	112812	Berosus	GENUS	59	Berosus	Gneus
160	113106	Helophorus	GENUS	54	Helophorus	Gneus
161	113196	Hydrobius	GENUS	65	Hydrobius	Gneus
165	112909	Paracymus	GENUS	67	Paracymus	Gneus
166	112938	Tropisternus	GENUS	69	Tropisternus	Gneus
169	114085	Eubrianax	GENUS	72	Eubrianax	Genus
170	114070	Psephenus	GENUS	73	Psephenus	Genus
175	130929	Atherix	GENUS	78	Atherix	Genus
176	121227	Blephariceridae	FAMILY	79	Blephariceridae	Family
177	121230	Agathon	GENUS	79	Blephariceridae	Family
178	121250	Bibiocephala	GENUS	79	Blephariceridae	Family
189	125930	Culicidae	FAMILY	221	Culicidae	Family
191	125956	Anopheles	GENUS	221	Culicidae	Family
196	121287	Deuterophlebia	GENUS	222	Deuterophlebia	Genus
198	125810	Dixa	GENUS	223	Dixa	Genus
199	136824	Dolichopodidae	FAMILY	226	Dolichopodidae	Family
201	136305	Chelifera	GENUS	227	Chelifera_Metachela	genus
202	135849	Clinocera	GENUS	228	Clinocera	genus
203	136327	Hemerodromia	GENUS	229	Hemerodromia	genus
204	136377	Oreogeton	GENUS	231	Oreogeton	genus
206	135920	Wiedemannia	GENUS	234	Wiedemannia	genus
207	146893	Ephydridae	FAMILY	235	Ephydridae	Family
210	150025	Muscidae	FAMILY	236	Muscidae	Family
213	130915	Glutops	GENUS	237	Glutops	Genus
215	125392	Maruina	GENUS	239	Maruina	Genus
216	125514	Pericoma	GENUS	240	Pericoma_Telmatoscopus	Genus_group
217	125468	Psychoda	GENUS	241	Psychoda	Genus
218	125763	Ptychopteridae	FAMILY	242	Ptychopteridae	Family
221	126640	Simuliidae	FAMILY	244	Simuliidae	Family
222	126703	Prosimulium	GENUS	244	Simuliidae	Family
223	126774	Simulium	GENUS	244	Simuliidae	Family
226	130436	Euparyphus	GENUS	245	Caloparyphus_Euparyphus	Genus-group
231	130934	Tabanidae	FAMILY	249	Tabanidae	Family
233	131527	Tabanus	GENUS	249	Tabanidae	Family
235	119656	Antocha	GENUS	252	Antocha	Genus
237	121027	Dicranota	GENUS	254	Dicranota	Genus
238	119690	Helius	GENUS	255	Helius	Genus
240	120732	Hesperoconopa	GENUS	256	Hesperoconopa	Genus
241	120094	Hexatoma	GENUS	257	Hexatoma	Genus
243	33634	Limnophila	GENUS	259	Limnophila	Genus
244	500746	Limonia	GENUS	260	Limonia	Genus
245	121118	Pedicia	GENUS	263	Pedicia	Genus
247	119037	Tipula	GENUS	265	Tipula	Genus

OTU – ITIS TSN Conversion Lookup Table for the GRYN

BugLab Code	TSN	Name	TaxaLevel	OTUCode	OTUName	OTULevel
250	100800	Baetis	GENUS	271	Baetis	Genus
251	100903	Callibaetis	GENUS	273	Callibaetis	Genus
252	100873	Centroptilum	GENUS	275	Centroptilum	Genus
258	101494	Baetisca	GENUS	283	Baetisca	Genus
260	101468	Brachycercus	GENUS	285	Brachycercus	Genus
261	101478	Caenis	GENUS	286	Caenis	Genus
263	101338	Attenella	GENUS	288	Attenella	Genus
264	101347	Caudatella	GENUS	289	Caudatella	Genus
267	101368	doddsi	SPECIES	291	Drunella_doddsi	Species
268	101233	Ephemerella	GENUS	296	Other_Ephemerella	Genus
271	101395	Serratella	GENUS	298	Serratella	Genus
275	101537	Hexagenia	GENUS	301	Hexagenia	Genus
279	100557	Cinygmula	GENUS	302	Cinygmula	Genus
280	100626	Epeorus	GENUS	303	Epeorus	Genus
281	100602	Heptagenia	GENUS	304	Heptagenia	Genus
282	100666	Ironodes	GENUS	305	Ironodes	Genus
283	100676	Leucrocuta	GENUS	306	Leucrocuta	Genus
285	100572	Rhithrogena	GENUS	308	Rhithrogena	Genus
286	100507	Stenonema	GENUS	310	Stenonema	Genus
287	101095	Leptophlebiidae	FAMILY	321	Paraleptophlebia	Genus
288	101108	Choroterpes	GENUS	318	Choroterpes	Genus
291	101148	Leptophlebia	GENUS	319	Leptophlebia	Genus
292	101187	Paraleptophlebia	GENUS	321	Paraleptophlebia	Genus
293	101096	Traverella	GENUS	323	Traverella	Genus
296	101041	Isonychia	GENUS	311	Isonychia	Genus
297	101030	Lachlania	GENUS	324	Oligoneuridae	Family
299	101570	Ephoron	GENUS	325	Ephoron	Genus
302	100951	Siphlonuridae	FAMILY	328	Siphlonuridae	Family
303	100996	Ameletus	GENUS	266	Ameletus	Genus
304	100953	Siphlonurus	GENUS	328	Siphlonuridae	Family
306	101429	Leptohyphes	GENUS	314	Leptohyphes	Genus
307	101405	Tricorythodes	GENUS	316	Tricorythodes	Genus
309	103683	Belostomatidae	FAMILY	329	Belostomatidae	Family
310	103717	Abedus	GENUS	329	Belostomatidae	Family
311	103684	Belostoma	GENUS	329	Belostomatidae	Family
314	103364	Corixidae	FAMILY	330	Corixidae	Family
323	103423	Trichocorixa	GENUS	330	Corixidae	Family
325	103769	Gelastocoris	GENUS	331	Gelastocoris	Genus
326	103801	Gerridae	FAMILY	332	Gerridae	Family
332	103613	Naucoridae	FAMILY	333	Naucoridae	Family
333	103614	Ambrysus	GENUS	333	Naucoridae	Family
335	103557	Notonectidae	FAMILY	335	Notonectidae	Family
338	103885	Veliidae	FAMILY	337	Veliidae	Family

OTU – ITIS TSN Conversion Lookup Table for the GRYN

BugLab Code	TSN	Name	TaxaLevel	OTUCode	OTUName	OTULevel
340	103900	Microvelia	GENUS	337	Veliidae	Family
341	103886	Rhagovelia	GENUS	337	Veliidae	Family
344	117232	Lepidoptera	ORDER	338	Lepidoptera	Order
350	117682	Petrophila	GENUS	338	Lepidoptera	Genus
355	115023	Corydalidae	FAMILY	344	Corydalidae	Family
359	115002	Sialis	GENUS	343	Sialis	Genus
365	101603	Aeshna	GENUS	345	Aeshna	Genus
369	101655	Oplonaeschna	GENUS	347	Oplonaeschna	Genus
371	102043	Calopterygidae	FAMILY	348	Calopterygidae	Family
372	102052	Calopteryx	GENUS	348	Calopterygidae	Family
373	102048	Hetaerina	GENUS	348	Calopterygidae	Family
374	102077	Coenagrionidae	FAMILY	350	Other_Coenagrionidae	Family
376	102139	Argia	GENUS	349	Argia	Family
382	102027	Cordulegaster	GENUS	351	Cordulegastridae	Family
385	101664	Gomphidae	FAMILY	353	Gomphidae	Family
386	101725	Erpetogomphus	GENUS	353	Gomphidae	Family
387	101665	Gomphus	GENUS	353	Gomphidae	Family
390	101738	Ophiogomphus	GENUS	353	Gomphidae	Family
394	102059	Archilestes	GENUS	354	Archilestes	Genus
396	101797	Libellulidae	FAMILY	356	Libellulidae	Family
404	102643	Capniidae	FAMILY	358	Capniidae	Family
412	103202	Chloroperlidae	FAMILY	359	Chloroperlidae	Family
415	103236	Kathroperla	GENUS	359	Chloroperlidae	Family
416	103233	Paraperla	GENUS	359	Chloroperlidae	Family
418	103254	Suwallia	GENUS	359	Chloroperlidae	Family
419	103273	Sweltsa	GENUS	359	Chloroperlidae	Family
420	102840	Leuctridae	FAMILY	360	Leuctridae	Family
424	102909	Moselia	GENUS	360	Leuctridae	Family
430	102540	Amphinemura	GENUS	361	Amphinemura	Genus
431	102567	Malenka	GENUS	362	Malenka	Genus
434	102605	Podmosta	GENUS	364	Podmosta	Genus
439	102591	Zapada	GENUS	367	Zapada	Genus
441	103142	Soliperla	GENUS	369	Soliperla	genus
443	102510	Yoraperla	GENUS	370	Yoraperla	genus
445	102917	Acroneuria	GENUS	371	Acroneuria	genus
450	103121	Doroneuria	GENUS	374	Doroneuria	Genus
457	103137	Cultus	GENUS	377	Cultus	Genus
460	103124	Isogenoides	GENUS	378	Isogenoides	Genus
462	102995	Isoperla	GENUS	379	Isoperla	Genus
463	103149	Kogotus	GENUS	380	Kogotus	Genus
464	103110	Megarcys	GENUS	381	Megarcys	Family
465	103180	Oroperla	GENUS	384	Oroperla	Genus
466	103134	Perlinodes	GENUS	382	Perlinodes	Genus

OTU – ITIS TSN Conversion Lookup Table for the GRYN

BugLab Code	TSN	Name	TaxaLevel	OTUCode	OTUName	OTULevel
467	103186	Pictetiella	GENUS	385	Pictetiella	Genus
468	103193	Setvena	GENUS	386	Setvena	Genus
469	103102	Skwala	GENUS	383	Skwala	Genus
472	102485	Pteronarcella	GENUS	391	Pteronarcella	Genus
473	102471	Pteronarcys	GENUS	392	Pteronarcys	Genus
474	102788	Taeniopterygidae	FAMILY	393	Taeniopterygidae	Family
482	116933	Amiocentrus	GENUS	397	Amiocentrus	Genus
483	116906	Brachycentrus	GENUS	398	Brachycentrus	Genus
484	116958	Micrasema	GENUS	399	Micrasema	Genus
486	116537	Heteroplectron	GENUS	400	Heteroplectron	Genus
488	117121	Agapetus	GENUS	402	Agapetus	Genus
489	117154	Anagapetus	GENUS	403	Anagapetus	Genus
491	117159	Glossosoma	GENUS	404	Glossosoma	Genus
493	117015	Helicopsychidae	FAMILY	405	Helicopsychidae	Family
494	117016	Helicopsyche	GENUS	405	Helicopsychidae	Family
496	115529	Arctopsyche	GENUS	407	Arctopsyche	Genus
497	115408	Cheumatopsyche	GENUS	408	Cheumatopsyche	Genus
499	115453	Hydropsyche	GENUS	409	Hydropsyche	Genus
502	115556	Parapsyche	GENUS	410	Parapsyche	Genus
503	115551	Potamyia	GENUS	411	Potamyia	Genus
504	115544	Smicridea	GENUS	412	Smicridea	Genus
507	115635	Agraylea	GENUS	413	Agraylea	Genus
509	115641	Hydroptila	GENUS	414	Hydroptila	Genus
510	115823	Ithytrichia	GENUS	415	Ithytrichia	Genus
511	115630	Leucotrichia	GENUS	416	Leucotrichia	Genus
512	115811	Mayatrichia	GENUS	417	Mayatrichia	Genus
513	115833	Neotrichia	GENUS	419	Neotrichia	Genus
515	115779	Oxyethira	GENUS	423	Oxyethira	Genus
516	115849	Palaeagapetus	GENUS	424	Palaeagapetus	Genus
518	116793	Lepidostomatidae	FAMILY	427	Lepidostomatidae	Family
519	116794	Lepidostoma	GENUS	427	Lepidostomatidae	Family
521	116684	Ceraclea	GENUS	428	Ceraclea	Genus
522	116651	Nectopsyche	GENUS	430	Nectopsyche	Genus
525	116607	Oecetis	GENUS	431	Oecetis	Genus
529	115969	Allocosmoecus	GENUS	433	Allocosmoecus	Genus
530	116253	Amphicosmoecus	GENUS	440	Amphicosmoecus	Genus
531	115935	Apatania	GENUS	395	Apatania	Genus
533	116017	Chyranda	GENUS	434	Chyranda	Genus
535	115907	Cryptochia	GENUS	435	Cryptochia	Genus
536	116265	Dicosmoecus	GENUS	436	Dicosmoecus	Genus
538	116025	Ecclisomyia	GENUS	437	Ecclisomyia	Genus
542	116001	Hesperophylax	GENUS	438	Hesperophylax	Genus
545	116438	Allomyia	GENUS	394	Allomyia	Genus

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BugLab Code	TSN	Name	TaxaLevel	OTUCode	OTUName	OTULevel
549	116046	Neophylax	GENUS	481	Neophylax	Genus
550	116039	Oligophlebodes	GENUS	483	Oligophlebodes	Genus
551	116315	Onocosmoecus	GENUS	442	Onocosmoecus	Genus
552	115972	Pedomoecus	GENUS	396	Pedomoecus	Genus
555	115974	Psychoglypha	GENUS	443	Psychoglypha	Genus
566	115273	Chimarra	GENUS	448	Chimarra	Genus
567	115319	Dolophilodes	GENUS	449	Dolophilodes	Genus
568	115258	Wormaldia	GENUS	450	Wormaldia	Genus
569	115867	Phryganeidae	FAMILY	451	Phryganeidae	Family
573	117043	Polycentropodidae	FAMILY	453	Other_Polycentropodidae	Family
578	117044	Polycentropus	GENUS	452	Polycentropus	Genus
581	115335	Psychomyia	GENUS	454	Psychomyia	Genus
582	115350	Tinodes	GENUS	455	Tinodes	Genus
587	117003	Gumaga	GENUS	479	Gumaga	Genus
589	116388	Neothremma	GENUS	482	Neothremma	Genus
599	76569	Ferrissia	GENUS	500	Ferrissia	Family
604	76483	Lymnaeidae	FAMILY	503	Other_Lymnaeidae	Family
616	70346	Valvata	GENUS	506	Valvata	Genus
627	76698	Physella	GENUS	504	Physa_Physella	Family
628	76591	Planorbidae	FAMILY	505	Planorbidae	Family
629	76592	Gyraulus	GENUS	505	Planorbidae	Family
633	70493	Hydrobiidae	FAMILY	508	Other_Hydrobiidae	Family
636	71570	Juga	GENUS	509	JUGA	Genus
639	80370	Margaritifera	GENUS	496	Margaritiferidae	Family
641	79930	Anodonta	GENUS	497	Unionidae	Family
646	81388	Pisidiidae	FAMILY	499	Pisidiidae	Family
647	81400	Pisidium	GENUS	499	Pisidiidae	Family
652	563956	Nemata	PHYLUM	510	Nematoda	Phylum
655	53964	Turbellaria	CLASS	513	Turbellaria	Order
662	68854	Naididae	FAMILY	5	Other_Oligochaeta	Subclass
665	125854	Dixella	GENUS	224	Dixella	Genus
666	103308	Triznaka	GENUS	359	Chloroperlidae	Family
667	120968	Rhabdomastix	GENUS	264	Rhabdomastix	Genus
670	114082	Acneus	GENUS	71	Acneus	Genus
671	127113	Atrichopogon	GENUS	81	Forcipomyiinae	Subfamily
672	125786	Ptychoptera	GENUS	242	Ptychopteridae	Family
673	125873	Meringodixa	GENUS	225	Meringodixa	Genus
674	144653	Sciomyzidae	FAMILY	243	Sciomyzidae	Family
680	116514	Marilia	GENUS	444	Marilia	Genus
684	114666	Curculionidae	FAMILY	10	Curculionidae	Family
685	121255	Blepharicera	GENUS	79	Blephariceridae	Family
689	126624	Thaumaleidae	FAMILY	251	Thaumaleidae	Family
706	130409	Caloparyphus	GENUS	245	Caloparyphus_Euparyphus	Genus-group

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BugLab Code	TSN	Name	TaxaLevel	OTUCode	OTUName	OTULevel
708	125799	Tanyderidae	FAMILY	250	Tanyderidae	Family
716	500453	Ormosia	GENUS	262	Ormosia	Genus
719	64183	Nematomorpha	PHYLUM	511	Nematomorpha	Phylum
720	120758	Molophilus	GENUS	261	Molophilus	Genus
722	116340	Ecclisocosmoecus	GENUS	441	Ecclisocosmoecus	Genus
723	100938	Baetodes	GENUS	272	Baetodes	Genus
724	115033	Corydalus	GENUS	339	Corydalus	Genus
728	126629	Thaumalea	GENUS	251	Thaumaleidae	Family
729	69456	obscura	SPECIES	1	Erpobdellidae	Family
732	114244	Oulimnius	GENUS	45	Oulimnius	Gneus
748	127778	Bezzia	GENUS	80	Ceratopogoninae	Subfamily
750	127152	Forcipomyia	GENUS	81	Forcipomyiinae	Subfamily
763	121278	Philorus	GENUS	79	Blephariceridae	Family
764	100713	Stenacron	GENUS	309	Stenacron	Genus
778	101239	inermis	SPECIES	296	Other_Ephemerella	Genus
782	130627	Stratiomys	GENUS	248	Stratiomys	Genus
784	568548	Camelobaetidius	GENUS	274	Camelobaetidius	Genus
798	102932	sabulosa	SPECIES	373	Claassenia_sabulosa	Species
799	102473	californica	SPECIES	392	Pteronarcys	Genus
800	102486	badia	SPECIES	391	Pteronarcella	Genus
808	115156	coloradensis	SPECIES	463	Rhyacophila_coloradensis_group	Species-group
809	116912	americanus	SPECIES	398	Brachycentrus	Genus
817	121288	coloradensis	SPECIES	222	Deuterophlebia	Genus
819	93789	lacustris	SPECIES	488	Gammarus	Genus
823	128511	Cardiocladius	GENUS	148	Cardiocladius	Genus
824	128215	Pentaneura	GENUS	216	Pentaneura	Genus
825	128429	Syndiamesa	GENUS	142	Syndiamesa	Genus
827	114237	Heterelmis	GENUS	35	Heterelmis	Genus
834	568598	hageni	SPECIES	277	Diphetor	Genus
835	101389	coloradensis	SPECIES	290	Drunella_coloradensis_flavilinea	Species-group
836	101385	spinifera	SPECIES	294	Drunella_spinifera	Species
837	102986	californica	SPECIES	372	Calineuria	Genus
838	102972	pacifica	SPECIES	375	Hesperoperla	Genus
851	127278	Dasyhelea	GENUS	80	Ceratopogoninae	Subfamily
854	76572	rivularis	SPECIES	500	Ferrissia	Family
857	69445	punctata	SPECIES	1	Erpobdellidae	Family
858	69412	marmorata	SPECIES	2	Haemopidae	Family
859	69381	complanata	SPECIES	3	Glossiphoniidae	Family
860	69398	stagnalis	SPECIES	3	Glossiphoniidae	Family
863	128575	Cricotopus	GENUS	154	Other_Cricotopus_Orthocladius	Genus-group
887	115048	Neohermes	GENUS	341	Neohermes	Genus
895	113265	Staphylinidae	FAMILY	77	Staphylinidae	Family
901	113835	Lampyridae	FAMILY	70	Lampyridae	Family

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BugLab Code	TSN	Name	TaxaLevel	OTUCode	OTUName	OTULevel
906	112165	Graphoderus	GENUS	19	Graphoderus	Genus
907	100801	Acentrella	GENUS	268	Acentrella	Genus
908	127729	Probezzia	GENUS	80	Ceratopogoninae	Subfamily
909	102594	cinctipes	SPECIES	367	Zapada	Genus
925		Aquarius	GENUS	332	Gerridae	Family
929	94026	azteca	SPECIES	489	Hyalella	Genus
933	127340	Culicoides	GENUS	80	Ceratopogoninae	Subfamily
943	101399	tibialis	SPECIES	298	Serratella	Genus
970	101370	grandis	SPECIES	292	Drunella_grandis	Species
999	598372	Ylodes	GENUS	432	Ylodes	Genus
1000	102919	abnormis	SPECIES	371	Acroneuria	genus
1013	128343	Boreoheptagyia	GENUS	136	Boreoheptagyia	Genus
1027	101128	Thraulodes	GENUS	322	Thraulodes	Genus
1029	114253	Neocylloepus	GENUS	41	Neocylloepus	Genus
1030	97326	leniusculus	SPECIES	490	Astacidae	Family
1031	101318	hecuba	SPECIES	299	Timpanoga_hecuba	Species
1032	115006	occidens	SPECIES	343	Sialis	Genus
1033	101348	hystrix	SPECIES	289	Caudatella	Genus
1046	113969	Elodes	GENUS	76	Scirtidae	Family
1071	101351	heterocaudata	SPECIES	289	Caudatella	Genus
1076	114180	quadrimaculatus	SPECIES	43	Optioservus	Gneus
1093	129368	Cryptochironomus	GENUS	90	Cryptochironomus	Genus
1094	129421	Demicryptochironomus	GENUS	93	Demicryptochironomus	Genus
1095	129525	Lauterborniella	GENUS	102	Lauterborniella	Genus
1101	129935	Paratanytarsus	GENUS	128	Paratanytarsus	Genus
1102	129623	Paratendipes	GENUS	110	Paratendipes	Genus
1103	129637	Phaenopsectra	GENUS	111	Phaenopsectra	Genus
1104	129851	Pseudochironomus	GENUS	122	Pseudochironomus	Genus
1105	129952	Rheotanytarsus	GENUS	129	Rheotanytarsus	Genus
1106	129730	Robackia	GENUS	113	Robackia	Genus
1107	129962	Stempellina	GENUS	130	Stempellina	Genus
1109	129975	Sublettea	GENUS	132	Sublettea	Genus
1111	128355	Diamesa	GENUS	137	Diamesa	Genus
1112	128401	Pagastia	GENUS	138	Pagastia	Genus
1115	128416	Pseudodiamesa	GENUS	140	Pseudodiamesa	Genus
1117	128477	Brillia	GENUS	145	Brillia	Genus
1118	128563	Corynoneura	GENUS	150	Corynoneura	Genus
1119		bicinctus group	SPECIES	152	Cricotopus_bicinctus_group	Species-group
1122		trifascia group	SPECIES	151	Cricotopus_trifascia_group	Species-group
1123	128670	Diplocladius	GENUS	156	Diplocladius	Genus
1135	128730	Heleniella	GENUS	163	Heleniella	Genus
1137	128750	Hydrobaenus	GENUS	166	Hydrobaenus	Genus
1140	128771	Krenosmittia	GENUS	167	Krenosmittia	Genus

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BugLab Code	TSN	Name	TaxaLevel	OTUCode	OTUName	OTULevel
1141	128776	Limnophyes	GENUS	168	Limnophyes	Genus
1142	128811	Lopescladius	GENUS	169	Lopescladius	Genus
1143	128821	Metriocnemus	GENUS	170	Metriocnemus	Genus
1146		Cricotopus (Nostocladius)	GENUS	153	Cricotopus_Nostocladius	Subgenus
1147	128874	Orthocladius	GENUS	155	Orthocladius_Symposiocladius	Subgenus
1148	128951	Parachaetocladius	GENUS	172	Parachaetocladius	Genus
1150	128978	Parametriocnemus	GENUS	176	Parametriocnemus	Genus
1151	128989	Paraphaenocladius	GENUS	177	Paraphaenocladius	Genus
1153	129011	Parorthocladius	GENUS	178	Parorthocladius	Genus
1156	129052	Pseudorthocladius	GENUS	181	Pseudorthocladius	Genus
1158	129086	Rheocricotopus	GENUS	184	Rheocricotopus	Genus
1159	129107	Rheosmittia	GENUS	185	Rheosmittia	Genus
1160	129152	Stilocladius	GENUS	187	Stilocladius	Genus
1162	568523	lignicola	SPECIES	155	Orthocladius_Symposiocladius	Subgenus
1163	129161	Synorthocladius	GENUS	189	Synorthocladius	Genus
1164	129182	Thienemanniella	GENUS	191	Thienemanniella	Genus
1166	127954	Boreochlus	GENUS	196	Boreochlus	Genus
1167	128440	Monodiamesa	GENUS	198	Monodiamesa	Genus
1168	128446	Odontomesa	GENUS	199	Odontomesa	Genus
1169	128452	Prodiamesa	GENUS	200	Prodiamesa	Genus
1170	128079	Ablabesmyia	GENUS	210	Ablabesmyia	Genus
1171	128026	Brundiniella	GENUS	205	Brundiniella	Genus
1172	128183	Larsia	GENUS	213	Larsia	Genus
1173	128034	Macropelopia	GENUS	206	Macropelopia	Genus
1174	128202	Nilotanypus	GENUS	214	Nilotanypus	Genus
1175	128207	Paramerina	GENUS	215	Zavrelimyia_Paramerina	Genus_group
1176		Thienemannimyia group	GENUS	217	Thienemannimyia	Genus
1180		coloradensis/flavilinea	SPECIES	290	Drunella_coloradensis_flavilinea	Species-group
1181	568634	pelosa	SPECIES	293	Drunella_pelosa	Species
1186	115045	crepusculus	SPECIES	342	Orohermes	Genus
1187	593042	dorsalis	SPECIES	351	Cordulegastridae	Family
1205	608146	phryganea	SPECIES	456	Himalopsyche_phryganea	Species
1206		brunnea/vemna groups	SPECIES	462	Rhyacophila_brunnea_vemna_groups	Species-group
1207	115099	angelita	SPECIES	458	Rhyacophila_angelita_group	Species-group
1208	115125	verrula	SPECIES	477	Rhyacophila_verrula_group	Species-group
1213	115101	betteni	SPECIES	460	Rhyacophila_betteni_group	Species-group
1214	115159	hyalinata	SPECIES	467	Rhyacophila_hyalinata_group	Species-group
1215	115163	alberta	SPECIES	457	Rhyacophila_alberta_group	Species-group
1217	80372	falcata	SPECIES	496	Margaritiferidae	Family
1219	112757	Hydraena	GENUS	55	Hydraena	Gneus
1220	101345	delantala	SPECIES	288	Attenella	Genus
1221	112777	Ochthebius	GENUS	57	Ochthebius	Gneus
1224	101255	aurivillii	SPECIES	295	Ephemerella_aurivillii	Species

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BugLab Code	TSN	Name	TaxaLevel	OTUCode	OTUName	OTULevel
1236	115038	cognata	SPECIES	339	Corydalus	Genus
1239	117226	Atopsyche	GENUS	406	Atopsyche	Genus
1244	114212	Macronychus	GENUS	38	Macronychus	Genus
1267	102484	princeps	SPECIES	392	Pteronarcys	Genus
1274	115151	brunnea	SPECIES	462	Rhyacophila_brunnea_vemna_groups	Species-group
1279	116266	atripes	SPECIES	436	Dicosmoecus	Genus
1294	129428	Dicrotendipes	GENUS	94	Dicrotendipes	Genus
1297	129535	Microtendipes	GENUS	104	Microtendipes	Genus
1298	129018	Psectrocladius	GENUS	180	Psectrocladius	Genus
1301	129657	Polypedilum	GENUS	112	Polypedilum	Genus
1303	128277	Procladius	GENUS	179	Procladius	Genus
1306	129872	Tanytarsus	GENUS	133	Tanytarsus	Genus
1308	129483	Glyptotendipes	GENUS	99	Glyptotendipes	Genus
1319	102050	americana	SPECIES	348	Calopterygidae	Family
1330	97421	Orconectes	GENUS	492	Cambaridae	Family
1331	97425	virilis	SPECIES	492	Cambaridae	Family
1344	598779	Subgenus neodinarthrum	SPECIES	427	Lepidostomatidae	Family
1361		unicolor group	SPECIES	427	Lepidostomatidae	Family
1364	103748	Ranatra	GENUS	334	Ranatra	Genus
1367	103755	fusca	SPECIES	334	Ranatra	Genus
1369	205006	antipodarum	SPECIES	507	Potamopyrgus_antipodarum	Family
1386	114198	Rhizelmis	GENUS	46	Rhizelmis	Gneus
1407	568601	quilleri	SPECIES	278	Fallceon	Genus
1415	101530	simulans	SPECIES	300	Ephemera	Genus
1501	115120	vaccua	SPECIES	474	Rhyacophila_vaccua	Species
1502	115121	valuma	SPECIES	476	Rhyacophilla_pellisa_valuma	Species-group
1505		vofixa group	SPECIES	478	Rhyacophila_vofixa_group	Species-group
1533	101722	borealis	SPECIES	353	Gomphidae	Family
1538	568826	Stictotarsus	GENUS	30	Stictotarsus	Genus
1539	609510	Asioplax	GENUS	312	Asioplax	Genus
1541	102142	emma	SPECIES	349	Argia	Family
1557	101656	armata	SPECIES	347	Oplonaeschna	Genus
1558	101835	mendax	SPECIES	356	Libellulidae	Family
1559	101728	lampropeltis	SPECIES	353	Gomphidae	Family
1565	116540	Phylloicus	GENUS	401	Phylloicus	Genus
1575	80371	margaritifera	SPECIES	496	Margaritiferidae	Family
1582	101772	cornutus	SPECIES	353	Gomphidae	Family
1598	609660	myops	SPECIES	327	Anthopotamus	Genus
1599	568555	Amercaenis	GENUS	284	Amercaenis	Genus
1600	101038	ammophila	SPECIES	324	Oligoneuridae	Family
1602	69368	montifera	SPECIES	3	Glossiphoniidae	Family
1618	85257	Maxillipoda, Subclass Copepoda	CLASS	494	Copepoda	Subclass
1646	568679	apachae	SPECIES	282	Psuedocloeon	Genus

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BugLab Code	TSN	Name	TaxaLevel	OTUCode	OTUName	OTULevel
1647	100771	Psuedocloeon	GENUS	282	Psuedocloeon	Genus
1665	115106	harmstoni	SPECIES	466	Rhyacophila_harmstoni	Species
1667		brunnea group	SPECIES	462	Rhyacophila_brunnea_vemna_groups	Species-group
1668		betteni group	SPECIES	460	Rhyacophila_betteni_group	Species-group
1669		Cricotopus/Orthocladius	GENUS	154	Other_Cricotopus_Orthocladius	Genus-group
1670	128689	Eukiefferiella	GENUS	159	Eukiefferiella	Genus
1672	129890	Micropsectra	GENUS	126	Micropsectra	Genus
1673	128408	Potthastia	GENUS	139	Potthastia	Genus
1674	129197	Tvetenia	GENUS	194	Tvetenia	Genus
1676	128844	Nanocladius	GENUS	171	Nanocladius	Genus
1678	129084	tnannulatus	SPECIES	183	Psilometriocnemus	Genus
1680	128272	pulcher	SPECIES	218	Djalmabatista	Genus
1681	206655	Paralauterborniella	GENUS	109	Paralauterborniella	Genus
1683	128968	Parakiefferiella	GENUS	174	Parakiefferiella	Genus
1684	129885	brevicosta	SPECIES	125	Constempellina	Genus
1685	129873	Cladotanytarsus	GENUS	124	Cladotanytarsus	Genus
1686	206646	Alotanypus	GENUS	202	Alotanypus	Genus
1687	129820	Tribelos	GENUS	119	Tribelos	Genus
1688	128520	Chaetocladius	GENUS	149	Chaetocladius	Genus
1689	128423	parva	SPECIES	141	Pseudokiefferella	Genus
1691	128712	Georthocladius	GENUS	161	Georthocladius	Genus
1692	129837	Xenochironomus	GENUS	120	Xenochironomus	Genus
1693	130039	pentatoma	SPECIES	134	Zavrelia	Genus
1694	129597	Paracladopelma	GENUS	108	Paracladopelma	Genus
1695	128470	Antillocladius	GENUS	144	Antillocladius	Genus
1696	128259	Zavrelimyia	GENUS	215	Zavrelimyia_Paramerina	Genus_group
1697	128737	Heterotrissocladius	GENUS	165	Heterotrissocladius	Genus
1698	129785	Stictochironomus	GENUS	117	Stictochironomus	Genus
1699	128170	Krenopelopia	GENUS	211	Krenopelopia	Genus
1700	129157	Trissocladius	GENUS	193	Trissocladius	Genus
1706		angelita group	SPECIES	458	Rhyacophila_angelita_group	Species-group
1707		alberta group	SPECIES	457	Rhyacophila_alberta_group	Species-group
1708		hyalinata group	SPECIES	467	Rhyacophila_hyalinata_group	Species-group
1709		sibirica group	SPECIES	472	Rhyacophila_sibirica_group	Species-group
1710		coloradensis group	SPECIES	463	Rhyacophila_coloradensis_group	Species-group
1712	568591	musseri	SPECIES	274	Camelobaetidius	Genus
1713	69450	microstoma	SPECIES	1	Erpobdellidae	Family
1714	609545	similis	SPECIES	274	Camelobaetidius	Genus
1715		verrula group	SPECIES	477	Rhyacophila_verrula_group	Species-group
1716	115189	tucula	SPECIES	473	Rhyacophila_tucula	Species
1717	115173	glaciera	SPECIES	464	Rhyacophila_glaciera	Species
1718	568553	Plauditus	GENUS	280	Plauditus	Genus
1719	568546	Acerpenna	GENUS	269	Acerpenna	Genus

OTU – ITIS TSN Conversion Lookup Table for the GRYN

BugLab Code	TSN	Name	TaxaLevel	OTUCode	OTUName	OTULevel
1720	568954	picta	SPECIES	3	Glossiphoniidae	Family
1721	69397	elongata	SPECIES	3	Glossiphoniidae	Family
1741	609909	decipiens	SPECIES	376	Perlesta	Genus
1742	114191	pecosensis	SPECIES	43	Optioservus	Gneus
1743	114166	addenda	SPECIES	33	Cleptelmis	Genus
1750	206620	pygmaea	SPECIES	269	Acerpenna	Genus
1751	114130	quadrinotata	SPECIES	34	Dubiraphia	Genus
1753	129564	Parachironomus	GENUS	107	Parachironomus	Genus
1754	128021	Apsectrotanypus	GENUS	203	Apsectrotanypus	Genus
1756	128324	Tanypus	GENUS	220	Tanypus	Genus
1757	129254	Chironomus	GENUS	88	Chironomus	Genus
1758	129350	Cladopelma	GENUS	89	Cladopelma	Genus
1759	129394	Cryptotendipes	GENUS	91	Cryptotendipes	Genus
1760		Radotanypus	GENUS	208	Radotanypus	Genus
1761	128488	Bryophaenocladius	GENUS	146	Bryophaenocladius	Genus
1763	129932	Nimbocera	GENUS	127	Nimbocera	Genus
1764	128173	Labrundinia	GENUS	212	Labrundinia	Genus
1766	129480	Gillotia	GENUS	98	Gillotia	Genus
1803	568556	Cercobrachys	GENUS	287	Cercobrachys	Genus
1806	128682	Epoicocladius	GENUS	158	Epoicocladius	Genus
1807	129516	Harnischia	GENUS	101	Harnischia	Genus
1809	129746	Stenochironomus	GENUS	116	Stenochironomus	Genus
1812	129470	Endochironomus	GENUS	96	Endochironomus	Genus
1813	128463	Acricotopus	GENUS	203	Apsectrotanypus	Genus
1814	128680	Doncricotopus	GENUS	157	Doncricotopus	Genus
1815	128070	Natarsia	GENUS	209	Natarsia	Genus

Appendix VI

WCMAFE Field Protocols

Stream Algae, Invertebrate, and Environmental Sampling Associated with Biological Water Quality Assessments

Field Protocols

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Preface

The sampling procedures described in this document were designed to provide data sufficient to characterize the algal and invertebrate assemblages for the purpose of biological assessment. In addition to describing methods for sampling algae and invertebrates, we also describe methods for characterizing the main chemical and physical conditions occurring at a stream site. We designed these procedures with an eye toward standardizing sampling methods used in the biological assessments of stream water quality. The invertebrate protocols were modified from the designs used by the States of Oregon and Washington and the BLM's National Aquatic Monitoring Center. The algae sampling protocol was modified from EPA Rapid Biological Assessment procedures. Procedures for collection of reach and site environmental data were modified from a variety of sources. These procedures produce data that are comparable with data derived from EPA's Western Pilot Stream Project. These collection procedures allow analysis of biotic data with either multimetric (e.g., B-IBI) or predictive model (e.g., RIVPACS) methods. Use of these procedures will allow users to share data, express their data in terms of standardized bioassessment measures, and thus directly compare their results with all other parties using these methods. As such, these methods provide a foundation on which to establish region-wide monitoring and assessment programs for quantifying stream resource condition. Their general use does not preclude use of other sampling procedures that may be needed to address the specific objectives of individual small-scale projects.

Sequence Of Data Collection

Data collection at each site consists of 12 steps summarized here. Separate sections describe details of the procedures used.

1. Check field equipment against list before leaving (page 3).
2. Read General Notes (page 5).
3. Complete the headers of the Site Data Form and copy this information to the Field Notebook (page 6).
4. Conduct site evaluation (pages 6 - 8).
5. Measure initial temperature, conductivity, and alkalinity (pages 8).
6. Collect water samples (pages 8 - 9).
7. Collect algae sample (pages 9 - 11).
8. Sample invertebrates (pages 11 - 13).
9. Conduct site measurements - physical features and plant cover (pages 13 - 16).
10. Characterize the channel type (pages 16 - 18).
11. Record an ending time and temperature.
12. Mark the location of the study site on a map.

Field Equipment

The following list identifies those items that will be used for field sampling at each site:

General:

Field data forms, field notebooks (Rite-in-the-Rain™ paper).

GPS to identify geographic location.

Permanent markers, pencils.

Wading shoes/boots with waders where needed.

Pump sprayer and wash bottles for washing insects and algae off of rocks, pans, and nets.

7.5' USGS Quadrangle Maps or other maps describing the study area.

Camera.

Photographic film (number canisters prior to leaving for field).

Water Chemistry and Temperature:

Thermometers (2).

Conductivity meter.

Field alkalinity test kit.

Three (3) 125 ml plastic collection bottles (acid washed) marked for:
Filtered (HNO_3), Filtered (HCL), and Unfiltered (H_2SO_4).

Two (2) 2 mL ampule of 37% HCL (Hydrochloric Acid).

Two (2) 0.5 mL ampules of 96% H_2SO_4 (Sulphuric Acid).

Optima grade concentrated HNO3 (Nitrix Acid) - leave in vehicle.

500 - 1000 µL Ependorf pipetter.

Pipet tips for pipetter.

One (1) 60 mL syringe.

One (1) disposable Millipore filter unit for syringes.

Label tape for outside of bottles.

Black medium-tip permanent marker (e.g., Sharpee®).

Algae:

Rubber sampling strap with 12cm^2 (4cm diameter) hole for delineating the surface area of rocks to be sampled.

Petri dish and spatula without slits or holes (for samples on soft-bottomed sediment).

PVC pipe for samples on large substratum (12 – 16” length, 4” diameter) fitted with a rubber collar at one end with pump and collection vial.

Stainless steel spoon, screw driver, toothbrush, and nailbrush for scraping algae.

Turkey baster

One 1L Nalgene jar for mixing composite samples permanently marked at 250mL, 500mL, and 750mL levels.

One 50 ml sample container marked at 40mL.

Labeling materials (preprinted Rite-in-the-Rain™ labels).

10% formalin.

Invertebrates:

10-sided die for generating random sample locations

0.09 m² Surber or D-frame sampler with 500 µm mesh net (net should be ~1 m long net to prevent backwashing.

500 µm brass sieve with protective cover and bottom pan.

14 liter bucket.

White plastic wash tub.

Two (2) 500 ml plastic sample jars.

Small spoons (2) for transferring samples to jars.

Forceps (2 pairs).

Labeling materials (preprinted Rite-in-the-Rain™ labels).

Buffered ($CaCO_3$) Formalin or 95% EtOH.

Channel:

100 m tape.

Depth measuring stick in 1 cm increments.

Gravelometer or ruler to measure substrate size.

Angular densiometer to measure channel shading.

Clinometer for measuring stream slope.

Dye for measuring current speed.

Stop watch for measuring current speed.

General Notes

When recording data and writing notes, be neat and legible!

Include all requisite information. If a situation occurs that does not seem to fit within the protocol, discuss the problem with the rest of the crew. Make a note in the field notebook and under the comments section of the site data form describing the issue, but **DO NOT LEAVE THE SITE UNTIL EVERY FIELD OF THE SITE DATA FORM HAS AN ENTRY**.

Be consistent. Fatigue, boredom, time constraints, and many other factors can affect the quality of information recorded in the field. If you believe anything is causing a change in the way the data are being collected, discuss the situation with the other crew members and make a decision together of how to remedy the problem.

Important: Rivers can be noisy places and it is easy to misunderstand what is being said. **When recording data, the recorder should always repeat the information and the collector should verbally (and loudly!) confirm what was said (or correct it), and both people must agree before the information is recorded.**

Recording Information

Information collected at each site should be recorded on the following forms:

- **Site Data Form** - for scoring reach condition and recording site measurements.
- **Site Summary Notebook** - for listing site names, ID numbers, and associated photographs, drawing site maps and recording general comments.

Definition of Terms

Study Site	The section of stream beginning at the bottom of the first habitat unit sampled and ending at the top of the last habitat unit sampled.
Habitat Unit	An area of stream that differs in flow and morphological characteristics from adjoining areas of the stream.
Riparian Area	The area from the top of the bank to the point where there is a distinctive change in upland vegetation or hillslope. If there is no clear transition, consider the area within 10 - 15 m of the bank when answering riparian related questions.

Header Information

The following information should be included in the Site Summary Notebook and on the Site Data Form (see Appendix). Site Name, Site ID number, and Photographic Documentation information should be recorded in the Site Summary Notebook.

Site Name	Record the full name of the stream. Include the river or creek designation. If an unnamed tributary is sampled, record the name of larger stream and indicate that it was a tributary (e.g. West Tributary of Fish Creek). **Be sure the stream is marked on the map**.
Site Code	Assign a unique site ID number to each site sampled. Site numbers are recorded on the Site Data Form, Site Summary Notebook, and the Water Chemistry, Algae, and Invertebrate Sample Labels.
Date	Record as day, month (spell it out), year. (e.g. 04 July 1998)
Crew	Record the crew's name or code.
Time and Temperature Measurements	The first and last pieces of information collected at each site are the temperature (°C) and time (military time).
Location	Record longitude and latitude from the GPS for each site (middle of study section). Record elevation from a 7.5' topographic map and/or the GPS.
Land Owner	Record the name of the land owner (Forest, Park, State, Private, etc.).
Crew Members	Record the full names and responsibilities of each crew member at every site. The Collector is the person who takes the samples. The Recorder is the person who writes the information into the field data form and notebooks. Crew members should alternate being collector and recorder throughout the field season.

Site Evaluations

Site evaluations will be used to help determine the suitability of Reference Sites and the degree or type of degradation occurring within Test sites. Upon arrival at the Study Site, walk a 500 to 1000 m section of the stream and score the Site Evaluation questions, identify the type of reach, and determine management activities. Portions of this evaluation were adapted from Montana Riparian and Wetland Research Program Protocols - http://www.rwrp.umt.edu/findb.html).

Site condition is assessed by scoring each of the 6 attributes as outlined below. These assessments should be completed independently by each crew member and the average reported. If scores differ substantially, reconcile your assessment and arrive at a consensus.

1. **Vegetative Cover -** Describe the % of the floodplain covered by mature perennial plants (tress, shrubs, or grass).

6 = > 95%

4 = 85 - 95%

2 = 75 - 85%.

0 = < 75%

2. **Erosional deposition into stream from surrounding hillslopes -** Scan the hillsides on both sides of the stream for evidence of active erosion.

6 = No erosional deposition is apparent.

4 = Some signs of erosional deposition are apparent, but these areas are confined to specific, limited locales along the stream (e.g., gulleys, washes, slumps, roads).

2 = Obvious signs of erosional deposition from the hillslopes are apparent.

0 = Mass wasting is evident on hillslopes. Stream deposition is significant enough to cause obvious changes in stream flow (e.g., debris avalanche, torrent tracks).

3. **Consumption of trees & shrubs by livestock:**

6 = 0 - 5%

4 = 5 - 25%

2 = 25 - 50%

0 = > 50%

4. **Stream incisement:**

6 = No incisement.

4 = Old incisement.

2 = Deep incisement with new floodplain development.

0 = Deep incisement with active downcutting.

5. **Percent of stream with active lateral cutting:**

6 = 5% or less of the streambank shows active lateral cutting.

4 = 5 - 15% of the streambank shows active lateral cutting.

2 = 15 - 35% of the streambank shows active lateral cutting.

0 = > 35% of the streambank shows active lateral cutting.

6. **Percent of streambank with deep, binding root mass:**

6 = > 85% of the bank with deep, binding root mass.

4 = 65 - 85% of the bank with deep, binding root mass.

2 = 35 - 64% of the bank with deep, binding root mass.

0 = < 35% of the bank with deep, binding root mass.

Management Activities

Rank all of the management activities, as described on the site data form, that occur along the Study Site according to their relative impact on the stream system. A ranking of 1 represents the most significant impact. Also note any specific impacts to the stream system.

Temperature, Conductivity, and Alkalinity

Temperature – Place the thermometer into the main flow. After 10 seconds, read and record the temperature in degrees Celsius.

Conductivity – Turn on the conductivity meter and place the probe into the main flow. When the reading stabilizes, record the conductivity as micro-Siemens / cm^2 ($\mu S/cm^2$). Note that you may need to change the sensitivity settings on the meter to obtain accurate measurements, but record all values in common (µ**S/**$\mathbf{cm^2}$) units (**not mS/**$\mathbf{cm^2}$).

Alkalinity – Use the test kit to determine the alkalinity of the water. Record the value as mg/L (= ppm) $CaCO_3$.

Water Chemistry Samples

Note: This procedure requires that you handle and add acid to water samples. Be extremely careful when pipetting and breaking the acid ampules into the bottles. Wear safety goggles and gloves.

Also, be extremely careful that you treat and label the water samples exactly as described below. Contaminated samples or mislabeled samples will result in unusable data.

Rinse syringe three times with filtered stream water. Rinse filters by passing 10-20 mL of stream water from the clean syringe through the filter before collecting any water for samples. The rest of that water can be used as the first part of the filtered stream water sample.

Fill and rinse each bottle three times with stream water. Do not breathe into the bottles. Do not place your fingers into the water in the bottles. Do not allow anything to fall into the bottles. Do not put labels inside of these bottles.

Fill one bottle a fourth time leaving ~ 5 mL extra space. Carefully break an H_2SO_4 ampule into the bottle, cap, and shake well. Label the outside of this bottle as "Unfiltered/H_2SO_4".

Fill a 50 mL syringe with stream water. Place a filter on the end of the syringe and push the water through the filter and into the second bottle. Repeat this process until the bottle is nearly full of water. Add the contents of an HCl ampule to the bottle, cap, and shake well. Label the outside of this bottle as "Filtered/HCl".

Fill a second bottle with filtered stream water using the same procedure, but preserve this with HNO3. Place a pipet tip on the pipetter. Be careful not to touch the end of the pipet tip that will go into the acid bottle. Withdraw 0.5 mL concentrated (optima) HNO_3

and squirt it onto a safe place on the ground where you will not step in it. Withdraw a second
0.5 mL aliquot of HNO_3 and add it to the water sample. Cap the bottle and shake it well. Label the outside of this bottle as "Filtered/HNO_3".

Place the acid ampules and pipet tips in a secure container.

If you mess up a sample, start over. It is better to take some extra time than to leave the site with samples of uncertain quality. Once you secure all three samples, tape the lids to ensure that the caps will not loosen and allow the water samples to leak.

Field blanks. At every 10th station, collect a set of field blank water samples. Use DI water as you would stream water in the process above. Using a small amount of DI water from a jug stored for the trip, rinse three polybottles, the syringe, and the filter. Do not contaminate the DI water in the jug. Fill one polybottle with unfiltered water. Fill the other two bottles with filtered DI water. Preserved the unfiltered water with H_2SO_4 as above and label the outside of the bottle "Unfiltered blank/H_2SO_4.". Preserved one bottle of filtered water with HCl as above and label the outside of the bottle "Filtered blank/HCl." Preserved the second bottle of filtered water with HNO_3 as above and label the outside of the
bottle "Filtered blank/HNO_3."

Algae (Periphyton)

The following procedures outline a stepwise approach for collecting periphyton samples from each of the 4 fast-water habitat units established for the reach.

Based on the type of substrate available, select one sampling method for the reach. The method should be selected based on the following priority: rock, bedrock/boulder, snag, sand, silt.

Rocks – Collect 4 pieces of substrate (5 – 25 cm diameter) from each of the 4 fast-water habitat units (i.e. riffles) for a total of 16 samples. Make sure to keep track of the upper surface of each piece of substratum. Where possible, all of these samples should be taken from a depth of approximately 15 - 20 cm (if the stream is <15cm deep sample at the deepest point). If substrate within the 5 - 25 cm diameter size-classes is unavailable, refer to the procedures for sampling loose sediments or large substrates below.

One-at-a-time, place each piece of substratum over the white pan. Wrap the rubber sampling strap around a rock so that the opening is not stretched and is placed over the top surface of the rock. The opening in the strap delineates an area on the upper surface of each piece of substratum that should be scraped, brushed and then rinsed into the white pan. First, scrape loose algae from the delineated area on the rock with a small spatula. Then brush the area (brushing dense periphyton clogs up the brush). Rinse the material into the white pan, but be careful to only rinse algae from the delineated area into the pan (not from other parts of the rock). Repeat for each piece of substratum rinsing the material into the pan to create 1 composite sample consisting of all 16 samples. Rinse the material from the white pan into the 1L Nalgene bottle.

Carefully examine all of the tools used for dislodging the periphyton and rinse any remaining material into the composite sample using a minimal amount of stream water.

Dilute the composite sample to either 250mL, 500mL, 750mL or 1000mL (use the smallest possible level). Record the level of dilution in the field notebook and on both sample labels.

Close the 1L bottle containing the composite sample, shake vigorously until all material is fully suspended and homogenized (clumps of algae broken up). Use the turkey baster to continue mixing and extract ~10 mL and place in the 50 mL periphyton sample container. Extract additional aliquots until 40 mL has been transferred to the sample container (as indicated by the 40 mL mark on the side of the container). Preserve with 2mL of 10% formalin.

Label these samples as “Rock” (inside and outside) and seal the cap with tape. Make sure that the date, stream name, and identification number are identical to what was recorded on the data sheets and on the macroinvertebrate samples.

Periphyton Sample

Date: 5 July 1998

Site ID #: PNW98 - 046

Sample Type: Rock

To avoid contamination of subsequent samples, thoroughly rinse all of the sampling tools before leaving the field.

Sampling from Unusual Substrates

The following sampling procedures should only be used in situations where substrate sizes of 5 - 25 cm diameter are unavailable.

Bedrock/Boulders (Large, Unremoveable Substrates) – Place the PVC pipe with the rubber collar over a piece of substratum that is submerged at a depth of approximately 15 - 20 cm (if the stream is <15cm deep sample at the deepest point) and press down with sufficient pressure to create a seal.

Dislodge the algae located within the pipe with a screwdriver. Place the rubber stopper, hoses, and vacuum pump assembly on the PVC pipe. Pump the algae-water solution from the pipe into the attached sampling container. Pour that sample into the 1L Nalgene sample homogenization jar.

Repeat steps 1-3 for one piece of substrate from 2 fast-water habitat units and two pieces from 2 fast-water habitat units, for a total of 8 samples per reach, combining all samples in the same 1L jar to create a composite sample.

Remove, preserve and label a 40 mL subsample from the 1L composite sample container by following steps outlined in the sampling protocols for “rocks”.

Record “Bedrock/Boulder Sample” on the sample jar labels and within the field notes.

Snags – Remove small logs or branches that have been in the water for long times (months) and scrape periphyton from a known area into the white pan. Use the small spatula, toothbrush and squirt bottle to remove algae from the snags and rinse them into the white pan. Use the rubber sampling strap to delineate an area on the snag or measure the area from which periphyton are scraped from each snag. Mark down the total area on the sample labels and all areas in the field notebook. Sample 16 snags.

Rinse sample from the white pan to the 1 L Nalgene bottle.

Remove, preserve and label a subsample (40mL) from the 1L composite sample container by following steps outlined in the sampling protocols for "rocks."

Record "Snag Sample," sample volume, and sample area on the sample jar labels and within the field notes.

Gravel and Sand – Invert the petri dish over a portion of sediments submerged at a depth of approximately 15-20cm (if the stream is <15cm deep sample at the deepest point) and trap the sediments by inserting the spatula under the dish. Transfer the sample to the 1L Nalgene sample homogenization container. Repeat this step for 16 samples, two from each habitat in the reach.

Pour a small amount (~20 - 30 mL) of stream water over the gravel and sand in the 1L Nalgene bottle, cover, and shake and swirl vigorously to remove algae from gravel and sands. Allow 10 seconds for sands and gravels to settle and pour algal-water suspension into the white pan. Repeat this step eight times so that algae is removed from the gravel and sands and rinsed into the white pan. Rinse the gravel and sand out of the 1L Nalgene sample homogenization container. Rinse that container with stream water. Then pour the algal-water suspension from the white pan into the 1L Nalgene container.

Remove, preserve and label a 40mL subsample from the 1L composite sample container by following the steps outlined in the sampling protocols for "rocks."

Record "Sand Sample", sample volume, and sample area on the sample jar labels and within the field notes.

Silt and Fine Loose Sediments – Invert the petri dish over a portion of sediments submerged at a depth of approximately 15-20cm (if the stream is <15cm deep sample at the deepest point) and trap the sediments by inserting the spatula under the dish.

Holding the spatula with the fines trapped under the dish, rinse all the sediments within the dish into the 1L Nalgene sample homogenization container. Repeat above steps to collect 16 total sediment samples within the reach.

Remove, preserve and label a 40mL subsample from the 1L composite sample container by following steps outlined in the sampling protocols for "rocks."

Record "Sediment Sample," sample volume, and sample area on the sample jar labels and within the field notes.

Invertebrate Sampling

Until we can determine which type of sample provides the most robust assessment of a stream's condition, we will collect 2 different types of samples: a 0.72 m^2 **fixed-area** sample from a standard habitat (the primary sample) and a 10-minute, **fixed-time** sample from multiple habitats (the secondary sample). If resources do not allow collection and processing of both types of sample, the fixed-area sample should be taken. **A 500 µm mesh net must be used to collect all samples**.

Primary Sample – The primary invertebrate sample will be taken from 4 different fast-water (e.g. riffles, runs) habitat units. Two separate 0.09 m² fixed-area samples will be taken from each unit for a total of 8 samples. If no fast-water habitats occur, take the 8 samples from shallow, slow-water habitat units. The 8 individual samples will be composited into a single sample that will be used to represent the study area. This composite sample will be preserved in 1 or more sample jars depending on the amount of material collected.

Sampling Locations for Fixed-Area Samples – Sampling will begin at the first fast-water habitat encountered at the site and will continue upstream with the next 3 fast-water habitat units. Determine net placement within each habitat unit by generating 2 pairs of random numbers between 0 and 9. The first number in each pair (multiplied by 10) represents the percent upstream along the habitat unit's length. The second number in each pair represents the percent of the stream's width from bank left. Repeat this process to locate the second sampling location. Take samples where the length and width distances intersect (estimate by eye). If it is not possible to take a sample at one or both of these locations (log in the way, too deep, cannot seal bottom of net, etc.), draw additional random numbers until you can.

Taking the Samples – Place the sampler so the mouth of the net is perpendicular to and facing into the flow of water. If there is no detectable flow, orient the net to most easily facilitate washing benthic material into the net. Collect invertebrates from within the 0.09 m² sampling frame in front of the net. If no sampling frame is used, visually imagine the square sampling plot in front of the net and restrict your sampling to within that area. Work from the upstream edge of the sampling plot backward and carefully pick up and rub stones directly in front of the net to remove attached animals. Quickly inspect each stone to make sure you have dislodged everything and then set it aside. If a rock is lodged in the stream bottom, rub it a few times concentrating on any cracks or indentations. After removing all large stones, disturb small substrates (i.e. sand or gravel) to a depth of about 10 cm by raking and stirring with your hands. Continue this process until you can see no additional animals or organic matter being washed into the net. After completing the sample, hold the net vertically (cup down!) and rinse material to the bottom of the net. If a substantial amount of material is in the net, empty the net into the 14 liter bucket for processing before continuing to the next sample location. Otherwise, move to the next sample location and repeat the above procedure.

Secondary Sample – The secondary invertebrate sample consists of a 10-minute, fixed-time sample taken from the different habitat types in the reach. Visually appraise the area and estimate the proportion of different habitat types. The amount of time spent sampling each habitat type should be allocated in proportion to the occurrence of each habitat type in the study reach. Do not sample more or less than 10 minutes. This sample will be preserved in a separate jar.

Field Processing, Preservation, and Labeling of the Sample

Field processing requires a 14-liter bucket, a white plastic wash tub, and a 500 µm sieve. The bucket will be used for decanting animals from inorganic substrates into the sieve. The wash tub will be used to transfer stream water to the bucket and then to visually inspect inorganic residue for heavy animals that were not decanted.

After taking a sample, empty the net's contents into the 14 liter bucket. If the net has a cup at the end, remove the cup over the top of the bucket and wash it out. The crew member not taking the sample should then begin processing the sample while other samples are being taken. Add water to the bucket with the sample and decant invertebrates and organic matter from the sample by mixing the contents of the bucket with your hand and then pouring suspended material through the 500 µm sieve. Repeat this process until no additional material can be decanted. Transfer the material in the sieve (invertebrates and organic matter) into the 2-liter sample jar with a small spoon and then wash any remaining material in the sieve into the jar with a wash bottle. Place the inorganic residue remaining in the bucket into the plastic wash tub and cover with water to about 1 cm in depth. Inspect the gravel on the bottom of the tub for any cased caddisflies or other animals that might remain. Remove any remaining animals by hand and place in the sample jar. Once the last of the 8 constant-area samples have been taken, make sure you thoroughly wash any remaining animals from the net by vigorously pouring water down the sides of the net and into the cup. You may also need to use the pump sprayer to dislodge tenacious clingers. Use this same procedure at the end of processing the fixed-time sample.

Once the samples have been processed, add enough water to the 2 plastic sampling jars to completely cover the contents and then preserve the samples with 70-80 ml of buffered formalin. Immediately label the jars **both INSIDE with a paper label and OUTSIDE on both the lid and bottle with a Sharpie permanent marker**. The following is an example of a properly completed inside label:

Invertebrate Sample

Date: 5 July 1998

Site ID #: PNW98 - 046

Sample Type: [✓ **Fixed-Area**] **10-minute**

Remember: Return a total of two sample jars from each site to the lab for identification: one containing the 8 combined fixed-area samples and one with the 10-minute qualitative sample.

Site Measurements

Stream Slope – Use the clinometer to measure stream slope. If possible, take 1 reading from the top to the bottom of the study site. You will need your partner to stand at the other end of the study site. **Both observer and partner should stand at waters edge**. Estimate percent slope by aligning the cross hair of the clinometer with a point on your partner equal in height to your eye and reading the **right-hand** scale on the clinometer. If the stream characteristics make a top to bottom reading impossible, break the study site into 2 or more equal length sections and take separate readings. Average these readings to characterize the entire study site. Record the clinometer reading in the field data form to the nearest 0.5%.

Stream Travel Time (current speed) – Mark off a 100 m section of stream. Place ~ 1 ml of flouroscene dye in a 1L bottle. Add ~ 500 mL of water, cap, and shake well. One person will release the dye at the zero (0) meter mark (upstream) and the other person will record the time it takes the leading and trailing edges of the dye plume to reach the 100 m mark. Note that the trailing edge is defined as the last portion of visible dye within the thalweg (main current) of the stream. Pockets of dye may persist in backwaters, which we will not include in our estimates.

Dominant Erosional Habitat Type - Using the following criteria, identify the dominant erosional habitat type for the study site.

Name	Code	Description	Name	Code	Description
Rapid	RA	Gradient >4% with swiftly flowing water and considerable surface turbulence. Rapids tend to have larger substrate sizes than riffles.	**Run**	RU	Runs are long, usually straight, low-gradient stream units without flow obstructions. The stream bottom is usually even and the water does not "pool".
Riffle	RI	Gradient <4% and shallow with moderate velocity and moderate surface turbulence.	**Step-Run**	SR	Stepruns are a series of runs that are separated by short (<3m) riffles or flow obstructions.

Dominant Depositional Habitat Type - Using the following criteria, identify the dominant depositional habitat type for the study site.

Name	Code	Description	Name	Code	Description
Lateral	LAT	As streams go around bends they scour laterally and lateral scour pools are created along the banks. The deepest portion is the stream margin.	**Plunge**	PLU	Plunge pools are formed as water drops over an object. The deepest portion of the pool is directly underneath the falling point.
Scour	SCO	Pool shape is often like a bowl. The deepest part of pool is in the center of the channel.	**Dammed**	DAM	Water backs up against an obstruction in the stream channel. The deepest portion will be against the object forming the obstruction.

Channel Shade - Take four densiometer readings from the center of each of the 4 habitat units sampled for invertebrates. Readings should be taken facing upstream, downstream, bank left, and bank right. For each reading, place the densiometer near the surface of the stream and level it before taking a reading. Estimate shading by assigning 0 -4 points to each square on the densiometer grid and summing across grid squares. Points are assigned based on the percent of each square containing a shade object: 0 for no objects, 1 for 25% cover, 2 for 50% cover, 3 for 75% cover, and 4 for 100% cover.

Width - Starting at the downstream edge of the first fast-water habitat unit, measure wetted stream width at 10 different transects located at approximately 10 m intervals. Record to the nearest 5 centimeters.

Depth - Take 3 depth measurements at 1/4, 1/2, and 3/4 width intervals along each of the width transects. Record the resulting 30 measurements to the nearest centimeter.

Substrate - Substrate size is measured in each habitat unit by both visual estimation and by measuring individual pieces of substrate.

Visual estimate — Each crew member should independently estimate the median substrate size present in the 4 sampled riffles by picking up a piece of substratum that you think represents the median size. Measure the particle with the gravelometer and assign it to one of the following categories. Each crew member should also estimate the

% of substrate particles in each of the substrate categories below.

Bedrock	BED	Solid rock forming a continuous surface.
Boulder	BO	Stones over 256mm in diameter.
Cobble	LC	Stones from 64-256mm in diameter.
Pebble	PB	Stones from 16-64mm in diameter.

Gravel	GR	Mix of rounded course material from 2-16mm in diameter.
Sand	SN	Small particles < 2 mm in diameter
Silt / Muck	MU	Mixture of very fine inorganic and organic material

Particle Size Measurements and Periphyton Cover — Measure ≥ 25 pieces of substrate and classify moss and algae cover on each substrate in each of the 4 habitat units by collecting particles along zigzag transects. In general use 3 transects per habitat unit, although you may have to vary the number of transects used depending on the width of the stream. You should measure rock size and characterize moss/algae cover on an approximately equal number of rocks at uniform intervals along each transect. We will measure these intervals in terms of boot lengths, and you will therefore need to estimate how many steps (heel to toe) you will have to take to reach each sampling point. To sample, begin at the bottom of the reach and walk (heel to toe) along the first transect. After walking the necessary number of steps to reach the 1st sampling point, stop, and **without looking down** reach down and pick up the piece of substrate nearest your big toe.

Characterize amount of moss, macro-algae, and micro-algae cover separately. If substrates are less than 2 cm in diameter, do not tally an entry, but measure the substrate size with the gravelometer as described below. Record moss and macro-algae cover using a scale from 0-2 with separate estimates for each, where:

0 indicates no moss or macro-algae present;
1 indicates some (but < 5% coverage) moss or macro-algae present;
2 indicates 5-25% cover of substratum by moss or macro-algae; and
3 indicates greater than 25% cover of substratum by moss or macro-algae.

Estimate average thickness of micro-algae (periphyton) on the rock with a 0-5 thickness scale, where:

0 indicates substrate is rough with no apparent growth;
0.5 indicates substrate is slimy, but biofilm is not visible (tracks cannot be drawn in the film with the back of your fingernail; endolithic algae can appear green but will not scratch easily from the substratum);
1 indicates a thin layer of microalgae is visible (tracks can be drawn in the film with the back of your fingernail);
2 indicates accumulation of microalgae to a thickness of 0.5-1 mm;
3 indicates accumulation of microalgae from 1 mm to 5 mm thick;
4 indicates accumulation of microalgae from 5 mm to 20 mm;
5 indicates layer of microalgae is greater than 2 cm.

(Note that if substrate is too large to pick-up, algal growth should still be characterized.)

Characterize substrate size by placing each particle through the smallest hole possible in the gravelometer and record the particle size as that of the largest opening the particle **will not pass through**. Continue this process, walking along each transect until a minimum of 25 measurements have been taken.

Map Depicting the Study Site - In the field notebook, draw a map that depicts the study site. At a minimal, the map should include the following information: compass direction, basic sketch showing the shape (plan view) and size (give scale) of the stream channel, an arrow to indicate the direction of flow, major habitat units/patches, large objects obstructing the stream channel, unique channel characteristics (e.g. islands, tributaries), and directions to the site.

Photographs - Take 3 photographs at each site: one from the bottom looking up, one from the top looking down, and one from whatever vantage point provides the best overall lateral view of the site. Record the exposure number and roll number in the Site Summary Notebook and on the Field Data Form. After a roll of film is complete, wrap the film in a piece of masking tape and write the roll number on the tape. Store exposed film in a zip lock bag and in a cool, dark place.

Channel-Type Characterization

Channel and Valley Type Classifications (adapted from Montgomery and Buffington, 1993, Channel classification, prediction of channel response, and assessment of channel condition, Report TFW-SH10-93-002, Washington State Timber/Fish/Wildlife).

The first step in classifying the channel is to establish the valley segment characteristics. Valleys are separated into 3 categories: colluvial, bedrock, or alluvial. In general, **colluvial valleys** are those in which colluvial fills (i.e., material from hill slopes) accumulate and are periodically excavated by the stream. In **bedrock valleys**, there is no contiguous alluvial bed. Some alluvial material may be temporarily stored in scour holes, or behind flow obstructions, but in general the bedrock valley channel bed lacks an alluvial cover, and there is little, if any, channel fill. In **alluvial valleys**, the channels are capable of sorting and transporting the load supplied to them from upslope channels, but the transport capacity is not sufficient to scour them to bedrock. Use the table below to classify channels as either colluvial, bedrock, or one of the following subcategories of alluvial channels: cascade channel, step-pool channel, plane-bed channel, pool-riffle channel, regime channel, or braided channel.

Classification of Stream Channels

	Colluvial	Bedrock	Alluvial					
			Cascade	Step-pool	Plane-bed	Pool-riffle	Regime	Braided
Predominant bed material	Variable	Bedrock	Boulder	Cobble/ boulder	Gravel/ cobble	Gravel	Sand	Variable
Bedform pattern	Variable	Variable	None	Vertical oscillatory	None	Laterally oscillatory	Multilayered	Laterally oscillatory
Dominant roughness elements	Boulders, large woody debris	Streambed, banks	Boulders, banks	Bedforms (steps, pools), boulders, large woody debris, banks	Boulders and cobbles, banks	Bedforms (bars, pools) boulders and cobbles, large woody debris, sinuosity, banks	Sinuosity, bedforms (dunes, riffles, bars), banks	Bedforms (bars, pools)
Dominant sediment sources	Hillslope, debris flows	Fluvial, hillslope, debris flows	Fluvial, hillslope, debris flows	Fluvial, hillslope, debris flows	Fluvial, bank erosion, debris flows	Fluvial, bank erosion, inactive channels, debris flows	Fluvial, bank erosion, inactive channels	Fluvial, bank erosion, debris flows
Typical slope (%)	>20	Variable	8 - 30	4 - 8	1 - 4	0.1 - 2	<0.1	<3
Typical confinement	Strongly confined	Strongly confined	Strongly confined	Moderately confined	Variable	Unconfined	Unconfined	Unconfined
Pool spacing (channel widths)	Variable	Variable	<1	1- 4	None	5 - 7	5 - 7	Variable

Appendices

Field Equipment Check List

Front and Back Pages of the Site Data Form

Field Equipment Check List

General:

Field data forms, field notebooks.

GPS to identify geographic location.

Permanent markers, pencils.

Wading shoes/boots with waders where needed.

Pump sprayer and wash bottles for washing insects and algae off of rocks, pans, and nets.

7.5' USGS Quadrangle Maps or other maps describing the study area.

Camera.

Water Chemistry and Temperature:

Thermometers (2).

Conductivity meter.

Field alkalinity test kit.

Three (3) 125 ml plastic collection bottles (acid washed).

One (1) 0.5 ml ampule of 96% H_2SO_4 (Sulphuric Acid).

One (1) 2.0 ml ampule of 37% HCl (Hydrochloric Acid).

250 mL Optima grade concentrated HNO_3 (Nitric Acid).

Epindorfer Pipettor.

Disposable pipet tips.

60 mL syringe s.

Disposable millipore filter units.

Protective gloves.

Safety glasses.

Alkaline solution for acid neutralization.

Label tape for outside of bottles.

Black medium-tip permanent marker (e.g., Sharpee®).

Algae:

Rubber sampling strap with 12cm^2 (4cm diameter) hole for delineating the surface area of rocks to be sampled.

Petri dish and spatula without slits or holes (for samples on soft-bottomed sediment).

12 – 16” length, 4” diameter (~32 cm^2) PVC pipe fitted with a rubber collar at one end (for samples on large substratum) with pump and collection vial.

Stainless steel spoon, screw driver, toothbrush, and nailbrush for scraping algae.

Turkey baster.

One 1L Nalgene jar for mixing composite samples permanently marked at 250mL, 500mL, and 750mL levels.

One 50 ml sample container marked at 40mL.

Labeling materials (preprinted Rite-in-the-Rain™ labels).

10% formalin.

Invertebrates:

10-sided die for generating random sample locations.

One 0.09 m² Surber or D-frame sampler with 500 µm mesh, 1 m long net to prevent backwashing..

One 500 µm brass sieve with protective cover and bottom pan.

One 14-liter bucket.

Two white plastic wash tubs.

Two (2) 500 - 1000 ml plastic sample jars.

Small spoons (2) for transferring samples to jars.

Forceps (2 pairs).

Labeling materials (preprinted Rite-in-the-Rain™ labels).

Buffered ($CaCO_3$) Formalin or 95% EtOH.

Channel:

100 m tape.

Depth measuring stick.

Gravelometer or ruler to measure substrate size.

Angular densiometer to measure channel shading.

Clinometer for measuring stream slope.

Dye for measuring current speed.

Stop watch for measuring current speed.

Site Data Form

Site Name:	**Latitude:**
Site Code:	**Longitude:**
Date: **Vehicle:**	**Elevation (m): Map = GPS =**
State: **Land Ownership:**	**Initial Time: Initial Temperature:**
Crew: Collector's Initials- Recorder's Initials-	**Final Time: Final Temperature:**
Type of Site (circle one): Reference Test	

Site Evaluation		
Vegetative cover	Score:	**6** = >95% **4** = 85 - 94% **2** = 75 - 84% **0** = <75%
Erosional deposition from surrounding slopes	Score:	**6** = None **4** = Some in specific, limited locales **2** = Obvious signs **0** = Mass wasting.
Consumption of trees & shrubs by livestock	Score:	**6** = 0 - 5% **4** = 5 - 25% **2** = 25 - 50% **0** = >50%
Stream incisement	Score:	**6** = No incisement. **4** = Old Incisement **2** = Deep incisement; new floodplain development **0** = Deep incisement; active downcutting
% bank with lateral cutting	Score:	**6** = < 5% **4** = 5 - 15% **2** = 15 - 35% **0** = >35%
% bank with deep, binding root masses	Score:	**6** = >85% **4** = 65 - 85% **2** = 35 - 64% **0** = < 35%

Management Activities:Rank and Describe		
Logging		Notes:
Agriculture		Notes:
Mining Activities		Notes:
Recreation		Notes:
Roads		Notes:
Stream Diversions (dams, culverts, etc.)		Notes:
Livestock Grazing		Notes:
Urbanization		Notes:
Overall Condition: Is this a good reference site?		

Water Sample (check all collected)	**Stream Water**	**Deionized Blanks**	**Notes**
Unfiltered with H_2SO_4			
Filtered with HCL			
Filtered with HNO_3			

Site Measurements (also see back of form)
Conductivity: μS/cm **Alkalinity:** ppm CaCO3 **Stream Travel Time (s/50m):** leading **(** **)**, trailing **(** **)**
Stream Slope: **%** **Periphyton Sample Volume:** 250ml 500ml 750ml 1000ml
Channel Classification: Braided Regime Pool-Riffle Plane-Bed Step-Pool Cascade Bedrock Colluvial
Dominant Erosional Habitat Type: Rapid Riffle Run Steprun
Dominant Depositional Habitat Type: Lateral Scour Plunge Dammed

Photographs								
Looking Upstream	Roll#:	Exp#:	Looking Downstream	Roll#:	Exp#:	Stream Overview	Roll#:	Exp#:

	Stream Transects									
Transect	1	2	3	4	5	6	7	8	9	10
Width (m)										
Depth (cm) at 0.25 width										
Depth (cm) at 0.50 width										
Depth (cm) at 0.75 width										

	Densiometer Measurements			
Direction	Unit 1	Unit	Unit 3	Unit 4
Upstream				
Left bank				
Right bank				
Downstream				

Visual estimate of % of riffles comprised of 7 substrate types / sizes (mm)								
	Aquatic Plants	BR	Boulder	Cobble	Pebble	Gravel	Sand	Silt /Muck
Name		BR	> 256	64-256	16-64	2- 16	< 2	
Notes:								

Visual estimate of median substrate size (use 12 size classes below).	Name: Size:	Name: Size:

	Stream Bed Particle Size Counts							
	Unit 1		Unit 2		Unit 3		Unit 4	
Particle Size Class (mm)	Tallies	Count	Tallies	Count	Tallies	Count	Tallies	Count
Bedrock								
180								
128								
90								
64								
45								
32								
22.6								
16								
11								
8								
< 8								

Total # of particles counted in all units: Median:

	Moss Cover Index			
Category	0	1	2	3
Tally				

	Macro-Algae Cover Index			
Category	0	1	2	3
Tally				

	Micro-Algae Cover Index						
Category	0	0.5	1	2	3	4	5
Tally							

Comments::