



United States Department of the Interior

NATIONAL PARK SERVICE

Water Resources Division

1201 Oakridge Drive, Suite 250

Fort Collins, Colorado 80525

March 20, 2023

To: Stuart West, Superintendent (EOD March 6, 2023), Black Canyon of the Gunnison National Park, Montrose, CO (BLCA) / Curecanti National Recreation Area, Gunnison, CO (CURE)

Danguole Bockus, Ecologist, BLCA/CURE

Nicole Gibney, Aquatic Ecologist, BLCA/CURE

Through: John Wullschleger, Fish Program Lead, Water Resources Division (WRD), Fort Collins, CO.

From: Nic Medley, Fish Biologist/Aquatic Ecologist, Fish Program, WRD, Fort Collins, CO. JOHN WULLSCHLEGER

Digitally signed by JOHN WULLSCHLEGER
Date: 2023.03.29 09:42:38 -06'00'

cc: Forrest (Ed) Harvey, Chief, WRD, Fort Collins, CO.

Subject: Memorandum regarding fish survey and collection of aquatic macroinvertebrate and periphyton samples to obtain inventory information in support of the development of a Backcountry and Wilderness Management Plan for BLCA, October 2021.

Background

Black Canyon of the Gunnison National Park is developing a Wilderness and Backcountry Management Plan that will guide visitor use and the natural resource management of the Black Canyon of the Gunnison Wilderness Area for many years.

Wilderness Character Monitoring indicators and measures, as per the interagency "Keeping It Wild" strategy document, have been used to inform trends in wilderness qualities including the natural quality. However, information is missing to inform the status of a key character measure; number of non-indigenous animal species in BLCA wilderness. Anecdotal reports suggest that aquatic invasive animal species such as the New Zealand mud snail (*Potamopyrgus antipodarum*) may already be present downstream of the park. Other anecdotal information also points to the

possible presence of native Colorado River fishes that needs to be scientifically verified. This data also would better inform other wilderness character measures such as number of indigenous animal species that are listed as threatened and endangered, sensitive, or of concern, and the number of extirpated indigenous animal species.

In support of this information need, the Inventory and Monitoring Division (IMD) agreed to provide funding through its Inventories 2.0 initiative, which goal is it to provide parks with the means to get detailed inventory data to enable science-based management decisions. In response to this offer to fund the parks efforts, the Fish Program of the Water Resources Division in Fort Collins, CO offered to assist BLCA and conduct a preliminary qualitative fish survey within in the canyon, and to collect aquatic the macroinvertebrate and periphyton samples that could be analyzed by an independent contractor, using the IMD funding. Subsequently, BLCA submitted a technical assistance request to WRD; Inventory of Aquatic Animal Species in BLCA Wilderness, TAR 18719.

Past Sampling Efforts

Access to the Gunnison River within BLCA is difficult. Easy access is afforded at only one location; via the East Portal Road that accesses a short reach of river between the Gunnison Diversion Dam (GDD) and Crystal Dam (CD), just outside the BLCA eastern boundary, within CURE. Past fish surveys conducted by Colorado Parks and Wildlife (CPW) have focused on this slow moving, lake-like reach above the GDD because it allows for the necessary boat access to hold the large, specialized sampling equipment generally required to sample fish in large, non-wadable rivers. BLCA has no records of any fish surveys below GDD within the park. Similarly, there appear to be no records of aquatic macroinvertebrate or periphyton sampling within the park.

Goals

The goal of the technical assistance request was to survey fish, periphyton, and aquatic macroinvertebrate communities in the Gunnison River through the Black Canyon of the Gunnison Wilderness within BLCA to characterize the extant species assemblages and, if possible, to identify native versus non-native species; a key wilderness character measure of the wilderness plan.

Survey Locations

Two river reaches were sampled in BLCA. The more downstream Red Rocks Canyon (RRC) site was located ~ 1km from the western boundary of the park and was accessed via hiking the Red Rock Canyon Route. Sampling was conducted on October 5, 2021 from the left bank of the Gunnison River. Fish were sampled in an ~250m reach from UTM 13 S 257236 E 4275491 to UTM 13 S 257351 E 4275299. Macroinvertebrates and periphyton were sampled approximately 50 m upstream of the confluence of Red Rock Creek irrigation return with the Gunnison River, within 10 m of UTM 13 S 257265 E 4275340, at elevation 1674 m (5492 ft).

The upstream, East Portal (EP) site, was accessed from the EP Road and was located ~ 350m downstream of the Gunnison Diversion Dam for the East Portal of the Gunnison Tunnel, just inside the far east boundary of the park. The USGS gage site was located within the reach. Sampling was conducted on October 7, 2021 from the left bank of the Gunnison River. Fish were sampled in an ~500 m reach from UTM 13 S269094 E4268180 to UTM 13 S269078 E4267731.

Macroinvertebrates and periphyton were sampled approximately 20 m upstream from the downstream termination of the East Portal Road within 10 m of UTM 13 S269091 E4267722, at elevation 1989 m (6526 ft). All sampling coordinates and elevations were derived from Google Earth, subsequent to the actual survey dates.

Flows varied between sampling dates and locations. RRC was sampled October 5, 2021 when daily mean discharge at the USGS Gage 09128000 (Gunnison River below Gunnison Tunnel) was 587 cfs. However, releases from upstream storage reservoirs were decreased considerably on the afternoon of October 6, and daily mean discharge was recorded as 328 cfs for October 7, 2021.

Methods

Periphyton: The attached periphyton community was qualitatively sampled from three cobbles. The cobbles were removed from the bed of the river, and periphyton scraped from the substrate using a firm bristled toothbrush. A single composite sample was made up to a volume of approximately 100 mls and preserved in 2-3% glutaraldehyde. Samples were processed by Sean Sullivan of Rhithron Associates Inc., Missoula, Montana, as per the methods described in their attached summary report of the results (Appendix 1, Table 1).

Aquatic Macroinvertebrates: The aquatic macroinvertebrate community was quantitatively sampled using a 0.5 mm, Hess bottom substrate sampler (13" I.D. x 16" H with an area of 133 square inches). At each site, three samples were collected from river left from boulder/cobble substrate, the dominant substrate at the site. Sampling locations were in flowing water, as far off the bank as was safe to wade. The sampler was worked into the substrate and all aquatic organisms and periphyton removed from the substrate within the sampler. Collections were preserved in 70% ethanol. Samples were processed by Timberline Aquatics of Fort Collins, Colorado, as per the methods described in their attached summary report of the results (Appendix 2).

Fish: Fish were qualitatively sampled by a three-person electrofishing crew, using a Smith Root LR-20 backpack electro-shocker set at 300V, 30Hz and 20% duty cycle. Sampling was focused on shoreline and low velocity habitats that may not have been the primary locations sampled in previous efforts, largely conducted by Colorado Parks and Wildlife in their regular surveys to document the status of the recreational non-native trout fishery. The primary goal was to document

the presence of fish species that had not previously been documented in the inner canyon within BLCA, specifically young of year or adult native flannel-mouth and bluehead suckers, speckled dace and mottled sculpin.

Results and Discussion

Periphyton (attached algae): The periphyton community at both EP and RRC presented as a short turf, numerically and volumetrically dominated by a diverse diatom assemblage of mostly small, adnate species (*Achnantheidium*, *Cocconeis* spp., *Encyonema* sp., and several small *Navicula* and *Nitzschia* spp.), typical of early and mid-successional diatom communities on cobble substrates in flowing rivers. Soft algae, by volume, were poorly represented by few genera of Cyanophyta (“blue-green” algae); *Homoeothrix* sp., *Leptolyngbya* sp., and the short branched Chlorophyte (“green algae”) *Chaetophorales* sp. The more upstream site, EP, also had some presence of planktonic blue-green algae (*Aphanizomenon* sp.) and diatom species (eg *Astrionella* sp.), almost certainly originating from upstream reservoirs (Appendix 1, Table 2, Table 3.).

Of note was the apparent low abundance of late successional filamentous diatoms and soft algal species, such as the green algae *Cladophora*, which is often in high abundance in regulated rivers.

No evidence was collected for the presence of the ‘aquatic nuisance’ diatom species *Didymosphenia geminata* (aka “rock snot”).

Algal community indices and metrics indicative of trophic state are provided by Rhithron Associates, Inc., Missoula, MT (Appendix 1, Table 4.).

Macroinvertebrates: The aquatic macroinvertebrate community at EP was dominated (represented by greater than 1% relative abundance within the community) by Baetid and Ephemerellid mayflies (*Baetis tricaudatus* and *Ephemerella dorothea infrequens*); small Dipteran chironomids (*Cricotopus/Orthocladius* sp., *Eukiefferiella* sp., *Potthastia* sp., *Synorthocladius* sp., *Tvetenia* sp.); the riffle beetle *Optioservus* sp., and; the amphipod crustacean (scud) *Gammarus* sp. (Appendix 2, Table 5, Table 6).

The community at RRC was characterized by Baetid mayflies (*Baetis tricaudatus*); a Hydroptilid micro-caddisfly (*Hydroptila* sp.); the large Pteranarcyid “salmon fly, *Pteranarcys californica*; small Dipteran chironomids (*Cricotopus nostocicola*, *Cricotopus/Orthocladius* sp., *Eukiefferiella* sp., *Microtendipes* sp., *Pagastia* sp., *Synorthocladius* sp., and *Tvetenia* sp.); the elmrid riffle beetle *Optioservus* sp.; the water mite *Hygrobates* sp.; the amphipod crustacean *Hyaella azteca*; the pea-clam *Pisidium* sp., and; clitellate oligochaete worms of the family Tubificidae.

Of note, was the general low abundance and diversity of several aquatic insect groups at both sites downstream of the dam, including Heptageniidae mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera).

The aquatic macroinvertebrate community at the more downstream site, RRC, was dominated by a similar, but more diverse aquatic community. Aquatic insect species richness (24 to 51) and diversity (2.64 to 3.79) increased from EP (upstream) to RRC (downstream). This downstream increase is consistent with previous findings, as the both the thermal regime and hydrograph recover from the effects of impoundments and dams.

No evidence was collected for the presence of non-native New Zealand mud snails (*Potamopyrgus antipodarum*).

Macroinvertebrate community indices and metrics indicative are provided by Timberline Aquatics, Fort Collins, CO. (Appendix 2.).

Fish: Only two species of non-native trout; brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) were caught at the two locations sampled in BLCA (Appendix 3). No other non-native, or native species of fish were documented at either site. The upper EP site was characterized by the presence of both trout species but rainbow trout were dominant (12 BT, 21 RBT). The lower RRC site was dominated by brown trout, but rainbow trout were present in low numbers (72 BT; 2 RBT).

Locations sampled were dominated by young of year (YOY), and early age classes of fish, reflecting the focus on sampling protected shoreline habitats more suitable for small and early age classes of fish of all species seeking shelter, and escaping competition from, and predation by large adult, non-native, predatory brown and rainbow trout that generally utilize more main channel habitats.

No native fish species were found at either site. Prior to the construction of the three upstream impoundments, the Gunnison River within BLCA would have possessed a thriving, cool-water native fish community. The absence of any native fish confirms that the environmental conditions downstream of the dams and impoundments can only support cold-water, non-native trout population, or that predation and competition is sufficient to extirpate the native fish community. The absence of even small, YOY native fish targeted in protected shoreline habitats suggests that adult native fish are also not likely migrating to, and spawning below the dams. Alternatively, if native fish did spawn, environmental conditions (water temperature) are too low to allow adequate growth, survival and recruitment into the adult population. Results suggest that altered water temperature and discharge patterns, and the presence of large numbers of large adult, non-native predatory fish are such that a self-sustaining native fish community cannot persist in the Gunnison River within BLCA.

Many dead YOY rainbow trout were observed at the channel margin at EP (not included in the data). This is almost certainly a result of such small-bodied fish being stranded in shallow river edge habitats that were quickly dewatered after the drop in flows the evening before sampling, when flows passing the USGS gage below the East Portal Gunnison River Diversion Dam dropped from 587 cfs to 328 cfs. It is possible that YOY fish may also have been stranded at RRC but this was not observed during the study as the site was sampled at steady flow, prior to the rapid reduction in flows.

Conclusions

Note: An excellent discussion of the general impacts of reservoirs and dams on Colorado mountain streams and specifically their impact on macroinvertebrate communities, is provided by Ward and Kondratieff (1992), and the references therein, and provides the basis of most of the general observations pertaining to the Gunnison River in Black Canyon below the three large regulating dams in Curecanti National Recreation Area. A comprehensive discussion of the impacts of dams on stream periphyton communities can be found within Asarian et al. (2015).

The results show that the aquatic communities in BLCA are very typical of those found in highly regulated rivers below dam impounded reservoirs with thermally dampened, cold water, hypolimnion releases and highly modified hydrographs. The results also document the often observed increase in species richness and diversity between the upper and lower sites as the river recovers from the greater impact of regulation immediately below the dam.

No evidence was found for the presence of non-native, invasive New Zealand Mud Snail, or the regionally native, but potential aquatic nuisance diatom species, *Didymosphenia geminata*.

Presence of Native and Non-native Species

One of the primary goals of the study was to document possible changes in native species assemblages indicative of the extent of impacts from the upstream dams, and to document the presence of non-native species; a key wilderness character measure for use in the wilderness plan.

Periphyton (Attached Algae): It is difficult to assess the actual nativity of many algal species. However, the observed periphyton community in the heavily regulated contemporary Gunnison River within BLCA is likely to be quite different to the expected community in the historic free-flowing Gunnison River in its natural state.

Periphyton communities on cobbles in Rocky Mountain streams generally exhibit a seasonal pattern of succession, which is initiated/reset by winter ice scour and high flows during spring

snowmelt. In a regulated river, periphyton succession is not reset because dampened temperature regimes prevent ice formation and diminished peak flows when water is stored behind the dam for irrigation use later in the summer. Consequently, the periphyton community in BLCA suggests a mature diatom community, but possibly limited by the reservoir nutrient status and grazing pressure, very different than its natural state (see Asarian et al 2015). The presence of diatom species associated with lentic habitats is a clear indication of the influence of upstream reservoirs. However, while not usually found in lotic systems, they are perhaps regionally native. The absence of other algal groups often associated with late successional communities (filamentous diatoms, Chlorophyta) perhaps indicates light limitation in the deep narrow Black Canyon but may also indicate intense grazing pressure or nutrient status.

Macroinvertebrates: Similarly, while it is difficult to assign nativity to many individual macroinvertebrate species, the community has been greatly influenced by the later successional stage of the autotrophic periphyton foodbase, and changed temperature and flow regime. In general, it is much easier to identify invertebrate groups that are likely missing from the community, rather than the nativity of extant dominant taxa that remain, which are all likely to be regionally native.

The development of a thick carpet of periphyton prevents some insect groups with specialized adaptations from persisting in place (e.g. Heptageniid mayflies). In contrast, small insects (Chironomids, Elmids beetles, Hydroptilid caddisflies) can bury into the periphyton matrix, protected in the boundary layer from the main force of flows. Small Baetid swimming mayflies can persist by moving out of the main flow when necessary.

The absence of many species (e.g. stoneflies) is likely linked to the dampened thermal regime and changed hydrograph and the absence of important life history cues. The absence of salmon fly (*Pteranarcys californica*) at the upper site, a “shredder” that is dependent upon riparian inputs usually originating from upstream, is likely due to the low availability of leaves and detritus that is now captured by the reservoir. The presence of salmon flies further downstream likely reflects that there is an adequate accumulation of riparian derived allochthonous food sources from upstream, but still below the dam. Similarly, the absence of many filterers and collectors (e.g. caddisflies) is likely due to the loss of fine particulate organic matter that is now captured upstream. The high density of small Hydroptilid caddisflies is likely related to them being small, caseless, algal grazers during their first four larval instar stages, similar to the Chironomids. This caddisfly group only possesses a case as a final instar (fifth stage), and so can stay protected in the boundary layer within the periphyton matrix for most of its life cycle.

The presence of amphipods is likely due to the absence of a spring hydrograph and dampened thermal regime that creates conditions similar to the stable spring habitats in which these species are usually found, though it is not clear why different species dominate at each site. While again, not representative of species that would be found in an unregulated system, they are likely regionally native.

Fish: The documented fish community is solely comprised of non-native trout species that have been introduced to create a recreational trout fishery, the conditions now being unsuitable for the persistence or reproduction of the former native fish community.

References

J.E. Asarian, Y. Pan, N.D. Gillett, and J. Kann. 2015. Periphyton Assemblages and Associated Environmental Conditions in the Klamath River 2004-2013. Prepared by Riverbend Sciences, Portland State University, and Aquatic Ecosystem Sciences LLC. for the Klamath Basin Tribal Water Quality Group. 48p. + appendices.

https://klamathwaterquality.com/documents/KlamPeriphyton_Phase2_20150819final.pdf

Ward, J. V., & Kondratieff, B. C. (1992). An illustrated guide to the mountain stream insects of Colorado. Niwot, Colo., University Press of Colorado (and references therein).

Appendix 1

Periphyton Report

Rhithron Associates, Missoula, MT

Analysis of biological samples:
Technical summary of methods and quality assurance procedures
Prepared for National Park Service, Black Canyon of the Gunnison National Park
Prepared for: Nic Medley, Project Manager



February 18, 2021

by

Sean Sullivan, Aquatic Ecologist
Rhithron Associates, Inc.
Missoula, Montana

Two qualitative three rock scrape composite periphyton samples collected within the Black Canyon of the Gunnison National Park (BCGNP) (Table 1) were delivered to Rhithron's laboratory facility in Missoula, Montana (RAI). Samples arrived on December 14th 2021.

A chain of custody document containing sample identification information was provided by the National Park Service (NPS) Project Manager. Upon arrival, samples were unpacked and examined, and checked against the NPS chain of custody. All samples arrived in good condition.

An electronic inventory spreadsheet was created which included project code and internal laboratory identification numbers and was verified and approved by the NPS Project Manager prior to upload into the Rhithron database.

Table 1: Locations of two composite periphyton samples collected from BCGNP

RAI_Sample_ID	Name	Description	Date	Code	Latitude	Longitude
NPS21NMP001	Red Rocks 1	Left bank of Gunnison River within BCGNP approximately 50 m upstream of the confluence of Red Rock Creek irrigation return with the Gunnison River.	10/5/2021	RR1	38.593	-107.787
NPS21NMP001	East Portal 1	Left bank of Gunnison River within BCGNP At East Portal Visitor Parking Lot, short distance upstream of the USGS gage, approximately 350 m below The Gunnison Diversion Dam for the East Portal of the Gunnison Tunnel.	10/7/2021	EP1	38.527	-107.648

Periphyton Identification and Enumeration Methods

Sample volumes were measured and recorded. The samples were thoroughly mixed by shaking, and split into 2 aliquots for diatom and soft-bodied algae analyses.

Permanent diatom slides were prepared: subsamples were taken and treated with 70% Nitric acid (HNO₃) and digested using a closed-vessel microwave digestion system (Milestone

Ethos EZ), following the method developed by the Academy of Natural Sciences, Philadelphia (Charles *et al.* 2002). The samples were neutralized by rinses with distilled water, and subsample volumes were adjusted to obtain adequate densities for slide mounts. Dilution and concentration factors, as appropriate, were recorded for each sample. Subsamples were dried onto 22-mm square coverslips. Coverslips were mounted on slides using Naphrax diatom mount. To ensure a high quality mount for identification and to make replicates available for archives, 3 slide mounts were made from each sample. One of the replicates was selected from each sample batch for identification. A diamond scribe mark was made to define a transect line on the cover slip, and a minimum of 600 diatom valves were identified along the transect mark. A Leica DM 2500 compound microscope, Nomarski contrast, and 1000x magnification were used for identifications. Diatoms were identified to the lowest possible taxonomic level, generally species, following standard taxonomic references (e.g.(Spaulding *et al.* 2021).

For the soft-bodied algae samples, the raw periphyton sample was manually homogenized and emptied into a porcelain evaporating dish. A small, random subsample of algal material was pipetted into a standard Palmer-Maloney counting chamber using a disposable Pasteur pipette. Visible (macroscopic) algae were also sub-sampled, in proportion to their estimated abundance relative to the total volume of algal material in the sample, and added to the liquid fraction on the slide. The Palmer-Maloney cell was then covered with a 22 x 30 mm coverslip.

Soft-bodied algae were identified to genus using a Leica DM 2500 compound microscope under 200X to 400X magnification, following standard taxonomic references. Three Natural Counting Units (NCU) of algae were identified, when possible. Living diatom cells were included in these counts, including these cells allows for the calculation of diatom species abundance(Charles *et al.* 2002).

Quality assurance procedures

Quality control procedures for taxonomic determinations of invertebrates involved checking accuracy, precision and enumeration. One sample was randomly selected and all organisms re-identified and counted by an independent taxonomist. Taxa lists and enumerations were compared by calculating Percent Taxonomic Disagreement (PTD) and Percent Difference in Enumeration (PDE)(Stribling *et al.* 2003, 2008). Routinely, discrepancies between the original identifications and the QC identifications are discussed among the taxonomists, and necessary rectifications to the data are made. Representatives of some common and rare periphyton taxa were photographed (Attachment A) for discussion. Discrepancies that cannot be rectified by discussions are routinely sent out to taxonomic specialists for identification. Quality control measures resulted in a PTD and PDE of 6.80% and 0.17% respectively. A Minimum Data Quality Objective (MDQO) of $\leq 15\%$ PTD was established as part of the National Rivers and Streams Assessment (USEPA 2017), these data meet the national standards for taxonomic quality control.

Data compilation

Taxa and counts were entered into Rhithron's customized laboratory information management system (LIMS). Standard metric calculations for periphyton assemblages were made using Rhithron's customized LIMS. Periphyton identifications and metrics were compiled in Microsoft Excel spreadsheets and flat data files for electronic delivery to NPS (Attachments A and B).

Results

Among both samples a total of 51 taxa were observed, overwhelmingly dominated by diatoms. Relatively few non-diatom (soft algae) taxa were observed in these analyses. Dominate soft algae taxa were *Homoeothrix* sp. and *Leptolyngbya* sp., both belonging to the class Cyanophyceae. The dominant diatom taxon encountered in both samples was *Achnanthes* *eutrophila*. Little has been published about this taxon's autecology; however, one could assume it has similar ecological characteristics as other *Achnanthes* spp. and be sensitive to disturbance gradients (Bahls 1993; Carlisle *et al.* 2022; Tang *et al.* 2016). The sub-dominate diatoms belonging to the genus *Cocconeis* are widespread and thought to tolerate a wide range of environmental conditions (Spaulding *et al.* 2021).

These two samples represent a limited view into the periphyton community in BCGNP. Additional sampling within the BCGNP would benefit any ecological interpretation of biological communities within the park.

References

- Bahls, L.L. (1993) Periphyton bioassessment methods for Montana streams. , 69.
- Carlisle, D.M., Spaulding, S.A., Tyree, M.A., Schulte, N.O., Lee, S.S., Mitchell, R.M. & Pollard, A.A. (2022) A web-based tool for assessing the condition of benthic diatom assemblages in streams and rivers of the conterminous United States. *Ecological Indicators* 135, 108513. <https://doi.org/10.1016/j.ecolind.2021.108513>
- Charles, D.F., Knowles, C. & Davis, R.S. (2002) Protocols for the analysis of algal samples collected as part of the U.S. Geological Survey National Water-Quality Assessment Program. *Report No. 02-06*, 124.
- Spaulding, S.A., Potapova, M.G., Bishop, I.W., Lee, S.S., Gasperak, T.S., Jovanoska, E., Furey, P.C. & Edlund, M.B. (2021) Diatoms.org: supporting taxonomists, connecting communities. *Diatom Research*. <https://doi.org/10.1080/0269249X.2021.2006790>
- Stribling, J.B., Moulton II, S.R. & Lester, G.T. (2003) Determining the quality of taxonomic data. *Journal of the North American Benthological Society* 22, 621–631. <https://doi.org/10.2307/1468357>
- Stribling, J.B., Pavlik, K.L., Holdsworth, S.M. & Leppo, E.W. (2008) Data quality, performance, and uncertainty in taxonomic identification for biological assessments. *Journal of the North American Benthological Society* 27, 906–919. <https://doi.org/10.1899/07-175.1>
- Tang, T., Stevenson, R.J. & Infante, D.M. (2016) Accounting for regional variation in both natural environment and human disturbance to improve performance of multimetric indices of lotic benthic diatoms. *Science of the Total Environment* 568, 1124–1134. <https://doi.org/10.1016/j.scitotenv.2016.03.060>
- USEPA (2017) National Rivers and Streams Assessment 2018-19: Laboratory Operations Manual. EPA-841-B-17-004. , 185.

Table 2. Periphyton species density, biovolume and relative abundance (based upon cells counted) for EP.

Phylum	Taxon	NCU Counted	Cells Counted	Density(NCU/sample)	Density(Cells/sample)	Total Biovolume (um3/sample)	Relative Abundance (Cells Counted)	Comment
Cyanophyta	Aphanizomenon	1	18	400,000	7,200,000	801,577,366	2.05	biovolume based on cell
Cyanophyta	Leptolyngbya	23	253	9,200,000	101,200,000	608,536,314	28.88	epiphyte, biovolume based on cell, cell count estimate (10um=5cells)
Heterokontophyta	Achnanthyidium eutrophilum	165	165	30,327,273	30,327,273	930,834,982	18.84	many girdle
Heterokontophyta	Achnanthyidium minutissimum	12	12	2,205,620	2,205,620	68,300,694	1.37	
Heterokontophyta	Amphora pediculus	18	18	3,308,430	3,308,430	182,377,190	2.05	
Heterokontophyta	Asterionella formosa	5	5	919,008	919,008	105,398,760	0.57	
Heterokontophyta	Cocconeis pediculus	92	92	16,909,752	16,909,752	18,689,596,347	10.50	
Heterokontophyta	Cocconeis placentula sensu lato	19	19	3,492,231	3,492,231	1,146,487,111	2.17	
Heterokontophyta	Diatoma moniliformis	1	1	183,802	183,802	20,677,686	0.11	
Heterokontophyta	Ellerbeckia arenaria	19	19	3,492,231	3,492,231	44,158,953,319	2.17	
Heterokontophyta	Encyonema caespitosum	4	4	735,207	735,207	989,294,017	0.46	
Heterokontophyta	Encyonema kamschatcicum v. parva	6	6	1,102,810	1,102,810	1,713,766,612	0.68	
Heterokontophyta	Encyonema leibleinii	2	2	367,603	367,603	2,628,363,636	0.23	
Heterokontophyta	Encyonema minutum	64	64	11,763,306	11,763,306	723,950,598	7.31	
Heterokontophyta	Encyonema silesiacum	28	28	5,146,446	5,146,446	1,610,837,686	3.20	
Heterokontophyta	Gomphonema minutum	13	13	2,389,421	2,389,421	345,271,405	1.48	
Heterokontophyta	Lindavia intermedia	1	1	183,802	183,802	558,952,165	0.11	
Heterokontophyta	Mayamaea permitis	1	1	183,802	183,802	3,464,580	0.11	
Heterokontophyta	Navicula cryptotenella	4	4	735,207	735,207	82,710,744	0.46	
Heterokontophyta	Navicula metareichardtiana	15	15	2,757,025	2,757,025	352,623,471	1.71	
Heterokontophyta	Navicula tripunctata	3	3	551,405	551,405	401,422,810	0.34	
Heterokontophyta	Nitzschia	2	2	367,603	367,603	15,880,463	0.23	Nitzschia sp2
Heterokontophyta	Nitzschia costei	32	32	5,881,653	5,881,653	511,311,691	3.65	
Heterokontophyta	Nitzschia dissipata	5	5	919,008	919,008	223,502,810	0.57	
Heterokontophyta	Nitzschia paleacea	59	59	10,844,298	10,844,298	551,627,726	6.74	
Heterokontophyta	Nitzschia sociabilis	3	3	551,405	551,405	88,004,231	0.34	
Heterokontophyta	Nitzschia soratensis	4	4	735,207	735,207	19,850,579	0.46	
Heterokontophyta	Nitzschia supralitorea	2	2	367,603	367,603	15,880,463	0.23	
Heterokontophyta	Odontidium hyemale	1	1	183,802	183,802	110,433,473	0.11	
Heterokontophyta	Planothidium frequentissimum	6	6	1,102,810	1,102,810	149,409,992	0.68	
Heterokontophyta	Rhoicosphenia abbreviata	5	5	919,008	919,008	179,206,612	0.57	girdle
Heterokontophyta	Rhoicosphenia lowei	2	2	367,603	367,603	161,285,950	0.23	
Heterokontophyta	Sellaphora atomoides	2	2	367,603	367,603	16,168,038	0.23	
Heterokontophyta	Stephanodiscus niagarae	4	4	735,207	735,207	9,155,728,850	0.46	
Heterokontophyta	Stephanodiscus parvus	6	6	1,102,810	1,102,810	27,716,636	0.68	
TOTALS		629	876	120,800,000	219,600,000	87,349,405,007	100.00	

Table 3. Periphyton species density, biovolume and relative abundance for RRC.

Phylum	Taxon	NCU Counted	Cells Counted	Density(NCU/sample)	Density(Cells/sample)	Total Biovolume (um3/sample)	Relative Abundance (cells counted)	Comment
Chlorophyta	Chaetophorales	13	38	2,254,545	6,590,210	1,457,889,391	3.98	
Cyanophyta	Chamaesiphon	2	2	346,853	346,853	43,586,852	0.21	
Cyanophyta	Homoeothrix	10	290	1,734,266	50,293,706	39,500,585	30.40	biovolume based on cell (1x1um), cell count estimates (10um=10cells)
Cyanophyta	Undetermined Cyanophyte	4	21	693,706	3,641,958	144,926,283	2.20	3-Sum colonial coccoid
Heterokontophyta	Achnanthidium eutrophilum	152	152	11,890,793	11,890,793	379,740,972	15.93	
Heterokontophyta	Achnanthidium minutissimum	10	10	782,289	782,289	28,287,571	1.05	
Heterokontophyta	Amphora pediculus	26	26	2,033,951	2,033,951	108,307,915	2.73	
Heterokontophyta	Aulacoseira ambigua	1	1	78,229	78,229	12,616,876	0.10	
Heterokontophyta	Cocconeis pediculus	46	46	3,598,529	3,598,529	3,388,754,976	4.82	
Heterokontophyta	Cocconeis placentula sensu lato	115	115	8,996,324	8,996,324	2,774,178,584	12.05	
Heterokontophyta	Diatoma moniliformis	3	3	234,687	234,687	28,162,405	0.31	
Heterokontophyta	Diatoma vulgaris	2	2	156,458	156,458	246,009,108	0.21	
Heterokontophyta	Ellerbeckia arenaria	1	1	78,229	78,229	3,929,018,583	0.10	
Heterokontophyta	Encyonema kamtschaticum v. parva	15	15	1,173,434	1,173,434	1,109,579,190	1.57	
Heterokontophyta	Encyonema minutum	73	73	5,710,710	5,710,710	301,439,820	7.65	
Heterokontophyta	Encyonema silesiacum	1	1	78,229	78,229	19,322,539	0.10	
Heterokontophyta	Epithemia sorex	6	6	469,373	469,373	630,837,867	0.63	
Heterokontophyta	Geissleria acceptata	6	6	469,373	469,373	46,228,085	0.63	
Heterokontophyta	Gomphonema kobayashii	12	12	938,747	938,747	141,375,272	1.26	
Heterokontophyta	Mayamaea permissis	2	2	156,458	156,458	3,041,321	0.21	
Heterokontophyta	Navicula capitatoradiata	3	3	234,687	234,687	120,980,997	0.31	
Heterokontophyta	Navicula cryptotenella	13	13	1,016,976	1,016,976	206,700,317	1.36	
Heterokontophyta	Navicula metareichardtiana	13	13	1,016,976	1,016,976	111,679,190	1.36	
Heterokontophyta	Navicula tripunctata	25	25	1,955,723	1,955,723	1,828,600,587	2.62	
Heterokontophyta	Nitzschia communis	1	1	78,229	78,229	27,536,574	0.10	
Heterokontophyta	Nitzschia costei	25	25	1,955,723	1,955,723	177,159,127	2.62	
Heterokontophyta	Nitzschia dissipata	2	2	156,458	156,458	48,814,835	0.21	
Heterokontophyta	Nitzschia palea	2	2	156,458	156,458	50,003,914	0.21	
Heterokontophyta	Nitzschia paleacea	20	20	1,564,578	1,564,578	83,652,773	2.10	
Heterokontophyta	Nitzschia soratensis	7	7	547,602	547,602	9,583,041	0.73	
Heterokontophyta	Odontidium hyemale	2	2	156,458	156,458	308,187,234	0.21	
Heterokontophyta	Planothidium frequentissimum	4	4	312,916	312,916	32,514,490	0.42	
Heterokontophyta	Platessa bahlsii	1	1	78,229	78,229	1,173,434	0.10	
Heterokontophyta	Reimeria sinuata	2	2	156,458	156,458	19,661,068	0.21	
Heterokontophyta	Rhoicosphenia abbreviata	5	5	391,145	391,145	50,848,786	0.52	
Heterokontophyta	Sellaphora atomoides	4	4	312,916	312,916	10,322,060	0.42	
Heterokontophyta	Stephanodiscus niaqarae	3	3	234,687	234,687	3,225,643,892	0.31	
TOTAL		632	954	52,201,399	108,044,755	21,145,866,509	100.00	

Table 4. Periphyton community metrics for EP and RRC.

Heading	Group	Metric	Value RR1	Value EP1
Community Structure	Distribution	Cosmopolitan Taxa Percent	62.35%	62.48%
Community Structure	Distribution	Native Taxa Percent	1.99%	0.00%
Community Structure	Diversity	Shannon H (log2)	3.65	3.69
Community Structure	Diversity	Species Richness	33	33
Community Structure	Dominance	Dominant Taxon Percent	25.21%	27.27%
Community Structure	Rare Taxa	Mountains Rare Taxa Percent	0.00%	0.00%
Community Structure	Rare Taxa	Plains Rare Taxa Percent	1.99%	0.00%
Inorganic Nutrients	Rhopalodiales	Rhopalodiales Percent	1.00%	0.00%
Inorganic Nutrients	Autotrophism	Nitrogen Autotroph Taxa Percent	54.23%	46.45%
Inorganic Nutrients	Trophic State	Eutraphentic Taxa Percent	42.29%	36.69%
Metals	Abnormality	Abnormal Cells Percent	0.00%	0.00%
Metals	Acid Tolerance	Acidophilous Taxa Percent	0.00%	0.00%
Metals	Disturbance	Disturbance Taxa Percent	1.66%	1.98%
Metals	Metals Tolerance	Metals Tolerant Taxa Percent	16.25%	25.12%
Organic Nutrients	Heterotrophism	Nitrogen Heterotroph Taxa Percent	4.15%	10.25%
Organic Nutrients	Oxidation	Low DO Taxa Percent	0.66%	0.17%
Organic Nutrients	Pollution	Pollution Index	2.44	2.30
Organic Nutrients	Saprobity	Polysaprobous Taxa Percent	20.23%	29.75%
Sediment	Brackishness	Mountains Brackish Taxa Percent	53.73%	38.51%
Sediment	Brackishness	Plains Brackish Taxa Percent	1.49%	3.31%
Sediment	Motility	Motile Taxa Percent	24.21%	23.80%
Sediment	Siltation	Siltation Taxa Percent	20.40%	21.82%

Appendix 2

Aquatic Macroinvertebrate Report

Timberline Aquatics Inc., Fort Collins, CO.



Timberline Aquatics, Inc.

Memo

To: Nic Medley, Water Resources Division, National Park Service

From: David E. Rees, Timberline Aquatics, Inc.

Date: 3/29/2023

Subject: Results from Black Canyon Gunnison River Benthic Macroinvertebrate Sampling in October 2021

Results from benthic macroinvertebrate biomonitoring in the Black Canyon of the Gunnison on 5 October and 7 October, 2021 are provided below. I have included a brief description of metrics used in this study, and would be happy to discuss any of these results by phone.

Metric Descriptions:

Shannon Diversity (Diversity) and Evenness (Evenness): Diversity and Evenness were used in this study to detect changes in macroinvertebrate community structure. In unpolluted waters, Diversity values typically range from near 3.0 to 4.0. In polluted waters, this value is generally less than 1.0. Evenness values range between 0.0 and 1.0. Values lower than 0.3 are often indicative of pollution from nutrient-enrichment.

Hilsenhoff Biotic Index (HBI): Most of the value from this metric lies in the detection of organic pollution, but it is also used to evaluate aquatic conditions in a variety of other circumstances. The HBI was originally developed using macroinvertebrate taxa from streams in Wisconsin; therefore, it may require regional modifications (Hilsenhoff 1988). Tolerance values for taxa occurring in this study area were taken from a list provided by the CDPHE, which was derived from a variety of regional sources. Although HBI values may naturally vary among regions, a comparison of the values produced within the same river system should provide information regarding locations impacted by nutrients and/or other aquatic disturbances. Values for the HBI range from 0.0 to 10.0, and increase as water quality decreases.

EPT: The design of this metric is based on the assumption that the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are generally more sensitive to pollution than other benthic macroinvertebrate orders. The EPT metric is currently an important

tool that is widely used in many regions of the United States. The EPT value is simply given as the total number of distinguishable taxa in the orders Ephemeroptera, Plecoptera, and Trichoptera found at each station. This value is expected to decrease in response to a variety of stressors.

Ratio of EPT to Chironomidae abundance (EPT/Chironomidae Ratio): This ratio has been widely used in the U.S. to test for impacts from nutrient-enrichment and other types of disturbances (Plafkin et al. 1989). The design of this metric incorporates the density of individuals in taxonomic orders that are generally considered to be sensitive to pollution (EPT taxa) in a ratio with the density of individuals from a family (Chironomidae) that are thought to be tolerant to most disturbances (Plafkin et al. 1989; King 1993). Limitations can result from variability in tolerances among EPT taxa, and certain species of Chironomidae that are relatively sensitive to pollutants. When aquatic conditions are favorable, values often range from 3.0 to 7.0 (but can be higher). Values usually decline to less than 1.0 when anthropogenic disturbances are having a negative influence on benthic macroinvertebrate communities.

Total Taxa: Total Taxa (or Taxa Richness) is reported as the total number of identifiable taxa collected from each sampling location. This metric is often used to provide an indication of habitat adequacy and water quality. The Total Taxa value will generally decline when communities are exposed to decreasing water quality or habitat degradation. This metric is similar to the EPT metric, except that it includes all aquatic macroinvertebrate taxa (including those that are thought to be tolerant to disturbances).

Density: Density was reported as the mean number of macroinvertebrates per m² found at each study site. This metric is valuable because it can be sensitive to changes in habitat that are independent of changes in water quality. For example, impacts from sediment deposition will often cause a reduction in macroinvertebrate Density before influencing metrics that rely on community composition. While the Density value may decrease in response to habitat degradation, this value may increase in response to nutrient-enrichment.

Table 5. Macroinvertebrate data (corrected) from the Gunnison River at the more upstream East Portal site (EP) collected on 7 October 2021.

Black Canyon Gunnison						
East Portal						
7 October 2021	1	Sample 2	3	Sum	Estimated # per m ²	Relative Abundance (for Sum)
Ephemeroptera						
<i>Baetis tricaudatus</i>	184	123	244	551	2136	9.71
<i>Ephemerella dorothea infrequens</i>	15	15	38	68	264	1.20
<i>Epeorus longimanus</i>				0		0.00
<i>Tricorythodes explicatus</i>				0		0.00
<i>Paraleptophlebia</i> sp.				0		0.00
Plecoptera						
<i>Hesperoperla pacifica</i>	4			4	16	0.07
<i>Isoperla</i> sp.				0		0.00
<i>Pteronarcys californica</i>				0		0.00
Trichoptera						
<i>Brachycentrus americanus</i>			4	4	16	0.07
<i>Arctopsyche grandis</i>				0		0.00
<i>Hydropsyche cockerelli</i>				0		0.00
<i>Hydropsyche occidentalis</i>				0		0.00
<i>Hydropsyche oslari</i>				0		0.00
<i>Hydroptila</i> sp.			4	4	16	0.07
<i>Lepidostoma</i> sp.		3		3	12	0.05
Diptera						
Chironomidae						
<i>Cricotopus nostocicola</i>				0		0.00
<i>Cricotopus/Orthocladus</i> sp.	544	225	578	1347	5221	23.75
<i>Cryptochironomus</i> sp.				0		0.00
<i>Diamesa</i> sp.	4	3		7	28	0.12
<i>Eukiefferiella</i> sp.	267	144	132	543	2105	9.57
<i>Microsestra/Tanytarsus</i> sp.	4	7		11	43	0.19
<i>Microtendipes</i> sp.				0		0.00
<i>Nanocladius</i> sp.				0		0.00
<i>Pagastia</i> sp.	79	26	57	162	628	2.86
<i>Parakiefferiella</i> sp.				0		0.00
<i>Paratanytarsus</i> sp.			4	4	16	0.07
<i>Phaenopsectra</i> sp.				0		0.00
<i>Potthastia</i> sp.	4			4	16	0.07
<i>Prodiamesa</i> sp.				0		0.00
<i>Synorthocladus</i> sp.	23	18	12	53	206	0.93
<i>Thienemanniella</i> sp.				0		0.00
<i>Tvetenia</i> sp.	702	472	788	1962	7605	34.59
Other Diptera						
<i>Atherix pachypus</i>				0		0.00
<i>Hemerodromia</i> sp.				0		0.00
<i>Lispoides aequifrons</i>		3	4	7	28	0.12
<i>Simulium</i> sp.			4	4	16	0.07
<i>Euparyphus</i> sp.				0		0.00
<i>Antocha</i> sp.	15	9	4	28	109	0.49
<i>Dicranota</i> sp.				0		0.00
Coleoptera						
<i>Optioservus</i> sp.	19	15	23	57	221	1.00
<i>Zaitzevia parvula</i>				0		0.00
				0		0.00
Odonata						
<i>Argia</i> sp.				0		0.00
Miscellaneous						
<i>Hygrobatas</i> sp.		11	4	15	59	0.26
<i>Lebertia</i> sp.				0		0.00
<i>Sperchon</i> sp.	4	7	12	23	90	0.41
<i>Torrenticola</i> sp.				0		0.00
<i>Crangonyx</i> sp.				0		0.00
<i>Gammarus</i> sp.	248	84	454	786	3047	13.86
<i>Hyalella azteca</i>				0		0.00
<i>Dugesia</i> sp.				0		0.00
<i>Pisidium</i> sp.				0		0.00
Lymnaeidae				0		0.00
<i>Physa</i> sp.				0		0.00
<i>Gyraulus</i> sp.				0		0.00
Naididae		7	15	22	86	0.39
Tubificidae with hair chaetae		3		3	12	0.05
Totals	2116	1175	2381	5672	21996	100.00
Shannon Weaver Diversity					2.64	
Calculated Evenness					0.576	
HBI					5.40	
EPT					6	
EPT/Chironomid Ratio					0.15	
Total Taxa per Site					24	
Density (mean #/m²)					21996	

Table 6. Macroinvertebrate data (corrected) from the Gunnison River at the more downstream Red Rock Canyon site collected on 5 October 2021.

Black Canyon Gunnison						
Red Rock						
5 October 2021	1	Sample 2	3	Sum	Estimated # per m ²	Relative Abundance (for Sum)
Ephemeroptera						
<i>Baetis tricaudatus</i>	5	45	9	59	229	1.36
<i>Ephemerella dorothea infrequens</i>	3	4	5	12	47	0.28
<i>Epeorus longimanus</i>			11	11	43	0.25
<i>Tricorythodes explicatus</i>	3	4	7	14	55	0.32
<i>Paraleptophlebia</i> sp.		4	7	11	43	0.25
Plecoptera						
<i>Hesperoperla pacifica</i>		8	3	11	43	0.25
<i>Isoperla</i> sp.		4	3	7	28	0.16
<i>Pteronarcys californica</i>		8		8	32	0.18
Trichoptera						
<i>Brachycentrus americanus</i>				0		0.00
<i>Arctopsyche grandis</i>		4		4	16	0.09
<i>Hydropsyche cockerelli</i>		4		4	16	0.09
<i>Hydropsyche occidentalis</i>		15		15	59	0.35
<i>Hydropsyche oslari</i>		4	5	9	35	0.21
<i>Hydroptila</i> sp.	35	23	50	108	419	2.49
<i>Lepidostoma</i> sp.				0		0.00
Diptera						
Chironomidae						
<i>Cricotopus nostocicola</i>	88	19	71	178	690	4.11
<i>Cricotopus/Orthocladius</i> sp.	305	496	183	984	3814	22.71
<i>Cryptochironomus</i> sp.	3			3	12	0.07
<i>Diamesa</i> sp.				0		0.00
<i>Eukiefferiella</i> sp.	20	345	35	400	1551	9.23
<i>Micropectra/Tanytarsus</i> sp.	26		5	31	121	0.72
<i>Microtendipes</i> sp.	28		15	43	167	0.99
<i>Nanocladius</i> sp.			3	3	12	0.07
<i>Pagastia</i> sp.		15		15	59	0.35
<i>Parakiefferiella</i> sp.	9	4		13	51	0.30
<i>Paratanytarsus</i> sp.	7		3	10	39	0.23
<i>Phaenopsectra</i> sp.	11			11	43	0.25
<i>Potthastia</i> sp.	33	8	26	67	260	1.55
<i>Prodiamesa</i> sp.	7			7	28	0.16
<i>Synorthocladius</i> sp.	37	19	33	89	345	2.05
<i>Thienemanniella</i> sp.		4		4	16	0.09
<i>Tvetenia</i> sp.	225	229	393	847	3283	19.55
Other Diptera						
<i>Atherix pachypus</i>			3	3	12	0.07
<i>Hemerodromia</i> sp.		4		4	16	0.09
<i>Lispoides aequifrons</i>	3	27		30	117	0.69
<i>Simulium</i> sp.		4	3	7	28	0.16
<i>Euparyphus</i> sp.		12		12	47	0.28
<i>Antocha</i> sp.				0		0.00
<i>Dicranota</i> sp.		4		4	16	0.09
Coleoptera						
<i>Optioservus</i> sp.	20	312	22	354	1373	8.17
<i>Zaitzevia parvula</i>	3			3	12	0.07
Odonata						
<i>Argia</i> sp.		4		4	16	0.09
Miscellaneous						
<i>Hygrobatas</i> sp.	86	143	105	334	1295	7.71
<i>Lebertia</i> sp.		19		19	74	0.44
<i>Sperchon</i> sp.	3	19		22	86	0.51
<i>Torrenticola</i> sp.		4		4	16	0.09
<i>Crangonyx</i> sp.	3		3	6	24	0.14
<i>Gammarus</i> sp.				0		0.00
<i>Hyalella azteca</i>	3	147		150	582	3.46
<i>Dugesia</i> sp.		8		8	32	0.18
<i>Pisidium</i> sp.	67	12	20	99	384	2.28
Lymnaeidae	7		7	14	55	0.32
<i>Physa</i> sp.		19	5	24	94	0.55
<i>Gyraulus</i> sp.	3			3	12	0.07
Naididae	9		9	18	70	0.42
Tubificidae with hair chaetae	93	90	50	233	904	5.38
Totals	1145	2094	1094	4333	16821	100.00
Shannon Weaver Diversity						
Calculated Evenness					3.79	
HBI					0.669	
EPT					6.15	
EPT/Chironomid Ratio					13	
Total Taxa per Site					0.10	
Density (mean #/m ²)					51	
					16821	

Appendix 3
Fish Data Sheets

Nhi Medla

Site/Trip ID: <u>Red rocks, BLCA</u>		Date: <u>10/5/2021</u>	Crew: <u>Bethany, Bidglette</u>	Page <u>1</u> of <u>1</u>
Reach Length: <u>~300m</u>	Stream Width:	Start time: <u>~2:00pm</u>	Volts: <u>300</u>	AC/DC:
Start Way Point: <u>Measured from Google Earth</u>		Finish time:	Frequency: <u>30</u>	
End Way Point:		Total Seconds: <u>~900</u>	Duty Cycle: <u>20%</u>	
Comments (weather, temperature, cloud cover, turbidity, flow?): <u>Sunny, warm, partly cloudy</u> <u>Sampled River left, between rock outcrops.</u> <u>1 Periphyton, RR</u> <u>3 Macro: RR1, RR2, RR3</u> <u>+ Fish survey / Presence / LEW</u>				

[illegible]

Nic Medley
Nicole Gibney

NPS Fish Data Form			
Site/Trip ID: <u>BLCA</u>	Date: <u>10/7/2021</u>	Crew: <u>Bethany</u>	Page <u>1</u> of <u>1</u>
Reach Length: <u>measured</u>	Stream Width:	Start time: <u>10:00 am</u>	Volts: <u>300</u>
<u>- 225m from Google</u>		Finish time: <u>11:00 am</u>	Frequency: <u>30</u>
Start Way Point: <u>Earth</u>		Total Seconds: <u>~500</u>	Duty Cycle: <u>20</u>
End Way Point:			
Comments (weather, temperature, cloud cover, turbidity, flow?): <u>Sunny, warm, partly cloudy.</u> <u>From cable, upstream, to head of riffle</u>			
<u>1 periphyton EP</u> <u>3 macro EP1, EP2, EP3</u> <u>Fish - shore line LEW.</u>			

[illegible]

