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Evaluation of the Environmental Effects of Stormwater Pollutants for Oak Ridge National Laboratory

R. L. Hinzman
G. R. Southworth
A. J. Stewart
M. J. Filson

Environmental Sciences Division
Publication No. 4359

MANAGED BY
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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ACRONYMS

ANOVA	analysis of variance
BCK	Bear Creek kilometer
BFK	Brushy Fork kilometer
BMP	best management practices
DMW	degassed mineral water
EDTA	ethylenediamine tetracetic acid
EFK	East Fork Poplar Creek kilometer
EFPC	East Fork Poplar Creek
EPA	Environmental Protection Agency
ESD	Environmental Sciences Division
FCK	Fifth Creek kilometer
GC/MS	gas chromatography/mass spectrometry
GC/FID	gas chromatography/flame ionization detection
NPDES	National Pollutant Discharge Elimination System
NRDC	National Resources Defense Council
NTU	nephelometric turbidity units
O&G	oil and grease
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
SAS	Statistical Analysis System
TOC	total organic carbon
TPH	total petroleum hydrocarbon
TSS	total suspended solids
TTU	Tennessee Technological University
UV	ultraviolet
WCK	White Oak Creek kilometer
WOC	White Oak Creek

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1. INTRODUCTION

Despite Best Management Practices (BMP), total suspended solids (TSS) and oil and grease (O&G) concentrations in stormwater runoff frequently have been above the National Pollutant Discharge Elimination System (NPDES) Permit effluent limits at ORNL. Although the effects of stormwater pollutants to aquatic ecosystems are of concern regionally and nationally, NPDES permit violations at ORNL are best addressed on a site-specific basis. This document explores several key questions to determine whether the TSS and O&G noncompliances at ORNL are primarily a regulatory problem (i.e., Category I and II effluent limits are neither reasonably achievable nor effective in achieving environmental protection), or a legitimate ecological concern that will require effective remediation.

The three tasks outlined in the study plan were to (1) clarify the degree of TSS and O&G noncompliances at ORNL, (2) provide guidance as to appropriate limits for TSS and O&G in Category I and II discharges, and (3) provide information about the effectiveness of possible mitigation or remediation measures for TSS and O&G in stormwater releases, assuming that such measures are needed for one or more ORNL Category I or II outfalls.

1.1 TOTAL SUSPENDED SOLIDS

Much literature exists on the effects of suspended solids on aquatic systems. Suspended solids are a ubiquitous feature of lotic ecosystems and can be influenced by anthropogenic factors as well as by natural biotic processes and abiotic conditions. Particle size, water velocity, and turbulence influence the effects of TSS on aquatic organisms. The European Inland Fisheries Advisory Commission (EIFAC 1965) identified four major effects of TSS on fish populations. High concentrations of TSS may (1) kill the fish directly, reduce their growth rate, or lower their resistance to disease, (2) prevent the successful development of fish eggs and larvae by reducing the availability of dissolved oxygen, (3) modify fish movement and/or migration behavior, or (4) reduce the abundance of food. A thickening of the respiratory epithelium and some fusing of gill lamellae has been observed in rainbow trout (*Salmo gairdneri*) held for extended periods in concentrations of TSS as low as 270 mg/L (Herbert and Merkins 1961). Herbert and Richards (1963) found a reduction in the growth of rainbow trout kept in water containing TSS at a concentration of 30 mg/L. In laboratory study, Shapovalov (1937) found that egg fry survival of *S. gairdneri* dropped from 79.9 to 29.8% when gravel was covered with silt.

Increases in TSS concentrations from 25 mg/L to 390 mg/L, due to intensive logging, can smother bottom-dwelling invertebrates, and have been shown to reduce invertebrate densities (Tebo 1955). In areas where sediment accumulates, macroinvertebrate populations can decline as much as 60% regardless of TSS concentrations (Gammon 1970). Reed (1977) found that after land/soil disturbances related to construction, benthic macroinvertebrate species richness and density in a stream receiving runoff from the site were reduced by 40 and 80% respectively. After a recovery period of approximately 4 months, during which a number of heavy late winter and early spring rains flushed some of the sediments from the riffle areas, the number of species had returned to levels noted prior to construction, but the total numbers of individuals remained at 80% of the original population. Suspended sediments can also affect the benthic invertebrate community by increasing drift (Mathers 1978). Rosenberg and Snow (1975) found that when TSS levels were increased artificially to between 100 and 500 mg/L, a significant increase in the drift of benthic invertebrates occurred. Kirk (1991) found that suspended sediments inhibited cladoceran populations but not rotifer populations, thus changing the zooplankton community structure in turbid lakes and reservoirs.

In addition to direct effects, many toxicants can adsorb to suspended solids, thereby changing the bioavailability of these materials (NAS 1974). In tests of water from Lake Reality on the Oak Ridge Reservation (ORR), particle-associated toxicants have been found to reduce the feeding rate of snails (R. L. Hinzman, unpublished data).

Annual loading rates can be misleading when used to evaluate potential environmental effects. This is because loading from non-point sources is very sporadic, with almost all of the input concentrated into a relatively few days during and following precipitation. At similar annual loading levels, biota near stormwater (non-point) outfalls usually experience much greater acute exposure than biota near point sources of discharge. Thus, short-lived precipitation events may have disproportionately large effects on environmental quality, particularly if the events occur during critical life stages such as spawning (Silverman et al. 1986).

During precipitation events, TSS concentrations in ORNL's Category I and II discharges sometimes exceed 50 mg/L. Several questions were addressed in this study. Are these TSS excursions similar, with respect to magnitude and duration, to those that occur in other streams on and near ORR? If so, the present limit for TSS may be overly protective and mitigation may not be required. Conversely, if the TSS excursions in the ORNL outfalls are much greater than those that occur in other streams, they could adversely affect biotic communities in White Oak Creek (WOC). In this situation, the present limits may be appropriate and mitigation may be needed. If the present limit for TSS is overly protective, what limit would be more appropriate? Additionally, assuming that a higher limit was in effect, which outfalls, if any, are likely to result in continued noncompliances? Finally, if mitigation procedures will be needed for one or more of the outfalls, what types of mitigation procedures are likely to be most cost-effective?

1.2 OIL AND GREASE

A major difficulty in defining and setting criteria for O&G is that these constituents are not definitive chemical categories. Instead, O&G includes thousands of organic compounds, some naturally occurring and some of anthropogenic origin, with varying physical, chemical, and toxicological properties. In aquatic habitats, petroleum and nonpetroleum oils may (1) float on the surface, (2) be emulsified in the water column, (3) be found in soluble form, and/or (4) settle to the bottom. Field and laboratory studies have shown both acute lethal toxicity and long-term sublethal toxicity of oils to aquatic organisms (EPA 1986). Sublethal effects, including interference with processes such as feeding and reproduction, have been reported for O&G at concentrations of 10 to 100 μg/L; petroleum concentrations as low as 1 μg/L can harm aquatic life (Jacobson and Boylan 1973). Oil pollutants of any kind may (1) kill fish by coating epithelial surfaces of gills, (2) cause fish kills by increasing the biological oxygen demand, (3) cause asphyxiation of benthic organisms when floating masses become engaged with surface debris and settle on the bottom, and (4) become incorporated into sediments, where they can have long-term adverse effects on benthic communities (EPA 1986).

The approach to evaluating oil and grease noncompliances is different from that of TSS in that, with rare exceptions, oil and grease, as measured by conventional gravimetric procedures, are not naturally occurring constituents of stream water. Nevertheless, the basic question to be addressed is similar to that developed for the TSS noncompliances: is the present discharge limit for O&G in ORNL Category I and II outfalls scientifically valid and technologically viable, and if so, which specific discharges are problematic?

Six areas, each defined by a question, were evaluated to provide guidance about ORNL's O&G noncompliances.

1. Does the gravimetric O&G measurement provide an accurate estimate of these constituents, or is the measurement method prone to artifacts? Significant portions of low-boiling fractions that volatilize at temperatures below 70°C are lost in the solvent removal step, which makes this method unsuitable for samples that contain light petroleum distillates such as gasoline. This method is generally used to measure relatively large concentrations of oil and may not provide the precision needed to detect quantities in the ≤10 mg/L range. Excessive concentrations of natural greases or synthetic or modified compounds and certain residue-type materials from heavy petroleum fractions are not well recovered because of their insolubility in the solvent. Many non-hydrocarbons, such as phenolics and hydrocarbons of non-petrogenic origin, are recovered by the procedure and may interfere with the determination (Elien 1990). In Bear Creek, high levels of O&G have sometimes been reported even though concurrent analyses of hydrocarbons by more sophisticated procedures [e.g., gas chromatography/mass spectrometry; (GC/MS)] showed no indication of hydrocarbons. Parking lot runoff undoubtedly contains fugitive crankcase oil, but it is also possible that the O&G measure is not a very reliable index of the concentration of total hydrocarbons. An effort was made to corroborate the O&G values in Category I and II effluents by the use of more specific analyses (e.g., total organic carbon). GC/MS is very powerful for identification and

measurement of hydrocarbons, but it is too expensive to be used for routine analyses (Elien 1990). For this reason GC/MS was not explored in this study.

2. Do large concentrations of O&G in Category I and II outfalls occur only during or immediately following periods of significant rainfall? Usually effluent limits are based on low-flow assumptions. However, O&G from storm flow may only occur when discharges to the stream are substantial. If so, limits based on low-flow assumptions may be overprotective.

3. Is there evidence of hydrocarbon contamination in the sediments of WOC? Brown et al. (1985) found that the type of petroleum found in sediment closely resembled that found in stormwater runoff, thereby strongly implicating stormwater runoff as the primary source for sediment contamination. They also found that hydrocarbons in the sediment were not resuspending. Brown et al. concluded that surface water was not being contaminated by resuspension and transport, but by oil-contaminated stormwater runoff. If hydrocarbons are not detected in the sediment, the notion that O&G noncompliances translate into adverse ecological impacts would be difficult to defend.

4. Does biological monitoring yield evidence for the exposure of aquatic organisms in WOC to hydrocarbons? Data from four biological monitoring tasks—toxicity testing, residues in biota, induction of detoxification enzymes in fish, and community structure of fish and benthic macroinvertebrates—were examined to answer this question. Liver detoxification enzymes (P450 and cytochrome b_5) are important in the biotransformation or metabolism of xenobiotics, such as pesticides, hydrocarbons, chlorinated hydrocarbons, and numerous biological molecules, including steroid hormones (Payne and Penrose 1975, Stegeman 1981). Increases in activity of these enzymes are generally associated with increased liver-somatic index values (Sloof et al. 1983, Fabacher and Baumann 1985).

5. Are the concentrations of O&G measured in WOC, or estimated to enter WOC from the Category I and II outfalls, likely to be ecologically harmful? This

question is addressed through a literature survey, wherein O&G concentrations causing ecological effects in other streams are compared to O&G concentrations in WOC.

6. Does O&G in ORNL's Category I and II outfalls contribute measurable toxicity to the discharges, based on EPA-approved methods for estimating toxicity? Discharges from three of the outfalls most prone to O&G violations were tested for toxicity to *Ceriodaphnia*. Also, tests with *Elimia* (a common gill-breathing snail in many streams on the Oak Ridge Reservation) were conducted to quantify possible sublethal effects of TSS and O&G on stream invertebrates. *Ceriodaphnia* and *Elimia* are relatively sensitive bioindicators. If little or no toxicity is detected for these organisms, it would seem reasonable to conclude that the influence of effluents entering WOC should be minimal to most aquatic communities. However, organisms that are more sensitive to the potentially toxic constituent(s) of effluents entering WOC may still be impacted.

2. METHODS

2.1 STUDY PLAN

This plan included three tasks to address the questions pertaining to TSS and O&G exceedances in Category I and II outfalls. Task 1 consisted of a comprehensive review of the ORNL NPDES data for permitted Category I and II outfalls in relation to TSS and O&G conditions in other local streams during base- and storm flow periods. Task 2 consisted of a review of recent literature to address regulatory and biological aspects of TSS and O&G. And Task 3 included the acquisition and analysis of new data (e.g., evaluation of the relationship between O&G measurements and more specific measurements of hydrocarbons; assessments of the toxicity of selected Category I and II outfalls).

2.1.2 Task 1: Review of NPDES Data

Given that the collective maximum discharge from Category I and II outfalls is small (about 1.8%; 4.3×10^6 L/d) relative to maximum flow in WOC (235×10^6 L/d at WCK 2.6), it seemed unlikely that Category I and II discharges would significantly increase TSS or O&G in WOC. Available NPDES data for 1988 to 1992 for TSS and O&G was used to explore this assumption. These data were analyzed to (1) characterize the location, frequency, and magnitude of the violations, (2) statistically identify and rank outfalls with respect to TSS and O&G releases, and (3) examine the violations in relation to rainfall events. The results of these analyses were compared with TSS and O&G measurements made for other local streams during base- and storm flow periods to determine whether TSS contributions to WOC via storm flow from Category I and II outfalls appreciably affect in-stream conditions. Local streams that were used to provide data for the comparisons were East Fork Poplar Creek (EFPC), Brushy Fork, Bear Creek, and Scarborough Creek.

Characterization of NPDES noncompliances

NPDES violations at ORNL for 1988–1992 are summarized in Appendix A, Table A.1. Noncompliances stemming from one-time incidents (e.g., oil spills or construction activity) can be differentiated from re-occurring violations due to stormwater runoff.

We examined the violations to identify which outfalls had frequent violations in the past 2 years. Outfalls that had violations in 1988–89, but not in 1990–92 may not be of ecological or regulatory concern. If remediation is required, the most efficient use of limited resources should be focused on outfalls with repeated violations in the past 2 years.

Ranking of outfalls

Category I and II outfalls were ranked with respect to TSS, O&G, and flow, using the Proc Rank procedure in SAS: (1) the mean contribution of TSS and O&G for each outfall for all violations during the 1988–92 time period was calculated; (2) the mean contribution of each outfall to the total loading of all outfalls for each parameter (TSS and O&G) was calculated and ranked 0–3 (least to most contributor); (3) the mean flow for each outfall was calculated and ranked (0–3, least to most) for its contribution to total discharge volumes to WOC (flow was included in this analysis to account for the potential of large volumes of water containing elevated levels of TSS and/or O&G to have ecological effects); and (4) the ranks for each of the three categories (TSS, O&G, and flow) were summed to provide a final ranking (0-9). Ranks for Category I outfalls may be biased due to small sample sizes. (These outfalls were monitored only once per year.)

Excursions related to precipitation events

To determine the correlation between precipitation amounts and the magnitude of the exceedance, separate regression analyses using the amount of precipitation (cm) for each date of a violation vs the magnitude of the violation (mean daily maximum, mg/L) were conducted for TSS and O&G. Only violations for Category II outfalls were examined due to small sample sizes for Category I outfall violations.

To determine if episodes of high concentrations of TSS in WOC were associated with adverse ecological effects, the duration and frequency of TSS excursions in various reference streams were compared to the duration and frequency of TSS excursions in WOC. The likelihood of ecological impact in WOC was estimated by comparing the expected impact on stream biota (based on literature information) to actual conditions (based on data available through ORNL's Biological Monitoring and Abatement Program).

2.1.3 Task 2: Literature Review

Much literature exists on the effects of TSS and O&G on biota in freshwater ecosystems. To specifically address ORNL compliance needs, this review focused on recent literature of selected topics, including (1) effects of parking lot/municipal runoff on stream biota; (2) assessment of the potential for TSS and O&G in ORNL's stormwater effluents to adversely affect biota in WOC; and (3) evaluation of Best Management Practices alternatives for reducing the concentrations of TSS and O&G in stormwater discharges. Five data bases (National Technical Information Service, Evironline, Pollution Abstracts, Environmental Bibliography, and DOT's Transportation Research Information Service) were searched for relevant literature published since 1988. An annotated bibliography appears in Appendix B. Documents listed in the bibliography now are on file in Bldg. 1505, Room 262.

T. F. Waters, in conjunction with Duke Power Company, is presently conducting a comprehensive and critical review of the published literature on the effects of sedimentation on the biota of small streams and rivers. Because of the immense volume of literature, this project will not be completed until winter 1993 or spring 1994. A representative from the Environmental Sciences Division (ESD) attended an information exchange meeting (hosted by Duke Power) in May 1992. Notes from this meeting appear in Appendix C.

A representative from ESD also attended a 1-day course entitled "Stormwater: Permitting, Treatment, and Compliance Strategies" presented by Government Institutes, Inc. This course covered topics including stormwater discharge permits and permit application, stormwater quality assessment, and stormwater treatment problems and technologies. Notes from this meeting are given in Appendix D.

Additional information on state-of-the-art stormwater treatment was provided by S. A. Chase (Oregon Department of Transportation, Portland, Oregon); D. B. Ivey (Oregon Museum of Science and Industry, Portland, Oregon); and W. C. Stewart (W&H Pacific, Portland, Oregon). Copies of this information are provided in Appendix E.

During the study period, the Natural Resources Defense Council (NRDC) challenged the EPA's stormwater discharge rule, promulgated under the Clean Water Act, on several grounds. The Ninth Circuit Court of Appeals granted the NRDC partial relief. A summary by Susan Ross (a law intern at ORNL) of that decision is given in Appendix F.

2.1.4 Task 3: Laboratory and Field Tests

TSS and Turbidity

To determine whether the TSS excursions in WOC are similar, with respect to magnitude and duration, to those that occur in other streams on and near the Oak Ridge Reservation, TSS and turbidity in water samples were measured 1 day before and 3 successive days following two separate precipitation events. Five sites in WOC [WOC kilometer (WCKs) 2.65, 3.4, 3.8, 5.1, and 6.8], one site on Fifth Creek at kilometer (FFK) 0.0, from WOC at the point of entry of selected ORNL Category I and II outfalls (outfalls 109, 224, 116, and 233), and one site from East Fork Poplar Creek, Bear Creek, Brushy Fork, and Scarborough Creek were sampled. Of the sites on WOC, WCK 6.8 is an upstream reference site, WCK 5.1 is upstream of most ORNL discharges, but is influenced by the 7000 area; the remainder of the sites are downstream of most ORNL discharges. Outfalls were selected based on ranking criteria (see sections 2.1.2 and 3.1). The site on EFPC (EFK 23.4 was chose because it is immediately downstream of Y-12 Plant discharge; one would expect to see similar trends at this site and the downstream WOC sites. The site on Bear Creek at kilometer (BCK) 7.8 is located downstream of most Y-12 Plant runoff, but does receive some runoff from Bear Creek Road. The first precipitation event (2.3 cm) occurred August 27-28, 1992, from about 7:00 p.m. to 7:00 a.m. The second event (2.2 cm) occurred September 10, 1992, from 2:00 to 5:00 p.m. One-liter grab samples were collected at each site. Water from each site was filtered through pre-dried, pre-weighed 0.7-μm pore glass fiber filters. The filters were dried for 24 h at 60-65°C and reweighed to determine the mass of TSS in the sample. A comparison of TSS concentrations in WOC with concentrations in other area streams by one-way ANOVA allowed us to determine whether the amount of TSS in WOC sites was significantly different from TSS in other area streams. Turbidity was measured with an HF Instruments turbidimeter in Nephelometric Turbidity Units (NTU). The graphs for turbidity and TSS concentrations were similar for both precipitation events. Turbidity is used as an indirect measure of TSS; thus, statistical analyses were only performed on TSS data.

Oil and Grease

To determine the validity of O&G measurements, 15 Category I or II effluents were collected during a precipitation event (3.2 cm) by ESD staff. The samples were analyzed for O&G and total organic carbon (TOC) by the Tennessee Technological University's (TTUs) Center for the Management, Utilization, and Protection of Water Resources. Samples were collected in two 1-L amber bottles (for O&G by the partition-gravimetric method; EPA 413.1) and a 50-ml vial with a teflon-lined seal (for TOC using the UV persulfate combustion-infrared technique; S.M. 5310C). All collection bottles were provided by TTU and cleaned to EPA specifications prior to sample collection. Immediately after collection, samples were packed on ice and shipped to TTU. The intercepts (and their respective uncertainties) from the regressions (PROC REG in SAS) between measured O&G and total organic carbon values provided estimates for possible bias in the O&G measurement procedure.

Sediment

Twenty-one sediment samples (three replicates per site) were analyzed for hydrocarbons. Samples were collected from three sites in WOC (WCKs 6.8, 4.2, and 3.5), two sites in East Fork Poplar Creek [EFK 23.4 (Station 17) and EFK 22.8 (behind K-Mart)] and from one site each in Hinds Creek and Brushy Fork. The Hinds Creek, Brushy Fork, and WCK 6.8 sites are relatively undisturbed sites; Hinds Creek and Brushy Fork receive some agricultural runoff. Sites WCKs 4.2 and 3.5 are located downstream of most runoff from ORNL; EFK 23.4 is located downstream of most runoff from the Y-12 Plant. Site EFK 22.8 is downstream from all Y-12 discharges and, at the time of these samplings, received runoff from parking lots associated with the old K-Mart site. In each stream, samples were collected from areas about 10 m apart. Where possible, replicates were collected from the middle of the stream and near each bank with a Cecso-lite plastic tray that had been beveled at one end. The sediment was passed through a 1.19-mm mesh sieve to remove large particles and poured into a 40-ml vial. The samples were analyzed for total petroleum hydrocarbons (TPH) using gas chromatography/flame ionization detection (GC/FID) by ORNL's Analytical Chemistry Department.

Toxicity Testing

To determine whether the effluents from ORNL Category I and II outfalls contribute measurable toxicity to WOC, single 4-L grab samples were collected on one date (July 22, 1992; 1.5 cm rainfall) from each of three outfalls (116, 224, 233). The samples were tested using *Ceriodaphnia dubia* (a freshwater microcrustacean) and *Elimia clavaeformis* (a pleurocerid snail). These tests allow the detection of toxic concentrations of materials such as hydrocarbons or metals.

A portion of each sample was centrifuged (20 minutes at 1000 rpm) to remove TSS. Four concentrations (100, 50, 25, and 12%) of the centrifuged and noncentrifuged water samples were tested for toxicity using a 7-d static renewal test measuring *Ceriodaphnia* survival and reproduction (EPA method 1002.0). A negative control consisting of 20% degassed mineral water (DMW) was included with each test.

Non-centrifuged and centrifuged (to remove TSS) water from outfalls 116, 224, and 233 was tested (concurrently with *Ceriodaphnia*) using a 3-d static renewal test measuring *Elimia* feeding rates. This test allowed a direct assessment of the possible sublethal effects of TSS and O&G on a common stream invertebrate (Hinzman, unpublished data). Snails were collected from WCK 6.8 and acclimated in the laboratory to 25°C. Three pre-weighed (wet weight) lettuce disks were placed in each replicate (four replicates per treatment) beaker containing 250 mL of water and 12 snails. At the end of each 24-h period, the uneaten portions of the lettuce disks were removed and weighed. Lettuce disks and water were renewed daily. The mean amount of lettuce eaten by the snails during the test period was calculated and compared with the amount eaten by snails in the control (water from WCK 6.8).

A second test using both *Ceriodaphnia* and *Elimia* was initiated on September 21, 1992, during an isolated thunderstorm for which no precipitation data were available. The test used full-strength water from outfall 116 and WOC water from about 10 m upstream and downstream of the point of entry of outfall 116. In addition, two treatments were applied to full-strength outfall 116 water being tested with *Ceriodaphnia*: (1) shavings of paraffin wax (to sorb O&G) were added, the sample was aerated for 1 hour, and then the paraffin shavings were removed by filtration (0.7-μm GF/F filter); or EDTA (a chelating agent which binds to many metals, thus reducing their bioavailability) was added (1 ppm) to full-strength water. Neither of these treatments is effective for the elimination of other toxicants such as chlorine, which is often a source of toxicity in ORNL streams, but which would not be expected to be a toxicant of concern in stormwater samples. Water from WCK 6.8 was used as a control for the *Elimia* tests; DMW was used as a control for the *Ceriodaphnia* tests.

3. RESULTS AND DISCUSSION

3.1 TASK 1: REVIEW OF NPDES DATA

3.1.1 Characterization

In an effort to determine which outfalls were the "worst offenders" from a compliance and ecological perspective, the NPDES data were examined in a number of ways. First, the violations were summarized (Appendix A) in tabular form. The date, location, magnitude, cause (if known) and remedy for each violation was identified. Second, the number of violations for each outfall from 1988 to 1992 was calculated. Third, the outfalls were ranked statistically following the procedure outlined in section 2.1.2. Each of these criteria were used when identifying outfalls to be used for testing and to determine those that might benefit from remediation. An evaluation of noncompliances for TSS and O&G (1988–1992) showed that of the 168 violations at the outfalls that ranked ≥2 (as determined by the statistical ranking procedure outlined in section 2.1.2 and discussed in following paragraphs), only 7% were due to one-time incidents (e.g., spills, construction activity; see Appendix A). The majority of TSS and O&G noncompliances were the result of stormwater runoff. This statistic demonstrates the care with which ORNL operations are conducted, while arguing for an evaluation of best management practices for stormwater runoff.

Eleven Category II outfalls account for about 57% of the noncompliances for TSS and O&G at ORNL. The outfalls with the most frequent excursions were as follows: Category I - 109 (7 noncompliances), 114 (6), and 116 (6); Category II - 209 (12), 216 (10), and 224 (13). These six outfalls account for 32% of the noncompliances for outfalls with a rank of ≥2 (see Table 1 for the rank for each outfall). Outfalls 109 and 116 each had one one-time violation; however, even with this reduction, these outfalls still rank as outfalls with the most frequent noncompliances for TSS and/or O&G. All of the violations for outfalls 209, 216, and 224 were associated with stormwater runoff. If outfalls 202, 230, 283 (eight noncompliances each) and outfalls 233 and 244 (each with nine noncompliances) are included in the analysis, 57% of the noncompliances for outfalls with a ranking of ≥2 are accounted for. All of the Category II outfalls listed here have had TSS and/or O&G noncompliances throughout the 4 years examined and are of continuing concern from both a regulatory and ecological viewpoint. Of the Category I outfalls listed above, outfall 109 had TSS and/or O&G noncompliances in 1988–90; outfall 114 in 1988–92; and outfall 116 in 1988–91. Mitigation of these 11 outfalls could significantly reduce the numbers of noncompliances at ORNL. Outfalls 216 and 224 are being studied for possible pipe clean-out, which may help decrease the number of TSS/O&G noncompliances at these outfalls.

When ranked on the basis of TSS, O&G, and flow (Table 1) the "worst" Category I outfalls were 110 (rank of 9), 108 (8), and 168 (7). The worst Category II outfalls were 218, 233, 242, 248, 249, 267, 268, 281, and 291; each of these had a rank of 6. When selecting outfalls for field and laboratory tests we considered the biological ranking of each outfall, the number of excursions during 1988–92, and stream location. (An attempt was made to sample problematic outfalls distributed throughout the WOC watershed.)

Plots of 1988–92 monthly NPDES data for TSS and O&G (Figs. 1–2) at X13, X14, and X15 show fairly constant concentrations, with occasionally high peaks. Regression lines through this data do not show increasing loading for either parameter.

Ceriodaphnia toxicity test failures were not correlated to high levels of precipitation. We examined the results of 36 test periods during 1988–92. TSS and O&G violations occurred during a variety of different precipitation levels and test failure rate (the percentage of all sites tested that failed, either from acute or chronic toxicity) ranged from 0 to 43% (Fig. 3). No ambient *Ceriodaphnia* tests have failed since June 1991, and precipitation during this time ranged from 0 to 5.3 cm per 7-d test period. TSS and O&G noncompliances coincided with toxicity test periods for which there were and were not test failures. It is not possible to determine whether the toxicity test failures that occurred when there were noncompliances were the result of high concentrations of TSS or O&G.

Table 1. The number of National Pollutant Discharge Elimination System excursions for total suspended solids (TSS) and oil and grease (O&G) and the respective ranking (based on TSS loading, O&G loading and discharge amounts) for outfalls in the White Oak Creek watershed with a rank of ≥ 2 (scale 0-9)

Outfall Number	Number of excursions	Ranking
102	4	5
108	2	8
109	7	3
110	2	9
114	6	4
116	6	6
144	3	4
168	2	7
202	8	3
203	7	4
209	12	4
216	10	4
218	2	6
223	5	5
224	13	4
225	5	5
230	8	5
233	9	6
242	4	6
244	9	4
248	6	6
249	2	6
264	2	3
267	2	6
268	6	6
281	3	6
283	8	6
284	6	2
285	7	3
291	2	6

Note: Shading indicated outfalls that were selected for field and or laboratory tests.

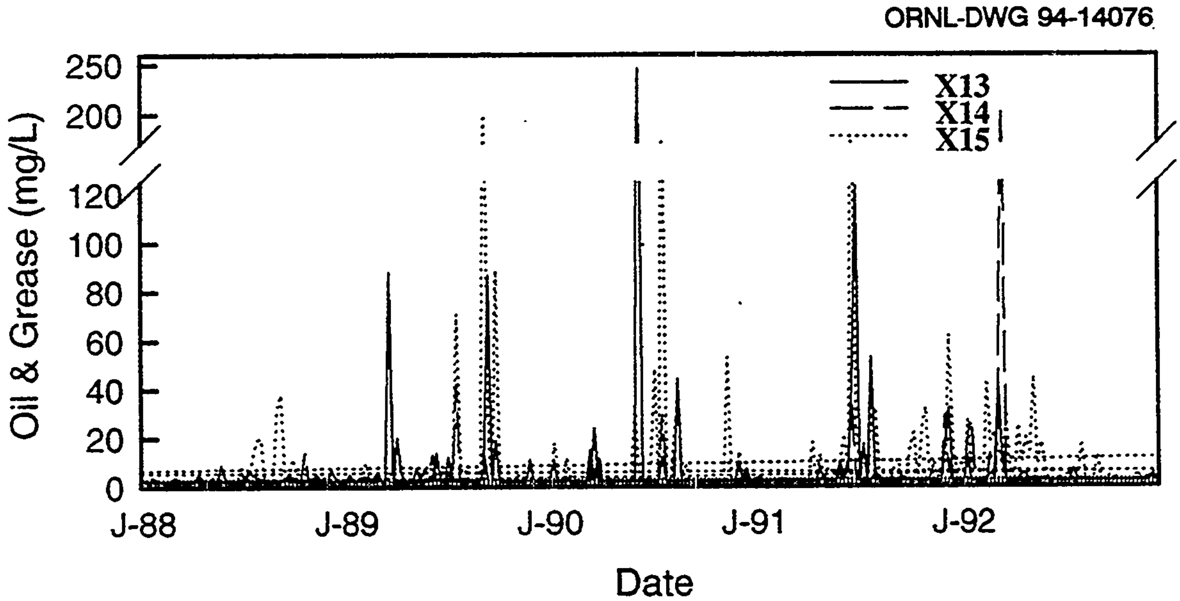

Fig. 1. National Pollutant Discharge Elimination System data for total suspended solids (1988–1992) collected from X13, X14, and X15. Regression lines through the data show long-term trends.

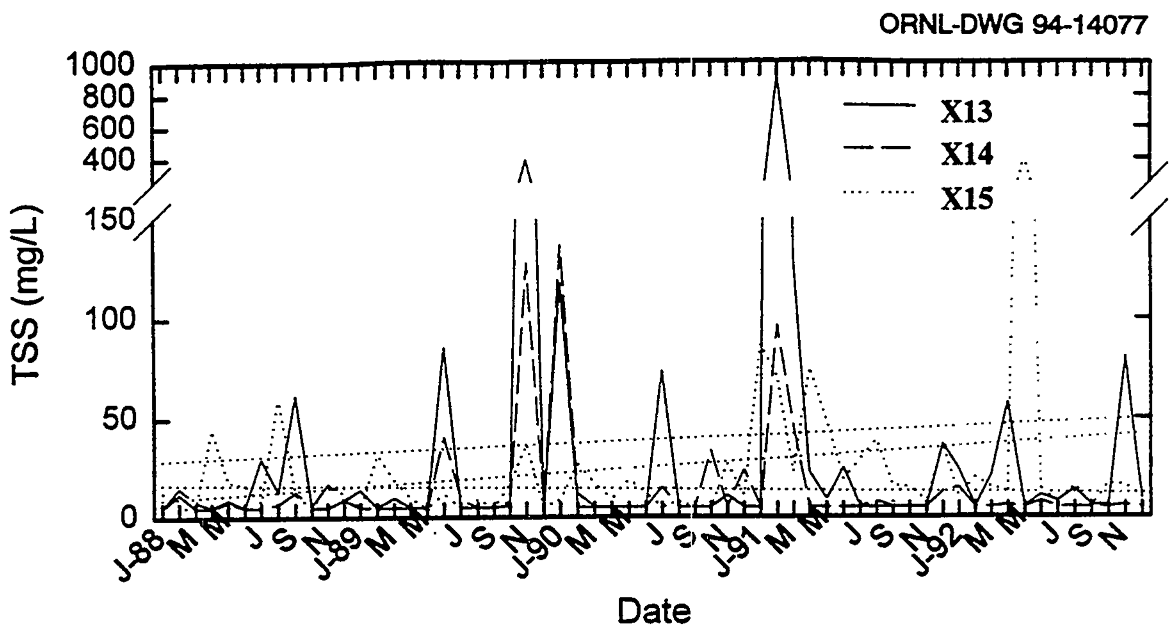

Fig. 2. National Pollutant Discharge Elimination System data for oil and grease (1988–1992) collected from X13, X14, and X15. Regression lines through the data show long-term trends.

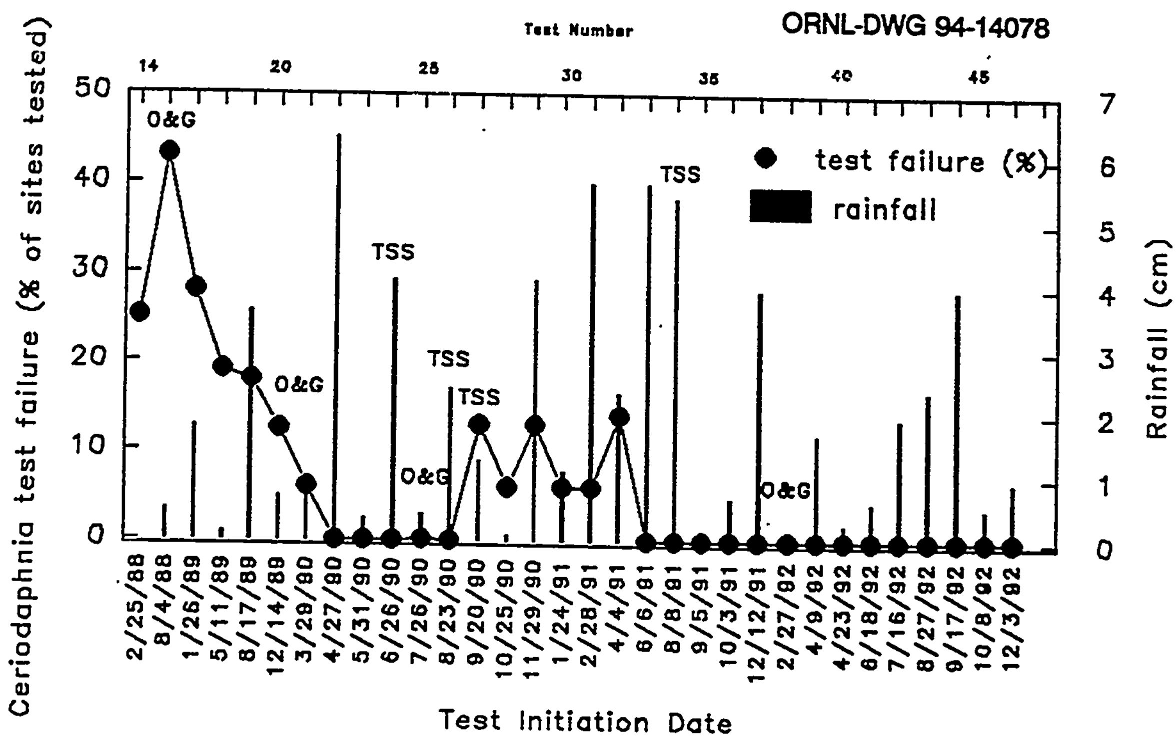

Fig. 3. *Ceriodaphnia* test failures (percentage of the sites tested) compared with precipitation amounts and National Pollutant Discharge Elimination System excursions.

For example, TSS noncompliances occurred at outfall 203 on September 20, 1990, and at outfall 202 on August 8, 1991. Both of these outfalls are located about 100 meters upstream from WCK 3.8. *Ceriodaphnia* exposed to WCK 3.8 had 100% mortality during the September 20, 1990, test, but had 0% mortality during the August 8, 1991, test. Because TSS and O&G are not routinely measured during toxicity tests, the contribution (or lack thereof) to mortality of these constituents cannot be determined. Of the failures observed for the 1988–1992 period, 43% and 25% occurred at WCKs 3.8 and 4.4 respectively (Table 2).

3.1.2 Excursions in Relation to Precipitation Events

Regression analyses showed no significant correlation between the amount of precipitation (in centimeters) and the mean concentration (in milligrams per liter, daily maximum) of TSS or of O&G for Category II outfalls (Table 3). This observation is

Table 2. *Ceriodaphnia* acute and chronic toxicity test results and corresponding 7-d precipitation amounts (1988–1992)

Test Initiation Date	Site	% Survival	Mean Reproduction	Rainfall (cm)
2/25/88	FCK 0.1	0	-	0.0
	FFK 0.0	0	-	
	WCK 3.8	0	-	
	WCK 4.4	0	-	
8/4/88	FFK 0.4	0	-	0.5
	WCK 3.8	0	-	
	WCK 4.4	0	-	
1/26/89	MEK 0.16	60	14.0	1.8
	WCK 3.8	0	-	
	WCK 4.4	0	-	
5/11/89	FFK 0.0	0	-	0.1
	WCK 3.8	0	-	
	WCK 4.4	0	-	
8/17/89	MEK 0.16	50	18.8	3.6
	WCK 4.4	10	9.0	
	WCK 6.8	50	13.8	
12/14/89	WCK 3.8	0	-	0.7
	WCK 4.4	30	14.0	
3/29/90	WCK 3.8	0	-	0.8
7/26/90	WCK 3.8	20	20.0	0.4
9/20/90	FFK 0.4	50	19.8	1.3
	WCK 3.8	0	-	
10/25/90	WCK 3.8	10	13.0	0.1
11/29/90	WCK 3.4	20	20.5	4.1
	WCK 4.4	30	8.3	
1/24/91	WCK 3.8	60	24.7	1.1
2/28/91	WCK 3.8	0	-	5.6
4/4/91	WCK 3.8	60	19.3	2.3

Note: FCK = First Creek kilometer, FFK = Fifth Creek kilometer, WCK = White Oak Creek kilometer, and MEK = Melton Branch kilometer.

Table 3. Rainfall[a] and mean oil and grease (O&G) and total suspended solid (TSS) concentrations for Category II outfalls on days when National Pollutant Discharge Elimination System excursions occurred

	Rainfall (cm)	Mean O&G (mg/L)	Mean TSS (mg/L)
		Category II outfalls	
Feb. 2, 1988	2.99		244.6
Apr. 6, 1988	1.75	4067.5	206.2
Sep. 24, 1988	0.74		179.5
Feb. 17, 1989	2.62	42.2	132.7
Mar. 20, 1989	1.45	49.0	
May 1, 1989	1.55		721.7
Sep. 11, 1989	0.64	36.0	93.0
Sep. 15, 1989	3.96	17.5	
Sep. 22, 1989	4.50	60.1	72.3
Nov. 27, 1989	0.36		56.0
Feb. 16, 1990	3.76	22.8	105.3
Mar. 16, 1990	5.08	23.5	184.5
Jun. 20, 1990	0.0001	28.7	66.0
Jun. 22, 1990	0.62		106.0
Jun. 29, 1990	0.0		220.0
Aug. 17, 1990	0.0001		54.0
Aug. 22, 1990	0.05		96.0
Sep. 13, 1990	0.28	25.0	312.0
Sep. 21, 1990	1.27		42.8
Sep. 22, 1990	0.0001		168.6
Nov. 28, 1990	1.70	57.0	
Mar. 6, 1991	0.13	31.0	151.0
Mar. 13, 1991	1.57		161.0
Mar. 22, 1991	0.69	109.0	132.6
Mar. 23, 1991	2.03	26.0	74.0
May 28, 1991		19.0	148.5
Jun. 25, 1991	1.57		32.5
Aug. 9, 1991	0.30		703.0
Aug. 26, 1991	2.62		85.0
Nov. 21, 1991	3.18	31.5	125.0
Nov. 22, 1991	3.18	26.0	51.0
Dec. 2, 1991	5.59	28.8	
Jan. 3, 1992	2.72	29.9	64.0
Feb. 25, 1992	2.16	52.8	86.0

[a]Rainfall was measured at the Atmospheric Turbulence and Diffusion Laboratory in Oak Ridge; rainfall amounts at Oak Ridge National Laboratory may have differed.

consistent with data showing that the maximum amounts of many contaminants are transported during the "first flush" of a precipitation event. Time-course changes in TSS concentrations in stormwater runoff should differ from those of O&G in stormwater runoff for fundamental reasons. TSS concentrations, for example, may continue to increase as rainfall continues, depending upon the type of streambed and the amount of vegetated buffer zone along the stream channel, TSS may be mobilized by erosion and the mobilization of TSS may increase as soils become saturated with water. The supply of TSS could be limitless. O&G, in contrast, is limited. O&G concentrations in stormwater runoff should be highest early in the runoff event (first flush; see Appendix E). Additional rainfall would then generate runoff with a lower concentration of O&G, because the O&G supply is diminished. For these reasons, accurate estimated of maximum concentrations of O&G should be based on first flush samples. Accurate estimates of maximum TSS concentrations in stormwater might require sampling later in the storm event, depending upon the physical characteristics of the stream and its surrounding area.

3.2 TASK 2: LITERATURE REVIEW

T. F. Waters is conducting a critical review of the voluminous literature on the biological effects of TSS and O&G. Therefore, we conducted a review of literature from the past 4 years on the databases listed in the methods section (2.1.3) of this report. Additional literature was reviewed to answer specific questions as needed. An annotated bibliography of the literature selected, based on apparent relevancy through abstracts or titles, can be found in Appendix B. We did not find material on state-of-the-art best management practices in the literature we examined. The seminar on stormwater management attended by an ESD representative did not provide information about "new" stormwater runoff treatment techniques. Networking with other environmental professionals located in the Pacific Northwest proved to be the best source of information. Information on leaf compost stormwater treatment systems and parking lot design can be found in Appendix E. Constructed wetlands, while not suitable for all stormwater problems, may be a viable strategy for some areas. Implementation of the leaf compost stormwater treatment system and parking lot design may require consultation from experts outside ORNL; constructed wetlands specialists are available on site (e.g., C. C. Trettin, A. J. Stewart, and B. A. Rosensteel).

3.3 TASK 3: LABORATORY AND FIELD TESTS

3.3.1 TSS and Turbidity

During the August sampling, two of the reference streams (Brushy Fork and Scarborough Creek) had high TSS loadings (Figs. 4–5). Background concentrations of TSS for Brushy Fork were greater than "storm level" TSS values for all sites other than Scarborough Creek. A construction site and an upstream cattle crossing location may explain the elevated TSS concentrations in Brushy Fork during August. TSS concentrations in Brushy Fork in September, were greater than at most sites, but were only about half as great as those noted in August (Figs. 6–7).

Bear Creek, Brushy Fork, EFPC, Fifth Creek and Scarborough Creek were classified as "reference" streams for purposes of statistical analyses. The remaining sites were classified as "WOC" sites. T-tests conducted using data from the August sampling period showed the sum of TSS for the 4 days for WOC sites was significantly lower than the sum of TSS for 4 days for the reference sites ($p = 0.02$). When Brushy Fork was excluded from this analysis, there was no significant difference between reference and WOC sites. We also found no significant difference between reference and WOC sites (whether or not Brushy Fork was included in the analysis) for the September sampling.

For the August samples, if WCK 6.8 (which is upstream of most ORNL operations) was included in the reference category, there was no significant difference between WOC and reference categories, whether or not Brushy Fork was included in the analysis. Including WCK 6.8 in the reference category for the September sampling did not alter the statistical results.

ORNL-DWG 94-14079

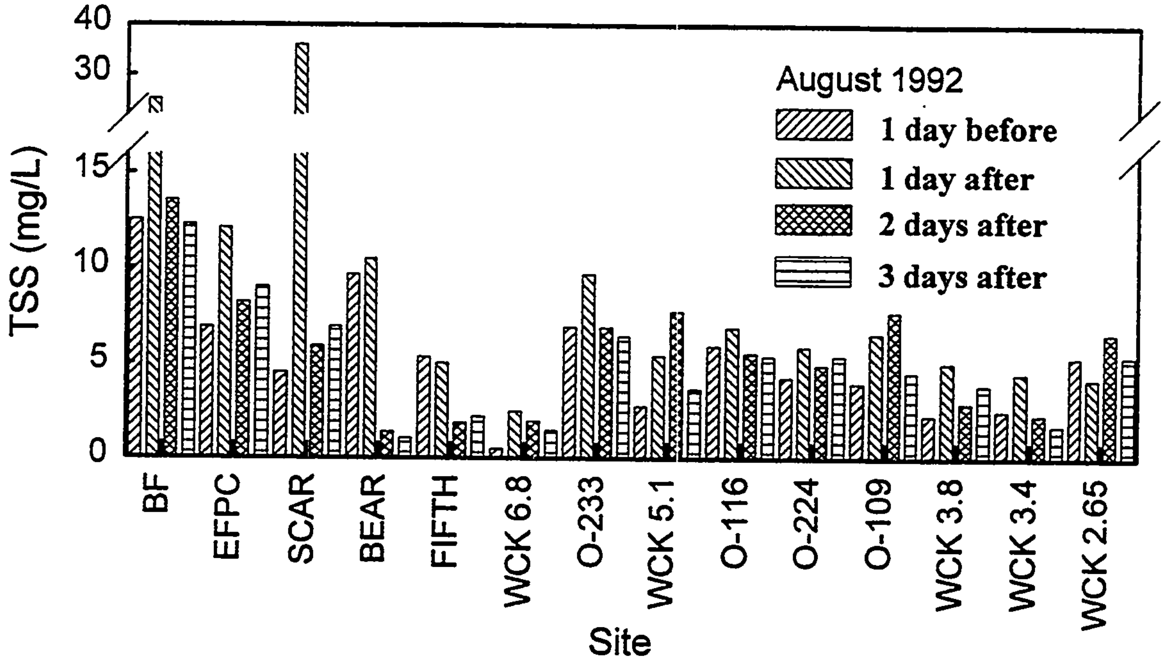

Fig. 4. Total suspended solid concentrations measured 1 day before and 3 days after a precipitation event at nine sites in White Oak Creek and five reference streams in August 1992. BF = Brushy Fork; EFPC = East Fork Poplar Creek; SCAR = Scarborough Creek; BEAR = Bear Creek; FIFTH = Fifth Creek; and WCK = White Oak Creek.

ORNL-DWG 94-14080

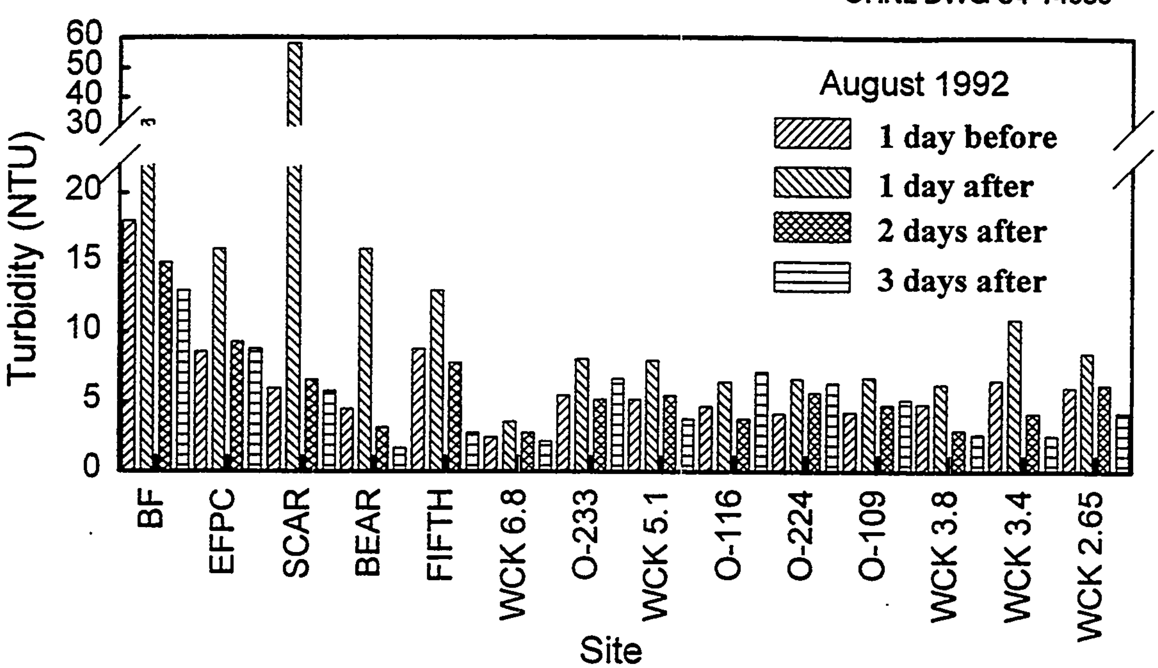

Fig. 5. Turbidity concentrations measured 1 day before and 3 days after a precipitation event at nine sites in White Oak Creek and five reference streams in August 1992.

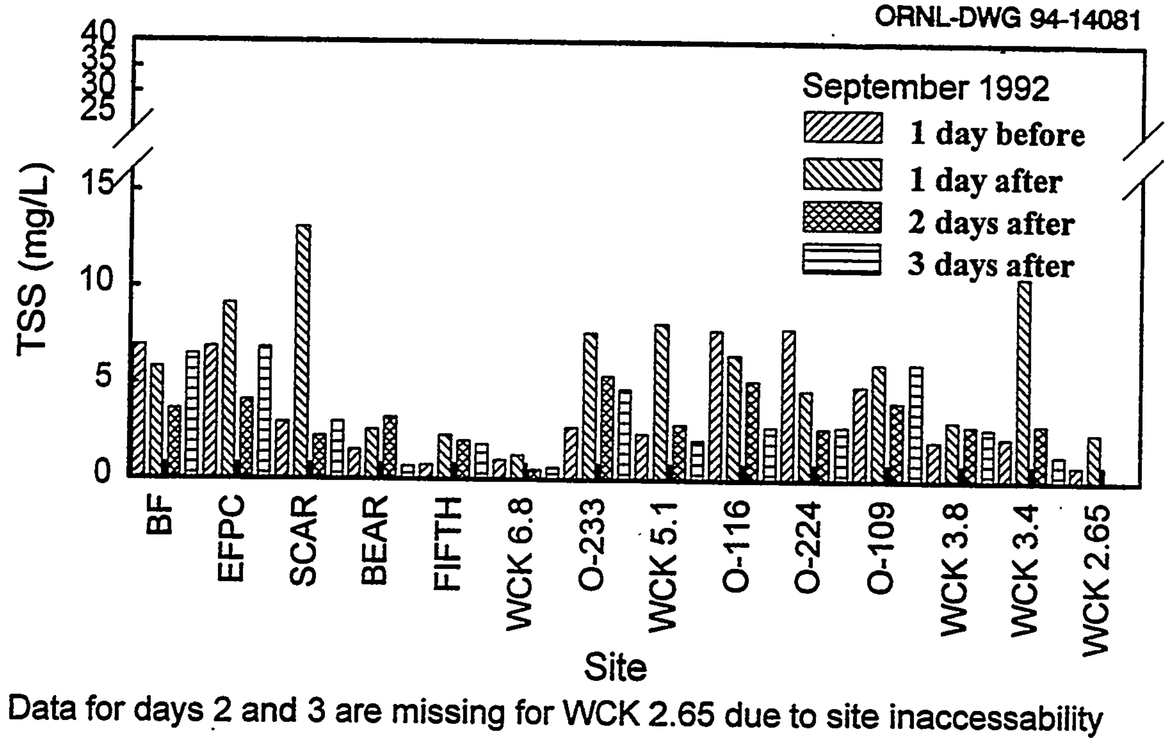

Fig. 6. Total suspended solid concentrations measured 1 day before and 3 days after a precipitation event at nine sites in White Oak Creek and five reference streams in September 1992.

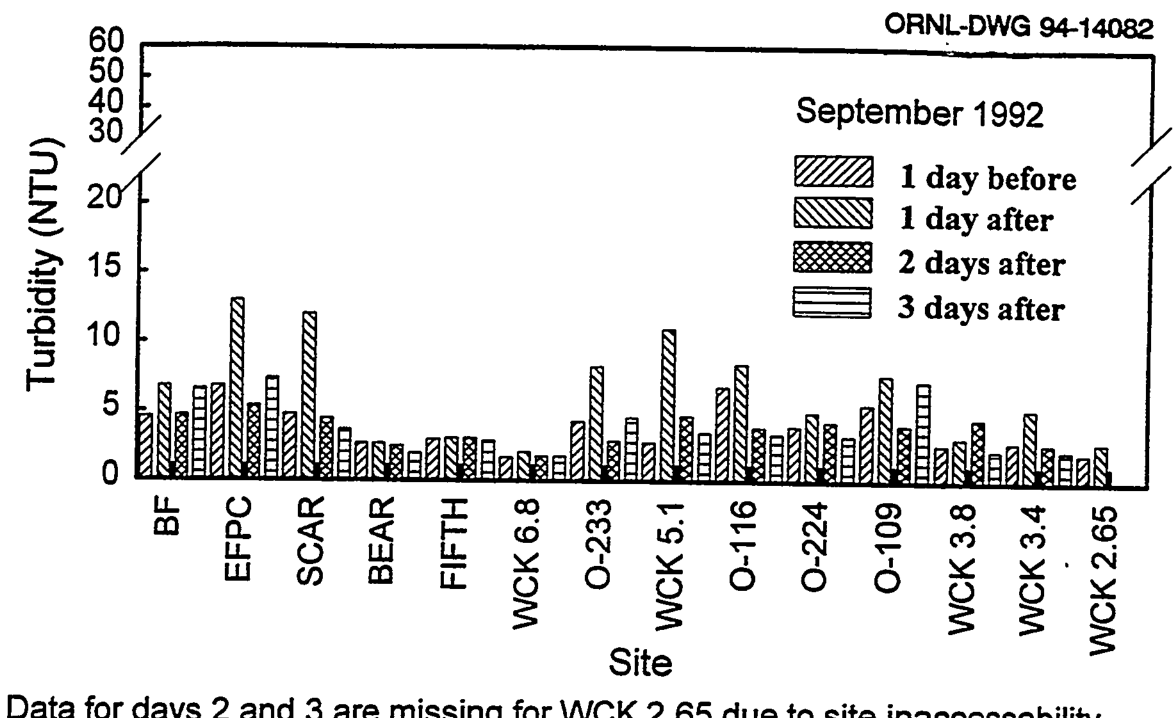

Fig. 7. Turbidity concentrations measured 1 day before and 3 days after a precipitation event at nine sites in White Oak Creek and five reference streams in September 1992.

In general, TSS levels were elevated 1 day after a precipitation event, and declined by the second day. By the third day, TSS levels were similar to pre-event levels. In our samplings, no TSS measurements reached noncompliance levels. However, we could not sample all sites during the storm event due to the distance between sites.

3.3.2 Oil and Grease

Regression analysis revealed no relationship between TOC and O&G. Hydrocarbons are about 80% carbon by weight. Therefore, one would expect the TOC value for a sample to be about 80% of the O&G value for the same sample. TOC:O&G ranged from 8 to 210% (mean = 54%) for the samples we collected. High O&G values do not correspond with high TOC values; this suggests that non-carbon containing materials are being measured in the O&G analysis. As would be expected, TOC values were less than the O&G values in all but one sample (Table 4). If these samples had been used for compliance purposes, there would have been five O&G exceedances, using the O&G methodology. Assuming that the same 15-mg/L daily maximum limit was set for TOC, only one violation would have occurred. Either TOC or O&G measurements could easily over estimate the amount of *toxic* hydrocarbon constituents present in the sample. Naturally occurring oils occur in differing amounts and depend on physicochemical conditions in the stream. However, TOC values for the headwaters of WOC averaged <0.96 mg/L and were detectable in 11 of 12 samplings; O&G was not detected in any (N = 12, <2 mg/L) samplings (ORR Environmental Report 1991). This result does not allow us to determine if increased concentrations of O&G downstream are due to anthropogenic influences, reach-specific differences in physicochemical condition, or a combination thereof.

3.3.3 Sediment

Total petroleum hydrocarbons (TPHs) are present in sediment at WCK 4.2 at concentrations that could be toxic to aquatic life (Table 5 and Sect. 1.2 of this report).

Table 4. Concentrations of total organic carbon (TOC) and oil and grease (O&G) in 15 outfalls on the White Oak Creek watershed

Outfall	TTU ID Number[a]	TOC (mg/L)	O&G (mg/L)	TOC:O&G
268	2257	4.99	<5.0	0.99
264	2258	3.12	5.6	0.56
116	2259	3.09	14.9	0.21
113	2260	2.39	6.3	0.38
102	2261	----[b]	<5.0	----[b]
209	2262	2.06	17.6	0.12
109	2263	3.66	5.9	0.62
203	2264	3.28	<5.0	0.66
216	2265	3.08	<5.0	0.62
224	2266	1.30	16.6	0.08
233	2267	2.79	15.9	0.18
223	2268	2.79	16.6	0.17
248	2269	6.77	15.8	0.43
144	2270	20.7	9.9	2.10
230	2271	6.71	15.0	0.45

[a]Tennessee Technological University Center for the Management, Utilization, and Protection of Water Resources identification number.
[b]No sample. Leaked out in transit.

Mean concentrations of 10.3 and 30.0 µg/g were found in sediments from WCKs 3.5 and 4.2 respectively. At WCK 6.8, by comparison, sediment concentrations of TPH were <5.0 µg/g. In Hinds Creek and Brushy Fork, mean TPH concentrations were 7.0 and 6.7 µg/g respectively. Sediment from these two stream sites was sampled below a bridge crossing and thus had the potential of having much higher loading than the upper WOC site. The GC/FID signatures at WCK 4.2 and EFK 23.4 were similar to one another but different from the signatures of the reference streams (Appendix G, Tables G.1–21). These signatures indicate an accumulation of hydrocarbons in WCK 4.2 that are probably associated with facility operations. The accumulation of TPHs in the sediment of WOC is of biological concern. Benthic macroinvertebrates are particularly susceptible to toxicants

Table 5. Total petroleum hydrocarbon concentrations (as measured by GC/FID[a]) in sediment samples

ORNL AC ID No.[b]	Field No.	Site	Concentration (μg/g)	Mean ± SE
920909-032	S-1	WCK 3.5	11.0	
920909-033	S-2	WCK 3.5	16.0	
920909-034	S-3	WCK 3.5	19.0	15.3 ± 2.3
920909-035	S-4	WCK 4.2	45.0	
920909-036	S-5	WCK 4.2	16.0	
920909-037	S-6	WCK 4.2	29.0	30.0 ± 8.4
920909-038	S-7	WCK 6.8	<5.0	
920909-039	S-8	WCK 6.8	<5.0	
920909-040	S-9	WCK 6.8	<5.0	<5.0
920909-041	S-10	HCK 12.9	<5.0	
920909-042	S-11	HCK 12.9	6.0	
920909-043	S-12	HCK 12.9	10.0	7.0 ± 1.5
920909-044	S-13	EFK 23.4	51.0	
920909-045	S-14	EFK 23.4	91.0	
920909-046	S-15	EFK 23.4	81.0	74.3 ± 12.0
920909-047	S-16	BFK 7.6	<5.0	
920909-048	S-17	BFK 7.6	10.0	
920909-049	S-18	BFK 7.6	<5.0	6.7 ± 1.7
920909-050	S-19	EFK 21.9	48.0	
920909-051	S-20	EFK 21.9	19.0	
920909-052	S-21	EFK 21.9	19.0	28.7 ± 9.7

[a]GC/FID = gas chromatography/flame ionization detection.
[b]Samples were collected September 8, 1992 and analyzed by the Oak Ridge National Laboratory Analytical Chemistry Division (ORNL AC).
Note: WCK = White Oak Creek kilometer, HCK = Hinds Creek kilometer, BFK = Brushy Fork kilometer, and EFK = East Fork Poplar Creek kilometer.

in sediment (EPA 1986). Toxicity testing of sediment from affected and reference areas could define the extent to which the hydrocarbon constituents are of ecological concern.

3.3.4 Toxicity Testing

Results of toxicity tests using *Ceriodaphnia* and *Elimia* are summarized in Table 6. Water from outfall 116 was acutely toxic to *Ceriodaphnia* on both test dates. The removal of TSS from outfall 116 water by centrifugation did not remove the toxicity. Water samples from outfalls 224 and 233 were not toxic to *Ceriodaphnia*.

Snails in uncentrifuged and centrifuged (to remove TSS) water samples from outfall 224 ate significantly less food than snails in the control at outfall 224 (uncentrifuged and centrifuged) ($p = 0.0001$; t-test mean wet weight eaten). Snails in uncentrifuged outfall 116 water also ate significantly less than snails in the control. However, centrifuging outfall 116 restored feeding rates to control levels. Water from outfall 233 did not inhibit snail feeding rates.

In a follow-up test, snail feeding rates were inhibited by water from outfall 116 and by water collected from WOC 10 m upstream and downstream of outfall 116. Outfall 116 water was toxic to *Ceriodaphnia* in this test, but water from WOC upstream and downstream of the outfall was not toxic. Addition of EDTA and paraffin to outfall 116 water removed the acute toxicity to *Ceriodaphnia*; there was no evidence of chronic toxicity to *Ceriodaphnia* for either treatment.

The three outfalls included in this test were chosen because they have (1) had numerous noncompliances in past years, (2) had high values in our ranking procedure (see Table 1), and (3) have different sources of runoff (e.g., gravel vs paved a parking lots and/or roof drains). Outfall 116, which was toxic to both species, drains a gravel parking lot. Outfall 224 drains a parking lot and roofs in the 4500-S area. That two of three of the outfalls we examined affected at least one of the species tested suggests that stormwater runoff probably is affecting aquatic communities in WOC. That *Elimia* are more sensitive than *Ceriodaphnia*, especially to in-stream constituents, prompts one to consider further testing to quantify the possible effects of stormwater runoff on stream biota. A stormwater drain toxicity survey with one or more species may further our

Table 6. Toxicity test results for *Ceriodaphnia dubia* and *Elimia clavaeformis* exposed to stormwater runoff from selected outfalls and instream White Oak Creek samples, July and September, 1992

Site-treatment	Elimia feeding	*Ceriodaphnia* survival	*Ceriodaphnia* reproduction
Outfall 116	●	●	NA
Outfall 116-C[a]	—	●	NA
Outfall 224	●	—	—
Outfall 224-C	●	—	—
Outfall 233	—	—	—
Outfall 233-C	—	—	—
Outfall 116	●	●	NA
WOC-upstream of outfall 116	●	—	—
WOC-downstream of outfall 116	●	—	—
Outfall 116-paraffin	NA	—	—
Outfall 116-EDTA[b]	NA	—	—

Note: "●" = significantly different from the control for this measure of toxicity; "—" = not significantly different from the control for this measure of toxicity; NA = not applicable due to 100% mortality of the adults.
[a]Centrifuged to remove total suspended solids.
[b]EDTA = Ethylenediamine tetracetic acid.

understanding of the question. Toxicity tests using serial dilutions of effluents or stormwater runoff can be used to estimate toxicity loading to a stream (cf. Hinzman 1993).

3.3.5 Biological Monitoring and Abatement Program Data

Liver detoxification enzymes (P450 and cytochrome b_5) are important in the biotransformation or metabolism of xenobiotics, such as pesticides, hydrocarbons, chlorinated hydrocarbons, and numerous biological molecules, including steroid hormones (Payne and Penrose 1975, Stegeman 1981). Increased activity of these enzymes is generally associated with increased liver-somatic index values (Sloof et al. 1983, Fabacher and Baumann 1985). Detoxification enzymes concentrations have been consistently elevated in fish from WOC, especially between WCKs 3.6 and 2.4 (S. M. Adams, unpublished data) as compared with fish from reference streams. Liver somatic index has also been higher in WOC fish as compared with controls, indicating toxicant stress.

Surveys of fish and benthic macroinvertebrate communities in WOC have shown that these populations have been affected by ORNL operations. The fish community status has been attributed to exposure to toxicant(s) (especially chlorine) and barriers to recolonization (e.g., weirs; M. G. Ryon, ORNL, unpublished data). Impacts to the macroinvertebrate community are thought to be caused primarily by the presence of toxicants, although impacts may also be associated with elevated temperatures, nutrient enrichment, and siltation (J. G. Smith, ORNL, unpublished data). The composition and structure of the invertebrate community near the main ORNL complex suggests that the overriding perturbation may be the intermittent release of toxicants, while the composition and structure of communities further downstream from ORNL suggests that other factors (e.g., siltation, nutrient enrichment) may be ecologically more important than point source discharges.

4. SUMMARY

The three tasks outlined in the study plan were (1) clarification of the TSS and O&G non-compliance situation at ORNL, (2) provision of guidance as to appropriate limits for TSS and O&G in Category I and II discharges, and (3) provision of information about the effectiveness of possible mitigation or remediation measures for TSS and O&G in stormwater releases, assuming that such measures are needed for one or more ORNL Category I or II outfalls.

A review of the NPDES noncompliance data clearly demonstrates that ORNL operations are conducted with care. Only 7% of the TSS/O&G noncompliances for outfalls with a rank of ≥2 were attributable to one-time incidents (e.g., spills). Of the TSS/O&G noncompliances resulting from stormwater runoff for outfalls ranked ≥2, 32% were attributed to six outfalls (109, 114, 116, 209, 216, and 224). By including outfalls 202, 230, 283, 233, and 244 in this list, 57% of the TSS/O&G noncompliances for outfalls ranked ≥2 can be accounted for.

To determine whether the TSS and O&G noncompliance situation at ORNL is primarily a regulatory problem or a legitimate ecological concern, we conducted laboratory and field tests. Two of the three outfalls that were tested were toxic to *Ceriodaphnia* and/or affected the feeding rate of *Elimia* in laboratory toxicity tests. Outfall 116 water was acutely toxic to *Ceriodaphnia* and reduced feeding in *Elimia*; outfall 224 water reduced feeding rates in *Elimia* but did not appear to affect *Ceriodaphnia*. In addition, water from WOC up- and downstream of outfall 116 affected snails. These results suggest that stormwater runoff from at least some of the outfalls experiencing noncompliances may be of ecological concern. However, we were unable to determine whether the toxicity that was detected was due to TSS, O&G, or some other constituent (i.e., a particle-associated toxicant). Both paraffin and EDTA treatments of outfall 116 water removed toxicity, suggesting that more than one constituent may be contributing to the toxic properties of the water. Although TSS concentrations in WOC were similar to or lower than concentrations seen in reference streams, aquatic communities in these streams appear to be in better condition than those in WOC. Thus, TSS concentrations may not be the only factor adversely affecting biota in WOC. Further monitoring to rigorously test the hypothesis that TSS is not affecting stream health may be justified.

Total petroleum hydrocarbons have accumulated in the sediments of at least some sites in WOC at concentrations that could be harmful to benthic biota. Brown et al. (1985) found that the type of petroleum found in sediment closely resembled that found in stormwater, strongly implicating stormwater runoff as the primary source for sediment contamination. We did not conduct TPH analyses on stormwater from ORNL, but the hydrocarbon signature in WOC sediments closely resembled that of EFPC sediments near the Y-12 Plant and was quite different from the hydrocarbon signatures of reference streams. These results imply that hydrocarbon accumulation in WOC sediments may be related to facility operations. Sediment toxicity testing could be conducted to assess the potential biological affects of this accumulation.

The O&G measurement is not a very sensitive measure of hydrocarbon content in water, and our results suggest that it is best used when measuring relatively large concentrations of oil. Measured TOC values did not correspond with measured O&G values suggesting that O&G is not responding to variations in hydrocarbon concentrations in water. Both O&G and TOC can overestimate the toxic constituents of hydrocarbons in water. However, given that ecological effects have been documented as low as 1–100 μg/L (Jacobsen and Boylan 1973), the 10 mg/L daily limit does not appear to be excessive if the measurement being used is measuring hydrocarbon content. Our data suggest that the O&G measurement may not be a reliable indicator of the presence of hydrocarbons. In many streams, TSS loads are derived primarily by erosion of stream bank materials. The erosion rates of bank materials are influenced greatly by bank-side vegetation rooting depth, the percentage of the area of the stream bank protected by vegetation cover, the root density in the soil of the stream bank, stream slope, and the meander pattern of the stream (D. Rosgen, Wildland Hydrology Consultants, personal communication). TSS concentrations in WOC during storm events did not differ greatly from those in other area streams, suggesting that in WOC, TSS from parking lot runoff was not a major component of the total TSS load. In fact, in-stream concentrations of TSS in our tests were lower than the literature values given for being harmful to biota. However, the precipitation events we observed were relatively small. Outfall 116 has had TSS violations as high as 1332 mg/L (in 1989), well above values reported to be biologically harmful. TSS concentrations 16 times lower than this value could adversely impact stream biota, especially if they occur during an organism's sensitive life stage. TSS concentrations as low as 80 mg/L have been shown to reduce macroinvertebrate densities by 60%, while in areas of sediment accumulation, benthic invertebrate populations have also decreased by 60% regardless of the suspended solid concentrations (Gammon 1970). Additionally, siltation has been implicated as one possible factor impacting the benthic macroinvertebrate community in WOC (J. G. Smith, unpublished data). The TSS limit of 50 mg/L at the discharge point probably is more restrictive than the O&G limit. While the occasional exceedance of 50 mg/L TSS discharges alone are unlikely to adversely affect stream biota, based on the complex nature of discharges to the stream and the conditions listed previously, efforts to minimize such occurrences at ORNL should be implemented. End-of-pipe remedial action may not reduce instream concentrations to <50 mg/L because of the contribution of natural processes (e.g., bank erosion and sediment resuspension), but it will reduce total sediment loading to the stream.

5. RECOMMENDATIONS

The "Stormwater: Permitting, Treatment and Compliance Strategies" course attended by T. L. Phipps emphasized that there are no "miracle cures." Given the ambiguities in the data, it would be difficult to argue for a monitoring-only status for TSS and O&G. A proactive approach may be the best solution to ORNL's TSS and O&G noncompliance situation. Therefore, we recommend the following course of action:

1. The O&G measurement does not appear to be the best measure of instream hydrocarbon concentrations. If the objective of the O&G limit is to limit hydrocarbon inputs to WOC, analyses that specifically measure hydrocarbons would be a better tool to use for compliance. A proactive approach for ORNL, given evidence of hydrocarbon inputs and possible effects in WOC, would be to take the initiative in developing NPDES monitoring protocol for hydrocarbons, while arguing for a monitoring only status during the development procedure. Because the gravimetric method for estimating O&G concentrations includes O&G constituents from natural sources, O&G concentrations in runoff samples containing high concentrations of O&G (as determined by gravimetric methodology) should be verified analytically using a technique that is more diagnostic of hydrocarbon contamination, which are presumably the intended constituents of regulatory concern. We suggest that the residue from the gravimetric O&G analyses that exceed 15 μg/L be re-dissolved in an appropriate solvent and analyzed by one or more (preferably more) procedures that would confirm the presence of petroleum hydrocarbons. This could be accomplished through the use of an Iatroscan analyzer, total organic carbon, hydrocarbons by thin layer chromatography/flame ionization detection, gas chromatography/mass spectrometry, or gas chromatography/flame ionization detection, as was done for the sediment samples in this study. Chemical composition of O&G extracts could be compared with that of stream sediment extracts to ensure that chemical analyses were indeed measuring those substances that accumulate in sediments downstream from ORNL discharges. Results of such studies would either corroborate the presence of high hydrocarbon concentrations in samples exceeding the NPDES limit for O&G, or provide additional evidence that the gravimetric O&G measurement produces

spurious NPDES violations when limits are low (such as 15 ppm). Simultaneous development of a quantitative hydrocarbon measurement to use for possible NPDES compliance should proceed. Ideally, TDEC could be presented with a proposal for direct monitoring of O&G constituents that have been shown to accumulate in sediments below ORNL, using analytical methods that are precise and accurate and that provide more chemical information than the relatively crude gravimetric procedure now used.

2. ORNL should consult with companies such as W&H Pacific or EMCON Northwest, Inc., about state-of-the-art stormwater treatment options; these options include leaf compost treatment system, Catch Basin Filter, etc. These systems are under development and may be adapted to fit ORNL's needs. It is likely that the newly developed drop-in leaf compost units or catch basins will be suitable for at least several of ORNL's parking lot drains. The small land area required for the traditional leaf compost units may be suitable in other areas where more traditional procedures (i.e., detention basins; see Appendix E for a comparison of costs) are not possible. W&H Pacific is working with private and state agencies in the Pacific northwest and has a patent pending for their system; EMCON Northwest, Inc., has a patent pending on the Catch Basin Filter.

3. If consultation with one or more of these companies shows that these methods are suitable for use at ORNL, it should be possible to argue for "monitoring only" status for TSS and O&G while the ORNL takes the initiative and participates in testing the new systems on those outfalls identified as being important contributors to ORNL's noncompliances.

4. If these systems are found to be inappropriate for use at ORNL, the contractors may have recommendations for other new techniques, not found in the published literature, that may be viable alternatives.

5. Other strategies, such as improved parking lot design and constructed wetlands, should be considered for all new construction. ORNL currently has personnel

available for consultation on BMPs such as constructed wetlands and establishing riparian vegetation to minimize bank erosion.

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APPENDIX A

Characterization of NPDES TSS and O&G Violations at ORNL 1988–1992

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1998 through May 30, 1992

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
3/31/88	19 mg/L oil and grease	STP X01	15.0 mg/L, daily maximum	Cause unknown. An investigation was pursued.
4/6/88	4497 mg/L oil and grease	Outfall 242	15.0 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
4/6/88	3638 mg/L oil and grease	Outfall 245	15.0 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
4/6/88	599 mg/L TSS	Outfall 202	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
4/6/88	137 mg/L TSS	Outfall 204	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
4/6/88	165 mg/L TSS	Outfall 216	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
4/6/88	65 mg/L TSS	Outfall 217	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
4/6/88	67 mg/L TSS	Outfall 244	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
4/6/88	106 mg/L TSS	Outfall 230	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
4/6/88	57 mg/L TSS	Outfall 233	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
4/6/88	60 mg/L TSS	Outfall 267	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
4/6/88	632 mg/L TSS	Outfall 268	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
4/6/88	256 mg/L TSS	Outfall 283	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
4/6/88	130 mg/L TSS	Outfall 291	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
5/10/88	178 mg/L TSS	CYRTF X02	50.0 mg/L, daily maximum	An intake tube fell from its bracket and collected nonrepresentative samples from the bottom of a basin.
8/09/88	Visible oil sheen	Pipe 249	No oil sheen	Discharge from oil through a floor drain in Building 2024. Administrative controls to keep personnel from discharging vat-cleaning solutions down floor drains.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
9/24/88	195 mg/L TSS	Outfall 248	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/24/88	164 mg/L TSS	Outfall 265	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
10/18/88	Visible oil sheen	Outfall 217	No oil sheen	Pipe 217 discharges steam condensate from the direction of 4500S. The sheen was apparently an isolated incident. EMC checked the sources to identify the reason for the sheen.
6/5/89	163 mg/L TSS	Outfall 102	50 mg/L, daily maximum	TSS exceedances appear to have been related to construction activity with the ORNL Distribution System Upgrade Project. Personnel have been advised to protect storm drains during construction and a study to install catch basins is being pursued.
6/5/89	911 mg/L TSS	Outfall 109	50 mg/L, daily maximum	TSS exceedances appear to have been related to construction activity with the ORNL Distribution System Upgrade Project. Personnel have been advised to protect storm drains during construction and a study to install catch basins is being pursued.
6/5/89	514 mg/L TSS	Outfall 111	50 mg/L, daily maximum	TSS exceedances appear to have been related to construction activity with the ORNL Distribution System Upgrade Project. Personnel have been advised to protect storm drains during construction and a study to install catch basins is being pursued.
6/5/89	1332 mg/L TSS	Outfall 113	50 mg/L, daily maximum	TSS exceedances appear to have been related to construction activity with the ORNL Distribution System Upgrade Project. Personnel have been advised to protect storm drains during construction and a study to install catch basins is being pursued.
6/5/89	3692 mg/L TSS	Outfall 116	50 mg/L, daily maximum	TSS exceedances appear to have been related to construction activity with the ORNL Distribution System Upgrade Project. Personnel have been advised to protect storm drains during construction and a study to install catch basins is being pursued.
6/5/89	109 mg/L TSS	Outfall 143	50 mg/L, daily maximum	TSS exceedances appear to have been related to construction activity with the ORNL Distribution System Upgrade Project. Personnel have been advised to protect storm drains during construction and a study to install catch basins is being pursued.
6/5/89	241 mg/L TSS	Outfall 144	50 mg/L, daily maximum	TSS exceedances appear to have been related to construction activity with the ORNL Distribution System Upgrade Project. Personnel have been advised to protect storm drains during construction and a study to install catch basins is being pursued.
6/5/89	56 mg/L TSS	Outfall 191	50 mg/L, daily maximum	The exceedance is attributed to algal growth on the water surface in the settling basin near the ORNL Consolidated Fuel Reprocessing Facility.
9/5/89	193.4 kg/day oil and grease	X01 (STP)	13.10 kg/day, daily maximum	The daily limit for this date cause the monthly limits to be exceeded. No cause was found.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
9/89	15.3 mg/L oil and grease	X01 (STP)	10.0 mg/L monthly average	The daily limit for this date cause the monthly limits to be exceeded. No cause was found.
9/89	17.9 kg/day oil and grease	X01 (STP)	8.7 kg/day, monthly average	The daily limit for this date cause the monthly limits to be exceeded. No cause was found.
9/89	32.5 mg/L, daily maximum	X02 (CYRTF)	15.0 mg/L daily maximum	An investigation into the exceedance revealed no known cause.
9/29/89	103 mg/L TSS	Outfall 108	50 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/29/89	32 mg/L oil and grease	Outfall 108	15 mg/L, daily maximum	An excess of debris was found in the concrete drain to Outfall 108. This material was removed. Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/29/89	66 mg/L TSS	Outfall 141	50 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/30/89	20 mg/L oil and grease	Outfall 165	15 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/30/89	67 mg/L oil and grease	Outfall 168	15 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/30/89	211 mg/L oil and grease	Outfall 169	15 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/30/89	67 mg/L TSS	Outfall 169	50 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
9/30/89	25 mg/L oil and grease	Outfall 173	15 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
11/27/89	56 mg/L TSS	Outfall 283	50 mg/L, daily maximum	The exceedance is attributed to loose fines conveyed from a drainage area near the 7500 area. A parking lot had undergone excavation in the course of remedial action. The discharge end of the pipe to Outfall 283 is partially below grade which causes standing water in the pipe. This outfall will be upgraded as part of an engineering project.
12/21/89	1200 mg/L oil and grease	VC7002	15 mg/L, daily maximum	Permit exceedances are attributed to regular cleaning activity in building 7002, despite trap cleaning. Engineers are looking for a better trap for the building.
12/21/89	4900 mg/L TSS	VC7002	40 mg/L, daily maximum	Permit exceedances are attributed to regular cleaning activity in building 7002, despite trap cleaning. Engineers are looking for a better trap for the building.
1/16/90	588 mg/L oil and grease	EF7002	15 mg/L, daily maximum	Permit exceedances are attributed to regular cleaning activity in building 7002, despite trap cleaning. Engineers are looking for a better trap for the building.
1/18/90	163 mg/L oil & grease	Vehicle cleaning facility (VC7002)	15 mg/L, daily maximum	Repeated violations from this facility. Trap cleaning has not solved the problem. Ongoing communication w/ state to try to solve the problem.
1/18/90	3271 mg/L TSS	VC7002	40 mg/L, daily maximum	Repeated violations from this facility. Trap cleaning has not solved the problem. Ongoing communication w/ state to try to solve the problem.
2/15/90	206 mg/L oil and grease	VC7002	15 mg/L, daily maximum	Repeated violations from this facility. Trap cleaning has not solved the problem. Ongoing communication w/ state to try to solve the problem.
2/15/90	2400 mg/L TSS	VC7002	40 mg/L, daily maximum	Repeated violations from this facility. Trap cleaning has not solved the problem. Ongoing communication w/ state to try to solve the problem.
2/16/90	Visible oil sheen	Outfall 241	No visible sheen	A liner ruptured during rehabilitation of an under ground sewer pipeline. The faulty liner was replaced and taken to the contractor for examination.
2/16/90	53 mg/L oil and grease	Outfall 109	15 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/16/90	21 mg/L oil and grease	Outfall 110	15 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
2/16/90	21 mg/L oil and grease	Outfall 112	15 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/16/90	45 mg/L oil and grease	Outfall 114	15 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/16/90	19 mg/L oil and grease	Outfall 170	15 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/16/90	26 mg/L oil and grease	Outfall 173	15 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/16/90	1087 mg/L TSS	Outfall 109	50 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/16/90	59 mg/L TSS	Outfall 110	50 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/16/90	350 mg/L TSS	Outfall 114	50 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/16/90	79 mg/L TSS	Outfall 115	50 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. This exceedance may have been influenced by parking lot construction, although the site was properly seeded, mulched and stabilized with straw. These storm drains are managed under Best Management Practices to minimize exceedances.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
2/16/90	182 mg/L TSS	Outfall 203	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. Outfall 203 has been targeted for remediation. These storm drains are managed under Best Management Practices to minimize exceedances.
2/16/90	21 mg/L oil and grease	Outfall 216	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/16/90	16 mg/L oil and grease	Outfall 233	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/16/90	16 mg/L oil and grease	Outfall 234	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/16/90	17 mg/L oil and grease	Outfall 247	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/16/90	44 mg/L oil and grease	Outfall 250	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/16/90	58 mg/L TSS	Outfall 268	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. Outfall 268 is in the area in which a gravel parking lot was recently installed. The lot was properly straw baled, but some runoff may have occurred. These storm drains are managed under Best Management Practices to minimize exceedances.
2/16/90	76 mg/L TSS	Outfall 283	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. Outfall 284 has been targeted for remediation. These storm drains are managed under Best Management Practices to minimize exceedances.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
3/16/90	17 mg/L oil and grease	Outfall 214	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
3/16/90	20 mg/L oil and grease	Outfall 223	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
3/16/90	39 mg/L oil and grease	Outfall 224	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. Outfall 224 has been targeted for remediation. These storm drains are managed under Best Management Practices to minimize exceedances.
3/16/90	290 mg/L TSS	Outfall 224	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. Outfall 224 has been targeted for remediation. These storm drains are managed under Best Management Practices to minimize exceedances.
3/16/90	18 mg/L oil and grease	Outfall 244	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. Outfall 244 has been targeted for remediation. These storm drains are managed under Best Management Practices to minimize exceedances.
3/16/90	79 mg/L TSS	Outfall 244	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. Outfall 244 has been targeted for remediation. These storm drains are managed under Best Management Practices to minimize exceedances.
5/2/90	87 mg/L TSS	X01 (STP)	45 mg/L, daily maximum	STP experienced an upset that resulted in effluent from the STP clarifier passing directly into the chlorine contact chamber due to extremely heavy rainfall. Administrative controls have been applied to avert another incident. A feasibility study to install an alarm is being conducted.
5/2/90	630 mg/L oil and grease	X01 (STP)	15 mg/L, daily maximum	STP experienced an upset that resulted in effluent from the STP clarifier passing directly into the chlorine contact chamber due to extremely heavy rainfall. Administrative controls have been applied to avert another incident. A feasibility study to install an alarm is being conducted.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
6/12/90	60 mg/L TSS	X02 (CYRTF)	50 mg/L, daily maximum	No reason for the exceedance was found. Algal clumps may have caused the problem.
6/20/90	27 mg/L oil and grease	Outfall 207	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
6/20/90	28 mg/L oil and grease	Outfall 230	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
6/20/90	31 mg/L oil and grease	Outfall 231	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
6/20/90	66 mg/L TSS	Outfall 233	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
6/29/90	395 mg/L TSS	Outfall 208	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
6/29/90	105 mg/L TSS	Outfall 209	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
6/29/90	205 mg/L TSS	Outfall 213	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
6/29/90	175 mg/L TSS	Outfall 215	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
6/29/90	analysis not complete, bottle broken	NA	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
7/31/90	88 mg/L oil and grease	X02 (CYRTF)	20 mg/L, daily maximum	The exceedance was attributed to a gearbox failure. The gearbox was repaired immediately.
7/31/90	20 mg/L oil and grease	X02 (CYRTF)	15 mg/L, monthly average	The exceedance was attributed to a gearbox failure. The gearbox was repaired immediately.
8/23/90	96 mg/L TSS	Outfall 203	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. Outfall 203 will be improved as part of an ORNL engineering project. These storm drains are managed under Best Management Practices to minimize exceedances.
8/24/90	419 mg/L TSS	Outfall 116	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
8/24/90	54 mg/L TSS	Outfall 209	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/13/90	21 mg/L oil and grease	Outfall 232	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/13/90	29 mg/L oil and grease	Outfall 291	15 mg/L, daily maximum	A subcontractor pumped muddy water into a storm water drain during an excavation. ORNL required the subcontractor to cease operations until BMP's were followed.
9/19/90	TSS Limit exceeded	6000 Area	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/13/90	312 mg/L TSS	Outfall 248	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
9/22/90	264 mg/L TSS	Outfall 223	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/22/90	155 mg/L TSS	Outfall 242	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/22/90	164 mg/L TSS	Outfall 261	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/22/90	71 mg/L TSS	Outfall 266	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/22/90	189 mg/L TSS	Outfall 268	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/30/90	52 mg/L TSS	Outfall 203	30 mg/L, monthly average	Additional monitoring was conducted due to permit renewal. Monthly average were exceeded based on additional monitoring.
9/30/90	34 mg/L TSS	Outfall 209	30 mg/L, monthly average	Additional monitoring was conducted due to permit renewal. Monthly average were exceeded based on additional monitoring.
9/30/90	82 mg/L TSS	Outfall 242	30 mg/L, monthly average	Additional monitoring was conducted due to permit renewal. Monthly average were exceeded based on additional monitoring.
10/4/90	Visible Sheen	Outfall 234	No visible sheen	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
10/28/90	Visible Sheen	Bldg. 2519 (Steam Plant)	No visible sheen	An expandable plug in an abandoned floor drain came out and about 1 cup of oil was released into the storm drain. Oil booms were placed across the drainage ditch and the oil was recovered. The floor drain was plugged and sealed with a solid cover.
11/19/90	24 mg/L oil and grease	X01 (STP)	15 mg/L, daily maximum	The exceedance is under investigation. No unusual operating conditions or upsets were noted. No additional exceedances occurred.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
11/19/90	15.5 kg/day oil and grease	X01 (STP)	13.1 kg/day, daily maximum	The exceedance is under investigation. No unusual operating conditions or upsets were noted. No additional exceedances occurred.
11/28/90	42 mg/L oil and grease	Outfall 209	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
11/28/90	56 mg/L oil and grease	Outfall 226	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
3/26/91	86 mg/L TSS	X01 (STP)	45 mg/L, daily maximum	An upset occurred due to high rainfall. An undetermined amount of sludge carried over from the clarifier and bounded to one of the sand filters when the other filter was being backwashed. The sludge ultimately ended up at the discharge point. As soon as it was noticed, the upset was corrected and normal operations resumed.
3/13/91	161 mg/L TSS	Outfall 202	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
3/22/91	82 mg/L TSS	Outfall 203	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
3/22/91	82 mg/L TSS	Outfall 209	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
3/23/91	21 mg/L oil and grease	Outfall 222	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
3/23/91	31 mg/L oil and grease	Outfall 223	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
3/23/91	74 mg/L TSS	Outfall 223	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
3/22/91	109 mg/L oil and grease	Outfall 224	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
3/22/91	107 mg/L TSS	Outfall 224	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
3/6/91	151 mg/L TSS	Outfall 225	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
3/22/91	70 mg/L TSS	Outfall 230	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
3/22/91	278 mg/L TSS	Outfall 264	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
3/22/91	15 mg/L oil and grease	Outfall 284	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
3/12/92	TSS	First Creek	Unpermitted discharge	Non-hazardous drill fluid was released and it flowed into First Creek. A barrier was erected to prevent further discharges.
5/7/91	145 mg/L oil and grease	X02 (CYRTF)	20 mg/L, daily maximum	No reason for the exceedance was found. Equipment was calibrated and monitoring of the situation continued.
5/28/91	20 mg/L oil and grease	Outfall 202	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
5/28/91	88 mg/L TSS	Outfall 202	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
5/28/91	80 mg/L TSS	Outfall 230	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
5/28/91	277 mg/L TSS	Outfall 244	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
5/28/91	149 mg/L TSS	Outfall 248	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
5/28/91	18 mg/L oil and grease	Outfall 284	15 mg/L, daily maximum	The exceedance was attributed to grease residue after maintenance was conducted n a compressor. Cleanup was initiated.
6/26/91	187 mg/L oil and grease	X01 (STP)	15 mg/L, daily maximum	No cause was determined for the exceedance. Monitoring will continue,
6/30/91	165 Kg/day oil and grease	X01	131 Kg/day (daily mass)	This exceedance is for an outfall where no new daily-maximum exceedances occurred, but where monitoring over the course of the second quarter of calendar year 1991 resulted in calculated exceedances of mass-loading limits and/or average limits.
6/30/91	14 Kg/day oil and grease	X01	8.7 Kg/day (Monthly avg. mass)	This exceedance is for an outfall where no new daily-maximum exceedances occurred, but where monitoring over the course of the second quarter of calendar year 1991 resulted in calculated exceedances of mass-loading limits and/or average limits.
6/30/91	16 mg/L oil and grease	X01	10 mg/L (Monthly avg. concentration)	This exceedance is for an outfall where no new daily-maximum exceedances occurred, but where monitoring over the course of the second quarter of calendar year 1991 resulted in calculated exceedances of mass-loading limits and/or average limits.
6/30/91	22 mg/L oil and grease	X02	15 mg/L (monthly avg. concentration)	This exceedance is for an outfall where no new daily-maximum exceedances occurred, but where monitoring over the course of the second quarter of calendar year 1991 resulted in calculated exceedances of mass-loading limits and/or average limits.
6/26/91	141 mg/L TSS	Outfall 244	30 mg/L (quarterly avg.)	This exceedance is for an outfall where no new daily-maximum exceedances occurred, but where monitoring over the course of the second quarter of calendar year 1991 resulted in calculated exceedances of mass-loading limits and/or average limits.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
6/26/91	77 mg/L TSS	Outfall 248	30 mg/L (quarterly avg.)	This exceedance is for an outfall where no new daily-maximum exceedances occurred, but where monitoring over the course of the second quarter of calendar year 1991 resulted in calculated exceedances of mass-loading limits and/or average limits.
6/26/91	32.5 mg/L TSS	Outfall 283	30 mg/L (quarterly avg.)	This exceedance is for an outfall where no new daily-maximum exceedances occurred, but where monitoring over the course of the second quarter of calendar year 1991 resulted in calculated exceedances of mass-loading limits and/or average limits.
6/26/91	11 mg/L oil and grease	Outfall 284	10 mg/L (quarterly avg.)	This exceedance is for an outfall where no new daily-maximum exceedances occurred, but where monitoring over the course of the second quarter of calendar year 1991 resulted in calculated exceedances of mass-loading limits and/or average limits.
6/4/91	40 mg/L oil and grease	X02	20 mg/L, daily maximum	Although the CYRWTF was not operating, heavy rainfall conveyed residual water out of the discharge basin. A removable plate has been installed on the plume to prevent further discharge when the plant in not operational.
6/12/91	24 mg/L oil and grease	X02	20 mg/L, daily maximum	No reason for the exceedance was found.
8/9/91	1515 mg/L TSS	Outfall 202	50 mg/L, daily maximum	Outfall 202 has an abandoned underground drain pipe that discharges during rain events. A work order was issued to plug the pipe.
8/9/91	78 mg/L TSS	Outfall 220	50 mg/L, daily maximum	Steam condensate is being discharged to the ground surface near the subject valve pit and runs downslope to WOC. A gravel filled french drain at the subject valve pit will be installed to accept the steam condensate discharge.
8/9/91	516 mg/L TSS	Outfall 224	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
8/26/91	85 mg/L TSS	Outfall 216	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/11/91	Visible oil sheen	WOC Embayment	Oil sheen observed	Operation of pile driving equipment caused droplets of lubricating oil to fall onto the water surface. The oil sheen was contained by a boom set up in case of a spill.
9/19/91	54 mg/L oil and grease	Outfall 104	15 mg/L	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
9/19/91	52 mg/L TSS	Outfall 104	50 mg/L	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/24/91	106 mg/L TSS	Outfall 106	50 mg/L	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/24/91	96 mg/L TSS	Outfall 107	50 mg/L	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/19/91	181 mg/L TSS	Outfall 109	50 mg/L	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/24/91	245 mg/L TSS	Outfall 116	50 mg/L	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/24/91	16 mg/L oil and grease	Outfall 116	15 mg/L	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/24/91	19 mg/L oil and grease	Outfall 144	15 mg/L	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/24/91	114 mg/L TSS	Outfall 144	50 mg/L	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
9/19/91	158 mg/L TSS	Outfall 173	50 mg/L	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
11/21/91	37 mg/L oil and grease	Outfall 224	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
12/2/91	31 mg/L oil and grease	Outfall 284	15 mg/L, daily maximum	The exceedance was caused by oil deposits on the floor conveyed into the storm drain. The area was promptly cleaned according to BMP.
11/21/91	101 mg/L TSS	Outfall 244	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
11/26/91	31 mg/L oil and grease	X01	15 mg/L, daily maximum	The result is questionable.
11/26/91	19.1 kg/day oil and grease	X01	13.1 kg/day, daily maximum	The result is questionable.
1/3/92	108 mg/L oil and grease	Outfall 101	15 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
1/3/92	195 mg/L oil and grease	Outfall 114	15 mg/L, daily maximum	Category I outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
11/21/91	22 mg/L oil and grease	Outfall 202	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
11/21/91	340 mg/L TSS	Outfall 202	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
11/21/91	26 mg/L oil and grease	Outfall 203	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
1/3/92	24 mg/L oil and grease	Outfall 204	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
11/21/91	87 mg/L TSS	Outfall 209	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
11/21/91	23 mg/L oil and grease	Outfall 209	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
11/21/91	51 mg/L oil and grease	Outfall 216	15 mg/L, daily maximum	The catch basin and trough of Outfall 216 may benefit from, and will be, cleaned out and stabilization measures will be enacted.
11/21/91	193 mg/L TSS	Outfall 216	50 mg/L, daily maximum	The catch basin and trough of Outfall 216 may benefit from, and will be, cleaned out and stabilization measures will be enacted.
11/21/91	57 mg/L TSS	Outfall 218	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
11/22/91	51 mg/L TSS	Outfall 221	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
11/21/91	55 mg/L TSS	Outfall 223	50 mg/L, daily maximum	The catch basin and trough of Outfall 223 may benefit from, and will be, cleaned out and stabilization measures will be enacted.
11/21/91	84 mg/L TSS	Outfall 224	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
11/21/91	83 mg/L TSS	Outfall 233	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
11/21/91	16 mg/L oil and grease	Outfall 233	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
1/3/92	16 mg/L oil and grease	Outfall 281	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
12/2/91	25 mg/L oil and grease	Outfall 282	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
1/3/92	21 mg/L oil and grease	Outfall 283	15 mg/L, daily maximum	No source of pollutants was found. Outfall 283 has been targeted for remediation. The effluent characteristics may improve when the pipe-improvement project is complete.
1/3/92	62 mg/L TSS	Outfall 283	50 mg/L, daily maximum	No source of pollutants was found. Outfall 283 has been targeted for remediation. The effluent characteristics may improve when the pipe-improvement project is complete.
12/2/91	40 mg/L oil and grease	Outfall 284	15 mg/L, daily maximum	A floor drain in NHF was the cause of previous exceedance. The air compressors thought to be the cause have been removed. This exceedance may have been the result of oil remaining in the piping. If any other exceedances occur, additional corrective measures will be implemented.
12/2/91	19 mg/L oil and grease	Outfall 285	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
1/3/92	82 mg/L oil and grease	Outfall 285	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/27/92	22 mg/L oil and grease	X01 (STP)	15 mg/L, daily maximum	No cause has be identified. BMP will continue to be implemented.
2/25/92	21 mg/L oil and grease	Outfall 203	15 mg/L, daily maximum	Outfall 203 includes a partially collapsed and clogged storm drain pipe that drains a grassy area near SWASA2. It has been targeted for remediation. Effluent characteristics may improve when the pipe-improvement project is complete.
2/25/92	17 mg/L oil and grease	Outfall 207	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
2/25/92	22 mg/L oil and grease	Outfall 214	15 mg/L, daily maximum	The drain system associated with this pipe may benefit from cleanout. Appropriate cleanout and stabilization measures will be evaluated and requests submitted to ORNL personnel to assist in carrying out measures, as appropriate.
2/25/92	122 mg/L TSS	Outfall 214	50 mg/L, daily maximum	The drain system associated with this pipe may benefit from cleanout. Appropriate cleanout and stabilization measures will be evaluated and requests submitted to ORNL personnel to assist in carrying out measures, as appropriate.
2/25/92	21 mg/L oil and grease	Outfall 216	15 mg/L, daily maximum	The drain system associated with this pipe may benefit from cleanout. Appropriate cleanout and stabilization measures will be evaluated and requests submitted to ORNL personnel to assist in carrying out measures, as appropriate.
2/25/92	54 mg/L oil and grease	Outfall 223	15 mg/L, daily maximum	The drain system associated with this pipe may benefit from cleanout. Appropriate cleanout and stabilization measures will be evaluated and requests submitted to ORNL personnel to assist in carrying out measures, as appropriate.
2/25/92	28 mg/L oil and grease	Outfall 224	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/25/92	184 mg/L oil and grease	Outfall 230	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/25/92	83 mg/L TSS	Outfall 230	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/25/92	81 mg/L oil and grease	Outfall 231	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/25/92	98 mg/L oil and grease	Outfall 233	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/25/92	53 mg/L TSS	Outfall 233	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
2/25/92	21 mg/L oil and grease	Outfall 234	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/25/92	19 mg/L oil and grease	Outfall 244	15 mg/L, daily maximum	The drain system associated with this pipe may benefit from cleanout. Appropriate cleanout and stabilization measures will be evaluated and requests submitted to ORNL personnel to assist in carrying out measures, as appropriate.
2/25/92	38 mg/L oil and grease	Outfall 249	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
2/25/92	115 mg/L oil and grease	Outfall 269	15 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
3/18/92	Visible oil sheen	WOC Embayment	No visible sheen	During installation of a CERCLA time-corrective action in WOC Embayments, oil drips from the jet-grouting unit being used resulted in a small oil sheen. The oil sheen was contained by boom place up- and downstream in case of a spill. The amount was to small to be absorbed by pads. No further corrective action was carried out.
3/29/92	Visible oil sheen	WOC Embayment	No visible sheen	During installation of a CERCLA time-corrective action in WOC Embayments, oil drips from the jet-grouting unit being used resulted in a small oil sheen. The oil sheen was contained by boom place up- and downstream in case of a spill. The amount was to small to be absorbed by pads. No further corrective action was carried out.
3/31/92	Visible oil sheen	WOC Embayment	No visible sheen	During installation of a CERCLA time-corrective action in WOC Embayments, oil drips from the jet-grouting unit being used resulted in a small oil sheen. The oil sheen was contained by boom place up- and downstream in case of a spill. The amount was to small to be absorbed by pads. No further corrective action was carried out.
3/3/92	18 mg/L oil and grease	X01 (STP)	15 mg/L, daily maximum	ORNL personnel are in the process of implementing more stringent influent criteria at the STP. It is anticipated that this may reduce the effluent oil & grease concentration at the STP.
3/12/92	94 mg/L oil and grease	X01 (STP)	15 mg/L, daily maximum	ORNL personnel are in the process of implementing more stringent influent criteria at the STP. It is anticipated that this may reduce the effluent oil & grease concentration at the STP.
5/8/92	85 mg/L TSS	Outfall 203	50 mg/L, daily maximum	The drain system associated with this pipe may benefit from cleanout. Appropriate cleanout and stabilization measures will be evaluated and requests submitted to ORNL personnel to assist in carrying out measures, as appropriate.

National Pollutant Discharge Elimination System, Oil and Grease, and Total Suspended Solids violations for Oak Ridge National Laboratory, January 1, 1988 through May 30, 1992 (continued)

Date	Exceedance of Permit Parameter	Location	Permit Requirement	What Occurred, Cause, and Remedy
5/8/92	51 mg/L TSS	Outfall 204	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
5/8/92	54 mg/L TSS	Outfall 209	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.
5/8/92	136 mg/L TSS	Outfall 224	50 mg/L, daily maximum	Category II outfalls may include runoff from streets, parking lots, roofs and lawns, condensate, non-contact cooling water and cooling tower blowdown. During periods of rainfall, exceedance of TSS and oil & grease parameters often occur. These storm drains are managed under Best Management Practices to minimize exceedances.

1992 DMR - 8022.2
1991 DMR - 8322.2
1990 DMR - 8322.2
1988 DMR - 8322.2 box 14

APPENDIX B

Annotated Bibliography

Brown, R.C., Pierce, R. H., and Rice, S. A. 1985. "Hydrocarbon Contamination in Sediment from Urban Stormwater Runoff," *Marine Pollution Bulletin*, Vol. 16(6), 236-240.

This investigation showed that urban stormwater runoff provides a significant amount of petrogenic material to receiving waters and sediments. A characteristic hydrocarbon 'fingerprint' for sediments and particulate matter in the Hillsborough Reservoir, Hillsborough River and upper Hillsborough Bay was provided. Determination of source material for petroleum contamination in stormwater runoff and river sediment indicated that crankcase oil was a primary contributor to sediment hydrocarbon contamination. A comparison of sediment hydrocarbons with hydrocarbons from stormwater runoff showed that the most probable source of crankcase oil-like petrochemicals found in sediment was the stormwater runoff.

A comparison of hydrocarbon composition in suspended particulate matter with that of accumulated bottom sediments in the reservoir, river and bay, during a non-storm period and rising tide showed no resuspension and upriver transport of petroleum contaminated bay sediment. No special influence of the bay upon the lower river was observed relative to hydrocarbon tracers, indicating that most contaminated sediment transport was downriver during storm events. Additional studies should be performed over various tidal cycles and storm events incorporating sediment cores, sediment grain size analysis and hydrocarbon characterization at more closely spaced stations near the river mouth to address adequately the question of specific hydrocarbon pollution sources, rate of petroleum influx and persistence of petrochemical contaminants in the sediment. (authors)

Chisholm, J. L., and Downs, S. C. 1978. *Stress and Recovery of Aquatic Organisms as Related to Highway Construction along Turtle Creek, Boone County, West Virginia*, U. S. Government Printing Office, Washington.

During and after construction of Appalachian Corridor G, a divided, four-lane highway, five benthic invertebrate samples were collected at each of four sites on Turtle Creek, and, for comparative purposes, three samples were collected at each of two sites on Lick Creek, an adjacent undisturbed stream. Diversity index, generic count, and total count initially indicated severe depletion or destruction of the benthos of Turtle Creek, but, within 1 year after highway construction was completed, the benthic community of Turtle Creek was similar to that of Lick Creek. The greatest degradation occurred near the headwaters of Turtle Creek because of erratic movement of sediment resulting from high streamflow velocity. Diversity indices ranged from 0 to 3.41 near the headwaters in the original channel, but only from 0.94 to 2.42 farther downstream in a freshly cut channel. The final samples from Turtle Creek, which were similar to those taken from Lick Creek at the same time, had generic counts of 10 at the most upstream site and 16 near the mouth. A total of 147 organisms was found near the headwaters, whereas a total of 668 was found near the mouth of the stream. The total number of organisms collected at each site was proportional to the drainage area and organism drift, rapid repopulation and stabilization of the benthic community occurred. Channel relocation, bank recontouring, and reseeding also accelerated the recovery of the benthic community. (authors)

This paper is primarily concerned with the effect of massive sediment transport due to major highway construction. (M. F.)

Cline, L. D., Robert, A. S., and Ward, J. V. 1982. "The Influence of Highway Construction on the Macroinvertebrates and Epilithic Algae of a High Mountain Stream," *Hydrobiologia*, Vol. 96, 149-159.

The response of a high elevation Rocky Mountain stream to highway construction activities was investigated over a three-year period during the ice-free season. Suspended solids and the proportion of fine sediment in the substrate increased at impacted sites, but rapidly returned to levels similar to reference sites following cessation of construction activities. During snowmelt runoff when suspended solids levels increased, there was little or no sedimentation of fine particles, even in depositional areas. At impacted sites algal species diversity and the organic content of the epilithon were reduced, and the detrital component was increased. The epilithon recovered less rapidly than suspended solids or substrate. The macroinvertebrate community was altered by construction activities at some locations but not others, and was generally less severely affected than anticipated. However, where an alteration occurred, reduction in density, abundance, and diversity were apparent, and the taxonomic composition was modified. The severity of the response was a function of the flow regime and the timing and duration of the impact at a given site. The hydrologic regime and high gradient of the study stream appeared to ameliorate to some extent the potentially adverse effects of short-term perturbations engendered by highway construction activities.

Donnelly, K. C., et al. 1985. "Evaluation of the Hazardous Characteristics of Two Petroleum Wastes," *Hazardous Waste and Hazardous Materials*, Vol. 2(2), 191-208.

A battery of short-term bioassays to detect various types of genotoxic damage were coupled with a GC/MS/DS analysis to evaluate the hazardous characteristics of an oily storm water runoff impoundment and combined API separator/slop oil emulsion solids waste. The organic compounds were extracted from each waste with dichloromethane and partitioned by liquid-liquid extraction into acid, base and neutral fractions. Each of these three primary fractions were tested in four strains of S. typhimurium to detect point mutations, six strains of B. subtilis to detect lethal damage to DNA, and haploid and diploid forms of A. nidulans to detect point mutations and various types of chromosome damage. Three of the four bioassays detected genotoxic constituent(s) in the three fractions of the storm water runoff impoundment waste, and two of the bioassays detected (the maximum) genotoxic response in the acid fraction with metabolic activation. The neutral fraction of the combined API separator/slop oil emulsion solids waste induced the maximum genotoxic response in the S. typhimurium and A. nidulans haploid bioassays, while the acid fraction induced maximum response in the B. subtilis DNA repair assay. Thus, biological analysis detected genotoxic compounds in all three fractions of both wastes; while chemical analysis tentatively identified mutagenic compounds in the extracts of only one of the two wastes. (authors)

Elien, M. February 1990. "A Review of Stormwater Management Practices at Petroleum Product Bulk Terminals," *Environment Canada*, approved for publication.

Stormwater runoff is the major source of effluent discharge from petroleum bulk terminals. The major pollutants associated with these operations are oil and grease and sometimes suspended solids. This report addresses several aspects of stormwater management at these facilities including treatment technologies, operating procedures, sampling and analytical procedures, and monitoring devices. It is based on a literature review, and several site visits conducted to document current practices. Recommendations are presented. (author)

The treatment techniques discussed here are types of gravity separators, types of air flotation processes, biological treatment, filtration, membrane separation, sorbents, centrifugation, and other coalescence techniques. Where applicable, these descriptions are accompanied by diagrams and tables.

The report discusses various techniques of measuring oil and grease content in water. The drawback of each technique is noted.

This is a very thorough document. (M. F.)

Harms, L. L. September 1984. *Nationwide Urban Runoff Program, Urban Runoff Control in Rapid City, South Dakota, Executive Summary*, Natl. Tech. Inf. Serv., Springfield, Va.

Six water quality sampling stations were installed to monitor water quality changes in Rapid Creek resulting from urban stormwater runoff in the Rapid City, South Dakota area. Five of the stations were in-stream locations on the creek while the sixth station was located on the drainage channel from a 2,000 acre watershed.

A total of 33 runoff events were monitored during 1980 to 1983, three of which were runoff from melting snow. Although some analyses of discrete samples were made, the norm was to composite the discrete samples in proportion to flow. Twenty complete data sets were obtained. Parameters measured included BOD, alkalinity, turbidity, pH, conductance, fecal coliforms, suspended solids, volatile suspended solids, total residue, total kjeldahl nitrogen, total and soluble phosphorus, ammonia, nitrate, sulfate, chloride, potassium, sodium, calcium, magnesium, and lead. All sampling sites were gaged by the United States Geological Survey for flow, and sophisticated sampling equipment was used at four locations during 1981 and 1982. Priority pollutants were determined at selected locations on three occasions. Precipitation for sampled events ranged from 0.08" to 2.99" and the urban discharge ranged from near zero to about 470 acre-feet.

Concentrations of in-stream constituents varied widely throughout the study, with the majority of the constituents increasing in concentration at the downstream stations. Increases of several thousand percent were noted for many parameters from above to below the urban area. High lead and suspended solids increases were particularly noticeable. It was noted that the municipal wastewater treatment facility would require about three years to deposit as many suspended solids in Rapid Creek as were washed into the creek in one day during storm event No. 21.

Many of the parameters correlate well with suspended solids concentrations. Therefore, the recommendation was made that remedial measures should concentrate on reducing the suspended solids loading to Rapid Creek. (author)

Kentucky Water Resources Research Institute September 1985. *Fiscal Year 1984 Program Report: Kentucky Water Resources Research Institute*, Natl. Tech. Inf. Serv., Springfield, Va.

The Kentucky Water Resources Research Institute Annual Report for Fiscal Year 1984 describes the problems and issues for the Commonwealth as determined by the State Advisory Council. The program goals and priorities of the Institute describe the areas of research the program addressed. A synopsis of each of the seven research projects is included. The seven projects funded by the Institute in Fiscal Year 1984 are: 02 - Identification of Soil-Water Chemical Parameters for the Prediction and treatment of Suspended Solids in Surface Water Reservoirs of Coal Mine Lands; 03 - Modeling of Overland Flow by the Diffusion Wave Approach; 04 - A Model for Assessing the Visual Resources of River Basins as an Aid to Making Landuse Planning Decisions; 05 - Development of General Guidelines for the Planning of Stormwater Management Facilities: Application to Urban Watersheds in Kentucky; 06 - Reductive Dechlorination of Toxic Chlorocarbons; 07 - Investigation of Pollution in a Karst Aquifer Utilizing Optical Brightener; and 08 - Hydraulic Design Algorithms for Upgrading and Enhancing Water Distribution Systems.

A brief description of the Institute's information transfer activities is provided along with the cooperative arrangements that exist between the Institute and other institutions. The State and University Advisory Councils are listed for 1984. The training accomplishments by fiscal year 1984 research projects is given in terms of category and academic level. (author)

Project 02, Identification of Soil-Water Chemical Parameters for the Prediction and Treatment of Suspended Solids in Surface Water Reservoirs of Coal Mine Lands, determined that coal mine sedimentation ponds are likely to have high levels of suspended solids. Results showed that by increasing the levels of dissolved solids the levels of suspended solids decreases. The study also found that adding NaOH to acidic sediment ponds increased the suspended solid concentration above health tolerance levels. However, sodium and calcium tended to control this rising suspended solid level. The report recommended that these elements should be monitored while NaOH is added.

The experiment also discovered that suspended solids do not have the characteristic of being either settleable or non-settleable. Changes in the environment can alter this characteristic in suspended solids. (M. F.)

Krofta, M. et al. March 1985. *Flotation Treatment of Contaminated Storm Run-Off Water*, Tech. Report No. LIR/03-85/124, Natl. Tech. Inf. Serv., Springfield, Va.

The feasibility of removing soluble arsenic (+5) from storm run-off water by dissolved air flotation (Supracell), dissolved air flotation and sand filtration combination (Sandfloat), granular carbon absorption, and ion exchange processes was experimentally demonstrated. The best pretreatment unit was Sandfloat clarifier consisting of both flotation and filtration. Sandfloat clarifier consistently removed over 90 percent of arsenic, turbidity and color, and over 50 percent of COD and oil and grease. Using a Sandfloat or a Supracell for pretreatment, and then using either carbon absorption or ion exchange for second-stage treatment, the soluble arsenic in the storm water can be totally removed. The waste sludges generated from the dissolved air flotation cell did not posses the characteristic of Extraction Procedure Toxicity and were not hazardous wastes. The dewatered sludge met the current New Jersey Dept. of Environmental Protection's limits on cadmium, chromium, copper, nickel, lead and zinc for land application. (authors)

It should be noted that this is the most current documentation located by this search on these devices. (M. F.)

Krofta, M. et al. November 1984. *Analysis of Sludges Generated from Flotation Treatment of Storm Run-Off Waters*, Tech. Report No. LIR/11-84/14, Natl. Tech. Inf. Serv., Springfield, Va.

The most feasible process for removal of suspended solids, arsenic, color turbidity and oil and grease from storm water treatment is either dissolved air flotation (Krofta Supracell) or dissolved air flotation-filtration (Krofta Sandfloat), depending on the effluent discharge standards. This report documents the pretreatment data and the characteristics of floated sludge by dissolved air flotation. The dewatered sludge met the current New Jersey Dept. of Environmental Protection limits on cadmium, chromium, copper, nickel, lead and zinc for land application. (authors)

The results yielded by the Krofta Supracell and Krofta Sandfloat show significant removal of the targeted pollutants. (M. F.)

Lenat, D. R., Penrose, D. L., and Eagleson, K. W. 1981. "Variable Effects of Sediment Addition on Stream Biota," *Hydrobiologia*, Vol. 79, 187-194.

Two upper Piedmont streams were studied to determine the effects of road construction, especially sediment inputs. Benthic macroinvertebrate data suggest that the stream community responded to sediment additions in two different ways. Under high flow conditions the benthic fauna occurs mainly on rocky substrates. As sediment is added to a stream the area of available rock habitat decreases, with a corresponding decrease in benthic density. There is, however, little change in community structure. Under low flow conditions, stable-sand areas may support high densities of certain taxa.

Density of the benthic macroinvertebrates in these areas may be much greater than the density recorded in control areas, and there are distinct changes in community structure. (authors)

This study was undertaken to try and resolve the conflicting data concerning how stream benthos are affected by sediment inputs. Some studies reported that the composition of the benthic communities was noticeable altered, while others claimed that there was no affect on the community structure. Some studies also claimed that the density of benthic macroinvertebrates was reduced greatly upon sediment addition, and other studies claimed that total density was unaffected by the addition of sediment. All procedures and results are carefully document and presented in this study. (M. F.)

Martin, E. H., and Smoot, J. L. April 1986. *Assimilative Capabilities of Retention Ponds*, FHWA/DOT/BMR-303-86, Natl. Tech. Inf. Serv., Springfield, Va.

The efficiency of a detention pond and wetlands temporary storage system to reduce constituent loads in urban runoff was determined. The reduction efficiencies for 22 constituents, including the dissolved, suspended, and total phases of many of the constituents were investigated. A new method, not previously discussed in technical literature, was developed to determine the efficiency of a temporary storage system unit such as a detention pond or wetlands. The method provides an efficiency, called the regression efficiency, determined by a regression made of loads-in against loads-out of a unit with the intercept of the regression constrained to zero. The regression efficiency of the treatment unit is defined as unity minus the regression slope.

The detention pond generally reduced suspended constituent loads. The pond had a regression efficiency of 65 percent in reducing suspended solids loads, 41 percent for suspended lead loads, 37 percent for suspended zinc loads, 17 percent for suspended nitrogen loads, and 21 percent for suspended phosphorus loads. Settling of heavier suspended particles was probably the primary process that brings about this reduction.

The wetlands was generally effective in reducing both suspended and dissolved constituent loads. Regression efficiencies for suspended constituents were 66 percent for solids, 75 percent for lead, 50 percent for zinc, 30 percent for nitrogen, and 19 percent for phosphorus. Dissolved phase constituent regression efficiencies were 38 percent for solids, 54 percent for lead, 75 percent for zinc, 13 percent for nitrogen, and 0 percent phosphorus. These load reductions were probably caused by various processes such as sedimentation, coagulation, filtration, absorption, and biological assimilation and transformation. Biochemical recycling of nutrients, such as nitrogen and phosphorus, likely account for the relatively small regression efficiencies estimated for these constituents in the wetlands.

The system (pond and wetlands combined) achieved appreciable reductions of loads for most constituents. Significant positive regression efficiencies for the system were found for all constituents except the nutrients dissolved nitrate and dissolved orthophosphate. System regression efficiencies were 55 percent for total solids, 83 percent for total lead, 70 percent for total zinc, 36 percent for total nitrogen, and 43 percent for total phosphorus. (authors)

Martin, H. L. 1989. *Waste Water Filtration Enhancement*, DP-MS--88-167, presented at the 10th AESF/EPA Conference on Pollution Control for the Metal Finishing Industry, Orlando, Florida, Jan. 23-25, 1989; to be published in the proceedings.

Removal of submicron particles from process solutions and waste water is now economically achievable using a new Tyvek(R) media in conventional filtration equipment. This new product greatly enhances filtration and allows use of the much improved filter aids and polymers which were recently developed. It has reduced operating costs and ensures a clean effluent discharge to the environment. This significant technical development is especially important to those who discharge to a small stream with low 7Q10 flow and must soon routinely pass the Toxicity tests that are being required by many States for NPDES permit renewal.

The Savannah River Plant produces special nuclear materials for the U. S. Government. Aluminum forming and metal finishing operations in M-Area, that manufacture fuel and target assemblies for the nuclear reactors, discharge to a waste water treatment facility using BAT hydroxide precipitation and filtration. The new Tyvek(R) media and filter aids have achieved 55% less solids in the filtrate discharged to Tims Branch Creek, 15% less hazardous waste (dry filter cake), 150%-370% more filtration capacity, 74% lower materials purchase cost, 10% lower total M-Area manufacturing cost, and have improved safety. Performance with the improved polymers is now being evaluated. (author)

Mathers, J. S. 1978. *The Effects of Highway Construction on Galt Creek, Ontario, Volume 1*, Ministry of Nat. Resour., Toronto.

Galt Creek, a small, hardwater, brook trout (Salvelinus fontinalis) stream, was monitored before (1972-73), during (1973-75), and after (1975-76) construction of a four-lane divided highway. During construction, suspended sediment concentrations below the construction site rose to 5,945 mg/l compared to a maximum of 31 mg/l before construction. In addition, a five-fold increase in bed-load discharge was observed in this area. The amount of sediment entering the stream was, however, reduced by implementation of a staged construction sequence, temporary seeding, and construction of sedimentation ponds. For example, the sedimentation ponds trapped a total of $177m^3$ (242 cu. yds.) of sediment.

Directly below the construction area fish biomass fell from 174 kg/ha to 47 hg/ha during the study period. Similar declines were observed among other stations in this zone. In contrast, invertebrate species composition and biomass remained about the same downstream of construction. The differential effects of sediments on stream biota are discussed.

Before and during highway construction chloride concentrations were generally less than 10 mg/l, but increased to a maximum of 68 mg/l in the winter after the highway opened. Other water chemistry parameters remained about the same. Further, heavy metal contamination of water or fish was not detected. Highway construction diminished the stream flow in the east branch of the Galt Creek by altering the groundwater regime. In this area, a decline in fish abundance and a shift in invertebrate species composition was recorded. (author)

Mathers, J. S. 1978. *The Effects of Highway Construction on Galt Creek, Ontario, Volume 2*, Ministry of Nat. Resour., Toronto.

This is the second of a two volume report and consists of the Appendices for the study discussed in Volume I.

In conjunction with this report, "An Annotated Bibliography on the Effects of Roads on Aquatic Systems", 1978, by Mary Shea and John S. Mathers, Ministry of Natural Resources, Toronto, Ontario, has been published, referring to many of the papers collected through a literature search for this study. (author)

Maughan, O. E. 1977. *The Biological and Economic Impact of Stream Alteration Work Along Tributaries of the Roanoke River, Charlotte County, Virginia*, Fish and Wildlife Serv., U. S. Department of the Interior.

This study was done to assess the impact of channelization on both the fish and the benthic communities in the Piedmont streams in Virginia. The study also observed the effect time had on these channelized areas.

Water chemistry, silt load, and flow of the test streams were not consistently effected by channelization. however, differences were seen in overstream cover, instream cover, substrate, and water temperature. The fish in the channelized area did not show significant differences in biomass and number when compared to fish from the reference stream; however, the evenness diversity in the channelized stream was considerably lower. This leads to the conclusion that the fish in the channelized stream are less stable than those in the reference stream. The benthic community also showed lower evenness diversity in the channelized area. There was also a decrease in benthic standing crops and an elevated drift rate of benthic organisms. It was noted that after several years, the channelized areas were not completely stable. (M. F.)

Norberg-King, T. J., et al. October 1990. "Application of Toxicity Identification Evaluation Procedures to the Ambient Waters of the Colusa Basin Drain, California," *Environmental Toxicology and Chemistry*, Vol. 10, 891-900.

Pesticides are applied to the rice fields in the Sacramento Valley to prevent the growth of plants, algae and insects that reduce rice yields. Following the pesticide application, field water is released into agricultural drains that in turn discharge into the Sacramento River and delta. Rice irrigation is the largest single use of irrigation water in the Sacramento Valley, and because the irrigation water (or rice return) flows are the primary source of drain effluent during the spring and summer (up to 33 percent of the total flow), these discharges can significantly affect drain water quality and resident aquatic organisms. Acute and chronic toxicity to freshwater organisms (Ceriodaphnia dubia) was observed in the drain water during the period that coincides with thee initial draining of the fields in 1986, 1987, and 1988. In 1988, a toxicity identification evaluation (TIE) was conducted using Ceriodaphnia dubia in an effort to identify the cause of toxicity. Both methyl parathion and carbofuran were identified as possible toxicants. Mixture tests and chronic toxicity tests indicated that the concentrations of methyl parathion and carbofuran in the water sample account for the toxicity observed in Ceriodaphnia dubia. (authors)

North Carolina Department of Natural Resources and Community Development Division of Environmental Management 1979. *Water Quality and Construction: A Management Plan*, Raleigh, N. C.

To develop a plan for control of erosion and sedimentation caused by construction, information was gathered on the following topics and is reported in Sections II through VI: 1) the extent of construction activities in the State; 2) the impact of sediment on water quality; 3) practices that can be used to mitigate adverse impacts; 4) the effectiveness of current programs for controlling erosion from construction activities; and 5) continuing water quality problems that have been identified by special water quality studies.

Although erosion control has vastly improved since the Sedimentation Pollution Control Act was enacted in 1973, some significant control problems remain. Surveys conducted during the preparation of this Plan indicate that more attention needs to be placed on every aspect of erosion control, from the submission and design of effective erosion control plans to the maintenance of devices that are eventually used for erosion control.

The Plan recommends a number of administrative changes to improve erosion control on governmental projects, primarily highways and landfills. Suggestions for improvements in local erosion control programs are also included in the Plan. For improving erosion control on non-governmental projects, requiring approval of erosion control plans prior to initiating construction is recommended as the most effective action. Several categories of management practices are identified for increased use in areas of long slopes in exposed cut and fill areas, near stream channels, and on uncovered, disturbed soil. In addition, more effective "winterization" of construction sites is urged. The recommended practices and methods of implementation are discussed in Sections VII and X.

Water quality problems caused by several secondary impacts of construction activities are not addressed in this Plan. Extensive streambank erosion occurring within, as well as downstream of, urban areas is not addressed. In addition, the erosion from secondary roads and roadside areas is a significant contributor to the sediment problem in North Carolina streams and rivers. (authors)

Section IV contains information on surface protection, runoff water control measures, and sediment traps. The methods for surface protection given are mulching, matting and netting, and block sodding. "Common sense planning," which includes proper use of field survey and proper seasonal timing, is also listed as a surface protection measure. The methods for runoff water control given are the implementing control measures for slopes along waterways near construction sites, constructing armored drainways over fill areas, grading stabilization structures, and protecting the streambank. The methods for sediment trapping given are the use of silt fences, dry pit/silt fence combinations, diversion berms loading to pit/silt fence traps, storm drain protection measures, and sediment basins. These management practices are presented in text form and some have accompanying tables and diagrams. (M. F.)

Oak Ridge National Laboratory Staff and IT Corporation May 1991. *Oak Ridge National Laboratory National Pollutant Discharge Elimination System Best Management Practices Plan*, Martin Marietta Energy Syst., Inc., U. S. Department of Energy, Oak Ridge, Tenn.

The Best Management Practices Plan provides guidelines for the operating Oak Ridge National Laboratory in the safest possible way. The guidelines it provides for keeping storm runoff pollutants out of Melton Branch (X13) and White Oak Creek (X14) include erosion control, spill control, good housekeeping, and preventive maintenance. The specifics of these control methods are listed in the Plan. The Category I outfalls are protected from hazardous runoff through training personnel not to conduct operations that would discharge runoff containing hazardous materials (i.e. vehicle cleaning or maintenance) into the drainage system. If it should come about that such activities must be conducted near a drainage system, the drains would be sufficiently blocked. (M. F.)

Oak Ridge National Laboratory, Office of Environmental and Health Protection, Environmental Surveillance and Protection Section October 1990. *Environmental Surveillance Data Report for the Fourth Quarter of 1989*, ORNL/M--839, U. S. Department of Energy, 34-102.

A total of 30 noncompliances were associated with the National Pollutant Discharge Elimination System (NPDES) permit. Thirteen of these violations were associated with the Vehicle Cleaning Facility, and 10 of the violations were due to the limit violations at cooling towers. The balance of the violations occurred at the HFIR ponds (one), the Steam Plant (two), the Coal Yard Runoff Facility (two), a Category II outfall (one), and the Equipment Maintenance Facility (one). (authors)

Two pollutants tested for in the runoff from ten selected sites are total suspended solids and oil and grease. The results of the tests for these and other parameters between October and December 1989 are included in this report in table form. (M. F)

Portele, G. J., et al. January 1982. *Effects of Seattle Area Highway Stormwater Runoff on Aquatic Biota*, WA-R9-39.11, Natl. Tech. Inf. Serv., Springfield, Va.

The impacts of stormwater runoff from Washington State freeways on aquatic ecosystems was investigated through a series of bioassays utilizing algae, zooplankton and fish. Algae and zooplankton were adversely affected by the soluble fraction of the runoff, while suspended solids caused high mortalities of rainbow trout fry. In addition, BOD_5 values similar to those reported in the stormwater literature were measured;

however, there were indications that results were influenced by toxicity to microbial populations. (authors)

While part of the research was to discover what pollutants are present in the stormwater runoff, another concern was how these pollutants can be removed or neutralized. Vegetation buffer zones that separate the highway from receiving waters would serve to remove some particulate from the drainage. The paper also claims that oxygen debt can be reduced in the receiving system by diluting the runoff 80 percent. (39) Finally, the paper supported the Environmental Protection Agency's recommendation of an application factor of 0.01 at sites with traffic flow of greater than 10,000 vehicles per day. "That is, inputs of highway runoff to a receiving body should not exceed one percent of the systems total volume." (40) (M.F.)

Reed, J. R. Jr. June 1977. *Stream Community Response to Road Construction Sediments*, Virginia Polytechnic Institute and State University, Blacksburg, Va.

This study investigated how aquatic macrobenthic and fish communities responded to the effects of siltation from highway construction. Community response was evaluated on the basis of community diversity and changes in the numbers of organisms and/or species. An innovative computer program was used to calculate the diversity indices, using the sequential comparison technique.

The primary response observed among the macrobenthic and fish communities was a reduction both in numbers of species and in organisms downstream from the construction. Responses of the macrobenthic community ranged from a reduction of 23 percent in numbers of species and 66 percent in numbers of organisms (based upon single comparisons) to a 40 percent reduction of species and an 85 percent reduction of organisms (based upon several observations of the same population). Single comparisons of fish communities showed reductions of approximately 20 percent in numbers of species and 40 percent in numbers of organisms. The diversity index also demonstrated a statistically significant long-term change in aquatic community structure, but was less meaningful for indicating initial effects or making single comparisons.

Findings suggest that drift is a major physical response of macrobenthos to increased siltation, and may be a primary mechanism for repopulating stressed habitats. This is contrary to the commonly held hypothesis that smothering is a major effect, and should be tested in further investigations. Fishes apparently vacated areas of increased siltation, but were able to repopulate such areas within 12 months after construction activities stopped, depending upon the stream's cleansing ability. In this connection, stream flow rate and gradient are significant factors.

In general, this study found that erosion-control measures as they commonly are applied in highway construction are of limited value in preventing damages to stream communities, especially in the early construction stages. This indicates a need for more comprehensive and particularly more timely application of appropriate erosion-control techniques. (author)

Rogers, J. G. June 1988. *Statement of Work for the Assessment of Ambient Environmental Monitoring Programs for the Installations Operated by Martin Marietta Energy Systems, Inc., at Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio*, ORNL/M--556, Martin Marietta Energy Syst., Inc., Oak Ridge, Tenn.

The realm of assessment of environmental monitoring programs at Martin Marietta Energy System, Inc. installations at Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio is detailed in this statement. The locations to be assessed include the plant perimeter fences, receiving streams, and off-site locations; locations to be excluded in the assessment are specific stack on-site point source emission monitoring locations, National Pollutant Discharge Elimination System (NPDES) water and biological monitoring locations, and on-site groundwater monitoring locations. The environmental monitoring programs to be assessed are ambient air, surface water, off-site groundwater, external gamma radiation, and biological monitoring programs. The vegetation, soil, and sediment sampling programs are also to be assessed.

It should be noted that this is only a statement of work, and no detailed information is given on these monitoring programs. (M. F.)

Shea, M., and Mathers, J. S. 1978. *An Annotated Bibliography on the Effects of Roads on Aquatic Systems*, Ministry Nat. Resour., Toronto.

Silverman, G. S., Stenstrom, M. K., and Fam, S. 1986. "Best Management Practices for Controlling Oil and Grease in Urban Stormwater Runoff," *The Environmental Professional*, Vol. 8, 351-362.

Reducing the quantity of oil and grease in urban stormwater runoff is necessary to protect the quality of San Francisco Bay. Traditional technologies designed for industrial settings and municipal wastewater treatment do not have the capability to remove oil and grease from stormwater on a cost-efficient basis given the sporadic nature of discharge and relatively low pollutant concentrations. Innovative control strategies are described that could easily be implemented following pilot study evaluations. Most of these strategies could be applied to relatively little drainage, and substantial overall reductions in oil and grease loading would result. Alternatively, there is some opportunity for basin-wide controls, which would restrict input to the watershed and end-of-pipe treatment of runoff immediately preceding it's discharge into the Bay. (authors)

A total of eight control measures were determined to effectively reduce the existence of oil and grease in the runoff that reaches the San Francisco Bay. These methods included: improving the street cleaning methods, using porous pavement in parking lots, channeling runoff water to vegetated areas, placing absorbents in sewer inlets, encouraging the recycling of used motor oil,and incorporating a test for oil leaks in emission inspections. A discussion of each of these in included in the report.

Control methods labeled "marginally favorable" included dissolved air flotation, corrugated or parallel plate separator, and high rate filtration. Those deemed "unfavorable" included conventional oil waste treatment systems (i.e. API-type oil/water separator), conventional secondary treatment, and combining stormwater with sanitary waste. The reasons for disapproval of these methods is included in the report. (M. F.)

Specht, W. L. July 1989. *Results of Interim Reports on the F/H Effluent Treatment Facility Biological Monitoring Program (U)*, WSRC-RP--89-649-Rev. 2, Westinghouse Savannah River Co., Aiken, S.C.

As required by the South Carolina Department of Health and Environmental Control under NPDES Permit SC0000175 (Special Condition #36), a biological monitoring program was approved on February 26, 1987 and initiated in July 1987 to assess the effects of the H-016 outfall (F/H Effluent Treatment Facility) on the biota of Upper Three Runs Creek. This report summarizes the results of data collected before the start-up of the ETF and data collected during the first six months of operation, as requested by SCDHEC (letter from C. C. Montgomery to S. R. Wright, 2/26/87).

The data indicate that there have been no measurable adverse impacts on the stream community after the first six months of ETF operation. However, the ETF was operating at less than 25% of design capacity during the first six months of operation, and further studies will be necessary to determine if the effluent will impact the stream under normal operating conditions. Toxicity tests conducted on the ETF effluent indicate that the effluent should not be toxic after mixing with Upper Three Runs Creek. (author)

The report notes that 31 parameters were used in analyzing Upper Three Runs Creek. Total suspended solids was one of these reference parameters. No table displays information on these results. (M. F.)

Specht, W. L., et al., eds.-comps. August 1990. *Compliance of the Savannah River Site D-Area Cooling System with Environmental Regulations (U): Demonstration in Accordance with Section 316(a) of the Clean Water Act September 1988 - February 1990*, WSRC-RP--90-778, Westinghouse Savannah River Co., Aiken, S.C.

This document presents information relating to a demonstration under Section 316(a) of the Clean Water Act for the 400-D Area cooling system at the Savannah River Site (SRS) near Aiken, South Carolina. The demonstration was mandated because the National Pollutant Discharge Elimination System (NPDES) permit for SRS (SC0000175), granted on January 1, 1984, specified in-stream temperature limits in SRS streams of 32.2°C at a ΔT limit of 2.8°C above ambient. To achieve compliance with in-stream temperature limits, the Department of Energy (DOE) and the South Carolina Department of Health and Environmental Control (SCDHEC) entered into a Consent Order (84-4-W) which temporarily superseded the temperature requirements and identified a process for attaining compliance. The preferred option for achieving thermal compliance in Beaver Dam Creek consisted of increased flow, with mixing of the raw water basin overflow with the cooling water discharge during the summer months. Although this action can achieve in-stream temperatures of less than 32.2°C, ΔT's still exceed 2.8°C. Therefore, a 316(a)

Demonstration was initiated to determine whether a balanced indigenous biological community can be supported in the receiving stream with ΔT's in excess of 2.8°C.

A Biological Monitoring Program for Beaver Dam Creek was approved by SCDHEC in June 1988 and implemented in September 1988. The program monitored the water quality, habitat formers, zooplankton, macroinvertebrates, fish, other vertebrate wildlife and threatened and endangered species in Beaver Dam Creek for an 18-month period (September 1988-February 1990). This document summarizes information collected during the monitoring program
and evaluates the data to determine whether Beaver Dam Creek presently supports a balanced indigenous biological community.

In the fall of 1988, extended reactor outages resulted in a decrease of the site's electrical and stream demands. Power generation in D Area was reduced, with resultant decreases in outfall temperatures at ΔT's in the receiving stream. Thermal mitigation, via increased flow, was not required during the summer of 1989. Therefore, the data collected during the biological monitoring program are reflective of the thermal and flow regimes that exist when D Area is operating at a reduced power level but do not reflect normal operating conditions for 400-D Area. The results of the monitoring program are being submitted to SCDHEC, as specified in the approved study plan. However, upon returning to a normal level of power generation, additional biological monitoring will be performed to document the effects of thermal mitigation on Beaver Dam Creek during normal operating conditions.

The dominant factors influencing biotic communities in Beaver Dam Creek during thermal mitigation are decreases in maximum stream temperatures and ΔT's during the summer months and an increases in stream discharge during period of mitigation. The data collected during the biological monitoring program indicate that under the conditions of reduced power generation that existed during the 316(a) Demonstration, the structure and function of biotic communities were not adversely affected by the thermal component of D-Area effluents. Additional studies will be necessary to determine the effect of routine levels of electrical and stream generation on the biotic communities of the receiving stream. (authors)

Story, C. H., and Gordon, D. E. November 1989. *Environmental Data Management System at the Savannah River Site*, WSRC-RP--89-438, presented at the Annual Westinghouse Corporate Computer Symposium, Pittsburgh, Pennsylvania, Nov. 6-7, 1989; to be published in the proceedings.

The volume and complexity of data associated with escalating environmental regulations has prompted professionals at the Savannah River Site to begin taking steps necessary to better manage environmental information. This paper describes a plan to implement an integrated environmental information system at the site. Nine topic areas have been identified. They are: administrative, air, audit & QA, chemical information/inventory, ecology, environmental education, groundwater, solid/hazardous waste, and surface water. Identification of environmental databases that currently exist, integration into a "friendly environment", and development of new applications will all take place as a result of this effort. New applications recently completed include Groundwater Well Construction, NPDES (Surface Water) Discharge Monitoring, RCRA Quarterly

Reporting, and Material Safety Data Sheet Information. Database applications are relational (Oracle RDBMS) and reside largely in DEC VMS environments. In today's regulatory and litigation climate, the site recognizes they must have knowledge of accurate environmental data at the earliest possible time. Implementation of this system will help ensure this. (authors)

Taylor, B. R., and Roff, J.C. 1986. "Long-term Effects of Highway Construction on the Ecology of a Southern Ontario Stream," *Environmental Pollution*, (Series A)40, 317-344.

Long-term sampling of a small stream revealed changes up to 6 years after completion of a major highway crossing. Suspended solids and rates of sedimentation declined below the construction site as silt was flushed downstream. Upstream conditions were not re-established for 5 years; incomplete recovery occurred downstream.

Complex changes in invertebrate communities occurred; for 2½ years after construction, populations increased downstream, and diversity declined. Trichoptèra and Diptera proliferated, while Plecoptera and Ephemeroptera remained unchanged, or declined. Five years after construction diversity had rebounded, as flushing of silt allowed repopulation,and silt-tolerant Diptera declined. Few species were lost or gained, but a restructuring of invertebrate communities was evident, especially among the Trichoptera.

Blacknose dace and creek chub increased disproportionately for 2 years, but bottom-feeding species rebounded when sedimentation rates declined. The creek is apparently still changing in response to nutrients and sediments introduced by erosion, and elevated production appears to be relatively persistent. (authors)

Sedimentation rates and suspended solids levels were reduced during the construction process by soil stabilization methods implemented in the early summer of 1974. The methods utilized were turfing, mulching, and natural recolonization. Though reduced, it still took years for the suspended soilds level to return to pre-construction levels. Similarly, turbidity levels rose during construction and remained high even after the work was complete. (M. F.)

Vogelsang, K. G. 1991. *Nonpoint Pollution Discharge Permit Testing and Control Strategies at Naval Air Station Whidbey Island*, Defense Tech. Inf. Cent., Alexandria, Va.

The purpose of this study was to analyze systematically a nonpoint storm water monitoring program at Naval Air Station Whidbey Island, Washington, to determine if more relevant data can be obtained at lower cost by revising the sampling location, frequency, or pollutants of interest. Current remedial investigations of contaminated sediments, station hazardous material use information and station management plans provided the bulk of the data.

Watershed review indicated that potential contamination by 26 compounds may be present in the storm runoff. Testing to identify the presence of these compounds is required to renew an existing National Pollution Discharge Elimination System permit for the air station. It was also found that the frequency of sampling could be reduced from 52 events per year to about 30 with no significant loss of statistical accuracy, thereby reducing the recurring cost of the sampling program.

Also discussed are management practices and structural improvements that are technically feasible for controlling the two most significant pollutants, oil and grease and suspended solids. Best Management Practices are recommended to prevent or clean the spill of aviation fuel at the spill location. Use of synthetic oil-sorbent booms is recommended in lieu of the existing baffle treatment system. (author)

Some Best Management Practices that were recommended for reducing contaminated storm runoff were the mechanical sweeping of streets, the reduction of peak flow velocity through drainage basins and sedimentation ponds, the use of silt screens by construction projects, the routine cleaning of storm sewers, the upkeep of drainage swales, the erection of vegetated buffer stripes, and use of minimal curb and gutter length. Beyond Best Management Practices, there were suggestions of wetland creation, oil/water separators, sorbents, and mechanical skimmers for reducing oil and grease in the runoff. These ways were deemed more economical than the methods of dissolved air flotation, land application by spraying, air stripping, and activated carbon absorption. Filtration and sedimentation were identified as the most effective ways to

remove total suspended solids. It was noted that wetlands and oil/water separators removed some total suspended solids without interfering with the removal of oil and grease. (M. F.)

Westinghouse Electric Corporation 1990. *1989 Effluent and Environmental Monitoring Report for the Bettis Atomic Power Laboratory*, WAPD-RC/E(EE)--1040, U. S. Department of Energy.

The results of the radiological and non-radiological monitoring programs for 1989 at the Bettis Laboratory are presented. The results obtained from the monitoring programs demonstrate that the existing procedures ensured that all environmental releases during 1989 were in accordance with applicable Federal and State regulations except the three minor instances where the site's National Pollutant Discharge Elimination System (NPDES) water discharge permit limits for suspended solids were exceeded for short periods of time. These instances are more fully discussed in the report. Evaluation of the environmental data indicates that operatoin of the Laboratory continued to have no adverse effect on the quality of the environment. A conservative assessment of radiation exposure to the general public as a result of Laboratory operations demonstrated that the dose received by an member of the public was well below the most restrictive dose limits prescribed by the Environmental Protection Agency and the Department of Energy. (author)

This report contains informative tables on various discharges from Bettis Atomic Power Laboratory. Suspended solids and oil and grease are among the documented discharges. The discription of NPDES permit violations, response actions, and environmental effects is concise. (M.F.)

Whipple, W. Jr., and Hunter, J. V. December 1980. *Detention Basin Settleability of Urban Runoff Pollution, Phase II*, Natl. Tech. Inf. Serv., Springfield, Va.

Because of the growing interest in stormwater management, and particularly of the possibility of using detention basins for removing particulate pollution, it is important to determine the effectiveness of such basins for removal of various polluting substances. In the study, samples of urban runoff were allowed to settle in a large tube, and the quantity of each pollutant settling in a given time period determined. There was more variability in rate of settlement of specific pollutants than for total suspended solids. Lead and hydrocarbons settled out 60-65% in 32 hours, only slightly slower than total suspended solids. BOD and copper were removed at somewhat lower rates, and zinc even lower. In the second phase of the work, two detention basins were modified by installing small outlets which restricted the outflow of stormwater long enough for settlement of particulate pollutants. Settleability of incoming stormwater was compared to the actual trap efficiency of the detention basin for various pollutants. These results indicate that laboratory settleability can be used to forecast probable trap efficiency for pollutants of proposed detention basins. (authors)

The laboratory settleability test for trap efficiency of these basins yield more reliable data than the trap efficiency data deduced from mathematical models that were previously relied on. The mathematical models revealed efficiency rates that were unrealistically high. Both laboratory and field tests determined that these retention basins that released stormwater over a time period of 18 - 32 hours were most effective for removing hydrocarbons, lead, BOD, and total phosphates. Seventy percent of the hydrocarbons were removed in this manner with the modified detention basin. (M. F.)

White, C. A., and Franks, A. L. March 1978. *Demonstration of Erosion and Sediment Control Technology, Lake Tahoe Region of California*, EPA Office of Res. and Dev., Cincinnati, Ohio.

A three-year project was conducted by the California State Water Resources Control Board to determine methods of preventing and correcting erosion problems which severely effect the quality of the waters of the State of California. Two-project sites were chosen in the vicinity of the Lake Tahoe basin in California. One project site, Northstar-at-Tahoe, is a well planned and constructed residential-recreational development constructed in the early 1970s. The cost of extensive predeveloped planning and erosion control at Northstar is currently less than $400 per developed unit or residential lot. With ultimate planned build-out, costs are expected to be reduced to $220 per developed unit. The other project site, Rubicon Properties - Unit No. 2, is an extremely poorly planned and constructed residential subdivision development constructed in the late 1950s and early 1960s. The cost of complete corrective erosion control at Rubicon Properties would range from $1,000 to $3,000 or more per residential lot.

At both project sites, extensive hydrologic and water quality monitoring programs were conducted to determine erosion rates and their impact upon aquatic ecosystems. Monitored parameters included precipitation, snow depth, stream flow, suspended sediment and concentration, and benthic macroinvertebrate communities. Postdevelopment erosion rates at Northstar are estimated to be 100 percent above predevelopment levels, resulting in only minor perturbations of the benthic macroinvertebrate community of West Martis Creek. Postdevelopment erosion rates within Rubicon Properties are estimated to be over 10,000 percent above predevelopment levels, resulting in up to 99 percent destruction of the benthic macroinvertebrate community in Lonely Gulch Creek. At both project sites, extensive demonstrations were made of predevelopment planning concepts, construction techniques, and corrective measures which may be used to substantially reduce erosion and sedimentation problems associated with developments which are typical to the subalpine to alpine Lake Tahoe region of California. Analyses were made to determine cost and effectiveness of the various erosion control techniques which were demonstrated at the project sites.

This report was submitted in fulfillment of Grant No. S803181-01 by the California State Water Resources Control Board under the partial sponsorship of the U. S. Environmental Protection Agency. This report covers the period from July 4, 1974, to July 4, 1977, and work was completed December 31, 1977. (authors)

Erosion control techniques utilized at Northstar-at-Tahoe are described in detail in Section VIII and include (1) contour willow wattling, (2) willow staking, (3) native shrub plantings, (4) rock lined drainage ditches, (5) rock breast walls, (6) slope scaling, (7) overhand removal, (8) grass seed and fertilizer drilling, (9) grass seed hydromulching rates, (10) grass hydromulching rates, (11) straw mulching rates, (12) various mulch tackifiers, and (13) various fertilizers at differing rates. Many of these same techniques were utilized at Rubicon Properties during the fall of 1976 and the spring of 1977 to try and rectify the errors in judgement made in the predevelopment stages of planning the community. Complete descriptions of the measures taken are also located in Section VIII. (M. F.)

Wilde, E. W. December 1991. *Effects of K-Reactor Pre-operational Cold Flow Testing on Total Suspended Solids in Pen Branch (U)*, WSRC-TR-91-624, Westinghouse Savannah River Co., Aiken, S. C.

Total suspended solids (TSS) levels were monitored by SRL Environmental Sciences personnel at two locations in the Pen Branch Creek system in conjunction with K reactor cold flow (pump) testing required as a part of the reactor restart effort. The TSS data were compared with flow and rainfall data collected simultaneously in an effort to obtain insight on the suspension and movement of particulate material in the Pen Branch system in response to natural and operational causes. Pump testing clearly caused higher TSS levels at the two sampling locations. The artificially elevated TSS levels were more pronounced at a sampling location near the reactor than at a sampling location farther downstream. Although the environmental data provided by this study were obtained and used exclusively for process control and research purposes, rather than for formal regulatory compliance (i.e. NPDES monitoring), the TSS levels determined by the comprehensive testing were compared with NPDES limits required at various SRS outfalls. TSS values in Pen Branch were seldom in excess of these limits. Because of the relatively few times that TSS values at the two sampling locations exceeded "typical" NPDES limits, and the fact that occasional relatively high TSS values could clearly be solely attributed to rainfall, it was concluded that no major adverse environmental impacts were caused to the Pen Branch system as a result of the K-Reactor pre-operational pump testing. (author)

Young, R. J., and Mackie, G. L. 1991. "Effect of Oil Pipeline Construction on the Benthic Invertebrate Community Structure of Hodgson Creek, Northwest Territories," *Canadian Journal of Zoology*, Vol. 69(8), 2154-2160.

During the ice-free seasons of 1984 and the winter and summer of 1985, we determined the effect of winter oil pipeline construction on benthic invertebrates of Hodgson Creek, Northwest Territories. Total suspended sediments increased from <2 mg L^{-1} to >300 mg L^{-1} at sampling stations downstream of the pipeline right-of-way during construction, with peak concentrations exceeding 3000 mg L^{-1}. A concurrent increase in benthic invertebrate drift density from 2.6 to 37.6/100 m^{-3} was observed downstream of construction. The effects of pipeline installation were observed up to 5 weeks following the end of construction. Following the spring snowmelt in 1985, no significant difference in standing crop, species richness, or functional group composition between stations upstream and downstream of the pipeline right-of-way was observed. We concluded that the negative impact of pipeline construction was limited to the period between construction and spring ice breakup. The frequency and magnitude of spate events were sufficient to remove accumulated sediments. Thus, the impact of natural perturbations in Hodgson Creek was greater that the effect of pipeline construction on benthic community structure. (authors)

No out of the ordinary measures were taken to restrict sediment flow to streams. The results of the tests to determine environmental impacts of winter construction are well documented. (M. F.)

Zwiers, D. M. February 1981. "Research and Development," supplement to *Water Pollution from Highways and Urban Areas, an Annotated Bibliography*, FHWA/MN-81/3, Natl. Tech. Inf. Serv., Springfield, Va.

An extensive library research program was carried out in 1978 to determine what publications are available that deal with water pollution from highways and urban areas. The literature search indicated that considerable research is being done in this area of study. A number of publications were located with should be helpful in determining how accurate the present method of estimating water pollution from highways is. There was as attempt to limit the researcher to articles published after 1970. Although the bibliography is extensive, it is not exhaustive.

The original report was published in 1978. Since the last time, an additional 114 articles have been reviewed to determine which ones related to the subject study.

The supplemental bibliography is published in two sections. Part 1 is a list of publications alphabetized by the author, with appropriate annotations. Part 2 is a list of all publications perused as a part of the research. Part 2 contains articles listed in Part 1. (author)

APPENDIX C

Notes from Duke Power Information Exchange Meeting
May 1992

Sedimentation Workshop
Hosted by Duke Power
May 21, 1992
Lake Norman, NC

Dr. Thomas F. Waters

Putting together a literature review of sedimentation. Gave a presentation on how and what he is and isn't doing.

Bulk of literature is on salmonid reproduction in the Pacific Northwest.

The Biological Effects of Inorganic Sediments in Small Streams

Definitions
I. steam - orders 3-6
II. sediments - a pollutant - anthropogenic
III. geographic - North American, US and Canada
IV. temporal - 1960's forward. Cordone and Kelley, 1961 Cal Fish and Game - Comprehensive review, landmark paper
    A.Most work done in the 1980's
    B.Probably 1000-2000 papers bulk of which are in the gray literature

Not Included in his review-
-No basic ecology
-Hydrological Physiological/Mechanical
-Erosion losses
-Dissolved solids ($<0.45\mu m$)
-Organic sediments (logging debris, etc.)
-Contaminated sediments
-Sediments in water supply
-sediments in reservoirs
-aesthetics and recreation
-large rivers

Will Cover-

I. Physical nature of stream sediments
    A. SS- Suspended sediments
    B. DS- Dissolved sediments
II. Sampling methods
    A. Sediments - SS & DS
    B. Biological
III. Sources of sediments
    A. Agriculture
    B. Forestry (roads) major source of sediment loading
    C. Mining
    D. Urbanization
    E. Others
IV. Effects of Suspended Sediments (SS) = turbidity (sort of, as a component of)

A. Primary Production (not much literature)
B. Macroinvertebrates (not much literature)
C. Fish - large effort
1.Acute mortality (Newcome & McDonalds 1991 N. Amer J. Fish Mngmt)
2.Respiratory impairments
3.Disease Pathogens
4.Visual & Feeding (1° due to turbidity)
5.Behavior, distribution (very important in Tom's opinion)
6.Reproduction (non-salmonid) (lots of pubs)

V. Effects on Salmonid Reproductive success
VI. Effects of Deposited sediments
A. Primary Production
B. Macroinverts
C.Fish habitat
VII. Prevention and Restoration
A.Erosion Control
B.Riparian Management
C.Gravel Cleaning
D.Flushing Flows
E.Sediment Traps(large lit)
F.Excavation and Dams - effective on small/short time scale
VIII. Bibliography
IX. Index

Basic Loading - an area of research that needs to be done. How much sedimentation occurs naturally. How much do the critters need? We need a good method for QUANTIFYING Base Loading

Also a need to look holistically. - on an ecosystem basis. Lots of work has been done on salmonid reproduction, but not much on a large scale type thing where everything is integrated.

Possible good source of information. S. C. Forest Experiment Station
USDA Forest Service Blacksburg, VA
Andrew Dolloff
Patricia Flebbe
Dennis Lemly

Will be looking at:
1) Effects of fines sediments on brook trout - rates of survival through emergence
2) Effects of fine sediments on the aquatic food base for trout
- role of large woody debris in storage of sediments
- macroinvertebrate production

Look up the SPCA - Sedimentation Pollution Control Act

Flint Holbrook, SC Land Resources: A good contact for law type stuff.

The Biological Effects of Inorganic Sediments in Small Streams

Thomas F. Waters

Effects of sediment on salmonid reproductive success Bibliography

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APPENDIX D

Notes from "Stormwater: Permitting, Treatment, and Compliance Strategies" Course September 1992

September 21, 1992

Roxanna Hinzman

Trip report: Arlington, VA; Storm water regulations conference

The conference covered five main topic areas: Storm Water Discharge Permits and Application Requirements, Storm Water Quality Assessment, Types of Monitoring, Treatment Problems, and Treatment Technologies. I'll attempt to "briefly" summarize the discussions, and will provide you with the course materials that I received for more in-depth study.

Storm Water Discharge Permits and Application Requirements

There are three types of permits - group, individual and general. I don't know want X-10 is applying for, but I'll cover the latter two.

The deadline for the group permit has passed, so that is a moot issue at this point. The deadline for the individual permit is October 1. If a general permit is applied for, a Notice-of-Intent (NOI) must be filed by October 1. The existing NPDES permit may be amended to include stormwater run-off.

Any accumulation area under RCRA will fall under the new regulations, and research activities will be affected. Generally, it appears that parking lots will still be exempted; however, lots holding parked vehicles (primarily transport vehicles) may be subject to the regulations. It will depend on the permitting agency.

There are advantages and disadvantages for each permit type (individual and general). The individual permit allows for some flexibility to negotiate with the regulatory agency, particularly concerning monitoring; however, analytical data for the affected sites are required on the application. On the other hand, the general permit is less costly (up-front) in that no data is required to apply, so that is the route I'm assuming Charlie Valentine is taking. One disadvantage to the general permit is that there doesn't appear to be any provision for negotiation in regards to monitoring. The general permit is site-specific and is based on water quality parameters. It will also include acute Whole Effluent Testing (WET). The individual permit may exclude acute WET.

Other requirements associated with the individual permit include an annual visual site inspection by a Pollution Prevention Team (PPT) or a professional engineer and/or annual monitoring (could end up being semi-annual). The site inspection should address Best Management Practices (BMPs) and pollution prevention measures. A pollution prevention plan must include the facility obligated to determine BMPs and the establishment of the PPT.

Roxanna Hinzman
September 21, 1992
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Oh yes, there is a citizens suit provision in the individual permit; however, no mention was made of one in the general permit. Also, the stormwater permit program contains a provision for the application of a permit for construction activities that involve 5 or more acres.

Storm Water Quality Assessment
This should consist of inspection of impacted sites and surrounding areas for corrections to storm sewer system, including roof drains, floor drains, parking lot catch basins, sump pumps, cooling waters, and vehicle maintenance areas.

A topographic map, required for an individual permit, would a useful tool in identifying potential problem areas. Also, schematic plans, particularly of subsurface utilities and sewer line connections, might reveal potential cross-connections. Dye/smoke tests or television line surveys might be useful.

It was also mentioned that aerial photographs could be used in developing a historical perspective of the facility.

Visual inspections, during dry weather, should be made to determine if process water is present. If there are any Superfund sites in the proximity of the facility, these should be identified as possible contamination sources. Information concerning past spills or leaks might be useful, particularly if the type(s) of material and volume is known. Even personnel interviews might help in establishing historical background data for the facility or site.

A description of a "typical" rainfall event was provided. It is dependent on three factors: (1) must be greater than 0.1 inch, (2) must be preceded by 72 hours of dry weather, and (3) must be within ± 50% of the average volume and duration for the area.

Types of Monitoring
Two types of samples are to be taken - "first flush" (grab) and flow-weighted (composite). A "first flush" should be taken within approximately the first 30 minutes of a rainfall event. Basic parameters for analysis should include oil/grease, BOD_5, COD, TSS, TKN, pH, phosphorus, WET, and WPC (water-priority chemicals). Samples should also be analyzed for temperature, cyanide, phenols, chlorine (TRC), NO_3-N, NO_2-N, fecal coliform, and fecal streptococcus. The latter two would provide an indication of cross-connection with sanitary wastewaters. Additional analyses might include metals (if any are major components of raw materials used in manufacturing), anions, radioactivity, surfactants, etc. Refer to handouts for a more complete listing.

A Total Organic Halides (TOX) test was mentioned. A particular benefit of this test is the lower cost associated. This might be particularly useful as part of a monitoring program. The test detects the cumulative total concentration of dissolved halogenated organics present in a water sample. Its detection limit is 0.005 ppb. Another test that could be used is oil/grease (Standard Methods 503-E) for determining the cumulative total concentration of dissolved petroleum-based organics in a water sample. The benefit of this test is its low cost (~ \$35-\$50/sample).

Treatment Problems and Treatment Technologies

This section was perhaps the weakest part of the conference in that, unfortunately, there was no "miracle cure" introduced. Rather, they are relying on the more traditional methods based on current wastewater treatment technologies. Various methods discussed included:

1. Flocculation and precipitation, combined with an oil/water separation device. The problems associated with this method are the space requirements and that it is most effective for higher molecular weight compounds. The lower weight compounds tend to remain soluble.

2. Electro-dialysis. This method is more inclined to be used for plating wastes.

3. Ultra-filtration or reverse osmosis. This method is slow, expensive and generates a lot of wastewater.

4. Neutralization using CaO or NaOH as a medium. This process is used primarily for acid wastes. The sludge contains high concentrations of metal precipitates.

5. pH adjustment utilizing an oxidant. Treatment for cyanide wastes. This method results in a metal hydroxide sludge and effluent gases of CO_2 and N.

6. Granular activated carbon. This process is based on a concentration gradient which affects removal efficiency (the lower the concentration, the less efficient). Also, the carbon must be reactivated which can be costly.

7. Ion exchange resins for metals (cation) or cyanide (anion). This process is expensive and requires quite a bit of space. Also, the eluate contains heavy metals and results in a heavy metal hydroxide sludge.

8. Bioremediation. The process is slow and may also result in toxic by-products.

9. Biological treatment. Includes stabilization ponds (cheap - natural aeration), facultative aerobic/anaerobic ponds (more expensive - requires mechanical aeration), and aerated lagoon (expensive - requires excessive aeration). There are also space/size limitations associated.

All of these treatment processes have a number of disadvantages associated with them including cost, space limitation, toxic sludge generation, etc. Additionally, there may be some ancillary permitting requirements, e.g., linings for ponds, etc.

The general consensus of the conference participants is that this new regulation is going to be a nightmare to comply with. It is going to be extremely costly to administer, both in capital expense
Roxanna Hinzman

September 21, 1992
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and labor expense. Though the deadline for filing an individual permit or NOI (for a general permit) is October 1, it is unlikely that permits will be issued for a couple of years while the state and federal regulatory agencies try to sort things out. If there is a conclusion to be drawn from this conference, it is that it would be in our best interest to adopt a "proactive" approach and use this time to begin monitoring the storm water system and identifying impacts before they become problematic. This should include conducting biomonitoring of the storm drains and receiving streams to determine potential toxicity.

I wish I could provide a little optimism, but I think you can see that this is going to be quite an undertaking. Thanks for the opportunity to attend in your absence, I feel it was worthwhile.

Did I say something about being brief? If you need more information, see me.

Terry

T. L. Phipps, 1504, MS-6351 (6-5094)

Enclosures

cc: L. A. Kszos
A. J. Stewart

APPENDIX E

Alternative Stormwater Treatment Systems

Compost Storm Water Treatment System

EXECUTIVE SUMMARY

March 2, 1992

Prepared by:

W&H PACIFIC
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EXECUTIVE SUMMARY

COMPOST STORM WATER TREATMENT SYSTEM

Problem - New Federal, state and regional regulations mandate the treatment of storm water runoff from roadways, bridges, industrial sites, airports, parking lots and other paved facilities. Heavy metals, oil & grease, nutrients and other pollutants from vehicular traffic build up on these paved areas. These pollutants are then flushed by storm waters into adjacent receiving waters and damage the receiving water ecosystem.

Conventional methods of treating storm water runoff include grassy swales and detention ponds, which require considerable land area for siting. In urban areas, land costs are high and land areas for siting properly sized swales and ponds are not available. As a result, adequate storm water treatment facilities often cannot be installed where needed most.

Project Goal - The goal of this project has been to develop and test an alternative method of treating storm water runoff which requires significantly reduced land area requirements.

Basic Approach - Many methods of treating polluted waters involve adsorption of the pollutants to a solid phase, cleansing the water, which then continues past the adsorption sites. Examples include activated sludge and trickling filters in wastewater treatment, and sand filters in water treatment. The challenge was to find a porous and stable adsorbent material which is readily available, and design a cost-effective engineered system to contain the adsorbent material so the intermittent and highly variable flows associated with storm water runoff could be effectively treated.

It is well known that mature, high quality composts have a very high capacity for adsorbing heavy metals, oils, greases, nutrients, and organic toxins. This capability is primarily due to the humic compound content of the compost. Humic compounds are stable, insoluble, high molecular weight bio-polymers which act as polyelectrolytes - similar in activity to ion-exchange resins.

The project plan was to evaluate high quality composts for use as a physical and molecular filter, develop an engineered infrastructure to contain the compost yet permit free passage of the treated storm water, and test a full scale prototype during the winter of 1991.

Funding Sources and Project Participants - The basic concept was developed by W&H Pacific (W&HP), working in conjunction with the Washington County Department of Land Use and Transportation (WCDLUT). An initial seed grant of $35,000 from the Metropolitan Service District of Portland (METRO) was given to Washington County through an intergovernmental agreement.

information on improving and standardizing bid and contract specifications and determining real costs for projects of this type. Construction cost for the prototype, which was built in a portion of an existing swale, was $12,500.00.

- Automatic flow monitoring and sampling of influent and effluent storm water flows was designed and installed by USA. The sampling protocol allowed determination of first flush (time paced) as well as longer term (flow paced) treatment efficiencies. Chemical laboratory tests were performed at the USA lab.

- Data evaluation was a continuing process in the testing protocol. Incoming data is evaluated for removal efficiency as well as adherence to design and operational theory. This information, supplemented by other operational data and observations, will result in final full-scale design specifications.

Results - The results of full-scale testing in nine storm events through November 1991, are extremely encouraging. Mean removal rates for the nine storms were:

Turbidity - 84%
Suspended Solids - 95%
Total Volatile Suspended Solids - 89%
COD - 67 %
Settleable Solids - 96%

During heavy storms in November, the first flush period (1st half hour of storm) had the heaviest pollutant loadings as well as highest removal rates. Average removal rates for first flush events were:

Turbidity - 93%
Settleable Solids - 98%
Total Volatile Suspended Solids - 97%
COD - 90 %

- Total phosphorus removal as high as 77 percent was observed during first flush periods in November, and has averaged 40 percent during the entire test period. Mean Total Kjeldahl Nitrogen removal was 56 percent.

- Metals such as lead, cadmium, chromium and nickel have been measured only in very low levels - close to detection limits. Copper is intermediate - average removal has been 67 percent. Zinc has been present in higher amounts - removal has averaged 88 percent. Aluminum and iron have been present in highest levels - average removal has been 87 percent and 89 percent respectively. These metals also showed significantly higher first flush removal rates under increased loading conditions.

- Oil & grease was evident in the influent as a surface slick and globules of oil. No surface sheen could be detected in the effluent. Petroleum Hydrocarbons removal has averaged 87 percent.

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COMPOST STORM WATER FILTER (CSF)

ANSWERS TO TYPICAL QUESTIONS

How much does a CSF cost?

Since the process is new, we are still determining exact costs. These will, of course, be highly dependent on site conditions, including such factors as storm intensity, pollutant loading rates and existing retrofit opportunity. The prototype facility, treating 72 acres of runoff, which was constructed in a pre-existing swale, cost approximately $12,500.00.

The most direct cost reduction as compared to swales, detention ponds and constructed wetlands will be in land utilization savings. The CSF requires about 3 % of the land area of a comparable designed storm water detention pond. In addition to direct land savings, additional cost reductions in fencing and security, landscape maintenance and liability must be considered.

How often do I have to replace the compost and maintain the CSF?

Compost replacement schedules will be primarily based on pollutant loading rates, particularly heavy metals. In the case of a large centrally located CSF, similar in design to the 185th Avenue site (draining 72 acres), we estimate that the front section, which treats the heaviest loadings, may require compost replacement on an annual basis (approximately 20 yards per annum). We anticipate that the remainder of the treatment cells will require replacement every 3 to 4 years. The smaller, modular CSF's will require compost replacement every year - amounting to about 1 to 1.5 yards of compost. The compost is quickly removed by a vacuum truck and replacement is relatively inexpensive.

How do we dispose of the compost? Is it a hazardous waste?

Because of its tremendous binding capacity, the compost can contain large amounts of heavy metals and still not be classified as a hazardous waste (i.e. fail the TCLP test). However, common sense dictates a management program in which the compost is replaced long before heavy metal concentrations approach a hazardous waste condition. We are starting with a clean compost, with a heavy metal content well below that contained in sewage sludges which are accepted for land application. Management of the CSF will dictate compost removal and replacement before metal content equals levels found in sewage sludge. An annual replacement schedule will guarantee this at most sites, so there will be no question of hazardous waste generation.

The used compost disposal will be taken care of by a maintenance contractor. The used compost material will be useful for erosion control at construction sites, along road shoulders, for landscape berms and as a top cover in landfill management for control of volatile organic compound emissions.

Organic contaminants (i.e., oil, grease, other petroleum hydrocarbons, pesticide, herbicide and solvent residues) will not accumulate but will be destroyed by microbial activity.

How permitable is a CSF?

Permitting is not a problem. We are working closely with the U.S. Environmental Protection Agency (U.S. EPA), the Oregon Department of Environmental Quality (DEQ) and the Washington Department of Ecology (DOE). These agencies are all very interested in the process. The U.S. EPA and Oregon DEQ are funding part of the 1992 - 1993 CSF refinement projects.

How dependable is the supply of compost?

The raw source of the material used in the process (i.e., leaves) is as dependable as the change in seasons. W&H PACIFIC will ensure the dependability of local supply, and most important, the quality standard of the compost produced for use in storm water treatment.

Who can construct the CSF? Is a special contractor required?

W&H PACIFIC will specify design, provide construction management, under contract, ensure that long-term maintenance requirements are met. The actual construction will be bid out to pre-qualified contractors.

How does it effect wildlife and wetlands?

The CSF protects wetlands and other bodies of water from accumulation of sediments, heavy metals, oils and grease, and other pollutants contained in storm waters. Preventing the accumulation of these pollutants in wetlands and other natural and constructed bodies of water prevents these materials from entering the food chain and reduces potential long-term liability risks for the client.

Does the CSF reduce liability?

Yes, the CSF reduces liability for owners in several ways.

1. Detention ponds used for storm water treatment contain standing water which act as a magnet for kids. The relatively large amounts of fencing required for detention pond security must be properly maintained to reduce liability from possible drowning. The CSF, on the other hand, contains one to two feet of water only during storms, and drains between storms. It presents a much lower hazard and attraction, as well as greatly reduces fencing, fence maintenance and other security requirements.

2. There is increasing evidence that heavy metals and other pollutants which accumulate in detention ponds, swales and constructed wetlands used for storm water treatment present a long-term threat to wildlife and can eventually cause underlying groundwater pollution. Prior removal of these pollutants through the managed approach used for the CSF will prevent this long-term potential problem.

3. In case of a fuel spill, the compost can be removed and disposed of. New compost will enable the CSF to become immediately effective at storm water treatment, at any season of the year. For detention ponds, and particularly swales, pollutant removal in case of spills is more difficult and expensive due to the larger areas covered. The swales will require removal of vegetation and the top layer of soil, reseeding and regrowth of the vegetation, before they again become effective for treatment purposes.

What is the longevity of materials used in construction?

The weirs, baffles, and piping can be designed for at least a 20-year life, depending on material selection. Since the drain rock is protected from sediment accumulation by the overlying geotextile fabric, it should have a similar life span. The geotextile fabric should have a ten-year life, and can be changed as necessary during a normal compost replacement cycle.

We have no unused land for any storm water treatment. Can we still use it?

A common problem in storm water treatment is the lack of room for siting conventional swales and detention ponds or the lack of available head at the storm water outfall to site a CSF. W&H PACIFIC is currently testing small drop-in modules to solve this problem. These are designed to fit under the pavement next to each individual catch basin, and then connect to the existing storm water drainage piping. These will require no additional land area for treatment, are completely covered so no area is lost for traffic or parking use, are easily maintained, and can be installed in new construction or retrofitted to existing sites.

If you have any additional questions, please feel free to contact Bill Stewart at W&H PACIFIC - (503) 626-0455.

W&H PACIFIC

COMPOST STORM WATER FILTER SYSTEM

TECHNICAL SUMMARY

METHODS & RESULTS

June 30, 1992

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1.0 INTRODUCTION

The following methods description and data summaries are taken from the results of the first year of testing of the compost storm water filter (CSF). These data, together with the accompanying Executive Summary, provide a good overview of the progress in the first year of development of this new storm water treatment technology.

2.0 SAMPLING, FLOW MEASUREMENT AND LABORATORY ANALYSIS

Sampling, Flow Measurement and Laboratory Analysis were provided by the Unified Sewerage Agency (USA). The majority of chemical analysis was performed at the USA Water Quality Laboratory.

2.1 Automatic Sampling and Flow Measurement

Two ISCO Model 3700 automatic samplers were installed at the site, one at the influent end and the other at the effluent end of the treatment system. These samplers were housed in Plasti-Fab Model 4A weatherproof fiberglass sampler shelters for protection against the elements and vandalism.

An ISCO Model 3230 flow meter, using the bubbler method of flow level measurement, was also located at the influent end of the system and connected to both of the samplers. The bubbler tube was placed just inside the 24-inch discharge pipe. The flow meter detected the onset of a storm event, triggering the automatic samplers, and converting the flow depth into a properly scaled flow rate value. The effluent sampler was set with a 10 minute delay to allow for the time required for initial discharge from the compost bed. The influent sample intake was placed in the discharge pipe, just after the bubbler; the effluent sample intake was placed at the discharge end of the 4-inch diameter perforated plastic drain pipe which ran the length of the treatment system.

The samplers were equipped with a storm pacing program. When the flow meter detected a flow depth of 0.2 feet in the discharge pipe, it was set to trigger both samplers to take two time-paced (first flush) samples (with 10 minute delay for effluent sampler). These samples were collected in each of two sample containers at 5 and 10 minute intervals (15 and 20 minutes for the effluent sampler). A one gallon glass container was used for oil & grease analysis and a one gallon polyethylene container was used for the remaining chemistries.

The storm program then switched the sampler to flow paced or weighted composite sampling. Each time the flow meter sensed 1,000 gallons, it triggered a flow pulse to the samplers. After 10 consecutive flow pulses, the samplers took a 170 ml sample into each of two additional polyethylene containers. The sampler then sent a pulse back to the flow meter to record exactly when it took the sample. This flow paced sampling mode continued until the flow meter did not sense flow for a continuous two hour period, or until 22 flow paced samples were collected, after which it turned the samplers off.

The sampling rate of 1 per 10,000 gallons was based on a rainfall of 0.2 inches and the size of the drainage area. It requires adjustment for different projected rainfalls and different drainage area sizes.

The flow data with the information documenting sample collection times was then downloaded from the flow meter to a portable laptop computer using ISCO Flowlink software.

2.2 Laboratory Analysis

Influent and effluent samples were collected from the automatic samplers by personnel of the USA lab as soon as possible following cessation of a sampled storm event.

Table 1 shows laboratory analysis procedures used for the water chemistry during this project. ICP analysis was used for the metals.

2.3 Fall 1991 Testing Period - Rainfall Characteristics and Sampling Dates

The testing facility was ready to receive storm water in early August 1991. However, as shown in Graph 1, based on rainfall data taken at the Portland Airport weather station, rainfall during the fall of 1991 was anomalous. Rainfall during the months of August, September and October were all below normal (August - 38 percent, September - 99.8 percent, October - 50.5 percent below normal). In November however, rainfall amounts increased to 19 percent above normal. These four months cover the data gathering period reported in this document.

Table 2 shows 24-hour rainfall amounts for the period as recorded at the Reedville Fire Station continuous monitoring rain gauge. The shaded areas of this table show storm events sampled and the sample numbers for each event. There was one isolated storm at the site on August 31, for which influent and effluent grab samples were obtained, which was not measured at the Reedville gauge since the gauge was out of service on that day.

3.0 RESULTS - DATA AND DATA ANALYSIS

For each storm sampled, influent and effluent samples were taken for both the time paced (first flush - FF) and flow paced (FP) part of the event. In some cases, one or the other is missing due to sampling problems. In the case of two storms, hand grab samples were taken - these are labeled as grabs (G). For this report, the results of sampling nine storm events, from August 9, 1991 through November 19, 1991, are presented.

Graphs of the mean data are used to illustrate the results of the testing program. The parameters will be discussed in five sections - Section 3.1 - Turbidity, Solids and COD; Section 3.2 - Nutrients; Section 3.3 - Metals; Section 3.4 - Oil & Grease, Miscellaneous; and Section 3.5 - Floatables. Section 3.6 gives a comparison of these data with receiving water data.

3.1 Turbidity, Solids and Chemical Oxygen Demand (COD)

Data for mean values of all data (first flush and flow paced storm portions equally weighed) for turbidity, solids and COD are shown in Graph 2, together with the mean percent removal for each set of data.

Turbidity (TURB) averaged an 84.2 percent improvement through the test period. Turbidity improvement is important in storm water treatment for both aesthetic and pollution prevention reasons.

Total suspended solid (TSS) removals, the most important of the solids fraction in respect to an indicator of pollution potential, averaged a very high 94.8 percent for the entire period. Total volatile suspended solids (TVSS) removal, which represents the organic fraction of the suspended solids, averaged 88.8 percent. Removal of suspended solids is primarily by direct filtration.

TABLE - 1

LABORATORY ANALYSIS PROCEDURES

ANALYSIS	UNITS	REFERENCE	EDITION	PROCEDURE	MIN. VALUE
Turbidity	NTU	EPA	Rev. 83	180	0.1
Conductivity - Lab	UMHO	Std. Methods	16	205	1
T-COD (Chemical Oxygen Demand)	mg/l	EPA	Rev. 83	410.4	2
pH - Lab	pH	EPA	Rev. 83	150.1	0.1
TS (Total Solids)	mg/l	Std. Methods	16	209A	2
TDS (Total Dissolved Solids)	mg/l	Std. Methods	16	209C	2
TSS (Total Suspended Solids)	mg/l	Std. Methods	16	209C	0.01
TVSS (Total Volatile Suspended Solids)	mg/l	Std. Methods	16	209D	0.01
Sett. Solids (Settleable Solids)	ml/l	Std. Methods	16	209E	0.1
NH3-N (Ammonia)	mg/l	Std. Methods	16	417G	0.01
TKN (Total Kjeldahl (Organic) Nitrogen)	mg/l	EPA	Rev. 83	351.2	0.2
NO2NO3-N (Nitrite-Nitrate Nitrogen)	mg/l	EPA	Rev. 83	353.2	0.01
T-PO4-P (Total Phosphorus)	mg/l	EPA	Rev. 83	365.4	0.02
S-OPO4-P	mg/l	EPA	Rev. 83	365.1	0.01
T-CA (Calcium)	mg/l	EPA	Rev. 83	200.7	0.06
T-Mg (Magnesium)	mg/l	EPA	Rev. 83	200.7	1.06
T-Na (Sodium)	mg/l	EPA	Rev. 83	200.7	0.05
T-K (Potassium)	mg/l	EPA	Rev. 83	200.7	1.6
Chloride	mg/l	Std. Methods	16	407-1	0.1
T-As (Arsenic)	ug/l	EPA	Rev. 83	206.3	0.1
T-Ba (Barium)	ug/l	EPA	Rev. 83	200.7	2
T-Be (Beryllium)	ug/l	EPA	Rev. 83	200.7	2
T-B (Boron)	ug/l	EPA	Rev. 83	200.7	36
T-Cd (Cadmium)	ug/l	EPA	Rev. 83	200.7	14
T-Cr (Chromium)	ug/l	EPA	Rev. 83	200.7	14
T-Co (Cobalt)	ug/l	EPA	Rev. 83	200.7	8
T-Cu (Copper)	ug/l	EPA	Rev. 83	200.7	10
T-Fe (Iron)	ug/l	EPA	Rev. 83	200.7	10
T-Pb (Lead)	ug/l	EPA	Rev. 83	200.7	120
T-Mn (Manganese)	ug/l	EPA	Rev. 83	200.7	2
T-Ni (Nickel)	ug/l	EPA	Rev. 83	200.7	20
T-Ag (Silver)	ug/l	EPA	Rev. 83	200.7	30
T-V (Vanadium)	ug/l	EPA	Rev. 83	200.7	16
T-Zn (Zinc)	ug/l	EPA	Rev. 83	200.7	4
T-Sb (Antimony)	ug/l	EPA	Rev. 83	200.7	56
T-Al (Aluminum)	ug/l	EPA	Rev. 83	200.7	10
T-Se (Selenium)	ug/l	EPA	Rev. 83	200.7	100
T-Tl (Thallium)	ug/l	EPA	Rev. 83	200.7	80
T-Hg (Mercury)	ug/l	EPA	Rev. 83	245.1	0.5
Oil & Grease	mg/l	EPA	Rev. 83	IR - 413.2	0.5
Pet. Hydro. (Petrolium Hydrocarbons)	mg/l	EPA	Rev. 83	IR - 418.1	0.5

Ref. - USA Laboratory

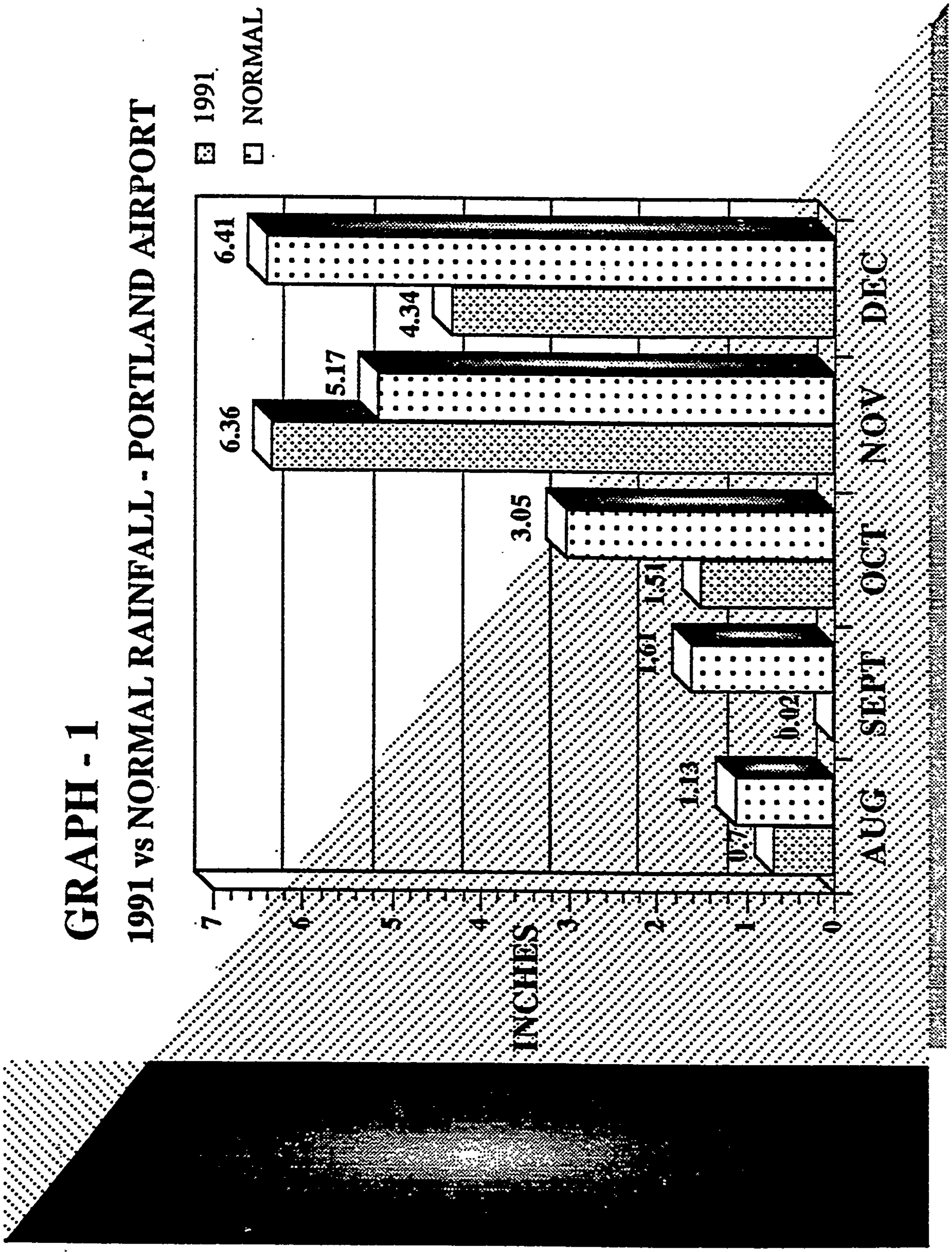

GRAPH - 1
1991 vs NORMAL RAINFALL - PORTLAND AIRPORT
1991
NORMAL
INCHES
0
1
2
3
4
5
6
7
0.7
1.13
0.02
1.61
1.51
3.05
6.36
5.17
4.34
6.41
AUG
SEPT
OCT
NOV
DEC

TABLE - 2

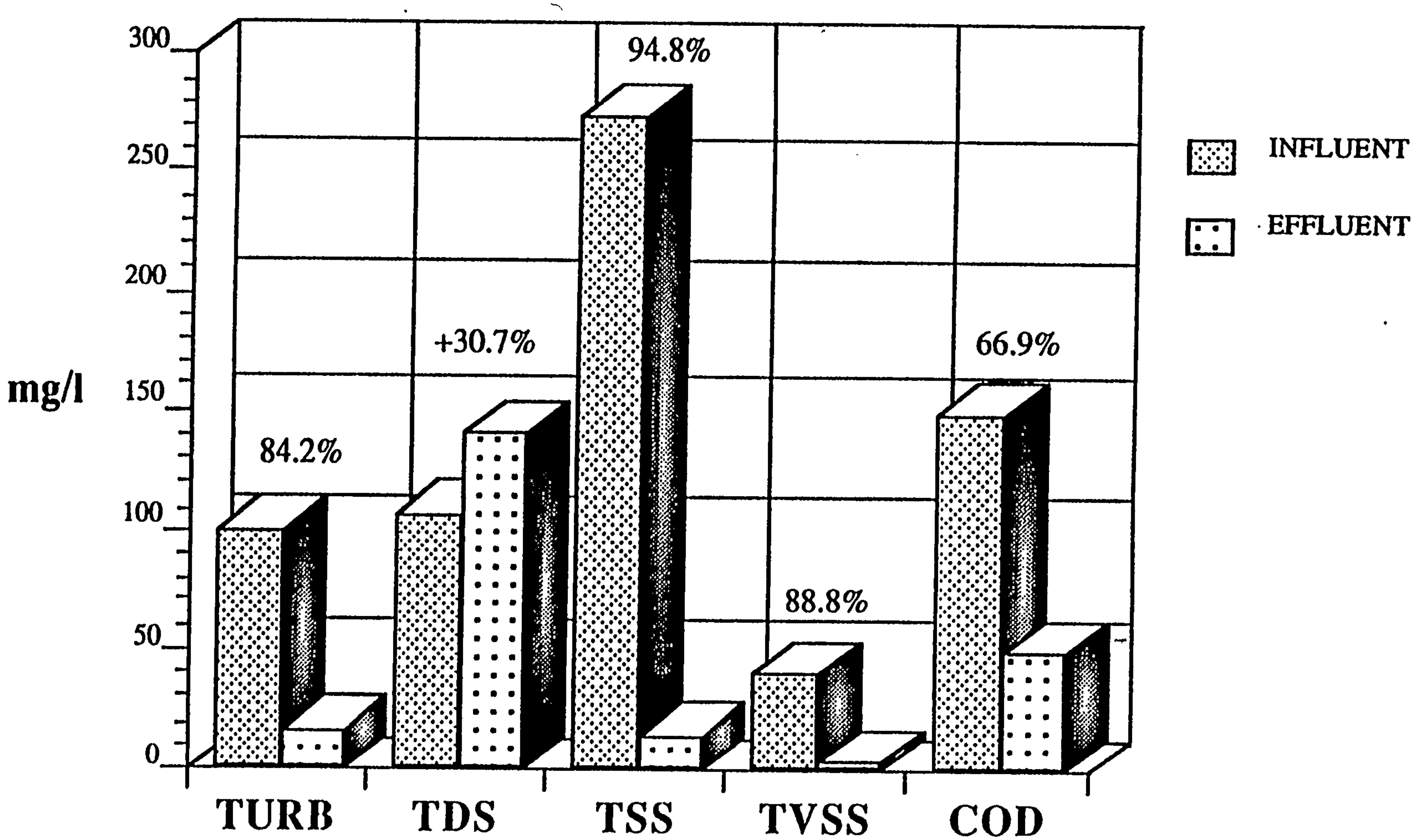
RAINFALL - REEDVILLE FIRE STATION
(24 HOUR TOTALS)

EVENT	DATE (1991)	24 HR TOTAL	SAMPLES TAKEN			
			INF - FF	EFF - FF	INF - FP	EFF - FP
1	15-Jul	0.080				
2	22-Jul	0.008				
3	13-Sep	0.008				
4	16-Oct	0.060				
5	22-Oct	0.600	521(G) 525	522(G)	526	527
6	23-Oct	0.120				
7	24-Oct	0.360				
8	25-Oct	1.474	545	547	546	548
9	26-Oct	0.497				
10	27-Oct	0.040				
11	28-Oct	0.599	549	551	550	552
12	1-Nov	0.020				
13	4-Nov	1.473				
14	5-Nov	0.814				
15	6-Nov	0.020				
16	7-Nov	0.040				
17	8-Nov	0.200				
18	9-Nov	0.100				
19	11-Nov	0.499				
20	12-Nov	0.317	571	572		
21	13-Nov	0.830	573	575	574	576
22	14-Nov	0.020				
23	16-Nov	0.897	577		578	579
24	17-Nov	1.621				
25	18-Nov	0.200				
26	19-Nov	1.376	582	583		
27	20-Nov	0.653				
28	21-Nov	0.240				
29	22-Nov	0.020				
30	23-Nov	0.280				
31	24-Nov	0.598				
32	25-Nov	1.010				
33	26-Nov	0.939				
34	27-Nov	0.020				
35	28-Nov	0.020				
36	29-Nov	0.020				
37	30-Nov	0.240				

31-Aug. - 0.32" Storm at Site - No Rain Data In Above
Shaded Area Indicates Samples Taken (Sample Numbers Given)
INF - Influent Sample
EFF - Effluent Sample
FF - First Flush Sample (Time Paced)
FP - Flow Paced Sample
G = Grab

GRAPH - 2

MEAN REMOVAL RATES - ALL DATA



While total solids (TS - not graphed) decreased in the effluent an average of 59.4 percent, total dissolved solids (TDS) showed a 30.7 percent mean increase. Total solids includes TDS, that soluble portion consisting primarily of ionic species, and total suspended solids (TSS), the larger particles more commonly associated with pollution problems. Because the compost acts as an ion exchanger, lighter soluble elements, such as potassium, calcium and magnesium, are lost in the exchange process with heavier elements such as nickel and zinc. This loss is reflected in the increased TDS in the effluent, and contributes to the relatively low (59.4 percent) TS removal rate.

Chemical Oxygen Demand (COD), a measurement of the oxygen-consuming capacity of inorganic and organic matter, averaged 66.9 percent. This removal efficiency was reduced in part by relatively poor removals in some of the earlier storms, due to the contamination by the insufficiently washed drainage gravel.

Graph 3 gives standard deviations for turbidity, TSS, TVSS and COD. Standard deviation measures the degree to which data tend to spread or deviate from the mean. In any treatment process, the influent storm waters can be expected to have a high variability, or standard deviation, in measured values. The object of a good treatment process is to reduce these levels to a consistent and reliable low level, with a low standard deviation. This is called a dampening effect. The standard deviation shown in Graph 3 illustrates very good dampening effected by the compost treatment system. This also indicates that the system is capable of withstanding high shock loadings while maintaining required effluent treatment standards.

It is commonly stated that the first flush portion (first half hour) of a storm event carries a significantly higher pollutant loading than the remaining or flow paced portion. A series of heavy storms during November 1991 provided an opportunity to examine this hypothesis, and test the effectiveness of the compost storm water filter under very heavy first flush conditions. These data are given in Table 3 and Graph 4. As can be seen, the first flush (FF) portion of these storms contained significantly higher loadings than the remaining flow paced (FP) portion. For example, during the first flush period, COD loading averaged 334.7 mg/l, as opposed to 59.0 mg/l during the remainder of the storm. The highest reading for COD occurred during the November 13 storm, with an influent strength of 644.0 mg/l and an effluent (treated) level of 46.0. This represents a 92.9 percent removal rate. During the November 13 first flush portion, total suspended solids (TSS) measured 1610.0 mg/l, the effluent 31.2 mg/l, giving a treatment efficiency of 98 percent. Values for other parameters, while not as extreme, also show the excellent shock loading and pollutant removal capabilities of the compost storm water treatment system.

3.2 Nutrients

Data showing mean removal rates during the testing period for total phosphorus (T-PO_4-P), total Kjeldahl (TKN), nitrite-nitrate nitrogen (NO_2 NO_3-N - shown as NO_3) and ammonia nitrogen (NH_3-N) are given in Graph 5.

Total phosphorus removal rates averaged 40.5 percent during the period. This removal rate is comparable to mean total phosphorus removals in alternative storm water treatment processes such as wet detention ponds and swales. As with the other pollutants, total phosphorus removal was highest during first flush events, when loading rates were greatest. Graph 6 shows removal rates for total phosphorus during first flush events in November (67.2 percent mean removal), as compared to the reduced influent levels and reduced treatment efficiency during the remainder (flow paced) portion of the storm event.

GRAPH - 3

STANDARD DEVIATION - ALL DATA

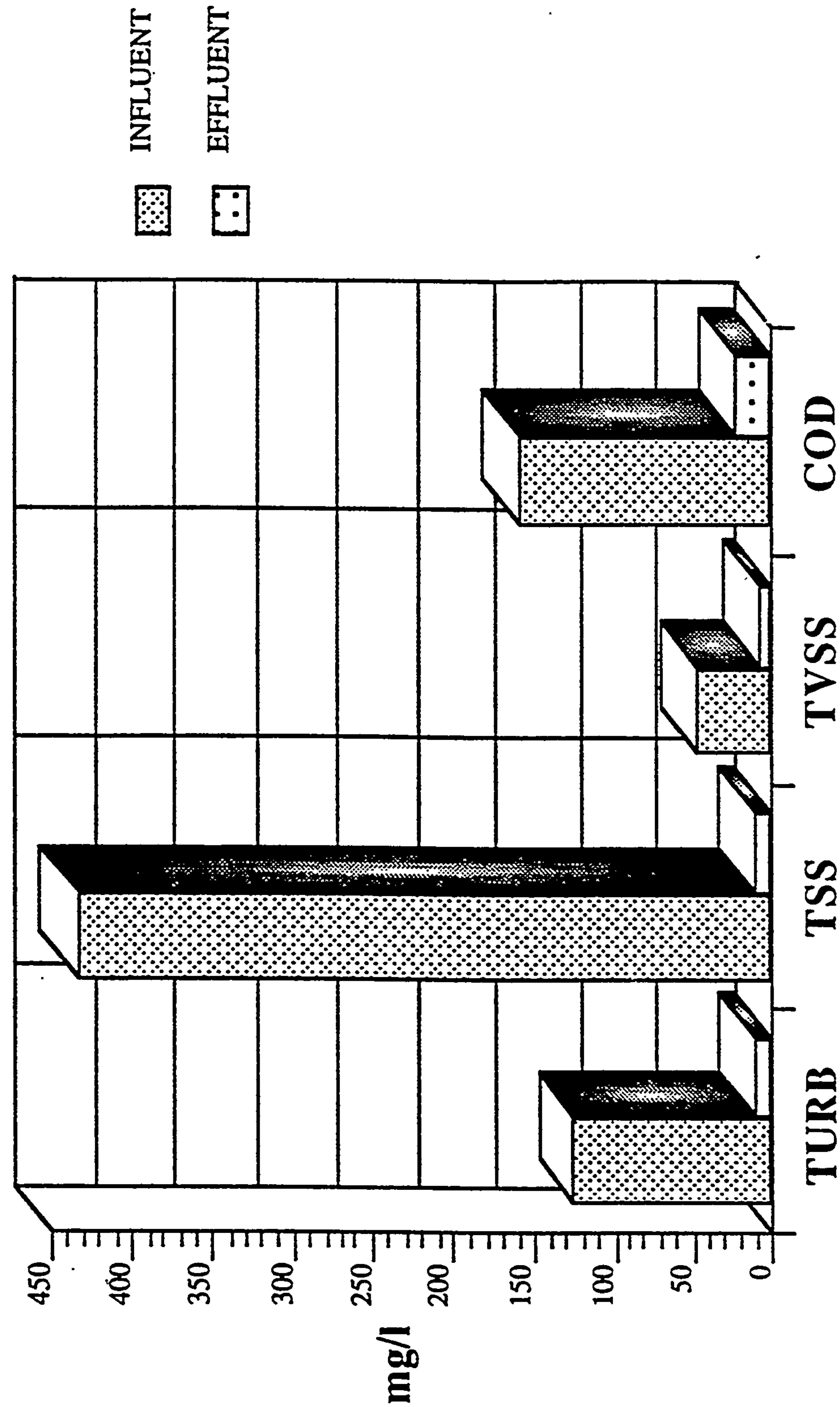


TABLE - 3

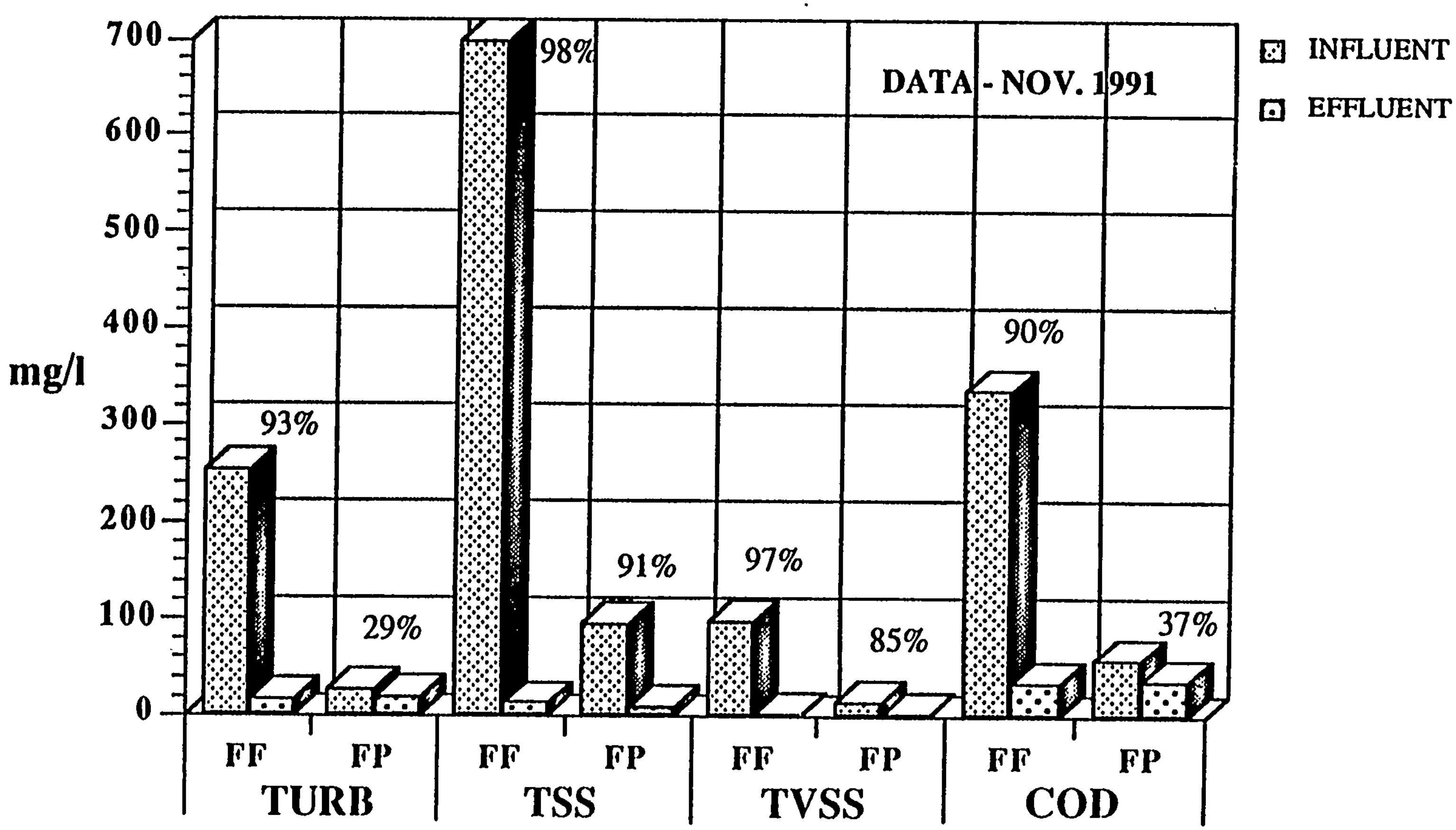
FIRST FLUSH (FF) VS. FLOW PACED (FP) (mg/l) - NOVEMBER 1991

DATE	TURB FF-I	TURB FF-E	TURB FP-I	TURB FP-E	TSS FF-I	TSS FF-E	TSS FP-I	TSS FP-E	TVSS FF-I	TVSS FF-E	TVSS FP-I	TVSS FP-E	COD FF-I	COD FF-E	COD FP-I	COD FP-E	T-PO4 FF-I	T-PO4 FF-E	T-PO4 FP-I	T-PO4 FP-E
12-Nov	350.0	8.0			330.0	2.3			72.3	1.1			150.0	32.0			3.20	1.40		
13-Nov	300.0	36.0	34.0	26.0	1610.0	31.2	151.0	13.0	170.0	6.8	21.5	3.5	644.0	46.0	54.0	29.0	4.40	1.00	1.40	1.00
15-Nov			18.0	11.0			38.2	4.2			9.6	1.3			64.0	45.6			0.90	1.00
19-Nov	110.0	6.0			156.0	2.3			48.0	0.2			210.0	27.0			0.64	0.31		
Mean	253.3	16.7	26.0	18.5	698.7	11.9	94.6	8.6	98.6	2.7	15.6	2.4	334.7	35.0	59.0	37.3	2.75	0.90	1.15	1.00
Standard Dev.	126.6	16.8	11.3	10.6	794.0	16.7	79.8	6.2	64.6	3.6	8.4	1.6	269.6	9.8	7.1	11.7	1.92	0.55	0.35	0.00
Maximum	350.0	36.0	34.0	26.0	1610.0	31.2	151.0	13.0	170.0	6.8	21.5	3.5	644.0	46.0	64.0	45.6	4.40	1.40	1.40	1.00
Minimum	110.0	6.0	18.0	11.0	156.0	2.3	38.2	4.2	48.0	0.2	9.6	1.3	150.0	27.0	54.0	29.0	0.64	0.31	0.90	1.00
N	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2
% REMOVAL		93.4%		28.8%		98.3%		90.9%		97.2%		84.5%		89.5%		36.8%		67.2%		13.0%
MEAN % REMOVAL (All Data)				84.2%				94.8%				88.8%				66.9%				41.6%

FF-I = First Flush (Time Paced) - Influent
FF-E = First Flush (Time Paced) - Effluent
FP-I = Flow Paced - Influent
FP-E = Flow Paced - Effluent

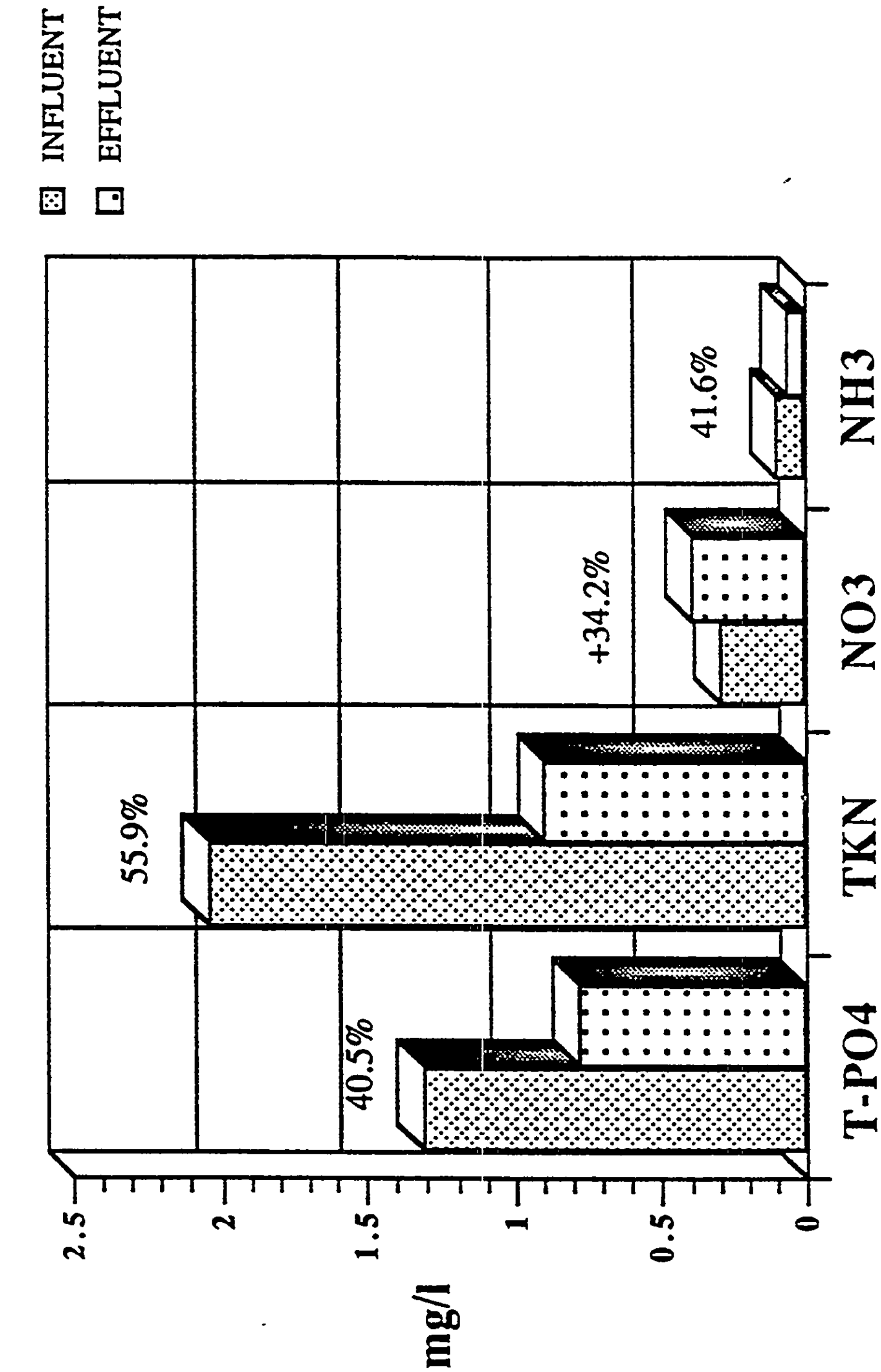
GRAPH - 4

FIRST FLUSH (FF) vs. FLOW PACED (FP) MEAN REMOVAL RATES



GRAPH - 5

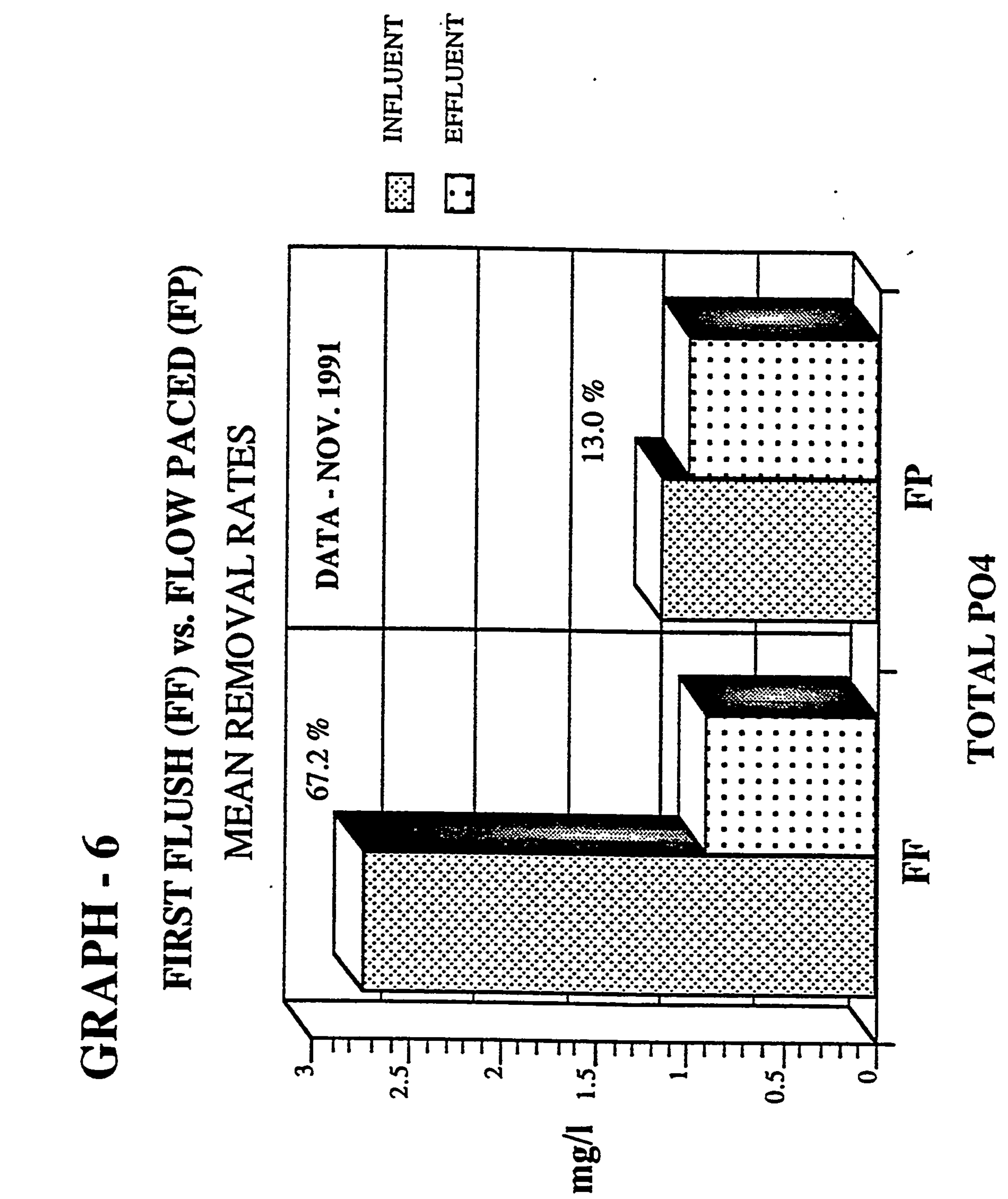
MEAN REMOVAL RATES - ALL DATA



GRAPH - 6

FIRST FLUSH (FF) vs. FLOW PACED (FP)

MEAN REMOVAL RATES



Graph 7 displays total phosphorus removals for all storm events tested, again showing the relationship between influent loading and removal efficiency. During the November 13 storm, when the influent phosphorus loading was the greatest encountered during the test period, total phosphorus removal efficiency achieved 77 percent.

There was an interesting relationship ascertained between total and soluble phosphorus in these tests. Total phosphorus includes particulate (i.e., phosphorus attached to solids) and soluble phosphorus. Graph 8 shows that the influent phosphorus contained a high proportion of particulate phosphorous (9:1 - particulate:soluble), while in the effluent from the compost storm water treatment facility, the soluble portion made up the highest proportion (1:9 - particulate:soluble). This indicates that the system is pulling out the particulate phosphorous, but the release taking place is primarily in the soluble form. Soluble phosphorus consistently showed a net increase across the compost filter, which may be due to the soluble phosphorus acting in an anion exchange reaction.

Organic nitrogen (TKN) showed a mean reduction of 55.9 percent during the test period, while nitrite-nitrate nitrogen increased in the effluent by 34.2 percent. Ammonia, which was probably chemically converted to nitrate in the system gave a mean removal rate of 41.6 percent. Again, ammonia removal efficiencies were best at the heaviest loading rates, with removal efficiencies as great as 81 percent under high influent ammonia values.

3.3 Metals

Four cations usually had increased values in the effluent. These were potassium, magnesium, calcium, and, to a lesser extent, sodium. These are the sacrificial cations involved in the cation exchange binding of the heavy metals. Boron was also seen to increase consistently in the effluent from the filter (Graph 10). Boron is an anion, and may have been acting as the sacrificial species for other anions.

Cadmium and lead were found either in very low and variable concentrations in the influent storm waters or were not detected.

The most common metals were aluminum and iron in the influent. Mean removal rates for these metals are shown in Graph 9. Mean removal for aluminum was 87 percent, and 89 percent for iron.

Graph 10 displays mean removal rates for those other metals which were found in concentrations exceeding 5 ug/l (ppb). The most common was zinc, which had a mean removal rate of 88 percent over the test period.

A comparison of removal rates in the first flush (FF) and flow paced (FP) periods for the November storms is given in Table 4 and Graph 11. The same relationship of highest pollutant loadings and greatest removal efficiency during the first half hour of the storm event, as was seen previously for solids and nutrients, is evident. As with the solids and nutrients, the compost storm water treatment system has shown excellent shock loading capabilities for metals as well.

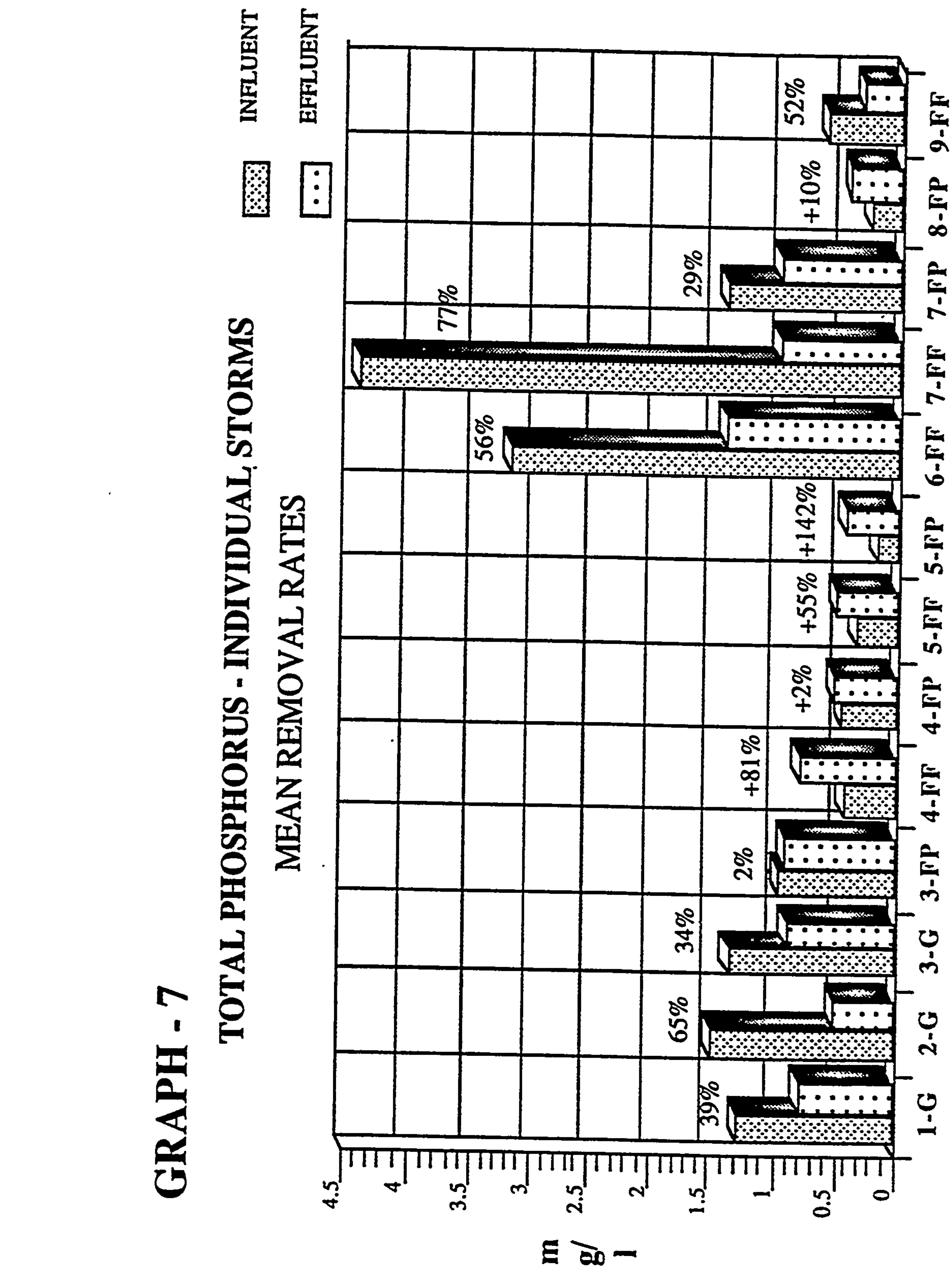
3.4 Oil & Grease, Miscellaneous

It proved impossible to obtain reliable quantitative information on oil & grease due to the configuration of the sampler intakes. The discharge pipe provided sufficient laminar flow and insufficient mixing which permitted these pollutants to rise to the surface where they could not be sampled. However, visual observations during and immediately following

GRAPH - 7

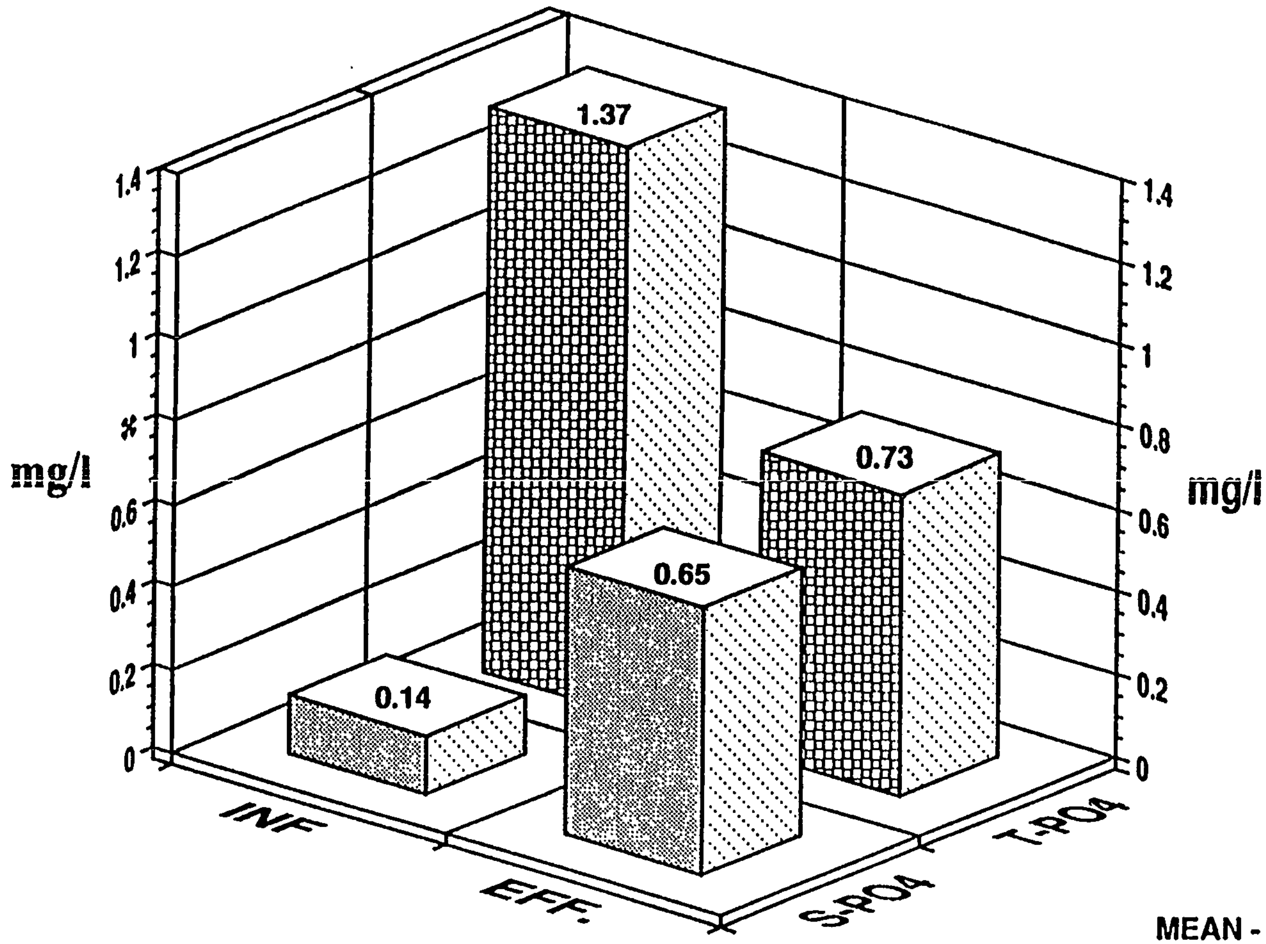
TOTAL PHOSPHORUS - INDIVIDUAL STORMS

MEAN REMOVAL RATES



GRAPH - 8

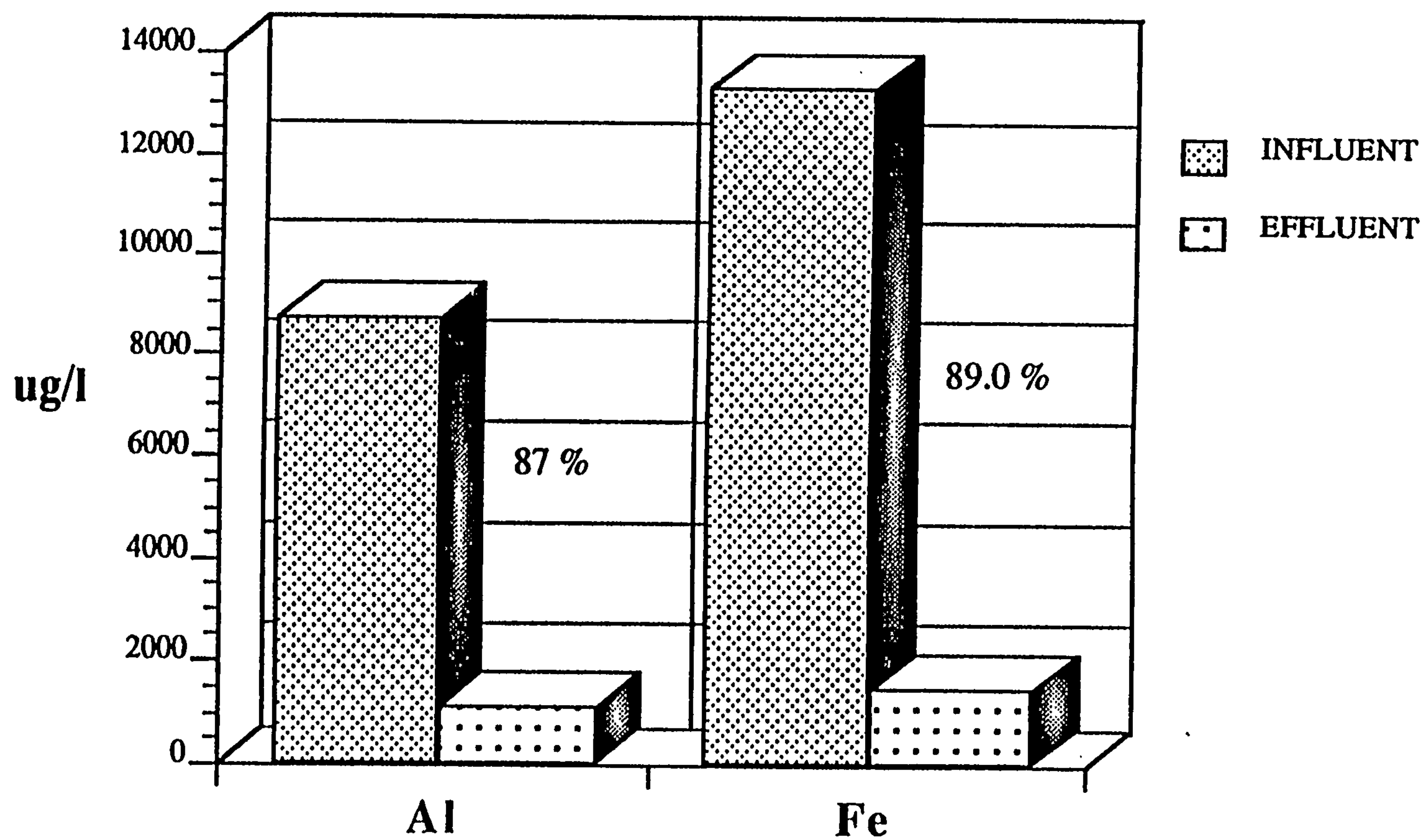
RELATIONSHIP - TOTAL PO_4 to SOLUBLE PO_4



MEAN - 3 SAMPLES

GRAPH - 9

MEAN REMOVAL RATES - ALL DATA



GRAPH - 10

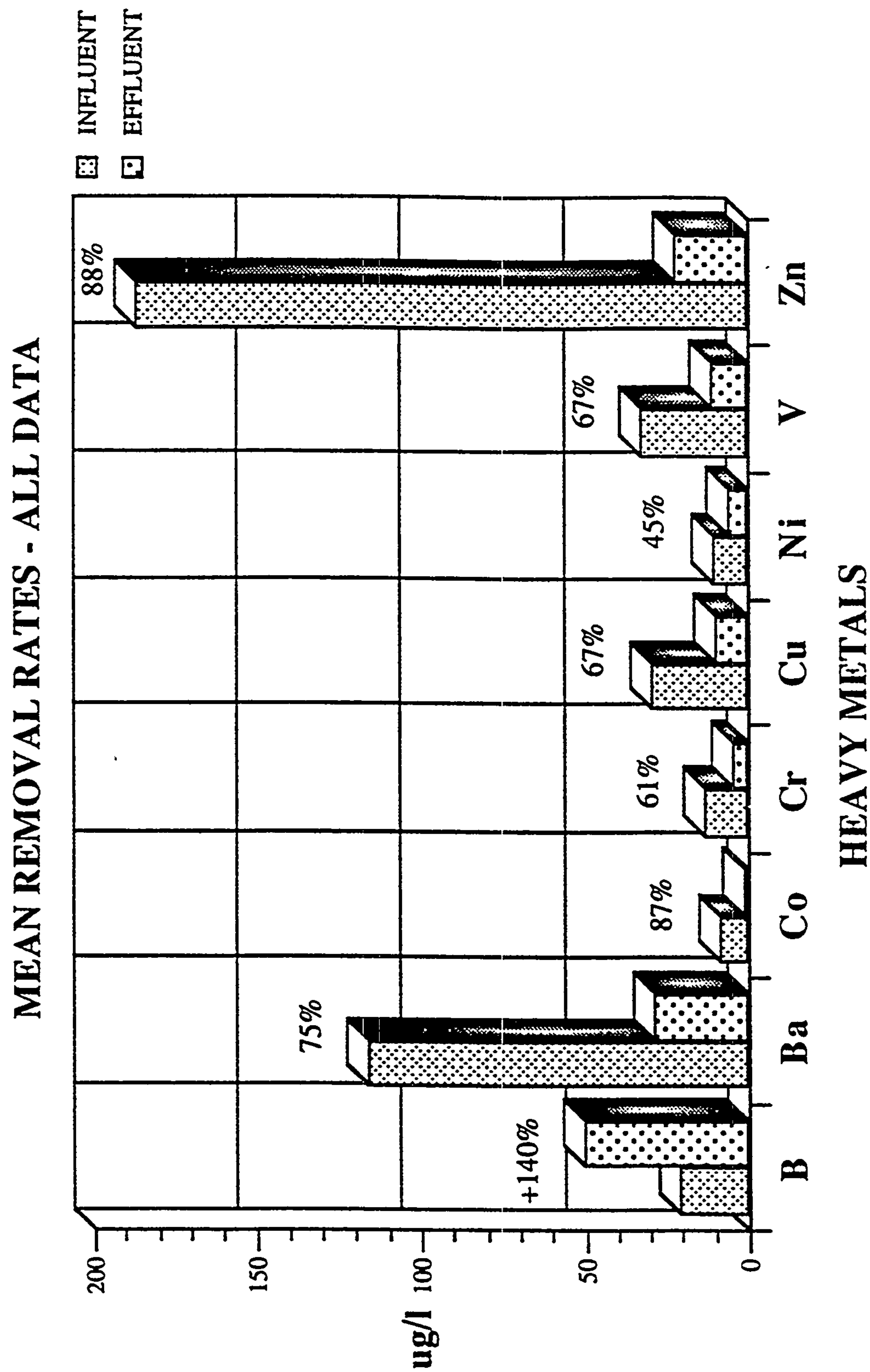

MEAN REMOVAL RATES - ALL DATA
INFLUENT
EFFLUENT
ug/l
200
150
100
50
0
+140%
75%
87%
61%
67%
45%
67%
88%
B
Ba
Co
Cr
Cu
Ni
V
Zn
HEAVY METALS

TABLE - 4

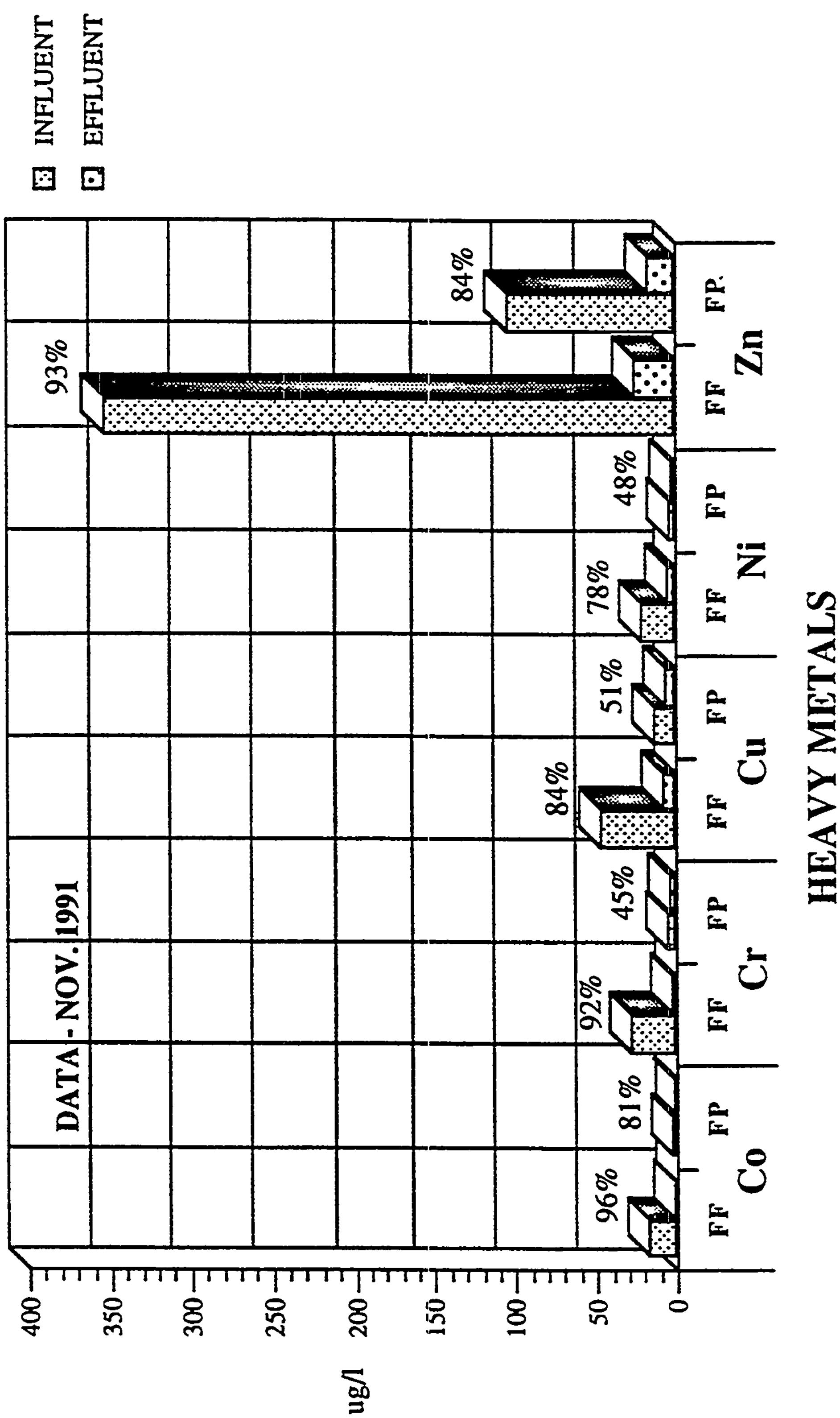
FIRST FLUSH (FF) VS. FLOW PACED (FP) - METALS (ug/l) - NOVEMBER 1991

DATE	Co FF-I	Co FF-E	Co FP-I	Co FP-E	Cr FF-I	Cr FF-E	Cr FP-I	Cr FP-E	Cu FF-I	Cu FF-E	Cu FP-I	Cu FP-E	Ni FF-I	Ni FF-E	Ni FP-I	Ni FP-E	Zn FF-I	Zn FF-E	Zn FP-I	Zn FP-E
12-Nov	12.86	0.29			17.96	1.65			35.59	6.74			19.61	4.36			274.40	21.89		
13-Nov	35.16	1.45	3.98	0.85	52.08	2.99	6.98	2.75	81.18	9.30	12.80	6.81	33.94	8.22	4.64	2.89	556.40	37.54	109.30	20.52
15-Nov			2.69	0.42			5.25	3.94			13.64	6.08			4.58	1.89			99.58	13.59
19-Nov	5.78	0.20			13.24	1.68			25.96	7.22			11.95	1.90			230.00	17.46		
Mean	17.93	0.65	3.34	0.64	27.76	2.11	6.12	3.35	47.06	7.75	13.22	6.45	21.83	4.83	4.61	2.39	353.60	25.63	104.44	17.06
Standard Dev.	15.33	0.70	0.91	0.30	21.19	0.77	1.22	0.84	29.50	1.36	0.59	0.52	11.16	3.19	0.04	0.71	177.03	10.55	6.87	4.90
Maximum	35.16	1.45	3.98	0.85	52.08	2.99	6.98	3.94	81.18	9.30	13.64	6.81	33.94	8.22	4.64	2.89	556.40	37.54	109.30	20.52
Minimum	5.78	0.20	2.69	0.42	13.24	1.65	5.25	2.75	25.96	6.74	12.80	6.08	11.95	1.90	4.58	1.89	230.00	17.46	99.58	13.59
N	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2
% REMOVAL		96.4%		81.0%		92.4%		45.3%		83.7%		51.2%		77.9%		48.2%		92.8%		83.7%
MEAN % REMOVAL (All Data)				87.4%				61.2%				66.7%				45.4%				88.3%

FF-I = First Flush (Time Paced) - Influent
FF-E = First Flush (Time Paced) - Effluent
FP-I = Flow Paced - Influent
FP-E = Flow Paced - Effluent

GRAPH - 11

FIRST FLUSH (FF) vs. FLOW PACED (FP)
MEAN REMOVAL RATES



storm events showed a distinct scum of oil & grease on the surface of the fore bay, particularly after heavy storms, while there was no evidence of sheen in the effluent waters. Theoretically, the compost medium should prove highly effective at adsorbing oil & grease residues. Once captured, these materials should be metabolized by microorganisms in the compost, leaving little or no oil & grease accumulation.

Samples were also tested for petroleum hydrocarbons which, because of their lower molecular weights, would mix better with the influent storm water. These data are shown in Graph 12, indicating a 86.7 percent mean removal rate. The effluent measurements for petroleum hydrocarbons were, except in one case, below detection limits.

Data for settleable solids are also shown in Graph 12. Settleable solids removal averaged 95.5 percent during the test period.

3.5 Floatables

Although not sampled quantitatively, visual observation showed large quantities of floatables entering with the influent storm water. Items included oil and other plastic containers, cigarette filters, leaves, wood debris and miscellaneous plastics. Normally many of these items would float over the surface of a treatment pond and into the receiving water. If the compost treatment facility is properly designed hydraulically (i.e. storm water does not spill over the final baffle), all of these items will be captured on the surface of the compost bed.

3.6 Comparison with Receiving Water Quality

On October 22, 1991, personnel of the USA lab took a grab sample from Beaverton Creek during the course of a 0.6 inch storm, and analyzed the samples. The sampling site was upstream of the compost storm water treatment site discharge. Beaverton Creek is the receiving water for the compost filter effluent. These data provide an interesting comparison of the pollutant levels of the treated effluent from the compost storm water filter, with those levels in the creek. These data are compared in Table 5 and in Graphs 13 to 15. Both the November first flush influent values and the cumulative mean influent data (all storms sampled with first flush and flow paced portions equally weighed) at the treatment facility site are used for comparison of potential levels of untreated storm water discharge into the creek. The mean effluent levels from the treatment facility are used to show treatment results.

Both mean total suspended solids and total volatile suspended solids from the treatment facility were lower than values in the receiving waters. Nutrients were generally higher, with the exception of nitrate, but nevertheless significantly lower than the raw storm water prior to treatment. For metals, zinc and barium showed the best results, effluent levels from the compost treatment being lower than those in the receiving water. Other heavy metals, particularly cobalt, chromium, copper, and nickel, were not significantly higher than those levels found in the creek waters. The one problem was Boron, which increased in concentration dramatically as a result of treatment, probably due to anion exchange losses.

GRAPH - 12

PETROLEUM HYDROCARBONS & SETTLEABLE SOLIDS

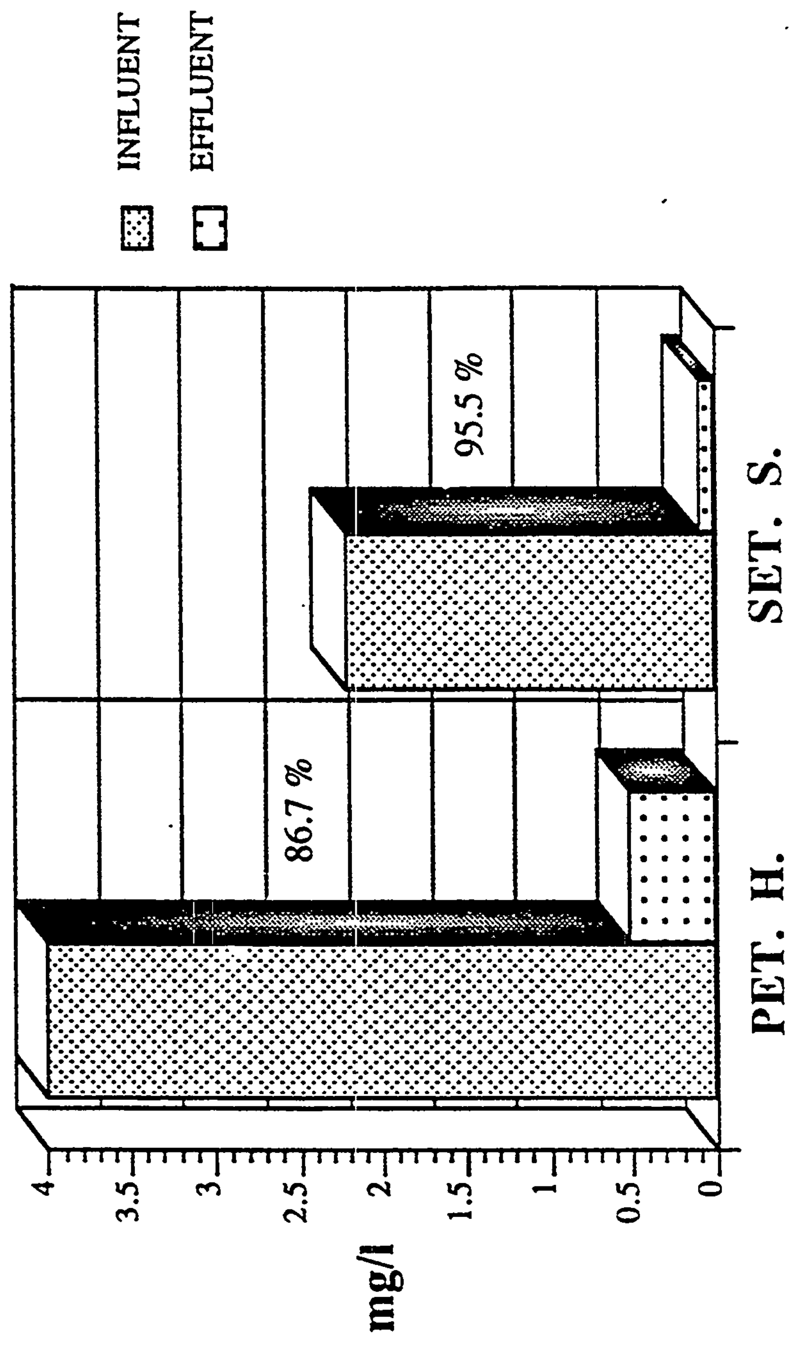


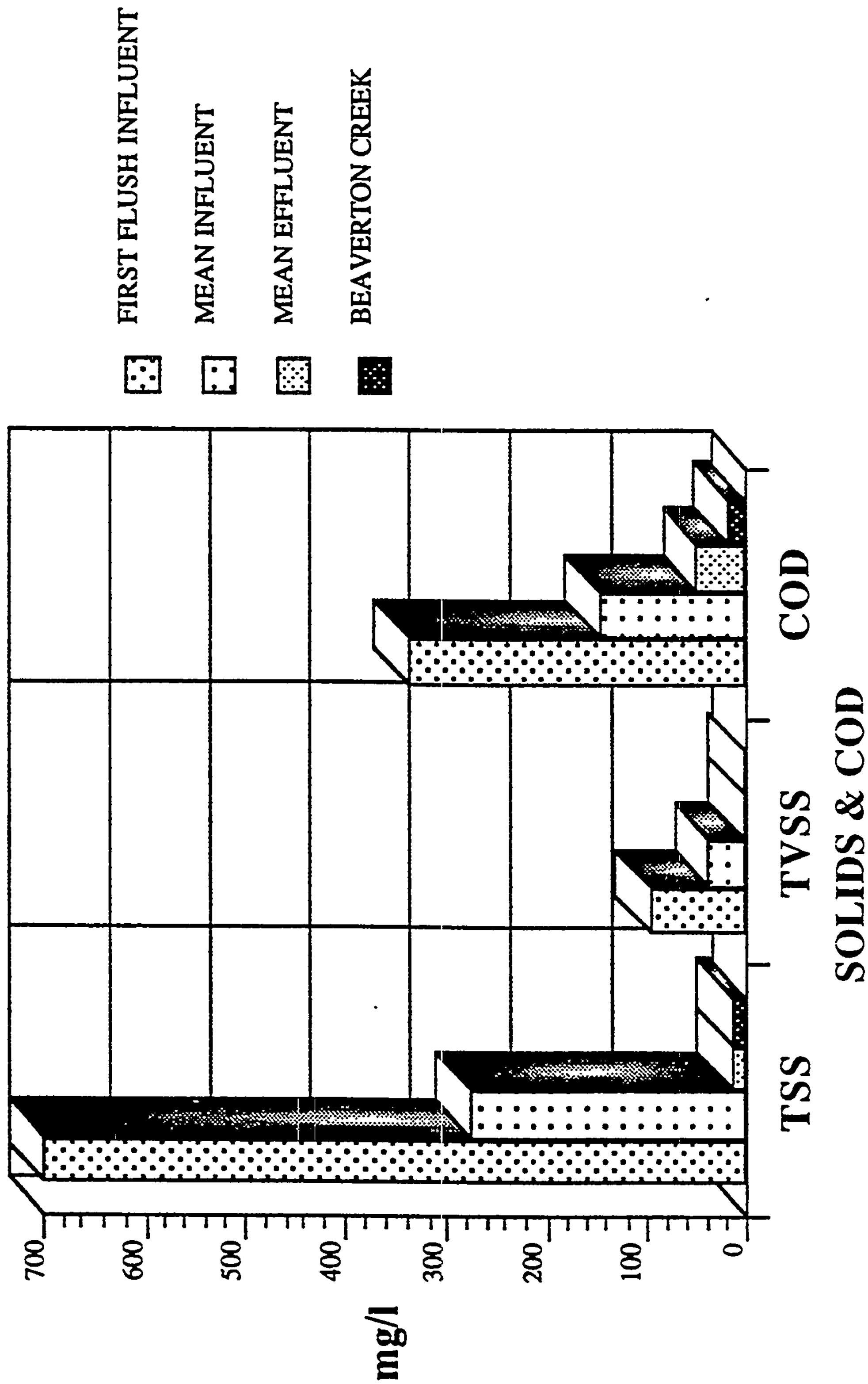
TABLE - 5

COMPARISON - STORMWWATER INFLUENT AND COMPOST FILTER EFFLUENT TO RECEIVING WATER QUALITY

POLLUTANT	UNITS	STORM WATER FIRST FLUSH INFLUENT (Mean - Nov. '91)	STORM WATER MEAN INFLUENT (Mean - All Data)	COMPOST FILTER MEAN EFFLUENT (Mean - All Data)	BEAVERTON CREEK DATA (Grab -10/22/91)
TS	mg/l		383.08	155.69	232.00
TDS	mg/l		108.08	141.23	216.00
TSS	mg/l	698.70	275.03	14.37	15.60
TVSS	mg/l	98.60	39.95	4.47	5.12
COD	mg/l	334.70	148.57	49.24	18.00
T-PO4	mg/l	2.75	1.31	0.78	0.29
S-PO4	mg/l		0.09	0.32	0.08
TKN	mg/l		2.04	0.90	0.65
NO3-N	mg/l		0.30	0.40	0.46
NH3-N	mg/l		0.10	0.06	0.03
Al	ug/l		8775.15	1134.44	478.00
B	ug/l		21.04	50.39	15.91
Ba	ug/l		116.24	28.63	51.85
Ca	mg/l		16.99	16.41	21.08
Co	ug/l	17.93	8.40	1.06	1.00
Cr	ug/l	27.76	12.77	4.95	2.01
Cu	ug/l	47.58	29.19	9.73	8.96
Fe	ug/l		13326.09	1469.12	1219.00
K	mg/l		2.73	5.95	2.85
Mg	mg/l		3.13	3.92	7.36
Mn	ug/l		282.07	35.54	1018.00
Na	mg/l		4.65	4.13	14.79
Ni	ug/l	21.83	10.66	5.82	3.32
V	ug/l		33.00	11.01	4.59
Zn	ug/l	353.60	188.73	22.04	36.82

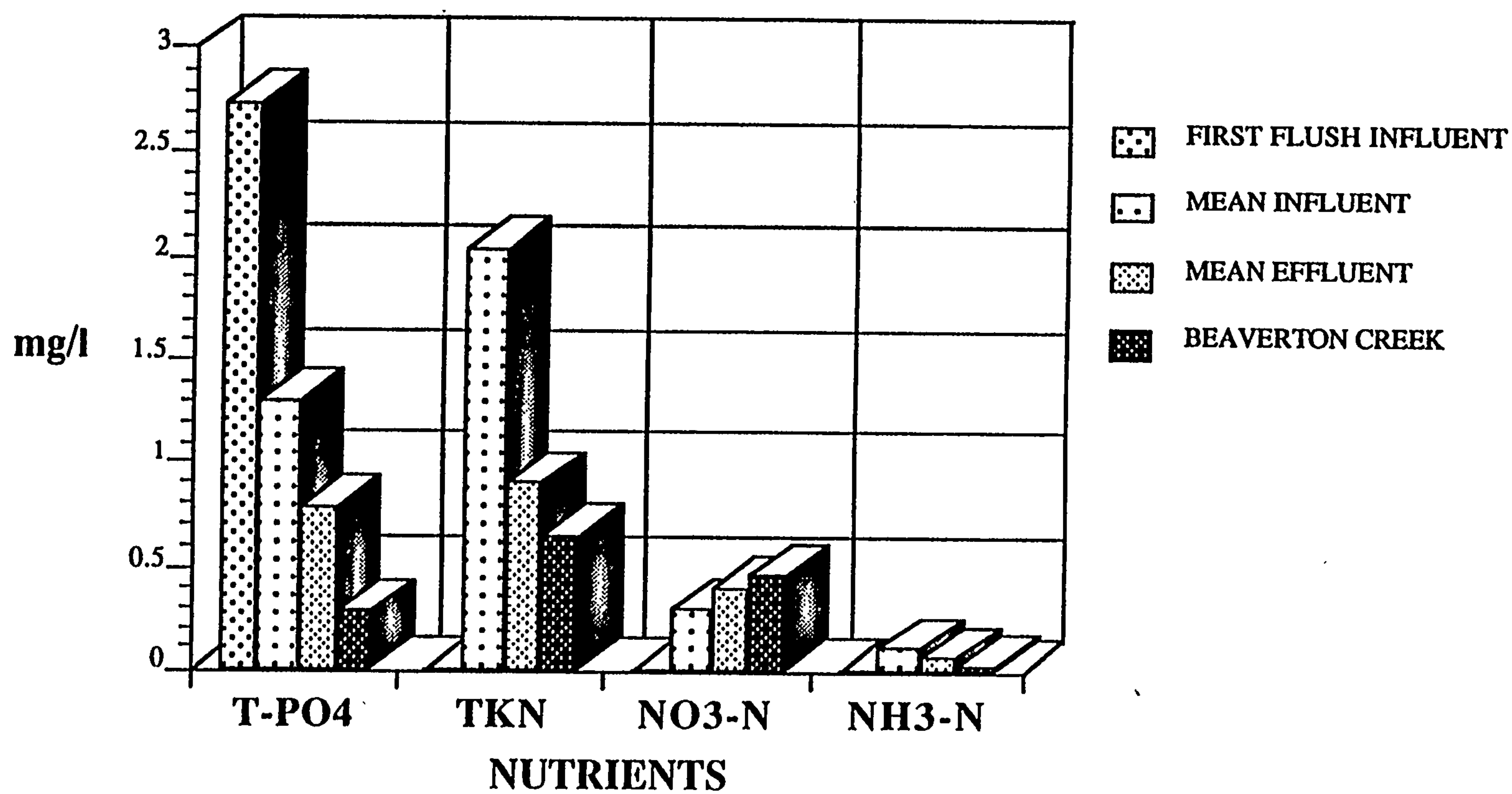
GRAPH - 13

TREATMENT EFFICIENCY vs. RECEIVING WATER DATA



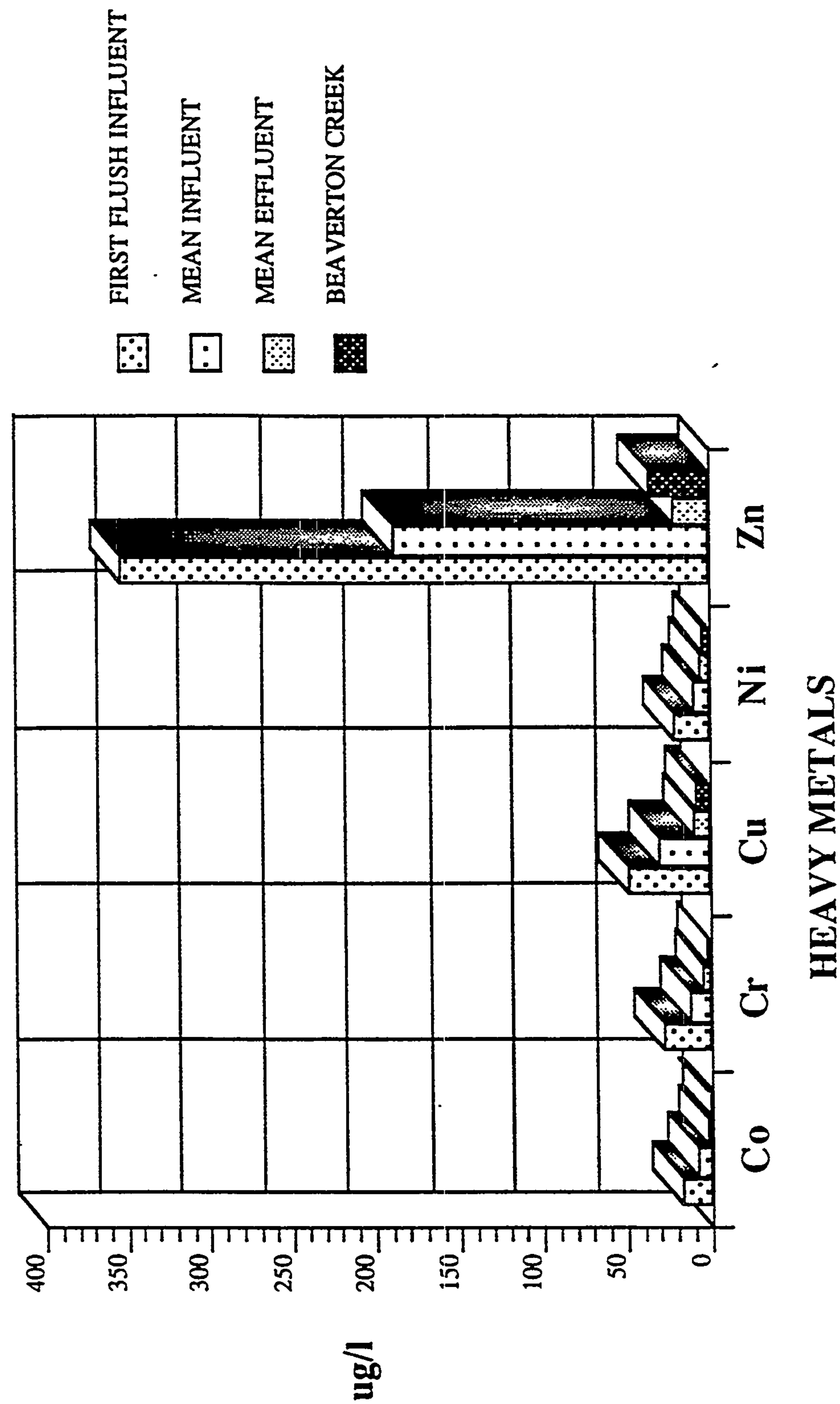
GRAPH - 14

TREATMENT EFFICIENCY vs. RECEIVING WATER DATA



GRAPH - 15

TREATMENT EFFICIENCY vs. RECEIVING WATER DATA



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Project Scientist

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November 13, 1992
Project 003.01

Ms. Roxana Hinzman
Oak Ridge National Laboratories
MS 6351
P.O. Box 2008
Oak Ridge, Tennessee 37831-2008

Re: Catch Basin Filter

Dear Ms. Hinzman:

Per our conversation the other day, I'm following up with the required information regarding the Catch Basin Filter. Thank you very much for your interest and please call me if you have any questions at (206) 485-5000.

Sincerely,

EMCON Northwest, Inc.

John Macpherson

John Macpherson
Senior Project Environmental
Chemist

cc: Brian O'Neal
Larissa Rovinsky

M/HINZ-L.n13/lha:2

EMCON
Northwest, Inc.

John Macpherson
Supervising Environmental Chemist

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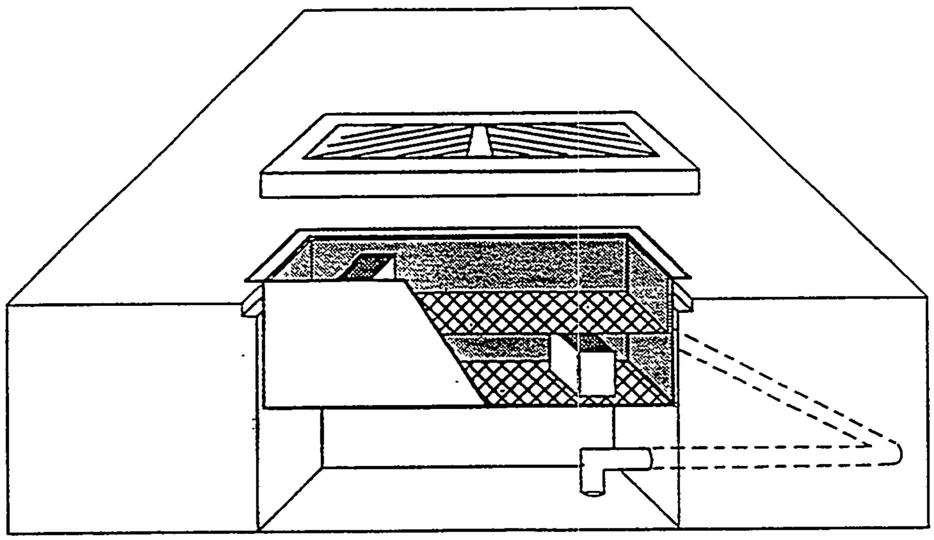
Catch Basin Filter ©

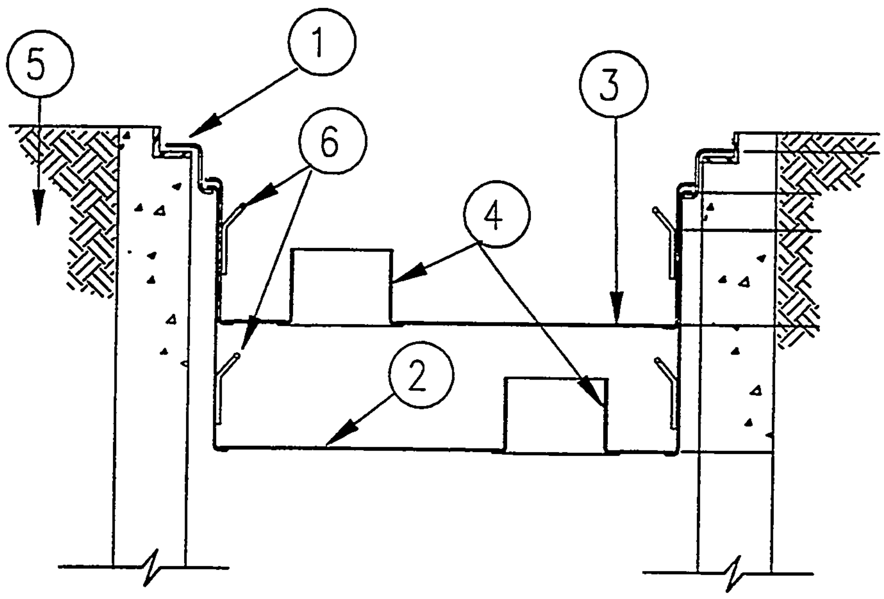


Patent Pending

The EMCON Catch Basin Filter ©

On-going research and development at the EMCON Northwest facility in Bothell, Washington has yielded a new (patent pending) Best Management Practice (BMP) technology known as the Catch Basin Filter. The Catch Basin Filter is a sedimentation/filtration device which is suspended inside catch basins to trap sediments, particulate heavy metals, oils, and other storm water contaminants. The Catch Basin Filter has proven effective in containing sediments and other contaminants on construction sites, car and truck wash facilities, parking lots, and industrial facilities. This new technology is being featured as an experimental BMP in The Washington State Department of Ecology's Stormwater Management Manual for the Puget Sound Basin.

CATCH BASIN FILTER©



(1) ADAPTER

(2) BOTTOM TRAY

(3) TOP TRAY

(4) WEIR

(5) CATCH BASIN

(6) LIFTING HANDLES

Catch Basin Filter ©
Applications

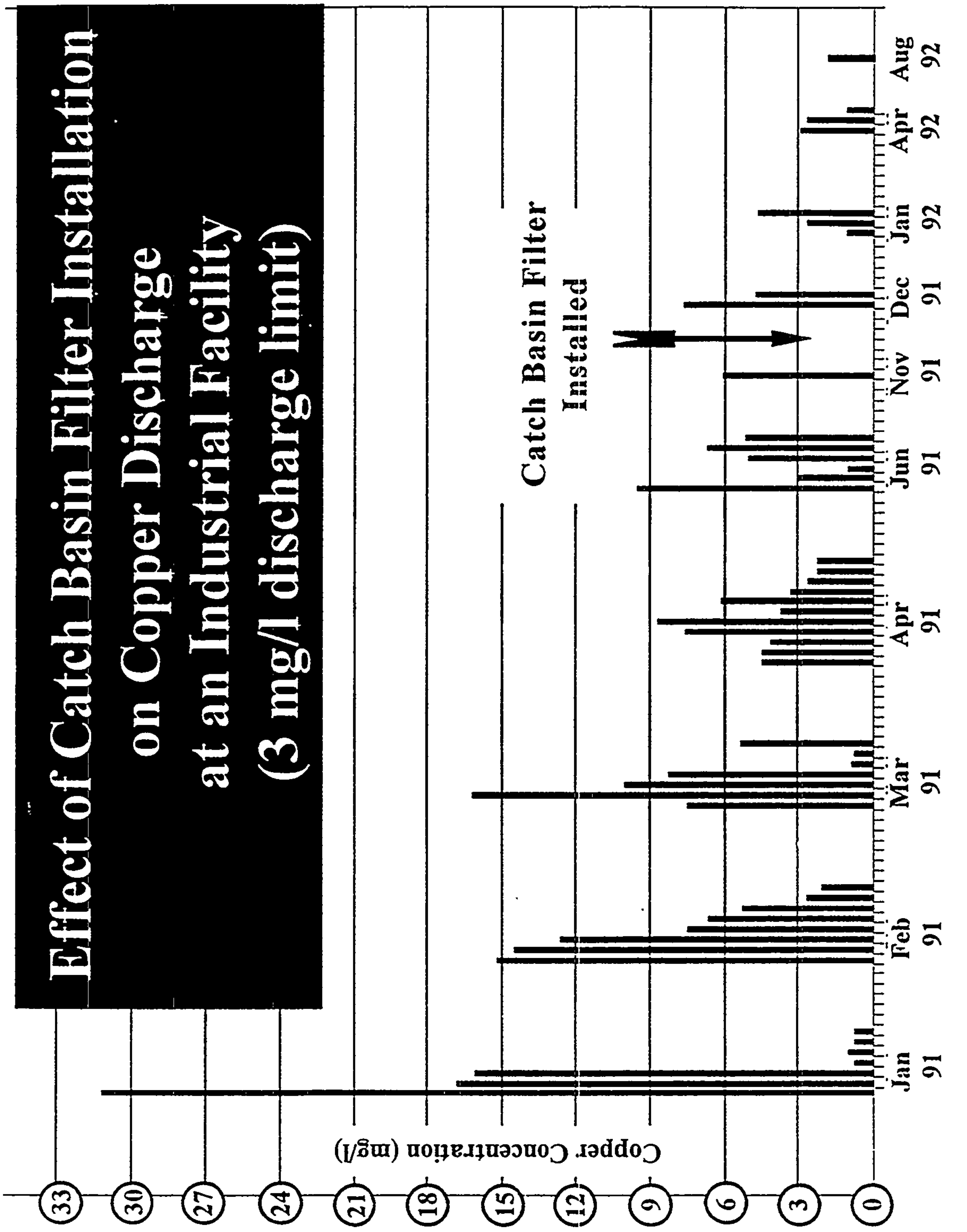
- Capture of *first flush* contaminants
- Industrial sites
- Construction sites
- Service stations
- Parking lots
- Marina boat hull refurbishing facilities
- Car and truck wash facilities

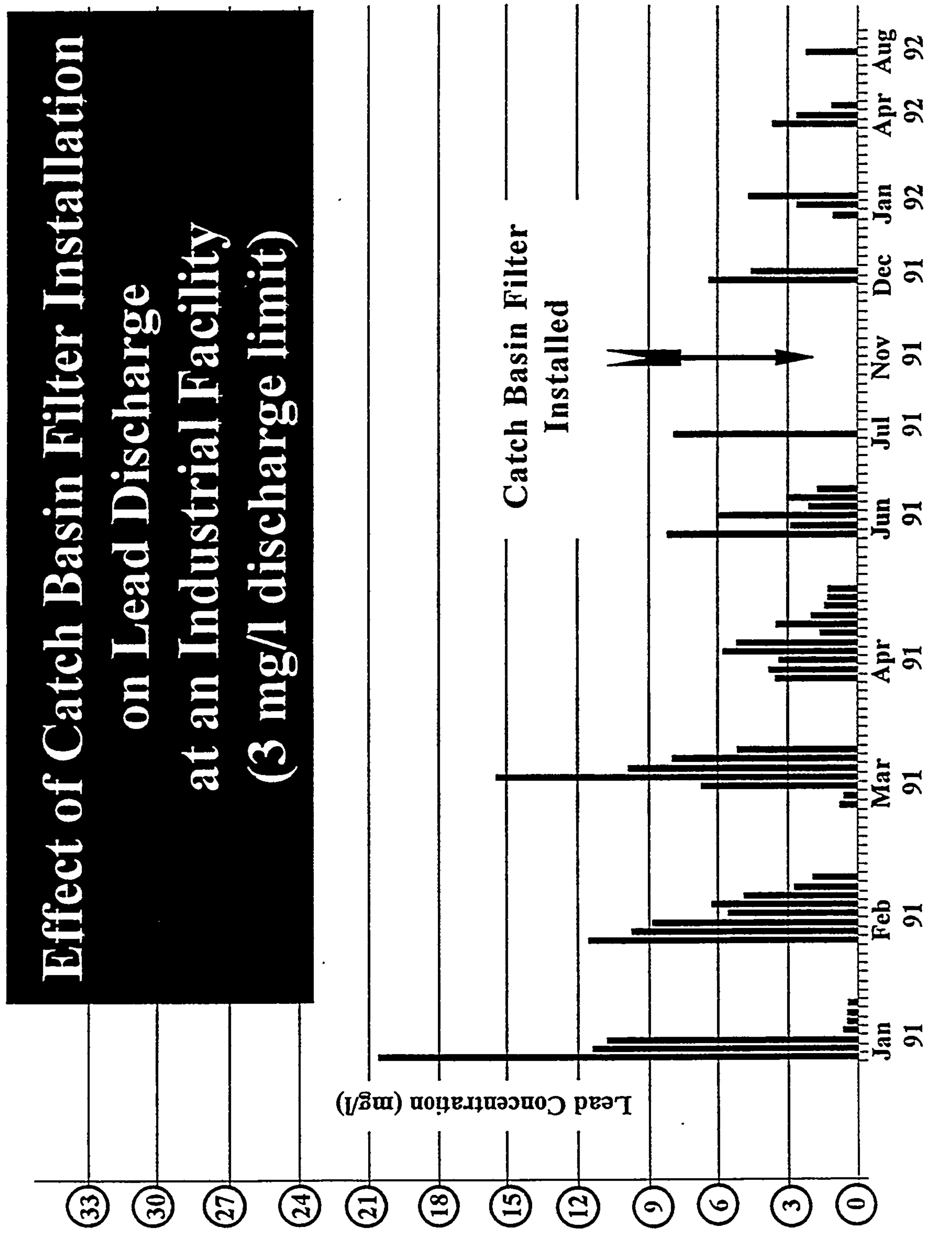
Catch Basin Filter Test - Construction Site

Sample	Copper (mg/l)	Lead (mg/l)	Zinc (mg/l)	TSS[1] (mg/l)
Before filter	0.590	0.640	0.360	1,200
After filter	0.084	0.085	0.084	120
Percent Reduction	85.8	86.7	76.7	90.0

1 Total Suspended Solids

Particle size distribution after filter; 96% 0 - 15 microns, 3.8% 15 - 30 microns, 0.34% 30 - 100 microns.


Effect of Catch Basin Filter Installation
on Copper Discharge
at an Industrial Facility
(3 mg/l discharge limit)
Catch Basin Filter
Installed
Copper Concentration (mg/l)
0
3
6
9
12
15
18
21
24
27
30
33
Jan 91
Feb 91
Mar 91
Apr 91
Jun 91
Nov 91
Dec 91
Jan 92
Apr 92
Aug 92


Effect of Catch Basin Filter Installation
on Lead Discharge
at an Industrial Facility
(3 mg/l discharge limit)
Lead Concentration (mg/l)
Catch Basin Filter
Installed
0
3
6
9
12
15
18
21
24
27
30
33
Jan 91
Feb 91
Mar 91
Apr 91
Jun 91
Jul 91
Nov 91
Dec 91
Jan 92
Apr 92
Aug 92

Rainfall Intensity Ranges (inches per hour)

	.01-.05	.06-.10	.11-.15	.16-.20	>20
Total Hours in this range.	90	20	7	4	3
Precent Average of Total Hours of Rainfall.	73%	16%	6%	3%	2%
Total Ranfall within this range. (inches)	2.49	1.43	0.96	0.73	0.79
Percent of total monthly rainfall within this range.	40%	22%	15%	11%	12%

Total Rainfall for Month
6.40" with (1) 16 hour 2.47" storm event

Assume 10,000 sq.ft. Catchment Area 0.95 run-off coefficient at 0.05 inches per hour, flow rate is 4.88 gpm at 0.01 inch per hour, flow rate is 9.77 gpm

OMSI
OREGON MUSEUM OF SCIENCE AND INDUSTRY

1945 SE Water Avenue
Portland, Oregon 97214-3354
503/797-4000

February 8, 1993

Roxanna Hinzman
Oak Ridge National Laboratory
MS 6351
P.O. Box 2008
Oak Ridge, TN 37831-2008

Dear Ms. Hinzman,

Rod McDowell asked me to send you our planting plans. You were specifically interested in the bioswales. Enclosed is a set of architect plans with a current site plan attached.

The creation of the bioswales was a joint venture between OMSI and the Bureau of Environmental Services (BES), City of Portland. It was specifically designed to reduce the particulate matter in the water runoff in our parking lots.

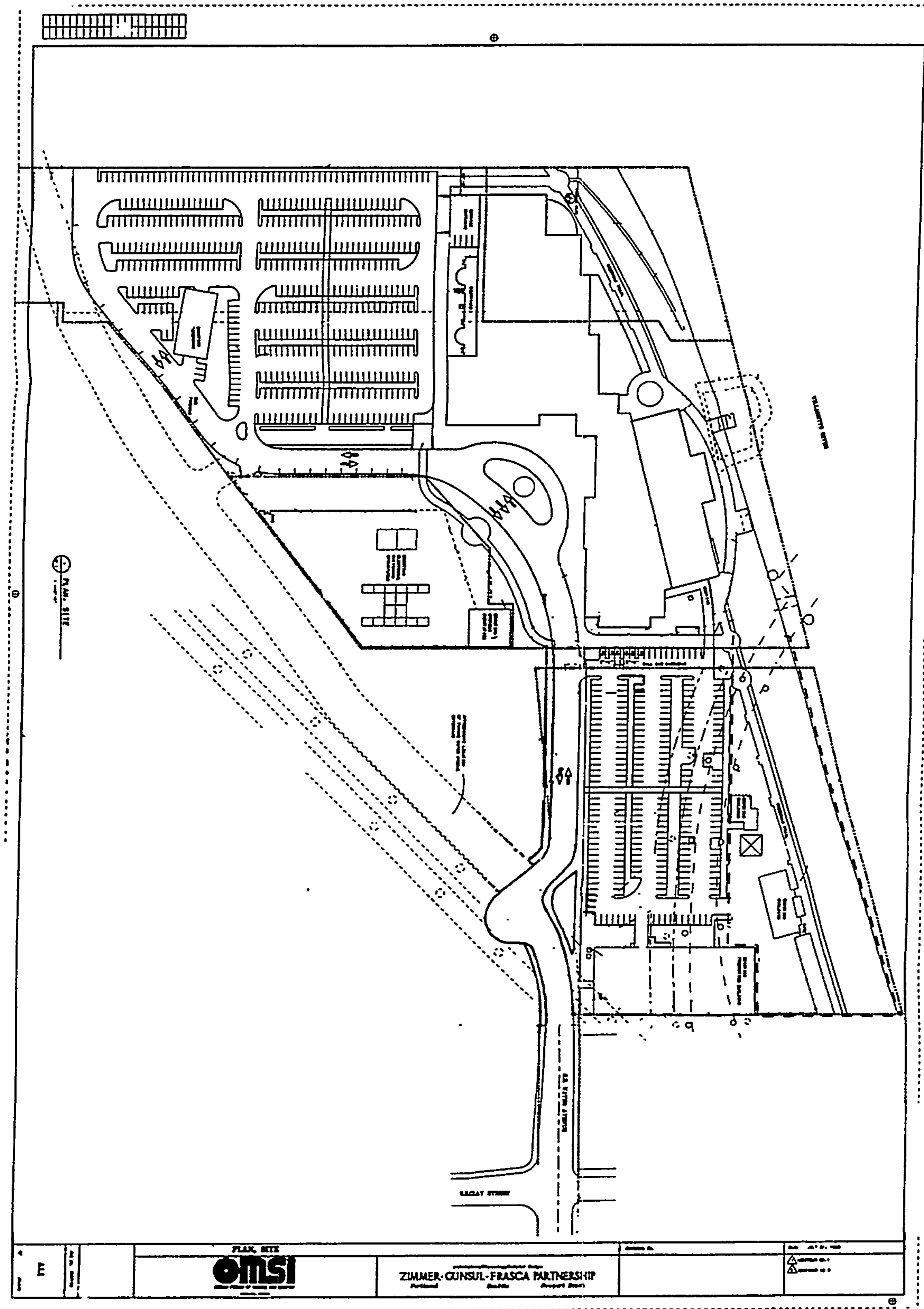
The effect has been a good one. Our visitors have expressed positive comments about the unusual quality of the landscaping. Our storm sewer bill from BES was reduced in half. The overall costs of construction was much less than the standard landscaping plan.

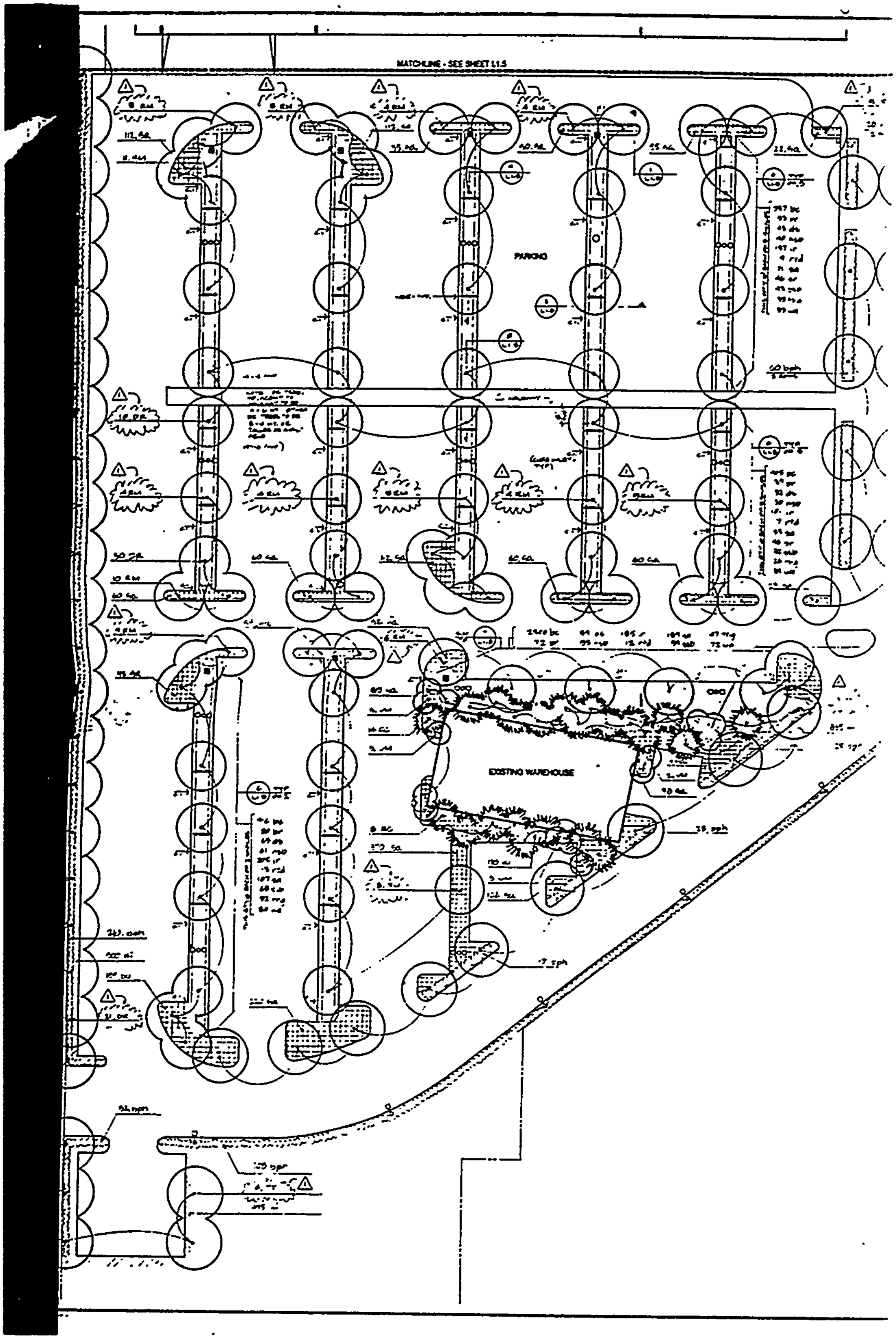
For further information from BES, you can call Ivy Francis at (503) 796-5326 or Barbara George (503) 796-7740.

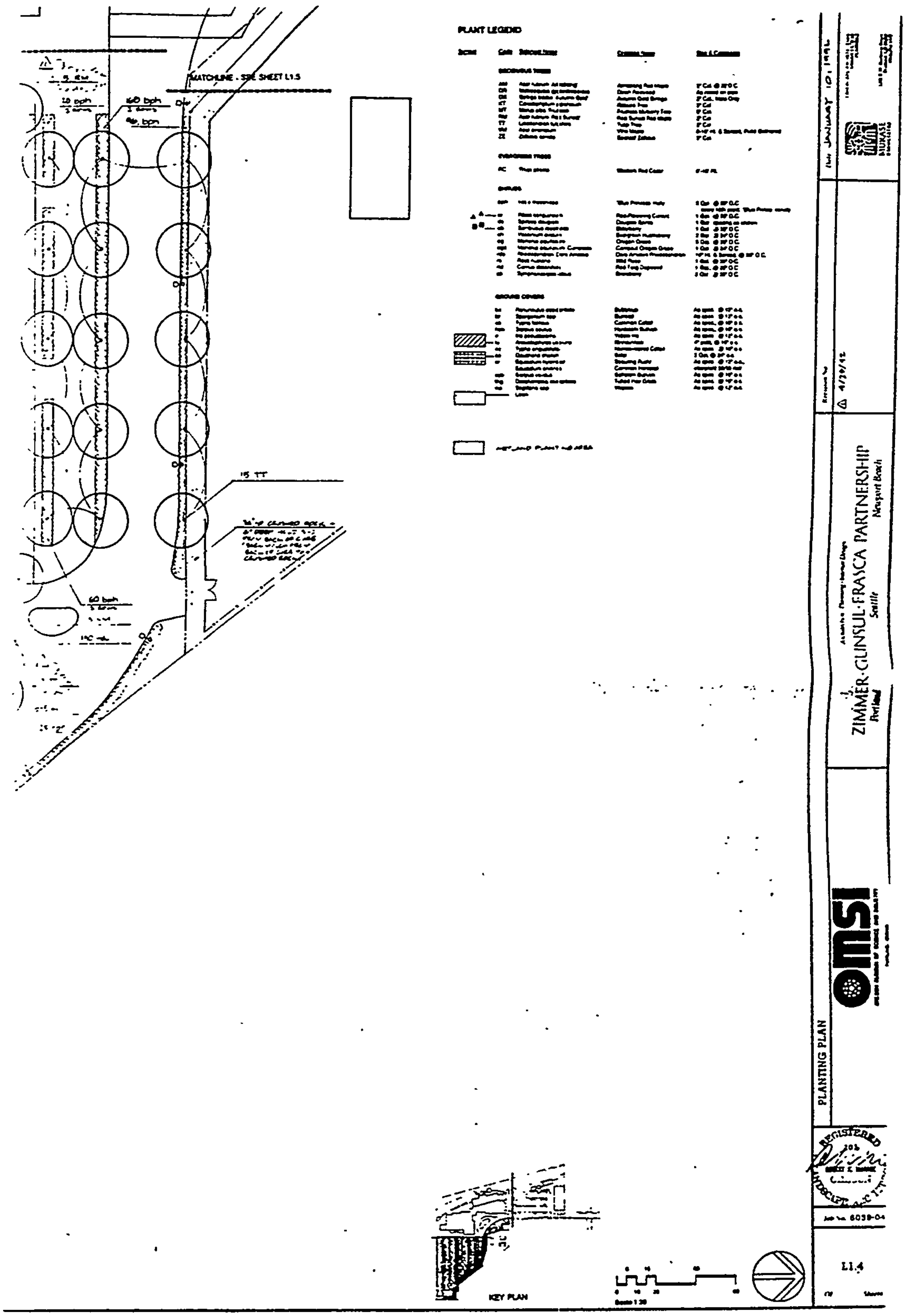
Thank you for your interest.

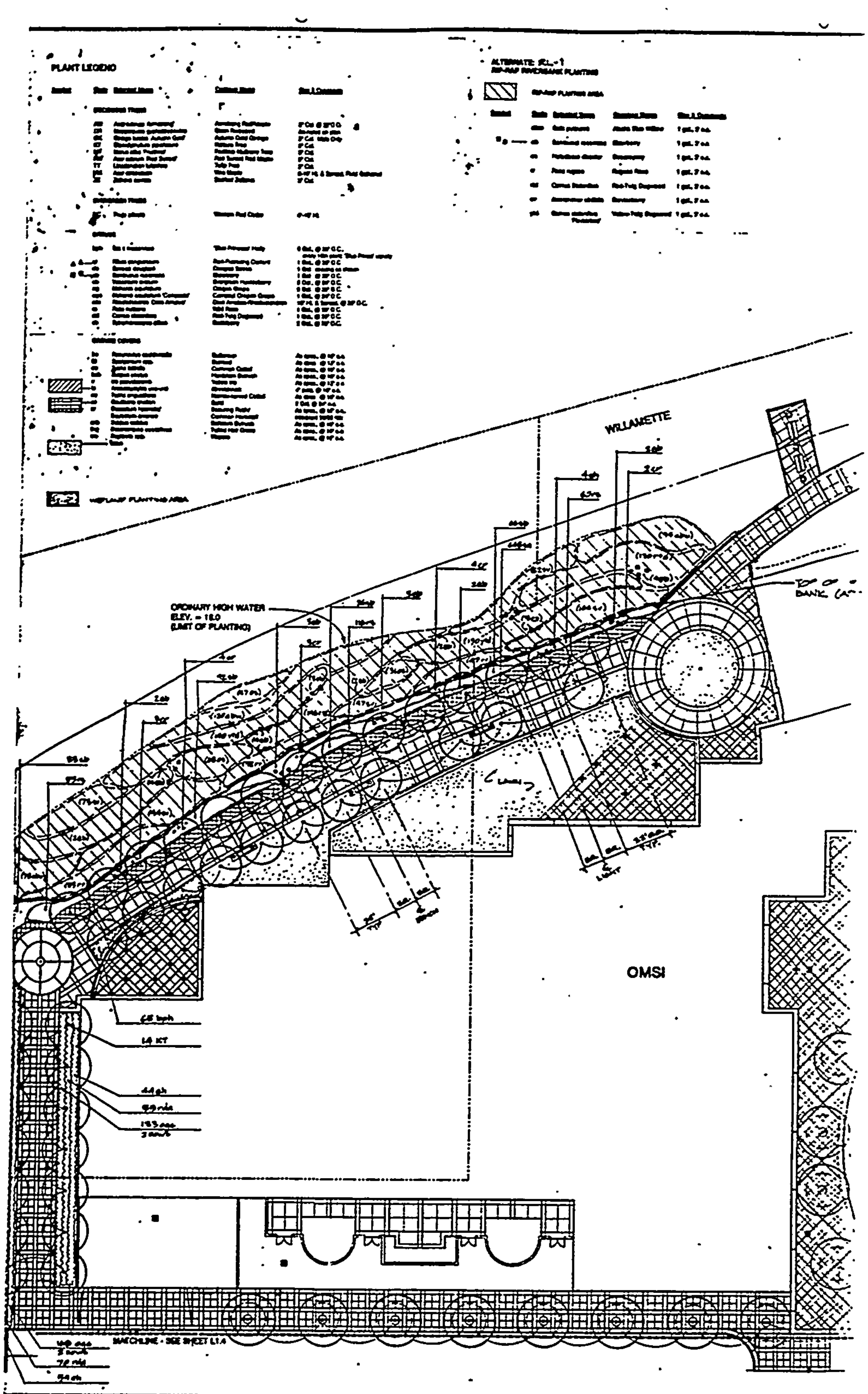
Yours sincerely,

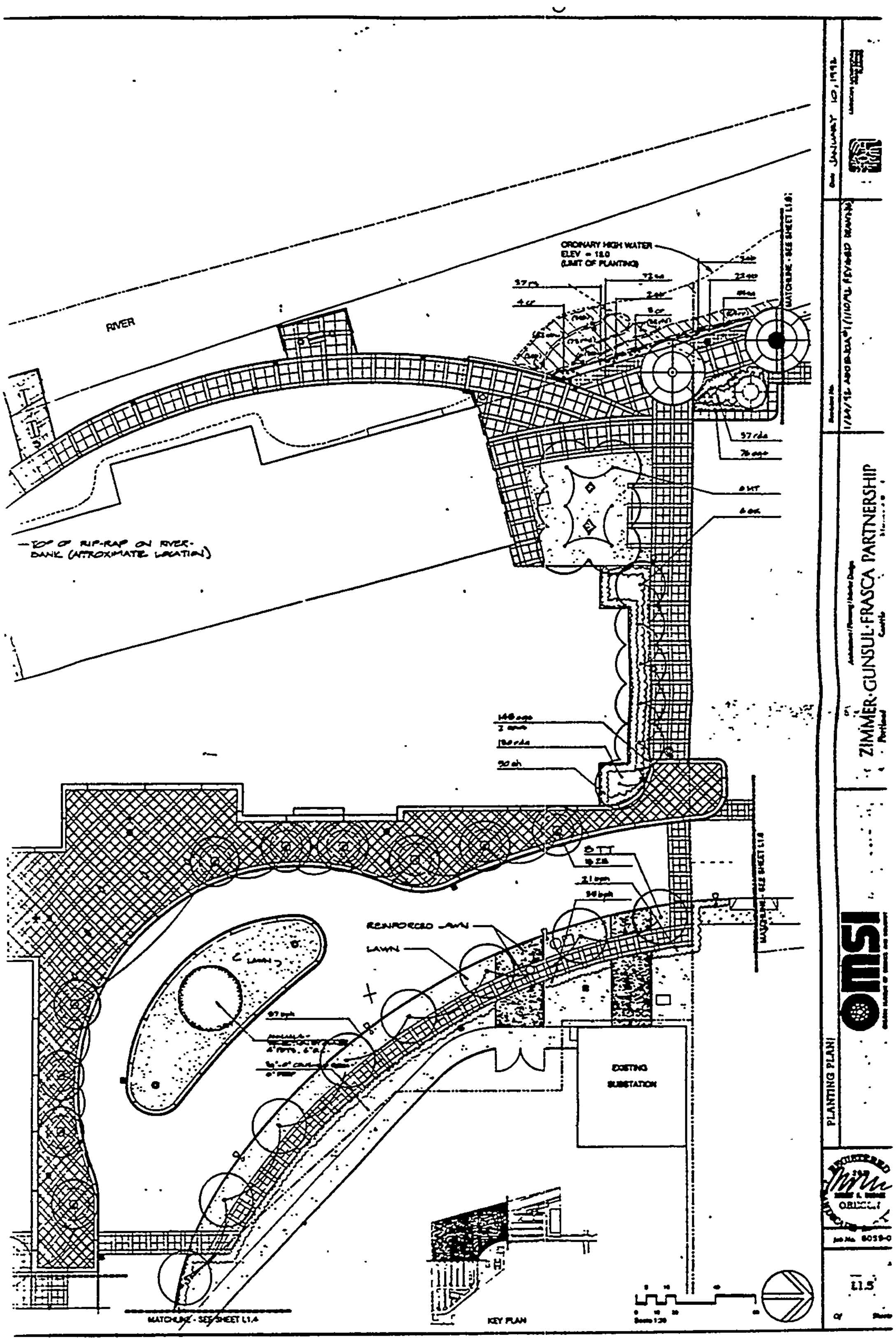
Dean B. Ivey
Vice President, Facility Services

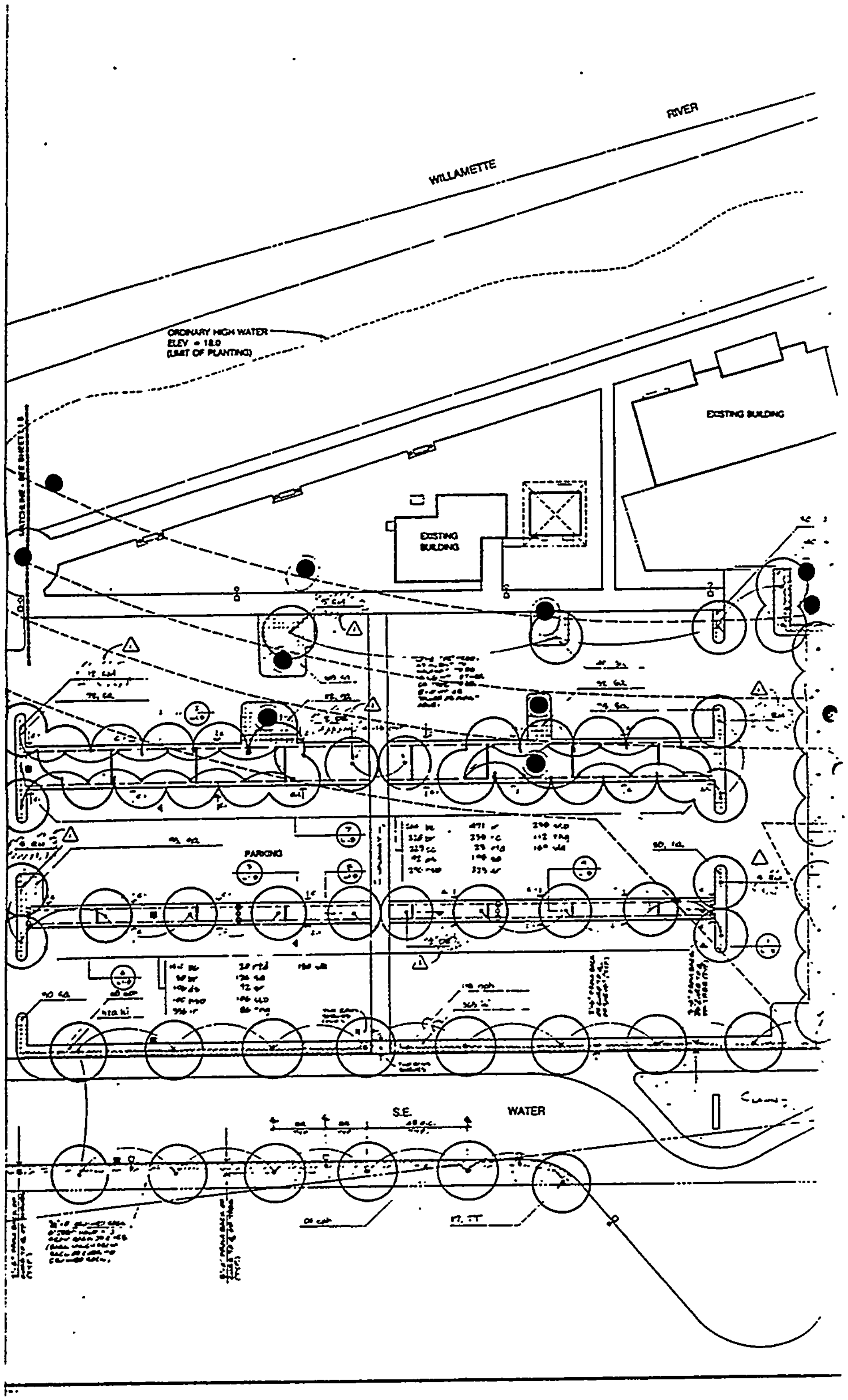

ZIMMER-GUNSUL-FRASCA PARTNERSHIP
omsi

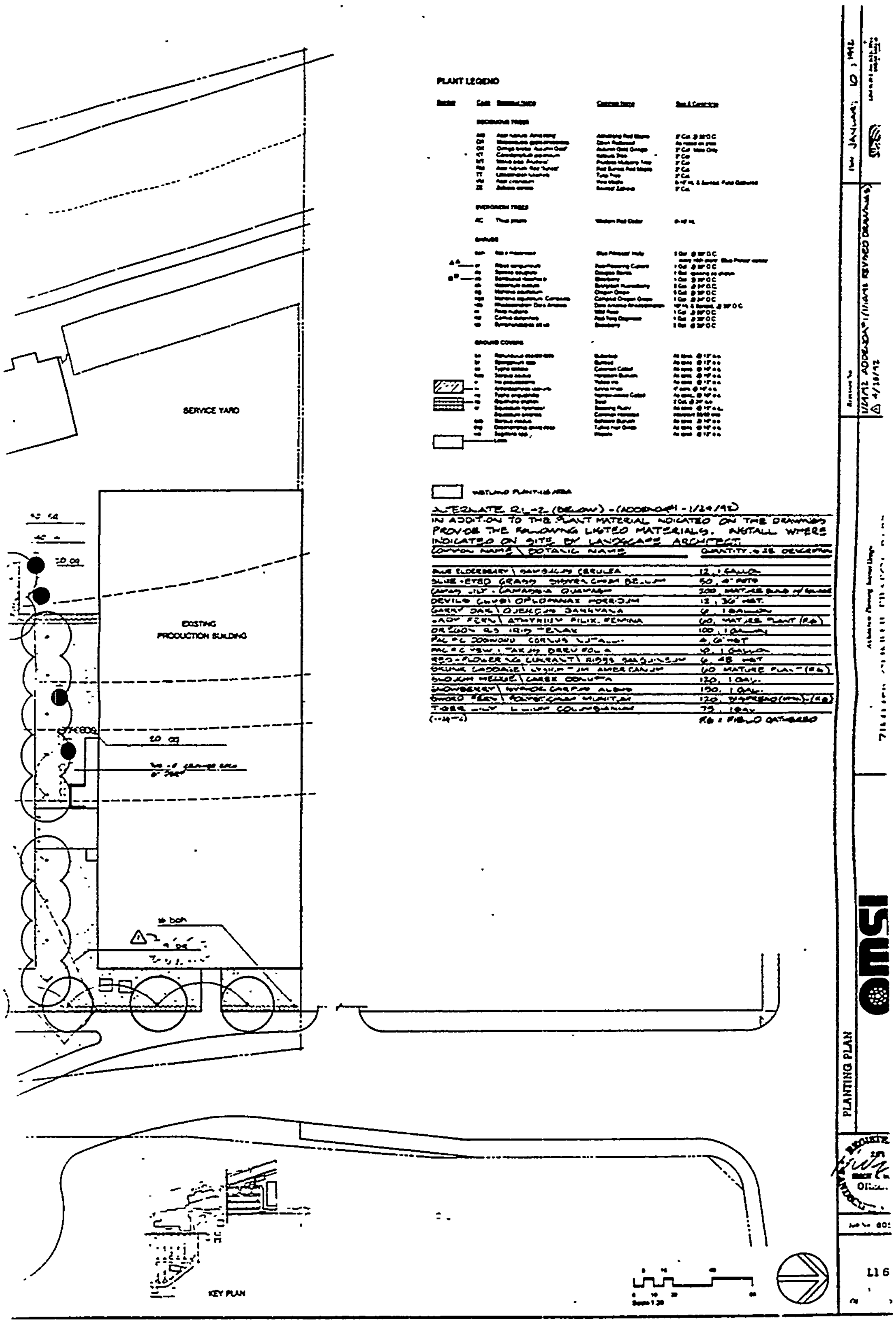

MATCHLINE - SEE SHEET L1.5
PARKING
EXISTING WAREHOUSE

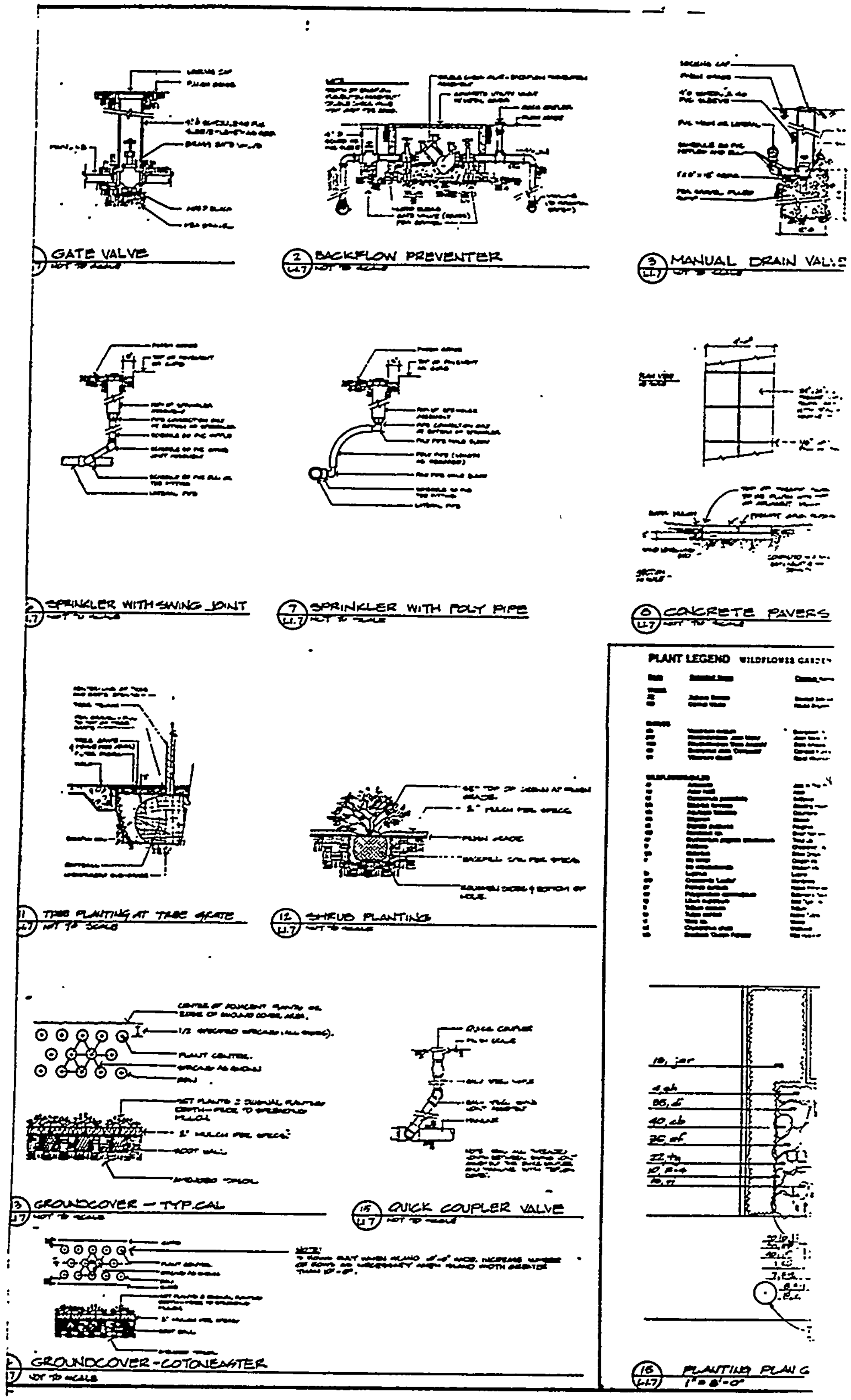

PLANT LEGEND
MATCHLINE - SEE SHEET L1.5
KEY PLAN
PLANTING PLAN
ZIMMER-GUNSUL-FRASCA PARTNERSHIP
Portland
Seattle
Newport Beach
omsi
L1.4

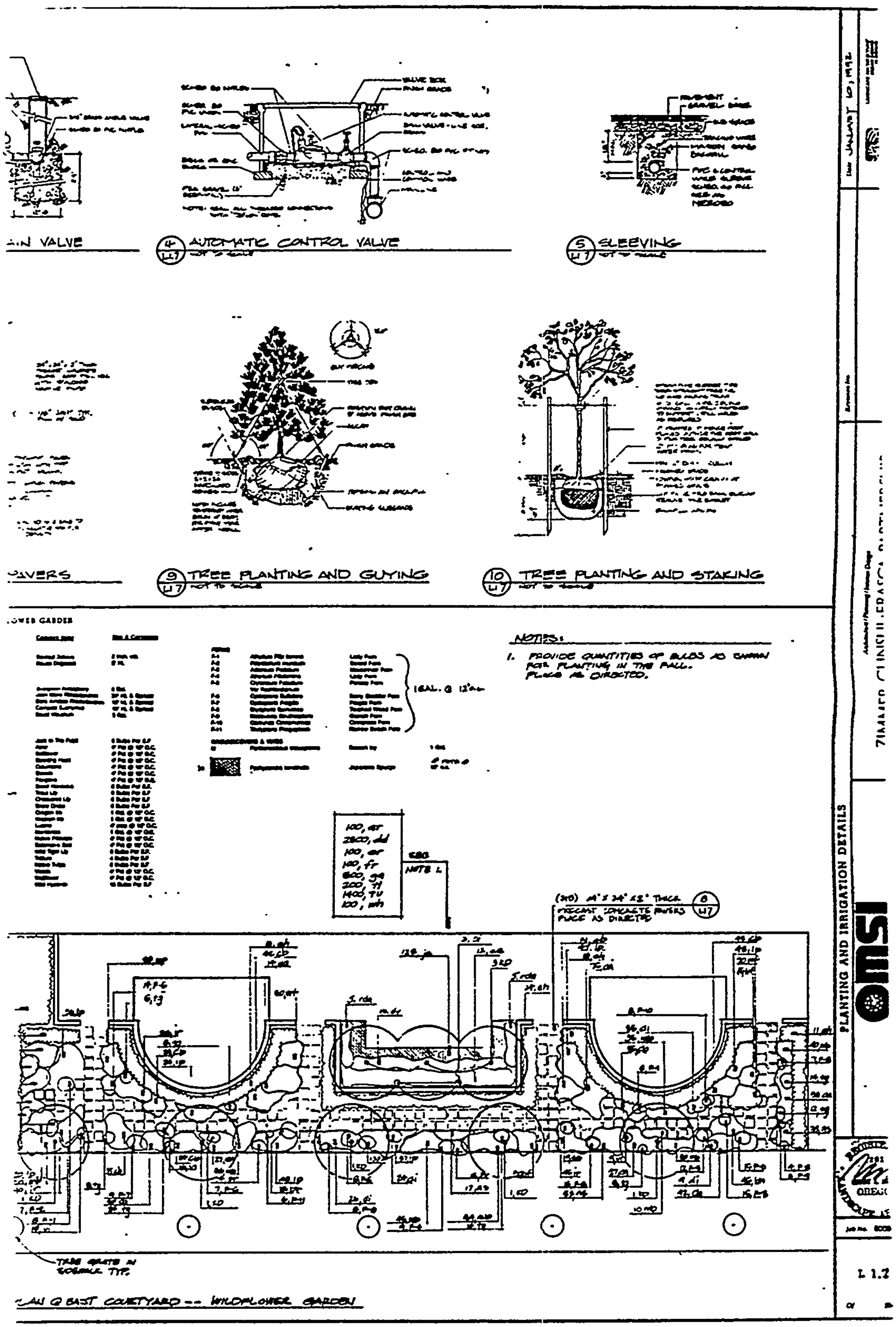

PLANT LEGEND
WILLAMETTE
ORDINARY HIGH WATER
ELEV. = 18.0
(LIMIT OF PLANTING)
OMSI
MATCHLINE - SEE SHEET L1.4

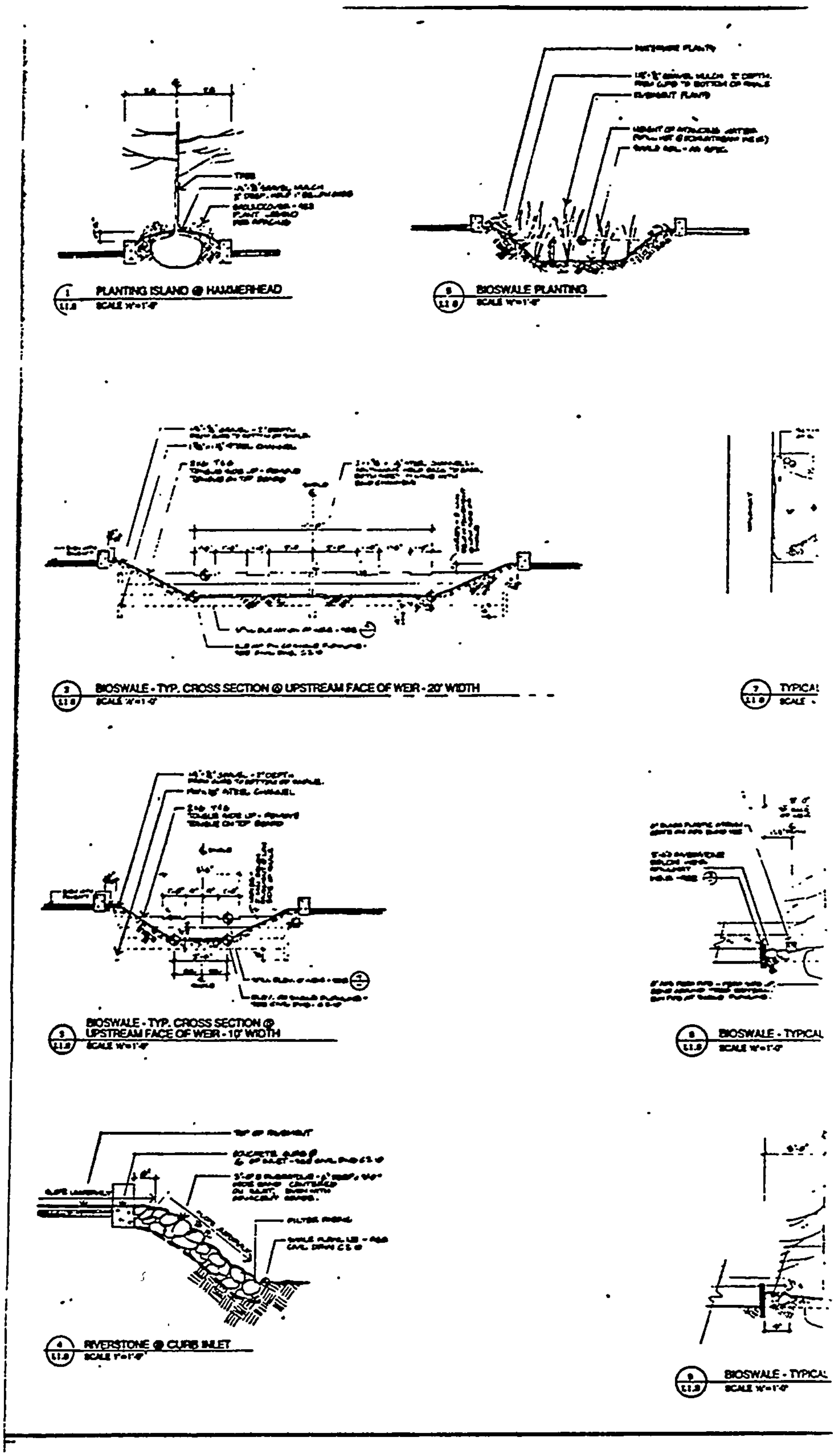

RIVER
ORDINARY HIGH WATER
ELEV = 18.0
(LIMIT OF PLANTING)
TOP OF RIP-RAP ON RIVER-BANK (APPROXIMATE LOCATION)
REINFORCED LAWN
LAWN
EXISTING SUBSTATION
KEY PLAN
MATCHLINE - SEE SHEET L1.4
MATCHLINE - SEE SHEET L1.6
ZIMMER·GUNSUL·FRASCA PARTNERSHIP
PLANTING PLAN
OMSI
L1.5

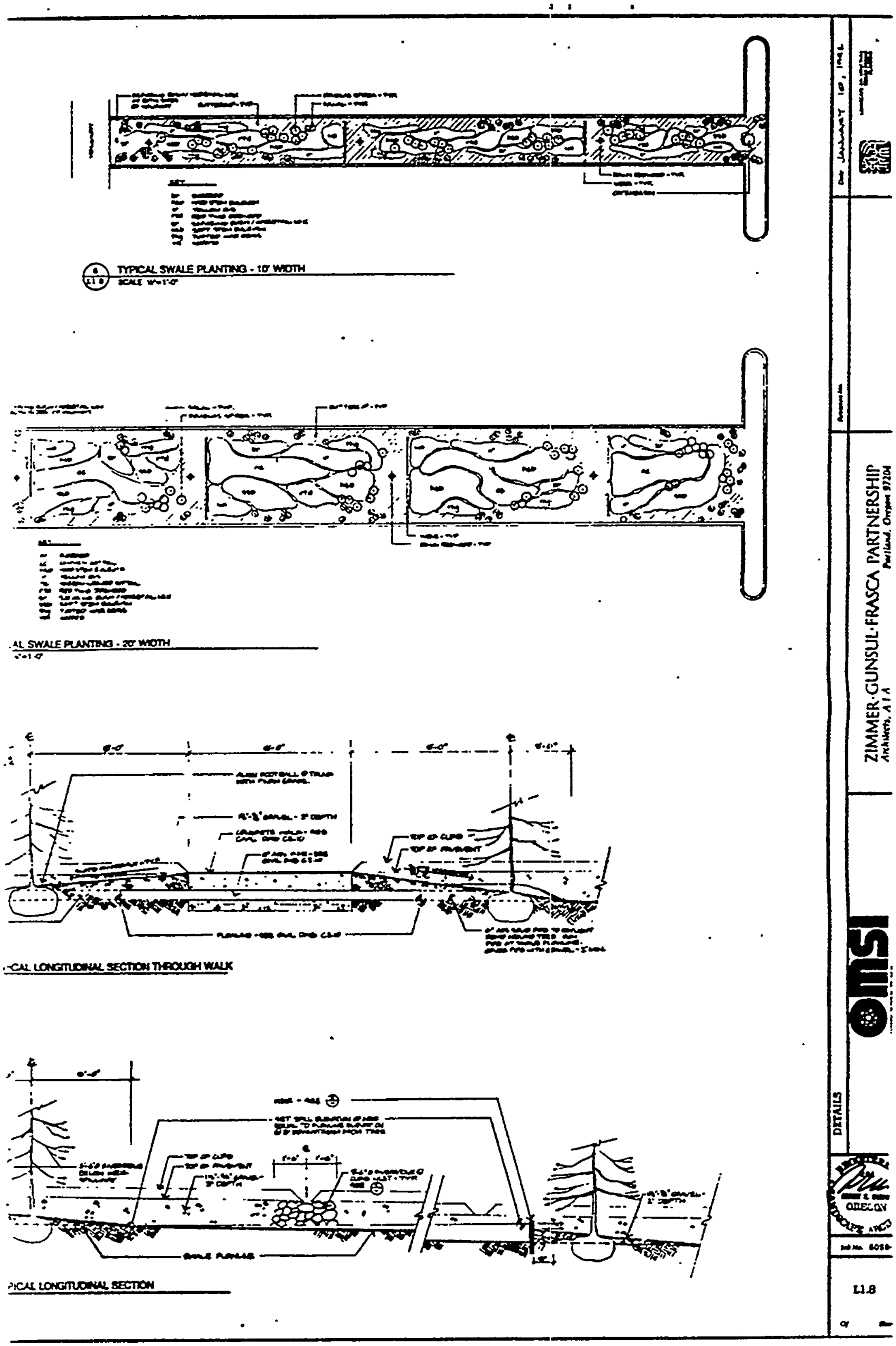

WILLAMETTE
RIVER
ORDINARY HIGH WATER
ELEV = 18.0
(LIMIT OF PLANTING)
EXISTING BUILDING
EXISTING
BUILDING
PARKING
S.E.
WATER


PLANT LEGEND
SERVICE YARD
EXISTING
PRODUCTION BUILDING
KEY PLAN
PLANTING PLAN
omsi
L16


GATE VALVE
BACKFLOW PREVENTER
MANUAL DRAIN VAL
SPRINKLER WITH SWING JOINT
SPRINKLER WITH POLY PIPE
CONCRETE PAVERS
PLANT LEGEND
TREE PLANTING AT TREE GRATE
NOT TO SCALE
SHRUB PLANTING
GROUNDCOVER — TYPICAL
QUICK COUPLER VALVE
GROUNDCOVER-COTONEASTER
PLANTING PLAN


AUTOMATIC CONTROL VALVE
SLEEVING
TREE PLANTING AND GUYING
TREE PLANTING AND STAKING
NOTES:
1. PROVIDE QUANTITIES OF BULBS AS SHOWN FOR PLANTING IN THE FALL. PLACE AS DIRECTED.
EAST COURTYARD -- WILDFLOWER GARDEN
PLANTING AND IRRIGATION DETAILS
omsi
L 1.2


PLANTING ISLAND @ HAMMERHEAD
BIOSWALE PLANTING
BIOSWALE - TYP. CROSS SECTION @ UPSTREAM FACE OF WEIR - 20' WIDTH
BIOSWALE - TYP. CROSS SECTION @ UPSTREAM FACE OF WEIR - 10' WIDTH
BIOSWALE - TYPICAL
RIVERSTONE @ CURB INLET
BIOSWALE - TYPICAL


TYPICAL SWALE PLANTING - 10' WIDTH
AL SWALE PLANTING - 20' WIDTH
CAL LONGITUDINAL SECTION THROUGH WALK
PICAL LONGITUDINAL SECTION
ZIMMER·GUNSUL·FRASCA PARTNERSHIP
Architects, A I A
Portland, Oregon 97204
omsi
DETAILS
OREGON
L1.8

APPENDIX F

National Resources Defense Council vs Environmental Protection Agency Case Summary

MEMORANDUM

To: Roxanna Hinzman

From: Susan Ross
Law Intern

Date: July 15, 1992

Subject: Summary of Natural Resources Defense Council v. U.S. EPA[1]
Decided June 4, 1992

The Natural Resources Defense Council (NRDC) challenged the EPA's storm water discharge rule, promulgated under the Clean Water Act, on several grounds, and the Ninth Circuit Court of Appeals granted the NRDC partial relief.

Congress passed the Clean Water Act amendments (CWA) in 1987[2]. A portion of these amendments established a new mechanism for regulating storm water runoff. Section 402(p) of the CWA instituted deadlines for the EPA to promulgate the appropriate regulations and for certain storm water dischargers to apply for permits. This section also established deadlines by which the EPA must act on the permits and the dischargers must implement the requirements of their permits.

The CWA temporarily barred the EPA from requiring permits for discharges composed entirely of storm water. This moratorium ends on October 1, 1992. There are five exceptions to this moratorium. The CWA requires permits for discharges falling into any one of the following categories:

> A discharge with respect to which a permit has been issued under Section 402 (p) before February 4, 1987;
>
> A discharge associated with industrial activity;

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1 Natural Resources Defense Council, Inc. v. U.S. EPA, 1992 U.S. App. LEXIS 12517 (9th Cir. 1992).

2 33 U.S.C. @ 1251.

A discharge from a municipal separate storm sewer system serving a population of 250,000 or more (large systems);

A discharge from a municipal separate storm sewer system serving a population of 100,000 or more but less than 250,000 (medium systems);

A discharge for which the EPA Administrator determines that the storm water discharge contributes to a violation of a water quality standard or is a significant contributor of pollutants to the waters of the U.S.[3]

Section 402(p) set out the following deadlines with respect to these permits:

the EPA shall establish regulations for permitting requirements for industrial and large municipal dischargers by February 4, 1989;

industrial and large municipal storm water dischargers must apply for permits by February 4, 1990;

the EPA must act on the applications by February 4, 1991; and

dischargers must comply with their permits no later than 3 years after issuance.

On November 16, 1990, the EPA issued final permit application rules for industrial activities and large municipalities[4], almost two years after the deadline set forth in Section 402(p). Under EPA's rules, these entities are subject to a two-part application process. In addition, indutrial dischargers may apply for either individual or group permits.

On March 21, 1991, the EPA amended these rules[5], extending the deadlines for submission of Part 1 of group industrial storm water applications to September 30, 1991[6] and submission of Part 2 to May 18, 1992. A final rule published on April 2, 1992 further extended the deadline for Part 2 of the application to October 1, 1992[7]. None of these EPA rules

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3 CWA @ 402(p)(2); 33 U.S.C. @ 1342(p)(2).

4 55 Fed. Reg. at 47,990.

5 56 Fed. Reg. at 12,098.

6 Congress ratified the September 30, 1991 date for Part 1 of group industrial applications in the Dire Emergency Supplemental Appropriations Act of 1991, P. L. 102-27 @ 307.

7 The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) clarifies the deadlines for storm water discharges associated with industrial activity from municipal facilities. This court's opinion does not require the EPA comply with deadlines that ISTEA altered or superseded. ISTEA deadlines are being reviewed under a separate case. See P. L. 102-240 @ 1068.

established dates for final approval or denial of applications, or dates for regulated groups to comply with their permits.

The NRDC challenged these rules on several grounds. First, the NRDC requested that the court declare unlawful the EPA's failure to issue industrial and large municipal storm water permitting regulations by February 4, 1989 and to declare unlawful the EPA's extension of the statutory deadlines for industrial activities and large municipalities to file permit applications. The court granted the NRDC relief, stating that the EPA does not have the authority to ignore unambiguous deadlines set by Congress.

The NRDC also requested that the court enjoin the EPA from extending permit applications deadlines any further. The court declined to grant the injunction, acting on the assumption that the EPA will follow the dictates of Congress and the court. Furthermore, injunctive relief might have involved extraordinary supervision, making such relief inappropriate.

However, the court did compel the EPA to revise the rules to include permit approval and compliance deadlines. By failing to include these deadlines, the court held that the EPA omitted a key component of the scheme set forth in the CWA. The court stated that the regulations should inform the regulated community of the CWA's outside dates for compliance. Furthermore, the CWA requires that the compliance deadlines be contained within the permits themselves.

The NRDC failed in its argument that small systems (systems serving a population of less than 100,000) should be subject to the same permitting schedule as medium systems. The NRDC claimed that placing small systems on the same schedule as medium systems would ensure that small systems are regulated when the moratorium on permitting ends on October 1, 1992. However, the CWA does not permit regulation of small systems prior to October 1, 1992.

The NRDC also failed in requesting the court to place medium systems on the same schedule as large systems. The NRDC believed that this scheduling plan would achieve closer compliance with the schedule set out in Section 402(p) of the CWA. The CWA requires the permitting schedule for medium systems to begin two years after the large systems process. Although the EPA's current schedule for medium systems is delayed, the medium systems permitting process is still on schedule in relation to the schedule for large systems. Consequently, the court held that the current deadline for medium systems is not unreasonable.

The NRDC claimed that the EPA's definition of "municipal separate storm sewer systems serving a population" of a specified size narrowed number of municipalities subject to the large and medium permitting regulations. However, the court did not find that the EPA's definition was arbitrary and capricious and, therefore, rejected NRDC's request to invalidate the definition.

The court upheld the NRDC's challenged the EPA's rule that excluded various types of "light industry" from the definition of "discharge associated with industrial activity." The rule excluded industries that the EPA considered more comparable to retail commercial or service industries: manufacturers of pharmaceuticals, paints, varnishes, lacquers, enamels, machinery, computers, electrical equipment, transportation equipment, glass products, fabrics, furniture, paper board, food processors, printers, jewelry, toys and tobacco products. The court held that the

EPA's exemption of these industries from the normal permitting process was arbitrary and capricious. The court vacated the rule and remanded it for further proceedings.

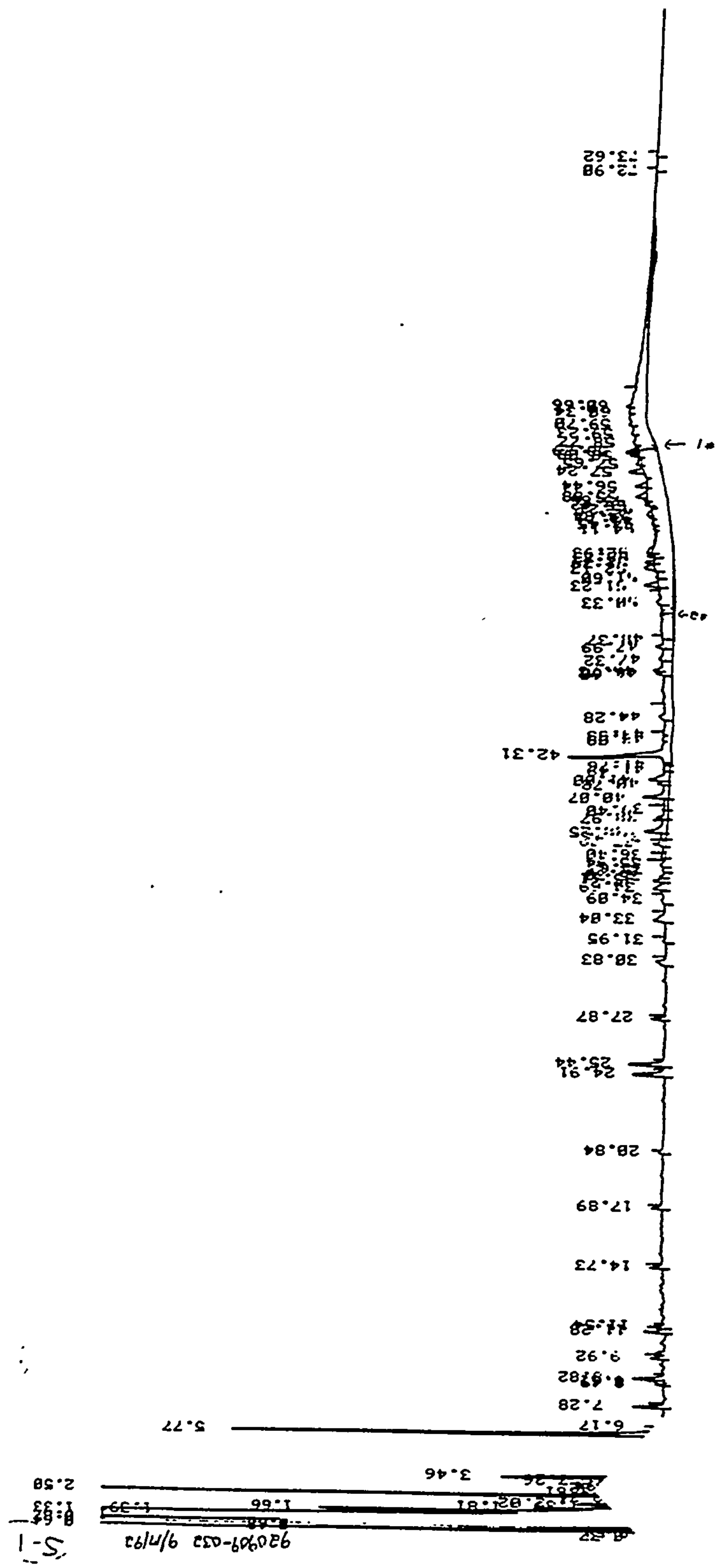
The court also upheld the NRDC's challenge of the EPA's exemption for construction sites of less than five acres. The EPA admits that the construction industry should be subject to storm water permitting: at high levels of intensity, construction is equivalent to other regulated industrial activities. The EPA originally proposed regulations that exempted construction operations that disturb less than one acre of land and are not part of a common development plan. The EPA determined that all other construction sites amounted to industrial activity. Orginally, the EPA proposed to exempt sites of less than one acre. However, in response to comments from the regulated community, the EPA increased the exemption from one acre to five acres. The court found that the EPA was arbitrary and capricious in increasing this exemption: the EPA could not support its perception that construction activities on less than five acres of land was non-industrial. The court invalidated this portion of the rule and remanded for further proceedings.

The NRDC claimed that oil and gas operations should be subject to the stricter standards that apply to mining operations, but the court refused to find the oil and gas standards arbitrary and capricious. The court also refused to uphold NRDC's contention that the EPA failed to establish substantive controls for municipal storm water discharges because the CWA gave the EPA Administrator discretion to determine what controls are necessary.

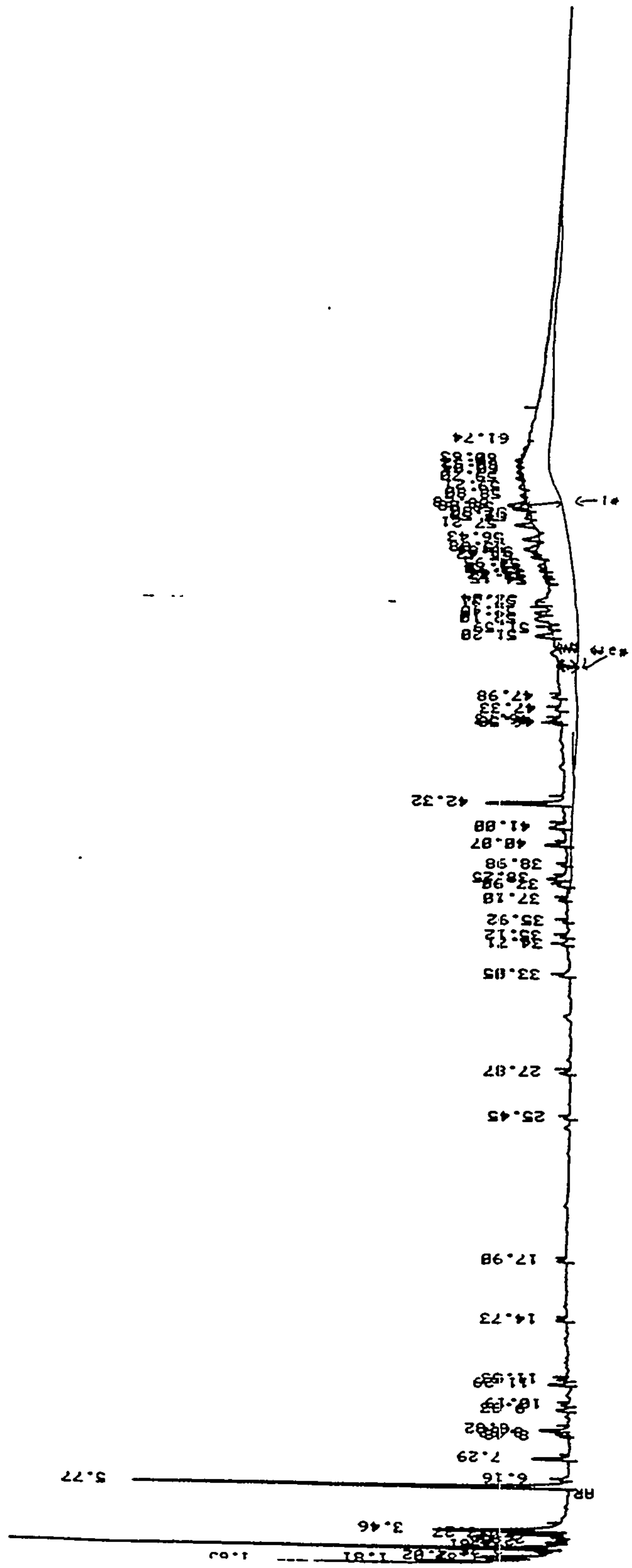
Finally, the court refused to uphold NRDC's contention that EPA's two-part group permit application process is invalid. The NRDC objected to the lack of opportunity for notice and comment before EPA approval of Part 1 of group industrial applications. Once the EPA approves Part 1, only a small subset of the group must submit Part 2 of the application, thus waiving the Part 2 filing requirement for a most of the group. The court stated that approval of Part 1 is a factual determination rather than a rule and, therefore, is not subject to a notice and comment period.

APPENDIX G

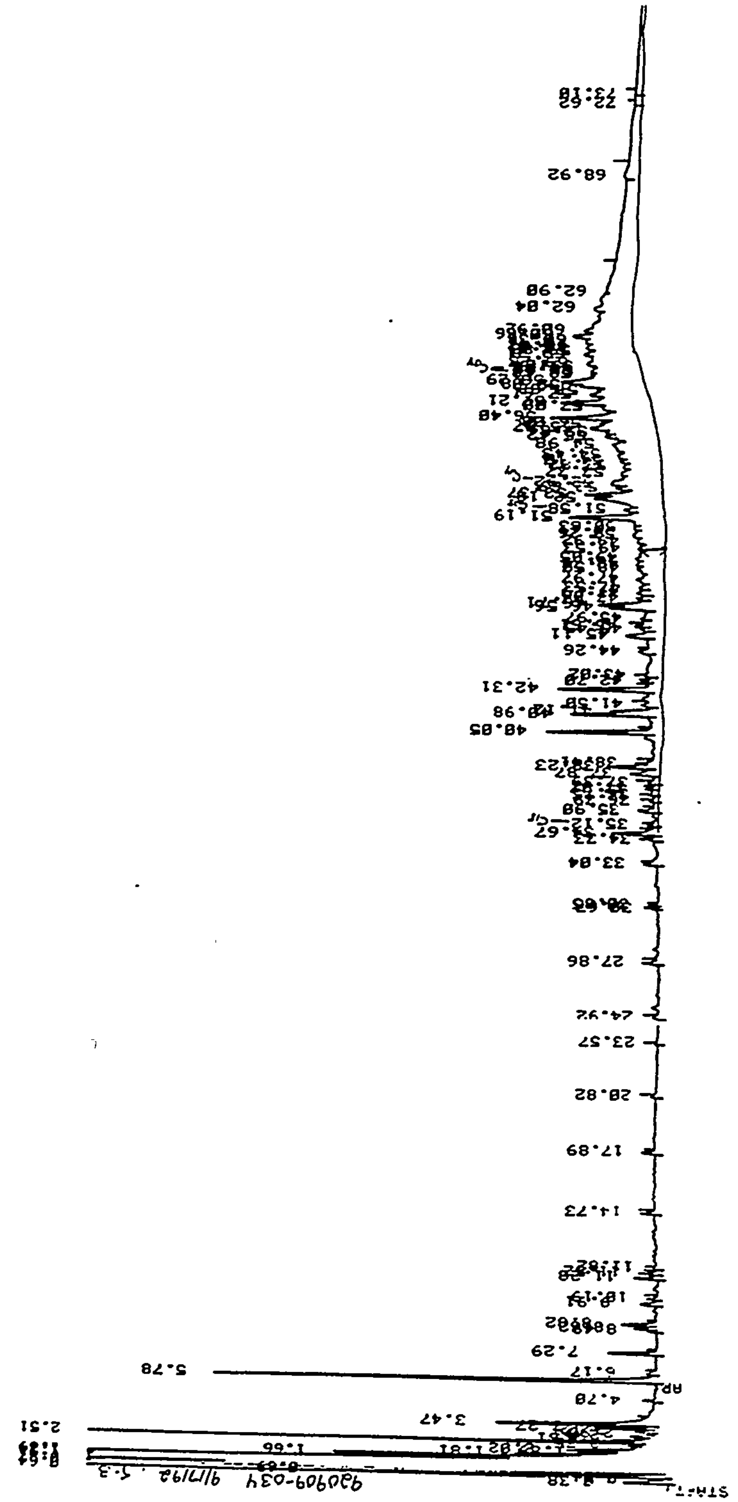
TPHC Profiles in Sediment



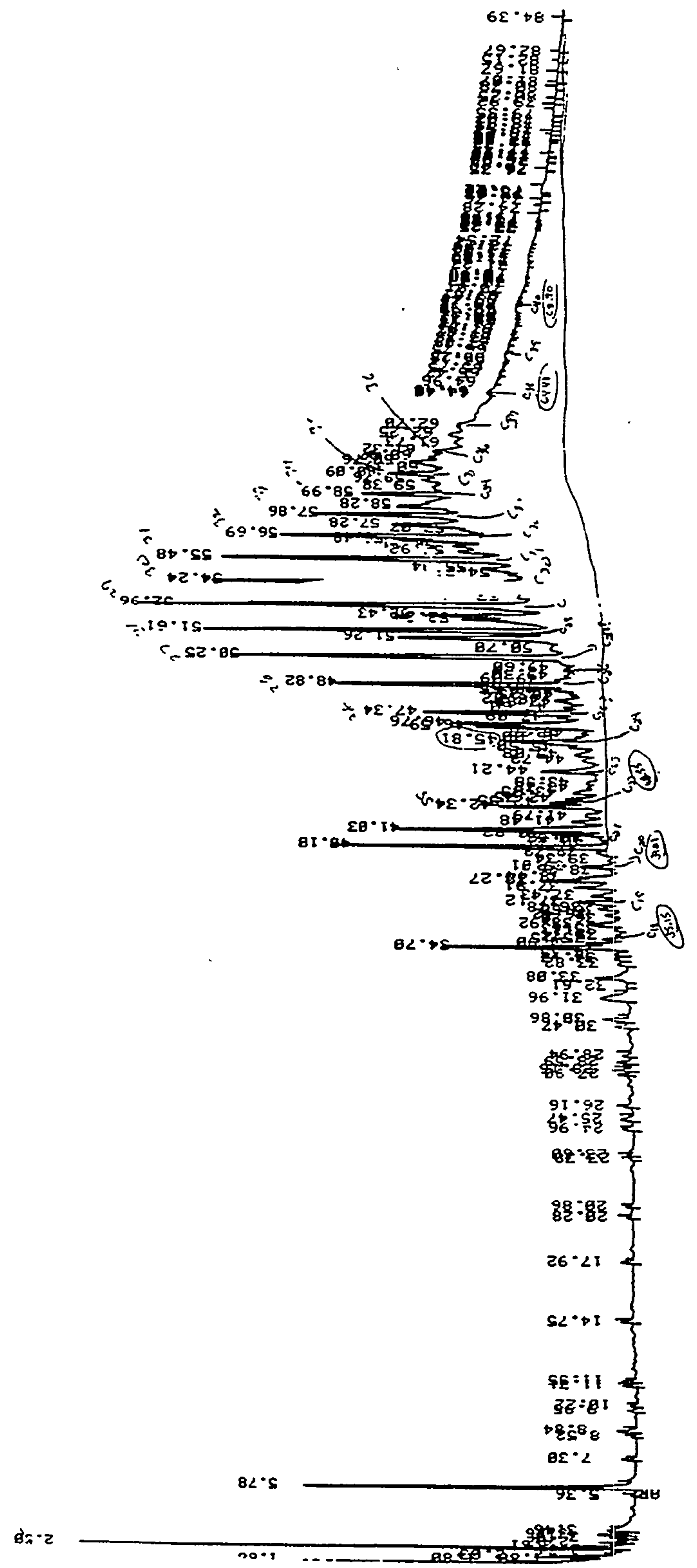
Total petroleum hydrocarbon profile in sediment from White Oak Creek kilometer 3.5.



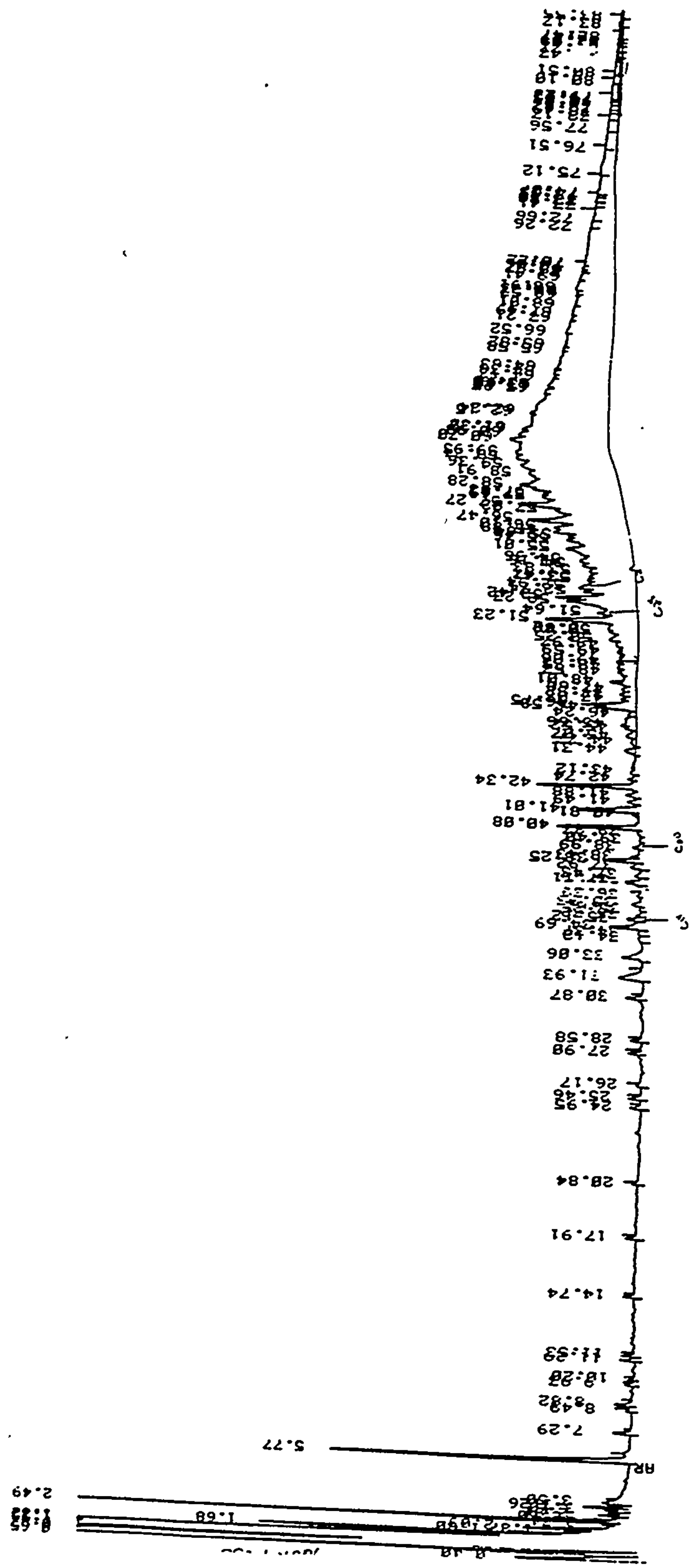
Total petroleum hydrocarbon profile in sediment from White Oak Creek kilometer 3.5.



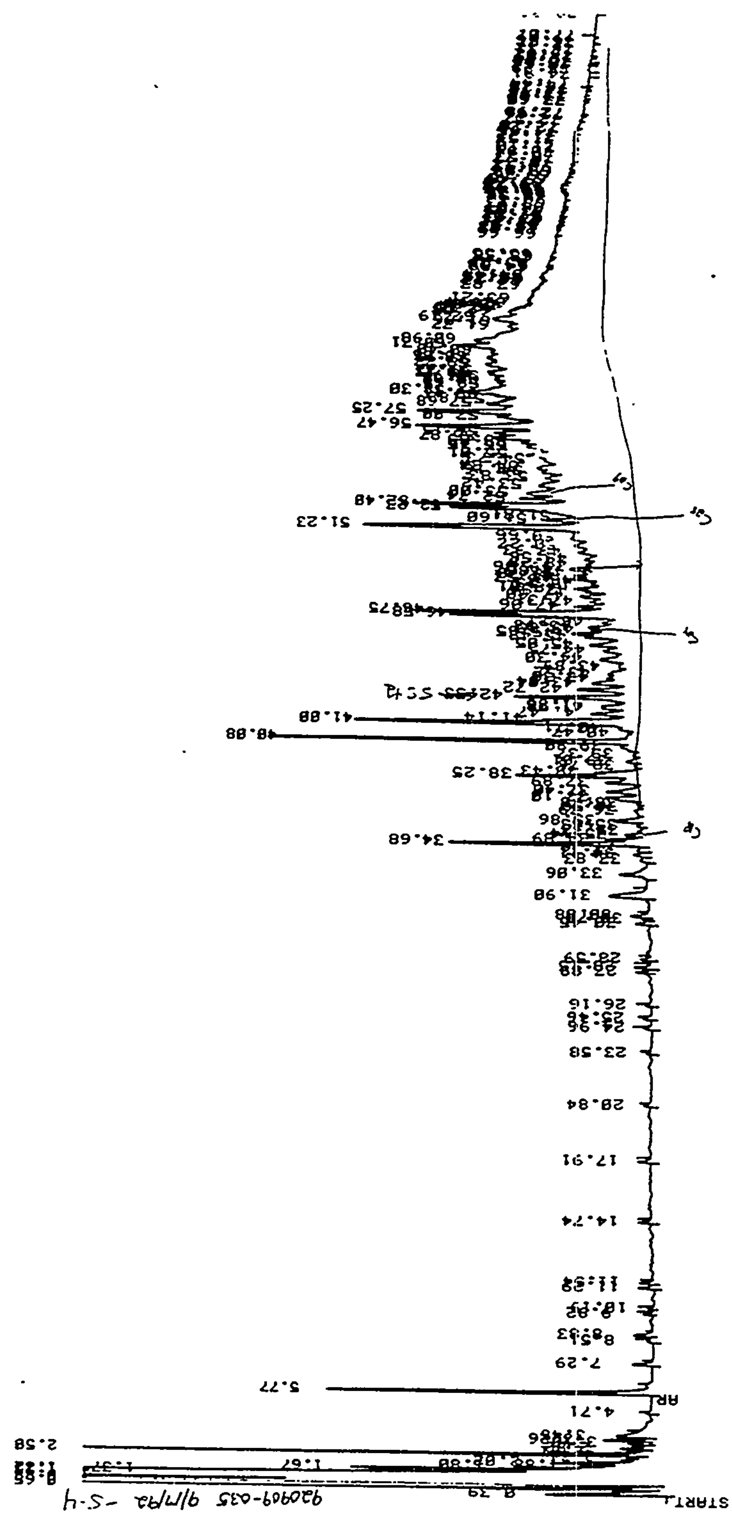
Total petroleum hydrocarbon profile in sediment from White Oak Creek kilometer 3.5.



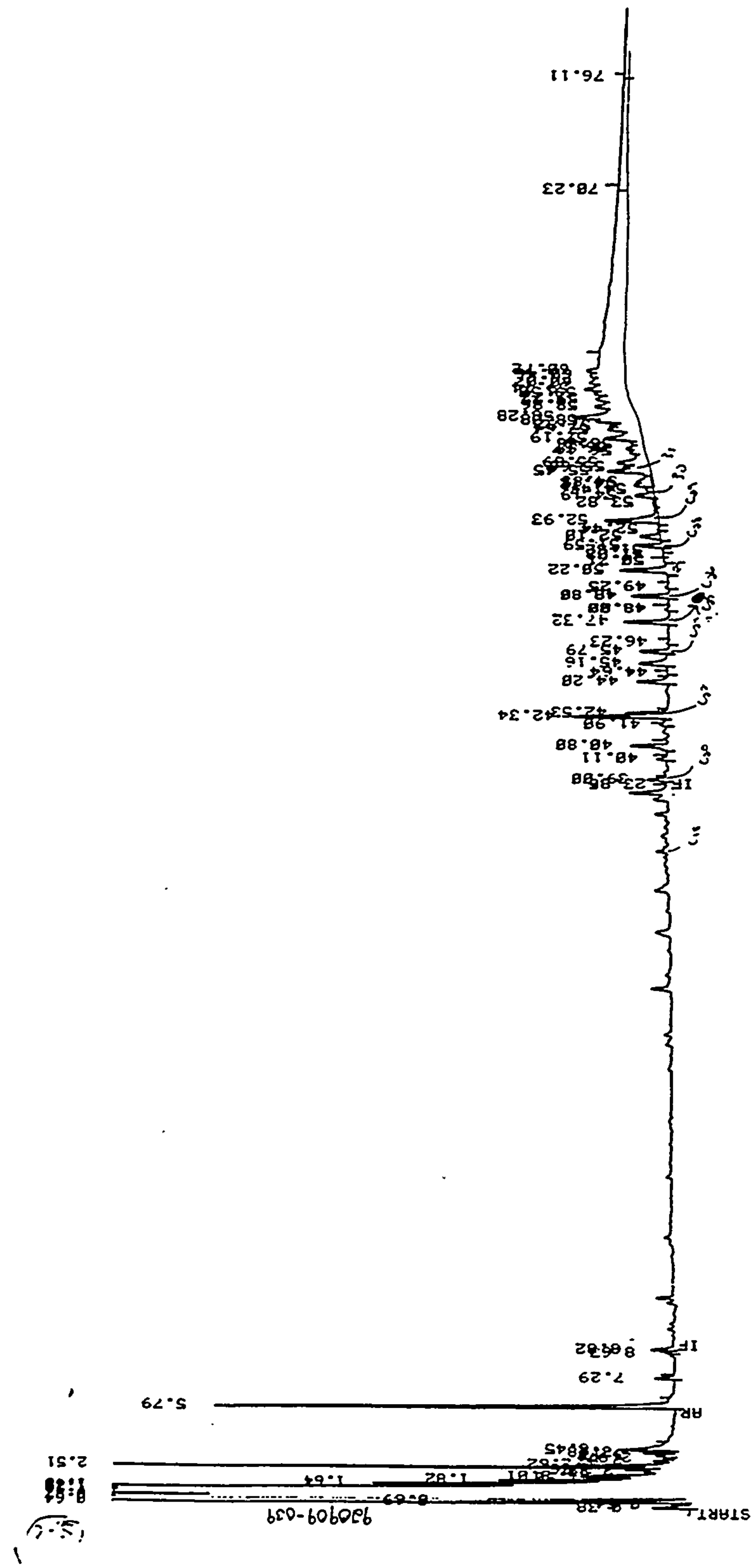
Total petroleum hydrocarbon profile in sediment from White Oak Creek kilometer 4.2.



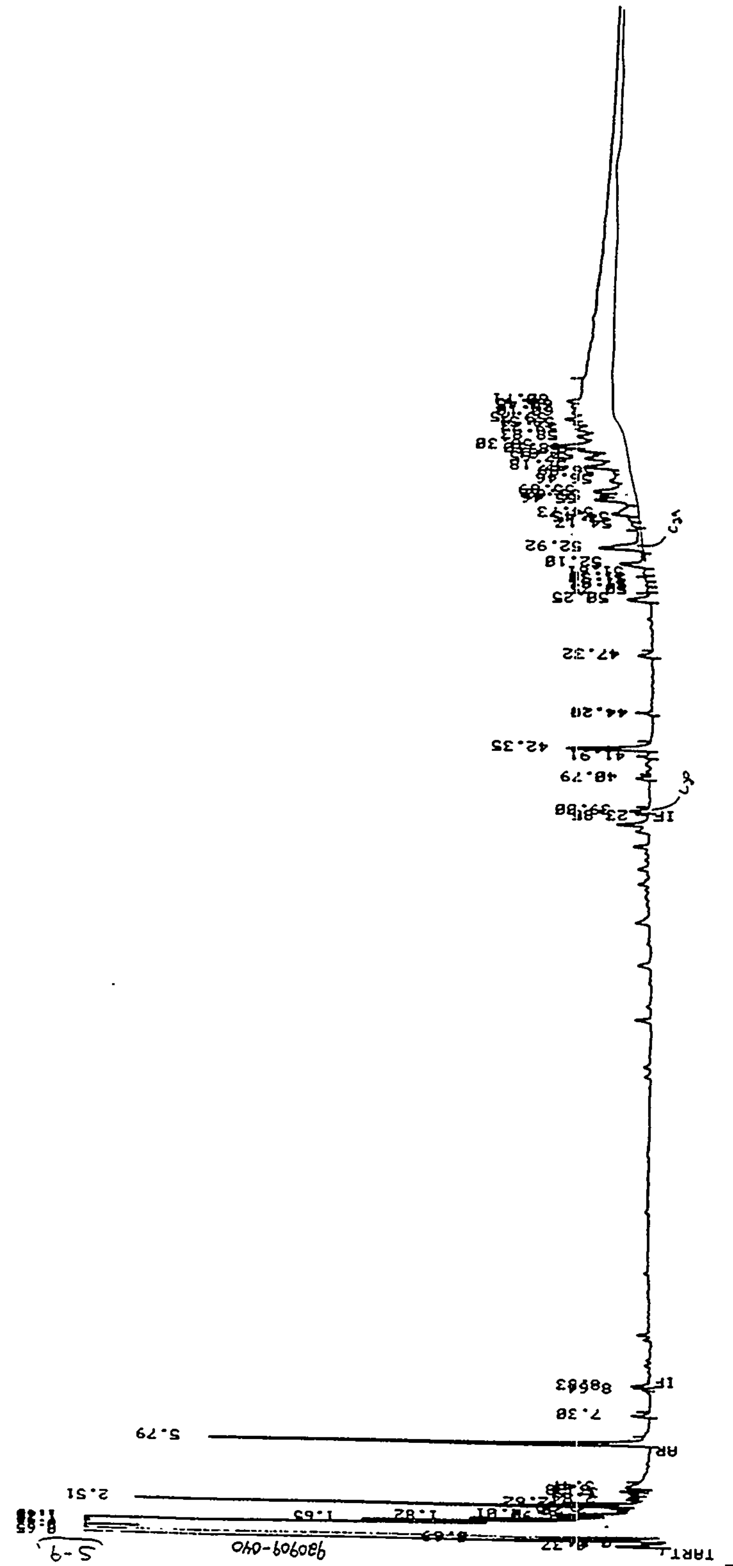
Total petroleum hydrocarbon profile in sediment from White Oak Creek kilometer 4.2.



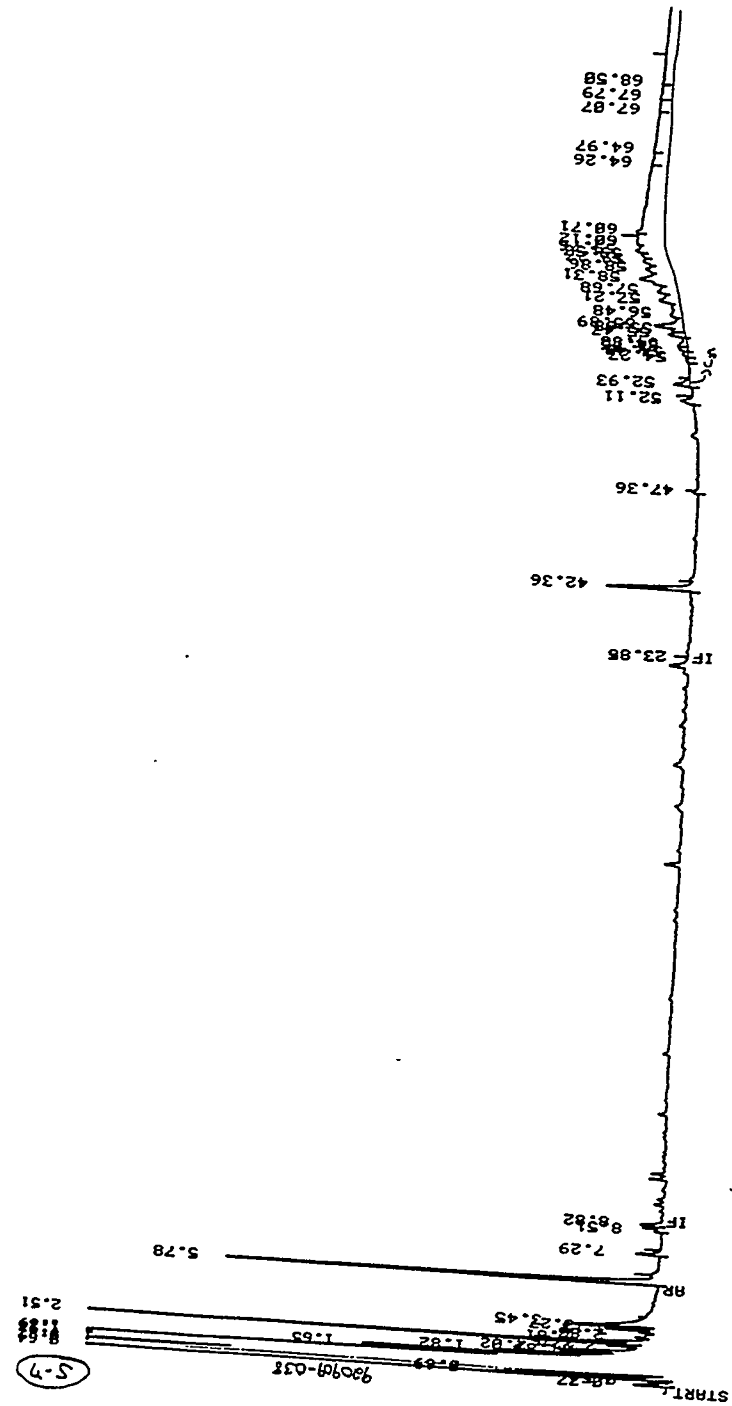
Total petroleum hydrocarbon profile in sediment from White Oak Creek kilometer 4.2.



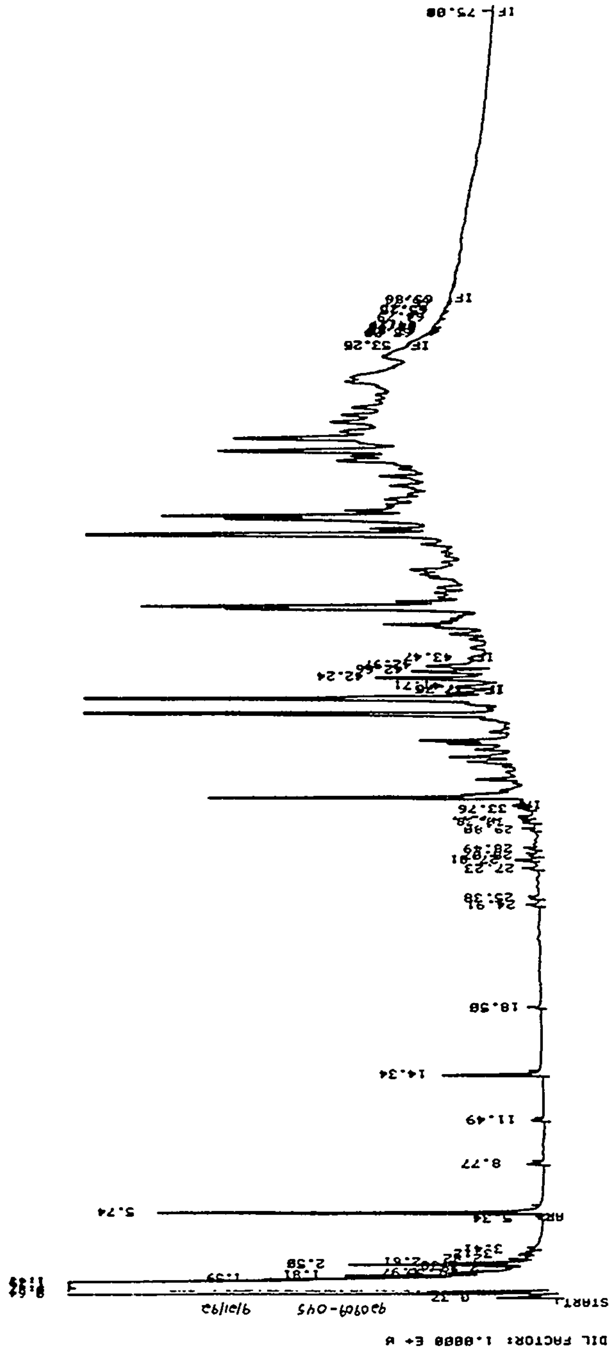
Total petroleum hydrocarbon profile in sediment from White Oak Creek kilometer 6.8.



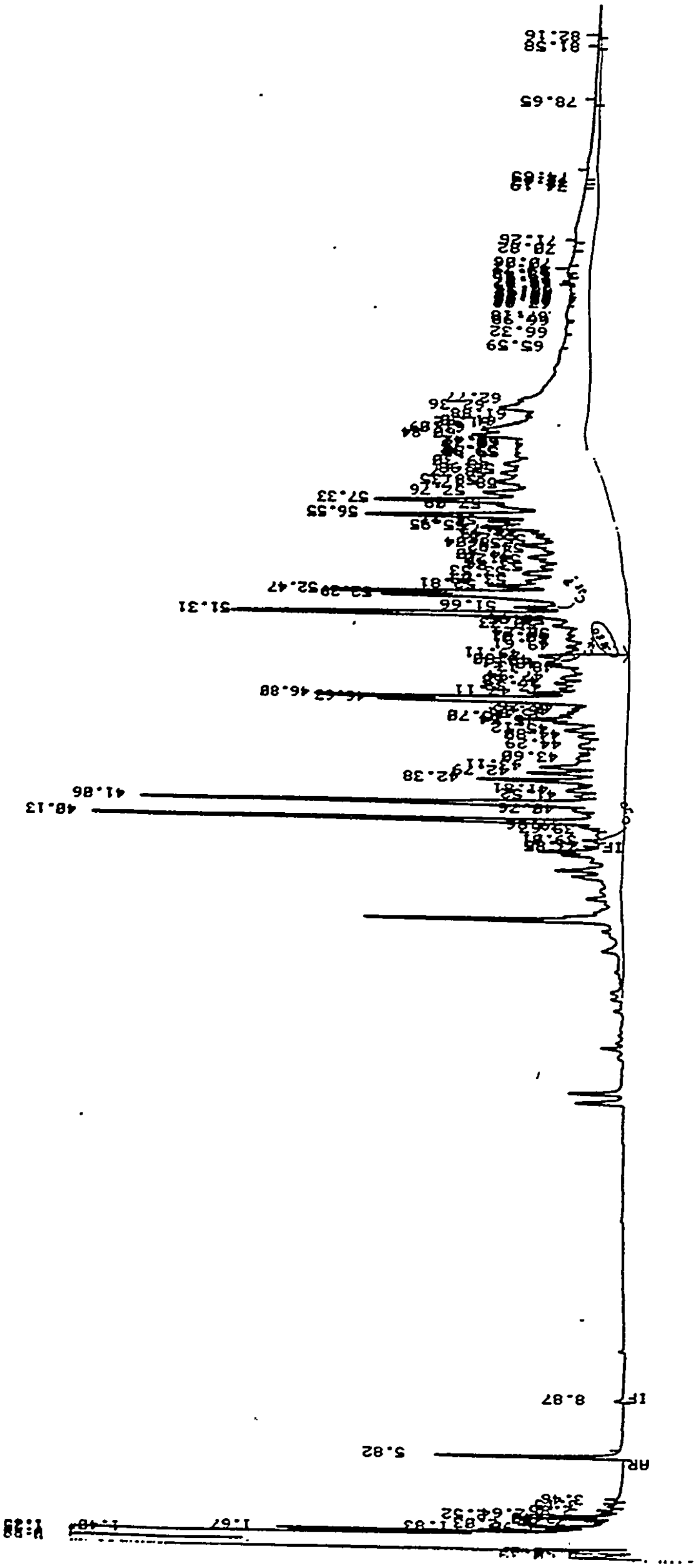
Total petroleum hydrocarbon profile in sediment from White Oak Creek kilometer 6.8.



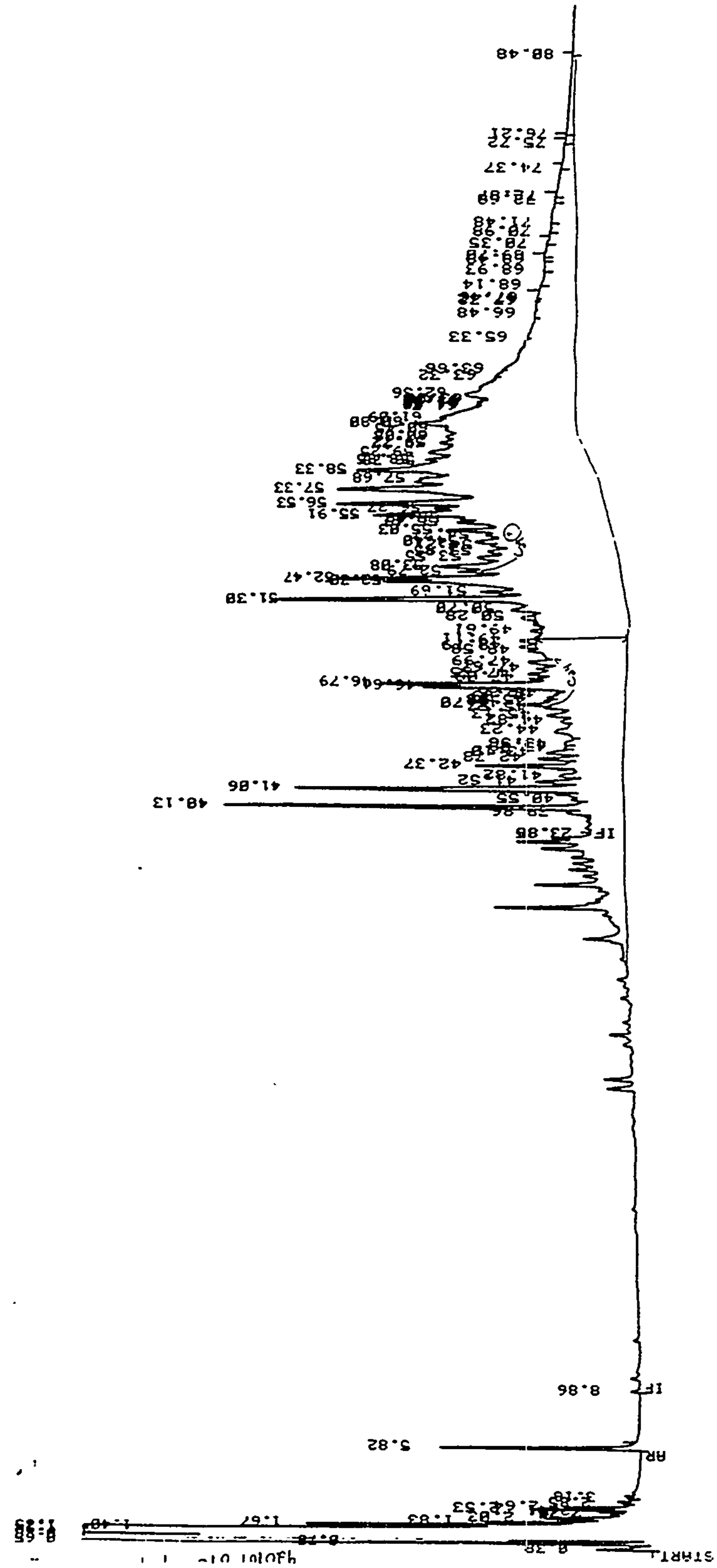
Total petroleum hydrocarbon profile in sediment from White Oak Creek kilometer 6.8.



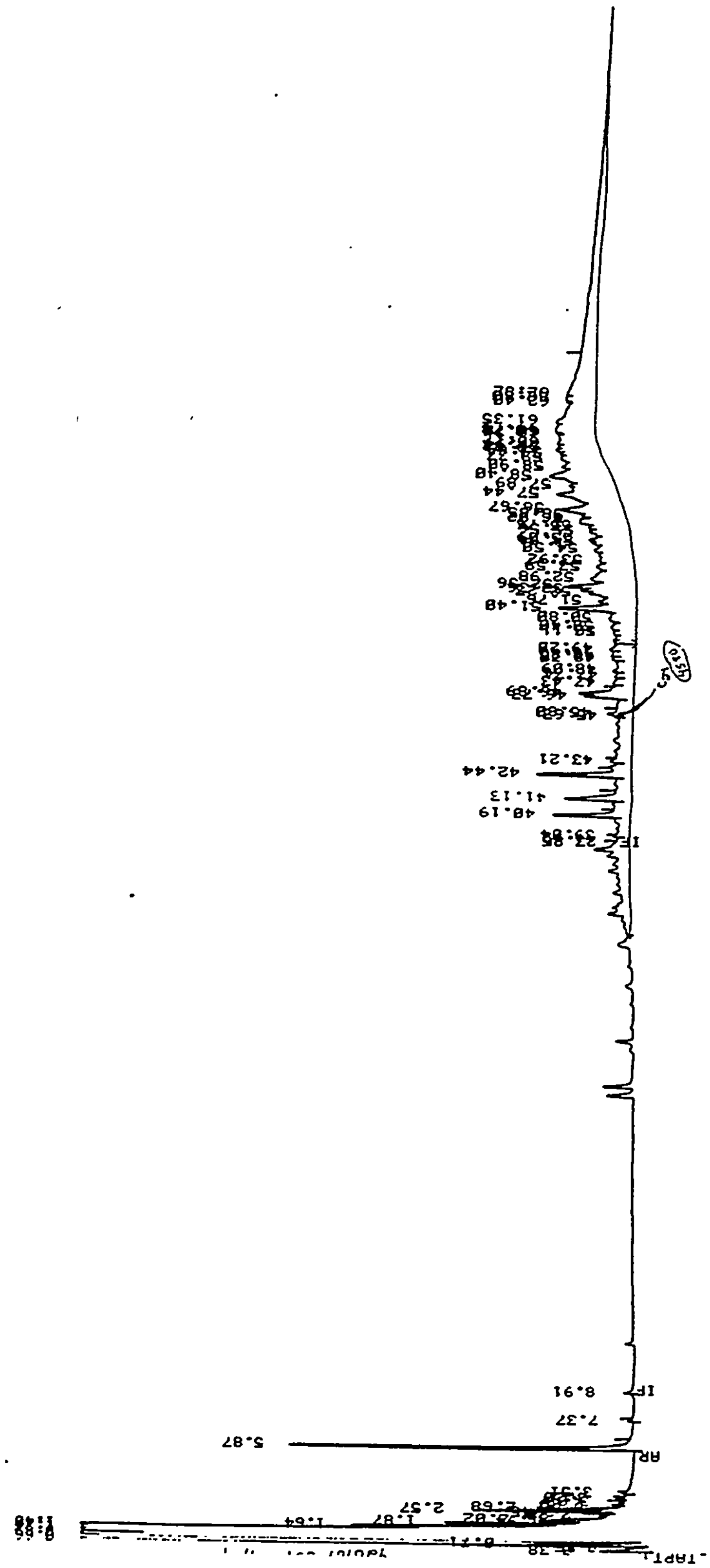
Total petroleum hydrocarbon profile in sediment from East Fork Poplar Creek at Station 17.



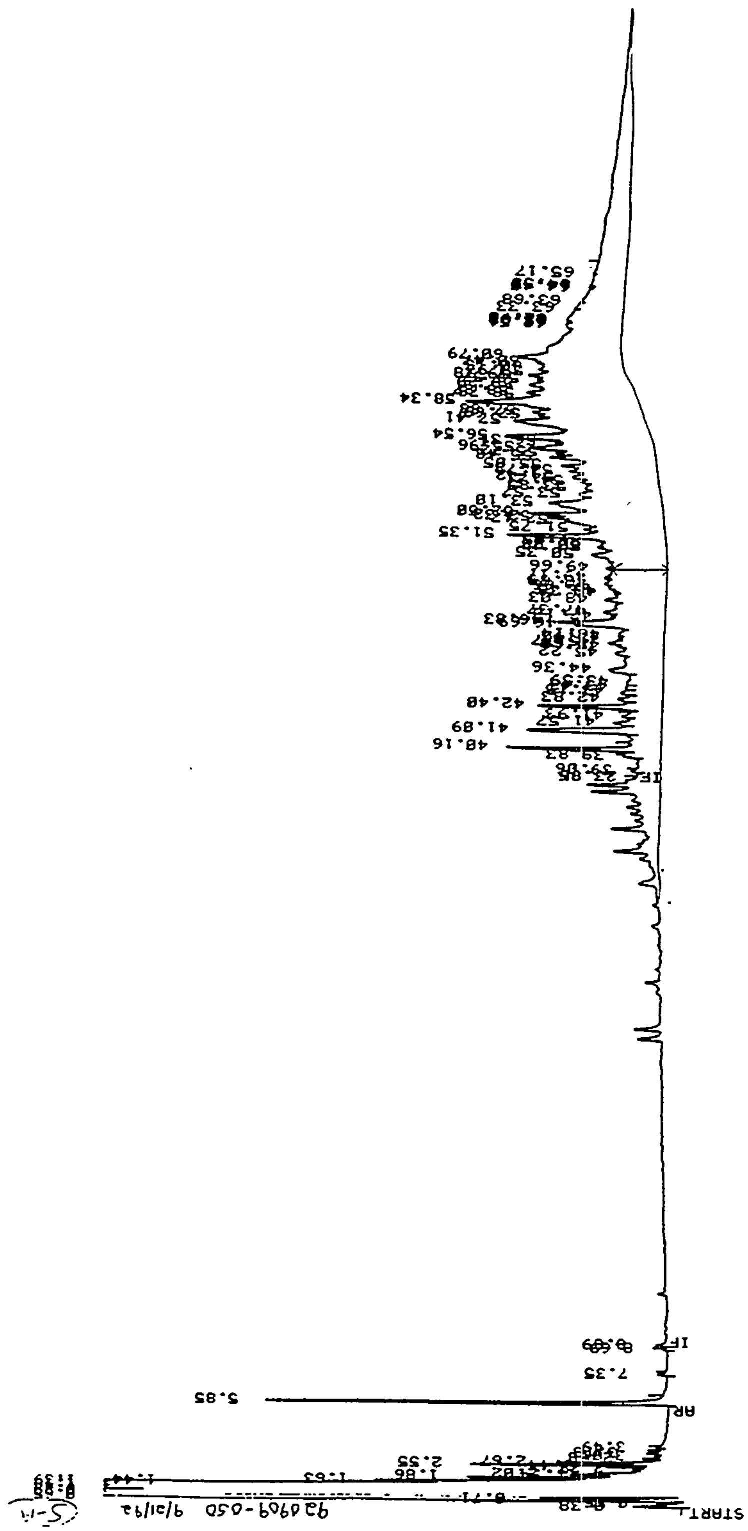
Total petroleum hydrocarbon profile in sediment from East Fork Poplar Creek at Station 17.



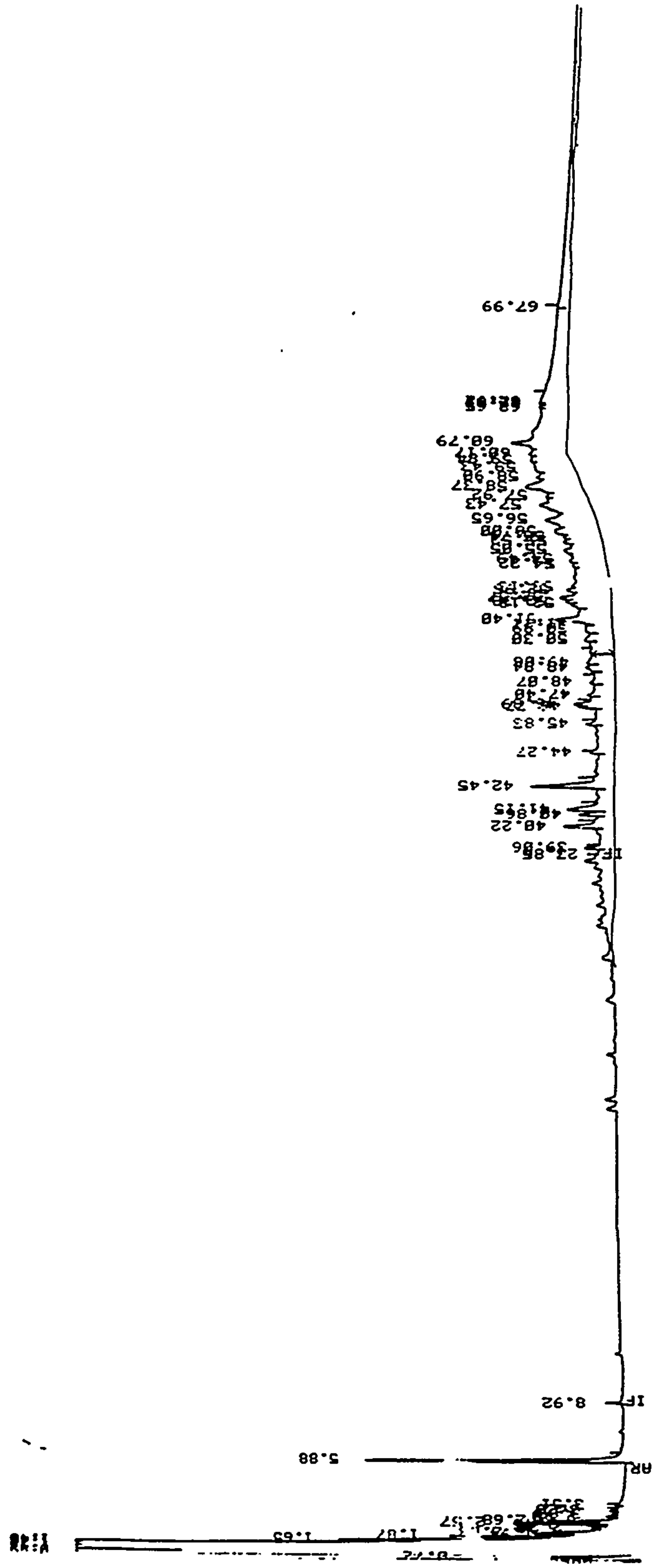
Total petroleum hydrocarbon profile in sediment from East Fork Poplar Creek at Station 17.



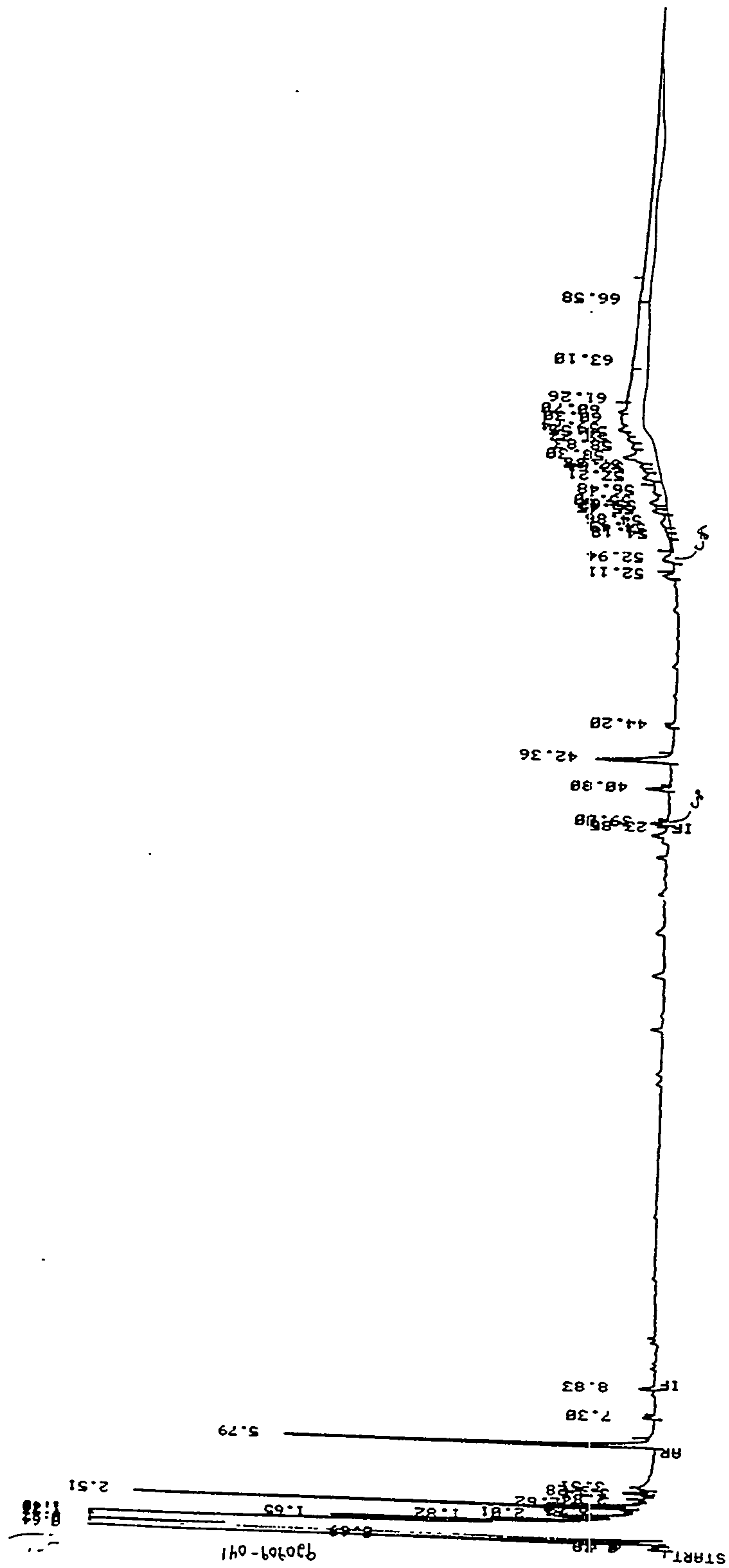
Total petroleum hydrocarbon profile in sediment from East Fork Poplar Creek behind K-Mart.



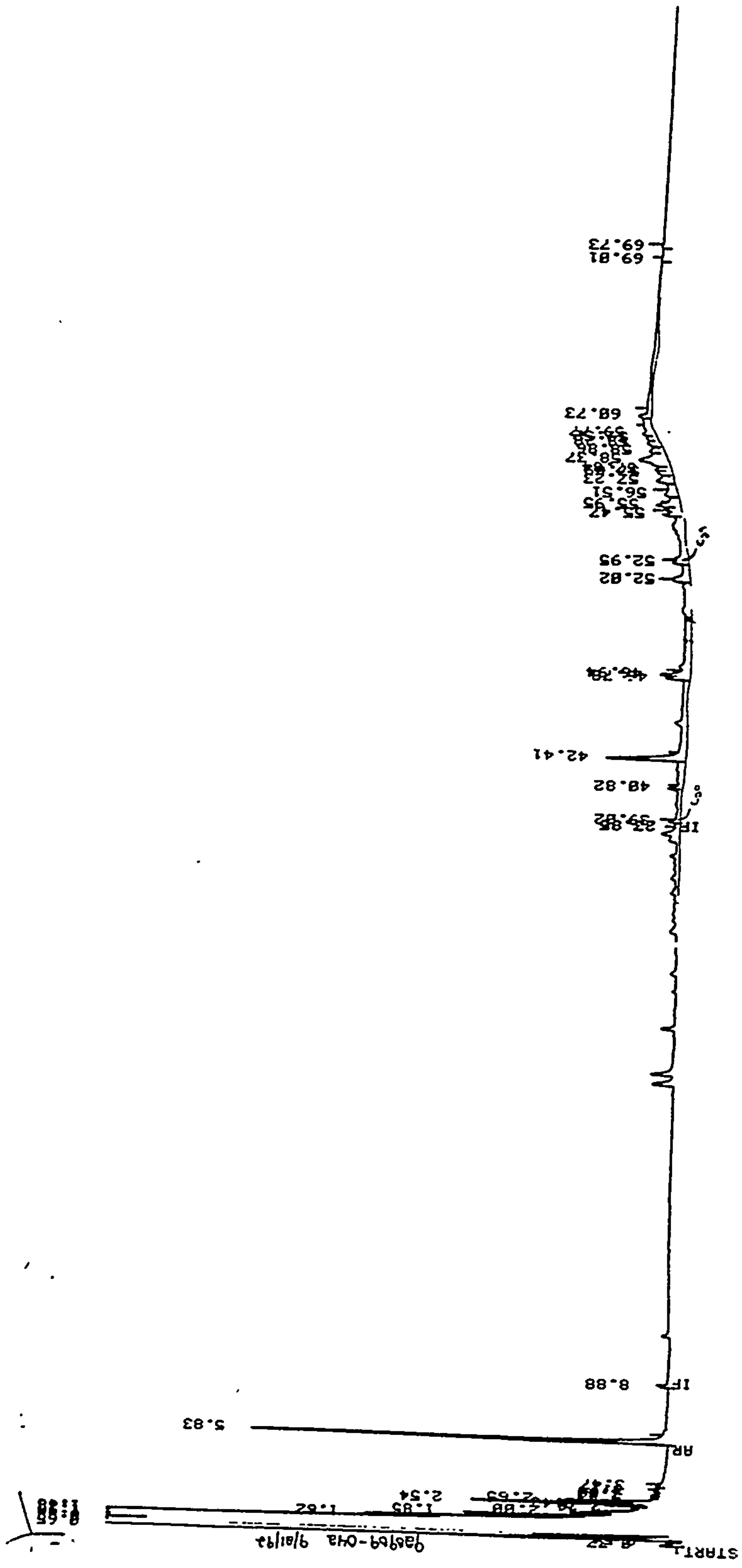
Total petroleum hydrocarbon profile in sediment from East Fork Poplar Creek behind K-Mart.



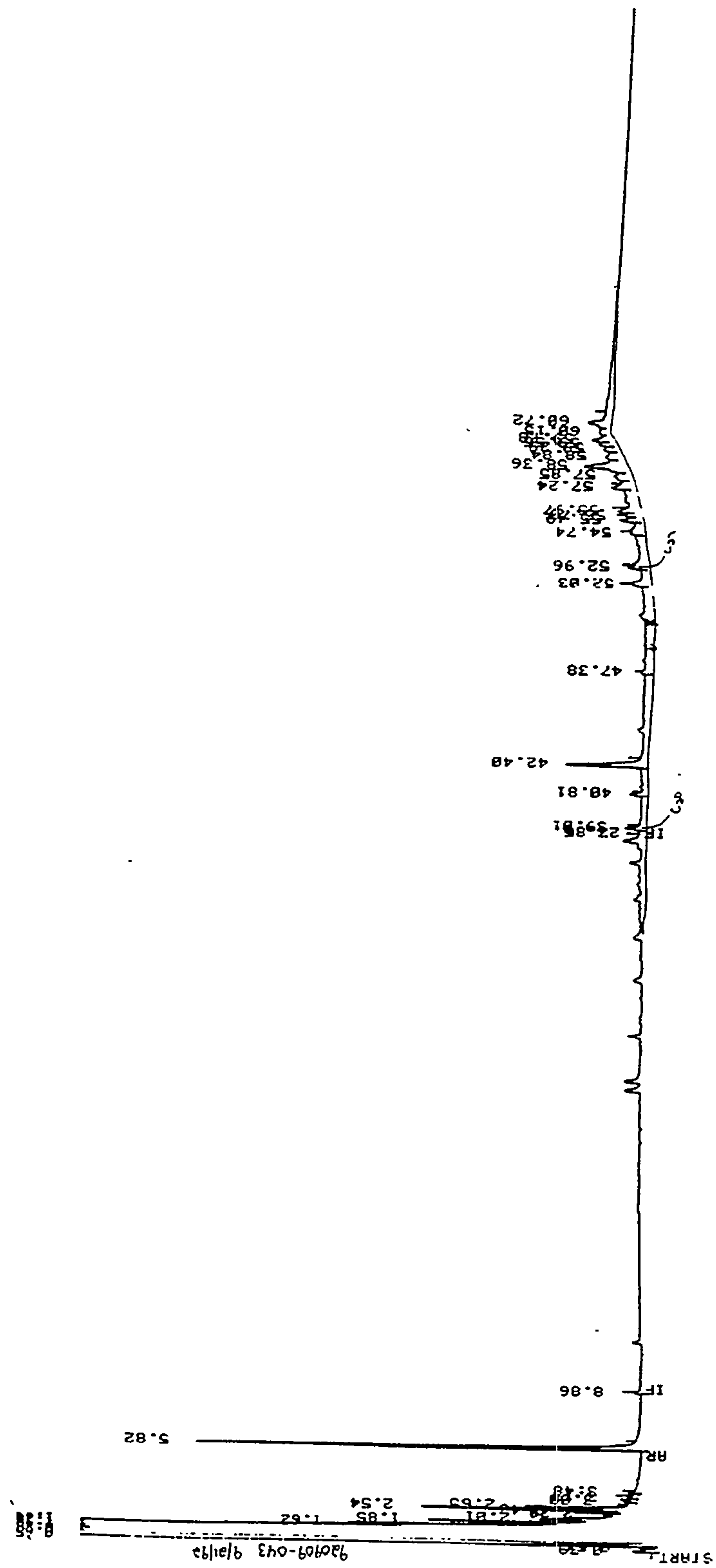
Total petroleum hydrocarbon profile in sediment from East Fork Poplar Creek behind K-Mart.



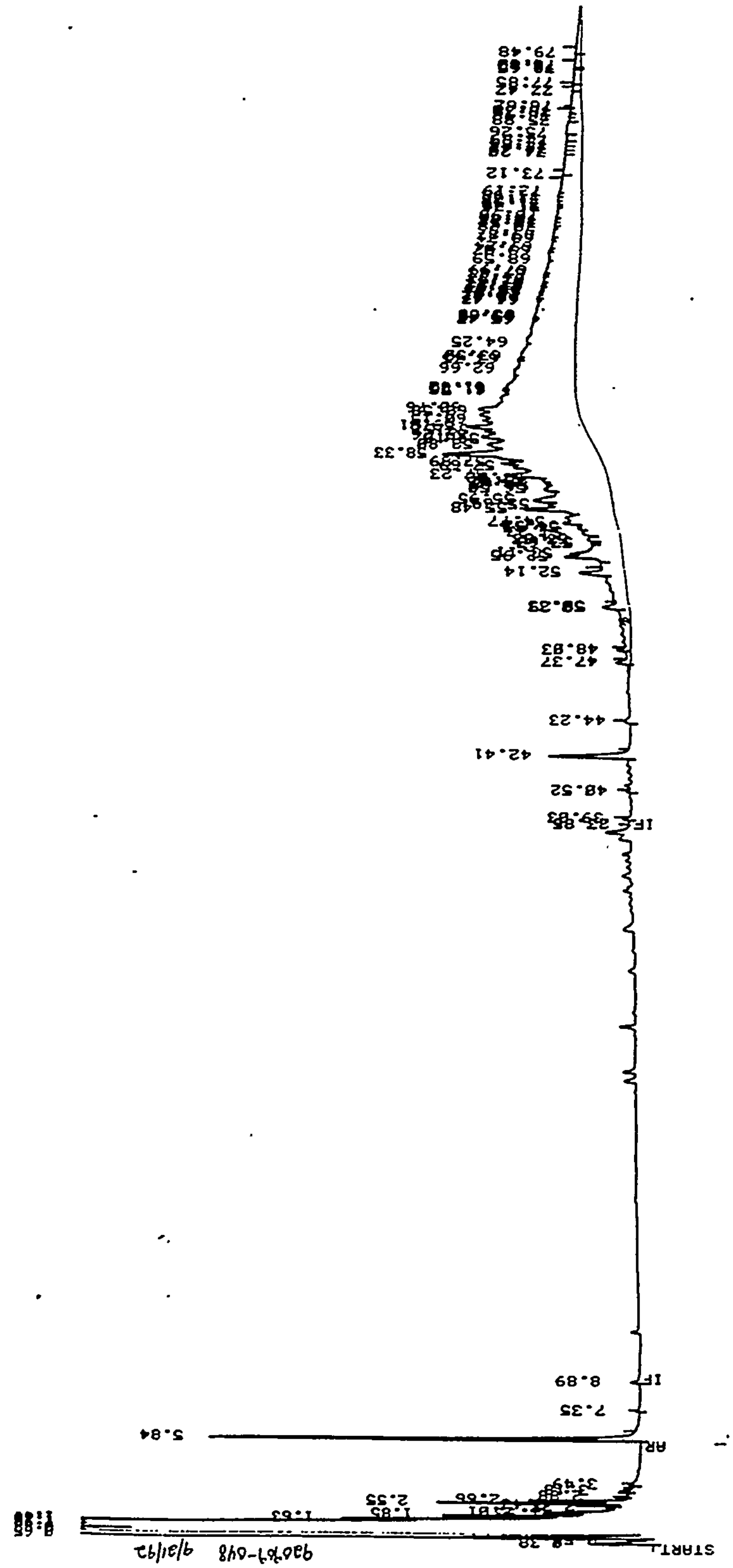
Total petroleum hydrocarbon profile in sediment from Hinds Creek.



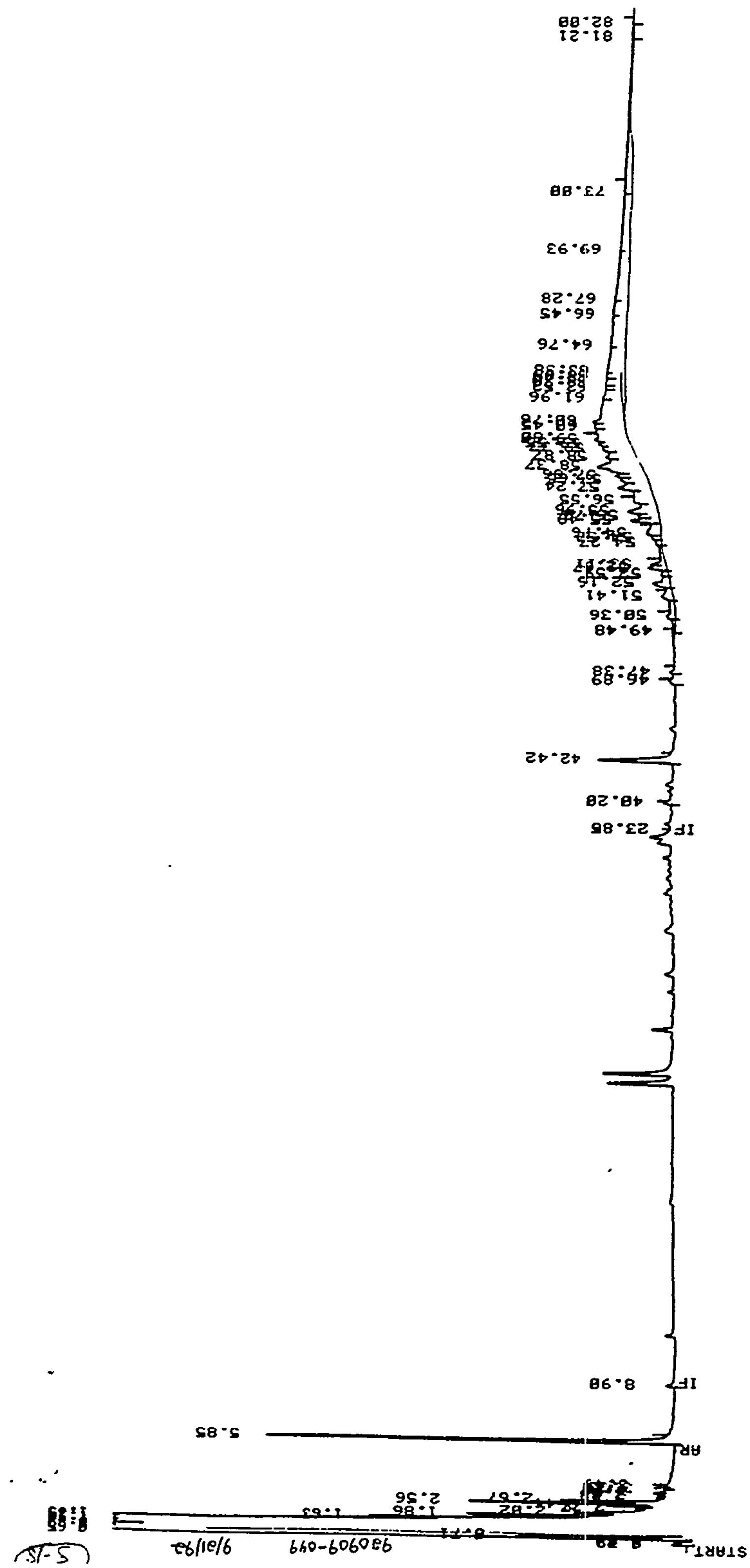
Total petroleum hydrocarbon profile in sediment from Hinds Creek.



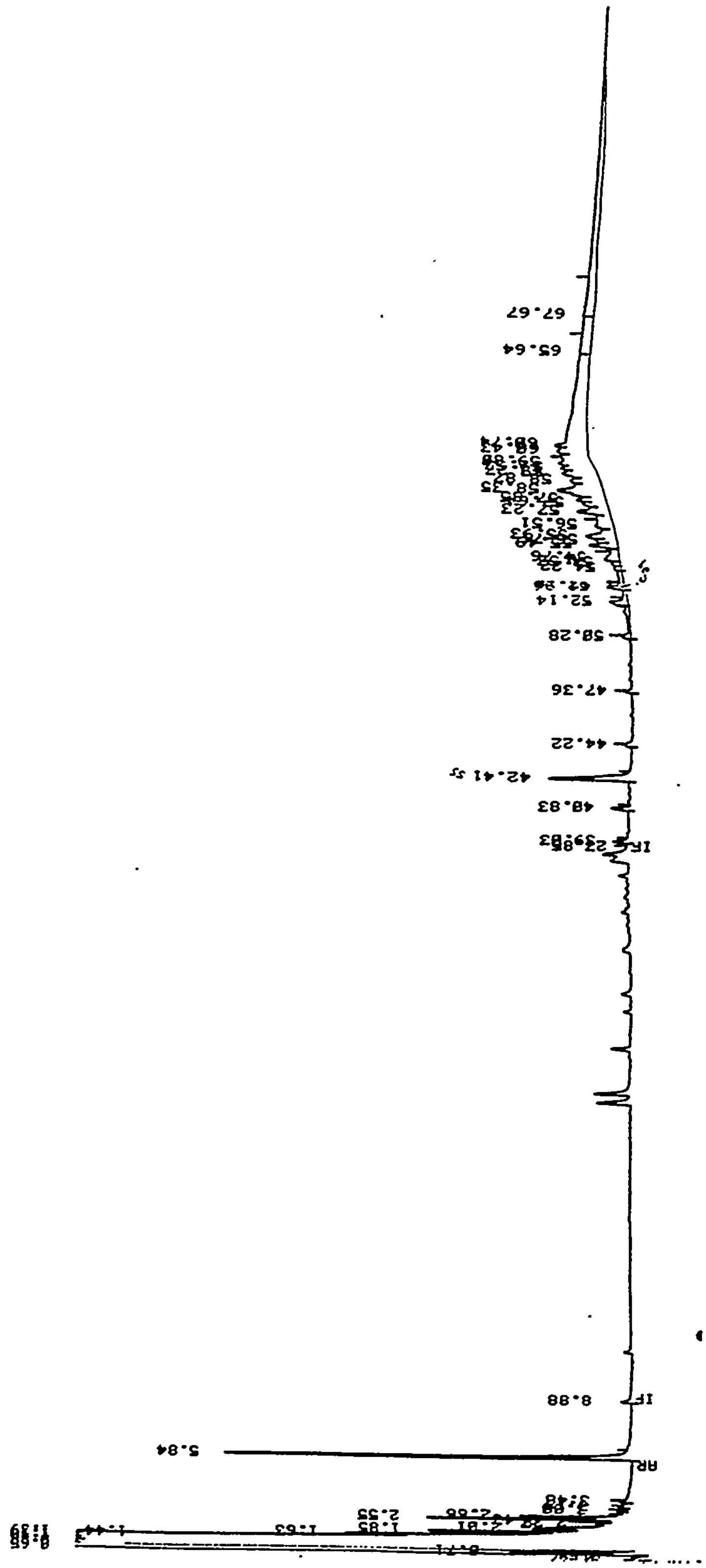
Total petroleum hydrocarbon profile in sediment from Hinds Creek.



Total petroleum hydrocarbon profile in sediment from Brushy Fork.



Total petroleum hydrocarbon profile in sediment from Brushy Fork.



Total petroleum hydrocarbon profile in sediment from Brushy Fork.

INTERNAL DISTRIBUTION

L. D. Bates, K-1001, MS-7169
B. A. Berven, 4500S, MS-6124
R. B. Cook, 1505, MS-6038
J. H. Cushman, 1503, MS-6352
V. H. Dale, 1505, MS-6035
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