

Dr. Kenn Brooks, Phone and FAX (360) 732-4464

Aquatic Environmental Sciences**FAX**

To: Jim Gauntt **From:** Dr. Kenneth M. Brooks

Fax: (770) 460-5573 **Pages:** 21

Phone: (770) 460-5553 **Date:** 03/18/97

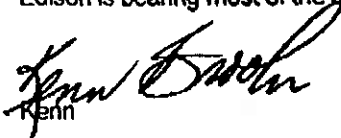
Re: Creosote treated railway tie study **CC:** Rich Monzingo

Urgent For Review Please Comment Please Reply Please Recycle

• **Comments:** Jim, enclosed are the original study protocols. Subsequently, the US Fish and Wildlife Service has required quarterly monitoring. The increased number of samples is not reflected in the original protocols. The cost per sample will be \$75.00, which is about a third of normal PAH analytical costs at these detection limits. Commonwealth Edison is requiring that someone else pay for the analytical costs associated with a second mesocosm study to examine PAH losses from new creosote treated ties. They will pay for construction of the mesocosm, security, sample collection and report writing. The analytical costs will be a little less than \$15,000.00.

I am also enclosing my response to the USFWS protocol review comments and the only published paper (that I am aware of), examining PAH accumulation adjacent to railway rights of way. Based on the results of Wan's paper, it is in your best interest to quantify that portion of the PAH originating from the creosote treated ties.

Commonwealth Edison confirmed that we have about a month before construction starts. If the RTA wishes to make a proposal to participate in this study, please advise. Considering that Commonwealth Edison is bearing most of the cost, this proposal to you is a real bargain.


Kenn

Proposal

**Evaluation of Polycyclic Aromatic Hydrocarbon Migration
From Railway Ties Into Balast and Adjacent Wetlands**

Prepared for:

*Jeff Smith and Rick Monzingo
Commonwealth Edison
P.O. Box 767
Chicago, IL 60690-0767*

Prepared by:

*Dr. Kenneth M. Brooks
Aquatic Environmental Sciences
644 Old Eaglemount Road
Port Townsend, Washington 98368*

Phone (360) 732-4464

September 23, 1996

Title Page

Title:

**Evaluation of Polycyclic Aromatic Hydrocarbon
Migration From Railway Ties Into Balast and
Adjacent Wetlands**

Company Responsible:

Aquatic Environmental Sciences

Address:

**644 Old Eaglemount Road
Port Townsend, WA 98368**

Telephone:

(360) 732-4464

Fax:

(360) 732-4464

Contact:

Dr. Kenneth M. Brooks

Evaluation of Polycyclic Aromatic Hydrocarbon Migration From Railway Ties Into Ballast and Adjacent Wetlands

Introduction. Commonwealth Edison operates a spur rail-line which crosses wetlands inhabited by the endangered Hines emerald dragonfly (*Somatochlora hineana*) in Will County, Illinois. This line, built in the 1950's, has been infrequently used in the last 30 years. In 1996, Commonwealth Edison received a Section 404 permit from the U.S. Army Corps of Engineers (COE) to replace unserviceable creosote ties supporting the rails.

Brooks (1996) examined PAH levels in the wetland adjacent to sections of the track supported by old (ca. 1950) creosote treated ties and sections where unserviceable ties had been replaced with new creosote treated ties. Three transects were examined at each of these treatments and compared with eight control samples. Surficial sediments were collected at 0.25, 0.50 and 1.00 meters from the base of the ballast and examined for parental PAH. Fifteen of the 18 treatment samples showed no contamination. However, one of three transects adjacent to the old tie railway section showed moderate PAH contamination (13 - 14 ppm) at 0.25 and 0.50 meters. Excepting one station, all of the samples collected adjacent to the newly installed ties were very close to control levels. The exception was a sample collected at 0.25 meters which contained 5.062 ppm parental PAH. None of the stations sampled at 1.0 meter from the ballast contained elevated levels of PAH.

Primarily high molecular weight PAH were observed at the elevated sample stations. These high molecular weight compounds are more refractory to microbial degradation and persist for longer periods of time than do the lower molecular weight PAH. Compounds characteristic of creosote (phenanthrene, fluorene, fluoranthene and acenaphthene) were not detected in these samples. This suggests that either the contamination occurred at some point in the past - or that the contamination was associated with some other source.

Based on the unknown effects of PAH on dragonflies - and the observation of elevated PAH levels in some samples - the U.S. Fish and Wildlife Service requested that creosote treated ties not be used where the spur crosses habitat used by *S. hineana*. The COE conditioned Commonwealth Edison's 404 permit requiring the use of untreated railway ties and required a five year study to examine PAH migration from creosote treated railway ties into adjacent wetlands. This proposal is designed to satisfy the requirement for a creosote migration study.

Proposal

1.0 Understanding of the project. The question being asked in this study is: To what extent do polycyclic aromatic hydrocarbons migrate from creosote treated railway ties into the adjacent environment. The study will examine three migration pathways:

- 1.1 via direct contamination from surface stormwater
- 1.2 via infiltration into shallow groundwater and then laterally into the wetland
- 1.3 via direct contamination of adjoining ballast.

1.1 Literature search. This study should begin with a reasonably comprehensive literature search and review to determine what is known regarding this issue. I have literature from the

Electric Power Research Institute (EPRI) regarding creosote migration from utility poles. The Railway Tie Association (RTA) has limited information which is being provided. A key word search will be conducted within appropriate databases. Relevant documentation will be obtained, reviewed and synthesized into a summary. An adequate search will identify and assess previous work in this and related areas. The advantages are:

- it will enable us to avoid duplication of previously conducted research
- tailor our final protocols to avoid previous errors and take advantage of previous findings
- help avoid mistakes made in previous studies of this and similar issues
- identify expected levels of PAH in ballast, water and sediment.

1.2 Preliminary study design. There are numerous potential sources of PAH associated with human activity. These confounding inputs are difficult, if not impossible, to control in areas of high human activity. Furthermore, creosote is a natural product, produced from the coking of coal, and it contains thousands of compounds. While creosote does contain perhaps 20% alkylated PAH, the majority are parental compounds associated with a wide variety of combustion sources. This makes analytical segregation of creosote derived PAH from other sources difficult, if not impossible. For these reasons, I recommend a "mesocosm study" conducted at a well controlled site remote from confounding sources of PAH. The proposed study would involve construction of three sections of simulated track. Figure 1 is a conceptual diagram of the study design.

This study could be conducted at a remote site in Illinois. This has the advantage of most closely matching the environments of concern (soils, rainfall and temperature in particular). However, there are several disadvantages:

- Finding a suitable remote site and obtaining the permits to conduct a study of this kind in a natural wetland would add significantly to the cost.
- A newly constructed "mesocosm" wetland would not have time to mature.
- Increased cost for security and sample collection.
- Difficulty in collecting samples during the "first flush" of rain

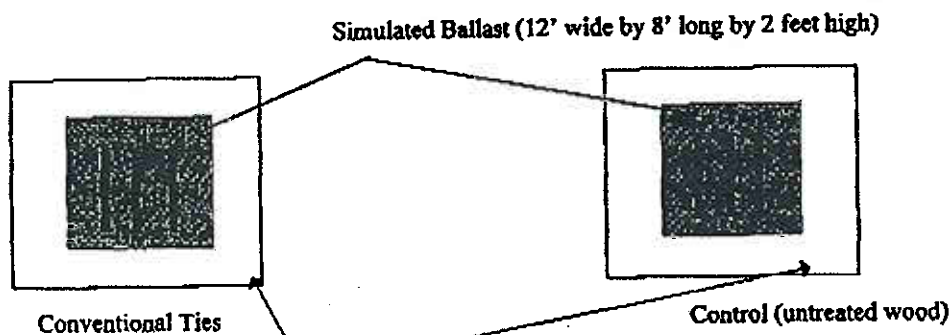
Aquatic Environmental Sciences is located on 160 acres of forest and pastureland with several experimental lakes and over three acres of mature constructed wetlands. Our facility is remote from all confounding sources of PAH. A test conducted on our grounds has the following advantages:

- the study can be conducted under any desired hydraulic regime in either organic or mineral soils.
- the study can be highly controlled with very little probability of accidental contamination or natural upset (floods, etc.)
- study costs will be reduced because of proximity of the study site to the laboratory facility.
- collection of "first flush" water samples is easily accomplished because Dr. Brooks lives on the property.

- the Battelle marine science laboratory is located approximately 20 minutes from our lab. Dr. Eric Crecelius has developed some very sensitive procedures allowing the determination of PAH concentrations in the parts per trillion in water. Battelle has an excellent reputation for high quality analysis and will conduct all of the analytical chemistry associated with this project.

Because of the preceding considerations, I recommend that the study be conducted at Aquatic Environmental Sciences.

Plan View



20' wide x 16' long by 18" deep pit lined with a 6 mil barrier and filled to a depth of 12 inches with a mixture of 20 to 30% silt and 70 to 80% sand. TOC in the top 4 cm of the sediment column will be adjusted to 2.5% (dry sediment weight) with the addition of an organic muck soil. Soils within the perimeter of each treatment will be kept saturated, or inundated rainwater supplemented with natural lake water.

Cross Sectional View



Figure 1. Schematic diagram illustrating the mesocosm layout for a study to examine PAH migration from creosote treated railway ties.

1.21 Sampling protocol. This study will monitor total organic carbon and sixteen priority PAH in water, ballast and sediments. Sediment PAH, which accumulate with time, will be monitored on an annual basis during summer (August) when temperatures are highest, facilitating PAH migration. Water will be examined for PAH during August and again in winter (February) to determine PAH loading during warm and cold weather. The following samples will be collected and analyzed. A summary of the analysis is provided in Table 1.

- 1.22 Storm water during the first flush following a period of at least 15 days of dry weather (GC/MS; EPA Method 625;).
- 1.23 Shallow ground water samples from a glass or stainless steel sump (GC/MS; EPA Method 625).
- 1.24 Sediment samples for PAH from the adjacent ground at distances of 0.0, 0.5 and 1.0 meters from the edge of the ballast along three transects (one transect adjacent to each tie). (GC/MS; EPA Method 8270).
- 1.25 Samples of ballast rock for PAH at distances of 5, 20 and 30 cm from each tie (GC/MS; Modified EPA Method 8270).
- 1.26 At the end of the study, core samples will be collected to the full depth of the ballast and sand substrate. These cores will be sectioned and each length analyzed individually for PAH to determine the potential for vertical migration (GC/MS; EPA Method 8270).

Table 1. Summary of analyses used to evaluate the migration of creosote derived PAH from treated railway ties.

Parameter	Treated Ties	Control	Samples/Year
Sediment Grain Size	Baseline and end of study	Baseline and end of study	(6 samples)
Total Organic Carbon	Baseline and annually thereafter	Baseline and annually thereafter	(6 samples)
Ballast PAH (5, 20 and 30 cm from each tie)	Baseline and annually	Baseline and annually (three samples from ballast)	(12 samples) (18 in yr. 1)
Shallow groundwater sample	Baseline and semiannually	Baseline and semiannually	(12 samples)
First flush water grab ¹	One summer, one winter event (3 replicate samples)	One summer, one winter event (3 replicate samples)	(12 samples)
Wetland surficial sediment PAH	Baseline and annually in August (0.0, 0.25, 0.5 and 1.0 meters along three transects)	Baseline and annually in August (0.0 meters on 3 transects)	(15 samples) 21 in yr. 1
Ballast and silt-clay core sample PAH analysis	End of study in 10 centimeter increments from the surface. One station in center of ballast; one at 0.0 meters and one at 1.0 meters from the edge of the ballast. (27 samples)	end of study in 15 cm increments at the center of the ballast and at 0.0 meters from the edge of the ballast (12 samples).	(39 samples at end of study)

Notes: 1) the summer first flush grab will be accomplished using 1" of artificial rain applied during hot (>85° F daytime temperature) weather. Air temperature will be recorded at 0800, 1300 and 1500 hours for 5 days before the test is conducted. Temperature, pH, dissolved oxygen and turbidity will be measured for each grab sample.

Sample collection will be conducted in accordance with protocols contained in the Puget Sound Estuary Program Protocols (PSEP, 1986). Analysis of PAH will be by EPA Method 625 for water and 8270 for soils and ballast. Normal QA/QC procedures will be provided (split samples, spikes, blanks, etc.)

1.22 Reporting. The results of this study will be detailed in annual reports commencing at the end of the first year. Annual reports will be submitted by March of each following year. A final report will provide an analysis of all findings. The results of this study will document the following:

- degree of vertical PAH migration through railway bed ballast to underlying substrates.
- transport of PAH into adjacent wetland soils by stormwater
- horizontal movement of PAH into adjacent shallow groundwater
- accumulation of PAH in railway ballast as a function of both horizontal distance and depth
- accumulation of PAH in adjacent wetland soils as a function of both horizontal distance and depth.
- a comparison of observed PAH levels with toxic thresholds and regulatory standards
- an examination of the microbial degradation of various molecular weight PAH. Our current understanding of PAH degradation is that the high molecular weight PAH are more refractory than the low molecular weight. If this hypothesis is true, we should see a shift in the composition of sedimented PAH from an initial mixture similar to creosote oil, to one in which the higher molecular weight benzo - and ideno- compounds are found in proportions in sediments exceeding those found in new creosote oil. This information will be valuable in understanding historical PAH contamination such as that observed adjacent to the Commonwealth Edison railway spur in Will County Illinois.

The BACT experimental design used in this study includes sufficient replicates to enable statistical tests of the difference between samples collected at control and treatment sites. The design is such that statistical significance can be examined using either regression or Analysis of Variance techniques.

***Aquatic Environmental Sciences
644 Old Eaglemount Road
Port Townsend, WA 98368
(360) 732-4464***

March 18, 1997

Rich Monzingo
Environmental Services
Commonwealth Edison, Inc.
125 S. Clark Street
P.O. Box 767
Chicago, IL 60690-0767

RE: Creosote migration study from railway ties into surrounding soils and wetland areas.

Dear Rich,

The following paragraphs answer questions raised by the U.S. Fish and Wildlife Service in their letter to you dated January 29, 1997.

- 1. Study location.** No comment. I will agree that the study should be conducted in a location as similar to the area of concern as possible. Selecting a study site is important to the quality of the results. It would appear appropriate to have me review the selected site prior to commencing construction of the mesocosm.
- 2. Section 1.2.** Preliminary study design indicates that there would be "three sections of simulated track" constructed for the study, whereas Figure 1 indicates that there will be two sections of track (treated and control). What is the third section intended to be?

Response. The number "three" was used in error. The proposal should have read "two."

- 3. Composition and structure of simulated railroad bed.** We recommend that the composition and structure of the simulated railroad bed and ballast be as similar as possible to the typical composition and structure of that at the ComEd project site or, minimally, be representative of railroad beds in general.

Response. I concur that the railroad bed and ballast be as similar as possible to the typical composition and structure of the ComEd project site. This implies that used creosote treated ties, similar to those already in place, should be used in the treatment mesocosm.

This study should answer questions specific to the ComEd project. However, there is an opportunity to examine the broader issue of potential environmental contamination from new railway ties in a second treatment mesocosm. It is my understanding that Commonwealth Edison would consider contributing to this part of an expanded study by constructing the additional mesocosm and paying for sample collection. A third party would be required to pay for the \$15,000.00 in additional analytical chemistry (assuming a quarterly sampling schedule). Commonwealth Edison would then consider having the resulting data analyzed and included in the final report documenting this study.

4. **Adjacent sediment TOC.** Dr. Brooks' June 23, 1996 report (Risk assessment for Hine's emerald dragonfly (*Somatochlora hineana*) associated with the use of creosote treated railway ties) indicated that total organic carbon (TOC) ranged from a low of 1.76% to a high of 5.88%. The report recommended that due to variability in TOC levels, PAH toxicity at each treatment site be evaluated on the basis of local TOC values. The mesocosm study has proposed a single TOC level of 2.5% in the top 4 cm of the silt/sand substrate. We recognize that it would not be feasible to create several treatment sites representing the variability of the TOC levels. We believe the 2.5% level is appropriate because it is lower than the average of 3.25% at the ComEd site, and thus would be more conservative in terms (of) PAH toxicity and migration.

Response: The bioavailability of polycyclic aromatic hydrocarbons is closely tied to total organic carbon content in receiving soils (sediments). My original comment was intended to indicate the need to evaluate toxicity associated with PAH at various sites along the existing right of way in light of the TOC observed in the samples from which the PAH were analyzed. It was my judgment that receiving sediments in the mesocosm should be adjusted to 2.5% TOC. Organic carbon content of receiving sediments has nothing to do with PAH migration rates from the railway ties - it effects the sediment binding and bioavailability of PAH. Other than that, I concur with the reasoning given by the USFWS. It should be noted that the TOC added to this mesocosm should be "natural" such that it contains a normal suite of bacterial flora common to this area. A sterile mesocosm will not mimic natural conditions with respect to the microbial degradation of creosote lost from the ties.

5. **Types of railway ties to be used.** The proposal did not provide any information regarding the description of the "conventional" creosote ties to be used at the treatment site. We recommend that the creosote-treated ties to be used be new ties with no more weathering, when installed, than would typically be done by railroad tie suppliers. We also recommend that the treated ties and the control ties be of the same tree species, if possible.

Response: The purpose of this study is to examine the environmental effects associated with the used creosote treated ties carrying this spur through a wetland. The word

"conventional" refers to railway ties similar to those currently in place. I agree that untreated control ties be of the same species.

6. Sampling Protocol. For the first flush water grab, where in relation to the ties and ballast will the samples be collected? How will these samples be collected? How much water is expected to be collected in each sample? If the answers to these questions are in GC/MS and EPA Method 625, please provide them for our review.

Response: GC/MS refers to the analytic method (Gas Chromatograph/Mass Spectrophotometer) and EPA Method 625 describes the procedures used during analysis. There are no specific sampling protocols published for field sampling in this type of study. However, general protocols for collecting surface water samples are contained in the Puget Sound Estuary Protocols (PSEP, 1996). This document contains the most thorough set of protocols appropriate to a wide range of environmental sampling that I am aware of. PSEP (1986) is approved by the EPA and where appropriate, references either EPA or ASTM protocols.

Stormwater will percolate through the ballast very quickly and spread out on the sand-silt substrate. The reason for installing a 6 mil barrier is to contain all rainwater, creating an artificial wetland. The original intent was to collect one liter of stormwater in a properly prepared glass container, at mid depth, from standing water contained within the polyethylene lined mesocosm. The sample should be taken at the mid point along the length of the simulated railway track at a distance of 0.5 to 1.0 meters from the edge of the ballast.

There are a number of ways in which the samples can be collected. My own preference is to use a battery operated peristaltic pump (MasterFlex™, etc.) with a short section of precleaned polyethylene running around the pump head and connected to either precleaned Teflon™ or glass tubing for the remainder of the sampling device. Separate tubing sets should be used for each sample. Assuming that a peristaltic pump is used, water should be collected at mid depth. This will insure that the water sample is not contaminated by silt suspended in the sampling procedure.

Alternatively, we could insert three, precleaned, Pyrex dishes into the sand-silt substrate to collect storm water. The water would then be transferred into one liter sampling bottles. All sample bottles, should be constructed of glass, pre-cleaned with a phosphate free detergent, thoroughly rinsed with hot tap water and analyte-free water. They should then receive an acetone rinse followed by a final rinse in high-purity methylene chloride. The lids should be in place on the container during this final rinse step (solvent in the container with the lid tightly screwed down) because the solvents may rinse plastic from the interior screw threads onto the Teflon™ lining. Firing of glass containers at approximately 350°C for four hours may be substituted for the final solvent rinse only if precautions are taken to avoid contamination as the container is dried and cooled.

7. Sampling differences between control and treatment mesocosms. Why are there differences between the treatment and control sites in distances of samples to be collected for the wetland surficial sediment PAH and for the ballast and silt-clay core sample PAH analysis (as indicated in Table 1).

Response: Other than atmospheric deposition, there are no sources of PAH to the control mesocosm. Replicate sediment samples are collected within the control mesocosm to provide a statistical basis (ANOVA or *t-test*) for evaluating PAH levels observed at varying distances from the creosote treated ties in the treatment mesocosm. Additional control samples will not significantly improve the power of the tests which will be determined by the number of treatment replicates. If significant levels of PAH are observed in sediments from the control mesocosm on the first sampling event, then additional samples will be taken at the same distances specified for the treatment mesocosm. However, at this point, there is no reason to expect PAH levels in the control mesocosm to increase above baseline and therefore the additional cost is not warranted.

8. How will the ballast sample be collected and analyzed? If the answer to this question is in EPA Method 8270, please provide it for our review.

Response: EPA Method 8270 is the method used to analyze for PAHs and contains no information regarding field procedures for sample collection. A copy of the analytical method is available from EPA. To the best of my knowledge, this study is the first to examine PAH concentrations in association with railway ties and stormwater. I am unaware of any published protocol for evaluating PAH in railroad ballast.

The PAHs lost from railway ties will be adsorbed to the surface of ballast rocks. In either case, a ca. 500 gram sample of ballast will be collected using properly cleaned stainless steel forceps and placed in a one liter, pre-cleaned glass bottle with a Teflon™ lid. All samples collected for semivolatile analysis should be stored in the dark, on ice at 4°C while in the field. Sediment samples (including ballast) can be frozen for later analysis. Water samples should be stored at 4°C in the dark until analyzed within 7 days.

It will be important that persons entering the mesocosm wear precleaned boots or some form of slip-on protection to insure that foot traffic does not contaminate the mesocosm with PAH. It is also important that these mesocosms be secured from trespass.

Polycyclic aromatic hydrocarbons will be washed from ballast rock using an appropriate solvent (hexane, etc.). The analytical laboratory should develop this part of the procedure. The methodology will depend, in part, on their best judgment. Dr. Brooks will work out details of this procedure with the lab at an appropriate time.

Sediment concentrations of PAH are normally measured in soft sediments and are expressed either as a percent of sediment dry weight, or as a proportion of the total organic carbon present in the sediment. In this case, we do not expect measurable amounts of TOC in the ballast. At least not in that part of the ballast lying above the artificially created water table. Therefore, the amount of PAH observed will be expressed

as a function of sediment dry weight. We could express the result in terms of surface area of the rock ballast. That can be done in a number of ways. One way is to carefully cover the surface of each stone with a single layer of aluminum foil. By comparing the weight of foil required to cover all surfaces in the sample with the surface area to weight ratio of the foil, it is possible to estimate the surface area of irregular surfaces, such as crushed rock ballast. Obviously, the foil method would be accomplished following removal of the PAH. This is time consuming and would not provide a useable metric for future work. However, I recommend that all ballast samples be archived. If we find high variance in the PAH content based on ballast weight, we may want to look at surface area as an alternate metric in an attempt to control variance.

Polycyclic aromatic hydrocarbons will be measured in the surficial layer (upper 2 cm) of the sandy-silt matrix mimicking wetland soils. This is where we are likely to find the highest concentrations of PAH. Approximately 100 grams of this layer will be removed using a precleaned stainless steel spatula and placed in a precleaned glass jar fitted with a Teflon™ liner. The spatula will be cleaned with reagent grade acetone in the field between each sample. Sample location will be at a fixed distance from the ballast - sediment interface. The lateral position of each sample will be determined using a random number generator. All samples will be collected within one meter from the middle of the of the simulated railway bed.

9. Use of Puget Sound Estuary Program Protocols. Are there particular reasons the Puget Sound Estuary Program Protocols was (were) selected for sample collection rather than protocols from the U.S. Environmental Protection Agency or the American Society for Testing and Materials (ASTM)? We would like the opportunity to review the Puget Sound protocol.

Response: The Puget Sound Estuary Program (1996) has brought together and expanded a broad range of EPA and ASTM protocols for the measurement of environmental variables in freshwater and marine environments. PSEP (1996) references EPA or ASTM protocols where they exist. In other words, PSEP (1996) expands, but does not replace either ASTM or EPA protocols. A copy of the most current edition of PSEP (1996) is provided on five 3.5" disks with this letter. Parts are written in WP 5.1 and parts in Word 6.0. I had no trouble interpreting either format using Word for Windows 95.

10. Sampling interval. We recommend that water and sediment samples be taken quarterly, rather than annually. If equilibrium is expected in just one year, one sample at each year of the two year study will essentially only give us end results. More frequent samples would provide more information on the route and rate of migration.

Response: Quarterly sampling will essentially increase the sample collecting and analysis cost by a factor of three to four. Railway rights of way have long lifetimes. It will likely take between one and two years to achieve an equilibrium between PAH lost

from the ties and PAH metabolism in the sediments by bacteria and photodegradation by sunlight in shallow wetland environments. The purpose of annual monitoring is to quantify long term PAH levels associated with the use of creosote treated railway ties.

Quarterly monitoring would be expensive, but will provide a better understanding of the short-term accumulation of PAH in wetland sediments. As a scientist, I am always in favor of more information. However, the question of study cost versus the level of understanding achieved, is one that Commonwealth Edison must address.

11. Detection limits. What will be the detection limits?

Response for sediment analyses. The following detection limits have been proposed by National Environmental Testing, Inc. for the Commonwealth Edison Company *PAH Sediment Sampling Study in River South Parcel*. These same detection limits are recommended for sediment analysis in this mesocosm study.

Parameter	Reporting Limit	Units
Solids, Total	0.1	%
Total Organic Carbon	0.001	%
Acenaphthene	0.020	mg/Kg
Acenaphthylene	0.020	mg/Kg
Anthracene	0.020	mg/Kg
Benzo(a)anthracene	0.0026	mg/Kg
Benzo(b)fluoranthene	0.0036	mg/Kg
Benzo(k)fluoranthene	0.0034	mg/Kg
Benzo(a)pyrene	0.0046	mg/Kg
Benzo(ghi)perylene	0.020	mg/Kg
Chrysene	0.020	mg/Kg
Dibenzo(a,h)anthracene	0.006	mg/Kg
Fluoranthene	0.020	mg/Kg
Fluorene	0.020	mg/Kg
Indeno(1,2,3-cd)pyrene	0.0086	mg/Kg
Naphthalene	0.020	mg/Kg
Phenanthrene	0.020	mg/Kg
Pyrene	0.020	mg/Kg

Response for water column PAH analyses. The replicated summer and winter stormwater samples are designed to determine the loss of PAH into the wetland in the first two years following construction during periods of high and low ambient temperature. I have no information regarding stormwater concentrations of PAH associated with railway ties. However, based on marine studies of water column PAH associated with creosote treated piling, I believe they will be low. We have measured

PAH concentrations within a few inches of marine piling, treated to 27 pcf, at less than 30 parts per trillion. However, the techniques are experimental, expensive and not recommended in this study.

A detection limit of $1.0 \mu\text{g}\cdot\text{L}^{-1}$ should be achievable using basic GC/MS for PAH in freshwater. Polycyclic aromatic hydrocarbon detection limits of 0.2 to $0.5 \mu\text{g}\cdot\text{L}^{-1}$ are possible for PAH analyses using Selected Ion Monitoring (SIM) analysis on a GC/MS system run in accordance with EPA Method 625. However, there are no EPA approved methods for the SIM technique and the cost is ca. \$35.00 more per sample. Photoenhanced toxicity of fluoranthene and anthracene has been observed in the range of ca. $3 \mu\text{g}\cdot\text{L}^{-1}$. I recommend that water samples be analyzed using SIM GC/MS with detection limits of $\leq 0.5 \mu\text{g}\cdot\text{L}^{-1}$.

I hope this answers those questions posed by the Fish and Wildlife Service.

Sincerely,

Dr. Kenneth M. Brooks
President, AES

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Railway Right-of-Way Contaminants in the Lower Mainland of British Columbia: Polycyclic Aromatic Hydrocarbons

Michael T. Wan*

ABSTRACT

Ballast from five railway rights-of-way and the adjacent ditches flowing to salmon streams in the Lower Mainland of British Columbia, Canada, were sampled in 1989 to determine the occurrence and levels of 16 selected polycyclic aromatic hydrocarbons (PAH). Reference and background levels of PAH in ditches leading to fish streams were obtained from pristine parklands and agricultural lands. PAH levels in sediments reported by Goyette and Boyd (1989) for Burrard Inlet (Inner Harbour), the commercial harbour of Vancouver, British Columbia, were used for comparison. All 16 PAH were found in the ballasts and ditch sediments/water of the five railway rights-of-way. In the ballasts, total levels of the 16 PAH varied from 1.562-58.773 g/m³, averaging 18.069 g/m³. The mean concentration of the total 16 PAH in ditch sediments was 213.47 µg/g (range, 1.89-1168.71 µg/g). PAH were not consistently found in ditch water at all study sites, but at sites where they occurred, the selected 16 compounds had an average total concentration of 606.9 µg/L (range, 1-3515.9 µg/L). PAH were not detected in the ditches of pristine parklands but low concentrations were detected in some agricultural samples. The total level of the 16 PAH in sediments from railway ditches were respectively 205 and 40 times higher than levels found in the sediments of farmland ditches and Burrard Inlet. Some biological implications of PAH-contaminated sediments and water from railway ditches discharging into fish habitats are discussed.

POLYCYCLIC AROMATIC HYDROCARBONS (PAH) are widely distributed in atmospheric and aquatic environments (Katz et al., 1980). The primary source of these contaminants is the inefficient combustion or pyrolysis of organic materials (Schmeltz and Hoffmann, 1976). Locomotive exhaust from the combustion of fossil fuels (i.e., coal, coke, and wood historically; petroleum products recently) is likely an important source of PAH in the ballasts and railway right-of-way ditches. Other likely sources of PAH are creosotes and petroleum products used for the preservation of railway ties, and herbicides (particularly those containing oil-based ingredients) applied for the control of weeds on rights-of-way. In addition, some

PAH may originate as atmospheric fallout of industrial airborne particulate matter.

In 1989, Environment Canada carried out a study to determine the levels of selected PAH in the ballasts and the right-of-way ditches of major railways operating in the Lower Mainland of British Columbia (i.e., B.C. Rail, Burlington Northern Rail, CN Rail, CP Rail, and Southern Railway of BC). The main objective of this study was to determine the occurrence and

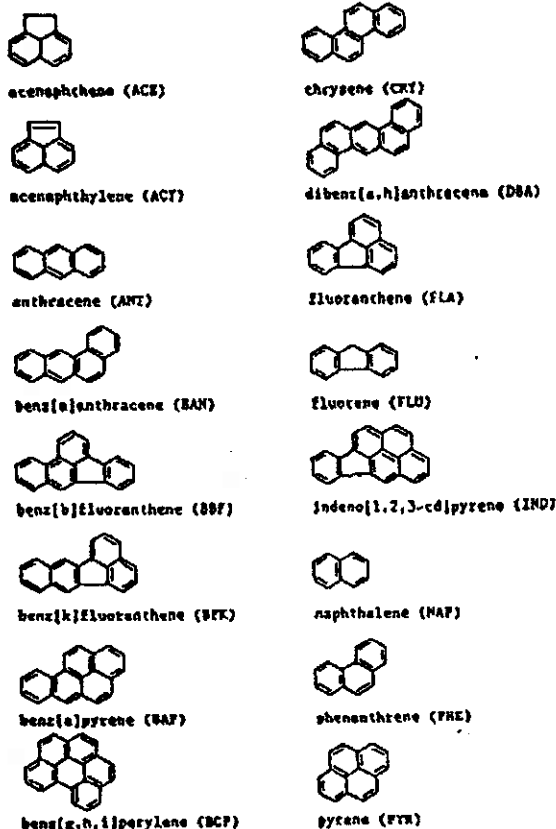


Fig. 1. Structures of selected polycyclic aromatic hydrocarbons (PAH).

Environment Canada, Conservation and Protection, Environmental Protection, Pacific & Yukon Region, 224 West Esplanade Avenue, North Vancouver, BC V7M 3H7 CANADA. Received 27 Mar. 1990.
 *Corresponding author.

Assume $P = 3.5$
 Sed depth \approx total sediment weight = $10,000 \times 5 \times 3.5 = 175,000 \text{ g}$
 $18 \text{ g/m}^2 \Rightarrow 100 \mu\text{g/g}$

WAN: RAILWAY RIGHT-OF-WAY CONTAMINANTS

levels of PAH in right-of-way ditches and to evaluate their significance and potential impact, if any, to aquatic invertebrates and Pacific salmon (*Oncorhynchus* spp.) and trout (*O. mykiss*) in streams receiving discharges from railways.

Although many PAH compounds exist, this study limits its scope to the 16 better known PAH (Fig. 1), many of which are not only toxic to fish and aquatic invertebrates but some are also suspected to be carcinogens and mutagens (Moore and Ramamoorthy, 1984; Heitkamp and Cerniglia, 1989). The chemical structures of these PAH compounds are illustrated in Fig. 1.

MATERIALS AND METHODS

Sampling Sites

Railway ballasts and right-of-way ditches removed from industrialized areas were selected as study sites (Fig. 2). The following additional criteria were applied in the selection of right-of-way ditches for monitoring, i.e., ditches that: (i) flowed directly into fish habitat or other waterbodies, (ii) did not receive industrial effluents, farm runoff, or residential sewage, (iii) were situated within 5 m of the railway ballast, and (iv) contained water approximately 0.25 m in width and 0.1 m in depth.

Based on the above considerations, six sites from five railway rights-of-way were selected for sampling near the end of the rainy season (during April 1989) to coincide with the period of maximum seasonal runoff. For comparison, six reference sites were also sampled to obtain data on background occurrence of PAH in both pristine and agricultural drainages. The sampling sites were designated with a number to guide the readers in the discussion (Fig. 2). This study was a one-time survey to determine the concentration of the selected sixteen PAH. In addition, data on Burrard Inlet (Inner Harbour) sediments (Goyette and Boyd, 1989) were also used for comparing PAH levels in different aquatic sediments.

Post 1989

Sampling Procedures

Amber sample bottles and jars were prewashed in pesticide grade acetone and petroleum ether and preheated to 325°C for 12 h before use. Solvent washed and heated aluminum foil was used to line all water bottles and glass jars to prevent contamination.

Gravels (size range: 0.1-5 cm) were collected from the top 5 cm of the ballast (randomly selected midsection) at each site within a square quadrant (30 cm by 30 cm). The contaminants from the gravel sample were extracted immediately at the site with 0.5-L ethyl acetate in a 1-L beaker using swirling action for 2 min. The acetate extracts were then decanted into 0.5-L amber glass bottles for storage in ice coolers.

Samples of water and sediment were obtained at random from ditches of both sides of the railway. Sampling was conducted within the same general area of each study site. Water samples were collected in 1-L amber bottles. Ten 100-mL composite samples were pooled to make up a 1-L sample per site during each sampling occasion. Ten 45-g composite sediment samples were collected from the ditches at each site and were stored in 500-g widemouth amber glass jars. The samples were obtained with a circular (15 cm diam.) steel trowel fitted with a 2-m wooden handle. A smaller steel trowel was used to transfer the required portion of the sediment to the storage jars. Samples were stored at 4°C and shipped to the laboratory the next day.

Sampling for what definition?

Polycyclic Aromatic Hydrocarbons Analysis

Polycyclic aromatic hydrocarbons analyses were conducted by the British Columbia Research Laboratory, Vancouver, BC. The sediment samples were air-dried and sieved using a 10-mesh screen, then blended and subsampled. A 20-g subsample was transferred to a flask with 100 mL of ethanol, 5 g KOH, and a few boiling chips. The sample was then refluxed for 2 h. After allowing the extract to cool, it was decanted through a glass wool plug into a 1-L separatory funnel containing 150 mL of deionized water. The sediment

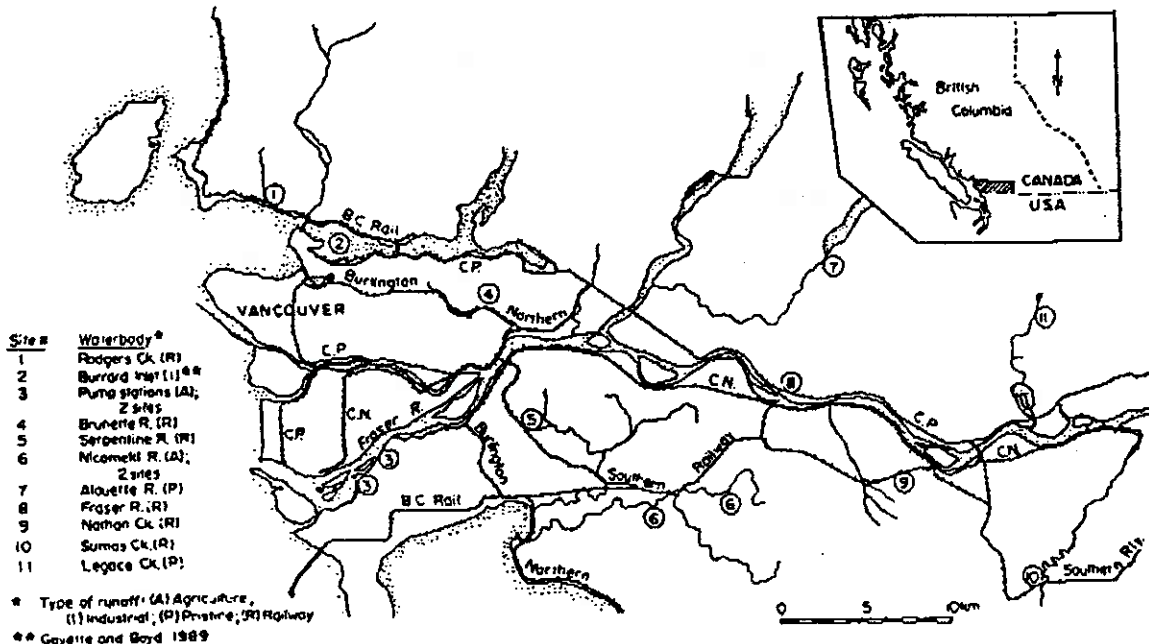


Fig. 2. Location of survey and sampling sites.

was then washed twice with 50 mL of ethanol added to the separatory funnel.

The water/ethanol mixture was extracted three times with 200 mL 2,2,4-trimethylpentane. The combined iso-octane extracts were then washed four times with 200-mL portions of warm (60°C) deionized water. The iso-octane extract was placed on a Florisil column and the PAH were eluted with benzene. The eluate was collected and transferred to 5 mL of hexane using rotary evaporator. The fraction was transferred to an activated silicic acid (10 g) column. The column was washed with 50 mL of hexane and the PAH eluted with 60 mL 40/60 mixture of dichloromethane and hexane. The PAH were transferred to 4 mL hexane using a roto-evaporator. When required, a third column of 5 cm of activated alumina in a 230 mm by 5 mm (i.d.) disposable pasteur pipette was used. The column was washed with 5 cm of hexane, and the concentrated PAH fraction from the previous step was added. A further 5 mL of hexane was added and the column was allowed to drain until the solvent reached the top of the column. The PAH were eluted with 10 mL of toluene and using a roto-evaporator, transferred to 4 mL of hexane. Method blanks, spike/recoveries, and a range of standards were analysed along with the cleaned up sample extracts.

The total volume of each water sample was recorded and transferred to a separatory funnel. The samples were ex-

tracted three times with 75 mL dichloromethane. The extracts were combined and transferred to 3 mL hexane, using a rotary evaporator. The concentrated sample extracts were cleaned up using silica gel and alumina as described above. The PAH fraction was taken up in 4 mL final volume of hexane.

The total volume of each ethyl acetate extract sample was measured and transferred to ca. 4 mL of hexane using a rotary evaporator. The concentrated extracts were then cleaned up using the same procedure described above. The PAH fraction was taken up in 4 mL hexane.

All cleaned extracts were analyzed on a Hewlett-Packard 5988A gas chromatograph/mass spectrometer (GC/MS) selected ion mode (HRGC/LRMS-SIM). A DB-5, 30 m by 0.25 mm (i.d.), fused-silica capillary column was directly coupled with the ion source. The MS was operated under electron impact (EI) ionization with a 70 eV ionization voltage. Quantification was based on selected ion monitoring listed as follows: ACY (152), ACE (154), FLU (166), PHE/ANT (178), FLA (202), FYR (202), BAN (228), CRY (228), BBF/BKF (252), BAP (252), BGP (252), IND (276), BGP (276), DBA (278).

Duplicate samples of sediment and water were fortified with the 16 PAH submitted to the laboratory along with regular samples. Their recovery rates are presented in Table 1. Polycyclic aromatic hydrocarbons are also categorized into

Table 1. Recoveries of PAH from sediment and water (quality control samples).

Compound	Abbrev.	Fortification level	N	Recovery, mean %	Detection limit
					$\mu\text{g}/\text{kg}$
Sediment					
Low molecular weight PAH (LPAH)					
Acenaphthene	ACE	800	2	50.6	10
Acenaphthylene	ACY	800	2	29.4	10
Anthracene	ANT	800	2	62.6	10
Fluorene	FLU	800	2	53.8	10
Naphthalene	NAP	800	2	11.0	10
Phenanthrene	PHE	800	2	83.3	10
High molecular weight PAH (HPAH)					
Benz[a]anthracene	BAN	800	2	114.8	50
Benz[b]fluoranthene	BBF	800	2	100.8	80
Benz[k]fluoranthene	BKF	800	2	108.8	80
Benz[a]pyrene	BAP	800	2	87.7	100
Benz[g,h,i]perylene	BGP	800	2	72.4	100
Chrysene	CRY	800	2	115.2	10
Dibenz[a,h]anthracene	DBA	800	2	62.3	100
Fluoranthene	FLA	800	2	97.9	50
Indeno[1,2,3-cd]pyrene	IND	800	2	67.1	100
Pyrene	PYR	800	2	100.6	50
Water					
Low molecular weight PAH (LPAH)					
Acenaphthene	ACE	80	2	88.9	0.1
Acenaphthylene	ACY	80	2	89.1	0.1
Anthracene	ANT	80	2	67.1	0.1
Fluorene	FLU	80	2	82.3	0.1
Naphthalene	NAP	80	2	92.3	0.1
Phenanthrene	PHE	80	2	81.3	0.1
High molecular weight PAH (HPAH)					
Benz[a]anthracene	BAN	80	2	95.4	0.5
Benz[b]fluoranthene	BBF	80	2	102.6	0.5
Benz[k]fluoranthene	BKF	80	2	104.8	0.5
Benz[a]pyrene	BAP	80	2	103.4	0.5
Benz[g,h,i]perylene	BGP	80	2	91.3	0.8
Chrysene	CRY	80	2	87.8	0.5
Dibenz[a,h]anthracene	DBA	80	2	130.1	0.8
Fluoranthene	FLA	80	2	93.0	0.5
Indeno[1,2,3-cd]pyrene	IND	80	2	89.1	0.8
Pyrene	PYR	80	2	96.4	0.5

two groups in the results/discussion: (i) LPAH—low molecular weight PAH, and (ii) HPAH—high molecular weight PAH (Table 1).

RESULTS AND DISCUSSION

Method Evaluation

Recovery rates of the 16 PAH in fortified water and sediment samples are presented in Table 1. The recovery rates for water were generally good, except for ANT and DBA. The recovery rate of ANT is low and DBA is high, and their causes are presently not known. For sediments, the recovery rates were also generally good, with the exception of the low molecular weight PAH such as ACE, ACY, ANT, FLU, NAP, and PHE. The recovery rates of these PAH in sediments in particular are lower than expected. The air-drying process and the use of rotary evaporation during extraction may have caused an appreciable loss of these PAH due to their high volatility. A recovery factor for each compound based on the mean recovery efficiency (Table 1) was applied in the calculation of the concentration of each PAH in both sediment and water samples.

Polycyclic Aromatic Hydrocarbons in Railway Ballasts

The occurrence and levels of the 16 PAH selected for this study are presented in Table 2. As expected, all 16 compounds were found in the six railway sampling sites of the Lower Mainland of British Columbia. The levels of total PAH varied considerably from site to site, averaging 18.069 g/m² (range, 1.562–58.773 g/m²).

Generally, the levels of LPAH (i.e., low molecular weight PAH with two to three aromatic rings) were much lower than the levels of HPAH (i.e., high molecular weight PAH with four to six aromatic rings) (Table 2). The mean concentration of the sum of LPAH was 2.009 g/m² (range, 0.081–6.965 g/m²),

whereas the mean concentration of the sum of HPAH was 16.060 g/m² (range, 1.481–51.808 g/m²). The causes of the comparatively low concentrations of LPAH are presently not known.

Individual LPAH such as ACE, ACY, ANT, FLU, and NAP were found with mean levels lower than 0.200 g/m², whereas PHE averaged 1.487 g/m² (range, 0.054–5.083 g/m²). For the individual HPAH, all the compounds under study were found at mean levels greater than 0.500 g/m², with the exception of DBA, which had a mean value of 0.164 g/m² (range, 0.033–0.743 g/m²). Mean concentrations of BBF, CRY, FLA, and PYR were greater than 2.00 g/m² (range, 0.095–11.72 g/m²).

Polycyclic Aromatic Hydrocarbons in Ditch Sediments

Similar to the findings for railway ballasts, the 16 PAH selected for study occurred in the sediments of all ditches sampled adjacent to the rights-of-way (Table 3). The levels of total PAH in ditch sediments varied considerably from site to site, averaging 213.47 mg/kg (range, 1.89–1168.71 mg/kg). Higher concentrations (i.e., greater than 50 mg/kg) of total PAH were found in sediments of ditches located closer to the ballasts (i.e., <1 m) than in sediments collected from more distant ditches (i.e., >1 m). Levels of both total LPAH and HPAH from Site 9 ditch sediments were substantially elevated. One possible cause could be the presence of creosote-treated power/telecommunication line poles erected in the ditches (along both sides of the railway) of Site 9, (Fig. 1).

There was a range of mean concentrations for individual LPAH, grouped as follows: with ACY and NAP (<0.50 mg/kg); ACE and ANT (>2 mg/kg); and FLU and PHE (>20 mg/kg), (Table 3). A similar trend in mean values in ditch sediments occurred with individual HPAH, grouped as follows: BGF, DBA, IND (<1 mg/kg); BBF and BAP (>1 mg/kg); and BAN, CRY, FLU, and PYR (>7 mg/kg).

Table 2. Polycyclic aromatic hydrocarbons† in railway ballasts of Lower Mainland, BC.

Compound, g/m ²	Location (see Fig. 2)						Mean, g/m ²
	1	4	5	8	9	10	
Low molecular weight PAH (LPAH)							
Acenaphthene	0.010	0.169	0.057	0.307	0.065	0.006	0.102
Acenaphthylene	0.003	0.008	0.024	0.170	0.004	0.002	0.035
Anthracene	0.030	0.158	0.130	0.613	0.119	0.007	0.176
Fluorene	0.089	0.175	0.049	0.625	0.082	0.009	0.172
Naphthalene	0.003	0.039	0.007	0.167	0.004	0.003	0.037
Phenanthrene	0.305	1.200	1.081	5.083	0.996	0.054	1.487
Total LPAH	0.640	1.749	1.348	6.965	1.270	0.081	2.009
High molecular weight PAH (HPAH)							
Benz[a]anthracene	0.771	0.858	0.464	3.983	0.567	0.589	1.205
Benz[b]fluoranthene	0.226	1.831	1.786	8.871	0.662	0.095	2.245
Benz[k]fluoranthene	0.039	0.775	0.947	6.860	0.334	0.066	1.504
Benz[a]pyrene	0.036	0.381	0.521	3.418	0.274	0.002	0.772
Benz[ghi]perylene	0.115	0.242	0.711	3.286	0.192	0.005	0.759
Chrysene	1.111	3.594	2.405	11.720	1.658	0.277	3.461
Dibenz[ah]anthracene	0.020	0.058	0.132	0.743	0.026	0.003	0.164
Fluoranthene	0.282	5.878	2.700	0.740	2.677	0.216	2.082
Indeno[1,2,3-cd]pyrene	0.046	0.347	0.808	3.966	0.229	0.002	0.899
Pyrene	0.701	4.438	2.282	8.271	1.949	0.226	2.969
Total HPAH	3.347	18.402	12.756	51.808	8.568	1.481	16.060
Total PAH	3.987	20.151	14.104	58.773	9.838	1.562	18.069

† Via ethyl acetate extract in the field and adjusted for recovery rates; see Table 1 for detection limits.

GMV
10/1
GMV
10/2

Table 3. Polycyclic aromatic hydrocarbons in ditch sediments of Lower Mainland railways, BC.

Compound, mg/kg†	Location (see Fig. 2)						Mean, mg/kg
	1	4	5	8	9	10	
Low molecular weight PAH (LPAH)							
Acenaphthene	0.14	1.68	1.68	0.08	12.73	0.02	2.22
Acenaphthylene	0.03	0.14	0.30	0.03	0.99	0.03	0.25
Anthracene	0.35	3.37	3.63	0.08	40.58	0.03	8.00
Fluorene	0.21	1.51	3.59	0.13	116.40	0.04	20.31
Naphthalene	0.09	1.09	0.09	0.27	0.73	0.46	0.46
Phenanthrene	1.33	2.07	12.70	0.36	203.59	0.17	36.70
Total LPAH	2.15	9.86	21.99	0.95	375.02	0.75	68.44
High molecular weight PAH (HPAH)							
Benz[a]anthracene	2.00	1.09	1.45	0.02	42.68	0.02	7.88
Benz[b]fluoranthene	2.47	0.74	0.59	<0.08	13.90	<0.08	2.95
Benz[k]fluoranthene	0.61	0.40	0.25	<0.10	7.06	<0.10	1.39
Benzo[a]pyrene	3.56	0.64	0.31	0.11	9.12	0.11	2.30
Benzo[g,h,i]perylene	2.17	0.14	0.14	0.14	1.40	0.14	0.69
Chrysene	5.09	1.81	2.13	0.97	59.46	0.06	11.44
Dibenz[a,h]anthracene	0.77	0.16	0.16	0.16	0.35	0.16	0.29
Fluoranthene	1.91	7.18	15.32	0.33	522.98	0.29	91.34
Indeno[1,2,3-cd]pyrene	1.31	0.13	0.13	0.15	1.74	0.15	0.60
Pyrene	4.76	6.58	10.10	0.19	135.00	0.21	26.14
Total HPAH	24.65	18.87	30.58	1.17	793.69	1.14	145.03
Total PAH	26.8	28.73	52.57	2.12	1168.71	1.89	213.47

† Dry weight and adjusted for recovery rates; see Table 1 for detection limits.

Polycyclic Aromatic Hydrocarbons in Ditch Water

Unlike the ballasts and ditch sediments, PAH were not consistently found in ditch water (Table 4). Of the six study sites, none of the 16 PAH was detected at Site 5, and trace amounts were found at Site 4, 8, and 10. However, high levels of PAH were found at Site 1 and 9. The levels of total PAH varied greatly in ditch water from nondetectable to 3515.9 µg/L (mean value 606.9 µg/L, n = 6).

Although none of the six LPAH were found above the detection limits in four sampling sites, they were all found in the remaining study sites, i.e., Sites 1 and 9 (Table 4). The levels of total LPAH at Sites 1 and 9 were 12.2 and 665.1 µg/L, respectively, yielding an average value of 112.9 µg/L (n = 6). For the HPAH,

none of the 10 HPAH was detected above the limit of detection in Site 5. However, small amounts (1 µg/L) were found at Sites 4, 8, and 10; whereas all 10 HPAH were found at Sites 1 and 9 at respective concentrations of 110.1 and 2850.8 µg/L (mean 493.4 µg/L, n = 6). As stated earlier, a possible cause of high levels of PAH at Sites 1 and 9 could be the presence of creosote-treated power/telecommunication line poles erected in the ditches.

The mean levels of the individual LPAH such as AYE and NAP were less than 1 µg/L; whereas concentrations of ACE, ANT, FLU, and PHE were more than 8 µg/L (Table 4). For the individual HPAH, mean levels of BAP and DBA were 0.4 and 0.7 µg/L, respectively, whereas BGP and IND had respective means of 4.1 and 7.3 µg/L. High mean values for the

Table 4. Polycyclic aromatic hydrocarbons in railway ditch water flowing to salmon streams in the Lower Mainland, BC.

Compound, µg/L†	Location (see Fig. 2)						Mean, µg/L
	1	4	5	8	9	10	
Low molecular weight PAH (LPAH)							
Acenaphthene	0.6	ND‡	ND	ND	49.2	ND	8.3
Acenaphthylene	0.1	ND	ND	ND	2.6	ND	0.4
Anthracene	2.7	ND	ND	ND	55.4	ND	9.7
Fluorene	0.6	ND	ND	ND	68.8	ND	11.6
Naphthalene	0.3	ND	ND	ND	0.8	ND	0.2
Phenanthrene	7.9	ND	ND	ND	488.3	ND	82.7
Total LPAH	12.2	ND	ND	ND	665.1	ND	112.9
High molecular weight PAH (HPAH)							
Benz[a]anthracene	11.5	ND	ND	ND	182.4	ND	32.3
Benz[b]fluoranthene	11.8	ND	ND	ND	141.3	ND	25.5
Benz[k]fluoranthene	6.2	ND	ND	ND	77.9	ND	14.0
Benzo[a]pyrene	2.5	ND	ND	ND	ND	ND	0.4
Benzo[g,h,i]perylene	9.1	ND	ND	ND	15.3	ND	4.1
Chrysene	15.4	ND	ND	ND	440.8	ND	76.0
Dibenz[a,h]anthracene	1.7	ND	ND	ND	2.3	ND	0.7
Fluoranthene	20.0	0.3	ND	0.5	1226.0	0.5	207.7
Indeno[1,2,3-cd]pyrene	12.5	ND	ND	ND	31.4	ND	7.3
Pyrene	19.4	0.5	ND	0.5	733.4	0.5	125.8
Total HPAH	110.1	1.0	ND	1.0	2850.8	1.0	494.0
Total PAH	122.3	1.0	ND	1.0	3515.9	1.0	606.9

† Adjusted for recovery rates.

‡ Not detected; see Table 1 for detection limits.

BGV = 7.06

BGV = 4.03

following HPAH were found: BAN, BBF, BKF, CRY, FLA, and PYR (32.3, 25.5, 14, 76, 207.7, and 125.8 µg/L, respectively). The close proximity of the ditch to the ballasts (i.e., <1 m) and the presence of creosote-treated power line poles in the ditch probably contributed to the high levels of PAH at Site 9.

Comparison of Polycyclic Aromatic Hydrocarbons in Sediments

A comparison of PAH levels in the sediments of five aquatic environments in the Lower Mainland of British Columbia is presented in Table 5. The 16 PAH selected for study were not detected in the ditch sediments of pristine parklands and agricultural pump stations. Low levels (i.e., <0.3 mg/kg) of ACE, FLU, PHE, FLA, and PYR were found in the sediments of farmland ditches. However, the levels of the 16 PAH found in the railway ditch sediments of the present study were higher than those reported for corresponding compounds in marine sediments from Burrard Inlet (Inner Harbour) (Goyette and Boyd, 1989).

The mean concentrations of total PAH, LPAH, and HPAH in railway ditch sediments are about 40, 38, and 41 times, respectively, higher than those in Inner Harbour sediments. Individual PAH such as ACE (2.72 mg/kg), FLU (20.3 mg/kg), and PHE (36.7 mg/kg) from railway sediments are 39, 88, and 61 times, respectively, higher than values from Inner Harbour sediments. For comparison levels (in mg/kg), BAN (0.23), BBF (0.28), BKF (0.28), BAP (0.13), CRY (0.23), FLA (0.94), and PYR (0.91), of railway ditch sediments are respectively 34, 11, 5, 18, 50, 97, and 29 times higher than levels of Inner Harbour sediments. Despite larger PAH multiples in railway ditch sediments (fresh water environment), the total and individual loadings of these compounds are probably higher in the Inner Harbour sediments (marine environment) when the size of the waterbodies are taken into consideration.

Implications to Aquatic Life

The potential for acute and chronic effects on aquatic invertebrates and salmonids in streams receiving railway drainage in the Lower Mainland of British Columbia was assessed with reference to the levels of LPAH and HPAH found.

LPAH such as NAP and NAP-isomers have 96-h LC50 values in the 1 to 2 mg/L range for certain fresh water and marine aquatic organisms including copepods (*Eurytemora* sp.), polychaetes (*Neanthes* sp.), shrimps (*Penaeus* sp.), crab larvae (*Cancer* sp.), and minnow fish (*Cyprinodon* sp.) (Anderson et al., 1974; Ott et al., 1978; NRCC, 1983). The FLU had 96-h LC50 values in the 0.5 to 1.0 mg/L range for polychaetes (Rossi and Neff, 1978). In the present study, mean levels of individual LPAH in railway ditch ranged from 0.2 to 83 µg/L, with a mean for the total LPAH level of 113 µg/L (range, ND-665 µg/L). At these levels, LPAH may not be expected to cause any acute lethality to fresh water aquatic invertebrates and fish. However, the chronic impact from long-term exposure of aquatic organisms to low levels LPAH is not well understood.

Not much is known on acute toxicity to aquatic invertebrates and salmonids of HPAH such as BAN, BBF, BKF, BAP, BGP, CRY, DBA, FLA, IND, and PYR. Mean levels of individual HPAH levels in ditch water in the present study were also in the µg/L range (i.e., 0.4-208 µg/L), with an average total HPAH level of 493 µg/L (range, ND-2850.8 µg/L). Generally, impacts on salmonids exposed to low concentrations of HPAH are poorly understood. However, recent studies indicate that some HPAH at low concentrations, e.g., BAP at 7000 µg/L, negatively affect the hatching process and subsequent swimming behavior of juvenile coho salmon (Ostrander et al., 1988, 1989). The HPAH such as BAN, BBF, BAP, CRY, DBA, and IND are known to be carcinogenic when animals are exposed to low levels of these chemicals over long pe-

Table 5. Polycyclic aromatic hydrocarbons in sediments of Lower Mainland, BC.

Compound, mg/kg†	Type of aquatic environment				
	Pristine ditches (n = 2)	Farm ditches (n = 2)	Agric. pump ditches (n = 2)	Railway ditches (n = 6)	Burrard inlet‡ (n = 20)
Low molecular weight PAH (LPAH)					
Acenaphthene	ND	0.14	ND	2.72	0.07
Acenaphthylene	ND	ND	ND	0.25	0.08
Anthracene	ND	ND	ND	8.00	0.60
Fluorene	ND	0.17	ND	20.31	0.23
Naphthalene	ND	ND	ND	0.46	0.21
Phenanthrene	ND	0.29	ND	36.70	0.60
Total LPAH	ND	0.60	ND	68.44	1.79
High molecular weight PAH (HPAH)					
Benzo[a]anthracene	ND	ND	ND	1.88	0.23
Benzo[b]fluoranthene	ND	ND	ND	2.95	0.28
Benzo[k]fluoranthene	ND	ND	ND	1.39	0.28
Benzo[a]pyrene	ND	ND	ND	2.31	0.13
Benzo[g,h,i]perylene	ND	ND	ND	0.69	0.25
Chrysene	ND	ND	ND	11.44	0.23
Dibenzo[a,h]anthracene	ND	ND	ND	0.29	0.11
Fluoranthene	ND	0.24	ND	91.34	0.94
Indeno[1,2,3-cd]pyrene	ND	ND	ND	0.60	0.21
Pyrene	ND	0.2	ND	26.14	0.91
Total HPAH	ND	0.44	ND	145.03	3.57
Total PAH	ND	1.04	ND	213.47	5.36

† Mean of data above detection limit, adjusted for recovery rates.
 ‡ Goyette and Boyd (1989), laboratory B data only, not adjusted for recovery rates.

riods (Dunn and Fee, 1979; NRCC, 1983; Baumann et al., 1987; Metcalfe et al., 1988; Goyette and Boyd, 1989). The effects of long-term exposure to fish of these HPAH are also not well understood. Accordingly, the presence of low levels of these compounds in railway ditches (sediments and water) leading to salmon habitat may be of concern.

The occurrence of PAH in the railway ballasts and right-of-way ditches presents a condition for continual transport of these contaminants into the fish-habitat in British Columbia via runoff, particularly during the wet seasons of the year. The major inputs of PAH in the railway drainage could be substantially reduced by changing certain practices. Replacing wooden ties with concrete ties could eliminate the need for chemical wood preservatives (a major source of PAH). The use of concrete ties would also allow the replacement of ballast herbicides (another possible source of PAH), as weeds could be controlled by the use of pressurized steam emission devices. It is speculated that innovative scrubbers and/or filters could be developed and installed in locomotive engines to remove PAH from the exhaust.

CONCLUSIONS

The following PAH were detected in ballasts and adjacent ditch sediments/water of railway rights-of-way in the Lower Mainland of British Columbia: ACE, ACY, ANT, BAN, BBF, BKF, BAP, BGP, CRY, DBA, FLA, FLU, IND, NAP, PHE, and PYR. This study indicates that railway rights-of-way are a potential source of PAH contamination to the aquatic environment. The levels of these contaminants in ditch sediments and water varied, with highest concentrations occurring where power and telecommunication line poles are erected in railway ditches. Although the PAH levels found in the ditch water were not acutely toxic to fish, chronic exposure of aquatic invertebrates and salmonid fish to low levels may be a concern. Feasible options exist to reduce the levels of PAH contamination in the railway drainages.

ACKNOWLEDGMENTS

I would like to thank the technical staff of Conservation & Protection Laboratory, Environmental Protection (Environment Canada, Pacific & Yukon Region), S. Szeto (Ag-

riculture Canada), S. Samis (Fisheries & Oceans Canada), and G. Masson (British Columbia Research Laboratory) for their comments. Partial funding of this project was provided by Fisheries & Oceans Canada.

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From Jerry
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EXECUTIVE DIRECTOR
James C. Gauntt

To Jim Gauntt

4-4-97

115 COMMERCE DRIVE • SUITE C • FAYETTEVILLE, GA 30214

TELEPHONE (770) 460-5553 • FAX (770) 460-5573

From

March 24, 1997

Mr. Stanley R. Thomas
VP Treated Wood Products Sales
Webster Industries
Box 297
Bangor, WI 54614

Dear Stan,

Following the "green-winged" (Hines emerald) dragon fly situation that Commonwealth Edison faced last year, they were required by the U.S. Fish and Wildlife Service to enter into a research program to measure the migration/accumulation of PAH originating from their existing creosoted tie track to determine if any hazards exist that might require further environmental review. The cost to Commonwealth Edison of this required study will be approximately \$30,000-35,000.

Dr. Kenn Brooks will conduct this study following the attached protocol he has developed using historical research precedents from the WWPI studies RTA has supported and partially funded. Dr. Brooks has tried to persuade Commonwealth Edison to also study newly treated ties, as well as older ties representative of existing track. The U.S. Fish and Wildlife Service has not required data on new ties at this time, thus Commonwealth Edison is reluctant to alone fund an additional \$30,000-35,000 for this additional research.

However, Commonwealth Edison has agreed to consider a co-op arrangement for this additional research. Commonwealth Edison would pay for mesocosm construction, security, sample collection and report writing if RTA would pay the analytical costs expected to be just under \$15,000 over a two-year period.

After contacting the Creosote Council, they have committed to fund half of these analytical costs should RTA approve the additional study. The RTA R&D Committee voted to recommend funding this research to the RTA Board recently in Chicago, if it could be done within budgetary constraints. Given the Creosote Council's commitment, RTA's cost would be only \$3,750/year for two years, well in our ability to stay within budgeted resources.

I have tentatively given the go ahead to approach Commonwealth Edison with a proposal along these lines, since the bargain this batch of research information represents is so substantial that it is my belief we can not afford to pass up this opportunity based on the attached documentation. Please forward your comments, questions and approval as a Board Member to me by April 4 so that we can formalize this approach.

Sincerely,

James C. Gauntt
Executive Director

Jim, I approve of
this expenditure!!
Stan Thomas



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April 17, 1997

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314-343-8484

James R. Duncan
Monticello Hardwood, Inc.
P.O. Box 1069
Monticello, MS 39654
601-587-4001

EXECUTIVE DIRECTOR
James C. Gauntt

Dr. Kenneth M. Brooks
Aquatic Environmental Sciences
644 Old Eaglemount Road
Port Townsend, WA 98368

Dear Dr. Brooks,

This is to confirm that the Railway Tie Association will participate financially in the research project we have discussed. We understand that RTA will provide an amount not to exceed \$3,750 (hopefully a little less) annually for a period of two years, billed in quarterly increments. We further understand that all results will be made available to the Railway Tie Association headquarters.

Please provide revised protocols for our files at your convenience as the process continues.

Best regards,

James C. Gauntt
Executive Director

JCG:dh

cc: Executive Committee

*Aquatic Environmental Sciences
644 Old Eaglemount Road
Port Townsend, WA 98368
Phone and FAX (360) 732-4464
Email brooks@olympus.net*

FILE
OR
Whatever you use for this stuff

September 6, 1999

James C. Gauntt
Railway Tie Association
115 Commerce Drive, Suite C
Fayetteville, GA 30214

Dear Jim,

The following is a preliminary proposal designed to give you some idea of the cost to answer appropriate questions relating to the environmental effects associated with railway rights-of-way. The questions posed are those that I believe can be asked and answered at a reasonable expense and with reasonable confidence of obtaining a scientifically defensible result. I have not visited the site and other than our telephone conversation and the map you faxed to me, I have no specific information regarding the environment associated with this portion of the rail line. Therefore, this proposal is general in nature. However, the proposal can be modified to fit the actual conditions within the specified cost. The following assumptions are based on information provided by you:

- Creosote treated ties will be replaced along a section of the right-of-way generally lying between Shoshoni and Thermopolis, Wyoming. The right-of-way is accessible from Highway 20.
- The rail line passes through one or more tunnels.
- The rail line passes close to Boysen Reservoir and parallels the Bighorn River in at least some areas.

Background. As you know, I have recently completed an evaluation of creosote treated highway bridges for the U.S. Forest Service. The *Wildwood* report has completed peer review and will be published in 2000. The *Timber Bridge Report* is being peer reviewed by Environment Canada, the U.S. EPA and Paul Cooper at the University of Toronto. A copy can be made available when the peer review is complete. I have also completed a study for Commonwealth Edison investigating polycyclic aromatic hydrocarbon (PAH) levels adjacent to their railway spur in Will County, Illinois. We are in the second year of a two-year mesocosm study investigating the loss of PAH from railway ties and its migration into ballast and adjacent wetland water and sediments. The final report for this last study will be written in late 1999 or early 2000. Lastly, the Sooke Basin Creosote Evaluation Study (Goyette and Brooks, 1999) has been peer reviewed and published by Environment Canada (copy of the CD-ROM version is included). More detail regarding these studies was provided in my report to you describing *The*

Environmental Risks Associated With The Use Of Pressure Treated Wood In Railway Rights-of-Way dated July 12, 1999. A copy of that report is provided as Attachment (1). Several studies are available describing the environmental effects associated with well-traveled highways. Other than the report of Wan (1991) no reports describing the environmental response to railway rights-of-way have been uncovered in several exhaustive literature searches.

Specific study questions. The proposed study is a modified BACT (Before, After, Control and Treatment) design using a *Triad Assessment* including *i*) physicochemical characterization of the environment; *ii*) invertebrate community assessment; *iii*) laboratory bioassays. This approach is frequently used in assessing risks associated with anthropogenic activity. The *Triad Assessment* is recognized and accepted by toxicologists and regulators.

The following questions are based on my experience in evaluating and modeling the loss, transport, toxicity and fate of polycyclic aromatic hydrocarbons and on my interaction with government regulators. Answers to these questions will help industry and the regulatory communities understand and manage the use of treated wood in railway transportation systems. These questions will add to the base of knowledge developed in previous studies – they will not duplicated previous research:

1. What are the soil, sediment and water concentrations of polycyclic aromatic hydrocarbons associated with *i*) weathered railway ties supporting an actively operating railway and *ii*) what changes in soil, sediment and water concentrations of polycyclic aromatic hydrocarbons can be anticipated when weathered ties are replaced with new railway ties? Samples will be collected along several transects to provide an understanding of changes in PAH concentrations as a function of distance.

2. What is the invertebrate response, as a function of distance from the toe of the ballast, to weathered ties and new ties supporting an operating railway?

3. Based on the acute and chronic toxicity of PAH, do the concentrations of PAH associated with railway rights-of-way pose a threat to living resources?

4. Are more polycyclic aromatic hydrocarbons (PAH) lost from ties exposed to the sun when compared to ties shielded from the sun in tunnels. This may seem like a trivial and/or unimportant question. However, my previous studies have resulted in development of a *Particulate PAH Transport Hypothesis*. Simply stated, this hypothesis suggests that creosote derived PAHs are lost as small particles from treated wood. The loss mechanism is likely thermal exudation from the wood and the formation of either blisters that pop or microspheres (droplets) that fall from treated wood into water or soils. These microparticles retain their physical integrity once they are incorporated into the soil or sediments. This hypothesis would explain the very patchy distribution of creosote derived PAH in natural environments. It would also add to our understanding of the toxicity of creosote derived PAH and explain why creosote derived PAH appears so much less toxic than Equilibrium Partitioning Theory would suggest. I could go on for pages describing why, but will defer that discussion until a later date. This part of this study will not provide an unequivocal answer to a very complex question. However, the results will more than justify the minimal cost assuming that tie creosote retention is evaluated by the treated wood industry.

Study methodology. The following activities are anticipated in support of this study. I have recently conducted a thorough literature review to determine the availability of papers describing the distribution of PAH and biological response associated with railway rights-of-way. I have obtained the few papers that are available. The literature search will be repeated by the end of this study to insure that any new work is included.

1. Develop an understanding of the existing rail line. This will require the cooperation of railway management. I need to know approximately when the existing ties were put in service and if ties have been replaced during routine maintenance since the last major upgrade. If possible, railway management should characterize the typical cargo carried on this line. If that list includes coal, metal ores or petroleum products, we need to know that before writing specific protocols. Sample analysis should include an examination of those elements or compounds that may result in adverse effects on invertebrates in the immediate vicinity of the tracks.

2. Development of specific protocols and collection of baseline samples. I will need to visit the site during the spring through fall seasons to finalize the study protocols, define sampling transects and collect baseline samples. The protocols described in this proposal can be modified on the spot to allow for the collection of baseline samples during this initial field trip.

2.1. Baseline physicochemical sampling. We need to determine baseline conditions along three transects adjacent to the operating track and three samples from a remote reference station in a similar environment. By remote, I mean several hundred feet from the right-of-way. We will collect ballast samples at 5 and 30 cm from the existing weathered ties and at three distances from the toe of the ballast (0.5m, 1.0 m, 3.0 m and 10.0m). This will be accomplished along a portion of the right-of-way that is closest to either Boysen Reservoir or a slow flowing section of the Bighorn River. The exact locations and distances will be determined during a site visit. We will accomplish this sampling once. It will require a total of 21 samples. This part of the study will document the long-term environmental response to the existing railway.

2.1.1. Chemical analyses. The samples will be analyzed for 16 parental polycyclic aromatic hydrocarbons using GC/MS or HPLC. I have been working with Test America in Illinois and they have developed adequate procedures for extracting PAH from ballast rock. If metal ores are shipped along this right-of-way, then we will also analyze for the appropriate metals. The proposed cost does not include the cost of metal analysis. Metal analyses are relatively inexpensive and adding them to the study would increase the total cost by ca. \$2,500.00.

2.1.2. Physical analyses. Additional physicochemical analyses will include determination of the Sediment Grain Size distribution (SGS); sediment Total Volatile Solids (TVS) and the pH, hardness, and temperature of the water (if present).

2.1.3. Biological analyses. We will collect three invertebrate samples from each of the three treatment transects plus a reference location (12 samples).

We focus on aquatic invertebrates because they are the most sensitive biological community. Ideally this should be accomplished in quiet water flowing at less than two to three cm/sec (Boysen Reservoir?). Polycyclic Aromatic Hydrocarbons released into the Bighorn River would likely be diluted so quickly that they could not be detected in sediments. If there is no water adjacent to the right-of-way, then we will look at another relatively stationary biological compartment (plants, earthworms, terrestrial burrowing insects, etc.)

2.1.4. Bioassay analyses. A single bioassay will be conducted on sediments from each transect. Each bioassay has five replicates and it is possible to statistically test the results of a single treatment bioassay against the reference area bioassay. Because PAH are most likely to be found in sediments, we will use the burrowing amphipod *Hyalloa azteca*. If sediments are too coarse, we will use *Daphnia magna*. (4 bioassays during each summer sampling event). If aquatic environments are not available, then we will focus on either nematodes or earthworms. If sediments are unavailable and soils are unacceptable (too rocky), we will drop this portion of the study.

3. Summer and Spring samples following tie replacement. This part of the study will evaluate the environmental response (soil-sediment chemistry and invertebrate response) to the presence of new creosote treated railway ties. We will use the same transects and distances defined in the baseline study. I would like to accomplish this three times (summer ~ spring ~ summer). The seasons are important because I have hypothesized that solar heating increases the loss of creosote derived PAH during hot summer days and that photo and chemical oxidation degrades these lost PAH during cool periods of the year when snow is not present. This part of the study will require the collection and analysis of 63 samples for PAH (and possibly for metals). If your budget does not allow for three post replacement sampling events, then we will collect the two summer samples and eliminate the spring sample. That reduces the number of expensive PAH analyses to 42.

The invertebrate community assessment described for the baseline study will be repeated during each of these three sample periods (24 or 36 samples).

Laboratory Bioassays. One bioassay will be completed at the nearest distance from the ballast (0.5 meters) for each transect and at the Reference location during each summer sampling period. (8 bioassays).

4. Railway tie retention study. This part of the study is designed to investigate the *Particulate Transport Hypothesis*. I am interested in differences in retention as a function of sun exposure. To accomplish this, we need a minimum of three samples from each of 6 weathered railway ties that are most exposed to the sun and from 6 weathered ties that are least exposed to the sun.(i.e. in a tunnel). This sampling and analysis should be conducted by industry and the results provided to AES. Dr. Brooks can supervise the sampling during one of the scheduled field trips. If absolutely necessary, and if the borer and plugs are provided, I could collect these samples and ship them to an industry laboratory for retention analysis.

In addition, once the weathered ties are replaced with new ties, I need to collect and analyze three ballast samples for PAH analysis at distances of 5 and 30 cm from the face of new ties in the tunnels. We will use simple *t-tests* to determine if the retention in sun exposed ties is

significantly different from shaded ties and to determine if ballast PAH concentrations in tunnels is significantly different from concentrations adjacent to sun exposed ties. We will do this during one summer and one spring sampling event (6 or 12 samples for PAH analysis).

5. **Study period.** As designed, this study must begin prior to creosote tie replacement. The following schedule is suggested. It can easily be changed to accommodate the maintenance schedule:

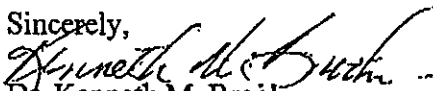
1. Winter of 1999 – 2000 – Rail-line characterization
2. Spring of 2000 – Baseline study
3. Summer or fall of 2000 – First post maintenance sampling.
4. Early Spring of 2000 – Spring sampling (optional)
5. Fall of 2000 – Second Summer sampling
6. Spring of 2001 – Final Report due.

6. **Interim and final reports.** A short interim report will be completed at the end of each of the first two years of this study. Study results will be documented in a thorough final report. A copy of the recently completed *Timber Bridge* report is provided as Attachment (2) to this document.

Costs. The cost for various elements of this study are provided in spreadsheet form in Attachment (3). The cost for the preferred study including baseline plus two summer and one spring sampling events is \$58,765.60. An option, excluding the spring sampling event is also presented at a cost of \$49,001.95. We will use only accredited laboratories for the PAH analysis and the bioassays.

Summary. This proposal is not as specific as I would like. However, more specificity is not possible without a site visit and more information with respect to the proposed maintenance activities. I am including a copy of the *Wildwood* Report to give you an idea of how this information is used to assess environmental risks. This report has been through peer review and is being published by the USDA Forest Products Laboratory. If it is necessary to reduce costs, then I recommend that we eliminate the Spring sampling period and focus on the summer sampling events when we expect maximum the PAH loss with the greatest chance of observing biological effects. I realize this kind of "worst case" approach may make you uncomfortable. However, if we do not look at the worst case, then the study results will lose legitimacy and opponents will simply conclude that adverse effects would have been observed during the summer.

Sincerely,


Dr. Kenneth M. Brooks
Aquatic Environmental Sciences

Costs for the Railway Tie Association proposal in Wyoming			
Item (Preferred design assuming a total of four sampling events)	Number	Unit Cost	Item Extension
1 Background investigation (cargo, schedule, etc.)	5	\$95.00	\$475.00
2 Specific protocol development	6	\$95.00	\$570.00
3 Baseline sampling (Dr. Brooks and one technician)	24	\$115.00	\$2,760.00
4 Three seasonal sampling events (Brooks plus one)	72	\$115.00	\$8,280.00
5 One interim report	4	\$95.00	\$380.00
6 One Final Report	80	\$98.00	\$7,840.00
7 Baseline PAH analysis	21	\$175.00	\$3,675.00
8 PAH analysis for three seasonal surveys	63	\$175.00	\$11,025.00
9 Sediment Grain Size analysis (one time)	15	\$45.00	\$675.00
10 Total Volatile Solids analysis	15	\$15.00	\$225.00
11 Hardness	12	\$25.00	\$300.00
15 Invertebrate community analysis	48	\$140.00	\$6,720.00
18 Bioassays by an accredited bioassay laboratory	12	\$750.00	\$9,000.00
17 Travel (four trips for two to Wyoming)	8	\$400.00	\$3,200.00
18 Lodging (12 days for two people)	12	\$55.00	\$660.00
19 Meals (12 days for two people)	24	\$25.00	\$600.00
20 POV Port Townsend to SeaTac	640	\$0.43	\$275.20
21 Study administrative costs	1	\$250.00	\$250.00
22 Ship Bioassay Samples	3	\$100.00	\$300.00
23 Ship PAH samples to Test America	4	\$125.00	\$500.00
24 Chemicals (formaldehyde, alcohol, bottles, etc.)	1	\$96.00	\$96.00
25 On-site car rental	12	\$39.95	\$479.40
28 Technician time preparing for each field trip.	24	\$20.00	\$480.00
		Total Study Cost	\$58,765.60
Item (Optional design assuming baseline plus two summer samples)	Number	Unit Cost	Item Extension
1 Background investigation (cargo, schedule, etc.)	5	\$95.00	\$475.00
2 Specific protocol development	6	\$95.00	\$570.00
3 Baseline sampling (Dr. Brooks and one technician)	24	\$115.00	\$2,760.00
4 Two seasonal sampling events (Brooks plus one)	48	\$115.00	\$5,520.00
5 One interim report	4	\$95.00	\$380.00
6 One Final Report	80	\$98.00	\$7,840.00
8 Baseline PAH analysis	21	\$175.00	\$3,675.00
9 PAH analysis for three seasonal surveys	42	\$175.00	\$7,350.00
10 Sediment Grain Size analysis (one time)	15	\$45.00	\$675.00
11 Total Volatile Solids analysis	15	\$15.00	\$225.00
15 Hardness	12	\$25.00	\$300.00
16 Invertebrate community analysis	36	\$140.00	\$5,040.00
17 Bioassays by an accredited bioassay laboratory	12	\$750.00	\$9,000.00
18 Travel (three trips for two to Wyoming)	6	\$400.00	\$2,400.00
19 Lodging (9 days for two people)	9	\$55.00	\$495.00
20 Meals (9 days for two people)	18	\$25.00	\$450.00
21 POV Port Townsend to SeaTac	480	\$0.43	\$206.40
22 Study administrative costs	1	\$250.00	\$250.00
23 Ship Bioassay Samples	2	\$100.00	\$200.00
24 Ship PAH samples to Test America	3	\$125.00	\$375.00
25 Chemicals (formaldehyde, alcohol, bottles, etc.)	1	\$96.00	\$96.00
26 On-site car rental	9	\$39.95	\$359.55
27 Technician time preparing for each field trip.	18	\$20.00	\$360.00
		Total Study Cost	\$49,001.95

KERR-McGEE CHEMICAL CORPORATION

FOREST PRODUCTS DIVISION

FAX COVER PAGE

To: James C. Gauntt

For Information Call: (317) 359-9007

From : Jeffrey C. Broadfoot

At: Kerr-McGee Chemical Corp

Pages: 3

Fax Number : (317) 357-1503

Jim:

Attached is the revised letter on the above subject.

Thanks for both your input and support!

Jeff

**Cross Ties & Switch Ties
Pre Fab Full & Flange Timber Crossings
Bridge Timber, Lumber, & Piling
Cross Tie Preplating & Bridge Paneling**

**KERR-McGEE CHEMICAL CORPORATION**

P. O. BOX 33668, Indianapolis, IN 46203

September 30, 1997

Dr. Ken Brooks
644 Old Eagle Mountain Road
Port Townsend, WA 98368

Re: RTA Treated Crosstie Field Test

Dear Dr. Brooks:

Per your request, we are furnishing eight (8) railroad crossties for use in a Railway Tie Association (RTA) sponsored field test at Commonwealth Edison's Will County Power Station in Romeoville, Illinois.

As information, we will be shipping these crossties this week. Of these eight (8) ties, four (4) are pressure treated with preservative and the other four (4) are untreated. Furthermore, in accordance with the test parameters which you have outlined, we certify that these crossties also meet the following criteria:

- Species - Northern Red Oak (*Quercus rubra*)
- Specifications - American Railway Engineering Association (AREA) Chapter 3, Ties And Wood Preservation (copy attached)
- Origin of Ties - Tennessee, Kentucky, & Indiana Procurement Area
- Method of Selection - Random
- Moisture Readings Before Treatment - 46% - 50%
- Method of Treatment - Rueping Method
- Type of Preservative Used - American Wood Preservers' Association (AWPA) Standard P2-95, Standard for Creosote Solutions (copy attached)
- Size - 7" x 9" x 8'6"
- Method of Drying Before Treatment - Air-Dried in "German Style" Stacking Yard
- Average Retention of Preservative in Ties - Pressure Treated to Seven (7) Pounds Per Cubic Foot (Treating Report Attached)
- 100% Incised
- 100% End-Plated
- 100% Double End-Trimmed

As discussed, these randomly selected ties, are representative of the type of wooden crossties used in railroad track beds throughout the United States, Canada, and Mexico. We have also included random borings from each of the charges from which these ties were taken. These borings, along with the treating reports, confirm that the approved conditioning and treating process procedures were followed, and that the results of this treatment were consistent with our expectations. Furthermore, please be advised that the conditioning and treating processes that we use is representative of crosstie manufacturing throughout North America.

Please feel free to call me at (317) 359-9007 with any questions or comments. We very much appreciate the opportunity to represent our Railway Tie Association in this very important field test.

Sincerely,

Jeff Broadfoot
Sr. Professional Sales Representative
Kerr-McGee Chemical Corporation
Forest Products Division

CC: Mr. Jim Gauntt, RTA
Mr. Dave Webb, RTA
Mr. Jeff Bull, Kerr-McGee
Mr. John McGinley, Kerr-McGee
Mr. Jim Moore, Kerr-McGee