Military Deployment
Periodic Occupational and Environmental Monitoring Summary (POEMS):
Camp Lemonnier, Djibouti: (2002 to 2014)

AUTHORITY: This Periodic Occupational and Environmental Monitoring Summary (POEMS) has been developed in accordance with Department of Defense (DOD) Instructions (DODI) 6490.03 and 6055.05, and Joint Staff memorandum MCM 0017-12, *See Section 11, References.*

PURPOSE: This POEMS documents the DOD assessment of occupational and environmental health (OEH) risk for Camp Lemonnier, Djibouti. It presents a qualitative summary of health risks identified at this location and their potential medical implications. The report is based on information collected from October 2002 through December 2014. This information includes OEH monitoring data.

This assessment assumes that environmental sampling at Camp Lemonnier during this period was performed at representative exposure points selected to characterize health risks at the *population–level*. Due to the nature of environmental sampling, the data upon which this report is based may not be fully representative of all the fluctuations in environmental quality or capture unique occurrences. While one might expect health risks pertaining to historic or future conditions at this site to be similar to those described in this report, the health risk assessment is limited to October 2002 through December 2014, unless stated otherwise in the discussions.

The POEMS can inform healthcare providers and others of environmental conditions experienced by individuals deployed to Camp Lemonnier during the period of this assessment; however, it does not represent an individual exposure profile. Individual exposures depend on many variables, including the duration, frequency, and location of the activities a person performs while working and/or spending time outside. Individual outdoor activities and associated routes of exposure are extremely variable and cannot be identified from or during environmental sampling. Individuals who sought medical treatment related to potential OEH exposures while deployed should have exposure/treatment noted in their medical record on a Standard Form (SF) 600 (Chronological Record of Medical Care).

Health protective exposure assumptions are used in assessing all health risks. For example, individuals are assumed to be constantly exposed (24 hours/day, 7 days/week) to the environmental conditions measured. Small groups of personnel assigned to Camp Lemonnier may be at greater risk than the general population due to operational requirements; these groups are identified when appropriate.

SITE DESCRIPTION: Camp Lemonnier is located in the Republic of Djibouti, where it serves as the primary base of operation for U.S. Africa Command forces in the Horn of Africa. Djibouti, with an area of 8,900 square miles, is located in eastern Africa, bordering the Gulf of Aden and the Red Sea, between Eritrea and Somalia. Djibouti is strategically located near one of the world's busiest shipping lanes and close to the Arabian oilfields. Most of Djibouti's countryside is desert coastal plain and plateau, separated by central mountains. Camp Lemonnier is located within the capital of Djibouti, Djibouti City, on the southern side of Djibouti-Ambouli International Airport, which serves as both a military and civilian airfield.

The U.S. military acquired the camp in 2002 and has continuously expanded the facility since then to accommodate increased troop strength and operations. In July 2006, operational control of Camp Lemonnier transitioned from the U.S. Marine Corps to the U.S. Navy. The camp is home to the Combined Joint Task Force-Horn of Africa (CJTF-HOA). The Seth Michaud Emergency Medical and Dental Facility at Camp Lemonnier provides medical services to service members supporting the CJTF-HOA mission. Between 2004 and 2014, Camp Lemonnier expanded from approximately 88 acres to over 500 acres. During that time, the base developed from an expeditionary camp to a long-term facility with living accommodations, transitioning from tents to air-conditioned Containerized Living Units (CLUs); the camp population expanded from several hundred to several thousand. Camp Lemonnier currently hosts U.S. personnel from all service branches and also utilizes workers from Djibouti and

other countries. Military personnel typically serve a six-month deployment at the camp, with the exception of U.S. Army personnel and the senior leadership, who serve a year-long deployment.

Facilities maintenance is provided by a Base Operations Services (BOS) contractor. BOS provide food services, vehicle maintenance, laundry, janitorial service, water treatment, solid waste disposal, and other services. BOS contract personnel include local nationals, third country nationals, and U.S. civilians. Health screening is required for these contract personnel prior to assignment to the camp.

Djibouti has a desert climate with hot and very dry weather conditions for most of the year. The average temperatures in the summer range from 85 to 107°F (July); winter temperatures range from 70 to 83°F (January). Temperatures above 110°F are common, especially in summer months. The rainy season is typically from October through April; the average total annual rainfall for Djibouti is only about six inches per year. The soil percolates poorly, causing water to pool at the surface during rain events. Standing water typically remains until it evaporates, which can disrupt camp operations.

SUMMARY: Conditions that may pose a moderate or greater health risk are summarized in Table 1. Table 2 provides population-based risk estimates for identified OEH conditions at Camp Lemonnier. As indicated in the detailed sections that follow Table 2, established controls that reduce health risk have been factored into this assessment. In some cases (e.g., ambient air) specific controls are noted, but not routinely available/feasible.

Table 1: Summary of Occupational and Environmental Conditions with Moderate or Greater Health Risk

Short-term health risks and medical implications:

The following may have caused acute health effects in some individuals ***during deployment*** at Camp Lemonnier.

Inhalation of dust: Coarse particulate matter less than 10 micrometers in diameter (PM_{10}) and fine particulate matter less than 2.5 micrometers in diameter ($PM_{2.5}$) are routinely present in the air at higher concentrations than would typically be experienced in the United States. Inhaling airborne dust associated with the dry climate, and smoke from burning trash, may have resulted in mild to more serious short-term health effects (e.g., eye, nose, throat, and lung irritation, coughing, sneezing, runny nose, and shortness of breath). Some individuals may have sought treatment for acute respiratory irritation during their time at Camp Lemonnier. Individuals who sought medical treatment for these symptoms while deployed should have exposure/treatment noted in their medical record.

Diesel Exhaust: Diesel exhaust is a complex mixture of gases, including oxides of nitrogen (NO and NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2), ozone, and diesel particulate matter. The particulate matter is composed of a solid core of elemental carbon with other substances, such as inorganic carbon, metals ash, sulfates, and silicates, attached to the surface. Short-term exposures to high concentrations of diesel exhaust can cause headache, dizziness, and irritation of the eyes, nose, and throat. It is possible that camp residents who worked near the sampled areas during the periods of moderate risk could have experienced some of these effects. Symptoms associated with short duration exposure to diesel exhaust would be expected to resolve after exposures ceased.

Heat illness: The short-term health risk of heat illness for unacclimated individuals and those with underlying health conditions is **moderate**. For all other individuals the risk is **low**.

Long-term health risks and medical implications:

The following may be associated with long-term health effects in some individuals who deployed to Camp Lemonnier**.**

Inhalation of dust: The inhalation of fine particulate matter ($PM_{2.5}$) poses a potential long-term health risk to individuals deployed to Camp Lemonnier. Individuals who routinely worked outdoors and inhaled $PM_{2.5}$ at levels present at the camp may develop health conditions such as chronic bronchitis, reduced lung function, and asthma. Individuals with a history of asthma or pre-existing cardiopulmonary disease are likely at greatest risk. At this time, there are no specific recommended post-deployment medical surveillance evaluations for individuals with particulate exposures. Providers should consider health status (e.g., any underlying conditions/susceptibilities) and unique OEH exposures (such as welding fumes and burn pit smoke) when addressing individual concerns. Although short-term effects from exposure to dust should have resolved post-deployment, providers should be prepared to consider the relationship between potential deployment exposures and current complaints.

Environmental Noise: Camp Lemonnier has a narrow footprint and all working and living areas are close to noise sources. The standard work shift at Camp Lemonnier is 12 hours and personnel spend much of their off-work hours within 100 to 150 yards of the flight-line and the generator stations, which are the main noise sources. As a result, Camp Lemonnier personnel may not consistently attain the full recovery period after noise exposure. It is likely that some individuals continuously exposed to environmental noise at the levels present at Camp Lemonnier would have experienced health effects such as headache, annoyance, fatigue, and possible hearing threshold shifts (temporary to permanent).

Acrolein: Incomplete fuel combustion is the primary source of acrolein release into the atmosphere. acrolein has a very disagreeable odor and breaks down rapidly in the air by reacting with other chemicals and sunlight. The major health effects of chronic inhalation exposure to acrolein in humans consist of general respiratory congestion and eye, nose, and throat irritation. It is likely that some camp residents sought medical treatment for such conditions while deployed. These symptoms are similar to those related to other environmental stressors present at Camp Lemonnier (e.g., dust and diesel exhaust), as well as to upper respiratory infections and allergies; thus it is impossible to directly link them to acrolein exposures.

Table 2: Population-Based Health Risk Estimates – Camp Lemonnier, Djibouti, Africa[1,2]

Source of Identified Health Risk[3]	Unmitigated Health Risk Estimate[4]	Control Measures Implemented[5]	Residual Health Risk Estimate[4]
Air			
Particulate matter less than 10 microns in diameter (PM_{10}) *(see paragraph 2.3)*	Short-term: **Low** to **moderate.** Daily levels vary. Acute health effects (e.g., eye and/or upper respiratory tract irritation) may be more pronounced during peak exposure days. More serious effects were possible in susceptible persons (e.g., those with asthma/existing respiratory diseases).	Air-conditioned living and working spaces provided For those not working in air conditioned spaces, time outdoors is minimized and doors or tent flaps remain closed. Water used for dust control on unpaved roads and work areas.	Short-term: **Low** overall but there were at least four periods during which health risk was elevated to **moderate.**
	Long-term: **No available health guidelines.**		Long-term: **No available health guidelines.**
Particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) *(see paragraph 2.4)*	Short-term: **Low.** Mild acute (short-term) health effects such as eye, nose, or throat irritation are likely in individuals who spent much of their time outdoors. Existing medical conditions (e.g., asthma or respiratory diseases) may be exacerbated.	Air-conditioned living and working spaces provided For those not working in air conditioned spaces, time outdoors is minimized and doors or tent flaps remain closed. Water used for dust control on unpaved roads and work areas.	Short-term: **Low**
	Long-term: **Low to moderate.** Repeated exposures to airborne concentrations of $PM_{2.5}$ that carry a low to moderate long-term health risk may still increase the possibility for development of chronic health conditions in some troops. These conditions include reduced lung function, chronic bronchitis, chronic obstructive pulmonary disease (COPD), asthma, and other cardiopulmonary diseases. Those with a history of asthma or pre-existing cardiopulmonary disease have a higher risk for developing these chronic conditions.		Long-term: **Low to Moderate.**
Airborne metals *(see paragraph 2.5)*	Short-term: **None identified.** Long-term: **None identified.**	Air-conditioned living and working spaces provided For those not working in air conditioned spaces, time outdoors is minimized and keeping doors or tent flaps closed. Water used for dust control on unpaved roads and work areas.	Short-term: **None identified.** Long-term: **None identified.**

Table 2: Population-Based Health Risk Estimates – Camp Lemonnier, Djibouti, Africa[1,2]

Source of Identified Health Risk[3]	Unmitigated Health Risk Estimate[4]	Control Measures Implemented[5]	Residual Health Risk Estimate[4]
Volatile organic compounds (VOCs) *(see paragraph 2.6)*	Short-Term: **Low.** The only VOC detected above military exposure guidelines was acrolein. Acrolein is a by-product of combustion. Concentrations of acrolein were well below the threshold concentrations known to cause health effects in humans. Long-term: **Moderate.** Acrolein concentrations exceeded long-term military exposure guidelines in 59% of samples. The major effects of chronic inhalation exposure to acrolein in humans consist of general respiratory congestion and eye, nose, and throat irritation.	Open pit burning avoided or burn pits located to minimize impacts to population centers. Living and working areas located away from roadways, runways and other fuel combustion sources when possible.	Short-term: **Low.** Long-term: **Moderate.**
Semi-volatile organic compounds *(see paragraph 2.7)*	Short-term: **None Identified.** Long-term: **None Identified.**	Avoid open pit burning or use controlled burning. Locate living and working areas away from roadways, runways and other fuel combustion sources	Short-term: **None identified.** Long-term: **None identified.**
Diesel exhaust *(see paragraph 2.8)*	Short-term: **Low** to **moderate**. Long-term: **Not evaluated**. There is insufficient data upon which to base a long-term risk assessment.	Living and working areas located away from roadways, runways, and generators when possible.	Short-term: **Low** to **moderate**. Long-term: **Not evaluated**. There is insufficient data upon which to base a long-term risk assessment.
Soil			
Soil exposures *(see paragraph 3)*	Short-term: **Not evaluated**. Short-term soil exposures do not typically pose a health risk. Consequently, no exposure guidelines exist. Long-term: **None Identified.**	Keep sleeves rolled down to limit skin contact. Wash hands frequently especially before eating. Shower after soil exposure to remove soil from skin.	Short-term: Not evaluated Long-term: **None identified.**
Water			
Water used for other purposes *(See paragraph 4.2)*	Short-term: **Low.** Long-term: **Low.**	Water treated by reverse osmosis. Active and ongoing drinking water surveillance program implemented.	Short-term: **Low.** Long-term: **Low.**

Table 2: Population-Based Health Risk Estimates – Camp Lemonnier, Djibouti, Africa[1,2]			
Source of Identified Health Risk[3]	**Unmitigated Health Risk Estimate[4]**	**Control Measures Implemented[5]**	**Residual Health Risk Estimate[4]**
Consumed water (water used for drinking) *(See paragraph 4.3)*	Short-term: **Low.** Bottled Water: The only analytes detected above military exposure guidelines (MEGs) were antimony, lead, and boron. Antimony and lead were detected in two separate bottled water samples in June and December 2005. Boron has also been sporadically detected in bottled water between 2005 and 2007 at levels that posed a low risk**.**	Source of U.S. Army Veterinary Command-approved water sources now limited to two vendors. Active and ongoing drinking water surveillance program implemented.	Short-term: **Low.**
	Long-term: **Low.** Bottled Water: Antimony and lead were detected in two separate bottled water samples in June and December 2005. Boron has also been sporadically detected in bottled water between 2005 and 2007 at levels that posed a low risk**.**		Long-term: **Low.**
Military Unique			
Ionizing radiation *See paragraph 5.3)*	Short-term: **Low.** Long-term: **Low.**	Applied principles of time, distance, and shielding. Medical/dental x-ray technicians enrolled in a radiation dosimetry program.	Short-term: **Low.** Long-term: **Low.**
Endemic Disease			
Gastrointestinal diseases *(See paragraph 6.2)*	Short-term: **Moderate.** Health effects of ingesting unapproved local food/water can temporarily incapacitate personnel (e.g., diarrhea) or result in prolonged illness (e.g., hepatitis A, typhoid fever, brucellosis, hepatitis E). Viral gastroenteritis can present at any time due to a high rate of personnel turnover, shared dining, berthing, bathroom facilities, and working spaces.	Standard preventive medicine measures: Immunizations (e.g., hepatitis A, typhoid fever), consuming food and water from approved sources, and habitability inspections to ensure cleanliness/sanitation.	Short-term: **Low.** Based on disease incident reporting from Camp Lemonnier, bacterial, protozoal, cholera, brucellosis, and hepatitis E infections present a low risk.
	Long-term: **Low**. The majority of gastrointestinal diseases do not cause prolonged illness.		Long-term: **Low** based on disease incident reporting from Camp Lemonnier.

Table 2: Population-Based Health Risk Estimates – Camp Lemonnier, Djibouti, Africa[1,2]

Source of Identified Health Risk[3]	Unmitigated Health Risk Estimate[4]	Control Measures Implemented[5]	Residual Health Risk Estimate[4]
Arthropod vector-borne diseases *(See paragraph 6.3)*	Short-term: **Moderate.** Vectors present in Djibouti (mosquitoes and sand flies) are capable of transmitting dengue fever, malaria, leishmaniasis, chikungunya, sandfly fever, West Nile fever, Crimean-Congo hemorrhagic fever, rickettsioses (tick-borne, spotted fever group), Rift Valley fever, and o'nyong-nyong. Risk for malaria is lower in the Djibouti City area.	Standard preventive medicine measures: Properly wear insecticide-treated uniforms and apply insect repellent to the skin, chemoprophylaxis in accordance with combatant command (COCOM) policy (e.g., malaria), and remove vector harborages within the camp.	Short-term: **Low** based on disease incident reporting from Camp Lemonnier.
	Long-term: **Low**. It is possible to be infected during deployment with leishmaniasis and not have clinically evident disease until redeployed.		Long-term: **Low** based on disease incident reporting from Camp Lemonnier.
Water contact diseases *(See paragraph 6.4)*	Short-term: **Low**. Flooding after heavy rainfall facilitates the spread of leptospirosis already present in the soil. Standing bodies of fresh water may support the snail vector for schistosomiasis.	Avoid fresh water sources, such as puddles/standing water, drainage areas, etc.	Short-term: **Low** based on disease incident reporting from Camp Lemonnier.
	Long-term: **Low** based on disease incident reporting from Camp Lemonnier.		Long-term: **Low** based on disease incident reporting from Camp Lemonnier.
Respiratory diseases *(See paragraph 6.5)*	Short-term: **Moderate**. The high rate of personnel turnover, shared dining, berthing, recreational facilities, and working spaces allow for the easy transmission of upper respiratory infections or influenza.	Influenza immunizations are given either before or during deployment. Local and third country national workers/contractors are required to complete health screening prior to employment. Potential tuberculosis exposure is addressed in the Post Deployment Health Assessment.	Short-term: **Low** for upper respiratory infections.
	Long-term: **Low.** The majority of respiratory diseases do not cause prolonged illness.		Long-term: **Low** based on disease incident reporting from Camp Lemonnier.
Animal contact diseases *(See paragraph 6.6)*	Short-term: **Low.** Exposures to animals and/or locations where animals are kept (barnyards, slaughterhouses) are the primary infection sources for anthrax, Q-fever, and rabies.	Standard preventive medicine measures, as well as COCOM policy, generally prohibit contact with, adoption, or feeding of feral animals. Immunizations for anthrax and rabies (rabies vaccination and/or immune globulin given if clinically directed).	Short-term: **Low** based on disease incident reporting from Camp Lemonnier.
	Long-term: **Low** based on disease incident reporting from Camp Lemonnier.		Long-term: **Low** based on disease incident reporting from Camp Lemonnier.
Venomous Animal/Insects			
Snakes, scorpions, and spiders *(See paragraph 7)*	Short-term: **Low.** If encountered, effects of venom vary with species from mild localized swelling (e.g., scorpion species) to potentially lethal (e.g., saw-scaled viper).	Standard preventive medicine measures, such as reducing harborages for these animals, as well as education on how to avoid them ("shake out boots before donning," etc.), reduce the risk of exposure.	Short-term: **Low.**

Table 2: Population-Based Health Risk Estimates – Camp Lemonnier, Djibouti, Africa[1,2]			
Source of Identified Health Risk[3]	**Unmitigated Health Risk Estimate[4]**	**Control Measures Implemented[5]**	**Residual Health Risk Estimate[4]**
	Long-term: **None identified**.		Long-term: **None identified.**
Heat/Cold Stress			
Heat *(See paragraph 8)*	Short-term: **Moderate.** Moderate risk of heat illness in summer months for unacclimated personnel.	Adequate periods of acclimation for newly reporting personnel. Work-rest cycles are adjusted based on monitoring - climatic conditions.	Short-term: **Low.**
	Long-term: **Low.**		Long-term: **Low.**
Noise *(See paragraph 9)*	Short-term: **Low**.	Hearing protection is readily available and used. Noise hazard areas and equipment are labeled.	Short-Term: **Low.**
	Long-term**: Moderate** for both occupational noise and environmental noise exposures		Long-term: **Low** for occupational noise, **moderate** for environmental noise
Unique Concerns			
La Douda Dump (airborne risks)	Short-term: **Low.** Smoke may cause irritation of the eyes, nose, and throat. No additional short-term health risk was identified above that associated with ambient air. The primary short-term risk driver for the air exposure pathway is dust (PM_{10} and $PM_{2.5}$).	Most personnel live and work in air-conditioned CLUs, buildings, or tents. Tent flaps, doors, and windows are typically closed to maximize the efficiency of the air conditioning.	Short-term: **Low.**
	Long-term: **Low.** While no long-term health risks have yet been identified in populations exposed to smoke associated with refuse burning, it is possible that a small number of individuals may experience long-term health effects. Specific factors that may increase risk include combined exposures (such as dust, industrial pollutants, and tobacco smoke) and individual susceptibilities, such as pre-existing health conditions or genetic factors.		Long-term: **Low.**

Table 2: Population-Based Health Risk Estimates – Camp Lemonnier, Djibouti, Africa[1,2]

Footnotes:

[1] Table 2 provides a qualitative estimate of population-based short- and long-term health risks associated with the occupational environment conditions at Camp Lemonnier. It does not represent an individual exposure profile. Actual individual exposures and health effects depend on many variables. For example, while a chemical may be present in the environment, if a person does not inhale, ingest, or contact a specific dose of the chemical for adequate duration and frequency, then there may be no health risk. Alternatively, a person at a specific location may experience a unique exposure, such as at the burn pit, which could result in a significant individual exposure. Any such person seeking medical care should have their specific conditions of exposure documented on Standard Form (SF) 600.

[2] This assessment is based on specific environmental sampling data and reports obtained from October 2002 through December 2014. Sampling locations are assumed to be representative of exposure points for the camp population but may not reflect all the fluctuations in environmental quality or capture unique exposure incidents.

[3] Table 2 is organized by major categories of identified sources of health risk. It only lists those sub-categories specifically identified and addressed at Camp Lemonnier. The health risks are presented as Low, Moderate, High, or Extremely High for both acute and chronic health effects. The risk level is based on an assessment of both the potential severity of the health effects that could be caused and probability that exposure would occur at a level to produce such health effects. Details can be obtained from the Navy and Marine Corps Public Health Center (NMCPHC). When no risk of either a specific acute or chronic health effects were determined, sources were excluded. More detailed descriptions of OEH exposures that were evaluated but determined to pose no health risk are discussed in the following sections of this report.

[4] Risks in Table 2 are based on quantitative surveillance thresholds (e.g., review of disease surveillance data) or screening levels (e.g., Military Exposure Guidelines (MEGs) for chemicals). Some previous assessment reports may provide slightly inconsistent risk estimates because quantitative criteria such as MEGs may have changed since the samples were originally evaluated and/or because this assessment makes use of all historic site data while previous reports may have only been based on a few samples.

[5] All OEH risk estimates represent residual risk after accounting for preventive controls in place. Occupational exposures and exposures to endemic diseases are greatly reduced by preventive measures in place. For environmental exposures related to airborne dust, there are limited preventive measures available and available measures have little efficacy in reducing exposure to ambient conditions.

1 Discussion of Health Risks at Camp Lemonnier, Djibouti, by Source

The following sections provide additional information about the OEH conditions summarized above. All risk assessments were performed using the methodology described in the U.S. Army Public Health Command Technical Guide 230, *Environmental Health Risk Assessment and Chemical Exposure Guidelines for Deployed Military Personnel* (USAPHC TG230). All OEH risk estimates represent residual risk after accounting for preventive controls in place. Occupational exposures and exposures to endemic diseases are greatly reduced by having preventive measures in place. For environmental exposures related to airborne dust, there are limited preventive measures available, and those that are have little efficacy in reducing exposure to ambient conditions.

2 Air

2.1 Site-Specific Sources Identified

The combination of multiple air pollution sources, climatic conditions, and topographic features contribute to air quality degradation at Camp Lemonnier.

- Djibouti's hot, dry climate results in very dusty conditions throughout the year. During the months of June to September, gusting winds, called Khamsin winds, pick up dust from the surrounding deserts. These hot, dry winds persist for 3 to 4 days at a time, gusting from the west at an average of 13 knots with peak gusts as high as 50 knots, contributing even more airborne dust than is typically present.
- Smoke plumes from burning garbage at the La Douda Dump regularly impact Camp Lemonnier. The dump is situated approximately 1.2 miles from the southern boundary of the camp. When winds shift from onshore to offshore at night, there are brief periods when Camp Lemonnier is downwind from the dump. These downwind periods are typically of short duration, lasting from two to four hours. The smell of burning refuse waste is clearly noticeable during these periods. The site of the camp's CLUs can be particularly impacted during temperature inversions, which occur frequently from October to March.
- Djibouti is an underdeveloped country, lacking clean, reliable, power generating systems. As a result, the biomass fuels (crop residues, dung, straw, and wood) are commonly used for cooking. Biomass fuels release respirable particles, carbon monoxide, and nitrogen oxides into the air, contributing significantly to air pollution.
- Vehicle emissions are another major contributor to the air pollution in Djibouti City, which has a population of over 650,000 people. Most of these vehicles are over 10 years old and generally use substandard fuels, which further contributes to air pollution.
- Although Djibouti lacks extensive industrial pollution sources, brick factories are known to burn tire rubber, plastic waste, and other combustibles as cheap energy sources.
- Emissions from military operations also degrade the ambient air quality. Camp Lemonnier has two solid waste incinerators that operate 12 hours/day processing up-to 20 tons of waste daily. Camp Lemonnier also operates a power plant capable of powering 4000 residential homes. The power plant and two incinerators combined consume 600 to 1,000 liters of diesel/JP-8 fuel daily. In addition to the power plant, as many as 160 portable power generators have been or remain in use site-wide at Camp Lemonnier. The numerous military vehicles and aircraft operations on the site also contribute air pollutants.

2.2 Particulate Matter

Particulate matter (PM) is a complex mixture of extremely small particles suspended in the air. Particulate matter includes solid particles and liquid droplets emitted directly into the air by sources such as power plants, motor vehicles, aircraft, generators, construction activities, fires, and natural windblown dust. Particulate matter can include sand, soil, metals, volatile organic compounds, allergens, and other compounds, such as nitrates or sulfates that are formed by condensation or transformation of combustion exhaust. Particulate matter composition and particle size vary considerably depending on the source. Generally PM of health concern is divided into two fractions—PM_{10}, which includes coarse particles with a diameter of 10 micrometers or less (0.0004 inches or one-seventh the width of a human hair), and fine particles less than 2.5 micron ($PM_{2.5}$), which can reach the deepest regions of the lungs when inhaled. Exposure to excessive PM is linked to a variety of potential health effects.

2.3 Particulate Matter, less than 10 microns

2.3.1 Exposure Guidelines

Short-term (24-hour) PM_{10} (mg/m^3):

- Negligible MEG = 0.250
- Marginal MEG = 0.420
- Critical MEG = 0.600

Long-term PM_{10} MEG (mg/m^3):

- Not defined and not available.

2.3.2 Sample Data/Notes

From October 2002 to December 2012, 416 ambient 24-hour air PM_{10} samples were collected at Camp Lemonnier. Particulate matter sampling was discontinued after 2012 as sufficient data were judged to be available to fully characterize the potential health risk associated with PM exposures at Camp Lemonnier. Results of analysis indicate that the airborne PM_{10} concentrations are routinely much higher than one would encounter in the United States. Data indicate that PM_{10} levels typically peak from June through September annually. This is consistent with summer conditions in Djibouti, when hot, gusty winds pick up sand and soil from the surrounding desert.

2.3.3 Short-term (Acute) Health Risk

Approach: To assess acute risk associated with PM_{10}, the highest concentration detected during each calendar quarter—commonly referred to as the quarterly peak concentration—was used to arrive at acute risk estimates for Camp Lemonnier. Peak concentrations ranged from a low of 0.1132 mg/m^3 to a high of 1.3 mg/m^3. The risk estimate for the highest peak concentration is calculated first. If that risk is low, no further calculations are needed, as the acute risk for all periods is low. If the highest peak concentration yields a risk of moderate or higher, additional calculations are repeated on the next highest peaks until the risk characterization changes (e.g., risk changes from moderate to low).

Risk Summary: Overall, the acute risk associated with PM_{10} exposure at the concentrations found at Camp Lemonnier is **low**. There were, however, four excursion periods during which acute health risk was elevated to **moderate** for a minimum of twenty-four hours. Those excursions occurred on 6–9 June 2004, 25–26 July 2005, 18 September 2007, and 29 June 2010. Though PM_{10} data collection was sporadic prior to 2004 and discontinued in 2012, the pattern of PM_{10} elevation seen in the existing data suggest that there were other periods during which health risk was elevated. Based on available data, these other periods of elevated health risk were likely infrequent and of short duration.

Medical Implications: At the **low** risk level, a small number of individuals may experience eye, nose, and throat irritation and seek medical attention. In most of these individuals, the symptoms are mild and

temporary, requiring no medical treatment. During periods of **moderate** risk, more individuals may be affected and the severity of symptoms increased. It is likely that some individuals who were outside extensively during the periods of elevated health risk sought treatment for acute upper respiratory tract irritation. Individuals who sought medical treatment for those symptoms should have exposure/treatment noted in their medical record. Symptoms associated with exposure to PM_{10} would be expected to resolve after exposures ceased. Health effects in persons with pre-existing health conditions (e.g., asthma, or cardiopulmonary diseases) may be exacerbated, especially during the relatively brief periods when airborne dust levels were high enough to elevate health risk.

Confidence in the Risk Assessment: Based on the availability of data, confidence in this risk assessment is high.

2.3.4 Long-term (Chronic) Health Risk

Health Guidelines not Defined for PM_{10}. The U.S. Environmental Protection Agency (EPA) has retracted its long-term standard (National Ambient Air Quality Standards [NAAQS]) for PM_{10} due to an inability to clearly link chronic health effects with PM_{10} exposures.
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2.4 Particulate Matter, less than 2.5 microns

2.4.1 Exposure Guidelines

Short-term (24-hour) $PM_{2.5}$ MEGs (mg/m^3):

- Negligible MEG = 0.065
- Marginal MEG = 0.250
- Critical MEG = 0.500

Long-term (1-year) $PM_{2.5}$ MEGs (mg/m^3):

- Negligible MEG = 0.015
- Marginal MEG = 0.065.

2.4.2 Sample Data/Notes

Sampling for $PM_{2.5}$ started at Camp Lemonnier in the fourth calendar quarter of 2007. From October 2007 to December 2012, 294 ambient 24-hour air samples were collected for $PM_{2.5}$. Particulate matter sampling was discontinued at Camp Lemonnier after 2012 as sufficient data were judged to be available to fully characterize the potential health risk associated with PM exposures at the camp. During data collection, approximately 91% (267 of 294 samples) results exceeded the 1-year Negligible MEG for $PM_{2.5}$. Similar to PM_{10}, peak levels of $PM_{2.5}$ typically occur annually from June to September.

2.4.3 Short-term (Acute) Health Risk

Approach: To assess acute risk associated with $PM_{2.5}$, quarterly peak concentrations of $PM_{2.5}$ from October 2007 to December 2012 were used. Quarterly peak concentrations detected during this period ranged from .0322 mg/m^3 to .4696 mg/m^3. Health risk associated with the highest peak concentration is calculated first. If the health risk associated with that concentration is low, no further calculations are done, as the acute risk for all periods is low. If the highest peak concentration yielded a risk of moderate or greater, additional calculations are repeated on the next highest peaks until the risk characterization changed (e.g., the risk estimate changed from moderate to low).

Risk Summary: The acute health risk associated with $PM_{2.5}$ exposure at the concentrations found at Camp Lemonnier is **low**.

Medical Implications: At ambient dust concentrations resulting in a **low** to **moderate** acute health risk, a small percentage of individuals may experience health effects such as eye, nose, throat and lung irritation, including coughing, sneezing, runny nose, and shortness of breath. Some individuals might

seek outpatient medical care, although most individuals would experience only mild effects at these levels of exposure. Symptoms would typically resolve when exposure ceases. A small number of individuals may experience more pronounced effects such as decreased lung function and worsening of pre-existing medical conditions such as asthma. These more pronounced effects are unlikely from a single, short-term period of exposure.

Confidence in the Risk Assessment: Although sampling locations were representative of population exposure points, no $PM_{2.5}$ data exists for Camp Lemonnier prior to October of 2007. As a result, the confidence in this risk assessment is medium.

2.4.4 Long-term (Chronic) Health Risk

Approach: For chronic health risk, it was assumed that the longest deployment lasted 12 months and that camp residents were exposed to the same levels of dust 24 hours per day over the full term of their deployment. Thus the exposure assumptions employed likely represent a worst-case exposure scenario. To assess chronic health risk associated with $PM_{2.5}$, annual average concentrations for $PM_{2.5}$ were calculated for each 12-month period from September 2008 through December 2012. The average of the 15 samples collected during the fourth quarter of 2007 was also used for chronic health risk estimation, although the use of this limited data may result in over- or underestimating the chronic health risk during 2007. Health risk associated with the highest annual average concentration is calculated first. If that health risk estimate is low, no further calculations are needed, as the chronic health risk for all years is low. If the highest annual average concentration yielded a health risk estimate of moderate or higher, additional calculations are repeated on the next highest annual averages until the risk characterization changes (e.g., the risk estimate changes from moderate to low). Annual average $PM_{2.5}$ concentrations for October 2007 through December 2012 ranged from 0.041 mg/m^3 to 0.096 mg/m^3.

Risk Summary: The chronic health risk associated with $PM_{2.5}$ exposure for the vast majority of personnel at Camp Lemonnier is **low**. Individuals who worked extensively outdoors during 2008–2010 (e.g., construction crews, sentries) are at **moderate** risk. Overall, the average $PM_{2.5}$ concentrations were reasonably similar from year to year, with the highest average concentration only slightly more than two times the lowest average concentration. Given the relative consistency of the data over the six years of sample collection, it is reasonable to infer that health risks associated with $PM_{2.5}$ for periods before data collection began and after collection ceased are similar to that for 2007–2012.

Medical Implications: Repeated, long-term exposure to the airborne concentrations of $PM_{2.5}$ that are routinely present at Camp Lemonnier may increase the probability of chronic health conditions in generally healthy troops over their lifetime. These conditions include reduced lung function, chronic bronchitis, chronic obstructive pulmonary disease (COPD), asthma, and certain cardiopulmonary diseases. For those with a history of asthma or pre-existing cardiopulmonary disease, there is higher risk for exacerbating those pre-existing conditions.

Confidence in the Risk Assessment: Confidence in the overall risk assessment associated with potential $PM_{2.5}$ exposures is medium. Although $PM_{2.5}$ exist only from the fourth calendar quarter of 2007 through the end of 2012, five full years of data collected through full climatic cycles exist; thus it is highly probable that existing data have successfully characterized the range of potential exposures.
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2.5 Airborne Metals

2.5.1 Sample Data/Notes

From October 2002 to December 2012, metals analysis was performed on 698 ambient air samples collected at Camp Lemonnier. None of the metals were detected above their corresponding MEGs published in USAPHC TG230.

2.5.2 Short-term (Acute) Health Risk

Approach: For screening purposes, all airborne metals detected from particulate matter sampling were compared to their corresponding 1-year Negligible MEGs. Metals without a single detection above that MEG were removed from further consideration. None of the metals detected from particulate matter sampling exceeded their respective 1-year Negligible MEGs.

Risk Summary: Airborne metals are not a source of acute health risk based on available data.

Medical Implications: None expected.

Confidence in the Risk Assessment: Based on the available data, confidence in this risk assessment is high.

2.5.3 Long-term (Chronic) Health Risk

Approach: Annual average concentrations of airborne metals detected are used to assess the long-term risk associated with potential long-term exposures. When calculating the average concentration, a surrogate value of half the laboratory limit of quantitation for that metal is used for each sample where the specific metal is not detected. For screening purposes, however, all airborne metals detected are first compared to their corresponding 1-year Negligible MEGs. Metals without a single detection above that MEG are removed from further consideration. None of the metals detected from particulate matter sampling exceeded their respective 1-year Negligible MEGs.

Risk Summary: Airborne metals are not a source of chronic health risk based on available data.

Medical Implications: None expected.

Confidence in the Risk Assessment: Based on the available data, confidence in this risk assessment is high.

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2.6 Volatile Organic Compounds

Volatile organic compounds (VOCs) are carbon-based chemicals that easily evaporate under normal atmospheric conditions. They can be naturally occurring or man-made. Man-made VOCs are emitted by a wide array of products that number in the thousands. Examples include paints and lacquers, paint strippers, industrial solvents, household cleaners, pesticides, building materials and furnishings, fuels and fuel combustion, and cigarette smoke. Most of the VOCs detected at Camp Lemonnier are associated with fuels and/or fuel combustion.

There are several sources of ambient VOCs at Camp Lemonnier, including motor vehicles, commercial and military flight operations, onsite electric power generation, refuse incineration, waste water treatment, fuel storage and transfer, routine maintenance operations, and offsite open burning of refuse and vegetation.

2.6.1 Sample Data/Notes

From October 2002 to December 2014, a total of 93 air samples were collected for VOC analysis. Two different methods were employed for VOC sampling at Camp Lemonnier, TO-17 and TO-14. The two methods have a slightly different suite of target analytes. Between the two methods, the laboratory can perform analysis for approximately 100 different VOC compounds. TO-14 sampling was accomplished in 2004, 2005, 2007, 2009, 2013, and 2014 (12, 4, 2, 9, 26, and 15 samples, respectively). TO-17 sampling was accomplished in 2013 (25 samples).

2.6.2 Short-term (Acute) Health Risk

Approach: For screening purposes, all compounds detected were first compared to their corresponding 1-year Negligible MEGs. Compounds without a single detection above that MEG were removed from further consideration. Only acrolein was present at concentrations above its 1-year Negligible MEG value of 0.00014 mg/m^3. Acrolein was detected at concentrations greater than its 1-year Negligible MEG in 40 of 68 (59%) of TO-14 samples (acrolein is not a TO-17 analyte). Overall, concentrations of acrolein ranged from none detected to 0.0094 mg/m^3 with an average concentration of approximately 0.0009 mg/m^3. The peak concentration of acrolein for each sampling event in 2004–2014 was used to assess the short-term health risk associated with potential acrolein exposures. Risk estimates for the highest peak were calculated first. As with other airborne compounds, if the highest peak concentration yielded a risk estimate of low, no further calculations were deemed necessary.

Risk Summary: Based on the available data, the short term health risk is **low**. Although acrolein is routinely present at concentrations above the 1-year Negligible MEG, the highest detected peak concentration was only 20% of the 14-day Negligible MEG. In addition, all concentrations were well below the EPA 8-hour Acute Exposure Guideline Level-1 value of 0.069 mg/m^3 for the general population, including sensitive sub-populations, which is based on mild, reversible irritation to the eyes and upper respiratory tract.

Medical Implications: None anticipated. Fuel combustion is the primary source of acrolein release to the atmosphere. Acrolein has a very disagreeable odor and breaks down rapidly in the air by reacting with other chemicals and sunlight. Most individuals can smell acrolein at a concentration of approximately 0.6 mg/m^3. Breathing small amounts of acrolein can cause watering of the eyes, burning of the nose and throat, and decreased breathing rate. These symptoms go away when exposure stops. Studies indicate that very slight eye irritation and annoyance/discomfort begin at about 0.2 mg/m^3, and nose/throat irritation and a decrease in respiratory rate at approximately 0.7 mg/m^3. Concentrations of acrolein detected at Camp Lemonnier were well below the threshold concentrations known to cause irritation, thus no health effects associated with short-term acrolein exposure would be expected.

Confidence in the Risk Assessment: Confidence in this risk assessment is medium based the available data. Even though there are significant gaps in data collection, Navy and Marine Corps Public Health Center undertook an exposure assessment in 2013–2014 to quantify VOC concentrations with special emphasis on potential acrolein exposures at Camp Lemonnier. These sampling events were of relatively short duration, but the resultant data lends itself well to acute risk assessment.

2.6.3 Long-term (Chronic) Health Risk

Approach: Because of the extreme variability in VOC sampling, the average concentration of all acrolein samples collected at Camp Lemonnier was used to assess the long-term health risk associated with potential acrolein exposures. When calculating the average concentration, a surrogate value of half the laboratory limit of quantitation was used for each sample where acrolein was not detected. This approach may overestimate the risk to the population as a whole.

Risk Summary: Based on the available data, the chronic risk associated with potential acrolein exposure is **moderate**. Acrolein was detected at concentrations above the long-term Negligible MEG in approximately 59% of the samples collect at Camp Lemonnier with an average concentration of approximately 0.0009 mg/m^3. This concentration exceeds the 1-year Negligible MEG and the Agency for Toxic Substances and Disease Registry Minimal Risk Level for chronic exposures up to 1 year by a factor of approximately ten.

Medical Implications: The major effects from chronic inhalation exposure to acrolein in humans consist of general respiratory congestion and eye, nose, and throat irritation. It is likely that some camp residents sought medical treatment for such conditions while deployed. These symptoms are similar to those related to other environmental stressors present at Camp Lemonnier (e.g., dust and diesel exhaust) as well as upper respiratory infections and allergies, thus it is impossible to link a direct causal effect to acrolein exposures.

Confidence in the Risk Assessment: Confidence in this risk assessment is low based the available data. There are significant gaps in data collection which forced a particularly conservative approach to the chronic risk assessment.
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2.7 Semi-Volatile Organic Compounds

Semi-volatile organic compounds (SVOCs) are compounds in ambient air formed during combustion; they are also present in the unburned portion of gasoline, diesel fuel, lubricating oils, wood, refuse, and other organic substances. Semi-volatile organic compounds include polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCBs), dioxin, and furans. They can be found in the air in minute concentrations everywhere, even the Antarctic. Semi-volatile organic compounds are present in air as vapors or adsorbed to the surface of small solid particles. Semi-volatile organic compounds in ambient air generally occur as complex mixtures rather than a single compound. There are several sources of SVOCs on and around Camp Lemonnier, including electric power generators, solid waste incinerators, motor vehicle exhaust, jet engine exhaust, and the La Douda Dump.

2.7.1 Sample Data/Notes

Twelve SVOC samples were collected in 2004 by the U.S. Army Center for Health Promotion and Preventive Medicine (now USAPHC) using a PS1 Sampler. The PS1 Sampler is a high-volume sampler capable of collecting all SVOC compounds for laboratory analysis. In addition, NMCPHC used a real-time photoelectric aerosol sensor capable of measuring total ambient particulate-bound PAH concentrations at Camp Lemonnier. Thirty-nine days of sampling in 2012, 2013, and 2014 generated more than 11,000 valid data points from multiple sampling locations based on where camp residents live, work, and recreate.

2.7.2 Short-term (Acute) Health Risk

Approach: For screening purposes, all compounds detected from PS1 sampling were first compared to their corresponding 1-year Negligible MEGs. Compounds without a single detection above that MEG were removed from further consideration. None of the SVOCs detected from PS1 sampling exceeded their respective 1-year Negligible MEGs.

For PAH data generated by the photoelectric aerosol sensor, no long-term military exposure guideline or EPA risk-based screening levels currently exist. Accordingly, health risk values for benzo(a)pyrene (the PAH with the highest potential for health impacts) published by the California Air Resources Board were used for health risk screening purposes. The California Air Resources Board risk-based

concentrations assume lifetime residential exposures (70 years) whereas exposures at Camp Lemonnier are typically one year or less. In addition, benzo(a)pyrene typically comprises less than five percent of the total amount of PAHs present in the atmosphere. In order to ensure a health protective assessment, however, all PAHs detected at the camp were assumed to be benzo(a)pyrene. None of the PAH concentrations detected at Camp Lemonnier survived screening after adjusting for the reduced period of exposure at Camp Lemonnier (1 year vice 70 years).

Risk Summary: Semi-volatile organic compounds are not a source of acute health risk based on available data.

Medical Implications: None based on available data.

Confidence in the Risk Assessment: Confidence in this risk assessment is low. No data exist after 2004 until PAH sampling was accomplished 2012–2014. In addition, the 2004 data was collected over a single 10-day period and the 2012–2014 sampling only addressed total, particle-bound PAHs rather than the entire suite of SVOC compounds.

2.7.3 Long-term (Chronic) Health Risk

Approach: For screening purposes, all compounds detected from PS1 sampling were first compared to their corresponding 1-year Negligible MEGs. Compounds without a single detection above that MEG were removed from further consideration. None of the SVOCs detected from PS1 sampling exceeded their respective 1-year Negligible MEGs.

For PAH data generated by the photoelectric aerosol sensor, no long-term military exposure guideline or EPA risk-based screening levels currently exist. Accordingly, health risk values for benzo(a)pyrene (the PAH with the highest potential for health impacts) published by the California Air Resources Board were used for health risk screening purposes. The California Air Resources Board risk based concentrations assume lifetime residential exposures (70 years) whereas exposures at Camp Lemonnier are typically one year or less. In addition, benzo(a)pyrene typically comprises less than five percent of the total amount of PAHs present in the atmosphere. In order to ensure a health protective assessment, however, all PAHs detected at the camp were assumed to be benzo(a)pyrene. None of the PAH concentrations detected at Camp Lemonnier survived screening after adjusting for the reduced period of exposure at Camp Lemonnier (1 year vice 70 years).

Risk Summary: Semi-volatile organic compounds are not a source of chronic health risk based on available data.

Medical Implications: None based on available data.

Confidence in the Risk Assessment: Confidence in this risk assessment is low. No data exist after 2004 until PAH sampling was accomplished 2012–2014. In addition, the 2004 data was collected over a single 10-day period and the 2012–2014 sampling only addressed total, particle-bound PAHs rather than the entire suite of SVOC compounds.
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2.8 Diesel Exhaust

Diesel exhaust is a complex mixture of gases, including oxides of nitrogen (NO and NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), carbon dioxide CO_2), ozone, and diesel particulate matter. Diesel particulate matter consists of small solid particles formed by the incomplete burning of fuel in a diesel engine. Diesel particulate matter is composed of a solid core of elemental carbon with other substances such as inorganic carbon, metals ash, sulfates, and silicates attached to the surface. The primary

source of diesel exhaust at Camp Lemonnier is from electricity generation at the Prime Power facilities and at tactical generators distributed around the camp. The gaseous components may also be generated by other combustion sources, including the solid waste incinerator, tactical and construction vehicles, and open burning at the La Douda Dump.

2.8.1 Sample Data/Notes

Diesel exhaust sampling was conducted 11–15 November 2012 and 13–23 September 2013. The November 2012 sampling included diesel particulate and the following gaseous components; NO, NO_2, CO, and SO_2. Sampling in 2013 included only the gaseous components. Diesel particulate matter concentrations in 2012, as represented by total carbon, ranged from 0.0041 mg/m^3 to 0.16 mg/m^3 during the sampling period. There are no current exposure guidelines for diesel particulates; however, all concentrations of diesel particulates detected in November 2012 (6/6) exceeded the 1-year Negligible MEG for diesel exhaust of which it is a part. The range of concentrations for the four gaseous components over both sampling events is as follows; NO, none detected to 18.58 mg/m^3; NO_2, none detected to 11 mg/m^3; SO_2, none detected to 0.5 mg/m^3 and CO, none detected to 21 mg/m^3.

2.8.2 Short-term (Acute) Risk

Approach: For screening purposes, all gaseous compounds detected were compared to their corresponding 1-year Negligible MEGs. Compounds without a single detection above that MEG were removed from further consideration. Concentrations of NO exceeded its 1-year Negligible MEG in 14% (5/36) of the samples. Four of those exceedances occurred in 2012 (4/13) and one in 2013 (1/23). Concentrations of NO_2 exceeded its 1-year MEG in 6% of samples (5/36). Both exceedances occurred in November 2012. Concentrations of CO exceeded its 1-year Negligible MEG in 8% of samples (3/36). As with NO_2, all exceedances occurred in November 2012.

Risk Summary: **Low** to **moderate**. Taken individually, the acute risk associated with the gaseous components of diesel exhaust would be low. Based on combined target organ effects of these compounds and the addition of diesel particulate concentrations, however, the acute health risk was **moderate** on 14–15 November 2012. Based on available data, the acute health risk was **low** on 11–13 November 2012 and 13–23 September 2013. There is insufficient data to estimate health risk for other periods.

Medical Implications: Short-term exposures to high concentrations of diesel exhaust can cause headache, dizziness, and irritation of the eyes, nose, and throat. It is possible that camp residents who worked near the sampled areas during the period of moderate risk could have experienced some of these effects. Symptoms associated with short-duration exposure to diesel exhaust would be expected to resolve after exposures ceased.

Confidence in the Risk Assessment: As data is limited to two sampling events, confidence in the risk assessment is low.

2.8.3 Long-term (Chronic) Health Risk

Approach: For chronic health risk, it is was assumed that the longest deployment lasts 12 months and that camp residents are exposed to the same levels of diesel exhaust 24 hours per day over the full term of their deployment. Thus the exposure assumptions employed likely represent a worst-case exposure scenario. To assess chronic health risk associated with diesel exhaust, all gaseous compounds detected are compared to their corresponding 1-year Negligible MEGs. Compounds without a single detection above that MEG are removed from further consideration. No current exposure guidelines exist for diesel particulates.

Risk Summary: Not evaluated. There is insufficient sampling data upon which to base a long-term health risk assessment. Even though there were multiple samples in which one or more gaseous components of diesel exhaust exceeded its respective screening value, all the data resulted from only two sampling events completed during similar climatic periods which produced relatively few samples.

Medical Implications: Prolonged exposures to diesel exhaust can increase the risk of cardiovascular disease, cardiopulmonary and respiratory diseases, and lung cancer. Exposures capable of causing these types of health outcomes are generally occupationally related.
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3 Soil

3.1 Surface Soil

3.1.2 Sample Data/Notes

From October 2002 to March 2008, 22 surface soil samples were collected. According to field data sheets, the samples were collected from areas and/or activities where the potential for soil exposure was high, such as in maintenance areas and physical training areas, during excavation and while filling sand bags. Laboratory analysis of soil samples includes SVOCs, heavy metals, pesticides, herbicides, and radionuclides. The primary exposure pathways associated with soil are dermal contact and incidental ingestion. Individuals involved in construction and maintenance activities are at greatest potential for exposure to soil. These individuals comprise a relatively small proportion of the overall camp population.

3.1.3 Short-term (Acute) Health Risk

Not evaluated. Exposure to soils does not generally pose short-term health risk. Consequently, no MEGs for short-term exposure to soils exist, and sampling data for soils are not evaluated for acute health risks**.**

3.1.4 Long-term (Chronic) Health Risk

Approach: For screening purposes, all compounds detected in the soil samples were compared to their corresponding 1-year Negligible MEGs. Compounds without a single detection above that MEG were removed from further consideration. None of the compounds detected exceeded their respective 1-year Negligible MEGs.

Risk Summary: Surface soil is not a source of health risk at Camp Lemonnier based on available data.

Medical Implications: None based on available data.

Confidence in the Risk Assessment: Confidence in the risk assessment is high despite the low number of samples. In the absence of a known or suspected source of pollution, release of hazardous materials in a specific area, or extensive use of fill material from remote locations during construction, the composition of native soils should be very similar across the base and should not change appreciably over time. Even with air deposition from an offsite source such as the La Douda Dump, changing the overall composition of surface soils would require several decades before sampling could detect minor differences in soil composition, especially given the camp's distance from the dump and local climatological phenomena that limit the hours that dump emissions impact the camp due to shifts in wind direction.
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4 Water

4.1 Site-Specific Sources Identified

Historically, two sources of potable water have been available at Camp Lemonnier: (1) bottled water from commercial vendors and (2) reverse osmosis (RO)-treated water supplied from one or more of the six onsite wells. Although RO-treated water has historically met potable water standards, it has not generally been used for drinking, because it is too hot to be palatable. As a result, RO-treated water is used mostly for cooking and personal hygiene purposes. Chilled, bottled water has been typically supplied throughout the camp for drinking.

4.2 Water for Other Purposes (RO-Treated Water)

4.2.1 Sample Data/Notes

Enhanced water surveillance, which includes chemical analysis, typically occurs at six-month intervals during military operations. Six samples of RO-treated water were submitted for analysis from 2005 to 2009. No RO-treated water sampling data exists prior to 2005 or after 2009. Reverse osmosis-treated water is used primarily for showering, personal hygiene, cooking, cleaning, and recreational activities. Two RO-treated samples exceeded 1-year drinking water MEGs; one sample from May 2007 exceeded the MEGs for selenium and magnesium, while a sample from June 2009 exceeded the MEG for antimony.

Selenium: Selenium was detected at a concentration of 0.099 mg/L in one of the six RO-treated water samples. This detection was above the 1-year Negligible MEG for Selenium in drinking water of 0.07 mg/L. There is no short-term drinking water MEG for selenium.

Magnesium: Magnesium was detected at a concentration of 34 mg/L in one of the six RO-treated water samples. This is above the 14-day Negligible drinking water MEG of 30 mg/L. There is no 1-year MEG for magnesium.

Antimony: Antimony was detected at a concentration of 0.01 mg/L in a single RO-treated water sample. This is above the 14-day and 1-year Negligible drinking water MEG of 0.006 mg/L.

4.2.2 Short-term (Acute) Health Risk

Approach: For screening purposes, any compound with a peak concentration less than or equal to 2.5 times the 14-day Negligible MEG for consuming 5-L/day is eliminated from further consideration. If a 14-day, 5-L/day Negligible MEG is not available, the more conservative 1-year, 5-L/day Negligible MEG is used for screening purposes. The 2.5 multiplier adjusts the 5-L/day MEG to a consumption rate of 2-L/day, which is equivalent to the consumption rate upon which the EPA Maximum Contaminant Levels (MCL) are established. This still provides a significant level of health protection when the primary route of exposure of non-drinking water is skin contact and incidental ingestion and when one considers that EPA MCL are based on thirty years of consumption. The selenium, magnesium and antimony detections were all less than their respective screening values.

Risk Summary: The short-term health risk associated with the use of RO-treated water for showering, personal hygiene, cooking, and recreational activities is **low**.

Health Implications: None identified based on the available sampling data.

Confidence in the Risk Assessment: Even though there few samples in the data set, confidence in this risk assessment is medium based on the limited potential for ingestion of RO-treated water.

4.2.3 Long-term (Chronic) Health Risk

Approach: In order to assess the health risk associated with the use of RO-treated water the following assumptions were made:

- RO-treated water is supplied for cooking.
- Deployments last a maximum of 12 months.
- The primary routes of exposure associated with RO-treated water are incidental ingestion through cooking and personal hygiene (i.e., brushing teeth/oral hygiene).
- Camp residents ingest far less than 2 liters (food preparation) of RO-treated water per day.

The average concentration of the two samples obtained over the 12-month period is used to estimate chronic health risk. If only a single sample was obtained during a 12-month period, the concentrations detected in that sample are used and assumed to remain unchanged until a follow-on sample indicates that chemical concentrations have changed. For screening purposes, any compound with a peak concentration less than or equal to 2.5 times the 14-day Negligible MEG for consuming 5-L/day is eliminated from further consideration. If a 14 day, 5-L/day Negligible MEG is not available, the more conservative 1-year, 5-L/day Negligible is used for screening purposes. The selenium, magnesium, and antimony detections were all less than their respective screening values.

Risk Summary: The long-term health risk associated with the use of RO-treated water for showering, personal hygiene, cooking, and recreational activities is **low**.

Health Implications: None identified based on the available sampling data.

Confidence in the Risk Assessment: Even though there are few samples in the data set, confidence in this risk assessment is medium, based on the limited potential for ingestion of RO-treated water and the conservative risk assessment approach.
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4.3 Consumed Water (Bottled Water)

4.3.1 Sample Data/Notes

Bottled drinking water has been purchased at Camp Lemonnier from suppliers approved by the U.S. Army Veterinary Services (a branch of the U.S. Army Public Health Center) since the camp was first occupied. Most bottled water was procured from sources in Djibouti and/or in the United Arab Emirates, but water sampling data indicate that at least ten different approved vendors have supplied bottled water during the time the camp has been in operation. From 2005 to 2009, 27 bottled water samples were submitted for analysis. No bottled water sampling data exists prior to 2005 or after 2009. Antimony, lead, and boron were detected in bottled water at concentrations above the 1-year MEGs for drinking water.

Antimony: Antimony was detected in a single bottled water sample from December 2005 at a concentration of 0.007mg/L. This concentration is just slightly above the 1-year drinking water MEG of 0.006 mg/L for consumption of water up-to 15 liters/day.

Boron: There were four boron exceedances in bottled water samples, all only slightly above the 1-year drinking water MEG of 0.93 mg/L for consumption of up-to 15-L/day of water. The exceedances were in

June and September 2005, June 2006, and August 2007, at concentrations ranging from 1.12 mg/L to 1.3 mg/L.

Lead: Lead was detected in a single sample of bottled water collected in June 2005. The concentration of lead in the sample was 0.332 mg/L. This concentration is well above the 1-year Negligible MEG for consumption of 5-L/day of drinking water.

4.3.2 Short-term (Acute) Health Risk

Approach: To determine the acute risk associated with consuming bottled water, the maximum detected concentration for each analyte with a MEG exceedance was used to perform the risk assessment. In order to determine the health risk associated with drinking bottled water, the following assumptions were made:

- Camp residents ingest less than 15-L/day of bottled water.
- Bottled water is delivered in distinct quantities that are rapidly consumed in a relatively short amount of time.

Risk Summary: Based on the above approach, the short-term risk associated with consuming bottled water at Camp Lemonnier is **low**.

Medical Implications: None. Short-term exposure to the levels of antimony, boron, and lead identified in these samples would not be expected to result in adverse health outcomes.

Confidence in the Risk Assessment: Confidence in the risk assessment is medium. Twenty-seven bottled water samples were taken from multiple brands over the assessment period. This is far more sampling data than one would expect to see from drinking water sources in the United States. There is also an active and ongoing drinking water surveillance program at Camp Lemonnier that further increases confidence in this assessment.

4.3.3 Long-term (Chronic) Health Risk

Approach: In order to determine the health risk associated with drinking bottled water, the following assumptions were made:

- Camp residents ingest less than 15-L/day of bottled water.
- Deployments last a maximum of 12 months.

Bottled water is supplied to Camp Lemonnier in distinct lots and from different approved vendors. Thus it is inappropriate to average analytical results across the spectrum of water samples. As a result, the maximum detected concentration for each analyte with a MEG exceedance was used to perform the long-term health risk determination. This process results in overestimation of the long-term health risk as it assumes that camp residents consumed water at the maximum detected concentration consistently during their deployment.

Risk Summary: Based on the above approach, the long-term risk associated with consuming bottled water at Camp Lemonnier is **low**.

Medical Implications:

Antimony: None. The most common source of antimony in drinking-water appears to be dissolution from metal plumbing and fittings and/or leaching from plastic bottles. People who drink water containing antimony well in excess of the MEG for many years could experience increases in blood cholesterol

and decreases in blood sugar. The World Health Organization (WHO) has set a guideline value for antimony of 0.02 mg/L, which is well above the MEGs for drinking water.

Boron: None. Naturally occurring boron is present in water primarily as a result of leaching from rocks and soils. The EPA has established a lifetime health advisory for boron in drinking water of 5 mg/L for adults based on consumption of 2 liters of water/day for thirty years and WHO has set a guideline value for boron in drinking water of 2.4 mg/L. The levels of boron detected in bottled water at Camp Lemonnier are all well below both the EPA health advisory and WHO guideline for boron in drinking water.

Lead: None. Lead is rarely found in source water. It generally enters water through corrosion of plumbing materials. Studies show that exposure to lead-contaminated water alone would not be likely to elevate blood lead levels in adults, as only 10–15% of the ingested lead is absorbed. However, adults who drink water with lead concentrations greater than the MEG for many years could develop kidney problems or high blood pressure. As the maximum Camp Lemonnier deployment is 12 months and the elevated lead levels were detected in only one bottled water sample, any brief exposure to lead that may have occurred from drinking bottled water is extremely unlikely to result in adverse health effects.

Confidence in the Risk Assessment: Confidence in the risk assessment is medium. Twenty seven bottled water samples were taken from multiple brands over the assessment period. This is far more sampling data than one would expect to see from drinking water sources in the United States. There is also an active and ongoing drinking water surveillance program at Camp Lemonnier which further increases confidence in this assessment.
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5 Military Unique

5.1 Chemical, Biological, Radiological, Nuclear (CBRN) Weapons

There were no specific hazard sources or exposure incidents documented in the Defense Occupational and Environmental Health Readiness System (DOEHRS) or the Military Exposure Surveillance Library (MESL) during the period October 2002 to December 2014.

5.2 Depleted Uranium

There were no specific hazard sources or exposure incidents documented in DOEHRS or MESL during the period October 2002 to December 2014.

5.3 Ionizing Radiation

5.3.1 Site-Specific Sources Identified

The following equipment in use at Camp Lemonnier serve as potential sources of radiation:

1) Medical and dental x-ray equipment used at Seth Michaud Emergency Medical and Dental Facility.

2) Devices for CBRNE detection: Smiths Detection APD-2000s are in use for chemical agent detection.

3) Z-Backscatters x-ray systems are used at the installation entry control points (ECPs) to scan vehicles for threats such as explosives and contraband.

4) Rapiscan Secure 1000 systems are used for screening pedestrians entering the base.

5.3.2 Short-term (Acute) Health Risks

Approach: The approach included identifying the equipment present at Camp Lemonnier, reviewing potential hazards associated with that equipment, and applying knowledge of the preventive measures in place.

Risk Summary: Ionizing radiation is not a source of health risk based on available information.

Medical implications: None.

Confidence in the Risk Assessment: Confidence for risk assessments is high. Known equipment configuration and operating procedures eliminate the potential for exposure to radiation at ECPs. X-ray shielding is in place, and medical/dental x-ray personnel are enrolled in a radiation dosimetry program to monitor potential exposures.

5.3.3 Long-term (Chronic) Health Risks

Approach: The approach included identifying the equipment present at Camp Lemonnier, reviewing potential hazards associated with that equipment, and applying knowledge of the preventive measures in place.

Risk Summary: Ionizing radiation is not a source of health risk based on available information.

Medical Implication: None.

Confidence in the Risk Assessment: Confidence for risk assessments is high. Known equipment configuration and operating procedures eliminate the potential for exposure to radiation at ECPs. X-ray shielding is in place, and medical/dental x-ray personnel are enrolled in a radiation dosimetry program to monitor potential exposures.
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5.4 Non-Ionizing Radiation

There were no specific hazard sources or exposure incidents documented in DOEHRS or MESL during the period October 2002 to December 2014.

6 Endemic Diseases

6.1 Sample Data/Notes

Assessed risk is the residual risk that exists in the presence of preventive measures.

- Department of Defense Directive 6490.02 series, Comprehensive Health Surveillance, establishes policy for routine health surveillance of all DOD personnel throughout their military service.
- The Disease Reporting System internet (DRSi) collects and maintains archives of Medical Event Reports (MERs) for all Services.
- Endemic diseases present in Djibouti were identified using the “Destinations” section of the Centers for Disease Control and Prevention (CDC) Travelers’ Health website, **http://wwwnc.cdc.gov/travel/destinations/djibouti.htm**.

- Where effective vaccines, such as those for Hepatitis A and B, are in place, risk to individuals is effectively reduced to none and these endemic diseases were excluded from further assessment.
- Actual disease prevalence in the local population is unknown due to inconsistent surveillance in the host nation.
- Overall, few disease reports associated with Camp Lemonnier were identified. Those that were reported for individuals without documented travel outside Camp Lemonnier were limited to routine influenza MERs during the H1N1 epidemic in 2009, when enhanced influenza reporting requirements were instituted. Disease reports associated with other locations within HOA were received for non-routine diseases, such as malaria, which have the potential to cause severe disease. Disease reports for routinely identified diseases that do not have ongoing or severe outcomes were not identified for individuals stationed in any HOA locations.

6.2 Gastrointestinal Diseases

United States Service members have little or no immunity to the food- and waterborne diseases present in Djibouti. To prevent food- and waterborne diseases among individuals deployed to Camp Lemonnier, food is purchased from approved sources and prepared in facilities where there is public health oversight (certificate of sanitation, health screening of food service workers, periodic inspections, etc.). Due to the potential presence of disease-causing organisms, as well as the high prevalence of improper food handling and preparation, local food and water are not approved for consumption. Viral gastroenteritis that is spread through contact or fomites (any inanimate object or substance capable of carrying infectious organisms) presents a recurrent risk due to a high rate of personnel turnover, shared dining, berthing, bathroom facilities, and working spaces.

Approach: The health risk for fomite-borne gastrointestinal infections and endemic food- and waterborne diseases to individuals deployed to Camp Lemonnier during the period of this assessment was epidemiologically assessed based on the combination of identified endemic diseases, knowledge of preventive measures in place, reviewing medical event reports associated with deployment to Camp Lemonnier, and directly communicating with military public health personnel stationed at Camp Lemonnier.

6.2.1 Short-term Health Risks

Risk Assessment:

- The short-term risk for viral gastroenteritis is **low.** Risk due to a high rate of personnel turnover, shared dining, berthing, bathroom facilities, and working spaces is not substantially different than that expected in similar settings within the United States.
- The short-term risk associated with food- and waterborne diseases at Camp Lemonnier is **low** (bacterial or viral gastroenteritis, protozoal diarrhea, cholera, brucellosis, hepatitis E).

Medical Implications: Gastroenteritis, particularly from viral agents, can cause periodic outbreaks in spite of preventive measures. A small number of infections may require greater than 72 hours convalescence and/or hospitalization.

Confidence in the Risk Assessment: Confidence in the risk assessment is medium. Food- and waterborne diseases, especially those with short convalescence and lack of long-term health effects, are often underreported for deployed military populations.

6.2.2 Long-term (Chronic) Health Risks

Risk Assessment: The long-term risk associated with food- and waterborne diseases is **low** for protozoal diarrhea and brucellosis.

Medical Implications: Long-term health effects resulting from infection with food- and waterborne diseases are rare.

Confidence in the Risk Assessment: Confidence in the risk assessment is high. Incidence of protozoal diarrhea and brucellosis in the post deployment military population is known to be extremely low.
Return to Table 2

6.3 Arthropod Vector-Borne Diseases

The climate and ecological habitat found in Djibouti support populations of arthropod vectors, including mosquitoes, ticks, and sand flies. Significant disease transmission in the local population (creating a reservoir) is sustained year-round and countrywide, including in urban areas. Risk is typically elevated during, and just after, the two brief rainy seasons, which approximately span March through October. Risk is higher in urban and other densely populated areas, or near where animals are kept. Removing vector harborages and spraying for vectors within Camp Lemonnier, as well as properly wearing insecticide-treated uniforms and applying insect repellent to the skin, are the main protective measures against vector-borne diseases. Of the endemic vector-borne diseases present in Djibouti, malaria is the only disease for which chemoprophylaxis is available.

Approach: The health risk for endemic vector-borne diseases to individuals deployed to Camp Lemonnier during the period of this assessment was epidemiologically assessed based on the combination of identified endemic diseases, knowledge of preventive measures in place, reviewing MERs associated with Camp Lemonnier deployment, and directly communicating with military public health personnel stationed at Camp Lemonnier.

6.3.1 Short-term (Acute) Health Risks

Risk Assessment: The short-term risk for the vector-borne diseases dengue fever, malaria, leishmaniasis (both visceral and cutaneous), chikungunya, sandfly fever, West Nile fever, Crimean-Congo hemorrhagic fever, rickettsioses (tick-borne, spotted fever group), Rift Valley fever, and o'nyong-nyong is **low**. Individuals who forward deploy from Camp Lemonnier to outlying areas may experience increased short-term risk.

Medical Implications: Dengue fever, malaria, cutaneous leishmaniasis, chikungunya, sandfly fever, West Nile fever, Crimean-Congo hemorrhagic fever, Rift Valley fever, o'nyong-nyong, and rickettsioses present in Djibouti have fairly short incubation periods ranging from days to weeks. Any of these diseases would initially present as acute fever and malaise, some are accompanied by rash, and would lead to acute, sometimes severe illness.

Confidence in the Risk Assessment: Confidence in the risk assessment is high. Sporadic reports of vector borne disease are received for individuals who deploy to remote locations subordinate to Joint Task Force Horn of Africa (JTF HOA); no vector-borne disease reports for individuals who resided within Camp Lemonnier were identified.

6.3.2 Long-term (Chronic) Health Risks

Risk Assessment: The long-term risk for leishmaniasis is **low**.

Medical Implications: Both visceral and cutaneous leishmaniasis may have extended incubation periods, ranging from a week to years. Although rare, it is possible to be infected during deployment, but not to have clinically evident disease until redeployed. Leishmaniasis should be considered in the differential diagnosis for any unusual skin lesions or chronic, systemic disease.

Certain vector-borne diseases have the potential to cause long-term health effects; individual history of infection with a vector borne disease should be considered when evaluating patients with chronic symptoms such as prolonged fatigue, depression, arthralgia or myalgia.

Confidence in the Risk Assessment: Confidence in the risk assessment is high. Incidence of leishmaniasis, particularly visceral, in the post-deployment military population is known to be extremely low.
Return to Table 2

6.4 Water Contact Diseases

Operations or activities that involve extensive freshwater contact may result in individuals being exposed to leptospirosis or schistosomiasis. The occurrence of flooding after heavy rainfall facilitates the spread of leptospirosis because, as water saturates the environment, *Leptospira* bacteria present in the soil pass directly into surface waters. Bodies of fresh water that contain snails (an intermediate host for schistosomes) should be considered an exposure source for schistosomiasis. Activities such as wading or swimming in freshwater sources may result in exposures to enteric diseases such as diarrhea and hepatitis via incidental ingestion of water. Prolonged water contact also may lead to the development of a variety of skin conditions, such as bacterial or fungal dermatitis. Elimination of standing and/or open bodies of fresh water protects against the spread of water contact diseases.

Approach: The health risk for endemic water-contact diseases to individuals deployed to Camp Lemonnier during the period of this assessment was epidemiologically assessed based on identifying endemic diseases, knowledge of preventive measures in place, reviewing MERs associated with deployment to Camp Lemonnier, and directly communicating with military public health personnel stationed at Camp Lemonnier.

6.4.1 Short-term (Acute) Health Risks

Risk Assessment: The short-term risk for leptospirosis and schistosomiasis is **low**.

Medical Implications: Leptospirosis, which has an incubation period of 5–14 days, presents as acute fever with nonspecific symptoms that last for a few days to 3 weeks or longer. *Schistosoma* species found in Djibouti have incubation periods of 6–12 weeks. Initial presentation of schistosomiasis includes fever, rash, and other systemic symptoms.

Confidence in the Risk Assessment: Confidence in the risk assessment is high. No reported cases of water contact diseases were identified from JTF HOA during the assessment period.

6.4.2 Long-term (Chronic) Health Risks

Risk Assessment: The long-term risk for schistosomiasis infection is **low**.

Medical Implications: Schistosomiasis infection does not always cause acute, systemic manifestations. Also, human infection with *S. mansoni* and *S. haematobium* may last in excess of 10 years. Although rare, it is possible to be infected while deployed but not to have clinically evident disease until redeployed.

Confidence in the Risk Assessment: Confidence in the risk assessment is high. Incidence of water contact diseases in the post-deployment military population is very low.
Return to Table 2

6.5 Respiratory Diseases

United States military populations living and working in close-quarter conditions are at risk for substantial person-to-person spread of upper respiratory infections, such as the common cold and influenza. Primary exposure pathways for tuberculosis are prolonged close contact (generally several hours per day for greater than three days per week in a closed space) with the local population or third country national contractors. United States personnel who remain on Camp Lemonnier have limited to no contact with the local population, and local and third country national workers/contractors are required to complete a health screening prior to employment.

Approach: The health risk for respiratory diseases to individuals deployed to Camp Lemonnier during the period of this assessment was epidemiologically assessed based on identifying endemic diseases, knowledge of preventive measures in place, reviewing MERs associated with deployment to Camp Lemonnier, and directly communicating with military public health personnel stationed at Camp Lemonnier.

6.5.1 Short-term (Acute) Health Risks

Risk Assessment:

- The short-term risk for upper respiratory infections is **low.** Risk due to a high rate of personnel turnover, shared dining, berthing, recreational facilities, and working spaces is not substantially different than that expected in similar settings within the United States.
- The short-term risk for tuberculosis is **low**.

Medical Implications: Upper respiratory infections, particularly from viral agents, can cause periodic outbreaks in spite of preventive measures. A small proportion of infections may require greater than 72 hours convalescence and/or hospitalization. Symptoms of tuberculosis, including fever, weight loss, night sweats, and cough, typically start within 1–6 months of infection. The lifetime risk for tuberculosis disease after becoming infected is 5–10%; half of this risk occurs in the first two years following infection.

Confidence in the Risk Assessment: Confidence in risk assessment is medium. Upper respiratory infections, especially those with short convalescence and lack of long-term health effects are not reportable for deployed military populations. Tuberculosis prevalence in the local population is unknown due to inconsistent surveillance within the host nation, but no reports of tuberculosis were identified for individuals at Camp Lemonnier during the assessment period.

6.5.2 Long-term (Chronic) Health Risks

Risk Assessment: The long-term risk for tuberculosis is **low**.

Medical Implications: Symptoms of tuberculosis can be delayed by two or more years following infection. Tuberculosis should be considered in assessing symptoms of fever accompanied by night sweats and cough.

Confidence in the Risk Assessment: Confidence in risk assessment is high. Actual prevalence of tuberculosis in the local population is unknown due to inconsistent surveillance within the host nation, but prevalence of tuberculosis in the post-deployment military population is known to be extremely low.
Return to Table 2

6.6 Animal-Contact Diseases

Just as with the human population in Djibouti, little disease surveillance or prevention has been conducted on the animal population of Djibouti. Animals are not routinely vaccinated against vaccine-preventable diseases, such as rabies or anthrax. Exposures to animals and/or locations where animals are kept (stray dogs/cats, barnyards, slaughterhouses) are the primary infection sources for all these diseases, and avoiding companion and farm animal contacts is the primary prevention strategy. Preventive measures in place include anthrax vaccination, which is effective in preventing both cutaneous and inhalation anthrax, and rabies post-exposure prophylaxis, which is effective and readily available for preventing onset of rabies in exposed individuals.

Approach: The health risk for endemic animal contact diseases to individuals deployed to Camp Lemonnier during the period of this assessment was epidemiologically assessed based on identifying endemic diseases, knowledge of preventive measures in place, reviewing MERs associated with deployment to Camp Lemonnier, and directly communicating with military public health personnel stationed at Camp Lemonnier.

6.6.1 Short-term (Acute) Health Risks

Risk Assessment: The short-term risk for anthrax (naturally acquired), Q-fever and rabies is **low**.

Medical Implications:

- Naturally occurring anthrax (non-weaponized) is an acute disease that usually affects the skin, while inhalation anthrax has mild and non-specific initial symptoms among unimmunized individuals.
- Symptoms of acute Q-fever, which may present one week to greater than one month after exposure, include fever, chills, and weakness.
- Rabies presents as an acute, viral encephalomyelitis and is almost invariably fatal.

Confidence in the Risk Assessment: Confidence in risk assessment is high. No reports of any animal contact diseases were identified during the risk assessment period.

6.6.2 Long-term (Chronic) Health Risks

Risk Assessment: The long-term risk for Q-fever and rabies is **low**.

Medical Implications: Q-fever is generally an acute febrile disease. However, considerable variation in severity and duration may be seen; infections may be unapparent or present as a nonspecific undifferentiated febrile syndrome. Q-fever should be considered in the differential diagnosis of an undifferentiated febrile syndrome when contact with animal placental tissues, birth fluids, or excreta has occurred.

Confidence in the Risk Assessment: Confidence in risk assessment is high. Actual disease prevalence in the local animal and human population is unknown due to inconsistent surveillance within the host nation but incidence of animal contact diseases in the post deployment military population is known to be extremely low.
Return to Table 2

7 Venomous Animals/Insects

The species listed below have home ranges that overlap the location of Camp Lemonnier, and may present a health risk if they are encountered. Information was taken from the Integrated Pest Management Plan for Camp Lemonnier, Djibouti as prepared by Naval Facilities Engineering Command Atlantic, December 2008, as well as Clinical Toxinology Resources, **http://www.toxinology.com/index.cfm**. The following list should not be considered inclusive; other venomous scorpions and snakes may be present in the region. See Section 10 for more information about pesticides and pest control measures.

7.1 Short-term (Acute) Health Risk

7.1.1 Spiders: Numerous species of spiders are found in Djibouti. The widow spider (*Latrodectus renivulvatus*) is the only known species whose bite presents a threat. Widow spider bites are mostly minor and even significant envenomation is unlikely to be lethal. Its bite is usually felt as a "sting," with delayed (10+ minutes) local pain and sweating. More severe envenomation may produce regional pain, tender draining lymph nodes, nausea, hypertension, and malaise. Health risk is **low**.

7.1.2 Scorpions: Numerous species of scorpion, such as *Butheolus andersoni,* are found in Djibouti. Stings by these scorpions are likely to cause only short-lived local effects, such as pain, without systemic effects. Health risk is **low**.

7.1.3 Snakes: Numerous species of snakes are found in Djibouti. A number of poisonous snakes whose ranges include the HOA region could be present in Djibouti. The following species are known to be present and could pose a health risk if encountered:

- *Naja haje* (Egyptian cobra or brown cobra): Bites are severe, with both local tissue damage and paralysis. The health risk associated with the bite of these snakes is **high**, but potential for encounters is low.
- *Psammophis sibilians* (olive grass snake, olive sand snake, hissing sand snake, striped sand snake, African beauty snake): Bites are generally minor, requiring symptomatic treatment only.

Overall, the health risk associated with snakes is **low**.

7.5 Long-term (Chronic) Health Risk

None identified.
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8 Heat/Cold Stress

8.1 Site-Specific Conditions

Djibouti is classified as a desert climate with hot and very dry weather conditions. Average temperatures in the summer range from 85 to 107°F (June–November) with temperatures in the winter ranging between 70 to 83°F (December–March). Preventive medicine personnel assigned to the Seth Michaud Emergency Medical and Dental Facility monitor and report heat stress conditions daily during the summer months.

8.2 Heat

8.2.1 Heat Exposure Guidelines

Heat advisory conditions are communicated to the camp population by displaying color-coded flags based on Wet Bulb Globe Temperature (WBGT) measurements. Wet Bulb Globe Temperature measurements are a composite temperature used to estimate the effect of temperature, humidity, wind speed, and solar radiation on individuals. The WBGT reading drives preventive measures, such as adjusting work/rest cycles and limiting outdoor activities, to reduce the risk of heat injury. The range of WBGT measurements and their corresponding color-coded flags are as follows:

Less than 80 White, 80 – 84.9 Green, 85 – 87.9 Yellow (Amber), 88 – 89.9 Red, 90 or above Black.

8.2.2 Sample Data/Notes

Wet Bulb Globe Temperature index measurements are taken hourly, from 0700 to 1900, to report the heat advisory conditions to camp residents. From June 16 to October 10, 2014, the only period for which heat stress data was available, Black Flag conditions remained in effect for 95% of the time from 0900 until 1600.

8.2.3 Short-term (Acute) and Long-term (Chronic) Health Risk

Approach: Onsite preventive medicine assets were interviewed about the conduct of the heat stress program, a review of climatologic data and available heat stress program data was undertaken and MERs and disease non-battle injury data were reviewed to assess heat injuries.

Risk Summary:

Short-term Health Risk: The short-term health risk of heat injury for unacclimated individuals (i.e., on site less than four weeks) and those with underlying health conditions is **moderate**. For all other individuals the risk is **low**.

The long-term health risk is l**ow.**

Medical Implications: Severity of heat illness can range from mild clinical signs such as clamminess, nausea, disorientation, or headache to life-threatening symptoms requiring hospitalization. Long-term medical implications from heat injuries are rare but can occur, especially with more serious injuries such as heat stroke. Individuals with a history of heat injury, even when medical attention was not sought, are at increased risk for future heat injury; repeat heat injury may have increased severity.

Confidence in the Risk Assessment: Based on generally available information on climatic conditions and the heat stress prevention program, the confidence in risk assessment is high. Individuals who experienced mild symptoms of heat illness may not have sought medical attention; this may lead to an underestimation of the risk.
Return to Table 1
Return to Table 2

8.3 Cold

8.3.1 Short-term (Acute) and Long-term (Chronic) Health Risks

None identified.

9 Noise

9.1 Continuous

9.1 Site-Specific Conditions

Camp Lemonnier has a narrow footprint, and all working and living areas are close to noise sources. Sources of potential noise include flight line operations (both fixed and rotary winged aircraft), Prime Power Plants I and II, individual tactical generators, motor vehicles, environmental control units, construction equipment and various power and hand tools in maintenance shops. The standard work shift at Camp Lemonnier is 12 hours, and personnel spend much of their off-work hours in relative close proximity to the flight line and the generator stations, which are the main noise sources. As a result, Camp Lemonnier personnel may not consistently attain the full recovery period after noise exposure.

9.1.1 Exposure Guidelines

The Services have established occupational exposure limits (OEL) for continuous or intermittent noise at 85 decibels on the A-weighted scale (dbA) focused on occupational noise exposures and the prevention of noise-induced hearing loss. These standards may be adjusted for longer work shifts, up to a maximum of 16 hours (see table below). A minimum eight-hour recovery time is required between shifts.

8 Hour	12 Hour	16 Hour
85	82.375	82

In addition, the EPA issued environmental (community) noise guidelines in 1974 (see table below), which addressed 24-hour noise exposure limits to prevent hearing loss, as well as interference with sleep and other human activities.

EPA Environmental Noise Guidelines		
Location	Criterion	Description
Interior	45 dB	Residences, hospitals, and schools; to prevent activity interference
Exterior	55 dB	Where human activities take place; to prevent activity interference
All Areas	70 dB	24-hour average; to prevent hearing loss

9.1.2 Sample Data/Notes

Occupational Noise: Sound level measurements were taken within industrial and maintenance shops as well as the flight line area during industrial hygiene surveys in 2003, 2007, and 2014 as well as during the Occupational and Environmental Health Site Assessment (OEHSA) in September 2012. Noise levels measured in some locations exceeded the OEL. When OELs were exceeded, the specific location/circumstances were recorded and availability and use of hearing protection, placarding of noise hazardous equipment, and recommendations for any needed remediation were noted in the reports.

Environmental Noise: Noise dosimetry was performed at Camp Lemonnier in November 2012 and September 2013 to determine if environmental noise sources constitute a noise-induced hearing loss hazard and/or have the potential for interfering with human activities during work and leisure periods. Noise dosimeters were placed at locations on Camp Lemonnier to capture 24-hour environmental noise measurements. Sampling locations included CLU along the road bordering the flight line, inside a

residential tent, and on the fence line of the Air Force radar site. All interior and exterior average noise levels in November 2012 and 2013 exceeded the EPA interior and exterior activity interference guidelines. Twenty-four hour average noise levels measured at the following locations exceeded the 70dB, 24-hour guideline for protection against noise-induced hearing loss for a least a portion of the two sampling events; all exterior flight line locations, the Air Force radar site (exterior), and the interiors of CLU in the D and E residential blocks.

9.1.3 Short-term (Acute) Health Risk

Approach: For occupational noise exposures, noise level measures associated with occupational exposures obtained during multiple industrial hygiene assessments were compared to the Navy/DOD OEL. Knowledge of Service level hearing conservation programs and the availability and compliance with the use of hearing protective devices, as reported in the industrial hygiene surveys, were factored into the assessment. The EPA Environmental Noise Guidelines were used as comparison values for assessing the risk associated with environmental noise.

Risk Summary: The short-term risk of noise-induced hearing loss associated with noise exposures at Camp Lemonnier is **low**.

Medical Implications: No health effects from purely occupational noise exposure would be expected. However, a few individuals could be expected to experience short term health effects, such as headache, annoyance, speech interference, and fatigue associated with environmental noise exposures. It is possible that some of these individuals sought medical treatment during their deployment.

Confidence in the Risk Assessment: Confidence in the health risk assessment is medium. The Services have a well-established hearing conservation program; hearing protection is readily available and generally worn by individuals with known occupational exposures. Available data on environmental noise exposures is somewhat less robust, but noise levels measured were consistent over the two sampling events approximately 10 months apart.

9.1.4 Long-term (Chronic) Health Risk

Approach: For occupational noise exposures, noise level measures associated with occupational exposures obtained during multiple industrial hygiene assessments were compared to the Navy/DOD OEL. Knowledge of Service-level hearing conservation programs and the availability and compliance with the use of hearing protective devices, as reported in the industrial hygiene surveys, were factored into the assessment. The EPA Environmental Noise Guidelines were used as comparison values for assessing the risk associated with environmental noise.

Risk Summary: The long-term risk of noise-induced hearing loss associated with purely occupational exposures is **low** with appropriate hearing protection. The long-term risk associated with prolonged exposure to environmental noise at the levels detected is **moderate.** The consistency of the data over the two sampling events suggests that the increased risk associated with environmental noise may apply to periods before and after the period of sampling.

Medical Implications: No health effects from purely occupational noise exposure would be expected. It is likely that some individuals continuously exposed to environmental noise levels such as those at Camp Lemonnier would be expected to experience health effects such as headache, annoyance, fatigue and possible hearing threshold shifts (temporary to permanent) associated with continuous environmental noise exposures during their deployment.

Confidence in the Risk Assessment: Confidence in the health risk assessment is medium. The

Services have a well-established hearing conservation program; hearing protection is readily available and generally worn by individuals with known occupational exposures. Available data on environmental noise exposures is somewhat less robust, but noise levels measured were consistent over the two sampling events approximately 10 months apart.
Return to Table 1
Return to Table 2

9.2 Impulse

9.2.1 Short-term (Acute) and Long-term (Chronic) Health Risks

No information about potential sources of impulse noise (140 dbA or greater) was available. The health risk was not evaluated during this assessment.

10 Unique Concerns

10.1 Asbestos and Lead-Based Paint

No asbestos containing material or peeling lead-based paint was identified in three industrial hygiene surveys completed during the period of this assessment of Camp Lemonnier.

10.1.1 Short-term (Acute) Health Risk

None identified based on available data.

10.1.2 Long-term (Chronic) Health Risk

None identified based on available data.

Confidence in the Risk Assessment: While there is limited industrial hygiene data available, the overwhelming majority of the structures onsite are recently renovated or new construction; confidence in health risk assessment is medium.

10.2 Potential Environmental Contamination Sources

In addition to environmental exposures already discussed, there may be specific occupational exposure pathways associated with vehicle, aircraft, and site maintenance. Typical chemicals of concern associated with potential occupational exposures are petroleum, oils, and lubricants. An exposure assessment plan to document potential occupational exposures was developed during the OEHSA in 2012 and validated during the 2014 industrial hygiene survey. In addition, there are procedures in place for storing, handling, using and disposing hazardous materials which generally minimize health risk.

10.2.1 Short-term (Acute) and Long-term (Chronic) Health Risks

The short- and long-term health risks are **low**.

Confidence in the Risk Assessment: Due to limited industrial hygiene sampling data, confidence in the health risk assessment is currently low.

10.3 Pesticides/Pest Control

Pest control services on Camp Lemonnier are provided through contract. Contract personnel are required to meet DOD certification requirements or have a state pest control operator's license. Pest

management services include the control of arthropod and vertebrate pests in and around buildings. Sanitation, glue traps, and exclusion are the primary means of non-chemical control in and around structures. Low-toxicity insecticidal baits are used effectively for cockroaches and ants. Most pesticides used onsite consist of contact chemicals or those that degrade rapidly in the environment. Onsite oversight of pest management activities is provided by a Pest Control Performance Assessment Representative from the Michaud Emergency Medical and Dental Facility.

10.3.1 Short-term (Acute) and Long-term (Chronic) Health Risks

Approach: Both the Camp Lemonnier Integrated Pest Management Plan and the existing contract vehicle for pest control services were reviewed for compliance with DOD and Navy policy. In addition, the Navy Entomology Center of Excellence was consulted about their knowledge of pest management activities at Camp Lemonnier.

Risk Summary:

Short-term health risk: None identified.

Long-term health risk: None identified.

Confidence in the Risk Assessment: Confidence in the risk assessment is high. The integrated pest management plan emphasizes non-chemical control over the use of chemical pesticides. The potential for camp residents to come in contact with improperly formulated insecticides is remote.

10.4 La Douda Dump

Based on interviews with onsite preventive medicine personnel, smoke and odors associated with the La Douda Dump have been the principal health concerns and one of the leading morale issues of individuals deployed to Camp Lemonnier for several years. The La Douda Dump is a 247-acre site situated approximately 1.2 miles southeast of Camp Lemonnier. The dump is the primary refuse disposal site for Djibouti City and surrounding areas. It also serves as the disposal site for waste products from animal slaughterhouses (offal) located in Djibouti. The offal is the major source of burning as most of the other refuse is scavenged. Waste material remaining after scavenging has also been known to combust, presumably due to the heat generated by natural decay. Disposal and burning of hazardous waste has been periodically reported. Smoke plumes from burning refuse at the La Douda Dump impact Camp Lemonnier for short periods on a routine basis.

10.4.1 Sample Data/Notes

From October 2002 to December 2014, data from 416 PM_{10} samples, 294 $PM_{2.5}$ samples, 93 air samples for VOCs, 12 SVOC samples and more than 11,000 PAH measurements via direct reading instruments have been generated. Sampling locations were established to characterize potential airborne contaminates from all potential emission sources in and around Camp Lemonnier at representative exposure points based on where camp residents live, work, and recreate. Although this sampling was not done specifically to characterize emissions from the La Douda Dump, it did capture the primary compounds that drive health risk associated with open burning (i.e., PAH, dioxins, and furans). Results of all air sampling are discussed in detail in Section 2 (Air) above.

10.4.2 Short-term (Acute) Health Risk

Approach: While air samples collected are not representative solely of the La Douda Dump, it was assumed for the purposes of this assessment that the La Douda Dump was the source of all identified air pollutants. The specific health risk assessment approach for PM_{10}, $PM_{2.5}$, VOC and SVOC is

described in the Section 2 above.

Risk Summary: No additional short-term health risk was identified above that associated with ambient air. The primary short-term and long-term risk drivers for the air exposure pathway are dust (PM_{10} and $PM_{2.5}$) and diesel exhaust, neither of which can be directly attributed to open burning at the La Douda Dump. Airborne dust is a complex mixture of solid and liquid particles from multiple sources, and diesel exhaust is primarily associated with onsite power generation.

Medical Implications: Individuals exposed to smoke from burning at the dump may experience red, burning eyes, irritated respiratory passages, and cough. The longer a person remains in the smoke plume the more likely these symptoms are to occur. The frequency of complaints and severity of symptoms may be worse during temperature inversions when smoke is trapped close to the ground for extended periods. However, many of these symptoms can also be induced by exposure to ambient dust, diesel exhaust, or the arid climate and may not be directly related to smoke from burning refuse. Any symptoms related to smoke exposure would generally be expected to subside when exposure ceases.

Confidence in the Risk Assessment: Confidence in the health risk assessment is medium. Sampling data for dioxins/furans is limited but levels detected were similar to worldwide background levels. The PAH (products of incomplete combustion) sampling was far more extensive and results are likely representative of year-round ambient concentrations.

10.4.3 Long-term (Chronic) Health Risk

Approach: While air samples collected are not representative solely of the La Douda Dump, it was assumed for the purposes of this assessment that the La Douda Dump was the source of all identified air pollutants. The specific health risk assessment approach for PM_{10}, $PM_{2.5}$, VOC and SVOC is described in the Section 2 above.

Risk Summary: No additional long-term health risks were identified above that associated with ambient air at Camp Lemonnier. The primary risk driver at Camp Lemonnier for long-term health risk is $PM_{2.5.}$ The specific contribution of open burning at the La Douda Dump to the long-term health risk associated with ambient air is indeterminate based on available sampling data.

Medical Implications: While no long-term health risks have yet been identified in populations exposed to smoke associated with refuse burning, it is possible that a small number of individuals may experience long-term health effects. Specific factors that may increase risk include combined exposures (such as dust, industrial pollutants, and tobacco smoke) and individual susceptibilities, such as preexisting health conditions or genetic factors.

Confidence in the Risk Assessment: Confidence in the health risk assessments is low. Sampling data for dioxins/furans is limited and PAH data, although extensive, was collected only during one calendar year.
Return to Table 2

11 References

POEMS developed according to:

1. **DODI 6490.03, *Deployment Health*, September 2011.**
2. **MCM 0017-12, *Procedures for Deployment Health Surveillance,* December 2012.**
3. **DODI 6055.05, Occupational and Environmental Health, November 2008.**
4. **Klaassen, C.D. *Casarett & Doull's Toxinology: the Basic Science of Exposures*, Chapter 2, Principles of Toxinology; Fifth Edition, McGraw Hill, New York.**

Site description and baseline information obtained from:

5. **Potomac-Hudson Engineering, Inc. – 2008 – Draft Drinking Water Management Action Plan, Camp Lemonnier, Djibouti – May 16, 2008.**
6. **Department of the Navy – 2003 Environmental Health Site Assessment of Camp, Lemonnier, Djibouti Africa – August 22, 2003.**
7. **Department of the Army – 2004 Deployment Occupational and Environmental Health (OEH) Risk Characterization – July 23, 2004.**
8. **Department of the Navy – 2004 Baseline Industrial Hygiene Survey, Camp Lemonnier, Djibouti – April 27, 2004.**
9. **Department of the Navy – 2007 Industrial Hygiene Survey of Camp Lemonnier, Djibouti –April 26, 2007.**
10. **Department of the Navy – 2009 Industrial Hygiene Survey of Camp Lemonnier, Djibouti, Africa – April 2009.**
11. **Occupational and Environmental Health Site Assessment, Camp Lemonnier, November 2012.**
12. **Department of the Navy – 2014 Industrial Hygiene Survey of Camp Lemonnier for 2014 – September 21, 2014.**
13. **Djibouti Post Report – eDiplomat – Area, Geography, and Climate Updated: July 19, 2005.**
14. **Integrated Pest management Plan – Camp Lemonnier, Djibouti: December 2008**

Sampling data were obtained from the:

15. **Defense Occupational and Environmental Health Readiness System (referred to as the DOEHRS-EH database) at https://doehrs-ih.csd.disa.mil/Doehrs/. Some of the data may be classified or otherwise have some restricted distribution. See discussion below.**

Additional environmental health reports/survey documents are from the:

16. **Military Exposure Surveillance Library: https://mesl.apgea.army.mil/mesl/. Some of the data and reports used may be classified or otherwise have some restricted distribution.**
17. **Department of Veterans Affairs-Environmental Letter – Burn Pits Throughout Iraq, Afghanistan, and Djibouti, April 26, 2010.**

Chemical hazards (air, water, soil) evaluated based on military exposure guidelines (MEGs) and risk assessment methodology in:

18. **USAPHC Technical Guide (TG230): Environmental Health Risk Assessment and Chemical Exposure Guidelines for Deployed Military Personnel, December, 2013 Revision.**
19. **USACHPPM, Particulate Matter Factsheet No. 64-009-0708, 2008.**
20. **EPA Toxicological Review of Acrolein, May 2003.**
21. **ATSDR Toxicological Profile for Acrolein, August 2007.**
22. **National Academy of Sciences, Committee on Toxinology: Acute Exposure Guideline Levels for Selected Airborne Chemicals, Volume 8 (2010).**
23. **California Air Resources Board and the Office of Environmental Health Hazard Assessment: Benzo[a]pyrene as a Toxic Air Contaminant, July 1994.**

Regional/country information on endemic/infectious disease and heat/cold from the:

24. **Centers for Disease Control and Prevention (CDC) Travelers' Health website (http://wwwnc.cdc.gov/travel/destinations/djibouti.htm), "Destinations" section, Djibouti.**
25. **World Health Organization Country Profiles/Djibouti (http://www.who.int/countries/dji/en/)**
26. **Clinical Toxinology Resources, University of Adelaide, Australia; http://www.toxinology.com/index.cfm**.

NOTE. The DOEHRS-EH database was queried to obtain the available sample data for air, soil, and drinking and nondrinking water sources at Camp Lemonnier, Djibouti, Africa. The data are currently assessed using the TG230 December 2013 Revision as described above contains, the general method involves an initial check of the data which eliminates all chemical substances not detected above 1-year Negligible MEG. Those substances screened out are not considered acute or chronic health hazards so are not assessed further. For remaining substances, acute and chronic health effects are evaluated separately for air and water (soil is only evaluated for long-term health risk). This is performed by deriving separate short-term and long-term population exposure level estimates (referred to as population exposure point concentrations) that are compared to MEGs derived for similar exposure durations. If less than or equal to Negligible MEG, the risk is low. If levels are higher than Negligible, then there is a chemical-specific toxicity and exposure evaluation by appropriate subject matter experts, which includes comparison to any available marginal, critical, or catastrophic MEGs. For drinking water, 15-L/day MEGs are used for the screening while site specific 5–15L/day are used for more detailed assessment. For nondrinking water (such as that used for personal hygiene or cooking) the "consumption rate" is limited to 2-L/day (similar to the EPA), which is derived by multiplying the 5-L/day MEG by a factor of 2.5. This value is used to conservatively assess nondrinking uses of water.

12 Where Do I Get More Information?

If a provider feels that the Service member's or Veteran's current medical condition may be attributed to specific OEH exposures at this deployment location, he/she can contact the Service-specific organization below. Organizations external to DOD should contact DOD Force Health Protection and Readiness.

Army Public Health Center – Phone: (800) 222-9698. **http://phc.amedd.army.mil/**

Navy and Marine Corps Public Health Center (NMCPHC) Phone: (757) 953-0700. **http://www.med.navy.mil/sites/nmcphc/Pages/Home.aspx/**

U.S. Air Force School of Aerospace Medicine (USAFSAM) Phone: (888) 232-3764. **http://www.wpafb.af.mil/afrl/711hpw/usafsam.asp**

DOD Force Health Protection and Readiness (FHP&R) Phone: (800) 497-6261. **http://fhpr.osd.mil**