



**National Aeronautics and  
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# **Final Programmatic Environmental Impact Statement for the Mars Exploration Program**





**FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT  
STATEMENT FOR THE MARS EXPLORATION  
PROGRAM**

**Science Mission Directorate  
National Aeronautics and Space Administration  
Washington, DC 20546**

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# FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR THE MARS EXPLORATION PROGRAM

## ABSTRACT

LEAD AGENCY: National Aeronautics and Space Administration  
Washington, DC 20546

POINT OF CONTACT FOR INFORMATION: Mark R. Dahl  
Mission and Systems Management Division  
Science Mission Directorate  
NASA Headquarters  
Washington, DC 20546  
(202) 358-4800

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This Final Programmatic Environmental Impact Statement (FPEIS) has been prepared by the National Aeronautics and Space Administration (NASA) in accordance with the National Environmental Policy Act (NEPA) of 1969, as amended, to assist in the decision-making process for the Mars Exploration Program (MEP). The FPEIS addresses the potential environmental impacts associated with continuing the preparations for and implementing the MEP.

The MEP would be a science-driven, technology-enabled effort to characterize and understand Mars using an exploration strategy which focuses on evidence of the presence of water. Following the pathways and cycles of water may lead to preserved ancient records of biological processes, as well as the character of environments on Mars. The Proposed Action addresses the preparation for and implementation of a coordinated series of robotic orbital, surface, and atmospheric missions to gather scientific data on Mars and its environments through 2020. Continued planning for sample return missions, which would enable study of Martian samples in Earth-based laboratories, would be included. Some MEP missions could use radioisotope power systems for electricity, radioisotope heater units for thermal control, and small quantities of radioisotopes in science instruments for experiments and instrument calibration. Environmental impacts associated with specific missions would be addressed in subsequent environmental documentation as required.

This FPEIS presents an overview of the currently-proposed MEP missions, available launch vehicles, the affected environment and the potential environmental consequences associated with the Proposed Action (the Preferred Alternative), the alternative to the Proposed Action, and the No Action Alternative.

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## EXECUTIVE SUMMARY

This Final Programmatic Environmental Impact Statement (FPEIS) has been prepared by the National Aeronautics and Space Administration (NASA) in accordance with the National Environmental Policy Act, as amended (42 U.S.C. 4321 *et seq.*) (NEPA); Executive Order (EO) 12114, *Environmental Effects Abroad of Major Federal Actions*; Council on Environmental Quality Regulations for implementing the procedural provisions of NEPA (40 CFR parts 1500–1508); and NASA policies and procedures at 14 CFR subpart 1216.3. The purpose of this FPEIS is to assist in the decision-making process concerning the Proposed Action, the implementation of the Mars Exploration Program (MEP), or its alternatives. The MEP would consist of a long-term, science-driven effort to characterize and understand Mars as a dynamic system—its present and past environment, climate cycles, geology, and biological potential.

The proposed MEP would encompass NASA's Mars robotic mission activities and research and as a goal would send at least one spacecraft to Mars during each launch opportunity extending through the first two decades of the twenty-first century. The coordinated MEP missions would support data collection and technology demonstrations critical to planning and implementing sample return missions and to planning future human missions to Mars.

### PURPOSE AND NEED FOR THE ACTION

With the MEP, NASA would establish a series of objectives to address the open scientific questions associated with the exploration of the planet. These objectives have been organized by the program as follows:

- determine if life exists or has ever existed on Mars,
- understand the current state and evolution of the atmosphere, surface, and interior of Mars, and
- develop an understanding of Mars in support of possible future human exploration.

The purpose of the action addressed in this FPEIS is to further the scientific goals of the MEP by continuing the exploration and characterization of the planet. On the basis of the knowledge gained from prior and ongoing missions (*i.e.*, the early Mariners, Viking, Mars Pathfinder, Mars Global Surveyor (MGS), Mars Odyssey, and the Mars Exploration Rovers), it appears that Mars, like Earth, has experienced dynamic interactions among its atmosphere, surface, and interior that are, at least in part, related to water. Following the pathways and cycles of water has emerged as a strategy that possibly may lead to a preserved record of biological processes, as well as the character of ancient environments on Mars. In addition to understanding the history of Mars, investigations undertaken in the MEP may shed light on current environments that could support existing biological processes.

Each mission in the long-term series would contribute incrementally to the overall program objectives, gathering data that builds upon the knowledge and insights gained from prior missions. Thus, MGS and Mars Odyssey continue the global reconnaissance

of the planet with studies of the Martian atmosphere, interior, magnetic field, and chemical and physical characteristics of the surface. The Mars Exploration Rover missions, launched in 2003, are intensively studying diverse local areas of the planet's surface and are providing data that are essential for placing the global data in a more meaningful context. Future missions encompassed by the Proposed Action would continue the systematic exploration of Mars begun by NASA with MGS in 1996, building upon the scientific data already returned and expected to be returned.

## **ALTERNATIVES EVALUATED**

The Proposed Action (Alternative 1, the Preferred Alternative) would consist of a long-term program that, as a goal, sends at least one spacecraft to Mars during each launch opportunity extending through the first two decades of the twenty-first century. Efficient launch opportunities to Mars occur approximately every 26 months. MEP missions would be launched on expendable launch vehicles (e.g., Delta or Atlas class) from either Cape Canaveral Air Force Station (CCAFS), Florida, or Vandenberg Air Force Base (VAFB), California.

The MEP would encompass NASA's Mars robotic mission activities and research undertaken to characterize the planet and its atmosphere, its geologic history, its climate and the relationship to Earth's climate change process; determine what resources it provides for future exploration; and undertake sample return missions in support of the search for evidence of past or present life on Mars. Each mission in the long-term series would contribute incrementally to the overall program objectives, gathering data which builds upon the knowledge and insights gained from prior missions. The MEP missions would also support data collection and technology demonstrations critical to planning future human missions to Mars.

International participation in the MEP could include, but not be limited to, the Canadian Space Agency, the European Space Agency (ESA), the French Space Agency, the German Space Agency, the Italian Space Agency, and the Russian Space Agency.

In the first decade of this century, MEP missions would focus on global reconnaissance of the planet and its environment, and *in situ* atmospheric or surface science investigations. The return of the first samples of Martian soil and rock could be undertaken in the following decade. The earlier missions, in addition to other purposes, would facilitate the sample return missions by identifying those areas of Mars most likely to contain samples of scientific importance, including potential evidence of past biological activity.

Under the Proposed Action, the MEP would consist of a series of robotic orbital, surface, and atmospheric missions to Mars. Some spacecraft could use radioisotope power systems (RPS) for continuous electrical power, radioisotope heater units (RHU) for thermal control, and small quantities of radioisotopes in science instruments for experiments and instrument calibration. At this time, it is envisioned that the MEP missions through the first decade would consist of the following:

- 2001 Launch Opportunity—NASA's Mars Odyssey orbiter was launched on April 7, 2001 and is currently in orbit about Mars.

- 2003 Launch Opportunity—NASA’s Mars Exploration Rovers (MER) project consists of two missions to send two identical rovers to two different sites on the surface of Mars. *Spirit* and *Opportunity* were launched in June and July, respectively, and successfully landed on Mars in January 2004. Each rover uses eight RHUs to provide thermal control. In addition, ESA’s Mars Express mission, consisting of an orbiter and the *Beagle 2* lander, was launched in June. Mars Express successfully entered orbit at Mars on December 25, 2003; *Beagle 2* was deemed lost after attempts to communicate with it failed after the scheduled landing on December 25.
- 2005 Launch Opportunity—NASA’s Mars Reconnaissance Orbiter (MRO) is intended to narrow the focus of potential landing sites to search for the most compelling indicators for bearing life.
- 2007 Launch Opportunity—A series of small, narrowly-focused missions, called Mars Scouts, is currently proposed to explore Mars at every other launch opportunity. The first Mars Scout mission, a lander called *Phoenix*, would be launched during this opportunity.
- 2009 Launch Opportunity—NASA’s Mars Science Laboratory (MSL) would conduct surface and sub-surface investigations to examine the aqueous history of Mars and search for potential building blocks of life. The MSL could utilize a RPS to provide uninterrupted electrical power. NASA would also launch a Mars Telecommunications Orbiter during this opportunity.
- 2011 Launch Opportunity—A second Mars Scout mission is proposed for launch during this opportunity.

Missions beyond 2011 could use orbiters, rovers, and landers and could include the first mission to return Martian samples. As new information and techniques become available during the course of the program, the timing, focus, and objectives of MEP missions in the second decade could be redirected.

Under Alternative 2, NASA would continue to explore Mars through 2020, but on a less frequent, less comprehensive, mission-by-mission basis. These missions may include international partners. Any mission proposed to continue the exploration of Mars would be developed and launched within the broader context of all other missions proposed for exploring other parts of the solar system. Robotic orbital, surface, and atmospheric missions could be used to explore Mars and could include sample return missions. Landed spacecraft could use RPSs for power generation or RHUs for thermal control of temperature-sensitive components in the spacecraft. Some spacecraft may carry small quantities of radioisotopes in science instruments for experiments and for instrument calibration.

Under the No Action Alternative, NASA would discontinue planning for and launching robotic missions to Mars through 2020. Currently operating NASA spacecraft at or en route to Mars would continue their missions to completion. New science investigations of Mars would only be made remotely from Earth-based assets, *i.e.*, ground- or space-based observatories, or from spacecraft developed and launched to Mars by non-U.S. space agencies.

## **ENVIRONMENTAL IMPACTS OF THE ALTERNATIVES INCLUDING THE NO ACTION ALTERNATIVE**

The environmental impacts of the Proposed Action and Alternatives are discussed in this FPEIS from a programmatic perspective. Because this FPEIS is being prepared during the planning stages for the MEP, specific proposed projects and missions within the MEP are only addressed in terms of a broad, conceptual framework. Each project or mission within the MEP that would propose use of RPSs or RHUs would be the subject of additional environmental documentation. While detailed analyses and test data for each spacecraft-launch vehicle combination are not yet available, there is sufficient information from previous programs and existing NEPA documentation to assess the potential environmental impacts.

Since the Proposed Action and Alternative 2 may include United States participation in foreign missions, NASA has also considered the environmental impacts of each action on the global commons and foreign nations in accordance with Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*, and NASA's *Procedural Requirements for Implementing the National Environmental Policy Act and Executive Order 12114* (NASA 2001b).

Under the No Action Alternative, launches of robotic missions to Mars by the U.S. would cease through 2020.

### **Nonradiological Consequences of the Alternatives**

The nonradiological environmental impacts associated with normal spacecraft launches from both CCAFS and VAFB have been addressed in previous environmental documentation (e.g., USAF 1998, USAF 2000, NASA 2002a). Rocket launches are discrete events that cause short-term impacts on local air quality. However, because launches are relatively infrequent events, and winds rapidly disperse and dilute the launch emissions to background concentrations, long-term effects from exhaust emissions would not be anticipated. If solid rocket motors are used, surface waters in the immediate area of the exhaust cloud might temporarily acidify from deposition of hydrogen chloride. Launching a mission during each opportunity to Mars (approximately every 26 months) under the Proposed Action or less frequently under Alternative 2 would result in negligible release of ozone-depleting chemicals with no anticipated long-term cumulative impacts.

A variety of accidents could occur during preparations for and launch of an expendable launch vehicle. Only two types of nonradiological accidents would potentially have consequences beyond the immediate vicinity of the launch site: a large liquid propellant spill during fueling operations, and a launch failure.

Of the postulated propellant spill accident scenarios, the most severe involves the release of nitrogen tetroxide. Toxic effects of the release would be limited to the immediate vicinity of the launch complex. A launch vehicle accident either on or near the launch pad within a few seconds of liftoff presents the greatest potential for impact to human health, principally to workers. CCAFS and VAFB use models to predict launch hazards to the public and on-site personnel prior to every launch. These models calculate the risk of injury resulting from debris and blast overpressure from a potential launch failure, and from exposure to toxic gases from either a normal launch or a

potential launch failure. Launches are postponed if the predicted risk of injury exceeds acceptable limits.

The potential short-term effects of an accident would include a localized fireball, falling fragments from explosion of the vehicle, release of unburned propellants and propellant combustion products, and for on-pad or very low altitude explosions, death or damage to nearby biota and brush fires near the launch pad. For missions using solid rocket motors, large pieces of unburned solid propellant would fall to the ground and may enter the ocean or nearby surface water bodies. Some mortality to aquatic life in that area would be expected until the propellant is fully dissolved; however, no long-term impacts are anticipated. Ground fires and debris resulting from an accident could damage or destroy nearby historic structures and archaeological sites.

Under the No Action Alternative no new robotic missions to Mars would be launched by the U.S. through 2020. There would only be potential socioeconomic impacts as some jobs in selected industries could be displaced or lost and tourism to view the launches would not occur.

### **Radiological Consequences of the Proposed Action and Alternative 2**

One or more of the missions to Mars could propose the use of radioisotopes under the Proposed Action and Alternative 2. Small quantities of radioisotopes may be used for instrument calibration or to enable science experiments, and RHUs or RPSs containing varying amounts of plutonium dioxide may be used to supply heat and electric power, respectively. Under both alternatives NASA will determine the appropriate level of NEPA documentation required for any mission proposing use of radiological material. If required, a nuclear risk assessment will be developed by the U.S. Department of Energy to address the human health and environmental risks associated with the use of radioactive material.

Plutonium-238 is the principal radionuclide of concern. It is used, in the form of plutonium dioxide, in RHUs and in the General Purpose Heat Source (GPHS) modules used for RPSs. Each RHU contains approximately 2.7 grams (0.1 ounce) of plutonium dioxide, having approximately 33.2 curies of activity. Each GPHS module contains approximately 600 grams (21 ounces) of plutonium dioxide, having approximately 7,400 curies of activity.

A nuclear risk assessment was developed for the MER-2003 project (NASA 2002b). Many of the parameters that determine the risks for a specific mission are expected to be similar to those associated with previous missions (*e.g.*, Galileo (NASA 1989), Ulysses (NASA 1990), and Cassini (NASA 1995a and NASA 1997)), including the MER-2003 project. Mission-specific factors that affect the estimated risk include: (1) the amount and type of radioactive material used in a mission, (2) the protective features of the devices containing the radioactive material, (3) the probability of an accident which can threaten the radioactive material, and (4) the accident environments (*e.g.*, propellant fires, debris fragments, and blast overpressure). The risks associated with a Mars exploration mission carrying radioactive material are, therefore, expected to be similar to those estimated for earlier missions. The population and individual risks associated with prior missions that have made use of radioactive material have all been shown to be relatively small.

## **SCIENCE COMPARISON**

Under the Proposed Action, NASA would implement a series of missions to Mars through the second decade of the twenty-first century to begin addressing fundamental scientific questions about the planet and its history. A fundamental precept of the Proposed Action is the cumulative gains in knowledge that can be achieved through the planned missions. NASA, and its international partners in the MEP, would maintain a level of flexibility in the planning of future missions, possibly redirecting the type and focus of specific missions based on the findings from prior missions. The ability to conduct long-term, detailed exploration of selected sites on the planet's surface is a critical aspect of this process, as is planning for the eventual return to Earth of samples of Martian soil and rock.

Under Alternative 2, NASA would abandon plans for sending coordinated scientific spacecraft to Mars during every possible launch opportunity through 2020. A decision to proceed with a mission to Mars in any future launch opportunity would be based on the merits of the proposed mission's specific science objectives and the resources available to implement it. The objectives of such a mission may not necessarily build upon the knowledge gained from previous missions to Mars; furthermore, any succeeding missions may not necessarily build upon the proposed mission's accomplishments.

Under the No Action Alternative, NASA would abandon plans for sending robotic scientific spacecraft to Mars through 2020. After currently-operating spacecraft have completed their missions, no new science would be gathered by NASA spacecraft from Mars orbit or from the planet's surface.

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## ABBREVIATIONS AND ACRONYMS

	<b>A</b>		
Al	aluminum	DOD	U.S. Department of Defense
Al <sub>2</sub> O <sub>3</sub>	aluminum oxide	DOE	U.S. Department of Energy
Am	americium	DOI	U.S. Department of the Interior
ANL-W	Argonne National Laboratories - West	DPEIS	Draft Programmatic Environmental Impact Statement
APXS	Alpha Particle X-ray Spectrometer		
ASI	Agenzia Spaziale Italiana		
	<b>B</b>		<b>E</b>
BEBR	Bureau of Economic and Business Research	EFH	essential fish habitat
		EO	Executive Order
	<b>C</b>	EPA	U.S. Environmental Protection Agency
Ca	calcium	ESA	European Space Agency
CAA	Clean Air Act	EWR	Eastern and Western Range
CARB	California Environmental Protection Agency Air Resources Board		
CCAFS	Cape Canaveral Air Force Station		<b>F</b>
CDS	Command Destruct System	FAA	Federal Aviation Administration
CEQ	Council on Environmental Quality	FDEP	Florida Department of Environmental Protection
CFR	Code of Federal Regulations	Fe	iron
Ci	curie(s)	FONSI	Finding of No Significant Impact
Cl	chlorine	FPEIS	Final Programmatic Environmental Impact Statement
Cm	curium	ft	feet
cm	centimeter(s)	FR	Federal Register
CNES	Centre National d'Etudes Spatiales	FTS	Flight Termination System
CO	carbon monoxide	FWS	U.S. Fish and Wildlife Service
CO <sub>2</sub>	carbon dioxide		
COMPLEX	Committee on Planetary and Lunar Exploration		<b>G</b>
CSA	Canadian Space Agency	g	gram(s)
		gal	gallon(s)
	<b>D</b>	GPHS	General Purpose Heat Source
dBA	decibels (A-weighted)	GRS	Gamma Ray Spectrometer
DOC	U.S. Department of Commerce		
			<b>H</b>
		H <sub>2</sub> O	water



SFWMD South Florida Water  
Management District  
SHPO State Historic Preservation  
Officer  
SJRWMD St. Johns River Water  
Management District  
SLC space launch complex  
SO<sub>2</sub> sulfur dioxide  
SRG Stirling Radioisotope  
Generator  
SRM solid rocket motor  
SSB Space Studies Board

**U**  
USAF U.S. Air Force  
USBC U.S. Bureau of the Census  
U.S.C. U.S. Code

**V**  
VAFB Vandenberg Air Force  
Base

**X**  
XRD X-ray Diffraction  
Spectrometer  
XRF X-ray Fluorescence  
Spectrometer

## COMMON METRIC/BRITISH SYSTEM EQUIVALENTS

### Length

1 centimeter (cm) = 0.3937 inch	1 inch = 2.54 cm
1 centimeter = 0.0328 foot (ft)	1 foot = 30.48 cm
1 meter (m) = 3.2808 feet	1 ft = 0.3048 m
1 meter = 0.0006 mile (mi)	1 mi = 1609.3440 m
1 kilometer (km) = 0.6214 mile	1 mi = 1.6093 km
1 kilometer = 0.53996 nautical mile (nmi)	1 nmi = 1.8520 km
	1 mi = 0.87 nmi
	1 nmi = 1.15 mi

### Area

1 square centimeter (cm <sup>2</sup> ) = 0.1550 square inch (in <sup>2</sup> )	1 in <sup>2</sup> = 6.4516 cm <sup>2</sup>
1 square meter (m <sup>2</sup> ) = 10.7639 square feet (ft <sup>2</sup> )	1 ft <sup>2</sup> = 0.09290 m <sup>2</sup>
1 square kilometer (km <sup>2</sup> ) = 0.3861 square mile (mi <sup>2</sup> )	1 mi <sup>2</sup> = 2.5900 km <sup>2</sup>
1 hectare (ha) = 2.4710 acres (ac)	1 ac = 0.4047 ha
1 hectare (ha) = 10,000 square meters (m <sup>2</sup> )	1 ft <sup>2</sup> = 0.000022957 ac

### Volume

1 cubic centimeter (cm <sup>3</sup> ) = 0.0610 cubic inch (in <sup>3</sup> )	1 in <sup>3</sup> = 16.3871 cm <sup>3</sup>
1 cubic meter (m <sup>3</sup> ) = 35.3147 cubic feet (ft <sup>3</sup> )	1 ft <sup>3</sup> = 0.0283 m <sup>3</sup>
1 cubic meter (m <sup>3</sup> ) = 1.308 cubic yards (yd <sup>3</sup> )	1 yd <sup>3</sup> = 0.76455 m <sup>3</sup>
1 liter (l) = 1.0567 quarts (qt)	1 qt = 0.9463264 l
1 liter = 0.2642 gallon (gal)	1 gal = 3.7845 l
1 kiloliter (kl) = 264.2 gal	1 gal = 0.0038 kl

### Weight

1 gram (g) = 0.0353 ounce (oz)	1 oz = 28.3495 g
1 kilogram (kg) = 2.2046 pounds (lb)	1 lb = 0.4536 kg
1 metric ton (mt) = 1.1023 tons	1 ton = 0.9072 mt

### Energy

1 joule = 0.0009 British thermal unit (BTU)	1 BTU = 1054.18 joule
1 joule = 0.2392 gram-calorie (g-cal)	1 g-cal = 4.1819 joule

### Pressure

1 newton/square meter (N/m <sup>2</sup> ) = 0.0208 pound/square foot (psf)	1 psf = 48 N/m <sup>2</sup>
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### Force

1 newton (N) = 0.2248 pound-force (lbf)	1 lbf = 4.4478 N
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### Radiation

1 becquerel (Bq) = 2.703 x 10 <sup>-11</sup> curies (Ci)	1 Ci = 3.70 x 10 <sup>10</sup> Bq
1 sievert (Sv) = 100 rem	1 rem = 0.01 Sv

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## 1 PURPOSE AND NEED FOR ACTION

This Final Programmatic Environmental Impact Statement (FPEIS) has been prepared by the National Aeronautics and Space Administration (NASA) to assist in the decision-making process as required by the National Environmental Policy Act, as amended (42 U.S.C. 4321 *et seq.*) (NEPA); Executive Order (EO) 12114, *Environmental Effects Abroad of Major Federal Actions*; Council on Environmental Quality Regulations for implementing the procedural provisions of NEPA (40 CFR parts 1500–1508); and NASA policies and procedures at 14 CFR subpart 1216.3. This FPEIS provides information associated with potential environmental impacts of implementing the Mars Exploration Program (MEP). The MEP would consist of a long-term, science-driven effort to characterize and understand Mars as a dynamic system—its present and past environment, climate cycles, geology, and biological potential. Chapter 2 of this FPEIS evaluates the alternatives considered to achieve the MEP.

### 1.1 BACKGROUND

In 1978, following the successful Viking Orbiter and Lander missions to Mars, the Committee on Planetary and Lunar Exploration (COMPLEX) of the National Academy of Science's Space Science Board (now Space Studies Board) identified a list of prioritized, interconnected primary objectives for the continued exploration of Mars (summarized in SSB 1990). These are to:

- intensively study local areas of the planet;
- explore the structure and general circulation of the Martian atmosphere;
- explore the structure and dynamics of Mars' interior;
- establish the nature of the Martian magnetic field and the character of the upper atmosphere and its interaction with the solar wind; and
- establish the global chemical and physical characteristics of the Martian surface.

COMPLEX further stated that "... the global and *in situ* studies of the planet and the return of Martian material are complementary components of an overall program of investigation; each of the components is separately necessary," and that "... the return of unsterilized surface and subsurface samples to Earth is a major technique for the exploration of Mars."

In an update to its 1978 report, COMPLEX extended and revised these objectives for the exploration of Mars (SSB 1990), emphasizing that:

- the importance of the scientific objectives of study of the Martian atmosphere, interior, magnetic field, and global properties should be given equal priority with the objective of intense study of local areas; and

- the geochemical, isotopic, and paleontological study of Martian surface material for evidence of previous living material should be a prime objective of future *in situ* and sample return missions.

In February of 1994 NASA announced the start of the Mars Surveyor Program (MSP) to address many of the scientific objectives established by COMPLEX. The MSP was initiated with the Mars Global Surveyor mission, launched in November 1996. Global Surveyor is currently operating in orbit about Mars. The Mars Climate Orbiter was launched in December 1998 and was lost during Mars orbit insertion in late September 1999. The Mars Polar Lander was launched in January 1999 and was lost in December 1999 during entry, descent, and landing operations.

Shortly thereafter, an independent assessment team was established by NASA to provide the agency with a number of recommendations for restructuring and reformulating the Mars program. This was followed by a period of intense planning, development, and review as a new architecture for the exploration of Mars was created. Principal among the considerations of the new architecture were the lessons learned from the missions lost in 1999, a realistic assessment of the available technologies and mission elements, and a complete review of the science goals and objectives for the Mars program.

The proposed MEP would consist of a long-term program that sends one or two spacecraft to Mars during each launch opportunity through the year 2020. Favorable launch opportunities to Mars occur approximately every 26 months. The MEP would encompass all of NASA's Mars robotic mission activities and research undertaken to characterize the planet and its atmosphere, its geologic history, its climate and the relationship to Earth's climate change process; to determine what resources Mars provides for future exploration; and to search for evidence of past or present life on Mars. The MEP missions would also support data collection and technology demonstrations critical to planning and carrying out future missions to Mars.

In the near term, MEP missions would focus on global reconnaissance of the planet and its environment, or on *in situ* atmospheric or surface science investigations. A long-term goal is to plan for the return of the first samples of Martian soil and rock. The earlier missions, in addition to other purposes, will facilitate this long-term goal by identifying those areas of Mars most likely to contain samples of scientific importance, including (potentially) evidence of past biological activity. In a recent study assessing the current state of Mars exploration, COMPLEX has expressed endorsement of NASA's proposed strategy for exploring Mars (SSB 2003).

Currently active missions<sup>1</sup> that are now managed within the MEP are the 1996 Mars Global Surveyor, the 2001 Mars Odyssey, and the 2003 Mars Exploration Rovers (MER-2003).

- Mars Global Surveyor was launched on November 7, 1996 and entered orbit about Mars on September 11, 1997. In March 1999 the spacecraft achieved

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<sup>1</sup> Mission opportunities dating back to 1996 are included to document the transition from the MSP to the restructured MEP.

its final mapping orbit to begin the global reconnaissance of Mars. The mission has studied the Martian surface, atmosphere, and interior during the past eight years. Among key science findings, Global Surveyor has taken pictures of gullies and debris flow features that suggest there may have been sources of liquid water, similar to aquifers on Earth, at or near the surface of the planet. Magnetometer readings show that the planet's magnetic field is not globally generated in the planet's core, but is localized in particular areas of the crust. Data from the spacecraft's laser altimeter have given scientists their first three-dimensional views of Mars' north polar ice cap. The prime mission concluded in February 2001 but a mission extension has allowed science mapping activities to continue. Global Surveyor may provide data relay services from spacecraft sent to the surface of Mars.

- Mars Odyssey, launched on April 7, 2001, is an orbiting spacecraft designed to remotely determine the composition of the planet's surface, to detect water and shallow buried ice, and to study the radiation environment, in part to determine its potential effects on the health of future human explorers. The spacecraft arrived at Mars on October 24, 2001, and entered its final mapping orbit in February 2002. Since then Odyssey has mapped virtually the entire surface of Mars. Visual and infrared images have been used to identify possible recent snowpacks on hillsides and to find exposed water ice near the south pole. These images have provided the first complete high resolution map of layered deposits in the south polar regions, and have been used to detect ancient, unweathered volcanic rocks and to map unusual mineral deposits. Maps of gamma rays and high-energy neutrons emitted from the planet have shown abundances of several elements, including silicon, iron, chlorine, potassium, and thorium. These maps have also shown large amounts of water ice buried just beneath the surface over large areas in the polar regions, and the thickness of the annual carbon dioxide frost as the Martian seasons change. The spacecraft has measured the background radiation levels in orbit at Mars, and shown them to be 2 to 3 times that around the Earth. Odyssey's science mission is scheduled to end in September 2006. During its mission Odyssey will also function as a communication relay system for spacecraft sent to the surface of Mars.
- The two identical spacecraft of the MER-2003 project, *Spirit* and *Opportunity*, were launched on June 10, 2003 and July 7, 2003, respectively. The purpose of this project is to place two mobile science laboratories (rovers) on the surface of Mars to conduct geological investigations that will establish surface verification for orbital remote sensing, and to characterize a diversity of rocks and soils which may hold clues to the presence of water at some time in the planet's past. *Spirit* arrived at Mars on January 3, 2004, and *Opportunity* arrived on January 25, 2004. To date, the rovers have explored the surface of Mars in regions over 4.6 kilometers (2.9 miles) from their respective landing sites, investigating up to eight separate locations within each region. Surface

operations for each rover, originally planned to last 90 Martian days (sols<sup>2</sup>), are currently expected to last at least 250 sols.

Although not part of the Mars program, the Mars Pathfinder lander-rover was launched on December 4, 1996, and landed successfully in the Ares Vallis region of Mars on July 4, 1997. Mars Pathfinder was the second mission in NASA's Discovery Program, and was primarily an engineering demonstration of key technologies and concepts for eventual use in future missions to Mars. Engineering milestones of the mission included demonstrating a new way of delivering a spacecraft to the surface of Mars by way of direct entry into the Martian atmosphere, and delivering and operating a semi-autonomous roving vehicle (*Sojourner*) to the surface of another planet. Though designed to last only 30 days, Mars Pathfinder transmitted data for almost 90 days until contact was lost on September 27, 1997. It returned more than 16,000 images from the lander and 550 images from the rover, more than 15 chemical analyses of rocks, and extensive data on winds and other weather factors.

## 1.2 PURPOSE OF THE ACTION

With the MEP, NASA would establish a series of objectives to address the open scientific questions recommended by COMPLEX as being important in the exploration of the planet. These objectives have been organized into a set of three goals to be pursued by the program. These goals are:

- determine if life exists or has ever existed on Mars
  - determine if life exists today
  - determine if life existed on Mars in the past
  - assess the extent of organic chemical evolution on Mars
- understand the current state and evolution of the atmosphere, surface, and interior of Mars
  - characterize the current climate and climate processes of Mars
  - characterize the ancient climate of Mars
  - determine the geological processes that have resulted in formation of the Martian crust and surface
  - characterize the structure, dynamics, and history of the planet's interior
- develop an understanding of Mars in support of possible future human exploration
  - acquire appropriate Martian environmental data such as those required to characterize the radiation environment
  - conduct *in situ* engineering and science demonstrations.

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<sup>2</sup> 1 sol = 1 Martian day = 24 hours, 37 minutes = 1.026 Earth days

The purpose of the action addressed in this FPEIS is to further the scientific goals of the MEP by continuing the exploration and characterization of the planet through systematic, coordinated missions. The scientific objectives for Mars exploration group naturally into those best achieved from orbit, on the planet's surface, or with returned samples, and form the basis for individual mission objectives. The MEP has been structured in such a way as to systematically achieve as many of the scientific objectives as feasible within the practical constraints of available funding and technology readiness. Each mission would contribute incrementally to the overall program objectives, gathering scientific data and demonstrating technological advancements which build upon the knowledge and insights gained from prior missions. Thus, Global Surveyor and Odyssey continue the global reconnaissance of the planet with studies of the Martian atmosphere, interior, magnetic field, and chemical and physical characteristics of the surface. The *Spirit* and *Opportunity* rovers will intensively study diverse, local areas of the planet's surface and provide data that are essential for placing the global data in a more meaningful context.

Future missions encompassed by the Proposed Action would continue the systematic exploration of Mars begun by NASA in 1996, building upon the scientific data already returned and expected to be returned.

### **1.3 NEED FOR THE ACTION**

Among the other planets of our solar system, Mars most captures the human imagination. Visited for the first time by the Mariner 4 spacecraft in July 1965, Mars has long had a special place in NASA's strategy for exploring the solar system. With its huge volcanoes and giant canyons, its polar caps and seasonal changes, and with the evidence of a potentially warmer and wetter past, Mars is unique in its attraction as a target for scientific exploration. Mars is also of special interest because studying it may help unlock the secrets of Earth's evolution and processes. Furthermore, Mars is the most probable target for eventual human exploration beyond the Moon.

On the basis of the knowledge gained from prior and ongoing missions (*i.e.*, the early Mariners, Viking, Mars Pathfinder, Global Surveyor, and Odyssey), Mars, like Earth, is known to have experienced dynamic interactions among its atmosphere, surface, and interior that are, at least in part, related to water. Thus, following the pathways and cycles of water has emerged as a strategy that possibly may lead to discovering a preserved record of biological processes, as well as the character of ancient environments on Mars. In addition to understanding the history of Mars, investigations undertaken in the MEP may shed light on current environments that could support existing biological processes.

In order to understand Mars as a dynamic system, a global context on information about the planet must first be established. The global knowledge can then be validated and expanded through focused surface investigations, verification of remote observations with surface investigations, and targeted reconnaissance from orbit. With a strong foundation of orbital and surface reconnaissance and directed investigations, scientists can then make a well-informed selection of the most promising local sites from which to obtain samples for return to Earth for comprehensive analysis.

## **1.4 NEPA PLANNING AND SCOPING ACTIVITIES**

On July 22, 2003, NASA published a Notice of Intent (NOI) in the *Federal Register* (68 FR 43378) to prepare a Programmatic Environmental Impact Statement and conduct scoping for the Mars Exploration Program. Public input and comments on alternatives, environmental impact issues, and environmental concerns were requested. The scoping period ended on September 5, 2003. One comment was received during this period from an individual who proposed a scientific methodology for detecting the presence of microbial life on the surface of Mars.

All MEP missions will individually require additional environmental documentation. This documentation could be a Tier 2 document (*i.e.*, an environmental assessment or an EIS) under this PEIS or be supported by the environmental decision-making process specified in the *Final Environmental Assessment (EA) for Launch of NASA Routine Payloads on Expendable Launch Vehicles from Cape Canaveral Air Force Station Florida and Vandenberg Air Force Base California* (NASA 2002a). U.S. participation in foreign MEP missions may require documentation under Executive Order (EO) 12114, *Environmental Effects Abroad of Major Federal Actions*.

Planning for Mars Odyssey (formerly called the Mars Surveyor 2001 mission) and the MER-2003 project began prior to final definition of the MEP. Potential environmental impacts of the Mars Odyssey mission and the MER-2003 project have already been discussed in separate NEPA documentation. NASA published a Finding of No Significant Impact for the Mars Surveyor 2001 mission in the *Federal Register* (65 FR 70947, November 28, 2000). The Final EIS for the MER-2003 project was made available (67 FR 76740, December 13, 2002), and the Record of Decision was signed on January 30, 2003.

## **1.5 RESULTS OF PUBLIC REVIEW OF THE DRAFT PEIS**

NASA published its Notice of Availability for the DPEIS for the Mars Exploration Program on April 22, 2004 (69 FR 21865), and mailed copies to 72 Federal, State and local agencies, organizations, and individuals. In addition, the DPEIS was publicly available in electronic format from a NASA server on the Internet. The U.S. Environmental Protection Agency published its Notice of Availability on April 23, 2004 (69 FR 22025), initiating the 45-day review and comment period.

The comment period for the DPEIS closed on June 7, 2004. A total of 10 comment submissions (letters and e-mails) were received: seven from Federal agencies, one from the State of Florida, one from the State of California, and one from the City of Titusville, Florida. No comment submissions were received from any private organizations or individuals. The comments received included “no comment” and recommendations to clarify or correct specific sections of text. All submissions received during the DPEIS public review period are found in Appendix B of this FPEIS.

## 2 DESCRIPTION AND COMPARISON OF ALTERNATIVES

This Final Programmatic Environmental Impact Statement (FPEIS) for the Mars Exploration Program (MEP) evaluates the following alternatives:

- Proposed Action (Alternative 1, the Preferred Alternative): NASA proposes to implement a program for the exploration of Mars that would consist of a coordinated series of robotic orbital, surface and atmospheric missions designed to gather scientific data on the planet and its environment through 2020. NASA would also continue planning for a potential return of Martian surface samples to Earth. One or more spacecraft would be launched at each launch opportunity to Mars, which occurs approximately every 26 months. The proposed program would include United States missions which may include foreign participation, and international missions with U.S. participation. The proposed program would include the option to evaluate, as appropriate, the use of radioisotope heater units (RHUs) or radioisotope power systems (RPSs) to enable specific mission objectives.
- Alternative 2: Under this Alternative, NASA would not implement a coordinated program for the exploration of Mars, but would continue to explore Mars on a less comprehensive, mission-by-mission basis through 2020.
- No Action Alternative: Under the No Action Alternative, NASA would discontinue planning for and launching robotic missions to Mars through 2020.

All MEP missions will individually require additional environmental documentation. For MEP missions to be launched from the U.S., this documentation could be a Tier 2 document (*i.e.*, an environmental assessment (EA) or an EIS) under this PEIS or be supported by the environmental decision-making process (*i.e.*, an environmental checklist) specified in the *Final Environmental Assessment (EA) for Launch of NASA Routine Payloads on Expendable Launch Vehicles from Cape Canaveral Air Force Station Florida and Vandenberg Air Force Base California* (Routine Payloads EA, NASA 2002a). U.S. participation in foreign MEP missions may require documentation under Executive Order (EO) 12114, *Environmental Effects Abroad of Major Federal Actions*.

### 2.1 DESCRIPTION OF THE PROPOSED ACTION (ALTERNATIVE 1)

NASA proposes to implement a coordinated set of robotic orbital, surface and atmospheric missions to gather scientific data on the planet Mars and its environment. Included among these missions would be U.S. missions that may or may not include international participation, as well as international missions with United States participation. It is intended that one or more major United States missions would be launched at every opportunity to Mars (approximately every 26 months) through at least the first two decades of the 21st century. The international participants with NASA in the MEP may include, but would not be limited to, the Canadian Space Agency, the European Space Agency (ESA), the French Space Agency (Centre National d'Etudes

Spatiales), the German Space Agency (Deutschen Zentrum für Luft- und Raumfahrt), the Italian Space Agency (Agenzia Spaziale Italiana), and the Russian Space Agency. NASA would continue to plan for a potential return of Martian surface samples to Earth for detailed analysis.

With the MEP, NASA would establish a series of objectives to address the open scientific questions associated with the exploration of the planet. These objectives have been organized into a set of three goals to be pursued by the program. These goals are: (1) determine if life exists or has ever existed on Mars, (2) understand the current state and evolution of the atmosphere, surface, and interior of Mars, and (3) develop an understanding of Mars in support of possible future human exploration.

As a goal, the program would launch at least one spacecraft at each launch opportunity, providing a set of robotic assets that would enable a near-continuous return of scientific data from Mars. In addition to its science mission, each orbiter spacecraft would include a communications relay capability designed to facilitate transmission of data to Earth from landed spacecraft and atmospheric probes. Each mission would be designed to support the ongoing program by validating technologies and providing data and lessons learned to future missions.

The MEP would ensure the development and demonstration of the technologies required to enable attainment of the goals and objectives as described in Chapter 1. Specifically, the program would enable new classes of Mars science investigations, including, for example, remote astrobiology and new techniques for *in situ* life detection. Technology developments and improvements over the course of the program would enable a progressive increase in the payload mass delivered to Mars orbit and to the surface by program spacecraft, enhance the capability to safely and precisely place payloads at any desired location on the surface, and enable full access to the subsurface, surface and atmospheric regions. Technology improvements would also enable long-lived (one Mars year (1.88 Earth years) or longer duration, as a goal) surface science investigations, and support the development of robotic assets to provide a nearly continuous data return from the surface.

U.S. MEP missions would be launched from either Cape Canaveral Air Force Station (CCAFS), Florida, or Vandenberg Air Force Base (VAFB), California, using expendable launch vehicles matched to each mission's requirements. Currently, the launch vehicles that would be employed by the MEP would be selected from the Delta and Atlas families of launch vehicles. Some U.S. missions may include foreign participation, including, but not limited to, provision of scientific investigations and instruments. Some United States missions may utilize RHUs to provide heat for temperature-sensitive spacecraft components or RPSs to provide electrical power. The use of RHUs or RPSs on some Mars exploration missions could facilitate longer duration missions, with more capable mobility systems, autonomy, and science instruments. Some United States missions may also employ science instruments that require the use of small amounts (on the order of a few milligrams or less) of radioactive isotopes for instrument calibration or for enabling the scientific experiments.

NASA may also participate in international missions, providing scientific instruments and participating in science investigations. Some international missions could also augment

NASA's MEP by providing telecommunications and data relay functions between NASA's spacecraft and Earth. United States participation in international missions may include the provision of RHUs for use on the international partner's spacecraft and may require environmental review in accordance with EO 12114.

The following set of missions is representative of the set envisioned by NASA for the MEP over the next decade (see Table 2-1). As each mission in the MEP is implemented, additional information and techniques are expected to become available which could affect the planning of subsequent missions in terms of the type of mission (e.g., orbiter, lander, atmospheric probe) as well as its timing, focus and objectives. As the specific missions become more fully defined, Tier 2 NEPA documentation or other environmental documentation will be prepared.

- The two identical spacecraft of the Mars Exploration Rover (MER) project, *Spirit* and *Opportunity*, were launched in June and July of 2003. *Spirit* landed successfully on January 3, 2004, and *Opportunity* landed successfully on January 25, 2004. The purpose of this project is to place two rovers on the surface of Mars to remotely conduct geological investigations and characterize a diversity of rocks and soils which may hold clues to past water activity. Each rover uses eight RHUs to provide thermal control. Because planning for this project began prior to final definition of the MEP, potential environmental impacts of the MER-2003 project have already been discussed in separate NEPA documentation. NASA published its final EIS (NASA 2002c) on December 16, 2002, and the Record of Decision was signed on January 30, 2003.
- Mars Express, launched in June 2003, is an ESA mission with NASA participation. The Mars Express spacecraft successfully entered Mars orbit on December 25, 2003. Mars Express also carried a lander, called *Beagle 2*. *Beagle 2* entered the Martian atmosphere on December 25, 2003, but was lost during entry, descent and landing operations. Radioisotope devices for heat or power are not used on Mars Express, however *Beagle 2* included science instruments with small quantities of radioactive materials. NASA has provided components for a radar instrument, participated in the development of a Swedish experiment which will study the interaction between the solar wind and the Martian atmosphere, and will provide support for American scientists selected to participate in several investigations. NASA complied with EO 12114 through an exchange of letters and information between NASA and ESA.
- The Mars Reconnaissance Orbiter mission would be launched in August 2005 and will investigate global atmospheric transport processes, conduct globally distributed observations of aqueous sediments and hydrological process indicators, and collect high-resolution imagery of the surface of Mars. Radioisotope devices for heat or power will not be used. NASA has designated the Reconnaissance Orbiter as a routine payload in accordance with the Routine Payloads EA (NASA 2002a) and Finding of No Significant Impact published by NASA (67 FR 41525, June 18, 2002).

**TABLE 2-1. CURRENT AND PROPOSED MISSIONS IN THE MARS EXPLORATION PROGRAM**

Year of Mission	Name of Mission	Current Status
1996	NASA Mars Global Surveyor* Orbiter	Currently operating in Mars orbit
1998	NASA Mars Climate Orbiter*	Mission lost
1999	NASA Mars Polar Lander*	Mission lost
2001	NASA Mars Odyssey Orbiter	Currently operating in Mars orbit
2003	NASA Mars Exploration Rovers <i>Spirit</i> and <i>Opportunity</i>	Currently operating on the surface of Mars
	ESA Mars Express Orbiter with <i>Beagle 2</i> Lander (Non U.S. mission)	Currently operating in Mars orbit (contact with <i>Beagle 2</i> lost)
2005	NASA Mars Reconnaissance Orbiter	In development
2007	NASA Mars <i>Phoenix</i> Lander (1st Mars Scout mission)	Proposed
2009	NASA Mars Science Laboratory	Proposed
	NASA Mars Telecommunications Orbiter	Proposed
2011	NASA 2nd Mars Scout mission	Proposed

\*These missions were performed under the Mars Surveyor Program, which evolved to the MEP.

Note: Specific MEP missions beyond 2011 are under review.

- In September 2007, NASA proposes to launch the first of a continuing series of competitively-selected small missions, called Mars Scouts. Mars Scout missions could utilize orbiter, lander, or atmospheric spacecraft to develop new ideas for the exploration of Mars. The first Mars Scout mission, named *Phoenix*, would consist of a stationary lander mission to the northern polar region of Mars. This mission's objectives would be to study the geologic history of water in the region and to search for evidence of a habitable zone that may exist in the ice-soil boundary. The *Phoenix* lander would carry a descent imager, panoramic cameras, a volatiles-analysis instrument, a trench-digging robot arm, a chemistry-microscopy instrument, and a suite of meteorological instruments. Since radioisotope devices for heat or power are not planned for the *Phoenix* mission, it will be reviewed for compliance with the requirements of the Routine Payloads EA (NASA 2002a).
- In October 2009, NASA proposes to launch a landed mission called the Mars Science Laboratory. The Science Laboratory rover would include a suite of instruments designed to seek answers to questions of geochemistry and biological processes, and measure aspects of surface and sub-surface materials potentially linked with ancient life and climate. The Mars Science Laboratory could utilize a RPS to provide uninterrupted electrical power and extend the spacecraft's operational lifetime. A Tier 2 EIS would be prepared for such a mission.

- Also in October 2009, NASA is planning to launch the Mars Telecommunications Orbiter, which would provide relay communications services for other spacecraft operating at Mars. Since radioisotope devices for heat or power are not planned for the Mars Telecommunications Orbiter mission, it will be reviewed for compliance with the requirements of the Routine Payloads EA (NASA 2002a).
- A second Mars Scout mission is currently contemplated for launch in November 2011. If the selected Scout mission does not meet the requirements of the Routine Payloads EA (NASA 2002a), a Tier 2 EA or EIS would be prepared.

Missions to Mars during the second decade would be planned along science pathways dependent upon the discoveries made by the preceding missions. Examples of such pathways could include continued orbital and landed exploration designed to examine the diversity of the planet, or focused exploration of surface and shallow subsurface polar ices and sediments. The decision to follow a particular science pathway would be driven by the importance of prior discoveries in the MEP. The possible future return of Martian surface samples to Earth for laboratory analyses would be an important element of any pathway.

As currently envisioned, one or more future missions to return Martian samples to Earth would consist of several spacecraft elements. These could include, but would not necessarily be limited to, a lander, a rover for collecting samples from several different locations, a Mars ascent vehicle, an Earth return vehicle, an Earth entry capsule, and a sample container. One or more of the elements may utilize RHUs to provide heat, a RPS to provide electrical power, and small quantities of radioisotopes in some science instruments. A Tier 2 EIS would be prepared for a Mars sample return mission, and would cover not only the mission implementation but also the recovery and retrieval of the returned sample container and its transportation to a secure sample handling facility. The potential location and construction of, and operational requirements for, a sample receiving facility would be addressed in separate environmental documentation.

### 2.1.1 MEP Spacecraft

Each United States spacecraft developed for a mission within the MEP would consist of subsystems and components typical of any spacecraft designed for deep space exploration. In general, such subsystems would include structures and mechanical devices, communications equipment, computers for command and attitude control, a propulsion subsystem, a subsystem for generating and distributing electrical power, and the payload of science instruments. Landed spacecraft would also include an atmospheric entry, descent, and landing system, and mobility and surface navigation subsystems for rovers.

NASA participation in international missions could include provision of science instrumentation and other mission hardware, assistance with mission communications and tracking, and sponsorship of scientists who would conduct specific science investigations. Agreements with the international partners would ensure that the

objectives and operation of such missions would be consistent with the goals of the MEP. Missions launched from international sites would be subject to the sponsoring partner's applicable environmental laws and regulations. Missions such as these would not be subject to NEPA documentation. Environmental review in accordance with EO 12114 may be applicable.

### 2.1.2 Science Instruments Requiring Small Quantities of Radioactive Materials

One or more MEP missions may require the use of science instruments that utilize small quantities of radioactive materials for instrument calibration or for conducting the experiment. Such instruments are typically the only instruments available to perform the designated scientific experiments, or they are the best available instruments for the assigned task (see Table 2-2). The instruments in this category would be used primarily for mineralogy studies of Martian rocks and soil, and may include but would not be limited to the Mössbauer Spectrometer, the Alpha Particle X-Ray Spectrometer (APXS), the X-Ray Fluorescence Spectrometer (XRF), the Neutron Activated Gamma Ray Spectrometer (GRS), and the X-Ray Diffraction/X-Ray Fluorescence Spectrometer (XRD/XRF). Typically, the small quantities of radioisotopes used in instruments such as these include americium-241, cadmium-109, cobalt-57, curium-244, hydrogen-3 (tritium), and iron-55, and in most cases would amount to not more than a few hundred millicuries of radioactive material.

The use of small quantities of radioactive material for NASA robotic missions is addressed in the Routine Payloads EA (NASA 2002a), and environmental documentation for MEP spacecraft meeting specific criteria defined in the EA would be covered (*i.e.*, supported by the environmental decision-making process specified in the EA). Any MEP missions meeting the criteria in the Routine Payloads EA are not expected to present any substantial environmental impact or risk to the public or to the environment during normal or abnormal launch conditions. MEP spacecraft that would carry radioactive sources in quantities above those covered by the Routine Payloads EA would require further environmental analysis and documentation.

### 2.1.3 Power Systems and Heat Sources for MEP Missions

Any mission to Mars will have unique electric power requirements for operation of spacecraft subsystems and science instruments, and thermal requirements for maintaining environmental conditions within design specifications for spacecraft components. A variety of potential power sources are available that could satisfy these requirements. Solar arrays, batteries, and radioisotopes are among the more commonly used power and heat sources for space missions. Solar arrays for electrical power have been used for all previous orbital missions and recent surface missions to Mars. Batteries are widely used as secondary sources of electrical power in conjunction with solar arrays. Some of the Mars missions could use radioactive material to provide power through the use of RPSs, or RHUs may be used to provide heat. These devices use the heat from the radioactive decay of plutonium dioxide (consisting mostly of plutonium-238, a non-weapons grade isotope of plutonium) to produce either electricity or heat. The final determination of the appropriate power and heat sources would be made during the detailed planning process for each mission.

**TABLE 2-2. REPRESENTATIVE SCIENCE INSTRUMENTS REQUIRING SMALL QUANTITIES OF RADIOISOTOPES**

Instrument Name	Instrument Function(s)	Radioisotope		
		Isotope	Quantity <sup>a</sup> (grams)	Activity <sup>a</sup> (millicuries)
Mössbauer Spectrometer	<ol style="list-style-type: none"> <li>1) Determine composition and abundance of iron-bearing minerals.</li> <li>2) Examine magnetic properties of surface materials.</li> <li>3) Identify minerals formed in hot, watery environments that could preserve fossil evidence of Martian life.</li> </ol>	cobalt-57	0.000058 g	500 mCi
Alpha Particle X-Ray Spectrometer (APXS)	Determine the elemental chemistry of rocks and soil by directly touching a rock or patch of soil.	curium-244	0.00061 g	50 mCi
X-Ray Fluorescence Spectrometer (XRF)	Determine elemental composition of subsurface rocks, abundance of rock-forming elements (e.g., magnesium, aluminum, silicon, calcium, titanium, iron), volatiles (e.g., sulfur, chlorine), and minor elements.	cadmium-109 iron-55	0.00002 g 0.00015 g	50 mCi 350 mCi
Neutron Activated Gamma Ray Spectrometer (GRS)	<ol style="list-style-type: none"> <li>1) Measure elemental composition of Martian surface.</li> <li>2) Measure the abundance of elements in a volume.</li> </ol>	hydrogen-3 (tritium)	0.0001 g	1,000 mCi
X-Ray Diffraction Spectrometer/ X-Ray Fluorescence Spectrometer (XRD/XRF)	<ol style="list-style-type: none"> <li>1) Perform <i>in situ</i> mineralogical analysis.</li> <li>2) Identify and quantify each mineral present in rocks.</li> </ol>	americium-241 iron-55	0.014 g 0.00015 g	50 mCi 350 mCi

a. Estimated values.

### 2.1.3.1 Solar Energy

Solar energy has played a vital role in the United States space program since its inception by providing electrical power for most spacecraft operating between the orbits of Mercury and Mars. Most MEP missions are expected to continue to rely on solar energy for electrical power for both orbiting and landed missions when appropriate.

Solar power consists of the direct conversion of solar energy into electricity. Solar cells typically used in space applications are capable of converting about 20% to 28% of the incident sunlight, both direct and indirect, into electrical energy. Solar cells are integrated into solar panels (arrays), with the size of the panels determined by the power requirements of the spacecraft.

While solar arrays are expected to be the primary source of electrical power for all orbiting spacecraft in the MEP, several factors need to be considered in their use in a landed mission to Mars. The Martian atmosphere scatters light so that a large fraction of the light that reaches the solar array will not be direct sunlight. Shadowing of the solar arrays by lander or rover hardware could impact array energy production. Dust driven by the Martian winds can obscure or damage the solar arrays and further reduce the amount of sunlight reaching the solar cells. Efforts to tailor solar array designs for the Martian environment and improve their operating lifetimes are continuing.

Landing site locations and the seasons on Mars can greatly effect the total solar energy available for conversion into electricity. Both the angle of sunlight relative to the solar array and the duration of daylight change with season. As on Earth, high latitudes and winter seasons reduce direct solar irradiance and shorten the period in which solar arrays can operate effectively.

#### 2.1.3.2 Batteries

One of the major limitations of solar power is that it is available only when solar cells are exposed to sunlight. At night on the surface of Mars or when an orbiting spacecraft passes into the shadow of Mars, the solar arrays will not generate electricity. Therefore, a secondary energy source is needed during these periods and batteries have typically been used for this purpose. Due to size, mass, thermal constraints, and lifetime limitations, batteries cannot be used as the primary source of electrical power for long-duration space missions.

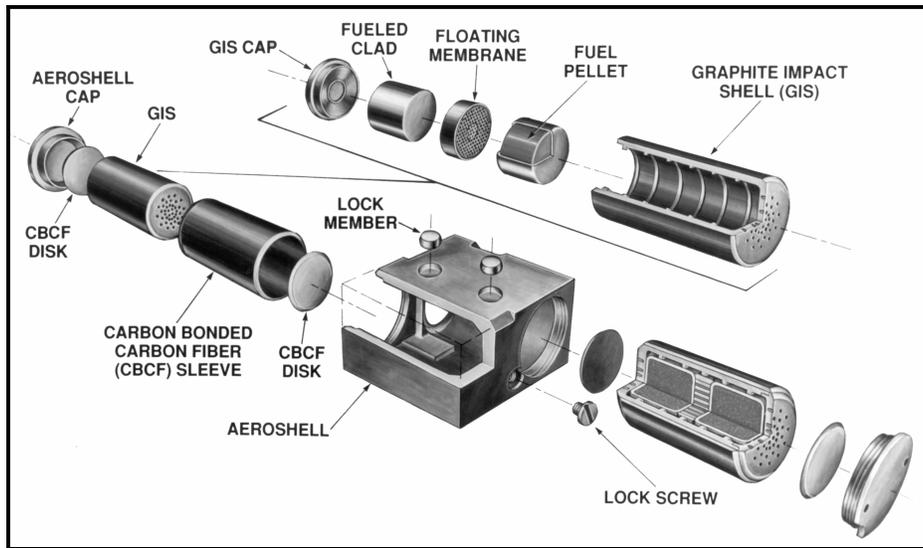
Most batteries used on spacecraft are rechargeable. When used in conjunction with a primary power source (e.g., a solar array) the primary source provides power to the spacecraft and maintains the charge in the battery. Only when the primary source is unable to supply the spacecraft with all of the needed electrical power is additional power drawn from the battery. Usable battery energy is a direct function of battery capacity and energy available for recharge from the solar arrays. As with solar arrays, the size, type, and mass of a battery is determined by the energy requirements and engineering constraints of the mission.

#### 2.1.3.3 Radioisotope Power Systems

One or more of the proposed Mars missions may use a RPS as the source of electrical power for the spacecraft engineering subsystems and science instruments. A RPS converts heat from the radioactive decay of plutonium dioxide into usable electrical power. RPSs have been used on 25 previous U.S. space missions, including six Apollo flights and the Pioneer, Viking, Voyager, Galileo, Ulysses, and Cassini missions. The U.S. Department of Energy (DOE) is currently developing new versions of the RPS (the Stirling Radioisotope Generator (SRG) (DOE 2002a), and the Multi-Mission

Radioisotope Thermoelectric Generator (MMRTG) (DOE 2002b)) for application to a variety of space missions, possibly including missions to the surface of Mars.

The common component of the SRG and MMRTG is the General Purpose Heat Source (GPHS). GPHS modules supply the thermal energy that is converted to electrical power by the RPS. A GPHS module (Figure 2-1) consists of a graphite aeroshell, two carbon-bonded carbon fiber insulator sleeves, two graphite impact shells, and four iridium clads, each of which contains a ceramic pellet of plutonium dioxide. Plutonium dioxide consists of approximately 71% by weight of plutonium-238, and the remainder consists mainly of oxygen and other isotopes of plutonium. A GPHS module has a mass of about 1.45 kilograms (kg) (3.2 pounds (lb)) and contains about 0.6 kg (1.3 lb) of plutonium dioxide. The total activity in a GPHS module is about 7,400 curies, with a thermal output of about 250 watts.



**FIGURE 2-1. A GENERAL PURPOSE HEAT SOURCE**

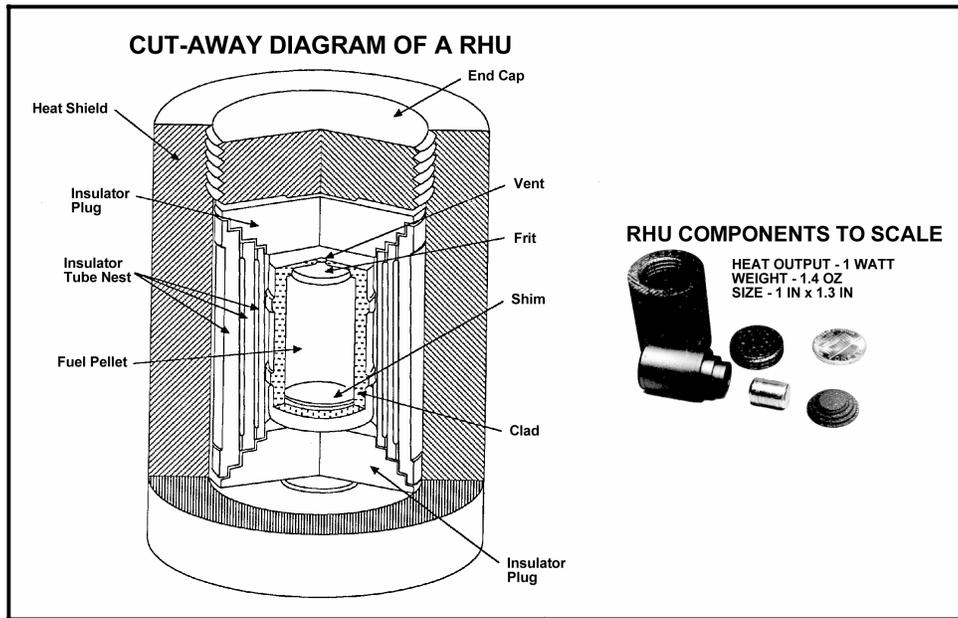
DOE has designed the GPHS to contain the plutonium dioxide during normal operations and under a wide range of accident environments (Bennett 1981). The primary function of the aeroshell is to protect the fueled clads against atmospheric heating in the event of inadvertent reentry. The graphite impact shells protect the fueled clads from ground or debris impact in the event of an accident. The graphite impact shell also serves as a redundant heatshield in the event of a GPHS aeroshell failure. Fine weave pierced fabric, the material used for the aeroshell and impact shell, is a carbon-carbon composite material woven with high-strength graphite fibers in three perpendicular directions. This material, used primarily by the U.S. Air Force (USAF) for missile nose cones, has demonstrated success for reentry protection.

The other major component of a RPS consists of a converter. The converter may be either passive (using thermocouples to convert heat directly into electricity) such as that under development for the MMRTG, or mechanical, such as the Stirling engine under

development for the SRG. The Stirling engine would convert the heat from the GPHS modules into mechanical energy, which in turn would be converted into electricity.

#### 2.1.3.4 Radioisotope Heater Units

One or more of the MEP missions could use RHUs to maintain the thermal environment inside the spacecraft. RHUs have been used on the Galileo, Cassini, Mars Pathfinder, and MER-2003 missions. Each RHU (Figure 2-2) would provide about one (1) watt of heat derived from the radioactive decay of about 2.7 grams (g) (0.1 ounces (oz)) of plutonium dioxide. The total activity of a RHU is approximately 33.2 curies. The exterior dimensions of a RHU are 2.6 cm (1.03 in) in diameter by 3.2 cm (1.26 in) in length.



**FIGURE 2-2. A RADIOISOTOPE HEATER UNIT**

RHUs are designed to contain the plutonium dioxide during normal operations and under a wide range of accident environments. The plutonium dioxide ceramic is encapsulated in a 70% platinum and 30% rhodium alloy clad. Protection against high temperature accident environments is provided by a fine weave pierced fabric of carbon graphite used as a heatshield, and a series of concentric graphite sleeves and end plugs to thermally insulate the encapsulated radioactive material. The plutonium dioxide is principally protected from ground or debris impact by the alloy clad. The heatshield and inner graphite insulators provide additional protection.

#### 2.1.4 Payload Processing

Industrial activities associated with integrating a MEP spacecraft to its launch vehicle would involve receipt of components, inspection, storage, assembly, and testing at the launch site. Spacecraft safety, security, and contamination control would be ensured throughout all processing phases. The spacecraft would be integrated with its launch

vehicle either at the launch pad or at a special integration facility near the pad, depending upon the procedures established for each particular vehicle.

Processing a MEP spacecraft at Kennedy Space Center (KSC)/CCAFS or at VAFB would involve hazardous materials. Such items would include but not be limited to propellants, oils, solvents, primers, sealants, and process chemicals. All effluents and wastes generated would be subject to Federal, State, and local environmental laws and regulations, and USAF regulations and requirements. KSC, CCAFS, and VAFB have permits and waste management programs in place for solid and hazardous wastes. NASA or its contractors would dispose generated hazardous wastes. In addition, at KSC, CCAFS, and VAFB all radiological safety controls and precautions relating to receipt, storage, handling, and installation of radioactive material would be strictly followed. No new payload processing facilities for MEP missions are anticipated at this time at KSC, CCAFS, or VAFB.

### 2.1.5 Space Launch Complexes

MEP missions could be launched from either CCAFS or VAFB. Each facility has several space launch complexes (SLCs) for launching a variety of vehicles. A SLC typically consists of launch pads, service towers, fuel storage areas, launch service buildings, support buildings, exhaust flumes, and other facilities that are needed to prepare, service, and perform launches. Security at a SLC is ensured by perimeter fences, guarded entrances, and restricted access. Since all operations in the SLCs could involve or would be conducted in the vicinity of liquid or solid propellants and explosive devices, the number of personnel permitted in the area, safety clothing to be worn, the type of activity permitted, and equipment allowed would be strictly regulated. The airspace over a launch complex would also be restricted as part of the overall security measures that would be in place for each launch. Table 2-3 presents an overview of the Atlas and Delta launch vehicles which could be used for U.S. MEP missions and their respective launch complexes.

### 2.1.6 Description of Launch Vehicles

U.S. MEP missions are expected to be launched on one of the Atlas or Delta vehicles listed in Table 2-3. NASA would select a vehicle from among this set with the launch capability that would meet the requirement for each particular mission. These launch vehicles have been addressed in previous NEPA documents (USAF 1996, USAF 1997, USAF 1998, USAF 2000, NASA 2002a).

The major sections of a launch vehicle consist of the first stage, the second stage, and the payload fairing (PLF). Some vehicles may use solid rocket motors (SRMs) attached to the first stage to augment the vehicle's first-stage thrust, and some missions may use a third stage to provide the final thrust needed to satisfy mission launch energy requirements.

**TABLE 2-3. MEP LAUNCH VEHICLES AND LAUNCH SITES**

Launch Vehicle	Launch Site	Typical First Stage <sup>a</sup>	Number of Attached SRMs <sup>b</sup>	Typical Second Stage <sup>a</sup>
<b>Atlas Launch Vehicles</b>				
Atlas II series	CCAFS: SLC-36 VAFB: No provision	158,700 kg (RP-1/LO <sub>2</sub> )	2 to 4 (up to 40,400 kg)	16,800 kg (LH <sub>2</sub> /LO <sub>2</sub> )
Atlas III series	CCAFS: SLC-36 VAFB: No provision	185,000 kg (RP-1/LO <sub>2</sub> )	None	21,700 kg (LH <sub>2</sub> /LO <sub>2</sub> )
Atlas V series	CCAFS: SLC-41 VAFB: SLC-3 East	317,500 kg (RP-1/LO <sub>2</sub> )	0 to 5 (up to 213,800 kg)	21,700 kg (LH <sub>2</sub> /LO <sub>2</sub> )
Atlas V Heavy	CCAFS: SLC-41 VAFB: SLC-3 East	952,500 <sup>c</sup> kg (RP-1/LO <sub>2</sub> )	None	21,700 kg (LH <sub>2</sub> /LO <sub>2</sub> )
<b>Delta Launch Vehicles</b>				
Delta II series	CCAFS: SLC-17 VAFB: SLC-2	94,100 kg (RP-1/LO <sub>2</sub> )	0 to 9 (up to 150,600 kg)	6,000 kg (Hydrazine/N <sub>2</sub> O <sub>4</sub> )
Delta III	CCAFS: SLC-17 VAFB: No provision	96,400 kg (LH <sub>2</sub> /LO <sub>2</sub> )	9 (150,600 kg)	16,700 kg (LH <sub>2</sub> /LO <sub>2</sub> )
Delta IV series	CCAFS: SLC-37 VAFB: SLC-6	204,100 kg (LH <sub>2</sub> /LO <sub>2</sub> )	0 to 4 (up to 112,100 kg)	21,300 kg (LH <sub>2</sub> /LO <sub>2</sub> )
Delta IV Heavy	CCAFS: SLC-37 VAFB: SLC-6	612,300 <sup>c</sup> kg (LH <sub>2</sub> /LO <sub>2</sub> )	None	29,000 kg (LH <sub>2</sub> /LO <sub>2</sub> )

Sources: USAF 1996, USAF 1997, USAF 1998, USAF 2000, NASA 2002a

- a. Some stages use a small amount of hydrazine (< 180 kg max.) for reaction control.
- b. Solid propellant composition would typically be aluminum powder, ammonium perchlorate, and hydroxyl-terminated polybutadiene binder.
- c. Three core stages.

Note 1: Propellant masses shown are typical values.

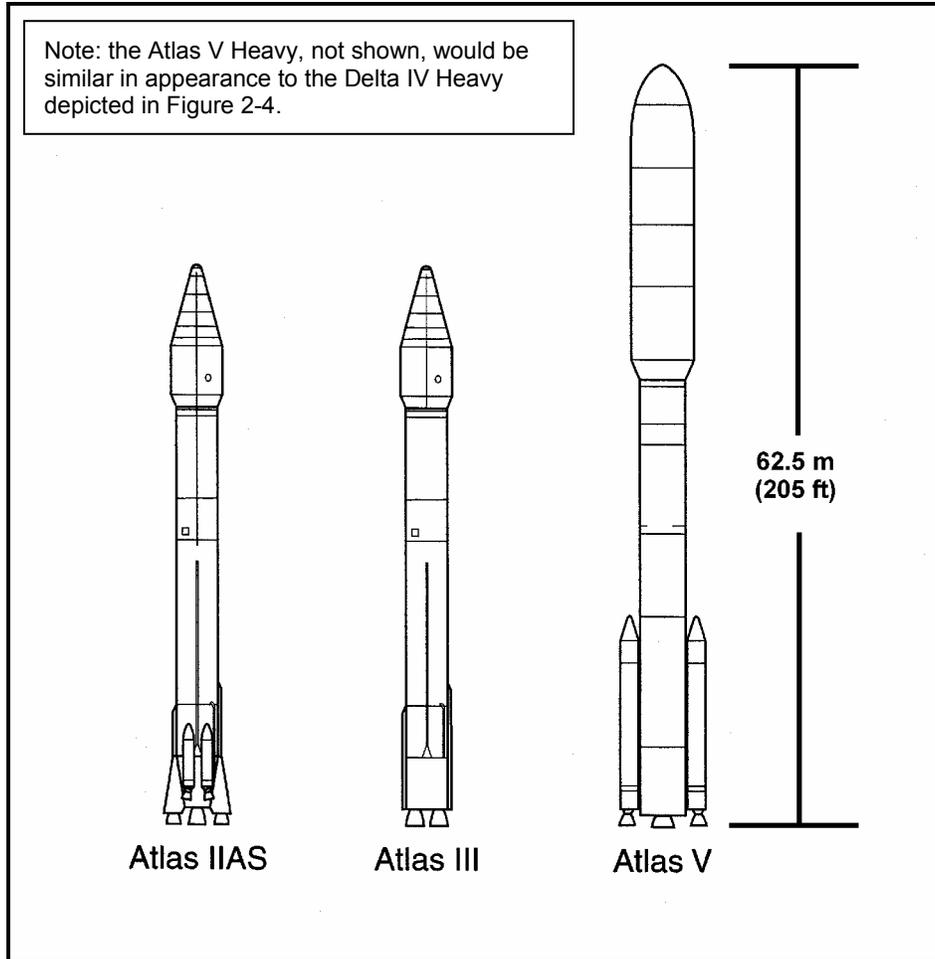
Note 2: Some MEP missions may require a third stage, which would typically consist of a SRM and associated structures and avionics.

SRM = solid rocket motor; RP-1 = rocket propellant-1; LH<sub>2</sub> = liquid hydrogen; LO<sub>2</sub> = liquid oxygen; N<sub>2</sub>O<sub>4</sub> = nitrogen tetroxide

1 kg = 2.2046 lb

### 2.1.6.1 Atlas Launch Vehicles

Table 2-3 and Figure 2-3 present the Atlas family of launch vehicles and the propellant (fuel and oxidizer) used in each stage of the vehicle. All Atlas configurations use rocket propellant-1 (RP-1, a refined kerosene) and liquid oxygen (LO<sub>2</sub>) in the first stage. Some Atlas configurations could use SRMs to augment the first stage. The solid propellant typically consists of powdered aluminum, ammonium perchlorate, and hydroxyl terminated polybutadiene binder. Liquid hydrogen (LH<sub>2</sub>) and LO<sub>2</sub> are used in the second stage (Centaur). Some Atlas stages use a relatively small amount of hydrazine (less than 180 kg (400 lb) maximum) for reaction control.



Source: NASA 2002a

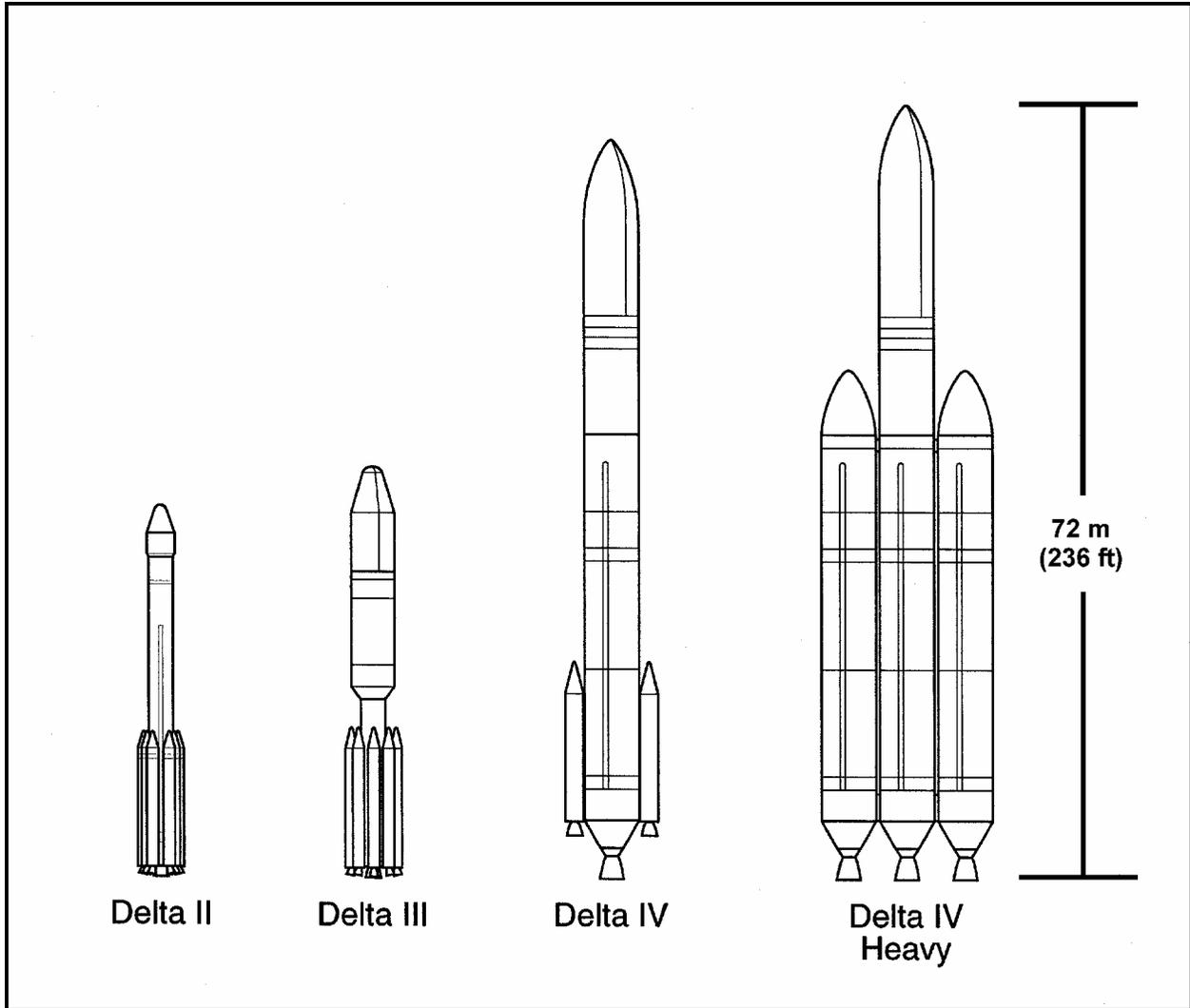
**FIGURE 2-3. THE ATLAS FAMILY OF LAUNCH VEHICLES**

### 2.1.6.2 Delta Launch Vehicles

Table 2-3 and Figure 2-4 present the Delta family of launch vehicles and the propellant used in each stage. Some Delta configurations use RP-1 and LO<sub>2</sub> in the first stage, while other configurations use LH<sub>2</sub> and LO<sub>2</sub>. Some Delta configurations also could use SRMs to augment the first stage. A combination of hydrazine and nitrogen tetroxide (N<sub>2</sub>O<sub>4</sub>) or a combination of LH<sub>2</sub> and LO<sub>2</sub> are used as second stage propellant. A relatively small amount of hydrazine (less than 145 kg (320 lb) maximum) is used for reaction control in some Delta stages.

### 2.1.6.3 Third Stage for Atlas or Delta Launch Vehicles

The Atlas and Delta launch vehicles for some MEP missions may require a third stage. The third stage would typically use solid propellant, the composition of which would be similar to the solid propellant in the SRMs. An appropriate third stage would be selected for each individual mission based upon the launch energy requirements for that particular mission.



Source: NASA 2002a

**FIGURE 2-4. THE DELTA FAMILY OF LAUNCH VEHICLES**

#### 2.1.6.4 Payload Fairing

The Payload Fairing (PLF) for either the Atlas or Delta launch vehicle would consist of either two or three sections constructed of aluminum and composite material. The PLF would enclose and protect the spacecraft from environmental, acoustic, and aerodynamic forces during launch and ascent.

#### 2.1.6.5 Flight Termination System

The Range Safety offices at both CCAFS and VAFB require launch vehicles to be equipped with a Flight Termination System (FTS) capable of causing destruction of the launch vehicle in the event of a major vehicle malfunction. The FTS, when activated, would initiate ordnance installed in the launch vehicle, destroying the vehicle.

#### 2.1.6.6 Launch Vehicle Processing

Atlas and Delta launch vehicle preparation activities and procedures during and after launch have been previously documented (USAF 1996, USAF 1997, USAF 1998, USAF 2000). These procedures and protocols are continuously being reviewed, and all NASA launches for MEP missions would follow these standard operating procedures.

Launch vehicle components for MEP missions would be received at CCAFS and VAFB, as needed, where they would be inspected, stored, and processed at appropriate facilities. When needed for launch, these components would be moved to launch vehicle assembly facilities, where the launch vehicle would be assembled, integrated, and tested. The PLF (containing the spacecraft) and, as required for each mission, SRMs and the third stage would be attached to the launch vehicle. Propellant loading and a final check out would be performed at the launch pad prior to scheduled liftoff.

Launch vehicle processing activities involve hazardous materials and would generate effluents and solid or hazardous wastes. Such items would include but would not be limited to propellants, oils, solvents, primers, sealants, and process chemicals and are subject to Federal, State, and local environmental laws and regulations, and USAF regulations and requirements. NASA or its contractors would dispose of generated hazardous wastes. CCAFS and VAFB have the necessary permits and procedures in place to accomplish launch vehicle processing activities in an environmentally responsible manner.

#### 2.1.6.7 Typical Ascent Profile for Launch Vehicles

The ascent profiles for each of the launch vehicles expected to be available for missions to Mars under the Proposed Action would have similar sequences of events. The exact timing of each event in the ascent profile for a particular MEP mission would depend upon both the selected vehicle and the mission launch requirements. Typically, the first stage and any attached SRMs would be ignited, and upon clearing the launch tower the vehicle would begin turning to the proper orientation. Within a few tens of seconds the vehicle would clear land and be over the ocean, continuing to accelerate and gain altitude. If equipped with SRMs, the SRM casings would be jettisoned after the solid propellant has burned out; the SRM casings would fall into the ocean. Upon main engine cutoff, the first stage would be separated, followed by ignition of the second stage engine and, shortly thereafter, separation of the PLF. The depleted first stage and the PLF components would fall into the ocean.

The second stage would be ignited shortly after separation from the first stage and would accelerate to low Earth orbit. After a brief coast period in Earth orbit the second stage engine would be restarted to place the spacecraft into an Earth-escape trajectory. Typically, after separation the depleted second stage would remain in orbit and reenter the atmosphere within about two to three months (USAF 1996); the depleted stage would typically burn up upon reentry. However, depending on specific mission launch energy requirements, after separation the depleted second stage may instead continue separately into interplanetary space. Following separation from the second stage, the third stage, if needed for the mission, would then ignite and provide the final acceleration to propel the spacecraft toward Mars. After completing its burn, the third

stage would be separated from the spacecraft and continue separately into interplanetary space.

### 2.1.7 Range Safety Considerations

CCAFS and VAFB have implemented range safety requirements (USAF 2004). For each launch, pre-determined flight safety limits would be established for the flight path of the launch vehicle. Wind criteria, fragments that could be produced in a launch accident, dispersion and reaction (*e.g.*, toxic plumes, fire) of liquid and solid propellants, human reaction time, data delay time, and other pertinent data are considered when determining flight safety limits. The Mission Flight Control Officer would take any necessary actions, including vehicle destruction, if, for example, the vehicle's trajectory deviates beyond the safety limits of the planned flight path.

### 2.1.8 Electromagnetic Environment

Launch vehicles may be subject to electromagnetic conditions such as lightning, powerful electromagnetic transmissions (*e.g.*, radar, radio transmitters), and charging effects (*i.e.*, electrical charges generated by friction and the resultant electrostatic discharges). NASA and the USAF address such conditions with respect to the design of the launch vehicle, as well as with ordnance (explosives, and explosive detonators and fuses), fuels, exposed surfaces of the vehicle, and critical electronic systems that must have highly reliable operations. A large body of technical literature exists on these subjects and has been used by NASA and the USAF in designing safeguards.

## **2.2 DESCRIPTION OF ALTERNATIVE 2**

Under Alternative 2, NASA would not implement a coordinated MEP, but would continue to explore Mars, on a less comprehensive, mission-by-mission basis. Any future robotic missions to Mars through 2020 would need to be proposed and compete for resources with all other missions under consideration by NASA for continuing exploration of the solar system. A decision to proceed with a mission to Mars in any future launch opportunity would be based upon the merits of the proposed mission's specific science and technology objectives and the resources available to implement it. The objectives of such a mission could, but may not necessarily, build upon the knowledge gained from previous missions to Mars; furthermore, any succeeding missions could, but may not necessarily, build upon the proposed mission's accomplishments. A mission to Mars sponsored by the U.S. could include international participation, and the U.S. could participate in an international mission to Mars.

Some spacecraft under this alternative may use radioisotope devices for power or for thermal control of temperature-sensitive components, and may carry small quantities of radioisotopes in some science instruments. Any proposed use of radioisotopes for an individual mission would be included in the description of the mission concept, and the appropriate level of mission-specific environmental documentation would be developed. Environmental documentation for a mission using only small quantities of radioisotopes, typically not more than a few hundred millicuries, in science instruments may be covered under NASA's Routine Payloads EA (NASA 2002a).

Missions to Mars sponsored by the U.S. under this alternative would be processed and launched using the procedures, facilities, and launch vehicles as described under the Proposed Action.

### **2.3 DESCRIPTION OF THE NO ACTION ALTERNATIVE**

Under the No Action Alternative NASA would abandon further exploration of Mars by new, robotic missions to the planet through 2020. Current NASA missions to Mars (*i.e.*, Mars Global Surveyor, Mars Odyssey, the MER–2003 rovers, and the Mars Reconnaissance Orbiter) would continue. After these missions have ended, no new science would be gathered by NASA spacecraft from Mars orbit or from the planet's surface. New science investigations of Mars would only be made remotely from Earth-based assets (*i.e.*, ground-based observatories or space-based observatories such as the Hubble Space Telescope) or from spacecraft developed and launched to Mars by non-U.S. space agencies. U.S. scientists could continue to participate in foreign missions to Mars.

As NASA continues to plan and implement missions to explore other bodies and regions in the solar system, the No Action Alternative would leave a significant gap in the expected knowledge to be gained.

### **2.4 ALTERNATIVES CONSIDERED BUT NOT EVALUATED FURTHER**

Alternatives considered but not evaluated further involve options that NASA considered when developing the MEP strategy. These alternatives were dismissed for a variety of programmatic and technical reasons or they failed to adequately support NASA's ability to meet the goals of the MEP as described in Chapter 1.

#### **2.4.1 Orbiter-Only Missions to Mars**

An alternative which consists of sending only orbiting spacecraft to explore Mars was dismissed from consideration because such a program would severely limit the extent of science that could be achieved. Without landed spacecraft, *in situ* surface and subsurface science investigations, and missions for returning samples to Earth, would not occur. The extent of knowledge to be gained using only remote sensing instruments from orbit would eventually reach a level of diminishing returns without accompanying verification measurements from the surface. (The dependencies between remote sensing and surface science is amply demonstrated on Earth. For example, visual and infrared agricultural terrain images taken from orbiting spacecraft and high-altitude aircraft must be calibrated with ground observations of crop types.) Finally, and most crucially, meaningful searches for evidence of past or present life simply cannot be made without the use of landed spacecraft.

#### **2.4.2 A Mars Exploration Program Without Planning for Sample Return**

This alternative would be similar in all aspects to the Proposed Action with the exception that NASA would abandon planning for a possible return to Earth, via robotic spacecraft, of samples of Martian surface material. This alternative would eliminate NASA's ability to perform long-term, laboratory-quality analyses of pristine Martian samples as

recommended by the Space Science Board (SSB 1990), and was dismissed from further consideration.

#### 2.4.3 Missions to Mars Without the Use of Radioisotope Power Systems and Radioisotope Heater Units

This alternative would involve missions to Mars similar to those described in the Proposed Action, but would do so without the use of radioisotope devices for either electrical power (*i.e.*, RPSs) or thermal control (*i.e.*, RHUs). Eliminating the use of RPSs for electrical power would limit the choice of available power system technology to solar arrays and batteries. This could restrict the selection of landing sites for some landed spacecraft or rovers to only those regions of Mars where solar illumination can provide sufficient power. In addition, a landed spacecraft or rover under this alternative would have limited power available for science instrument operation and data collection activities during the Martian night or in areas of deep shadow. Lastly, the operational lifetime of a landed spacecraft or rover could be limited to the useful lifetime of the solar arrays or batteries.

Eliminating the use of RHUs for thermal control of temperature-sensitive components would limit the operational lifetime of a landed spacecraft or rover.

This alternative would therefore severely restrict NASA's ability to gather *in situ* science and meet the goals of the MEP, and was dismissed from further consideration.

#### 2.4.4 Missions to Mars Without the Use of Radioisotope Power Systems

This alternative would involve missions to Mars similar to those described in the Proposed Action, but would do so without the use of radioisotope devices for electrical power (*i.e.*, RPSs). Eliminating the use of RPSs for electrical power would limit the available power system technology to solar arrays and batteries. This could restrict the selection of landing sites for some landed spacecraft to only those regions of Mars where solar illumination can provide sufficient power. In addition, a landed spacecraft under this alternative would not have sufficient power capabilities to operate all of its science instruments during the Martian night. Lastly, the operational lifetime of a landed spacecraft or rover could be limited to the useful lifetime of the solar arrays or batteries.

This alternative would therefore restrict NASA's ability to gather *in situ* science and meet the goals of the MEP, and was dismissed from further consideration.

### **2.5 COMPARISON OF ALTERNATIVES INCLUDING THE PROPOSED ACTION**

This section summarizes and compares the potential environmental impacts of the Proposed Action and the Alternatives. The anticipated impacts associated with normal implementation of the Proposed Action or an Alternative are considered first. This discussion is followed by a summary and comparison of the potential nonradiological accident impacts and radiological consequences and risks from an accident associated with the Proposed Action or Alternative 2. Table 2-4 presents a summary comparison of the anticipated environmental impacts associated with normal implementation of the

Proposed Action and the Alternatives. More detailed information on the potential environmental impacts can be found in Chapter 4.

### 2.5.1 Environmental Impacts of Normal Implementation of the Proposed Action and Alternatives

Normal implementation of the Proposed Action or Alternative 2 would involve spacecraft launches from CCAFS and VAFB. These launches would be consistent with the mission and designated land use at these facilities. The potential environmental impacts associated with normal launches for either the Proposed Action or Alternative 2 would be the same as, or very similar to, the environmental impacts resulting from normal launches from these launch sites, which have been addressed in previous environmental documentation (e.g., USAF 1998, USAF 2000, NASA 2002a). The anticipated number of MEP launches, typically one or two every 26 months, would be within the normal complement of launches at CCAFS and VAFB, and would not stimulate the addition of a large number of new employment opportunities at either site.

The environmental impacts associated with implementing either the Proposed Action or Alternative 2 would occur largely from the exhaust products emitted from the Atlas or Delta launch vehicles carrying SRMs; these impacts have been shown to be short term in nature. High concentrations of SRM exhaust products, principally aluminum oxide ( $\text{Al}_2\text{O}_3$ ) particulates, carbon monoxide (CO), hydrogen chloride (HCl), nitrogen ( $\text{N}_2$ ), and water ( $\text{H}_2\text{O}$ ), would occur in the exhaust cloud that would form at the launch complex (under the high temperatures of the SRM's exhaust, the CO would be quickly oxidized to carbon dioxide ( $\text{CO}_2$ ) and  $\text{N}_2$  may react with oxygen to form nitrogen oxides ( $\text{NO}_x$ )). Due to the relatively high gas temperatures, this exhaust cloud would be buoyant and would rise quickly and begin to disperse near the launch pad. Some HCl deposition would occur around the SLCs, however, high concentrations of HCl would not be expected, and damage to vegetation and prolonged acidification of nearby water bodies should not occur. No long-term adverse impacts to air quality in offsite areas would be expected from launching all the missions in the MEP. The Range Safety offices at CCAFS and VAFB use models to predict launch hazards to the public and on-site personnel prior to every launch. These models calculate the risk of injury resulting from toxic exhaust gases from normal launches. Launches are postponed if the predicted risk of injury exceeds acceptable limits.

If rain were to occur shortly after launch, some short-term acidification of nearby water bodies could occur with the accompanying potential for some mortality of aquatic biota. Biota that happened to be in the path of the exhaust could be damaged or killed. As the launch vehicles gain altitude, a portion of the solid rocket motor exhaust (specifically HCl,  $\text{Al}_2\text{O}_3$ , and  $\text{NO}_x$ ) would be deposited in the stratosphere, resulting in a short-term reduction in ozone along each vehicle's flight path. Recovery, however, would be rapid. Exhaust from launch vehicles using only liquid propellants (primarily CO,  $\text{CO}_2$ , and  $\text{H}_2\text{O}$ ) would have negligible impacts on the environment.

Threatened or endangered species should not be jeopardized nor would critical habitats be affected at CCAFS by exhaust product deposition. At VAFB, disturbance and incidental take could occur among several threatened or endangered species. VAFB

**TABLE 2-4. SUMMARY COMPARISON OF THE MEP PROPOSED ACTION AND ALTERNATIVES**

Impact Category	Program Alternatives <sup>a</sup>	
	Normal Implementation of the Proposed Action and Alternative 2	No Action Alternative
Land Use	<u>CCAFS/VAFB</u> <sup>b</sup> —No adverse impact on non-launch related land uses.	<u>CCAFS/VAFB</u> —No change to existing conditions.
Air Quality	<u>CCAFS/VAFB</u> —No anticipated long-term adverse air quality impacts expected in on-site or offsite areas.	<u>CCAFS/VAFB</u> —No change to existing conditions.
Noise and Sonic Boom	<u>CCAFS/VAFB</u> —Short-term worker and public exposure to sound levels > 90dBA; exposure levels within OSHA and EPA guidelines for affected workers and public.	<u>CCAFS/VAFB</u> —No change to existing conditions.
Geology and Soils	<u>CCAFS/VAFB</u> —Some particulate and acidic deposition near launch complex with SRM use. No long-term adverse impacts expected to underlying geology or soils.	<u>CCAFS/VAFB</u> —No change to existing conditions.
Hydrology and Water Quality	<u>CCAFS/VAFB</u> —Potential short-term acidification of nearby surface waters with SRM use. No long-term adverse impacts expected to hydrology or water quality.	<u>CCAFS/VAFB</u> —No change to existing conditions.
Biological Resources	<u>CCAFS/VAFB</u> —Biota in launch complex and surrounding areas could be damaged or killed during launch; with SRM use, possible acidification of nearby surface waters could cause some mortality of aquatic biota. No long-term impacts expected to endangered or threatened species or critical habitat. Necessary permits would be obtained and NASA will comply with required mitigation measures at VAFB.	<u>CCAFS/VAFB</u> —No change to existing conditions.
Socioeconomics	<u>CCAFS/VAFB</u> —No long-term impacts expected. Possible temporary increase in local tourism during launch periods.	<u>CCAFS/VAFB</u> —No large-scale changes to existing conditions. Potential loss of some jobs and some local tourism.
Cultural/Historical/Archaeological Resources	<u>CCAFS/VAFB</u> —No adverse impact expected.	<u>CCAFS/VAFB</u> —No change to existing conditions.
Global Environment	Not anticipated to adversely affect global climate. Temporary localized decrease in ozone along the flight path with rapid recovery. No long-term adverse impact expected.	No change to existing conditions.

a. One or more launches to Mars are assumed to occur every 26 months for the Proposed Action and a similar frequency is assumed for Alternative 2. No U.S. launches to Mars would occur under the No Action Alternative.

b. CCAFS would also include KSC where applicable.

dBA = A-weighted decibels; OSHA = Occupational Safety & Health Administration

has the necessary incidental take permits, and monitoring and mitigation measures are in place.

Noise and sonic booms would be associated with each launch. However, neither launch site workers nor the public would be adversely affected. No impacts to cultural, historical or archaeological resources would be expected at either launch site. Neither the Proposed Action nor the Alternatives would be expected to disproportionately impact either minority or low-income populations near either launch site.

There could be potential socioeconomic impacts associated with the No Action Alternative. Some jobs in selected industries could be displaced or lost if NASA abandons plans for future robotic missions to Mars, and tourism to view MEP launches would not occur.

### 2.5.2 Environmental Impacts of Nonradiological Accidents for the Proposed Action and Alternative 2

This section provides a discussion on potential nonradiological accidents that could occur at either CCAFS or VAFB by implementing the Proposed Action or Alternative 2. There would be no difference in environmental impacts associated with nonradiological accidents for either the Proposed Action or Alternative 2.

A variety of nonradiological accidents could occur during preparation for and launch of spacecraft at CCAFS and VAFB. The two most significant accidents would be liquid fuel spills or launch vehicle failures.

The potential for off-site consequences would be limited primarily to liquid propellant spills of  $N_2O_4$ , RP-1,  $LH_2$ ,  $LO_2$ , and hydrazine during fueling operations of the launch vehicle and a launch failure at or near the launch pad. USAF safety requirements (USAF 2004) specify detailed policies and procedures to be followed to ensure worker and public safety during liquid propellant fueling operations. If a spill were to occur, rapid oxidation of propellant (e.g.,  $N_2O_4$  in the case of a Delta II) combined with activation of the deluge water system would limit the potential toxic effects of the propellant to the immediate vicinity of the launch pad. Workers performing propellant loading would be equipped with protective clothing and breathing apparatus and uninvolved workers would be excluded from the area during propellant loading. Propellant loading would occur only shortly before launch, further minimizing the potential for accidents.

A launch vehicle failure on or near the launch area during the first few seconds of flight could result in the release of the propellants (solid and liquid) onboard the launch vehicle and the spacecraft. The resulting emissions would resemble those from a normal launch from an Atlas or a Delta, consisting of CO and  $NO_x$ , and for vehicles with SRMs, HCl and  $Al_2O_3$  particulates from the burning solid propellant. A launch vehicle failure would result in the prompt combustion of a portion of the liquid propellants, depending on the degree of mixing and ignition sources associated with the accident, and somewhat slower burning of the solid propellant fragments. Falling debris would be expected to land on or near the launch pad resulting in potential secondary ground-level explosions and localized fires. After the launch vehicle clears land, debris from an

accident would be expected to fall over the ocean. Modeling of accident consequences with meteorological parameters that would result in the greatest concentrations of emissions over land areas indicates that the emissions would not reach levels threatening public health. Some unburned solid and liquid propellants could enter surface water bodies and the ocean. Unburned solid and liquid propellants entering surface water bodies could result in short-term, localized degradation of water quality and potentially fatal conditions to aquatic life. Such chemicals entering the ocean would be rapidly dispersed and buffered, resulting in little long-term impact on water quality and resident biota.

### 2.5.3 Environmental Impacts of Radiological Accidents for the Proposed Action and Alternative 2

This section provides a discussion on potential radiological accidents that could occur for the Proposed Action or Alternative 2.

Just as some earlier NASA missions have used radioisotopes to meet mission requirements of power, heat, and scientific investigations, one or more of the MEP missions could also require the use of radioisotopes. Under the Proposed Action and Alternative 2, small quantities of radioisotopes may be used as part of science experiments, and plutonium dioxide could be used to supply heat or electric power. For both alternatives, NASA would determine the appropriate level of NEPA documentation required for each mission proposing the use of radioactive material. When a Tier 2 document is determined to be necessary, a nuclear risk assessment would be developed in support of the EA or EIS to address the human health and environmental risks associated with the use of the radioactive material. The risk analysis would address the probability of a release of radioactive material in the event of an accident and the consequences of the release.

The risks associated with prior missions that have made use of radioactive material have all been shown to be relatively small (NASA 1989, NASA 1990, NASA 1995a, NASA 1997, NASA 2002b). Mission-specific factors that affect the estimated risk have included:

- the amount and type of radioactive material used in a mission,
- the protective features designed into the devices containing the radioactive material,
- the probability of an accident which can threaten the radioactive material, and
- the environments (ground impact, fragments, explosion, fire) associated with the accidents.

Nuclear risk assessments have not yet been performed for any of the future MEP missions under consideration. However, many of the parameters that would determine the risks for these proposed missions are expected to be similar to those associated with earlier missions for which risk assessments have been performed. These factors influencing risk would be considered in mission-specific risk assessments performed as part of the Tier 2 EA or EIS.

### **3 DESCRIPTION OF THE AFFECTED ENVIRONMENT**

This Chapter briefly describes the local and global environments that could potentially be affected by implementing the Proposed Action (Alternative 1) or Alternative 2. Local impacts could affect the regional areas surrounding the launch sites at Cape Canaveral Air Force Station (CCAFS), Florida, and Vandenberg Air Force Base (VAFB), California. Global impacts could affect the global atmosphere and landmass.

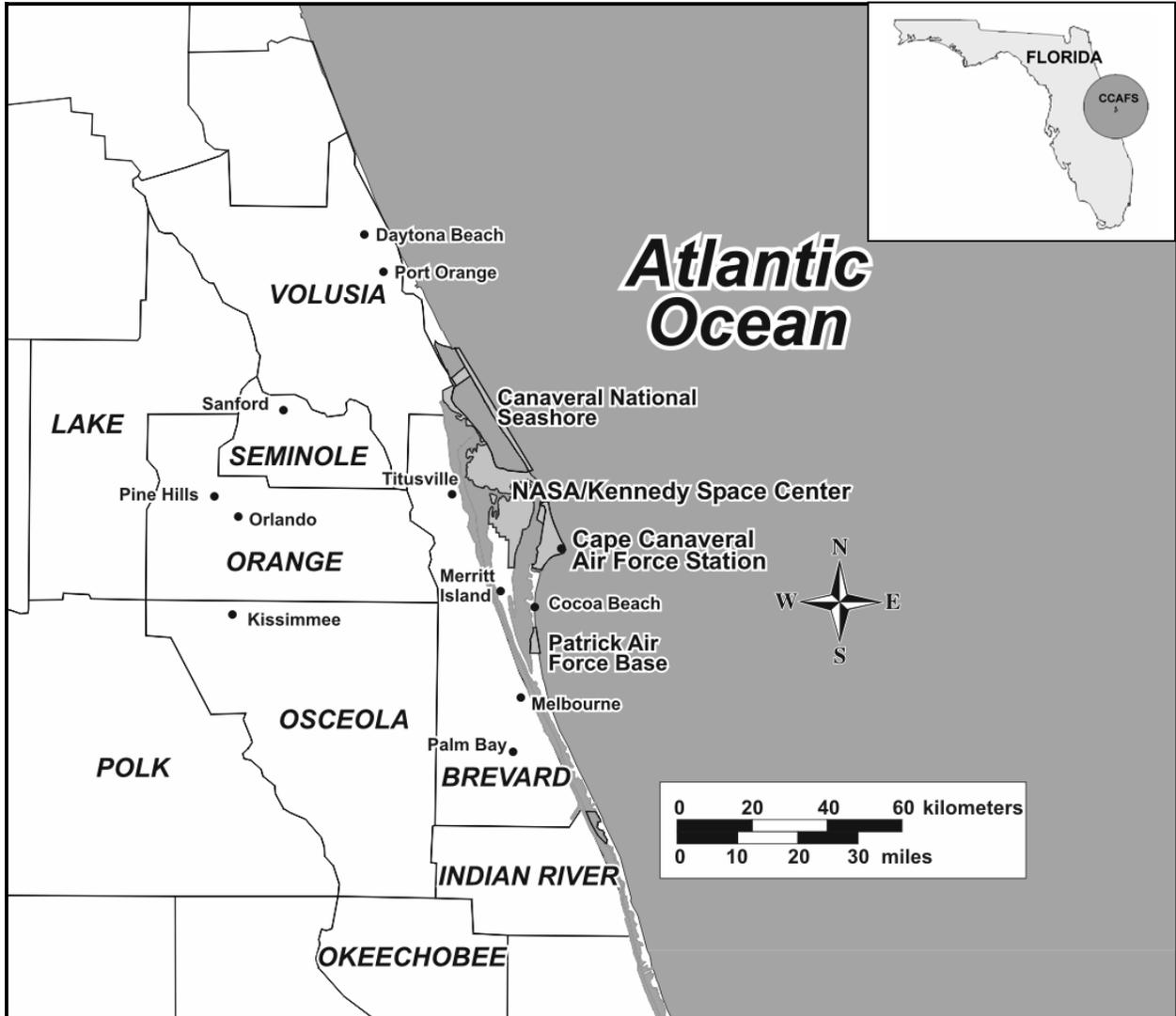
The affected environments have been addressed in previous National Environmental Policy Act (NEPA) documentation and are summarized in this Chapter. Principal sources for the following information include the U.S. Air Force's (USAF) *Final Environmental Impact Statement for the Evolved Expendable Launch Vehicle Program* (USAF 1998), the USAF's *Final Supplemental Environmental Impact Statement for the Evolved Expendable Launch Vehicle Program* (USAF 2000), the National Aeronautics and Space Administration's (NASA) *Final Environmental Assessment for Launch of NASA Routine Payloads on Expendable Launch Vehicles from Cape Canaveral Air Force Station, Florida and Vandenberg Air Force Base California* (NASA 2002a), and NASA's *Final Environmental Impact Statement for the Mars Exploration Rover-2003 Project* (NASA 2002b). Other documentation summarized includes, but is not limited to, the CCAFS *Integrated Natural Resource Management Plan* (USAF 2001) and the Kennedy Space Center's (KSC) *Environmental Resources Document* (NASA 2003).

Section 3.1 describes the affected environment at and surrounding CCAFS, Section 3.2 describes the affected environment at and surrounding VAFB, and Section 3.3 discusses the global environment.

Under both the Proposed Action and Alternative 2, planning would continue for one or more future missions to return Martian samples to Earth. While potential landing sites for the returned sample container have not been determined, the affected environments of all proposed sites would be described in a Tier 2 EIS. Similarly, while potential sites for a secure sample receiving facility have not been determined, the affected environments of all proposed sites would be described in separate environmental documentation.

#### **3.1 CAPE CANAVERAL AIR FORCE STATION REGIONAL AREA**

CCAFS is located on the east coast of Florida in Brevard County on the Canaveral Peninsula (Figure 3-1). The Canaveral Peninsula is a barrier island located approximately 96 kilometers (km) (60 miles (mi)) east of Orlando. The northern boundary of CCAFS abuts the KSC boundary on the barrier island (Figure 3-2). The southern boundary abuts Port Canaveral. CCAFS is separated from KSC to the west by the Banana River. The Atlantic Ocean borders CCAFS along its eastern boundary. The Merritt Island National Wildlife Refuge (MINWR) lies within the boundaries of KSC.



**FIGURE 3-1. THE REGIONAL AREA NEAR CCAFS**

### 3.1.1 Land Use

CCAFS occupies about 6,400 hectares (ha) (15,800 acres (ac)) of land. Major land uses at CCAFS include launch operations and launch support, restricted development, port operations, industrial area, and airfield operations. Approximately 25% of the station is developed, with over 40 space launch complexes (SLC) and support facilities, many of which have been deactivated. The remaining 75% is undeveloped land (USAF 2001).

Within the regional area, a total of eight land use and land cover categories have been classified. These are urban areas; agriculture; rangeland; upland forests; water; wetlands; barren land; and transportation, communication, and utilities rights-of-way. Land use surrounding CCAFS includes an active sea port, and recreation and wildlife management areas. Agricultural uses include crops, citrus, and pasturage.

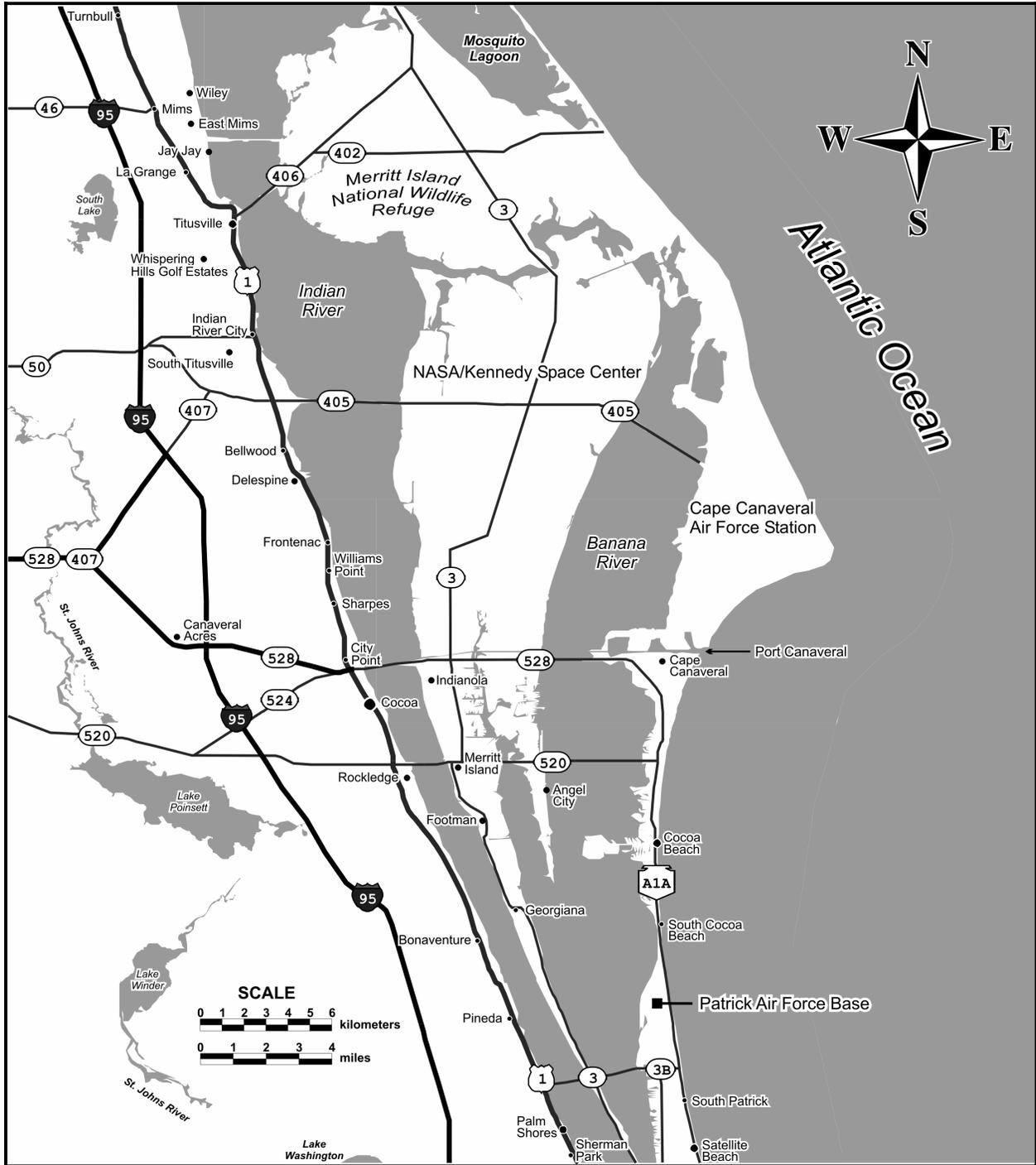


FIGURE 3-2. CCAFS AND THE SURROUNDING AREA

### 3.1.2 Atmospheric Environment

#### 3.1.2.1 Climate

Long, relatively humid summers and mild winters characterize the climate at CCAFS and throughout Brevard County. Temperatures in both summer and winter are moderated by the waters of the Indian River Lagoon system and the Atlantic Ocean. Rainfall is heaviest in summer, with about 65% of the annual total of 142 centimeters (56 inches) falling from June through October in an average year. The other 35% is evenly distributed throughout the average year. CCAFS is vulnerable to hurricanes and their associated storm tides during summer and fall. Historic data show that the storm tide height for a Category 5 (strongest) hurricane would reach to 4.6 meters (15 feet), inundating most of CCAFS. The high hurricane winds necessitate adherence to special construction codes, established to reduce wind load-damage to structures. Maximum temperatures in summer show little day to day variation. Minimum temperatures in winter may vary considerably from day to day, largely due to cold fronts that move across the U.S. from the northwest to the east and southeast (USAF 2001).

#### 3.1.2.2 Air Quality

Air quality is regulated through the National Ambient Air Quality Standards (NAAQS) promulgated under the Clean Air Act, as amended (42 U.S.C. 7401 *et seq.*) (CAA). Under NAAQS, Federal primary and secondary air quality standards are established for six criteria pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO<sub>2</sub>), ozone (O<sub>3</sub>), particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>, particulate matter less than 10 and 2.5 microns in diameter, respectively), and sulfur dioxide (SO<sub>2</sub>). The Federal primary standards set limits to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. The Federal secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings from any known or anticipated adverse effects of a pollutant (EPA 2003a).

Florida has also established air quality standards for criteria pollutants (FAC 2004). The State standards closely follow the Federal standards, but there are differences. Florida has not established a standard for PM<sub>2.5</sub>, and the State standard for SO<sub>2</sub> is more stringent than the Federal standard for comparable measurement averaging times.

Air quality at CCAFS is considered good (FDEP 2002). Table 3-1 compares ambient concentrations with current Federal and State standards. Ambient concentrations of criteria pollutants for Brevard and Orange Counties for 2001 did not exceed the Federal or State standards. Brevard County, including CCAFS, is considered by the Florida Department of Environmental Protection (FDEP) to be in attainment or unclassifiable with respect to criteria pollutants (FDEP 2002). Therefore, the CAA general conformity rules would not apply.

**TABLE 3-1. SUMMARY AIR QUALITY DATA NEAR CCAFS FOR 2002**

Criteria Pollutant	Federal Standard <sup>a</sup> µg/m <sup>3</sup> (ppm)		Florida State Standard µg/m <sup>3</sup> (ppm)	2002 Ambient Concentrations µg/m <sup>3</sup> (ppm)
Carbon Monoxide (CO)				
1-hour Average	40,000 (35)	Primary	40,000 (35)	(5)
8-hour Average	10,000 (9)	Primary	10,000 (9)	(3)
Lead (Pb)				
Quarterly Average	1.5	Both Primary & Secondary	1.5	no data
Nitrogen Dioxide (NO <sub>2</sub> )				
Annual Arithmetic Mean	100 (0.053)	Both Primary & Secondary	100 (0.053)	(0.011)
Ozone (O <sub>3</sub> )				
1-hour Average	235 (0.12)	Both Primary & Secondary	235 (0.12)	(0.090)
8-hour Average	157 (0.08)	Secondary	no standard	(0.076)
Particulate Matter (PM <sub>10</sub> )				
Annual Arithmetic Mean	50	Both Primary & Secondary	50	18
24-hour Average	150	Secondary	150	67
Particulate Matter (PM <sub>2.5</sub> )				
Annual Arithmetic Mean	15	Both Primary & Secondary	no standard	7.8
24-hour Average	65	Secondary	no standard	24
Sulfur Dioxide (SO <sub>2</sub> )				
Annual Arithmetic Mean	80 (0.03)	Primary	60 (0.02)	(0.001)
24-hour Average	365 (0.14)	Primary	260 (0.10)	(0.005)
3-hour Average	1,300 (0.5)	Secondary	1,300 (0.5)	(0.013)

Sources: EPA 2003a, FAC 2004, FDEP 2002

- a. Federal primary standards are levels of air quality necessary, with an adequate margin of safety, to protect the public health. Federal secondary standards are levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.

µg/m<sup>3</sup> = micrograms per cubic meter

ppm = parts per million

On July 18, 1997, the U.S. Environmental Protection Agency (EPA) adopted the 8-hour O<sub>3</sub> standard, which is intended to eventually replace the one-hour standard. On April 15, 2004, the EPA issued the first phase of the final rule in the *Federal Register* (FR), designating nonattainment areas of the country that exceed the new standard (69 FR 23857). The EPA designated the entire State of Florida as unclassifiable/attainment for the new 8-hour O<sub>3</sub> standard.

Also on July 18, 1997, the EPA promulgated a new standard for fine particles (PM<sub>2.5</sub>). States were required to submit their recommendations for designating individual counties as attainment or nonattainment by February 2004. On January 5, 2005, the EPA agreed with Florida's recommendations and classified the entire State of Florida as unclassifiable/attainment for the new fine particle standard (70 FR 943).

### 3.1.3 Ambient Noise

Ambient noise levels at CCAFS have not been monitored. The ambient noise levels at KSC, where similar industrial activities occur, range from about 60 A-weighted decibels

(dBA) to 80 dBA, similar to levels found in many industrial settings. Noise levels at resorts and on the beaches near Cape Canaveral probably range from 45 to 55 dBA (USAF 1998).

#### 3.1.4 Geology and Soils

CCAFS lies on a barrier island composed of relict beach ridges. There are four stratigraphic units: the surficial sands, the Caloosahatchee Marl, Hawthorn Formation, and the limestone formations of the Floridan Aquifer. The Upper Floridan Aquifer is under artesian pressure (the natural pressure that helps boost water upwards in wells) in the vicinity of CCAFS. The Hawthorn Formation separates the Floridan Aquifer from other aquifers (groundwater basins) in the area. CCAFS is not in an active sinkhole area. It lies in a Seismic Hazard Zone 0 (very low risk of seismic events) (USAF 1998).

Soils in the CCAFS area include five major associations. The three most prominent soil types are contained in the Canaveral-Palm Beach-Welaka Association. These soils are highly permeable and allow water to quickly percolate into the ground. There is no prime or unique farmland at CCAFS (USAF 1998).

#### 3.1.5 Hydrology and Water Quality

##### 3.1.5.1 Surface Waters

The major surface water resources in the region include the upper St. Johns River Basin, the Indian River, the Banana River, the Mosquito Lagoon, and a portion of the Kissimmee River on the western border of Osceola County. Except for the portions that are part of the Intercoastal Waterway between Jacksonville and Miami, these water bodies are shallow, estuarine lagoons. The Indian and Banana Rivers are connected by the Barge Canal at Port Canaveral. Surface drainage at CCAFS is generally westward toward the Banana River (USAF 1998).

The launch complexes expected to be used for the Proposed Action or Alternative 2 do not lie within the 100-year floodplain, nor are they located in a wetland.

##### 3.1.5.2 Surface Water Quality

The St. Johns River, from Lake Washington south, and its tributaries are classified by the State of Florida as Class I surface waters (potable water supply) and serve as the source of potable water for Melbourne and for much of the surrounding population. Near CCAFS, the Mosquito Lagoon and portions of the Indian River have been designated as Class II waters (shellfish propagation and harvesting). The remaining surface waters in the vicinity (the Banana Creek, the Banana River, and portions of the Indian River south of Titusville) have been designated as Class III waters (recreation, fish, and wildlife management).

Areas of the Banana River south of CCAFS, and the entire Mosquito Lagoon north of CCAFS have been designated as Aquatic Preserves under Florida's Aquatic Preserve Act of 1975 (Florida Administrative Code 62-302.700). Aquatic Preserves have

exceptional biological, aesthetic, and scientific values and have substantial restrictions placed on activities like oil and gas drilling and effluent discharges (NASA 2003).

Surface waters within the MINWR, the Canaveral National Seashore, and the Banana River Aquatic Preserve located near CCAFS have been designated as Outstanding Florida Waters, and as such are afforded the highest protection by the State of Florida (Florida Administrative Code 62-302.700). The State established this special designation for surface waters that demonstrate recreational or ecological significance. Other Outstanding Florida Waters in the vicinity of CCAFS include the Mosquito Lagoon Aquatic Preserve, the Archie Carr National Wildlife Refuge, the Pelican Island National Wildlife Refuge, the Sebastian Inlet State Recreation Area, the Indian River Aquatic Preserve – Malabar to Vero Beach, and the Indian River North Beach Program Area. In addition, the EPA's National Estuary Program has selected the Indian River Lagoon System, which includes the Mosquito Lagoon, as an Estuary of National Significance. There are no designated wild or scenic rivers located on or near CCAFS (USAF 1998, NASA 2003).

Brevard County, the State of Florida, and the U.S. Fish and Wildlife Service (FWS) maintain long-term water quality monitoring stations located in the Mosquito Lagoon, the Banana River, the Banana Creek, the Indian River, and other locations on or near KSC. Surface water quality has been characterized as generally good, with best areas of water quality adjacent to undeveloped areas of the lagoon, *i.e.*, the North Banana River, the Mosquito Lagoon, and the northern-most portion of the Indian River. The waters tend to be alkaline and have good buffering capacity. Water samples have been analyzed for various parameters from inland bodies of water near CCAFS and KSC. Certain metals (*e.g.*, aluminum, calcium, chlorides, iron, magnesium, potassium, sodium), one pesticide (*i.e.*, dieldrin), and some poly aromatic hydrocarbons (*e.g.*, naphthalene, fluorene) were measured above detection limits. The detection limits for these parameters were below the Class I (potable water) and Class II (shellfish propagation and harvesting) water quality criteria except for dieldrin (NASA 2003).

### 3.1.5.3 Groundwater Sources

Groundwater underlying CCAFS occurs in three aquifer systems: the surficial aquifer, a secondary semi-confined aquifer, and the Floridan Aquifer. The surficial aquifer is unconfined and extends from just below the ground surface to a depth of about 21 m (70 ft). Recharge of the surficial aquifer is largely by percolation of rainfall and runoff. Near CCAFS, wells that tap this aquifer are used primarily for non-potable uses; however, Mims and Titusville, located about 16 km (10 mi) northwest of CCAFS, and Palm Bay, located about 64 km (40 mi) south of CCAFS, use the surficial aquifer for public water supply. The secondary, semi-confined aquifers are found below confining layers, but above and within the Hawthorn Formation. Recharge is minor and depends on leakage through surrounding lower permeability soils. A confining layer of clays, sands, and limestone, ranging from 24 to 37 m (80 to 120 ft) thick, restricts exchange between the surficial aquifer and the deeper Floridan Aquifer. The Floridan Aquifer is the primary source of potable water in central Florida. CCAFS receives its potable water from the City of Cocoa, which draws its water from a non-brackish area of the Floridan Aquifer (USAF 1998, NASA 2003).

#### 3.1.5.4 Groundwater Quality

In the immediate vicinity of CCAFS, groundwater from the Floridan Aquifer is highly mineralized (primarily by chlorides) because of entrapment of seawater in the aquifer, lateral intrusion caused by inland pumping, and lack of flushing because of distant freshwater recharge areas.

The secondary semi-confined aquifer lies between the surficial aquifer and the Floridan Aquifer and is contained within the relatively thin Hawthorn formation. Groundwater recharge is by upward leakage from the Floridan system as well as lateral intrusion from the Atlantic Ocean. Water quality varies from moderately brackish to brackish.

Groundwater quality in the surficial aquifer system at CCAFS remains good because of immediate recharge, active flushing, and a lack of development. Groundwater from the surficial aquifer meets Florida's criteria for potable water (Class G-II, total dissolved solids less than 10,000 milligrams per liter (mg/l) (10,000 parts per million (ppm)) and national drinking water criteria for all parameters other than iron and total dissolved solids.

There are several sites in Florida listed as manufacturers or users of perchlorates. However, Florida (and therefore Brevard County and CCAFS) is not listed as having areas that contain high levels of perchlorate contamination of groundwater or soils (EPA 2003b).

#### 3.1.5.5 Offshore Environment

From CCAFS to the coast out to sea, sandy shoals lead to a deepening sea floor where the bank slopes down to the Blake Plateau. Offshore currents usually reflect the general northern flow of the Gulf Stream. Water movements in the area indicate a shoreward current, although wind generally determines current flow at the surface. The prevailing winds transport surface waters toward shore, with an offshore component in shallow bottom waters that diminishes rapidly with distance offshore. The net effect is that material suspended in the water tends to be confined to the area near the coast, and heavier material (e.g., sand) is deposited in this area. The occasional northward winds result in a net movement of surface waters offshore, with an onshore movement of higher density bottom waters. Materials suspended in surface waters are transported offshore, and heavier bottom materials move onshore.

#### 3.1.6 Biological Resources

The region surrounding CCAFS has several terrestrial and aquatic conservation and special designation areas (e.g., wildlife management areas and aquatic preserves).

##### 3.1.6.1 Terrestrial Resources

The majority of the land at and near CCAFS, including KSC/MINWR and the Mosquito Lagoon/Cape Canaveral National Seashore, is undeveloped and in a near-natural state. These areas host a variety of plant communities, ranging from mangrove swamps and salt marshes to freshwater wetlands, coastal dunes, and beaches. Within

the undeveloped areas at CCAFS, there are eleven natural communities: Beach Dune, Scrub, Hydric Hammock, Coastal Grassland, Xeric Hammock, Estuarine Tidal Swamp, Coastal Strand, Maritime Hammock, Estuarine Tidal Marsh, Coastal Interdunal Swale and Shell Mound (USAF 2001).

These natural communities support many reptile, amphibian, bird, and mammal species. Such species include alligator, snakes, turtles, toads, waterfowl, wading birds, warblers, owls, squirrel, raccoon, white-tail deer, skunk, and rabbit (USAF 2001). In addition, the CCAFS/KSC area, including the MINWR, is host to diverse populations of migratory birds that are protected by the Migratory Bird Treaty Act, as amended (16 U.S.C. 703 *et seq.*). Many migratory birds also use this area as wintering grounds (NASA 2003, USAF 2001).

### 3.1.6.2 Aquatic Resources

Diverse freshwater, estuarine, and marine fish inhabit the waters around CCAFS. Inland waters support sea trout and redfish sport fisheries. The tidal zone supports an abundance of several species of marine invertebrates, as well as small fish that are food for many shore birds. Several species of gulls, terns, sandpipers, and other birds use the beaches of the Cape Canaveral area. In addition, these beaches are important to nesting sea turtles.

Commercial and recreational fishing is a major economic asset to the region. The Mosquito Lagoon is considered among the best oyster and clam harvesting areas on the east coast.

The conservation of essential fish habitat (EFH) is an important component of building and maintaining sustainable fisheries. The Magnuson-Stevens Fishery Conservation and Management Act, as amended (16 U.S.C. 1801 *et seq.*) (M-S Act), calls for direct action to stop or reverse the continued loss of fish habitats. Toward this end, Congress mandated the identification of habitats essential to managed species and measures to conserve and enhance this habitat. The M-S Act requires cooperation among the U.S. Department of Commerce, acting through the National Marine Fisheries Service (NMFS), eight regional Fishery Management Councils, fishing participants, and Federal and state agencies to protect, conserve, and enhance EFH. Federal agencies are to consult with the NMFS on ways to minimize adverse impacts on EFH from the agencies' non-fishing activities. The USAF has a programmatic consultation in place with the NMFS on EFH regarding Delta IV and Atlas V launches from CCAFS (USAF 2000), and will consult with NMFS regarding launches of other vehicles within the Delta and Atlas families from CCAFS (Chambers 2003b).

### 3.1.6.3 Threatened and Endangered Species

Table 3-2 presents a list of Federal and State of Florida threatened and endangered species, and species of special concern, known to occur at or near CCAFS.

**TABLE 3-2. THREATENED, ENDANGERED, AND SPECIES OF SPECIAL CONCERN OCCURRING AT OR NEAR CCAFS**

Common Name	Scientific Name	Federal Status	State Status
<b>Plants</b>			
Beach-star	<i>Remirea maritima</i>	---	E
Coastal vervain	<i>Verbena maritima</i>	---	E
Curtiss milkweed	<i>Asclepias curtissii</i>	---	E
East coast lantana	<i>Lantana depressa</i> var. <i>floridana</i>	---	E
Hand fern	<i>Ophioglossum palmatum</i>	---	E
Nakedwood	<i>Myrcianthes fragrans</i>	---	T
Nodding pinweed	<i>Lechea cernua</i>	---	T
Sand dune spurge	<i>Chamaesyce cumulicola</i>	---	E
Satinleaf	<i>Chrysophyllum oliviforme</i>	---	T
Scaevola	<i>Scaevola plumieri</i>	---	T
Sea lavender	<i>Tournefortia gnaphalodes</i>	---	E
Shell mound prickly-pear	<i>Opuntia stricta</i>	---	T
<b>Reptiles and Amphibians</b>			
American Alligator	<i>Alligator mississippiensis</i>	T(S/A)	SSC
Atlantic Green Sea Turtle	<i>Chelonia mydas</i>	E	E
Atlantic Hawksbill Sea Turtle	<i>Eretmochelys imbricata</i>	E	E
Atlantic Loggerhead Sea Turtle	<i>Caretta caretta</i>	T	T
Atlantic Ridley Sea Turtle	<i>Lepidochelys kempii</i>	E	E
Eastern Indigo Snake	<i>Drymarchon corais couperi</i>	T	T
Florida Pine Snake	<i>Pituophis melanoleucus mugitus</i>	---	SSC
Gopher Tortoise	<i>Gopherus polyphemus</i>	---	SSC
Leatherback Sea Turtle	<i>Dermochelys coriacea</i>	E	E
<b>Birds</b>			
American Oystercatcher	<i>Haematopus palliatus</i>	---	SSC
Arctic Peregrine Falcon	<i>Falco peregrinus tundrius</i>	---	E
Bald Eagle	<i>Haliaeetus leucocephalus</i>	T	T
Black Skimmer	<i>Rynchops niger</i>	---	SSC
Brown Pelican	<i>Pelecanus occidentalis</i>	---	SSC
Florida Scrub-Jay	<i>Aphelocoma coerulescens</i>	T	T
Least Tern	<i>Sterna antillarum</i>	---	T
Little Blue Heron	<i>Egretta caerulea</i>	---	SSC
Piping Plover	<i>Charadrius melodus</i>	T	T
Reddish Egret	<i>Egretta rufescens</i>	---	SSC
Roseate Spoonbill	<i>Ajaia ajaja</i>	---	SSC
Snowy Egret	<i>Egretta thula</i>	---	SSC
Southeastern American Kestrel	<i>Falco sparverius paulus</i>	---	T
Tricolored Heron	<i>Egretta tricolor</i>	---	SSC
White Ibis	<i>Eudocimus albus</i>	---	SSC
Wood Stork	<i>Mycteria americana</i>	E	E
<b>Mammals</b>			
Finback Whale	<i>Balaenoptera physalus</i>	E	E
Florida Manatee	<i>Trichechus manatus</i>	E	E
Florida Mouse	<i>Peromyscus floridanus</i>	---	SSC
Gray Bat	<i>Myotis grisescens</i>	E	E
Humpback Whale	<i>Megaptera novaeangliae</i>	E	E
North Atlantic Right Whale	<i>Eubalaena glacialis</i>	E	E
Sei Whale	<i>Balaenoptera borealis</i>	E	E
Southeastern Beach Mouse	<i>Peromyscus polionotus niveiventris</i>	T	T

Sources: FDACS 2003, FFWCC 2004, USAF 2001

E = Endangered; SSC = Species of Special Concern; T = Threatened  
(S/A) = listed by similarity of appearance to a listed species

The Florida manatee, a subspecies of the endangered West Indian Manatee, occurs near CCAFS/KSC. The FWS and the State of Florida have designated selected inland waterways around CCAFS/KSC as manatee protection areas (refuges and sanctuaries) (67 FR 680, 67 FR 68450, 69 FR 40796).

Loggerhead, green, and leatherback sea turtles use the beaches at CCAFS as nesting habitat. Nesting typically occurs between May and October. The launch complexes use exterior lighting for safety and security reasons. Sea turtle adults and hatchlings are sensitive to artificial lighting near their nesting beaches. Extensive research has demonstrated that artificial lighting deters adult female turtles from emerging from the water and nesting. After emerging from the nests, the hatchlings use moonlight and starlight reflected off the ocean as a guide to finding the ocean. If the inland lighting is brighter than the reflected light, the hatchlings may get disoriented and never reach the ocean. CCAFS's lighting management plan minimizes light impacts on sea turtle nesting beaches (USAF 2001).

A large population of the threatened southeastern beach mouse has been found at CCAFS launch sites where open grassland habitat is maintained. Coastal grasslands and strand provide habitat for the highest population densities at CCAFS. Other primary habitat is the coastal dune (USAF 1998).

Wood storks are year around residents of the Cape Canaveral area, nesting in treetops of mangrove swamps and near water impoundments. Florida scrub jays use the oak scrub habitat at CCAFS. Least terns typically nest between May and June and use sandy or gravelly beaches and gravel rooftops in an industrial area at CCAFS from April to October. Least terns are sensitive to disturbance during nesting.

Four endangered whale species (finback, humpback, North Atlantic right, and sei) occur in the coastal waters near CCAFS. The National Marine Fisheries Service has designated critical habitat for the North Atlantic right whale, which includes marine waters adjacent to the coasts of Georgia and Florida, including the Cape Canaveral area (59 FR 13500).

### 3.1.7 Socioeconomics

Socioeconomic resources in the area surrounding CCAFS include its population; economy; transportation systems; public and emergency services; and recreation opportunities. These resources are described below.

#### 3.1.7.1 Population

The regional area surrounding CCAFS includes all or portions of five counties surrounding Brevard County; Indian River, Orange, Osceola, Seminole, Volusia, also called the six-county region. From 1990 to 2000, the six-county region grew by 27.6% (1,932,646 to 2,466,553) whereas Florida's population grew by 23.5% (12,937,926 to 15,982,378). The population in Brevard County grew by 19.4% (398,978 to 476,230), a lower rate than both the State and region during this period (USBC 2001). Between 1990 and 2000, the minority population in Brevard County grew from 10% to 16.3%. "Hispanic or Latino" and "Black or African American" made up approximately 83% of the minority population (USBC 1990, USBC 2000).

All counties included in the regional area of interest are expected to have population increases through 2020. Using the 2000 census as a baseline, Brevard County

population is expected to increase by almost 15% (547,000) by the year 2010 and by 30% (619,000) by the year 2020 (BEBR 2002).

Persons whose income is less than the poverty threshold are designated as low-income persons by the Council on Environmental Quality (CEQ 1997). In the year 2000, 9.5% of Brevard County reported incomes below the 1999 poverty threshold. The percentage of persons living in Brevard County and whose incomes were below the poverty threshold (9.5%) in 2000 was less than the three-year average of 11.9% for the United States as a whole (USBC 2000, DOC 2001).

### 3.1.7.2 Economy

The region's economic base is tourism and manufacturing, with tourism attracting more than 20 million visitors annually. Walt Disney World®, Sea World®, and Universal Studios Florida®, along with KSC, are among the most popular tourist attractions in the State. Several cruise lines anchor at Port Canaveral providing a multimillion-dollar economic boost to Brevard County, and the Port's cargo business is emerging as a major economic contributor to Central Florida.

Industrial sectors in Brevard County providing significant employment in 2000 were services (34.2%), wholesale and retail trade (24.3%), government (14.3%), manufacturing (13.8%), construction (5.9%), finance, insurance and real estate (3.3%), transportation, communications and public utilities (2.8%), and agriculture and fishing (1.1%). Brevard County had 220,413 people employed in 2000 with an unemployment rate of 2.8% (BEBR 2001).

The employment pool at CCAFS involves about 5,700 military and civilian personnel, all associated with the USAF (Chambers 2003a). Military personnel are attached to the 45<sup>th</sup> Space Wing at Patrick Air Force Base (PAFB), approximately 32 km (20 mi) to the south of CCAFS (USAF 2001). A majority of the employed are contractor personnel from companies associated with missile testing and launch vehicle operations.

### 3.1.7.3 Transportation Systems

Numerous Federal, State, and county roads afford access to CCAFS. Freight rail service is available; there is limited passenger service. The Florida East Coast Railway provides rail transportation in the CCAFS/KSC area.

The region has three major airports: Orlando International, Daytona Beach International, and Melbourne International. CCAFS contains a skid strip (runway) for Government aircraft and delivery of launch vehicle components.

Port Canaveral is the nearest navigable seaport to CCAFS. With six existing cruise terminals and two more planned, Port Canaveral has become the second busiest cruise port in the world (Port Canaveral 2003).

#### 3.1.7.4 Public and Emergency Services

Emergency medical services for CCAFS personnel are provided at the Occupational Health Facility at KSC. Additional health care services are provided by nearby public hospitals located outside of CCAFS.

CCAFS obtains its potable water under contract from the city of Cocoa water system and uses up to 3.8 million liters (1 million gallons (gal)) per day (USAF 1998). The onsite water distribution system is sized to accommodate the short-term high-volume flows required for launches.

A mutual-aid agreement exists between the City of Cape Canaveral, Brevard County, KSC, and the range contractor at CCAFS for reciprocal support in the event of an emergency or disaster (USAF 1998). Further, CCAFS range operations and the Brevard County Office of Emergency Management have agreements for communications and early warning in the event of a launch accident.

When a launch is scheduled, the Federal Aviation Administration (FAA) is notified, and air traffic in a FAA-designated area around the launch corridor is controlled. Notification is also made, via the U.S. Coast Guard, to offshore vessels 10 days prior to launch regarding the location of the debris impact corridor (USAF 1998).

#### 3.1.7.5 Recreation

Recreational activities focus primarily on coastal beaches, inland waterways (*e.g.*, the Indian, Banana, and St. Johns Rivers), and freshwater lakes scattered throughout the region (USAF 1998). The Canaveral National Seashore lies to the north of CCAFS, and the MINWR, which includes most of KSC, lies immediately to the west. Within the confines of CCAFS, the use of recreational activities and facilities is limited to CCAFS personnel. Military and civilian personnel may use recreational and cultural facilities available in local communities.

#### 3.1.8 Cultural/Historic/Archaeological Resources

Cultural facilities on station, including the Air Force Space and Missile Museum and the original NASA mission control, are all located at the southern portion of the base.

A 1978 survey of MINWR identified four historic sites: Sugar Mill Ruins, Fort Ann, Dummett Homestead, and the Old Haulover Canal. Of the four sites, only the Old Haulover Canal is listed on the National Register of Historic Places (NRHP).

Archaeological investigations at CCAFS indicate that human occupation of the area first occurred approximately 4,000 years ago. Federal regulations require that NASA takes into consideration the impact of its activities on cultural resources which are on, or are considered eligible for listing on, the NRHP. Surveys of CCAFS recorded 56 prehistoric and historic archaeological sites, with several identified as eligible for listing on the NRHP. Launch Pads 5/6, 14, 19, 26, 34, and the original Mission Control Center at CCAFS are listed on the NRHP and form a National Historic Landmark District associated with the Man in Space Program. Launch Complexes 1/2, 3/4, 9/10, 17,

21/22, 31/32, and the original site of the Cape Canaveral Lighthouse and the Lighthouse itself are considered as eligible for listing on the NRHP (USAF 2001).

### **3.2 VANDENBERG AIR FORCE BASE REGIONAL AREA**

VAFB is located in the western portion of Santa Barbara County, on the coast of south central California (Figure 3-3). State Route 246 and the Santa Ynez River administratively divide VAFB into North and South Vandenberg. SLCs expected to be used for the Proposed Action or Alternative 2 are located in both North and South Vandenberg. VAFB is bounded on the west by 56 km (35 mi) of Pacific Ocean coastline. The nearest cities to VAFB are Santa Maria, Lompoc, and Guadalupe. The islands of Channel Island National Park extend along the southern California coast from Point Conception near Santa Barbara to just north of Los Angeles. The western-most of the islands lies about 60 km (37 mi) to the south and east of VAFB.

#### **3.2.1 Land Use**

VAFB occupies approximately 39,822 ha (98,400 ac) of land, about 6% of the total land area of Santa Barbara County. Most of the base is open space. Developed areas are occupied by facilities associated with USAF activities which include launch operations, launch support, airfield, and station support areas. South Vandenberg is less developed than North Vandenberg, with most of the infrastructure situated in North Vandenberg. Open spaces in South Vandenberg are leased for grazing (USAF 1998).

#### **3.2.2 Atmospheric Environment**

##### **3.2.2.1 Climate**

The climate in the vicinity of VAFB is characterized by warm, dry weather, with wet weather (a little more than a foot of rainfall per year) occurring from November to April. The driest periods occur during the fall. The Pacific Ocean exerts a moderating influence on local weather patterns. Winds predominantly occur from the northwest with infrequent easterly winds, generally occurring during the fall. The strongest winds occur during midday in the winter, and low winds occur in the evening and early morning hours. Calms (periods of no wind) are rare. Coastal fog and low clouds are common during nighttime and early morning hours, especially during summer (USAF 1998).

##### **3.2.2.2 Air Quality**

Air quality at VAFB is administered through the Santa Barbara County Air Pollution Control District (SBCAPCD). The California Environmental Protection Agency's Air Resources Board (CARB), the State agency responsible for air quality in California, considers Santa Barbara, San Luis Obispo, and Ventura Counties as one air basin called the South Central Coast Air Basin.

California has established air quality standards for criteria pollutants that differ somewhat from the Federal standards (see Section 3.1.2.2). With the exception of the

8-hour CO standard, which is the same as the Federal standard, California standards for criteria pollutants are generally more stringent than the Federal standards (CARB 2002).

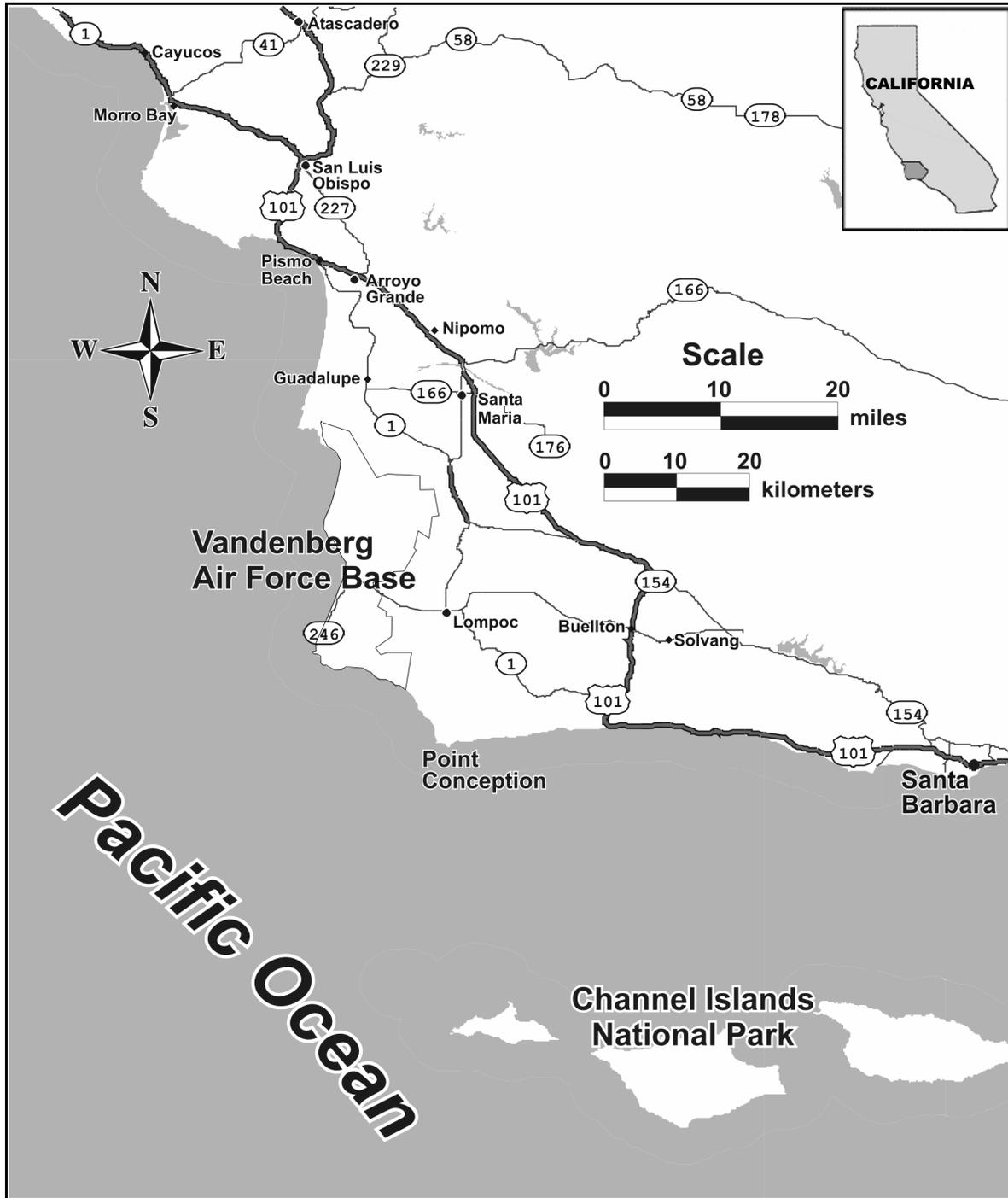


FIGURE 3-3. THE REGIONAL AREA NEAR VAFB

Criteria pollutants, total hydrocarbons, total reduced sulfur, and meteorological data (ambient temperature, wind speed and direction) are monitored at a station located on South Vandenberg. Table 3-3 presents a summary of the 2002 concentrations of criteria pollutants obtained at this station. Measured concentrations were below the Federal and State standards at this station (SBCAPCD 2002, CARB 2003). Based upon currently available data, Santa Barbara County is in attainment for all Federal NAAQS (EPA 2004b). On April 15, 2004, the EPA designated Santa Barbara County as unclassifiable/attainment for the new 8-hour ozone standard (69 FR 23857). On January 5, 2005, the EPA agreed with California's recommendations and classified Santa Barbara County as unclassifiable/attainment for the new fine particle (PM<sub>2.5</sub>) standard (70 FR 943).

**TABLE 3-3. SUMMARY AIR QUALITY DATA AT VAFB FOR 2002**

Criteria Pollutant	Federal Standard <sup>a</sup> µg/m <sup>3</sup> (ppm)		California State Standard µg/m <sup>3</sup> (ppm)	2002 Ambient Concentrations µg/m <sup>3</sup> (ppm)
Carbon Monoxide (CO)				
1-hour Average	40,000 (35)	Primary	23,000 (20)	(0.82)
8-hour Average	10,000 (9)	Primary	10,000 (9)	(1.3)
Lead (Pb)				
Quarterly Average	1.5	Both Primary &	no standard	no data
30-day Average	no standard	Secondary	1.5	no data
Nitrogen Dioxide (NO <sub>2</sub> )				
Annual Arithmetic Mean	100 (0.053)	Both Primary &	no standard	(0.001)
1-hour Average	no standard	Secondary	470 (0.25)	(0.018)
Ozone (O <sub>3</sub> )				
1-hour Average	235 (0.12)	Both Primary &	180 (0.09)	(0.084)
8-hour Average	157 (0.08)	Secondary	no standard	(0.078)
Particulate Matter (PM <sub>10</sub> )				
Annual Arithmetic Mean	50	Both Primary &	20	18
24-hour Average	150	Secondary	50	48.8
Particulate Matter (PM <sub>2.5</sub> )				
Annual Arithmetic Mean	15	Both Primary &	12	no data
24-hour Average	65	Secondary	no standard	no data
Sulfur Dioxide (SO <sub>2</sub> )				
Annual Arithmetic Mean	80 (0.03)	Primary	no standard	(0.002)
24-hour Average	365 (0.14)	Primary	105 (0.04)	(0.014)
3-hour Average	1,300 (0.5)	Secondary	no standard	(0.032)
1-hour Average	no standard		655 (0.25)	(0.006)

Sources: EPA 2003a, CARB 2002, CARB 2003, SBCAPCD 2002

- a. Federal primary standards are levels of air quality necessary, with an adequate margin of safety, to protect the public health. Federal secondary standards are levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.

µg/m<sup>3</sup> = micrograms per cubic meter

ppm = parts per million

The USAF and the SBCAPCD have agreed to cooperate in the air quality program managed by Santa Barbara County. Under this agreement, changes in activities at VAFB are coordinated with and permitted through the SBCAPCD. Any new emissions

on VAFB from stationary sources would be considered within the context of the agreement (USAF 1998, USAF 2000).

### 3.2.3 Ambient Noise

VAFB is an operational air base with training activities that would contribute to ambient noise. Expected noise levels outside VAFB would be typical of levels in urban areas with little industrialization (USAF 1998).

In August 1993, noise levels from a Titan IV launch were measured at the City of Lompoc, to the east of VAFB. The Titan IV has been the largest expendable launch vehicle in the U.S. inventory with the greatest potential for noise impacts. The recorded sound level for the Titan IV was 88 dBA, higher than noise levels experienced in urban industrialized areas. Rocket launches are intermittent events, and such noise levels are not expected to increase the ambient noise levels in nearby areas (USAF 1998).

Space launches from VAFB also generate sonic booms during vehicle ascent and stage reentry. Launch-generated sonic booms are directed upward and in front of the vehicle and occur predominantly over the Channel Islands and the Pacific Ocean.

### 3.2.4 Geology and Soils

The recent geologic history of the VAFB region is characterized by alternating periods of deposition and uplift. North Vandenberg lies within the Coastal Range geomorphic province while South Vandenberg lies within the Transverse Ranges geomorphic province. Coastal sand dunes, alluvium, and underlying marine sedimentary rocks characterize the geology of VAFB. Topography within VAFB ranges from sea level to about 610 m (2,000 ft) above mean sea level in the Santa Ynez Mountains (USAF 1998).

All of the south central coast of California is considered to be a seismically active region. VAFB is located in Seismic Hazard Zone IV (areas likely to sustain major damage from earthquakes). The Lions Head Fault runs through North Vandenberg, and the Hosgri, Santa Ynez, and Honda faults run through South Vandenberg. The Hosgri fault is the only fault on the base considered to be active (*i.e.*, has ruptured within the last 10,000 years) (USAF 1998). The active San Andreas Fault lies about 100 km (62 mi) to the northeast of the VAFB area.

The soils tend to be very sandy at VAFB, are generally less than 0.9 m (3 ft) in depth, and have a high buffering capacity. Soil slopes range from level to in excess of 25% in some areas. There is no prime or unique farmland in the launch operations areas at VAFB (USAF 1998).

### 3.2.5 Hydrology and Water Quality

#### 3.2.5.1 Surface Waters

Surface water resources on VAFB are characterized by several major and numerous minor drainage areas or watersheds. Major drainages include the San Antonio Creek

and the Santa Ynez River. The San Antonio Creek is the largest drainage on North Vandenberg, while the Cañada Honda Creek is the major drainage for South Vandenberg. The Santa Ynez River forms the boundary between North and South Vandenberg. The Shuman Creek drains the northernmost areas of Vandenberg while the Jalama Creek drains the southernmost extents of Vandenberg.

The launch complexes proposed to be used for the Proposed Action or Alternative 2 do not lie within the 100-year floodplain nor are they located in a wetland.

#### 3.2.5.2 Surface Water Quality

Surface flows have been sampled near space launch complexes on both North and South Vandenberg. The San Antonio Creek, Santa Ynez River and Shuman Creek receive off-Base agricultural runoff, resulting in elevated dissolved solids, phosphates, and nitrates (USAF 1998).

#### 3.2.5.3 Groundwater Sources

The Monterey shale underlying the region supports a minimal amount of groundwater in fracture zones. The lower section of this formation contains greater amounts of water than the upper section. The depths to the water table vary from 42 m (138 ft) to 40 m (131 ft) (NASA 1998a). Groundwater in the vicinity of VAFB is present in four groundwater basins (aquifers): the Lompoc Upland Basin, the Lompoc Plain Basin, the Lompoc Terrace Basin, and the San Antonio Creek Valley Basin. In 1997 VAFB was connected to the State Water Project providing VAFB with supplemental water, thus relieving overdraft conditions in the local aquifers.

#### 3.2.5.4 Groundwater Quality

Groundwater quality in the region meets all National Primary Drinking Water Regulation standards, although water in the San Antonio Valley Creek Basin currently exceeds drinking water standards for total dissolved solids, manganese, and iron (USAF 1998). A slight decrease in water quality has occurred in the region due to the use of water for irrigation. As irrigation water flows through the soil and back to the basin, it gathers salt, increasing the salinity of the groundwater (USAF 1998).

There are several sites in California listed as manufacturers or users of perchlorates. However, VAFB is not listed as an area that has high levels of perchlorate contamination of groundwater or soils (EPA 2003b).

#### 3.2.5.5 Offshore Environment

From the VAFB coast out to sea, the seafloor slopes to a narrow shelf, followed by submarine canyons. Coastal currents along the shoreline transport sand and sediments into these canyons, where they are swept to the deep sea floor.

The California current flows southward along the shore from the Washington-Oregon border to Southern California. It is modified by seasonal variations in wind direction that give California's near-shore region "oceanic seasons". Beginning in March, prevailing

westerly winds, combined with the effects of the Earth's rotation, drive surface waters offshore, resulting in upwelling (*i.e.*, cold, deep, oceanic water, including dissolved nutrients, brought to the surface). The upwelling period continues until September, when northwesterly winds die down and the cold upwelling begins to sink. This period, characterized by relatively high surface temperatures, is known as the Oceanic Period and lasts through October. In winter, changes in atmospheric conditions over the Pacific Ocean bring southwesterly winds. In response to these winds, a northward surface current begins and flows along the coast inland of the California current. This current, called the Davidson Current, generally lasts through February, when the prevailing winds shift and the cycle repeats.

### 3.2.6 Biological Resources

VAFB and the regional area (the coast line, near-shore waters, and the Channel Islands) support a wide variety of plants and wildlife, including marine mammals, birds, fish, reptiles amphibians, and invertebrates.

#### 3.2.6.1 Terrestrial Resources

Plant communities include coastal salt marsh, coastal sage scrub, central dune scrub, riparian woodland, a variety of chaparral types, and diverse upland woodland communities. Most of VAFB supports natural vegetation. The undeveloped areas include coastal scrub, characterized by sparse vegetative species such as mock heather, California sage brush, dune lupine, and deerweed (USAF 1998).

Common mammalian species include mule deer, coyote, bobcat, jackrabbit, cottontail, skunk, ground squirrel, and numerous nocturnal rodents. The region contains a diversity of bird species, such as redtailed hawks, American kestrels, white-tailed kites, and other common land birds. Shore birds are abundant on all sandy beaches.

Over 2,000 species of plants and animals can be found within the Channel Islands National Park. One hundred and forty-five of these species are unique to the islands and found nowhere else in the world.

#### 3.2.6.2 Aquatic Resources

Reptiles and amphibians on VAFB include several snake species, the Pacific tree-frog, western toad, and the California legless lizard.

Harbor seals, protected under the Marine Mammal Protection Act, as amended (16 U.S.C. 1361 *et seq.*), use the beaches at Purisima Point and the rocky shoreline between Rocky Point and the boathouse on South Vandenberg (south of SLC-6) as resting and pupping areas. Purisima Point is identified by the NMFS as a breeding area in the annual harbor seal census. The Santa Barbara County Local Coastal Plan identifies marine mammal resting and pupping grounds as environmentally sensitive habitat and provides policies designed to help protect these areas (USAF 1998).

This coastal area from Lookout Rock to Pedernales Point is protected under an agreement with the State of California as a marine ecological reserve. VAFB has a

Memorandum of Agreement with the California Department of Fish and Game to limit access to these areas only to military operations and scientific research (USAF 1998).

The sea otter, several species of seals, and many species of whales inhabit the region either as residents or transients and are protected by the Marine Mammal Protection Act. The USAF was granted authorization by the NMFS for the incidental take of marine mammals for specified launch activities for the period February 6, 2004 through February 6, 2009 (69 FR 5720).

The USAF has a programmatic consultation in place with the NMFS on essential fish habitat (see Section 3.1.6.2) regarding Delta IV and Atlas V launches from VAFB (USAF 2000), and will consult with NMFS regarding launches of the Delta II from VAFB (Chambers 2003b).

### 3.2.6.3 Threatened and Endangered Species

Table 3-4 presents a list of Federal and State of California threatened and endangered species, and species of special concern that are known to occur at or near VAFB.

Two listed bird species, the California least tern and the western snowy plover, occur on the beaches of VAFB. The California least tern nests in sand dunes on North Vandenberg from mid April to August, and uses the waters off South Vandenberg for foraging and migration (USAF 1998). The western snowy plover nests from about March to September on VAFB beaches from Purisima Point northward and on South Vandenberg.

FWS Biological and Conference Opinions, which govern potential adverse effects to Federally endangered species, are in place for Delta II, Delta IV, and Atlas V launches from VAFB (FWS 1999a, FWS 1999b, FWS 2001, FWS 2003). Depending on the launch vehicle, the Opinions address incidental take of the California least tern and the western snowy plover during their breeding and nesting seasons. The Opinions also address harassment of the southern sea otter, the California brown pelican, the southwestern willow flycatcher, the California red-legged frog, the tidewater goby, and the unarmored threespine stickleback.

## 3.2.7 Socioeconomics

### 3.2.7.1 Population

Between 1990 and 2000, the population of Santa Barbara County grew by 8% (369,608 to 399,347). In 2000, minority persons made up nearly 43% of the residents. Of the total population in 2000, Whites comprised 56.9%, Hispanic or Latino groups made up 34.2%, and other groups including Black or African American, American Indian and Alaska Native, Asian, and Native Hawaiian and Other Pacific Islander comprised approximately 8.9% (USBC 1990, USBC 2000). Santa Barbara County is expected to have population increases through 2020. Using the 2000 census as a baseline, the population is expected to increase by almost 17% (67,900) by the year 2010, and by almost 38% (151,750) by the year 2020 (CDFDRU 2001, CDFERU 2001).

Persons whose income is less than the poverty threshold are designated as low-income persons by the Council on Environmental Quality (CEQ 1997). In the year 2000, 14.3% of the potentially affected population reported incomes below the 1999 poverty threshold (USBC 2000).

**TABLE 3-4. THREATENED, ENDANGERED, AND RARE SPECIES OCCURRING AT OR NEAR VAFB**

Common Name	Scientific Name	Federal Status	State Status
<b>Plants</b>			
Beach layia	<i>Layia carnosa</i>	E	E
Beach spectaclepod	<i>Dithyrea maritima</i>	---	T
Gambel's watercress	<i>Rorippa gambelli</i>	E	T
Gaviota tarplant	<i>Hemizonia increscens ssp. Villosa</i>	E	E
La Graciosa thistle	<i>Cirsium loncholepis</i>	E	T
Lompoc yerba santa	<i>Erodactyon capitatum</i>	E	R
Seaside's bird's beak	<i>Cordylanthus rigidus ssp. Littoralis</i>	---	E
Surf thistle	<i>Cirsium rhotophilum</i>	---	T
<b>Fish</b>			
Coho salmon	<i>Oncorhynchus kisutch</i>	T	---
Steelhead trout	<i>Oncorhynchus mykiss irideus</i>	E	---
Tidewater goby	<i>Eucyclogobius newberryi</i>	E	---
Unarmored threespine stickleback	<i>Gasterosteus aculeatus williamsonii</i>	E	E
<b>Reptiles and Amphibians</b>			
Arroyo Toad	<i>Bufo californicus</i>	E	---
California red-legged frog	<i>Rana aurora draytonii</i>	T	---
California tiger salamander	<i>Ambystoma californiense</i>	E	---
Green sea turtle	<i>Chelonia mydas</i>	T	---
Leatherback sea turtle	<i>Dermochelys coriacea</i>	E	---
Loggerhead sea turtle	<i>Caretta caretta</i>	T	---
Olive (Pacific) Ridley sea turtle	<i>Lepidochelys olivacea</i>	T	---
<b>Birds</b>			
American peregrine falcon	<i>Falco peregrinus anatum</i>	---	E
Bald eagle	<i>Haliaeetus leucocephalus</i>	T	E
Belding's savanna sparrow	<i>Passerculus sandwichensis beldingi</i>	---	E
California black rail	<i>Laterallus jamaicensis coturniculus</i>	---	T
California brown pelican	<i>Prelacanus occidentalis californicus</i>	E	E
California least tern	<i>Sterna antillarum browni</i>	E	E
Least Bell's vireo	<i>Vireo bellii pusillus</i>	E	E
Southwestern willow flycatcher	<i>Empidonax traillii extimus</i>	E	E
Western snowy plover	<i>Charadrius alexandrinus nivosus</i>	T	---
Western yellow-billed cuckoo	<i>Coccyzus americanus occidentalis</i>	---	E
<b>Mammals</b>			
Blue whale	<i>Balaenoptera musculus</i>	E	---
Finback whale	<i>Balaenoptera physalus</i>	E	---
Guadalupe fur seal	<i>Arctocephalus townsendi</i>	T	T
Humpback whale	<i>Megaptera novaenangliae</i>	E	---
North Pacific Right whale	<i>Eubalaena japonica</i>	E	---
Sei whale	<i>Balaenoptera borealis</i>	E	---
Southern sea otter	<i>Enhydra lutris nereis</i>	T	---
Sperm whale	<i>Physeter macrocephalus</i>	E	---
Steller sea lion	<i>Eumetopias jubatus</i>	T	---

Sources: USAF 1998, CDFG 2004, DOD 2003a

E = Endangered; R = Rare; T = Threatened

### 3.2.7.2 Economy

The largest employers in Santa Barbara County in 2000 were services (including health care), retail trade, technology sectors, agriculture, State and local government (including education), manufacturing, and tourism. Out of a total labor force of 204,400, 96.3% of the people were employed. Significant employment was provided in the services-producing sector (34.9%): hotels/health services (13.0%), trade (10.3%), government (8.3%), and finance (2.0%). In the goods-producing sector (6.5%), manufacturing (4.3%) and construction (2.0%) were significant (CDFERU 2001). VAFB supports over 18,000 military, civilian, and contractor personnel in various fields such as launch operations, security police, civil engineering, services, personnel support, and health services (VAFB 2003).

### 3.2.7.3 Transportation Systems

VAFB is accessible by State and County roads and access to the base is controlled. Rail access to VAFB is maintained through three branch lines that connect VAFB with the Southern Pacific Railroad mainline. Several daily passenger and freight trains pass through VAFB between the Pacific Ocean and VAFB launch facilities. Trains transiting VAFB are suspended when launches are conducted. Prior to a launch, VAFB personnel communicate with appropriate railway authorities aided by electronic surveillance systems, posted railroad schedules, and radio communications to minimize potential risk to people and property (USAF 1998). There are no large commercial airports within the immediate vicinity of VAFB.

### 3.2.7.4 Public and Emergency Services

Public health care services are provided at area hospitals in the cities of Lompoc and Santa Maria. VAFB personnel have access to limited medical services at the base hospital; services beyond the capability of the base hospital are referred to area hospitals.

The San Antonio Aquifer and the Lompoc Terrace Ground Water Basin are used as primary sources of water for VAFB. The base uses approximately 12.9 million liters (3.42 million gal) of water per day. The base is also connected to the State Water Project for supplemental supply of water. Under this, VAFB may obtain approximately 17 million liters (4.5 million gal) per day (USAF 1998).

VAFB maintains onsite emergency services, including specialized teams trained to respond to launch emergencies (USAF 1998). The City of Lompoc and VAFB have a mutual aid agreement in the event of an emergency, with a communications hotline to notify the City immediately in the event of a major accident on the base. If a launch vehicle were to impact areas outside VAFB, the USAF would respond accordingly.

When a launch is scheduled, the Federal Aviation Administration (FAA) is notified, and air traffic in a FAA-designated area around the launch corridor is controlled. Notification is also made, via the U.S. Coast Guard, to offshore vessels 30 days prior to launch regarding the location of the debris impact corridor. Personnel on offshore oil platforms

in the launch corridor are also notified in advance and evacuation or sheltering procedures are put into effect (USAF 1998).

#### 3.2.7.5 Recreation

Two county parks are located within the coastal area of VAFB: Jalama Beach County Park on the southern side, and Ocean Beach County Park on the western side. Among recreational activities are day-use picnicking, overnight camping, site-seeing areas, diving, swimming, and fishing. The parks are temporarily closed during a launch (USAF 1998).

Access to VAFB is currently restricted to military and Department of Defense civilian personnel. The Space and Missile Heritage Center at SLC-10, accessible to the public through the Public Affairs Office, is a National Historic Landmark dedicated to missile and space launch activity at VAFB.

The Channel Islands National Park is located on five of the eight Channel Islands off the California coast south and east of VAFB. Among recreational activities are day-use picnicking, overnight camping, site-seeing areas, boating and kayaking.

#### 3.2.8 Cultural/Historic/Archaeological Resources

There are over 2,300 known prehistoric archaeological sites, 200 historic archaeological sites, 140 Traditional Cultural Properties, 110 historic structures, 77 NRHP-eligible Cold War facilities, several historic trails, and more than 10 significant paleontological sites on the base. Cultural resources at VAFB are present at and in the vicinity of SLC-3 and SLC-6, and certain elements of SLC-2 and SLC-3 associated with the Cold War have been determined eligible for listing in the NRHP.

### **3.3 GLOBAL ENVIRONMENT**

This section provides a general overview of the global environment. It includes basic descriptions of the troposphere, stratosphere, global population distribution and density, surface characteristics, and general climate characteristics.

#### 3.3.1 Troposphere

The troposphere is the atmospheric layer closest to the Earth's surface. This layer accounts for more than 80% of the mass and essentially all of the water vapor, clouds, and precipitation contained in the Earth's atmosphere. The height of the troposphere ranges from an altitude of 10 km (6 mi) at the poles to 15 km (9 mi) at the equator. As the height increases the temperature tends to decrease. In general, the troposphere is well mixed and aerosols in the troposphere are removed in a short period of time as a result of this mixing and scavenging by precipitation. A narrow region called the tropopause separates the troposphere and the stratosphere. Emissions from rocket launches include particulate matter, oxides of nitrogen, carbon monoxide, and chlorine compounds. Removal of most of these from the troposphere occurs over a period of less than one week, preventing a buildup of these products on a global level (USAF 1998).

### 3.3.2 Stratosphere

The stratosphere extends from the tropopause up to an altitude of approximately 50 km (31 mi). In general, vertical mixing is limited within the stratosphere, providing little transport between the layers above and below. Thus, the relatively dry, ozone-rich stratospheric air does not easily mix with the lower, moist, ozone-poor tropospheric air. The lack of vertical mixing and exchange between atmospheric layers provides for extremely long residence times, on the order of months, causing the stratosphere to act as a reservoir for certain types of atmospheric pollution (USAF 1998). The Montreal Protocol is designed to protect the stratospheric ozone layer by phasing out production and consumption of substances that deplete the ozone layer. It was first signed in 1987 and additional requirements were adopted through 1999. Recent measurements indicate that stratospheric chlorine levels are decreasing, consistent with expected declines resulting from the Montreal Protocol.

### 3.3.3 Population Distribution and Density

Global population distribution and density are important factors taken into account when global consequences of potential accident scenarios, such as inadvertent reentry from Earth orbit, are considered. For a mission requiring an assessment of potential global consequences, the global population is projected to the year of interest (*i.e.*, the mission's launch opportunity) based upon the most recent demographic statistics. The details of the global population projection would be reported as part of the analysis for any MEP mission requiring a Tier 2 EA or EIS.

### 3.3.4 Surface Types

Global surface type characteristics are also important factors taken into account when global consequences of potential accident scenarios are considered. The total surface area of the Earth is typically subdivided into the fraction of water and the fraction of land. The land fraction is further subdivided into the fractions consisting of soil and rock. The details of global surface types would be reported as part of the analysis for any MEP mission requiring a Tier 2 EA or EIS.

## 4 ENVIRONMENTAL CONSEQUENCES

This Chapter of the Final Programmatic Environmental Impact Statement (FPEIS) for the Mars Exploration Program (MEP) presents information on the potential environmental impacts of implementing the Proposed Action or the alternatives. The impacts are examined for three areas: (1) the region surrounding Cape Canaveral Air Force Station (CCAFS), Florida; (2) the region surrounding Vandenberg Air Force Base (VAFB), California; and (3) the global environment.

NASA is proposing a coordinated series of robotic orbital, surface, and atmospheric missions to Mars that would gather scientific data on the Martian environment. NASA would also continue with planning for a potential return of Martian samples to Earth. The missions would be launched to Mars about every 26 months from CCAFS or VAFB through 2020. MEP missions sponsored by the United States may or may not include international participation. The MEP may also include U.S. participation in international missions. The proposed MEP could include some missions using radioisotope heater units (RHUs) for thermal control and radioisotope power systems (RPSs) to generate electricity. In addition, small quantities of radioisotopes could be used on some of the instruments on-board the spacecraft for science investigations and instrument calibration.

The potential environmental impacts discussed in this Chapter are based on a representative set of missions as described in Chapter 2. As each specific MEP mission becomes more fully defined, additional environmental documentation will be prepared. This additional documentation could be a Tier 2 document (*i.e.*, an environmental assessment (EA) or an EIS) under this PEIS, or be supported by the environmental decision-making process (*i.e.*, environmental checklist) specified in the *Final Environmental Assessment (EA) for Launch of NASA Routine Payloads on Expendable Launch Vehicles from Cape Canaveral Air Force Station Florida and Vandenberg Air Force Base California* (Routine Payloads EA, NASA 2002a). U.S. participation in foreign MEP missions may require documentation under Executive Order (EO) 12114, *Environmental Effects Abroad of Major Federal Actions*. As each MEP mission is implemented, additional information and techniques are expected to become available which could affect the planning of subsequent mission timing, focus and objectives as well as the type of mission (*e.g.*, orbiter, lander, rover, atmospheric mission, and sample return).

Under Alternative 2, NASA would not implement a coordinated MEP, but would continue to explore Mars through 2020, on a less comprehensive, mission-by-mission basis. Some spacecraft under this alternative may use radioisotope devices for power and for thermal control of temperature-sensitive components, and may carry small quantities of radioisotopes in some science instruments. Any mission to Mars that proposes use of radioisotope devices would be the subject of appropriate environmental documentation.

The environmental impacts of the Proposed Action (Alternative 1, the Preferred Alternative) and Alternative 2 are discussed in this Chapter from a programmatic perspective. Specific proposed projects and missions within the MEP will only be addressed in terms of a broad, conceptual framework. Each project or mission within

the MEP that would use RHUs or RPSs would be the subject of separate environmental documentation. While detailed analyses and test data for each spacecraft-launch vehicle combination are not yet available, there is sufficient information from previous programs and existing environmental documentation to generally assess the environmental impacts.

The RPSs and RHUs are manufactured, assembled, and tested by the U.S. Department of Energy (DOE). The plutonium dioxide would be formed into pellets suitable for use in an RPS or RHU at DOE's Los Alamos National Laboratory (LANL) in New Mexico. The pellets would be encapsulated in an iridium cladding (for an RPS) or a platinum-rhodium cladding (for a RHU) at LANL. The encapsulated RPS pellets would then be shipped to Argonne National Laboratory-West (ANL-W) in Idaho for final RPS assembly and testing. Final assembly of the RHUs would occur at LANL and the RHUs would then be shipped to ANL-W. DOE would then transport the RPSs or RHUs to the appropriate launch site. The impacts of these activities have been addressed in existing DOE environmental documentation, such as the *Environmental Assessment for the Future Location of Heat Source/Radioisotope Power System Assembly and Test Operations Currently Located at the Mound Site* (DOE 2002c).

Under the No Action Alternative NASA would discontinue launching new robotic scientific spacecraft to Mars through 2020. New science investigations of Mars would only be made remotely from Earth-based assets, *i.e.*, ground- or space-based observatories, or from spacecraft developed and launched to Mars by non-U.S. space agencies.

Since the Proposed Action and its alternatives may include U.S. participation in international missions, NASA would consider the environmental impacts of these proposed actions in accordance with EO 12114.

#### **4.1 ENVIRONMENTAL IMPACTS OF THE PROPOSED ACTION**

The nonradiological environmental impacts associated with spacecraft launches from both CCAFS and VAFB have been addressed in previous environmental documentation and are summarized in Sections 4.1.1 through 4.1.3. The principal documentation summarized includes the U.S. Air Force's (USAF) *Final Environmental Impact Statement for the Evolved Expendable Launch Vehicle Program* (USAF 1998), the USAF's *Final Supplemental Environmental Impact Statement for the Evolved Expendable Launch Vehicle Program* (USAF 2000), and NASA's Routine Payloads EA (NASA 2002a).

The number of spacecraft launched under the Proposed Action would average less than one per year, since efficient launch opportunities to Mars occur only about every 26 months. This launch rate would be small when compared to ongoing programs at CCAFS and VAFB. The USAF has assessed environmental impacts through 2020 based upon annual average rates of various sized vehicles of approximately 19 launches per year from CCAFS and approximately seven launches per year from VAFB (USAF 1998). More recently the USAF assessed environmental impacts through 2020 based upon annual average rates of 10 Atlas V and 11 Delta IV launches per year from CCAFS, and approximately three launches per year of each vehicle from VAFB

(USAF 2000). The proposed average launch rate of one or fewer MEP spacecraft per year would be included in and not increase the previously approved launch rates beyond the scope of approved launch vehicle programs at CCAFS and VAFB (e.g., USAF 1996, USAF 1997, USAF 1998, USAF 2000). Therefore, nonradiological environmental impacts expected from U.S. MEP launches would be within the USAF analyses summarized below.

#### 4.1.1 Environmental Impacts of Preparing for the MEP Missions

Payload and launch vehicle processing at Kennedy Space Center (KSC)/CCAFS or at VAFB would involve a number of industrial activities that include the use of hazardous materials. Hazardous wastes, other solid and liquid wastes, and air emissions would be involved. Such material would include but not be limited to propellants, oils, solvents, primers, sealants, and process chemicals. Processing of the launch vehicles for U.S. MEP missions would entail activities common to expendable launch vehicles at CCAFS and VAFB, which have been addressed in existing environmental documentation and facility permits. Launch vehicle processing activities are subject to Federal, State, and local environmental laws and regulations and USAF regulations and requirements (see Section 4.9). NASA or its contractors would acquire hazardous materials and would dispose generated hazardous wastes. In addition, CCAFS and VAFB have programs for pollution prevention and spill prevention. Airborne emissions from liquid propellant loading and off-loading of the spacecraft and the launch vehicle are closely monitored using vapor detectors. Systems for loading hypergolic propellants (which ignite spontaneously when mixed) use air emission controls.

Some spacecraft and launch vehicle integration personnel at KSC/CCAFS and VAFB could potentially be exposed to ionizing radiation hazards from radioactive sources during normal ground processing and launch preparation activities for some MEP missions. Integration and launch processing activities involving radioactive materials at the launch site are subject to extensive review and authorization of all activities by the local radiation protection authority prior to initiation of any operation. Such operations are actively monitored by launch site radiation safety professionals to ensure adherence to approved operating and emergency procedures, and to maintain operational personnel exposures at levels that are as low as reasonably achievable (USAF 1999, NASA 2001a).

#### 4.1.2 Environmental Impacts of Normal MEP Launches

The primary environmental impacts of normal launches from both CCAFS and VAFB would be associated with airborne emissions from the launch vehicles. The selected launch vehicles could be propelled by both solid and liquid propellants. Several launch vehicle configurations, described in Section 2.1.6, are available for the MEP missions. Mission planners would carefully match mission requirements with launch vehicle capabilities when selecting a launch vehicle.

#### 4.1.2.1 Land Use

Processing of MEP payloads, spacecraft, and launch vehicles would be consistent with the designated land uses at CCAFS and VAFB.

CCAFS. Atlas launch vehicles are launched from Space Launch Complex 36 (SLC-36) and SLC-41, and Delta launch vehicles are launched from SLC-17 and SLC-37. These launch complexes are within the launch operations land use category. There would be no impact to land use at CCAFS in preparing proposed MEP mission launches.

VAFB. Delta launch vehicles are launched from SLC-2 and SLC-6. Atlas launch vehicles are launched from SLC-3 East. These launch complexes are within the space launch activity land use category. There would be no impact to land use at VAFB in preparing proposed MEP mission launches.

#### 4.1.2.2 Air Quality

Rocket launches are discrete events that cause short-term impacts on local air quality. However, because launches are relatively infrequent events, and winds rapidly disperse and dilute the launch emissions to background concentrations, long-term effects from exhaust emissions would not be anticipated.

Rocket motor emissions from each of the MEP launches would form a cloud at the launch pad during the first few seconds after ignition and liftoff. This high-temperature cloud would be buoyant, rising quickly, and would tend to stabilize at an altitude of a few hundred meters near each launch area. The exhaust cloud would then dissipate through mixing with the atmosphere. Exhaust products would be distributed along each vehicle's flight path, but emissions per unit length of trajectory would decrease as each vehicle accelerates.

First stage liquid propellant engines that use rocket propellant-1 (RP-1) and liquid oxygen (LO<sub>2</sub>) would primarily produce carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), and water vapor as combustion products. First stage liquid propellant engines that use liquid hydrogen (LH<sub>2</sub>) and LO<sub>2</sub> would produce water vapor. Solid propellant, consisting of ammonium perchlorate, aluminum powder, and hydroxyl-terminated polybutadiene (HTPB) binder in the solid rocket motors (SRMs), would primarily produce aluminum oxide particulates (Al<sub>2</sub>O<sub>3</sub>), CO, hydrogen chloride (HCl), and nitrogen (N<sub>2</sub>). Under the high temperatures of the SRM's exhaust the CO would be quickly oxidized to CO<sub>2</sub>, and the N<sub>2</sub> may react with ambient oxygen to form nitrogen oxides (NO<sub>x</sub>). Most of these emissions would be removed from the atmosphere over a period of less than one week, yielding no long-term accumulation of these products (USAF 1998).

All launch vehicles considered for the MEP missions have been previously analyzed in existing environmental documentation (e.g., USAF 1996, USAF 1997, USAF 1998, and USAF 2000). No long-term adverse impacts on ambient air quality were found.

For both the Proposed Action and Alternative 2, the most significant potential health hazard during a mission launch would be from the HCl emitted from the exhaust from solid propellant if SRMs are used. The Range Safety offices at CCAFS and VAFB use models to predict launch hazards to the public and on-site personnel prior to every

launch. These models calculate the risk of injury resulting from toxic exhaust gases from normal launches. Launches are postponed if the predicted risk of injury exceeds acceptable limits. The allowable collective public risk limit at CCAFS and VAFB is  $30 \times 10^{-6}$  with an individual risk of  $1 \times 10^{-6}$  over the varying population densities. This approach takes into account the exhaust plume's toxic concentration, direction, and dwell time, and emergency preparedness procedures (USAF 2000).

CCAFS. The entire State of Florida is in attainment for all National Ambient Air Quality Standards (NAAQS) criteria pollutants, including the proposed  $PM_{2.5}$  standard based on preliminary data (FDEP 2002, 69 FR 23857). Based on the USAF findings cited above, emissions from launch of MEP missions at CCAFS would not be sufficient to jeopardize the attainment status of the region.

VAFB. Santa Barbara County is in attainment for all Federal NAAQS criteria pollutants (EPA 2004c). Based on the USAF findings cited above, emissions from launch of MEP missions at VAFB would not be sufficient to jeopardize the attainment status of the region.

However, the county did not meet the State of California's more stringent one-hour  $O_3$  standard (SBCAPCD 2003). Conformity analyses have been completed for Delta II, Delta IV, and Atlas V launches in compliance with the U.S. Environmental Protection Agency's (EPA) Conformity Rule and California's State Implementation Plan, and were found to be below *de minimus* levels for  $O_3$ . In agreement with Santa Barbara County, VAFB has site-specific reporting requirements for the facility (USAF 1998, USAF 2000).

#### 4.1.2.3 Noise

Noise impacts associated with launches occur during launch vehicle liftoff and ascent. Increased noise levels would occur for only a short period during the launch (typically less than two minutes), diminishing rapidly as the launch vehicle gains altitude and moves downrange.

CCAFS and VAFB. Non-essential workers would be removed from the launch area prior to liftoff, and those remaining would have noise protection and would be exposed to noise levels anticipated to be below Occupational Safety and Health Administration regulations for unprotected workers (140 dBA maximum, 115 dBA 15-minute average). Short-term launch noise may annoy some area residents. With only one or two MEP launches occurring every 26 months, such noise would be infrequent. Noise levels outside the property lines would not exceed the EPA maximum 24-hour average exposure level of 70 dBA for the general public and would present no health hazard.

Sonic booms would occur in offshore areas. Ships and other maritime vessels in the area would be warned in advance of launch events, and no adverse impacts would be expected (USAF 1998).

#### 4.1.2.4 Geology and Soils

The primary exhaust products from the SRMs— $Al_2O_3$  particulates and HCl gas—would be dispersed depending upon particle size distribution and wind conditions. Aluminum

would largely contribute as fugitive (airborne) dust, and there could be temporary acidification of soil from the HCl. The primary exhaust products from liquid propellant stages would be CO, CO<sub>2</sub>, and water.

CCAFS and VAFB. Assuming SRMs are used, wet deposition of HCl could occur within a few hundred meters of the launch pad. If a rainstorm passes through the exhaust cloud shortly after launch, wet HCl deposition could occur at further distances from the launch complex. The soils at CCAFS have relatively high buffering capacities and are not expected to be adversely affected (Schmalzer *et al.* 1998). Soils at VAFB are buffered by salt spray from onshore winds depositing sea salt that would aid in neutralizing acid deposition from launch exhaust (USAF 2000). No long-term adverse impacts to geology or soils at CCAFS or VAFB would be expected.

At VAFB seismic events are taken into consideration during launch complex design, as required by California building codes (USAF 2000).

#### 4.1.2.5 Hydrology and Water Quality

Water would be used for acoustic damping, cooling, post-launch washdown, fire suppression, and potable uses. Groundwater and surface water resources and water quality could be potentially impacted by the disposal of water used for a launch, and by the deposition of launch exhaust products into nearby surface water bodies.

CCAFS—Groundwater. The City of Cocoa, which pumps water from the Floridan Aquifer, is contracted to supply water to CCAFS and Patrick Air Force Base. The City of Cocoa has sufficient capacity to supply sources to meet usage demands for the MEP missions.

Water used during MEP launches would be collected and treated, if necessary, prior to being released to grade in accordance with a Florida Department of Environmental Protection wastewater discharge permit, or released to the wastewater treatment plant. It is not expected that groundwater quality would be substantially affected by the discharge of this water.

CCAFS—Surface Water. Depending on meteorological conditions, the launch exhaust cloud could drift over the Atlantic Ocean or the Banana River near CCAFS. If SRMs are used, surface waters in the immediate area of the exhaust cloud might acidify from deposition of HCl if a rainstorm passes through the exhaust cloud. The large volumes of water bodies in the vicinity of CCAFS, combined with their natural buffering capacity, suggest that the increased acidity caused by HCl deposition would return to normal levels within a few hours (USAF 1996). Al<sub>2</sub>O<sub>3</sub> particulates would also settle from the exhaust cloud. Al<sub>2</sub>O<sub>3</sub> particulates are relatively insoluble in local surface waters and would settle out of the water column as sediment. Long-term elevation of aluminum levels in the water column would not be expected. No long-term adverse impacts to hydrology or water quality would be expected.

If SRMs are not used, the exhaust products of CO (which would quickly oxidize to CO<sub>2</sub>) and water vapor would have no impact to surface water.

VAFB—Groundwater. VAFB utilizes water from local aquifers and water supplied by the State Water Project. Large amounts of water would not come in contact with permeable soils at VAFB because water used for launches is not released to grade. Water is collected, treated, and recycled at the launch site, treated at the base wastewater treatment plant, or, if necessary, disposed as hazardous waste. MEP launches from VAFB would therefore not adversely impact groundwater quality.

VAFB—Surface Water. Depending on meteorological conditions, the launch exhaust cloud could drift over Bear Creek, Cañada Honda Creek, Shuman Creek, San Antonio Creek, the Santa Ynez River, or the Pacific Ocean. If SRMs are used, there would be little wet deposition of HCl at the distances of these water bodies from the launch complex. Wet deposition would occur away from the launch complex only if a rainstorm passes through the exhaust cloud, an infrequent event at VAFB. Even if wet deposition occurs, changes in acidity in near-shore oceanic waters are expected to be small and temporary because of the large volume of the near shore waters and the natural buffering capacity of the ocean. Increased acidity in fresh waters would be transient as the streams flow to the ocean and the acid is neutralized by the streams' natural buffering capacities.  $Al_2O_3$  particulates would also settle from the exhaust cloud.  $Al_2O_3$  particulates are relatively insoluble at the acidity levels of local surface waters, and would settle out of the water column as sediment. Long-term elevation of aluminum levels in the water column would not be expected. No long-term adverse impacts to hydrology or water quality would be expected.

If SRMs are not used, the exhaust products of CO (which would quickly oxidize to  $CO_2$ ) and water vapor would have no impact on surface water quality.

#### 4.1.2.6 Offshore Environment

The offshore environments at CCAFS and VAFB would be impacted by the jettisoned launch vehicle sections (*i.e.*, the depleted first stage, payload fairing (PLF), and SRM casings). Launch trajectories would be created and modified to ensure safety on the ground and at sea. Notice would be given to pilots and mariners prior to launch. The underlying areas at risk from falling debris or jettisoned stages would be cleared until all launch operations are completed. For launches from VAFB, precautions would be taken to ensure that jettisoned sections would not fall on offshore oilrigs or any of the Channel Islands. The SRM casings would land closest to shore, at distances ranging from a few tens of kilometers (km) (tens of miles (mi)) to over 200 km (125 mi) in pre-approved SRM drop zones. PLF sections and the first stage would land much further from shore, also in pre-approved drop zones. These distances would be highly dependent on the specific launch vehicle, its mission characteristics, and other factors such as wind effects (USAF 2000).

Any small amounts of residual propellants would be released to the surrounding water. Metal parts would eventually corrode, but toxic concentrations of the metals would be unlikely because of the slow rate of the corrosion process and the large volume of ocean water available for dilution. RP-1 is weakly soluble in water. Depending on the launch vehicle, any residual RP-1 fuel in the first stage would form a localized surface film which would evaporate within hours. When SRMs are used, the residual propellant

in the SRM casings would be released slowly and should not reach toxic concentrations except in the immediate vicinity of the casings (USAF 1998).

#### 4.1.2.7 Biological Resources

Biological resources would not be adversely affected by MEP mission launches except for those fauna and flora in the immediate vicinity of the launch pads. High temperatures within the exhaust cloud and acidic deposition (if SRMs are used) from the exhaust cloud could damage or kill biota within the immediate vicinity of the launch pad. Freshwater resources could potentially be exposed to short-term increases in acidity by HCl deposition from the exhaust cloud, but such changes are expected to be small and of short duration. Al<sub>2</sub>O<sub>3</sub> particulate deposition from the SRMs would result in only short-term elevations in aluminum concentrations in the water column, and the elevations would probably not be of sufficient magnitude or duration to impact freshwater biota. Long-term population effects on terrestrial biota would not be expected. The short-term elevation of noise levels generated by the launches would probably disturb terrestrial biota near the launch complex but is not expected to result in long-term adverse impacts (USAF 1996). Jettisoned launch vehicle sections that land in the water would be subject to corrosion and release of residual propellant. However, it is unlikely that these sections would have an adverse impact on marine species.

CCAFS—Terrestrial and Aquatic Biota. Short-term impacts to terrestrial fauna and flora in the immediate vicinity of the launch complex could be expected due to launches. Aquatic biota in nearby water bodies, such as the Banana River and the near-shore areas of the Atlantic Ocean, should not be adversely affected by acidic deposition from the exhaust cloud if SRMs are used (USAF 1996). A fish kill occurs after most Space Shuttle launches from KSC as a direct result of surface water acidification (Schmalzer *et al.* 1998). However, there have been no fish kills reported in either the Banana River or the near-shore areas of the Atlantic Ocean from HCl and Al<sub>2</sub>O<sub>3</sub> deposition from normal launch of a Delta II (NASA 1995b). Since the launch vehicles contemplated for MEP missions launched from CCAFS would use considerably smaller SRMs than those used on the Space Shuttle, fish kills would not be anticipated.

Sonic booms would occur over the open ocean following a launch. The USAF has determined that the sonic boom noise levels from even the largest expendable launch vehicles would be far below the level thought to cause harm to marine mammals (USAF 2000).

CCAFS—Threatened or Endangered Species. No adverse impacts on threatened or endangered species would be expected. CCAFS has a light management plan that addresses mitigation of impacts to nesting sea turtles during night-time launches (USAF 1998).

VAFB—Terrestrial and Aquatic Biota. Short-term impacts to terrestrial fauna and flora in the immediate vicinity of the launch complex could be expected due to launches. No long-term impacts to aquatic biota would be expected from the infrequent, short-term changes in acidity. Marine resources are not expected to be adversely impacted (USAF 1998).

Sonic booms would occur over open ocean and over the Channel Islands southeast of VAFB following a launch. These islands harbor a diverse assemblage of marine mammals that might be disturbed, but not permanently harmed, by sonic booms. Pinniped (e.g., seals, walrus) harassment permits are included in the National Marine Fisheries Service's (NMFS) incidental take authorization of marine mammals for specified launch activities for the period February 6, 2004 through February 6, 2009 (69 FR 5720). MEP missions launched from VAFB would be covered under this authorization during this time period.

VAFB—Threatened or Endangered Species. Two Federally endangered bird species, the California least tern and the western snowy plover, are the subject of U.S. Fish and Wildlife Service (FWS) Biological and Conference Opinions (FWS 1999a, FWS 1999b, FWS 2001, FWS 2003). These Opinions address incidental take and temporary flushing of the least tern and snowy plover due to space vehicle launches from SLC-2, SLC-3 East, and SLC-6. Individual take permits and mitigation plans are in place. The Opinions also address harassment of the southern sea otter, the California brown pelican, the southwestern willow flycatcher, the California red-legged frog, the tidewater goby, and the unarmored threespine stickleback. Beach layia (a plant species) and California red-legged frogs are monitored for launch exhaust deposition impacts. MEP missions launched from VAFB would be covered under these Opinions.

#### 4.1.2.8 Socioeconomics

The proposed launch rate of one or fewer MEP spacecraft per year would not increase previously approved launch rates beyond the scope of approved launch vehicle programs at CCAFS and VAFB (e.g., USAF 1998, USAF 2000). MEP launches would therefore not result in measurable impacts to socioeconomic factors such as demography, employment, transportation, and public or emergency services at both CCAFS and VAFB.

#### 4.1.2.9 Environmental Justice

Implementation of the MEP would not be expected to result in disproportionately high and adverse impacts to low-income or minority populations.

#### 4.1.2.10 Cultural/Historic/Archaeological Resources

CCAFS. SLC-17 is an active launch complex and is eligible for listing on the National Register of Historic Places (NRHP) because of its significance as the longest continually active launch site, and its association with events that have made a significant contribution to history (USAF 1996). The USAF has requested guidance from the State Historic Preservation Officer (SHPO) on how to best preserve the historical significance of SLC-17 while it continues to serve the Nation's space program. As modifications occur to the launch complex, special care is taken to preserve historical information through documentation and collection of historical data.

At SLC-41 and SLC-37, no cultural or archaeological resources would be impacted by normal launch operations, nor are there buildings or sites that are listed or eligible for listing in the NRHP (USAF 2000).

VAFB. In consultation with the SHPO, elements of SLC-2 have been determined to be eligible for listing in the NRHP. No modification to the launch complex would occur as a result of continued launch operations.

Cultural resources present at and near SLC-3 and SLC-6 would not be adversely impacted by normal launch operations. Elements at SLC-3 have been determined to be eligible for listing in the National Register of Historic Places but are unlikely to be impacted as a result of launches. The SHPO has concurred that a NRHP-eligible site near SLC-6 would be minimally impacted from launches (USAF 2000).

#### 4.1.2.11 Global Environment

For the purposes of this FPEIS, with the exception of the near-pad environment, the global environment encompasses the ocean and atmosphere.

Troposphere. Launching one or more missions every 26 months would result in the deposition of exhaust products released along the launch vehicle's trajectory as it ascends through the troposphere. Exhaust products would mostly include HCl, NO<sub>x</sub>, and Al<sub>2</sub>O<sub>3</sub> particulates from SRMs, and CO, CO<sub>2</sub>, NO<sub>x</sub>, and water vapor from stages using liquid propellants. While there could be ground-level impacts from these products, deposition of small quantities of some exhaust products in the troposphere could contribute to conditions such as global warming. However, this material would be removed from the troposphere in a short period of time.

Stratosphere. Launch of the proposed MEP missions would result in the deposition of small quantities of ozone-depleting chemical compounds from the combustion products released along the launch vehicle's trajectory as it ascends through the stratosphere. Launch vehicles with SRMs would have the greatest potential for impact. SRMs use ammonium perchlorate as an oxidizer and chlorine compounds are released during combustion, which are the principal contributors to stratospheric ozone depletion from launch vehicles. In general, ozone-depleting chemicals in exhaust emissions for launch vehicles with SRMs would be chlorine (from HCl), nitrogen compounds (from NO<sub>x</sub>), and aluminum (in Al<sub>2</sub>O<sub>3</sub> particulates) (USAF 1998).

Because of uncertainties about the current loading of ozone-depleting chemicals in the stratosphere, the effects of a launch can be more accurately calculated as a percent increase in the rate of stratospheric ozone depletion relative to a launch not occurring. The ozone depletion rates associated with these exhaust products have been estimated (Jackman *et al.* 1998, Jackman 1998). These estimates were used in combination with the estimated mass of combustion products potentially emitted to the stratosphere by launch vehicles to develop an estimate of annual average global ozone depletion (USAF 1998, USAF 2000, NASA 2002a). While a large fraction of launch emissions would occur in the lower atmosphere and not reach the stratosphere, the estimates were based on an assumption that all emissions occurred in the stratosphere. For example, the annual average ozone depletion rate for the normal launch of an Atlas V with SRMs has been estimated to be almost zero (USAF 2000).

Exhaust emissions consisting of NO<sub>x</sub>, Al<sub>2</sub>O<sub>3</sub>, and HCl deposited in the stratosphere from launch vehicles with SRMs have been estimated (USAF 2000). The estimated

quantities were applied to the annual average ozone depletion rates associated with each compound. Based on previous calculations, the estimated annual average ozone depletion rate for a normal launch would be small. For example, normal launch of a Delta II 7925 Heavy has been estimated to contribute less than 0.0015% of the average annual ozone depletion rate (NASA 2002b). Ozone depletion would occur along the trajectory of the launch vehicle, but it has been estimated that the depletion trail from a launch vehicle is largely temporary, and would be self-healing within a few hours of the vehicle's passage (AIAA 1991).

Global Climate Change. Solar energy is absorbed by the Earth and a portion of this energy is radiated back to the atmosphere. Global warming occurs when certain gases (called greenhouse gases) in the atmosphere trap the re-radiated solar energy within the atmosphere causing the Earth's average surface temperature to rise. Examples of greenhouse gases are water vapor, CO<sub>2</sub>, methane, nitrous oxide (N<sub>2</sub>O), ozone, perfluorocarbons, and hydrofluorocarbons. Indirect contributors to global warming include gases such as CO, NO<sub>x</sub>, and non-methane hydrocarbons. These photochemical gases can influence the rate of creation and destruction of gases that, in turn, influence global climate change.

Over the last 100 years, the Earth's average surface temperature has risen by about 0.5° Celsius (1° Fahrenheit). It is postulated that this increase may be due to the addition of greenhouse gases from human activities. A rise in the Earth's average surface temperature could impact the climate, which in turn may lead to changes in the biosphere (e.g., changes in rainfall patterns and sea surface levels), which could have impacts on fauna, flora, and the human environment. In 2002, the U.S. emitted a net total of  $6.2 \times 10^{12}$  kilograms (kg) ( $1.3 \times 10^{13}$  pounds (lb)) of greenhouse gases (measured in terms of CO<sub>2</sub> equivalent), of which about 83% was CO<sub>2</sub> emissions (EPA 2004a).

Launching the proposed MEP missions would result in the emission of global warming gases, principally CO<sub>2</sub> and water vapor. Emission estimates from expendable launch vehicles such as those contemplated for MEP missions have been previously reported (USAF 1998, USAF 2000). The estimated emissions of greenhouse gases from the largest of the launch vehicles contemplated for MEP missions was estimated to be about  $9.8 \times 10^4$  kg ( $2.2 \times 10^5$  lb), negligible compared to the total greenhouse gases emitted in the U.S.

#### 4.1.2.12 Orbital and Reentry Debris

During a normal launch of a typical expendable launch vehicle, the SRM casings (if the vehicle uses SRMs to augment first-stage thrust), the depleted first stage, and the PLF would be jettisoned at separate times and fall into the ocean. The second stage would be ignited shortly after separation from the first stage and would accelerate to low Earth orbit. After a brief coast period in Earth orbit the second stage engine would be restarted to place the spacecraft into an Earth-escape trajectory. Typically, after separation the depleted second stage would remain in orbit and reenter the atmosphere within about two to three months (USAF 1996); the depleted stage would typically burn up upon reentry. On rare occasions portions of the second stage may survive reentry and impact the Earth's surface. Depending on specific mission launch energy

requirements, after separation the depleted second stage may instead continue separately into interplanetary space. A third stage, typically using a solid rocket motor, could be required by some MEP missions to provide additional thrust to place the spacecraft onto the proper trajectory to Mars. After separation from the spacecraft, the depleted third stage would continue separately into interplanetary space. Therefore, a normal launch to Mars for any proposed MEP mission would not contribute to orbital debris.

#### 4.1.3 Potential Environmental Impacts of Nonradiological Accidents

The potential nonradiological environmental impacts associated with accidents with the launch vehicles used for the proposed MEP missions have been discussed in previous USAF and NASA environmental documentation and are summarized here (USAF 1998, USAF 2000, NASA 2002a, NASA 2002b).

A variety of accidents could occur during preparations for and launch of an expendable launch vehicle. Only two types of nonradiological accidents would potentially have off-site consequences: a liquid propellant spill during fueling operations and a launch failure. Liquid propellants for the launch vehicles available for the MEP would consist of RP-1, LH<sub>2</sub>, LO<sub>2</sub>, nitrogen tetroxide (N<sub>2</sub>O<sub>4</sub>), and hydrazine, and are discussed in Section 2.1.6. The potential consequences at CCAFS and VAFB of these accidents are discussed below.

Liquid Propellant Spill. Of the postulated propellant spill accident scenarios, the most severe would involve release of N<sub>2</sub>O<sub>4</sub> (NASA 2002a). Because N<sub>2</sub>O<sub>4</sub> rapidly converts to NO<sub>x</sub> in the air, toxic effects of the release would be limited to the immediate vicinity of the launch complex. Activating the launch pad water system and spraying the evaporates would substantially reduce and limit potential exposures in the vicinity of the spill, and in turn, reduce the amount of propellant dispersed downwind. During fueling, propellant transfer personnel would be equipped with protective clothing and breathing apparatus, and uninvolved personnel would be excluded from the area. Similar protocols and procedures would be followed when loading other types of liquid propellant. USAF safety requirements specify that plans and procedures be in place to protect the workforce and the public during fueling operations (USAF 2004).

Launch Failures. A launch vehicle accident either on or near the launch pad within a few seconds of liftoff presents the greatest potential for impact to human health, principally to workers. For both the Proposed Action and Alternative 2, the most significant potential health hazard during a launch accident would be from the HCl emitted from the burning of solid propellant if SRMs are used. The Range Safety offices at CCAFS and VAFB use models to predict launch hazards to the public and on-site personnel prior to every launch. These models calculate the risk of injury resulting from toxic gases, debris, and blast overpressure from potential launch failures. Launches are postponed if the predicted risk of injury exceeds acceptable limits. The allowable collective public risk limit at CCAFS and VAFB is  $30 \times 10^{-6}$  with an individual risk of  $1 \times 10^{-6}$  over the varying population densities. This approach takes into account the probability of a catastrophic failure, the resultant plume's toxic concentration, direction, and dwell time, and emergency preparedness procedures (USAF 2000).

Range Safety requirements mandate destruct systems on both liquid propellant tanks and SRMs. In the event of destruct system activation, the propellant tanks and SRM casings would be ruptured, and the entire launch vehicle would be destroyed. A catastrophic launch failure would involve burning solid propellant and the ignition of liquid propellant (e.g., hypergolic fuel, RP-1, LH<sub>2</sub>, or LO<sub>2</sub>). The potential short-term effects of an accident would include a localized fireball, falling fragments from explosion of the vehicle, release of uncombusted propellants and propellant combustion products, and for on-pad or very low altitude explosions, death or damage to nearby biota and brush fires near the launch pad. Unburned pieces of solid propellant with high concentrations of ammonium perchlorate could fall on land or into bodies of water. Perchlorate could leach into surrounding soil or water resulting in high concentrations in the immediate vicinity of the propellant fragment, and could result in adverse, localized impacts to the terrestrial or aquatic environment. Some mortality to biota in those areas could be expected until the solid propellant is fully dissolved. However, pieces of unburned solid propellant falling on land would be collected and disposed as hazardous waste. Similarly, large pieces falling in fresh water areas would be collected and disposed, minimizing the potential for perchlorate contamination (DOD 2003b).

Debris from launch failures has the potential to adversely affect managed fish species and their habitats in the vicinity of the launch site. Ammonium perchlorate in the solid propellant used in some launch vehicle configurations contemplated for MEP missions contains chemicals that, in high concentrations, have the potential to result in adverse impacts to the marine environment. Fish species that inhabit the waters in the vicinity of the launch site and their habitats are required to be addressed regarding potential adverse effects from the launch of MEP missions. The USAF has consulted with the NMFS on essential fish habitat regarding launches of Delta IV and Atlas V vehicles from CCAFS and VAFB (USAF 2000), and will consult with NMFS regarding launches of other Delta and Atlas vehicles (Chambers 2003b). MEP missions launched from CCAFS and VAFB would be covered under these consultations.

Launch accident debris has the potential to adversely affect pinneped resting and pupping areas at VAFB. Threatened or endangered plant species at both CCAFS and VAFB could be subject to fires if a launch accident were to occur. A fire caused by a launch accident has the potential to destroy historic structures or damage archaeological sites directly, and the attendant fire-fighting activities are also capable of causing damage to prehistoric and historic resources.

Beginning two hours before a launch, a Brevard County Emergency Management Center representative is present at a CCAFS launch console with direct audio and video communications links to the Center. A communications hot line is maintained between VAFB and the City of Lompoc during launches.

#### 4.1.4 Radiological Accident Assessment

Some MEP missions may use devices with varying amounts of radioactive material, such as RHUs for heat generation or RPSs for electric power generation, and small quantities of radioisotopes in some science instruments. These types of devices have been used in prior NASA missions and have been previously analyzed for their potential

impact resulting from this use. Risk assessments addressing the environmental impacts associated with missions that use radioactive material have been performed in support of EISs for five NASA flight projects: Galileo (NASA 1989), Ulysses (NASA 1990), Cassini (NASA 1995a and NASA 1997), Mars Surveyor 2001 (draft<sup>1</sup>) (NASA 1999), and Mars Exploration Rovers (MER)–2003 (NASA 2002b). The risk assessments associated with these EISs provide a historical perspective of the potential risk factors associated with the missions proposed for the MEP that may utilize radioactive material. The population and individual risks associated with the earlier missions identified above have all been shown to be relatively small. Estimates of the risk of one cancer fatality within a potentially exposed population have been very small, on the order of 1 in 100,000 or less. Estimates of the risk of fatal cancer to the average potentially exposed individual have been extremely small, on the order of 1 in 10 million or less. These risk assessments also provide an historical perspective on the increasing level of completeness, accuracy, and detail that NASA and DOE have incorporated into each mission risk assessment.

In addition to the potential human health consequences of launch accidents that could result in a release of radioactive material, potential environmental impacts due to land contamination were also examined in the earlier risk assessments. These included contamination of natural vegetation, wetlands, agricultural land, cultural, archaeological and historic sites, urban areas, inland water, and the ocean. Land areas estimated to be contaminated above a predefined screening level are identified in these risk assessments for the purpose of evaluating the need for potential characterization and cleanup.

A risk assessment was developed for the MER–2003 project, consisting of the *Spirit* and *Opportunity* rovers. Additional environmental documentation would be required for any MEP mission that proposes to use radioactive material. Should that documentation take the form of an EA or EIS, a mission-specific risk assessment would be performed. The parameters that determine the risks for a specific mission have been identified in the above referenced mission risk assessments. The risks associated with a MEP mission carrying radioactive material are, therefore, expected to be driven by the same risk factors identified in the earlier mission risk assessments. Mission-specific factors that affect the estimated risk include: the amount and type of radioactive material used in a mission; the safety features of the devices containing the radioactive material; the probability of an accident which can threaten containment of the radioactive material; and, the accident environments.

Plutonium-238 has been the principal radionuclide of concern. The plutonium is used, in the form of plutonium dioxide, in RHUs and in the General Purpose Heat Source (GPHS) modules used in RPSs. Each RHU contains approximately 2.7 grams (g) (0.1 ounces (oz)) of plutonium dioxide, approximately 33.2 curies of activity. Each GPHS module contains approximately 600 g (21 oz) of plutonium dioxide, about 7,400 curies. DOE and NASA are developing a new generation of RPSs that could be used

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<sup>1</sup> A risk assessment was being prepared for the Mars Surveyor 2001 lander-rover mission when that mission was cancelled.

for future deep space and planetary surface missions. One of the advanced RPSs is called the Multi-Mission Radioisotope Thermoelectric Generator (MMRTG). Another conversion system using a Stirling engine is also under development. Both of these RPS concepts would use GPHS modules as the heat source. The MMRTG would use eight GPHS modules. The Stirling Radioisotope Generator (SRG) would use two GPHS modules. In comparison, 18 GPHS modules are used on the generation of radioisotope thermoelectric generators used on previous and current missions (DOE 2002a, DOE 2002b).

DOE has spent over 20 years in the engineering, fabrication, safety testing, and evaluation of the RHU and GPHS, building on the experience gained from previous heat source development programs and an information base that has grown since the 1950s. DOE has designed the current RHU and GPHS to assure that the plutonium dioxide is contained or immobilized to the maximum extent practical during all mission phases, including ground handling, transportation, launch, and unplanned events such as atmospheric reentry from Earth orbit (NASA 1995a, NASA 2002b). Radioisotope power systems contemplated for possible use in MEP missions will incorporate safety features similar to those used for previous NASA missions.

Small quantities of radioactive material may be used in some science instruments on landed MEP missions. Earlier NASA missions have used materials such as americium-241, cobalt-57, curium-242, and curium-244, among others, in less-than curie quantities within science instruments (see Table 2-2). Because of the purposes for which these small quantities of radioactive material are needed (e.g., instrument calibration, target excitation), it is generally not practical to protect and contain the material in the event of a launch accident.

Accident environments associated with all of the launch vehicles currently considered for the MEP missions are expected to be similar to the environments that have been analyzed for the earlier NASA missions. Those environments include blast, fragments, fires, and mechanical impacts. The previous risk assessments considered combinations of accident environments to assess the potential for damage to the devices containing radioactive material. Blast impacts are the static and dynamic pressures resulting from explosive failure of the propellant tanks. Fragments result from the explosive failure of propellant tanks; fragments can come from the tank itself as well as other launch vehicle and spacecraft components. Liquid propellant fires are typically modeled as fireballs that consume available fuel. The solid propellant fire environments of concern are associated with collocation of the radioactive devices and blocks of solid propellant. Ground impact that could cause mechanical damage to a RHU or GPHS module is considered for accidents near the launch pad and for accidents leading to suborbital or orbital reentry.

In addition to identifying the factors that determine the radiological risks associated with a mission, the development of a risk assessment provides the opportunity to generate feedback into the mission design to possibly reduce the impact of these factors. For example, in preparation for the MER-2003 project, an issue was identified associated with the potential risk of ground impact of the spacecraft, containing RHUs, in a configuration that included an intact third stage with a solid propellant motor. To

address this issue, a break-up system was added to the third stage motor that would reduce the probability of an intact impact of the spacecraft with the third stage during an early launch phase accident. NASA has used, and will continue to use, this process to assess and manage potential radiological risks associated with each mission. Each mission risk assessment would build upon the information and insights developed in earlier assessments of all types of launches and tailor the assessment to the specific mission parameters. It is reasonable to expect that risk and safety assessments performed for future MEP missions may result in mission modifications intended to address mission-specific risk factors.

The risk assessments performed for the previous missions provide significant insight into what could be the expected risk drivers and risks associated with any MEP missions that may involve use of radioactive material. These previous EIS risk assessments indicate that the potential radiological risks have not been sufficient to preclude launch. While these risk assessments have identified likely contributors to mission risk, the process of understanding and analyzing the factors affecting risk continues to evolve. The mission-specific risk assessments required for any MEP mission that proposes use of radioactive material would continue to build upon the knowledge base and insights developed in earlier assessments as well as provide feedback into the MEP mission design.

#### **4.2 ENVIRONMENTAL IMPACTS OF ALTERNATIVE 2**

Under Alternative 2, NASA would not implement a coordinated MEP, but would continue to explore Mars on a less comprehensive, mission-by-mission basis. Spacecraft may or may not be launched to Mars at each launch opportunity that occurs about every 26 months. Environmental impacts of preparing for a mission to Mars, its normal launch and potential nonradiological accidents would be expected to be comparable to those of individual missions within the Proposed Action, as described in Sections 4.1.1 through 4.1.3.

Some spacecraft launched under Alternative 2 could use RPSs to generate electricity for the spacecraft, RHUs for thermal control, and may carry small quantities of radioisotopes in science instruments. The potential radiological risks associated with missions under this alternative would be assessed using the same techniques described in Section 4.1.4 for missions under the Proposed Action.

#### **4.3 ENVIRONMENTAL IMPACTS OF THE NO ACTION ALTERNATIVE**

Under the No Action Alternative, NASA would discontinue launching robotic missions to Mars. There would only be potential socioeconomic impacts in that some jobs in selected industries could be displaced or lost, and potential tourism for viewing MEP launches would not occur.

#### **4.4 CUMULATIVE IMPACTS**

The potential cumulative impacts associated with use of the launch vehicles and facilities addressed within this FPEIS have been assessed using currently available information. However, should there be changes to the MEP as proposed in this decade,

or changes into the next decade which have a bearing on the environmental impacts of the program, launch vehicles, facilities, or other aspects of this FPEIS, appropriate additional environmental documentation would be prepared, if required.

**Proposed Action**—Based on the representative set of missions described in Chapter 2, NASA would launch one or more missions every 26 months through 2020. In addition, there could be several international launches occurring abroad (e.g., the European Space Agency's Mars Express mission, launched in June 2003).

The proposed MEP launches through 2020 would not increase previously analyzed launch rates or use launch vehicles or systems beyond the scope of approved programs from CCAFS or VAFB (e.g., USAF 1996, USAF 1997, USAF 1998, USAF 2000). In the near term, U.S. MEP missions would use expendable launch vehicles within the Delta and Atlas families of vehicles. Since the launch rate for the Proposed Action would be within the rates previously approved for these vehicles at these launch sites, there would not be any substantial increase in cumulative impacts for payload processing and launch of MEP missions. Therefore, long-term cumulative effects to the local and global environment by the Proposed Action would not be substantial.

Various components of the spacecraft and launch vehicles proposed for the MEP would be manufactured at different facilities around the United States, with final integration of the components occurring at CCAFS or VAFB. Each of these facilities would be required to follow applicable Federal, State, and local regulations governing areas such as air pollution, noise ordinances, wastewater disposal, pollution prevention, disposal of hazardous waste, and worker safety and health. Spacecraft and launch vehicle manufacturing are specialized activities with only a limited number of units manufactured each year. While such activities could generate air pollutants, noise, and hazardous waste, any quantities would be small compared to major high-volume industrial activities.

The use of the facilities at KSC, CCAFS and VAFB for processing MEP spacecraft, launch vehicle components, and for launch of MEP missions would be consistent with existing land uses at each facility. No new processing facilities for MEP missions are anticipated at this time at KSC, CCAFS, or VAFB, and any impacts from their use for MEP missions are expected to be within the scope of previously approved programs (e.g., USAF 1998, USAF 2000, NASA 2002a). Appropriate documentation and relevant analyses would be prepared for missions using radioisotopes. Implementing MEP missions at either facility would be unlikely to add new jobs to the workforce.

Launching MEP spacecraft would principally contribute to exhaust emission impacts on and near the launch complexes at both CCAFS and VAFB. If SRMs are used, launches could result in scorched vegetation, and partially or completely defoliated trees near the launch complex from flame and acidic deposition. Deposition could also impact nearby bodies of water, resulting in temporary elevation of acidity levels. Launch vehicle configurations without SRMs would be expected to have little acidic deposition on plants and water bodies, but would scorch nearby vegetation. While these impacts may persist with continued use of a launch complex, and the MEP launches would contribute to these conditions, they are probably not irreversible. At KSC, NASA found that in

affected areas near the Space Shuttle launch pads, vegetation reestablished itself after the launches stopped (Schmalzer *et al.* 1998).

On a short-term basis, the proposed MEP launches would contribute ozone-depleting chemical compounds to the stratosphere. The USAF has estimated that the total contribution from large expendable launch vehicles with SRMs to the average annual depletion of ozone would be small (approximately 0.014 percent per year) (USAF 2000). By comparison, a 3 to 7 percent annual decrease in ozone at mid-latitudes occurs as a result of the current accumulation of ozone-depleting substances in the stratosphere. However, it has been estimated that the depletion trail from a launch vehicle is largely temporary, and would be self-healing within a few hours of the vehicle's passage (AIAA 1991). Furthermore, because launches at CCAFS and VAFB are always separated by at least a few days, combined impacts in the sense of holes in the ozone layer combining or reinforcing one another cannot occur (USAF 2000). MEP launches without SRMs would contribute negligible amounts of ozone-depleting chemicals.

Rocket launches result in the emission of greenhouse gases (CO<sub>2</sub>, trace emissions of nitrous oxides (NO<sub>x</sub>) emitted by the SRMs, and water vapor). The exhaust cloud would also contain CO, which, under the high temperatures of the SRM's exhaust, would quickly react with oxygen in the atmosphere to form CO<sub>2</sub>. Emissions of greenhouse gases from launch vehicles have been previously estimated (USAF 1998, USAF 2000). These estimates indicate that exhaust emissions from proposed MEP mission launches would be a very small fraction (on the order of 10<sup>-5</sup> percent) of the annual net greenhouse gases (6.2x10<sup>12</sup> kg) (1.3x10<sup>13</sup> lb) CO<sub>2</sub> equivalent in 2002) emitted by the United States (EPA 2004a).

CCAFS. Other activities on or near CCAFS that are not connected with the MEP that could occur through the second decade includes the proposed development and construction of the International Space Research Park located on 160 hectares (400 acres) of KSC. These and other potential construction activities at and in the vicinity of CCAFS could potentially contribute to increases in noise, particulates and dust, solid waste disposal, and the potential for involving wetlands and endangered species. An EIS for the International Space Research Park has been prepared. It is anticipated that, should NASA approve this project, phased construction would occur over the next 20 to 25 years.

VAFB. Other activities at VAFB that are not connected with the MEP may include renovations to launch facilities proposed for use in the Ground-Based Midcourse Defense Extended Test Range program. The U.S. Army Space and Missile Defense Command published its Final EIS in July 2003 (DOD 2003b). Construction activities would include renovations and/or minor modifications to existing buildings. Such activities could potentially contribute to increases in noise, particulates and dust, solid waste disposal, and the potential for special situations involving culturally sensitive areas and endangered species. Testing activities could contribute to impacts from launch activities. The proposed launch rate for this purpose is at least five launches per year for ten years. The test launch vehicles would involve SRMs, which could result in acidic and particulate deposition at or near the launch sites.

**Alternative 2**—The launch rate for Alternative 2 would probably be less than the expected rate of one or two launches to Mars every 26 months for the Proposed Action. Therefore, cumulative impacts addressed for the Proposed Action are expected to envelop those for Alternative 2.

**No Action Alternative**—Some adverse long-term socioeconomic impacts could occur if jobs are lost due to NASA's discontinuation of the robotic exploration of Mars under the No Action Alternative.

#### **4.5 ENVIRONMENTAL EFFECTS THAT CANNOT BE AVOIDED**

The Proposed Action and Alternative 2 would involve rocket launches. Ignition of the launch vehicle's main engines and SRMs (if used) would produce  $\text{Al}_2\text{O}_3$ , CO,  $\text{CO}_2$ , HCl,  $\text{N}_2$ ,  $\text{NO}_x$  and water vapor during a normal launch. The launch exhaust cloud would be concentrated near the launch pad during the first moments of launch. Thereafter, the launch cloud would be transported downwind and upward.

If SRMs are used, biota in the immediate vicinity of the launch pad could be damaged or killed by the intense heat and potentially by HCl deposition from the exhaust cloud. No long-term adverse effects to biota would be anticipated at either CCAFS or VAFB.  $\text{Al}_2\text{O}_3$  particulates could also be deposited at the launch site as the exhaust cloud travels downwind. Jettisoned launch vehicle components (*i.e.*, the depleted first stage, SRM casings, and PLF) would fall into the ocean. Residual propellants could be released into the water, and the hardware would eventually corrode. Levels toxic to marine biota are not expected, as there is a large amount of water to dilute any released substances.

#### **4.6 INCOMPLETE OR UNAVAILABLE INFORMATION**

##### **4.6.1 Proposed Action**

This FPEIS is being developed prior to finalizing individual MEP missions, with the exception of the Mars Odyssey orbiter, the MER–2003 rover missions, *Spirit* and *Opportunity*, and the 2005 Mars Reconnaissance Orbiter (see Section 1.4). Under the Proposed Action, successive missions in the MEP would rely on scientific findings and demonstrated technologies of previous missions. NASA could change the focus of later missions, select different instrumentation, and perhaps adjust mission frequency to best use this new information. The selection of launch vehicles and launch site locations, and the total number of missions throughout the overall timeframe of the MEP would be subject to change. However, at least one launch would occur at each opportunity to Mars, which occurs approximately every 26 months.

Some missions may propose the use of RPSs for power generation, RHUs for thermal control, and small quantities of radioisotopes in some science instruments. Any proposed use of radioisotopes for an individual mission would be included in the description of the mission concept. Detailed risk assessments for such missions would be developed when sufficient detail becomes available, and each mission would require its own environmental documentation.

The Mars exploration effort could also include missions undertaken by international participants in the MEP. NASA's participation in these missions may include, but not be limited to, principal investigator responsibilities for science experiments, supply of instrument and spacecraft hardware and software, and science data analysis. In the event that anticipated foreign missions do not occur, NASA may decide to reevaluate the sequence and focus of its future missions. Should such a reevaluation result in changes to its proposed missions, NASA would prepare appropriate environmental documentation as needed.

A major component of the MEP is continued planning for one or more missions that would return samples of Mars. At the time of publication of this FPEIS, preliminary concepts for a sample return mission are being studied and would continue to be refined and evaluated. A sample return mission would be the subject of separate environmental documentation. A Tier 2 EIS would be prepared for implementation of a sample return mission, and would include recovery of the returned sample container at Earth and its transportation to a secure handling facility. At the time of publication of this FPEIS, the location, design and operational requirements for a returned sample receiving facility are being studied and would continue to be refined and evaluated, and would be the subject of separate environmental documentation.

#### 4.6.2 Alternative 2

Under Alternative 2, any future U.S. missions to Mars would not be planned within the context of a comprehensive program, but would occur on a scientifically less coordinated basis than the Proposed Action. Each mission would require independent environmental documentation. Some missions may propose use of RPSs for power generation, RHUs for thermal control, and small quantities of radioisotopes in some science instruments. Any requirements for use of radioisotopes for an individual mission would be made as the mission concept is refined, and the appropriate level of mission-specific environmental documentation would be developed. Environmental documentation for a mission using only small quantities of radioisotopes, typically not more than a few hundred millicuries, in science instruments may be covered under NASA's Routine Payloads EA (NASA 2002a).

One or more sample return missions could also be undertaken under this alternative. Such missions would be addressed under appropriate mission-specific environmental documentation. Similarly, the location, design, and operational requirements for a returned sample receiving facility would be the subject of separate environmental documentation.

### **4.7 RELATIONSHIP BETWEEN SHORT-TERM USES OF THE HUMAN ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY**

#### 4.7.1 Short-Term Uses

The proposed MEP missions would be launched from CCAFS and VAFB, and thus the short-term affected environment would include these two launch sites and their

surrounding areas. At CCAFS, short-term uses of the area include commercial, NASA and USAF operations, urban communities, a fish and wildlife refuge, citrus groves, residential communities, and recreational areas. VAFB short-term uses also include commercial, NASA and USAF operations, rural communities, a marine ecological reserve, and grazing and agricultural land. Additionally, VAFB and the surrounding area is recognized as a biologically important area that lies in a transitional zone between cool, moist conditions of northern California and semi-desert conditions of southern California, and supports numerous species of plants and plant communities (NASA 1998a). The MEP missions would be conducted in accordance with past and ongoing NASA and USAF procedures for operations at the CCAFS and VAFB launch sites. Should an accident occur at CCAFS or VAFB causing a radiological release, short-term uses of contaminated areas could be curtailed, pending mitigation.

#### 4.7.2 Long-Term Productivity

No change to land use at CCAFS and VAFB or their surrounding regions would be anticipated because of the proposed MEP mission launches. The regions would continue to support human habitation and activities, wildlife habitats, citrus groves, grazing and agricultural land, and cultural, historical and archaeological areas. No long-term effects on these uses are anticipated because of the MEP missions. However, should an accident occur at CCAFS or VAFB causing a radiological release, the productivity and other long-term uses and resources of contaminated land areas could be impacted, pending mitigation.

Successful completion of the MEP could benefit the United States space program, which is important to the economic stability of the areas surrounding both launch sites. In addition to the localized economic benefits, implementation of the MEP would have broader socioeconomic benefits. These include technology spin-offs to industry and other space missions, maintaining the unique capability of the United States to conduct complex planetary missions by scientists and engineers, and supporting the continued scientific education and development of resources for graduate students at universities and colleges. Furthermore, real-time data and images acquired by the MEP missions would be made available to the general public, schools, and other institutions via a broad variety of media including the Internet. Scientific findings from the MEP would advance our knowledge and understanding of the solar system and the origin of life, and would contribute to the scientific and technological education of future generations.

Beginning with the two 1996 missions to Mars, the Mars Pathfinder lander-rover and the Mars Global Surveyor orbiter, through the most recent mission, the MER-2003 rovers, unique imagery and data has been received by the scientific community and provided to the public. This information provides invaluable information about Mars, its geology, climate, atmosphere, and a variety of other factors to further our understanding of the origin and evolution of the solar system. Future missions are planned considering this information, which include identifying landing sites, areas of unique geological features, areas of potential biological interest for possible sample return missions, and eventual human exploration.

The MEP would implement a series of scientific investigations and experiments, developed and prioritized by the broad planetary science community, that support the goals of the program. It would include comprehensive Mars data analyses with the involvement of the space science community, and due to the program's broad scope, essentially all sectors of society would be expected to benefit.

A focused, cohesive, coordinated public engagement plan would be created for the MEP that would reach out nationwide to encourage students in science, technology, engineering, and mathematics and would give the general public access to scientific discoveries and technical innovations generated by the exploration of Mars.

While Mars public engagement would have broad, nationwide reach, every effort would be made to personalize programs through community-based efforts that utilize a network of local resources (e.g., schools, museums, libraries, civic centers) that could expand or deepen the experience. Such opportunities would include, but not be limited to, programs for students to learn science and engineering concepts (e.g., how to send commands to a spacecraft and analyze data), participative contests such as naming of spacecraft for the general public, access to scientists and engineers through public and on-line events, and the real-time return and dissemination of data so that people worldwide could follow discoveries in tandem with the Mars science teams. Innovative and constructive opportunities to involve scientists and engineers in public engagement would be actively developed and evaluated, and would create possibilities that would give the public regular behind-the-scenes views of the teams at work in all mission phases.

#### **4.8 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES**

An irreversible resource commitment results from the use of a resource that cannot be replaced within a reasonable timeframe. The use of a resource that cannot be replaced is termed an irretrievable resource commitment.

The selection of either the Proposed Action or Alternative 2 would not immediately result in the irreversible and irretrievable commitment of resources. That commitment is made upon the decision to proceed with each individual mission. For each mission launch, quantities of various resources, including energy, fuels, and other materials, would be irreversibly and irretrievably committed. The use of these resources would be associated with the fabrication, launch, and operation of each MEP mission. Impacts associated with the use of these resources would be discussed within the mission-specific documentation. In general, the following would be involved.

##### **4.8.1 Energy and Fuels**

The fabrication processes for MEP spacecraft and launch vehicles would involve use of electrical and fossil-fuel energy. This use constitutes an irretrievable commitment of resources but would not impose any significant energy impacts. The launch and operation of spacecraft could consume solid propellant and would consume liquid propellant and other fluids. The solid propellant ingredients would include ammonium perchlorate, aluminum powder, and HTPB binder. The fluid substances could include

RP-1, hydrazine, LO<sub>2</sub>, LH<sub>2</sub>, nitrogen tetroxide, and other fluids used for hydraulics and cleaning.

#### 4.8.2 Other Materials

The total quantities of other materials used for the proposed MEP missions that would be irreversibly and irretrievably committed would be relatively minor. Among the more plentiful of these materials would be primarily steel, aluminum, titanium, iron, molybdenum, plastic, glass, nickel, chromium, lead, zinc, and copper. Less common materials committed to the proposed missions may include small quantities of silver, mercury, gold, rhodium, gallium, germanium, hafnium, niobium, platinum, plutonium, tantalum, cobalt, curium, cadmium, and americium.

### 4.9 ENVIRONMENTAL COMPLIANCE AT CCAFS AND VAFB

Table 4-1 presents an overview of environmental laws, regulations, reviews and consultation requirements applicable to operations at both CCAFS and VAFB, and includes permits, licenses, and approvals. The information presented in Table 4-1 is summarized from the *Final Environmental Impact Statement for the Evolved Expendable Launch Vehicle Program* (USAF 1998), the *Final Supplemental Environmental Impact Statement for the Evolved Expendable Launch Vehicle Program* (USAF 2000), and NASA's Routine Payloads EA (NASA 2002a). The referenced documents present the relevant discussions, analyses, potential environmental impacts and applicable mitigation plans within each topic of concern. The launch of a MEP mission from either facility would follow all applicable requirements, and no new permits, licenses, or approvals would be required.

**TABLE 4-1. OVERVIEW OF ENVIRONMENTAL COMPLIANCE APPLICABLE TO MEP MISSION LAUNCHES AT CCAFS AND VAFB**

CCAFS	VAFB
<b>Air Resources</b>	
<p>Air permits are required for activities considered as stationary sources having the potential to release air pollutants such as launch support activities (e.g., vehicle preparation, assembly, propellant loading), but are not required for emissions from mobile sources such as launch vehicles during liftoff and ascent. Existing equipment and services would be used.</p>	
<p>CCAFS currently operates under Title V (40 CFR 70) of the Clean Air Act, as amended (42 U.S.C. 7401 <i>et seq.</i>), as a single facility. Commercial launch service providers are required to obtain Title V permits for their operations.</p>	<p>VAFB is exempted from Title V requirements as a result of agreements between DOD, EPA, and the Santa Barbara County Air Pollution Control District, and has site-specific operational and reporting requirements.</p>
<b>Noise</b>	
<p>Regulations and guidelines prescribed by the Noise Control Act, as amended (42 U.S.C. 4901 <i>et seq.</i>), the Occupational Safety and Health Administration (OSHA), and the National Institute of Occupational Safety and Health would be followed.</p>	

**CCAFS**

**VAFB**

---

**Water Resources**

The Clean Water Act, as amended (33 U.S.C. 1251 *et seq.*), provides regulatory guidelines for water quality.

Wastewater is discharged in accordance with the National Pollutant Discharge Elimination System (NPDES) permit conditions. Water used during launch would be discharged under a Florida Department of Environmental Protection permit or disposed by a certified contractor.

Wastewater is discharged in accordance with NPDES permit conditions. Wastewater discharge is managed through a Waste Discharge Requirement and Report of Waste Discharge Program. Water used during launch would be treated and recycled, or disposed.

---

**Floodplains and Wetlands**

Executive Order (EO) 11988, *Floodplain Management*, and EO 11990, *Protection of Wetlands*, would be followed. No added impacts to floodplains and wetlands beyond those normally associated with typical launches would be anticipated.

---

**Coastal Zone Management**

The regulatory framework for coastal zone management is provided by the Federal Coastal Zone Management Act, as amended (16 U.S.C. 1451 *et seq.*), which establishes a national policy to preserve, protect, develop, restore, and enhance the resources of the nation's coastal zone. CCAFS and VAFB would follow the respective States' requirements. No added impacts beyond those normally associated with launches would be anticipated.

---

**Biological Resources**

Federal mandates for the conservation of biological resources include, but are not limited to, the Endangered Species Act, as amended (16 U.S.C. 1531 *et seq.*) (ESA), the Marine Mammal Protection Act, as amended (16 U.S.C. 1361 *et seq.*), and the Migratory Bird Treaty Act, as amended (16 U.S.C. 703 *et seq.*). CCAFS and VAFB both have ESA-listed (endangered or threatened) species. USAF consultations with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service are in place or in process, and VAFB has incidental take permits. Established standard practices (*e.g.*, complying with the light management plan for nesting sea turtles and hatchlings at CCAFS) would be observed to minimize impacts to these resources.

---

**Cultural Resources**

Directives of Section 106 of the National Historic Preservation Act (NHPA), as amended (16 U.S.C. 470 *et seq.*), would be followed. The State Historic Preservation Officer and the Federal Advisory Council on Historic Preservation would be consulted, if necessary, to determine if the Proposed Action or Alternative 2 could adversely impact cultural resources within CCAFS or VAFB, although no adverse impacts are expected. Implementation of either the Proposed Action or Alternative 2 would likely cause no adverse effects to archaeological, historic, or cultural resources, but failed launches and the effects of fire-fighting or cleanup could damage historic sites, archaeological deposits, and other cultural properties. If such incidents were to occur, all federal laws pertaining to Historic Preservation would be followed, including (but not limited to) the NHPA, the Native American Graves Protection and Repatriation Act (25 U.S.C. 3001 *et seq.*), and the Archaeological Resources Protection Act, as amended (16 U.S.C. 470aa *et seq.*).

---

**Worker and Public Safety and Health**

OSHA regulations would be followed to ensure worker and public safety and health from excessive noise, exposure to hazardous materials and hazardous wastes, and ingestion of toxic fumes from operations such as fueling. The 45<sup>th</sup> Space Wing at CCAFS and the 30<sup>th</sup> Space Wing at VAFB each have the responsibility to follow range safety guidelines as outlined in EWR 127-1, *Eastern and Western Range Safety Requirements*.

---

**CCAFS**

**VAFB**

---

**Hazardous Material Management**

Hazardous materials are controlled through Federal regulations such as the Comprehensive Environmental Response, Compensation, and Liability Act, as amended (42 U.S.C. 9601 *et seq.*), the Toxic Substances Control Act, as amended (15 U.S.C. 2601 *et seq.*), and the Hazardous Material Transportation Act, as amended (49 U.S.C. 1803 *et seq.*). Air Force Instruction AFI 32-7086, *Hazardous Material Management*, provides guidance for managing hazardous materials.

Hazardous material would be procured and managed by the commercial launch service provider. The 45<sup>th</sup> Space Wing Operations Plan (OPlan) 32-3, *Hazardous Material Response Plan*, provides guidance for hazardous material spills.

Hazardous material would be procured and managed by the commercial launch service provider. The 30<sup>th</sup> Space Wing Plan 32-4002, *Hazardous Materials Emergency Response Plan*, provides guidance for hazardous material spills.

---

**Hazardous Waste Management**

The Resource Conservation and Recovery Act, as amended (42 U.S.C. 6901 *et seq.*), provides regulatory guidance on managing hazardous wastes. Air Force Instruction AFI 32-7042, *Solid and Hazardous Waste Compliance*, provides guidance on managing hazardous waste. Hazardous wastes must be collected, labeled appropriately, and stored in hazardous waste collection areas prior to disposal.

Hazardous wastes would be managed by the commercial launch service provider or by NASA. The 45<sup>th</sup> Space Wing OPlan 19-14, *Petroleum Products and Hazardous Waste Management Plan*, would be followed.

Hazardous wastes would be disposed by an approved contractor. The 30<sup>th</sup> Space Wing Plan 32-7043-A, *Hazardous Waste Management Plan*, would be followed.

---

**Pollution Prevention**

The Pollution Prevention Act, as amended (42 U.S.C. 13101 *et seq.*), provides the regulatory framework. DOD Directive 4210.15, *Hazardous Material Pollution Prevention*; USAF Policy Directive AFPD 32-70, *Environmental Quality*; and USAF Instruction AFI 32-7080, *Pollution Prevention Program*, provide pollution prevention guidelines. NASA participates in a partnership with the military services called the Joint Group on Pollution Prevention to reduce or eliminate hazardous material or processes.

Pollution prevention guidelines are provided by the 45<sup>th</sup> Space Wing *Pollution Prevention Program Guide and Pollution Prevention Management Action Plan*.

Pollution prevention guidelines are provided by the 30<sup>th</sup> Space Wing Plan 32-7080, *Pollution Prevention Program Guide and Pollution Prevention Management Action Plan*.

---

**Spill Prevention**

Hazardous material spills are addressed under the 45<sup>th</sup> Space Wing OPlan 32-3, *Hazardous Materials Response Plan*. The commercial launch service provider will, in most cases, be responsible for clean-up of any released hazardous material. When a spill of a Federally listed oil or petroleum occurs, as per the 45<sup>th</sup> Space Wing OPlan 19-4, *Hazardous Substance Pollution Contingency Plan*, the substance is collected and removed for disposal by a certified contractor.

Hazardous material spills are addressed under the 30<sup>th</sup> Space Wing Plan 32-4002, *Hazardous Materials Emergency Response Plan*. The commercial launch service provider will, in most cases, be responsible for clean-up of any released hazardous material.

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## 6 AGENCIES AND INDIVIDUALS CONSULTED

This Final Programmatic Environmental Impact Statement (FPEIS) for the Mars Exploration Program (MEP) was preceded by a Draft Programmatic Environmental Impact Statement (DPEIS), which was made available for review and comment by Federal, State, and local agencies and the public on April 23, 2004. The public review and comment period closed on June 7, 2004. Comments were considered during the preparation of the FPEIS.

In preparing the PEIS, NASA has actively solicited input from a broad range of interested parties. In addition to publication in the *Federal Register* of a Notice of Intent (NOI) (68 FR 43378) and a Notice of Availability (66 FR 21865) for the DPEIS, NASA mailed copies of the DPEIS directly to agencies, organizations, and individuals who may have interest in environmental impacts and alternatives associated with the MEP. In addition, the DPEIS was publicly available in electronic format from a NASA server on the Internet.

Comments on the DPEIS were solicited or received from the following:

### **Federal Agencies**

- Council on Environmental Quality
- National Science Foundation
- Office of Management and Budget
- U.S. Dept. of Agriculture
- U.S. Dept. of the Air Force
- U.S. Dept. of Commerce
  - National Oceanic and Atmospheric Administration
  - National Marine Fisheries Service
- U.S. Dept. of Energy
- U.S. Dept. of Health and Human Services
  - Centers for Disease Control and Prevention
  - National Cancer Institute
- U.S. Dept. of Homeland Security
  - Federal Emergency Management Agency
  - U.S. Coast Guard
- U.S. Dept. of the Interior
  - Fish and Wildlife Service
  - National Park Service
- U.S. Dept. of State
- U.S. Dept. of Transportation
  - Federal Aviation Administration
  - Research and Special Programs Administration
- U.S. Environmental Protection Agency
- U.S. Nuclear Regulatory Commission

## **State Agencies**

California Environmental Protection Agency  
California State Clearinghouse  
East Central Florida Regional Planning Council  
Florida Department of Environmental Protection  
Florida State Clearinghouse  
State of Florida, Office of the Governor  
State of California, Office of the Governor

## **County Agencies**

### Florida

Brevard County  
    Board of County Commissioners  
    Natural Resources Management Office  
    Office of Emergency Management  
    Planning and Zoning Office  
    Public Safety Department

Lake County  
Orange County  
Osceola County  
Seminole County  
Volusia County

### California

Santa Barbara County  
    Air Pollution Control District  
    Association of Governments  
    Department of Environmental Health Services  
    Department of Planning

## **Local Agencies**

### Florida

Canaveral Port Authority  
City of Cape Canaveral  
City of Cocoa  
City of Cocoa Beach  
City of Kissimmee  
City of Melbourne  
City of Merritt Island  
City of New Smyrna Beach  
City of Orlando  
City of West Melbourne  
City of St. Cloud  
City of Titusville

## California

City of Guadalupe, Office of the Mayor  
City of Lompoc, Office of the Mayor  
City of San Luis Obispo, Office of the Mayor  
City of Santa Barbara, Office of the Mayor  
City of Santa Maria, Office of the Mayor

## **Organizations**

The American Association for the Advancement of Science  
American Astronomical Society  
American Institute of Aeronautics and Astronautics  
American Society of Mechanical Engineers  
Audubon of California  
Audubon of Florida  
Economic Development Commission of Florida's Space Coast  
Environmental Defense Fund  
Federation of American Scientists  
Friends of the Earth  
Global Network Against Weapons and Nuclear Power in Space  
Greenpeace  
Indian River Audubon Society  
Mars Society  
National Space Society  
National Wildlife Federation  
Natural Resources Defense Council  
The Planetary Society  
Santa Barbara Audubon Society  
Sierra Club  
Union of Concerned Scientists

## **Individuals**

Mr. Stephen Locke  
Mr. John D. Sickler

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**APPENDIX A**  
**GLOSSARY OF TERMS**

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## APPENDIX A

### GLOSSARY OF TERMS

- accident environment**—Conditions resulting from an accident, such as blast overpressures, fragments, and fire.
- affected environment**—A description of the existing environment that could be affected by the Proposed Action or its alternatives.
- ambient air**—The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. (It is not the air in the immediate proximity of an emission source.)
- Atlas**—A family of launch vehicles manufactured by the Lockheed Martin Space Systems Company.
- attainment**—An area is designated as being in attainment by the U.S. Environmental Protection Agency (EPA) if it meets the **National Ambient Air Quality Standards (NAAQS)** for a given **criteria pollutant**. Non attainment areas are areas in which any one of the NAAQS have been exceeded, maintenance areas are areas previously designated non attainment and subsequently re-designated as attainment, and unclassifiable areas are areas that cannot be classified on the basis of available information as meeting or not meeting the NAAQS for any one criteria pollutant.
- criteria pollutants**—The Clean Air Act required the EPA to set air quality standards for common and widespread pollutants after preparing criteria documents summarizing scientific knowledge on their health effects. Currently, there are standards in effect for six criteria pollutants: sulfur dioxide (SO<sub>2</sub>), carbon monoxide (CO), particulate matter equal to or less than 10 microns in diameter (PM<sub>10</sub>), nitrogen dioxide (NO<sub>2</sub>), ozone (O<sub>3</sub>), and lead (Pb).
- cultural resources**—The prehistoric and historic districts, sites, buildings, objects, or any other physical activity considered important to a culture, subculture, or a community for scientific, traditional, religious, or any other reason.
- cumulative impact**—The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes other such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.
- curie (Ci)**—A measure of the radioactivity level of a substance (*i.e.*, the number of unstable nuclei that are undergoing transformation in the process of radioactive decay). One curie equals the disintegration of  $3.7 \times 10^{10}$  (37 billion) nuclei per second, and is equal to the radioactivity of one gram of radium-226.

**de minimis (emissions)**—Emissions that are below threshold levels of **NAAQS** pollutants from Federal actions in non attainment or maintenance areas (see **attainment**).

**decibel**—A logarithmic measurement unit that describes a particular sound pressure quantity to a standard reference value.

**Delta**—A family of space launch vehicles manufactured by the Boeing Aerospace Company.

**essential fish habitat**—Congress defined essential fish habitat for Federally managed fish species as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. 1802(10)). The conservation of essential fish habitat is an important component of building and maintaining sustainable fisheries.

**General Conformity Rule**—Applicable to non attainment or maintenance areas (see **attainment**) as designated by the EPA, and ensures that Federal actions conform to each State Implementation Plan (SIP) for air quality. The SIPs, approved by the EPA, are each State's individual plan to achieve the **NAAQS** as required by the Clean Air Act. The EPA is required to promulgate a Federal Implementation Plan (FIP) if a State defaults on its SIP. A conformity requirement determination for the action is made from influencing factors, including, but not limited to, non attainment or maintenance status of the area, types of emissions and emission levels resulting from the action, and local impacts on air quality.

**General Purpose Heat Source (GPHS)**—A passive heating device (heat source) that uses radioactive decay of plutonium dioxide to provide heat for conversion into electricity.

**geology**—The study or science of the Earth (or any solid celestial body), its history, and its life as recorded in the rocks.

**hydrazine (N<sub>2</sub>H<sub>4</sub>)**—A toxic, colorless liquid fuel that is hypergolic (*i.e.*, can burn spontaneously on contact) when mixed with an oxidizer such as nitrogen tetroxide (N<sub>2</sub>O<sub>4</sub>). Vapors may form explosive mixtures with air.

**in situ**—From the Latin for *in the original place*; used in planetary exploration to describe those science investigations conducted close to or within the phenomena being observed or measured.

**isotope**—Any of two or more species of atoms of a chemical element with the same atomic number and nearly identical chemical behavior, but with differing atomic mass (number of neutrons) or mass number and different physical properties.

**Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)**—A new generation power source consisting of a radioisotope heat source (GPHS modules) and a thermoelectric converter that transforms thermal energy into electricity.

**National Ambient Air Quality Standards (NAAQS)**—Section 109 of the Clean Air Act requires the EPA to set nationwide standards, the NAAQS, for widespread air pollutants. Currently, six pollutants are regulated by primary and secondary NAAQS (see **criteria pollutants**). The primary NAAQS set limits to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. The secondary NAAQS set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings from any known or anticipated adverse effects of a pollutant.

**nitrogen oxides (NO<sub>x</sub>)**—Gases formed primarily by fuel combustion, and which contribute to the formation of acid rain. Hydrocarbons and oxides of nitrogen combine in the presence of sunlight to form ozone, a major constituent of smog.

**nitrogen tetroxide (N<sub>2</sub>O<sub>4</sub>)**—A liquid oxidizer that can cause spontaneous ignition with many common materials such as paper, leather, and wood. It also forms strong acids in combination with water, and contact can cause severe chemical burns. It is a yellow-brown liquid which is easily frozen or vaporized.

**payload**—The element(s) that a launch vehicle or spacecraft carries over and above what is necessary for the operation of the vehicle. For a launch vehicle, the spacecraft being launched is the payload; for a scientific spacecraft, the suite of science instruments is the payload.

**payload fairing (PLF)**—The protective shell on a launch vehicle that encapsulates the spacecraft through atmospheric ascent.

**radioisotope heater unit (RHU)**—A passive heating device that uses the radioactive decay of plutonium dioxide to produce heat; typically used to control and maintain the thermal environment of temperature-sensitive spacecraft components.

**sea breezes**—Winds occurring at the surface from the ocean towards the land.

**second stage**—The launch vehicle stage that provides thrust during ascent, but not at liftoff.

**spectrometry**—A technique that is used to identify the makeup of samples by analyzing the sample's ionic composition and distribution.

**Stirling Radioisotope Generator (SRG)**—A new generation power source consisting of a radioisotope heat source (GPHS modules) and a converter that uses a Stirling-cycle engine to transform thermal energy into electricity.

**stratigraphy**—The study of the layers of rocks, including their formation, distribution, deposition, and age.

**stratosphere**—An upper portion of the atmosphere above the troposphere reaching a maximum height of 50 kilometers (31 miles) above the Earth's surface. The temperature is relatively constant in the lower stratosphere and gradually

increases with altitude. The stratosphere is the Earth's main ozone producing region.

**take**—To pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect (50 CFR 10.12).

**third stage**—The launch vehicle stage that provides the final thrust required to place a launch vehicle's payload into its proper trajectory or orbit.

**tropopause**—The boundary between the troposphere and stratosphere, usually characterized by an abrupt change of lapse rate; the change is in the direction of increased atmospheric stability from regions below to regions above the tropopause; its height varies from 15 kilometers (9 miles) in the tropics to about 10 kilometers (6 miles) in polar regions.

**troposphere**—The portion of the atmosphere next to the Earth's surface in which the temperature rapidly decreases with altitude, clouds form, and convection is active. The troposphere begins at ground level and extends to an altitude of 10 to 12 kilometers (6 to 8 miles) above the Earth's surface.

**APPENDIX B**  
**RESPONSES TO PUBLIC REVIEW COMMENTS**

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## APPENDIX B

### RESPONSES TO PUBLIC REVIEW COMMENTS

NASA published a Notice of Availability (NOA) of the Draft Programmatic Environmental Impact (DPEIS) for the Mars Exploration Program in the Federal Register on April 22, 2004 (69 FR 21865) and mailed copies to 72 Federal, State and local agencies, organizations, and individuals. The U.S. Environmental Protection Agency published its NOA for the DPEIS in the Federal Register on April 23, 2004 (69 FR 22025). The DPEIS was mailed by NASA to 72 potentially interested Federal, State and local agencies, organizations and individuals. In addition, the DPEIS was publicly available in electronic format from a NASA server on the Internet. The public review and comment period closed on June 7, 2004. A total of 10 comment submissions (letters and e-mails) were received: seven from Federal agencies, one from the State of Florida, one from the State of California, and one from the City of Titusville, Florida. No comments were received from any private organizations or individuals.

This appendix provides specific responses to the comments received from the agencies and individuals listed in Table B-1. Copies of each submission, including attachments, are presented in the following pages. The relevant comments in each submission are marked and numbered for identification (unless already enumerated in the submission). The comments received included “no comment” and recommendations to clarify or correct specific sections of text. NASA’s response to each identified comment is presented in Table B-2, which follows the submissions.

**TABLE B-1. AGENCIES AND INDIVIDUALS PROVIDING COMMENTS**

<b>Comment Submission Number</b>	<b>Organization</b>
1	U.S. Environmental Protection Agency Office of Federal Activities
2	U.S. Environmental Protection Agency Office of Radiation and Indoor Air
3	United States Air Force - Patricia J. Vokoun
4	United States Air Force - Gabriel Garcia
5	United States Air Force - James Carucci
6	Federal Aviation Administration
7	U.S. Department of the Interior
8	State of Florida Department of Environmental Protection
9	State of California
10	City of Titusville, Florida



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
WASHINGTON, D.C. 20460

MAY 21 2004

OFFICE OF  
ENFORCEMENT AND  
COMPLIANCE ASSURANCE

Mark R. Dahl  
Mars Program Office  
Office of Space Science  
NASA Headquarters  
Washington, DC 20546

Dear Mr. Dahl:

The Environmental Protection Agency (EPA) has reviewed the Draft Programmatic Environmental Impact Statement (DPEIS) for the Mars Exploration Program [CEQ # 040180]. Our review is pursuant to the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act.

NASA proposes to implement a series of missions to Mars through the second decade of the twenty-first century, launching from Vandenberg Air Force Base (VAFB) and Cape Canaveral Air Force Station (CCAFS). EPA believes that the DPEIS provides an adequate discussion of the potential environmental impacts of these particular Mars missions and rates the document as LO, Lack of Objections. **| -1-1**

We appreciate the opportunity to review this DPEIS. We look forward to reviewing future documents related to this project. The staff contact for this review is Summer Allen, at (202) [REDACTED].

Sincerely,

Anne Norton Miller  
Director  
Office of Federal Activities

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**Comment Submission #1: U.S. Environmental Protection Agency  
Office of Federal Activities**



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
WASHINGTON, D.C. 20460

JUN - 2 2004

OFFICE OF  
AIR AND RADIATION

Mark R. Dahl, Program Executive  
Mars Exploration Program Office  
Office of Space Science - Code SM  
National Aeronautics and Space Administration  
Washington, DC 20546-0001

Dear Mr. Dahl:

Thank you for your letter dated April 14, 2004, requesting the Environmental Protection Agency (EPA) to review and comment on the Draft Programmatic Environmental Impact Statement (DPEIS) for NASA's Mars Exploration Program (MEP).

We have reviewed the draft and concluded that there would be no problem with preparing a Final PEIS. The document addresses the major topics of environmental and public health concern in preparations for and during NASA's MEP launches. **-2-1**

We have one recommendation to make with regard to Federal Aviation Administration (FAA) and United States Coast Guard (USCG) restrictions during a launch at either Cape Canaveral Air Force Station (CCAFS) or Vandenberg Air Force Base (VAFB). On Page 3-22, the last paragraph in Section 3.2.7.4 gives reference to notification being made to the FAA and offshore vessels of a scheduled launch where a designated area around the launch corridor is controlled. This controlled launch corridor is discussed within the VAFB section of Public and Emergency Services, but in the corresponding section of the CCAFS discussion, Page 3-13, Section 3.1.7.4, there is no similar reference. If there are launch restrictions at CCAFS as there are at VAFB, it should be stated within the text of the document. **-2-2**

We acknowledge and appreciate NASA's programmatic approach to addressing environmental and public health concerns related to all mission launches associated with the MEP. We appreciate the opportunity to participate in this important program.

Sincerely,

Elizabeth A. Cotsworth, Director  
Office of Radiation and Indoor Air

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**Comment Submission #2: U.S. Environmental Protection Agency  
Office of Radiation and Indoor Air**

Subject: RE: NASA Mars Program Draft EIS

Date: Mon, 7 Jun 2004 15:22:59 -0400

From: "Vokoun Patricia Ctr AF/ILEPB"

<[REDACTED]>

To: "Mark Dahl" <[REDACTED]>

Cc: "Bush Jack Civ AF/ILEPB" <[REDACTED]>,  
"Novak Robert J Civ AFSPC/CEV"

<[REDACTED]> ,

"Carver Terri L Civ AFSPC/JA"

<[REDACTED]>

Dear Mr. Dahl,

Thank you for the opportunity to comment on the Draft Programmatic Environmental Impact Statement (PEIS) for the Mars Exploration Program. We think the Draft PEIS is adequate for public release. We would like to review it again at the Preliminary Final EIS stage, when we would be able to see comments from the public and NASA responses.

|-3-1  
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If we can provide further assistance, please do not hesitate to contact Mr. Jack Bush at (703) [REDACTED],

[REDACTED], or Ms. Patricia Vokoun, (703) [REDACTED].

Sincerely,

Patricia J. Vokoun, P.E.  
Bases & Units Branch  
Programs Division  
DCS/Installations & Logistics  
Crystal Gateway One, Suite 1000  
1235 Jefferson Davis Highway  
Arlington, VA 22202  
(703) [REDACTED]

**Comment Submission #3: United States Air Force (Vokoun)**

From: Garcia Gabriel GS-14 30 SW/SEY <[REDACTED]>  
To: Garcia Gabriel GS-14 30 SW/SEY <[REDACTED]>, "mep.nepa@hq.nasa.gov" <mep.nepa@hq.nasa.gov>  
Cc: McCombs Mike L GS-14 30 SW/SES <[REDACTED]>, Cortopassi Ronald B GS-15 30 SW/SE <[REDACTED]>, <[REDACTED]>, Smith Dian L Contr 30 SW/SRS <[REDACTED]>, Valentine Ronald F Jr GS-14 30 SW/SESI <[REDACTED]>, <[REDACTED]>, Aulabaugh Stanley E Civ 30 SW/SESI <[REDACTED]>, <[REDACTED]>, Wiskowski Tara L GS-11 30 CES/CEVPP <[REDACTED]>  
Subject: RE: Comments Re: Draft Programmatic EIS for Mars Exploration Program (SEY - Flight Analysis)  
Date: Tue, 1 Jun 2004 20:56:07 -0000

The following are comments to the subject document.

Page viii, para 6: It should be noted that CCAS and VAFB also provide toxic risk assessments for the normal launch exhaust products for all launch operations. Currently, the document only refers to launch failures.

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Please let me know if you have any questions on the above comment.

Thanks,

Gabriel Garcia  
Chief, Flight Analysis  
30 SW/SEY  
Vandenberg AFB CA 93437-5230  
Email: [REDACTED]  
Voice: (805) [REDACTED] DSN [REDACTED]  
Fax: (805) [REDACTED] DSN [REDACTED]

**Comment Submission #4: United States Air Force (Garcia)**

ENVIRONMENTAL REVIEW SHEET	
<b>PROJECT #</b>	<b>PROJECT TITLE</b>
	REVIEW and COMMENTS on Draft EIS for the Mars Exploration Program
<b>REVIEWERS ORGANIZATION: 30CES/CEVPC (Cultural Resources)</b>	
ORGANIZATION COMMENTS/SUGGESTIONS/RECOMMENDATIONS	
<ol style="list-style-type: none"> <li>1. I have reviewed those sections of the DEIS for the Mars Program at VAFB that specifically relate to Cultural Resources, Historic Resources, Archaeology, and land use. My comments follow below.</li> <li>2. Throughout the DEIS, the danger of localized brush fires and larger-area fires caused by launch failures is discussed. Page 4-13 even notes that threatened plant species could be endangered if a post launch fire occurs. Yet the authors note on page 2-20 (in a generally excellent overall summary of potential impacts from the program) that there is "No adverse impact expected" at VAFB for the category of "Cultural/Historical/Archaeological Resources". How can this be if we agree that post-launch wildfires may occur? It is a well-established fact that fires have the ability to damage archaeological sites, not to mention historic buildings and other cultural resources. VAFB has over 2,300 prehistoric archaeological sites, hundreds of historic archaeological sites and scores of historic buildings and facilities that are eligible for listing on the National Register of Historic Places (NRHP). A fire caused by a Mars Program launch has the potential to destroy historic structures or damage archaeological sites directly, and fire-fighting activities are also capable of causing damage to prehistoric and historic resources. These potential effects must be added to the DEIS, where appropriate, and Table 2-4 on page 2-20 should note the potential damaging effects of launch-related fires.</li> <li>3. Figure 3-3 (page 3-15), showing the "Regional Area Near VAFB" should be corrected to show the outline of Vandenberg itself. Why waste a page on a graphic that shows the region but not the boundary of the air force base?</li> <li>4. There are a number of errors and oversights in the discussions on page 3-23 that describe the historic and cultural resources of VAFB. At the top of the page, the first full (short) paragraph mentions "The Space and Missile Heritage Center" on VAFB. This paragraph should be rewritten to clarify that SLC-10, the Space and Missile Heritage Center, is also a National Historic Landmark (NHL), which is a special category of historic property listed on the NRHP. In other words, SLC-10, an old Thor launch facility, is not just the VAFB "museum", it is also an important historic site. Also, Section 3.2.8 has a number of errors. There are no elements of SLC-6 that have been found eligible for the NRHP. Elements of SLC-2 and SLC-3 were <b>determined</b> eligible for listing on the NRHP, but such determinations are not based on SHPO "recommendations". NRHP eligibility determinations are based on Air Force findings, to which the SHPO is asked to concur. The SHPO does not "recommend eligibility" as the DEIS authors state. Finally, correct the last sentence of section 3.2.8 to read: "there are over 2,300 known prehistoric archaeological sites, 200 historic archaeological sites, 140 Traditional Cultural Properties, 110 historic structures, 77 NRHP-eligible Cold War facilities, several historic trails, and 10 + significant paleontological sites on the base".</li> <li>5. Based on comments 2 and 4 above, the meager discussions at the top of page 4-10 must be corrected. First, VAFB consultations with the SHPO about NRHP-eligible Cold War resources at VAFB was not "recent". And secondly, the elements of SLC-2 that are eligible for the NRHP were <b>determined</b> to be so by consultations between the Air Force and the California SHPO. These are not open-ended recommendations made by SHPO, but final determinations of eligibility. Lastly, the discussions about the potential impacts of launch-related fires, fire-fighting activities, and potential radiological contamination from launch mishaps (see comment #6, below) should be noted in this section instead of the blanket statement that NRHP-eligible resources will not likely be affected.</li> <li>6. Section 4.7.2 on page 4-20 briefly discusses impacts on the physical environment if there is a radiological release following a launch. Again, in reference to comment 2 above (Table 2-4), the thorough cleanup of contaminated soils over a large area would have obviously the potential to impact buried archaeological sites and other historic properties. Again, this possibility must be added to the discussions of potential impacts to cultural resources sites.</li> <li>7. Table 4-1 on page 4-24 must be corrected. At the top of page 4-24, the authors should state that "<b>Implementation</b> of the proposed Mars program will likely cause no adverse effects to archaeological, historic, or cultural resources, but failed launches and the effects of fire-fighting or cleanup could damage historic sites, archaeological deposits, and other cultural properties. If such incidents were to occur, all federal laws pertaining to Historic Preservation would be followed, including (but not limited to) the National Historic Preservation Act, the Native American Graves Protection and Repatriation Act, and the Archaeological Resources Protection Act."</li> <li>8. Thank you for the opportunity to review this DEIS.</li> </ol> <p style="text-align: right;"> <b>James Carucci, Ph.D.</b>  <b>Historic Archaeologist / Cold War Specialist</b>  <b>Vandenberg Air Force Base</b>  <b>Phone (805) [REDACTED]</b>  <b>7 June 2004</b> </p>	

**Comment Submission #5: United States Air Force (Carucci)**

**COMMENT INCORPORATION SUMMARY**

COMMENT INCORPORATOR:		DATE: June 4 2004				
COMMENTOR: Michon Washington		ORGANIZATION OF COMMENTOR: FAA/AST				
TITLE OF DOCUMENT: Draft Programmatic Environmental Impact Statement for the Mars Exploration Program						
ITEM NO.	PAGE NO.	LINE NO.	FIG. NO.	RE-VIEWER	RECOMMENDED CHANGES <i>(Exact wording of suggested change)</i>	HOW COMMENT WAS INCORPORATED <i>(If not incorporated, why?)</i>
1.	ix			MW	Last paragraph on the page indicates that the population and individual risks are "relatively small." This statement should be quantified.	
2.	2-19; 4-4; 4-17			MW	Be consistent in noting that carbon monoxide in solid rocket motor exhaust would oxidize to carbon dioxide under high temperatures of the exhaust.	
3.	3-6			MW	Please define "artesian pressure."	
4.	3-10		3-2	MW	The sources used to develop this table may be out of date (1997 and 2001). Suggest that consultation with the appropriate state wildlife management agency, U.S. Fish and Wildlife Service, and National Oceanic and Atmospheric Administration Fisheries be initiated to ensure that the PEIS addresses all threatened, endangered, proposed, or candidate species at CCAFS. Please note that the Florida Fish and Wildlife Conservation Commission updated the <i>Florida's Endangered Species, Threatened Species, and Species of Special Concern</i> report on 29 January 2004.	
5.	3-13			MW	Please confirm whether additional action has been taken since the publication of the USAF 2001 reference to list Launch Complexes 1/2, 3/4, 9/10, 17, 21/22, 31/32, the original site of the Cape Canaveral Lighthouse and the Lighthouse itself on the National Register of Historic Places.	
6.	3-14			MW	Please clarify what is meant by "Calms are rare."	
7.	3-19			MW	Please clarify whether the proposed launches to support the MEP would be included under the existing authorization for the incidental take of marine mammals.	
8.	3-21		3-4	MW	The USAF 1998 source used to develop this table may be out of date. Suggest that consultation with the appropriate state wildlife management agency, U.S. Fish and Wildlife Service and National Oceanic and	

**COMMENT INCORPORATION SUMMARY**

ITEM NO.	PAGE NO.	LINE NO.	FIG. NO.	RE-VIEWER	RECOMMENDED CHANGES <i>(Exact wording of suggested change)</i>	HOW COMMENT WAS INCORPORATED <i>(If not incorporated, why?)</i>
9.	4-2			MW	Atmospheric Administration Fisheries be initiated to ensure that the PEIS addresses all threatened, endangered, proposed, or candidate species at VAFB. Please confirm whether launches to support the MEP would be in excess of the 10 Atlas V and 11 Delta IV launches from CCAFS and 3 Atlas V and 3 Delta IV launches from VAFB.	
10.	4-5			MW	Please confirm whether CCAFS is in attainment for all NAAQS criteria pollutants as the referenced source was published in 2001. In addition, the CARB 2003b reference indicates that the Environmental Protection Agency would make a decision on attainment status by April 2004. Please clarify whether this decision has been finalized.	
11.	4-5			MW	It should be noted that noise impacts associated with launch occurs during launch vehicle lift off as well as during vehicle flight.	
12.	4-8			MW	Please explain what is meant by no fish kills from a "normal launch."	
13.	4-8			MW	The statement that "no adverse impacts to biota are expected as a result of sonic booms" needs to be supported.	
14.	4-16 – 4-17			MW	It is not clear that the combined impacts of current operations at CCAFS and VAFB and operations proposed as part of this action have been calculated.	
15.	4-17			MW	The PEIS states that launch activities would generate air pollutants, noise, and hazardous waste but that the quantities would be small compared to major industrial activities. This statement should be quantified to provide context for the reader.	
16.	4-17			MW	The PEIS states that the average annual depletion of ozone would be small. Recommend that this be quantified.	
17.	4-17			MW	The PEIS states that the exhaust emissions from proposed MEP launches would be a very small fraction of the total global warming gases. Recommend that this be quantified.	
18.	4-24			MW	Please clarify whether the State Historic Preservation Officer and the Federal Advisory Council on Historic Preservation have been consulted for this action. If not, please explain why.	



## United States Department of the Interior

OFFICE OF THE SECRETARY  
OFFICE OF ENVIRONMENTAL POLICY AND COMPLIANCE

Richard B. Russell Federal Building  
75 Spring Street, S.W.  
Atlanta, Georgia 30303

ER 04/311

June 3, 2004

Mark R. Dahl  
Mars Program Office  
Office of Space Science  
NASA Headquarters  
Washington, DC 20546

RE: Mars Exploration Program

Dear Mr. Dahl:

The Department of the Interior has reviewed the referenced application. We have no comments to provide for your consideration. If you have any questions, I can be reached at 404 [REDACTED].

| -9-1  
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Sincerely,

Gregory Hogue  
Regional Environmental Officer

cc:  
FWS, R4  
OEPC, WASO

**Comment Submission #7: U.S. Department of the Interior**



Jeb Bush  
Governor

## Department of Environmental Protection

Marjory Stoneman Douglas Building  
3900 Commonwealth Boulevard  
Tallahassee, Florida 32399-3000

Colleen M. Castille  
Secretary

April 19, 2004

Mr. Mark R. Dahl, Program Executive  
Mars Exploration Program Office  
Office of Space Science  
NASA Headquarters  
Washington, DC 20546-0001

RE: National Aeronautics and Space Administration – Draft Programmatic  
Environmental Impact Statement for the Mars Exploration Program – Cape  
Canaveral Air Force Station, Brevard County, Florida.  
SAI # FL200404195942C

Dear Mr. Dahl:

The Florida State Clearinghouse, pursuant to Presidential Executive Order 12372, Gubernatorial Executive Order 95-359, the Coastal Zone Management Act, 16 U.S.C. §§ 1451-1464, as amended, and the National Environmental Policy Act, 42 U.S.C. §§ 4321, 4331-4335, 4341-4347, as amended, reviewed the referenced Draft Programmatic Environmental Impact Statement (DPEIS).

Based on the information contained in the subject DPEIS, the state has determined that the proposed project is consistent with the Florida Coastal Management Program. **-10-1**

Thank you for the opportunity to review this project. If you have any questions regarding this letter, please contact Ms. Lauren P. Milligan at (850) [REDACTED].

Yours sincerely,

Sally B. Mann, Director  
Office of Intergovernmental Programs

SBM/lm

"More Protection, Less Process"

Printed on recycled paper.

**Comment Submission #8: State of Florida  
Department of Environmental Protection**



Arnold  
Schwarzenegger  
Governor

STATE OF CALIFORNIA  
Governor's Office of Planning and Research  
State Clearinghouse and Planning Unit



Jan Boel  
Acting Director

June 8, 2004

Mark R. Dahl  
National Aeronautics and Space Administration  
NASA Headquarters  
Code SM  
Washington, DC 20546

Subject: Mars Exploration Program  
SCH#: 2004044004

Dear Mark R. Dahl:

The State Clearinghouse submitted the above named Draft EIS to selected state agencies for review. The review period closed on June 7, 2004, and no state agencies submitted comments by that date. This letter acknowledges that you have complied with the State Clearinghouse review requirements for draft environmental documents, pursuant to the California Environmental Quality Act.

|-9-1

Please call the State Clearinghouse at (916) [REDACTED] if you have any questions regarding the environmental review process. If you have a question about the above-named project, please refer to the ten-digit State Clearinghouse number when contacting this office.

Sincerely,

Terry Roberts  
Director, State Clearinghouse

1400 TENTH STREET P.O. BOX 3044 SACRAMENTO, CALIFORNIA 95812-3044  
TEL (916) 445-0613 FAX (916) 323-3018 www.opr.ca.gov

**Comment Submission #9: State of California**

**Document Details Report  
State Clearinghouse Data Base**

**SCH#** 2004044004  
**Project Title** Mars Exploration Program  
**Lead Agency** National Aeronautics and Space Administration

**Type** EIS Draft EIS

**Description** NASA proposes to implement a coordinated set of robotic orbital, surface and atmospheric missions to gather scientific data on the planet Mars and its environment. Included among these missions would be U.S. missions that may or may not include international participation, as well as international mission with United States participation. It is intended that one or more major United States missions would be launched at every opportunity to Mars (approximately every 26 months) through at least the first two decades of the 21st century.

**Lead Agency Contact**

**Name** Mark R. Dahl  
**Agency** National Aeronautics and Space Administration  
**Phone** 202-358-1588 **Fax**  
**email**  
**Address** NASA Headquarters  
Code SM  
**City** Washington **State** DC **Zip** 20546

**Project Location**

**County** Santa Barbara  
**City** Lompoc  
**Region**

**Cross Streets**

Parcel No.	Township	Range	Section	Base

**Proximity to:**

**Highways**  
**Airports**  
**Railways**  
**Waterways**  
**Schools**  
**Land Use** VAFB Operations

**Project Issues** Air Quality; Archaeologic-Historic; Coastal Zone; Economics/Jobs; Noise; Toxic/Hazardous; Vegetation; Water Quality; Wildlife; Landuse

**Reviewing Agencies** Resources Agency; California Coastal Commission; Department of Conservation; Department of Fish and Game, Region 5; Office of Historic Preservation; Department of Parks and Recreation; Department of Water Resources; Office of Emergency Services; Caltrans, Division of Aeronautics; Caltrans, District 5; Department of Health Services; Air Resources Board, Airport Projects; Regional Water Quality Control Board, Region 3; Department of Toxic Substances Control; Native American Heritage Commission

**Date Received** 04/28/2004 **Start of Review** 04/28/2004 **End of Review** 06/07/2004

Note: Blanks in data fields result from insufficient information provided by lead agency.

**Comment Submission #9: State of California – Attachment**

From: "Chivers, Mandy" <[REDACTED]>  
To: "'mep.nepa@hq.nasa.gov'" <mep.nepa@hq.nasa.gov>  
Cc: "Harmer, Tom - City Manager"  
<[REDACTED]>,  
"Williams, Hugh" <[REDACTED]>  
Subject: Mars Exploration Program  
Date: Wed, 26 May 2004 10:34:07 -0400

May 26, 2004

Mark R. Dahl  
Program Executive  
Mars Exploration Program Office  
National Aeronautics and Space Administration  
Headquarters  
Washington, DC 20546-0001

Attention: SM

Dear Mr. Dahl:

In reply to your correspondence of April 14 2004, the  
Titusville Environmental Commission reviewed the Draft  
Programmatic Environmental Impact Statement for the Mars  
Exploration Program on and recommended approval.

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Should you have any questions in regards to this matter, or  
if I could be of any further assistance to you, please  
contact my office at your convenience.

Sincerely,

Mandy Chivers  
Planning Department  
City of Titusville  
321-[REDACTED]

**Comment Submission #10: City of Titusville, Florida**

**TABLE B-2. RESPONSES TO COMMENTS**

<b>Comment Number</b>	<b>Response</b>
1-1	Thank you for your comments.
2-1	Thank you for your comments.
2-2	The appropriate text has been added to Section 3.1.7.4.
3-1	Thank you for your comments.
4-1	The appropriate text has been added to the Executive Summary and to Section 2.5.1.
5-2	Discussion of the potential impacts to historical structures and archaeological sites due to launch accidents has been added to the appropriate sections of the PEIS. Please note that Table 2-4 only summarizes impacts from normal launches; as such, the potential environmental impacts presented there are valid.
5-3	An outline of the VAFB boundary has been added to Figure 3-3.
5-4	The suggested changes and corrections have been made.
5-5	The suggested corrections have been made in Section 4.1.2.10. Please note that this section addresses impacts from a normal launch. The potential affects of launch accidents are addressed in Sections 4.1.3 and 4.1.4.
5-6	Cultural resource uses have been added to the general discussion of long-term productivity. However, the types of potential impacts to any long-term resources have not been individually addressed.
5-7	The suggested text (with minor modification) has been added to the Cultural Resources section of Table 4-1.
6-1	Order-of-magnitude risk estimates have been added to Section 4.1.4, rather than in the Executive Summary.
6-2	Discussion of the topic has been made consistent as suggested.
6-3	A parenthetical definition of "artesian pressure" has been added.
6-4	The references for Table 3-2 have been updated, but no changes to the contents of the table are required. The State of Florida, the U.S. Fish and Wildlife Service, and the National Marine Fisheries Service (NOAA Fisheries) were sent copies of the Draft PEIS for formal review and did not submit comments.
6-5	USAF 2001 is the latest reference available.
6-6	A parenthetical definition of "calms" has been added.
6-7	This is explicitly stated in Section 4.1.2.7 under Environmental Impacts.

6-8	The references for Table 3-4 have been updated, but no changes to the contents of the table are required. The State of California, the U.S. Fish and Wildlife Service, and the National Marine Fisheries Service (NOAA Fisheries) were sent copies of the Draft PEIS for formal review and did not submit comments.
6-9	A statement on the modeled launch rates used in USAF 1998 has been added to the introduction to Section 4.1. The launch rates cited here are annual averages used by the USAF, based on the U.S. National Mission Model (NMM) to support the analyses in the cited references. The NMM includes military, civil (e.g., NASA), and commercial launches. MEP missions would be included in these rates.
6-10	The State of Florida remains in attainment for all Federal NAAQS (see FDEP 2002). The U.S. Environmental Protection Agency issued the new 8-hour ozone rule on April 30, 2004 (see 69 FR 23857). Santa Barbara County, California, has been determined to be in attainment for all Federal NAAQS (see EPA 2004c). Relevant text and reference citations have been revised accordingly.
6-11	Clarifying text has been added to Section 4.1.2.3.
6-12	Clarifying text has been added to Section 4.1.2.7.
6-13	Clarifying text has been added to Section 4.1.2.7.
6-14	Operations due to this Proposed Action at either launch site would be within, and not exceed, currently approved operations at both sites.
6-15	Please note that this text addresses facilities around the United States for specialized manufacturing of launch vehicle and spacecraft components and not activities at the launch sites. As stated, these facilities are subject to the applicable Federal, State, and local environmental laws and regulations.
6-16	Estimates of the release of ozone-depleting chemicals have been added to Section 4.4.
6-17	Estimates of the release of greenhouse (global warming) gases have been added to Section 4.4.
6-18	The California and Florida State Historic Preservation Offices and the Federal Advisory Council on Historic Preservation were not consulted for this action since no impacts to historical or archaeological resources have been identified. Any consultations would be done, if necessary, for individual launches within the Mars Exploration Program.
7-1	Thank you for your comments.
8-1	Thank you for your comments.
9-1	Thank you for your comments.
10-1	Thank you for your comments.

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