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ENVIRONMENTAL ASSESSMENT

FOR

LONG-RANGE OVERWATER DIFFUSION EXPERIMENT AT PACIFIC MISSILE RANGE FACILITY

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EXECUTIVE SUMMARY

The Departments of Defense and Commerce, Washington, DC, propose to conduct the Long-Range Overwater Diffusion (LROD) Experiment over the ocean west of the Pacific Missile Range Facility (PMRF), Kauai, Hawaii, during July 1993. LROD is an atmospheric diffusion experiment designed to provide quantitative information on alongwind diffusion at short (≤ 5 km), intermediate (5 to 50 km), and long (50 to 100 km) ranges. It will be the first experiment to measure alongwind diffusion rates at intermediate and long downwind distances. The information gained from the LROD experiment will lead to improved quantitative estimates of the downwind hazards presented by short-term releases of hazardous air pollutants (such as might occur in a transportation accident in which a tank of hazardous material is ruptured).

The LROD experiment will consist of the release of the inert, nontoxic tracer gas sulfur hexafluoride (SF_6) from an Air Force C-130 aircraft flying perpendicular to the mean wind direction. Approximately 1,000 kg of SF_6 will be released over a 100-km line during each of the planned 16 trials. The tracer cloud will be sampled as far as 100 km downwind by real-time SF_6 samplers mounted on PMRF boats, ships, and a twin-engine aircraft. All tracer dissemination and sampling will occur over international waters more than 22 km (12 nm) west of the Islands of Kauai and Niihau, Trials will only be conducted with offshore (easterly) winds. The frequency of onshore (westerly) winds in the proposed experiment area is less than 1 percent during July. Meteorological measurements will be made during each trial on several of the boats or ships and a single-engine aircraft.

This environmental assessment was prepared in compliance with Executive Order 12114, Environmental Effects Abroad of Major Federal Actions (4 January 1979). Although the experiment is a Federal action, it is not a major Federal action.

The environmental assessment did not identify significant environmental impacts for the proposed LROD experiment. There are no known adverse environmental effects for SF_6 under the proposed release conditions, and the maximum 8-hour average SF_6 concentration at the ocean's surface is expected to be 5 million times smaller than the threshold limit value and permissible exposure limit. The aircraft, ship, and boat operations supporting the experiment will be well within the scope of routine PMRF activities. Also, the aircraft, ships, and boats will be deployed from existing facilities.

Two alternatives were considered to conducting the LROD experiment at PMRF: (1) conduct the experiment at some location other than PMRF and (2) do not conduct the experiment. Meteorological conditions favorable for the conduct of the LROD experiment occur during the summer in the vicinity of several Pacific islands near the latitude of Kauai. However, the potential for environmental effects is no less at these islands. Also, these islands lack the support infrastructure available at PMRF and are more remote from the U.S. mainland. The no action alternative was rejected because the data that will be provided by the LROD experiment are needed to improve meteorologists' understanding of the behavior of short-term releases of hazardous air pollutants and there is no potential for significant environmental effect.

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I. PURPOSE AND NEED FOR THE PROPOSED ACTION

The Long-Range Overwater Diffusion (LROD) Experiment is an atmospheric diffusion experiment proposed for conduct over the waters of the Pacific Missile Range Facility (PMRF), Kauai, Hawaii, during July 1993. The experiment will be conducted by the Departments of Defense and Commerce. Data acquired during the LROD experiment will lead to improved quantitative estimates of the downwind hazards presented by short-term releases of hazardous air pollutants (such as might occur in a transportation accident in which a tank containing hazardous material is ruptured).

The LROD experiment will focus on measurements of alongwind diffusion rates. Alongwind diffusion is poorly understood, even at short range, because of the lack of empirical data. This data gap exists because: (1) alongwind cloud growth is not a major concern when modeling continuous sources of air pollution, (2) it is only in recent years that scientists have recognized that concentration exposure histories may be as important as total dosages (time-integrated concentrations), and (3) samplers capable of making time-resolved concentration measurements have not been readily available until recently. The need for the LROD experiment was identified during a literature review of overwater transport and diffusion processes (Bowers, 1992). The review was done in response to a request by the Naval Surface Warfare Center (NSWC), Dahlgren, Virginia (Joint Operational Test and Information Directorate, 1991).

The combination of tracer and meteorological data collected during LROD will improve meteorologists' understanding of alongwind diffusion over water or land at short to long range. Although the data collected during the experiment should lead to improvements in the accuracy of most atmospheric transport and diffusion models, the LROD experiment is sometimes identified within the Navy by the name of a specific Navy diffusion model - the Vapor, Liquid, and Solid Tracking (VLSTRACK) model.

This environmental assessment was prepared in compliance with Executive Order 12114, Environmental Effects Abroad of Major Federal Actions (4 Janaury 1979). Although the experiment is a Federal action, it is not a major Federal action.

11. DESCRIPTION OF THE PROPOSED ACTION

A. Background

The majority of research on the transport and diffusion of air pollutants has focused on continuous sources of air pollution (such as industrial stack emissions) because these sources are the principal contributors to the global atmospheric loading of air pollution. However, in recent years, increasing attention has been placed on the transport and diffusion of short-term air pollutant releases. These releases are usually accidental and often involve hazardous materials. Examples include transportation accidents in which tank cars containing liquified natural gas or chlorine are ruptured.

In contrast to air pollutant releases in which the environmental effects are only apparent after a fairly lengthy time, short-term releases of hazardous materials usually present an immediate threat to life and/or property. Current atmospheric transport and diffusion models for short-term pollutant releases commonly assume that the alongwind and crosswind diffusion rates are the same because little is known about alongwind diffusion. However, short-range diffusion experiments (Nickola, 1971) and theoretical analyses (Wilson, 1981) indicate that this is a poor assumption.

The LROD experiment is designed to fill the data gap on alongwind diffusion. It will be conducted over water rather than over land, primarily to maximize the probability of acquiring data on alongwind diffusion at short, intermediate, and long ranges.

B. Description of the LROD Experiment

The experiment will consist of the release of the inert, nontoxic tracer gas sulfur hexafluoride (SF,) from an Air Force C-130 aircraft flying perpendicular to the mean wind direction (Figure 1). During each trial, a cloud of SF, will be released about 22 km offshore by the aircraft. The typical release will be 9.6 g/m over 100 km for a total release of about 960 kg of SF, per trial. A maximum of 16 trials will be conducted.

The approximately 100-km long disseminated SF, cloud will be sufficiently long that diffusion from the ends of the line will not affect the concentration at its center as far as 100 km downwind. At downwind distances of more than 20 to 30 km, the SF, cloud will become uniformly mixed in the vertical within the marine boundary layer so that variations in the concentration at its center will be entirely due to alongwind diffusion.

The tracer cloud will be sampled at the surface and aloft by real-time SF, analyzers mounted on boats or ships and a twin-engine aircraft. Meteorological conditions during each trial will be documented by instruments mounted on ships and on a specially instrumented single engine research aircraft.

U.S. Army Dugway Proving Ground (DPG), Utah, is responsible for the design and management of the LROD experiment. The SF, dissemination and sampling will be performed by the Department of Commerce National Oceanic and Atmospheric Administration (NOAA), Environmental Research Laboratories (ERL), Air Resources Laboratory Field Research Division (ARLFRD), Idaho Falls, ID. The NOAA ARLFRD has over 20 years of experience in conducting SF_6 tracer studies for U.S. Government agencies [Environmental Protection Agency (EPA), Army, Air Force, etc.] and industry.

C. Proposed Experiment Site

The proposed location for the LROD experiment is within the overwater air space of PMRF, Barking Sands, Kauai. PMRF is on the west side of the Island of Kauai (Figure 1), the western-most of the major islands in the Hawaiian chain. An analysis of climatological summaries of ship surface weather observations made in Hawaiian coastal waters (Naval Weather Service Command, 1971a) indicates a very high frequency of occurrence of easterly trade winds over the waters west of Kauai during the summer. For example, during July, easterly winds occur over 60 percent of the time and winds from the northeast through southeast occur over 97 percent of the time. The high frequency of winds from the same direction is very favorable for the conduct of LROD and is one of the principal reasons that the waters west of Kauai and the month of July were selected for the experiment.

Figure 1 also shows the experimental layout for the typical LROD trial. All SF_6 dissemination and sampling will be over international waters more than 22 km (12 nm) from land. This separation from land will minimize perturbations produced in the trade winds and vertical structure of the marine boundary layer by the upwind Island of Kauai. The 100-km SF_6 dissemination line is perpendicular to the prevailing wind direction. The sampling line extends 100 km downwind (i.e., to the west) from the center of the dissemination line.

The possibility of a significant change in wind direction during a trial is extremely remote. For example, winds from the southwest through northwest occur less than 1 percent of the time during July. The almost complete lack of westerly winds increases the chances of successful experiment conduct and virtually precludes the possibility that the tracer will be advected back over the Islands of Kauai and Niihau.

D. Toxicity of Sulfur Hexafluoride (SF_6)

1. <u>Use</u>

SF_6 is used commercially as an inert filler gas in electrical equipment, as a protective atmosphere for casting magnesium alloys, and as a tracer for leak detection. It is used as a gaseous insulator for high-voltage generators, other electrical equipment, and radar wave guides. Appendix A is a material safety data sheet for SF_6.

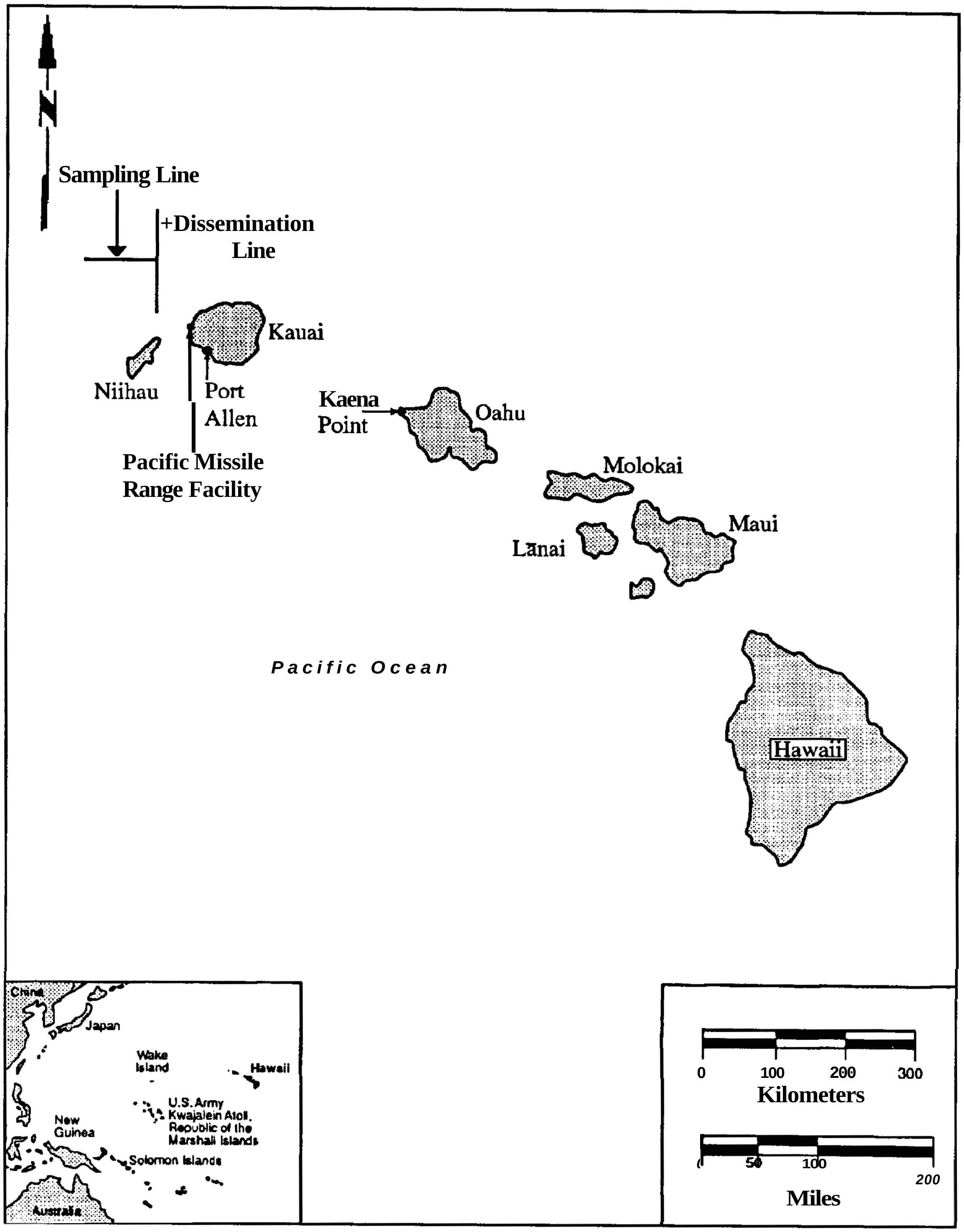

Figure 1. The Pacific Missile Range Facility (PMRF) is on the west side of the Island of Kauai. The nominal locations for the LROD experiment's SF_6 dissemination and sampling lines are west of Kauai.

Because of its low toxicity, low reactivity, and ease of detection, SF_6 has been widely used as a tracer gas for indoor and outdoor source dissemination experiments and for measuring gas exchange coefficients in lakes (Sage and Howard, 1989).

SF_6 is widely used as an atmospheric tracer because it is one of the few readily detected tracer materials with no known adverse environmental consequences. Its advantages as a tracer are that: (1) the detection threshold of about 5 parts per trillion (ppt) is well above the global-average background concentration of about 1 ppt, and (2) there are samplers that can detect SF_6 in real time with a time resolution of about 1 sec.

Use of SF_6 for outdoor releases was assessed in several DPG environmental assessments (EAs). Each EA concluded that there was no potential for significant environmental effect. The most recent of these EAs is for a light detection and ranging (lidar) test conducted in 1992 (Andrulis Research, Inc., 1992). Other DPG tests using SF_6 were addressed in an EA by Kincaid (1986). Approximately 1,000 kg of SF_6 will be used during each trial of the LROD test.

The suitability of SF_6 for use as an atmospheric tracer is illustrated by the fact that it is routinely used in atmospheric diffusion studies conducted for the U.S. EPA (for example, Allwine, et. al., 1992).

2. <u>Regulation</u>

SF_6 is listed as a nonflammable gas, but not as a hazardous material by the Department of Transportation (DOT) (Appendix A). It is not listed as a hazardous waste under the Resource Conservation and Recovery Act (RCRA) or as a hazardous substance under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (Appendix A).

3. <u>Chemical and Physical Properties</u>

SF_6 is a colorless, odorless, nonflammable gas consisting of sulfur and fluorine. Pure SF_6 is unreactive chemically at ambient temperatures and is considered physiologically inert (Sax and Lewis, 1989). Impure grades of SF_6 may contain small amounts of lower fluorides of sulfur, which are toxic and corrosive (Sax and Lewis, 1989). SF_6 has a molecular weight of 146.07, a sublimation point of -63°C, a melting point of -50.8°C, and a solubility in water of 31 g/l (Sage and Howard, 1989).

4. <u>Toxicity</u>

If present in sufficient quantity, SF_6 can displace oxygen and be an asphyxiation hazard. Direct contact with the liquid material or escaping gas can cause frostbite injury (Appendix A). If SF_6 is heated to temperatures above 800°C, it will decompose into toxic fluoride and sulfur oxides. The threshold limit value (TLV) established for SF_6 by the American Conference of Government and Industrial Hygienists (ACGIH) and the permissible exposure limit (PEL) established for SF_6 by the Occupational Safety and Health Administration (OSHA) are both 1,000 parts per million (ppm) (6,000 mg/m^3) (Appendix

A). The TLV and **PEL** are time-weighted averages for exposure over an 8-hour work day.

The above toxicity information indicates that *SF*, is only slightly toxic. Massive doses of SF, injected into the bloodstream can be fatal. For rabbits, an intravenous median lethal dose **(LD,,)** of **5,790** mg/kg has been demonstrated (Appendix **A**).

5. Environmental Effects and Fate

SF, released into the environment will be diluted and dispersed by atmospheric dispersion processes. Because it is physiologically inert, **SF**, is not likely either to react or to be degraded in the environment (Sage and Howard, **1989).** Because SF, has a high density, it could be subject to accumulation (if released in a confined area) and could present an asphyxiation hazard. However, this is not likely to occur in the open ocean.

Sage and Howard **(1989)** list an estimated bioconcentration factor of **89** for *SF*,, based on a recommended regression equation. Therefore, *SF*, is not expected to bioconcentrate appreciably in fish and aquatic organisms. *SF*, is very resistant to attack and extreme conditions are required for abiotic degradation. For example, it resists molten **KOH** and steam at 500°C (Sage and Howard**, 1989).**

111. ALTERNATIVES CONSIDERED

A. Conduct Experiment at a Site Other Than PMRF

The coastal waters near several islands in the North Pacific also have meteorological conditions favorable for the conduct of the LROD experiment. For example, meteorological conditions in the vicinity of Johnston Island during the summer are very similar to the conditions west of Kauai (Naval Weather Service Command, 1971b). However, these islands lack the range support resources (ships, aircraft, range control, and range safety) available at PMRF. It would be expensive and time-consuming to create the infrastructure required for the LROD experiment at another island. Also, because the other islands are more remote from the U.S. mainland than Kauai, conduct of the LROD experiment at one of these islands would require greater transportation costs.

B. No Action: Do Not Conduct Experiment

Failure to conduct the proposed experiment would mean that the alongwind diffusion data would not be collected. Therefore, the inadequate knowledge of alongwind diffusion and the uncertainties that this data gap introduces in atmospheric transport and diffusion model predictions for short-term releases of hazardous air pollutants would continue. The potential benefit to the greater public welfare of more accurate predictions of the hazard areas downwind from accidental releases of hazardous materials would not be achieved.

IV. AFFECTED ENVIRONMENT

A. Introduction

During the proposed LROD experiment, the SF_6 dissemination and sampling will take place within a 100-km by 100-km area that begins 22 km west of the Island of Kauai (Figure 1). The Air Force C-130 dissemination aircraft, twin-engine sampling aircraft, and the NOAA research aircraft will take off and land from the PMRF airfield; the PMRF sampling boats and/or ships will be deployed from their normal berths at Port Allen on the south side of Kauai.

The Draft Environmental Impact Statement for the Strategic Target System (Gallien, et al., 1992) contains a detailed description of this environment and is incorporated by this reference. Portions of the information in that document are summarized in this description of the affected environment. Because the aircraft, boat, and ship operations in support of the LROD experiment will be well within the scope of normal PMRF activities, the emphasis in this section is on the environment that may be affected by the SF_6 dissemination and sampling, activities unique to the LROD experiment.

B. Climate and Air Quality

The climate of the Island of Kauai is mild and semitropical. According to climatological data tabulated for July by the Naval Weather Service Command (1971a), precipitation occurs over the proposed LROD experiment area (i.e., the ocean west of Kauai) less than 2 percent of the time and there is no ceiling (less than 5/8 cloud coverage) over 76 percent of the time. The relative humidity is in the range of 60 to 90 percent and the temperature is in the range of 22.8 to 26.7°C (73 to 80°F) over 90 percent of the time. Also, the temperature of the ocean surface is within ±1°C of the air temperature about 68 percent of the time, with a median temperature difference of -0.5°C (air cooler than water). Thus, the prevailing atmospheric stability is near neutral to slightly unstable.

Easterly trade winds prevail over the ocean west of Kauai during July. Winds from the east, northeast, and southeast occur 62.5, 29.4, and 5.4 percent of the time, respectively. The wind speed near the ocean surface is in the range of 5.7 to 10.8 m/sec 69 percent of the time and averages 8.0 m/sec. The sea height is less than or equal to 1.2 m 62 percent of the time. The typical depth of the marine boundary layer is about 2,000 m (Hahn, et al., 1992).

According to Gallien, et al. (1992), the air quality in the vicinity of PMRF is generally excellent. The area is classified as an attainment area for all of the National Ambient Air Quality Standards (NAAQS) as well as the State of Hawaii ambient air quality standards (Hawaii Department of Health, 1986). The principal air pollutant emissions in the vicinity of PMRF are from diesel-powered generators, aircraft, and various rocket launches. Also, it is a common practice to burn the sugar cane fields near PMRF, which can produce short periods with heavy smoke and ash. The prevailing easterly winds transport these emissions toward the LROD experimental area. However, the prevailing wind speed, stability, and marine boundary layer depth represent high dilution conditions. Consequently, air quality in the experiment area should be better than it is in the vicinity of PMRF.

C. Topography, Geology, and Soils

PMRF is in a low-lying coastal plain on the west side of the Island of Kauai, the oldest of the eight main Hawaiian Islands. The island consists of a single great shield volcano similar to Mauna Loa on the Island of Hawaii. Formation of Kauai was probably completed before the end of the Pliocene epoch. Subsurface conditions are stable, and the sandy surface soils have been flattened and stabilized by ground cover. The soil is permeable and drains readily. Wind erosion can be severe when vegetation is removed.

D. Vegetation

Habitat types in the vicinity of PMRF include ruderal vegetation, kiawe/koa haole scrub, dune vegetation, coastal strand vegetation, and wetland vegetation. Two species in the area are Federally listed as Category I candidates. Ohai *(Sesbania tomentosa)* is a spreading shrub or small tree that is usually found in arid coastal areas on the leeward sides of the Hawaiian Islands. Adder's tongue *(Ophioglossum concinnum)* is a diminutive, ephemeral fern also found in dry coastal areas. It is present above ground only during the rainy season.

E. Water Resources

The groundwater and surface waters at PMRF are significant mainly for support of native plants and animals. The aquifer is a lens of brackish groundwater floating on seawater. It is recharged from rainfall and seepage from underlying sediments. Marine water quality off PMRF is good.

F. Wildlife

According to Gallien, et al. (1992), 40 species of birds have been identified at PMRF. Of these, the following are endemic to Hawaii and are Federally listed as threatened or endangered: (1) the American (Hawaiian) coot *(Fulica americana alai)*, (2) the black-necked (Hawaiian) stilt *(Himantopus mexicanus knudseni)*, (3) the Common moorhen *(Gauinula chloropus sandwicensis)*, (4) the Hawaiian duck *(Anas wyvilliana)*, and (5) the Newell's shearwater *(Puffinus newelli)*. The endemic (but unlisted) short-eared (Hawaiian) owl *(Asio flammeus sandwichensis)* is also present. The remaining 34 species include 24 exotic, four migratory, and six indigenous species. One of the migratory species, the Laysan albatross *(Diomedea immutabilis)*, is protected under the Migratory Bird Treaty Act (Gallien, et al., 1992). Other wildlife in the waters near Kauai and Niihau include the humpback whale *(Megaptera novaeangliae)*, Hawaiian monk seal *(Monachus schauinslandi)*, and green sea turtle *(Chelonia mydas)*.

G. Threatened and Endangered Species

Table 1 is a summary of the threatened and endangered species in the vicinity of PMRF. Of these, the species most likely to occur in the offshore

LROD experiment area are the humpback whale and green sea turtle. The humpback whale is a Federally listed endangered species and the green sea turtle is a Federally listed threatened species. Humpback whales breed and give birth in Hawaiian coastal waters during the winter, but spend their summers in feeding grounds off the coast of Alaska. An estimated 90 percent of the Hawaiian population of green sea turtles breeds and nests at French Frigate Shoals from May through August, although Gallien, et al. (1992) reference a reported finding of a sea turtle nest on PMRF in 1985. Green sea turtles spend the majority of their lives foraging and resting near shore.

H. Noise

The principal noise sources at PMRF are aircraft operations and rocket launches. Noise from rocket launches is infrequent and short term.

I. Socioeconomics

The economy of Kauai is dominated by tourism and agriculture. Commercial tourist facilities on Kauai are concentrated on the eastern and southern shores of the island. Most of the land around PMRF is planted in sugar cane, but Polihale State Park to the north of PMRF is a popular beach. The community nearest PMRF is Kekaha, 13 km to the south. The Forbidden Island of Niihau is privately owned and may not be visited without the permission of its owner.

Table 1. Summary of Threatened and Endangered Species in Vicinity of PMRF".

Species	Status	Remarks
Ohai *(Sesbania tomentosa)*	Federally listed as Category I candidate	A spreading shrub or small tree, usually found in arid leeward coastal areas of Hawaiian Islands
Adder's Tongue *(Ophioglossum concinnum)*	Federally listed as Category I candidate	Diminutive, ephemeral fern found in dry coastal areas of Hawaiian Islands; present above ground during the rainy season only
Hawaiian Duck *(Anas wyvilliana)*	Federally listed endangered species	Endemic to Hawaiian Islands and found from sea level to 1,000 m above sea level; 90% of Hawaiian ducks on Kauai are believed to use mountain stream habitats at elevations above 300 m
American (Hawaiian) Coot *(Fulica americana alai)*	Federally listed subspecies of common American coot	Preferred habitat is thickly vegetated fresh and brackish marshland; most of Hawaiian coots on Kauai are believed to breed on Niihau
Hawaiian Gallinule *(Gallinula chloropus sandwicensis)*	Federally listed endangered subspecies of common moorhen of North America and Eurasia	Endemic to Hawaiian Islands and found only on Kauai and Oahu; preferred habitat includes thickly vegetated freshwater ponds, marshes, reservoirs, and taro patches
Hawaiian Black-Necked Stilt *(Himantopus mexicanus knudseni)*	Federally listed endangered subspecies of the black-necked stilt of North America	Endemic to Hawaiian Islands and found on all islands except Lanai; nesting locations include reservoirs, settling basins, ponds, marshes, and taro patches
'well's Shearwater *'ffiltus lewelli)*	Federally listed threatened species	Pelagic species that comes ashore only to breed (April to November); usually nests in burrows beneath dense vegetation; eggs hatch in July and August, and fledging occurs in October and November

Table 1. Summary of Threatened and Endangered Species in Vicinity of PMRF" (Continued).

Species	Status	Remarks
Humpback Whale *(Megaptera novaeangliae)*	Federally listed endangered species	Breeds and gives birth in Hawaiian waters during winter and migrates to feeding grounds off coast of Alaska in summer
Hawaiian Monk Seal *(Monachus schauinslandi)*	Federal and Hawaiian listed endangered species	Hawaii's only endemic mammal; tends to stay near land, but may also feed in deeper water away from islands; several are regularly seen around Kauai
Hawaiian Hoary Bat *(Vespertilio cinereus semotus)*	Federally listed endangered subspecies of the hoary bat of North and South America	Roosts in trees of various species during day and feeds on flying insects concentrated by offshore winds at night; commonly found between sea level and 1,200 m above sea level
Green Sea Turtle *(Chelonia mydas)*	Federally listed threatened species	Found worldwide where water temperature remains above 20°C (68°F); 90% of Hawaiian population breeds and nests at French Frigate Shoals in May through August, but one nest was found on PMRF in 1985; spend most of their lives foraging and resting near shore; may bask on sandy beaches

"From Gallien, et al. (1992).

V. ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED ACTION AND ALTERNATIVES

A. Environmental Consequences of the Proposed Action

1. Air Quality

The DPG Meteorology Division performed a dispersion model analysis of the air quality impact of SF_6 emissions during the proposed LROD experiment (Appendix B). DPG's Real-Time Volume Source [Dispersion] Model (RTVSM) (Bjorklund, **1990)** was used. For the model, SF_6 was assumed to be released **50 m** above the surface in a crosswind line 100 km long. The SF_6 dissemination rate was assumed to be **9.6** g/m, resulting in a total dissemination of **960** kg per trial. Meteorological conditions considered in the model calculations covered the range of conditions expected in the proposed LROD experiment area during July. The SF_6 dissemination height of **50** m is the lowest height at which the C-130 dissemination aircraft will fly. Higher dissemination heights result in lower maximum air quality impacts at the ocean surface and were not considered in the model.

The RTVSM model analysis described in Appendix B shows that the maximum air quality impact of the SF_6 releases will occur between **0.5** and 1.0 km downwind from the dissemination line as the tracer cloud first mixes to the surface. The predicted peak instantaneous SF_6 concentration of **1.4** mg/m^3 is over **4,000** times smaller than the TLV and PEL for an 8-hour exposure **(6,000 mg/m^3).**

This predicted peak instantaneous concentration is subject to the uncertainties inherent in all current dispersion model predictions of concentrations downwind from short-term releases. (The LROD experiment is designed to fill this data gap.) However, the total dosage (time-integrated concentration) can be predicted with far greater confidence than the peak instantaneous concentration because it does not require an accurate description of alongwind diffusion. The predicted maximum total SF_6 dosage is 0.28 mg·min/m^3. Assuming a maximum of two trials per day, the maximum total SF_6 dosage for a single day is **0.56 mg·min/m^3**. If this dosage is averaged over 8 hours, the resulting SF_6 concentration of 0.0012 mg·min/m^3 is less than the TLV and PEL by a factor of about **5** million.

The other atmospheric emissions during the LROD experiment will be the exhaust from diesel-powered generators, five PMRF boats or ships, a twin-engine aircraft, a single-engine NOAA research aircraft, and an Air Force C-130 four-engine transport. Emissions from the generators, boats or ships, and aircraft will be well within the emissions from these sources during typical PMRF test operations.

2. Topography, Geology, and Soils

No geologic or topographic features will be affected by the activities of the experiment. All activities will occur over international waters. The aircraft and ships used in the experiment will be deployed from existing facilities. No construction will be associated with the experiment. Because the SF, tracer will be released only with easterly (offshore) winds, it will not be transported to the Islands of Kauai and Niihau.

3. Vegetation

The SF, tracer has no effect on vegetation and, as noted above (Paragraph V.A.1), trials will be conducted only when the winds will transport the tracer away from the Islands of Kauai and Niihau.

4. Water Resources

The SF, tracer disseminated during the LROD experiment will be released more than 22 km offshore with offshore winds. Thus, this material will not reach the Islands of Kauai and Niihau. Also, the SF, will be quickly dissipated in the atmosphere. The maximum instantaneous SF, concentration at the ocean surface will be about **$1.4\ mg\cdot min/m^3$** (0.2 ppm). The solubility of **SF,** in water is negligible. Consequently, the experiment will not affect water quality.

5. Wildlife

Because the experiment will only be conducted with offshore winds, no plants or wildlife on the Islands of Kauai and Niihau will be exposed to the SF, tracer.

6. Threatened and Endangered Species

The proposed LROD experiment has little potential to affect any threatened or endangered species. With the exception of the **SF,** tracer releases, all activities of the experiment will be well within the scope of routine PMRF activities (such as airfield operations) addressed in Gallien, et al., 1992. The two endangered or threatened species that could potentially be found within the overwater experiment area are the humpback whale and green sea turtle. However, Hawaiian humpback whales spend their summers in Alaskan coastal waters and the majority of Hawaiian green sea turtles spend their summers at French Frigate Shoals. Also, the green sea turtles spend most of their time in coastal waters. Thus, it is unlikely that either species will be present in the experiment area during July. Even if they are present, there is no SF, inhalation hazard at the maximum concentrations expected. Because SF, is a gas, there also is no ingestion hazard.

7. Noise

Noise from aircraft, boat, and ship operations will be within the range of routine daily PMRF activities and much less than the noise from PMRF rocket launches. It is possible that the low-flying dissemination and/or sampling aircraft could disturb humpback whales in the experiment area. In the event that whales are observed in this area, the minimum flight altitude will be increased to the altitude specified by the PMRF environmental office as necessary to avoid disturbing the whales. If an acceptable altitude cannot be agreed upon, the test will be delayed until the whales leave the area.

8. Socioeconomics

Approximately 25 LROD participants will visit PMRF for two to three weeks during July 1993. Although they will benefit local hotels, restaurants, and other service establishments, the effects will be minor.

9. Energy, Conservation, and Irretrievable Commitments of Resources

Diesel and aviation fuels will be required for aircraft, boat, and ship operations during the proposed LROD experiment. To reduce costs, the experimental design will minimize the use of these fuels. SF, is a commercially manufactured gas. The chemicals and fossil fuels used in the manufacture of the SF, and fossil fuels required for transportation, including transportation of equipment for the experiment and participants from the U.S. mainland to PMRF, are the only irretrievable commitments of resources.

10. Unavoidable Adverse Effects

No significant adverse environmental effects will result from conducting the proposed LROD experiment. Thus, no mitigation will be required.

B. Environmental Consequences of Alternatives Considered

1. Conduct Experiment at Site Other Than PMRF

The potential for environmental effects of conducting the experiment at another site would be at least as great as the potential at PMRF. The economic effects of this alternative would be the additional expense of creating an infrastructure to support the experiment at another island and the additional transportation costs. Also, creation of the required infrastructure would have considerable potential for environmental effects.

2. No Action: Do Not Conduct Experiment

There are no environmental consequences for this alternative. However, the information needed to develop atmospheric transport and diffusion models that can more accurately predict the downwind hazard areas for short-term releases of hazardous materials would not be acquired. Thus, the environmental benefits of more accurate model predictions of downwind hazards would be lost.

VI CONCLUSIONS

The proposed LROD experiment will not cause any significant environmental impacts. The SF, tracer releases will be made with offshore winds over international waters, more than 22 km west of the Islands of Kauai and Niihau. There are no known adverse environmental effects for SF, under the proposed release conditions. The aircraft, ship, and boat operations during the experiment will be well within the scope of routine PMRF activities. The aircraft, ships, and boats will be deployed from existing facilities.

APPENDIX A. MATERIAL SAFETY DATA SHEET FOR SF_6

MATERIAL SAFETY DATA SHEET
ACCUDRI® SF6 - Sulfur Hexafluoride

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: ACCUDRI® SF6 - Sulfur Hexafluoride

OTHER/GENERIC NAMES: Sulfur Fluoride

PRODUCT USE: Industrial chemical.

MANUFACTURER: Allied-Signal Inc.
101 Columbia Road, Box 1139
Morristown, New Jersey 07962-1139

FOR MORE INFORMATION CALL:
(Monday-Friday, 9:00am-4:30pm)(EST)
Product Safety Department: (201)-455-4157

IN CASE OF EMERGENCY CALL:
(24 Hours/Day, 7 Days/Week)
(201)-455-2000.

2. COMPOSITION/INFORMATION ON INGREDIENTS

INGREDIENT NAME	CAS #	WEIGHT %
Sulfur Hexafluoride	2551-62-4	100

Trace impurities and additional material names not listed above may also appear in the Regulatory Information section (#15) towards the end of the MSDS. These materials may be listed for local "Right to Know" compliance and for other reasons.

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: A colorless, odorless gas with no warning properties. Non-flammable. Avoid breathing vapors. Wear self-contained breathing apparatus or air-supplied respirator.

POTENTIAL HEALTH WARDS:

SMN: Direct contact with the liquefied material cr escaping compressed gas may cause frostbite injury.

EYES: Direct contact with the liquefied material or escaping compressed gas nay cause frostbite injury.

INHALATION: Pure SF6 is of a low order of toxicity, but may act as an asphyxiant if oxygen is reduced to below 16%, as indicated by paleness and possible cyanosis (blue skin).

INGESTION: No: applicable (gas at normal conditions).

DELAYED EFFECTS: None known.

Ingredients found on one of the OSHA designated carcinogen lists are listed below.

Ingredient Name	NTP Status	IARC Status	OSHA List
No ingredients listed in this section			

 Continued on Page 2

MATERIAL SAFETY DATA SHEET-
ACCUDRI® SF6 - Sulfur Hexafluoride

4. FIRST AID MEASURES

SKIN: Wash exposed area extremely thoroughly, but gently in cases of frostbite-like injury, with soap and water. Contact a physician if irritation or pain persists.

EYE: Flush eyes with copious amounts of warm water for at least 15 minutes. Contact a physician if irritation, pain, swelling, excessive tearing, or photophobia (paid sensitiveness to strong light) persists.

INHALATION: Immediately remove to fresh air. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen provided a qualified operator is available. Contact a physician.

INGESTION: Not applicable.

ADVICE TO PHYSICIAN: No specific treatment. Treat according to symptoms present.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES:
FLASH POINT: Not applicable.
FLASH POINT METHOD: Not applicable.
AUTOIGNITION TEMPERATURE: Not applicable.
UPPER FLAME LIMIT (Volume % in air): Not applicable.
LOWER FLAME LIMIT (Volume % in air): Not applicable.
FLAME PROPAGATION RATE (Solids): Not applicable.
OSHA FLAMMABILITY CLASS: Non-combustible gas.

EXTINGUISHING MEDIA:
If involved in a fire, use dry chemical or carbon dioxide for snail fires or water spray, fog, or regular foam for large fkes.

UNUSUAL FIRE AND EXPLOSION HAZARDS:
Cylinders may explode in heat ai fire. Fire may produce irritating or poisonous gases.

SPECIAL FIREFIGHTING PRECAUTIONS/INSTRUCTIONS:
Wear self-contained breathing apparatus. Cool cylinders exposed to heat of fixe with flooding amounts of water. Apply water from as far a distance as possible.

6. ACCIDENTAL RELEASE .MEASURES

IN CASE OF SPILL OR OTHER RELEASE (Always wear recommended personal protective equipment)
Evacuate unprotected personnel. Stay upwind. Protected personnel (see Section 8) may shut off leak if without risk. Product will disperse itself.

Spills and releases may have to be reported to Federal and/or local authorities. See the Regulatory Information section (#15) regarding reporting requirements.

Continued on Page 3

MATERIAL SAFETY DATA SHEET
ACCUDRI® SF6 - Sulfur Hexafluoride

7. HANDLING AND STORAGE

NORMAL HANDLING: (Always wear recommended personal protective equipment)
Observe precautions on cylinder label. Protect cylinders from physical damage.

STORAGE RECOMMENDATIONS:
Protect cylinders from physical damage, heat, and sunlight Store in an area of low fire risk

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING CONTROLS:
General mechanical ventilation.

PERSONAL PROTECTIVE EQUIPMENT:
SKIN PROTECTION:
Rubber gloves and coveralls.

EYE PROTECTION:
Safety glasses.

RESPIRATORY PROTECTION:
Self-contained breathing apparatus or air-supplied respirator.

ADDITIONAL RECOMMENDATIONS:
None.

EXPOSURE GUIDELINES: (Guidelines exist for the following ingredients)

Ingredient Name	ACGIH TLV	OSHA PEL	Other Limit
Sulfur Hexafluoride	1000 ppm (TWA)	1000 ppm (TWA)	None

* = Limit established by Allied-Signal for internal use.
** = Workplace Environmental Exposure Level (AIHA).
*** = Biological Exposure Index

Other exposure limits for the potential decomposition products are as follows:

None.

9. PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE: Colorless gas. [Container: 115 lb. cylinders]
PHYSICAL STATE: Gas.
ODOR: Odorless.
SPECIFIC GRAVITY: (Water = 1.0) Not applicable (gas).
SOLUBILITY IN WATER: (Weight %) Slight.
pH: Not applicable.
BOILING POINT: Sublimes @ -63.9°C, 1 atm.
MELTING POINT: -50.8°C @ 32.5 psia
VAPOR PRESSURE: Not applicable (gas).
VAPOR DENSITY: (Air = 1.0) 5.1 @ 1 atm., 21.1°C

 Continued on Page 4

MATERIAL SAFETY DATA SHEET
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EVAPORATION RATE: Not applicable. Compared *to:* Not **applicable.**
% VOLATILES: *Not* applicable (gas).
FLASH POINT: Not applicable.
(Flash point method **and** additional flammability data **are** found in section **5.)**

10. STABILITY AND REACTIVITY

NORMALLY STABLE? (Conditions to Avoid)
Stable under normal conditions.

INCOMPATABILITIES:
Hot reactive metals. Liquefied *gases* in contact wit!! **water** *can* explode violently.

HAZARDOUS DECOMPOSITION PRODUCTS:
Thermal and electrical arc decomposition products: GASES--fluorides of sulfur (particularly sulfuryl fluoride, a convulsant, and thionyl fluoride and thionyl tetrafluoride, pulmonary irritants).
SOLIDS--metal fluorides and sulfides which can be highly toxic and irritating.

HAZARDOUS POLYMERIZATION?
Will not occur.

11. TOXICOLOGICAL INFORMATION

IMMEDIATE (ACUTE) **EFFECTS:**
LD50 (rabbit): intravenous, 5790 mg/kg

DELAYED (SUBCHRONIC & CHRONIC) EFFECTS:
None cited.

OTHER DATA:
None.

12. ECOLOGICAL INFORMATION

Not **applicable** (inorganic).

13. DISPOSAL CONSIDERATIONS

RCRA:
Is **the unused** product a RCRA hazardous waste **if discarded?** No.
If yes, :he RCRA ID number is: Not applicable.

OTHER DISPOSAL CONSIDERATIONS:

The information offered here **is** for the product as **shipped.** Use and/or alterations to **the** product **such as mixing with other** materials may significantly change **the characteristics** of **the** material and alter the **RCRA classification and** :he proper **disposal** method.

 Continued on Page 5

MATERIAL SAFETY DATA SHEET
ACCUDRI® SF6 - Sulfur Hexafluoride

14. TRANSPORT INFORMATION

US DOT HAZARD CLASS: 2.2 - NONFLAMMABLE GAS

US DOT ID NUMBER: UN1080

For additional information on shipping regulations affecting this material, contact the information number found on the first page.

15. REGULATORY INFORMATION

TOXIC SUBSTANCES CONTROL ACT (TSCA):
TSCA INVENTORY STATUS: Material is on the TSCA chemical inventory.

OTHER TSCA ISSUES: None.

SARA TITLE III/CERCLA:
RQs & TPQs:
"Reportable Quantities" (RQs) and/or "Threshold Planning Quantities" (TPQs) exist for the following ingredients.

Ingredient	SARA/CERCLA RQ(lbs)	SARA EHS TPQ(lbs)
No ingredients listed in this section		

Spills resulting in the loss of any ingredient at or above its RQ requires immediate notification to the National Response Center (1-800-424-8802) and to your Local Emergency Planning Committee.

SECTION 311 HAZARD CLASS: Immediate. Pressure.

SARA 313 TOXIC CHEMICALS:
The following ingredients are SARA 313 "Toxic Chemicals". CAS #'s and wt.% are found in section #2.

Ingredient	Comment
No ingredients listed in this section	

STATE RIGHT TO KNOW:

In addition to the ingredients found in section 2, the following are listed for state right-to-know purposes:

Ingredient	Wt.%	Comment
No ingredients listed in this section		

ADDITIONAL REGULATORY INFORMATION:
None.

WHMIS CLASSIFICATION (CANADA):
Not determined.

FOREIGN INVENTORY STATUS:
Canadian DSL (Domestic Substances List)
EINECS (European Inventory of Existing Commercial Chemical Substances)

 Continued on Page 6

MATERIAL SAFETY DATA SHEET
ACCUDRI® SF6 - Sulfur Hexafluoride

16. OTHER INFORMATION

CURRENT ISSUE DATE: August 1992
PREVIOUS ISSUE DATE: May 1589

***CHANGES* TO MSDS FROM PREVIOUS ISSUE DATE ARE DUE TO THE FOLLOWING:**
Conversion of existing product MSDS to new format.

OTHER INFORMATION: None. . .

APPENDIX 8. AIR QUALITY MODEL ANALYSIS

Meteorology Division
Dugway Proving Ground
Technical Note 93-70-1R
29 **March** 1993

DISPERSION MODEL ANALYSIS **OF** THE MAXIMUM AIR QUALITY IMPACT **OF** THE DO49 LONG-RANGE OVERWATER DIFFUSION EXPERIMENT

BACKGROUND

The Long-Range Overwater Diffusion (LROD) Experiment is a scientific experiment that will be conducted by **U.S.** Army Dugway Proving Ground (DPG), the National Oceanic and Atmospheric Administration (NOAA), and **U.S.** Air Force. As discussed by Bowers (1992), LROD is designed ***to*** fill an important data gap affecting the accuracy of transport and diffusion model predictions for short-term releases of air pollutants. The data collected during LROD will be of considerable scientific interest and will contribute to an improved understanding and modeling of accidental releases of hazardous materials.

LROD is currently scheduled to be conducted within the airspace of the Pacific Missile Range Facility, Barking Sands, Kauai, Hawaii during July **1993.** During each trial, a cloud of the gaseous tracer sulfur hexafluoride (SF_6) will be released more than 22 km (12 mm) offshore by an Air Force **C-130** aircraft flying perpendicular to the mean wind direction. The typical release will be 9.6 g m^{-1} of SF, over a distance of up to 100 km for a total of approximately 960 **kg** of **SF,** per trial. The tracer cloud **will** be sampled by continuous real-time SF_6 samplers mounted on ships deployed at various downwind distances up to **100** km from the release line. As the tracer cloud moves downwind, it will also be sampled by an SF, sampler mounted in a second aircraft. A maximum **of** 20 trials are planned. The SF_6 dissemination and sampling **will** be performed **by** the National Oceanic and Atmospheric Administration (NOAA) Environmental Research Laboratories, Atmospheric Research Laboratory, Field Research Division (ARLFRD). NOAA ARLFRD has over 20 years of experience in performing similar **SF,** tracer studies for agencies **of** the **U.S.** Government, including the Environmental Protection Agency.

Sulfur hexafluoride is an inert, colorless, odorless gas that is the principal material in current use as an atmospheric tracer because: **(1)** it has no known adverse environmental effects, (2) it can be detected at very low concentrations (a few parts per trillion), and (3) the atmospheric background concentration is well below the detection threshold. There are two potential hazards associated with SF_6. First, if released in a confined area in sufficient quantities, it can present an asphyxiation hazard. Second, if raised to a temperature above about 800 °C, it can decompose into toxic fluoride and sulfur oxide compounds. Neither hazard exists for LROD. The Threshold Limit Value (TLV) and Permissible Exposure Limit (PEL) established for exposure to SF_6 over an 8-hour work day are both 6,000 mg m^{-3} (1,000 parts per million). The purpose of this technical note is to use dispersion modeling to estimate the maximum SF_6 concentrations that will be produced near the ocean surface by the LROD trials for comparison with the TLV/PEL.

CALCULATION PROCEDURES

The air quality impact of the LROD test was calculated using DPG's Real-Time Volume Source [Dispersion] Model (RTVSM) (Bjorklund, 1990). Table 1 summarizes the source inputs assumed in the RTVSM calculations. The release height of 50 m is the lowest that the aircraft will be above the ocean surface during dissemination. Release heights higher than 50 m will result in lower maximum SF_6 concentrations near the ocean surface than predicted for a 50-m release height. The initial cloud dimensions in Table 1 were obtained by dividing the wingspan of a C-130 transport by 4.3 to account for the effects on initial cloud growth of the aircraft's wingtip vortices.

The U.S. Naval Weather Service Command's Summary of Synoptic Meteorological Observations (SSMO) for Hawaiian and Selected North Pacific Island Coastal Marine Areas (Volume I, June 1971) indicates that a relatively narrow range of meteorological conditions can be expected west of Kauai during the month of July. (The high frequency of favorable meteorological conditions was a major factor in selecting this location and time period for LROD.) Table 2 gives the meteorological conditions for three cases that cover the range of expected conditions. The [Monin-]Obukhov lengths in Table 2 were calculated from the wind speed, air temperature, water temperature, and relative humidity using

Table 1. Source Inputs Assumed in the RTVSM Calculations.

Parameter	Parameter Value
SF_6 Dissemination Height (m)	50
SF_6 Dissemination Rate (g m^{-1})	9.6
SF_6 Line Source Length (km)	100
SF_6 Initial Cloud Dimensions[a]	
Alongwind (m)	9.4
Vertical (m)	9.4

[a] Standard deviations of initial alongwind and vertical concentration distributions.

Table 2. Meteorological Conditions Assumed for LROD Experiment.

	Parameter Value		
Parameter	Case 1	Case 2	Case 3
Wind Speed at 10 m (m s^{-1})	5	10	5
Air Temperature (°C)	24	26	28
Water Temperature (°C)	25	26	27
Relative Humidity (%)	80	75	70
Obukhov Length	-27.7	-194.4	-533.3

virtual temperatures as recommended by DiCristofaro and Hanna (1989) to account for latent heat effects on stability. The atmospheric stabilities represented by the three cases range from slightly unstable to neutral.

Table 3 lists the RTVSM meteorological inputs for the three cases summarized in Table 2. With the exception of the mixing depths and 10-m wind speeds, the inputs in Table 3 were derived from the information in Table 2 using the procedures developed by DiCristofaro and Hanna (1989) for the Minerals and Management Service's Offshore and Coastal Dispersion (OCD) Model. Because RTVSM uses a power-law rather than logarithmic wind profile, the wind-profile exponents in Table 3 were obtained from logarithmic least-squares regression fits to the OCD wind profiles for the first 100 m above the ocean. The mixing depth of 2,000 m assumed for all three cases is the typical depth of the marine boundary layer in Hawaiian waters (Hahn et al., 1992).

Table 3. Meteorological Inputs Assumed in the RTVSM Calculations.

Parameter	Parameter Value		
	Case 1	Case 2	Case 3
Wind Speed at 10 m (m s^{-1})	5	10	5
Wind-Profile Exponent	0.05	0.08	0.07
Turbulence Intensities			
Lateral (rad)	0.128	0.091	0.042
Vertical (rad)	0.062	0.057	0.047
Mixing Depth (m)	2,000	2,000	2,000

RESULTS

Figures 1 and 2 show the calculated centerline profiles of peak instantaneous SF_6 concentration and total SF_6 dosage (time-integrated concentration), respectively. Both figures show that the maximum air quality impact of LROD will occur between about 0.5 and 1.0 km downwind from the dissemination line as the tracer cloud first mixes to the surface. Figure 1 shows that the peak instantaneous concentration decreases with downwind distance beyond 1 km, but that the rate of decrease changes at 20-30 km as the tracer cloud fills the surface mixing layer. Similarly, Figure 2 shows that the centerline dosage becomes constant beyond 20-30 km. These results are explained by the following: (1) no further vertical mixing is possible after the cloud fills the surface mixing layer, (2) atmospheric mixing from either end of the line source has not yet reached the center of the cloud at 100 km downwind, and (3) integration over the duration of cloud passage removes the effects of alongwind mixing from the total dosage. At distances beyond 100 km, mixing from the ends of the line source and variations in the mixing depth will eventually cause the dosage at the cloud centerline to decrease once again with distance from the release line.

As discussed above, the TLV and PEL for exposure to SF_6 are both 6,000 mg m^{-3} for an 8-hour period. In contrast, the peak instantaneous concentrations in Figure 1 are only about 0.8-1.4 mg m^{-3}, depending on the case. The total dosages in Figure 2 can be used to estimate the maximum 8-hour average SF_6 concentrations that might occur on any LROD test day. The maximum dosages in Figure 2 range from 0.13 to 0.28 mg min m^{-3} between 0.5 to 1.0 km from the dissemination line. Assuming that two trials are conducted under the same meteorological conditions during an 8-hour period, the maximum total dosages for two trials range from 0.26 to 0.56 mg min m^{-3}. If these dosages are averaged over 8 hours, the resulting maximum 8-hour average SF_6 concentrations range from 0.0005 to 0.0012 mg m^{-3}, which is less than the allowable exposure by a factor of about 5 million. Thus, the model calculations show that the air quality impact of LROD will be negligible.

REFERENCES

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Bowers, J. F., 1992: Literature review of long-range overwater transport and diffusion. Report No. DPG/JOD-92/036, U.S. Army Dugway Proving Ground, Dugway, UT.

DiCristofaro, D. C. and S. R. Hanna, 1989: OCD: The Offshore and Coastal Dispersion Model, volume I: User's guide. Sigma Research Corporation Report No. A085-1 prepared for Minerals Management Service, Herndon, VA.

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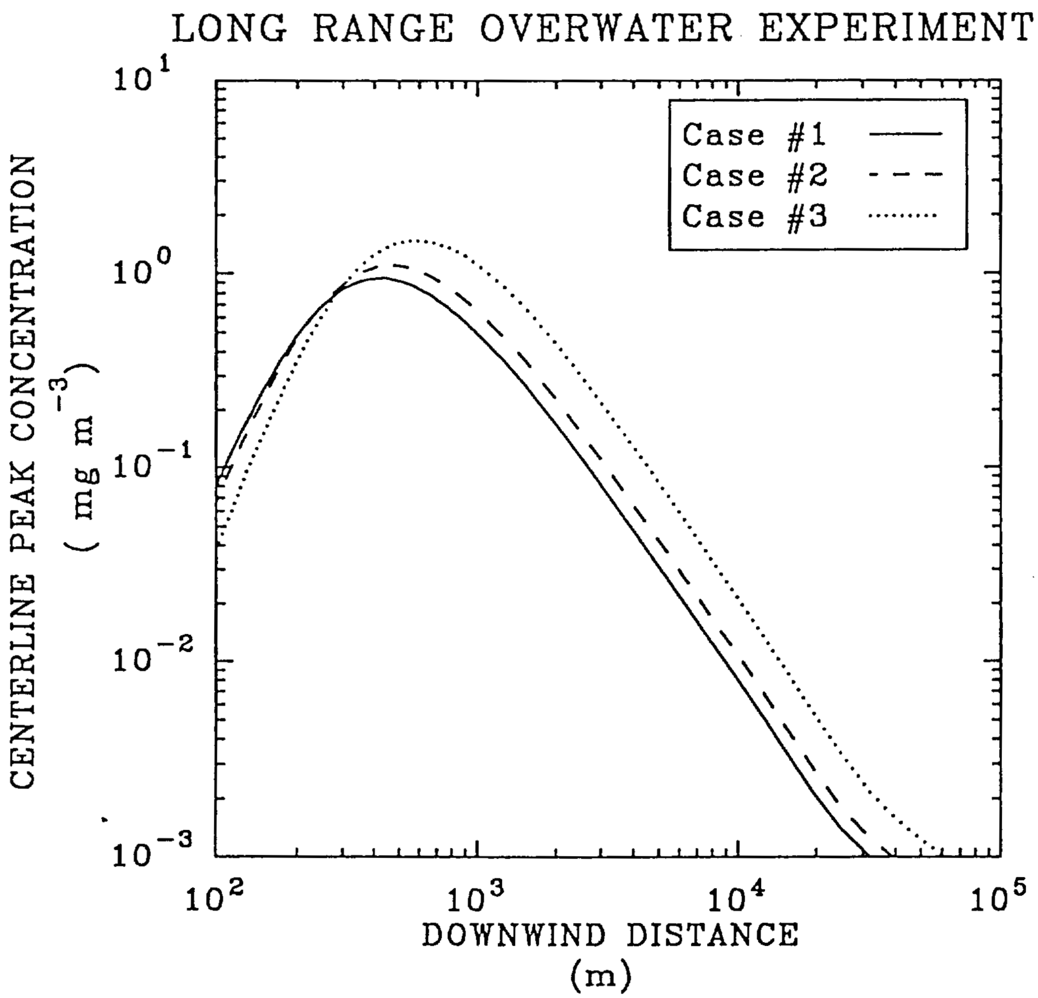

Figure 1. Calculated centerline profiles of peak instantaneous SF_6 concentration versus downwind distance for the LROD experiment. See Tables 2 and 3 for definition of the three meteorological cases.

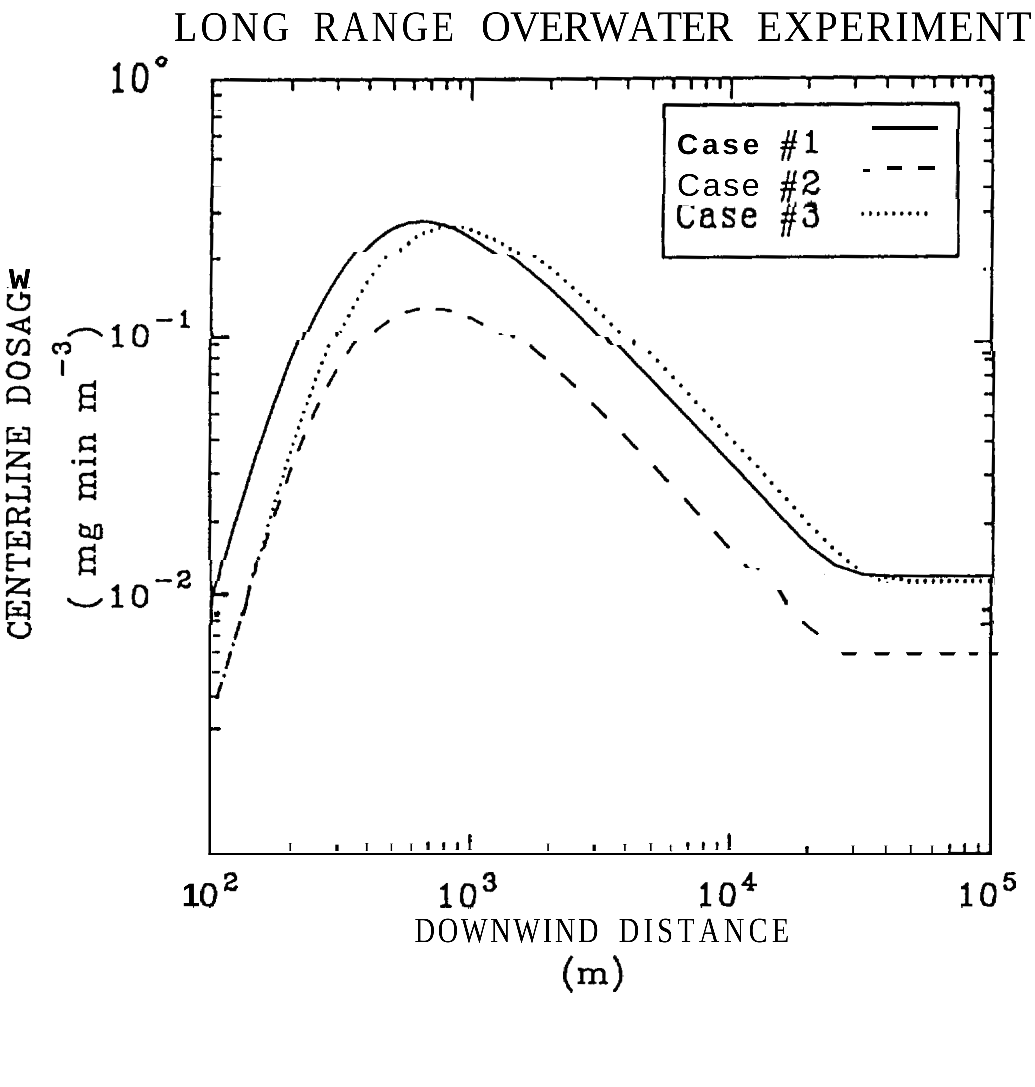

Figure 2. **Calculated centerline profiles of total dosage (time-integrated concentration) versus downwind distance for a single trial of the LROD experiment. See Tables 2 and 3 for definition of the three meteorological cases.**

APPENDIX C. AGENCIES AND PERSONS CONTACTED

C-1. U.S. Army Dugway Proving Ground, Utah

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C-4. Pacific Missile Range Facility
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C-5. Pacific Fleet Environmental Office
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Joseph Cook

C-6 National Oceanic and Atmospheric Administration
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Timothy Crawford

APPENDIX D. LIST OF PREPARERS

This environmental assessment was prepared by the Materiel Test Directorate, U.S. Army Dugway Proving Ground, Utah. The preparers were:

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Research Biologist
Environmental Technology Section
Life Sciences Division

James F. Bowers
Chief, Meteorology Division

Christina M. Wheeler
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APPENDIX F. ABBREVIATIONS

ACGIH - American Conference of Government and Industrial Hygienists

ARLFRD - Air Resources Laboratory Field Research Division

CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act

DOT - U.S. Department of Transportation

DPG - U.S. Army Dugway Proving Ground

EA - environmental assessment

EPA - U.S. Environmental Protection Agency

ERL - Environmental Research Laboratories

FWPCA - Federal Water Pollution Control Act

LROD - long-range overwater diffusion

MSDS - material safety data sheet

NAAQS - National Ambient Air Quality Standards

NOAA - National Oceanic and Atmospheric Administration

NSWC - U.S. Naval Surface Warfare Center

OSHA - Occupational Safety and Health Administration

PEL - permissible exposure limit

PMRF - Pacific Missile Range Facility

ppt - parts per trillion

RCRA - Resource Conservation and Recovery Act

RTVSM - Real-Time Volume Source [Dispersion] Model

SF_6 - sulfur hexafluoride

STEL - short term exposure limit

TLV - threshold limit value

TSCA - Toxic Substances Control Act

VLSTRACK - Vapor, Liquid, and Solid Tracking Model

APPENDIX G. GLOSSARY

advection - process of transport of an atmospheric property solely by the mass motion of the atmosphere

LD, - A calculated dose of a substance introduced by any route, other than inhalation, which is expected to cause death to 50 percent of a defined experimental animal population.

marine boundary layer - surface boundary layer over ocean or large body of water

mean wind direction - horizontal wind direction averaged over a specified period (usually 10 minutes to one hour); direction is the direction from which the wind is flowing

micrometeorological characteristics - those parameters (means and variances of orthogonal wind components; vertical fluxes of heat, water vapor, and momentum, etc.) that describe the turbulent state of the surface boundary layer

permissible exposure limit (PEL) - the average concentration of toxic gas to which the normal person can be exposed without injury for 8 hours per day, 5 days per week for an unlimited period

perturbation - disturbance

ruderal - growing in rubbish, poor land, or waste

specific gravity - ratio of the mass of a solid or liquid to the mass of an equal volume of distilled water at 4°C or of a gas to an equal volume of air or hydrogen under prescribed temperature and pressure conditions

sublimation point - the temperature at which the vapor pressure of the solid phase of a compound is equal to the total pressure of the gas phase in contact with it; analogous to the boiling point of a liquid

surface boundary layer - that part of the lower atmosphere that is directly influenced by the presence of the earth's surface

threshold limit value (TLV) - the average concentration of toxic gas to which the normal person can be exposed without injury for 8 hours per day, 5 days per week for an unlimited period

time-integrated concentration - concentration of airborne material at a fixed point integrated over specified time limits (usually the time of passage of a cloud of material over a point)

vapor pressure - the pressure exerted by a vapor in equilibrium with its solid or liquid phase