

# Exhibit C

**Rubicon Trail Monitoring Plan  
Preliminary Monitoring Results**  
Center for Regional Environmental Science and Technology (CREST)  
California State University, Sacramento  
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**I. Background and Rationale for a Monitoring Program on the Rubicon Trail.**

The Rubicon Trail, located in El Dorado and Placer counties of northern California, represents one of the oldest recreational Off-Highway Vehicle (OHV) Trails in the United States. In response to growing concerns regarding the deterioration of the trail and possible environmental impacts of trail use, El Dorado County has developed the Rubicon Trail Master Plan (RTMP), which includes as one of its goals "to preserve and protect environmental and cultural resources". In order to meet this goal, the County has developed an environmental monitoring and reporting program to provide water quality and other environmental data for segments along the trail on a regularly scheduled basis. The development of this monitoring program requires preliminary technical data regarding the condition of the trail and the magnitude of environmental changes experienced throughout a recreational season. The Center for Regional Environmental Science and Technology (CREST) is a center of over 20 faculty members from over 10 different academic departments on the Sacramento State University campus who have expertise and ongoing interests in regional environmental topics. The CREST faculty members work both independently and collaboratively on projects depending on scope and specific needs. Storm water runoff contamination due to vehicle usage is currently a major concern in many urban areas and is analogous to concerns about the runoff from the Rubicon Trail. Caltrans has several storm water research projects underway to mitigate this issue in California urban areas. Recent results show that typical road sweepings contain high levels of oil, grease and heavy metal ions. Sediment and road sweeping facilitate the transport of these toxic species into the source drinking water supply. CREST is currently working collaboratively with the CSUS Office of Water Programs on two Caltrans projects related to these storm water issues in Northern California, including studies in the Lake Tahoe Basin.

The study summarized in this report was conducted under contract to Environmental Stewardship & Planning, Inc. (ESP) and El Dorado County to provide information necessary for the CEQA review and the development of an RTMP that addresses environmental quality issues associated with activities on the Rubicon Trail.

**A. Objectives of the Preliminary Environmental Monitoring Study.**

1. Obtain a general physical evaluation of the trail and how that physical state changes throughout a typical summer recreational use season. (June 2005 - November 2005) This includes:

a) Observation of general change in geological and hydrological profile of the trail and the surrounding area. For example, note which areas change from water ways to dry trail bed throughout the season and which areas change from flowing water to stagnant water as the season progresses. The results indicate the type of environmental sampling and analysis required throughout a recreational season and as part of an ongoing management program.

b) Observation of general change in physically observable impacts of OHV uses, including oil and grease contamination, human waste, and soil disturbance (erosion and water turbidity).

c) Determination of specific sites appearing most influenced by significant OHV and human interaction and thereby necessitating significant monitoring to evaluate potential detrimental impacts from these interactions.

d) Determination of appropriate sample sites best representative for field blank baseline values.

2. Determination of sampling, storage, and analysis protocols best suited for the specific nature of the environmental samples collected.

a) Identification of reproducible protocols and methods to evaluate the reproducibility.

b) Establishment of sampling protocols ideally will be straightforward enough to permit trail-user volunteer participation in future monitoring.

3. Obtain baseline quantitative values throughout the season for the suspected contaminants of oil and grease, E-coli, and heavy metals. Identify the variance in these contamination levels from site to site and at different points on the trail. Compare these values to the background values obtained from field blank samples.

4. Comparison of obtained values to limit values deemed acceptable for environmental samples.
5. Determination of a preliminary understanding of the short term and long-term fate or mobility of contamination.
6. Identification of any potential sites or mechanisms for long-term cumulative contamination problems.
7. Formulation of a reasonable and cost effective long-term monitoring plan for the trail, ideally involving trail user volunteers for sampling and observation mapping.
  - a) Consultation with ecological experts to identify species most sensitive to contamination and formulate a simple monitoring protocol to watch these species for signs of contaminant exposure.

#### **B. Environmental Impact Associated with Motor Vehicle Operation**

The environmental impact of motor vehicle operation can be categorized in four classifications:

##### **1. Emissions.**

- a. **Volatile Organic Compounds.** Gasoline and other light hydrocarbon based species. These compounds easily enter the gas phase where they can detrimentally alter air quality. Additionally, some of the compounds are soluble in water to the extent that they can influence water quality.
- b. **Nonvolatile Organic Compounds.** Non-volatile compounds include oil and grease. Oil and grease are categorized as larger carbon chain hydrocarbon based compounds. These compounds are mostly water insoluble and tend to form a film on the surface of water bodies. Some of these larger hydrocarbon species are toxic to wildlife where they have been observed to coat the bodies and gills of fish and other aquatic species. Dissolved oxygen content of the water can be degraded under conditions of severe contamination. Additionally, soils and the existing plant life can be negatively impacted by oil and grease. Some native plant life is less able to accommodate oil and grease contamination compared to other plant life, leading to a change in native species ecology in contaminated areas. Plant life ecology alteration can impact the food chain and result in insect and animal species impact.

##### **2. Metals**

Lead (Pb), Copper (Cu), Zinc (Zn), Cadmium (Cd), and other dissolved metals are present in motor oil and grease at significantly high levels. These metal ions are incorporated into the oil and grease as to improve the performance of vehicle motor and drive train lubrication. ( Davis, A.P ; Chemosphere, 44, (2001) 997-1009: "Loading Estimates of Lead

*Copper, Cadmium and Zinc in Urban Runoff from Specific Sources*”). Zinc is a major metal contaminant associated with tire wear and copper with brake pad emissions. Cadmium is often found in batteries and engine oil.

As a result, general vehicle use and contamination due to an oil spill or leak causes these metal ions to be released into the environment. Significant levels have been found in road sweepings and constitute the major non-point source pollution in many urban areas and a significant source of pollution in non-urban areas. Many metals are known to be highly toxic to animal and aquatic life forms at very low concentration levels. Buckley, J.A. et al. *Comparative Biochemistry and Physiology Part C: Comparative Pharmacology*, 78 (1), 1984, 105-110. *"A cupric ion - copper Bioaccumulation in Coho Salmon Exposed to Copper Containing Treated Sewage"*. Also see Reports from Agency for Toxic Substance and Disease Registry, [www.atsdr.cdc.gov](http://www.atsdr.cdc.gov).

Of particular concern is the fact that metal ions can be significantly soluble in water, which means that a rain event can easily wash the metal ions into hydrologic systems. Of added concern is the propensity of metal ions to remain unchanged in the environment and to concentrate or build up to reach toxic levels. Some heavy metals are known to bioaccumulate or concentrate in life forms. ( Trombulak, S.C. et al, *Conservation Biology*, 14, (1), 2000, 18-24; *"Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities"*). Recent studies have shown that heavy metals sequester and accumulate in lake bottom sediments. This is a significant problem in some urban areas of the Great Lakes where fish currently contain such high levels of metal contamination that they should not be consumed.(See US EPA Great Lakes Contaminated Sediments Program [www.epa.gov](http://www.epa.gov)).

**4. Sedimentation.** Sedimentation occurs when mineral and organic particles of different sizes are transported from their place of origin by water, wind, gravity, or ice. This process occurs naturally; however, human activities can accelerate it, causing unnaturally high levels of sediment in our rivers, lakes and streams. Sediments also carry nutrients into the water supplies which reduce water quality through increasing water turbidity. The long-term effect of sedimentation promotes algae blooms, fills creeks, streams and small drainages and fosters weed growth. If uncontrolled, sedimentation can smother plants, degrade or eliminate aquatic habitats, suffocate fish and make riparian habitats unsuitable for wildlife. Of particular concern is the ability of vehicle contaminants to attach to sediment particles. Oil, grease and heavy metals deposited on roadways attach to sediments which can then be carried into nearby waterways.

**C. Short-term and long-term cumulative impacts.** In examining the environmental impact related to external activity, it is prudent to consider both short-term or temporal influences as well as long-term cumulative impacts. Although the results from the preliminary monitoring studies can provide seasonal impact data, it is actually the long-term irreversible and cumulative environmental impacts which are of greater concern.

For example, oil, grease, and heavy metals deposited on the roads, freeways, and in parking lots are becoming an area of significant concern due to the ability of storm water run-off to carry these contaminants into the water system where they can build up to harmfully impact aquatic life and enter the drinking water supply. Biomagnification, the transfer of metal contamination up the food chain is of particular concern within the water system. A recent study of storm water detention basins found that much of this oil, grease, and metal contamination is sequestered in the water basin sediments. The macroinvertebrates living in these sediments are found to contain high levels of the contamination which is then passed up the food chain where fish and waterfowl ingest these primary food sources.

Numerous studies have shown the ability of plant life to uptake metal ion contamination which presents an additional contaminant pathway into the food chain. The long-term exposure to some contaminants has been shown to alter habitat and subsequently modify the ecology in such a way as to alter the species living within that habitat. Caltrans and similar watershed concerned agencies within the state of California and within other states have begun examining the associated vehicle originating contamination levels and potential storm water treatment technologies. CREST is currently working on one project directed at testing the effectiveness of oil, grease and metal ion removal from simulated storm water. The idea is to identify potential filtering media and design for widespread utilization in storm drains.

Although the potential environmental impact on the Rubicon trail and other off-road vehicle trails is minor compared to the issues of the California freeway system and urban centers, irresponsible and reckless use of these recreational areas can have potentially severe consequences. The associate contamination from vehicle breakdown, lubricant and coolant leaks and abuse of the recreational trail and its environs presents the same concerns to the water, habitat, and sediment quality. A monitoring plan which evaluates the current environmental state of the trail and monitors the short-term and long-term changes can provide information helpful to maintaining the trail, protecting the environment and sustaining the continued recreational activities.

## **II. Sample Collection and Analysis Methods.**

In order to obtain an environmental "snapshot" regarding the state of the Rubicon Trail and a benchmark for the environmental impact related to a typical recreational season, a preliminary monitoring plan was devised and implemented during the 2005 recreational season. This initial study was designed to identify the contaminant loads and capture any significantly changing environmental state of the water and sediment quality directly related to the four-wheeling recreational activities on the trail during the season.

As described more fully below, the study included extensive water and sediment sampling prior to the major trail use, immediately after the two major trail events (the Jeepers Jamboree and the July 4th holiday), and after the first rainfall after the close of the season. The study also included the collection of field blanks which were obtained at locations removed from the trail and deemed to remain free from the impact of the recreational events.

**A. Sampling Sites and Time Tables.**

1. **Sampling Sites.** All sampling sites were mapped with a GIS unit and represent a range of sites expected to show little to no environmental impact to sites representing regions suspected of significant contaminant exposure. Extensive field notes were recorded and photos were taken to capture the physical characteristics each site. Blank sample sites off trail were identified and sampled according to the same protocol as trail sampling sites.

2. **Sampling Timetable.** The predominant recreational use of the trail is seasonal with the heaviest use occurring in July and August. The preliminary monitoring plan monitored the identified locations four times per year:

a) Spring following the snowmelt and prior to the recreational use of the trail. During the 2005 pre-recreational season, this sampling occurred on June 28, 2005.

b) Mid summer following the July 4th holiday. During the 2005 recreational season, this sampling took place on July 7, 2005

c) Late Summer following the Jeepers Jamboree event. During the 2005 recreational season, this sampling took place on August 1, 2005.

d) First Flush, following the first heavy rain of the season. During the 2005 post recreational season, this post first heavy rain sampling took place on November 9, 2005.

**B. Sampling Protocol.**

1. **Water Samples.** Water samples were obtained by grab sample techniques and deposited in cleaned and sanitized amber glass bottles. Samples were acidified with 1mL of concentrated hydrochloric acid (HCl) in the field. The samples were kept cool and transported back to lab for acid stabilization within 6 hours. Duplicate samples were obtained for each sample site.

2. **Sediment Samples.** Sediment samples were collected by a scoop method and deposited in clean whirl packs. Sediment samples are intended to monitor surface and water edge contamination and only penetrate the surface approximately 2 inches. Again, blank sediment samples were obtained from regions remote from the trail.

3. **Core Samples.** Core samples were obtained to monitor the depth of contamination and the long-term diffusion of contamination downward, through the earth's crust. The sequestering of contamination in certain soil, clay or mineral layers will be evaluated. Core samples will be obtained 3 feet deep using pvc pipe fitted with caps for transportation.

4. Coliform Water Samples. Coliform sampling was obtained in sanitized collection tubes, double bagged in Whirl Pak® sampling bags and transported back to the laboratory within six hours for analysis.

### C. Sample Analysis Methods

1. Oil and Grease in Water Samples. Water samples were analyzed for automobile oil and grease contamination using a modification of EPA method 1664. This is a hexane extraction method followed by gravimetric analysis. A copy of the full EPA method is given at the end of this report. Provided here is a brief summary of the analysis protocol utilized on the samples.

Procedure: Oil & Grease Extraction from water, modified from EPA Method 1664:

a. An amber 1000 mL glass bottle containing water and sample are checked for pH level of less than 2 by dipping a glass stirring rod into the bottle. A drop of the sample is allowed to fall onto pH paper for determination of pH. If the pH of sample solution is above pH of 2, addition of 1mL of concentrated HCl is added to the sample and mixed by hand (shaking of bottle). If sample is not at pH<2 addition of more HCl is required until the sample solution has reached a pH< 2 indicated by the pH paper. Glass rod is rinsed with small amount of n-Hexane back into sample bottle.

b. Extraction of Sample. Sample is poured into a 2 L separatory funnel. To the empty sample bottle, 30 mL of n-hexane is added and shaken to rinse the interior surfaces of bottle. The n-hexane is then poured into the separatory funnel. Extraction of organic material is performed by shaking the separatory funnel for no more than 2 minutes and frequently vented. After shaking, the organic and aqueous phases are allowed to separate and stand for 15-20 minutes. Aqueous layer (lower layer in separatory funnel) is allowed to drain off into original glass bottle (sample container) for future extractions. A small amount of the organic layer is allowed to pass through with the aqueous layer to reduce water uptake in sample. About 10 grams of sodium sulfate was placed in filter paper which was placed in a filter funnel and rinsed with 20 mL of n-Hexane (the n-Hexane rinsate is discarded). Organic layer is then drained through sodium sulfate into a tared 100 mL round bottom flask containing two glass balls. A repeat of extraction of the sample is carried out a second time. After obtaining the second extraction, the 100 mL RB flask is put on a flash evaporator (roto-evaporator) to pull off the n-hexane. A third extraction is performed as above with additional steps. The separatory funnel is rinsed with 15 mL of n-hexane including the tip of the separatory funnel and 10 mL of n-hexane through the sodium sulfate. The RB flask containing the third extraction and rinse is put on the roto-evaporator. The n-hexane is pulled off until RB flask is dry. The RB flask containing sample is placed in a desiccator and allowed to completely dry for a day or more and then weighed.

c. Cleaning of glassware.

i) 1000 mL Amber glass sample bottles are cleaned using soap, rinsed with tap water and then rinsed with DI water. Next bottles are rinsed with 10-20 mL of n-hexane, and allowed to dry. PTFE-lined caps are also included in this process.

- ii) 100 mL round bottom flasks are cleaned using 5-10 mL of methylene chloride, 5-10 mL of acetone and 5-10 mL of isopropyl alcohol. The RB flask are allowed to bake in an oven overnight and then placed in a dessicator while hot to prevent absorption of water while cooling.
- iii) 2 liter separatory funnels are rinsed with n-hexane and acetone, then water washed, and then again with DI water. Separatory funnels are air-dried.
- iv) Filter funnels are rinsed with small portion of n-hexane, then with DI water, and a last rinse with acetone. Allowed to air dry.
- v) Sodium Sulfate is dried in an oven at 160-180 and placed in a desiccator before use.

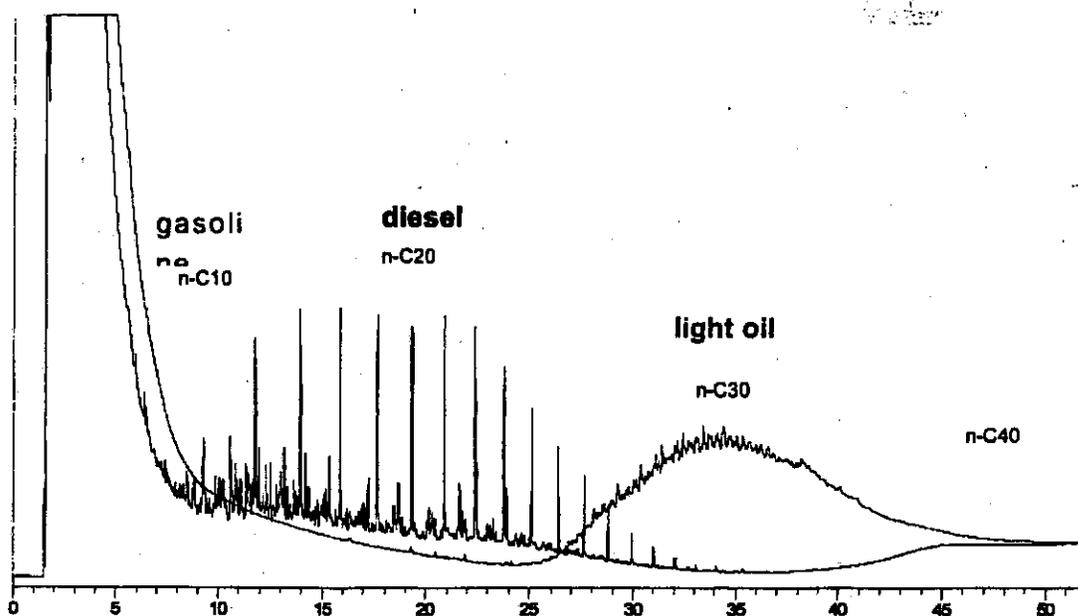
d. **Quality Control and Quality Assurance for Oil and Grease in Water Analysis.** The oil and grease or Hexane Extractable Organic Material (HEOM) technique was checked using an lab prepared test sample prepared using used motor oil dissolved in deionized water at a concentration of 10ppm, 5ppm, 1ppm and 0.5 ppm. The test samples were analyzed by the same extraction methods as described previously. The results show a 95% or greater extraction percentage for the 10ppm and 5ppm samples. The lower concentration samples of 1ppm and 0.5 ppm are characterized by a lower overall average extraction percentage of 80% using the hexane based extraction procedure.

The resulting oil and grease from water extraction analysis was washed into a small bottle with n-hexane for subsequent analysis by gas chromatography to assist in identification of the specific types of compounds present.

e) **Gas Chromatography FID Analysis for Petroleum Product Classification from HEOM Extracts.**

The quantitative oil and grease analysis of both the water and sediment samples is a gravimetric technique which measures the masses of hexane extractable organic material (HEOM). In addition to the oil, grease, gasoline and diesel vehicle contamination, decomposing plant material would also be extracted in the process. In order to provide conclusive information regarding the chemical identity of the extracted material and its potential link to vehicle contamination, a gas chromatography technique was utilized to further characterize the hexane extracts. Method development utilizing the gas, diesel, oil and grease standards used in the percent recovery sonication versus Soxhlet extraction studies (summarized in Table 1) were utilized to determine if the type of petroleum product could be identified and distinguished with the GC FID method. The use of the Gas Chromatography- Flame Ionization Detection method (GC FID) is a method which separates mixtures into their components based typically on boiling point. In the case of hydrocarbons and petroleum based products, the boiling points of compounds are directly related to the number of carbon atoms in the compounds and somewhat on the molecular arrangement of these carbon atoms in the compound structure. For example, a compound containing a greater number of carbon atoms would be expected to have a higher boiling point and would be retained in the GC-FID column longer. To test the applicability of this technique to the samples from the present study, GC-FID was performed on standards used in the sonication extraction method test and confirmed that each standard was identifiable by GC FID. Additionally, the technique detection limit was well below the 20 parts per thousand standards used in method development. **Figure 1** shows the separation of the oil and grease standards in a typical gas chromatogram with the ranges of each type of petroleum product listed above their corresponding peaks.

The use of the GC FID was determined to be capable of identifying each type of standard petroleum product based upon retention time in the chromatographic column. The detection limit of the technique was well below the 20 ppt standards utilized in the study. Figure 1 shows the separation of the petroleum standards with the characteristic retention time ranges labeled above the peaks. The labels C-10, C-20, C-30 and C-40 refer to the hydrocarbon chain length (number of carbon atoms) for the different petroleum products which increases in the order gas < diesel fuel < light oil < heavy oil. This same ordering related to the volatility of the petroleum products with gasoline being the most volatile and likely to dissipate into the atmosphere over time.



**Figure 1.** GC FID Chromatogram of separation and identification of different oil and greases. The figure represents the overlay of standard gas, oil and grease standards to illustrate that different signals are obtained from the distinct type of petroleum product present. If more than one product is present, each will be observed with only minor overlap between signals. Data Source: CREST CSUS; Ric Cuchetto and Ted Foster, PhD ( Folsom Lake College).

**2. Solvent Extractable Oil and Grease from Sediment Samples.** The EPA provides two acceptable methods for the analysis of oil and grease (and other organic solvent extractable species) from solid or slurry sediments. Methods 3550b and 3550c are procedures for extracting nonvolatile and semivolatile organic compounds from solids such as soils, sludges and wastes. The ultrasonic process ensures intimate contact of the sample matrix with the extraction solvent. The detailed EPA procedure is provided at the end of this report.

The second EPA method for oil and grease analysis in sediments involves a Soxhlet extraction. Method 3540 is a procedure for extracting non-volatile and semivolatile organic compounds

from solids such as soils, sludge and wastes. The Soxhlet extraction process ensures intimate contact of the solvent with the sample matrix.

Both methods suffer slightly from the potential loss of volatile organic compounds and as a result, the obtained data should be viewed as measuring slightly low for extractable organic components. The EPA sources imply that the Soxhlet procedure may be somewhat superior to the sonication method in extraction efficiency and its ability to retain the volatile organic components ([www.epa.gov](http://www.epa.gov)). However, the Soxhlet analysis procedure is considerably more labor and time intensive, resulting in lower sample throughput. Given the large number of sediment samples collected for analysis, we determined it advisable to evaluate a direct in lab comparison of the two methodologies on standard samples closely representing the actual samples to be analyzed.

The two analysis methods were tested on duplicate samples of a standard sediment prepared by mixing a laboratory sediment composed of silica, Ottawa sand and white quartz with used motor oil. The sonication method was compared using a mixed solvent system of dichloromethane and n-hexane with the process utilizing pure n-hexane as the solvent system. Table 1 summarizes the results of the method comparison. The sonication method appeared to more consistently extract a higher percentage of oil and grease when the mixed solvent system was employed. Therefore, all future sediment sonication extractions employed the mixed solvent system.

The Soxhlet and sonication methods were then compared for percent recovery of extractable petroleum using petroleum standards made up at 20 ppt for diesel fuel, motor oil, lube oil, and transmission oil (20% each by mass). These standards were prepared by placing 50 ml of water and 50 ml of commercially purchased oil and grease (gasoline, diesel, motor oil, lube oil, and transmission oil) in a 150 ml graduated cylinder. A degassing apparatus was used to pump nitrogen gas from the bottom of the cylinder through the water up and through the oil for 4 hours to simulate weathering of the oil. The objective was to subject the oil to conditions on the trail as to get a more reliable data for comparison to sediment samples. The percent recovery (extractable return) for diesel fuel, motor oil, lube oil, and transmission fluid was 87 %, 98%, 98%, and 99% respectively. Gasoline average recovery was very low resulting in a 10 % recovery. Therefore, in the determination of light, gasoline type petroleum components, a different analysis method must be employed to detect gasoline range organics.

**Table 1** Summary of standards employed and analysis results from the comparison of the Soxhlet and sonication sediment HEOM (oil and grease) analysis procedures.

<b>Standards</b>	<b>Percent Extractable Material Recovery Sonication Method</b>	<b>Percent Extractable Material Recovery Soxhlet Method</b>
Std #1, 35mg/g hex/dichloro	75	
Std #2, 35mg/g hex/dichloro	82	
Std #3, 35mg/g hex/dichloro	85	
Std with oil #1 hexane	79	
Std with oil #2 hexane	83	
Std with oil #3 hexane	79	
Gasoline Std #1 10/20/05	14	9
Gasoline Std #2 10/20/05	9	18
Diesel Std #1 10/20/05	81	84
Diesel Std #2 10/20/05	87	86
Motor Oil Std #1 10/21/05	98	99
Motor Oil Std #2 10/21/05	95	100
Lube Oil Std #1 10/21/05	95	98
Lube Oil Std #2 10/21/05	96	100
Transmission Std #1 10/25/05	99	100
Transmission Std #2 10/25/05	95	100
*All GDMLT Std #1 10/25/05	84	85
*All GDMLT Std #2 10/25/05	80	82

Source: CREST CSUS \* GDMLT Standards were composed of 20% Gasoline; 20% Diesel fuel; 20% motor oil; 20% lubrication oil; 20% transmission fluid.

The numerical data for these method standardization experiments is provided in Table 1. Since both the sonication and Soxhlet methods compared very closely in percent recovery and reproducibility, EPA Method 3550c (sonication) was chosen as the main extraction procedure of sample after July 07, 2005. The reason for choosing Method 3550c is that it requires less time, uses less solvent, and results in an overall reduction in analysis cost per sample. The following represents a working summary of the standard operating procedure used in the monitoring study.

#### a) Sonication of Sediment Samples.

\* Materials and procedure below are for one trial per sample. Three trials were completed for each sample for a total of 45 g of sample.

**Summary of Sonication Procedure.** A 100 mL round bottom flask which contains 3 glass beads is pre-weighed. The syringe filter holder and 1.6-micron filter on top of a 0.7-micron filter is attached to the syringe. The 100 mL round bottom flask is placed below the tip of the filter holder and attached syringe. 15.0 grams of sample weighed to the nearest 0.1mg is placed in 100. mL beaker. 15 grams of sodium sulfate is added to the sample and mixed well. 15mL of hexane

and 15mL of dichloromethane is added to the beaker and stirred gently. The beaker is placed in a sonicator and sonicated for 6 minutes. Gentle stirring is performed midway through the sonication at approximately 3 minutes.

Upon completion of the sonication procedure, the sample solvent mixture is slowly transferred into the syringe using a glass rod to prevent sediment from entering the syringe. The liquid is filtered through the filter holder and collected in the weighed round bottom flask. The process is repeated with an additional 15mL of hexane and 15 mL of dichloromethane. The second filtrate is added to the first filtrate in the round bottom flask. The round bottom flask is then attached to the flask evaporator to remove some of the solvent. 15mL of hexane and 15mL of dichloromethane is added to the beaker still containing the sample. The beaker is sonicated again for 6 minutes.

The sample is filtered through the syringe apparatus depositing the filtrate in the round bottom flask containing the first two sample filtrates. The syringe is then rinsed with 5.0 mL of hexane and 5.0 mL of dichloromethane in order to rinse any oil and grease adhering to the glass into the round bottom flask. The solvent is then removed from the round bottom flask using a roto-evaporator. The resulting round bottom flask containing the oil and grease contaminants of interest is then set in a dessicator for a minimum of 6 hours prior to weighing.

**3. Core Samples.** A limited number of core samples using pvc pipe were obtained to evaluate if contamination was diffusing downward through the sediment layers. It is not unreasonable to expect that with precipitation events, the oil, grease, and metal contamination might be carried downward through the sediment and sequester in a hospitable more organic (humus rich) soil environment. Samples were obtained from areas suspected of contamination problems, such as Spider Lake and Lower Little Sluice. A field blank was obtained at a site on the trail, but predicted to have been exposed to minimum vehicle or human contact through physical and olfactory observations.

Core samples were obtained by pounding 2-inch diameter, 2-foot length of cleaned pvc pipe into the sediment. Some samples were less than two foot in length due to hitting impenetrable material. Markings were placed on the outside of the pvc pipe to indicate the level of sample obtained. The samples were capped, transported back to the laboratory and maintained refrigerated at 4°C in the pvc tubes until analysis. Prior to analysis, the tubes were sawed open and the physical appearance of the core sample was documented. In most cases, the undisturbed core sample was photographed. In most samples, a clear gradient or layer like appearance was evident.

Each core sample was analyzed for HEOM (Hexane Extractable Organic Material) in two-inch increments following the same procedure used on the surface sediment samples. The sediment sonication methodology using the mixed solvent system was employed on these samples. Each sample was run in duplicate.

**4. Metals Analysis in Core Sediment Samples.** Fresh portions of core sample were taken from the main core monitoring sample for heavy metal analysis. A 15 gram sample of core sediment was weighed and placed in a clean beaker containing 30 mL nanopure water.

The core sample sediment / nanopure water mixture was sonicated for 6 minutes with mixing after 3 minutes in order to release the water soluble heavy metals contained in the sediment. The sediment slurry was centrifuged for 10 minutes to separate the sediment from the water and then filtered using a 0.3-micron filter using the same filtering apparatus and technique utilized in the sediment oil and grease procedure previously described. The filtering removes particulate matter from the sample.

The resulting soluble metal containing water sample was analyzed for copper and cadmium utilizing atomic adsorption spectroscopy. Atomic adsorption spectroscopy was performed using a Perkin Elmer atomic adsorption spectrophotometer equipped with a graphite furnace. This technique is capable of providing metal concentrations down to the parts per trillion for the metals of interest to the present study. In each case the furnace temperature program employed were those recommended (Varian Analytical Instrument Co) for the specific metal. In the case of copper analysis, trace metal grade nitric acid was added to the sample (5%) as a matrix modifier.

For cadmium, trace metal grade phosphoric acid is added as the matrix modifier (5%). These modifiers are required to assure that the metal ions in solution are in the appropriate form for accurate analysis. Calibration curves for each metal were prepared using atomic adsorption standards purchased from Varian Instrument Company. Dilutions of these standards were prepared using nanopure water. The calibration curve standard concentrations were prepared using the instrument's automation capabilities. Instrument and sample preparation blanks were composed of nanopure water with 5% nitric acid or phosphoric acid depending on the metal ion being analyzed.

### **III. Results from Preliminary Monitoring**

**A. Physical Observation of Rubicon Trail.** Each sampling expedition consisted of a minimum of five individuals. In addition to sample collection, these individuals took a visual and olfactory survey of the trail at each sampling site and collection date. One notable physical change observed was the change in the amount of water present on and around the trail as a function of time throughout the summer season. For example, the June sampling period contained smaller creeks, streams, and pools of water. Many of these smaller water bodies were completely dried up by the July 7th sampling date. As a result, the sampling protocol for many sites changed based upon these changing conditions.

In terms of contamination observations, the consistent perception by each sampling individual was that the trail showed strong visual and olfactory-based evidence of contamination associated with vehicle use. The types of contamination included puddles of oil, drip paths and grease spots on the rock and surrounding soils. These areas were also characterized by strong petroleum based odors.

The quantity of contamination was observed to significantly increase as a function of time from the June 28th sampling through the July 7th and August 1st sampling dates. Additionally, the level of visual and olfactory contamination levels was perceived to be very site specific. For example, an area of the trail named "Little Sluice" represented one of the most obviously

contaminated areas of the trail and one showing the greatest increase in vehicle based contamination as a function of time throughout the season.

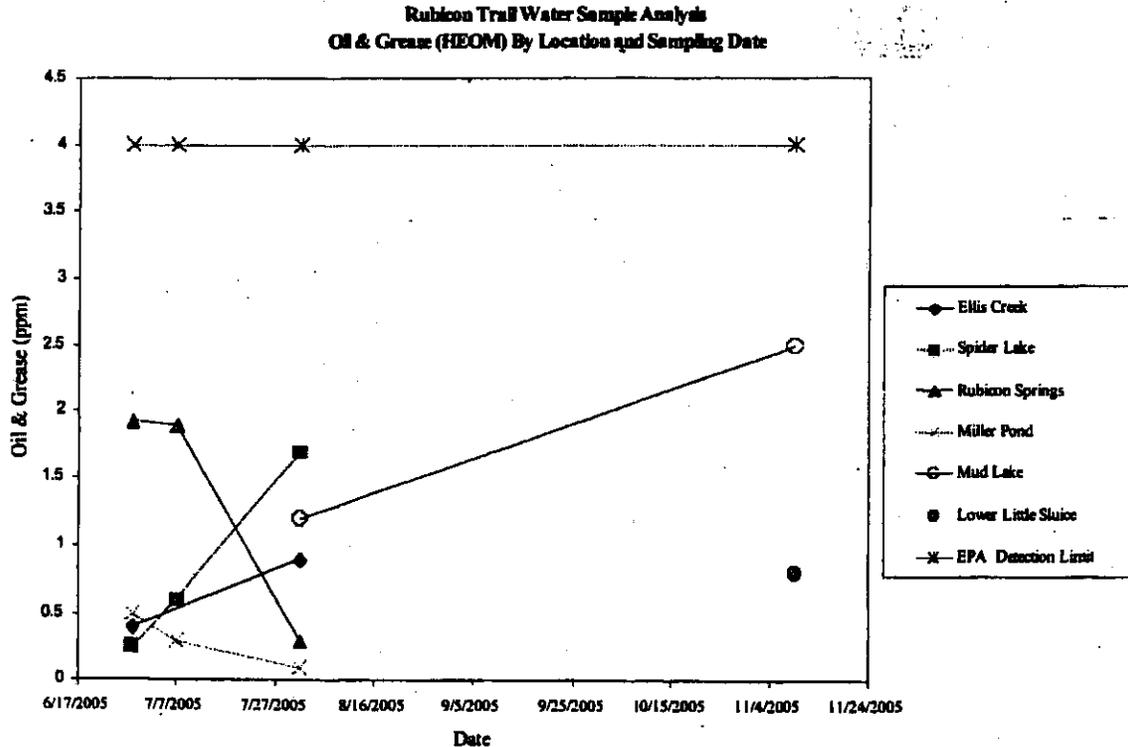
Another area that showed a significant increase in contamination (based on visual perception) was the area immediately around Spider Lake. This site was observed to be increasingly contaminated with human excrement and litter as well as vehicle based contamination.

On the other hand, there were other portions of the trail which showed very little evidence of environmental impact throughout the sampling dates. These unimpacted sites were used to represent field blanks for data comparisons. Notes and photographs were taken to document the trail conditions during each sampling. For example, Figure 2 illustrates some of the contamination incidents observed in Little Sluice. We would recommend that a more diligent and detailed survey of the trail condition throughout the season would be beneficial to determine the changing trail conditions. This would best be accomplished through GPS mapping the trail into discreet sections and visually counting, typing and estimating the size of contamination spots throughout the recreational season.

**B. Oil and grease in water samples.** The analysis of oil and grease in water samples depends upon the ability to obtain an adequate water sample. In this study, the ability to obtain water samples changed throughout the study timeline due to drying conditions occurring over the summer study period. We found fewer opportunities for water sampling as the season progressed. In some instances, water sampling locations early in the season were transformed into sediment sampling locations by the July sampling date. The November 9th sampling followed a significant rain event which again provided more sites with accumulated water sufficient for water sampling.

Figure 2 graphically depicts the trend in HEOM results as a function of sampling date and compares these values to the EPA detection limit for the method. Overall, only a slight increase in oil and grease contamination is observed as a function of time throughout the sampling period up until and including the August sample collection date which corresponds to the heavy recreational use period. However, this data must be evaluated cautiously since this may not be taken to imply that oil and grease contamination is absent from the water bodies. In fact, it may only imply that contamination in water bodies is dissipated into the larger water body very quickly, thereby diluting the contamination down to background levels of contamination; that the oil and grease is carried and accumulated in another location by the flowing water; or that the oil and grease quickly incorporates into the sediment adjacent or at the floor of the water body sampled. It may also imply that little oil and grease contamination is directly introduced into the trail water bodies. Additionally, oil and grease from vehicle contamination represents only a subset of the possible organic compounds which may be extracted via the hexane extraction method utilized in this portion of the study. There are also some naturally occurring compounds which would also be extractable by the techniques employed here. As a result, the recommendations for future study suggest that the water extracts be further analyzed by gas chromatography and mass spectrometry which would provide direct information regarding the type (and source) of compounds included in the extracts.

Further examination of Figure 2, including the results of the sampling date represented by November 9th, 2005, shows a more significant increase in the HEOM obtained from the water sampled during this time. Again, the November sampling date occurred following the first significant rain event of the season. We hypothesize that the rain event may have washed some surface oil and grease contamination into the water body to account for the observed increase in HEOM. However, this second observed increase appears low based upon a perhaps incorrect initial assumption that the entire surface oil and grease contamination may have been carried via storm water run-off into the fed water body.



**Figure 2. Oil and Grease Contamination in Rubicon Trail Water Bodies. Data Source: CREST. EPA Water Quality Level Regulates Oil and Grease Contamination in Water greater than 15ppm.**

Table 2. summarizes the numerical data for the water sample oil and grease determination levels. The numerical data is represented in ppm or ug/L. The numerical data illustrates that the initial sampling on June 28th presented a significant number of water sampling sites. The vast majority of sampling sites showed very small quantities of HEOM. Oil and grease is largely insoluble in water and less dense than water. As a result of these properties, oil and grease contamination would be expected to form a grease-like thin film on the top of the water and to accumulate near the shore-line with the winds blowing toward shore. Particular attention was paid to water sampling in these locations.

For example, Spider Lake was sampled on the shore with the wind blowing toward the sampling direction. Any oil and grease film on the surface of the water would be expected to accumulate near this sampling site. Very little HEOM was obtained from samples collected on the June 28th sampling at any of the water sampling locations. Examination of the HEOM levels obtained as a function of sampling time for particular sites such as Mud Lake show a slight additional increase in HEOM as a function of sampling date. However, the increases observed were not large. The EPA states that the maximum concentration of oil and grease in water be below 15 ppm to meet water quality standards. The data obtained from the samplings on the Rubicon Trail during the 2005 season are well below this value. In fact, the values are below the 4 ppm method detection limit.

Table 2. Oil and grease (HEOM) analysis data of Rubicon Trail water samples as a function of the sampling date and trail location during the 2005 season.

Rubicon Trail Water Oil/Grease			
Date	Bottle #	Description of Sample/Site	O&G (ppm)
6/28/2005	118	Ellis Creek d/s @ crossing, lake side of fallen log, Water Depth 1ft.	0.0
6/28/2005	123	Ellis Creek d/s @ crossing, lake side of fallen log, Water Depth 1ft.	1.3
6/28/2005	143	Ellis Creek d/s @ crossing, lake side of fallen log, Water Depth 1ft.	0.2
6/28/2005	60	Ellis Creek u/s @ crossing near west bank, Water Depth 1ft.	0.4
6/28/2005	77	Ellis Creek u/s @ crossing near west bank, Water Depth 1ft.	0.1
6/28/2005	90	Ellis Creek u/s @ crossing near west bank, Water Depth 1ft.	0.4
6/28/2005	134	Spider Lake, reddish pool, 3 to 4 inches deep, ED#4 East of man made dam, pic #18	0.0
6/28/2005	119	Spider Lake Water Depth 12 to 18 inches, winds low towards sampling area, pic 11&12	0.0
6/28/2005	138	Spider Lake Water Depth 12 to 18 inches, winds lows towards sampling area, pic 11&12	0.1
6/28/2005	142	Spider Lake Water Depth 12 to 18 inches, winds lows towards sampling area, pic 11&12	0.9
6/28/2005	129	Rubicon Springs u/s @ 1410	1.5
6/28/2005	130	Rubicon River d/s @ 1430 1 of 2	0.6
6/28/2005	110	Rubicon River d/s @ 1430 2 of 2	3.7
6/28/2005	109	Miller Pond 1 @ 0920	0.5
7/7/2005	Bag	East of Dam, Spider lake, GPS- notebook	0.6
7/7/2005	Bag	On trail water sample GPS- 39° 1ft. 18.99 in N, 120° 16ft. 52.457 in W	0.2
7/7/2005	115	Rubicon Site #4 d/s from plastic #331 @ 1345	2.0
7/7/2005	120	Rubicon Site #2 u/s from plastic #330 @ 1417	1.8
7/7/2005	114	Miller Pond #2 @ 1000	0.3
7/7/2005	132	Miller Pond #1 @ 0930	0.3

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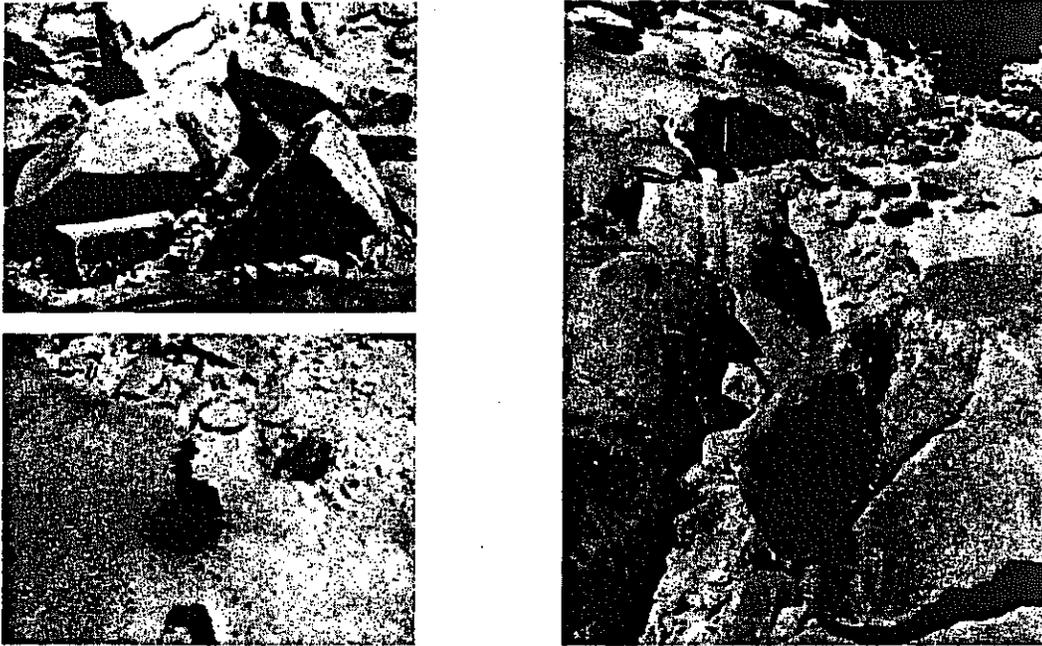
8/1/2005	165	Rubicon upstream @ 1117	0.3
8/1/2005	177	Rubicon River d/s @ 1145	0.3
8/1/2005	49	Miller Pond #2 @ 0830	0.1
8/1/2005	147	Rubicon River below Creek 10 ppm TDS @ 1205 pH 6.7@ 19C	0.0
8/1/2005	75	Spider Lake Site #1 @ 1025	1.7
8/1/2005	70	Mud Lake North side of lake @ 1346	1.2
8/1/2005	94	Ellis Creek u/s water 8" deep not flowing very fast @1508	0.9
8/1/2005	86	Ellis Creek d/s water 2-6" deep flowing quickly @ 1508	0.9
11/9/2005	200	Mud Lake #1 11/09/05 B#200	2.6
11/9/2005	172	Mud Lake #2 East End 11/09/05 B#172	3.1
11/9/2005	148	Mud Lake #3 West End 11/09/05 B#148	1.8
11/9/2005	166	Lower Little Sluice 11/09/05 #166	1.7
11/9/2005	174	Lower Little Sluice 11/09/05 #174	0.5
11/9/2005	169	Lower Little Sluice 11/09/05 #169	0.8
11/9/2005	202	Lower Little Sluice 11/09/05 #202	0.2

**C. Results from Analysis of Oil and Grease in Sediments.**

General physical and olfactory observations of the trail immediately indicated an increase in sediment contamination as a function of recreational trail use at the Little Sluice, Spider Lake and other more randomly distributed sties along the trail. As shown in Figures 3 and 4, oil and grease contamination was obvious at specific sites throughout the sampling season.

**Figure 3. Lower Little Sluice 07/07/05**



**Figure 4. Lower Little Sluice 08/01/05**

Oil and grease analysis utilizing the sonication method with the mixed dichloromethane / hexane solvent system was employed to determine the extent of sediment contamination. Sediment samples were taken from the surface of the trail, not penetrating more than two inches. The results indicate high levels of sediment contamination in the tens of parts per thousand which translates into mg HEOM per gram of sediment. Table 3 summarizes the sediment extraction results from different sites along the trail at each sampling date.

**Table 3. Summary of Rubicon Trail sediment analyses for HEOM (oil, grease and other petroleum products).****Sediment HEOM Hexane Extractable Organic Material (Oil and Grease) Analysis**

<u>Description</u>	<u>Type</u>	<u>Conc Sample (mg/g sed)</u>	<u>Average (mg/g sed)</u>
<b>6/28/2005</b>			
Blank #1 GC FID	MB	0.0	0.00
Blank #2 GC FID	MB	0.0	
Field Blank, #401.1, 6/28/05	Son	0.1	0.10
Field Blank, #401.2, 6/28/05	Son	0.1	
Field Blank, #401.3, 6/28/05	Son	0.2	
Field Blank, #401.1, 6/28/05	Sox	0.4	0.35
Field Blank, #401.2, 6/28/05	Sox	0.3	
Ellis Creek crossing, #402.1, 6/28/05	Son	0.1	0.10
Ellis Creek crossing, #402.2, 6/28/05	Son	0.0	
Ellis Creek crossing, #402.3, 6/28/05	Son	0.0	
Ellis Crk. cross., #402.1, both side, 6/28	Sox	0.7	0.55
Ellis Crk. cross., #402.2, both side, 6/28	Sox	0.4	
seasonal creek crossing, #403.1, 6/28/05	Son	0.0	0.00
seasonal creek crossing, #403.2, 6/28/05	Son	0.0	
seasonal creek crossing, #403.3, 6/28/05	Son	0.0	
seasonal creek crossing, #403.1, 6/28/05	Sox	0.2	0.20
seasonal creek crossing, #403.2, 6/28/05	Sox	0.2	
S. Lake sed., #405.1, 6/28/05	Sox	55.3	40.05
S. Lake sed., #405.2, 6/28/05	Sox	24.8	
S. Lake sed., #405.1, 6/28/05	Son	23.9	23.80
S. Lake sed., #405.2, 6/28/05	Son	23.9	
S. Lake sed., #405.3, 6/28/05	Son	23.0	
S. Lake sed., #405.11, 6/28/05	Son	23.6	23.50
S. Lake sed., #405.22, 6/28/05	Son	23.4	23.40
S. Lake; site 1, #406.1, 6/28/05	Sox	17.2	19.20
S. Lake; site 1, #406.2, 6/28/05	Sox	21.2	
S. Lake; site 1, #406.1, 6/28/05	Son	18.7	15.90
S. Lake; site 1, #406.2, 6/28/05	Son	16.7	
S. Lake; site 1, #406.3, 6/28/05	Son	12.4	
Middle Little Sluice #408.1 6/28/05	Son	0.1	0.20
Middle Little Sluice #408.2 6/28/05	Son	0.2	
Middle Little Sluice #408.3 6/28/05	Son	0.2	
Middle Little Sluice #408.1 6/28/05	Sox	0.1	0.15
Middle Little Sluice #408.2	Sox	0.2	
Miller Pond 1, #415.2, 6/28/05	Sox	0.4	0.20
Miller Pond 1, #415.3, 6/28/05	Son	0.0	
Rubicon R., #414.1, 6/28/05	Sox	0.4	0.40

7/7/2005

Blank #3 GC FID	MB	0.0	0.00
Blank #4 GC FID	MB	0.0	
Ellis Creek West-1, 7/7/05	Sox	0.2	0.20
Ellis Creek West-2, 7/7/05	Sox	0.2	
Ellis Creek West-1, 7/7/05	Son	0.1	0.10
Ellis Creek West-2, 7/7/05	Son	0.1	
Ellis Creek West-3, 7/7/05	Son	0.1	
Field Blank, #401.1, 7/7/05	Son	0.3	0.23
Field Blank, #401.2, 7/7/05	Son	0.2	
Field Blank, #401.3, 7/7/05	Son	0.2	
Field Blank, #401.1, 7/7/05	Sox	0.6	0.60
Field Blank, #401.2, 7/7/05	Sox	0.6	
L.L.S. 422.22, 7/7/05	Son	28.1	24.30
L.L.S. 422.11, 7/7/05	Son	20.5	
L.L.S., #422.1, 7/7/05	Sox	24.6	23.80
L.L.S., #422.2, 7/7/05	Sox	23.0	
Miller Pond 1, #416.1, 7/7/05	Son	0.4	0.40
Miller Pond 1, #416.2, 7/7/05	Son	0.4	
Miller Pond 1, #416.3, 7/7/05	Son	0.4	
Miller Pond 1, #416.1, 7/7/05	Sox	0.2	0.20
Miller Pond 1, #416.2, 7/7/05	Sox	0.2	
Upper L.S., #417.1, 7/7/05	Son	4.9	5.30
Upper L.S., #417.2, 7/7/05	Son	5.6	
Upper L.S., #417.3, 7/7/05	Son	5.5	
Upper L.S., #417.1, 7/7/05	Sox	6.3	6.50
Upper L.S., #417.2, 7/7/05	Sox	5.7	
Overlook seds., 420.1, 7/7/05	Son	25.2	26.50
Overlook seds., 420.2, 7/7/05	Son	26.3	
Overlook seds., 420.3, 7/7/05	Son	28.0	
Overlook seds., 420.1, 7/7/05	Sox	27.0	26.25
Overlook seds., 420.2, 7/7/05	Sox	25.5	
Rubicon d/s #421.1, 7/7/05	Son	0.2	0.20
Rubicon d/s #421.2, 7/7/05	Son	0.2	
Rubicon d/s #421.3, 7/7/05	Son	0.3	
Rubicon d/s #421.1, 7/7/05	Sox	0.2	0.15
Rubicon d/s #421.2, 7/7/05	Sox	0.1	
S. Lake seds., #405.1, 7/7/05	Sox	32.1	27.65
S. Lake seds., #405.2, 7/7/05	Sox	23.2	
Spider site- 405.1, 7/7/05	Son	28.5	28.30
Spider site- 405.2, 7/7/05	Son	28.5	
Spider site- 405.3, 7/7/05	Son	27.9	
Walker Hill-1, 7/7/05	Son	8.5	8.00
Walker Hill-2, 7/7/05	Son	7.5	
Walker Hill-3, 7/7/05	Son	8.0	
Walker Hill-1, 7/7/05	Sox	9.2	8.95
Walker Hill-2, 7/7/05	Sox	8.7	

**8/1/2005**

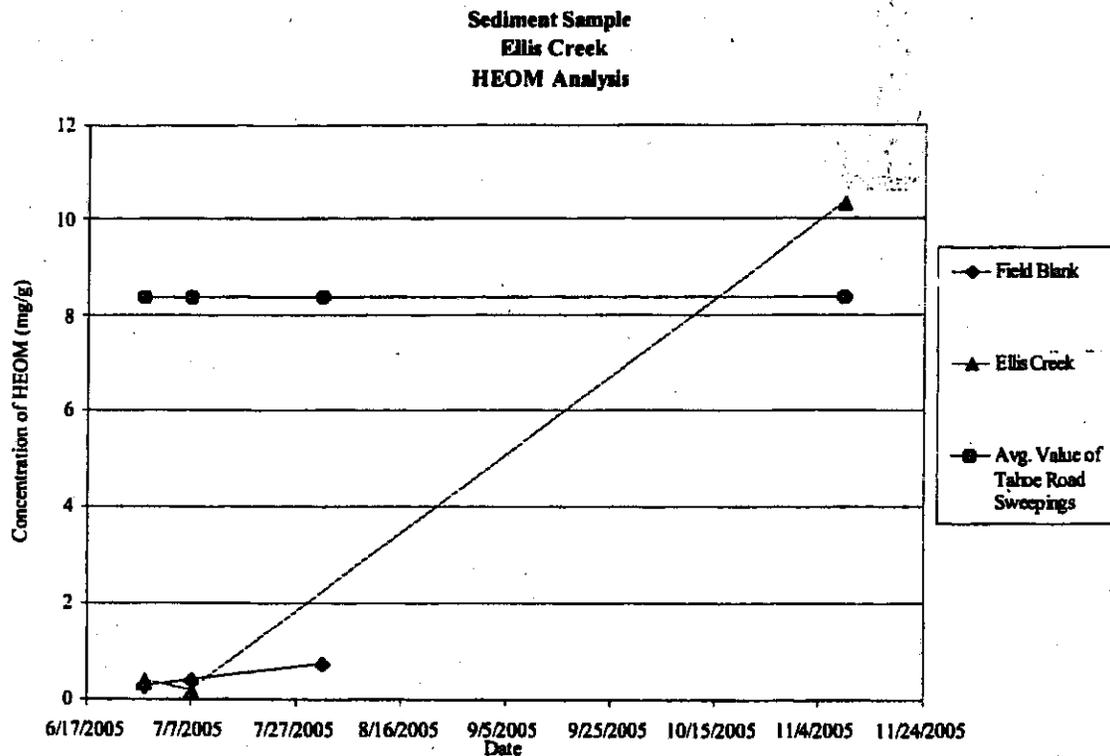
Blank #5 GC FID	MB	0.0	0.00
Blank #6 GC FID	MB	0.0	
Field Blank #1, 8/1/05	Son	0.8	0.75
Field Blank #2, 8/1/05	Son	0.7	
L.L.S. #1, 8/1/05	Son	34.6	31.73
L.L.S. #2, 8/1/05	Son	32.4	
L.L.S. #3, 8/1/05	Son	28.2	
Miller Pond 2, #423.1, 8/1/05	Son	0.2	0.20
Miller Pond 2, #423.2, 8/1/05	Son	0.2	
Miller Pond 2, #423.3, 8/1/05	Son	0.3	
Miller Pond 2, #423.1, 8/1/05	Sox	0.2	
Miller Pond 2, #423.2, 8/1/05	Sox	0.1	
Rubicon R., d/s seds., #412.1, 08/01/05	Sox	0.3	0.16
Rubicon R., d/s seds., #412.2, 8/1/05	Sox	0.3	
Rubicon R., d/s seds., #412.1, 8/1/05	Son	0.1	
Rubicon R., d/s seds., #412.2, 8/1/05	Son	0.1	
Rubicon R., d/s seds., #412.3, 8/1/05	Son	0.1	
Spider site, betw. dam&meadow, #1, 8/1/05	Son	13.1	13.00
Spider site, betw. dam&meadow, #2, 8/1/05	Son	12.4	
Spider site, betw. dam&meadow, #3, 8/1/05	Son	13.5	

**11/9/2005**

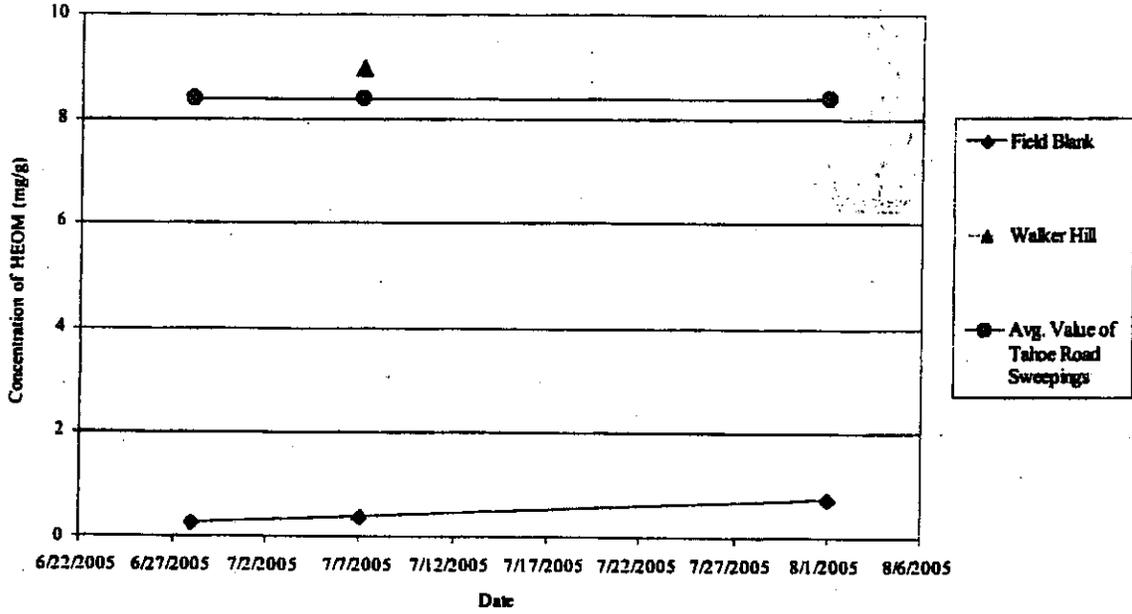
Ellis Creek West 11/09/05 ECW1	Son	12.5	12.50
Ellis Creek West 11/09/05 ECW2	Son	8.2	8.20
Ellis Creek East 11/09/05 ECE1	Son	0.2	0.15
Ellis Creek East 11/09/05 ECE2	Son	0.1	
LLS 11/09/05 #NU1.1	Son	1.5	1.40
LLS 11/09/05 #NU1.2	Son	1.3	
LLS 11/09/05 #NU2.1	Son	0.5	0.50
LLS 11/09/05 #NU2.2	Son	0.5	
LLS 11/09/05 #NU3.1	Son	1.6	1.90
LLS 11/09/05 #NU3.2	Son	2.2	
LLS 11/09/05 Camp Flat	Son	0.2	0.20

The sediment contamination observed on the heavily used portions of the trail showed a significant increase as the recreational season progressed. Figure 5 graphically summarizes the graphical trends in sediment contamination level at locations throughout the trail. In each graph the line representing the Avg. Value of Tahoe Road Sweepings was utilized as a comparison standard. This standard was obtained by a composite of Lake Tahoe road sweeping which was then analyzed for oil and grease using the sonication method utilized on the sediment samples. The field blanks were taken from geologically similar sites close to the trail. These samples were expected to contain an equivalent level of extractable organic material to the trail sampling sites. Field blanks that initially indicated no evidence of HEOM and maintained this no detect

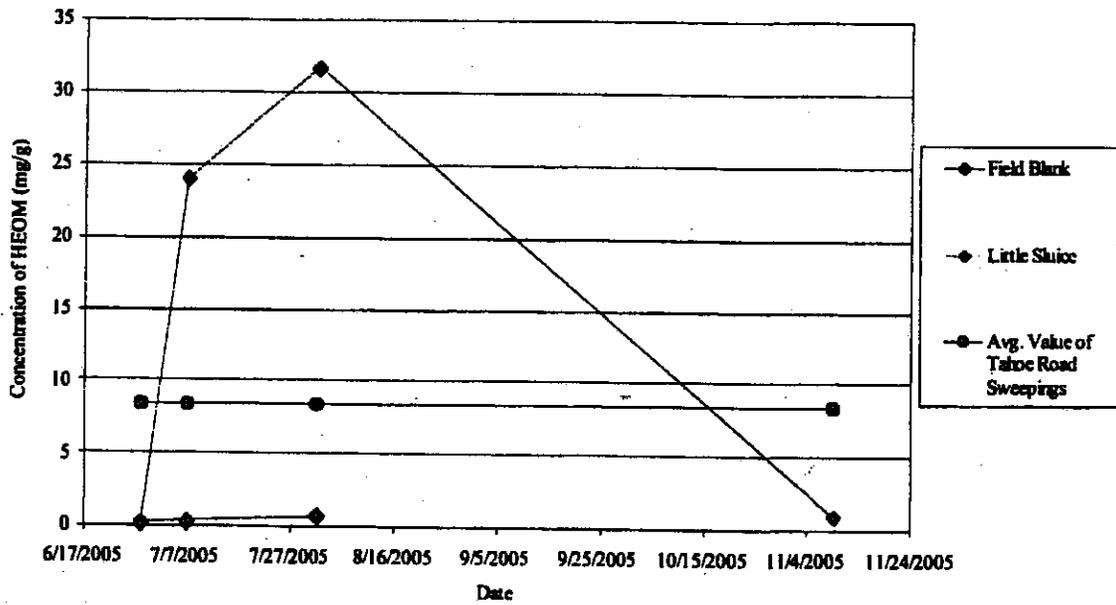
level throughout all sampling dates. Therefore, the zero HEOM levels of the blank samples suggests that at most a very small percentage of the HEOM values obtained in the trail samples is due to naturally occurring organic material, although this direct extrapolation is not conclusive.



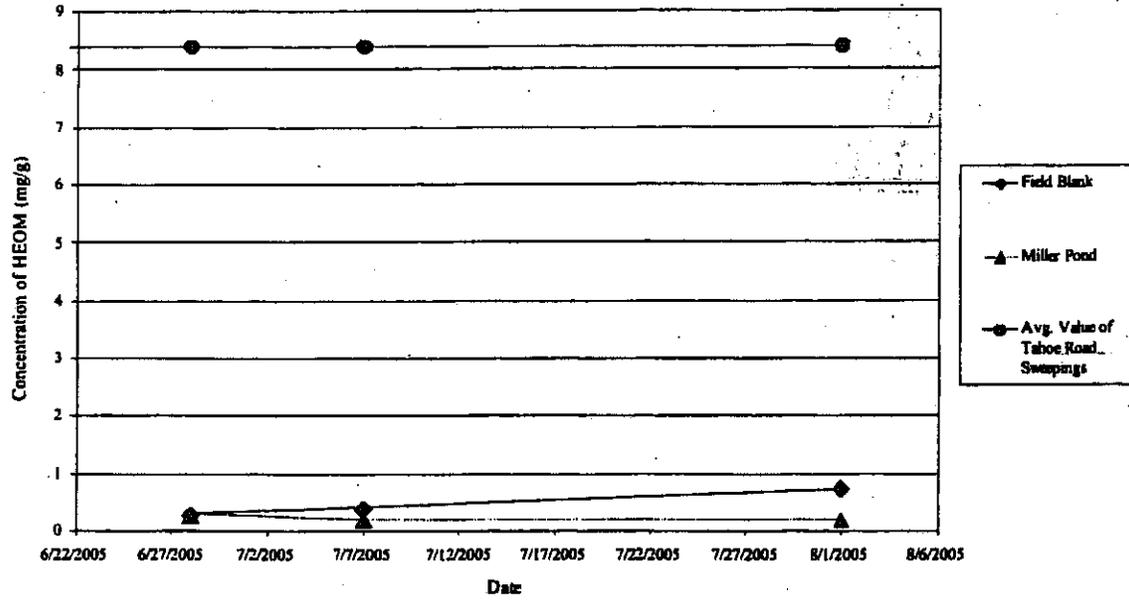
**Sediment Sample  
Walker Hill  
HEOM Analysis**



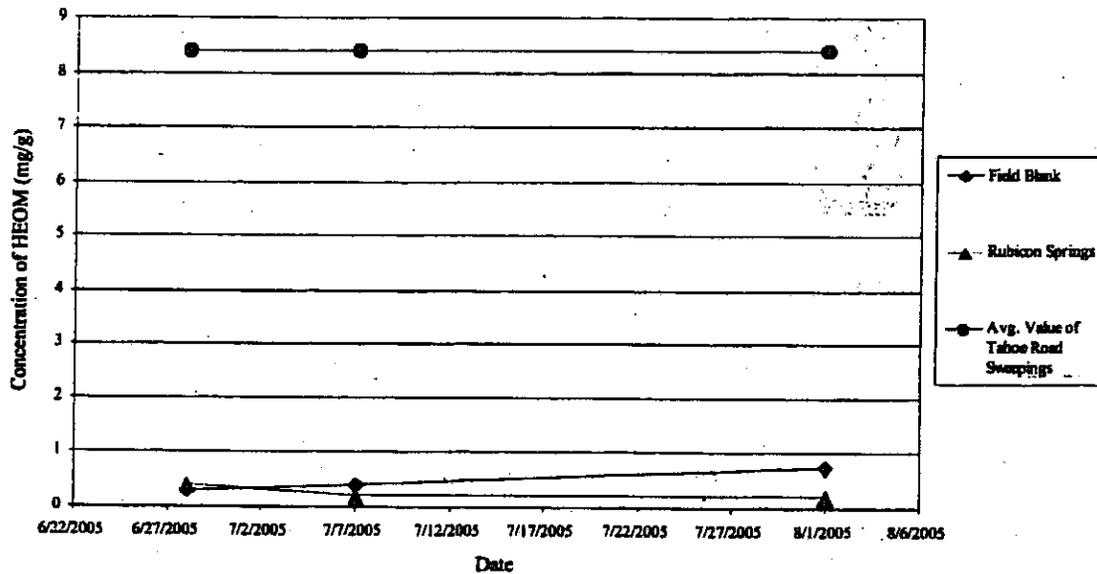
**Sediment Sample  
Little Sluice  
HEOM Analysis**



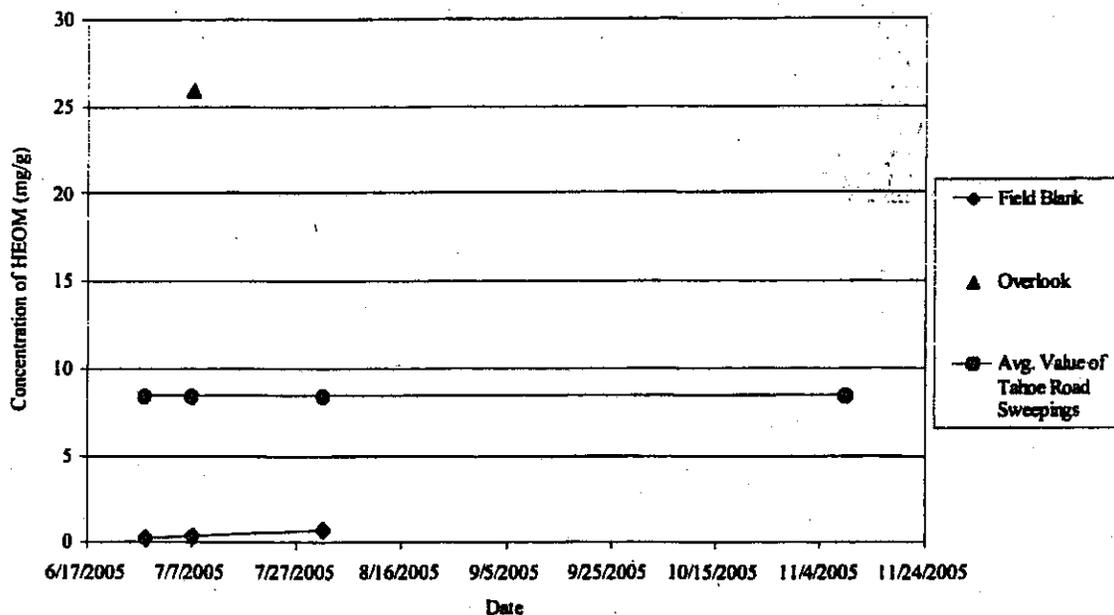
Sediment Sample  
Miller Pond  
HEOM Analysis



Sediment Sample  
Rubicon Springs  
HEOM Analysis



**Sediment Samples  
Overlook  
HEOM Analysis**

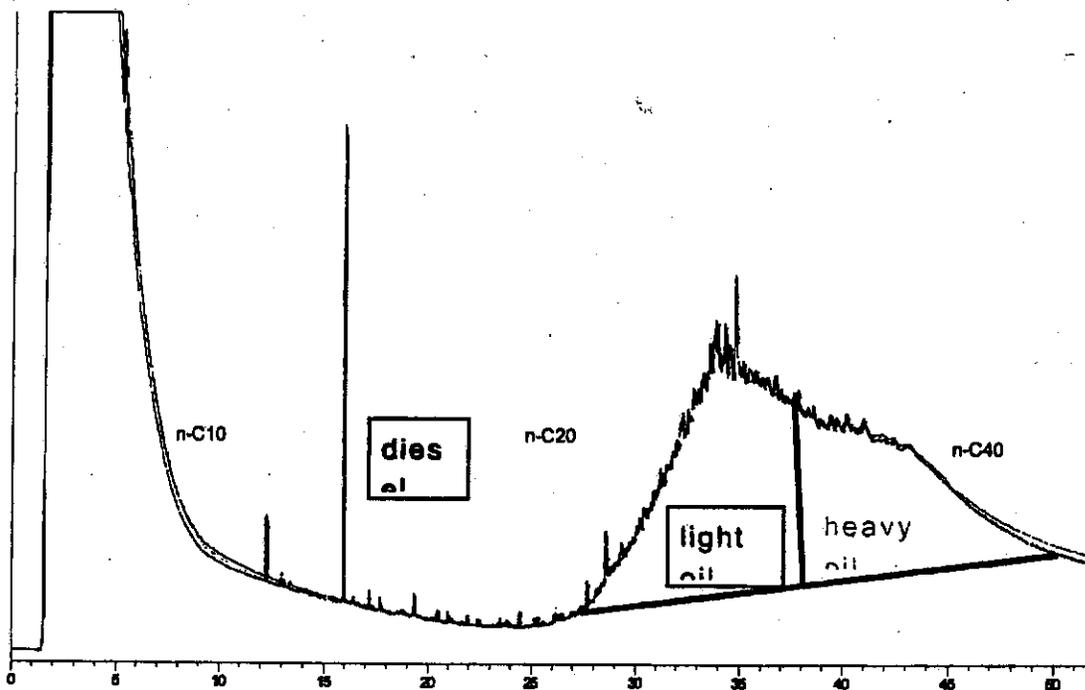


Examination of the graphical depictions illustrates that Ellis Creek and Little Sluice showed a change in sediment HEOM as a function of sampling date. Both the Miller Pond and Rubicon Springs samples showed HEOM levels comparable to the filed blank (an approximate zero detection result). The remaining sampling locations presented data that showed comparable or greater levels of HEOM than that obtained from Lake Tahoe roads. Of particular interest is the data obtained from the Little Sluice location. Closer examination of the Little Sluice graph clearly illustrates a trend in which the sediment contamination increases as a function of time into the recreational use season. The results show that the level of HEOM increased from a very low level (approximately a non-detect value comparable to the field blank) of HEOM on the pre-season 6/28/05 sample to approximately 20 parts per thousand 9 days later on 7/07/06 (post fourth of July holiday use) to over 30 parts per thousand approximately one month later and following two major OHV special events. However, the sediment sampling following the recreational season AND first major rain (November 9th), showed a significant decrease in sediment contamination level (almost a non-detect value comparable to the field blank) in exactly the same locations.

Interestingly, the vehicle-based contamination oil and grease had migrated from the surface level sediment. As this migration took place following the first major rain of the season, it was hypothesized that the contaminants had either washed off the surface level sediment and entered the storm water run-off to enter one of the downstream water bodies, or that it may have been washed into deeper sediment layers. Although the definitive fate of the oil and grease has not been fully determined, the small increase in oil and grease contamination in the nearby water bodies sampled on November 9th does not support the theory that these contaminants are fully

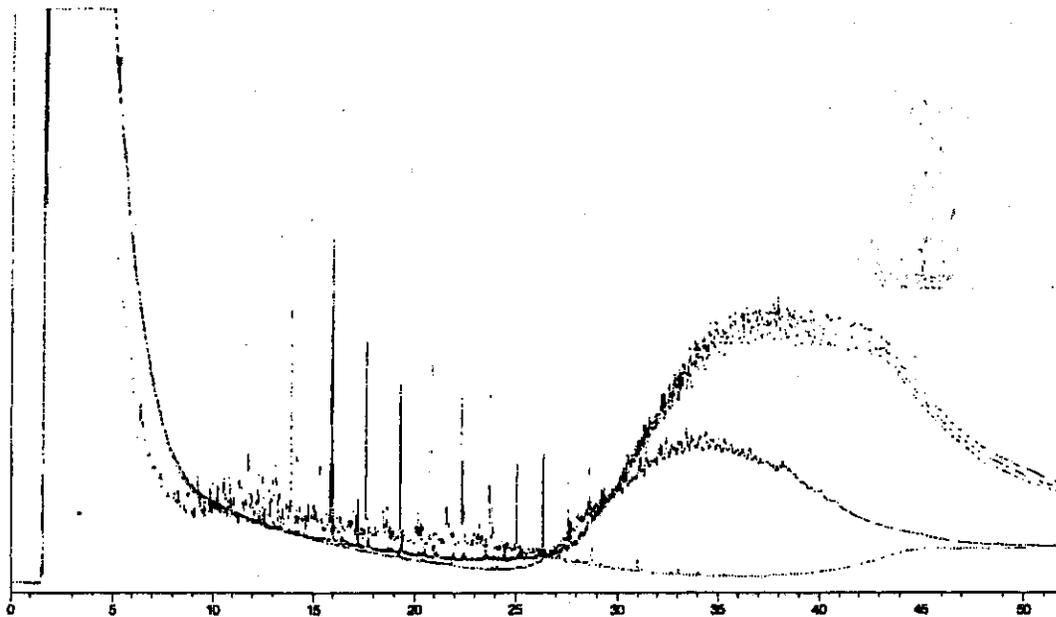
washed into nearby water bodies. In fact, preliminary core sample results indicate a strong possibility that some of the oil and grease may be carried deeper in the sediment where it may sequester and concentrate in soil layers.

All sediment samples and blanks were analyzed by GC-FID to identify types of oil and grease in the sampling area. Most samples had light oil and lube oil in the sediment. An interesting sharp single peak appeared in some samples in the diesel range of organics, yet the rest of the sample only contained light to heavy oil as shown in Figure 6. This peak value is also found in standard analyses of transmission fluid. The peak is thought to be some type of anticorrosion additive, but further analysis using a GC mass spectrometer is required to identify the compound specifically. However, the presence of the peak in the petroleum transmission standard and the environmental sediments serves as a confirming marker that the extracted oil and grease from the environmental sediments is almost certainly vehicle based in origin.



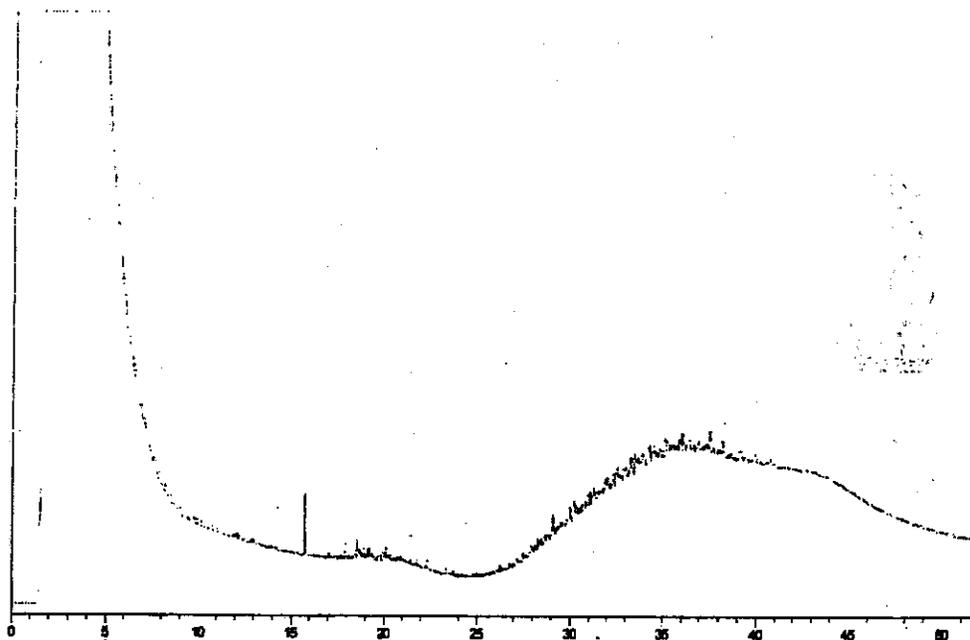
**Figure 6.** GC FID Chromatogram of Spider Lake sediment samples showing light to heavy oil and a single peak in the diesel range. The single peak is characteristic of an additive found in transmission fluid. The presence of this peak in the sediment sample is strongly suggestive that the sediment contamination is a vehicle petroleum product.

To establish this point more conclusively, the Spider Lake sediment extract was "spiked" with a small amount of the standard diesel fuel and light oil standards. The GC-FID of the resulting mixture is shown in Figure 7. In the figure, the green plot represents the unspiked Spider Lake sediment, the orange plot represents pure diesel fuel, and the pink plot represents pure light oil. The aqua blue plot represents the Spider Lake sediment with a spike of diesel fuel. The increase in the peak at 16 minutes column retention time shows that this peak evident in the pure Spider Lake sediment is most likely the additive found in diesel fuel.



**Figure 7.** GC FID Chromatogram of Spider Lake sediment samples with diesel fuel and light oil standard spikes. Note that the single peak found in the sediment is identified as a component in diesel fuel.

Figure 8 shows the GC-FID analysis of three extracts from sediment samples taken at Little Sluice. The extremely close comparison of the three trials illustrates the reproducibility of the analysis methodology. The figure additionally suggests that the sediment extract is composed of gasoline, diesel and oil. Again the transmission fluid peak is again evident in this sample.



**Figure 8.** GC FID Lower Little Sluice sediment sample extracted with the sonication methodology. Note that the sample contains evidence of gasoline, oil and diesel fuel. Again the diesel fuel additive peak is apparent in the sample. The figure represents three extractions of the independent aliquots of the same sample showing the reproducibility of the sonication and GC FID techniques.

#### **D. Results from Core Sample Analysis.**

Little Sluice represents a portion of the trail physically and analytically showing some of the highest levels of vehicular based sediment contamination. Figure 4 shows the steady increase in sediment oil and grease contamination reported in parts per thousand as a function of time throughout the recreational season. However, following the first major rain event a significant decrease (nearly 0 ppt) in sediment oil and grease was observed.

We speculate that the rain event assists in the transport of the oil/ grease contamination. Examination of the Little Sluice November 9th water sample data shows no evidence that the oil and grease was washed into a nearby waterbody. On the other hand, rapid mixing and dilution of the oil and grease in the large water might obscure any indication of this transport mechanism. Alternatively, the oil and grease is comprised of organic components which are hydrophobic (water hating). It is therefore possible that the oil and grease carried into water bodies via rain events actually concentrates in shoreline or bottom water-body sediments which characteristically provide more hospitable environments for the organic compounds.

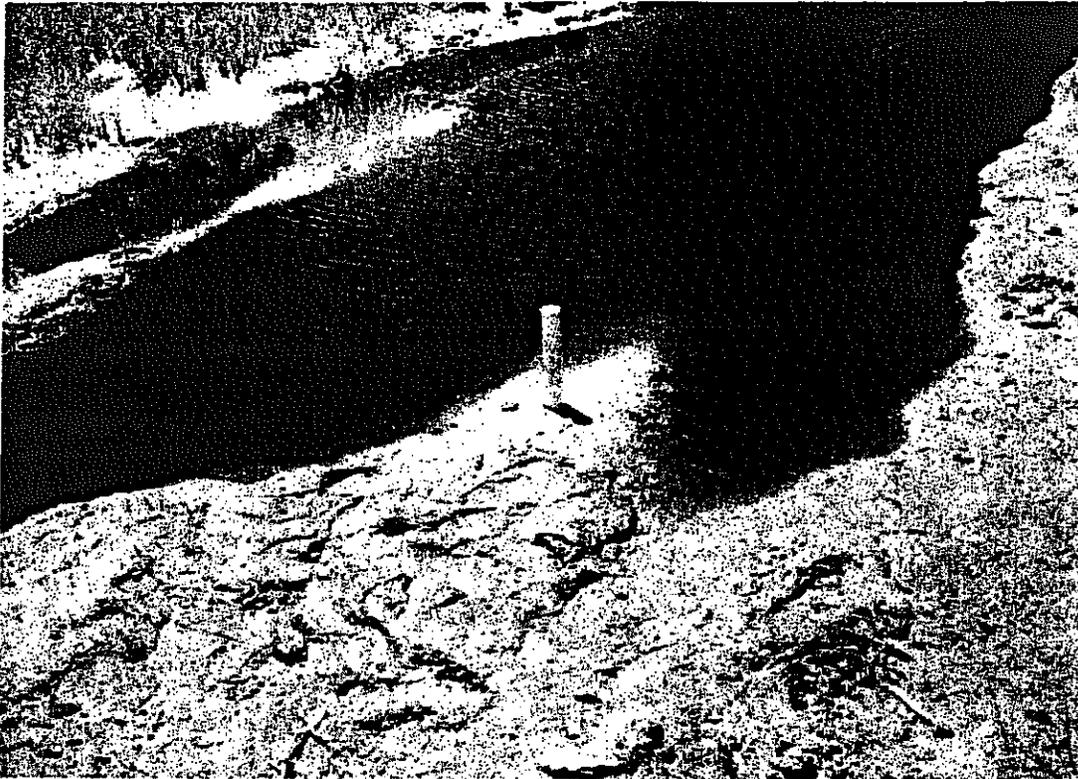
We also speculate that oil and grease contamination may not be entirely washed off into nearby water bodies, but may be carried downward deeper into the sediment layer where it can sequester and accumulate in a more organic rich subsoil layer. Interesting information regarding these hypotheses was explored through analysis of core sampling.

A limited number of core samples using pvc pipe were obtained to evaluate if contamination was diffusing downward through the sediment layers. It is not unreasonable to expect that with precipitation events, the oil, grease, and metal contamination might be carried downward through the sediment and sequestered in a hospitable more organic (humus rich) soil environment. Samples were obtained from areas suspected of contamination problems, such as Spider Lake and Lower Little Sluice. A field blank was obtained at a site representative of the trail, but predicted to have been exposed to minimum vehicle or human contact. The samples capped and maintained in the pvc tubes, were transported back to the laboratory for analysis. Prior to analysis, the tubes were sawed open and the physical appearance of the core sample were documented. In most samples, a clear gradient or layer like appearance was evident. In many of the samples, a gravel / loose pebble top layer (closer to the surface) was followed by soil like layers that appeared very dark, and wet. A distinct odor of petroleum was evident in some samples.

Figure 9 shows an example of the site core sampling. Figure 10 shows an example of the core samples (sliced open prior to analysis) obtained at the seasonal crossing and Little Sluice. The top picture depicts the field blank. Notice that the core samples obtained from the portions of the trail showing considerable use and potential contamination problems have a layered appearance. This layering is absent in the field blank sample which appears very uniform and consistent in composition.

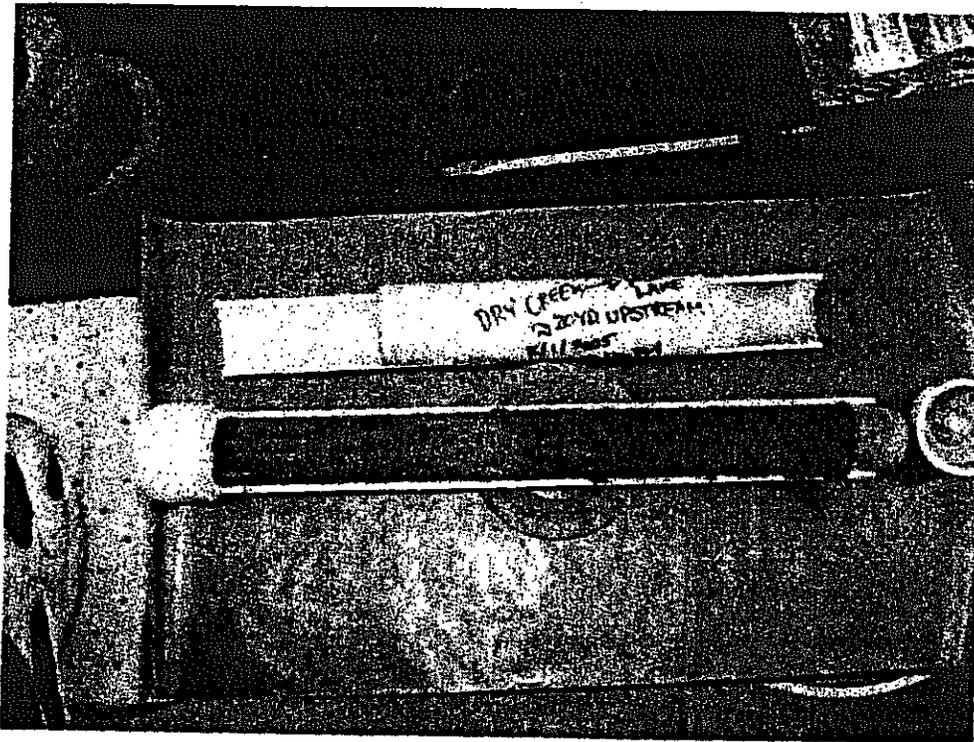
Examination of Table 4 shows the results from a subset of the core sampling. Notice that the HEOM values for the field blank are low and fairly consistent. In contrast, examination of the Little Sluice and seasonal crossing samples show fairly high levels of HEOM that appear in layers. We are currently examining the core extracts by GC-FID.

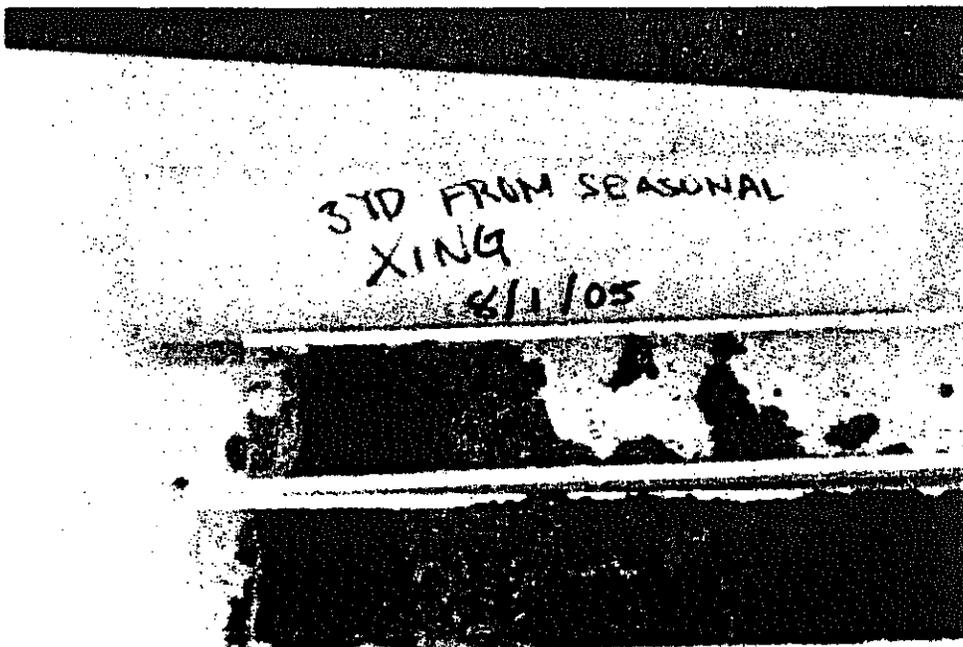
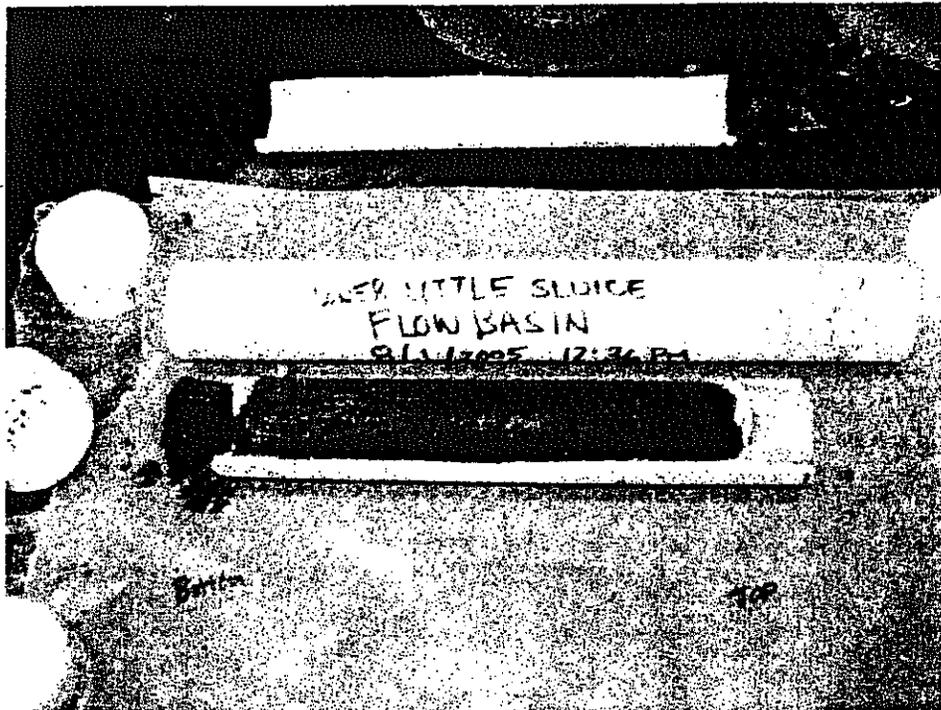
**Figure 9.** A typical core sample acquisition.





**Figure 10.** Sliced open core samples prior to analysis. The top sample represents the field blank. The lower pictures represent contaminated site cores.





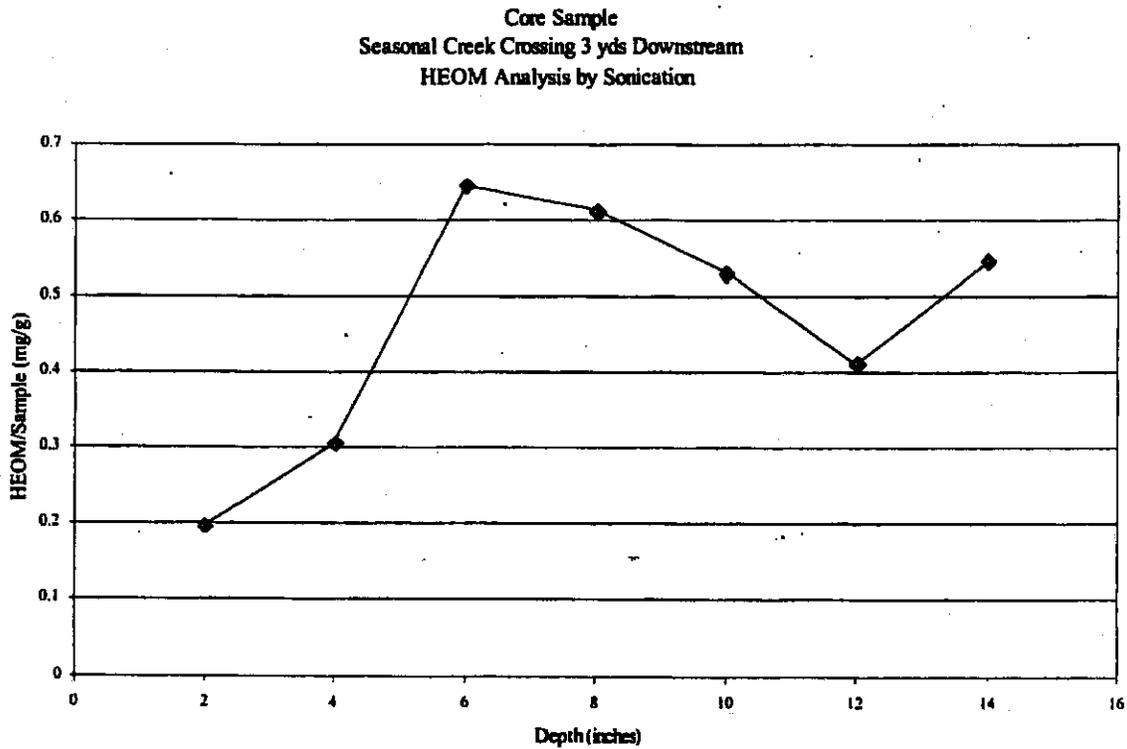
**Table 4.** Sonication results for HEOM (oil, grease, and petroleum in core samples as a function of distance from the surface). Notice a gradient layer appearance of the data. The blank shows very little extractable material.

<b>Core Sample Location</b>	<b>Depth of Sample</b>	<b>HEOM Extract per gram of Sample (ppt)</b>
3yd from Seasonal Xing	2" from Surface	0.1967
	4" from Surface	0.3055
	6" from Surface	0.6449
	8" from Surface	0.6118
	10" from Surface	0.5307
	12" from Surface	0.4109
	14" from Surface	0.546
Lower Little Sluice Flow Basin	2" from Surface	1.196
	4" from Surface	1.052
	6" from Surface	0.5458
	8" from Surface	0.3779
	10" from Surface	0.1722
Spider Lake Site #1 Pic#46	2" from Surface	0.5984
	4" from Surface	0.0194
	6" from Surface	0.0727
	8" from Surface	0.2146
Dry Creek -Mud Lake ~20 yd Upstream Sample Blank	2" from Surface	0.2307
	6" from Surface	0.1266
	10" from Surface	0.0395
	14" from Surface	0.0318
Top of Ellis Creek Xing East Side	2" from Surface	0.0526
	4" from Surface	0.1113
	6" from Surface	0.0957
	8" from Surface	0.0786
	10" from Surface	0.0456
Flat Base at Walker Hill	2" from Surface	0.2842
	4" from Surface	0.1513
	6" from Surface	0.3277
	8" from Surface	0.2927
	10" from Surface	0.1108
	12" from Surface	0.4924
	14" from Surface	0.4779
	16" from Surface	0.0395
	18" from Surface	0.1186
	20" from Surface	0.5477
Spider Lake Meadow	2" from Surface	0.2166

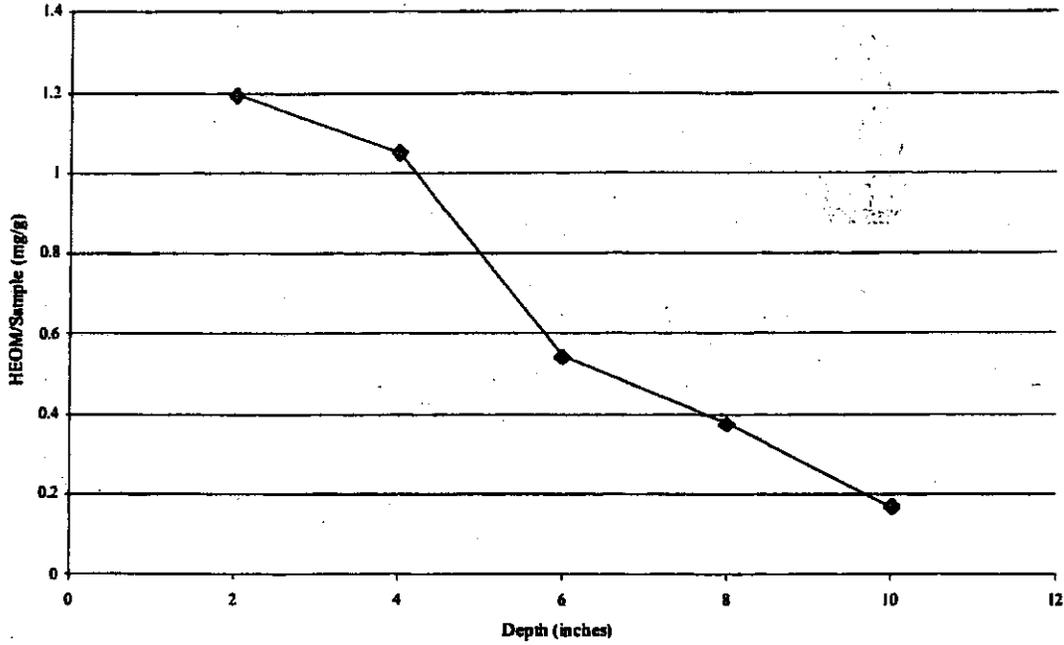
	4" from Surface	0.2884
	6" from Surface	0.1969
	8" from Surface	0.1666
Dry Pond	2" from Surface	0.7133
	4" from Surface	0.5573
	6" from Surface	1.823
	8" from Surface	2.082
	10" from Surface	0.1091
	12" from Surface	1.54
15 yd from Seasonal Creek Xing	14" from Surface	1.423
	16" from Surface	0.8179
	2" from Surface	0.3556
	4" from Surface	0.2249
	6" from Surface	0.4307
	8" from Surface	0.807
	10" from Surface	0.6768

Figure 11 graphically illustrates the HEOM levels as a function of core sample location and depth.

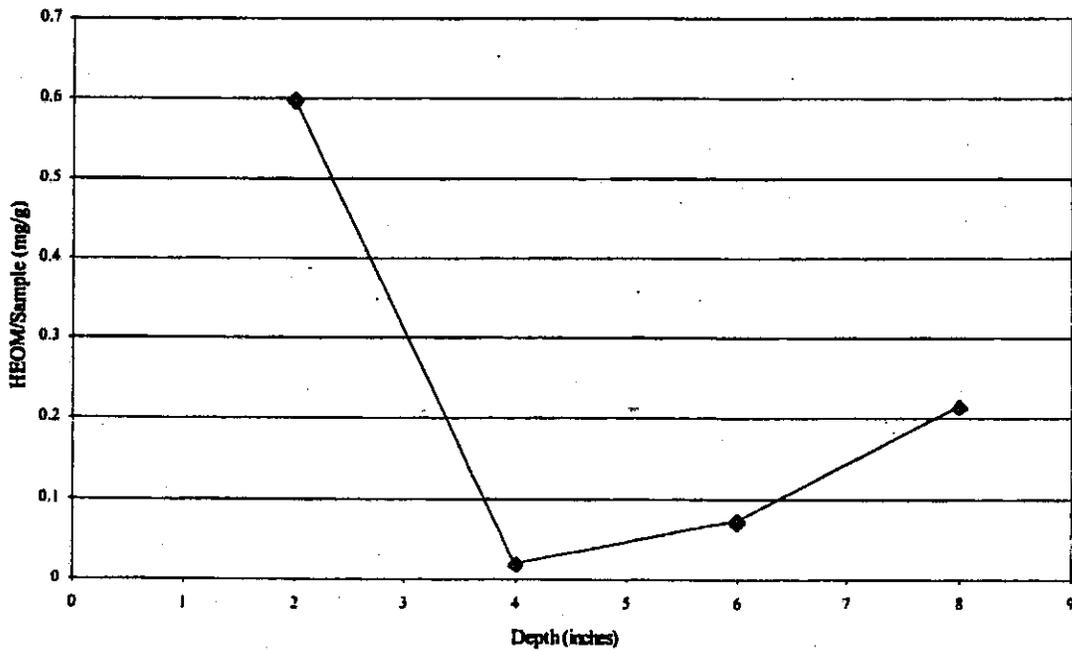
Figure 11. Core sample graphs as a function of depth and sample location.



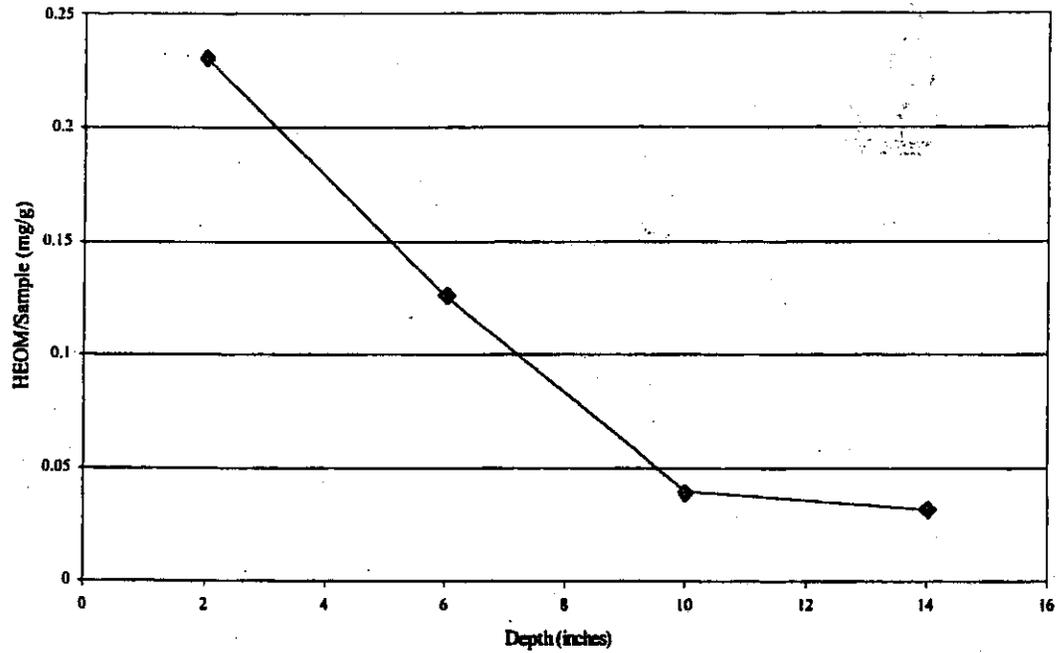
Core Sample  
Lower Little Sluice Flow Basin  
HEOM Analysis by Sonication



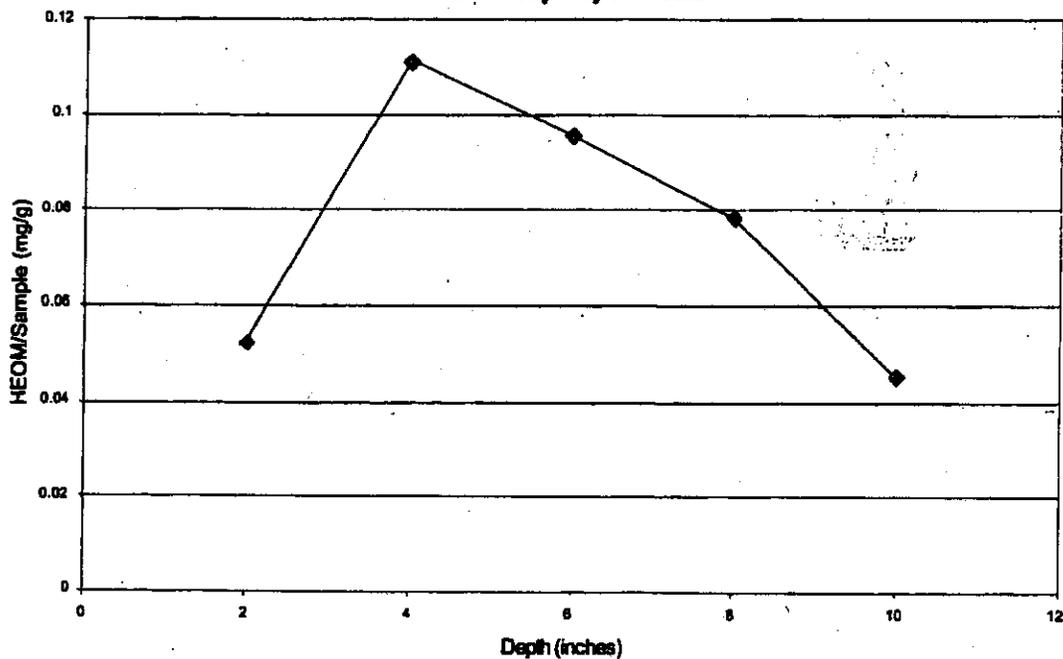
Core Sample  
Spider Lake  
HEOM Analysis by Sonication



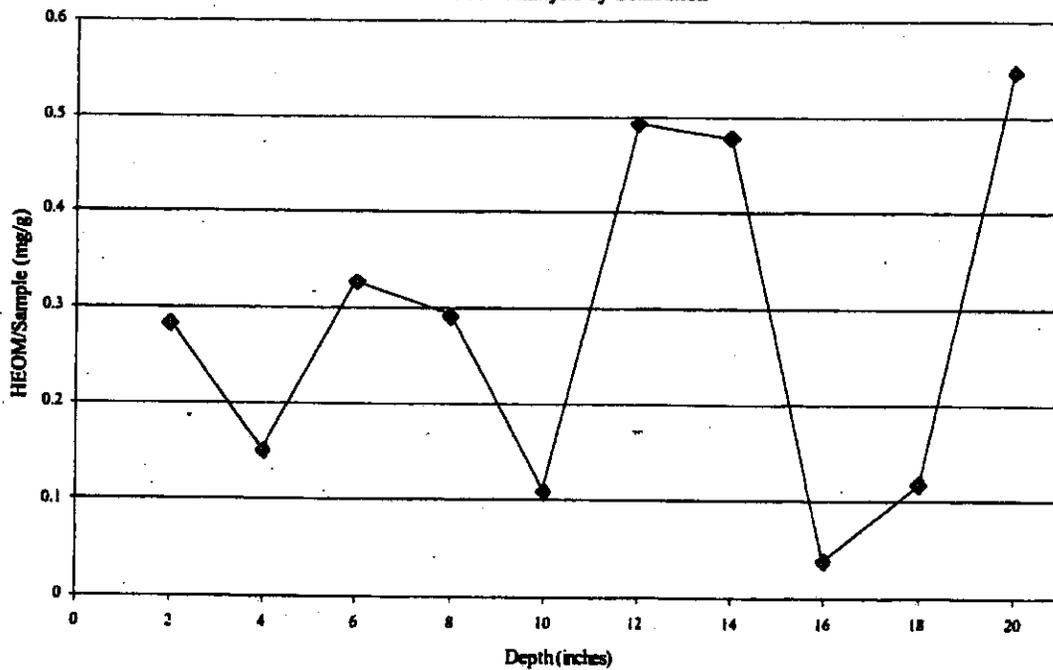
Core Sample  
Dry Creek Field Blank (off trail)  
HEOM Analysis by Sonication



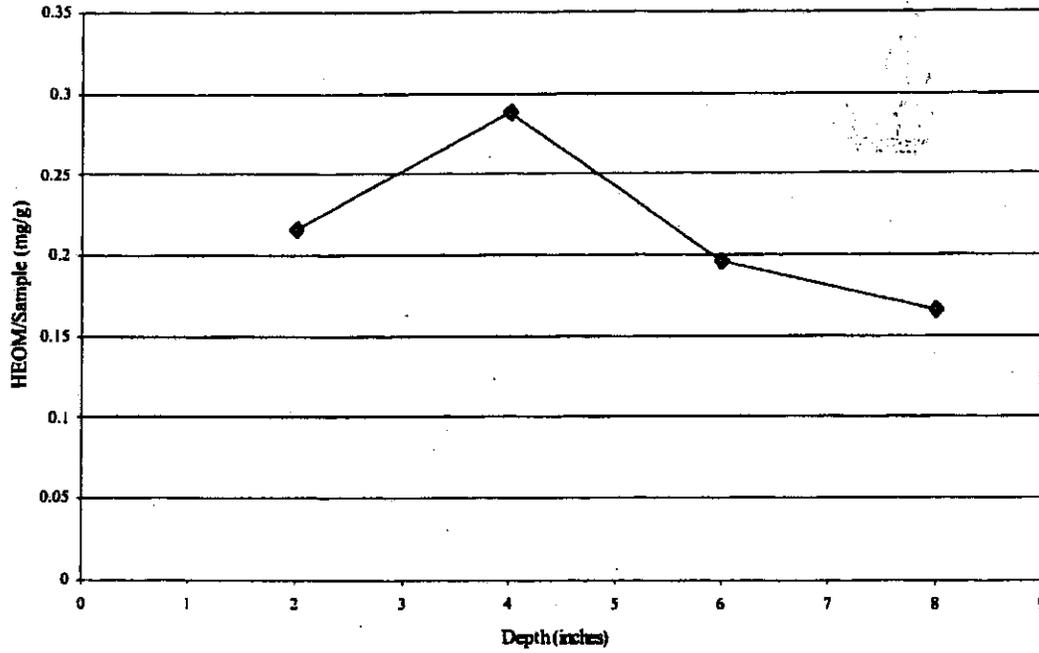
Core Sample  
Ellis Creek Crossing Eastside  
HEOM Analysis by Sonication



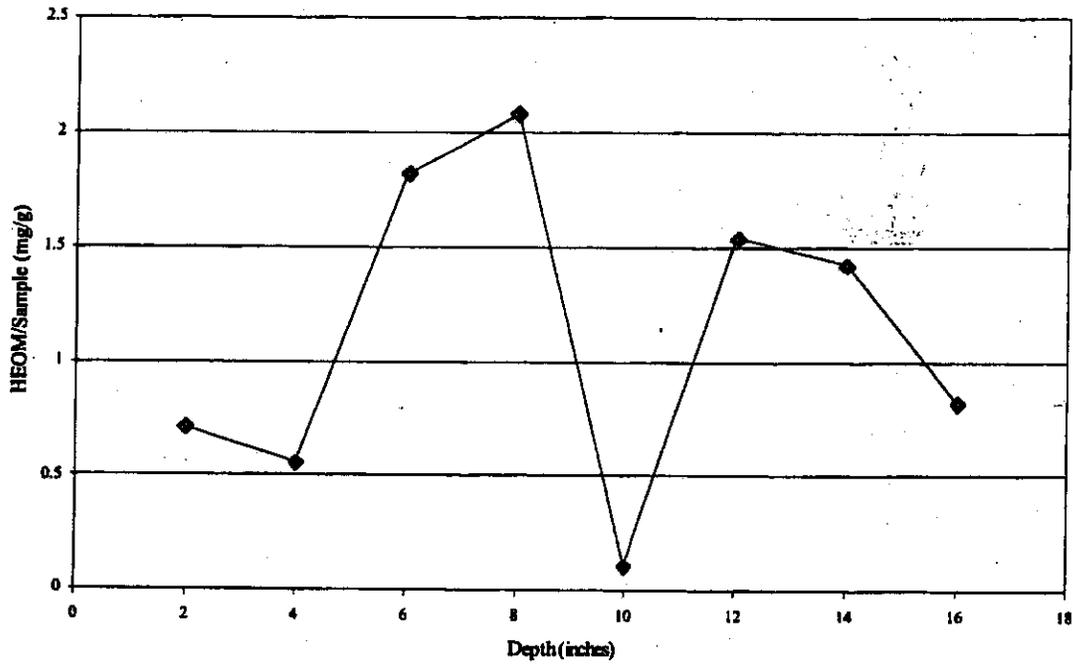
Core Sample  
Flat Base at Walker Hill  
HEOM Analysis by Sonication

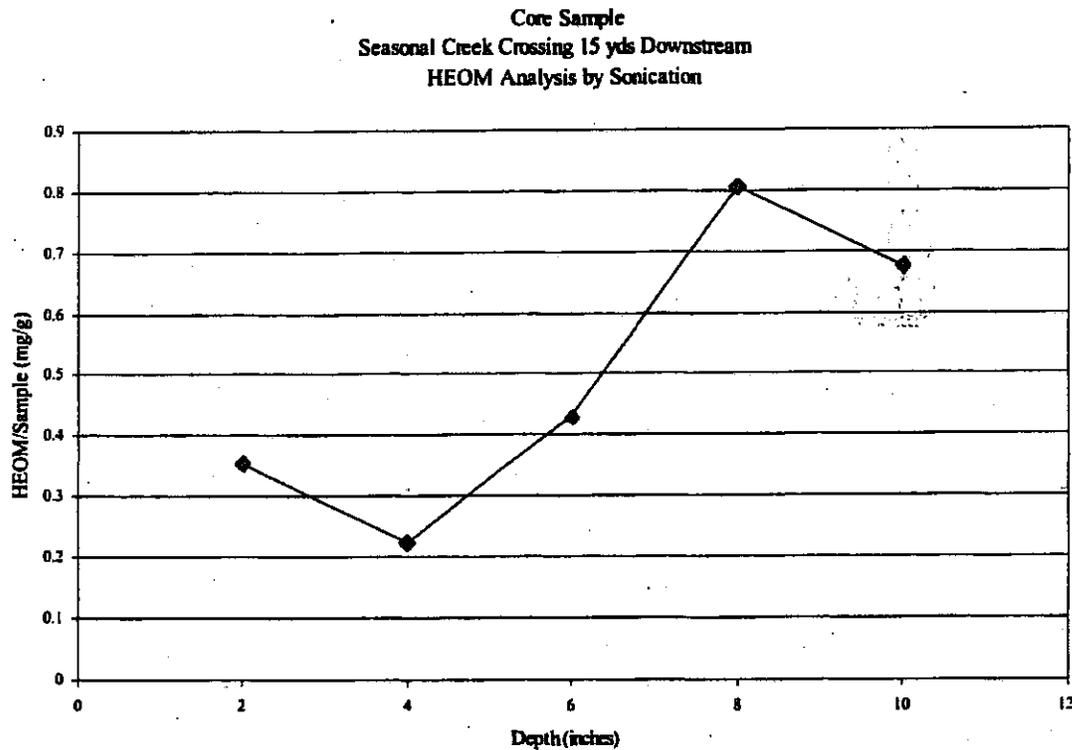


Core Sample  
Spider Lake Meadow  
HEOM Analysis by Sonication



Core Sample  
Dry Pond  
HEOM Analysis by Sonication





**E. Preliminary Results of Heavy Metals Analysis.**

Preliminary results show evidence of copper and cadmium in the core sediment samples of sites evidenced to show significant petroleum based sediment contamination from HEOM and GC-FID results. By comparison, the blank core samples give non-detects for both metals. Additionally, the metal ions appear in the sediment layers associated with higher HEOM levels.

Table 5 summarizes the preliminary copper and cadmium metal ion levels in several core samples. The results are provided in parts per billion. The sediment samples analyzed are the same samples shown in Table 4. The presence of cadmium and copper in the core samples is strongly suggestive of a vehicle based source.

**Table 5. Cadmium and Copper Atomic Adsorption Results for Selected Core Samples.**

Sample Location /Depth	HEOM mg/g	Cadmium (ppb)	Copper (ppb)	Zinc (ppm)
Lower Little Sluice 2 inches	1.196	155.8	0.0	267.3
Lower Little Sluice 4 inches	1.052	556.4	108.5	109.2
Seasonal Creek 6 inches	0.6449	163.3	38.6	136.8

Field Blank	0.1266	0.0	0.0	46.01
Dry Pond 6 inches	1.823	0.0	0.0	379.3
Dry Pond 8 inches	2.082	0.0	0.0	455.1
Tahoe Road Sweepings	8.4		488	40.0

Interpretation of the heavy metal analysis results is largely speculative. However, the limited data undeniably shows cadmium and copper metal ions present in samples contaminated by vehicle based petroleum products. The fact that metal ions are found six inches deep into the sediment may suggest that contamination might be migrating downward through the soil and rock layers. The metals are not observed in the field blank or at a site with naturally based HEOM. Further metal analysis of the extended set of core samples is warranted.

#### IV. Concluding Remarks from Preliminary Monitoring.

1. The Rubicon Trail changes significantly in physical character throughout a sampling season. Early in the season, the trail is characterized by ponds, streams, creeks and a significant level of water. The Rubicon Trail shows evidence of environmental impact directly associated with vehicle usage on the trail. Oil, grease, diesel, petroleum products and specific vehicle related heavy metal contaminants were found throughout the trail. The levels of HEOM monitored contaminants increased as a function of recreational use. The preliminary work suggests that the contamination of sediment is the greatest concern. However, the mobility and final fate of sediment contamination may well be surface water or ground water and is a topic for further study. A limited temporal study, such as the one performed here, can not address long-term accumulation or contaminant fate issues. The long-term accumulation and fate issues are potentially the most important with respect to the natural habitat and the potentially irreversible consequences of irresponsible trail use.

The preliminary evaluation of the trail highlights areas of specific concern. Particularly, Little Sluice is an area observed to both physically and analytically suffer contamination exposure due to OHV recreational use. Spider Lake, Ellis Creek and the Seasonal Crossing are additional areas for monitoring attention. In future monitoring, it would be useful to identify the flow destination of running waters through these impacted areas and subsequently monitor them for transported contamination problems. Field blank values obtained in the initial monitoring were adequately selected based on the low contamination values obtained in these samples which remained constant throughout the sampling season.

The preliminary study provided the opportunity to develop and test sampling, transport and analysis protocols. Most samples were obtained and analyzed in duplicate which afforded the opportunity to check consistency and reproducibility in the methods. The sampling protocols are straightforward and provide an opportunity for volunteer involvement with only brief training. The only issue with sampling is the limitation on sample number based upon sampling team size and ability to pack out samples. The water samples were obtained in liter sized amber bottles which are cumbersome and become heavy with number of samples. A vehicle based assistance "pick up" within the trail was very useful on the first sampling trip of last season. This coordinated effort should be pursued in future monitoring.

The sampling analysis by EPA approved methods worked well on the samples. The significant results associated with sediment and core sampling begs for further investigation into the nature and mobility of the contaminants. A ground water and water body bottom sediment sampling and analysis is suggested. Metal contamination of the ground water is a possible fate of the metal contamination which should be explored.

The E-coli monitoring indicated that only one positive E-coli result, in Spider Lake following a June special event, was obtained. However, this only implies that the E-coli levels in the water are below significant levels of detection with the tests utilized. Significant visual observations of human excrement on the trail suggest that a health sanitation issue should be of concern. Education in good camping practices could alleviate this issue. The vehicle related contamination levels is very trail site specific, with Little Sluice being an area of the trail of great concern. Much of the contamination in this area stems from large spills and leaks. Close attention to these "trouble spots" is warranted.

#### **V. Recommendations For Future Monitoring**

The preliminary monitoring data suggests that the vehicle recreational activity on the Rubicon Trail comes with some environmental consequences including:

1. Oil and grease and other petroleum product contamination of the water and sediments.
2. Heavy metals associated with vehicle use in found in the sediments and core samples.
3. Human waste contamination of sediment and soil.

It is advisable to establish an ongoing monitoring plan to continue to assess the short-term temporal and long-term cumulative environmental impacts of trail use. Volunteer involvement by the user community can ensure that the monitoring plan is successful and serve as an educational tool that encourages an increased level of responsible trail use. We also recommend that a user meeting be planned to present and explain the results of each year's monitoring, to show manifesting trail degradation or improvement trends, and to answer questions regarding the technical data. We recommend a plan including the following:

1. Four sampling and surveying events per year.
  - a) Sampling (1) Spring before the recreational season.
  - b) Sampling (2) Summer Sampling I. Early July
  - c) Sampling (3) Summer Sampling II. Early August -
  - d) Sampling (4) following first flush - precipitation event.
2. Physical "State of the Trail" Surveying. Teams will walk the trail and document physical characteristics of the trail including streams flowing, water bodies present, and obvious contamination sites using GIS mapping, log book entries, and photographs. Contamination site data can be logged as number of visually perceivable incidents per given trail mileage. This data can be data based and serve to record the trail areas most impacted and may serve to guide

regulation and controls in these specific areas if deemed necessary. An ecological survey of species can be obtained during these surveys.

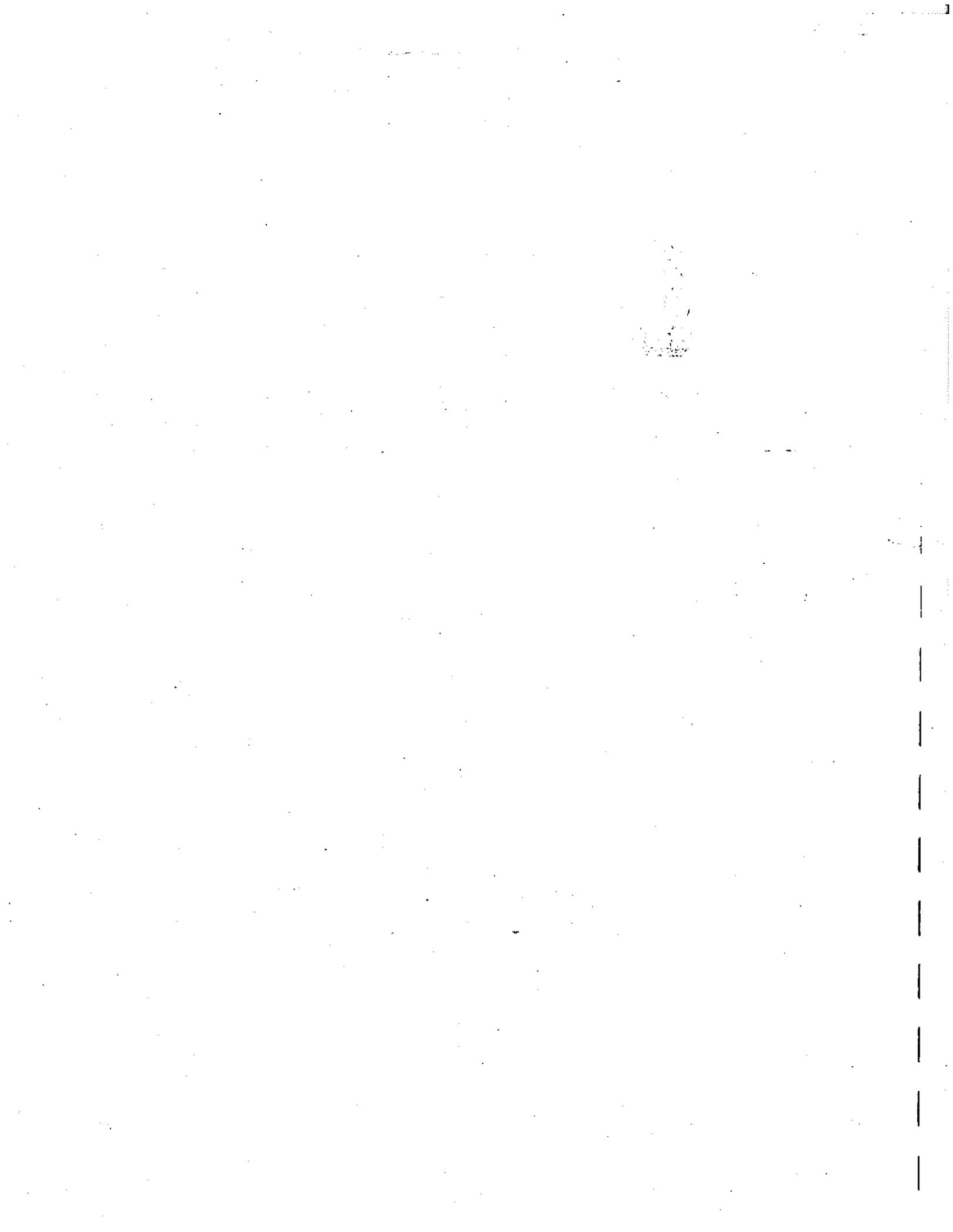
3. An ecological survey of species and natural community impact. The ecological survey will sample several communities along gradients away from the Rubicon Trail. Abiotic (e.g., light, pH) and chemical (e.g., oil, heavy metals) measurements will be utilized to understand the potential impact of manmade disturbances on communities, relative to natural variation. The following communities should be sampled:

1. Soil Microbial community sampling
  - a. Biotic: Soil samples hydrated and sampled for protozoa and bacterial diversity and abundance
  - b. Abiotic: pH
2. Stream and pond survey
  - a. Biotic: Construct food webs and determine species composition (species diversity and abundance): bacteria, protozoa, algae, and invertebrates.
  - b. Abiotic: pH, DO,
3. Vegetation survey
  - a. Biotic: Plant community composition (species diversity and abundance), invasive species abundance, herbivore damage
  - b. Abiotic: Light, soil moisture

4. Water Samples. Water grab samples should be monitored in duplicate for petroleum oil and grease and heavy metal contamination levels. Water samples should additionally be monitored for E-Coli. Grease and Oil extracts should be examined via GC-FID and Mass Spectrometry Analysis to establish the source of HEOM, since there are some natural sources of organic material which are extractable under the same analysis protocol. Examination of the samples for specific markers associated with vehicle use is necessary. Metals analysis should be accomplished utilizing an analytical technique capable of low detection limits, such as atomic adsorption (graphite furnace) or ICP Mass spectrometry. Metal to be monitored:  $\text{Cu}^{+2}$ ,  $\text{Ni}^{+2}$ ,  $\text{Pb}^{+2}$ ,  $\text{Cd}^{+2}$ ,  $\text{Zn}^{+2}$ . Additionally, water bodies should be measured for turbidity in order to evaluate the sedimentation issue plaguing many California water bodies, such as Lake Tahoe. Ground water sampling on contamination "trouble spots" should be obtained. A small permanent well could be constructed for monitoring purposes.

5. Sediment Samples. Sediment grab samples and core samples should be monitored for oil, grease, petroleum products, and heavy metals. The oil and grease contaminant samples should be further analyzed by GC-FID and mass spectrometry to identify the origin and composition of the contamination. Core samples over several years-would permit evaluation of the vertical and horizontal migration of contamination over time with respect to trail site. The long-term fate of contamination can then be extrapolated. GIS mapping of sample site is again critical to these experiments.

**Concluding Remarks:** CREST gratefully appreciates the opportunity to assist El Dorado County in evaluation of one of Northern California's resources. We would like to offer our assistance in future monitoring programs.



## **2006 Monitoring Results**



