# Evaluating Disturbance of Benthic Macroinvertebrate Communities by Off-Road Vehicle Traffic in the Nueces River, Uvalde and Zavala Counties, Texas, USA

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## INTRODUCTION

The operation of off-road vehicles (ORVs) in streams and rivers is a popular form of recreation both nationally and in Texas. Questions exist as to what damage, if any, this activity causes to the physical and biological components of affected water bodies (Phillips 2002). In an attempt to assess the potential effects of ORV activities on stream biota of the Nueces River, the Nueces River Authority partnered with Texas Parks and Wildlife Department and the Texas Commission on Environmental Quality (TCEQ) to survey the biological community in areas of the river where both the presence and absence of ORV activity was apparent.

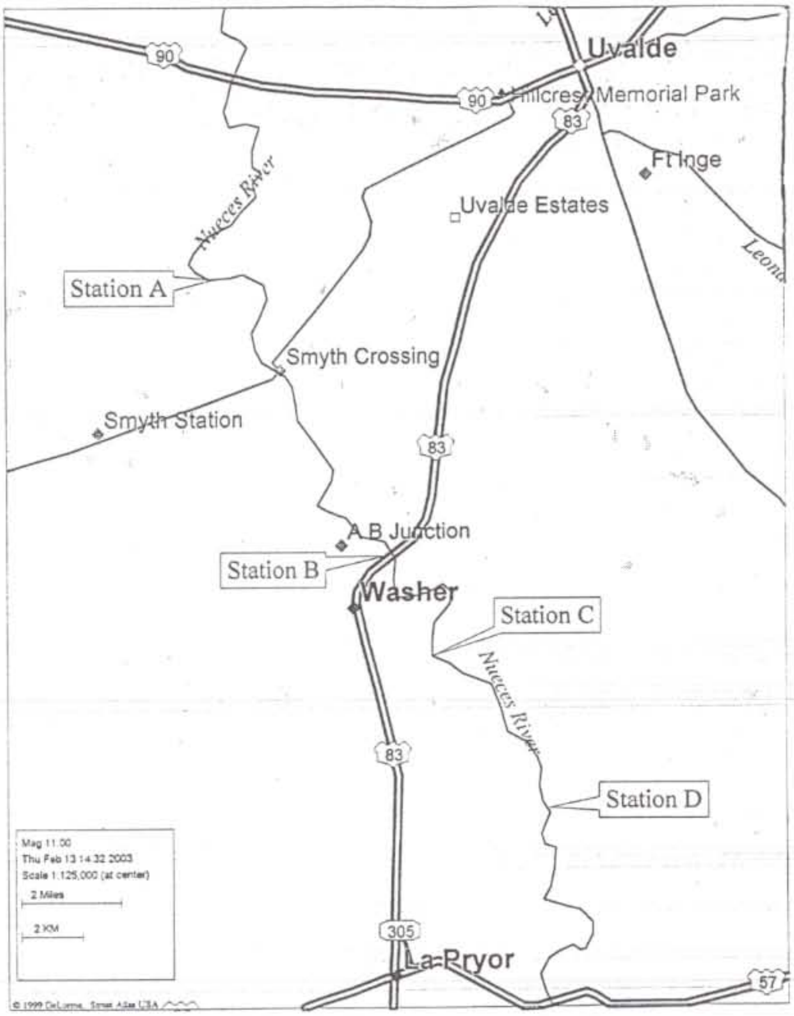
## AREA DESCRIPTION

Four sampling sites were selected based upon varying degrees of ORV traffic that occurred at each location (Table 1). The degree of ORV activity within each site was determined by comparing the amount of tire tracks visible in the river substrate, which primarily consisted of cobble, and adjacent ORV access points on the river banks. All sites were similar in geology, land use, and persistence of flow and these observations were confirmed by Nueces River Authority staff. All sites are located west and southwest of Uvalde, Texas between the U.S. Highway 90 and U.S. Highway 57 river crossings (Figure 1).

Table 1: Site locations listed in order from upstream to downstream.

| Site | Degree of traffic | latitude | longitude |
|---|---|---|---|
| A | Moderate | 29°08'49"N | 99°54'36"W |
| B | High | 29°03'56"N | 99°51'00"W |
| C | Moderately high | 29°02'08"N | 99°50'12"W |
| D | None (Control) | 28°59'27"N | 99°47'51"W |

Figure 1: Site locations along the Nueces River.




## METHODS AND MATERIALS

The TCEQ collected samples in April and September 2002 from driven and undriven riffles at each site (Table 2). Riffle habitats exhibiting visible tire tracks were selected to represent driven riffles and riffle areas showing no signs of tire tracks were selected as control riffles. No determination could be made as to the span of time between the sampling event and the most recent ORV activity within a given riffle area. In April, one riffle at Site C contained tire tracks in its upper portion and no tracks in the lower portion. This riffle was sampled separately in both driven and undriven areas (Table 2).

Five minute kicknet samples, using a D-frame kicknet, were collected from each selected riffle following EPA's Rapid Bioassessment (RBA) Methodology (Barbour et al., 1999). Approximately one hundred organisms were randomly picked from each kicknet sample according to the RBA protocols and preserved in 70% ethyl alcohol. The organisms were returned to the laboratory and identified to the recommended taxonomic classification levels according to Texas Natural Resource Conservation Commission's (TNRCC's) 1999 Receiving Water Assessment Procedures Manual (TNRCC 1999). Benthic macroinvertebrate taxonomic identification manuals were used to identify specimens (Pennak 1989, Merritt and Cummins 1996). The remainder of each kicknet sample was preserved in 10% formalin and returned to the laboratory where all remaining organisms were removed and enumerated.

The total numbers of individuals for each sample (100 count plus the remainder in the sample) were used in the statistical analysis. The approximate 100 organisms selected according to RBA protocols were used to determine Index of Biotic Integrity (IBI) scores for each riffle (TNRCC 1999). Ranges of IBI scores relate to aquatic life use. Scores less than 22 correspond to a limited aquatic life use, 22-28 to an intermediate aquatic life use, 29-36 to a high aquatic life use, and greater than 36 to an exceptional aquatic life use.

The Nueces River Authority collected water samples at each site for routine chemical analysis and measured field physicochemical parameters using a Hydrolab multiprobe instrument. Flow data was collected using a Marsh-McBirney flow meter. Habitat assessments were conducted at each site by the TCEQ following the TNRCC's 1999 Receiving Water Assessment Procedures Manual (TNRCC 1999). A detailed discussion of the habitat measurements will be developed as an addendum to this report. This addendum will be completed by August 31, 2003 and will be submitted by the TCEQ Surface Water Quality Monitoring (SWQM) Team. Texas Parks and Wildlife Department also conducted an assessment of the fish community at each site.

## STATISTICAL ANALYSIS

In order to compare sites where vehicle traffic occurred to those where it did not occur, two different approaches were used. Comparisons were made using two sample t-tests at a 95% confidence interval with Minitab 13 statistical software. Data from the April and September sampling events were analyzed separately.

- Total number of individuals from three riffles at Site B, which receives a high degree of traffic, were compared to total number of individuals from three riffles at Site D, the undriven (control) site.

- Total number of individuals from all driven riffles at Sites A, B, and C (five separate riffles) were compared to total number of individuals from all undriven (control) riffles at Sites A, B, C, and D (six separate riffles).

## RESULTS AND DISCUSSION

The total number of individuals and IBI scores for each riffle are shown in Table 2. The IBI scores for April rated driven and control riffles as supporting high or exceptional aquatic life uses (Figure 2). September IBI scores ranged from limited to exceptional aquatic life uses (Figure 3). Some riffles originally sampled in April could not be resampled in September because the depth of the Nueces River increased at some of these riffle areas due to recent rainfall events. In this situation, a different riffle was selected and sampled.

Table 2: Total Number of Individuals and IBI Scores for each Sampled Riffle.

| Site | Status | April IBI | September IBI | April Total Numbers | September Total Numbers |
|---|---|---|---|---|---|
| C | Driven ¶ * | High (33) | Intermediate (27) | 308 | 774 |
| C | Undriven ¶ § | High (31) | Not sampled | 1200 | Not sampled |
| C | Undriven* | High (34) | High (34) | 1708 | 2366 |
| B | Driven | High (29) | Limited (16) | 613 | 226 |
| B | Driven | High (32) | Intermediate (28) | 145 | 618 |
| B | Driven | High (31) | Intermediate (26) | 655 | 1369 |
| B | Undriven* | High (31) | High (32) | 862 | 1778 |
| A | Driven* | High (34) | High (36) | 778 | 3221 |
| A | Undriven* | High (31) | Exceptional (37) | 2319 | 2068 |
| D | Undriven | High (34) | High (35) | 544 | 2515 |
| D | Undriven* | High (34) | High (32) | 3173 | 1102 |
| D | Undriven | Exceptional (37) | High (30) | 2537 | 1702 |

¶ Samples collected from the same riffle.
§ This undriven (control) riffle was not used in the statistical analysis. The riffle was sampled to provide a side by side comparison between undriven and driven areas in a single riffle.
* Same riffle was sampled in April and September.

Figure 2: IBI scores for all driven and control riffle sites from April.

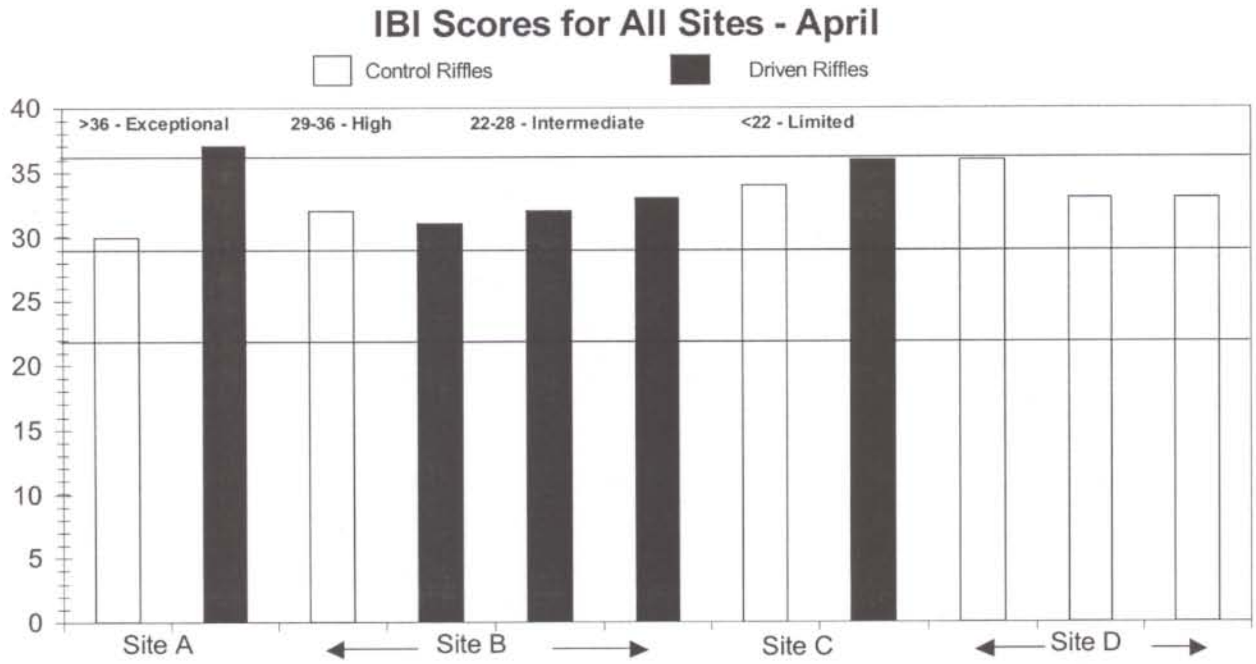
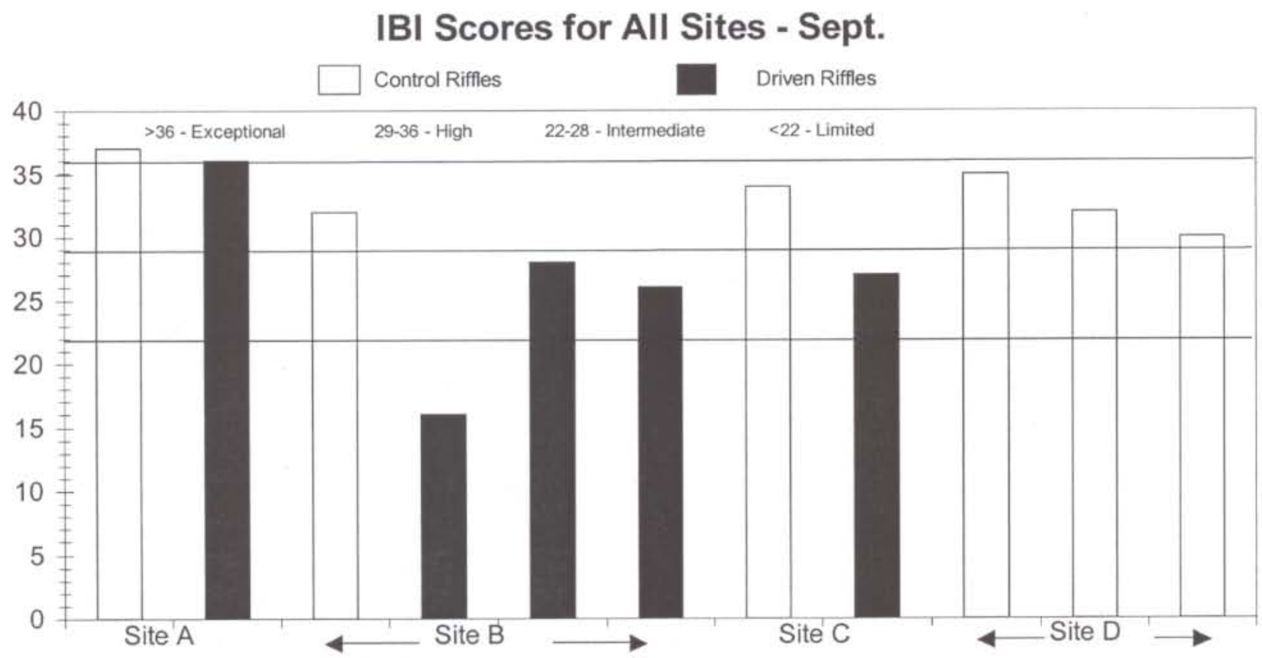



Figure 3: IBI scores for all driven and control riffle sites from September.



Although not significantly different, when the total number of individuals in each riffle from April and September are compared, the amount of total number of individuals among the driven sites appear to be related to the amount of perceived traffic each site receives (Figure 4 & 5). The number of individuals collected at Site A in September could be attributed to the abundant algae that was observed at this site.

Figure 4: Total number of individuals at all driven and control riffles from April.

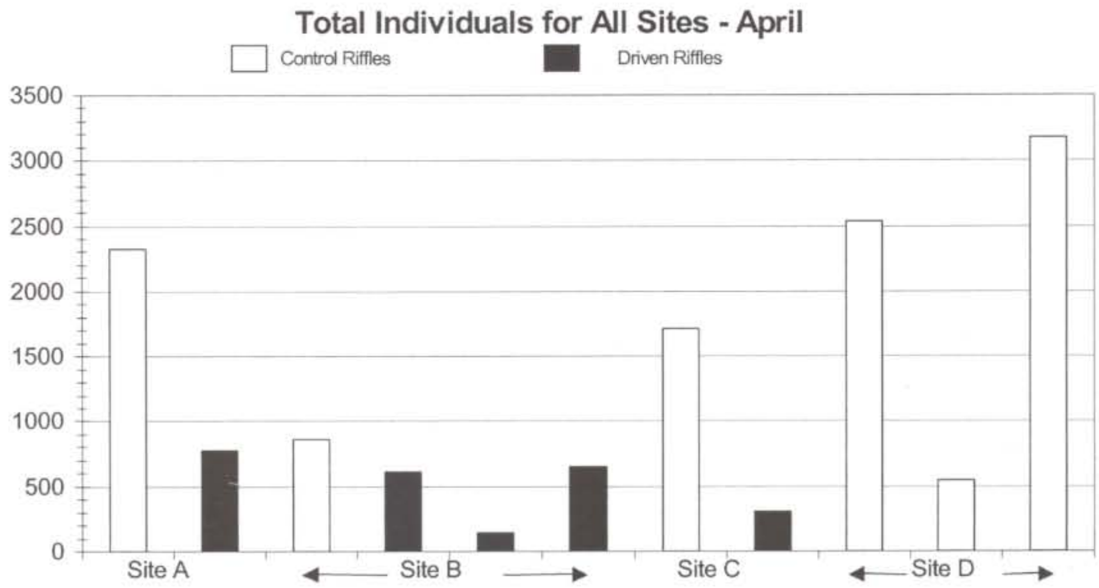
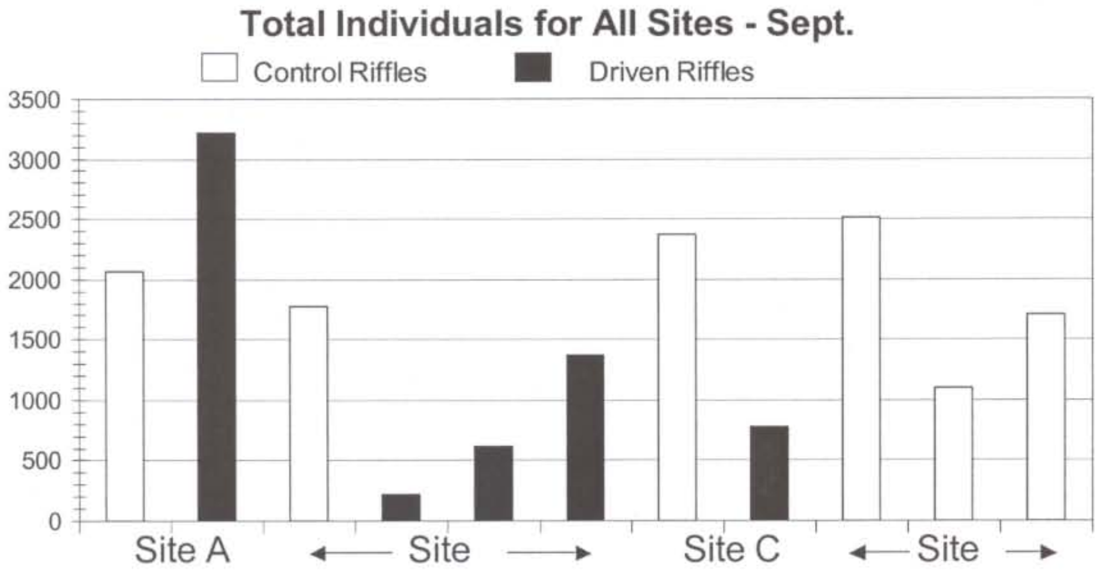



Figure 5: Total number of individuals at all driven and control riffles from September.



A two-sample t-test using the total number of individuals in the three driven riffles at Site B and the three control riffles at Site D showed that the driven and control riffles were not significantly different using a 95% confidence interval for the April ($p = 0.117$) and September ($p=0.122$) samples (Figure 6 & 7). Though the controls are not significantly different from driven riffles, greater total number of individuals are present in riffles at Site D as compared to the heavily driven Site B riffles.

Figure 6: Comparison of Driven Riffles at Site B versus Control Riffles at Site D from April.

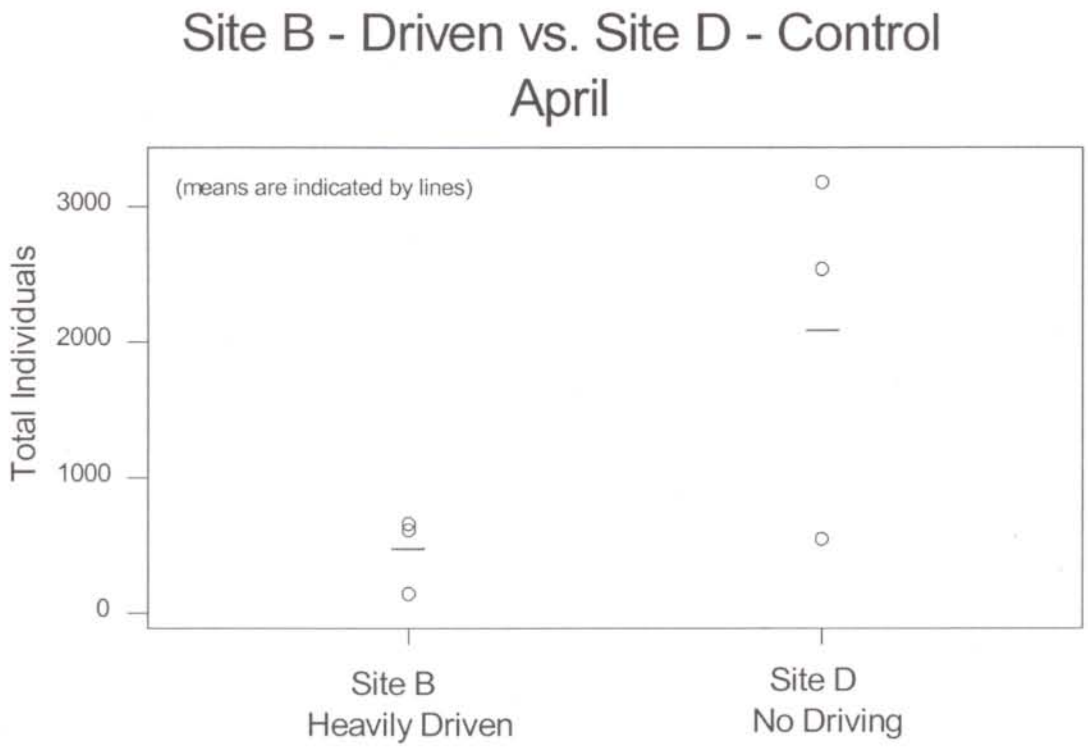
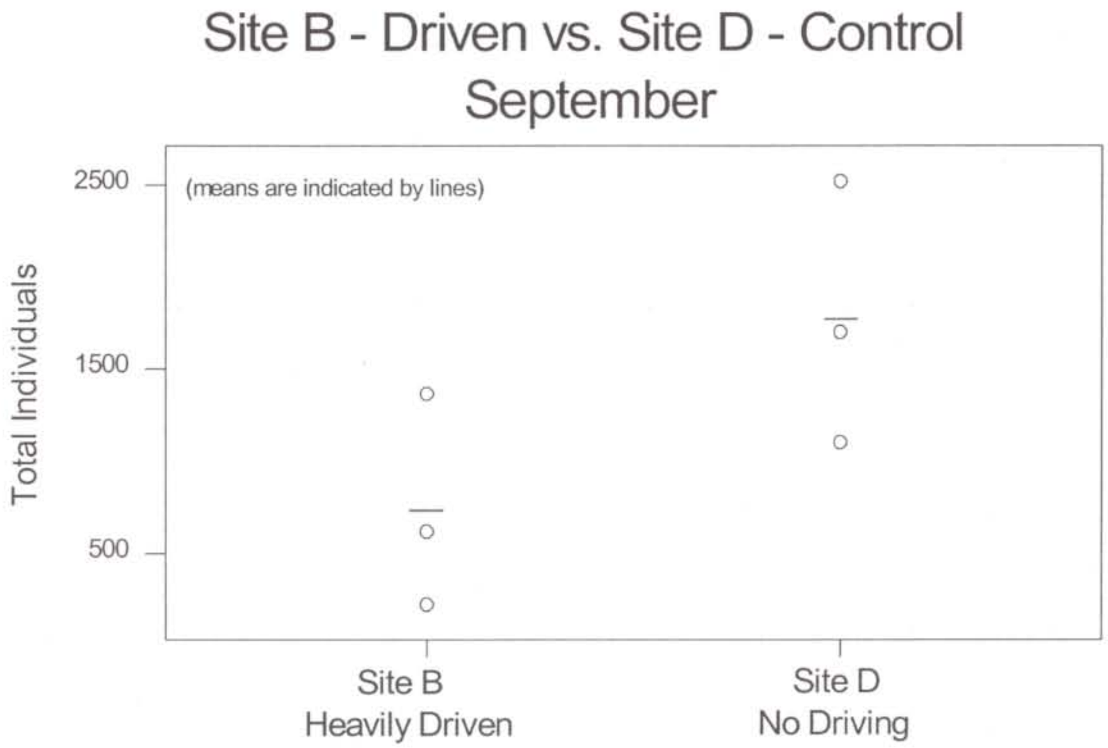


Figure 7: Comparison of Driven Riffles at Site B versus Control Riffles at Site D from September.




When all driven riffles were compared to all the control riffles in April, the results showed a significant difference (p = 0.025). There was no significant difference when all driven riffles were compared to all control riffles in September (p=0.285). The variability among these comparisons could be attributed to patchiness in benthic macroinvertebrate distribution and differences observed in the riffles. Comparisons of driven riffles versus control riffles from the April and September sampling events are shown in Figures 8 and 9.

Figure 8: Comparison of Driven Riffles versus Control Riffles from April.

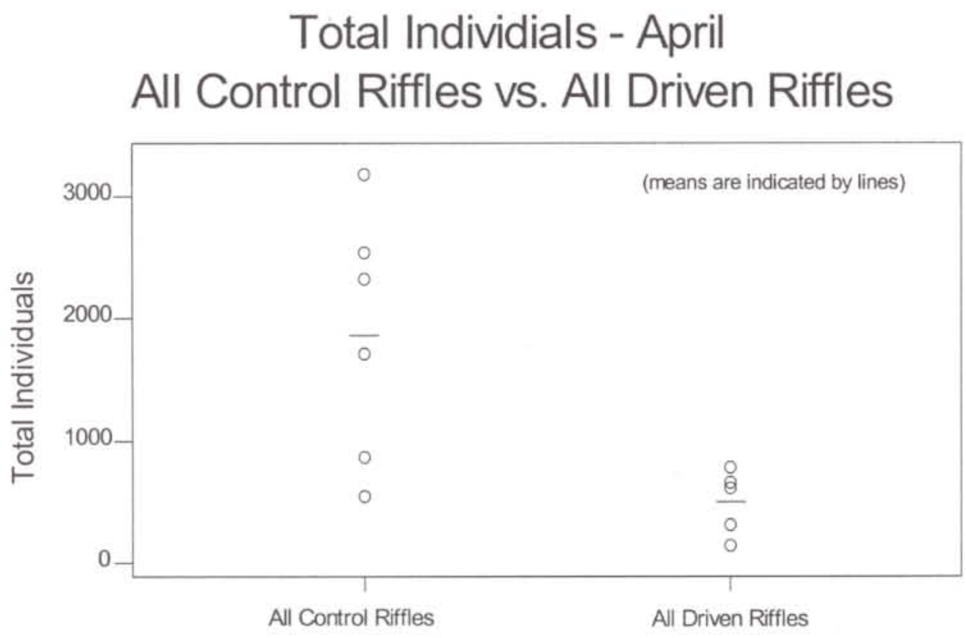
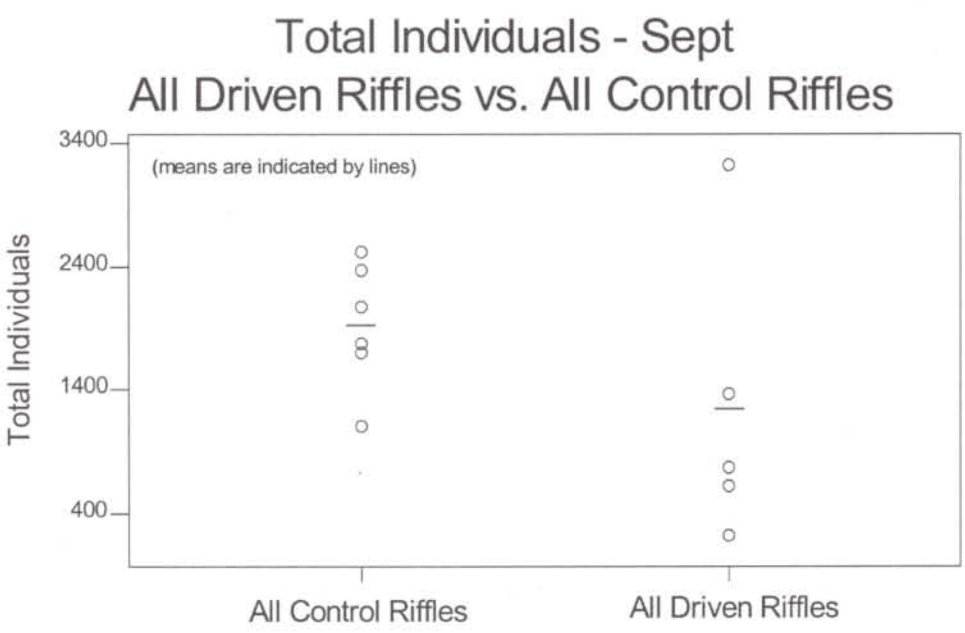
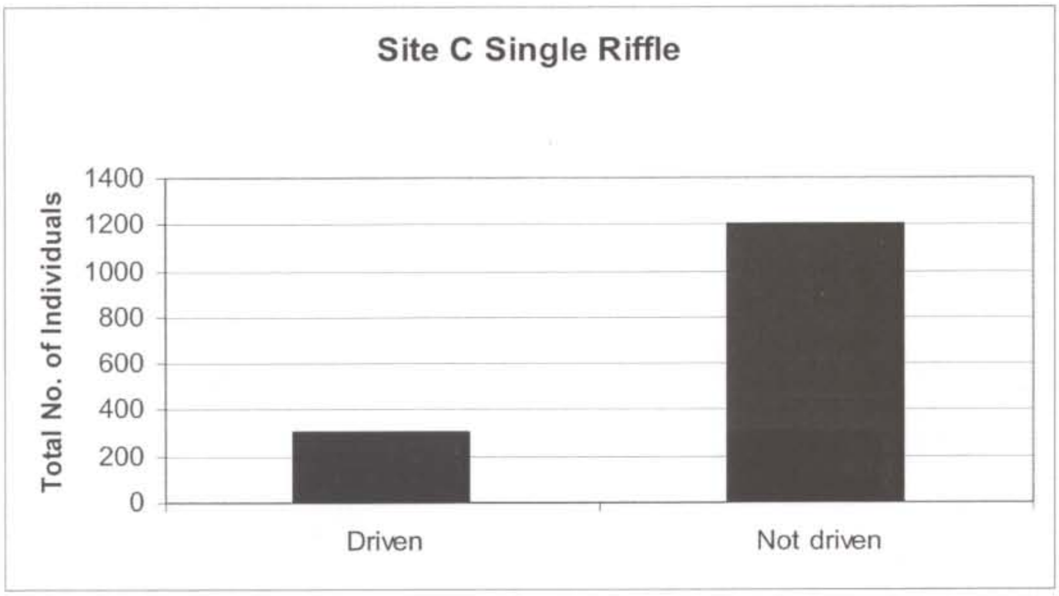



Figure 9: Comparison of Driven Riffles versus Control Riffles from September.



A single riffle at Site C, where samples in April were taken in the driven and undriven portions of that riffle, provided a side by side comparison of total numbers of individuals, as previously stated. Though there was only one sample taken in each area, it was the only riffle containing both a driven area and an undriven (control) area. The total number of individuals show that more individuals were collected in the undriven area than in the driven area (Figure 10). The control area of the riffle was not used in statistical analysis even though the IBI score and total numbers are reported in Table 2.

Figure 10: Comparison of total numbers of individuals collected from one riffle which contained driven and undriven areas.




Field parameters and routine water chemistry results were similar at all four sites in April and September and are listed in Appendix A. Habitat data is still being analyzed and will be submitted by the SWQM team at a later date.

## CONCLUSION

After analyzing the April and September data, information as to what potential effects ORV activities have on the benthic macroinvertebrate community were unclear. Although potential trends in the benthic community were noted, including greater variability in control riffles and the total number of individuals from driven riffles were clustered in a lower range when compared to control riffles, additional sampling events would be appropriate to determine if these trends are long term. However, other factors, such as algal cover, patchiness, or flow fluctuations may be shaping the benthic community. Visual inspection of the Nueces River does indicate unnatural river modifications from ORV activities. Visual inspection of the river showed that sites with heavy traffic lacked an abundance of algae and macrophytes in areas where vehicle tracks were present. The areas without vehicle tracks typically had abundant amounts of algae and macrophytes on the substrate. Generally, the sites with moderate to high ORV traffic had noticeable modifications to banks and riffles due to the vehicle traffic. Specifically at Site B, areas were cut out in the river banks where ORV traffic was entering the river. At all the driven sites, ORV traffic tended to create artificial riffles in the river bed where ORV traffic crossed a section of the river. In these areas the riffles were created by vehicle tires which left peaks and valleys in the gravel where they crossed.

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TCEQ Surface Water Quality Monitoring Team: Anne Rogers, Bill Harrison, Jack Davis, and Brenda Smith for assistance with the collection of biological, flow, and habitat data.

Landowners in Zavala and Uvalde Counties for granting access to several river sampling locations through their property.

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# Appendix A

**Field Parameters, Routine Water Chemistry Data**
**and**
**Flow Data**

| Appendix A: Field and water chemistry data (April 2002) | | | | |
|---|---|---|---|---|
| **Constituent** | **Site A** | **Site C** | **Site D** | **Site B** |
| Date | 4/16/02 | 4/17/02 | 4/17/02 | 4/18/02 |
| Temperature (°C) | 24.8 | 25.0 | 26.5 | 25.2 |
| Dissolved Oxygen mg/L) | 7.1 | 7.2 | 7.9 | 7.9 |
| Conductivity | 445.5 | 379.3 | 364.3 | 391.3 |
| pH | 8.2 | 8.4 | 8.4 | 8.4 |
| % Dissolved Oxygen | 90.7 | 82.2 | 104.2 | 97.8 |
| TSS | <1 | 1 | <1 | <1 |
| VSS | <1 | <1 | <1 | <1 |
| TDS | 354 | 320 | 310 | 327 |
| Total Phosphorus | 0.022 | 0.022 | 0.016 | 0.019 |
| Turbidity | 0.20 | 0.35 | 0.70 | 0.45 |
| Alkalinity | 184 | 135 | 135 | 151 |
| Hardness | 234 | 183 | 174 | 196 |
| Chloride | 22 | 22 | 21 | 23 |
| Sulfate | 18 | 19 | 20 | 19 |
| Ammonia - N | <0.02 | 0.04 | <0.02 | 0.03 |
| Nitrate-Nitrite - N | 1.6 | 1.4 | 1.4 | 1.4 |
| TOC | 5.21 | 0.73 | 0.73 | 0.61 |
| Ortho Phosphorus | <0.002 | <0.002 | <0.002 | <0.002 |
| Chlorophyll - *a* | 0.36 | 0.16 | 0.20 | 0.35 |
| Flow (cfs) | 46.77 | 33.00* | 51.29 | 47.33 |

*** Provisional flow data from USGS Gauge 018092000, Nueces River bl Uvalde, TX.**

| Appendix A: Field and water chemistry data (September 2002) | | | | |
|---|---|---|---|---|
| **Constituent** | **Site A** | **Site C** | **Site D** | **Site B** |
| **Date** | **9/17/02** | **9/17/02** | **9/18/02** | **9/18/02** |
| **Temperature (°C)** | **25.7** | **27.6** | **27.4** | **27.4** |
| **Dissolved Oxygen mg/L)** | **7.5** | **7.8** | **6.3** | **7.0** |
| **Conductivity** | **455.7** | **381** | **374.6** | **401.8** |
| **pH** | **7.8** | **8.0** | **8.0** | **8.0** |
| **% Dissolved Oxygen** | **96.6** | **103.8** | **84.0** | **94.3** |
| **TSS** | **2** | **2** | **1** | **1** |
| **VSS** | **1** | **2** | **<1** | **1** |
| **TDS** | **254** | **214** | **209** | **225** |
| **Total Phosphorus** | **0.016** | **0.134** | **0.124** | **0.125** |
| **Turbidity** | **0.30** | **0.35** | **0.50** | **0.25** |
| **Alkalinity** | **213** | **171** | **171** | **185** |
| **Hardness** | **229** | **180** | **176** | **194** |
| **Chloride** | **Not sampled** | **Not sampled** | **Not sampled** | **Not sampled** |
| **Sulfate** | **Not sampled** | **Not sampled** | **Not sampled** | **Not sampled** |
| **Ammonia - N** | **<0.02** | **<0.02** | **<0.02** | **<0.02** |
| **Nitrate-Nitrite - N** | **1.22** | **0.90** | **0.90** | **0.92** |
| **TOC** | **0.53** | **0.66** | **0.76** | **0.59** |
| **Ortho Phosphorus** | **<0.002** | **<0.002** | **<0.002** | **<0.002** |
| **Chlorophyll - *a*** | **0.60** | **0.38** | **0.22** | **0.22** |
| **Flow (cfs)** | **68.75** | **77.37** | **66.53** | **80.21** |

**Appendix B**

**Nueces River Macroinvertebrate Species List**

| Class | Order | Family | Genus |
|---|---|---|---|
| **Turbellaria** | **Tricladida** | **Planariidae** | |
| **Enopla** | **Hoplonemertea** | **Tetrastemmatidae** | ***Prostoma* sp.** |
| **Oligochaeta** | | | |
| **Gastropoda** | **Neotaenioglossa** | **Hydrobiidae** | |
| **Gastropoda** | **Basommatophora** | **Planorbidae** | ***Helisoma/Planorbella* sp.** |
| **Malacostraca** | **Amphipoda** | **Hyalellidae** | ***Hyalella* sp.** |
| **Malacostraca** | **Decapoda** | **Cambaridae** | |
| **Arachnida** | **Trombidiformes (Hydracarina)** | | |
| **Insecta** | **Ephemeroptera** | **Baetidae** | ***Baetis* sp.** |
| | | | ***Baetodes* sp.** |
| | | | ***Camelobaetidius* sp.** |
| | | | ***Fallceon* sp.** |
| | | | ***Plauditus* sp.** |
| | | **Isonychiidae** | ***Isonychia* sp.** |
| | | **Heptageniidae** | ***Stenonema* sp.** |
| | | **Leptophlebiidae** | ***Neochoroterpes* sp.** |
| | | | ***Thraulodes* sp.** |
| | | | ***Traverella* sp.** |
| | | **Leptohyphidae** | ***Allenhyphes* sp.** |
| | | | ***Tricorythodes* sp.** |
| | **Odonata** | **Coenagrionidae** | ***Argia* sp.** |
| | | **Libellulidae** | ***Brechmorhoga* sp.** |
| | **Hemiptera** | **Naucoridae** | ***Ambrysus* sp.** |
| | | | ***Cryphocricos* sp.** |
| | | **Veliidae** | |
| | **Megaloptera** | **Corydalidae** | ***Corydalus* sp.** |
| | **Trichoptera** | **Hydroptilidae** | ***Hydroptila* sp.** |

| | | | |
|---|---|---|---|
| | | | *Neotrichia* sp. |
| | | | *Ochrotrichia* sp. |
| | | | *Oxyethira* sp. |
| | | Hydropsychidae | *Cheumatopsyche* sp. |
| | | | *Hydropsyche* sp. |
| | | | *Smicridea* sp. |
| | | Philopotamidae | *Chimarra* sp. |
| | | Polycentropodidae | *Neureclipsis* sp. |
| | | | *Polycentropus* sp. |
| | | | *Polyplectropus* sp. |
| | | Odontoceridae | *Marilia* sp. |
| | Lepidoptera | Pyralidae | *Petrophila* sp. |
| | Coleoptera | Dytiscidae | *Stictotarsus* sp. |
| | | Lutrochidae | *Lutrochus* sp. |
| | | Psephenidae | *Psephenus* sp. |
| | | Elmidae | *Cylloepus* sp. |
| | | | *Hexacylloepus* sp. |
| | | | *Macrelmis* sp. |
| | | | *Microcylloepus* sp. |
| | | | *Neoelmis* sp. |
| | Diptera | Tipulidae | *Hexatoma* sp. |
| | | Ceratopogonidae | *Bezzia* sp. |
| | | | *Dasyhelea* sp. |
| | | | *Probezzia* sp. |
| | | Chironomidae | |
| | | Simuliidae | *Simulium* sp. |
| | | Athericidae | *Atherix/Suragina* sp. |
| | | Empididae | *Hemerodromia* sp. |
| | | Tabanidae | *Tabanus* sp. |