



4/1/94 - 00977

COMMONWEALTH of VIRGINIA
DEPARTMENT OF ENVIRONMENTAL QUALITY

Peter W. Schmidt
Director

P. O. Box 10009
Richmond, Virginia 23240-0009
(804) 762-4000

4/1/94

Commander
Atlantic Division
Naval Facilities Engineering Command
1510 Gilbert Street (Building N-26)
Norfolk, Virginia 23511-2699

Attn: Mr. David M. Forsythe
Code 18224

RE: Q Area Drum Storage Yard, Naval Base Norfolk

Dear Mr. Forsythe:

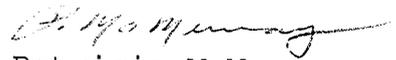
On the phone this morning you inquired whether it would be necessary to collect samples for specific constituents of TPH (Total Petroleum Hydrocarbons) prior to completing the risk assessment for the Q Area Drum Storage Yard.

In lieu of additional sampling to complete the risk assessment, you may present a qualitative or semi-quantitative assessment of risk due to TPH constituents. The attached paper entitled "Soil Cleanup Criteria for Selected Petroleum Products" may be helpful in developing the risk assessment. Please note that this paper does not represent official DEQ (Department of Environmental Quality) policy on assessing risk due to TPH. The risk assessment should be based on conservative assumptions about the proportions of the most toxic constituents of TPH along with standard default exposure assumptions. The cleanup levels derived for TPH should also be based on conservative assumptions.

Q Area Drum Storage Yard
Page 2

Also attached for your information is the section of the Virginia regulations related to soil contaminated with petroleum products. If you have any questions or need further information, please call me at (804) 762-4186.

Sincerely,



Patricia McMurray
Toxicologist
Office of Federal
Facilities Restoration
and Superfund

JLM

Soil Cleanup Criteria for Selected Petroleum Products

Sofia K. Stokman
Richard Dime, Ph.D.
New Jersey Department of Environmental Protection
Hazardous Site Mitigation Administration
Trenton, New Jersey

ABSTRACT

A large number of sites are contaminated with petroleum products which may pose a potential health hazard. Therefore, risk assessment and acceptable soil cleanup levels for these products are urgently needed. This paper compares alternatives for developing cleanup objectives for soil contaminated with petroleum products. A soil cleanup objective based on the concentrations of total petroleum hydrocarbons versus a soil cleanup objective based on the concentration of individual chemical constituents of concern is investigated.

A review of the chemical composition of crude oil, gasolines, petroleum naphtha, fuel oil No. 1 (jet fuel, kerosene), fuel oil No. 2 (heating oil, diesel oil), fuel oil No. 6 (Bunker "C"), lubricating oil, fresh motor oil and used motor oils (over 5,000 and 10,000 km usage) was undertaken to identify individual chemical constituents that would be harmful to public health and/or the environment. The carcinogenic polycyclic aromatic hydrocarbons (PAHs) and benzene were identified as constituents of concern. A lifetime soil exposure model based on pica tendencies and ingestion of soil was used to estimate soil concentrations of these constituents that would result in a one in a million (1×10^{-6}) cancer risk if exposure were to occur. These levels were compared with residual concentrations of CaPAHs and benzene in soil after cleanup to 100 ppm total petroleum hydrocarbons (PHs) for each petroleum product studied. For those constituents remaining in concentrations which would exceed a 1×10^{-6} if exposure were to occur, a soil cleanup objective which reduces the health risk to an acceptable level was proposed. In addition, the proposed cleanup objectives were compared to "normal" soil background levels of CaPAHs and benzene.

With the exception of motor oils used over 10,000 km, using 100 ppm of total PHs as the soil cleanup objective results in residual soil levels of CaPAHs and benzene not yielding a 1×10^{-6} cancer risk. Changing the soil cleanup objective from 100 ppm to 60 ppm will reduce CaPAHs from used motor oils over 10,000 km to an acceptable cancer risk level of one in a million. "Normal" background soil levels of benzene are exceeded in all products for which data were available.

Determination of soil cleanup objectives based on residual soil levels of CaPAHs and benzene cannot be further refined at this time due to the limited information available on the concentration of these compounds in petroleum products and in "normal" soil background levels.

INTRODUCTION

Large-scale terrestrial pollution can result from the production, transportation, storage and voluntary land disposal of petroleum products. Exposure to these products may result in adverse effects on public health and on the environment. This paper examines alternatives for developing acceptable soil cleanup levels (ASCLs) for soil contaminated with petroleum products. The focus is on

exposure to contaminated soils through ingestion (pica) and inhalation and on the migration of petroleum compounds into groundwater. The literature was reviewed to identify constituents in petroleum products that are toxic and/or harmful in the environment. ASCLs were determined for carcinogenic constituents using risk assessment techniques. Soil cleanup levels for carcinogenic constituents were compared to a total petroleum hydrocarbons (PHs) cleanup objective of 100 ppm.

DETERMINATION OF ACCEPTABLE SOIL CONTAMINANT LEVELS

Risk assessment and soil cleanup objectives are presented only for individual chemical constituents of petroleum products which have the highest toxicity, the ability to migrate and/or are present in significant amounts. Emphasis was placed on chronic toxic effects (particularly carcinogenic) due to long-term exposure to contaminated soils. In order to accomplish this task, the following was performed: (1) review of physical/chemical properties, health effects and environmental fate of selected petroleum products; (2) identification of carcinogenic constituents and estimation of concentrations present in each particular petroleum product; (3) estimates of residual soil concentrations of carcinogenic constituents when 100 ppm total petroleum hydrocarbons is used as a cleanup objective; and (4) comparison of estimates with concentrations resulting in a cancer risk of one in a million (1×10^{-6}) and with "normal" background soil levels to determine if any of the carcinogenic constituents remain in the soil in concentrations that may pose a threat to public health. Comparison to background also was made since many regulatory agencies consider cleanup to background an appropriate remedial objective.

Due to space limitations, all areas reviewed are not covered in detail. This paper discusses briefly the toxicity and environmental fate of selected petroleum products.

IDENTIFICATION AND TOXICITY OF CONSTITUENTS IN PETROLEUM PRODUCTS

The following petroleum products are reviewed in this paper for identification of toxic constituents: crude oil, petroleum naphtha, gasolines, fuel oil No. 1 (jet fuel, kerosene), fuel oil No. 2 (heating oil, diesel oil), fuel oil No. 6 (Bunker "C"), lubricating oil, fresh motor oil, and used motor oils (over 5,000 and 10,000 km usage).

A review of the literature indicates that the most toxic constituents of petroleum products are the aromatics. After the aromatic fractions, toxicity decreases from olefins through naphthenes to paraffins. Within each group, the hydrocarbons of lower molecular weight tend to be more toxic. Exposure to high and low boiling fractions of petroleum (crude oil) is associated with carcinogenic effects. Moreover, exposure to polycyclic aromatic hydrocarbons (PAHs) present in certain heavy

residual oils* and to benzene present in unleaded gasoline* currently is being investigated for carcinogenic effects of these products. Crude oil is mutagenic* and is at the present time under toxic review.* Kerosene currently is being tested for carcinogenicity.*

This paper primarily is concerned with chronic effects due to long-term exposure to soils contaminated with petroleum products. Of all the constituents identified, the carcinogenic polycyclic aromatic hydrocarbons (CaPAHs) and benzene (a known human carcinogen) are of most concern,^{1,4} and cleanup objectives for soils contaminated with petroleum products are based on these compounds.

ENVIRONMENTAL FATE

Little is known about the environmental chemistry and ultimate fate of petroleum hydrocarbons in the soil environment. Their fate in land is affected primarily by their distribution, volatilization and leaching potential.* Low molecular weight aromatic hydrocarbons such as benzene, toluene, xylene, etc., which have a high Henry's Law constant, tend to partly evaporate. The remainder will migrate to different depths of the soil column where little or no volatilization to the atmosphere occurs.

The proportion of the petroleum hydrocarbons that will bind to soil versus those which will continue to migrate toward groundwater depends primarily on the type of soil, the particular petroleum product, the size of the spill and the amount of rainfall.* In general, leaching to groundwater is favored by high rainfall and permeable soils and increases for chemicals with high solubility, low diffusion coefficients and low absorption coefficients* such as the aromatics benzene, toluene and xylene.

Biodegradation is an important factor for removal of PAHs in general, but high molecular weight multiring compounds such as polycyclic aromatic hydrocarbons (PAHs) tend to remain in soil for long periods of time. Biodegradation may be enhanced in soils previously contaminated with PAHs. Naphthalene, a PAH with two rings, behaves differently from other PAHs because of its lower molecular weight and relatively high water solubility.* The rate of microbial degradation of PAHs in subsurface soil and in groundwater is favored under aerobic conditions.

Although migration of contaminants to groundwater is of concern, this paper is concerned primarily with chronic effects due to long-term exposure to contaminated soils.

ESTIMATED CONCENTRATIONS OF CaPAHs AND BENZENE

Concentrations of CaPAHs and of benzene in petroleum products vary depending on the type of crude oil and on the fractionation process used to derive the petroleum products. Table I summarizes information on the concentration of CaPAHs and benzene in the various petroleum products studied. The CaPAHs (benzo[a]pyrene (BaP), benzo[b]fluoranthene, chrysene, dibenz[a,h]anthracene, benzo[a]anthracene, indeno[1,2,3-c,d]pyrene) often are present in crude oils in very small quantities relative to the other PAHs.* However, as indicated in Table I, used or spent petroleum products are enriched in content of BaP and other CaPAHs by as much as 200-fold in some cases.*

Information on the concentration of benzene in the various petroleum products studied is very limited. Of all the products listed, gasoline has the highest concentration of benzene ranging from 0.6 to 2.9% vol. for all grades and octanes. Of the gasolines, the concentration of benzene is highest in leaded gasoline (regular) during winter time. The concentrations of total benzenes (benzene, toluene, xylene and other substituted benzenes) of 10.2% in a highly aromatic fuel oil No. 2 and of 1.0% in fuel oil No. 6* indicate, as expected, that higher concentrations of benzene are found in low boiling fuels than in high

boiling fuels. The concentration of benzene alone in these two products was not reported.

Table I
Estimated Concentrations (ppm) of CaPAHs and Benzene
in Selected Petroleum Products

Petroleum Product	Total CaPAHs*, ppm	Benzene, % Vol.
Crude Oil	12:26.3(a) Below 100(b)	0.1(c)
Gasoline (regular)	22.6(c)	1.1-2.9(f)
Gasoline (high octane)	9.7(c)	-
Gasoline (low octane)	7.4(c)	1.1-2.9(f)
Gasoline (unleaded)	1.7(c)	0.6-2.3(g)
Petroleum asphalt	-	0.2(h)
Fuel Oil No. 1 (jet fuel)	0.15(d)	-
Fuel Oil No. 1 (kerosene)	0.05(b)	-
Fuel Oil No. 2 (heating oil)	4.0(e)	-
Fuel Oil No. 2 (diesel oil)	0.7(b)	-
	0.03(c)	-
	37.3(d)	-
Fuel Oil No. 6 (Bunker "C")	329(a)	-
Lubricating Oil	0.3(c)	-
Fresh Motor Oil	0.2(c)	-
Used Motor Oil	5.8(e)	-
Used Motor Oil (5,000+ km)	303.4(e)	-
Used Motor Oil (10,000+ km)	446.6(c)	-

*Ranging from one to four CaPAHs from a total of six depending on the study and on the particular petroleum product: Benzo[a]anthracene, chrysene, BaP, benzo[b]fluoranthene, dibenz[a,h]anthracene and indeno[1,2,3-c,d]pyrene.

-Insufficient information available

(a) National Academy Press*

(b) U.S. EPA

(c) Verschuver**

(d) U.S. EPA*

(e) Secherre**

(f) Shelton**

(g) Shelton**

(h) Mellan**

ESTIMATED RESIDUAL SOIL CONCENTRATIONS OF CaPAHs AND BENZENE

Assuming a soil cleanup level of 100 ppm of total PHs, residual levels of CaPAHs and of benzene in soil contaminated with petroleum products were estimated. Residual soil levels were estimated using the highest concentrations of CaPAHs and of benzene reported in the various studies reviewed. It was assumed that no losses of these compounds occurred due to evaporation, biodegradation or migration to groundwater. Residual soil levels of CaPAHs and benzene were then compared to concentrations of CaPAHs and benzene which would result in a one in a million cancer risk if exposure were to occur. The residual soil concentrations also were compared to "normal" soil background levels of CaPAHs and benzene.

Calculation of Acceptable Soil Contaminant Levels

The acceptable soil contaminant level (ASCL) that would protect human health is based on direct contact exposure with the contaminated soil. A worst case exposure model for carcinogens* modified from Ford and Gurba** is shown below:

$$\left(\text{Acceptable Soil Cleanup Level} \right) = \left(\frac{10^{-6}}{C} \right) \times \left(\frac{1000 \text{ g/kg}}{L} \right) \quad (1)$$

etc:

- A = Acceptable cancer risk = 1×10^{-6} (one in a million)
- C = Carcinogenic potency factor (U.S. EPA CAG)
 - = $11.53 \text{ (mg/kg/day)}^{-1}$ for BaP and $0.0052 \text{ (mg/kg/day)}^{-1}$ for benzene.
 - = 1000 g/kg = conversion factor
- L = Lifetime average daily soil intake = 0.0028 g/kg/day

The model takes into account exposure to contaminated soils over a lifetime. Soil exposure is based on pica tendencies (in children), hand to mouthing and inhalation of dust. It is assumed that a 1×10^{-6} cancer risk is acceptable. Potency factors were obtained from the U.S. EPA, Cancer Assessment Group (CAG). The modified model does not take into consideration the half-life of the contaminants in soil. Intake of soil during peak pica years is assumed to be 2.5 g/day and not the 10 g/day contained in the original model.

Unfortunately, carcinogenic potency factors do not exist for specific CaPAHs except for BaP. It is assumed that all CaPAHs are as carcinogenic as BaP, and the potency factor for BaP was used in the calculation. This assumption is consistent with the U.S. EPA's approach to estimating cancer risks from exposure to mixtures of PAHs. Acceptable soil contaminant levels of 0.03 ppm and 6.9 ppm were calculated for CaPAHs and benzene, respectively.

Soil Background Levels of CaPAHs and Benzene

Information on soil background levels of CaPAHs and benzene was obtained from the literature. Limited information exists on soil background levels of PAHs in general.

Natural PAHs are due to plant synthesis, forest and prairie fires, volcanoes, etc. Anthropogenic sources are primarily from the extraction, processing and burning of fossil fuels. Most of the research on soil background levels of PAHs has been performed on BaP. Therefore, selection of "normal" soil background levels of PAHs was based on BaP.

The concentration of total PAHs (the sum 5 to 20 PAHs) usually exceeds 10 times the concentration of BaP.³⁶ BaP levels ranging from less than 5 to 10 ppb are generally found in agricultural soils.⁶ Typical concentrations of BaP in soils of the world range from about 100 to 1,000 ppb, and values exceeding 100,000 ppb have been reported near known sources.³⁷ It has been suggested that endogenous BaP concentrations in soil are 1-3 ppb and never exceed 10 ppb.³⁸ A level of 50 ppb was selected as the "normal" background of total PAHs in soil since this level is typically found as background.⁶

Limited data are available on benzene levels in soils. Levels ranging from 13 to 115 ppb of benzene were reported in soil samples taken in the vicinity of chemical plants that use or produce benzene.³⁹ No information exists on the level of benzene in "clean" soils. A soil background level of less than 10 ppb was selected since this level is within the range of "normal" soil background levels of most organics.⁶

The ASCL of 30 ppb for CaPAHs (assuming a 1×10^{-6} cancer risk) is within the range of typical soil background levels of PAHs. However, the ASCL of 6.9 ppm for benzene exceeds typical soil background levels of benzene.

Examination of Table 2 reveals that, after site remediation to 110 ppm of total PHs, only soil contaminated with used motor oils over 10,000 km will have concentrations of CaPAH that exceed a 1×10^{-6} cancer risk (by approximately 67%). As shown

Table 2
Estimated Residual Soil Concentrations (ppm) of CaPAHs Exceeding Concentration of CaPAHs at 10^{-6} Cancer Risk and "Normal" Soil Background Level of CaPAHs

Petroleum Product	Total CaPAHs*, ppm	Total CaPAHs Exceeding 10^{-6} Cancer Risk**	Total CaPAHs Exceeding "Normal" Soil Background***
Crude oil	3×10^{-3} (a)	N	N
Gasoline (regular)	7×10^{-4} (b)	N	N
Gasoline (high octane)	7×10^{-4} (b)	N	N
Gasoline (low octane)	2×10^{-4} (b)	N	N
Gasoline (unleaded)	-	-	-
Petroleum naphtha	-	-	-
Fuel Oil No. 1 (jet fuel)	2×10^{-3} (c)	N	N
Fuel Oil No. 1 (kerosene)	3×10^{-4} (d)	N	N
Fuel Oil No. 2 (heating oil)	4×10^{-4} (e)	N	N
Fuel Oil No. 2 (diesel oil)	4×10^{-4} (e)	N	N
Fuel Oil No. 6 (Bunker "C")	3×10^{-3} (b)	N	N
Lubricating Oil	1×10^{-3} (a)	N	N
Fresh Motor Oil	2×10^{-3} (b)	N	N
Used Motor Oil	6×10^{-2} (b)	N	N
Used Motor Oil (5,000+ Km)	3×10^{-2} (b)	N	N
Used Motor Oil (10,000+ Km)	3×10^{-2} (b)	Y	N

*One to four CaPAHs from a total of six depending on study and on particular petroleum product: Benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)perylene.

**CaPAHs at 10^{-6} cancer risk (based on BaP): 0.03 ppm

***"Normal" soil background of PAHs 0.03 ppm

- Insufficient information available

Y Exceeding

N Not exceeding

(a) National Academy Press

(b) Van Duyn

(c) U.S. EPA

(d) U.S. EPA

Table 3
Estimated Residual Concentrations (ppm) of Benzene Exceeding Concentration of Benzene at 10^{-6} Cancer Risk and "Normal" Soil Background Level of Benzene

Petroleum	Benzene, ppm	Benzene Exceeding 10^{-6} Cancer Risk*	Benzene Exceeding "Normal" Soil Background**
Crude oil	0.2(a)	N	Y
Gasoline (regular)	1.1-2.9(b)	N	Y
Gasoline (high octane)	-	N	Y
Gasoline (low octane)	1.1-2.9(b)	N	Y
Gasoline (unleaded)	0.6-2.3(c)	N	Y
Petroleum naphtha	0.2(d)	N	Y
Fuel Oil No. 1 (jet fuel)	-	-	-
Fuel Oil No. 1 (kerosene)	-	-	-
Fuel Oil No. 2 (heating oil)	-	-	-
Fuel Oil No. 2 (diesel oil)	-	-	-
Fuel Oil No. 6 (Bunker "C")	-	-	-
Lubricating Oil	-	-	-
Fresh Motor Oil	-	-	-
Used Motor Oil	-	-	-
Used Motor Oil (5,000+ Km)	-	-	-
Used Motor Oil (10,000+ Km)	-	-	-

*ASCL for benzene at 10^{-6} cancer risk: 6.9 ppm

**"Normal" soil of benzene: less than 0.01 ppm

- Insufficient information available

Y Exceeding

N Not exceeding

(a) Seitzman

(b) Seitzman

(c) Seitzman

(d) Seitzman

in Table 3, soil contaminated with crude oil, naphtha and gasoline (all grades and octanes) has benzene levels below the ASCL for benzene. Comparison with "normal" soil background levels reveals that residual soil concentrations of CaPAHs are within the range of "normal" soil background levels of PAHs. However, residual soil concentrations of benzene from contamination with crude oil, petroleum naphtha and gasoline (all grades and octanes) are above the "normal" soil background level of benzene as expected. The residual soil concentrations of benzene from crude oil and naphtha exceed the soil background level of benzene in excess of 20 times and that from gasoline by 90 times.

CONCLUSIONS AND RECOMMENDATIONS

Assuming a soil cleanup level of 100 ppm for total petroleum hydrocarbons, most of the residual soil levels of CaPAHs and benzene are below their corresponding concentrations resulting in a 1×10^{-6} cancer risk. An exception is the residual soil level of CaPAHs from contamination with used motor oils over 10,000 km which has a risk of 1.6×10^{-6} . In this case, lowering the soil cleanup level of 100 ppm to 60 ppm for total PHs will decrease soil concentrations of total CaPAHs from contamination of the above product to levels resulting in a cancer risk of 1×10^{-6} . Alternatively, testing soil samples for CaPAHs could be performed after soil is cleaned to 100 ppm of total PHs to determine if CaPAHs levels remaining in soil are acceptable.

Comparison of residual soil levels of CaPAHs and benzene with their respective soil background levels, indicates that, in general, residual levels of CaPAHs are within the range of typical soil background levels of PAHs. On the other hand, residual soil levels of benzene exceed the assumed "normal" soil background level of benzene. Further refinement of this comparison cannot be made at this time due to limited information on "normal" soil background levels of these compounds and due to the volatilization of benzene with time.

A more extensive data base on petroleum products is needed to refine the risk assessment approach proposed. Specifically, more data on the identification and concentration of chemical constituents, behavior in the soil environment, toxicity and normal soil background concentrations are needed.

More toxicity testing of petroleum products and individual constituents is needed to better understand the carcinogenic potency of individual CaPAHs and of mixtures before a more refined ASCL can be estimated.

In summary, with the exception of motor oils used over 10,000 km, 100 ppm of total PHs as a soil cleanup objective appears to result in residual soil levels of CaPAHs and benzene not exceeding a 1×10^{-6} cancer risk. Although this cleanup objective is protective in a direct soil contact scenario, it may not adequately address groundwater protection.

ACKNOWLEDGEMENTS

We greatly appreciate the assistance of Professor Richard Bartha, Rutgers University, Dr. Neill K. Weaver, American Petroleum Institute and Dr. Merry L. Morris, New Jersey Department of Environmental Protection, in the development of this manuscript.

REFERENCES

1. Carl, H. Jr. and Doemel, K., "Chemical and Physical Properties of Refined Petroleum Products," Boulder, CO, National Oceanic and Atmospheric Administration/Environmental Research Laboratories, Marine Ecosystems Analysis Program, NOAA Technical Memorandum ERL MESA-17, U.S. Department of Commerce (Oct. 1977), 3-26.
2. Bingham, E., Troset, R.P. and Warshawsky, "Carcinogenic Potential of Petroleum Hydrocarbons. A Critical Review of the Literature," *J. of Environ. Path. and Toxicol.* 3, (1979), 483-563.

3. U.S. EPA, "Estimation of the Public Health Risk From Exposure to Gasoline Vapor Via the Gasoline Marketing System," Staff Paper submitted for review to the Science Advisory Board, Office of Health and Environmental Assessment, Office of Air Quality and Planning and Standards, U.S. EPA, Washington, DC, June 1984.
4. Sheppard, E.P., Wells, R.A. and Georgiadiou, P.E., "The Mutagenicity of the Prudhoe Bay Crude Oil and Its Residues from an Experimental In Situ Burn," *Environ. Research* 30, (1983), 427-441.
5. National Institute for Occupational Safety and Health, "Registry of Toxic Effects of Chemical Substances," 1983 Supplement to the 1981-82 Edition, U.S. Government Printing Office, Washington, DC, (DHHS(NIOSH), 84-101), 1984.
6. Sittig, M., *Handbook of Toxic and Hazardous Chemicals and Carcinogens*, 2nd. Ed., Noyes Publications, Park Ridge, NJ, 1985.
7. Bossert, E. and Bartha, R., "The Fate of Petroleum in Soil Ecosystems," In: *Petroleum Microbiology*, Ronald H. Atlas, Ed., McMillan Publishing Company, New York, NY 435-670, 1984.
8. American Petroleum Institute, "The Land Treatability of Appendix VIII Constituents Present in Petroleum Industry Wastes," American Petroleum Institute, Washington, DC, API Publication 4379 Document B-974-220, May 1984.
9. Bonazountas, M., "Mathematical Pollutant Fate Modeling of Petroleum Products in Soil Systems," Lectures at Conference on Environmental and Public Health Effects of Soils Contaminated with Petroleum Products, University of Massachusetts, Amherst, MA, Boston, MA, Epsilon International Inc., Oct. 1983.
10. National Academy Press, "Chemical Composition of Petroleum Hydrocarbon Sources," In: *Oil in the Sea, Impact, Effects*, National Academy Press, Washington, DC, 1985, 17-42.
11. U.S. EPA, "An Exposure and Risk Assessment for Benzo(a)pyrene and Other Polycyclic Aromatic Hydrocarbons," Final Draft Report, Office of Water Regulations and Standards, U.S. EPA, Washington, DC, 1982, 5-187.
12. Verschueren, K., *Handbook of Environmental Data on Organic Chemicals*, 2nd. Ed., Van Nostrand Reinhold Company, Inc., New York, NY, 1983.
13. U.S. EPA, "Quantitative Analysis of Polynuclear Aromatic Hydrocarbons in Liquid Fuels," Environmental Sciences Research Laboratory, U.S. EPA, Research Triangle Park, NC, EPA-600/2-80-069, Apr. 1980.
14. Sechanen, A.N., "Hydrocarbons in Gasolines, Kerosenes, Gas Oils, and Lubricant Oils," In: *The Chemistry of Petroleum Hydrocarbons*, Reinhold Publishing Corporation, New York, NY, 1, 1954.
15. Mellan, J., "Pure Hydrocarbons," In: *Handbook of Solvents*, Reinhold Publishing Corporation, New York, NY, 1, 1957.
16. Shelton, E.M. and Dickson, C.L., "Motor Gasolines, Winter 1984-85," National Institute for Petroleum and Energy Research, Bartlesville, OK. Work performed for the American Petroleum Institute, Washington, DC, NIPER-140PPS 85/3, June 1985.
17. Shelton, E.M. and Dickson, C.L., "Motor Gasolines, Summer 1984," National Institute for Petroleum and Energy Research, Bartlesville, OK. Work performed for the American Petroleum Institute, Washington, DC, NIPER-138PPS 85/1, Feb. 1985.
18. Dime, R. and Greim, B., "Calculation of Cleanup Levels for Contaminated Soils," Unpublished Manuscript, N.J. Department of Environmental Protection, Hazardous Site Mitigation Administration, Trenton, NJ, 1985.
19. Ford, K.L. and Gurba, P., "Health Risk Assessment For Contaminated Soils," *Proc. of the 5th National Conference on Management of Uncontrolled Hazardous Waste Sites*, Washington, DC, Nov. 1984.
20. Edwards, N.T., "Polycyclic Aromatic Hydrocarbons (PAHs) in the Terrestrial Environment--A Review," *J. Environ. Qual.* 4, (1983), 427-441.
21. U.S. EPA, "An Exposure and Risk Assessment for Benzene," Final Draft Report, Office of Water Regulations and Standards, U.S. EPA, Washington, DC, 1980.

>
§8.7 Soil Contaminated With Petroleum Products.

A. Applicability.

1. The specific requirements contained in this section apply to requests by the owner or operator of a solid waste disposal facility for approval of disposal of soil contaminated solely with petroleum and petroleum products, including but not limited to diesel fuels, kerosene, gasoline, hydraulic fluids, JP-4, and motor oil.

2. Any contaminated soil from a state other than Virginia that is classified as a hazardous waste in the state of origin shall be managed as a hazardous waste. Such wastes are not acceptable for disposal in a solid waste management facility in the Commonwealth.

B. Required Information.

1. A statement from the generator certifying that the soil is non-hazardous waste as defined by the Virginia Hazardous Waste Management Regulations or federal regulations under Subtitle C, Resource Conservation and Recovery Act.

2. The amount of petroleum contaminated soil to be disposed.

3. A description of the sampling protocol and a copy of all laboratory analyses.

4. If generated in a state other than Virginia, certification from the generator that the waste is not considered a hazardous waste in its state of generation.

C. Testing Requirements.

1. Analytical methods. Following methods shall be used in the analysis of the contaminated soil:

a. The presence of any free liquid shall be determined by EPA SW-846 method 9095, Paint Filter Liquids Test.

b. The total petroleum hydrocarbon (TPH) concentrations shall be determined by using EPA method 418.1 for chemical analysis of water and wastewater, which has been modified for use with soil.

c. The sum of benzene, toluene, ethyl benzene, and xylene (BTEX) concentrations shall be determined by

using EPA SW-846 method 5030/8020.

d. The soil shall be tested for total organic halogens (TOX) in accordance with test methods contained in EPA SW-846.

e. The soil contaminated by leakage from an underground tank shall be tested for EP toxicity using EPA SW-846 method 1310. If the tank contained motor oil the testing may be limited to heavy metals; tanks that contained all other petroleum products shall be tested for lead and any other compound covered by that test known to be present.

f. The soil contaminated as a result of anything other than leakage from an underground storage tank shall be tested by the Toxicity Characteristic Leaching Procedure (TCLP). If other TCLP constituents are not tested for, the generator shall be able to certify that the soil is not a hazardous waste, and certify that it did not contain those constituents not tested.

2. Sampling. A minimum of one composite sample shall be analyzed for each required test for every 100 cubic yards of soil to be disposed. In the case of soil reclaimed by thermal treatment, a minimum of one sample shall be analyzed for every production day composited hourly.

3. Waivers.

a. In the case of soil contaminated with gasoline, the testing requirements for EP toxicity or TCLP for lead, TOX, or the paint filter liquids test may be waived, if the request for disposal contains a statement from the State Water Control Board that the material was contaminated with unleaded gasoline, does not contain any halogenated hydrocarbons, or free liquids. The statement from the SWCB may certify any or all of the above. The waiver shall be granted by the Department.

b. Waiver for BTEX testing requirements may be granted, if the generator can provide sufficient documentation that the material does not contain any benzene, toluene, ethyl benzene, or xylenes, and the amount of material to be disposed is less 20 cubic yards.

D. Disposal Criteria.

1. Soils failing the EP toxicity or the TCLP test shall be managed in accordance with the Virginia Hazardous Waste

Management Regulations.

2. Soils exhibiting greater than 100 milligram per kilogram (mg/kg) of TOX may not be disposed of until separate approval from the Department is granted. This request shall document the cause for the high TOX level.

3. If the concentration of total BTEX is greater than 10 mg/kg or TPH is greater than 500 mg/kg, the soil cannot be disposed of in any sanitary or industrial landfill unless the facility permit expressly allows such disposal.

4. If the concentration of TPH is less than 500 mg/kg and total BTEX is less than 10 mg/kg, the disposal of the contaminated soil may be approved for permitted sanitary or industrial landfills equipped with liners and leachate collection systems.

5. If the concentration of TPH is less than 100 mg/kg and total BTEX is less than 10 mg/kg, the disposal of the contaminated soil may be approved for any permitted sanitary or industrial landfill.

6. Soil containing less than 50 mg/kg TPH and total BTEX less than 10 mg/kg may be used as clean fill. This soil, however, may not be disposed of closer than 100 feet of any regularly flowing surface water body or river, 500 feet of any well, spring or other groundwater source of drinking water, and 200 feet from any residence, school, hospital, nursing home or recreational park area. In addition, if the soil is not to be disposed of on the generator's property, the generator shall notify the property owner that the soil is contaminated and with what it is contaminated.

E. Exemptions.

1. Contaminated soil resulting from an underground storage tank release or from a spill may be considered for an exemption from the limits specified in § 8.7.D. of these guidelines where the total volume of contaminated soil from a cleanup site is less than 20 cubic yards, and the contaminated soil is not a hazardous waste. This exemption may only be granted by the Department.

2. The State Water Control Board may approve the disposal of contaminated soil resulting from an emergency cleanup of a spill of petroleum products, provided that the waste is non-hazardous as defined by the Virginia Hazardous Waste Management Regulations or by federal regulations under Subtitle C, RCRA, and the State Water Control Board notifies the Department regarding the spill.

3. Soil contaminated with petroleum products resulting from ordinary household functions may be disposed with the general household waste.