ENVIRONMENTAL CONTAMINANTS ENCYCLOPEDIA

FLUORANTHENE ENTRY

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Like a library or most large databases (such as EPA's national STORET water quality database), this document contains information of variable quality from very diverse sources. In compiling this document, mistakes were found in peer reviewed journal articles, as well as in databases with relatively elaborate quality control mechanisms [366,649,940]. A few of these were caught and marked with a "[sic]" notation, but undoubtedly others slipped through. The [sic] notation was inserted by the editors to indicate information or spelling that seemed wrong or misleading, but which was nevertheless cited verbatim rather than arbitrarily changing what the author said.

Most likely additional transcription errors and typos have been added in some of our efforts. Furthermore, with such complex subject matter, it is not always easy to determine what is correct and what is incorrect, especially with the "experts" often disagreeing. It is not uncommon in scientific research for two different researchers to come up with different results which lead them to different conclusions. In compiling the Encyclopedia, the editors did not try to resolve such conflicts, but rather simply reported it all.

It should be kept in mind that data comparability is a major problem in environmental toxicology since laboratory and field methods are constantly changing and since there are so many different "standard methods" published by EPA, other federal agencies, state agencies, and various private groups. What some laboratory and field investigators actually do for standard operating practice is often a unique combination of various standard protocols and impromptu "improvements." In fact, the interagency task force on water methods concluded that [1014]:

> It is the exception rather than the rule that water-quality monitoring data from different programs or time periods can be compared on a scientifically sound basis, and that...
>
> No nationally accepted standard definitions exist for water quality parameters. The different organizations may collect data using identical or standard methods, but identify them by different names, or use the same names for data collected by different methods [1014].

Differences in field and laboratory methods are also major issues related to (the lack of) data comparability from media other than water: soil, sediments, tissues, and air.

In spite of numerous problems and complexities, knowledge is often power in decisions related to chemical contamination. It is therefore often helpful to be aware of a broad universe of conflicting results or conflicting expert opinions rather than having a portion of this information arbitrarily censored by someone else. Frequently one wants to know of the existence of information, even if one later decides not to use it for a particular application. Many would like to see a high percentage of the information available and decide for themselves what to throw out, partly because they don't want to seem uniformed or be caught by surprise by potentially important information. They are in a better position if they can say: "I knew about that data, assessed it based on the following quality assurance criteria, and decided not to use it for this application." This is especially true for users near the end of long decision processes, such as hazardous site cleanups, lengthy ecological risk assessments, or complex natural resource damage assessments.

For some categories, the editors found no information and inserted the phrase "no information found." This does not necessarily mean that no information exists; it simply means that during our efforts, the editors found none. For many topics, there is probably information "out there" that is not in the Encyclopedia. The more time that passes without encyclopedia updates (none are planned at the moment), the more true this statement will become. Still, the Encyclopedia is unique in that it contains broad ecotoxicology information from more sources than many other reference documents. No updates of this document are currently planned. However, it is hoped that most of the information in the encyclopedia will be useful for some time to come even with out updates, just as one can still find information in the 1972 EPA Blue Book [12] that does not seem well summarized anywhere else.

Although the editors of this document have done their best in the limited time available to insure accuracy of quotes or summaries as being "what the original author said," the proposed interagency funding of a bigger project with more elaborate peer review and quality control steps never materialized.

> The bottom line: The editors hope users find this document useful, but don't expect or depend on perfection herein. Neither the U.S. Government nor the National Park Service make any claims that this document is free of mistakes.

The following is one chemical topic entry (one file among 118). Before utilizing this entry, the reader is strongly encouraged to read the README file (in this subdirectory) for an introduction, an explanation of how to use this document in general, an explanation of how to search for power key section headings, an explanation of the organization of each entry, an information quality discussion, a discussion of copyright issues, and a listing of other entries (other topics) covered.

See the separate file entitled REFERENC for the identity of numbered references in brackets.

HOW TO CITE THIS DOCUMENT: As mentioned above, for critical applications it is better to obtain and cite the original publication after first verifying various data quality assurance concerns. For more routine applications, this document may be cited as:

> **Irwin, R.J., M. VanMouwerik, L. Stevens, M.D. Seese**, and **W. Basham.** 1997. Environmental Contaminants Encyclopedia. National Park Service, Water Resources Division, Fort Collins, Colorado. Distributed within the Federal Government as an Electronic Document (Projected public availability on the internet or NTIS: 1998).

Fluoranthene (C16-H10, CAS number 206-44-0)

Brief Introduction:

Br.Class: General Introduction and Classification Information:

Fluoranthene is a high molecular weight, 4-ring PAH and an EPA Priority Pollutant [697,634].

Fluoranthene is included on the expanded scan of PAHs and alkyl PAHs recommended by NOAA [828]; this list includes the PAHs recommended by the NOAA's National Status and Trends program [680].

Br.Haz: General Hazard/Toxicity Summary:

Fluoranthene is an irritant. The toxicological properties, however, have not been thoroughly investigated [870].

The heavier (4-, 5-, and 6-ring) PAHs such as this one are more persistent than the lighter (2- and 3-ring) PAHs and tend to have greater carcinogenic and other chronic impact potential [796].

Within an aromatic series, acute toxicity increases with increasing alkyl substitution on the aromatic nucleus [851]. For example, there is an increase in toxicity as alkylation of the naphthalene structure increases. The order of most toxic to least in a study using grass shrimp (Palaemonetes pugio) and brown shrimp (Penaeus aztecus) was dimethylnaphthalenes > methylnaphthalenes > naphthalenes [853].

Acute toxicity is rarely reported in humans, fish, or wildlife, as a result of exposure to low levels of a single PAH compound such as this one. PAHs in general are more frequently associated with chronic risks. These risks include cancer and often are the result of exposures to complex mixtures of chronic-risk aromatics (such as PAHs, alkyl PAHs, benzenes, and alkyl benzenes), rather than exposures to low levels of a single compound (Roy Irwin, National Park Service, Personal Communication, 1996, based on an overview of literature on hand). See also "PAHs as a group" entry.

For additional details on immunological effects of PAHs in general, see ATSDR [881].

Potential effects of PAHs on humans were summarized by the Agency for Toxic Substances and Disease Registry in a 1995 toxicological profile for polycyclic aromatic hydrocarbons [881], so no lengthy summary will be attempted here.

This compound often occurs together with other PAHs, some possibly more toxic or otherwise hazardous (see "PAHs as a group" entry).

Br.Car: Brief Summary of Carcinogenicity/Cancer Information:

Information from EPA 1996 IRIS database [893]:

Evidence for classification as to human carcinogenicity; weight-of-evidence classification

Classification: D; not classifiable as to human carcinogenicity, based on no human data and inadequate data from animal bioassays.

Human carcinogenicity data: None.

Animal carcinogenicity data: Inadequate.

This compound has not been treated as a carcinogen for model calculation purposes in some previous EPA risk-based (RBC and PRG) models [302,406,868,903], but this tentative distinction was made for the purpose of choosing a modeling scenario based on current (often inadequate) knowledge rather than for the purpose of strongly stating that this compound is definitely not a carcinogen; the non-carcinogenic benchmarks are sometimes nearly as low as the carcinogenic benchmarks (Stan Smucker, personal communication, EPA, 1996).

However, these classifications may have been premature. Fluoranthene is a potent co-carcinogen [870].

NOTE: A co-carcinogen is a noncarcinogenic chemical that, when present with another carcinogenic chemical, enhances that chemical's carcinogenicity [494].

Some co-carcinogenic activity was noted for fluoranthene when combined with mixtures of other PAHs in dermal treatments of mice [40]. PAH compounds usually occur in the presence of other PAH compounds, and one of the few things that is relatively clear is that PAH mixtures in water, sediments, and organism internal tissues often tend to be both carcinogenic and phototoxic [911].

The debates on exactly how to perform both ecological and human risk assessments on the complex mixtures of PAHs typically found at contaminated sites, are likely to continue. There are some clearly wrong ways to go about it, but defining clearly right ways is more difficult. PAHs such as this one usually occur in complex mixtures rather than alone. Perhaps the most unambiguous thing that can be said about complex PAH mixtures is that such mixtures are often hazardous in many ways, including carcinogenicity and phototoxicity. (James Huckins, National Biological Service, and Roy Irwin, National Park Service, personal communication, 1996).

Fluoranthene is a phototoxic PAH [494,887]. Although not definitive, as discussed above, phototoxicity represents one clue suggesting possible carcinogenicity.

The International Agency for Research on Cancer (IARC) and the EPA have determined that fluoranthene is not classifiable as to its carcinogenicity to humans [788].

IARC Summary and Evaluation [366]: No data are available in humans. Inadequate evidence of carcinogenicity in animals. Overall evaluation: Group 3: The agent is not classifiable as to its carcinogenicity to humans. [IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-1985. (Multivolume work).,p. S7 63 (1987)].

Br.Dev: Brief Summary of Developmental, Reproductive, Endocrine, and Genotoxicity Information:

Fluoranthene has growth-promoting effects on some higher plants as well as on planktonic algae [366].

Laboratory experiments have shown mutagenic effects [870].

Br.Fate: Brief Summary of Key Bioconcentration, Fate, Transport, Persistence, Pathway, and Chemical/Physical Information:

The heavier (4-, 5-, and 6-ring) PAHs such as this one are more persistent than the lighter (2- and 3-ring) PAHs [796].

Fluoranthene was found in groundwater at a coal and oil gasification plant some 30 years after the plant shut down [788].

Environmental Fate/Exposure Summary [366]:

Fluoranthene's release into air and water is quite general since it is a universal product of combustion of organic matter and is present in fossil fuel products. Its release is greatest in areas of high anthropogenic activity. Both in air and water it is largely associated with particulate matter. When released into water, it will rapidly become adsorbed to sediment and particulate matter in the water column, and bioconcentrate into aquatic organisms. In fact, concentrations in shellfish such as clams and mussels are an excellent indicator of pollution in a localized area. In the unadsorbed state it will degrade by photolysis (half-life days to weeks). It appears to be stable in sediment for decades or more. Because it is strongly adsorbed to soil, it should remain in the upper few centimeters of the soil. However, its detection in groundwater demonstrates that it can be transported there by some process(es). It should biodegrade in a few years in the presence of acclimated microorganisms. The fluoranthene released in the atmosphere will photodegrade in the free state (half-life 4-5 days). Aerosols and particulate matter containing sorbed fluoranthene is sufficiently stable to be transported long distances while being subject to gravitational settling and rainout. Photochemical smog situations enhance the degradation of both the sorbed molecule and the free vapor. Human exposure is from ambient air and ingesting food contaminated with products of combustion or prepared in such a manner (smoking, charcoal broiling) as to generate polynuclear aromatic hydrocarbons. Exposure from drinking water is less common since water treatment such as filtration and chlorination removes fluoranthene. Distribution systems lined with coal tar or asphalt can sometimes contribute measurable amounts of fluoranthene to water.

Synonyms/Substance Identification:

1,2-(1,8-Naphthylene)Benzene [366]
1,2-Benzacenaphthene [366]
Benzene, 1,2-(1,8-Naphthalenediyl)- [366]
Benzene, 1,2-(1,8-Naphthylene)- [366]
Benzo(jk)fluorene [366]
Idryl [870]
RCRA Waste Number U120 [870]

Associated Chemicals or Topics (Includes Transformation Products):

See also individual entries:

PAHs as a group
Fluoranthene/pyrene, C1-
PAHs, Alkyl Homologs of
Petroleum, General

Fluoranthrene is a misspelling of Fluoranthene (CAS Number 206-44-0) and has been a common enough mistake to make it into some publications, including government contracts and reports.

Metabolism/Metabolites [366]:

Metabolites of fluoranthene are trans-2,3-dihydrodihydroxyfluoranthene & trans-2,3-dihydrodiol-1,10-beta-epoxyfluoranthene. [Barfknecht TR et al; Human cell mutagenicity of polycyclic aromatic hydrocarbon components of diesel emissions; dev toxicol environ sci 10 (toxicol eff emiss diesel engines): 277-94 (1982)].

The metabolite of fluoranthene ... obtained upon incubation with liver homogenate from Aroclor pretreated rats ... 2,3-Dihydro-2,3-dihydroxyfluoranthene. [Lavoie EJ et al; Carcinogenesis 3 (8): 841-846 (1982)].

Water Data Interpretation, Concentrations and Toxicity (All Water Data Subsections Start with "W."):

W.Low (Water Concentrations Considered Low):

No information found.

W.High (Water Concentrations Considered High):

Median concentrations in industrial effluents is usually less than 10 ug/L) for 15 PAHs. The number of samples ranged from 1,182 (benzo[b]fluoranthene) to 1,288 (phenanthrene); the percentage of samples in which PAHs were detected ranged from 1.5 (benzo[g,h,i]perylene) to 7.0 (fluoranthene) [881].

Groundwater samples from the site of a Seattle coal and oil gasification plant which ceased operation in 1956 were found to contain acenaphthylene, acenaphthene, fluorene, phenanthrene, fluoranthene, pyrene, and chrysene at concentrations ranging from not detected (detection limit 0.005 mg/L) to 0.25, 0.18, 0.14, 0.13, 0.05, 0.08, and 0.01 mg/L, respectively [881].

W.Typical (Water Concentrations Considered Typical):

In a recent study (1993) which involved the collection and analysis of approximately 140 urban runoff samples from a number of different source areas in Birmingham, Alabama, and under various rain conditions, fluoranthene was one of two organic compounds detected most frequently (23% of samples). The highest frequencies of detection occurred in roof runoff, urban creeks, and combined sewer overflow samples. The maximum reported concentration of fluoranthene in these samples was 130 ug/L [881].

In an assessment of STORET data covering the period 1980-82, Staples et al. (1985) reported median concentrations in ambient water of less than 10 ug/L for 15 PAHs (acenaphthene, acenaphthylene, anthracene, benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, benzo[a]pyrene, chrysene, fluoranthene, fluorene, indeno[1,2,3-c,d]pyrene, naphthalene, phenanthrene, and pyrene). The number of samples ranged from 630 (naphthalene) to 926 (fluoranthene) [881].

In a more recent study by Pham et al. (1993), raw water samples from 5 areas in the St. Lawrence River and its tributaries were analyzed for 12 PAHs. The highest mean total PAH concentrations were observed in samples collected in the spring (27.3 ng/L) and autumn (21.03 ng/L), which was attributed to snow melt and increased runoff during these respective seasons. The lowest mean total PAH concentration was observed in summer (14.63 ng/L). High molecular weight PAHs were detected more frequently in the spring and autumn samples. Phenanthrene, benzo[b]fluoranthene, fluoranthene, and pyrene were predominant, comprising on average 33.8%, 17.4%, 17.1% and 12.8% of the total PAHs, respectively. With the exception of anthracene and benzo[b]fluoranthene, a general decrease in concentration with increasing molecular weight was observed [881].

Shiraishi et al. (1985) found PAHs in tap water at concentrations of 0.1-1.0 ng/L, primarily as chlorinated derivatives of naphthalene, phenanthrene, fluorene, and fluoranthene. The significance to human health of these compounds is not known (Eisler 1987) [881].

Trace amounts of fluoranthene were found in samples of rain and snow from Norway, probably originating from combustion of fossil fuels [500].

Water Concentrations [366]:

> DRINKING WATER: Ottawa drinking water (Jan-Feb 1978) 0.55 and 1.9 ng/l(1). 18 U.S. cities - (finished water) not detected in 11 cities (detection limit 0.1-0 ng/l), 1-8.9 ng/l in 7 cities, 94.5 ng/l in Wheeling WV(2). Derwent England finished water 0.8 ng/l(2). Filtration,

activated carbon treatment and chlorination remove considerable amounts of fluoranthene from drinking water. However distribution systems with asphalt or coal tar linings can contribute fluoranthene to the tap water. In one extreme case, Portland Oregon, the raw water had 4 ng/l and the distributed water 640 ng/l fluoranthene(2). Nordic tap water <0.58-24 ng/l(7). Detected at >0.1 ug/l in finished water from 5 of 10 utilities in Ohio River Basin(9). GROUND WATER: Concn as high as 10 ug/l have been detected in contaminated ground water in the Netherlands(3). Groundwater in Germany 26.2-169.0 ng/l(2). Detected in raw water from ground water supply in Ohio River Basin(9). Detected in 1 of 4 wells sampled in November down gradient from spray irrigation field treating wastewater from wood preserving plant using creosote; these samples in July showed no PAH(11). SURFACE WATER: Detected in 8 of 10 sites on Ohio River and tributaries(10) and the raw water of 7 of 9 utilities using surface water sources in the Ohio River Basin(9). River water 15-258 ng/l(10). 13 U.S. cities - raw water not detected in 6 cities (detection limit 0.1-8 ng/l), 4-25 ng/l in 5 cities, 114, 408 and 756 ng/l in Philadelphia, Pittsburg and Wheeling, WV, respectively(2). River Trent and tributaries in England 12-928 ng/l in suspended particulates and 1.1-16 ng/l in solution(11). Reservoir water 1.2 ng/l in suspended particles and 1.3 ng/l in solution(11). RAINWATER: Portland Oregon urban area 110 ng/l avg, site west of city 1.7 ng/l avg(4). Major PAH component of Los Angeles rainwater(5). Minor to major component in dissolved and particulate fraction of Norwegian rain and snow(6). Snow (Germany) 106 and 200 ng/l avg in 2 studies(8). [(1) Benoit FM et al; Int J Environ Anal Chem 6: 277-87 (1979) (2) Sorrell RK et al; Environ Int 4: 245-54 (1980) (3) Zoeteman BCJ et al; Sci Total Environ 21: 187-202 (1981) (4) Pankow JF et al; Environ Sci Technol 18: 310-8 (1984) (5) Kawamura K, Kaplan IR; Environ Sci Technol 17: 497-501 (1983) (6) Lunde G et al; Organic Micropollutants in Precipitation in Norway; p.17 SNSG project FR-9/76 (1977) (7) Kveseth K et al; Chemosphere 11: 623-39 (1982) (8) Herrmann R; Water Air Soil Pollut 16: 445-67 (1981) (9) Ohio River Valley Water Sanit Comm; Water Treatment Process Modifications for Trihalomethane Control and Organic Substances in the Ohio River; Ohio River Valley Water Sanit Comm Cinncinnati OH pp.209-11 (1979) (10) Ohio River Valley Water Sanit Comm; Assessment of Water Quality Conditions. Ohio River Mainstream 1978-9. Ohio River Valley Water Sanit Comm Cinncinnati OH p.T-52 (1980) (11)

Middleton AC; Basic Life Sci 28: 137-49 (1984)].

... Detectable levels of pahs /observed/ in 88% of 25 tap waters tested in United Kingdom & in the Netherlands. Mean concn of ... Fluoranthene /was/ 17 ng/l ... [National Research Council. Drinking Water & Health, Volume 4. Washington, DC: National Academy Press, 1981. 83].

Effluents Concentrations [366]:

Those industries with mean raw or treated wastewater concns of fluoranthene exceeding 500 ppb include: iron and steel manufacturing, metal finishing, organic chemicals and plastic manufacturing and timber products processing(1). Maximum raw wastewater concn of 55, 35, 16, and 5 ppm have been observed in metal finishing, iron and steel manufacturing, timber products processing, and nonferrous metals manufacturing, respectively(1). Urban runoff from a commercial site contained 157.5 ng/l associated with particulates and 3.4 ng/l in soluble form. The fluoranthene was principally associated with particulates 125-250 um and < 45 um in size(2). Nationwide urban runoff program detected fluoranthene in 10% of the samples analyzed (51 catchments in 19 cities including 11 of the 18 major river basins in the contiguous U.S.), at concn of 0.3-12 ug/l(3); fluoranthene was found in unspecified waste water at 0.1-45 ug/l(4); domestic sewage effluent at 0.01 ug/l(5); effluent spray tower of municipal incinerator at 0.54 ug/l(5); effluent from sewage treatment plant in Norway at 0.126 and 0.515 ug/l in fall and spring dry period and at 0.082 and 1.66 ug/l after rain in fall and spring(6); and in effluent of tire manufacturing plant at 0.8 ug/l(7). [(1) USEPA; Treatability Manual; pp.I.10.13-1 to I.10.13-5 USEPA-600/2-82-001A (1981) (2) Hoffman EJ et al; Environ Sci Technol 18: 580-7 (1984) (3) Cole RH; J. Water Pollut Control Fed 56: 898-908 (1984) (4) IARC; Polynuclear Aromatic Compounds. Part I. Chemical environmental and experimental data; 32: 355-7 (1983) (5) Verschueren K; Handbook of Environmental Data on Organic Chemicals; 2nd ed Van Nostrand Reinhold New York pp.671-4 (1983) (6) Kveseth K et al; Chemosphere 11: 623-39 (1982) (7) Jungclaus GA et al; Anal Chem 48: 1894-6 (1976)].

W.Concern Levels, Water Quality Criteria, LC50 Values, Water Quality Standards, Screening Levels, Dose/Response Data, and Other Water Benchmarks:

W.General (General Water Quality Standards, Criteria, and Benchmarks Related to Protection of Aquatic Biota in General; Includes Water Concentrations Versus Mixed or General Aquatic Biota):

Cautionary note: This is a phototoxic compound (see more detailed discussion in the "PAHs as a group" entry). Therefore, any of the water criteria which have been developed for it using bioassays performed in the absence of UV light may be under-protective. Phototoxicity of certain PAHs was discovered when organisms which had survived lab exposures to PAHs died quickly after being moved into sunlight. An increase in toxicity due to photo-induced changes is called phototoxicity. For certain PAHs, tests performed in the presence of UV or other solar radiation show greatly increased toxicity to those same organisms at PAH concentrations below maximum solubility [888,889,911,887; Reprinted with permission from Environmental Toxicology and Chemistry, Volume 6, Newstead, J.L. and J.P. Geisy. Predictive models for photoinduced acute toxicity of polycyclic aromatic hydrocarbons to Daphnia magna. Copyright 1987 SETAC]. The reader should be aware that the authors of this document have not yet been able to determine which of the following criteria and benchmarks were developed in the presence or absence of UV light:

EPA 1996 IRIS database information [893]:

Ambient Water Quality Criteria for Aquatic Organisims:

Acute Freshwater: 3.98E+3 ug/L

Older references: Freshwater Acute Criteria: Insufficient data to develop criteria. Lowest Observed Effect Level: 3,980 ug/L [446,928].

NOTE: Acute toxicity to freshwater aquatic life occurs at concentrations as low as 3,980 ug/L and would occur at lower levels among sensitive species [302,366].

Chronic Freshwater: None

Older references: Freshwater Chronic Criteria: None Published [446,928].

Acute Marine: 4.0E+1 ug/L

Older references: Marine Acute Criteria: Insufficient data to develop criteria. Lowest Observed Effect Level: 40 ug/L [446,928].

NOTE: Acute and chronic toxicity to saltwater aquatic life occurs at concentrations as low as 16-40 ug/L and would occur at lower levels among sensitive species [302,366].

Chronic Marine: 1.6E+1 ug/L

Older references: Marine Chronic Criteria: Insufficient data to develop criteria. Lowest Observed Effect Level: 16 ug/L [446,928].

Reference: 45 FR 79318 (11/28/80)

Contact: Criteria and Standards Division / OWRS / (202)260-1315

Discussion: Criteria were derived from a minimum data base consisting of acute and chronic tests on a variety of species. Requirements and methods are covered in the reference to the Federal Register.

Oak Ridge National Lab, 1994: Ecological Risk Assessment Freshwater Screening Benchmarks for concentrations of contaminants in water [649]. For a definition of meaning of each benchmark, see entry entitled: Benchmarks, Ecological Risk Assessment Screening Benchmarks. To be considered unlikely to represent an ecological risk, field concentrations should be below all of the following benchmarks (ug/L) [649]:

Fluoranthene (ug/L):

33.6 = National Ambient Water Quality Final Acute Value

6.16 = National Ambient Water Quality Final Chronic Value

301 = Secondary Acute Value

16.8 = Secondary Chronic Value

30 = Lowest Chronic Value - Fish

15 = Lowest Chronic Value - Daphnids

54,400 = Lowest Chronic Value - Aquatic plants

32 = Population EC2O

Acute and Chronic Criteria for Aquatic and Wildlife Uses in Arizona are 2000 ug/L and 1600 ug/L, respectively [881].

Maximum Concentration Levels in Florida for Mixing Zone Pollutants is 540 ug/L [881].

W.Plants (Water Concentrations vs. Plants):

EC50 Selenastrum capricornutum (alga) 54,400 ug/l/96 hr, toxic effect: cell numbers; 54,600 ug/l/96 hr, toxic effect: chlorophyll a [USEPA; In-depth Studies on Health and Environmental Impacts of Selected Water Pollutants (1978) USEPA Contract No 68-01-4646 as cited in USEPA; Ambient Water Quality Criteria Doc: Fluoranthene p.B-6 (1980), [366].

EC50 Skeletonema costatum (alga) 45,000 ug/l/96 hr, toxic effect: chlorophyll a; 45,600 ug/l/96 hr, toxic effect: cell numbers [USEPA; In-depth Studies on Health and Environmental Impacts of Selected Water Pollutants. (1978) USEPA Contract No 68-01-4646 as cited in USEPA; Ambient Water Quality Criteria Doc: Fluoranthene p.B-6 (1980) [366].

W.Invertebrates (Water Concentrations vs. Invertebrates):

See also Sed.Invertebrate section below for pore water toxicities.

LC50 for Artemia salina (brine shrimp) was 40 ug/L (ppb) for a 1-hr exposure [998].

LC50s for Aedes aegypti (mosquito) were 12 and 10 ug/L (ppb) for a 1-hr and a 24-hr exposure, respectively [998].

LC50 for Aedes taeniorhynchus (mosquito) was 48 ug/L for a 24-hr exposure [998].

LC50 for Culex quinquefasciatus (mosquito) was 45 ug/L for a 24-hr exposure [998].

LC50 for Ceriodaphnia dubia (water flea) was 45.0 ug/L for a 48-hr exposure [998].

LC50s for Daphnia magna (water flea) were 4 ug/L (0.004 mg/L, ppm), 1300 mg/L and 320 mg/L for 1-hr, 24-hr and 48-hr exposures, respectively [998].

For fluoranthene, the 48-hr EC50 for Daphnia magna was 325 mg/L [754].

LC50 Mysid shrimp 40 ug/l/96 hr [USEPA; Ambient Water Quality Criteria Doc: Fluoranthene (Draft) p.B-1 (1980)] [366].

LC50 Polychaete 500 mg/l/96 hr [USEPA; Ambient Water Quality Criteria Doc: Fluroanthene (Draft) p.B-1 (1980)] [366].

EPA Acute-chronic: ratio LC50 to NOEL for mysid shrimp is 2.5 [USEPA; Ambient Water Quality Criteria Doc: Fluoranthene (Draft) p.B-1 (1980)] [366].

W.Fish (Water Concentrations vs. Fish):

Acute Criteria for Cold- and Warm-Water Fisheries in Arizona are each 2000 ug/L [881].

Chronic Criteria for Cold- and Warm-Water Fisheries in Arizona are each 1600 ug/L [881].

LC50 Bluegill 3,980 ug/l/96 hr [USEPA; Ambient Water Quality Criteria Doc: Fluoranthene (Draft) p.B-1 (1980) [366].

LC50 for Lepomis macrochirus (bluegill) was >32 mg/L for a 24-hr exposure [998].

LC50 Cyprinodon variegatus (sheepshead minnow) > 560,000 ug/l/96 hr [USEPA; Ambient Water Quality Criteria Doc: Fluoranthene p.B-7 (1980) [366].

LC50s for Cyprinodon variegatus (sheepshead minnow) were >560 mg/L for 24-, 48- and 72-hr exposures. The no-observed-effect-concentration (NOEC) for death was 560 mg/L [998].

LC50s for Pimephales promelas (fathead minnow) were 6.83 and 7.1 ug/L (ppb) for 6-day and 30-day exposures, respectively [998].

W.Wildlife (Water Concentrations vs. Wildlife or Domestic Animals):

No information found.

W.Human (Drinking Water and Other Human Concern Levels):

EPA 1996 IRIS database information [893]:

Human Health (10-6) Risk Level for

Carcinogens) in ug/L [893]:

Water & Fish: 4.2E+1 ug/liter [893]. Same concentration previously published as Criteria for Water and Organisms routes of exposure: 42 ug/L [689,928].

Discussion: The WQC of 4.2E+1 ug/L is based on consumption of contaminated aquatic organisms and water [893]. NOTE: For the protection of human health from the toxic properties of fluoranthene ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 42 ug/l [302,366, and USEPA; Ambient Water Quality Criteria Doc: Fluoranthene p.C-47 (1980).

Criterion based on exposure through consumption of fish Only: 5.4E+1 ug/liter [893]. A WQC of 5.4E+1 ug/L has also been established based on consumption of contaminated organisms only [893].

Same concentration previously published as Criteria for Organisms Only: 54 ug/L [689,928]. Reference: 45 FR 79318 (11/28/80) [893].

Drinking Water MCL: None Published [446,893,928].

Drinking Water Health Advisories: none given [893].

NOTE: Before citing a concentration as EPA's water quality criteria, it is prudent to make sure you have the latest one. Work on the replacement for the Gold Book [302] was underway in March of 1996, and IRIS is updated monthly [893].

EPA Region 9 Preliminary remediation goals (PRGs) for tap water [868]: 1.5E+03 ug/L.

The sport fish community "human threshold criteria" for fluoranthene in Wisconsin public water supplies are [881]:

warm water communities: 28 ug/L

cold water communities: 9.1 ug/L

The sport fish community "human threshold criteria" for fluoranthene in Wisconsin non-public water supplies are [881]:

warm water communities: 32 ug/L
cold water communities: 9.5 ug/L

Numeric Water Quality Criteria in Arizona [881]:

Domestic water source: 280 ug/L
Fish consumption: 130 ug/L
Full body contact: 5600 ug/L
Partial body contact: 5600 ug/L

Criteria for human health protection in Missouri [881]:

Fish consumption: 54 ug/L
Drinking water supply: 40 ug/L
Groundwater: 40 ug/L

Water Quality Criteria in Kentucky for Protection of Human Health from the Consumption of Fish Tissue Substances Not Linked to Cancer [881]: 54 ug/L

Domestic Water Supply Source Criteria for Substances Not Linked to Cancer--Maximum Contaminant Level (organics) [881]: 0.042 mg/L

Other Historical Human Water Standards [366]:

1970 World Health Organization European Standards for drinking water recommends a concn of PAH's /polynuclear aromatic hydrocarbons/ not exceeding 0.2 ug/l /Polynuclear aromatic hydrocarbons/ [Sittig, M. Handbook of Toxic And Hazardous Chemicals. Park Ridge, NJ: Noyes Data Corporation, 1981. 334].

European standard for polycyclic aromatic hydrocarbons is: ground waters, up to 0.05 ug/l; drinking waters, up to 0.1 ug/l. /Polycyclic aromatic hydrocarbons/ [Borneff J, Kunte H; Arch Hyg Bacteriol 153 (3): 220-229 (1969) as cited in Health and Welfare Canada; Polycyclic Aromatic Hydrocarbons p.106 (1979) Report No. 80-EHD-50].

W.Misc. (Other Non-concentration Water Information):

Fluoranthene is a phototoxic PAH [494,887].

The attempt to develop a drinking water criterion for Polyaromatic nuclear hydrocarbons (PAH) as a class is hindered by several gaps in the scientific data base: (1) The PAH class is composed of numerous compounds having diverse biological effects and varying carcinogenic potential. A "representative" PAH mixture, has not been defined. (2) The common practice of using data derived from studies with benz(a)pyrene (BaP) to make generalizations concerning the effects of environmental PAH may not be scientifically sound. (3) No chronic animal toxicity studies involving oral exposure to PAH mixtures exist. (4) No direct human data concerning the effects of exposure to defined PAH mixtures exist. /Polynuclear aromatic hydrocarbons/[366, USEPA; Ambient Water Quality Criteria Doc: Polynuclear Aromatic Hydrocarbons p.C-118 (1980)].

Sediment Data Interpretation, Concentrations and Toxicity (All Sediment Data Subsections Start with "Sed."):

Sed.Low (Sediment Concentrations Considered Low):

No information found.

Sed.High (Sediment Concentrations Considered High):

No information found.

Sed.Typical (Sediment Concentrations Considered Typical):

Fluoranthene was detected in 100 % of urban-bay samples from the Puget Sound area. The mean concentration was 4196 ug/kg dry weight (ppb), while the median concentration was 490 ug/kg (ppb) [852].

Fluoranthene was detected in 80.9 % of non-urban-bay samples from the Puget Sound area. The mean concentration was 4596 ug/kg dry weight (ppb), while the median concentration was 150 ug/kg (ppb) [852].

> NOTE: The above values are not normalized for total organic carbon (TOC) content. Urban bay concentrations may be lower than non-urban bay concentrations due to more frequent dredging practices in urban bays, and also to the fact that most of the urban bays are at the mouths of rivers which are continually depositing "clean" sediment into these bays.

Sediment Concentrations [366]:

> Lake sediment 0.42 ppb, river sediment 0.39 ppb, Buzzards Bay sed 0.110-0.790 ppb, Atlantic shelf

sediment 0.0104-0.0167 ppb(1). Port Angeles harbor, Wash (area contaminated with fuel oil) 110-1100 ppb, Dungeness Bay (nearby relatively pristane area) 7.5-24 pbb(3). Dumwamish River sediment, Wash 1700 ppb(4). Severn Estuary, England (drainage system for industrial and domestic effluent) 0.5-5.2 ppm(5). Boston: sediment from mouth of Charles River extending into Massachusetts Bay decreases from 13000 ppb to 19 ppb as one gets further away from Boston; Gulf of Maine 19-120 ppb; Atlantic Ocean (beyond continental shelf) 4-11 ppb - combustion source suggested(6). Lake Erie surficial sediment, up to 1-10 km from coal-fired power plant and in direction of current 275-600 ppb, 1-10 km from power plant not in direction of current 70-110 ppb(7). Two remote Adirondack, NY lakes sediment 0-4 cm 460 and 1200 ppb, 4-8 cm 400 and 320 ppb 8-80 cm 3-81 and 11-25 ppb(9). Georges Bank surface sediment (various sites and seasons) 1-130 ppb including pyrene(10). Unspecified industrial river in US - below chemical plant 1-60 ppm in sediment although not detected in the river water(11). NY bight sediment 1200 ppb decreasing to 4.3 ppb in deep sea(12). Pettaquamscutt River, RI (rural, without point sources) 1600 ppb(12). Sediment in remote areas of South America, Africa and the Pacific atolls not detectable - 9.8 ppb(12). [(1) Santodonato J et al: pp.77-176 in Health and Ecological Assessment of Polynuclear Aromatic Hydrocarbons; Pathotox Publ Inc Park Forest South IL (1980) (2) Sims RC, Overcash MR; Res Rev 88: 1-68 (1983) (3) MacLeod WD Jr et al; Symp Fate Effects Petroleum Hydrocarbons on Marine Ecosystems and Organisms pp.385-96 (1977) (4) MacLeod WD Jr et al; Anal Chem 54: 386-92 (1982) (5) John ED et al; Bull Environ Contam Toxicol 22: 653-9 (1979) (6) Windsor JG Jr, Hites RA; Geochim Cosmochim Acta 42: 27-33 (1979) (7) Eadie BJ et al; Chemosphere 11: 185-91 (1982) (8) Ehrlich GG et al; Ground Water 20: 703-10 (1982) (9) Tan YL, Heit M; Geochim Cosmochim Acta 45: 2267-79 (1981) (10) Boehm PD, Farrington JW; Environ Sci Technol 18: 840-5 (1984) (11) Hites RA et al: ACS Symp Ser 94: 63-90 (1979) (12) Hites RA et al; Adv Chem Ser 185(Pet Mar Environ): 289-311 (1980)].

Sewage sludge (United Kingdom) 0.35-11.43 ppm dry wt(1). (1) McIntyre AE et al: Anal Lett 14: 291-309 (1981) [366].

Sed.Concern Levels, Sediment Quality Criteria, LC50 Values, Sediment Quality Standards, Screening Levels, Dose/Response Data and Other Sediment Benchmarks:

Sed.General (General Sediment Quality Standards, Criteria, and Benchmarks Related to Protection of Aquatic Biota in General; Includes Sediment Concentrations Versus Mixed or General Aquatic Biota):

Oak Ridge National Lab, 1994: Risk Assessment Screening Benchmarks for Sediment Concentrations. To be considered unlikely to represent an ecological risk, field concentrations should be below the following benchmark in mg/kg (ppm) dry weight [652]:

6.2 = Sediment Quality Criterion at 1% Organic Carbon (EPA).

Benthic organisms should be acceptably protected in freshwater sediments containing < or = 620 ug fluoranthene/g organic carbon, and in saltwater sediments containing < or = 300 ug fluoranthene/g organic carbon (except possibly where a locally important species is very sensitive or sediment organic carbon is < 0.2%) [879].

NOTE: Confidence limits are 290 to 1300 ug/g o.c. for freshwater sediments and 140 to 640 ug/g o.c. for saltwater sediments. The upper confidence limits should be interpreted as concentrations above which impacts on benthic species should be expected; conversely, the lower confidence limits should be interpreted as concentrations below which impacts on benthic species should be unlikely [879].

Long 1992: After studying a large amount of data (including NOAA and AET data) on sediment concentrations versus toxic effects, Long concluded that fluoranthene concentrations of about 1 ppm (dry weight) or more often have been associated with toxic effects [444]. Effects in sediments were observed with mean fluoranthene concentrations as low as 382 +/- 241 ppb [444].

AET, 1988: The apparent effects threshold concentrations for fluoranthene in sediments proposed for Puget Sound ranged from 1.7 mg/kg dry weight (microtox) to 30 mg/kg dry weight (amphipod) [416]. Although the authors of the Puget Sound AETs have cautioned that Puget Sound AETs may not be appropriate for comparison with data from other geographic areas, so few concern levels for this chemical have been published that the proposed Puget Sound concern level is included in this text as a reference item.

The Canadian AET concentration, adapted from NOAA (1990), for fluoranthene sorbed to marine sediments is 1.000 mg/kg dry weight [864]. An AET is defined as the lowest concentration of a compound in sediment at which biological effects (usually changes in composition of benthic invertebrate communities) are observed to occur [864].

> NOTE: Even lower concentrations of this PAH may be of concern related to its contribution to "total or total carcinogenic PAH" sums (see the "PAHs as a group" entry).

NOAA 1995: After studying its own data from the National Status and Trends Program as well as many literature references concerning different approaches to determining sediment criteria, NOAA suggested that the potential for biological effects of this contaminant sorbed to sediments was highest in sediments where its concentration exceeded the 5100 ppb dry weight Effects Range-Median (ERM) concentration and was lowest in sediments where its concentration was less than the 600 ppb dry weight Effects Range-Low (ERL) concentration [664]. To improve the original 1990 guidelines [233], the 1995 report included percent (ratios) incidence of effects for ranges below, above, and between the ERL and ERM values. These numbers represent the number of data entries within each concentration range in which biological effects were observed divided by the total number of entries within each range [664]:

<ERL	20.6
ERL-ERM	63.6
>ERM	92.3

> The 1995 study also compared these derived ERM values to criteria developed with other methods. For example, the national sediment quality criteria proposed by the US EPA (1993) for fluoranthrene is 300 ug/gram organic carbon (goc), with 95% confidence limits of 140 and 640 ug/goc [664]. Assuming a total organic carbon (TOC) concentration of 1%, this is equivalent to 3000 (1400 - 6400) ppb dry weight. This criterion value was lower than the ERM value of 5100 by a factor of 1.7. Note that increasing the percent TOC would increase the EPA criteria value [664].

Ontario Ministry of the Environment Freshwater Sediment Guidelines, 1993. Lowest effect level:

750 ug/kg dry weight. Severe effect level: 1020 mg/kg organic carbon [761].

St. Lawrence River Interim Freshwater Sediment Criteria, 1992. No effect: 20-200 ug/kg dry weight. Minimal effect: 600 ug/kg dry weight. Toxic effect: 200 mg/kg organic carbon [761].

Environment Canada Interim Sediment Quality Assessment Values. Threshold effect level: 111.3 ug/kg dry weight. Probable effect level: 2354.9 ug/kg dry weight [761].

Sed.Plants (Sediment Concentrations vs. Plants):

No information found.

Sed.Invertebrates (Sediment Concentrations vs. Invertebrates):

The acute toxicity of fluoranthene spiked into saltwater sediments was tested for two invertebrates. Test results follow and include pore water toxicities and organic carbon conditions of the tests [879]:

LC50s [879]:

Amphipod (Corophium spinicorne) -
  sediment toxicity = >13.6 ug/g dry weight
  pore water toxicity = >27.5 ug/L
    -organic carbon conditions: 0.48% TOC

Amphipod (Rhepoxynius abronius) -
  sediment toxicity = >6.5 ug/g dry weight
  pore water toxicity = 29.4 ug/L
    -organic carbon conditions: 0.31% TOC

NOTE: TOC = total organic carbon; test conditions were static and of 10-day duration; sediment medium was sand with organic matter added.

Sed.Fish (Sediment Concentrations vs. Fish):

The acute toxicity of fluoranthene spiked into freshwater sediments was tested for two fish. Test results follow and include organic carbon conditions of the tests [879]:

LC50s [879]:

Fathead minnow (Pimephales promelas) -
  sediment toxicity = 0.437 ug/g dry weight

-organic carbon conditions: 0.70% TOC
-test conditions: Static; 30-day duration

Channel catfish (Ictalurus punctatus) -
sediment toxicity = 3.683 ug/g dry weight
-organic carbon conditions: 0.70% TOC
-test conditions: Static; 4-day duration

NOTE: TOC = total organic carbon

Sed.Wildlife (Sediment Concentrations vs. Wildlife or Domestic Animals):

No information found.

Sed.Human (Sediment Concentrations vs. Human):

No information found.

Sed.Misc. (Other Non-concentration Sediment Information):

In a study of the effects of motor boat activity on the water and sediment quality of a drinking water reservoir near Washington, D.C., only a few PAHs (like phenanthrene, pyrene, and fluoranthene) were commonly found in the sediments, unlike the water samples in which all 11 of the PAHs monitored were frequently found [653].

Soil Data Interpretation, Concentrations and Toxicity (All Soil Data Subsections Start with "Soil."):

Soil.Low (Soil Concentrations Considered Low):

In Holland, 0.1 ppm of fluoranthene indicates a background concentration of fluoranthene [347].

Soil.High (Soil Concentrations Considered High):

In Holland, 10 ppm of fluoranthene indicates a moderate soil contamination [347].

Concentrations of PAH's in bioassay earthworms and bioassay soil from 15 sites at the Times Beach Confined Disposal Facility in Buffalo, N.Y. (1987): The mean concentration of fluoranthene in the soil was 2.4 ppm (dry weight), the range was 0.19-7.5 ppm.

Soil Concentrations (mg/kg dry weight) Polycyclic Aromatic Hydrocarbons (PAHs) at Contaminated Sites. Highest values found at wood preserving, gas works, and coking site plants (mg/kg dry weight) [881]:

Fluoranthene	3,664

Soil.Typical (Soil Concentrations Considered Typical):

PAHs are ubiquitous in soil and are distributed globally. One study found fluoranthene at concentrations above 150 ug/kg in arctic soils [788,881].

Soil Concentrations [366]:

Nova Scotia soil (30 samples) 0.3-66 ppb, 8 ppb median. Soil cores 180 m downgradient from point where near surface groundwater was contaminated by coal tar derivates 0.9 m depth 0.06 ppm, 1.8-6.1 m depth 0.01 ppm(8). Northeast US urban soil 180 ppb, soil removed from large urban area 48 and 63 ppb(12). US soil outside northeast 0.6-35 ppb(12). Soil in Pacific islands not detectable to 5.8 ppb, Enewetok atoll (petroleum influence) 600 ppb(12). [(1) Santodonato J et al: pp.77-176 in Health and Ecological Assessment of Polynuclear Aromatic Hydrocarbons; Pathotox Publ Inc Park Forest South IL (1980) (2) Sims RC, Overcash MR; Res Rev 88: 1-68 (1983) (3) MacLeod WD Jr et al; Symp Fate Effects Petroleum Hydrocarbons on Marine Ecosystems and Organisms pp.385-96 (1977) (4) MacLeod WD Jr et al; Anal Chem 54: 386-92 (1982) (5) John ED et al; Bull Environ Contam Toxicol 22: 653-9 (1979) (6) Windsor JG Jr, Hites RA; Geochim Cosmochim Acta 42: 27-33 (1979) (7) Eadie BJ et al; Chemosphere 11: 185-91 (1982) (8) Ehrlich GG et al; Ground Water 20: 703-10 (1982) (9) Tan YL, Heit M; Geochim Cosmochim Acta 45: 2267-79 (1981) (10) Boehm PD, Farrington JW; Environ Sci Technol 18: 840-5 (1984) (11) Hites RA et al: ACS Symp Ser 94: 63-90 (1979) (12) Hites RA et al; Adv Chem Ser 185(Pet Mar Environ): 289-311 (1980)].

Sewage sludge (United Kingdom) 0.35-11.43 ppm dry wt(1). (1) McIntyre AE et al: Anal Lett 14: 291-309 (1981) [366].

Background Soil Concentrations of Polycyclic Aromatic Hydrocarbons (PAH concentration in ug/kg) [881]:

(The below table is not indented to allow it to fit the margins):

Compound	Rural soil	Agricultural Soil	Urban Soil
Fluoranthene	0.3-40	120-210	200-166,000

Soil.Concern Levels, Soil Quality Criteria, LC50 Values, Soil Quality Standards, Screening Levels, Dose/Response Data and

Other Soil Benchmarks:

Soil.General (General Soil Quality Standards, Criteria, and Benchmarks Related to Protection of Soil-dwelling Biota in General; Includes Soil Concentrations Versus Mixed or General Soil-dwelling Biota):

Soil criteria for evaluating the severity of contamination under the Dutch Soil Cleanup (Interim) Act (1982): 0.1 ppm of fluoranthene indicates a background concentration of fluoranthene. 10 ppm of fluoranthene indicates a moderate soil contamination. 100 ppm indicates a threshold value which requires immediate cleanup [347].

Soil.Plants (Soil Concentrations vs. Plants):

No information found.

Soil.Invertebrates (Soil Concentrations vs. Invertebrates):

Concentrations of PAH's in bioassay earthworms and bioassay soil from 15 sites at the Times Beach Confined Disposal Facility in Buffalo, N.Y. (1987): The mean concentration of fluoranthene in the soil was 2.4 ppm (dry weight), the range was 0.19-7.5 ppm. The mean concentration of fluoranthene in earthworms was 0.19 ppm (ash-free dry weight) and the range was <0.12-2.4 ppm [347].

Soil.Wildlife (Soil Concentrations vs. Wildlife or Domestic Animals):

No information found.

Soil.Human (Soil Concentrations vs. Human):

EPA 1996 National Generic Soil Screening Level (SSL) designed to be conservative and protective at the majority of sites in the U.S. but not necessarily protective of all known human exposure pathways, land uses, or ecological threats [952]:

SSL = 3100 mg/kg for ingestion pathway [952].

SSL = 210 to 4300 mg/kg for protection from migration to groundwater at 1 to 20 Dilution-Attenuation Factor (DAF) [952].

Preliminary remediation goals (PRGs), 1995 [868]:

Residential Soil: 2.6E+03 mg/kg wet wt.
Industrial Soil: 2.7E+04 mg/kg wet wt.

NOTE:

1) PRGs focus on the human exposure pathways of ingestion, inhalation of particulates and volatiles, and dermal absorption. Values do not consider impact to groundwater or ecological receptors.
2) values are based on a non-carcinogenic hazard quotient of one.
3) PRGs for residential and industrial landuses are slightly lower concentrations than EPA Region III RBCs, which consider fewer aspects [903].

EPA 1995 Region III Risk Based Concentration (RBC) to protect from transfers to groundwater:

980 mg/Kg dry weight [903].

Soil.Misc. (Other Non-concentration Soil Information):

No information found.

Tissue and Food Concentrations (All Tissue Data Interpretation Subsections Start with "Tis."):

Tis.Plants:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Plants:

No information found.

B) Body Burden Residues in Plants: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

Algae (moderately polluted site on coast of Norway) < 4-900 ppb(1). [(1) Knutzen J, Sortland B; Water Res 16: 421 (1982)] [366].

Tis.Invertebrates:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Invertebrates:

No information found.

B) Concentrations or Doses of Concern in Food Items Eaten by Invertebrates:

No information found.

C) Body Burden Residues in Invertebrates: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

Details of fluoranthene content (ug/kg or ppb) in whole body samples of mussels) from Snug Harbor, Alaska, an area heavily oiled by the Exxon Valdez Crude Oil, 4/15/89 [971]:

Note: Concurrent measurements of water quality, as well as equilibrium partitioning estimates of water quality based on concentrations in fish and mussels, both confirm that PAH concentrations did not exceed water quality criteria at the time these concentrations were measured in mussel tissues [971]. These values are wet weight (Jerry Neff, Battelle Ocean Sciences, Duxbury, MA, personal communication 1996):

fluoranthene: 10.7 ug/kg = ppb

Concentrations of PAH's in bioassay earthworms and bioassay soil from 15 sites at the Times Beach Confined Disposal Facility in Buffalo, N.Y. (1987): The mean concentration of fluoranthene in the soil was 2.4 ppm (dry weight), the range was 0.19-7.5 ppm. The mean concentration of fluoranthene in earthworms was 0.19 ppm (ash-free dry weight) and the range was <0.12-2.4 ppm [347].

Information from HSDB [366]:

Clams (Great Barrier Reef) 0.05-.7 ppb(1). Mollusks (unpolluted locations) 1.7-11 ppb(1,2), polluted locations 7.8-4992 ppb(1,3-5). Softshell clam (Coos Bay, Oregon) industrialized bay front 110.7 ppb, more remote bay site 10.5 ppb(6). Mussels (Yakina Bay, Oregon) industrialized bay front 179.9 ppb avg, more remote bay site 46.9 ppb avg(7). Mussels (fjord in Norway, site near outfall of ferro smelter) 20122 ppb(5). Mussels near sewage treatment plant 77-190 ppb(9). Coast of Norway - polluted areas: starfish 13-18 ppb, sponge 48 ppb(3). Gastropod (Hamilton, Ont. on Lake Ontario) 97.5 ppb(8). [(1) Smith JD et al; Environ Sci Technol 18: 353-8 (1984) (2) Iosifidou HG et al; Bull Environ Contam Toxicol 28: 535 (1982) (3) Knutzen J, Sortland B; Water Res 16: 421 (1982) (4) Galloway WB et al; Environ Toxicol Chem 2: 395-410 (1983) (5)

Bjoerseth A et al; Sci Total Environ 13: 71-86 (1979) (6) Mix MC, Schaeffer RL; Marine Pollut Bull 14: 94-7 (1983) (7) Mix MC, Schaeffer RL; Mar Environ Res 9: 193-210 (1983) (8) Kalas L et al: pp.567-76 in Hydrocarbons and Halogenated Hydrocarbons in the Aquatic Environment: Afgan BK, Mackay D eds; Plenum Press New York (1980) (9) Kveseth K et al; Chemosphere 11: 623-39 (1982).

Oligochaete worms and chironomid midges (in Lake Erie sediment 1-10 km from coal-fired power plant) 10 ppb and 30-130 ppb, respectively(1). [(1) Eadie BJ et al; Chemosphere 11: 185-91 (1982)].

Tis.Fish:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Fish (Includes FDA Action Levels for Fish and Similar Benchmark Levels From Other Countries):

No information found.

B) Concentrations or Doses of Concern in Food Items Eaten by Fish:

No information found.

C) Body Burden Residues in Fish: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

No detections of this compound were made in certain samples of Exxon Valdez fish [971].

The fluoranthene concentration in mosquitofish with extremely elevated total PAH concentrations (60.79 mg/kg) was 10 mg/kg [201].

Detected in pike and carp in Hamilton Harbor and the Detroit River, Michigan(10). (10) Konasewich D et al; Status Report on Organic and Heavy Metal Contaminants in the Lakes Erie, Michigan, Huron and Superior Basins; Great Lakes Qual Rev Board p.148 (1978)] [366].

Tis.Wildlife: Terrestrial and Aquatic Wildlife, Domestic Animals and all Birds Whether Aquatic or not:

A) As Food: Concentrations or Doses of Concern to Living Things Which Eat Wildlife, Domestic Animals, or Birds:

No information found.

B) Concentrations or Doses of Concern in Food Items Eaten by Wildlife, Birds, or Domestic Animals (Includes LD50 Values Which do not Fit Well into Other Categories, Includes Oral Doses Administered in Laboratory Experiments):

No information found.

C) Body Burden Residues in Wildlife, Birds, or Domestic Animals: Typical, Elevated, or of Concern Related to the Well-being of the Organism Itself:

No information found.

Tis.Human:

A) Typical Concentrations in Human Food Survey Items:

See also Tis.Invertebrates, C) and Tis.Fish, C), above.

Food Survey Results [366]:

Coconut oil 18 ppb, soy oil 1.3 ppb, olive oil 3.2 ppb, peanut oil 3.3 ppb(1), smoked fish 1.6-12 ppb(1) smoked, barbecued or charcoal broiled meat 0.6-49 ppb(1). Kale 5316-1196 ppb. Ham, lightly smoked 4.0-14.0 ppb, heavily smoked 48.0-156.0 ppb. Charcoal-broiled hamburger; fat 13.3 ppb, lean 0.3 ppb(1). Bakers yeast 18.5-93 ppb(1). Most frequently found in oysters, smoked food, liquid smoke, vegetable oils, wax, charcoal broiled steaks, roasted coffee(2). Fresh kale 55.4-253.4 ppb, 116.9 ppb, avg(3). U.K. total diet 0.99 ug/day which includes % of total input (avg concn): cereal 32% (1.38 ppb), meat 7% (0.48 ppb), fish 2% (0.81 ppb), oil and fats 14% (1.76 ppb), fruit and sugar 16% (0.93 ppb), root vegetables 5% (0.26 ppb), other vegetables 17% (1.50 ppb), beverages 1% (0.08 ppb), milk 6% (0.15 ppb)(4). Milled flour and fractions except bran 1.5-3.4 ppb, bran 28 ppb, breakfast cereals 1.4-18 ppb, barley malt 0.8-26 ppb, cooking oil 0.2-7.5 ppb(5). Nigerian fish smoked 34.5 ppb, dried (3 methods) 5.3-13.9 ppb(6). [(1) Santodonato J et al; pp.77-176 in Health and Ecological Assessment of Polynuclear Aromatic Hydrocarbons; Pathotox Pub Inc Park Forest South IL (1980) (2) Fazio T, Howard JW; pp.461-505 in Handbook of Polycyclic Aromatic Hydrocarbons; Bjorseth A ed Marcel Dekker New York (1983) (3) Vaessen HAMG et al; Tox

Environ Chem 7: 297-324 (1984) (4) Dennis MJ et al: Food Chem Toxic 21: 569-74 (1983) (5) Lawrence JF, Weber DR; J Agric Food Chem 32: 794-7 (1984) (6) Afolabi OA et al; J Agric Food Chem 31: 1083-90 (1983)].

Skim milk powder 1.5 ppb, powdered baby formula 8.0 ppb(1). [(1) Lawrence JF, Weber DF; J Agric Food Chem 32: 794-7 (1984)] [366].

B) Concentrations or Doses of Concern in Food Items Eaten by Humans (Includes Allowable Tolerances in Human Food, FDA, State and Standards of Other Countries):

For risk to human adults eating fish, separate carcinogenic and non-carcinogenic risk-based fish tissue concentrations were calculated [903]. The following EPA Region III fish tissue risk-based concentration (RBC) benchmark utilizes the lower of the two (carcinogenic vs. non-carcinogenic) concentrations, rounded to two significant figures [903]:

RBC Benchmark = 54 mg/Kg wet weight. However, the reader should keep in mind that elevated concentrations of individual PAHs often occur in the presence of complex mixtures of PAHs, and that complex mixtures of PAHs often display carcinogenic and phototoxic properties (see "PAHs as a group" entry).

The Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis, but may not exist for other toxic effects such as carcinogenicity. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime [893]:

EPA IRIS RfD: 4E-2 mg/kg-day (Confidence: Low) [893].

EPA PRG RfD oral: 4E-2 mg/kg-day [868].

Slope factor: none given [893].

C) Body Burden Residues in Humans: Typical, Elevated, or of Concern Related to the Well-being of Humans:

EPA has suggested that taking 0.04 mg fluoranthene into your body each day is not likely to cause any significant, noncancer harmful health effects [788].

Fluoranthene was detected in skin lipid of 9 roofers at median concn of 1.2 ng/mg lipid (range: 0.3-8.9); Total ng in sample from 36 sq cm area of forehead, 2.7 Median (range: 0.6 To 36). [Wolff MS et al; Detection of polycyclic aromatic hydrocarbons in skin oil obtained from roofing workers; Chemosphere 11 (6): 595-9 (1982) [366].

Tis.Misc. (Other Tissue Information):

Fluoranthene is a phototoxic PAH [494,887; Reprinted with permission from Environmental Toxicology and Chemistry, Volume 6, Newstead, J.L. and J.P. Geisy. Predictive models for photoinduced acute toxicity of polycyclic aromatic hydrocarbons to Daphnia magna. Copyright 1987 SETAC].

Bio.Detail: Detailed Information on Bioconcentration, Biomagnification, or Bioavailability:

During the Exxon Valdez spill, bioconcentration explained the buildup of PAHs in tissues better than biomagnification; most accumulation was of an equilibrium partitioning nature across the gills rather than from the food chain [971]. Immature fish seem to have higher bioconcentration of PAHs than adults, perhaps because their PAH breakdown systems are not fully developed and at times perhaps because of a higher percentage of lipid tissues (yolk tissues, etc) [971] (confirmed by Jerry Neff, Battelle Ocean Sciences, Duxbury, MA, personal communication 1996).

Bioconcentration factor, log BCF [848]: 4.08 for microorganisms in water; 3.24 for Daphnia magna.

Half-life of depuration by oysters is 5 days [848].

Bioconcentration [366]:

In a 21 day bioconcentration test in a flow-through tank, the log BCF in rainbow trout was 2.58(1). Fathead minnows - 28 day experiment in flow-through tank log BCF 3.60 peak after 7 days; depuration occurs in 2 days(5). When oysters were suspended in oil-treated enclosures contaminated with fluoranthene dissolved in Prudhoe crude oil, the log BCF was 4.09 after 2 days exposure(2). After the oysters were transferred to clean water, depuration half-life was 5 days(2). The log BCF for fish calculated from the log Kow (5.22(3)) is 3.74(4,SRC). [(1) Spehar RL et al; J Water Pollut Control Fed 52: 1703-74 (1980) (2) Lee RF et al; Environ Sci Technol 12: 832-8 (1978) (3) Mackay D et al; Chemosphere 9: 701-11 (1980) (4) Lyman WJ et al; Handbook of Chemical Property

Estimation Methods. Environmental behavior of organic compounds; McGraw-Hill New York pp.5.1 to 5.30 (1982) (5) Carlson RM et al; Implications to the Aquatic Environment of Polynuclear Aromatic Hydrocarbons Liberated from Northern Great Plains Coal; USEPA-600/3-79-093 (1979)].

Interactions:

No information found.

Uses/Sources:

In a recent study (1993) which involved the collection and analysis of approximately 140 urban runoff samples from a number of different source areas in Birmingham, Alabama, and under various rain conditions, fluoranthene was one of two organic compounds detected most frequently (23% of samples) [881].

Fluoranthene concentrations: gasoline 0.7-10 ppm, higher in high octane gasoline than low(2); motor oil 0.06-0.28 ppm(2); Coal tar 54 and 20,000 ppm(2). (2) Verschueren K; Handbook on Environmental Data on Organic Chemicals; 2nd ed Van Nostrand Reinhold New York p.671-4 (1983)].

See Chem.Detail section below for more fluoranthene concentrations in petroleum products.

Fluoranthene was found in groundwater at a coal and oil gasification plant some 30 years after the plant shut down [788].

Trace amounts of fluoranthene were found in samples of rain and snow from Norway, probably originating from combustion of fossil fuels [500].

In a 1981-82 study that characterized air levels of 13 PAHs in Los Angeles, it was reported mean ambient particle-phase PAH concentrations ranging from 0.32 ng/m3 for benzo[k]fluoranthene to 3.04 ng/m3 for combined benzo[g,h,i]perylene and indeno[1,2,3-c,d]pyrene. Mean concentrations of anthracene, fluoranthene, pyrene, chrysene, benz[a]anthracene, combined perylene and benzo[e]pyrene, benzo[b]fluoranthene, and benzo[a]pyrene were 0.54; 0.94, 1.62, 0.97, 0.48, 0.43. 0.94, and 0.64 ng/m3, respectively [881].

Benner and Gordon (1989) postulated that the observed decrease in PAH concentrations over the 1975-85 decade resulted from the increasing use of catalytic converters in U.S. automobiles over that period. These authors also reported concentrations of PAHs in a typical vapor-phase sample from the Boston Harbor Tunnel for four PAHs included in this profile: anthracene (32.3 ng/m3), fluoranthene (25.6 ng/m3), phenanthrene (184 ng/m3), and pyrene (28.3 ng/m3.

Therapeutic Uses [366]:

Crude coal tar was widely used in the clinical treatment of acute and chronic dermatoses, eg, infantile and varicose eczema, occupational and contact dermatitis, and psoriasis. ... The exposure of the US population to dermatologic coal tar preparations may be extensive, since psoriasis alone is estimated to affect about 2% of the population. [NIOSH; Criteria Document: Coal Tar Products p.26 (1977) DHEW Pub. NIOSH 78-107].

Natural Occurring Sources [366]:

Crude oil, fossil fuels(1,2). Since fluoranthene is a product of incomplete combustion, there will be natural sources arising from volcanoes, forest fires, etc. (SRC) [(1) Verschueren K; Handbook of Environmental Data on Organic Chemicals; 2nd ed Van Nostrand Reinhold New York pp.671-4 (1983)].

Artificial Sources [366]:

Fluoranthene occurs ubiquitously in products of incomplete combustion such as in exhaust gases from gasoline engines, stack gases from municipal incinerators, emissions from coal tar pitch, coal tar, coke ovens, burning coal, gasoil, gas(1). Sewage sludge, spills of motor oil, gasoline, and other petroleum products. Fluoranthenes/pyrenes are high relative to naphthalene in samples from combustion sources; the opposite is true for petroleum products(2). [(1) Verschueren K; Handbook of Environmental Data on Organic Chemicals; 2nd ed Van Nostrand Reinhold New York pp.671-4 (1983) (2) Sporstol S et al; Environ Sci Technol 17: 282-6 (1983)].

/Laboratory tests/ conducted on steel panels coated with coal tar /revealed that/ after 1 wk of static testing, several PAHs were found in leachate samples. ... /Fluoranthene among 6 others/ ranged from 13 to 56 ug/l. ... in EPA laboratory, coal-tar-based coatings were tested on glass plates with flowing tap water. Concn of PAHs /were found/ in water after 25 & 165 days ... /Incl fluoranthene among 2 others/ at 14000 to 46000 ng/l ... /Leachate samples from/ petroleum asphalt coatings on ductile-iron pipe...analyzed by HPLC ... & gc/ms using recirculation test system & sampling times ranging from 10 min to 293 hr ... Fluoranthene was measured at 7 ng/l, the highest concn for any single PAH covered by world health organization standards. ... /Leachates from/ cement- & asphalt-lined cast-iron pipe /were tested/ using number of analytical techniques ... Fluoranthene (4-6 ng/l) ... /Identified/ in water that had been in contact with asphalt lining. [National Research Council. Drinking Water & Health, Volume 4. Washington, DC: National Academy Press, 1981. 78].

... Samples /were collected/ at inlet & outlet of 12000 gal (45600-l) storage tank which had a 5-yr old commercial coal-tar lining. ... Influent & effluent concn in ug/l ... For fluoranthene was (0.003 & 0.081), Respectively ... [National Research Council. Drinking Water & Health, Volume 4. Washington, DC: National Academy Press, 1981. 88].

Forms/Preparations/Formulations:

No information found.

Chem.Detail: Detailed Information on Chemical/Physical Properties:

Solubility [870]: Almost insoluble in water (0.265 ppm in freshwater at 25 degrees C; 0.1 +/- 0.06 ppm in seawater at 25 degrees C). Soluble in ethanol, ether, benzene, chloroform, carbon disulfide, glacial acetic acid.

Vapor pressure [870]: 0.0013 kPa at 20 degrees C (0.01 mm); 6.7x10(-7) at 25 degrees C (5x10(-6) mm)

Octanol/Water partition coefficient (low Kow) [848]: 4.70 - 6.50

Log Kow value for fluoranthene [971]: 5.22

Sorption partition coefficient (low Koc) [848]: 4.58 - 6.38

Density [848]: 1.252 g/cm3 at 0 degrees C

Melting point [848]: 107-110 degrees C

Boiling point [870]: 375 degrees C

Concentrations of fluoranthene in South Louisiana crude, Kuwait crude, No. 2 fuel oil, and Bunker C residual were 5.0, 2.9, 37, and 240 mg/kg (ppm), respectively [177]. Another study showed concentrations of fluoranthene in South Louisiana crude and Kuwait crude were 6.2 and 2.9 10(-6)g/g oil (ppm), respectively [747].

PAH concentrations (ug/g oil sampled) were determined for three different crude oil sample types (weathered and unweathered oil) taken from the Exxon Valdez oil spill. Fluoranthene was not detected in any of them [790; Reprinted with permission from Environmental Toxicology and Chemistry, Vol.14(11), W.A. Stubblefield, G.A. Hancock, W.H. Ford, and R.K. Ringer, "Acute and Subchronic Toxicity of Naturally Weathered Exxon Valdez Crude Oil in Mallards and Ferrets." Copyright 1995 SETAC].

Fluoranthene content (mg/kg or ppm) in one fresh sample of Exxon Valdez Crude Oil [971]: 2 mg/kg = ppm

Fluoranthene content in one fresh sample of NSFO (Fuel Oil 5, Chuck Rafkind, National Park Service, Personal Communication, 1996): 31.6 ng/mg or ppm.

Fluoranthene content in one sample of groundwater subjected to long term contamination of NSFO (Fuel Oil 5), possibly mixed with some JP-4, motorgas, and JP-8, Colonial National Historical Park Groundwater Site MW-10 (Chuck Rafkind, National Park Service, Personal Communication, 1996): 818.8 ng/L or ppt

NOTE: The above two PAH concentrations were analyzed by a GC/MS/SIM NOAA protocol [828] modified with methylene chloride extraction for use with water samples (Guy Denoux, Geochemical and Environmental Research Group, Texas A&M University, personal communication 1996).

Fluoranthene concentrations in Used Engine Oil: 55.0 ppm [519; Reprinted with permission from Environmental Toxicology and Chemistry, Volume 12, Upshall, C., J.F. Payne and J. Hellou. Induction of MFO enzymes and production of bile metabolites in rainbow trout (Oncorhynchus mykiss) exposed to waste crankcase oil. Copyright 1992 SETAC].

Fluoranthene is found in unleaded, premium unleaded, and leaded gasolines at 1.84 % volume of gasoline [796].

Fate.Detail: Detailed Information on Fate, Transport, Persistence, and/or Pathways:

Sorption of PAHs to soil and sediments increases with increasing organic carbon content and is also directly dependent on particle size. One researcher found that about 2 times more fluoranthene, benz(a)anthracene, and benzo(a)pyrene were retained by marsh sediment than by sand [788].

Another study showed how biodegradation of PAHs was related to molecular weight. The 2- and 3-ring PAHs degraded rapidly while the 4-ring PAHs (fluoranthene, pyrene, benzo(a)anthracene, and chrysene) generally biodegraded 50% in a few months [815].

Calculated half-lives of direct sunlight photolysis for 50% conversion at 40 degrees N latitude of midday in midsummer: 21 hours (near the surface); 160 days (5-m deep inland water with no sediment-water partitioning); and 200 days (inland water with sediment partitioning) [848].

Half-life of fluoranthene in groundwater is 6720 to 21,120 hours, based on unacclimated aqueous aerobic biodegradation half-life [848].

Half-lives in soil [848]: 44-182 days; 39 days for 5 mg/kg treatment, 34 days for 50 mg/kg treatment; >50 days; 18 weeks; 7.8 years.

Environmental Fate [366]:

> TERRESTRIAL FATE: Fluoranthene adsorbs strongly to soil and would be expected to remain in the upper layers of soil. However, it has been detected in groundwater samples which demonstrates that it can be transported there by some process(es) It slowly degrades in soil (half-life ca 5 mo to 2 yr). (SRC).

AQUATIC FATE: When fluoranthene is released into water it will partially sorb to sediment and particulate matter in the water column including phytoplankton, zooplankton and detrital particles(1). Photolysis should occur in the surface layers of water (half-life 21 hr in clear water, ca 200 hr in turbid water). When a crude oil dispersion was placed in the top of a water column in a controlled ecosystem in Saanich Inlet, Canada, the fluoranthene concn in the water column decreased exponentially, declining to half its initial concentration in 3-4 days. After 17 days, 10% of the fluoranthene was recovered in the sediment(1). In another study, fluoranthene concns in sediment core samples in an area near a ferro-smelter in Norway were approximately constant until the 6-8 cm depth, which corresponded to 1923 when the smelter was installed(2). This suggests that little or no degradation occurred in the sediment. (SRC) [(1) Lee RF et al; Environ Sci Technol 12: 832-8 (1978) (2) Bjorseth A et al; Sci Total Environ 13: 71-86 (1979)].

ATMOSPHERIC FATE: Fluoranthene released into the atmosphere exists as the free vapor as well as adsorbed to particulate matter. The unadsorbed chemical will photolyze as well as react with such molecules as ozone, nitrogen oxides and sulfur oxides. The half-life is approximately 4-5 days. The sorbed molecule is considerably more stable, traveling long distances under appropriate wind conditions. It will be subject to gravitational settling and rainout. The sorbed chemical, however, appears to degrade at about the same rate as the free chemical under photochemical smog conditions. (SRC)

Biodegredation [366]:

It has been shown that several bacterial strains isolated from the marine environment(1) and sewage(2) are capable of degrading fluoranthene. When crude oil enriched with fluoranthene was incubated with coastal sediment in a flowing seawater system, 1.9%-2.4% of the chemical was removed per week translating to a half-life of 143-182 days(3,4) or a degradation rate of 2 ng/g-soil per hour at a concn of 10 ug/g(3). Microbial degradation was more rapid in upper surfaces than in lower layers of sediment and greatest where the sediment grain size was largest(4). When percolated through a soil column in a mixture of polynuclear aromatic hydrocarbons (PAHs), fluoranthene degraded with a half-life of 44 days(3,5). When 7 applications of PAH-containing oily sludge was amended to soil over a two year period and then monitored for an additional year and a half, the fluoranthene residue in the soil at the end of the 2 year ammendation period was decreased by 39% in the following year and a half(6). In the sludge ammendation experiment 4.7% of the applied fluoranthene remained after 3 1/2 years(6).

Mixed results were reported in a static biodegradability test employing a domestic wastewater inoculum where 100% and 0% of the fluoranthene was degraded in four successive weekly subcultures at concentrations of 5 and 10 mg/l respectively(7). In a pilot wastewater treatment plant, no fluoranthene was lost due to biodegradation(8). [(1) Soli G; Hydrocarbon-oxidizing bacteria and their possible use as controlling agents of oil pollution in the ocean; NTIS AD-763 655. Naval Weapons Ctr China Lake CA (1973) (2) Patterson JW, Kodukala PS; Chem Eng Prog 77: 48-55 (1981) (3) Sims RC, Overcash MC; Res Rev 88: 1-68 (1983) (4) Gardner WS et al; Water Air Soil Pollut 11: 339-47 (1979) (5) Groenewegen D, Stolp H; Zentrablat Bakteriol Parasitenkd Infektionskr Hyg Abt 1: Orig Reike B 162: 225-32 (1976) (6) Bossert I et al; Appl Environ Microbiol 47: 763-7 (1984) (7) Tabak HH et al; J Water Pollut Control Fed 53: 1503-18 (1981) (8) Petrasek AC et al; J Water Pollut Control Fed 55: 1286-96 (1983)].

Abiotic Degradation [366]:

Fluoranthene absorbs solar radiation strongly and thereby can undergo direct photolysis(1,2). Polynuclear aromatic hydrocarbons also photodecompose in the atmosphere by reaction with ozone, other oxidants, nitrogen oxides, and sulfur oxides while singlet oxygen is considered to be the major oxidant species in water(2). Fluoranthene is found both in the free and adsorbed state in both the aqueous and atmospheric compartments and photodegradation is usually different in the sorbed state. No significant degradation was observed when fluoranthene vapor adsorbed on coal fly ash from the electrostatic precipitator of a power plant was irradiated for 3.3 hr using a xexon lamp(3). When filters containing pure fluoranthene were exposed to air and synthetic smog (1 hr exposure equivalent of 100 hr exposure to natural smog), 20 and 24% of the compound decomposed in air in 48 hr in darkness or light, respectively. 59% was lost in 1 hr when exposed to smog and light(4). When filters containing fluoranthene sorbed on combustion particules were exposed, 4% of the compound was lost in 48 hr in air and light while 59% was lost in 1 hr exposed to synthetic smog and light(4). Therefore it would appear that sorbed fluoranthene is less reactive than the free vapor in air but equally reactive in photochemical smog(4). It should be noted that sorption on certain types of surfaces (e.g. silica gel) greatly enhances photodecomposition(2). When particulate matter from air was analyzed immediately and after being stored in a sealed envelope, it was found that 37% and 92% of the flouranthene was lost in storage after 3 weeks and 1 yr, respectively(2). PAHs do not contain groups amenable to hydrolysis (2). [(1) IARC; Polynuclear Aromatic Compounds. Part I. Chemical environmental and experimental data; 32: 355-7 (1983) (2)

Sims RC, Overcash MR; Res Rev 88: 1-68 (1983) (3) Korfmacher WA et al; Environ Sci Technol 14: 1094-9 (1980) (4) Santodonato J et al; pp.77-176 in Health and Ecological Assessment of Polynuclear Aromatic Hydrocarbons; Pathotox Publ Inc Park Forest South NY (1980)].

In water, the half-life resulting from direct photolysis of flouranthene in near surface waters exposed to sunlight (latitude 4 deg N, midday, midsummer) is calculated to be 21 hr(1). If the water body is deep or turbid, the sunlight is attenuated. For example, in a well mixed body of water 5 m deep that contained sediment of 20 mg/1, the half-life is increased to 160 hr if one does not take partitioning to particulate matter into account and 200 hr if one does(1). Photolysis of PAH's in nonpolar organic solvents are typically 10-100 times less than in water(1). Sorption onto green and blue green algae photosensitizes the degradation of fluoranthene(2). In the presence of algae at a concn of 1-10 mg/1 chlorophyll, the photodegradation rate is increased by a factor of 6.6-11(2). [(1) Zepp RG, Schlotzhauer PF; pp. 141-58 in Polynuclear Aromatic Hydrocarbons; Ann Arbor Sci Publ Jones PW, Leber eds; Ann Arbor MI (1979) (2) Zepp RG, Schlotzhauer PF; Environ Sci Technol 17: 462-8 (1983)].

Soil Adsorption/Mobility [366]:

No specific data relating to fluoranthene's adsorption to soil or sediment could be found in the literature. However using its log octanol/water partition coefficient, 5.22(1), one can calculate a Koc of 66,000(2,SRC). [(1) Mackay D et al; Chemosphere 9: 701-11 (1980) (2) Karickhoff SW; Chemosphere 10: 833-46 (1981) (3) Lee RF et al; Environ Sci Technol 12: 832-8 (1978)].

Volatilization from Water/Soil [366]:

Volatilization of fluoranthene from water is not an important process(1). Less than 1% was volatilized in a pilot wastewater treatment plant(2). Volatilization from soil will also be unimportant because of its low vapor pressure(3) and strong adsorption to soil(1). [(1) Sims RC, Overcash MR; Res Rev 88: 1-68 (1983) (2) Petrasek AC et al; J Water Pollut control Fed 55: 1286-96 (1983) (3) USEPA; Treatability Manual pp.I.10.13-1 to I.10.13-5 USEPA-600/2-82-001A (1981) (4) Santodonato J et al; pp.77-176 in Health and Ecological Assessment of Polynuclear Aromatic Hydrocarbons; Pathotox Publisher Inc Park Forest South NY (1981)].

Absorption, Distribution and Excretion [366]:

Fluoranthene has been found in human urine and feces. [USEPA; Ambient Water Quality Criteria Doc: Fluoranthene (Draft) p.C-2 (1980)].

The demonstrated toxicity of fluoranthene by oral and dermal administration indicates that it can pass across epithelial membranes. The high lipid solubility of fluoranthene supports this observation. [Smyth HF et al; Am In Hyg Assoc J 23: 95 (1962) as cited in USEPA; Ambient Water Quality Criteria Doc: Fluoranthene (Draft) p.C-21 (1980)].

Five normal adult volunteers without cutaneous disease applied 2% crude coal tar to the skin for 8 hr periods on 2 consecutive days. Blood extracts subjected to gas chromatography and mass spectrophotometry yielded evidence of absorption in all 5 volunteers. ... Fluoranthene was found in 4 of the volunteers. [Storer JJ et al; Arch Dermatol 120 (7): 874-877 (1984)].

Biological Half-Life [366]:

Half-life for depuration by Crassostrea virginica (oysters),: 5 days from an oil treated enclosure. [Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 674].

Laboratory and/or Field Analyses:

For risk assessment, damage assessment, drinking water, or to determine if biodegradation has occurred, the NOAA expanded scan for PAHs and alkyl PAHs [828], or equivalent rigorous and comprehensive scans (such as SW-846 method 8270 modified for Selective Ion Mode detection limits and an equivalent list of alkyl PAH analytes), are recommended.

Recommended detection limits:

Most of the PAH methods which have been commonly used historically for routine monitoring, including PAH parent compound standard methods:

EPA 8270 (8270 includes several PAH parent compounds along with a long list of other organics) for solid waste/RCRA applications [1013], and

EPA NPDES method 610 as specified in 40 CFR Part 136 (method 610 includes 16 PAH parent compounds) [1010],

EPA method 625 for Base/Neutral Extractables (method 625 includes several PAH parent compounds

> along with a long list of other organics) as specified in 40 CFR Part 136 [1010],

are all inadequate for generating scientifically defensible information for Natural Resource Damage Assessments [468]. These standard EPA scans do not cover important alkyl PAHs and do not utilize low-enough detection limits. When biological effects, ecological risk assessment, damage assessment, or bio-remediation are being considered, detection limit should be no higher than 1-10 ng/L (ppt) for water and 1 ug/kg (ppb) dry weight for solids such as tissues, sediments, and soil.

> Note: Utilizing up to date techniques, many of the better labs can use detection limits of 0.3 to 1 ppb for tissues, sediments, and soils. When no biological resources are at risk, detection limits for solids should nevertheless generally not be above 10 ppb. One reason that low detection limits are needed for PAHs is that so many of the criteria, standards, and screening benchmarks are in the lower ppb range (see various entries on individual PAHs).

In the past, many methods have been used to analyze for PAHs [861,1010,1013]. However, recent (1991) studies have indicated that EPA approved methods used for oil spill assessments (including total petroleum hydrocarbons method 418.1, semi-volatile priority pollutant organics methods 625 and 8270, and volatile organic priority pollutant methods 602, 1624, and 8240) are all inadequate for generating scientifically defensible information for Natural Resource Damage Assessments [468]. These general organic chemical methods are deficient in chemical selectivity (types of constituents analyzed) and sensitivity (detection limits); the deficiencies in these two areas lead to an inability to interpret the environmental significance of the data in a scientifically defensible manner [468].

If a Park Service groundwater investigation at Colonial National Historical Park performed in response to contamination by Fuel Oil 5 had utilized EPA semi-volatile scan 8270 or any of the other typical EPA scans (625, etc.) all of which only include parent compounds and typically utilize detection limits in the 170-600 ppb range, the false conclusion reached would have been that no PAHs were present in significant (detection limit) amounts. This false negative conclusion would have been made because the parent compound PAHs present constituted only 7.6% of the PAHs detected in groundwater by the expanded scan [828], and the highest concentration found for any parent compound was 8.4 ppb, far below the detection limits used on the older standard EPA scans. Utilizing the NOAA protocol expanded scan [828], it was determined that 92.4% of the total concentration values of the PAHs detected in groundwater were alkyl PAHs, and that all 39 PAHs and alkyl PAHs were present. Of course, all 39 PAHs were also present in the fresh product, in much higher concentrations, and also having alkyl compounds with the highest percentage of higher values compared to parent compounds (see Chem.Detail section in separate PAHs entry for more details).

In a similar vein, if the Park Service sediment investigation at Petersburg National Historical Battlefield (see Chem.Detail section in separate PAHs entry, this study was performed in response to contamination by Diesel) had utilized EPA semi-volatile scan 8270 or any of the other typical EPA scans (625, etc.), all of which only include parent compounds and often utilize detection limits no lower than the 170-600 ppb range, the false conclusion reached would have been that only one PAH was present in significant (detection limit) amounts. This false negative conclusion would have been made because the parent compound PAHs present constituted only 2.4% of the PAHs detected in sediments, and the highest concentration found for any parent compound except pyrene was 85.5 ppb, far below the detection limits used on the older standard EPA scans. Pyrene was 185 ppb, which would have been non-detected on many of the EPA scans, but not all. However, utilizing the NOAA protocol expanded scan [828], it was determined that 97.6% of total quantity of PAHs detected in sediments were alkyl PAHs, and that all 39 PAHs and alkyl PAHs were present in these sediments.

When taking sediment samples for toxic organics such as PCBs, PAHs, and organochlorines, one should also routinely ask for total organic carbon analyses so that sediment values may be normalized for carbon. This will allow comparison with the newer EPA interim criteria [86,127]. TOC in sediments influences the dose at which many compounds are toxic (Dr. Denny Buckler, FWS Columbia, personal communication).

In some cases (where the expanded scans are too expensive) an alternative recommendation is that one screen sediments with a size-exclusion high-performance liquid chromatography (HPLC)/fluorescence method. The utility and practicality of the HPLC bile and sediment screening analyses were demonstrated on board the NOAA R/V Mt. Mitchell during the Arabian Gulf Project. Estimates of petroleum contamination in sediment and fish were available rapidly, allowing modification of the sampling strategy based on these results [522].

Variation in concentrations of organic contaminants may sometimes be due to the typically great differences in how individual investigators treat samples in the field and in the lab rather than true differences in environmental concentrations. This is particularly true for volatiles and for the relatively lighter semi-volatiles such as the naphthalene PAHs, which are so easily lost at various steps along the way. Contaminants data from different labs, different states, and different agencies, collected by different people, are often not very comparable. In fact, as mentioned earlier in the disclaimers, the interagency task force on water methods concluded that [1014]:

> It is the exception rather than the rule that water-quality monitoring data from different programs or time periods can be compared on a scientifically sound basis, and that...

> No nationally accepted standard definitions exist for water quality parameters. The different organizations may collect data using identical or standard methods, but identify them by different names, or use the same names for data collected by different methods [1014].

As of 1997, the problem of lack of data comparability (not only for water methods but also for soil, sediment, and tissue methods) between different "standard methods" recommended by different agencies seemed to be getting worse, if anything, rather than better. The trend in quality assurance seemed to be for various agencies, including the EPA and others, to insist on quality assurance plans for each project. In addition to quality control steps (blanks, duplicates, spikes, etc.), these quality assurance plans call for a step of insuring data comparability [1015,1017]. However, the data comparability step is often not given sufficient consideration. The tendency of agency guidance (such as EPA SW-846 methods and some other new EPA methods for bio-concentratable substances) to allow more and more flexibility to select options at various points along the way, makes it harder in insure data comparability or method validity. Even volunteer monitoring programs are now strongly encouraged to develop and use quality assurance project plans [1015,1017].

At minimum, before using contaminants data from diverse sources, one should determine that field collection methods, detection limits, and lab quality control techniques were acceptable and comparable. The goal is that the analysis in the concentration range of the comparison benchmark concentration should be very precise and accurate.

It should be kept in mind that quality control field and lab blanks and duplicates will not help in the data quality assurance goal as well as intended if one is using a method prone to false negatives. Methods may be prone to false negatives due to the use of detection limits that are too high, the loss of contaminants through inappropriate handling, or the use of an inappropriate methods such as many of the EPA standard scans. This is one reason for using the NOAA expanded scan for PAHs [828]; or method 8270 [1013] modified for Selective Ion Mode (SIM) detection limits (10 ppt for water, 0.3 to 1 ppb for solids) and additional alkyl PAH analytes; or alternative rigorous scans. These types of rigorous scans are less prone to false negatives than many of the standard EPA scans for PAH parent compounds (Roy Irwin, National Park Service, Personal Communication, 1997).

For a much more detailed discussion of the great many different lab and field methods for PAHs in general, see the entry entitled PAHs as a group (file name starting with letter string: PAHS). There the reader will find much more detailed discussions of lab methods, holding times, containers, comparability of data from different methods, field sampling methods, quality assurance procedures, the relationship of various methods to each other, the various EPA standard methods for various EPA programs, the pros and cons of various methods, and additional documentation concerning why many standard EPA methods are inadequate for certain applications. A decision tree key for selecting the most appropriate methods for oil or oil products spills is also provided in the lab section of the PAHs entry. Due to the length of these discussions, they are not repeated here (see PAHs entry).