AQUATIC RESOURCE STUDIES IN THE RESOLUTION STUDY AREA

RESOLUTION COPPER MINING

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EXECUTIVE SUMMARY

Resolution Copper Mining, LLC (RCM) is currently in the prefeasibility phase of the development of a copper mine located near Superior, Pinal County, Arizona. In order to assist RCM in obtaining the necessary environmental permits, WestLand Resources, Inc. (WestLand) was retained by RCM to conduct baseline biological studies in the Resolution Project Area. Surveys reported here focus specifically on aquatic habitats in Mineral Creek, Devils Canyon, and two tributaries to Devils Canyon, Rancho Rio and Hackberry Creeks (the Study Area).

The first objective of the surveys was to describe the diversity and abundance of aquatic taxa associated with perennial and intermittent streams in the Study Area. The second objective was to examine seasonal changes in the aquatic taxa in the Study Area. Aquatic taxa covered in this study include: phytoplankton (free-floating algal cells), periphyton (algae attached to surfaces of rocks and plants), zooplankton (free-floating animals), and macroinvertebrates (benthic and free-swimming herbivorous and carnivorous invertebrates species—mostly insects). Collectively, these organisms form the basis of aquatic food webs, as phytoplankton and periphyton are consumed by zooplankton and macroinvertebrates, which are in turn consumed by each other and larger animals such as fish and amphibians.

A total of 49 taxa of phytoplankton, 70 taxa of periphyton, 3 taxa of zooplankton, and 80 taxa of macroinvertebrates were detected in the Study Area during aquatic resources investigations in June and October 2011. In general, the diversity and abundance of aquatic organisms in the Study Area appear to be greater in June than in October, though seasonal diversity and abundance vary by taxon and from site to site. Macroinvertebrate diversity at Mineral Creek, for example, appears to be greater in June, whereas at Devils Canyon it is greater in October. The general pattern of numerical dominance of one or two species is a relatively consistent feature of the aquatic communities studied, even though the dominant taxa vary among sampling locations and between seasons. The results of this study suggest that phytoplankton, periphyton, and zooplankton are more diverse and abundant in Devils Canyon than in Mineral Creek, however, macroinvertebrates appear to be considerably more diverse and abundant in Mineral Creek than in Devils Canyon. The trophic impacts of higher level predators and herbivores (fish, frogs, and crayfish) may help explain the differences observed between Devils Canyon and Mineral Creek.

1. INTRODUCTION

Resolution Copper Mining, LLC (RCM) is currently in the prefeasibility phase of the development of a copper mine located near Superior, Pinal County, Arizona. In order to assist RCM in obtaining the necessary environmental permits, WestLand Resources, Inc. (WestLand) was retained by RCM to conduct baseline biological studies in the Resolution Study Area (***Figure 1***). The goal of these surveys was to provide information regarding the biological and natural resource features in the Resolution Study Area. Surveys reported here focus specifically on aquatic habitats in Mineral Creek, Devils Canyon, and two tributaries to Devils Canyon, Rancho Rio and Hackberry Creeks (the Study Area) (***Figure 2***).

The first objective of the surveys was to describe the aquatic taxa associated with perennial and intermittent streams in the Study Area and to determine the abundance of aquatic taxa among sample locations, between the two sampling periods, and among habitats sampled within streams. The second objective was to examine seasonal changes in the aquatic organisms at the study locations.

The goals of this report are to: 1) describe the diversity and abundance of aquatic taxa detected in the Study Area in 2011, 2) provide a seasonal comparison of aquatic taxa and microenvironments observed during surveys in June and October 2011, and 3) present a comparison of aquatic organisms found in Mineral Creek and those found in Devils Canyon and its tributaries.

1.1. BACKGROUND ON AQUATIC ORGANISMS

The aquatic organisms studied in this investigation include phytoplankton, periphyton, zooplankton, and macroinvertebrates. Phytoplankton or planktonic algae, are microscopic plants that drift freely in water, forming the basis of food chains in aquatic ecosystems. Periphyton, by contrast, are benthic microscopic plants that are attached to rocks or larger plants in aquatic ecosystems. These plants can grow in multiple forms, including algal mats and long filaments that drift with the current. Commonly, periphyton reproduces via segments of filaments that detach from the growing strand, thus entering the phytoplankton. Zooplankton, animals (commonly microscopic) that drift with the current, feed on phytoplankton and periphyton and sometimes other smaller zooplankton (Likens 2010). Larger animals that can move against the current and are visible to the naked eye, known as macroinvertebrates, include herbivores of phytoplankton and periphyton as well as predators of zooplankton and other animals (Hauer and Resh 2006).

These groups of aquatic organisms may be used as bioindicators of the health of stream and pond ecosystems for a variety of reasons. These communities may respond rapidly to environmental changes. Increases or decreases in water flow rates, for example, may induce changes in the diversity and abundance of aquatic organisms before any effects on terrestrial communities are noticeable (Lodge 1991, Hart and Finelli 1999, Bunn and Arthington 2002). However, establishing causal relationships for changes in aquatic communities requires extensive datasets, as the diversity and abundance of these communities vary seasonally (Callanan et al. 2008) and in response to ambient environmental changes such as water temperature and flow rate (Vannote and Sweeney 1980, Hart and Finelli 1999, Bunn and Arthington 2002). Thus, the dominant taxon in a community may vary over time, while the diversity of taxa remains relatively similar (Hutchinson 1961). This natural pattern of seasonality must be taken into

account when investigating possible effects of external factors on the diversity and abundance of aquatic organisms.

1.2. STUDY AREA DESCRIPTION

The Study Area is situated in the Pinal Mountains immediately east of Superior. The Study Area includes portions of the spatially intermittent drainage of Devils Canyon (stream miles 9.0 to 8.7 and 5.3 to 4.7 from confluence with Mineral Creek) and two of its tributaries, Rancho Rio and Hackberry Creeks, as well as a stretch of the perennial Mineral Creek (stream miles 12.0 to 10.2 from confluence with Gila River). Elevations in the Study Area range from a minimum of approximately 2,400 feet (732 meters) along Mineral Creek to a maximum of roughly 3,900 feet (1,189 meters) along Rancho Rio Creek. The Study Area includes land administered by the Arizona State Land Department (State Land) at Devils Canyon and its tributaries, private land, land administered by the Bureau of Land Management (BLM), and land administered by the US Forest Service Tonto National Forest (TNF) (***Figure 2***). Four vegetation types are found in the immediate vicinity of the Study Area, including Interior Riparian Deciduous Forest, Arizona Upland Subdivision of Sonoran Desertscrub (Arizona Upland Desertscrub), Interior Chaparral, and Madrean Evergreen Woodland (Brown 1994).

2. METHODS

Aquatic samples were collected in the Study Area in June and October 2011. The two sampling trips were conducted by WestLand and Aquatic Consulting & Testing, Inc. during a relatively dry period of the year (June 13-15, 2011) and following the monsoon season (October 5-7, 2011). Sample locations were selected based on the availability of the following microhabitats: 1) pool, which is relatively deep, calm water (***Appendix A, Photos 1, 2, 4, and 10***); 2) riffle, shallow flowing water (***Appendix A, Photos 3, 5, 11, and 15***); and 3) edge, shallow calm water along a stream margin (***Appendix A, Photos 3, 9, and 14***). These microhabitats were sampled using different techniques, as explained below. Sampling procedures and locations were modified where required to accommodate low-water conditions. In total, four sites in Mineral Creek, five sites in Devils Canyon, two sites in Hackberry Creek, and one site in Rancho Rio Creek were sampled. At each site, pool, riffle, and edge microhabitats were sampled for phytoplankton, periphyton, zooplankton, and macroinvertebrates. Samples were analyzed in the laboratory by Aquatic Consulting & Testing, Inc. The following paragraphs describe the protocols for collecting and analyzing each of the four sample types.

2.1. SAMPLE COLLECTION

Phytoplankton samples were collected by hand by scooping a 50-milliliter (50-ml) centrifuge tube through the water near the surface. Floating algal mats, when observed, were also sampled using a similar technique. Algal samples collected in centrifuge tubes were preserved in the field with Lugol's iodine solution.

Sampling for periphyton, algae attached to rocks and plant surfaces in aquatic systems, consisted of scraping a 4 cm^2 surface area from rocks removed from the streambed. Rocks were scraped with a razor blade to ensure thorough removal of periphyton within the sampling perimeter. Filamentous algae

attached to subsurface rocks via rhizoidal branches were carefully scraped to preserve the anchoring structure. All samples were transferred to individual 50-ml centrifuge tubes for transport.

All sites were sampled for zooplankton using an 80-micrometer (80-µm) zooplankton net (***Appendix A, Photo 2***). Pools were sampled by tossing and towing the net across the surface of the pool or pulling the net vertically through the pool where appropriate. Riffles and edges were sampled by submerging the net in the water for a set period of time. The contents of the net were then thoroughly rinsed into the collection bottle, and the resultant sample was transferred to 50-ml centrifuge tubes. The sample tubes were treated in the field with a light dose of Lugol's iodine solution for preservation.

Macroinvertebrates were sampled with a Ponar dredge (***Appendix A, Photo 17)*** in pools or with a kick-net in riffles and edges. The Ponar dredge was used in pools in order to collect samples from the bottom of the pools and return them to the surface. In riffles, the net was placed in the flowing water and the streambed was kicked upstream in order to cause macroinvertebrates to dislodge and float into the net. After the initial collection, the samples were sifted with a 600-µm screen to wash out fine sediments and remove larger rocks. The samples were then transferred to zip-lock bags, and preserved with 95% ethanol for transport.

All collected samples were stored and transported to the laboratory on ice. Samples preserved in ethanol were fortified with fresh 95% ethanol prior to storage and transport.

Due to the structure of microhabitats, different sampling techniques were used to obtain samples. Thus, comparisons of diversity and abundance of species groups among these microhabitats should be interpreted with caution and with this caveat in mind.

2.2. ANALYSIS

Phytoplankton and periphyton samples were refrigerated and either examined within 48 hours or preserved in the laboratory with Lugol's iodine solution. As needed, additional portions were acid-treated and burn-mounted to facilitate diatom identifications. Organism identifications were made using a Nikon Diaphot inverted phase-contrast microscope. If required, samples were concentrated using an Utermöhl settling chamber. Organism densities were computed using the settling chamber, concentration factor, and micrometer-measured sample area or using Sedgwick-Rafter counting cells. Algae identifications were made with the aid of taxonomic keys (Smith 1950, Prescott 1962, Chapman 1964, Tilden 1968, Benson and Rutherford 1975, Patrick and Reimer 1975, Warner 1977, Czarnecki and Blinn 1978, Prescott 1978, Rivers 1978, Bold and Wynne 1985, Sze 1986, Dodd 1987, Dillard 1989, Crawford et al. 1990).

Zooplankton samples were examined by dissecting microscope and enumerated using a counting chamber. Densities were determined from the count and volume sampled. Identifications were made to the lowest possible taxonomic level using taxonomic keys (Pennak 1989, Thorp and Covich 1991, Arnett 1993, Merritt et al. 2008).

Macroinvertebrate samples were pre-sorted and initially screened for content. The sorting process involved separating macroinvertebrates from debris in each sample. A 300-count sub-sampling approach was conducted for each sample using a process similar to that described by Barbour et al. (1999). Samples

were rinsed with tap water in a No. 35 sieve then placed in a gridded tray for sorting. This process involved separating macroinvertebrates from debris and picking organisms from a random number of grids until 300 or more individual macroinvertebrates were obtained. Macroinvertebrates were identified to the lowest practical taxonomic level based on the life-stage of the specimens. This level of identification was typically genus or species for mayflies, caddisflies, and many dipterans. The family Chironomidae (the non-biting midge family) was identified to the genus-level in most cases.

As part of the quality control protocols, Timberline Aquatics, Inc. sorted macroinvertebrate samples and had each identification checked by an additional taxonomist. Approximately 10% of the identifications were also checked by a taxonomist at Colorado State University. As an additional means of quality assurance and quality control, specimens were sent to another specialist for confirmation in instances where the classification of a taxon was difficult or questionable.

3. RESULTS

3.1. DIVERSITY AND ABUNDANCE OF AQUATIC ORGANISMS

A total of 49 taxa of phytoplankton, 70 taxa of periphyton, 3 taxa of zooplankton, and 80 taxa of macroinvertebrates were detected in the Study Area during aquatic resource investigations. The following paragraphs describe the diversity and abundance of these taxa identified in June and October by sample site and microhabitat. As mentioned in the Methods, different sampling methods were used among the different microhabitats in some cases, thus comparisons should be viewed with caution. We present the comparisons below but at best the numerical differences should be interpreted as qualitative indicators of differences.

3.1.1. Phytoplankton

3.1.1.1. June

Nineteen taxa of phytoplankton were detected in pools, riffles, and edges in Mineral Creek in June. *Selenastrum* sp. (Chlorococcales: Oocystaceae) was the most abundant taxon, representing 39% of all organisms identified. The average density of organisms was greatest in pools (73 organisms/ml, range: 6 - 213 organisms/ml). Edges contained an average of 53 organisms/ml (range: 9 to 116 organisms/ml), and riffles supported an average of 39 organisms/ml (range: 5 to 123 organisms/ml) (***Table 1***).

Thirty taxa of phytoplankton were detected in pools, riffles, and edges in Devils Canyon in June. *Microspora* sp. (Microsporales: Microsporaceae) was the most abundant taxon, representing 41% of all organisms identified. The average density of organisms was greatest in edges (46,653 organisms/ml, range: 362 - 175,005 organisms/ml). Pools contained an average of 9,984 organisms/ml (range: 35 - 21,338 organisms/ml), and riffles supported an average of 946 organisms/ml (range: 45 - 1,846 organisms/ml) (***Table 2***).

Eighteen taxa of phytoplankton were detected in pools, riffles, and edges in Hackberry and Rancho Rio Creeks in June. *Spirulina* sp. (Oscillatoriales: Pseudanabaenaceae), *Oscillatoria* sp. (Oscillatoriales: Osillatoriaceae), and *Scenedesmus* sp. (Chlorococcales: Scenedesmaceae) were the most abundant taxa,

representing 36%, 31%, and 27% of all organisms, respectively. The remaining 15 taxa identified constituted only 6% of all organisms detected. The density of organisms varied considerably in pools, which contained an average of 3,793,288 organisms/ml (range: 989 - 9,886,390 organisms/ml). Edges contained an average of 1,040 organisms/ml (range: 251 - 1,829 organisms/ml), and the single riffle sampled contained 532 organisms/ml (***Table 3***).

3.1.1.2. October

Eighteen taxa of phytoplankton were detected in pools, riffles, and edges in Mineral Creek in October. *Oscillatoria* sp. (Oscillatoriales: Osillatoriaceae) was the most abundant taxon, representing 27% of all organisms identified. The average density of organisms was greatest in riffles (44 organisms/ml, range: 18 - 96 organisms/ml). Pools contained an average of 37 organisms/ml (range: 24 - 52 organisms/ml), and edges supported an average of 31 organisms/ml (range: 13 - 44 organisms/ml) (***Table 4***).

Twenty-seven taxa of phytoplankton were detected in pools, riffles, and edges in Devils Canyon in October. *Ulothrix* sp. (Ulotrichales: Ulotrichaceae) was the most abundant taxon, representing 27% of all organisms identified. The average density of organisms was greatest in pools (5,301 organisms/ml, range: 13 - 25,405 organisms/ml). Riffles contained an average of 4,555 organisms/ml (range: 108 - 13,381 organisms/ml), and edges supported an average of 225 organisms/ml (range: 93 - 357 organisms/ml) (***Table 5***).

Seventeen taxa of phytoplankton were detected in pools and edges in Hackberry and Rancho Rio Creeks in October. *Ankistrodesmus* sp. (Chlorellales: Chlorellaceae) was the most abundant taxon, representing 57% of all organisms identified. The average density of organisms was greatest in pools (2,480 organisms/ml, range: 50 - 4,910 organisms/ml). Edges contained an average of 2,010 organisms/ml (range: 68 - 3,951 organisms/ml) (***Table 6***).

3.1.2. Periphyton

3.1.2.1. June

Twenty-seven taxa of periphyton were detected in Mineral Creek in June. *Epithemia sorex* (Rhopalodiales: Rhopalodiaceae) was the most abundant taxon, representing 23% of all organisms. The average density of periphyton was greatest in pools (365,929 organisms/ml, range: 6,792 - 953,489 organisms/ml). Riffles contained an average of 95,949 organisms/ml (range: 2,623 - 363,762 organisms/ml) and edges supported an average of 13,596 organisms/ml (range: 339 - 38,985 organisms/ml) (***Table 7***).

Thirty-three taxa of periphyton were detected in Devils Canyon in June. *Melosira varians* (Meloseirales: Melosiraceae) was the most abundant taxon, representing 33% of all organisms. The average density of periphyton was greatest in riffles (679,068 organisms/ml, range: 632,556 - 725,580 organisms/ml). Edges and pools both contained relatively low densities of periphyton. Densities in edges averaged 71,191 organisms/ml (range: 366 - 166,278 organisms/ml) and those in pools averaged 65,902 organisms/ml (range: 582 - 144,186 organisms/ml) (***Table 8***).

Twenty-seven taxa of periphyton were detected in Hackberry and Rancho Rio Creeks in June. *Achnanthes affinis* (Achanthales: Achnanthaceae) was the most abundant taxon, representing 56% of all organisms. Periphyton density averaged 8,087 organisms/ml (range: 1,120 - 15,054 organisms/ml) in the edge samples, and was 7,930 organisms/ml in the single pool sampled (***Table 9***).

3.1.2.2. October

Thirty-six taxa of periphyton were detected in Mineral Creek in October. *Rhoicosphenia curvata* (Cymbellales: Rhoicospheniaceae) was the most abundant taxon, representing 30% of all organisms. The average periphyton density was greatest in the riffles (23,193 organisms/ml, range: 3,943 - 78,649 organisms/ml). Edges contained an average of 18,515 organisms/ml (range: 1,635 - 67,646 organisms/ml) and pools supported an average of 2,881 organisms/ml (range: 26 - 6,307 organisms/ml) (***Table 10***).

Thirty-six taxa of periphyton were also detected in Devils Canyon in October. *Cyclotella meneghiniana* (Thalassiosirales: Stephanodiscaceae) was the most abundant taxon by far, representing 74% of all organisms. Periphyton densities in samples varied considerably. In particular, one edge sample contained 91% of all periphyton sampled from Devils Canyon. As such, densities in edge samples averaged 1,978,879 organisms/ml and varied by three orders of magnitude (range: 1,524 - 7,800,000 organisms/ml). Pools contained an average of 103,949 organisms/ml (range: 881 - 361,078 organisms/ml, and riffles supported an average of 74,776 organisms/ml (range: 3,766 - 145,786 organisms/ml) (***Table 11***).

Nineteen taxa of periphyton were detected in Hackberry and Rancho Rio Creeks in October. *Rhopalodia gibba* (Rhopalodiales: Rhopalodiaceae) was the most abundant taxon, representing 38% of all organisms. Periphyton densities averaged 2,257 organisms/ml in edge samples (range: 574 - 3,940 organisms/ml), and 1,218 organisms/ml in pool samples (range: 921 - 1,514 organisms/ml). Both Hackberry Creek samples contained higher periphyton densities than the Rancho Rio Creek samples (***Table 12***).

3.1.3. Zooplankton

3.1.3.1. June

Few zooplankton were detected in Mineral Creek in June. Of four pools and edges sampled, only one pool sample contained zooplankton, all of which were rotifers (phylum: Rotifera). The density of rotifers in this sample was 16,318 organisms/m^3. No cladocerans (order: Cladocera), copepods (subclass: Copepoda) or ostracods (class: Ostracoda) were detected in this sample, and no zooplankton taxa were present in any other Mineral Creek samples (***Table 13***).

Three taxa of zooplankton were detected in the pools, riffles, and edges of Devils Canyon in June. Copepods were the most abundant zooplankton, representing 61% of all organisms identified. The density of organisms was greatest in the edge sample, which contained 22,595 organisms/m^3. Pools contained an average of 6,354 organisms/m^3 (range: 5,021 - 9,414 organisms/m^3), and riffles contained an average of 2,981 organisms/m^3 (range: 0 - 5,962 organisms/m^3) (***Table 14***).

Three taxa of zooplankton were also detected in pools and riffles in Hackberry and Rancho Rio Creeks in June. Copepods were the most abundant zooplankton, representing 53% of all organisms identified. The

average density of organisms was greatest in the pool samples (15,167 organisms/m^3, range: 1,569 - 32,008 organisms/m^3). The single riffle sample contained 11,147 organisms/m^3 (***Table 15***).

3.1.3.2. October

Relatively few zooplankton were detected in the Study Area in October. No zooplankton were present in the pool and riffles sampled in Mineral Creek (***Table 16***). One pool sample from Devils Canyon contained zooplankton, all of which were cladocerans (1,506 organisms/m^3). No zooplankton taxa were present in any of the remaining pool, riffle, or edge samples from Devils Canyon (***Table 17***). By contrast, zooplankton were present in both pools sampled in Hackberry and Rancho Rio Creeks. Three zooplankton taxa were identified in the Hackberry Creek pool (total density: 40,105 organisms/m^3) and two taxa were identified in the Rancho Rio Creek pool (total density: 36,753 organisms/m^3). Copepods were the most abundant taxon in the Hackberry Creek pool, representing 69% of all organisms. Cladocerans were the most abundant taxon in the Rancho Rio Creek pool, representing 62% of all organisms (***Table 18***).

3.1.4. Macroinvertebrates

3.1.4.1. June

Sixty-two taxa of macroinvertebrates were detected in Mineral Creek in June. *Tricorythodes* sp. (Ephemeroptera: Leptohyphidae) was the most abundant taxon, representing 52% of all organisms counted. Macroinvertebrate counts were highest in the riffle samples (average: 255 organisms, range: 167 to 352 organisms). Edge samples contained an average of 120 organisms (range: 42 to 193 organisms), and pool samples contained an average of 48 organisms (range: 17 to 103 organisms) (***Table 19***).

Six taxa of macroinvertebrates were detected in Devils Canyon in June, one of which was Northern crayfish (*Orconectes virilis*). *Cricotopus*/*Orthocladius* sp. (Diptera: Chironomidae) was the most abundant taxon, representing 53% of all organisms counted. Pool samples contained an average of 9 organisms (range: 2 to 21 organisms), while the single edge sample contained 8 organisms and the single riffle sample contained 2 organisms (***Table 20***).

Five taxa of macroinvertebrates were detected in pools from Hackberry and Rancho Rio Creeks in June. *Cricotopus*/*Orthocladius* sp. (Diptera: Chironomidae) was the most abundant taxon, representing 57% of all organisms counted. Macroinvertebrate abundance was greater in Rancho Rio Creek, with 57 organisms in the pool sample from Rancho Rio Creek and 4 organisms in the pool sample from Hackberry Creek. Likewise macroinvertebrate diversity was greater in Rancho Rio Creek, as five taxa were present in that sample, compared to only two taxa present in the Hackberry Creek sample (***Table 21***).

3.1.4.2. October

In October, 42 taxa of macroinvertebrates were detected pools, riffles, and edges at Mineral Creek. *Thraulodes* sp. (Ephemeroptera: Leptophlebiidae) was the most abundant taxon, representing 29% of all organisms counted. Macroinvertebrates were most abundant in riffle samples (average: 152 organisms,

range: 49 - 190 organisms). By contrast, edges contained an average of 20 organisms (range: 6 - 53 organisms), and pools contained an average of 9 organisms (range: 4 - 17 organisms) (***Table 22***).

Twenty-five taxa of macroinvertebrates were detected in Devils Canyon in October. The subfamily Ceratopogoninae (Diptera: Ceratopogonidae) was the most abundant taxon, representing 65% of all organisms counted, though members of this family were only present in one pool location. Macroinvertebrates were generally most abundant in pool samples, which contained an average of 56 organisms (range: 4 - 163 organisms). Riffle samples contained an average of 18 organisms (range: 8 - 27 organisms), and the single edge sampled contained 15 organisms (***Table 23***).

Relatively few macroinvertebrates, representing a total of three taxa, were detected in Rancho Rio Creek in October. *Callibaetis* sp. (Ephemeroptera: Baetidae) comprised 67% of all 12 organisms counted. Three species of oligochaete worms (Haplotaxida: Enchytraeidae) and a single *Thermonectus marmoratus* (Coleoptera: Dytiscidae) were also identified (***Table 24***).

3.2. SEASONAL COMPARISON OF AQUATIC ORGANISMS

The diversity and abundance of aquatic taxa varied seasonally and by site. A total of 41 taxa of phytoplankton, 54 taxa of periphyton, three taxa of zooplankton, and 63 taxa of macroinvertebrates were identified in the Study Area in June. By contrast, 35 taxa of phytoplankton, 54 taxa of periphyton, three taxa of zooplankton, and 55 taxa of macroinvertebrates were identified in the Study Area in October. The following sections provide a comparison of seasonal findings in the Study Area by taxon and sample site.

3.2.1. Phytoplankton

Phytoplankton abundance in the Study Area was far greater in June than in October. Throughout the Study Area, average phytoplankton densities in pools were greater in June than in October (1,141,011 versus 2,874 organisms/ml). In particular, densities in pools in Hackberry Creek were more than 1,000 times greater in June than in October (5,689,438 versus 4,910 organisms/ml). In general, densities in edges were greater in June as well, including those in Devils Canyon, which were more than 200 times greater in June than in October (46,653 versus 225 organisms/ml). Densities in riffles, however, tended to be higher in October; those in Devils Canyon, for example, were roughly five times greater in October than in June (4,555 versus 946 organisms/ml) (***Table 25***).

The dominant phytoplankton taxa varied at each site between June and October. The most abundant taxa in Mineral Creek were *Selenastrum* sp. (Chlorococcales: Oocystaceae) in June (39% of all organisms identified) and *Oscillatoria* sp. (Oscillatoriales: Osillatoriaceae) in October (27% of all organisms identified). In Devils Canyon, *Microspora* sp. (Microsporales: Microsporaceae) was the most abundant taxon in June (41% of all organisms identified) and *Ulothrix* sp. (Ulotrichales: Ulotrichaceae) was the most abundant taxon in October (27% of all organisms identified). The most abundant taxa in Hackberry and Rancho Rio Creeks were *Spirulina* sp. (Oscillatoriales: Pseudanabaenaceae), *Oscillatoria* sp., and *Scenedesmus* sp. (Chlorococcales: Scenedesmaceae) in June (36%, 31%, and 27% of all organisms identified, respectively), and *Ankistrodesmus* sp. (Chlorellales: Chlorellaceae) in October (57% of all organisms identified).

Phytoplankton diversity in the Study Area appeared to be roughly similar in June and October, though slightly more taxa were identified in June than in October. Mineral Creek samples contained 19 taxa of phytoplankton in June and 18 taxa in October, Devils Canyon samples had 30 taxa in June and 27 taxa in October, Hackberry Creek samples had 14 in both June and October, and Rancho Rio Creek samples had 10 taxa in June and seven taxa in October. However, though the total diversity of taxa was similar between periods, June and October samples contained many seasonally unique taxa at each site. At Mineral Creek, for example, nine taxa were found only in June, eight taxa only in October, and 10 taxa were found at both sample times. Samples from Devils Canyon, Hackberry Creek, and Rancho Rio Creek displayed similar patterns of seasonal taxa diversity (***Table 26***).

3.2.2. Periphyton

Periphyton were more abundant in June at some sites in the Study Area and in October at others. The average density in pools at Mineral Creek, for example, was more than 125 times greater in June than in October (365,926 versus 2,881 organisms/ml). Likewise, the average density of periphyton detected in edges at Rancho Rio Creek was more than 25 times greater in June than in October (15,054 versus 574 organisms/ml). However, the average density of periphyton in edges at Devils Canyon, which was the highest density recorded in the Study Area in both June and October, was more than 25 times greater in October than in June (1,978,879 versus 71,191 organisms/ml). Similarly, roughly four times as many periphyton were detected in edges at Hackberry Creek in October than in June (3,940 versus 1,120 organisms/ml), though Hackberry Creek had few periphyton overall relative to other sites (***Table 27***).

The dominant periphyton taxa varied at each site between June and October. The most abundant taxa in Mineral Creek were *Epithemia sorex* (Rhopalodiales: Rhopalodiaceae) in June (23% of all organisms) and *Rhoicosphenia curvata* (Cymbellales: Rhoicospheniaceae) in October (30% of all organisms). In Devils Canyon, *Melosira varians* (Meloseirales: Melosiraceae) was the most abundant taxon in June (33% of all organisms) and *Cyclotella meneghiniana* (Thalassiosirales: Stephanodiscaceae) was the most abundant taxon in October (74% of all organisms). The most abundant taxa in Hackberry and Rancho Rio Creeks were *Achnanthes affinis* (Achanthales: Achnanthaceae) in June (56% of all organisms) and *Rhopalodia gibba* (Rhopalodiales: Rhopalodiaceae) in October (38% of all organisms).

The diversity of periphyton in the Study Area appeared to be greater in October than in June. Rancho Rio Creek was the exception, in which 20 periphyton taxa were detected in June and only five taxa were detected in October. At Mineral Creek, Devils Canyon, and Hackberry Creek, however, more taxa were recorded in October than in June. As with phytoplankton, many seasonally unique periphyton taxa were detected at all sites. Rancho Rio Creek samples, in particular, contained 20 taxa in June and five taxa in October, none of which were present at both sampling periods. Samples from Mineral Creek, Devils Canyon, and Hackberry Creek displayed similar patterns of seasonal taxa diversity (***Table 28***).

3.2.3. Zooplankton

As with phytoplankton, zooplankton abundance in the Study Area appeared to be greater in June than in October, although relative seasonal abundances varied from site to site. At Mineral Creek, where the average zooplankton density in pools was 4,080 organisms/m^3 in June, none were detected in October.

Likewise, zooplankton abundance at pools in Devils Canyon was more than 20 times greater in June than in October (6,354 versus 301 organisms/m^3). However, average zooplankton densities in pools at Hackberry Creek were higher in October than in June (40,105 versus 21,967 organisms/m^3) and zooplankton densities in Rancho Rio Creek pools were more than 20 times greater in October than in June (36,753 versus 1,569 organisms/m^3). Nonetheless, the overall set of data suggests that zooplankton were more abundant in the Study Area in June than in October (***Table 29***).

The dominant zooplankton taxa varied at each site between June and October. In Mineral Creek, only rotifers were detected in June and no zooplankton taxa were detected in October. In Devils Canyon, the copepods were most abundant taxon detected in June (61% of all organisms) and cladocerans were the only taxon detected in October. Copepods were the most abundant zooplankton taxon in Hackberry and Rancho Rio Creeks in June (53% of all organisms) and in Hackberry Creek in October (69% of all organisms), but cladocerans were the most abundant taxon in Rancho Rio Creek in October (62% of all organisms).

Zooplankton diversity in the Study Area appeared to be slightly greater in June than in October as well. Two more taxa of zooplankton were detected at Devils Canyon in June than in October, and one more taxon was detected then in both Mineral and Rancho Rio Creeks as well. By contrast, Hackberry Creek samples contained three taxa, the maximum detected, in both June and October. No samples contained ostracods, the fourth taxon potentially detectable in this analysis (***Table 30***).

3.2.4. Macroinvertebrates

As with periphyton, macroinvertebrates were more abundant in June at some sites and in October at others. The average count of macroinvertebrates at Rancho Rio Creek in June, for example, was nine times greater than the average count in October (57 versus 6 organisms). Likewise, the average count in edges at Mineral Creek in June was 6 times the respective count in October (120 versus 20 organisms). Devils Canyon pool samples, however, contained an average of 6 times as many macroinvertebrates in October than in June (56 versus 9 organisms) (***Table 31***).

The dominant macroinvertebrate taxa varied at each site between June and October. The most abundant taxa in Mineral Creek were *Tricorythodes* sp. (Ephemeroptera: Leptohyphidae) in June (25% of all organisms) and *Thraulodes* sp. (Ephemeroptera: Leptophlebiidae) in October (29% of all organisms). In Devils Canyon, *Cricotopus/Orthocladius* sp. (Diptera: Chironomidae) was the most abundant taxon in June (53% of all organisms) and the subfamily Ceratopogoninae (Diptera: Ceratopogonidae) was the most abundant taxon in October (65% of all organisms). *Cricotopus/Orthocladius* sp. was also the most abundant taxon in Hackberry and Rancho Rio Creeks in June (57% of all organisms), though *Callibaetis* sp. (Ephemeroptera: Baetidae) was the most abundant taxon in Rancho Rio Creek in October (67% of all organisms).

The diversity of macroinvertebrates appeared to be greater in June in Mineral Creek but was higher in October in Devils Canyon. Mineral Creek samples, for example, contained 62 taxa in June and 42 taxa in October, while Devils Canyon samples had 25 taxa in October and only six taxa in June. As with phytoplankton and periphyton, many seasonally unique macroinvertebrates were detected at all sites. For

instance, Devils Canyon samples contained four unique taxa in June, 23 unique taxa in October, and only two taxa that were common to both sampling periods. This pattern of seasonal taxa diversity was also present at Mineral and Rancho Rio creeks (***Table 32***).

3.3. COMPARISON OF MINERAL CREEK AND DEVILS CANYON FINDINGS

In general, phytoplankton, periphyton, and zooplankton were found to be more diverse and abundant in Devils Canyon than in Mineral Creek, while macroinvertebrates were found to be more diverse and abundant in Mineral Creek. This pattern was true for findings in both June and October. ***Table 33*** provides a general comparison of Mineral Creek and Devils Canyon findings, and the following paragraphs compare these findings in detail by taxon.

Phytoplankton were more diverse and abundant in Devils Canyon than in Mineral Creek. In June, 30 phytoplankton taxa were identified in samples from Devils Canyon, whereas only 19 were identified in samples from Mineral Creek. Similarly, Devils Canyon samples in October contained 27 taxa and Mineral Creek samples contained 18 taxa. At both sites, a single taxon constituted roughly 40% of organisms in June (*Selenastrum* sp. at Mineral Creek and *Microspora* sp. at Devils Canyon), and a different taxon composed 27% of organisms in October (*Oscillatoria* sp. at Mineral Creek and *Ulothrix* sp. at Devils Canyon) (***Table 26***). However, phytoplankton densities in pools, riffles, and edges in June and October were consistently higher in Devils Canyon than in Mineral Creek (***Table 25***).

Periphyton diversity and abundance appear to be roughly similar between Mineral Creek and Devils Canyon, if not slightly greater in Devils Canyon. More periphyton taxa were detected at Devils Canyon than at Mineral Creek in June (33 versus 27), and 36 taxa were detected at both sites in October (***Table 28***). The average density of periphyton detected in June was greater overall in Devils Canyon but was higher in pools at Mineral Creek. In October, average densities in pools, riffles, and edges were all higher at Devils Canyon. The average density in edges, in particular, was more than 100 times greater at Devils Canyon than at Mineral Creek (1,978,879 versus 18,515 organisms/ml) (***Table 27***).

Like phytoplankton, zooplankton appear to be more diverse and abundant in Devils Canyon than in Mineral Creek. In June, three zooplankton taxa were identified in samples from Devils Canyon, whereas only one taxon was identified in samples from Mineral Creek. Devils Canyon samples contained higher total densities of zooplankton at pools, riffles, and edges (***Table 30***), though higher densities of rotifers were detected at Mineral Creek (***Table 29***). In October, one taxon was identified in Devils Canyon samples and no zooplankton were found in Mineral Creek samples (***Table 30***).

Unlike other aquatic taxa, macroinvertebrates were considerably more diverse and abundant at Mineral Creek than at Devils Canyon. Mineral Creek samples contained more than 10 times as many macroinvertebrate taxa as Devils Canyon samples in June (62 versus six), and more than 1.5 times as many in October (42 versus 25) (***Table 32***). Likewise, average June counts for macroinvertebrates in pools, riffles, and edges at Mineral Creek were markedly greater than those at Devils Canyon. In October, average counts were greater overall at Mineral Creek than at Devils Canyon, though average counts in pools were greater at Devils Canyon than at Mineral Creek (56 versus 9 organisms) (***Table 31***).

4. DISCUSSION

The results of this study suggest a seasonal pattern in aquatic organism diversity and abundance in the Study Area. In general, diverse assemblages of aquatic organisms exist at all sites, though the diversity and abundance of aquatic organisms appear to be greater in June than in October. Additionally, these communities are commonly dominated by a single taxon, which varies by location and sample period. In Devils Canyon, for example, *Melosira varians* (Meloseirales: Melosiraceae) was the dominant periphyton taxon in June, accounting for 33% of organisms, whereas 74% of the periphyton detected in October were *Cyclotella meneghiniana* (Thalassiosirales: Stephanodiscaceae). Dominant taxa were rarely repeated among sample locations and periods, however the pattern of dominance was relatively consistent for phytoplankton, periphyton, zooplankton, and macroinvertebrates across sampling locations and periods. Seasonal patterns of dominance are features of aquatic communities that have long been recognized (Hutchinson 1961) and likely result from the dynamic environmental conditions (such as water temperature, volume, and flow rate and nutrient concentrations) that accompany the aquatic communities in perennial and intermittent streams.

The differences in aquatic diversity and abundance observed at Mineral Creek and Devils Canyon may be explained by trophic relations with larger animals. In particular, longfin dace (*Agosia chrysogaster*), lowland leopard frogs (*Lithobates yavapaiensis*), and canyon tree frogs (*Hyla arenicolor*) are abundant in Mineral Creek (WestLand 2012, in prep), may account for the lower densities of phytoplankton, periphyton, and zooplankton observed in Mineral Creek relative to Devils Canyon. Longfin dace are omnivores that will feed on phytoplankton, periphyton, zooplankton, and macroinvertebrates, depending on availability (Arizona Game & Fish Department [AGFD] 2006a, 2006b). Frog tadpoles are primarily herbivores that consume periphyton. In Devils Canyon, by contrast, longfin dace are absent and lowland leopard frogs are rare, though green sunfish (*Lepomis cyanellus*) and northern crayfish (*Orconectes virilis*) are abundant (WestLand 2009). The primary foods of the non-native fish include insects and mollusks (Hassan-Williams and Bonner 2007), which may explain the dearth of macroinvertebrates detected in Devils Canyon relative to Mineral Creek. Northern crayfish also prey on macroinvertebrates and likely limit the diversity and abundance of these organisms there (Global Invasive Species Database 2012). Thus, the unique features of the aquatic communities identified in Mineral Creek and Devils Canyon may reflect the composition of the broader communities present at these sites, including fish, amphibians, and crustaceans.

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TABLES

Table 1. Phytoplankton densities (organisms/ml) sampled in Mineral Creek on June 15, 2011.

Taxon	Family	Pool				Riffle				Edge			
		1	2	3	4	1	2	3	4	1	2	3	4
Achnanthes	Achnanthaceae	5	2			20		1		5			6
Anabaena	Nostocaceae						6						54
Caloneis	Naviculaceae	2				3	2			2			
Ceratium	Ceratiaceae											1	
Chlamydomonas	Chlamydomonadaceae			1									
Cocconeis	Cocconeidaceae	5			2	3			1	1		4	4
Cryptomonas	Cryptomonadaceae									1			
Cyclotella	Stephanodiscaceae		1										
Epithemia	Rhopalodiaceae		2		7				5	2	2	6	29
Gomphonema	Gomophonemataceae	6			4	4					1		
Mesotaenium	Mesotaeniaceae						1					10	
Mougeotia	Zygnemataceae				15							16	13
Navicula	Naviculaceae	7		3	22	17	2	2	4			13	8
Oscillatoria	Oscillatoriaceae										3		
Phacus	Euglenaceae							1			1		
Rhoicosphenia	Rhoicospheniaceae	2		1		3			1	2	1	2	2
Selenastrum	Oocystaceae	186				73							
Spirulina	Pseudanabaenaceae			6									
Synedra	Fragilariaceae		1	4	6		2	1	4		1	21	
All Phytoplankton		213	6	15	56	123	13	5	15	13	9	73	116

Table 2. Phytoplankton densities (organisms/ml) sampled in Devils Canyon on June 13-14, 2011.

Taxon	Family	Pool			Riffle		Edge			
		Upper Devils Canyon	Middle Devils Canyon		Middle Devils Canyon		Upper Devils Canyon	Middle Devils Canyon		
			2	3	1	3		1	2	3
Chlamydomonas	Chlamydomonadaceae			56		1,236	1,185			
Chroococcus	Chroococcaceae			452						
Cladophora	Cladophoraceae			85						
Cocconeis	Cocconeidaceae				6	34				6,351
Cosmarium	Desmidiaceae								42	1,411
Cryptomonas	Cryptomonadaceae	3							42	
Cyclotella	Stephanodiscaceae			85				22	84	3,528
Epithemia	Rhopalodiaceae		254	56	14	34		178	42	706
Euglena	Euglenaceae	1	169	28		17		3	84	
Fragilaria	Fragilariaceae							39		
Gomphonema	Gomophonemataceae			28		17		8		706
Hyalotheca	Desmidiaceae									31,049
Melosira	Melosiraceae			931		203	34			
Mesotaenium	Mesotaeniaceae		1,694						253	
Microspora	Microsporaceae									88,914
Mougeotia	Zygnemataceae		1,524						337	
Navicula	Naviculaceae	6	85	56		51	119	25	42	
Oscillatoria	Oscillatoriaceae		2,540	1,552		135	423		632	31,755
Pediastrum	Hydrodictyaceae								169	
Phacotus	Phacotaceae		85							
Phacus	Euglenaceae					17				
Rhizoclonium	Cladophoraceae									9,174
Rhoicosphenia	Rhoicospheniaceae							17		
Scenedesmus	Scenedesmaceae	20	677	169		68	237	22	253	
Selenastrum	Oocystaceae		12,871	4,347					6,743	
Staurastrum	Desmidiaceae			28						

Table 2. Phytoplankton densities (organisms/ml) sampled in Devils Canyon on June 13-14, 2011.

Taxon	Family	Pool			Riffle		Edge			
		Upper Devils Canyon	Middle Devils Canyon		Middle Devils Canyon		Upper Devils Canyon	Middle Devils Canyon		
			2	3	1	3		1	2	3
Surirella	Surirellaceae							3		
Synedra	Fragilariaceae	3	169	198	25	34	68	45	84	1,411
Tetraedron	Chlorococcaceae	2					34			
Ulothrix	Ulotrichaceae		1,270	508					337	
All Phytoplankton		35	21,338	8,579	45	1,846	2,100	362	9,144	175,005

Table 3. Phytoplankton densities (organisms/ml) sampled in Hackberry and Rancho Rio Creeks on June 13, 2011.

Taxon	Family	Pool			Riffle	Edge	
		Hackberry A	Hackberry B	Rancho Rio	Rancho Rio	Hackberry A	Rancho Rio
Achnanthes	Achnanthaceae			8			
Anabaena	Nostocaceae			212	200		67
Caloneis	Naviculaceae			8	2		
Ceratium	Ceratiaceae	2,117					
Chlamydomonas	Chlamydomonadaceae		31,755				
Chlorella	Chlorellaceae	21,170					
Chroomonas	Chroomonadaceae					25	
Elakatothrix	Scenedesmaceae	4,234					
Gomphonema	Gomophonemataceae		21,170		2	17	2
Melosira	Melosiraceae	38,106					
Merismopedia	Merismopediaceae					305	
Navicula	Naviculaceae				38	8	25
Oscillatoria	Oscillatoriaceae	508,080	2,963,800	152	78	85	132
Scenedesmus	Scenedesmaceae	59,276	3,048,480	152	174	220	18
Spirulina	Pseudanabaenaceae	317,550	3,810,600	169		85	
Spirogyra	Zygnemataceae			152	27		
Synedra	Fragilariaceae		10,585	136	11		7
Volvox	Volvocaceae	541,952				1,084	
All Phytoplankton		1,492,485	9,886,390	989	532	1,829	251

Table 4. Phytoplankton densities (organisms/ml) sampled in Mineral Creek on October 7, 2011.

Taxon	Family	Pool				Riffle				Edge			
		1	2	3	4	1	2	3	4	1	2	3	4
Achnanthes	Achnanthaceae	2			2							1	2
Caloneis	Naviculaceae	3							2	4	2		
Chlamydomonas	Chlamydomonadaceae											2	2
Closterium	Closteriaceae									1			
Cocconeis	Cocconeidaceae	1	3	1			1			2	2	1	
Cosmarium	Desmidiaceae					28							
Cyclotella	Stephanodiscaceae			3	1			5			2	2	
Cymbella	Cymbellaceae				2			5	3				2
Gomphonema	Gomophonemataceae				1		2	1			2	1	
Navicula	Naviculaceae	6	8	14	4	17	3	6	7	14	1	3	13
Nitzschia	Bacillariaceae	10				45				13	2		
Oscillatoria	Oscillatoriaceae		20	22	19		14	17				13	17
Rhoicosphenia	Rhoicospheniaceae	2	2	2							1	1	1
Rhopalodia	Rhopalodiaceae					6							
Scenedesmus	Scenedesmaceae									4			
Synedra	Fragilariaceae			9	8		5	3	6			3	7
Tetraedron	Chlorococcaceae			1									
Trachelomonas	Euglenaceae										1		
All Phytoplankton		24	33	52	37	96	25	37	18	38	13	27	44

Table 5. Phytoplankton densities (organisms/ml) sampled in Devils Canyon on October 5-6, 2011.

Taxon	Family	Pool					Riffle			Edge	
		Upper Devils Canyon	Middle Devils Canyon				Middle Devils Canyon			Middle Devils Canyon	
			New	1	2	3	New	1	3	New	1
Achnanthes	Achnanthaceae									22	
Anabaena	Nostocaceae	167			17		4,827				
Ankistrodesmus	Chlorellaceae							6			
Chlamydomonas	Chlamydomonadaceae	11		3				33			11
Cladophora	Cladophoraceae						5,589			6	
Cocconeis	Cocconeidaceae		2					6	6	45	
Cryptomonas	Cryptomonadaceae			1							
Cyclotella	Stephanodiscaceae					5,081			42		28
Cymbella	Cymbellaceae	6									
Epithemia	Rhopalodiaceae		1			106	339	4	3	6	2
Gomphonema	Gomophonemataceae		7							248	
Melosira	Melosiraceae					6,033			106	14	
Microspora	Microsporaceae						339				
Navicula	Naviculaceae	220	4	4	1	106	85		3	8	
Nitzschia	Bacillariaceae			3							
Oocystis	Oocystaceae							11			
Oscillatoria	Oscillatoriaceae	70	117		18	1,588		35			22
Pediastrum	Hydrodictyaceae	39									
Peridinium	Podolampaceae				1						
Phacus	Euglenaceae						169				
Rhoicosphenia	Rhoicospheniaceae						85				
Rhopalodia	Rhopalodiaceae		3		8	318	847	10	11		30
Scenedesmus	Scenedesmaceae	248			4		339				
Spirogyra	Zygnemataceae				14	847	762				
Synedra	Fragilariaceae	100	1	2	2	212		3	6	8	
Tetraedron	Chlorococcaceae	19									

Table 5. Phytoplankton densities (organisms/ml) sampled in Devils Canyon on October 5-6, 2011.

Taxon	Family	Pool					Riffle			Edge	
		Upper Devils Canyon	Middle Devils Canyon				Middle Devils Canyon			Middle Devils Canyon	
			New	1	2	3	New	1	3	New	1
Ulothrix	Ulotrichaceae				7	11,114					
All Phytoplankton		880	135	13	72	25,405	13,381	108	177	357	93

Table 6. Phytoplankton densities (organisms/ml) sampled in Hackberry and Rancho Rio Creeks on October 6, 2011.

Taxon	Family	Pool		Edge	
		Hackberry	Rancho Rio	Hackberry	Rancho Rio
Anabaena	Nostocaceae		22		45
Ankistrodesmus	Chlorellaceae	2,794		2,364	1
Ceratium	Ceratiaceae	127		141	
Chlamydomonas	Chlamydomonadaceae	508		529	3
Chroomonas	Chroomonadaceae			71	
Cocconeis	Cocconeidaceae		8		
Gomphonema	Gomophonemataceae	42	3		6
Melosira	Melosiraceae	85		106	
Navicula	Naviculaceae	42	6	35	13
Oocystis	Oocystaceae		11		
Pediastrum	Hydrodictyaceae	339		247	
Peridinium	Podolampaceae	42			
Scenedesmus	Scenedesmaceae	169		141	
Selenastrum	Oocystaceae	127		35	
Staurastrum	Desmidiaceae	169			
Synedra	Fragilariaceae	212		106	
Trachelomonas	Euglenaceae	254		176	
All Phytoplankton		4,910	50	3,951	68

Table 7. Periphyton densities (organisms/ml) sampled in Mineral Creek on June 15, 2011.

Taxon	Family	Pool				Riffle				Edge			
		1	2	3	4	1	2	3	4	1	2	3	4
Achnanthes lanceolata	Achnanthaceae		1,075		17,364	1,479	1,277			12,771	2,016		
Achnanthes sp.	Achnanthaceae	152,966											
Cocconeis placentula	Cocconeidaceae	155,515	336	1,748	49,922	806	202	2,151	27,453	1,344	1,210	67	403
Cymbella pusilla	Cymbellaceae				13,023								
Epithemia adnata	Rhopalodiaceae		403	4,167							1,613		
Epithemia argus	Rhopalodiaceae				45,581								
Epithemia sorex	Rhopalodiaceae		471	9,074	303,876		134	3,495	123,540		2,420	101	2,084
Gomphonema olivaceum	Gomophonemataceae					202							
Gomphonema parvulum	Gomophonemataceae	183,559				1,949			13,727	4,705	134		
Gomphonema subclavatum	Gomophonemataceae									2,689			
Gomphonema truncatum	Gomophonemataceae		605					1,613	34,317	2,016	403		403
Melosira sp.	Melosiraceae				32,558								
Navicula cryptocephala	Naviculaceae	5,099				269						101	
Navicula decussis	Naviculaceae		807			134			20,590		807		269
Navicula graciloides	Naviculaceae	35,692						1,748					
Navicula symmetrica	Naviculaceae		538										
Navicula tripunctata	Naviculaceae				15,194					1,344			
Nitzschia angustata	Bacillariaceae											67	
Nitzschia fonticola	Bacillariaceae		269										
Nitzschia sigma	Bacillariaceae	127,472	202							2,689			
Nitzschia sp.	Bacillariaceae			67		67	202						

Table 7. Periphyton densities (organisms/ml) sampled in Mineral Creek on June 15, 2011.

Taxon	Family	Pool				Riffle				Edge			
		1	2	3	4	1	2	3	4	1	2	3	4
Rhoicosphenia curvata	Rhoicospheniaceae	186,109	1,882			470	806	1,210		4,033	1,344		
Surirella sp.	Surirellaceae	2,549											
Synedra acus	Fragilariaceae	73,934	202			202			48,044	672	807		134
Synedra affinis	Fragilariaceae				4,341								
Synedra delicatissima	Fragilariaceae								6,863				
Synedra ulna	Fragilariaceae	30,593			6,512	941		672	89,224	6,721	672		336
All Periphyton		953,489	6,792	15,059	488,375	6,520	2,623	10,892	363,762	38,985	11,428	339	3,633

Table 8. Periphyton densities (organisms/ml) sampled in Devils Canyon on June 13-14, 2011.

Taxon	Family	Pool				Riffle		Edge			
		Upper Devils Canyon	Middle Devils Canyon			Middle Devils Canyon		Upper Devils Canyon	Middle Devils Canyon		
			1	2	3	1	3		1	2	3
Achnanthes affinis	Achnanthaceae	25									
Achnanthes lanceolata	Achnanthaceae	20					4,651				9,302
Achnanthes microcephala	Achnanthaceae							98			
Cocconeis placentula	Cocconeidaceae				1,047	106,977	18,605		134		2,326
Cocconeis sp.	Cocconeidaceae		2,326								
Cyclotella atomus	Stephanodiscaceae								1,747		
Cyclotella meneghiniana	Stephanodiscaceae	12	97,674			200,000	88,372				
Cymbella pusilla	Cymbellaceae					13,953					
Cymbella sp.	Cymbellaceae										1,163
Epithemia adnata	Rhopalodiaceae			44,651	698	125,581			403	76,744	3,488
Epithemia argus	Rhopalodiaceae						32,558				
Epithemia sorex	Rhopalodiaceae		13,953	24,186		27,907	23,256		807	13,953	
Gomphonema acuminatum	Gomophonemataceae					4,651					
Gomphonema parvulum	Gomophonemataceae	10	6,977	1,860		41,860	9,302				4,651
Gomphonema grunowii	Gomophonemataceae				349						
Melosira sp.	Melosiraceae			5,581						53,488	
Melosira varians	Melosiraceae			930	17,093	27,907	497,674			5,814	75,581
Navicula cari	Naviculaceae	22	9,302	7,442	349	51,163		122	538	3,488	6,977
Navicula cryptocephala	Naviculaceae									2,326	
Navicula cuspidata	Naviculaceae			8,372							
Navicula decussis	Naviculaceae		2,326		698	13,953					
Navicula grimmei	Naviculaceae				349						
Navicula sp.	Naviculaceae	12									
Navicula symmetrica	Naviculaceae	5									
Nitzschia frustulum	Bacillariaceae	139									

Table 8. Periphyton densities (organisms/ml) sampled in Devils Canyon on June 13-14, 2011.

Taxon	Family	Pool				Riffle		Edge			
		Upper Devils Canyon	Middle Devils Canyon			Middle Devils Canyon		Upper Devils Canyon	Middle Devils Canyon		
			1	2	3	1	3		1	2	3
Nitzschia gracilis	Bacillariaceae	27									
Nitzschia kutzingiana	Bacillariaceae	285					9,302	73			
Nitzschia romana	Bacillariaceae	25									
Rhoicosphenia curvata	Rhoicospheniaceae		4,651		349	9,302					1,163
Surirella sp.	Surirellaceae				349						
Synedra acus	Fragilariaceae		2,326		1,047	9,302		24	269	3,488	
Synedra affinis	Fragilariaceae		4,651							4,651	3,488
Synedra ulna	Fragilariaceae			2,791	698		41,860	49	269	2,326	5,814
All Periphyton		582	144,186	95,813	23,026	632,556	725,580	366	4,167	166,278	113,953

Table 9. Periphyton densities (organisms/ml) sampled in Hackberry and Rancho Rio Creeks on June 13, 2011.

Taxon	Family	Pool	Edge	
		Rancho Rio	Hackberry A	Rancho Rio
Achnanthes affinis	Achnanthaceae	2,823		10,754
Cocconeis sp.	Cocconeidaceae			134
Cyclotella sp.	Stephanodiscaceae			67
Cymbella minuta	Cymbellaceae	134		67
Cymbella pusilla	Cymbellaceae			538
Cymbella sp.	Cymbellaceae	134		67
Epithemia adnata	Rhopalodiaceae	134		
Epithemia sp.	Rhopalodiaceae			67
Gomphonema affine	Gomophonemataceae			202
Gomphonema parvulum	Gomophonemataceae	269		
Gomphonema subtile	Gomophonemataceae			134
Melosira sp.	Melosiraceae		90	
Navicula cari	Naviculaceae	269		67
Navicula cryptocephala	Naviculaceae	403		134
Navicula cuspidata	Naviculaceae			67
Navicula globulifera	Naviculaceae		90	
Navicula lanceolata	Naviculaceae		67	
Navicula notha	Naviculaceae			67
Navicula radiosa	Naviculaceae	134		
Nitzschia accedans	Bacillariaceae		45	
Nitzschia fonticola	Bacillariaceae	269		336
Nitzschia frustulum	Bacillariaceae		739	
Nitzschia romana	Bacillariaceae		22	
Rhoicosphenia curvata	Rhoicospheniaceae		67	
Surirella sp.	Surirellaceae	134		
Synedra affinis	Fragilariaceae	807		202
Synedra ulna	Fragilariaceae	2,420		2,151
All Periphyton		7,930	1,120	15,054

Table 10. Periphyton densities (organisms/ml) sampled in Mineral Creek on October 7, 2011.

Taxon	Family	Pool				Riffle				Edge			
		1	2	3	4	1	2	3	4	1	2	3	4
Achnanthes lanceolata	Achnanthaceae	340	38			33	1,269	32	95	58	1,395	17	
Cocconeis placentula	Cocconeidaceae		301			66	8,880	1,355	111	117	11,158	202	32
Cocconeis sp.	Cocconeidaceae									29			
Cyclotella atomus	Stephanodiscaceae			3					32				
Cyclotella meneghiniana	Stephanodiscaceae							1,097				84	
Cymbella affinis	Cymbellaceae											235	
Cymbella amphicephala	Cymbellaceae		38										
Cymbella norvegica	Cymbellaceae				29								
Cymbella sp.	Cymbellaceae	30	75					32	32				79
Epithemia adnata	Rhopalodiaceae				29								32
Epithemia sorex	Rhopalodiaceae	44			701	263	634	194	854	175	697	17	270
Gomphonema parvulum	Gomophonemataceae		38			197	1,269	484			1,395	50	16
Gomphonema grunowii	Gomophonemataceae	192	301	2	29	1,577	18,393	516	47	847	12,553	34	127
Mastogloia sp.	Mastogloiaceae							65					
Navicula cari	Naviculaceae					131	634			29	2,790		
Navicula cryptocephala	Naviculaceae		38		117			484	395			202	413
Navicula cuspidata	Naviculaceae											34	
Navicula decussis	Naviculaceae		226	3	29	99	1,269	65	63	88	2,092	84	79
Navicula grimmei	Naviculaceae				29						1,395		16
Navicula minuscula	Naviculaceae				292								
Navicula pupula	Naviculaceae				146				16				222
Navicula sp.	Naviculaceae				29			65				17	32
Navicula tripunctata	Naviculaceae									29			16
Nitzschia accedans	Bacillariaceae	813	1,243	13	730	821	5,074	1,291	870	88	16,737	588	651
Nitzschia angustata	Bacillariaceae											252	
Nitzschia dissipata	Bacillariaceae	518				131					3,487	34	16

Table 10. Periphyton densities (organisms/ml) sampled in Mineral Creek on October 7, 2011.

Taxon	Family	Pool				Riffle				Edge			
		1	2	3	4	1	2	3	4	1	2	3	4
Nitzschia fonticola	Bacillariaceae	251	75							88			
Nitzschia sp.	Bacillariaceae	15										34	
Pinnularia divergentissima	Pinnulariaceae							32					
Rhoicosphenia curvata	Rhoicospheniaceae	133	414			559	39,324	871	16	29	12,553	50	
Rhopalodia gibba	Rhopalodiaceae				4,030			387	506		697		667
Rhopalodia gibberula	Rhopalodiaceae				117				126				111
Surirella patella	Surirellaceae			2		33	634	32		29	697		
Synedra acus	Fragilariaceae					33				29			32
Synedra affinis	Fragilariaceae	30											
Synedra ulna	Fragilariaceae		38	3			1,269		16			34	
All Periphyton		2,366	2,825	26	6,307	3,943	78,649	7,002	3,179	1,635	67,646	1,968	2,811

Table 11. Periphyton densities (organisms/ml) sampled in Devils Canyon on October 5-6, 2011.

Taxon	Family	Pool					Riffle		Edge			
		Upper Devils Canyon	Middle Devils Canyon				Middle Devils Canyon		Middle Devils Canyon			
			New	1	2	3	New	3	New	1	2	3
Achnanthes lanceolata	Achnanthaceae	238	29		3,060	2,006	54	824			50,000	1,455
Cocconeis placentula	Cocconeidaceae		314		1,530	7,021	296	2,471	325	30	50,000	2,182
Cyclotella meneghiniana	Stephanodiscaceae		2,196	3,434	296,818		2,097				6,000,000	83,640
Cyclotella sp.	Stephanodiscaceae					56,171		106,250	74	149		
Cymbella affinis	Cymbellaceae											2,909
Cymbella minuta	Cymbellaceae				4,590						50,000	
Cymbella pusilla	Cymbellaceae						27					
Epithemia adnata	Rhopalodiaceae				4,590						50,000	2,182
Epithemia argus	Rhopalodiaceae		285									
Epithemia sorex	Rhopalodiaceae		86	4,578	3,060		27		30	119	150,000	1,455
Epithemia turgida	Rhopalodiaceae									30		
Gomphonema parvulum	Gomophonemataceae	110							30			
Gomphonema subclavatum	Gomophonemataceae	18			1,530					30	100,000	727
Gomphonema grunowii	Gomophonemataceae	37	1,055		7,650	1,003	645	824	858		100,000	3,637
Melosira varians	Melosiraceae		485	763		24,073	296	27,180	192	89		
Navicula arvenis	Naviculaceae	37										
Navicula cari	Naviculaceae										50,000	
Navicula cryptocephala	Naviculaceae	37				2,006		1,647				
Navicula decussis	Naviculaceae						27		15	60		
Navicula grimmei	Naviculaceae					1,003		824				
Navicula lanceolata	Naviculaceae					3,009						
Navicula laterostrata	Naviculaceae			763								
Navicula minuscula	Naviculaceae											1,455
Navicula notha	Naviculaceae	37										
Navicula pupula	Naviculaceae	55										
Navicula sp.	Naviculaceae				1,530					30		1,455

Table 11. Periphyton densities (organisms/ml) sampled in Devils Canyon on October 5-6, 2011.

Taxon	Family	Pool					Riffle		Edge			
		Upper Devils Canyon	Middle Devils Canyon				Middle Devils Canyon		Middle Devils Canyon			
			New	1	2	3	New	3	New	1	2	3
Nitzschia accedans	Bacillariaceae	312			4,590		108			30	300,000	
Nitzschia frustulum	Bacillariaceae						54					
Nitzschia gracilis	Bacillariaceae											1,455
Nitzschia vermicularis	Bacillariaceae				10,710						150,000	727
Pinnularia sp.	Pinnulariaceae										50,000	
Rhoicosphenia curvata	Rhoicospheniaceae						27			30		
Rhopalodia gibba	Rhopalodiaceae		29	37,391	19,890	7,021	54	4,942		2,084	550,000	5,818
Synedra acus	Fragilariaceae		29			2,006	54	824		30	100,000	
Synedra affinis	Fragilariaceae					1,003						
Synedra ulna	Fragilariaceae		29		1,530						50,000	2,182
All Periphyton		881	4,537	46,929	361,078	106,322	3,766	145,786	1,524	2,711	7,800,000	111,279

Table 12. Periphyton densities (organisms/ml) sampled in Hackberry and Rancho Rio Creeks on October 6, 2011.

Taxon	Family	Pool		Edge	
		Hackberry	Rancho Rio	Hackberry	Rancho Rio
Achnanthes lanceolata	Achnanthaceae			35	
Cocconeis placentula	Cocconeidaceae	34		35	
Cymbella pusilla	Cymbellaceae	252			
Cymbella sp.	Cymbellaceae			69	
Epithemia argus	Rhopalodiaceae	202			
Epithemia sorex	Rhopalodiaceae	84	29	138	31
Gomphonema affine	Gomophonemataceae	67			
Gomphonema parvulum	Gomophonemataceae			69	
Gomphonema subclavatum	Gomophonemataceae		833		527
Navicula cari	Naviculaceae			207	
Navicula cryptocephala	Naviculaceae	34		380	
Navicula decussis	Naviculaceae			104	
Navicula globulifera	Naviculaceae	17			
Navicula sp.	Naviculaceae				16
Navicula symmetrica	Naviculaceae	67			
Nitzschia accedans	Bacillariaceae	655	44	207	
Nitzschia fonticola	Bacillariaceae	34			
Rhopalodia gibba	Rhopalodiaceae	34	15	2,558	
Synedra acus	Fragilariaceae	34		138	
All Periphyton		1,514	921	3,940	574

Table 13. Zooplankton densities (organisms/m^3) sampled in Mineral Creek on June 15, 2011.

Taxon	Pool				Riffle			
	1	2	3	4	1	2	3	4
Rotifers (Phylum: Rotifera)				16,318				
Copepods (Subclass: Copepoda)								
Cladocerans (Order: Cladocera)								
Ostracods (Class: Ostracoda)								
All Zooplankton	0	0	0	16,318	0	0	0	0

Table 14. Zooplankton densities (organisms/m^3) sampled in Devils Canyon on June 13-14, 2011.

Taxon	Pool				Riffle		Edge
	Upper Devils Canyon	Middle Devils Canyon 1	Middle Devils Canyon 2	Middle Devils Canyon 3	Middle Devils Canyon 1	Middle Devils Canyon 3	Upper Devils Canyon
Rotifers (Phylum: Rotifera)	941	1,569		2,824		5,962	1,695
Copepods (Subclass: Copepoda)	4,079	4,079	1,883	2,197			20,900
Cladocerans (Order: Cladocera)	314		7,531				
Ostracods (Class: Ostracoda)							
All Zooplankton	5,334	5,648	9,414	5,021	0	5,962	22,595

Table 15. Zooplankton densities (organisms/m^3) sampled in Hackberry and Rancho Rio Creeks on June 13, 2011.

Taxon	Pool			Riffle
	Hackberry A Vertical Tow	Hackberry B	Rancho Rio	Rancho Rio
Rotifers (Phylum: Rotifera)	1,255			929
Copepods (Subclass: Copepoda)	8,159	11,925		10,218
Cladocerans (Order: Cladocera)	22,594		1,569	
Ostracods (Class: Ostracoda)				
All Zooplankton	32,008	11,925	1,569	11,147

Table 16. Zooplankton densities (organisms/m^3) sampled in Mineral Creek on October 7, 2011.

Taxon	Pool				Riffle			
	1	2	3	4	1	2	3	4
Rotifers (Phylum: Rotifera)								
Copepods (Subclass: Copepoda)								
Cladocerans (Order: Cladocera)								
Ostracods (Class: Ostracoda)								
All Zooplankton	0	0	0	0	0	0	0	0

Table 17. Zooplankton densities (organisms/m^3) sampled in Devils Canyon on October 5-6, 2011.

Taxon	Pool					Riffle			Edge
	Upper Devils Canyon	Middle Devils Canyon				Middle Devils Canyon			Middle Devils Canyon 2
		New	1	2	3	New	1	3	
Rotifers (Phylum: Rotifera)									
Copepods (Subclass: Copepoda)									
Cladocerans (Order: Cladocera)	1,506								
Ostracods (Class: Ostracoda)									
All Zooplankton	1,506	0	0	0	0		0	0	0

Table 18. Zooplankton densities (organisms/m^3) sampled in Hackberry and Rancho Rio Creeks on October 6, 2011.

Taxon	Pool	
	Hackberry	Rancho Rio
Rotifers (Phylum: Rotifera)	1,130	
Copepods (Subclass: Copepoda)	27,678	13,858
Cladocerans (Order: Cladocera)	11,297	22,895
Ostracods (Class: Ostracoda)		
All Zooplankton	40,105	36,753

Table 19. Macroinvertebrates detected (organisms counted) in Mineral Creek on June 15, 2011.

Taxon	Family	Pool				Riffle				Edge			
		1	2	3	4	1	2	3	4	1	2	3	4
Baetis notos	Baetidae					1							
Baetis sp. *(tricaudatus)*	Baetidae					3	1						
Fallceon quilleri	Baetidae					3			1				
Caenis sp.	Caenidae		2	1					1			6	
Homoleptohyphes sp.	Leptohyphidae					9	3	2	11		5	1	2
Tricorythodes sp.	Leptohyphidae	29	73	1	19	143	35	82	148	182	98	3	72
Choroterpes sp.	Leptophlebiidae		1		1	27	35	26	48	3	3		
Phylloicus mexicanus	Calamoceratidae		2								1	2	
Helicopsyche sp.	Trichoptera										4		1
Cheumatopsyche sp.	Hydropsychidae	1		1		33	62	2	18				
Hydropsyche sp.	Hydropsychidae					5	1						
Hydroptila sp.	Hydroptilidae				1	5			2				
Leucotrichia sp.	Hydroptilidae					1							
Ochrotrichia sp.	Hydroptilidae					2			2				
Lepidostoma sp.	Rubiaceae			2									
Leptoceridae	Leptoceridae											1	
Limnephilidae	Limnephilidae										4		
Chimarra sp.	Philopotamidae					2	3						
Cricotopus/Orthocladius sp.	Chironomidae					2		1	9			1	2
Eukiefferiella sp.	Chironomidae					2		1					
Parametriocnemus sp.	Chironomidae							1				1	
Thienemanniella sp.	Chironomidae									1	1		
Tvetenia sp.	Chironomidae					3							
Larsia sp.	Chironomidae			1									
Paramerina sp.	Chironomidae	1	4							1	1		
Pentaneura sp.	Chironomidae									2			

Table 19. Macroinvertebrates detected (organisms counted) in Mineral Creek on June 15, 2011.

Taxon	Family	Pool				Riffle				Edge			
		1	2	3	4	1	2	3	4	1	2	3	4
Thienemannimyia sp. group	Chironomidae			4		3	1	1	5			9	
Cladotanytarsus sp.	Chironomidae									2			
Paratanytarsus sp.	Chironomidae				1								1
Rheotanytarsus sp.	Chironomidae					4	1	1					
Tanytarsus sp.	Chironomidae										2	1	1
Cryptochironomus sp.	Chironomidae								1				
Lauterborniella sp.	Chironomidae	1	6								3		
Polypedilum sp.	Chironomidae	7	1	2		9	2		1	1			
Culicoides sp.	Ceratopogonidae												1
Probezzia sp.	Ceratopogonidae					2						1	
Hemerodromia sp.	Empidadae					1							
Simulium sp.	Simuliidae						1						
Caloparyphus sp.	Stratiomyidae					17			1				
Euparyphus sp.	Stratiomyidae					1							
Chrysops sp.	Tabanidae			1		1	1				1		1
Hexatoma sp.	Limoniidae		2	2	2	4	11	43	30		13	7	16
Helichus sp.	Dryopidae											1	
Postelichus sp.	Dryopidae					1		2	2			2	
Oreodytes sp.	Dytiscidae								1				
Stictotarsus roffi	Dytiscidae								2				
Stictotarsus aequinoctialis	Dytiscidae											1	
Macrelmis sp.	Elmidae			1		5	16	2	2			1	
Microcylloepus sp.	Elmidae		2			16						3	4
Ordobrevia nubifera	Elmidae										1		
Peltodytes sp.	Haliplidae	2							3				1
Psephenus sp.	Psephenidae		1				1						

Table 19. Macroinvertebrates detected (organisms counted) in Mineral Creek on June 15, 2011.

Taxon	Family	Pool				Riffle				Edge			
		1	2	3	4	1	2	3	4	1	2	3	4
Microvelia sp.	Veliidae					2	1						
Rhagovelia sp.	Veliidae						2						
Petrophila sp.	Crambidae					1							
Erpetogomphus sp.	Gomphidae	3	8		3	1		1	1	1	2		1
Argia sp.	Coenagrionidae						12		7			1	
Hetaerina sp.	Calopterygidae		1										
Hygrobates sp.	Procellariidae			1									
Lebertia sp.	Lebertiidae							1					
Sperchon sp.	Sperchonidae					43	15	1					
Naididae	Naididae												1
All Macroinvertebrates		44	103	17	27	352	204	167	296	193	139	42	104

Table 20. Macroinvertebrates detected (organisms counted) in Devils Canyon on June 13-14, 2011.

Taxon	Family	Pool				Riffle	Edge
		Upper Devils Canyon	Middle Devils Canyon 1	Middle Devils Canyon 2	Middle Devils Canyon 3	Middle Devils Canyon 1	Middle Devils Canyon 3
Cricotopus/Orthocladius sp.	Chironomidae	12	6	1		2	3
Parametriocnemus sp.	Chironomidae						1
Tvetenia sp.	Chironomidae	1	1	1	1		2
Paramerina sp.	Chironomidae		1		2		2
Thienemannimyia sp. group	Chironomidae	7	1				
Orconectes sp.	Cambaridae	1					
All Macroinvertebrates		21	9	2	3	2	8

Table 21. Macroinvertebrates detected (organisms counted) in Hackberry and Rancho Rio Creeks on June 13, 2011.

Taxon	**Family**	**Pool**	
		Hackberry A	**Rancho Rio**
Cricotopus/Orthocladius sp.	Chironomidae	3	32
Thienemanniella sp.	Chironomidae		9
Tvetenia sp.	Chironomidae		3
Thienemannimyia sp. group	Chironomidae	1	5
Cladotanytarsus sp.	Chironomidae		8
All Macroinvertebrates		4	57

Table 22. Macroinvertebrates detected (organisms counted) in Mineral Creek on October 7, 2011.

Taxon	Family	Pool				Riffle				Edge			
		1	2	3	4	1	2	3	4	1	2	3	4
Baetis notos	Baetidae					1	3						
Fallceon quilleri	Baetidae					3	1	3					
Caenis sp.	Caenidae												1
Homoleptohyphes sp.	Leptohyphidae					3							
Tricorythodes sp.	Leptohyphidae	1				40	4	1	13	1	9	1	
Thraulodes sp.	Leptophlebiidae	3	1		1	54	71	73	2		2		
Cheumatopsyche sp.	Hydropsychidae	1				11	27	26			3	1	
Ochrotrichia sp.	Hydroptilidae							1					
Lepidostoma sp.	Rubiaceae							1					
Chimarra sp.	Philopotamidae						2	2			1		
Cricotopus/Orthocladius sp.	Chironomidae					1							
Parametriocnemus sp.	Chironomidae			1					1				
Paramerina sp.	Chironomidae							1					
Pentaneura sp.	Chironomidae						1						
Thienemannimyia sp. group	Chironomidae					1	1		1		2		
Cladotanytarsus sp.	Chironomidae		1	2	2					2		1	3
Paratanytarsus sp.	Chironomidae											1	
Rheotanytarsus sp.	Chironomidae						5						
Sublettea sp.	Chironomidae								1				
Tanytarsus sp.	Chironomidae		11								11		
Paratendipes sp.	Chironomidae			1		1		1	4		3	1	
Polypedilum sp.	Chironomidae	1	1				13	33	3		1		
Saetheria sp.	Chironomidae											2	
Ceratopogoninae	Ceratopogonidae	1								3	4		
Doichopodidae	Doichopodidae		1										
Simulium sp.	Simuliidae					1	5	2					
Chrysops sp.	Tabanidae		1			9	7	4	5		3		

Table 22. Macroinvertebrates detected (organisms counted) in Mineral Creek on October 7, 2011.

Taxon	Family	Pool				Riffle				Edge			
		1	2	3	4	1	2	3	4	1	2	3	4
Hexatoma sp.	Limoniidae						1	1	2		1		
Postelichus sp.	Dryopidae					26			4				
Stictotarsus roffi	Dytiscidae								1				
Microcylloepus sp.	Elmidae				1	1	9	6	2		1		
Psephenus sp.	Psephenidae								1				
Abedus sp.	Belostomatidae							1					
Rhagovelia sp.	Veliidae					1							
Petrophila sp.	Crambidae					1							
Corydalus sp.	Corydalidae							5			1		
Anisoptera sp. 1	n/a*								1				
Erpetogomphus sp.	Gomphidae					3	1	1	1			1	
Argia sp.	Coenagrionidae		1			25	39	23	7		6		1
Lebertia sp.	Lebertiidae										1		
Enchytraeidae	Enchytraeidae			2							4	3	
Tubificidae	Tubificidae												4
All Macroinvertebrates		7	17	6	4	182	190	185	49	6	53	11	9

*Anisoptera is the suborder containing dragonflies.

Table 23. Macroinvertebrates detected (organisms counted) in Devils Canyon on October 5-6, 2011.

Taxon	Family	Pool				Riffle		Edge
		Upper Devils Canyon	Upper Devils Canyon (Dredge)	Middle Devils Canyon 1	Middle Devils Canyon 3	Middle Devils Canyon 1	Middle Devils Canyon 3	Middle Devils Canyon 3
Baetis sp. *(tricaudatus)*	Baetidae						1	
Fallceon quilleri	Baetidae						2	
Caenis sp.	Caenidae			1		4	6	
Thraulodes sp.	Leptophlebiidae						5	
Hydroptila sp.	Hydroptilidae						2	
Ablabesmyia sp.	Chironomidae					2		
Macropelopia sp.	Chironomidae			1				
Paramerina sp.	Chironomidae				1			
Thienemannimyia sp. group	Chironomidae			1				
Paratanytarsus sp.	Chironomidae				2		6	1
Tanytarsus sp.	Chironomidae				1			
Beardius sp.	Chironomidae							1
Polypedilum sp.	Chironomidae						3	
Ceratopogoninae	Ceratopogonidae	161	17					
Doichopodidae	Doichopodidae		1					
Chrysops sp.	Tabanidae		1					
Laccophilus maculosus	Dytiscidae	1						
Gymnochthebius sp.	Hydraenidae		1					
Hydrochus sp.	Hydrophilidae		1					
Argia sp.	Coenagrionidae	1					1	
Acarina sp. 1	n/a*			1				
Lebertia sp.	Lebertiidae							1
Helisoma sp.	Planorbidae						1	
Lumbriculidae	Lumbriculidae					2		
Tubificidae	Tubificidae		2		29			12
All Macroinvertebrates		163	23	4	33	8	27	15

*Acarina is the subclass containing ticks and mites.

Table 24. Macroinvertebrates detected (organisms counted) in Rancho Rio Creek on October 6, 2011.

Taxon	**Family**	**Pool**	
		2	**2 (Net)**
Callibaetis sp.	Baetidae		8
Thermonectus marmoratus	Dytiscidae		1
Enchytraeidae	Enchytraeidae	3	
All Macroinvertebrates		3	9

Table 25. Average phytoplankton densities (organisms/ml) sampled at all sites in June and October.

Site	June			October		
	Pool	Riffle	Edge	Pool	Riffle	Edge
Mineral Creek	73	39	53	37	44	31
Devils Canyon	9,984	946	46,653	5,301	4,555	225
Hackberry Creek	5,689,438	*	1,829	4,910	*	3,951
Rancho Rio Creek	989	532	251	50	*	68
All Sites	1,141,011	368	18,890	2,874	1,977	574

*No samples collected.

Table 26. Summary of phytoplankton densities (organisms/ml) sampled by site in June and October.

Taxon	Family	Mineral Creek		Devils Canyon		Hackberry Creek		Rancho Rio Creek	
		June	October	June	October	June	October	June	October
Number of Taxa		**19**	**18**	**30**	**27**	**14**	**14**	**10**	**7**
Achnanthes	Achnanthaceae	39	7		22			8	
Anabaena	Nostocaceae	60			5,011			479	67
Ankistrodesmus	Chlorellaceae				6		5,158		1
Caloneis	Naviculaceae	9	11					10	
Ceratium	Ceratiaceae	1				2,117	268		
Chlamydomonas	Chlamydomonadaceae	1	4	2,477	58	31,755	1,037		3
Chlorella	Chlorellaceae					21,170			
Chroococcus	Chroococcaceae			452					
Chroomonas	Chroomonadaceae					25	71		
Cladophora	Cladophoraceae			85	5,595				
Closterium	Closteriaceae		1						
Cocconeis	Cocconeidaceae	20	11	6,391	59				8
Cosmarium	Desmidiaceae		28	1,453					
Cryptomonas	Cryptomonadaceae	1		45	1				
Cyclotella	Stephanodiscaceae	1	13	3,719	5,151				
Cymbella	Cymbellaceae		12		6				
Elakatothrix	Scenedesmaceae					4,234			
Epithemia	Rhopalodiaceae	53		1,284	461				
Euglena	Euglenaceae			302					
Fragilaria	Fragilariaceae			39					
Gomphonema	Gomophonemataceae	15	7	759	255	21,187	42	4	9
Hyalotheca	Desmidiaceae			31,049					
Melosira	Melosiraceae			1,168	6,153	38,106	191		
Merismopedia	Merismopediaceae					305			
Mesotaenium	Mesotaeniaceae	11		1,947					
Microspora	Microsporaceae			88,914	339				
Mougeotia	Zygnemataceae	44		1,861					
Navicula	Naviculaceae	78	96	384	431	8	77	63	19
Nitzschia	Bacillariaceae		70		3				
Oocystis	Oocystaceae				11				11

Table 26. Summary of phytoplankton densities (organisms/ml) sampled by site in June and October.

Taxon	Family	Mineral Creek		Devils Canyon		Hackberry Creek		Rancho Rio Creek	
		June	October	June	October	June	October	June	October
Number of Taxa		**19**	**18**	**30**	**27**	**14**	**14**	**10**	**7**
Oscillatoria	Oscillatoriaceae	3	122	37,037	1,850	3,471,965		362	
Pediastrum	Hydrodictyaceae			169	39		586		
Peridinium	Podolampaceae				1		42		
Phacotus	Phacotaceae			85					
Phacus	Euglenaceae	2		17	169				
Rhizoclonium	Cladophoraceae			9,174					
Rhoicosphenia	Rhoicospheniaceae	14	9	17	85				
Rhopalodia	Rhopalodiaceae		6		1,227				
Scenedesmus	Scenedesmaceae		4	1,446	591	3,107,976	310	344	
Selenastrum	Oocystaceae	259		23,961			162		
Spirulina	Pseudanabaenaceae	6				4,128,235		169	
Spirogyra	Zygnemataceae				1,623			179	
Staurastrum	Desmidiaceae			28			169		
Surirella	Surirellaceae			3					
Synedra	Fragilariaceae	40	41	2,037	334	10,585	318	154	
Tetraedron	Chlorococcaceae		1	36	19				
Trachelomonas	Euglenaceae		1				430		
Ulothrix	Ulotrichaceae			2,115	11,121				
Volvox	Volvocaceae					543,036			
All Phytoplankton		657	444	218,454	40,621	11,380,704	8,861	1,772	118

Table 27. Average periphyton densities (organisms/ml) sampled at all sites in June and October.

Site	June			October		
	Pool	**Riffle**	**Edge**	**Pool**	**Riffle**	**Edge**
Mineral Creek	365,926	95,947	13,594	2,881	23,193	18,515
Devils Canyon	65,902	679,068	71,191	103,949	74,776	1,978,879
Hackberry Creek	*	*	1,120	1,514	*	3,940
Rancho Rio Creek	7,930	*	15,054	921	*	574
All Sites	192,805	290,321	35,531	48,519	40,388	799,409

*No samples collected.

Table 28. Summary of periphyton densities (organisms/ml) sampled by site in June and October.

Taxon	Family	Mineral Creek		Devils Canyon		Hackberry Creek		Rancho Rio Creek	
		June	October	June	October	June	October	June	October
Number of Taxa		**27**	**36**	**33**	**36**	**7**	**17**	**20**	**5**
Achnanthes affinis	Achnanthaceae			25				13,577	
Achnanthes lanceolata	Achnanthaceae	35,982	3,277	13,973	57,666		35		
Achnanthes microcephala	Achnanthaceae			98					
Achnanthes sp.	Achnanthaceae	152,966							
Cocconeis placentula	Cocconeidaceae	241,157	22,222	129,089	64,169		69		
Cocconeis sp.	Cocconeidaceae		29	2,326				134	
Cyclotella atomus	Stephanodiscaceae		35	1,747					
Cyclotella meneghiniana	Stephanodiscaceae		1,181	386,058	6,388,185				
Cyclotella sp.	Stephanodiscaceae				162,644			67	
Cymbella affinis	Cymbellaceae		235		2,909				
Cymbella amphicephala	Cymbellaceae		38						
Cymbella minuta	Cymbellaceae				54,590			201	
Cymbella norvegica	Cymbellaceae		29						
Cymbella pusilla	Cymbellaceae	13,023		13,953	27		252	538	
Cymbella sp.	Cymbellaceae		248	1,163			69	201	
Epithemia adnata	Rhopalodiaceae	6,183	61	251,565	56,772			134	
Epithemia argus	Rhopalodiaceae	45,581		32,558	285		202		
Epithemia sorex	Rhopalodiaceae	445,195	3,849	104,062	159,355		222		60
Epithemia turgida	Rhopalodiaceae				30				
Epithemia sp.	Rhopalodiaceae							67	
Gomphonema acuminatum	Gomophonemataceae			4,651					
Gomphonema affine	Gomophonemataceae						67	202	
Gomphonema olivaceum	Gomophonemataceae	202							
Gomphonema parvulum	Gomophonemataceae	204,074	3,449	64,660	140		69	269	
Gomphonema subclavatum	Gomophonemataceae	2,689			102,305				1,360
Gomphonema subtile	Gomophonemataceae							134	
Gomphonema truncatum	Gomophonemataceae	39,357							
Gomphonema grunowii	Gomophonemataceae		34,618	349	115,709				
Mastogloia sp.	Mastogloiaceae		65						
Melosira sp.	Melosiraceae	32,558		59,069		90			

Table 28. Summary of periphyton densities (organisms/ml) sampled by site in June and October.

Taxon	Family	Mineral Creek		Devils Canyon		Hackberry Creek		Rancho Rio Creek	
		June	October	June	October	June	October	June	October
Number of Taxa		**27**	**36**	**33**	**36**	**7**	**17**	**20**	**5**
Melosira varians	Melosiraceae			624,999	53,078				
Navicula arvenis	Naviculaceae				37				
Navicula cari	Naviculaceae		3,584	79,403	50,000		207	336	
Navicula cryptocephala	Naviculaceae	5,469	1,649	2,326	3,690		414	537	
Navicula cuspidata	Naviculaceae		34	8,372				67	
Navicula decussis	Naviculaceae	22,607	4,097	16,977	102		104		
Navicula globulifera	Naviculaceae					90	17		
Navicula graciloides	Naviculaceae	37,440							
Navicula grimmei	Naviculaceae		1,440	349	1,827				
Navicula lanceolata	Naviculaceae				3,009	67			
Navicula laterostrata	Naviculaceae				763				
Navicula minuscula	Naviculaceae		292		1,455				
Navicula notha	Naviculaceae				37			67	
Navicula pupula	Naviculaceae		384		55				
Navicula radiosa	Naviculaceae							134	
Navicula sp.	Naviculaceae		143	12	3,015				16
Navicula symmetrica	Naviculaceae	538		5			67		
Navicula tripunctata	Naviculaceae	16,538	45						
Nitzschia accedans	Bacillariaceae		28,919		305,040	45	862		44
Nitzschia angustata	Bacillariaceae	67	252						
Nitzschia dissipata	Bacillariaceae		4,186						
Nitzschia fonticola	Bacillariaceae	269	414				34	605	
Nitzschia frustulum	Bacillariaceae			139	54	739			
Nitzschia gracilis	Bacillariaceae			27	1,455				
Nitzschia kutzingiana	Bacillariaceae			9,660					
Nitzschia romana	Bacillariaceae			25		22			
Nitzschia sigma	Bacillariaceae	130,363							
Nitzschia vermicularis	Bacillariaceae				161,437				
Nitzschia sp.	Bacillariaceae	336	49						
Pinnularia divergentissima	Pinnulariaceae		32						
Pinnularia sp.	Pinnulariaceae				50,000				

Table 28. Summary of periphyton densities (organisms/ml) sampled by site in June and October.

Taxon	Family	Mineral Creek		Devils Canyon		Hackberry Creek		Rancho Rio Creek	
		June	October	June	October	June	October	June	October
Number of Taxa		**27**	**36**	**33**	**36**	**7**	**17**	**20**	**5**
Rhoicosphenia curvata	Rhoicospheniaceae	195,854	53,949	15,465	57	67			
Rhopalodia gibba	Rhopalodiaceae		6,287		627,229		2,592		15
Rhopalodia gibberula	Rhopalodiaceae		354						
Surirella patella	Surirellaceae		1,427						
Surirella sp.	Surirellaceae	2,549		349				134	
Synedra acus	Fragilariaceae	123,995	94	16,456	102,943		172		
Synedra affinis	Fragilariaceae	4,341	30	12,790	1,003			1,009	
Synedra delicatissima	Fragilariaceae	6,863							
Synedra ulna	Fragilariaceae	135,671	1,360	53,807	53,741			4,571	
All Periphyton		1,901,867	178,357	1,906,507	8,584,813	1,120	5,454	22,984	1,495

Table 29. Average zooplankton densities (organisms/m^3) sampled at all sites in June and October.

Site	June			October		
	Pool	Riffle	Edge	Pool	Riffle	Edge
Mineral Creek	4,080	0		0	0	*
Devils Canyon	6,354	2,981	22,595	301	0	0
Hackberry Creek	21,967	*	*	40,105	*	*
Rancho Rio Creek	1,569	11,147	*	36,753	*	*
All Sites	7,931	2,444	22,595	7,124	0	0

*No samples collected.

Table 30. Summary of zooplankton densities (organisms/m^3) sampled by site in June and October.

Taxon	Mineral Creek		Devils Canyon		Hackberry Creek		Rancho Rio Creek	
	June	October	June	October	June	October	June	October
Number of Taxa	**1**	**0**	**3**	**1**	**3**	**3**	**3**	**2**
Rotifers (Phylum: Rotifera)	16,318		12,991		1,255	1,130	929	
Copepods (Subclass: Copepoda)			33,138		20,084	27,678	10,218	13,858
Cladocerans (Order: Cladocera)			7,845	1,506	22,594	11,297	1,569	22,895
Ostracods (Class: Ostracoda)								
All Zooplankton	16,318	0	53,974	1,506	43,933	40,105	12,716	36,753

Table 31. Average macroinvertebrates detected (organisms counted) at all sites in June and October.

Site	June			October		
	Pool	Riffle	Edge	Pool	Riffle	Edge
Mineral Creek	48	255	120	9	152	20
Devils Canyon	9	2	8	56	18	15
Hackberry Creek	4	*	*	*	*	*
Rancho Rio Creek	57	*	*	6	*	*
All Sites	29	204	97	27	107	19

*No samples collected.

Table 32. Summary of macroinvertebrates detected (organisms counted) by site in June and October.

Taxon	Family	Mineral Creek		Devils Canyon		Hackberry Creek		Rancho Rio Creek	
		June	October	June	October	June	October	June	October
Number of Taxa		**62**	**42**	**6**	**25**	**2**	*****	**5**	**3**
Baetis notos	Baetidae	1	4				*		
Baetis sp. *(tricaudatus)*	Baetidae	4			1		*		
Callibaetis sp.	Baetidae						*		8
Fallceon quilleri	Baetidae	4	7		2		*		
Caenis sp.	Caenidae	10	1		11		*		
Homoleptohyphes sp.	Leptohyphidae	33	3				*		
Tricorythodes sp.	Leptohyphidae	885	70				*		
Choroterpes sp.	Leptophlebiidae	144					*		
Thraulodes sp.	Leptophlebiidae		207		5		*		
Phylloicus mexicanus	Calamoceratidae	5					*		
Helicopsyche sp.	Trichoptera	5					*		
Cheumatopsyche sp.	Hydropsychidae	117	69				*		
Hydropsyche sp.	Hydropsychidae	6					*		
Hydroptila sp.	Hydroptilidae	8			2		*		
Leucotrichia sp.	Hydroptilidae	1					*		
Ochrotrichia sp.	Hydroptilidae	4	1				*		
Lepidostoma sp.	Rubiaceae	2	1				*		
Leptoceridae	Leptoceridae	1					*		
Limnephilidae	Limnephilidae	4					*		
Chimarra sp.	Philopotamidae	5	5				*		
Cricotopus/Orthocladius sp.	Chironomidae	15	1	24		3	*	32	
Eukiefferiella sp.	Chironomidae	3					*		
Parametriocnemus sp.	Chironomidae	2	2	1			*		
Ablabesmyia sp.	Chironomidae				2		*		
Macropelopia sp.	Chironomidae				1		*		
Thienemanniella sp.	Chironomidae	2					*	9	

Table 32. Summary of macroinvertebrates detected (organisms counted) by site in June and October.

Taxon	Family	Mineral Creek		Devils Canyon		Hackberry Creek		Rancho Rio Creek	
		June	October	June	October	June	October	June	October
Tvetenia sp.	Chironomidae	3		6			*	3	
Larsia sp.	Chironomidae	1					*		
Paramerina sp.	Chironomidae	7	1	5	1		*		
Pentaneura sp.	Chironomidae	2	1				*		
Thienemannimyia sp. group	Chironomidae	23	5	8	1	1	*	5	
Cladotanytarsus sp.	Chironomidae	2	11				*	8	
Paratanytarsus sp.	Chironomidae	2	1		9		*		
Rheotanytarsus sp.	Chironomidae	6	5				*		
Sublettea sp.	Chironomidae		1				*		
Tanytarsus sp.	Chironomidae	4	22		1		*		
Beardius sp.	Chironomidae				1		*		
Paratendipes sp.	Chironomidae		11				*		
Cryptochironomus sp.	Chironomidae	1					*		
Lauterborniella sp.	Chironomidae	10					*		
Polypedilum sp.	Chironomidae	23	52		3		*		
Saetheria sp.	Chironomidae		2				*		
Culicoides sp.	Ceratopogonidae	1					*		
Probezzia sp.	Ceratopogonidae	3					*		
Ceratopogoninae	Ceratopogonidae		8		178		*		
Doichopodidae	Doichopodidae		1		1		*		
Hemerodromia sp.	Empidadae	1					*		
Simulium sp.	Simuliidae	1	8				*		
Caloparyphus sp.	Stratiomyidae	18					*		
Euparyphus sp.	Stratiomyidae	1					*		
Chrysops sp.	Tabanidae	5	29		1		*		
Hexatoma sp.	Limoniidae	130	5				*		
Helichus sp.	Dryopidae	1					*		
Postelichus sp.	Dryopidae	7	30				*		

Table 32. Summary of macroinvertebrates detected (organisms counted) by site in June and October.

Taxon	Family	Mineral Creek		Devils Canyon		Hackberry Creek		Rancho Rio Creek	
		June	October	June	October	June	October	June	October
Laccophilus maculosus	Dytiscidae				1		*		
Oreodytes sp.	Dytiscidae	1					*		
Stictotarsus roffi	Dytiscidae	2	1				*		
Stictotarsus aequinoctialis	Dytiscidae	1					*		
Macrelmis sp.	Elmidae	27					*		
Thermonectus marmoratus	Dytiscidae						*		1
Microcylloepus sp.	Elmidae	25	20				*		
Gymnochthebius sp.	Hydraenidae				1		*		
Hydrochus sp.	Hydrophilidae				1		*		
Ordobrevia nubifera	Elmidae	1					*		
Peltodytes sp.	Haliplidae	6					*		
Psephenus sp.	Psephenidae	2	1				*		
Abedus sp.	Belostomatidae		1				*		
Microvelia sp.	Veliidae	3					*		
Rhagovelia sp.	Veliidae	2	1				*		
Petrophila sp.	Crambidae	1	1				*		
Corydalus sp.	Corydalidae		6				*		
Anisoptera sp. 1	n/a[1]		1				*		
Erpetogomphus sp.	Gomphidae	21	7				*		
Argia sp.	Coenagrionidae	20	102		2		*		
Hetaerina sp.	Calopterygidae	1					*		
Acarina sp. 1	n/a[2]				1		*		
Hygrobates sp.	Procellariidae	1					*		
Lebertia sp.	Lebertiidae	1	1		1		*		
Sperchon sp.	Sperchonidae	59					*		
Helisoma sp.	Planorbidae				1		*		
Orconectes sp.	Cambaridae			1			*		
Enchytraeidae	Enchytraeidae		9				*		3

Table 32. Summary of macroinvertebrates detected (organisms counted) by site in June and October.

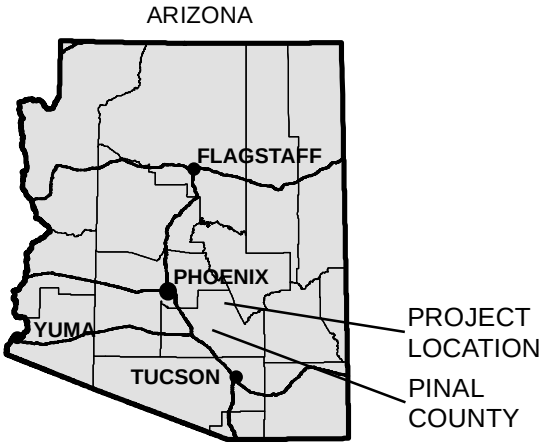
Taxon	Family	Mineral Creek		Devils Canyon		Hackberry Creek		Rancho Rio Creek	
		June	October	June	October	June	October	June	October
Lumbriculidae	Lumbriculidae				2		*		
Naididae	Naididae	1					*		
Tubificidae	Tubificidae		4		43		*		
All Macroinvertebrates		1,688	719	45	273	4	*	57	12

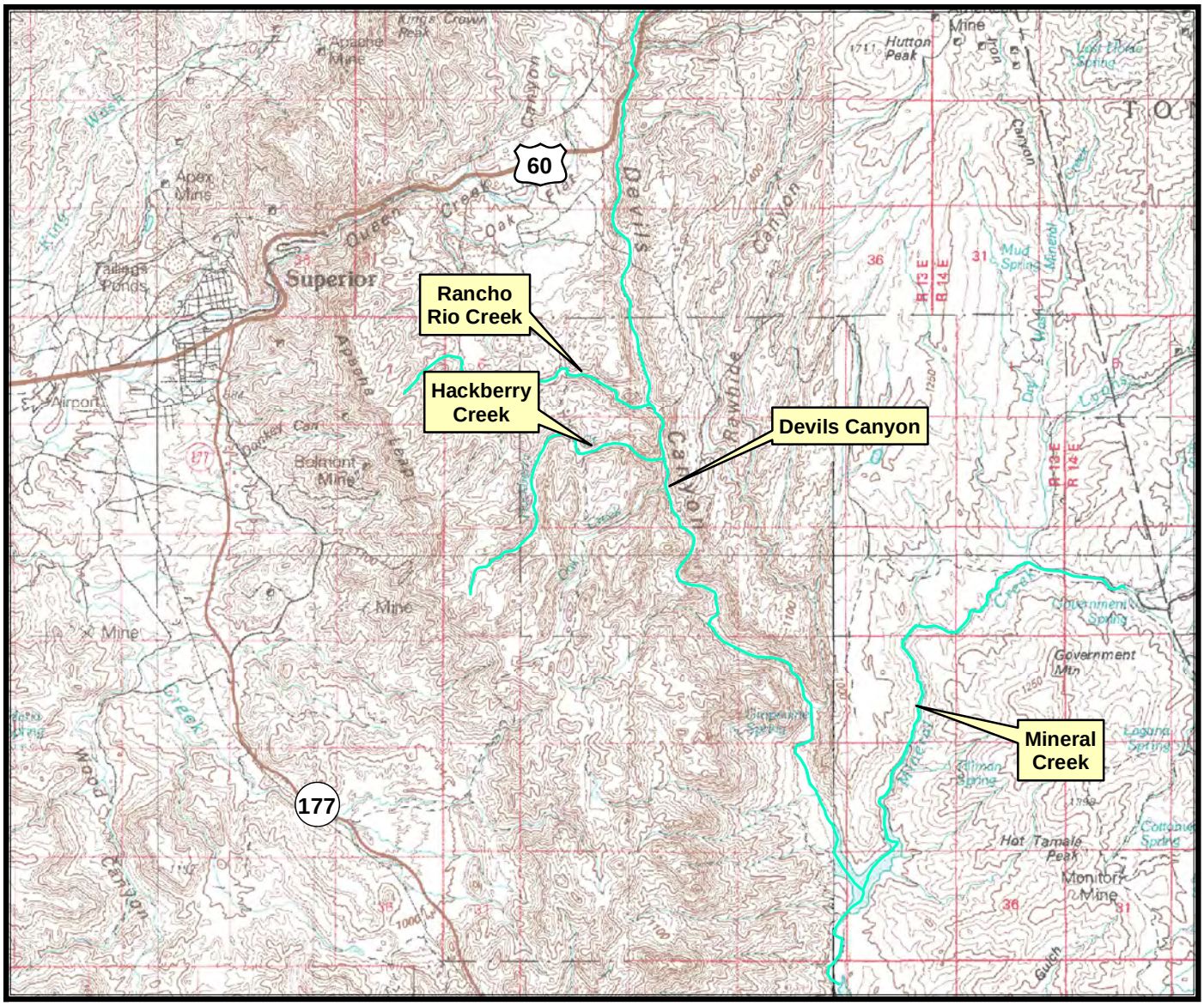
*No samples collected.
[1] Anisoptera is the suborder containing dragonflies.
[2] Acarina is the subclass containing ticks and mites.

Table 33. General comparison of taxa diversity and abundance between Mineral Creek and Devils Canyon in June and October.

Taxon	Mineral Creek		Devils Canyon	
	Diversity	Abundance	Diversity	Abundance
June				
Phytoplankton	Lower	Lower	Higher	Higher
Periphyton	Lower	Lower	Higher	Higher
Zooplankton	Lower	Lower	Higher	Higher
Macroinvertebrates	Higher	Higher	Lower	Lower
October				
Phytoplankton	Lower	Lower	Higher	Higher
Periphyton	Similar	Lower	Similar	Higher
Zooplankton	Lower	Lower	Higher	Higher
Macroinvertebrates	Higher	Higher	Lower	Lower

FIGURES





Pinal County, Arizona,
1:100,000 Globe & Mesa USGS Quadrangles

N

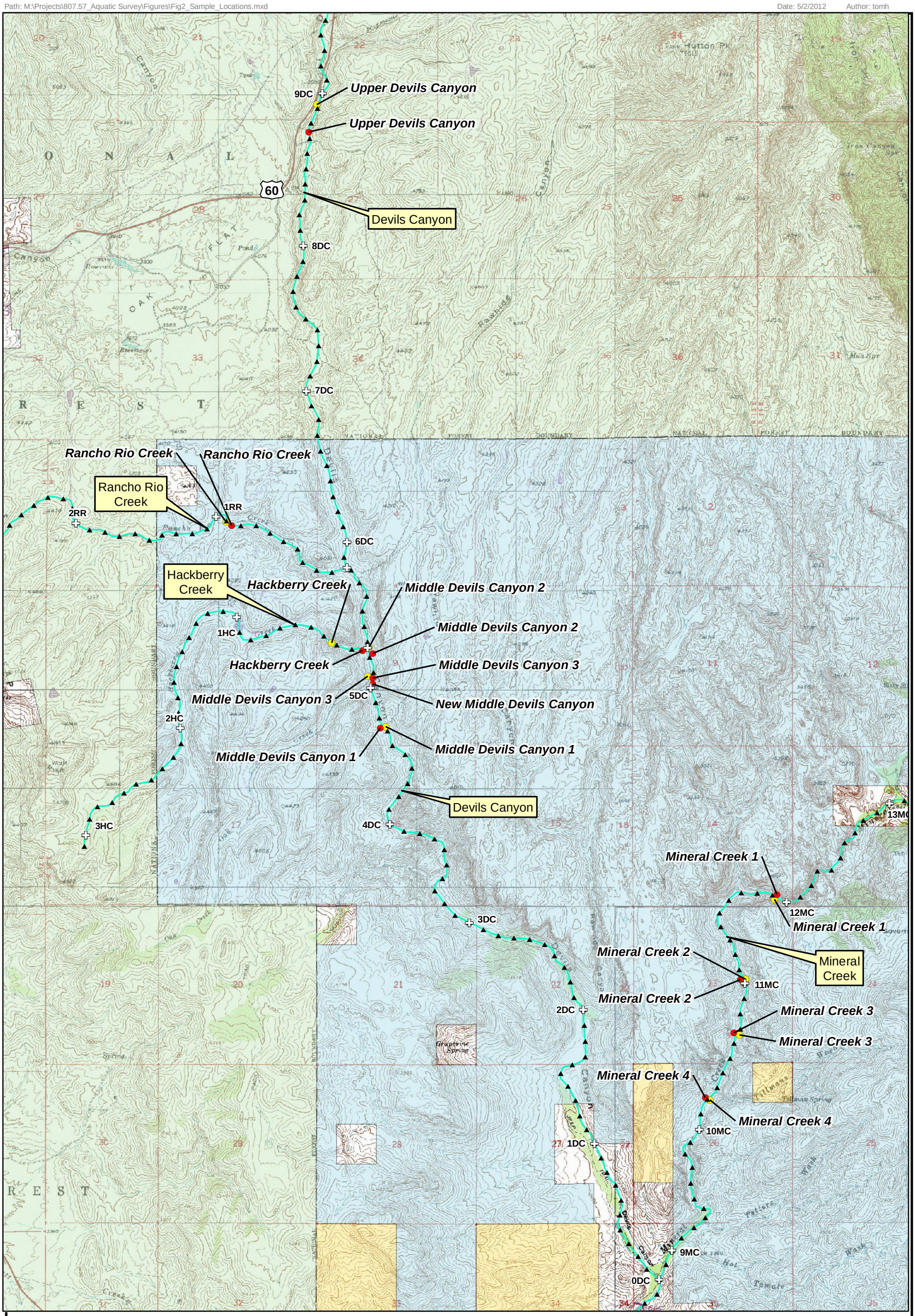
0 8,000 16,000 Feet

WestLand Resources, Inc.
Engineering and Environmental Consultants

RESOLUTION COPPER MINING
Aquatic Resources Surveys

VICINITY MAP
Figure 1

Path: M:\Projects\807.57_Aquatic Survey\Figures\Fig2_Sample_Locations.mxd Date: 5/2/2012 Author: tomh



Pinal County, Arizona,
Superior, Pinal Ranch, Teapot Mountain
& Hot Tamale Peak USGS 7.5' Quadrangles

LEGEND

- June Sample Locations
- October Sample Locations
- 10 Stream Miles Along Creeks (Tenth Mile Increment Indicted by ▲)

Surface Management (provided by BLM)

- Bureau of Land Management (BLM)
- Private Land (No Color)
- State Trust Land
- US Forest Service (USFS)

WestLand Resources, Inc.
Engineering and Environmental Consultants

0 1,500 3,000 Feet

N

RESOLUTION COPPER MINING

Aquatic Resources Surveys

AQUATIC RESOURCES SAMPLE LOCATIONS

Figure 2

APPENDIX A

Photo 1

View of pool at Upper Devils Canyon. Photo taken June 13, 2011.

Photo 2

View of a pool at Mineral Creek (site 1). Note the dip net used to take samples. Photo taken June 15, 2011.

Photo 3

View of a riffle at Mineral Creek (site 1). Algae visible along stream bank in this view. Photo taken June 15, 2011.

Photo 4

View of a pool at Mineral Creek (site 2). Photo taken June 15, 2011.

Photo 5

View of a riffle at Mineral Creek (site 2). Photo taken June 15, 2011.

Photo 6

View of a pool at Mineral Creek (site 3). Photo taken June 15, 2011.

Photo 7

View of a riffle at Mineral Creek (site 3). Photo taken June 15, 2011.

Photo 8

View of a pool at Mineral Creek (site 4). Photo taken June 15, 2011.

Photo 9

View of a riffle at Mineral Creek (site 4). Photo taken June 15, 2011.

Photo 10

View of pool looking upstream at Middle Devils Canyon (site 1). Photo taken October 5, 2011.

Photo 11

View of a riffle at Middle Devils Canyon (site 1). Photo taken October 5, 2011.

Photo 12

View of pool at Middle Devils Canyon (site 2). Photo taken October 5, 2011.

Photo 13

View of pool at lower Hackberry Creek. Photo taken October 6, 2011.

Photo 14

View looking at pool at Rancho Rio Creek. Algae prevalent on edge. Photo taken October 6, 2011.

Photo 15

View of pool at Mineral Creek (site 1). Photo taken October 7, 2011.

Photo 16

View of riffle at Mineral Creek (site 1). Photo taken October 7, 2011.

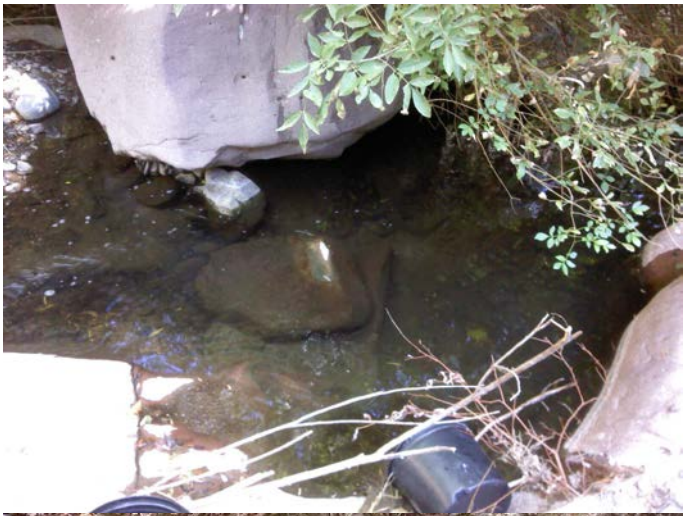


Photo 17

View of pool at Mineral Creek (site 2). Note the Ponar dredge used to sample macroinvertebrates. Photo taken October 7, 2011.

Photo 18

View of riffle at Mineral Creek (site 2). Photo taken October 7, 2011.

Photo 19

View of pool at Mineral Creek (site 4). Photo taken October 7, 2011.

Photo 20

View of riffle at Mineral Creek (site 4). Photo taken October 7, 2011.