6. POTENTIAL FOR HUMAN EXPOSURE

6.1 OVERVIEW

JP-5, JP-8, and Jet A fuels have not been identified in any of the 1,832 hazardous waste sites that have been proposed for inclusion on the EPA National Priorities List (NPL) (ATSDR 2015a). However, the number of sites evaluated for JP-5, JP-8, and Jet A fuels is not known.

JP-5, JP-8, and Jet A fuels are complex mixtures of aromatic and aliphatic hydrocarbons whose exposure potentials are based on the mixtures themselves and on the individual components of the mixtures (primarily n-alkanes, branched alkanes, benzene and alkylbenzenes, naphthalenes, and PAHs, particularly in the case of environmental exposures once degradation begins). There are few methods for analyzing the environmental fate of jet fuels *per se*; instead, methods are used to analyze the proportions of the component hydrocarbons of jet fuels.

Jet fuel may be released to the environment by in-flight jettisoning of fuel and from spills or leaks to soil or water during use, storage, or transportation. Jet fuel jettisoned from planes can be transported via airborne dispersion, and some of it can be transformed photochemically to ozone and other components of smog. Jet fuel may form aerosols as a result of reactions with atmospheric chemicals, but the specific composition of the particulate material is not known. Most of the jet fuel released to water evaporates into the air. The more volatile components of jet fuels (low molecular weight alkanes) evaporate from soil and water and enter the atmosphere where they are degraded. Components with higher boiling points persist longer in soil and water. Some components of JP-5, JP-8, and Jet A fuels are soluble in water (e.g., the aromatics—benzene, toluene, and xylene). Under turbulent water conditions, the more soluble hydrocarbons remain dissolved longer and may partition to soils and sediments and be biodegraded. The rate and extent of biodegradation are dependent on the ambient temperature, the presence of a sufficient number of microorganisms capable of metabolizing the component hydrocarbons, the amount of aromatic species in the jet fuel, and the concentration of jet fuel. Some components also volatilize or migrate through the soil to groundwater.

The National Occupational Exposure Survey conducted by NIOSH between 1980 and 1983 estimated that 1,076,518 employees (including 96,255 females) were exposed to kerosene, a primary component of JP-5, JP-8, and Jet A fuels, in the workplace. Worker exposure was most likely in industries associated with machinery and special trade contractors. Populations most likely to be exposed to JP-5, JP-8, and Jet A fuels include those involved in jet fuel manufacturing or refueling operations, aircraft and fuel tank

maintenance, or using JP-8 in military vehicles or as fuel heating or lighting sources; populations near an area where Jet A, JP-5, or JP-8 have been dumped; and populations working or living on military bases where the fuels are used or stored (and where leaks and spills are likely to occur). The general population is unlikely to be exposed to jet fuels, and any exposure that does occur is most likely to be limited to populations living on or near a refinery producing these and other substances, airports, or military installation where these fuels are utilized. Unintentional exposure to JP-5, JP-8, and Jet A fuels may occur as a result of groundwater contamination from accidental spills or contact with soils that have been contaminated with jet fuels. Since kerosene is a substance still used as a fuel for cooking and heating, it is expected that members of the general population who use things such as kerosene heaters or lamps may be exposed through dermal and inhalation routes.

6.2   RELEASES TO THE ENVIRONMENT

The Toxics Release Inventory (TRI) data should be used with caution because only certain types of facilities are required to report (EPA 2005). This is not an exhaustive list. Manufacturing and processing facilities are required to report information to the TRI only if they employ 10 or more full-time employees; if their facility is included in Standard Industrial Classification (SIC) Codes 10 (except 1011, 1081, and 1094), 12 (except 1241), 20–39, 4911 (limited to facilities that combust coal and/or oil for the purpose of generating electricity for distribution in commerce), 4931 (limited to facilities that combust coal and/or oil for the purpose of generating electricity for distribution in commerce), 4939 (limited to facilities that combust coal and/or oil for the purpose of generating electricity for distribution in commerce), 4953 (limited to facilities regulated under RCRA Subtitle C, 42 U.S.C. section 6921 et seq.), 5169, 5171, and 7389 (limited S.C. section 6921 et seq.), 5169, 5171, and 7389 (limited to facilities primarily engaged in solvents recovery services on a contract or fee basis); and if their facility produces, imports, or processes ≥25,000 pounds of any TRI chemical or otherwise uses >10,000 pounds of a TRI chemical in a calendar year (EPA 2005).

JP-5 and JP-8 are fuel mixtures used by the U.S. military and NATO as aviation fuels. As a result of normal aircraft operations and fuel storage, JP-5 and JP-8 can be released into the environment. Under some conditions, it is common practice for aircraft to jettison excess fuel into the air, releasing it into the environment (IARC 1989). Jet A and Jet A-1 are used as civilian aviation fuels, and therefore, accidental releases could potentially occur at production (refineries) or storage (e.g., airport) facilities.

Releases of Jet A, JP-5, and JP-8 are not required to be reported under SARA Section 313; consequently, there are no data for these compounds in the 2011 TRI (EPA 2005).

6.2.1   Air

There is no information on releases of JP-5, JP-8, and Jet A fuels to the atmosphere from manufacturing and processing facilities because these releases are not required to be reported (EPA 2005).

JP-5, JP-8, and Jet A fuels may be released into the air as vapors during aircraft loading and unloading operations or as a result of their normal use as a jet fuel for civilian or military aircraft (Air Force 1981a; NIOSH 1989). Releases into the air may also occur as a result of volatilization of these fuels from contaminated soils or spill sites (Air Force 1989b). Atmospheric emissions of jet fuels may be determined primarily by detection of their volatile hydrocarbon components.

6.2.2   Water

There is no information on releases of JP-5, JP-8, and Jet A fuels to the water from manufacturing and processing facilities because these releases are not required to be reported (EPA 2005).

Jet fuels may be released into surface water or groundwater as a result of leaking storage tanks and pipelines, surface runoff of unburned fuel residue, airborne jettisoning of fuels, and spills during dispensing operations and aircraft maintenance (Guiney et al. 1987a; Klein and Jenkins 1983). Leakage of jet fuels including JP-5 from storage tanks at the Patuxent Naval Air Test Center (NATC), Patuxent River, Maryland, has resulted in "severe environmental insult" to a Navy fuel farm and adjacent areas (Navy 1988). During the winter of 1976–1977 a pipeline connecting underground storage tanks ruptured, releasing an undetermined amount of JP-5 and other jet fuels into the subsurface system. The existence and possible extent of groundwater contamination are unknown; however, surface waters near the site are known to be contaminated with jet fuels including JP-5 (Arthur et al. 1992). Widespread contamination of groundwater at the Diego Garcia Navy Support Facility has been reported after several major releases of JP-5 fuel from 1991 to 1998 (Hansen 1999). From 1996 to 1998, over 70,000 gallons of JP-5 fuel were recovered from contaminated groundwater using a vacuum-enhanced skimming technique that removes fuel floating at the surface of the water table.

On October 16, 1982, a crack in a petroleum pipeline near Ebensburg, Pennsylvania, released an estimated 1,310 barrels of "aviation kerosene" into a stream (Guiney et al. 1987a, 1987b). Kerosene and

other petroleum products were released by accidental spills and discharges into Newark Bay and its major tributaries. From 1986 to 1991, about 306 gallons of kerosene were released to Newark Bay or its tributaries (Crawford et al. 1995).

6.2.3 Soil

There is no information on releases of JP-5, JP-8, and Jet A fuels to the soil from manufacturing and processing facilities because these releases are not required to be reported (EPA 2005).

JP-5, JP-8, and Jet A fuels may be released into soil as a result of accidental spills and leaks in underground or aboveground storage tank systems. From March to June 1971, an accidental spill released >14 tons of JP-5 jet fuel mixed with jet fuel no. 2 at a storage facility in Searsport, Maine (Dow et al. 1975). During the winter of 1976–1977, soils at a fuel farm at Patuxent NATC, Patuxent River, Maryland, were contaminated with an unknown quantity of JP-5 when a pipeline connecting underground storage tanks ruptured (Arthur et al. 1992). Since that time, site investigations have revealed that the fuel has moved through several acres of sandy soil to a depth of 20–30 feet (Arthur et al. 1992).

On November 27, 2001, a pipeline ruptured and released approximately 2,500 barrels of JP-8 into a drainage system that ultimately leads to a nature preserve near Vidor, Texas (Texas Commission of Environmental Quality 2004). The spill resulted in contamination of the Neches River and various managed pasture lands and hardwood forests.

6.3 ENVIRONMENTAL FATE

6.3.1 Transport and Partitioning

The transport and dispersion of JP-5, JP-8, and Jet A fuels are dependent on the water solubility and volatility of the component hydrocarbon fractions. Lower molecular weight hydrocarbons such as n-alkanes may volatilize relatively quickly from both water and soil, while larger aliphatics may be sorbed to organic particles in water or soil. Aromatic hydrocarbons will be dissolved in the aqueous phase in both soil and water and may undergo some volatilization. Information on the specific physical and chemical properties of several of the component hydrocarbons (e.g., benzene, toluene, xylene, and naphthalene) can be found in the ATSDR toxicological profiles for these chemicals. The many hydrocarbons that compose JP-5, JP-8, and Jet A fuels can be divided into a few groups of hydrocarbon classes with similar properties (Air Force 1989b). These include paraffins (also called alkanes, which are

saturated straight-chain hydrocarbons), cycloparaffins (saturated cyclic hydrocarbons), aromatics (fully unsaturated cyclic compounds), and olefins (also called alkenes, which are unsaturated straight-chain and cyclic hydrocarbons). Paraffins and cycloparaffins (alkanes and cycloalkanes) are the major hydrocarbon components of JP-5 and JP-8 and together constitute approximately 80–90% by volume of the fuels (IARC 1989). Aromatics constitute approximately 17% of JP-8 and 18% of JP-5 (Army 1988). It is important to point out that the specific composition of jet fuels varies among manufacturers and probably among batches (Air Force 1989a; DOD 1992, 2013). JP-5 and JP-8 may also contain low levels of nonhydrocarbon contaminants and additives including sulfur compounds, gums, naphthenic acids, antioxidants, static inhibitors, icing inhibitors, and corrosion inhibitors (DOD 1992, 2013; IARC 1989).

Transport processes have been shown to be more significant than transformation processes in determining the initial fate of lower molecular weight petroleum hydrocarbons released to soil and groundwater systems (Air Force 1989b). Evaporation from water is the major removal process for low molecular weight, volatile hydrocarbons, such as those found in JP-5 and JP-8 (EPA 1983). Loss of JP-8 from water was determined to be primarily due to evaporation in a quiescent flask test system study (Dean-Ross et al. 1992). Loss of individual hydrocarbon components of JP-8 was related to molecular weight and vapor pressure, with low molecular weight components (toluene and n-octane) being removed within 10 days, and high molecular weight components (1-methylnaphthalene and n-dodecane) persisting (Dean-Ross et al. 1992). Laboratory experiments have shown that the evaporation rate of jet fuel and its components increases with wind velocity and, to a lesser extent, with temperature and fuel-layer thickness (Air Force 1988). Comparisons of dissolution and evaporation rates under several wind-speed and mixing conditions showed that evaporation was the dominant fate process for jet fuel components in water.

In a study by Coleman et al. (1984), the partitioning of kerosene (the primary constituent of JP-5 and JP-8) into drinking water after 17 hours of incubation resulted in only 0.7% of the kerosene being dissolved in the water. Further analysis of the kerosene indicated that although kerosene contains approximately 50% aliphatic hydrocarbons (by weight percent), the water-soluble fractions (WSFs) contained primarily aromatic constituents (>93%) including benzenes and naphthalenes as shown in Table 6-1 (Coleman et al. 1984).

JP-8 also evaporates from soil, although evaporation in not as important a fate process in soil as it is in water. When water/sediment slurries were treated with JP-8, rates of removal were much slower than from water alone. The addition of sediments to water inhibited the evaporative removal of JP-8,

6. POTENTIAL FOR HUMAN EXPOSURE

Table 6-1. Analysis of Water-Soluble Fraction of Kerosene

Kerosene	Whole product[a]	Water-soluble fraction[b]	
		0.5 Hours	17 Hours
Alkanes + cycloalkanes	68.6	4.5	0.5
Benzene + substituted benzenes	13.7	63.5	53.2
Naphthalene+ substituted naphthalenes	5.7	29.6	44.8

[a]Estimated weight percent
[b]Estimated weight percent of constituents dissolved in water after 0.5 or 17 hours of incubation

Source: Coleman et al. 1984

6. POTENTIAL FOR HUMAN EXPOSURE

apparently by adsorbing the components of JP-8 and thus rendering them unavailable for evaporation (Dean-Ross et al. 1992).

Horizontal and vertical migration of JP-5 components has been demonstrated by field observations and laboratory experiments. Model soil core terrestrial ecosystems and outdoor soil cores were treated with JP-5 to mimic a spill and watered to simulate rainfall (Air Force 1982a). The individual hydrocarbon components of JP-5 were found to vertically migrate to varying depths in quantities independent of one another, apparently independent of aqueous leachate movement. Movement of JP-5 in the laboratory occurred to a depth of 50 cm with the majority of hydrocarbons being transported in the first 10 cm. Of the 14 hydrocarbons present, only one component, 1,3,5-trimethylbenzene, was detected below 20 cm. Hydrocarbon components did not persist past the 131st day of the experiment. The outdoor soil core showed movement of JP-5 to a 30-cm depth. The majority of hydrocarbons were seen at 10, 20, and 30 cm. Hydrocarbon components were detectable in the core until the 173rd day of the experiment (Air Force 1982a). Horizontal and vertical migration of jet fuels has also been confirmed by detection of JP-5 hydrocarbons in soil several meters from the spill site (Arthur et al. 1992).

The movement of a synthetic kerosene through soil was found to be dependent on the moisture content of the soil. The greater the moisture content (e.g., 4% compared with 0.8%) of the soil, the less the adsorption of the more volatile components of the kerosene and the greater and more rapid the penetration of the liquid component through the soil. Conversely, the upward mobility of both the liquid and vapor phases of kerosene through soil decreased with increased moisture content; at field capacity, the upward capillary movement of the kerosene was completely inhibited (Acher et al. 1989). Desorption of a simulated kerosene applied to three types of soil, each with a moisture content at 70% of field capacity, was found to be complete after 30 days of exposure to the atmosphere with the slowest desorption from the soil having the greatest organic content (Yaron et al. 1989). Kerosene loss from a dune sand, a loamy sand, and a silty loam soil after 50 days showed that volatilization of all kerosene components was greatest from the dune sand and loamy sand soils. The larger pore size of these types of soil compared with the silty loam soil was thought to be the reason for the increased volatilization (Galin et al. 1990). Movement of kerosene through three grades of sand was affected mainly by volatilization of the C9–C13 components; the volatilization of specific kerosene components was generally inversely related to their carbon number (Galin et al. 1990).

The movement of kerosene through various types of soil over a 12-hour period was studied. Upward, downward, and lateral movement was greatest in soil of the mica/kaolinite type (11% clay content); 40,

102, and 45 cm, respectively. Movement through soils that were primarily kaolinite (clay content of 26–52%), regardless of the direction, ranged between 20 and 33 cm (EPA 1986). Application of herbicides such as S-ethyl dibutylthiocarbamate to a field using kerosene as a solvent (up to a volume of 40 gallons per acre) increased the inactivation of the herbicide on soil, whereas acetone, benzene, and xylene did not. The accelerated inactivation possibly resulted from a change in surface tension that facilitated the volatilization of the herbicide from the soil (Danielson and Gentner 1970).

Studies on the permeability of compacted micaceous soil used as a potential liner for landfills found that the permeability of the soil to kerosene varied from 3 to 4 orders of magnitude greater compared with water (EPA 1984).

Klein and Jenkins (1983) exposed flagfish and rainbow trout to WSF of JP-8 in static acute bioassays and continuous-flow bioassays. The mean concentration of JP-8 in whole-body tissue samples increased with increasing concentration of the WSF of the fuel. The bioconcentration factor (BCF), expressed as the ratio of the concentration in tissue to the concentration of the WSF of JP-8 in the aqueous environment, was found to be 159 (log value of 2.2). Adult flagfish exposed to 2.54 mg/L, for 14 days yielded a BCF of 130 (log value of 2.1). Adult flagfish that were placed in uncontaminated water exhibited a depuration rate similar to the accumulation rate. Similar experiments with rainbow trout showed no relationship between JP-8 concentrations in surrounding water and whole-body concentrations in the fish. The relatively low BCF of 63–112 (log value of 1.8–2.1) calculated for rainbow trout indicates that the WSF of JP-8 does not concentrate as readily in this species.

6.3.2   Transformation and Degradation

6.3.2.1   Air

No studies on the transformation or degradation of JP-5, JP-8, and Jet A fuels in the atmosphere were located. However, volatile components of jet fuels such as benzene, toluene, xylenes, and PAHs may be expected to enter the atmosphere where they are subjected to degradation processes. Further information on the atmospheric degradation of selected volatile hydrocarbons is presented in the ATSDR toxicological profiles for these chemicals (ATSDR 1995, 2007a, 2007b, 2015b). The photooxidation half-life range for a group of representative chemicals of kerosene, JP-5, and JP-8 was reported as 0.2–1.1 days (API 2010a). Studies on JP-4, a jet fuel mixture of gasoline and kerosene, indicate that jet fuels react photochemically in air in the presence of nitrogen oxide compounds to form ozone, but the effect of temperature on the nitrous oxide oxidation rate is uncertain (Air Force 1981b, 1982b). Reactions of JP-4

produce large amounts of aerosol material (Air Force 1981b), and it should be noted that JP4 has a considerable gasoline component compared to straight kerosene.

6.3.2.2 Water

Biodegradation of jet fuels is dependent on the degradation of the various hydrocarbon fractions present in the oils. The relative order for biodegradation of the hydrocarbon fractions from the most readily degraded to the least is as follows: n-alkanes, iso-alkanes, olefins, low molecular weight aromatics (at low, nontoxic concentrations), PAHs, and cycloalkanes (Bartha and Atlas 1977; Edgerton et al. 1987).

Conflicting data exist on the biodegradation of jet fuels and kerosene. Biodegradation of JP-8 in water was studied using quiescent flask test systems (Dean-Ross et al. 1992). Microbial activity in flasks of water incubated at 30°C on a shaker at 200 revolutions/minute for 4 days was inhibited by all concentrations of JP-8 tested (0.01, 0.1, 1%), as indicated by a depression of glucose mineralization in comparison to a control. The study authors suggested that one possible explanation for the lack of biodegradation in water samples is the toxicity of JP-8 to microorganisms at the concentrations tested, which may severely inhibit microbial activity (Dean-Ross et al. 1992).

Microorganisms readily able to degrade hydrocarbons were isolated from the Neuse River estuary in North Carolina. Although the estuary was relatively free of hydrocarbon contamination, 63% of the bacteria and 71% of the fungi isolated from surface water samples were able to utilize kerosene as the sole carbon source (Buckley et al. 1976). Weathered kerosene (volatile components were allowed to escape prior to testing) was spiked with four hydrocarbon markers, and the degradation of the markers was monitored. All four markers were degraded by a water-sediment mixture from an "oiled arm" of an Ohio lake; more rapid-degradation was associated with mixtures taken from relatively polluted areas of the lake (Cooney et al. 1985), suggesting that biodegradation is enhanced by the presence of acclimated microorganisms. Marine bacteria capable of using jet fuel no. 1 were isolated from Narragansett Bay, Rhode Island. Most of the bacteria were found to utilize the aliphatic components of the jet fuel, primarily hexadecane, while only a few of the bacteria were able to degrade the aromatic components. The bacteria were able to degrade the hexadecane at 0°C, but degradation was significantly improved when the incubation temperature was increased to 8 and 16°C; similar but not such dramatic effects were seen in the degradation of naphthalene with increased temperature (Cundell and Traxler 1976).

Petroleum residues were measured in the northern Arabian Sea to assess the contamination following the oil spills resulting from the Gulf War in 1991. Little change in variables related to oil pollution took place in any compartment of the marine environment-water, plankton, fish, or sediments (Sengupta et al. 1993).

Kerosene achieved 58.6% of its theoretical biochemical oxygen demand (BOD) after 28 days using an activated sludge inoculum obtained from a municipal waste water treatment plant and the manometric respirometry test (OECD 301F). It was classified as not readily biodegradable, but was inherently biodegradable since significant degradation did occur (API 2010a). Two distillate fuels with similar composition to JP-5 and JP-8, a low sulfur diesel fuel and a Nigerian diesel fuel, achieved 60 and 57.5% of their theoretical BOD within 28 days using an activated sludge and the manometric respirometry (OECD 301F) test, and an aviation turbine fuel (Chemical Abstracts Service Registry Number not stated) was degraded up to 46% within 10 days in fresh water amended with nutrient salts (nitrogen and phosphorous) using a study method that appears to be similar to the closed bottle test (OECD 301D) (API 2010a). The degradation rates were 53 and 2% after 10 days using seawater with and without the nutrient amendments, respectively. Over 99% removal of the hydrocarbon fraction of kerosene type aviation fuels (Jet A, Jet A-1, and JP-8) in water-soluble fractions were observed using mixed microbial cultures isolated from aviation fuel contaminated groundwater in a chemostat culture apparatus over a 113-hour incubation period (API 2010a). These study results suggest that many of the components of these mixtures are quickly degraded and are not expected to be persistent in the environment.

6.3.2.3 Sediment and Soil

Ample evidence exists to indicate that many of the components of kerosene, JP-5, JP-8, and Jet A fuels are biodegraded in soil. Microbial degradation in soils is greatest for the aromatic fractions of jet fuels, while the biodegradation of the aliphatic hydrocarbons decreases with increasing carbon chain length and the degree of branching. Evaporation is the primary fate process for these aliphatics (Air Force 1989b).

Application of JP-5 to terrestrial soil core ecosystems and outdoor soil cores resulted in a stressed condition as indicated by an increased rate of carbon dioxide (CO_2) production within 1 day of application (Air Force 1982a). The carbon dioxide production of the cores returned to a rate almost comparable to that of the controls following the increase. A possible reason for this increase was increased activity of microorganisms that utilize the component hydrocarbons of JP-5. The study authors concluded that soil microbes are able to degrade JP-5 in cultures inoculated with soil organisms (Air

Force 1989a). In a quiescent flask study, JP-8 was found to be nontoxic to sediment microorganisms (Dean-Ross et al. 1992). The study authors found that removal of some components of JP-8 from active soil (soil containing microorganisms) was significantly faster than removal in sterilized soil. Subsurface microorganisms present at a fuel spill at Patuxent NATC were able to utilize JP-5 as their sole carbon source (Navy 1988). The study author concluded that potential exists for promoting in situ biodegradation of some of the hydrocarbon components by stimulating the growth of indigenous microflora. Although most soils contain microorganisms capable of degrading hydrocarbons in situ, the factors that limit the bioremediation process (e.g., restricted bioavailability of the contaminant, nutrient limitations, potential toxicity of fuel hydrocarbons and associated contaminants, inadequate reduction/oxidation [redox] potential, inadequate or excessive moisture, acidic or basic conditions, and oxygen deficiency) need to be overcome in order to stimulate the degradation of jet fuels in soil and groundwater (Arthur et al. 1992).

The environmental fate of hydrocarbons present in kerosene was studied following a pipeline rupture that contaminated 1.5 hectares of a New Jersey wheat field with kerosene (Dibble and Barth 1979). Hydrocarbon levels were measured in the upper 30 cm of the soil and the 30–45 cm soil core over a 2-year period. After 6 months, the hydrocarbon content began to decrease in the upper 30 cm of soil and at 21 months, the hydrocarbon content was reduced to trace amounts as volatilization and biodegradation removed the hydrocarbons from the soil surface. However, hydrocarbons associated with the kerosene spill were still detected at soil depths of 30–45 cm. The disappearance rate was strongly correlated with the monthly average temperatures. The highest disappearance rates occurred during the warmer summer months but were markedly slower in winter as both volatilization and aerobic biodegradation are attenuated by colder temperatures. Seed germination studies using the contaminated soil 1 year after the spill (0.34% kerosene concentrations) showed that kerosene delayed seed germination, but that the percent germination was unaffected (Dibble and Bartha 1979). Landfarming techniques (tillage of soil using agricultural implements) developed in The Netherlands to enhance biodegradation of contaminants demonstrated that after one growing season, kerosene (initial concentration of 1,000–10,000 mg/kg dry matter) was significantly degraded (final concentration of 500 mg/kg dry matter) in 40 cm of soil (Soczo and Staps 1988).

The addition of nitrogen (as urea) to soil increases the biodegradation potential of kerosene; however, kerosene was found to inhibit the urease activity of soil microbes by up to 35%, suggesting that sources of nitrogen other than urea should be used (Frankenberger 1988). The bacterial species in the genera Achromobacter, Pseudomonas, and Alcaligenes, isolated from the soil of an active oil field in Louisiana,

were able to aerobically degrade kerosene as determined by oxygen uptake (Cooper and Hedrick 1976). Soil Pseudomonas species were able to degrade kerosene to a greater extent than were Enterobacter species with stationary phases occurring after 10 and 8 days, respectively (Butt et al. 1988). Seven years after the dumping of sludge containing kerosene at two sites, vegetation at each site showed little recovery. Although the bacterial biomass had declined at both sites, microbial activity, as determined by carbon dioxide evolution, was greater at the site that had received more precipitation and had the more aerated soil (Jones 1977). Oxidation of kerosene by soil microbes, as determined by dehydrogenase activity, increased with increasing loading rates (up to 60% w/w oil/dry soil) for up to 7 days of incubation, but decreased thereafter. Dehydrogenase activity in soil treated with kerosene was 32 μg formazan/g soil/24 hours (Frankenberger and Johanson 1982).

A study was conducted to investigate the loss of JP-8 in soil with the presence of vegetation (Karthikeyan et al. 1999). A biodegradation unit consisting of a sandy soil (82–90% sand, 8–16% silt, 2% clay, and 0.6–1.1 % organic matter) that had previously been contaminated with toluene, phenol, trichloroethylene (TCE), and trichloroethane (TCA) was used to grow alfalfa plants. JP-8 was added to different parts of the biodegradation chamber at depths ranging from 10 to 30 cm and the system was irrigated with water. The overall average level was about 1,700 mg JP-8 per kg of soil at the start of the experiment. Approximately 3 months following the initial application of JP-8 to the system, the total petroleum hydrocarbon (TPH) levels had decreased to about 215 mg/kg (0–10 cm), 1,249 mg/kg (10–20 cm), and 405 mg/kg (20–30 cm) at the front location of the test system. Concentrations at the back location were significantly lower. Experiments conducted on air-dried soils used as sterile controls suggested that volatilization could account for up to about 52% of the losses from these experiments; however, biodegradation was also considered a significant environmental fate process.

6.4   LEVELS MONITORED OR ESTIMATED IN THE ENVIRONMENT

Reliable evaluation of the potential for human exposure to JP-5, JP-8, and Jet A fuels depends in part on the reliability of supporting analytical data from environmental samples and biological specimens. Concentrations of JP-5, JP-8, and Jet A fuels in unpolluted atmospheres and in pristine surface waters are often so low as to be near the limits of current analytical methods. In reviewing data on JP-5, JP-8, and Jet A fuel levels monitored or estimated in the environment, it should also be noted that the amount of chemical identified analytically is not necessarily equivalent to the amount that is bioavailable. The analytical methods available for monitoring JP-5, JP-8, and Jet A fuels in a variety of environmental media are detailed in Chapter 7.

6. POTENTIAL FOR HUMAN EXPOSURE

6.4.1   Air

Components of jet fuels can enter the atmosphere through evaporation from spills and leaks, vaporization during fueling operations, fuel jettisoning, and burning in engines. In a "third generation closed aircraft shelter," which has approximately 3 times the interior volume of a "first generation closed aircraft shelter," the concentration of JP-8 in the air was measured as 12 mg/m^3 during refueling operations. In the immediate vicinity of the refueler technician, JP-8 concentrations were determined to be <22 mg/m^3 (Air Force 1981a). In contrast, concentrations of JP-4 (a more volatile jet fuel than either JP-5 or JP-8) ranged from 75 to 267 mg/m^3 in a similar structure during fueling operations. Concentrations of JP-4 in a first-generation shelter ranged from 533 to 1,160 mg/m^3 (Air Force 1981a).

A study by Puhala et al. (1997) examined jet fuel vapor exposures at three U.S. Air Force bases in the United States. At the time of sampling, JP-8 was only used at one base, JP-5 and JP-8 at another, and a third used only JP-4. Breathing zone samples were collected for workers in aircraft maintenance, fuel handling, and flight-line positions.

Mean exposure concentrations for all samples collected were 0.01 ppm benzene (SD=0.0l) and 1.33 ppm naphthas (SD=l.95) for aircraft maintenance positions; 0.01 ppm benzene (SD=0.0l) and 0.61 ppm naphthas (SD=0.90) for fuel handling positions; and 0.004 ppm benzene (SD=0.005) and 0.33 ppm naphthas (SD=0.40) for flight-line positions.

6.4.2   Water

No data were located that discussed specific levels of JP-5, JP-8, and Jet A fuels in water. During October of 1983, a leaking pipeline south of Ebensburg, Pennsylvania, released approximately 1,310 barrels of "aviation kerosene" into a trout stream (Guiney et al. 1987a, 1987b). Total organic carbon (TOC) content in the stream water was approximately 30–60 ppm during the initial few months following the spill, which is approximately 1.5–2 times greater than background (Guiney et al. 1987b). During the winter of 1976–1977, a leak of unknown quantity in a pipeline at Patuxent NATC in Maryland resulted in surface water contamination and possible groundwater contamination by JP-5 (Arthur et al. 1992).

6.4.3   Sediment and Soil

An unknown quantity of JP-5 leaked from a pipeline during the winter of 1976–1977 at Patuxent NATC in Maryland, resulting in several acres of soil contamination to a depth of 20–30 feet (Arthur et al. 1992). Storage and aircraft refueling operations at research facilities such as Scott Base have resulted in jet fuel contamination of soils in the Ross Dependency, Antarctica (Aislabie et al. 1998). TPH levels in contaminated soils of the Ross Dependency ranged from <2 to 17,488 µg/g, with the highest levels observed near leaking pipelines carrying JP-8 and other fuel leak locations near storage and re-fueling areas. The hydrocarbon profile in these contaminated soils consisted of C_9–C_{14} alkanes, C_2–C_4 benzenes, naphthalene, and methyl naphthalene. Quantitative amounts collected from soil samples at Scott Base are shown in Table 6-2.

Concentrations of kerosene-range hydrocarbons in sediment collected one month after an aviation kerosene leaked into a trout stream were reported as "saturated" (Guiney et al. 1987b). Approximately 14 months after the leak, one site still had kerosene-hydrocarbon sediment levels of 18.0±10.8 ppm and a second site had a mean concentration of 9.3±9.0 ppm, while a control site had levels of <2.0 ppm. Kerosene-hydrocarbon sediment levels returned to normal levels in the stream 21 months after the spill.

TPH levels were measured in soil samples located at the Dobbins Air Force Base located in Marietta, Georgia (Reed and Sterner 2002). This facility had a fuel farm that contained eight 50,000-gallon above-ground storage tanks used to store and distribute JP-4, JP-5, and JP-8 from the mid-1950s through 1993. TPH levels at depths of 1–2 feet below the surface ranged from 517 to 2,239 mg/kg in four out of eight grab samples of soil collected in 1997. Xylene levels ranged from 0.026 to 0.70 mg/kg; however, other common constituents of JP-5 and JP-8 such as benzene, toluene, and ethylbenzene were not detected in the 1997 preliminary sampling. Sampling conducted in 2001 at soil depths 1–8.5 feet below the surface had detectable benzene levels of 1.3–31 mg/kg and TPH-gasoline range organics ranged from 1 to 3,400 mg/kg, while TPH-diesel range organics ranged from 7.8 to 9,800 mg/kg (Reed and Sterner 2002). TPH levels in soil samples collected at the site of a Harrier jet fueled by JP-8 that crashed near Wright-Patterson Air Force Base, Ohio ranged from 389 to 11,657 mg/kg and from 3,100 to 8,500 mg/kg for samples collected on two consecutive days and analyzed by two different analytical methods (Merrill 1998). Soil samples collected at Misawa Air Base, Japan in 1998 had TPH levels (total aliphatics and aromatics) ranging from 703 to 11,938 mg/kg at three locations where jet fuels had been stored (Vermulen et al. 1998).

6. POTENTIAL FOR HUMAN EXPOSURE

Table 6-2. Hydrocarbon Levels (µg/g) from Jet Fuels in Soil Samples from Scott Base, Antarctica

Hydrocarbon	1	2	3	4	5	6
C9	123	<2	<2	486	1,220	50
C10	383	623	<2	1,740	3,570	163
C11	663	543	263	2,170	4,176	246
C12	446	1,570	554	1,780	3,490	250
C13	240	1,120	653	1,016	1,763	166
C14	<2	900	443	493	920	63
C2-benzenes	772	<2	<2	<2	<2	<2
C3-benzenes	1,338	1,825	<2	360	<2	<2
C4-benzenes	818	2,009	<2	836	<2	<2
Naphthalene	190	773	<2	<2	<2	<2
C1-Napthalene	196	1,076	<2	<2	<2	<2

Source: Aislabie et al. 1998

6.4.4   Other Environmental Media

No data were located that discussed specific levels of JP-5 or JP-8 in other environmental media such as food or terrestrial or aquatic plants and animals. Concentrations of kerosene-range hydrocarbons in fish collected during the year following an "aviation kerosene" leak into a trout stream ranged from 2.60 to 14.37 ppm by weight (Guiney et al. 1987b). Shellfish taken from unpolluted waters have been found to contain between 1 and 12 μg/g wet weight of total hydrocarbons, while fish have been found to contain between 4 and 14 μg/g total hydrocarbons (steam distillable) (Connell and Miller 1980).

6.5   GENERAL POPULATION AND OCCUPATIONAL EXPOSURE

Exposure of the general population to JP-5,JP-8, and Jet A fuels is most likely to be limited to populations living on or near a military installation where JP-5 or JP-8 are utilized or near commercial airports using Jet A fuel. Unintentional exposure to JP-5 and JP-8 may occur as a result of groundwater contamination from spilled jet fuels or contact with soils that have been contaminated with jet fuels. Atmospheric exposure may occur from fuel leakage, spillage, engine cold starts, and high-altitude aircraft fuel jettisoning (Ritchie et al. 2003). Occupational exposure will occur in individuals involved in the production of JP-5, JP-8, or Jet A fuels; fueling and defueling aircraft; cleaning up spills and leaks of jet fuel; and aircraft and fuel tank maintenance. It was reported that over 1 million U.S. military and civilian personnel are occupationally exposed to JP-8, JP-8 + 100, JP-5, or to the civil aviation equivalents, Jet A or Jet A-1 annually (Ritchie et al. 2003). Exposure occurs via four primary scenarios: (1) direct dermal contact with raw fuel and/or aerosols; (2) secondary dermal contact with clothing or other items such as gloves that are contaminated by the fuel; (3) inhalation exposure to fuel or exhaust; or (4) oral exposure to aerosol or to fuel contaminated food or water. In addition to aircraft fueling applications, JP-8 is used for fueling land vehicles and equipment, fueling of heaters and lighting sources, as a coolant in aircraft, combat obscurant, to suppress environmental sand or dust, decontaminate military vehicles and equipment, and as a carrier for herbicide applications (Ritchie et al. 2003).

Because jet fuels such as JP-5, JP-8, and Jet A are complex mixtures of hundreds of aliphatic and aromatic hydrocarbons, exposure to JP-5, JP-8, and Jet A is typically monitored by measuring THCs and certain aromatic components such as benzene, toluene, ethylbenzene, xylenes, and naphthalene in air or expired breath with the knowledge that the levels of these substances may also arise from sources other than jet fuels. Members of the Air National Guard at the Warfield Air National Guard Base in Essex, Maryland were monitored for exposure to JP-8 during normal working hours from August to October

2001 (Tu et al. 2004). Pre-work concentrations of JP-8 constituents in exhaled breath ranged from below the detection limits to 7.6 mg/m^3 and post-work samples ranged from 0.2 to 11.5 mg/m^3; an increase in postwork levels was only found in fuel cell workers and fuel specialists with the greatest change occurring in the fuel cell workers. A control group of 18 nonsmoking, unexposed subjects living in an urban environment had exhaled breath concentrations of 0.30–2.13 mg/m^3 (pre-work) and 0.21–2.28 mg/m^3 (post-work). Merchant-Borna et al. (2012) examined 73 U.S. Air Force personnel at three different bases and monitored their exposure to JP-8 constituents. They categorized the individuals at these bases into low- and high-exposure groups based upon expected exposure scenarios given their job descriptions. The high-exposure group primarily consisted of fuel system workers involved in the removal, repair, inspection, and modification of aircraft fuel systems; the low-exposure group primarily consisted of workers with intermittent or low-no exposure employed in fuel distribution or maintenance, aircraft inspection and maintenance, and administrative/clerical office work. The geometric mean 8-hour time-weighted average (TWA) concentration of JP-8 constituents (THC, benzene, toluene, ethylbenzene, xylene, and naphthalene) in personal air samples were significantly higher in the high-exposure group as compared to the low-exposure group (p<0.0001), with the exception of toluene. The geometric mean 8-hour TWAs for THC were 0.52 mg/m^3 (range 0.24–22.01 mg/m^3) and 2.64 mg/m^3 (range 0.24–73.93 mg/m^3) for the low and high exposure groups, respectively (Merchant-Borna et al. 2012; Proctor et al. 2011). The geometric mean 8-hour TWAs for benzene, ethylbenzene, and naphthalene were 0.88 µg/m^3 (range 0.2–250 µg/m^3), 0.72 µg/m^3 (range 0.1–224 µg/m^3), and 0.37µg/m^3 (range 0.2–11 µg/m^3), respectively, in the low-exposure group, and 1.98 µg/m^3 (range 0.2–99 µg/m^3), 5.57 µg/m^3 (range 0.2–390 µg/m^3), and 2.25µg/m^3 (range 0.2–55 µg/m^3), respectively, in the high-exposure group. These results are consistent with the findings of Maule et al. (2013) who examined breathing zone levels of Air Force personnel similarly assigned to high- and low-exposure groups. The geometric mean work-shift THC concentration of high-exposure personnel was reported as 4.4 mg/m^3, while that of the low-exposure group was 0.9 mg/m^3. A study of fuel cell maintenance workers reported geometric mean breathing zone naphthalene levels of 614 mg/m^3 (Chao et al. 2006). The work-shift naphthalene geometric means were 4.8 and 0.7 µg/m^3 for the high- and low-exposure groups, respectively. Egeghy et al. (2003) measured levels of benzene and naphthalene in the air and breath of Air Force personnel exposed to JP-8. Based upon job function, personnel were pre-assigned to high- (fuel maintenance), moderate- (fuel handling, distribution, recovery, and testing), and low- (jobs with minimal jet fuel exposure) exposure groups. Levels of naphthalene in both air and breath samples were highest for personnel assigned to the high-exposure category and there was little overlap in air levels among workers assigned to the high-, moderate-, and low-exposure groups. Benzene levels were also greater in air and breath samples of workers assigned to the high-exposure category; however, there was substantial overlap

in air levels for each category, suggesting that sources other than JP-8 (e.g., smoking or gasoline exhaust) could be accounting for some of the benzene exposure among these personnel (Egeghy et al. 2003). Even so, the authors noted that benzene levels exceeded the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) of 1.6 mg/m^3 in 5 and 15% of the air concentrations of the moderate- and high-exposure groups, respectively. Benzene and naphthalene levels in personal air were also considerably greater in this study (485 µg/m^3 for naphthalene in the high exposure category and 252 µg/m^3 for benzene in the high-exposure category) as compared to the studies of Merchant-Borna et al. (2012) and Maule et al. (2013). The elevated levels in the Egeghy et al. (2003) study may be due to the fact that personnel were actively monitored while working in tanks and the use of fire suppression foam in this study, which increases exposure (Merchant-Borna et al. 2012).

6.6   EXPOSURES OF CHILDREN

This section focuses on exposures from conception to maturity at 18 years in humans. Differences from adults in susceptibility to hazardous substances are discussed in Section 3.7, Children's Susceptibility.

Children are not small adults. A child's exposure may differ from an adult's exposure in many ways. Children drink more fluids, eat more food, breathe more air per kilogram of body weight, and have a larger skin surface in proportion to their body volume. A child's diet often differs from that of adults. The developing human's source of nutrition changes with age: from placental nourishment to breast milk or formula to the diet of older children who eat more of certain types of foods than adults. A child's behavior and lifestyle also influence exposure. Children crawl on the floor, put things in their mouths, sometimes eat inappropriate things (such as dirt or paint chips), and spend more time outdoors. Children also are closer to the ground, and they do not use the judgment of adults to avoid hazards (NRC 1993).

Children are expected to be exposed to JP-5, JP-8, and Jet A fuels by the same routes that affect general population adults; however, barring an accidental spill near their residence, it is unlikely that children will be exposed to significant levels of these fuels as they are primarily used in the aviation industry and the highest exposure levels are expected to occur for workers and military personnel involved in aviation fueling procedures or the production of kerosene-based fuels. Children residing on or near military bases where JP-8 and JP-5 are used may experience a slightly higher level of exposure than children of the general population.

As mentioned in Section 3.7, Children's Susceptibility, exposure to kerosene via ingestion is one of the most common forms of acute childhood poisoning in many developing countries, since kerosene is used for cooking, heating, and lightning and is usually stored in containers and places easily accessible to children.

6.7 POPULATIONS WITH POTENTIALLY HIGH EXPOSURES

Military or civilian workers involved in fueling and defueling operations may be exposed to higher levels of JP-5, JP-8, and Jet A fuels than members of the general population (Air Force 1981a; Merchant-Borna et al. 2012; Tu et al. 2004). Maintenance workers who monitor jet fuel storage tanks may be exposed to components of these fuels via inhalation of jet fuel vapors. Maintenance workers may also be dermally exposed to jet fuels while sampling, gauging, and draining water (condensation) from fuel storage tanks (Chao et al. 2005; NIOSH 1989). The military also uses JP-8 in ground vehicles, generators, cooking stoves, and tent heater; workers involved in fueling and maintaining this equipment may also be exposed to higher levels. Workers in the petroleum industry may receive intermittent inhalation, oral, and dermal exposure to kerosene and jet fuels during the refining process. Exposure is most likely to occur during the distillation of crude oil, when monitoring and servicing of equipment are carried out, or when sampling must be done (Runion 1988). Use of a respirator, protective clothing, and increased ventilation can all reduce worker exposure to jet fuel vapor. The use of JP-8 rather than JP-4 reduces occupational exposure to jet fuel vapors for maintenance workers and pilots because the vapor pressure of JP-8 is an order of magnitude less than JP-4 at 38°C. This results in less vapor being vented from JP-8-fueled aircraft than JP-4-fueled aircraft (Air Force 1981a). The similarly low volatility of JP-5 suggests that reduced exposure to JP-5 vapors will also occur in aircraft fueled with JP-5.

6.8 ADEQUACY OF THE DATABASE

Section 104(i)(5) of CERCLA, as amended, directs the Administrator of ATSDR (in consultation with the Administrator of EPA and agencies and programs of the Public Health Service) to assess whether adequate information on the health effects of JP-5, JP-8, and Jet A fuels is available. Where adequate information is not available, ATSDR, in conjunction with NTP, is required to assure the initiation of a program of research designed to determine the health effects (and techniques for developing methods to determine such health effects) of JP-5, JP-8, and Jet A fuels.

The following categories of possible data needs have been identified by a joint team of scientists from ATSDR, NTP, and EPA. They are defined as substance-specific informational needs that if met would

reduce the uncertainties of human health assessment. This definition should not be interpreted to mean that all data needs discussed in this section must be filled. In the future, the identified data needs will be evaluated and prioritized, and a substance-specific research agenda will be proposed.

6.8.1 Identification of Data Needs

Physical and Chemical Properties.   The physical and chemical properties of JP-5 and JP-8 (kerosene) and their primary component chemicals are well defined and can be used to estimate the fate of these jet fuels following release to the environment (Air Force 1989b; IARC 1989). However, because jet fuels are complex mixtures of hydrocarbons, their environmental fate is determined by both the characteristics of the mixture and the individual components, making modeling based on physical and chemical properties difficult. Additional information on the identification of the compounds used as additives would be useful in assessing the environmental fate of jet fuels. Data needs associated with specific compounds that are components of JP-5 and JP-8 (e.g., benzene, toluene, xylene, and PAHs) are presented in the ATSDR toxicological profiles for these chemicals (ATSDR 1995, 2007a, 2007b, 2015b).

Production, Import/Export, Use, Release, and Disposal.   According to the Emergency Planning and Community Right-to-Know Act of 1986, 42 U.S.C. Section 11023, industries are required to submit substance release and off-site transfer information to the EPA. The TRI, which contains this information for 2011, became available in November of 2013. This database is updated yearly and should provide a list of industrial production facilities and emissions.

JP-5 and JP-8 are used primarily as military aviation fuels (Air Force 1989b; IARC 1989). Most releases of jet fuels are the result of in-flight jettisoning of fuel and spills either on land or water (Arthur et al. 1992; IARC 1989). Production, consumption, import, and export volumes are available for kerosene and jet fuels (EIA 2013c; EPA 2012a). Further information on the production volumes for each specific jet fuel, environmental releases, and disposal of jet fuels would aid in assessing the potential for human exposure as a result of accidental or intentional release.

Environmental Fate.   The environmental fate of JP-5, JP-8, and Jet A fuels is based on the environmental partitioning of the major hydrocarbon fractions. For aliphatic hydrocarbons, volatilization of lower molecular weight alkanes and sorption to organic matter for larger aliphatics, followed by biodegradation, are the primary degradation processes (Air Force 1982a; Cooney et al. 1985; Dean-Ross et al. 1992). Aromatic components are most susceptible to biodegradation in warm water or soil,

although some volatilization may occur in colder waters (Walker et al. 1976). Jet fuel contaminants that migrate through soil may contaminate groundwater. The deposition of aliphatics from the water column may persist for over a year (Oviatt et al. 1982). Jet fuel that spills or leaks into soil can migrate both vertically and horizontally (Air Force 1982a). JP-5, JP-8, and Jet A fuels jettisoned into the atmosphere probably contribute photochemically to the formation of ozone and particulates (Air Force 1981b, 1982b), and some of the fuel components and reactant products are probably transported via wind dispersion. Environmental fate data needs associated with specific compounds that are components of JP-5, JP-8, and Jet A fuels (e.g., benzene, toluene, xylene, and PAHs) are presented in the ATSDR toxicological profiles for these chemicals (ATSDR 1995, 2007a, 2007b, 2015b). Information on light- and chemical-mediated reactions of jet fuel components would aid in determining the fate of JP-5, JP-8, and Jet A fuels in soil and water. More information on the fate of individual components of these fuels under varying environmental conditions, including the interaction of JP-5, JP-8, and Jet A fuels with different soil types, would be helpful in determining any horizontal and vertical migration patterns of jet fuels in contaminated groundwater systems.

Bioavailability from Environmental Media. The extent of absorption of JP-5, JP-8, and Jet A fuels by inhalation, oral, and/or dermal routes is unknown. However, toxicity data are available for humans exposed to jet fuels and kerosene by each of these routes (Porter 1990; Subcommittee on Accidental Poisoning 1962). These data indicate that absorption does occur. The extent of absorption by these routes depends on the volatility, solubility, lipophilicity, and other properties of the specific jet fuel components. Several of these component compounds have been discussed in their individual ATSDR toxicological profiles (e.g., benzene, toluene, xylene, and PAHs), which should be consulted for further information (ATSDR 1995, 2007a, 2007b, 2015b). More data linking exposure levels of jet fuels with biological levels of component chemicals would be useful in determining which chemicals in the mixture are most likely to be absorbed and by which routes. This information would aid in determining daily human exposure levels and more accurately assessing the risks associated with exposure to jet fuels.

Food Chain Bioaccumulation. Data on the bioaccumulation of JP-8 in flagfish, rainbow trout, and golden shiners suggest that bioaccumulation and biomagnification are low (Klein and Jenkins 1983). Aquatic organisms are able to bioaccumulate some hydrocarbon fractions; however, depuration occurs if the source of the contamination is removed (Klein and Jenkins 1983). JP-5, JP-8, and Jet A fuels are expected to separate into their individual hydrocarbon components in the environment, and the bioaccumulation potentials of these components are believed to be independent of each other. Further studies are needed to determine the biomagnification potentials of these components up the food chain

within aquatic and terrestrial ecosystems. Specific research needs are presented in the individual ATSDR toxicological profiles on specific hydrocarbon components such as benzene, toluene, xylenes, and PAHs (ATSDR 1995, 2007a, 2007b, 2015b). Research on the biomagnification of jet fuels as actual mixtures would not be useful because they are not available to the food chain as mixtures.

Exposure Levels in Environmental Media.   Reliable monitoring data for the levels of JP-5, JP-8, and Jet A fuels in contaminated media at hazardous waste sites are needed so that the information obtained on levels of JP-5, JP-8, and Jet A fuels in the environment can be used in combination with the known body burden of JP-5, JP-8, and Jet A fuels to assess the potential risk of adverse health effects in populations living in the vicinity of hazardous waste sites.

There is limited information available on the levels of jet fuels found in air, soil, or water where jet fuels are used or stored. Some information exists on the levels of JP-8 in the air in closed buildings during refueling operations (Air Force 1981a). Very little information is available for JP-5, JP-8, and Jet A fuels concentrations in soil, water, and other environmental media (Arthur et al. 1992; Guiney et al. 1987a, 1987b; Navy 1988). More data on levels of jet fuels or their components in the environmental media around facilities where jet fuels are produced, stored, and used would be useful to assess the potential risk from these likely sources of exposure.

Reliable monitoring data for the levels of JP-5, JP-8, and Jet A fuels in contaminated media at hazardous waste sites are needed so that the information obtained on levels of these fuels in the environment can be used in combination with the known body burdens of JP-5, JP-8, and Jet A fuels to assess the potential risk of adverse health effects in populations living in the vicinity of hazardous waste sites.

Exposure Levels in Humans.   Populations known to have an increased risk of exposure to JP-5, JP-8, and Jet A fuels and their component hydrocarbons include: workers who manufacture or use the fuels; workers involved with monitoring and servicing jet fuel storage tanks; people living or working on military installations where military jet fuels are used or stored; and populations living or working near a spill, leak, or dump site (Air Force 1981a; NIOSH 1989; Runion 1988). Although there are studies assessing the exposure levels of these groups (Maule et al. 2013; Merchant-Borna et al. 2012; Tu et al. 2004), further information is needed to assess the continuing levels of exposure for these populations. This information is necessary for assessing the need to conduct health studies on these populations.

This information is necessary for assessing the need to conduct health studies on these populations.

Exposures of Children.   Unless an accidental spill occurs near their residence, it is unlikely that children will be exposed to JP-5, JP-8, and Jet A fuels since they are primarily used in the aviation industry and the highest exposure levels are expected to occur for workers and military personnel involved in aviation fueling procedures. Children residing on military bases where JP-8 and JP-5 are used may experience a slightly higher level of exposure than children of the general population.

Child health data needs relating to susceptibility are discussed in Section 3.12.2, Identification of Data Needs: Children's Susceptibility.

Exposure Registries.   No exposure registries for JP-5, JP-8, and Jet A fuels were located. This substance is not currently one of the compounds for which a sub-registry has been established in the National Exposure Registry. The substance will be considered in the future when chemical selection is made for sub-registries to be established. The information that is amassed in the National Exposure Registry facilitates the epidemiological research needed to assess adverse health outcomes that may be related to exposure to this substance.

6.8.2   Ongoing Studies

No ongoing environmental fate studies for JP-5, JP-8, and Jet A fuels were identified using the National Institutes of Health (NIH) RePORTER version 6.1.0 (NIH Research Portfolio Online Reporting Tools) or the Defense Technical Information Center (DTIC) online database.