DRAFT REPORT

ENVIRONMENTAL ASSESSMENT FOR THE EXPANSION OF THE WALLOPS FLIGHT FACILITY LAUNCH RANGE

Prepared for

National Aeronautics and Space Administration
Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, VA 23337

April 2009

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VA 23337

Lead Agency: National Aeronautics and Space Administration

Cooperating Agency: Federal Aviation Administration Office of Commercial Space Transportation

Proposed Action: Expansion of the Wallops Flight Facility Launch Range on Wallops Island

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ABSTRACT

This Environmental Assessment addresses the proposed expansion of the launch range at the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC) Wallops Flight Facility (WFF), which is located on the Eastern Shore of Virginia. Under the Proposed Action, NASA and Mid Atlantic Regional Spaceport (MARS) facilities would be upgraded to support up to and including medium large class suborbital and orbital expendable launch vehicle (ELV) launch activities from WFF.

The Proposed Action would have both adverse and beneficial impacts to environmental and socioeconomic resources; however, most adverse impacts are minor and of short duration and none are considered significant. Adverse impacts would be mitigated to the greatest extent practicable to minimize the effects on resources.

PURPOSE AND NEED FOR THE ACTION

The purpose for the Proposed Action is to enhance the respective NASA and MARS facilities at WFF such that they are able to accommodate a wider variety of new launch vehicles and payloads, and to support launching of spacecraft from Pad 0-A. The expansion would be consistent with national space policies, including the National Aeronautics and Space Act of 1958 and the 1994 National Space Transportation Policy, both of which contain the primary objective of keeping the United States at the forefront of space transportation technology.

The Proposed Action is needed to ensure the continued viability of NASA and MARS in serving the rapidly growing civil, defense, academic, and commercial aerospace market. Additionally, WFF and MARS are located within the only NASA-owned launch range, and therefore they provide an established location solely under NASA control and focused on NASA's schedule, budget, and mission objectives.

ALTERNATIVE DESCRIPTIONS

No Action Alternative

Under the No Action Alternative, NASA and MARS would not expand launch activities at WFF. The full potential of the launch range capacity at WFF would not be utilized in support of the WFF and MARS missions. Existing launch activities, which consist of a maximum of 12 orbital rocket launches per year from Pad 0-B, would continue.

Proposed Action

The Proposed Action is to expand and upgrade NASA and MARS facilities to support up to and including medium large class suborbital and orbital ELV launch activities from WFF. Components of the Proposed Action include site improvements required to support launch operations (such as facility construction and infrastructure improvements); testing, fueling, and processing operations; up to two static fire tests per year; and launching an additional six vehicles and associated spacecraft per year from Pad 0-A.

<u>Site Improvements to Support Launch Operations</u>

- Minor modifications to the boat dock on the north end of Wallops Island
- Construction of a dedicated Payload Fueling Facility (PFF), a facility dedicated to payload processing (Payload Processing Facility, or PPF) and storage

- Construction of new roads and minor upgrades to existing roads
- Construction of a new launch complex in approximately the same location as the existing Pad 0-A, including a Liquid Fueling Facility (LFF)
- Minor interior modifications to launch support facilities

Transportation, Handling, and Storage

The transportation and handling of various cargo, launch vehicle, and payload components would be ongoing as the components are delivered to Wallops Main Base or Island via barge or airplane, and then transported via road to various facilities and the launch pad.

Launch Activities

A maximum of six additional orbital-class launches per year would occur from Pad 0-A, resulting in a maximum of 18 orbital-class launches from MARS (12 existing launches from Pad 0-B, and 6 additional launches from Pad 0-A under the Proposed Action). Launches may be conducted during any time of the year, and any time of the day or night. In addition to launches, static test firing of rocket engines would occur at Pad 0-A up to two times per year.

SUMMARY OF ENVIRONMENTAL IMPACTS

No environmental impacts are anticipated as a result of the No Action Alternative. Potential environmental impacts resulting from the Proposed Action are summarized below.

Topography and Drainage – Site improvement activities would not substantially alter topography; therefore, changes to natural drainage patterns would be minor. Permanent stormwater control measures such as retention basins would be constructed to provide adequate drainage for the new building sites, and to mitigate the effects of increased runoff from impervious surfaces.

Geology and Soils – Construction activities along with spills or leaks of pollutants that may occur during construction or transportation of materials would have the potential to affect soils. NASA and MARS would implement site-specific best management practices for vehicle and equipment fueling and maintenance, and spill prevention and control measures. Driven piles would create long-term changes to the subsurface geology immediately around the driven piles; however, the changes would be site specific and negligible.

Surface Water including Wetlands – Construction activities, spills or leaks of pollutants during construction activities, spill or leaks during transportation of materials or from storage facilities, and launch failures that may result in release of liquid propellants would all have the potential to affect surface waters including wetlands. NASA and MARS would minimize adverse impacts to surface waters by acquiring permits as necessary, and implementing site-specific best management practices to reduce potential impacts. Approximately 2.3 hectares (5.7 acres) of wetlands would be affected. Prior to construction, NASA and MARS would complete a jurisdictional wetland delineation and coordinate with applicable agencies. NASA and MARS would obtain necessary permits and would implement mitigation measures to ensure no net loss of wetlands.

Marine Waters – Spent ELV stages falling into the ocean are a potential source of pollution to marine environments. Marine waters would be affected if a barge or vessel were to spill fuels or other substances that could contaminate the open ocean or estuary environment. Toxic concentrations are not anticipated in the open ocean due to the mixing and dilution rates associated with the wave movement and the vastness of the ocean environment; therefore, adverse impacts on marine waters would be short term and localized.

Floodplains – All facility construction and infrastructure improvements would take place within the 100-year and 500-year floodplains. Because Wallops Island is the location for WFF's core launch range functions, and is entirely within the floodplain, no practicable alternatives exist. NASA and MARS would minimize floodplain impacts and protect and restore the natural and beneficial functions of floodplains to the maximum extent possible.

Coastal Zone Management – All activities under the Proposed Action occur within Virginia's Coastal Management Area. NASA has determined that the Proposed Action is consistent with the Coastal Zone Management Program.

Stormwater – Construction activities would result in permanent changes to stormwater conveyance due to disruptions of the natural drainage. NASA and MARS would obtain necessary permits and minimize impacts to stormwater conveyance and stormwater quality during construction.

Wastewater – No adverse impacts would occur, because the WFF wastewater treatment plant (WWTP) has the capacity to treat the approximately 4 percent increase in wastewater from the new facilities.

Groundwater – Under the Proposed Action, NASA would provide potable water to the PPF and PFF for drinking water supply, fire suppression, and industrial water use. In addition, static fire testing would require the use of deluge water. Implementation of the Proposed Action would increase the system's annual water use but withdrawal amounts would be within the limit allowed by NASA's existing groundwater withdrawal permit.

Air Quality – Construction activities would generate fugitive dust and combustion emissions would occur as a result of site improvements. Operation of generators and boilers would result in emissions of pollutants. NASA and MARS would minimize adverse impacts to air quality by implementing site-specific construction and industrial best management practices such as fugitive dust control and engine/system maintenance and testing. Release of hazardous chemicals including propellants and halon would be minimized by the use of good operating procedures and the implementation of the WFF Spill Prevention Control and Countermeasures Plan. No far-field impacts from rocket exhaust are anticipated. Short-term adverse impacts in the area immediately surrounding the launch pad, resulting from rocket exhaust, include high temperature exhaust gas mixture and elevated carbon monoxide concentrations.

Noise – Construction and transportation activities have the potential to generate temporary increases in noise levels from heavy equipment operations. Launch activities would create loud instantaneous noise that may be heard for several miles from WFF. The Proposed Action is not expected to have noise impacts on the surrounding areas in excess of applicable thresholds of significance.

Orbital and Reentry Debris – The envelope spacecraft (ES) would comply with all requirements of NASA Procedural Requirements (NPR) 8715.6, for limiting orbital debris, and NASA Standard 8719.14, which requires preparation of a debris assessment.

Hazardous Materials and Hazardous Waste Management – The principal hazardous materials used under the Proposed Action would be liquid propellants (primarily liquid oxygen [LOX] and rocket propellant 1 [RP-1]), hypergolic propellants, pressurized gases, and various solvents and compounds used to process the ELV and spacecraft. The greatest potential impact to the environment would result from an accident (e.g., leak, fire, or explosion) at a storage location or, to a lesser degree, from an accidental release during fueling, payload processing, or launch activities (e.g., spills or human exposure). The short- and long-term effects of an accident on the environment would vary greatly depending upon the type of accident and the substances involved. NASA has implemented various controls to prevent or minimize the effects of an accident involving hazardous materials on NASA property.

Radiation – Operation of the PPF, PFF, and handling of the ES could result in a potential source of radiation. However, the amount of radioactive materials is very small and the materials are encapsulated; therefore, the use of radioactive materials in payloads would not present any significant impact or risk to the public or to the environment during normal or abnormal launch conditions.

Munitions and Explosives of Concern – Ground disturbances such as excavations and clearing may have the potential to encounter munitions and explosives of concern (MEC) on Wallops Island during construction. A qualified MEC expert would evaluate the area proposed for ground disturbance and conduct a survey of the area if necessary prior to construction activities.

Vegetation – Long-term adverse impacts to vegetation would occur due to the loss of forest, shrub, and wetland plant communities due to the construction of the PPF and PFF; however, they would be localized and would not present a substantial adverse effect. Minor adverse effects on vegetation from launches would also occur, but would be limited to a localized area around Pad 0-A.

Terrestrial Wildlife and Migratory Birds – Short-term adverse impacts to wildlife and migratory birds may occur during construction activities and long-term impacts may occur due to the loss of wetland and forest habitat. Implementation of mitigation measures such as limiting the removal of existing vegetation for construction would minimize the impacts.

Threatened and Endangered Species – The U.S. Fish and Wildlife Service (USFWS) determined that rocket launches from Pad 0-B are not likely to jeopardize the continued existence of the piping plover on Wallops Island. Because Pad 0-A is further away from the piping plover habitat on the southern end of Wallops Island than Pad 0-B, NASA has determined that the Proposed Action is also not likely to jeopardize the continued existence of the piping plover. Because sea turtles only use the beach on occasion, and ELV launches are infrequent, NASA determined that launch activities would have no effect on federally protected sea turtles.

Marine Mammals and Essential Fish Habitat – Spent stages would fall into the ocean many miles offshore; no adverse effects on marine species are anticipated as a result of spent stages falling into the ocean. Debris and toxic materials from launch failures have a small potential to adversely affect marine mammals or managed fish species and their habitats in the vicinity of the project area. Implementation of emergency cleanup procedures would minimize the impacts.

Population, Employment, and Income – Construction activities would increase local employment opportunities and benefit local stores and businesses.

Environmental Justice – Disproportionately high or adverse impacts to low-income or minority populations are not anticipated because there would be no displacement of residences or businesses.

Health and Safety – Construction activities at the WFF site could result in short-term impacts to human health and safety and the increased usage of local fire, police, and medical services.

Cultural Resources – The Proposed Action may have indirect visual and auditory effects on identified historic properties in the area of potential effect, including the USCG Lifesaving Station and Observation Tower, but these effects would not likely be adverse. NASA has determined that the proposed construction would have no effect on archaeological resources.

Transportation – Temporary impacts to traffic flow would occur during construction activities and launch activities. With implementation of mitigation and safety measures related to launch-day traffic closures, no significant impacts on transportation are anticipated.

Cumulative Impacts – Cumulative impacts were evaluated for surface waters including wetlands, groundwater, air quality, biological resources, and socioeconomic resources. No significant cumulative impacts are anticipated from the Proposed Action when added to other known and foreseeable WFF and regional actions.

Summary – The Proposed Action would have both adverse and beneficial impacts to environmental or socioeconomic resources. However, most adverse impacts are minor and of short duration and none are considered significant. Adverse impacts to wetlands, vegetation, and terrestrial wildlife and migratory birds are anticipated; no other adverse impacts would occur to environmental or socioeconomic resources under the Proposed Action. Adverse impacts would be minimized to the greatest extent practicable, and mitigation measures would be implemented as necessary.

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°C	Degrees Celsius
°F	Degrees Fahrenheit
ACAM	Air Conformity Applicability Model
ACHP	Advisory Council on Historic Preservation
AEGL	Acute exposure guideline level
AIAA	American Institute for Aeronautics and Astronautics
Al_2O_3	Aluminum oxide
ALOHA	Areal Locations of Hazardous Atmospheres Model
amsl	Above mean sea level
ANSI	American National Standards Institute
AP	Ammonium Perchlorate
APE	Area of Potential Effect
AST	Aboveground storage tank
CAA	Clean Air Act
CBRA	Coastal Barrier Resources Act
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cm	Centimeters
CMA	Coastal Management Area
CNWR	Chincoteague National Wildlife Refuge
CO	Carbon monoxide
CO_2	Carbon dioxide
COMET	Commercial Experiment Transporter
CRA	Cultural Resources Assessment
CSLA	Commercial Space Launch Act
CWA	Clean Water Act
CZM	Coastal Zone Management
dB	Decibel
dBA	Decibel weighted to the A-scale
DCR	Department of Conservation and Recreation
DOD	Department of Defense
DOT	Department of Transportation
EA	Environmental Assessment
EFH	Essential Fish Habitat
EG&G	EG&G Technical Services
EHS	Extremely hazardous substance
EIS	Environmental Impact Statement
EJIP	Environmental Justice Implementation Plan
ELV	Expendable Launch Vehicle
EO	Executive Order
EPA	Environmental Protection Agency
ERPG	Emergency Response Planning Guideline
ES	Envelope Spacecraft
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map

FONSI	Finding of No Significant Impact
GDC	General Duty Clause
GEO	Geosynchronous Orbit
GSFC	Goddard Space Flight Center
GTO	Geosynchronous Transfer Orbit
H_2	Hydrogen
HAP	Hazardous Air Pollutant
HCl	Hydrogen chloride
HERO	Hazards of Electromagnetic Radiation to Ordnance
HERP	Hazards of Electromagnetic Radiation to Personnel
HIF	Horizontal Integration Facility
H_2O	Water
HTPB	Hydroxyl-terminated polybutadiene
Hz	Hertz
ICP	Integrated Contingency Plan
IIP	Instantaneous Impact Point
in	Inches
IPA	Isopropyl Alcohol
JPA	Joint Permit Application
kg	Kilogram
km	Kilometers
kph	Kilometers per hour
kW	Kilowatt
LEO	Low Earth Orbit
L_{eq}	Time-averaged sound level
LFF	Liquid Fueling Facility
LH_2	Liquid hydrogen
LOC	Level of concern
LOX	Liquid oxygen
LWCA	Land and Water Conservation Act
μ/m^3	Micrograms per cubic meter
MACT	Maximum Achievable Control Technology
MARS	Mid-Atlantic Regional Spaceport
MBTA	Migratory Bird Treaty Act
MEC	Munitions and Explosives of Concern
mi	Miles
MLAS	Max Launch Abort System
MMH	Monomethylhydrazine
MMPA	Marine Mammal Protection Act
mph	Miles per hour
MONs	Mixed oxides of nitrogen
MSDS	Material Safety Data Sheet
N_2	Nitrogen
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration

NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NFSAM	Nuclear Flight Safety Assurance Manager
N_2H_4	Hydrazine
NHPA	National Historic Preservation Act of 1966
NIOSH	National Institute for Occupational Safety and Health
NMFS	National Marine Fisheries Service
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxide
NOAA	National Oceanic and Atmospheric Administration
NOTAMS	Notice to Airmen
NOTMARS	Notice to Mariners
NPD	NASA Policy Directive
NPDES	National Pollutant Discharge Elimination System
NPR	NASA Procedural Requirements
NRC	Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NSPS	New Source Performance Standards
NSR	New Source Review
NTO	Nitrogen tetroxide
O_3	Ozone
ORK	Orbit Raising Kit
OSMA	Office of Safety and Mission Assurance
OSHA	Occupational Safety and Health Administration
OSPL	Overall sound pressure level
Pb	Lead
PFF	Payload Fueling Facility
P.L.	Public Law
PM_{10}	Particulate matter less than or equal to 10 microns
$PM_{2.5}$	Particulate matter less than or equal to 2.5 microns
POL	Petroleum, oils, lubricants
PPF	Payload Processing Facility
ppm	Parts per million
ppt	Parts per thousand
PSD	Prevention of Significant Deterioration
PTE	Potential to emit
RCRA	Resource Conservation and Recovery Act
REC	Record of Environmental Consideration
REEDM	Rocket Exhaust Effluent Dispersion Model
RF	Radio frequency
RICE	Reciprocating internal combustion engines
RP	Rocket Propellant
SO_2	Sulfur dioxide
SRIPP	Shoreline Restoration and Infrastructure Protection Program
SWPPP	Stormwater Pollution Prevention Plan
TE	Transporter Erector
TEEL	Temporary Emergency Exposure Limit
TLV	Threshold Limit Value

TWA	Time Weighted Average
UAV	Unmanned Aerial Vehicle
UDMH	Unsymmetrical dimethylhydrazine
URS	URS Group, Inc.
USACE	U.S. Army Corps of Engineers
U.S.C.	United States Code
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
UST	Underground Storage Tank
VAC	Virginia Administrative Code
VCFSA	Virginia Commercial Space Flight Authority
VDEQ	Virginia Department of Environmental Quality
VDGIF	Virginia Department of Game and Inland Fisheries
VDHR	Virginia Department of Historic Resources
VEC	Virginia Employment Commission
VMRC	Virginia Marine Resources Commission
VOC	Volatile organic compound
VPDES	Virginia Pollutant Discharge Elimination System
VSMP	Virginia Stormwater Management Program
WFF	Wallops Flight Facility
WRP	Wallops Research Park
WWTP	Wastewater Treatment Plant

SECTION ONE MISSION, PURPOSE AND NEED, AND BACKGROUND INFORMATION

1.1 INTRODUCTION

This Environmental Assessment (EA) has been prepared to evaluate the potential environmental impacts from the proposed expansion of the launch range at Wallops Flight Facility (WFF).

In 1997, the National Aeronautics and Space Administration (NASA) prepared an *Environmental Assessment for Range Operations Expansion at the National Aeronautics and Space Administration Goddard Space Flight Center Wallops Flight Facility* (Launch Range Operations Expansion EA) for the expansion of the Mid-Atlantic Regional Spaceport (MARS) at WFF. Specific actions addressed included construction of a new launch pad, minor modifications to an existing launch pad, minor modifications to utility infrastructure, expansion of capabilities to accommodate both solid- and liquid-fueled rockets, and increasing launch frequency to 12 orbital-class launches per year. NASA and MARS are proposing to again expand facilities at WFF to accommodate larger rockets and payloads. As the launch range expansion would require Federal actions (as defined in Title 40 of the Code of Federal Regulations [CFR] Section 1508.18) involving both NASA and the Federal Aviation Administration (FAA) Office of Commercial Space Transportation, this EA has been prepared to satisfy the National Environmental Policy Act (NEPA) obligations of both agencies. NASA, as the WFF property owner and Lead Agency, is responsible for ensuring overall compliance with applicable environmental statutes, including NEPA. The FAA Office of Commercial Space Transportation has served as a Cooperating Agency in the preparation of this EA because of its role in licensing the Virginia Commercial Space Flight Authority (VCSFA) to operate MARS as a commercial launch site, as well as licensing the launches of commercial vehicles that may be launched from MARS. The FAA will use this EA to support the modification or renewal of VCSFA's Launch Site Operator License and issuance of launch licenses for commercial vehicles.

This EA has been prepared in accordance with NEPA, as amended (Title 42 of the United States Code (U.S.C.) 4321–4347), the Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 CFR 1500–1508), NASA's regulations for implementing NEPA (14 CFR Subpart 1216.3), and the *NASA Procedural Requirement (NPR) for Implementing NEPA and Executive Order (EO) 12114* (NPR 8580.1). NEPA requires the preparation of an EA for Federal actions that do not qualify for a Categorical Exclusion and may not require an Environmental Impact Statement (EIS). If this EA determines that the environmental effects of the proposed action are not significant, a Finding of No Significant Impact (FONSI) will be issued. Otherwise, a Notice of Intent to prepare an EIS will be published.

This EA will be reviewed for adequacy at least every 10 years or at any time prior if major changes to the Proposed Action are under consideration or substantial changes to the environmental conditions occur. As such, the document may be supplemented in the future to assess new proposals or to address changes in existing conditions, impacts, and mitigation measures.

1.2 BACKGROUND

1.2.1 Project-Related Missions

1.2.1.1 Wallops Flight Facility

WFF is a NASA facility under the management of the Goddard Space Flight Center (GSFC). During its early history, the mission of WFF was primarily to serve as a test site for aerospace technology experiments. Over the last several decades, the WFF mission has evolved toward a focus on supporting scientific research through carrier systems (i.e., airplanes, balloons, rockets, and uninhabited aerial systems) and mission services. NASA owns the WFF property and has multiple tenants, including MARS, the U.S. Navy, the U.S. Coast Guard (USCG), and the National Oceanic and Atmospheric Administration (NOAA). Each tenant relies on NASA for some of its institutional and programmatic services, but also has its own missions.

1.2.1.2 Mid-Atlantic Regional Spaceport

MARS is an FAA-licensed commercial spaceport on Wallops Island. MARS' mission is to develop and operate a multi-user spaceport at WFF that provides low-cost, safe, reliable, "schedule friendly" space access for commercial, government, and academic users (MARS, 2008). The VCSFA, of Norfolk, Virginia, is responsible for the development and operation of MARS. A use agreement between NASA and VCSFA gives VCSFA non-exclusive privileges to operate the site. NASA provides project management, range operations, safety, and environmental support of launch activities via reimbursable service contracts (NASA, 1997). Additionally, for certain missions, roles may reverse, and VCSFA can provide reimbursable launch services to NASA, the U.S. Department of Defense (DOD), and other government customers.

1.2.1.3 Federal Aviation Administration

FAA's mission is to ensure public health and safety and the safety of property, while protecting the national security and foreign policy interests of the United States during commercial launch and reentry operations. In addition, FAA is directed to encourage, facilitate, and promote commercial space launches and reentries (FAA, 2008).

The FAA Office of Commercial Space Transportation regulates U.S. commercial space launch and reentry activities, as well as the operation of non-Federal launch and reentry sites, as authorized by EO 12465 and Title 49 U.S.C., Subtitle IX, Chapter 701 (formerly the Commercial Space Launch Act [CSLA] of 1984). FAA issued a Launch Site Operator License to VCSFA to operate MARS in December 1997, which allows VCSFA to operate the MARS site as a commercial space launch site. The FAA renewed the license in November 2002 and again in December 2007.

1.2.2 Site Location

WFF is located in the northeastern portion of Accomack County, Virginia, on the Delmarva Peninsula, and is comprised of three separate land masses: the Main Base, Wallops Mainland, and Wallops Island (Figure 1). The MARS facilities are located on Wallops Island and include Launch Complex 0, comprised of Launch Pads 0-A and 0-B (Figure 2).

Figure 3 shows the primary existing NASA and MARS facilities, described below, that would be utilized to support the Proposed Action.


Wallops Main Base
Wallops Mainland
Wallops Island
Launch Complex 0
WALLOPS STATION (NASA)
WALLOPS ISLAND (NASA)
WALLOPS FLIGHT CENTER
Wallops Island
CHINCOTEAGUE
Chincoteague Inlet
Bogues Bay
Watts Bay
Atlantic
Wattsville
Nash Corner
New Church
Horntown
Sanders
The Oaks
Wishart
Lookout Towers
Radio Towers
Landing Strip
Ohio
Pennsylvania
Maryland
New Jersey
Washington DC
Delaware
West Virginia
Kentucky
Virginia
Richmond
Chesapeake Bay
Site Location
Tennessee
North Carolina
Norfolk
Virginia Beach
Atlantic Ocean
0.5
0
0.5
1
Miles
Title: Vicinity Map
URS Proj No: 15301614
Figure: 1
Client : NASA
Expansion of the Launch Range at Wallops Flight Facility

Title: Wallops Island Viewed from the South	
	URS Proj No:15301614
	Figure: 2
Client : NASA	
Expansion of the Launch Range at Wallops Flight Facility	

Title: **Wallops Island Existing and Proposed Facilities**

URS Proj No: 15301614

Figure: 3

Client : NASA

Expansion of the Launch Range at Wallops Flight Facility

1.2.3 Existing MARS Facilities

1.2.3.1 Launch Complex 0

Launch Complex 0, which includes Pads 0-A and 0-B, is located on the southern end of Wallops Island and is used for launching suborbital and orbital rockets. Launches may be conducted during any time of the year and any time of the day or night.

Pad 0-A is a facility for launch vehicles with up to a 90,909-kg (200,000-lb) maximum load. Originally designed for the Conestoga vehicle, which was launched once in October 1995, Pad 0-A has been inactive; its launch service gantry (a large vertical structure with platforms at different levels used for erecting and servicing expendable launch vehicles [ELVs] before launch) and portions of the existing launch pad were removed in fall 2008, rendering Pad 0-A unusable for launching until a new gantry is built.

Pad 0-B is a 1,766-square-meter (19,000-square-foot) pad with a 31 meter (102 foot) high gantry, which supports the launching of vehicles with gross lift-off weights up to 227,273 kg (501,000 lbs) into orbit. Vehicle and payload handling within the pad and service tower area are accomplished by a transporter-erector vehicle and a mobile crane. Recent launches from Pad 0-B include the U.S. Air Force's Tactical Satellite-2 (TacSat-2) mission in December 2006, the U.S. Missile Defense Agency's Near Field Infrared Experiment in April 2007, and the Alliant Techsystems/NASA HyBolt-Soarex-ALV-X1 suborbital rocket launched in August 2008.

1.2.3.2 Horizontal Integration Facility

A Horizontal Integration Facility (HIF) that will support the pre-flight processing, horizontal integration, and preparation of launch vehicles and payloads is currently being constructed in the middle of Wallops Island. The HIF will cover approximately 2,322 square meters (25,000 square feet) and has been designed to accommodate temporary storage of fueled spacecraft and vehicle stages. Activities in the HIF will include but are not limited to removal of flight hardware from cargo containers, inspection, testing, and encapsulation of launch vehicle motors and stages, and final integration of the payload within the launch vehicle. A Record of Environmental Consideration (REC) was prepared for the HIF facility (NASA, 2009a).

1.2.4 NASA Facilities

MARS may use NASA assets, depending on the particular mission, including but not limited to:

- Range Control Center
- Test laboratories and machine shops
- Mobile and fixed launchers
- Blockhouses
- Dynamic balancing equipment
- Wind measuring devices
- Communications and control instrumentation
- Television and optical tracking stations
- Surveillance and radar tracking units

1.2.4.1 Payload Processing Facilities

MARS actions associated with payload processing at WFF include storage, transportation, assembly, and fueling. These actions take place at the Main Base, Wallops Mainland, and Wallops Island.

Payload processing occurs on the Main Base in several buildings (H-100, F-7, F-10, M-16, and M-20), and on Wallops Island in Buildings X-15, W-65, and Y-15. WFF can support multiple payload processes simultaneously, including fabrication, environmental testing, integration, telemetry ground stations, and clean room facilities. Work areas are available to perform preparatory and post-integration inspections (NASA, 2005).

1.2.4.2 Boat Docks

There are two existing boat docking facilities at WFF. One consists of a 98-square-meter (1,055-square-foot) concrete platform at the boat basin behind the WFF Visitor Information Center on the Main Base. The other boat docking facility is the same size and is located at the boat basin adjacent to the old USCG Station on north Wallops Island (labeled as the “Boat Dock” on Figure 3). These facilities are utilized for docking and unloading cargo that is too large for over-the-road transportation.

The existing approach channel and basin area on the north end of Wallops Island (labeled as “Barge Path” on Figure 3) is dredged as needed to maintain a water depth of at least 1.2 meters (4 feet) at low tide. Adequate water depths at the Main Base approach channel and basin have precluded the need to perform maintenance dredging at this facility in recent years.

1.2.5 Launch Trajectories

WFF’s geographic location provides ideal access to Low Earth Orbit (LEO, where an object, typically a satellite, orbits the Earth at altitudes between approximately 300 to 1,500 kilometers [200 to 930 miles] above the Earth) (Figure 4) for ELVs, offering a wide array of launch vehicle trajectory options that are directed away from populated areas. The ground-based range is only limited by land masses, and the coastline of Wallops Island is oriented such that a launch azimuth (the initial heading of the launch vehicle) of 135 degrees is perpendicular to the shoreline. Generally, launch azimuths from WFF vary between 90 and 160 degrees (Figure 4) depending on flight safety parameters (such as predicted impact areas of spent stages and launch vehicle reliability) and specific mission objectives. Trajectory options outside of these launch azimuths can be achieved by in-flight azimuth maneuvers.

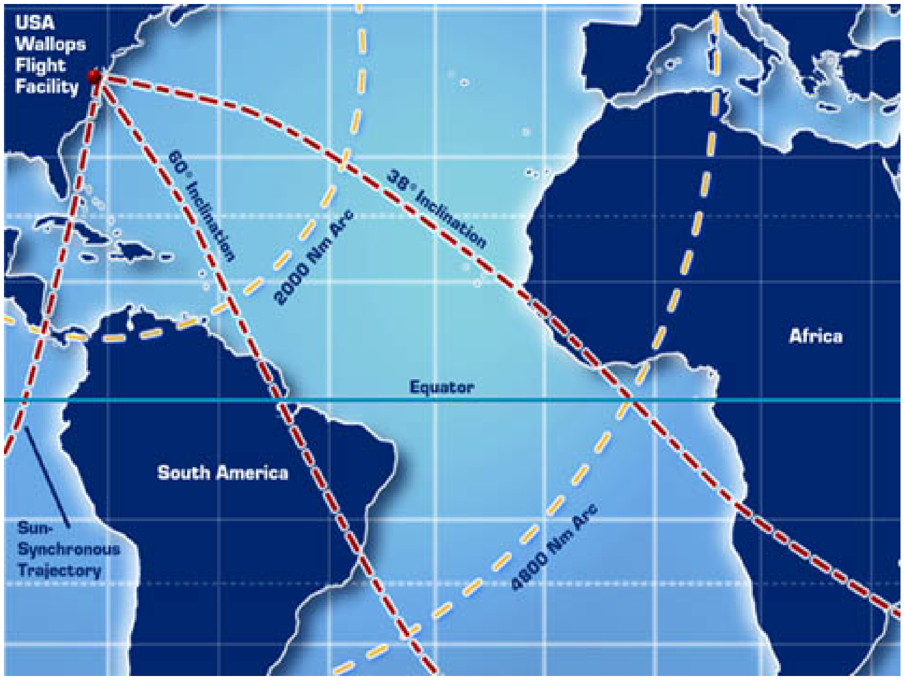


Figure 4: Wallops Flight Facility Launch Vehicle Trajectory Options

MARS launches occur within the WFF Research Range, which extends over the Atlantic Ocean for 4.8 kilometers (3 miles) and includes the airspace above that distance to conduct flight operations. The WFF Research Range routinely employs a variety of support infrastructure that includes ground-based and mobile systems for tracking and surveillance, a range control center for launch operations management, and digital photographic and video services for Range Safety support, surveillance, and post-launch analysis. Launch clearances are coordinated by the WFF Test Director and may include those required for airspace and oceanic impact areas from the FAA, North American Aerospace Defense Command, the U.S. Navy Fleet Area Control and Surveillance Facility, and the USCG.

1.3 PURPOSE AND NEED FOR THE PROPOSED ACTION

1.3.1 Purpose

The purpose for the Proposed Action is to enhance the respective NASA and MARS facilities such that they are able to accommodate a wider variety of new launch vehicles and payloads, and to support launching of spacecraft from Pad 0-A. The expansion would be consistent with national space policies, including the National Aeronautics and Space Act of 1958 and the 1994 National Space Transportation Policy, both of which contain the primary objective of keeping the United States at the forefront of space transportation technology. Additionally, the Proposed Action would be consistent with WFF's vision that it will be a national resource for enabling low-cost, aerospace-based science and technology research through the following mission elements:

- Enabling scientific research through the development and deployment of low-cost, highly capable suborbital and orbital research carriers, project management, and mission services

- Enabling aerospace technology advances supporting NASA's Science, Exploration Systems, and Aeronautics Mission Directorates through advanced technology development, testing, and operational support
- Enabling education, the commercial development of space, and other innovative partnerships by leveraging WFF's unique capabilities and expertise to collaborate with industry, academia, and other government agencies

1.3.2 Need

The Proposed Action is needed to ensure the continued viability of NASA and MARS in serving the rapidly growing civil, defense, academic, and commercial aerospace market. Additionally, WFF and MARS are located within the only NASA-owned launch range, and therefore they provide an established location solely under NASA control and focused on NASA's schedule, budget, and mission objectives. Such range control is critical to mission success as budgets tighten and program requirements dictate short turn-around times that are often difficult to accomplish at a launch range controlled by a non-NASA entity.

1.4 FEDERAL AVIATION ADMINISTRATION INVOLVEMENT

The CSLA (Public Law [P.L.] 98-575), as codified (49 U.S.C. Subtitle IX, Ch. 701, Commercial Space Launch Activities, 49 U.S.C. Sections 70101-70119) (1994) declares that the development of commercial launch vehicles and associated services are in the national economic interest of the United States. To ensure that launch services provided by private enterprises are consistent with the national security and foreign policy interests of the United States and do not jeopardize public safety and safety of property, the CSLA authorizes the Department of Transportation (DOT) to license and regulate U.S. commercial launch activities. Within the DOT, the Secretary of Transportation's authority under the CSLA has been delegated to the FAA's Office of Commercial Space Transportation. The FAA's proposed modification of the license to operate MARS and any future licensure of individual commercial launch vehicles would be consistent with its responsibilities under the CSLA.

1.5 USE OF THIS ENVIRONMENTAL ASSESSMENT

This EA evaluates the environmental effects of both NASA and MARS facility expansion at WFF and the launch of larger vehicles and spacecraft from MARS Pad 0-A.

As several different launch vehicles and spacecraft could launch from Pad 0-A at MARS, the largest launch vehicle and payload, in terms of size, weight, and dimension, was chosen as the demonstration, or "envelope," vehicle and payload to provide a benchmark for assessing impacts on resources at WFF and the surrounding environment. The envelope concept is described below in more detail.

1.5.1 Envelope Concept

Under the envelope concept, existing and future launch vehicles and spacecraft (satellites that are launched into space aboard ELVs, also called payloads) smaller than the "envelope" launch vehicle and spacecraft would be expected to have fewer impacts; for example, if the envelope ELV has an insignificant impact on a resource, a smaller ELV would fall within the same range of impacts and also have an insignificant impact.

The envelope ELV and the envelope spacecraft (ES) define the upper limits of the quantities and levels of commonly used materials and systems of the launch vehicle or payload. Orbital Sciences Corporation's Taurus II would be the largest ELV expected to be launched from MARS Pad 0-A under the Proposed Action; therefore, the Taurus II has been selected as the envelope launch vehicle for the purposes of this EA. Other smaller launch vehicles that may be launched from MARS Pad 0-A are described in Section 2.2.3; however, the environmental impacts were analyzed for the Taurus II only. Future launch vehicles not specifically mentioned in this EA would be considered within the scope of this document if analysis determines that their impacts do not exceed those associated with the envelope launch vehicle. The subsequent analysis and final determination would be documented in a REC to be kept in the official project files. If the analysis finds that the impacts are outside the scope of this EA, further NEPA documentation (a separate EA or an EIS) would then be prepared.

No specific spacecraft has been identified as the ES; instead, the ES should be considered a hypothetical payload whose components, materials and associated quantities, and flight systems represent a comprehensive bounding reference design (refer to Section 2 for the parameters of the ES). Any proposed payload that presents lesser or equal values of environmentally hazardous materials or sources in comparison to the ES would fall within the same range of impacts as the ES described in this EA. Again, as with the launch vehicles, spacecraft analyses would be documented in a REC; additional NEPA documentation would be prepared as needed.

1.6 RELATED ENVIRONMENTAL DOCUMENTATION

NASA has a long history of environmental stewardship. The following NEPA documents and environmental resources reports were used as the basis for describing the current operations and existing conditions, and to provide information on various spacecraft and programs discussed in this EA.

- *Environmental Resources Document NASA Goddard Space Flight Center's Wallops Flight Facility, Wallops Island, Virginia*. (NASA, 2008a)
- *Record of Environmental Consideration (REC) for Construction of a Horizontal Integration Facility on Wallops Island, Goddard Space Flight Center Wallops Flight Facility, Wallops Island, Virginia 23337*. (NASA, 2009a)
- *Record of Environmental Consideration (REC) for Demolition and Reconstruction of Launch Pad 0-A on Wallops Island, Goddard Space Flight Center Wallops Flight Facility, Wallops Island, Virginia 23337*. (NASA, 2008b)
- *Record of Environmental Consideration (REC) for the Max Launch Abort System (MLAS) Test, Goddard Space Flight Center Wallops Flight Facility, Wallops Island, Virginia 23337*. (NASA, 2008d)
- *Falcon 9 Launch from Wallops Flight Facility*. *Preliminary Appraisal of Impacts*. (NASA, 2007a)
- *Environmental Assessment for the Operation and Launch of FALCON 1 and FALCON 9 Space Vehicles Cape Canaveral Air Force Station, Florida*. (NASA, 2007b)
- *Final Environmental Assessment for the Orbital/Sub-Orbital Program Space and Missile Systems Center, Kirtland Air Force Base, New Mexico*. (Detachment 12/RP, 2006)

- *Final Site-Wide Environmental Assessment, Wallops Flight Facility, Goddard Space Flight Center*. (NASA, 2005)
- *Environmental Assessment for a Payload Processing Facility, National Aeronautics and Space Administration Goddard Space Flight Center Wallops Flight Facility, Wallops Island, Virginia 23337*. (NASA, 2003a)
- *Final Environmental Assessment Update for Launch of NASA Routine Payloads on Expendable Launch Vehicles*. (NASA, 2002a)
- *Volume 1: Programmatic Environmental Impact Statement for Licensing Launches*. (FAA, 2001)
- *Environmental Assessment for Range Operations Expansion at the National Aeronautics and Space Administration Goddard Space Flight Center Wallops Flight Facility*. (NASA, 1997)

SECTION TWO ALTERNATIVES

As required by CEQ regulations, NASA evaluated the No Action Alternative as well as the Proposed Action. Because hundreds of millions of dollars in existing NASA and MARS infrastructure are already available for use, and WFF contains the only NASA-owned and operated launch range, WFF is the only launch site that can meet the stated Purpose and Need of enabling low-cost, quick turn-around aerospace research and commercial access to space. Therefore, no other launch sites were considered to be reasonable alternatives.

2.1 NO ACTION ALTERNATIVE

Under the No Action Alternative, NASA and MARS would not proceed with expansion activities at Pad 0-A. The full potential of the launch range capacity at WFF would not be utilized in support of the WFF and MARS missions. Existing launch activities, which consist of a maximum of 12 orbital rocket launches per year from Pad 0-B, would continue.

2.2 PROPOSED ACTION

The Proposed Action is to expand and upgrade NASA and MARS facilities to support up to and including medium large class suborbital and orbital ELV launch activities from WFF. Components of the Proposed Action include site improvements required to support launch operations (such as facility construction and infrastructure improvements); testing, fueling, and processing operations; up to two static fire tests per year; and launching of an additional six vehicles and associated spacecraft per year from Pad 0-A.

The proposed site improvements needed to support expanded launch activities are described below, and are followed by a description of the potential launch vehicles and spacecraft. Figure 3 shows a view of Wallops Island with the existing and planned facilities that would support the Proposed Action.

2.2.1 Site Improvements

2.2.1.1 Modifications to Boat Dock

NASA would make minor modifications to the boat dock on the north end of Wallops Island, such as installing additional fendering, sheet piling, and armor stone. Ongoing maintenance dredging would continue at the North Wallops Island Boat Basin to ensure a navigable channel and docking area.

2.2.1.2 Payload Fueling Facility

Before launch on an ELV, a spacecraft (payload) must be prepared for its mission. The preparations include such activities as checking electrical circuits, testing lines or tanks for leaks, and loading liquid propellants into fuel tanks. Because these and other preparations must be done under controlled conditions in clean environments (e.g., free of dust and particulates) and because some of the materials (i.e., liquid and solid propellant and explosives) that are handled or loaded are hazardous, special facilities are utilized for these operations.

NASA would construct a facility dedicated to payload fueling that would be located on the north end of Wallops Island (Figure 3). The new Payload Fueling Facility (PFF) would include a high bay, employee dress-out room, several equipment rooms, and a loading dock. Payloads would be handled by bridge cranes located within the high bay area. The footprint of the PFF would occupy approximately 700 square meters (7,500 square feet).

Loading of hypergolic propellants, which could be hydrazines (e.g., anhydrous hydrazine, monomethylhydrazine [MMH], or unsymmetrical dimethylhydrazine [UDMH]), as fuels for mono or bipropellant systems would be conducted by highly trained personnel in a dedicated area in the PFF. The oxidizers used for these systems could include nitrogen tetroxide (NTO) and mixed oxides of nitrogen (MONs). Each loading operation would be independent, sequential, and conducted using a closed loop system.

Upon completion of PFF activities, the payload would be prepared for transportation to a separate Payload Processing Facility (PPF) or to the HIF.

2.2.1.3 Payload Processing Facility

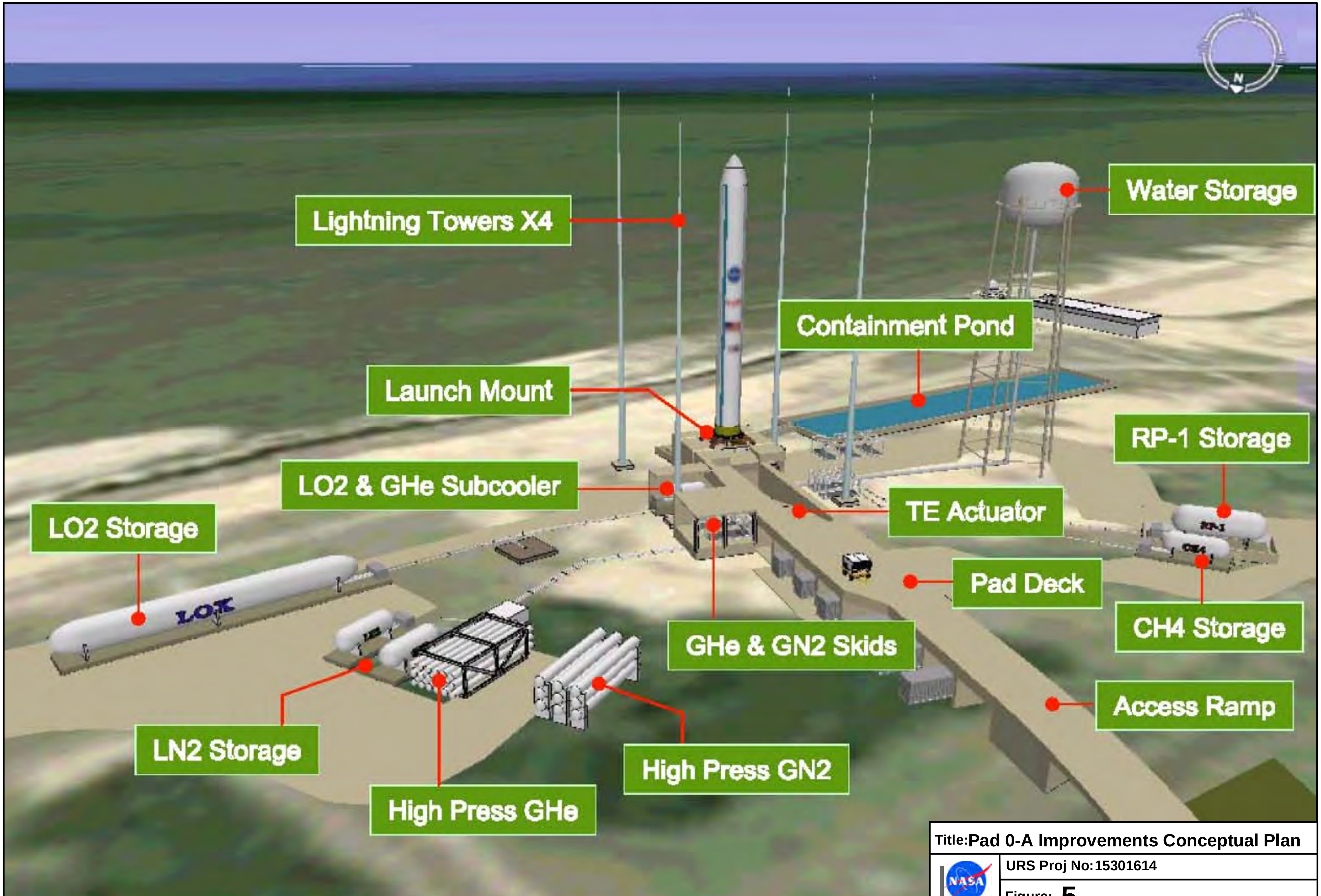
MARS or a commercial entity would construct an approximately 1,115-square-meter (12,000-square-foot) PPF dedicated to payload processing and storage on north Wallops Island approximately 183 meters (600 feet) east of the proposed PFF (Figure 3). Payloads would be transported from offsite locations to this facility prior to fueling for initial assembly, inspection, cleaning, and testing. Following fueling, the fueled payload could be transported back for final assembly prior to being integrated into the launch vehicle. Following final payload processing, the payload would be transported south to the HIF for integration into the launch vehicle.

2.2.1.4 Transportation Infrastructure

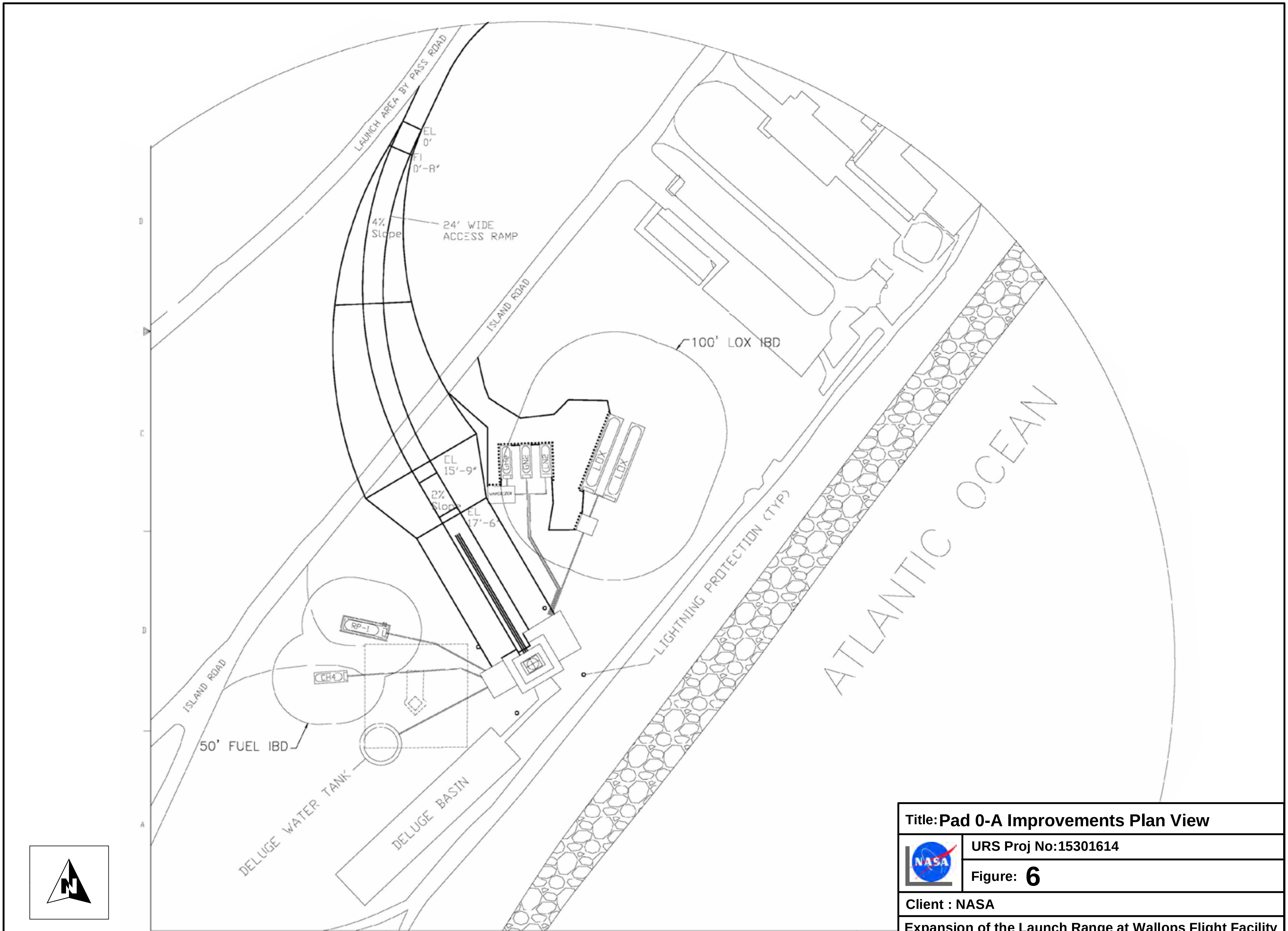
NASA would make transportation improvements necessary to transport cargo from the existing boat dock on the north end of Wallops Island to the proposed PFF or PPF, from the PPF or PFF to the HIF, and from the HIF to the launch pad. Infrastructure improvements include construction of new roads and minor upgrades to existing roads. New road construction could be up to 664 linear meters (2,178 feet) of 6 meter (20 foot) wide road, adding approximately 0.4 hectare (1 acre) of additional asphalt pavement. The widening or straightening of existing roads could add up to an additional 0.2 hectare (0.5 acre) of pavement.

2.2.1.5 Pad 0-A Improvements

A new MARS launch complex including a pad access ramp, launch pad, and deluge system would be constructed in approximately the same location as the existing pad (Figures 5 and 6).



Title: Pad 0-A Improvements Conceptual Plan	
URS Proj No:15301614	Figure: 5
Client : NASA	
Expansion of the Launch Range at Wallops Flight Facility	



Title: Pad 0-A Improvements Plan View

URS Proj No:15301614

Figure: **6**

Client : NASA

Expansion of the Launch Range at Wallops Flight Facility

The combined improvements to Pad 0-A would result in an overall pad complex footprint of approximately 2.8 hectares (6.8 acres). New construction would add approximately 1.5 hectares (3.7 acres) of impervious surface, which would consist primarily of concrete pavement. Because demolition of portions of the launch pad and the entire gantry at Pad 0-A have been completed, only minor additional demolition activities would occur.

Pad Access Ramp

MARS would construct a new ramp to the launch pad to transport the ELV from the HIF for placement on the launch mount. The ramp would be located on the northwest side of the pad and would be an open pile causeway type structure 7.3 meters (24 feet) wide, and approximately 152 meters (500 feet) long.

Launch Pad

The launch pad would have an elevated launch stool and deck, a wind monitor, a lightning protection system, a perimeter security fence, audible and visual warning systems, and camera towers. A launch services building approximately 465 square meters (5,000 square feet) in size would be constructed below the pad deck and would provide equipment storage and pad crew support functions (e.g., restrooms, telephone service, etc.). A partially below-grade flame duct and a hydraulic system for the Transporter/Erector/Launcher (the vehicle that carries and elevates the ELV into launch position) would also be built (shown as Transporter Erector [TE] Actuator on Figure 5).

Deluge System

As the new launch pad would be designed to support both normal launches and on-pad static firing for launch vehicle testing, there is a risk to the launch pad resulting from exposure to the extended heat load and excessive vibration and noise; therefore, a water deluge system would be constructed to absorb the heat load and suppress vibration and noise from the engines. The deluge system would include a 378,500-liter (100,000-gallon) aboveground water storage tank, pumps, and a trench and retention basin for the deluge water. Each launch or static fire would utilize the entire capacity of the tank for water suppression of engine vibration and noise.

Once used, the deluge water would be discharged to a 1,160-square-meter (12,500-square-foot) concrete-lined retention basin and tested for potential release via a water control structure to a newly constructed unlined stormwater basin. If necessary, the deluge water would be treated (i.e., pH adjustment) before release, or removed for disposal if it does not meet the standards for discharge to surface water. If discharged to the unlined stormwater basin, the release period may last over a period of several days due to the large quantity of water to be discharged.

The water source for the deluge system would be NASA’s potable water system, which is permitted by the Virginia Department of Environmental Quality (VDEQ) to withdraw groundwater from the underlying aquifer.

2.2.1.6 Liquid Fueling Facility

A Liquid Fueling Facility (LFF) would be constructed adjacent to Pad 0-A and would include the following infrastructure:

- One 132,500-liter (35,000-gallon) kerosene (RP-1) aboveground storage tank

- One 303,000-liter (80,000-gallon) aboveground cryogenic storage tank and one 30,000-liter (8,000-gallon) stainless steel aboveground cryogenic storage tank that will both be used for liquid oxygen (LOX) storage
- One 3,030-liter (800-gallon) stainless steel aboveground cryogenic storage tank that will store liquid methane
- Two 106,000-liter (28,000-gallon) stainless steel cryogenic aboveground storage tanks that will hold liquid nitrogen
- Assorted high-pressure aboveground steel tanks that will hold up to 141-cubic-meters (5,000-cubic-feet) of high pressure gaseous helium and/or gaseous nitrogen
- Assorted K-bottles containing up to 99-cubic-meters (3,500-cubic-feet) storage of medium pressure gaseous nitrogen
- Support equipment that would include piping, pumps, heat exchangers, vaporizers, valves, control systems, concrete pads and pedestals, and other miscellaneous items

2.2.1.7 Modifications to Existing Launch Support Facilities

Several existing facilities could undergo minor interior modifications to support the launch of commercial medium large class orbital rockets; these facilities would include the blockhouses (launch control buildings), communication support systems, radar, and antennae improvements.

In addition to constructing a dedicated PFF, NASA may make minor interior modifications to building V-55 so that it could also serve as a temporary PFF. Modifications could include the installation of explosion-proof electrical outlets, ventilation system changes, and the installation of vapor monitoring devices. Fueling operations would generally be the same as in the PFF, however, use of this building for fueling would be irregular and only if the primary PFF was not available.

2.2.1.8 Construction Timeline Estimate

Table 1: Estimated Construction Timeline

Project Component	Start Date	Finish Date	Length of Time
Modifications to Boat Dock	August 2009	February 2010	6 months
PFF	January 2010	January 2011	12 months
PPF	January 2010	January 2011	12 months
Transportation Infrastructure	August 2009	February 2010	6 months
Pad 0-A Improvements	July 2009	July 2010	12 months
Existing Facility Modification	August 2009	Ongoing	Ongoing

2.2.2 Transportation and Handling of Components

While a maximum of 18 orbital-class launches per year could occur from MARS (12 existing launches from Pad 0-B, and 6 additional launches from Pad 0-A under the Proposed Action), the transportation and handling of various cargo, launch vehicle, and payload components would be ongoing as the components are delivered to Wallops Main Base or Island via barge or airplane, and then transported via road to various facilities and the launch pad.

Hazardous materials would be brought to Wallops Island via barge or truck and stored and handled in a PPF, the PFF, the HIF, and the LFF. Approximately two barges per launch would deliver the launch vehicle, payload, and related cargo to one of the NASA boat docks several months prior to launch. Cargo would then be offloaded for land-based transport to launch vehicle or Payload Processing Facilities. Some of the cargo to be unloaded may contain hazardous materials.

Hazardous operations include ordnance handling and installation, loading of liquid propellants, hazardous systems tests, mating of a payload to a solid propellant motor (solid motors would be utilized as ELV upper stages, as explained in Section 2.2.3), and propellant leak tests. Hazardous materials may include liquid and solid propellants, small explosive charges for stage separation or flight termination, batteries, solvents, and various materials in small quantities within a payload. Hypergolic propellants (described in Section 4.2.6) would be transported to WFF several days to a week prior to fueling, and would be stored in DOT-approved shipping containers inside controlled access facilities on Wallops Island. Payloads would be fueled directly from the containers. Following fueling operations, any remaining propellant would be returned to the manufacturer. No bulk or permanent storage is anticipated for hypergolic propellants.

2.2.3 Launch Activities

A maximum of six additional orbital-class launches per year would occur from Pad 0-A, resulting in a maximum of 18 orbital-class launches from MARS (12 existing launches from Pad 0-B, and 6 additional launches from Pad 0-A under the Proposed Action). Launches may be conducted during any time of the year, and any time of the day or night.

In addition to launches, static test firing of rocket engines would occur at Pad 0-A. Static test firing is conducted while the ELV is held stationary on the launch pad. The purpose of the test is to assess the functionality of engine design in a non-flight situation. While no more than one static test firing a year is planned, a test anomaly may necessitate a second test within months. Accordingly, this EA assumes two static test fires to be conducted within every 12 month period. A description of potential launch vehicles and spacecraft follows.

2.2.3.1 Launch Vehicles

An ELV is composed of stages, each of which contains its own engines and fuel (also known as propellant). A launch vehicle is considered to be expendable if any significant part of it (i.e., a stage) is not retrieved and refurbished. Stages are either mounted on top of one another, or attached alongside another stage. The first stage is at the bottom and is usually the largest, and the second stage and subsequent upper stages are above it, usually decreasing in size. In a typical case, the first stage engines fire to propel the entire rocket upwards. When the engines run out of fuel, they are detached from the rest of the rocket (usually with some kind of small explosive charge) and fall away. This leaves a smaller rocket, with the second stage on the bottom, which then fires; this process is repeated until the final stage's motor burns to completion.

Commercial ELVs are divided into four classes based on the weight of the payload (Table 2) as defined in 14 CFR Subsection 420.19. A payload is anything carried by the launch vehicle that is not essential to its flight operations, including but not limited to spacecraft, cargo, scientific instruments, and experiments.

Table 2: ELV Weight Classes Based on Payload Weight

100 nautical mile orbit	Weight Class in Kg (Lbs)			
	Small	Medium	Medium Large	Large
28 degrees* inclination	≤ 1,996 (4,400)	>1,996 (4,400) to ≤5,035 (11,100)	>5,035 (11,100) to ≤8,391 (18,500)	>8,391 (18,500)
90 degrees inclination	≤1,497 (3,300)	>1,497 (3,300) to ≤3,810 (8,400)	>3,810 (8,400) to ≤6,834 (15,000)	>6,834 (15,000)

*28 degrees inclination orbit from a launch point at 28 degrees latitude

There are a variety of ELV systems available for commercial or government missions: the Taurus II and the Falcon family of ELVs would be launched from MARS Pad 0-A, and are covered within this EA. The Taurus II is the largest liquid-propelled launch vehicle and will serve as the envelope launch vehicle as described in Section 1. The Taurus II and Falcon family of ELVs would accommodate the desired range of payload masses, provide the needed trajectory capabilities, and meet NASA's requirements for highly reliable launch services.

Launch vehicles can utilize either liquid or solid propellants. In a liquid-propellant rocket, an oxidizer is combined with the fuel during launch to produce thrust. The propellant and oxidizer are stored in separate tanks. Liquid propellants used in rockets can be categorized into three different types: petroleum, cryogens, and hypergolics. Petroleum propellants are derived from crude oil, with RP-1 being the most common petroleum used in rockets. Cryogenic propellants are liquefied gases such as liquid hydrogen (LH_2) and LOX. Hypergolic propellants are those that ignite spontaneously without an external aid (such as a spark) and include hydrazine, MMH, and UDMH. NTO, MON, or nitric acid is usually used as an oxidizer for hypergolic propellant systems.

Solid-propellant rockets have casings filled with a mixture of solid compounds (propellant and oxidizer combined) that burn rapidly and emit hot gases from a nozzle to produce thrust. Solid propellants used in rockets are classified as either homogenous (having the same composition throughout) or composite (composed of different compounds). ELVs typically use composite solids. Composite propellants consist of powders or mixtures that use a finely ground mineral salt (typically ammonium perchlorate) as an oxidizer. The propellant itself is usually aluminum. Composite propellants are identified by the type of binder that is used. The most common binders are polybutadiene acrylic acid acrylonitrile and hydroxyl-terminated polybutadiene (HTPB). Table 3 in Section 2.2.3.3 includes specifications on the type of motors and propellants associated with the Taurus and Falcon ELVs.

Payloads on ELVs are typically launched into one of the following orbits:

1. LEO, which is between 160–2,000 kilometers (100–1,240 miles) above the Earth's surface
2. Geosynchronous orbit (GEO), a circular orbit at an altitude of 35,786 kilometers (22,236 miles) above the Earth's surface
3. A geosynchronous transfer orbit (GTO), which is between a LEO and a GEO, is mathematically derived based on the vehicle's velocity
4. A sun-synchronous orbit, is 800–1,000 kilometers (500–625 miles) above the Earth's surface and rotating approximately 8 degrees off the polar orbit

Below is a general description of the Taurus and Falcon ELVs. Appendix A contains detailed ELV descriptions.

2.2.3.2 Taurus II

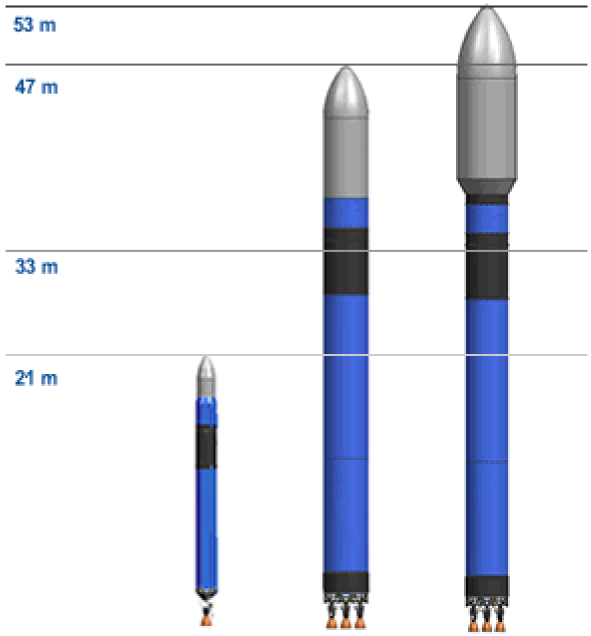
The Taurus II (Figure 7) is a two-stage launch vehicle with a gross lift-off weight of 290,000 kg (639,340 lbs) (Orbital, 2008). An optional third stage can be added. Taurus II incorporates both solid and liquid stages; the first stage uses LOX and RP-1 as the propellants, the second stage is a solid motor propelled by HTPB, and the optional third stage uses either NTO and hydrazine or solid HTPB as propellant. Taurus II utilizes 20 kg (44 lbs) of Halon-1301 for fire suppression.

2.2.3.3 Falcon Family

The Falcon family of launch vehicles utilizes a partially refurbishable launch system designed and manufactured by Space Exploration Technologies Corporation (SpaceX, 2008). The Falcon launch vehicles (Figure 8), which include the Falcon 1, Falcon 1e (not pictured), and Falcon 9, are two-stage and use liquid propellant (LOX and RP-1) for both stages.

Figure 7: Artist's Rendering of the Taurus II Launch Vehicle at WFF.

Source: Orbital Taurus II Fact Sheet, 2008



	Falcon 1	Falcon 9	Falcon 9
LEO	570 kg	9,300 kg	8,700 kg
GTO	--	3,400 kg	3,100 kg
Fairing diameter	1.5 m	3.6 m	5.2 m

Figure 8: Falcon Family of Launch Vehicles

Source: Global Security, 2008

Falcon 1 and 1e

The Falcon 1 is a two-stage, liquid-propelled vehicle with a gross lift-off weight of approximately 27,273 kg (60,000 lbs) that can carry small-class payloads between 125 to 570 kg (275 to 1,257 lbs). The Falcon 1 measures 21.3 meters (70 feet) in length with a diameter of 1.68 meters (66 inches), tapering to 1.52 meters (60 inches) on the second stage.

The Falcon 1e, which is planned to replace the Falcon 1 in mid-2010, is based on the Falcon 1; however, it has an extended first stage tank. The Falcon 1e has a gross lift-off weight of approximately 35,000 kg (77,150 lbs) and an overall length of approximately 27 meters (88.5 feet). Falcon 1e can carry small-class payloads up to 1,010 kg (2,220 lbs) into LEO (SpaceX, 2008).

Falcon 9

The Falcon 9 has a gross lift-off weight of approximately 333,400 kg (735,000 lbs) and a maximum length of 54 meters (177 feet). Typical maximum payload weights are 6,800 kg (15,000 lbs) for LEO, but can be much higher (as shown on Figure 8) depending on the altitude of the orbit (lower orbits support higher weights). For GTO, the Falcon 9 Block 2 design can carry payloads up to a maximum of 4,540 kg (10,000 lbs) (typical, not maximum masses are shown in Figure 8).

Table 3: Falcon Family and Taurus II Motors and Propellants

Name	Motor type	Potential Maximum Propellant
Taurus II	1st stage: 2 AJ26-62 engines 2nd stage: ATK Castor-30 solid motor 3rd stage (optional) Orbit Raising Kit (ORK): Helium pressure regulated bi-propellant propulsion system 3rd stage (optional) Star 48V: solid kick motor	155,220 L (41,005 gal) LOX/79,237 L (20,932 gal) RP-1 12,814 kg (28,250 lb) HTPB (12% HTPB, 20% Al, 68% NH4ClO4) 322 kg (710 lb) NTO/358 kg (789 lb) MMH 2,010 kg (4,431 lb) HTPB
Falcon 1	1st stage: SpaceX Merlin 1A or 1C 2nd stage: SpaceX Kestrel	12,708 L (3,357 gal) LOX/8,245 L (2,178 gal) RP-1 2,203 L (582 gal) LOX/1,325 L (350 gal) RP-1
Falcon 1e	1st stage: 1 SpaceX Merlin 1C+ 2nd stage: 1 SpaceX Kestrel 2	44,300 kg (97,665 lb) LOX and RP-1 combined 4,028 kg (8880 lb) LOX and RP-1 combined
Falcon 9	1st stage: 9 SpaceX Merlin engines 2nd stage: 1 SpaceX Merlin engine	114,372 L (30,213 gal) LOX/74,205 L (19,602 gal) RP-1 12,708 L (3,357 gal) LOX/8,245 L (2,178 gal) RP-1

Sources: (NASA, 2002a), (SpaceX, 2008), (Orbital, 2008)

2.2.3.4 Envelope Spacecraft

Spacecraft (also called payloads) are satellites that are launched into space to be used in communications systems, for remote sensing, in weather systems, for planetary exploration, and as scientific experiments. Spacecraft may contain mechanical structures, batteries or solar power cells, transmitters, receivers, antennas, other communication system components, small radioactive sources, recovery systems, in-space maneuvering systems, and science and technology instruments (e.g., lasers, sensors, atmospheric sampling devices, optical devices, and biological experiments). No specific spacecraft has been identified as the ES; instead, the ES should be considered a hypothetical payload whose components, materials, associated quantities, and flight systems represent a comprehensive bounding reference design. Any proposed payload that presents lesser or equal values of environmentally hazardous materials or sources in comparison to the ES may be considered within the purview of this EA.

Launches with two or more payloads on a single ELV would be covered by this EA if, when combined, they do not exceed the ES characteristics. However, if the payloads exceed the ES characteristics defined in this EA, additional NEPA review would be required.

For this EA, the ES characteristics do not incorporate any components with unusual potential for substantial environmental impact (including payloads involving radioisotope thermoelectric generators and radioisotope heater units, as well as the equipment and operations associated with extraterrestrial sample return).

Figure 9 illustrates the relevant features of the ES, which would be launched into Earth orbit or toward another body in the solar system.

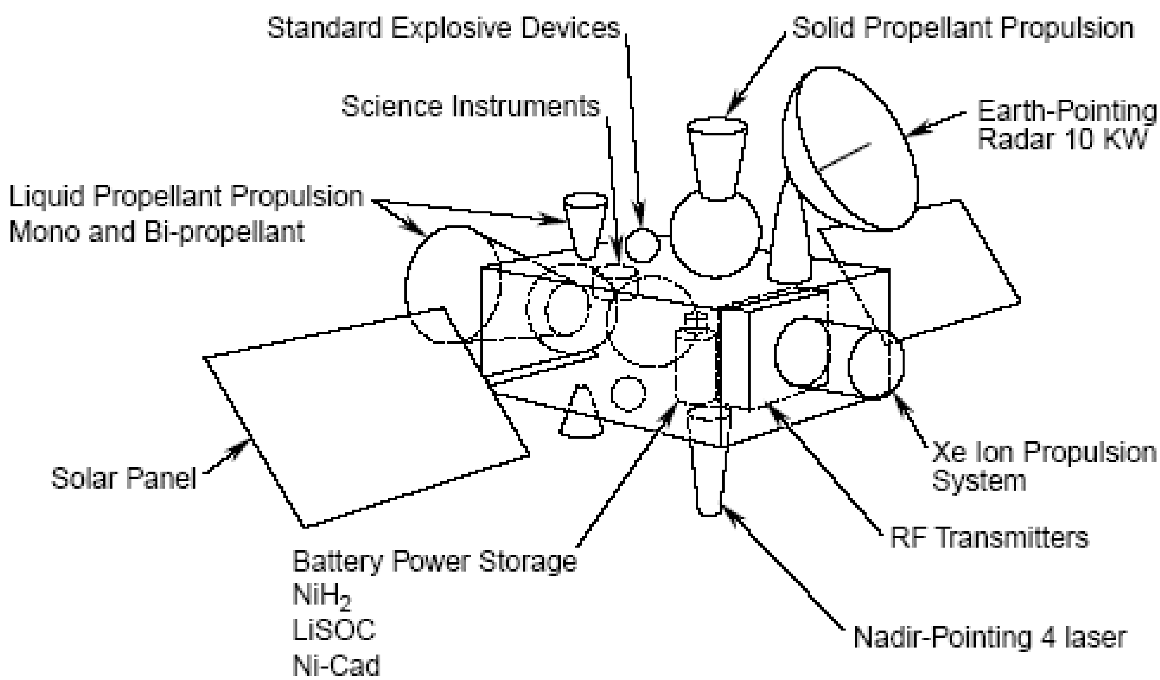


Figure 9: Envelope Spacecraft

Table 4 lists the major materials together with the maximum quantities that would be carried by the ES (see also Payload Checklist, Appendix B). Minor materials that are not listed may be included on the ES as long as they pose no substantial hazard to the human environment. The Payload Checklist in Appendix B provides steps to evaluate whether the ES fits within the envelope characteristics.

Table 4: Summary of Envelope Spacecraft Subsystems and Characteristics

Component	Envelope
Structure	Unlimited: aluminum, magnesium, carbon resin composites, titanium, and other materials unless specified as limited. Limited: beryllium, nanomaterials, limits based on specific material to be evaluated on a case-by-case basis
Radio Frequency	Electromagnetic fields must be within American National Standards Institute (ANSI)-recognized acceptable levels as stated in Institute of Electrical and Electronics Engineers C95.1-1991. Documentation requirement for REC is radio frequency data confirming compliance.
Lasers	Meets ANSI Safety standards (ANSI Z136.1-2000 and Z136.6-2000). Documentation requirement for REC is laser data confirming compliance.
Radioactive Materials	Quantity and type of radioactive material are within the approval authority level of the NASA Nuclear Flight Safety Assurance Manager (NFSAM). Documentation requirement for REC is copy of Radioactive Materials Report as per NPR 8715.3 Section 5.5.2.
Biological Agents	Biological agents must meet conditions of Biosafety Level 1 of the National Institute of Health and Center for Disease Control Biosafety in Microbiological and Biomedical Laboratories. Documentation requirement for REC is laboratory data confirming compliance.
Chemical Release	Must not pose a substantial hazard and cannot have a significant adverse affect on the atmosphere.
Orbital Debris Generation	Must comply with the requirements of NASA Policy Directive (NPD) 8710.3 NASA Policy for Limiting Orbital Debris Generation and NASA Safety Standard 1740.1. A debris assessment would need to be prepared as required by this policy.
Propulsion	Mono- and bipropellant hypergolic fuel/oxidizer; 1,507 kg (3,322 lbs) of combined hydrazine, MMH, NTO, and NO_X; spacecraft and any upper stage hypergolic propellant quantities shall be added together to determine if the proposal is within the ES bounding case. Solid rocket motor; 3000 kg (6614 lbs) Ammonium Perchlorate (AP)-based solid propellant (examples of solid rocket motor propellant that might be on a spacecraft are a Star-48 kick stage, descent engines, an extra-terrestrial ascent vehicle, etc.)
Communications	Various 10–100 Watt (radio frequency) transmitters
Power	Unlimited Solar cells; 5 kiloWatt-Hour Nickel-Hydrogen or Lithium ion battery, 300 Amp-hour Lithium-thionyl chloride, or 150 Amp-hour Hydrogen, Nickel-Cadmium, or Nickel-Hydrogen battery
Science instruments	10 kiloWatt radar ANSI safe lasers (Section 4.1.2.1.3)
Hypergols	2nd stage payload may contain up to 774 kg (1,706 lbs) 3rd stage (optional) may contain up to 885 kg (1,951 lbs)
Other	DOT Class 1.4 Electro-Explosive Devices for mechanical systems deployment Radioisotopes in quantities limited to the amounts that are within the approval authority for launch by the NFSAM as per NPR 8715.3B Chapter 6 (see NPR 8715.3B in the references for website link) Propulsion system exhaust and inert gas venting Sample returns are considered outside of the scope of this EA. Must comply with the requirement of NPD 8700.3A, Safety and Mission Assurance Policy for NASA Spacecraft, Instruments, and Launch Services.

SECTION THREE AFFECTED ENVIRONMENT

Section 3 presents information regarding existing resources at Wallops Island that may be affected by the proposed alternatives. This section contains discussions on resources under the three main categories of Physical Environment, Biological Environment, and Social and Economic Environment. Because the majority of the Proposed Action that could affect the environment would take place on Wallops Island (as opposed to the Main Base or Wallops Mainland), this section does not provide a comprehensive description of conditions (e.g., soil types, air emissions, etc.) for these two additional land areas. For more information about the existing conditions on the Main Base or Wallops Mainland, please refer to the 2008 WFF Environmental Resources Document (NASA, 2008a).

3.1 PHYSICAL ENVIRONMENT

3.1.1 Land Resources

This section is based on information taken from the 1994 soil survey for Accomack County, Virginia (U.S. Department of Agriculture [USDA], 1994); the 2005 WFF Site-Wide EA (NASA, 2005); and the 2008 WFF Environmental Resources Document (NASA, 2008a). Discussed in this section are Topography and Drainage, Geology, Soil, Atlantic Ocean Substrate, and Land Use within the WFF operating area.

3.1.1.1 Topography and Drainage

Wallops Island is a barrier island approximately 11 kilometers (7 miles) long and 807 meters (2,650 feet) wide. It is bordered by Chincoteague Inlet to the north, Assawoman Inlet to the south, the Atlantic Ocean to the east, and marshland to the west. Assawoman Inlet is often filled in and opens only intermittently during and after major storm events; under most conditions the silt effectively connects Wallops Island to the north end of Assawoman Island.

Much of the Atlantic shoreline of Wallops Island has been lined with an armor stone seawall to protect critical NASA, U.S. Navy, and MARS infrastructure. The beach has nearly or completely eroded in areas armored with the seawall. The unarmored shoreline segments at the north and south ends of the island consist of low sloping sandy beaches. The sandy portion of Wallops Island has an elevation of about 2.1 meters (6.9 feet) above mean sea level (amsl) (NASA, 2008a). The highest elevation on Wallops Island is approximately 4.6 meters (15 feet) amsl (NASA, 2005). Most of the island is below 3.0 meters (10 feet) amsl (NASA, 2005).

Wallops Island is separated from the mainland by a marshy bay. The marshes flood regularly with the tides and are drained by an extensive system of meandering creeks. Surface water on Wallops Island flows east through numerous tidal tributaries that subsequently flow to the Atlantic Ocean. Additionally, Wallops Island has storm drains that divert the water flow to several individual discharge locations.

Barrier islands are dynamic geologic features. They migrate, erode, and accrete in response to physical processes such as waves, tides, and wind. The Atlantic shoreline of Wallops Island has experienced erosion throughout the 6 decades that WFF has occupied the site. On the southern portion of the island, near the MARS facility, shoreline retreat averaged about 3.7 meters (12 feet) per year from 1857 to the present (NASA, 2008a). Further south, adjacent to Assawoman Inlet, shoreline retreat exceeded 5 meters (16.4 feet) per year during that same time period (NASA, 2008a).

As is typical of barrier islands, Wallops Island exhibits environmental zonation related to changes in topography across the island profile. Generally, dunes and maritime forest are found at the highest elevations, and beaches and marshes are found at the lowest. On Wallops Island, previous hardened structures, such as groins, weirs, beach beams, and beach prisms, have disturbed natural sediment transport processes, thereby changing the island's structure. The seawall that was constructed to protect critical infrastructure on the island has fixed the shoreline position, but has resulted in complete erosion of the beach seaward of the wall, preventing long-term natural maintenance of the gently sloping near-shore and beach systems that would have existed under natural conditions. In addition, without a beach to provide a source of sand, the island's ability to create and maintain natural dunes is limited.

3.1.1.2 Geology

Located within the Atlantic Coastal Plain Physiographic Province, Wallops Island is underlain by approximately 2,133 meters (7,000 feet) of sediment. The sediment lies atop crystalline basement rock. The sedimentary section, ranging in age from Cretaceous to Quaternary (approximately 145.5 to 2.5 million years ago), consists of a thick sequence of terrestrial, continental deposits overlain by a much thinner sequence of marine sediments. These sediments are generally unconsolidated and consist of clay, silt, sand, and gravel.

The regional dip of the soil units is eastward, toward the Atlantic Ocean. The two uppermost stratigraphic units on Wallops Island are the Yorktown Formation and the Columbia Group, which is not subdivided into formations. The Yorktown Formation is the uppermost unit in the Chesapeake Group and was deposited during the Pliocene epoch of the Tertiary Period (approximately 5.3 to 1.8 million years ago). The Yorktown Formation generally consists of fine to coarse glauconite quartz sand, which is greenish gray, clayey, silty, and in part, shelly. The Yorktown Formation occurs at depths of 18 to 43 meters (60 to 140 feet) in Accomack County (NASA, 2008a).

3.1.1.3 Soil

The soil classifications for Wallops Island, shown in Table 5, are based on the 1994 USDA Soil Survey of Accomack County, Virginia.

Table 5: Predominant Soil Types at Wallops Island

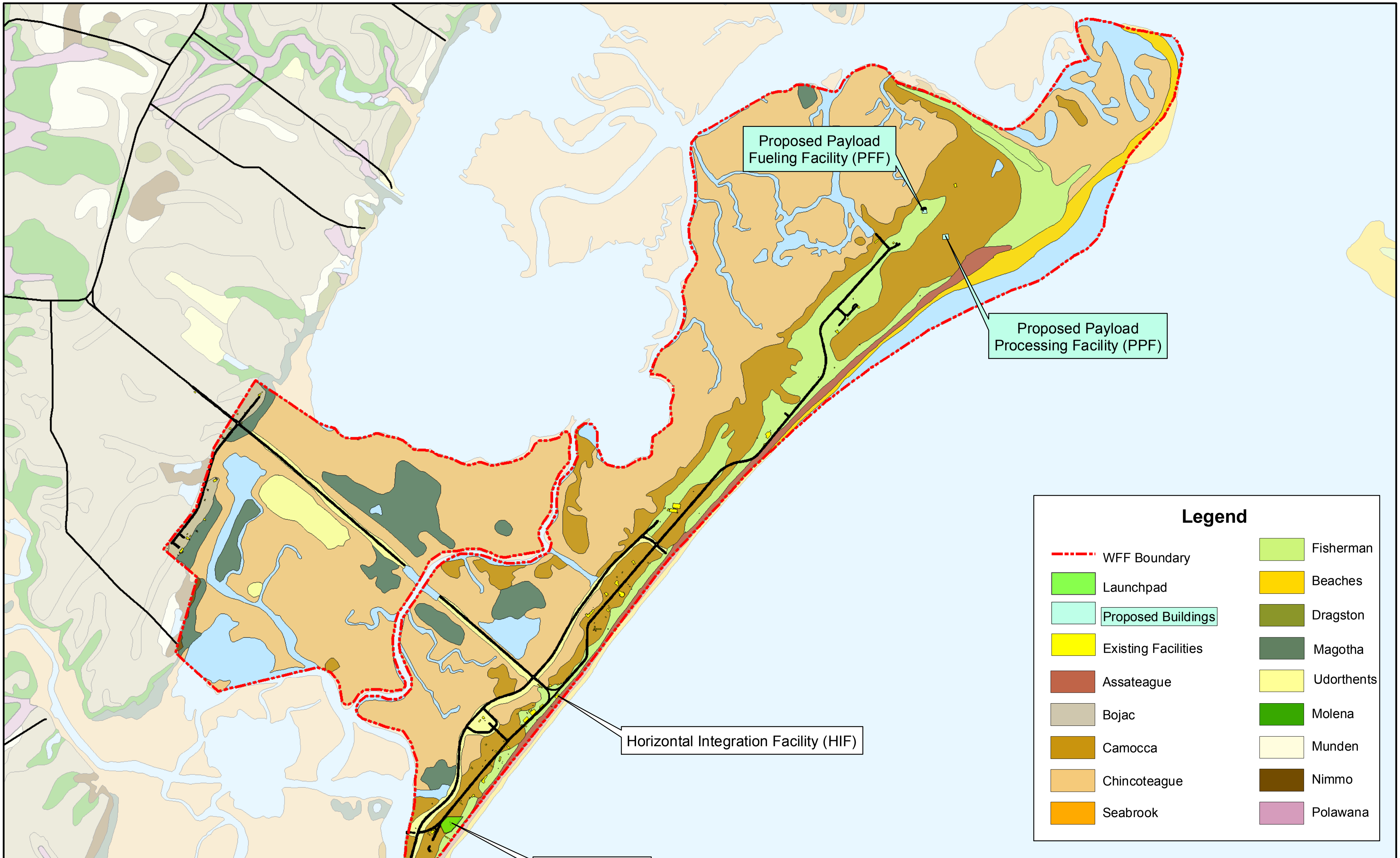
Location	Soil Type	Typical Slopes (percent)	Description
Wallops Island – eastern portion	Chincoteague silt loam	0–1	Nearly level, very deep, very poorly drained hydric soils. This soil provides a suitable wildlife habitat.
Wallops Island – east of Chincoteague silt loam	Udorthents and Udipsamments	0–35	Nearly level to steep, very deep, and range from well-drained to somewhat poorly drained.
Wallops Island – southern end	Fisherman Assateague fine sands complex	0–35	Nearly level to steep, very deep, moderately well-drained, to excessively drained. This soil is used mainly for wildlife habitat and recreation.
Wallops Island – depressions and areas associated with dunes and salt marshes	Fisherman Comacca fine sands complex	0–6	Very poorly to moderately well-drained.
Wallops Island – central and western portions in depressions and on flats associated with dunes and saltmarshes	Comacca fine sand	0–2	Nearly level, very deep, very poorly drained. The soil is used mainly for wildlife habitat and recreation.
Wallops Island – eastern portion	Assateague fine sand	2–35	Gently to steeply sloping, very deep, excessively drained. This soil is rarely flooded and is used primarily for wildlife and recreation.
Wallops Island – eastern portion	Beaches	0-10	Moderately sloping and used mainly for wildlife habitat.

Source: NASA, 2008a

The Coastal Plain soils of the Eastern Shore are generally very level soils, and many soil types are considered to be prime farmland by the USDA. The dominant agricultural soils are high in sand content, which results in a highly leached condition, an acidic pH, and a low natural fertility (USDA, 1994). Adequate artificial drainage improves productivity for poorly drained soils. Prime and unique farmlands in Accomack County include the following soils:

- Bojac fine sandy loam soils
- Bojac loamy sand soils
- Munden fine sandy soil
- Munden loamy sand
- Dragston fine sandy loam, if adequately drained
- Nimmo fine sandy loam, well drained

No prime or unique soils are found on Wallops Island; therefore, the Farmland Protection Policy Act (7 U.S.C. 4201 *et seq*.) does not apply to this project and will not be discussed further (Figure 10).



Title: Soil Types

URS Proj No: 15301614

Figure: 10

Client : NASA

Expansion of the Launch Range at Wallops Flight Facility

3.1.1.4 Land Use

Wallops Island consists of 1,680 hectares (4,150 acres), most of which is marshland, and includes launch and testing facilities, blockhouses, rocket storage buildings, assembly shops, dynamic balancing facilities, tracking facilities, U.S. Navy facilities, and other related support structures (Figure 11). Wallops Island is zoned for industrial use by Accomack County. The marsh area between Wallops Mainland and Wallops Island is classified as marshland in the County's Comprehensive Plan. Wallops Mainland consists mostly of marshland and is bordered by agricultural land to the west, Bogues Bay to the north, and an estuary to the south. The area surrounding Wallops Island consists of rural farmland and small villages and is regulated by local county government and several town councils (NASA, 2008a). Corn, wheat, soybeans, cabbage, potatoes, cucumbers, and tomatoes are examples of the commodities produced on the surrounding farms.

Area businesses include fuel stations, retail stores, markets, and restaurants. The Town of Atlantic is located 8.05 kilometers (5 miles) to the northeast and has a land area of approximately 183 hectares (452 acres); Wattsville is located 12.5 kilometers (7.8 mile) to the north and has a land area of approximately 330 hectares (815 acres); and Assawoman is located 8.05 kilometers (5 miles) to the southwest and has a land area of approximately 33.6 hectares (83 acres). Each of these towns has a population of less than 500 people.

The Town of Chincoteague, located approximately 24 kilometers (15 miles) northeast of Wallops Island, on Chincoteague Island, Virginia, is the largest of the surrounding communities, with approximately 4,317 year-round residents. The island attracts a large tourist population during the summer months to visit the public beaches and attend the annual Assateague Island pony swim and roundup. Because of this, hotels and motels as well as other summer-season tourist businesses can be found on Chincoteague Island (NASA, 2008a).

3.1.2 Water Resources

The southern and eastern portions of Wallops Island are part of the Eastern Lower Delmarva watershed. The western portion of Wallops Island is part of the Chincoteague Bay watershed, while the remaining Wallops Island surface waters flow into many small unnamed watersheds. The Chincoteague Bay watershed has a relatively small population, with an average density of less than 105 people per square kilometer (40 per square mile), little topographic relief, and a high water table. Large areas of the watersheds on Wallops Island are comprised of tidal wetlands.

3.1.2.1 Surface Waters

Chincoteague Inlet forms the northern boundary of Wallops Island and its western side is bounded by water bodies that include (from north to south) Ballast Narrows, Bogues Bay, Cat Creek, and Hog Creek. This western boundary of Wallops Island includes a section of the Virginia Inside Passage, a federally maintained navigational channel frequently used by commercial and recreational boaters alike. The Atlantic Ocean lies to the east of Wallops Island.

Surface waters in the vicinity of Wallops Island are saline to brackish and are influenced by the tides. Outgoing tidal flow is generally north and east to Chincoteague Inlet and out to the Atlantic Ocean; incoming tides flow in the reverse direction. The VDEQ has designated the surface waters around Wallops Island as Class II – Estuarine Waters (NASA, 2008a). The Atlantic Ocean is designated as Class I – Open Ocean. Surface waters in Virginia must meet the water quality criteria specified in 9 Virginia Administrative Code (VAC) 25-260-50. This set of criteria establishes limits for minimum dissolved oxygen concentrations, pH, and maximum temperature for the different surface water classifications in Virginia. In addition, Virginia surface waters must meet the surface water criteria specified in 9 VAC 26-260-140. This set of criteria provides numerical limits for various potentially toxic parameters. For the Class I and II waters in the vicinity of Wallops Island, the saltwater numerical criterion is applied. Both sets of standards are used by the Commonwealth of Virginia to protect and maintain surface water quality.

No wild or scenic rivers are located on, or adjacent to, Wallops Island; therefore, the Wild and Scenic Rivers Act (16 U.S.C. 1271-1287) does not apply to this project and will not be discussed further.

3.1.2.2 Wetlands

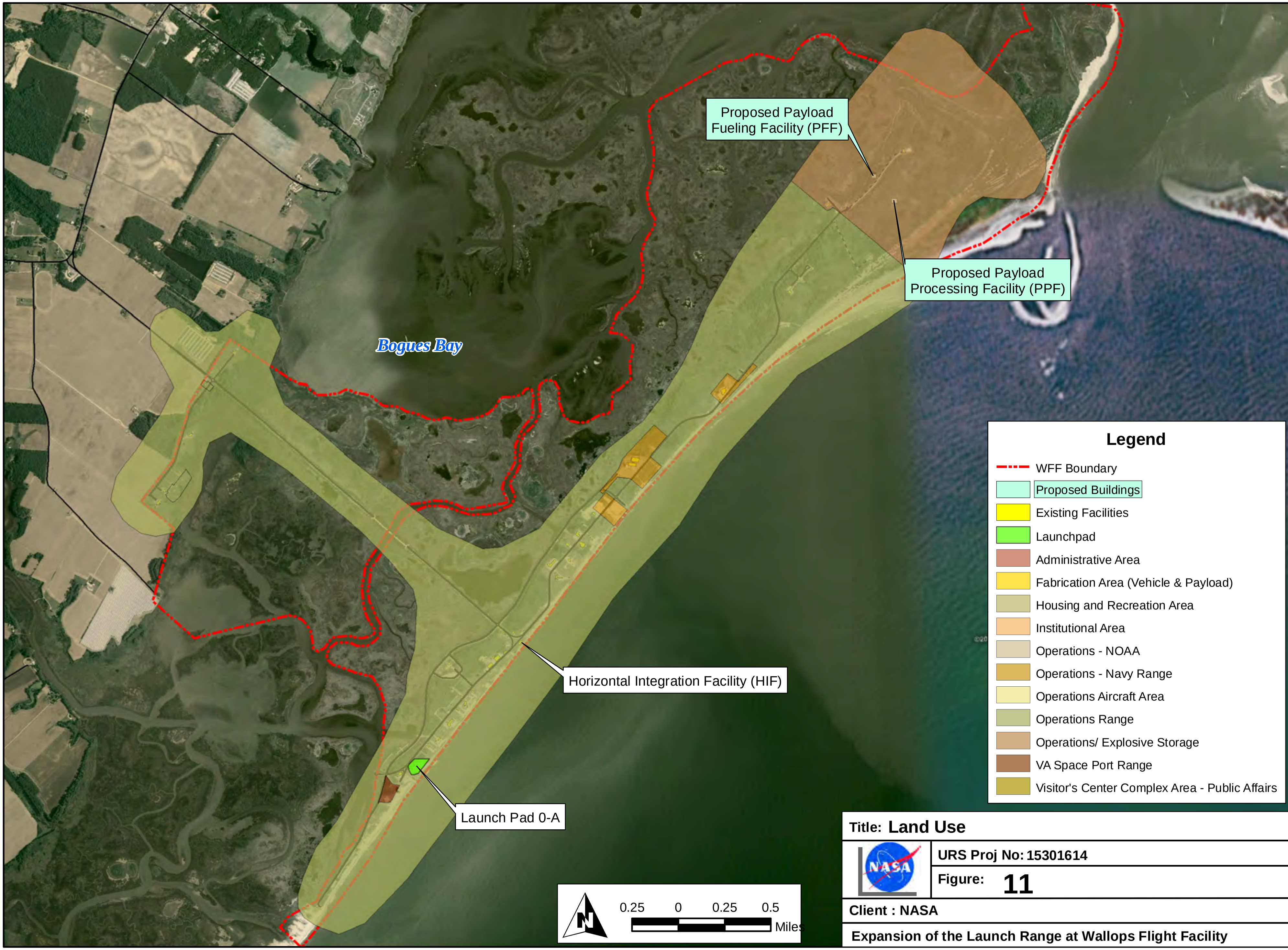
EO 11990 (Wetland Protection) directs Federal agencies to minimize the destruction, loss, and degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetland communities. In accordance with the Clean Water Act (CWA) (33 U.S.C. §1251 et seq.), projects at WFF that involve dredging or filling wetlands require Section 404 permits from the U.S. Army Corps of Engineers (USACE). Title 14 of CFR Part 1216.2 (NASA regulations on Floodplain and Wetland Management) directs WFF and its tenants to minimize wetland impacts.

In addition, permits may be required from the Virginia Marine Resources Commission (VMRC), Accomack County Wetlands Board, and the Virginia DEQ for work that may impact wetlands. A Joint Permit Application (JPA), filed with VMRC, is used to apply for permits for work in the waters of the United States, including wetlands, within Virginia. The VMRC plays a central role as an information clearinghouse for local, State, and Federal levels of review; JPAs submitted to VMRC receive independent yet concurrent review by local wetland boards, VMRC, VDEQ, and USACE (NASA, 2008a).

Extensive wetland systems border Wallops Island. The island has non-tidal freshwater emergent wetlands and several small freshwater ponds in its interior, and freshwater forested/shrub wetlands, estuarine intertidal emergent wetlands, and maritime forests on its northern and western edges**.** Marsh wetlands also fringe Wallops Mainland along Arbuckle Creek, Hog Creek, and Bogues Bay. Figure 12 provides further details on the types and locations of wetland communities present on Wallops Island.

3.1.2.3 Marine Waters

The NASA and MARS launch complexes are located on Wallops Island, a barrier island directly on the Atlantic Ocean. Offshore of Wallops Island, the Atlantic Ocean's depth ranges from less than 1 meter (3.28 feet) to 18.3 meters (60 feet). Continental slope waters in this area maintain a fairly uniform salinity range (32 to 36 parts per thousand [ppt]) throughout the year, with pockets of high salinity water (38 ppt) found near the Gulf Stream in the fall (NASA, 2003b). There are distinct differences in stratification of the Mid-Atlantic Ocean water column between summer and winter. In the winter, the water column temperature is vertically well-mixed, while in the summer, the temperature is more vertically layered (NASA, 2003b).


Proposed Payload
Fueling Facility (PFF)
Proposed Payload
Processing Facility (PPF)
Bogues Bay
Horizontal Integration Facility (HIF)
Launch Pad 0-A
Legend
WFF Boundary
Proposed Buildings
Existing Facilities
Launchpad
Administrative Area
Fabrication Area (Vehicle & Payload)
Housing and Recreation Area
Institutional Area
Operations - NOAA
Operations - Navy Range
Operations Aircraft Area
Operations Range
Operations/ Explosive Storage
VA Space Port Range
Visitor's Center Complex Area - Public Affairs
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Miles
Title: Land Use
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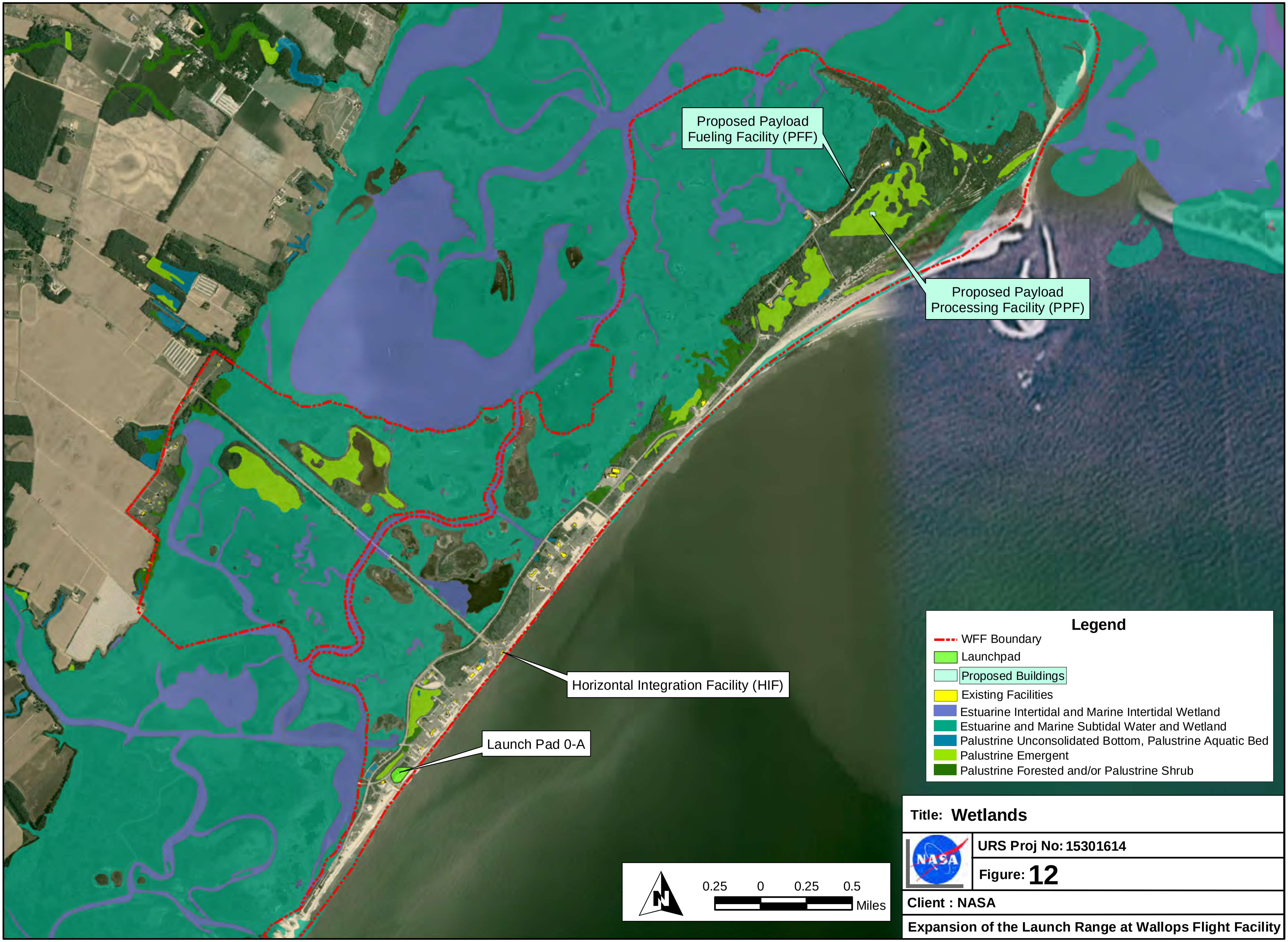
Figure: 11
Client : NASA
Expansion of the Launch Range at Wallops Flight Facility



Proposed Payload Fueling Facility (PFF)
Proposed Payload Processing Facility (PPF)
Horizontal Integration Facility (HIF)
Launch Pad 0-A
Legend
WFF Boundary
Launchpad
Proposed Buildings
Existing Facilities
Estuarine Intertidal and Marine Intertidal Wetland
Estuarine and Marine Subtidal Water and Wetland
Palustrine Unconsolidated Bottom, Palustrine Aquatic Bed
Palustrine Emergent
Palustrine Forested and/or Palustrine Shrub
0.25 0 0.25 0.5 Miles
Title: Wetlands
URS Proj No: 15301614
Figure: 12
Client : NASA
Expansion of the Launch Range at Wallops Flight Facility

3.1.2.4 Floodplains

EO 11988 (Floodplain Management) requires Federal agencies to take action to minimize occupancy and modification of the floodplain. Specifically, EO 11988 prohibits Federal agencies from funding construction in the 100-year floodplain unless there are no practicable alternatives. As shown on the Flood Insurance Rate Maps (FIRMs) produced by the Federal Emergency Management Agency (FEMA), the 100-year floodplain designates the area inundated during a storm having a 1-percent chance of occurring in any given year. The 500-year floodplain designates the area inundated during a storm having a 0.2-percent chance of occurring in any given year.

FIRM Community Panels 5100010070B and 5100010100C indicate that Wallops Island is located entirely within the 100-year and 500-year floodplains (see Figure 13).

3.1.2.5 Coastal Zone Management

Wallops Island is one of a limited number of barrier islands along the Atlantic Coast of the United States. Barrier islands are elongated, narrow landforms that consist largely of unconsolidated and shifting sand, and lie parallel to the shoreline between the open ocean and the mainland. Barrier islands provide protection to the mainland, prime recreation resources, important natural habitats to unique species, and valuable economic opportunities to the country. Wallops Island also contains coastal primary sand dunes that serve as protective barriers from the effects of flooding and erosion caused by coastal storms (NASA, 2008a).

The Coastal Barrier Resources Act (CBRA [P.L. 97-348], 16 U.S.C. 3501-3510), enacted in 1982, designated various undeveloped coastal barrier islands as units in the Coastal Barrier Resources System. Designated units are ineligible for direct or indirect Federal financial assistance programs that could support development on coastal barrier islands; exceptions are made for certain emergency and research activities. Wallops Island is not included in the Coastal Barrier Resources System; therefore, the CBRA does not apply.

VDEQ is the lead agency for the Virginia Coastal Zone Management (CZM) Program, which is authorized by NOAA to administer the Coastal Zone Management Act of 1972. Any Federal agency development in Virginia’s Coastal Management Area (CMA) must be consistent with the enforceable policies of the CZM Program. Although Federal lands are excluded from Virginia’s CMA, any activity on Federal land that has reasonably foreseeable coastal effects must be consistent with the CZM Program (VDEQ, 2008b). Enforceable policies of the CZM Program that must be considered when making a Federal Consistency Determination include:

- **Fisheries Management**. Administered by VMRC, this program stresses the conservation and enhancement of shellfish and finfish resources and the promotion of commercial and recreational fisheries.
- **Subaqueous Lands Management.** Administered by VMRC, this program establishes conditions for granting permits to use State-owned bottomlands.
- **Wetlands Management.** Administered by VMRC and VDEQ, the wetlands management program preserves and protects tidal wetlands.
- **Dunes Management.** Administered by VMRC, the purpose of this program is to prevent the destruction or alteration of primary dunes.

- **Non-Point Source Pollution Control.** Administered by the Virginia Department of Conservation and Recreation (DCR), the Virginia Erosion and Sediment Control Law is intended to minimize non-point source pollution entering Virginia's waterways.
- **Point Source Pollution Control.** Administered by VDEQ, the Virginia Pollutant Discharge Elimination System (VPDES) permit program regulates point source discharges to Virginia's waterways.
- **Shoreline Sanitation.** Administered by the Virginia Department of Health, this program regulates the installation of septic tanks to protect public health and the environment.
- **Air Pollution Control.** Administered by VDEQ, this program implements the Federal Clean Air Act (CAA) through a legally enforceable State Implementation Plan.
- **Coastal Lands Management.** Administered by the Chesapeake Bay Local Assistance Department, the Chesapeake Bay Preservation Act guides land development in coastal areas to protect the Chesapeake Bay and its tributaries.

Because Wallops Island is within Virginia's CMA, NASA activities are subject to the Federal Consistency requirement.

3.1.2.6 Stormwater

Wallops Island has storm drains that divert stormwater flow to several individual discharge locations. The northern portion of Wallops Island drains by overland flow to Bogues Bay and Chincoteague Inlet via Sloop Gut and Ballast Narrows. The central portion of the island drains primarily to the west toward Bogues Bay. Cross-culverts under Island Road drain stormwater collected by culverts and ditches. Flap gates have been installed west of Island Road to convey stormwater to Bogues Bay via Hog Creek. Tidal flaps have been installed on most outfalls west of Island Road to minimize tidal influence on internal drainage ways.

The CWA National Pollutant Discharge Elimination System (NPDES) (33 U.S.C. 1342) requires permits for stormwater discharges associated with industrial activities. VDEQ is authorized to carry out NPDES permitting under the VPDES (9 VAC 25-151). Currently, there are no permitted stormwater outfalls located on Wallops Mainland or Wallops Island; however, NASA maintains a Stormwater Pollution Prevention Plan (SWPPP) to ensure that its operations have minimal impact on stormwater quality.

The Virginia Stormwater Management Program (VSMP) regulations (4 VAC 3-20), administered by DCR, require that construction and land development activities incorporate measures to protect aquatic resources from the effects of increased volume, frequency, and peak rate of stormwater runoff and from increased non-point source pollution carried by stormwater runoff. The VSMP also requires that land-disturbing activities of 0.4 hectare (1 acre) or greater develop a SWPPP and acquire a permit from DCR prior to construction. Construction and demolition activities on Wallops Island are subject to VSMP permitting. As such, NASA and its tenants develop SWPPPs and acquire the necessary permits as part of early project planning.

Title: **Floodplains**

URS Proj No: 15301614

Figure: 13

Client : NASA

Expansion of the Launch Range at Wallops Flight Facility

3.1.2.7 *Wastewater*

NASA owns and operates a wastewater treatment plant (WWTP) that has the capacity to treat up to 1,135,623 liters per day (300,000 gallons per day). The WWTP currently treats flows of approximately 227,125 liters per day (60,000 gallons per day). Wastewater is pumped through a force main from Wallops Island and Wallops Mainland to the collection system on the Main Base. Treated wastewater from the WWTP is discharged via a single outfall to an unnamed freshwater tributary to Little Mosquito Creek under WFF's VPDES permit VA0024457. The WFF chemistry laboratory tests the wastewater discharge on a daily basis to ensure discharges do not exceed permitted limits.

3.1.2.8 *Groundwater*

VDEQ manages groundwater through a program regulating the withdrawals in certain areas, called Groundwater Management Areas, under the Groundwater Management Act of 1992. Wallops Island lies within the Eastern Shore Groundwater Management Area, which includes Accomack and Northampton counties. Any person, business, or community wishing to withdraw 1,135 kiloliters (300,000 gallons) or more per month in a declared management area must obtain a permit from VDEQ.

VDEQ has identified four major aquifers on the Eastern Shore of Virginia: the Columbia aquifer and the three aquifers that comprise the Yorktown-Eastover aquifer system.

The Columbia aquifer is known as the water table aquifer, and primarily consists of Pleistocene (approximately 1.8 million to 10,000 years ago) sediments of the Columbia Group (NASA, 2008a). It is unconfined and typically overlain by wind-deposited beach sands, silts, and gravel. The aquifer occurs between the depths of 1.5 and 18.3 meters (5 and 60 feet) below the ground surface, with the water table ranging between the depths of 0 and 9.1 meters (30 feet) below the ground surface. In general, the Columbia aquifer on the Delmarva Peninsula is recharged by surface waters or infiltration of precipitation. On Wallops Island, groundwater flow is generally west and north toward nearby creeks and the marsh area that separates the island from the mainland.

The Yorktown-Eastover system is a multiaquifer unit consisting of late Miocene and Pliocene (approximately 11 to 1.8 million years ago) deposits and is composed of the sandy layers of the Yorktown and Eastover Formations (NASA, 2008a). The top of the shallowest confined Yorktown-Eastover aquifer in the area of Wallops Island is typically found at a depth of approximately 30.5 meters (100 feet) below the ground surface. It is separated from the overlying Columbia aquifer by a 6.1- to 9.1-meter-thick (20- to 30-foot-thick) confining layer (aquitard) of clay and silt. The Yorktown-Eastover aquifers are classified as the upper, the middle, and the lower Yorktown-Eastover aquifers. Correspondingly, each Yorktown-Eastover aquifer is overlain by the upper, middle, and lower Yorktown-Eastover aquitards. The Yorktown-Eastover aquifers on the Delmarva Peninsula are generally recharged by surface waters or infiltration of precipitation from areas located beyond the immediate vicinity of WFF.

Groundwater Appropriation

Groundwater from the Columbia and Yorktown-Eastover Multiaquifer System is the sole source of potable water for WFF and the surrounding area. No major streams or other fresh surface water supplies are available as alternative sources of water for human consumption. The Columbia and Yorktown-Eastover Multiaquifer System is designated and protected by the U.S.

Environmental Protection Agency (EPA) as a sole-source aquifer (EPA, 2007a). A sole-source aquifer is a drinking water supply located in an area with few or no alternative sources to the groundwater resource, and if contamination occurred, using an alternative source would be extremely expensive. The sole-source aquifer designation protects an area's groundwater resource by requiring the EPA to review any proposed projects within the designated area that are receiving Federal financial assistance. All proposed projects receiving Federal funds that would have potential impacts on groundwater quantity or quality are subject to review to ensure they do not endanger the water source. Additionally, the Accomack-Northampton Planning District Commission has established a groundwater management program for the entire Eastern Shore of Virginia. This Commission includes a Groundwater Committee, established in 1990, that monitors usage and ensures that an optimal balance exists between groundwater withdrawals and recharge rates. This balance helps to minimize the problems of water quality due to saltwater intrusion, aquifer de-watering, and well interference in the general area (NASA, 2008a).

Two supply wells located on Wallops Mainland provide potable and fire suppression water to all Wallops Island facilities. These supply wells are several hundred feet deep and withdraw water from the Middle Yorktown-Eastover Aquifer. No supply wells are located on Wallops Island and all water is piped from wells and treatment facilities on Wallops Mainland**.**

Wallops Mainland and Wallops Island combined are permitted by VDEQ to withdraw up to 6,800 kiloliters (1,800,000 gallons) per month and up to 50,345 kiloliters (13,300,000 gallons) per year. Actual combined Wallops Mainland and Wallops Island withdrawals have averaged 3,700 kiloliters (977,697 gallons) per month between 2002 and 2007 (NASA 2008a).

Groundwater Quality

WFF's chemical laboratory performs routine analytical sampling of WFF's water systems in accordance with Federal and State requirements and submits the results to the State for review. Recent sampling of the drinking water system found that all parameters are within regulatory limits. Currently, there are no remedial actions underway that could affect the supply wells on Wallops Mainland.

3.1.3 Air Quality

The CAA (P.L. 108-201, 42 U.S.C. 85 *et seq.*), as amended, requires EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. The CAA established two types of NAAQS: primary and secondary standards. Primary standards set limits to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

The EPA has set NAAQS for six principal pollutants that are called "criteria" pollutants. They are: carbon monoxide (CO), nitrogen oxides (NO_X), ozone (O_3), lead (Pb), particulate matter less than or equal to 10 microns (PM_{10}), particulate matter less than or equal to 2.5 microns ($PM_{2.5}$), and sulfur dioxide (SO_2). Although States have the authority to adopt stricter standards, the Commonwealth of Virginia has accepted the Federal standards and has incorporated them by reference in 9VAC5-30 (VDEQ, 2008a; see Table 6).

Table 6: National Ambient Air Quality Standards

Pollutant	Averaging Time	Primary/Secondary NAAQS	NAAQS Violation Determination[a]
O_3	8 hour	0.075 ppm [b]	3-year average of the annual 4th highest daily maximum 8-hour average concentration
CO	8 hour	9.0 ppm	Not to be exceeded more than once per calendar year
	1 hour	35.0 ppm	Not to be exceeded more than once per calendar year
NO_2	Annual arithmetic mean	0.053 ppm	Annual average
SO_2	Annual arithmetic mean	0.03 ppm	Not to be exceeded more than once per calendar year
	24 hour	0.14 ppm	Not to be exceeded more than once per calendar year
	3 hour	0.5 ppm	Not to be exceeded more than once per calendar year
PM_{10}	Annual arithmetic mean	Revoked[c]	Expected number of days per calendar year with a 24-hour average concentration above 150 $\mu g/m^3$ cannot be exceeded more than once per year on average over a 3-year period
	24 hours	150 $\mu g/m^3$	
$PM_{2.5}$	Annual arithmetic mean	15 $\mu g/m^3$	3-year average of annual arithmetic mean
	24 hour	65 $\mu g/m^3$	3-year average of 98th percentile of the 24-hour values determined for each year
Pb	Quarterly average	1.5 $\mu g/m^3$	Quarterly arithmetic mean

[a]A NAAQS violation results in the re-designation of an area; however, an exceedance of the NAAQS does not always mean a violation has occurred.

[b]New O_3 8-hour standard effective May 30, 2008.

[c]Revoked annual PM_{10} standard December 2006.
$\mu g/m^3$ = micrograms per cubic meter
ppm = parts per million
NA = not applicable
NO_2 = nitrogen dioxide

Source: Derived from EPA, 2008

Federal regulations designate Air Quality Control Regions, or airsheds, that cannot attain compliance with the NAAQS as non-attainment areas. Areas meeting the NAAQS are designated as attainment areas. Wallops Island and Mainland are located in Accomack County, an attainment area for all criteria pollutants; therefore, a General Conformity Review (under Section 176(c) of the CAA) does not apply to the facilities prior to implementing a Federal action.

Wallops Island and Wallops Mainland are considered a synthetic minor source, and the two land masses are combined into a facility-wide State operating air permit for stationary emission sources (Permit Number 40909, amended August 3, 2006). A facility is considered a major source in an attainment area if all of its sources together have a potential to emit greater than or equal to 90.7 metric tonnes per year (100 tons per year) of the criteria pollutants, or greater than or equal to 9.1 metric tonnes per year (10 tons per year) of a single Hazardous Air Pollutant (HAP) or 22.7 metric tonnes per year (25 tons per year) of combined HAPs. Table 7 lists the emissions for Wallops Island and Mainland based on the 2007 annual update form, which provides VDEQ with consumption rates for the previous calendar year.

Table 7: Calendar Year 2007 Air Emissions at Wallops Island

Pollutant	Emissions (metric tonnes per year/tons per year)
CO	0.46 / 0.51
NO_X	1.93 / 2.13
SO_2	2.98 / 3.28
VOC	0.05 / 0.06
PM_{10}	0.20 / 0.22
PM	0.18 / 0.20

Source: VDEQ, 2008c
VOC = volatile organic compound

Prevention of Significant Deterioration

Separate pre-construction review procedures have been established for projects that are proposed to be built in attainment areas versus non-attainment areas. The pre-construction review process for new or modified major sources is called New Source Review (NSR) and consists of a Prevention of Significant Deterioration (PSD) review for sources located in an attainment area. This review process is intended to keep new air emission sources from causing existing air quality to deteriorate beyond acceptable levels codified in the Federal regulations. Construction of major new stationary sources in attainment areas must be reviewed in accordance with the PSD regulations. The PSD rule defines a major source as any source with a potential to emit (PTE) of 90.7 metric tonnes per year (100 tons per year) or more of any criteria pollutant for source categories listed in 40 CFR 52.21(b)(1)(i), or 226.8 metric tonnes per year (250 tons per year) or more of any criteria pollutant for source categories that are not listed. If a new source is determined to be a major source for any criteria pollutants, then other remaining criteria pollutants would be subject to PSD review if those pollutants are emitted at rates that exceed the following significant emission thresholds:

- 90.7 metric tonnes per year (100 tons per year) for CO
- 36.3 metric tonnes per year (40 tons per year) for NO_X, VOC, and SO_2 each
- 13.6 metric tonnes per year (15 tons per year) for PM_{10}
- 22.7 metric tonnes per year (25 tons per year) for PM

Major sources that exceed any of the PSD thresholds are subject to PSD review for all criteria pollutants. Although the Wallops Island and Mainland are assumed not to be a major source under the PSD program, nor one of the listed source categories, to continue to protect air quality in designated attainment areas, a PSD applicability analysis must be conducted for each Federal project. NASA ensures that before each project is initiated, PTE is calculated to not only assess whether a permit to construct for applicable sources is needed, but also to document that the entire project does not trigger PSD.

Minor New Source Review

The minor NSR permit program applies to the construction, reconstruction, relocation, or modification of any stationary source that will emit regulated air pollutants above minimum exemption levels. If a permit is required, it must be obtained before any activity on the project can begin. Prior to installing any new stationary emission sources, NASA is responsible for assessing if a permit-to-construct application is necessary, and if so, for preparing and filing the applicable Form 7 permit application forms.

New Source Performance Standards

New Source Performance Standards (NSPS) regulations (40 CFR 60) establish pollutant emission limits and monitoring, reporting, and recordkeeping requirements for various emission sources based on source type and size. These regulations apply to new, modified, or reconstructed sources. According to the State operating permit, and confirmation by NASA environmental personnel, there are no emission sources (i.e., boilers, storage vessels, emergency generators) that are subject to NSPS.

National Emission Standards for Hazardous Air Pollutants

Section 112(a) of the CAA Amendments requires the development of emission standards for listed HAPs from new and modified equipment at stationary major and area sources (i.e., a source that is not a major HAP source). Emission standards promulgated under this subsection require the maximum degree of reduction in emissions of HAPs for specific source categories. The standards are to be established by taking into consideration the cost of achieving such emission reductions, and any non-air quality health and environmental impacts and energy requirements.

NESHAP regulations, codified at 40 CFR Parts 61 and 63, regulate HAP emissions. Part 61 was promulgated prior to the 1990 CAA Amendments and regulates specific HAPs: asbestos, benzene, beryllium, coke oven emissions, inorganic arsenic, mercury, radionuclides, and vinyl chloride. The 1990 CAA Amendments established an original list of 189 HAPs to be regulated, which resulted in the promulgation of Part 63, also known as the Maximum Achievable Control Technology (MACT) standards. These MACTs regulate emissions from major HAP sources and specific source categories that emit HAPs.

Wallops Island and Wallops Mainland are currently considered a minor or area HAP source, and are therefore not subject to NESHAP regulations for major sources. The facility would, however, be subject to area source NESHAP regulations when these regulations are promulgated by EPA.

Condition 19 of the March 24, 2008, Stationary Source Permit to Operate establishes a federally enforceable limit of 8.5 metric tonnes per year (9.4 tons per year) of hydrogen chloride (HCl) and 0.91 metric tonnes per year (1.0 ton per year) of Pb. These limits are placed on the combustion of solid fuel propellants during static rocket motor test firing events.

3.1.3.1 Regional Meteorology

WFF is located in the climatic region known as the humid continental warm summer climate zone. Large temperature variations during the course of a single year and lesser variations in average monthly temperatures typify the region. The climate is tempered by the proximity of the Atlantic Ocean to the east and the Chesapeake Bay to the west. Also affecting the climate is an oceanic current, know as the Labrador Current, which originates in the polar latitudes and moves southward along the Delmarva coastline. The current creates a wedge between the warm Gulf Stream offshore and the Atlantic coast. The climate of the region is dominated in winter by polar continental air masses and in summer by tropical maritime air masses. Clashes between these two air masses create frontal systems, resulting in thunderstorms, high winds, and precipitation. Precipitation in this climate zone varies seasonally.

Four distinct seasons are discernible in the region. In winter, sustained snowfall events are rare. Spring is wet with increasing temperatures. Summer is hot and humid with precipitation occurring primarily from thunderstorm activity. Autumn is characterized by slightly decreasing temperatures and strong frontal systems with rain and sustained winds.

Climate records are maintained by the WFF Meteorological Office. A summary of local climate data for 2007 is presented in Table 8, along with record high and low temperatures over a 44-year timeframe (NASA, 2008a).

Table 8: Temperature Records at Wallops Flight Facility

Mo	Avg Max Temp °C (°F)[1]	Avg Min Temp °C (°F)[1]	Avg Precip cm (in)[1]	Avg Hum (%)[1]	Avg Vis km (mi)[1]	Avg Wind Speed kph (mph)[1]	Record Hi °C (°F)/ Year[2]	Record Low °C (°F)/ Year[2]
Jan	6.7 (44)	-2.2 (28)	7.92 (3.12)	66.8	13.1 (8.13)	15.2 (9.42)	26.1 (79)/2002	-20 (-4)/1965
Feb	7.8 (46)	-1.7 (29)	7.67 (3.02)	59.2	12.7 (7.89)	14.8 (9.18)	26.1 (79)/1997	-20 (-4)/1971
Mar	11.7 (53)	2.2 (36)	9.65 (3.80)	61.8	13.3 (8.26)	18.0 (11.16)	30 (86)/1990	-10 (14)/ 1980, 1996
Apr	17.2 (63)	6.7 (44)	7.21 (2.84)	63.3	12.4 (7.73)	16.3 (10.13)	33.9 (93)/1990	-4.4 (24)/1969
May	21.7 (71)	11.7 (53)	7.85 (3.09)	66.7	13.9 (8.61)	15.3 (9.48)	36.1 (97)/1991	1.1 (34)/1974
Jun	26.7 (80)	17.2 (63)	8.61 (3.39)	70.6	12.5 (7.77)	14.0 (8.73)	36.1 (97)/1964	4.4 (40)/1967
Jul	29.4 (85)	20.6 (69)	9.50 (3.74)	68.8	13.6 (8.42)	12.9 (8.00)	38.3 (101)/1993	10.6 (51)/1965
Aug	28.9 (84)	20 (68)	9.73 (3.83)	72.0	12.2 (7.61)	11.8 (7.35)	38.3 (101)/1977	8.3 (47)/1982
Sept	25.6 (78)	16.1 (61)	8.90 (3.50)	70.3	15.1 (9.40)	12.5 (7.77)	35.6 (96)/1983	4.4 (40)/1970
Oct	20 (68)	10 (50)	7.57 (2.98)	72.7	12.7 (7.87)	12.8 (7.97)	32.8 (91)/2007	-3.3 (26)/1976
Nov	15 (59)	4.4 (40)	6.93 (2.73)	68.3	14.7 (9.13)	11.6 (7.23)	28.3 (83)/1974	-7.2 (19)/1967, 1974, 1976
Dec	9.4 (49)	0 (32)	8.33 (3.28)	78.8	12.1 (7.52)	13.0 (8.10)	25 (77)/1998	-15.6 (4)/1989

cm = centimeters　km = kilometers　kph = kilometers per hour
in = inches　mi = miles　mph = miles per hour

[1] Average Maximum Temperature, Minimum Temperature, Precipitation, Humidity, Visibility, and Wind Speed are based on data, by month, from January 1, 2007, through December 31, 2007.
[2] Record High Temperatures and Low Temperatures are based on a 44-year time period from 1963 through 2007.
Source: Wallops Range User's Guide, 2007.

For Wallops Island, prevailing winds in the fall and winter tend to be from the northwest, but stormy nor'easters can occur. These 2- to 3-day storms produce severe conditions offshore, with high winds, cold rain, and steep seas due to the open distance of water over which wind can blow from the northeast. Prevailing winds in the summer are southerly, increasing in mid-morning to typically lower than 20 knots and usually dying down at dusk. Offshore fog is uncommon, but can be produced during the spring when a warm, moist, southerly flow of air passes over the cold ocean water.

Winds at Wallops Island are an important influence on the physical environment, as well as on the success of the NASA and MARS missions. Launch vehicles operate under very narrow wind conditions; therefore wind speed and direction are constantly monitored prior to a launch. Wind speeds are the strongest during the fall and winter months, with winds exceeding 55 kilometers per hour (kph, 30 knots) more than 5 percent of the time from November through February. Wind speeds peak in December, when winds exceed 55 kph (30 knots) more than 6 percent of the time. During these months, the predominant wind direction is from the northwest. During March and April, winds are more southerly but still strong. March winds exceed 55 kph (30 knots) nearly 5 percent of the time.

An inversion is another meteorological aspect that affects NASA and MARS missions, whereby ambient air temperature increases with height for some distance above the ground (as opposed to the normal decrease in temperature with height). This effect traps cold air beneath warm air and does not allow emissions (for example, rocket exhaust) to rise and disperse properly. Table 9 describes the temperature, wind structure, and characteristic mixing rate.

Table 9: Dispersion Characteristics within Selected Atmospheric Layers

Atmospheric Layer Altitude Range	Temperature Structure	Wind Structure	Characteristic Mixing Rate
Below nocturnal inversion 0–500 m	Increase with height	Very light or calm	Very poor
Below subsidence inversion 0–1500 m	Decrease with height to inversion base	Variable	Generally fair to inversion base
Troposphere 0.5–20 km	Decrease with height	Variable; increase with height	Generally very good
Stratosphere 20–67 km	Isothermal or increase with height	Tends to vary seasonally	Poor to fair
Mesosphere-Thermosphere Above 67 km	Decrease with height	Varies seasonally	Good

Source: NASA, 2005

3.1.3.2 Atmosphere

The Earth's atmosphere is best described in terms of four principal layers: the troposphere, the stratosphere, the mesosphere, and the ionosphere. These layers have indistinct boundaries. They are identified by temperature, structure, density, and composition.

The lowest level of the atmosphere, the troposphere, extends upward from the Earth's surface to approximately 10 kilometers (6.2 miles). The Earth's weather evolves within this very turbulent region. This layer contains an estimated 75 percent of the total mass of the atmosphere. Solar radiation penetrates the atmosphere, causing heating at the surface that decreases with height within the lower atmosphere. This variation in temperature makes the troposphere the most dynamic of the four atmospheric layers. The troposphere is composed of 76.9 percent nitrogen and 20.7 percent oxygen by weight. The relative concentrations of these gases are highly uniform throughout the lower atmosphere. Water vapor is the next largest component (1.4 percent average by volume throughout the lower atmosphere), although its concentration is rather variable near the Earth's surface. Trace gases make up the remainder of the lower atmosphere. These gases, in order of decreasing amount, are argon, carbon dioxide, neon, helium, methane, krypton, nitrous oxide, hydrogen, xenon, and ozone.

The stratosphere extends from 10 to 50 kilometers (6.2 to 31 miles) and is identified by both physical stability and maximum ozone concentration. It is characterized by an increase in temperature and a decrease in density with altitude. This is due to the ozone layer, which absorbs ultraviolet solar radiation and reradiates it back at longer wavelengths. The base of the stratosphere is marked by an increase in ozone concentration over levels found in the troposphere. The highest ozone concentrations are found near the middle of the stratosphere, in the center of the ozone layer, at approximately 25 kilometers (15.5 miles).

An ozone molecule contains three atoms of oxygen and is produced by the chemical combination of an oxygen molecule with an atom of oxygen. Atomic oxygen is produced by the breakdown of molecules of oxygen, nitrogen dioxide, or ozone. The ozone distribution in the stratosphere is maintained as the result of a dynamic balance between creation and destruction mechanisms. The distribution fluctuates seasonally by approximately 25 percent and annually by approximately 5 percent. Although it comprises only several parts per million (ppm) in the stratosphere, ozone absorbs virtually all ultraviolet solar radiation of wavelengths less than 295 Angstroms, and much of the radiation in the range of 290 to 320 Angstroms (the ultraviolet-B region). Ozone also contributes to the heat balance of the Earth by absorbing radiation in the infrared, near the 9,600-Angstrom wavelength.

The mesosphere extends from 50 to 80 kilometers (31 to 50 miles) and is a transition layer between the stratosphere and the ionosphere. The base of the mesosphere marks the upper boundary of the ozone layer. This area is warmed by the absorption of solar ultraviolet energy by ozone. Ozone production/destruction also occurs in the lower part of the mesosphere, although these mechanisms are most critical in the stratosphere. The temperature and density of the mesosphere decrease with altitude, reaching a minimum at the top of the mesosphere.

The ionosphere, or thermosphere, which extends from 80 to beyond 1,000 kilometers (50 to 621 miles), is characterized by high ion and electron density. Although this region is significantly less dense compared to the atmosphere at the Earth's surface, it still causes some drag on satellites orbiting within it. The ionosphere's several layers of differing properties are particularly important to low-frequency radio communications. It is also the region where the auroras originate. The ionosphere is influenced by solar radiation, variations in the Earth's magnetic field, and motion of the upper atmosphere. Because of these interactions, the properties of the ionosphere vary greatly with time (daily, seasonally, and over the approximately 11-year solar cycle) and geographical latitude (NASA, 2005).

3.1.3.3 Emissions from Rocket Launches

NASA and MARS routinely launch suborbital and orbital rockets. During a typical flight of a three-stage rocket, several materials are ejected into the atmosphere. As propellant is burned from the first-, second-, and third-stage rockets, exhaust gases and products of combustion mix with the air and are dispersed by the wind. Chemicals, usually gaseous or liquid, may be released from a scientific payload in the higher reaches of the trajectory, mix with the air, and become driven by the wind. The rocket components outgas materials due to low pressure and aerodynamic heating. In guided rockets, attitude control fluids or gases may be released. Rockets with guidance systems are also equipped with destruct systems that rupture the propellant tanks and release all remaining propellants in the event of an in-flight vehicle failure. Under normal launch conditions, all of these emitted compounds are distributed along the rocket trajectory. Burn times per stage vary per rocket. The quantities emitted per unit length of the trajectory are greatest at ground level and decrease continuously as the rocket launches (NASA, 2005). Combustion products emitted from solid rocket propellant are predominantly aluminum oxide (Al_2O_3), CO, HCl, water (H_2O), nitrogen (N_2), carbon dioxide (CO_2), and hydrogen (H_2). The meteorological rockets also emit SO_2 and a small amount of Pb. Liquid-fueled rockets predominately emit PM_{10}, SO_2, nitrogen dioxide (NO_2), CO, and volatile organic compounds (VOCs). The criteria and HAP emissions are regulated by the EPA and the Commonwealth of Virginia under the State-adopted NAAQS. Because rockets are considered mobile emission sources, they are not required to be permitted by the EPA.

3.1.3.4 Prevention of Accidental Releases

Section 112(r) of the CAA Amendments, the Prevention of Accidental Releases, requires owners and operators of stationary sources to identify onsite hazards and describe the appropriate steps used to prevent and minimize the effects of an accidental release involving an extremely hazardous substance (EHS), such as hydrazine. Section 112(r)(7) applies to facilities that have more than a threshold quantity of a toxic (ranges from 225 to 9,000 kg [500 to 20,000 lbs]) or flammable (4,500 kg [10,000 lbs]), and requires preparation of a Risk Management Plan.

Wallops Island has been assessed for its applicability to this rule, and no Risk Management Plan is required. However, Section 112(r)(1) applies to any owner or operator of stationary sources producing, processing, handling, or storing any EHS. There are no chemical quantity threshold levels associated with this section, known as the General Duty Clause (GDC). Although there is no definition of an EHS, there are criteria that can be used to determine if a substance is extremely hazardous. According to a 1989 Senate Report on the CAA there are criteria that EPA may use to determine if a substance is extremely hazardous. The report expressed the intent that an EHS is any agent that may or may not be listed[1] or otherwise be identified by any government agency, which may as the result of short-term exposures associated with releases to the air cause death, injury, or property damage due to its toxicity, reactivity, flammability, volatility, or corrosivity. The GDC is a performance-based provision, which recognizes that owners and operators have primary responsibility in the prevention of onsite chemical accidents. It requires the owner/operator to be continuously vigilant about hazards and it is a continuing obligation, rather than a one-time compliance event.

As part of this responsibility, facilities must develop and implement standard operating procedures to manage the risk associated with the storage and handling of chemicals, regardless of their amount. NASA has prepared an Integrated Contingency Plan (ICP), which combines

[1] EHS are not limited to the list of regulated substances listed under Section 112(r), nor the extremely hazardous substances under EPCRA §302 (40 CFR Part 355, Appendices A and B).

requirements and provides for the implementation of several plans (i.e., Spill Prevention Control and Countermeasures Plan, Hazardous Substance Contingency Plan, Hazardous Waste Operations and Emergency Response, and SWPPP). Its purpose is "to minimize hazards to human health and the environment from fires, explosions, or from any unplanned, sudden, or gradual releases of oil or hazardous substance to the air, soil, surface water, or sanitary sewer system at the facility" (NASA, 2001b). In addition, as described in further detail in Section 4.4.3 (Health and Safety), WFF conducts its operations in accordance with its Range Safety Manual, Hydrazine Contingency Plan, and project-specific Ground Safety Plans. NASA routinely works with onsite and local emergency organizations to ensure these plans can be implemented effectively if needed.

3.1.3.5 Open Burning

On the south end of Wallops Island, NASA operates an Open Burn Area for the treatment of hazardous waste solid fuel rocket motors and igniters. Rocket motors that do not meet launch or test specifications and cannot be reused are thermally treated in this area to render them non-reactive. On average, the Open Burn Area is used 4 days a year. The primary combustion products from the thermal destruction process are the same as those resulting from the launch of rockets containing these motors, which include CO, CO_2, water, N_2, H_2, HCl, Al_2O_3, and Pb.

3.1.3.6 Halon

Bromotrifluoromethane (trade name Halon-1301) is used as a fire suppression and explosion protection agent in the aviation and space flight industry. Halon contains bromine, which is known to destroy the upper ozone in the stratospheric layer. Halon-1301 is used as an effective fire and explosion suppression agent during launch activities. This chemical is regulated by the EPA under 40 CFR Part 82 Subpart H, Protection of Stratospheric Ozone. The regulation bans the manufacture of blends of these halons (i.e., blends containing two or more halons) and requires organizations to provide training on halon emissions reduction to any technicians who test, maintain, service, repair, or dispose of halon-containing equipment (40 CFR 82.270(c)). Technicians must receive on-the-job training within 30 days of hiring to satisfy the training requirement. They should be trained regarding control of the process to ensure minimal losses of halon to the atmosphere (EPA, 2001).

The EPA does not establish numeric limits on the quantities of Halon-1301 that can be released to the atmosphere for fire suppression use, but does prohibit the intentional release of it during repair, testing, technician training, and disposal of equipment that contains halon. Halon and halon-containing equipment must be properly disposed of at the end of its useful life; proper disposal is defined as sending such equipment for halon recovery for recycling by an acceptable facility that operates in accordance with National Fire Protection Association Standard 10 and Standard 12A, or destruction using one of several processes identified in the rule (EPA, 2001).

Section 604 of the CAA set phaseout targets of Class I ozone-depleting substances, which include halon; therefore, the production and import of virgin (non-recycled) halons have currently been phased out in the U.S. There are a few exceptions to the import of halon, and the import of halon contained within rockets would qualify as one of the exceptions.

3.1.4 Noise

The EPA's Noise Control Act of 1972 (42 U.S.C. 4901 to 4918) as amended by the Quiet Communities Act of 1978, states that it is the policy of the United States to promote an environment for all Americans free from noise that jeopardizes their health or welfare.

3.1.4.1 Noise Standards and Criteria

Noise is defined as any loud or undesirable sound. The standard measurement unit of noise is the decibel (dB), generally weighted to the A-scale (dBA), corresponding to the range of human hearing (Table 10). Since sounds in the outdoor environment are usually not continuous, a common unit of measurement is the L_{eq}, which is the time-averaged sound energy level. The L_{10} is the sound level exceeded 10 percent of the time and is typically used to represent peak noise levels. Similarly, the L_{01} and L_{90} are the noise levels exceeded 1 percent and 90 percent of the time, respectively. The 1-hour L_{eq} is the measurement unit used to describe monitored baseline noise levels in the vicinity of WFF. It conforms to the requirements in 23 CFR Part 772 and is a descriptor recommended by the Federal Highway Administration for describing noise levels during peak traffic periods. EPA guidelines, and those of many other Federal agencies, state that outdoor sound levels in excess of 55 dB night level are "normally unacceptable" for noise-sensitive land uses such as residences, schools, or hospitals.

The U.S. Occupational Safety and Health Administration (OSHA) regulates noise impacts to workers. OSHA regulations on noise standards ensure that workers are not exposed to noise levels higher than 115 dBA. Exposure to 115 dBA is limited to 15 minutes or less during an 8-hour work shift. Exposure to impulsive or impact noise (loud, short duration sounds) is not to exceed 140 dB peak sound pressure level.

Table 10: Typical Noise Levels of Familiar Noise Sources and Public Responses

Thresholds/Noise Sources	Sound Level (dBA)	Subjective Evaluation[a]	Possible Effects on Humans[a]
Human threshold of pain	140	Deafening	Continuous exposure to levels above 70 dBA can cause hearing loss in the majority of the population
Siren at 100 feet Loud rock band	130		
Jet takeoff at 200 feet Auto horn at 3 feet	120		
Chain saw Noisy snowmobile	110		
Lawn mower at 3 feet Noisy motorcycle at 50 feet	100	Very Loud	
Heavy truck at 50 feet	90		
Pneumatic drill at 50 feet Busy urban street, daytime	80	Loud	
Normal automobile at 50 mph Vacuum cleaner at 3 feet	70		Speech interference
Air conditioning unit at 20 feet Conversation at 3 feet	60	Moderate	

Thresholds/Noise Sources	Sound Level (dBA)	Subjective Evaluation[a]	Possible Effects on Humans[a]
Quiet residential area Light auto traffic at 100 feet	50		Sleep interference
Library Quiet home	40	Faint	
Soft whisper at 15 feet	30		
Slight rustling of leaves	20	Very Faint	
Broadcasting studio	10		
Threshold of Human Hearing	0		

[a]Both the subjective evaluations and the physiological responses are continuums without true threshold boundaries. Consequently, there are overlaps among categories of response that depend on the sensitivity of the noise receivers.
Source: EPA, 1974

The Accomack County code states that "...any loud, disturbing, or unreasonable noise in the county, which noise is of such character, intensity or duration as to be detrimental to the life, health, or safety of any person, or to disturb the quiet, comfort, or response of any reasonable person" is prohibited (Accomack County, 2001). Table 11 shows the specific noise limitations by land use as regulated by Accomack County.

Table 11: Accomack County Noise Guidelines by Land Use

District/Land Use	Daytime Level (dBA)	Nighttime Level (dBA)
Residential	65	55
Agricultural	65	55
Business	70	60
Industrial	70	60
Barrier Island	65	55

Source: Accomack County, 2001

As a general rule, the above levels should not be exceeded; however, exceptions to the rule exist. According to Article II, Section 38-35 of the Accomack County code, "This article shall not apply to noises generated by commercial or industrial operations except for those noises that emanate from the boundaries of such commercial or industrial site and affect persons who are not working onsite at such commercial or industrial operation." Noise levels from rocket launches attenuate rapidly, are low frequency, and occur infrequently. There are no County-specific regulations regarding unacceptable levels of dBA at noise-sensitive receptors such as schools, hospitals, courts, and churches; although the Accomack County code states that noise would be deemed excessive when it "unreasonably interferes with the workings of such institution or building, provided that conspicuous signs are displayed on or near such building or institution indicating that such is a school, church, hospital, clinic or other public building."

Noise sources associated with activities on Wallops Island include vehicular and air traffic, and target and rocket launches. In general, vehicular traffic on Wallops Island is minimal, and rocket launches are relatively infrequent and of short duration. WFF and Navy air traffic from the Main Base flies over Wallops Mainland and Wallops Island. Wind, wildlife, and wave action are the predominant sources of naturally occurring noise on Wallops Island.

Noise levels and frequencies from rocket launches are basically dependent upon the thrust of the rocket motors. The Conestoga launch vehicle is the largest rocket launched from Wallops Island to date. An overall sound pressure level (OSPL) of approximately 107dB resulting from the Conestoga could extend as far as 12.07 kilometer (7.5 miles) from the launch site. The towns of Atlantic and Chincoteague, as well as some farms, are located within this 12.07-kilometer (7.5-mile) radius. The OSPL would be maintained for one to two seconds and then rapidly decrease.

Although a maximum of 12 launches per year can occur at WFF, since 2001, NASA has averaged six sounding rocket launches and one orbital launch per year from the launch areas on Wallops Island. The marshland and water surrounding Wallops Island act as a noise buffer zone due to the sound absorption capacity of the vegetation. Noise levels from rocket launches attenuate rapidly, are low frequency, and occur infrequently. According to the WFF Public Affairs Office, no complaints have been received from the public regarding noise resulting from a rocket launch (Flowers, pers. comm.).

3.1.4.2 Noise Monitoring Program

In 1992, WFF performed a noise monitoring survey and modeling program to determine baseline noise levels around the facility. Of the thirteen sites selected for the noise-monitoring program, four were on Wallops Island and one was in the town of Assawoman along the route to Wallops Island.

Noise levels at each site were monitored for periods ranging from 15 minutes to 1 hour, depending on the site and predominant source of noise. A period of 1 hour was used at sites monitored during peak traffic conditions. Shorter periods were used for sites monitored during off-peak traffic conditions and sites in natural environments where noise levels were relatively constant.

Wallops Island was found to contain a wide range of background noise levels. At the northern portion of Wallops Island, natural sounds of wind, trees, and birds are the predominant source of the 53-dBA noise level. At the southern end of the island, as well as along the eastern seawall, the sounds of water and waves generate a noise level of about 64 dBA. In the interior of the island, near roads and buildings, noise levels are about 61 dBA during off-peak traffic periods and 64 to 65 dBA during peak a.m. and p.m. traffic (NASA, 2005).

3.1.4.3 Subsonic and Supersonic Noise (Sonic Booms)

Subsonic noise is defined as the noise caused by a designated medium having a speed less than that of sound (referred to as Mach 1). Aircraft and rocket launches are the primary sources of subsonic noise at WFF, but cannon fire, gun fire, and machinery operation also contribute.

Supersonic noise (a sonic boom) is defined as the noise caused by a designated medium having a speed greater than Mach 1. The energy range of sonic booms is concentrated in the 0.1 to 100 hertz (Hz) frequency range, which is considerably below that of subsonic aircraft, gunfire, and most industrial noise. The largest portion of the total acoustic energy produced by a launch vehicle is usually contained in the low-frequency end of the spectrum (1 to 100 Hz). Launch vehicles also generate sonic booms. A sonic boom differs from other sounds in that it is impulsive and very brief. Because a sonic boom is not generated until the vehicle reaches supersonic speeds, the launch site itself does not experience a sonic boom. The entire boom footprint is typically in the area of 19 kilometers (12 miles) downrange of the launch site and directed skyward along the trajectory of the rocket (Patterson, pers. comm.).

The duration of a sonic boom is brief—less than a second: 100 milliseconds (0.100 second) for most fighter-sized aircraft and 500 milliseconds (0.500 second) for the space shuttle or Concorde jetliner.

Aircraft are prohibited from causing supersonic noise in the airspace over WFF unless a waiver is granted by the Flight Standards Office of the FAA. Supersonic flights over the Atlantic must be coordinated through the Navy's Virginia Capes Fleet Area Control and Surveillance Facility. Supersonic, low-flying rocket and target launches that cause sonic booms are limited to Wallops Island eastward over the Atlantic Ocean (NASA, 2005).

3.1.5 Orbital and Reentry Debris

Orbital debris, as a result of U.S. and foreign space activities, may reenter the Earth's atmosphere. NASA's launch project managers must employ design and operation practices that limit the generation of orbital debris, consistent with mission requirements and cost effectiveness. NPR 8715.6, "NASA Procedural Requirements for Limiting Orbital Debris," requires that each program or project conduct a formal assessment for the potential to generate orbital debris. General methods to accomplish this policy include:

- Depleting onboard energy sources after completion of mission
- Limiting orbit lifetime after mission completion to 25 years or maneuvering to a disposal orbit
- Limiting the generation of debris associated with normal space operations
- Limiting the consequences of impact with existing orbital debris or meteoroids
- Limiting the risk from space system components surviving reentry as a result of post-mission disposal
- Limiting the size of debris that survives reentry

3.1.6 Hazardous Materials and Hazardous Waste

3.1.6.1 Hazardous Materials Management

The WFF ICP, developed to meet the requirements of 40 CFR Part 112 (Oil Pollution Prevention and Response), 40 CFR Part 265 Subparts C and D (Hazardous Waste Contingency Plan), and 9 VAC 25-91-10 (Oil Discharge Contingency Plan), serves as the facility's primary guidance document for the prevention and management of oil, hazardous material, and hazardous waste releases. The ICP includes the following procedures for hazardous materials management at the entire WFF facility, including Wallops Island:

- Each container of hazardous material is labeled in English with the following minimal description: name of chemical and all appropriate hazard warnings.

- Each work area has Material Safety Data Sheets (MSDSs) on file for each hazardous material used onsite. Each MSDS is in English and contains all required information. WFF utilizes an online electronic chemical inventory that contains links to appropriate MSDSs and is accessible to all WFF personnel through the GSFC intranet. Individual WFF support contractor offices train their personnel in the applicable hazardous communication pertinent to the requirements for each employee.
- Spill contingency and response procedures are prepared and implemented.
- The WFF Environmental Office offers annual ICP training to all Wallops and tenant personnel as well as to all visiting project teams.

3.1.6.2 Hazardous Waste Management

The regulations that govern hazardous waste management are the Resource Conservation and Recovery Act (RCRA, 42 U.S.C. 6901 *et seq.*) and Virginia's Hazardous Waste Management Regulations (9 VAC 20-60). A solid waste is any material that is disposed, incinerated, treated, or recycled except those exempted under 40 CFR 261.4. All hazardous wastes are classified as solid wastes. Wallops Main Base is separated from Wallops Island and Wallops Mainland by approximately 11.2 kilometers (7 miles) of public roadway. As they are not contiguous, each has been assigned its own EPA hazardous waste generator number. Shipment of hazardous waste between the two sites is illegal except by a licensed hazardous waste transporter. To facilitate the transportation of rocket motors declared hazardous waste from the Main Base to the Wallops Island, NASA has its own hazardous waste transporter license. NASA uses licensed hazardous waste transporters to transport hazardous waste off site to licensed treatment, storage, and disposal facilities.

Wallops Island and Wallops Mainland are together classified as a Large Quantity Generator because the area has the potential to generate more than 1,000 kg (2,205 lbs) of hazardous waste per month. In calendar year 2007, 4,070 kg (8,972 lbs) of hazardous waste including various expired chemicals, jet fuel mixed with hydraulic fluid, used oil, oily condensate, oily rags, paint cans, and paint thinner were generated on Wallops Island and Wallops Mainland combined (NASA, 2008a). Hazardous wastes generated on Wallops Island are stored on the Mainland at Building U-081, a less-than-90-day accumulation area in which hazardous waste may be stored for up to 90 days from the date of initial accumulation. In addition, Satellite Accumulation Areas are established in individual laboratories, shops, or other facilities designated by the generator for the accumulation of waste, not to exceed 208 liters (55 gallons) of hazardous waste, or 0.95 liter (1 quart) of extremely or acutely hazardous waste.

Wallops Island hazardous waste generators are responsible for the following:

- Properly containerizing waste
- Properly labeling waste containers with information pertaining to the contents and with the words "Hazardous Waste"
- Ensuring that less than 208 liters (55 gallons) of hazardous waste or less than 0.95 liter (1 quart) of acute hazardous waste are accumulated at or near the point of generation
- Properly completing and transferring a disposal inventory sheet to the NASA Environmental Office

3.1.6.3 Petroleum Storage Tank Management

Supporting the Wallops Island facilities are a total of 21 above ground storage tanks (ASTs) and 2 underground storage tanks (USTs). Both the ASTs and USTs are used for the storage and dispensing of heating oil. Occasionally, temporary tanks are brought to Wallops Island during construction activities and typically contain diesel fuel and gasoline. All fuel storage tanks must be operated in accordance with Virginia storage tank regulations (9 VAC 25-91 [AST] and 9 VAC 25-580 [UST]), which are overseen by the VDEQ Tidewater Regional Office.

3.1.7 Radiation

Radiation-emitting materials and equipment are used at WFF in space flight research, earth sciences research, atmospheric research, testing and integration of space flight hardware, and communications. Radiation-emitting materials and equipment are used and stored under a comprehensive radiation protection program. NASA's Safety Office administers the program, and the GSFC Radiation Safety Committee provides oversight.

Radiation-emitting materials and equipment can be classified as either ionizing or non-ionizing radiation. Ionizing radiation is any type of radiation capable of directly or indirectly producing ions as it passes through a medium. In general, ionizing radiation has considerably greater kinetic energy than non-ionizing radiation. Non-ionizing radiation is not strong enough to produce free ions as it passes through media (NASA, 2005).

3.1.7.1 Ionizing Radiation

The Federal Nuclear Regulatory Commission (NRC) licenses the use and storage of ionizing source material, special nuclear material, and byproduct material. Source material is any radioactive material that contains at least 0.05 percent by weight of uranium and/or thorium, excluding special nuclear material. Special nuclear material is plutonium, uranium 233, or uranium enriched in the isotopes 233 or 235. Byproduct material is any radioactive material derived from production or use of special nuclear material.

The NRC has issued license number 19-05748-02 to NASA for NRC-regulated radioactive materials. The NRC license is considered a Broad Type A license, generally issued to large facilities with comprehensive radiological programs. The license requires NASA to have a Radiation Safety Officer and a committee to act in place of the NRC in making day-to-day decisions.

Sources of ionizing radiation include radioactive materials for science instruments and experiments and for instrument calibration. They are used in the laboratory, in the field, and aboard payloads. There is no permanent storage of radioactive sources at WFF except for NASA's two calibration sources for radiation monitoring equipment (NASA, 2005).

3.1.7.2 Non-Ionizing Radiation

Rocket launches and payloads may use or contain equipment that produces non-ionizing radiation including lasers, radars, microwaves, and ultraviolet and high-intensity lamps. The biological effects of lasers are well known, including damage to the eye or skin. The hazards of lasers are also well known, and proper handling techniques have been developed and implemented (NASA, 2005). Per OSHA Directive STD 01-05-001-PUB 8-1.7, *Guidelines for Laser Safety and Hazard Assessment*, and Chapter 6, "Laser Hazards," of Section III, "Health Hazards," of OSHA Technical Manual TED 01-00-015 (TED 1-0.1 5A), all laser operators must be trained in the proper use of the class of lasers they use. All lasers can be classified into one of four categories based on use and light intensity in compliance with the American National Standard Institute (ANSI) standard 7136.6:

- Class I lasers are considered exempt and are typically enclosed in a protective device. Control measures are not required for the operation of a Class I laser.
- Class II lasers are low-power visible continuous wave and high pulse-rate frequency lasers. These lasers are incapable of producing eye injury within the duration of a blink. If a user stares directly into the laser beam, eye injury can occur.
- Class III lasers are medium-power lasers. These lasers can cause serious eye injury if the user looks directly into the beam.
- Class IV lasers are high-power lasers and are usually only found in controlled research laboratory settings. These lasers can present serious skin and eye hazards and can ignite flammable targets, create hazardous airborne contaminants, and have a potentially lethal, high-current, high-voltage power supply.

Sources of radio-frequency radiation that produce power densities greater than 100 milliwatts per square centimeter are also potentially hazardous. Sources of radio frequency radiation associated with rocket launches at WFF often include radar units, induction heating devices, and radio-frequency generators. Radio frequency radiation is measured by the Safety Office.

The DOD establishes permissible exposure limits for personnel exposed to radiation based on international standards. The DOD Radio Frequency Safety Standard (DOD Instruction 6055.11), which is in agreement with the general industry consensus standard (IEEE C95.1-1999), assumes worst-case conditions in developing the frequency dependent permissible exposure limits used to determine potential Hazards of Electromagnetic Radiation to Personnel (HERP) limits. The NASA Safety Office implements DOD Instruction 6055.11 for WFF and MARS.

Potential Hazards of Electromagnetic Radiation to Ordnance (HERO) are determined by the NASA Safety Office for radio frequency emitting systems at WFF because electro-explosive devices may be accidentally initiated or their performance degraded by exposure to radio frequency environments. Some of the systems on Wallops Island have been qualified as HERO safe or HERO susceptible by U.S. Navy or Air Force testing. Navy criteria for HERO are established in Ordnance Publication 3565, based on average radiated power density over a relatively short time period as opposed to the longer time periods used for HERP analyses (NASA, 2005).

3.1.8 Munitions and Explosives of Concern

Munitions and Explosives of Concern (MEC) are explosive munitions (bombs, shells, grenades, etc.) that did not function as designed and may pose a risk of detonation. According to a map of historic Ordnance and Explosives Impact Areas dated September 2006, there are nine known historic live fire and bombing areas off of Wallops Island; none of these are currently active. On the northernmost portion of the island, there was a target center, active between 1946 and 1959, and the Gunboat Point bombing area, used in 1952, with a firing line that extended approximately 3.2 kilometers (2 miles) southeast into the ocean. Along this firing line, there was also a sea target, utilized in the late 1940s and early 1950s, located approximately 1.6 kilometers (1 mile) out to sea. A machine gun and rocket firing area, used in the 1950s, was located on the northern portion of the island with a line of fire that extends approximately 8 kilometers (5 miles) southeast into the ocean. An explosive ammunition test facility was located on the central portion of the island shoreline with a firing line that extends approximately 8 kilometers (5 miles) east-southeast into the ocean. A strafing target, used to test aircraft machine guns, was located on land on the northeastern tip of Wallops Island.

3.2 BIOLOGICAL ENVIRONMENT

3.2.1 Vegetation

Wallops Island is a barrier island that contains various ecological succession stages, including beaches, dunes, swales, maritime forests, and marsh. These natural vegetative zones form a series of finger-like stands that merge or grow into each other. The northern and southern dune vegetation on Wallops Island directly borders saltmarshes.

The dune system from east to west includes the sub-tidal zone, inter-tidal zone, and upper beach zone. The inter-dune swale zone includes the area located between the westernmost portion of the dune zone and the maritime zone. The dune and swale zone is an extremely harsh environment. Biotic resources in this zone must be very adaptable to contend with high temperatures, high winds, salt, sandblasting, drought, and low nutrient levels in the sandy soil medium (NASA, 2008a). Dominant species within the dune system include seabeach orach (*Atriplex arenaria*), common saltwort (*Salsola kali*), sea rocket (*Cakile edentula*), American beachgrass (*Ammonphila breviligulata*), seaside goldenrod (*Solidago sempervirens*), and common reed (*Phragmites australis*).

The sub-tidal zone on the eastern side of Wallops Island extends from the lower limit of low tide to the seaward-most limit of wave action. Because of the dynamics of wave action, few plants exist in the sub-tidal zone. Phytoplankton are prevalent, as well as macroalgae, and algae attached to substructure.

The inter-tidal zone is a transition zone exposed during low tide and totally submerged at high tide. The inter-tidal zone is an extremely dynamic area. Plant species are virtually nonexistent in the inter-tidal zone located on the eastern portion of Wallops Island because of the deleterious effects of wave action on the stability of the zone. Microscopic plants and animals exist in the minute spaces between individual sand grains in the eastern inter-tidal zone.

The upper beach zone extends from the high tide mark to the crest of the easternmost dune. On Wallops Island this zone is found on the northern and extreme southern sections of the island. The remaining eastern section of the island is a developed, operational area that is protected by an extensive seawall built where the upper beach zone would normally exist. Vascular plant life maintains a tenuous foothold in this area. Plants such as sea rocket and beach grass are scattered on the northern part of the island.

On the southern part of Wallops Island, the dune and swale zone extends to the tidal marsh on the western side of Wallops Island with no maritime forest present. In the central and northern areas, the dune and swale zone extends to the maritime zone that starts where the secondary dune line once existed. The northern part of Wallops Island within the dune and swale zone is in an almost natural state, and is dominated by northern bayberry (*Morella pensylvanica*), wax myrtle (*Morella cerifera*), groundsel-tree (*Baccharis halimifolia*), and American beachgrass.

The central portion of Wallops Island is dominated by common reed and maintained lawn areas. Common reed is invasive and has the ability to grow in areas with very low habitat value; it is considered by many to be an undesirable plant. Due to its successful competition with many other plant species, the common reed has virtually taken over much of the area in the center of Wallops Island.

A small area of maritime forest zone exists on the central portion of the island, with an expansive thicket zone on the northern part. The thicket zone is dominated by extensive clusters of northern bayberry, wax myrtle, and groundsel-tree. The thicket zone in some areas is virtually impenetrable due to dense stands of poison ivy (*Toxicodendron radicans*) and greenbriar (*Smilax* spp.), which is also pervasive on other areas of Wallops Island. The northern maritime forest zone is dominated by loblolly pine (*Pinus taeda*) and cherry trees (*Prunus* spp.), with an understory of northern bayberry, wax myrtle, and groundsel-tree.

Between Wallops Island and Mainland extends 461 hectares (1,140 acres) of tidal marsh. A tidal marsh is an area of low-lying wetlands that is influenced by the tides. The marsh is interlaced with small streams known locally as "guts." The marsh itself can be divided into the low marsh and the high marsh—each a distinctive community. The low marsh, which is inundated at high tide, is dominated by saltmarsh cordgrass (*Spartina alterniflora*). The high marsh, which is flooded by approximately 50 percent of the high tides, is dominated by salt meadow cordgrass (*S. patens*). As the marshes provide suitable habitat for both feeding and reproduction, these areas are of tremendous importance to marine life and to the terrestrial and avian species that depend on the marshes for their existence (NASA, 2008a).

3.2.2 Terrestrial Wildlife and Migratory Birds

Wallops Island hosts both terrestrial and aquatic forms of fauna that comprise its biotic communities. Terrestrial and aquatic species are particularly concentrated in the tidal marsh areas, which provide abundant habitat.

The Migratory Bird Treaty Act (MBTA, 16 U.S.C. 703-712) was enacted to ensure the protection of shared migratory bird resources. The MBTA prohibits the take and possession of any migratory bird, their eggs, or nests, except as authorized by a valid permit or license. The statutory definition of "take" is "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture or kill." A migratory bird is any species that lives, reproduces, or migrates within or across international borders at some point during its annual life cycle.

The Atlantic Flyway route is of great importance to migratory waterfowl and other birds during the spring and fall. The coastal route of the Atlantic Flyway, which in general follows the eastern seaboard, is a regular avenue of travel for migrating land and water birds that winter on the waters and marshes south of Delaware Bay. Ducks, geese, shorebirds, songbirds, and raptors pass through the Atlantic Flyway. Some species use Wallops Island as a stopover point, while others use the island and surrounding habitats as an overwintering area.

3.2.2.1 Invertebrates

Wallops Island, particularly the tidal marsh area, has an extensive variety of invertebrates. Saltmarsh cordgrass marshes have herbivorous (plant eating) insects such as the saltmarsh grasshopper (*Orchelium fidicinium*) and the tiny plant hopper (*Megamelus* spp.). Plant hopper eggs are in turn preyed upon by a variety of arthropods, the group of animals that includes insects, spiders, and crustaceans. The tidal marshes are inhabited by a number of parasitic flies, wasps, spiders, and mites. The spiders prey mostly on herbivorous insects, and mites prey primarily on microarthropods (small invertebrates) found in dead smooth cordgrass. Saltmarsh mosquitoes (*Ochlerotatus sollicitans*) and greenhead flies (*Tabanus nigrovittatus*) are prevalent insects on Wallops Island.

Particular species inhabit different areas of the marsh depending on their ability to adapt to the fluctuating tides. Many insects and arachnids (e.g., spiders and ticks) can tolerate lengthy submersions. Insects that cannot sustain long submersions tend to move up the marsh vegetation during high tide. For example, periwinkle snails (*Littorina irrorata*) and mud snails (*Ilyanassa obsoleta*) can withstand lengthy submersions and are found mainly on the marsh surface, while the majority of the predatory spiders, which are unable to withstand submersions, live within the vegetation above the mean high water level.

3.2.2.2 Amphibians and Reptiles

Amphibians and reptiles use the dune and swale zones of Wallops Island for foraging. Fowler's toad (*Bufo woodhoussei*) can be found under stands of bayberry. The green tree frog (*Hyla cinerea*) can be found in the wetter areas in the northern portion of Wallops Island. Some species of reptiles such as the black rat snake (*Elapha obsoleta*), hognose snake (*Heterodon platyrhinos*), snapping turtle (*Chelydra serpentina*), box turtle (*Terrapene carolina*), and northern fence lizard (*Sceloporus undulatus*) can be found in low-lying shrubby areas. Diamondback terrapin (*Malaclemys terrapin*) can be found in saltmarsh estuaries, tidal flats, and lagoons.

3.2.2.3 Mammals

Mammals such as white-tailed deer (*Odocoileus virginianus*), opossum (*Didelphis marsupialis*), raccoon (*Procyon lotor*), and gray squirrel (*Sciurus carolinensis*) are plentiful on Wallops Island. Raccoon and red fox (*Vulpes vulpes*) are occasionally found in the upper beach zone and the inter-tidal zone. The gray squirrel and opossum make their homes in the maritime forest along with other mammals that use other sections of the island for forage and shelter.

Mammals such as raccoon, red fox, white-footed mouse (*Peromyscus leucopus*), meadow vole (*Microtus pennsylvanicus*), rice rat (*Oryzomys palustris*), white-tailed deer, and Eastern cottontail rabbit (*Sylvilagus floridanus*) are found in the dune and swale zone.

3.2.2.4 Avifauna

During spring and fall migrations, approximately 15 species of shorebirds feed on microscopic plants and animals in the inter-tidal zone. Abundant among these are the sanderling (*Calidris alba*), semi-palmated plover (*Charadrius semipalmatus*), red knot (*Calidris canutus*), short-billed dowitcher (*Limnodromus griseus*), and dunlin (*Calidris alpina*). The willet (*Catoptrophorus semipalmutus*) is very common during the breeding season. Royal tern (*Sterna maxima*), common tern (*S. antillarum*), and least tern (*S. hirundo*) can be observed during the summer months. In addition, the piping plover (*Charadrius melodus*) and Wilson's plover (*Charadrius wilsonia)* sometimes nest on the northern and southern ends of Wallops Island.

Laughing gulls (*Larus atricilla*), herring gulls (*L. argentatus*), and great black-backed gulls (*L. marinus*) commonly forage in the upper beach zone and the intertidal zone. Forster's terns (*S. foresteri*) are common in the marshes and on occasion may winter on Wallops Island. Birds that use the shrub zones include various species of sparrows, red-winged blackbirds (*Agelaius phoeniceus*), boat-tailed grackles (*Quiscalus major*), and fish crows (*Corvus ossifragus*). Birds common in the shrub zone include the song sparrow (*Melopiza melodia*), gray catbird (*Dumetella carolinensis*), yellowthroat (*Geothlypis trichas*), and mourning dove (*Zenaida macroura*). Resident Canada geese (*Branta canadensis*) are found year-round in open upland portions of the property.

Raptors, including State endangered peregrine falcons (*Falco peregrinus*), northern harriers (*Circus cyaneus*), and osprey (*Pandion haliaetus*), inhabit the marsh areas west of Wallops Island. Great horned owls (*Bubo virginianus*) can be found in the maritime forest, and bald eagles (*Haliaeetus leucocephalus*) can often be seen flying over the facility although they do not nest on Wallops Island. There is an active bald eagle nest just north of the WFF Main Base; this nest is located more than 12.8 kilometers (8 miles) away from Wallops Island.

3.2.3 Threatened and Endangered Species

Under Section 7 of the Federal Endangered Species Act (ESA), as amended, (U.S.C. 1531-1544) Federal agencies, in consultation with the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS), are required to evaluate the effects of their actions on special status species of fish, wildlife, and plants, and their habitats, and to take steps to conserve and protect these species. Special status species are defined as plants or animals that are candidates for, proposed as, or listed as sensitive, threatened, or endangered by USFWS.

The Virginia Endangered Species Act (29 VAC 1-563 – 29.1-570) is administered by the Virginia Department of Game and Inland Fisheries (VDGIF) and prohibits the taking, transportation, processing, sale, or offer for sale of any State or federally listed threatened or endangered species. As a Federal agency, NASA voluntarily complies with Virginia's Endangered Species Act.

Table 12 shows the State and federally listed threatened or endangered species that may occur on and near Wallops Island.

Table 12: Threatened and Endangered Species in the WFF Area

Scientific Name	Common Name	Expected Seasonal Presence*	Status
Megaptera novaeangliae	Humpback Whale	All	Federally Endangered
Balaeanoptera physalus	Fin Whale	Spring, Summer	Federally Endangered
Eubalaena glacialis	Right Whale	Summer	Federally Endangered
Dermochelys coriaces	Leatherback Sea Turtle	Summer	Federally Endangered
Eretmochelys imbricate	Hawksbill Sea Turtle	Unknown	Federally Endangered
Lepidechelys kempi	Kemp's Ridley Sea Turtle	All	Federally Endangered
Charadrius melodus	Piping Plover	All	Federally Threatened/State Threatened
Caretta caretta	Loggerhead Sea Turtle	All	Federally Threatened
Chelonia mydas	Atlantic Green Sea Turtle	Unknown	Federally Threatened
Charadrius wilsonia	Wilson's Plover	All	State Endangered
Falco peregrinus	Peregrine Falcon	Fall	State Endangered
Bartramia longicauda	Upland Sandpiper	Spring, Fall Migration	State Threatened
Sterna nilotica	Gull-billed Tern	Spring, Fall Migration	State Threatened

Source: NASA, 2008a
* Source: Department of the Navy, 2002

The three federally endangered whale species are transient to the waters off Wallops Island. The Leatherback, Hawksbill, Kemp's Ridley, Loggerhead, and Atlantic green sea turtles are known to migrate along east coast beaches. One sea turtle nest was discovered on north Wallops Island in summer 2008 although none of the embryos survived to hatch. Other than this nest, sea turtle crawl tracks, a sign of potential nesting activity, have seldom been found on Wallops Island beaches.

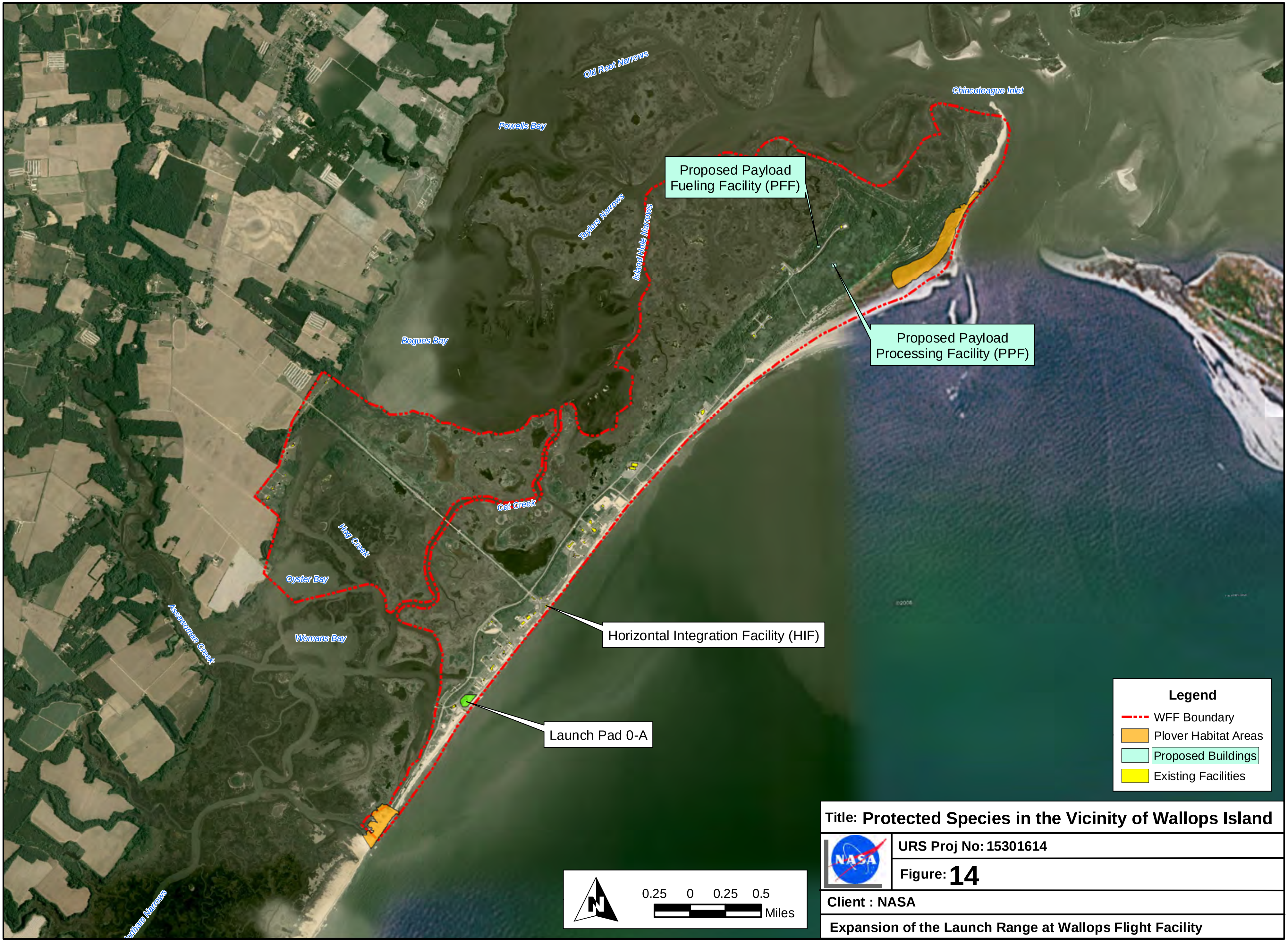
Piping plover nesting habitat has been delineated on the beaches and dunes at the northern and southern ends of Wallops Island. Wilson's plovers tend to nest with piping plovers. Gull-billed terns can be found nesting on the beaches or mud flats on Wallops Island. A resident pair of peregrine falcons nests on a hacking tower on the northwest side of Wallops Island; migrating peregrine falcons occur along the Wallops Island beach during fall migration.

Figure 14 shows the known locations of protected species in the vicinity of WFF. The ESA also regulates the critical habitat of threatened and endangered species. Critical habitat is defined as the geographical area essential to the survival and recovery of a species. Although Wallops Island is not designated as critical habitat, the piping plover is known to breed on Wallops Island; therefore, portions of the island are managed as protected areas by NASA (Figure 14). The northern and southern beaches have been closed to vehicle and human traffic during the plover's nesting season (March 15th through September 1st) since 1986. Biologists from the USFWS Chincoteague National Wildlife Refuge (CNWR) and VDGIF monitor piping plover nesting activities and provide advice to NASA on protection and management of the species. Biologists from the WFF USDA Wildlife Service Office aid with predator control.

On April 22, 1997, NASA initiated formal Section 7 consultation with USFWS for potential impacts to the piping plover from the expansion of range operations at WFF and MARS Launch Pad 0-B. On July 14, 1997, the USFWS issued a biological opinion on the effects of the range expansion on the piping plover (Appendix C). In summary, the USFWS stated that depending on the time of year, time of day, and proximity to the launch site, piping plovers may temporarily abandon the area during migration or the breeding season during a rocket launch. However, the USFWS did not anticipate that the range expansion and operations would result in the incidental take of any piping plovers because of the short duration of the disturbance, the long distance between the disturbance and the area used by plovers, the limited number of launches during the nesting season, and the lack of other disturbances (e.g., recreation) to the plovers on Wallops Island. As part of this consultation, NASA agreed to monitor piping plovers. The monitoring plan can be found in Appendix C.

3.2.4 Marine Mammals

The Marine Mammal Protection Act of 1972 (MMPA, 16 U.S.C. 1361 et seq.) prohibits the taking of marine mammals in U.S. seas. Section 101(a)(5) of the MMPA directs the Secretary of the Department of Commerce to allow, upon request, the incidental (but not intentional) take of marine mammals. There are 23 marine mammal species within the area offshore of Wallops Island (NASA, 2008a). This includes cetaceans (whales, dolphins, and porpoises) and pinnipeds (seals). See Table 13 for a list of the most common marine mammals found offshore of Wallops Island.



Title: **Protected Species in the Vicinity of Wallops Island**

URS Proj No: 15301614

Figure: 14

Client : NASA

Expansion of the Launch Range at Wallops Flight Facility

As documented in a Memorandum for the Record dated April 3, 2003, the NASA Environmental Office consulted Mr. Ken Hollingshead of the NMFS Office of Protected Resources on March 26, 2003; Mr. Hollingshead stated "WFF is not required to submit an application for the incidental take of marine mammals" as "the level of impact from WFF activities does not warrant a Letter of Authorization."

Table 13: Marine Mammals Offshore of Wallops Island

Common Name	Scientific Name	Common Name	Scientific Name
Pygmy Sperm Whale	*Kogia breviceps*	Atlantic White-Sided Dolphin	*Lagenodelphis acutus*
Dwarf Sperm Whale	*Kogia simus*	Risso's Dolphin	*Grampus griseus*
True's Beaked Whale	*Mesoplodon mirus*	Striped Dolphin	*Stenella coeruleoalba*
Blainville's Beaked Whale	*Mesoplodon densirstris*	Spinner Dolphin	*Stenella longirostris*
Sowerby's Beaked Whale	*Mesoplodon bidens*	Clymene Dolphin	*Stenella clymene*
Cuvier's-Beaked Whale	*Ziphius cavirostris*	Melon-Headed Whale	*Peponocephala crassidens*
Northern Bottlenose Whale	*Hyperoodon ampullantus*	Short-Finned Pilot Whale	*Globicephala macrorhynchus*
Rough-Toothed Dolphin	*Steno bredanensis*	Long-Finned Pilot Whale	*Globicephala melas*
Bottlenose Dolphin	*Tursiops truncates*	Harbor Porpoise	*Phocoena phocoena*
Atlantic Spotted Dolphin	*Stenella frontalis*	Harbor Seal	*Phoca vitulina*
Pantropical Spotted Dolphin	*Stenella attenuata*	Gray Seal	*Halichoerus grypus*
Common Dolphin	*Delphinus* spp.		

Source: NASA, 2003a

3.2.5 Fish

Common fish in the waters near Wallops Island include the Atlantic croaker (*Micropogonias undulatus*), sand shark (*Carcharias taurus*), smooth dogfish (*Mustelus canis*), smooth butterfly ray (*Gymnura micrura*), bluefish (*Pomatomidae saltatrix*), spot (*Leiostomus xanthurus*), and summer flounder (*Paralichthys dentatus*) (NASA, 2008a). Salinity and water depths play a major role in determining if a coastal fish species is present in the bays and inlets near the island.

3.2.5.1 Essential Fish Habitat

The tidal marsh areas of Wallops Island act as nursery grounds for a variety of fish species due to the protection the marsh grasses provide and the abundance of food (NASA, 2008a). Eelgrass, for example, provides protection to the spot, the northern pipefish (*Syngnathus fuscus*), the dusky pipefish (*Syngnathus floridae*), and the bay anchovy (*Anchoa mitchilli*).

The Magnuson-Stevens Fishery Conservation and Management Act of 1976 (Magnuson-Stevens Act, 16 U.S.C. 1801 et seq.), as amended, gives the U.S. exclusive management authority over fisheries, except for highly migratory species of tuna, within a fishery conservation zone of 5 to

322 kilometers (3 to 200 miles) offshore. The Mid-Atlantic Fisheries Management Council is responsible for managing fisheries in Federal waters off the Atlantic Coast, including the project area fisheries, in accordance with the Magnuson-Stevens Act. To promote the long-term health and stability of managed fisheries, the Mid-Atlantic Fisheries Management Council utilizes Fishery Management Plans for the following species or species complexes: mackerel, squid and butterfish, bluefish, dogfish, surf clam and ocean quahog, summer flounder, scup, sea bass, and tilefish. The Magnuson-Stevens Act also mandates the identification of Essential Fish Habitat (EFH) for managed species. EFH is defined as the waters or substrate necessary for fish to spawn, breed, feed, or grow to maturity.

EFH is designated for areas of the Atlantic Ocean within which WFF performs its missions. Areas surrounding Wallops Island also feature intermittent floating *Sargassum* habitat, which is considered EFH. Live/hard EFH communities are not known to occur naturally offshore of Wallops Island, except for those that exist on manmade structures such as shipwrecks and artificial reefs.

3.3 SOCIAL AND ECONOMIC ENVIRONMENT

3.3.1 Population

In 2006, the U.S. Census Bureau reported that the population of the Commonwealth of Virginia was about 7.6 million, and Accomack County's population was 39,345, with a population density of 218 people per square kilometer (84.2 people per square mile) (U.S. Census Bureau, 2000). The population growth rate in Accomack County between 2000 and 2006 was approximately 2.7 percent (U.S. Census Bureau, 2008a).

The village of Assawoman, approximately 8 kilometers (5 miles) to the southwest, is the closest residential community to Wallops Island. The towns of Wattsville and Atlantic are the closest incorporated communities to Wallops Island and are located approximately 13 kilometers (8 miles) and 8 kilometers (5 miles) northwest of Wallops Island, respectively. There is no specific census data available for Wattsville because it is an unincorporated residential area.

Chincoteague Island, Virginia, is approximately 13 kilometers (8 miles) northeast of Wallops Island. The Town of Chincoteague is the most densely populated area in Accomack County, with a resident population of 4,317 people. Area populations fluctuate seasonally. During the summer months the population increases due to tourism and vacationers who visit the nature reserve and beaches of Assateague Island. Daily populations often reach up to 15,000 in the summer months. Special events, such as the annual pony swim and roundup/auction, sponsored by the Chincoteague Volunteer Fire Department in July, draw crowds of up to 40,000. Table 14 lists the 2000 U.S. Census population of nearby towns in Accomack County (U.S. Census Bureau, 2008a).

Table 14: Town Population and Housing Units in Accomack County

Location	Population	No. of Housing Units
Accomack Town	547	234
Atlantic Town	539	272
Belle Haven Town	480	257
Bloxom Town	395	180
Chincoteague Town	4,317	3,970
Hallwood Town	290	120
Keller Town	173	87
Melfa Town	450	210
Onancock Town	1,525	725
Onley Town	496	273
Painter Town	246	114
Parksley Town	837	404
Saxis Town	337	194
Tangier Town	604	272
Wachapreague Town	236	229

Source: U.S. Census Bureau, 2008a

3.3.2 Recreation

WFF is located on Virginia's Eastern Shore, a popular tourist destination. Many tourists and vacationers visit Accomack County throughout the late spring, summer, and early fall. Regional attractions include the Assateague Island National Seashore and CNWR. Winter hunting season draws people to hunt local game including dove, quail, deer, fox, and many types of geese and ducks.

Accomack County also offers an assortment of recreational opportunities. Three county park facilities support a variety of activities, including basketball, football, golf, soccer, softball, and volleyball. Tennis courts, public beaches, and indoor movie theaters also provide sources of recreation and entertainment throughout the area.

Many other activities and facilities are offered to WFF and tenant employees and their families through the Wallops Employee Morale Association. There are also numerous WFF clubs (e.g., Eco Club, Fitness Club, and Music Club) and recreational facilities.

3.3.3 Employment and Income

This section provides general background information on employment and income data for the WFF region. This includes 2000 U.S. Census data on the employment, unemployment, income, and poverty characteristics of the region complied by the Virginia Employment Commission (VEC) and by Virginia Polytechnic Institute (Eastern Shore Chamber of Commerce, 2007). The section also includes employment statistics for WFF itself.

The unemployment rate in Virginia was 3.0 percent in 2007 (VEC, 2009). In 2007, Accomack County was approximately average in the Delmarva region in terms of unemployment rates. The total labor force of Accomack County is 19,091 people, 18,309 of whom are employed, resulting in an unemployment rate of 4.1 percent (VEC, 2009). Employment fluctuates seasonally in Accomack County and the Town of Chincoteague, with decreased unemployment occurring from June through October (VEC, 2009). Overall, the unemployment rates in Virginia and Accomack County have been declining since 2000.

Table 15 lists the distribution by broad occupational categories for Virginia, Accomack County, and Chincoteague, as reported by the U.S. Census Bureau.

Table 15: Occupational Distribution (percent)

Category	Virginia	Accomack County	Chincoteague
Management, professional, and related occupations	38	24	26
Sales and office occupations	26	22	26
Production, transportation, and material moving occupations	13	20	9
Service occupations	14	17	17
Construction, extraction, and maintenance occupations	10	11	15
Farming, fishing, and forestry occupations	1	6	7

Source: U.S. Census Bureau, 2000

Table 16 shows the income and poverty rates of the Commonwealth of Virginia, Accomack County, and Chincoteague. Accomack County and Chincoteague both have a higher percentage of families below the poverty level and a lower per capita income than Virginia as a whole; however, Accomack County and Chincoteague do not include major urban centers.

Table 16: Income and Poverty

Region	Median Household Income (2007)	Per Capita Income (2007)	Percent of Families Below Poverty Level (2007)
Virginia	$53,066	$28,255	9.9
Accomack County	$35,048	$18,468	18.0
Chincoteague	$36,566	$24,549	13.4

Source: U.S. Census Bureau, 2008b

In 2008, WFF employed a total of 1,485 people; 1,027 of those supported NASA (including 238 civil servants and 789 contractors), MARS employed 3 full-time people, and the remainder worked for either NOAA or the U.S. Navy (NASA, 2008a). The VEC reported that in 2007 NASA was the fourth largest employer in Accomack County; other large employers on the Eastern Shore are Perdue Farms (1,900 employees) and Tyson Foods (950 employees) (VEC, 2008).

Employment categories at WFF consist largely of managerial, professional, and technical disciplines with higher than regional average salaries. The mean salary of NASA employees for fiscal year 2008 was $88,047, while the median salary is in the $80,000-$90,000 range (NASA, 2008a). The median family income for Accomack County in 2008 was $41,845. Due to the wide gap between salaries of WFF employees and most area residents, the facility contributes considerably to the local economy (NASA, 2008a).

3.3.4 Environmental Justice

The goal of environmental justice from a Federal perspective is to ensure fair treatment of people of all races, cultures, and economic situations with regard to the implementation and enforcement of environmental laws and regulations, and Federal policies and programs. EO 12898, *Federal Action to Address Environmental Justice in Minority Populations and Low Income Populations,* (and the February 11, 1994, Presidential Memorandum providing additional guidance for this EO) requires Federal agencies to develop strategies for protecting minority and low-income populations from disproportionate and adverse effects of Federal programs and activities. The EO is "intended to promote non-discrimination in Federal programs substantially affecting human health and the environment."

Accomack County is on the lower end of income measures in the region, with a 2005 median family income of $32,837. As a result, the county is also on the higher end of poverty levels in the region based on U.S. Census Bureau data reports. The per capita income in Accomack County in 2007 was reported to be $18,468, with an estimated 18.0 percent of people below the poverty level (U.S. Census Bureau, 2008b). The per capita income in the Commonwealth of Virginia in 2007 was reported to be $28,255, with an estimated 9.9 percent of people below the poverty level statewide (U.S. Census Bureau, 2008b).

NASA has prepared an Environmental Justice Implementation Plan (EJIP) to comply with EO 12898 (NASA, 1996). The EPA's Environmental Justice Coordinators Council has defined minority communities as exceeding a 50 percent minority population. Table 17 provides a review of Accomack County Census data used to determine the baseline for the facility's EJIP.

Table 17: Environmental Justice Concerns – by Census Tract, Accomack County, VA

Tract	Location	Percent Minority 2000	Percent Low Income 2000	Percent Poverty 2000
9901	MD/VA line south including Fisher's Point	1.97	51.53	12.80
9902	MD/VA line south including Wallops Island to Assawoman Inlet	41.75	49.96	16.38
9903	West of 9902 and 9904, MD/VA line south to Ann's Cove Road	24.66	55.94	19.28
9904	East of Mears Station Road, South of 9902 south to Horseshoe Lead	59.14	51.61	27.14

Source: NASA, 2008a

Chincoteague Island, at approximately 13 kilometers (8 miles) northeast of Wallops Island, is the closest populated area to the seaward side of Wallops Island. No minority or low-income communities exist on the portion of Chincoteague Island that lies within a 4-kilometer (2.5-mile) radius of Wallops Island.

EO 13045, *Protection of Children from Environmental Health Risks and Safety Risks,* encourages Federal agencies to consider the potential effects of Federal policies, programs, and activities on children. The closest day care centers, schools, camps, nursing homes, and hospitals are addressed within the EJIP.

3.3.5 Health and Safety

Three local emergency health services are located in the vicinity of Wallops Island. WFF has its own health unit with a full-time nursing staff and a full-time physician to provide first aid and immediate assistance to patients in emergency situations. The Health Unit operates from 8:00 a.m. to 4:30 p.m. After-hours emergency medical care is provided by the Emergency Medical Services staff of the WFF Fire Department. The Chincoteague Community Health Center on Chincoteague Island and the Atlantic Community Health Center in Oak Hall, Virginia, also provide emergency assistance, and both are located within 8 kilometers (5 miles) of WFF. Four hospitals are also located in the region, all within 64 kilometers (40 miles) of WFF. These hospitals include:

- Atlantic General Hospital in Berlin, Maryland
- McCready Memorial Hospital in Crisfield, Maryland
- Peninsula Regional Medical Center in Salisbury, Maryland
- Shore Memorial Hospital in Nassawadox, Virginia

The Peninsula Regional Medical Center in Salisbury serves as the regional trauma center for the Delmarva Peninsula. If additional trauma care is needed, Sentara Norfolk General Hospital is 19 minutes away (by helicopter) from the Shore Memorial Hospital in Nassawadox, Virginia. Accomack and Northampton County Health Departments offer clinical services. Five nursing homes on Virginia's Eastern Shore and eight nursing homes on Maryland's Lower Eastern Shore are available to the surrounding communities.

3.3.5.1 Fire and Police Protection

The WFF Fire Department provides emergency services to the neighboring community and has a Mutual Aid Agreement with the Accomack-Northampton Fireman's Association for any outside assistance needed at WFF (NASA, 2008a). There are 21 existing Fire and Rescue stations in Accomack County. The local fire companies closest to Wallops are in the towns of Atlantic, Chincoteague, and New Church, Virginia.

Fire company personnel are housed in two buildings on the facility, one on Wallops Island and one on Wallops Main Base (NASA, 2008a). There are 24-hour fire and protection services, and personnel are also trained as first responders for hazardous materials, waste, and oil spills. The fire fighting personnel maintain three shifts of nine employees: two officers and seven fire fighters. All are Emergency Medical Technicians and two employees per shift are Advanced Life Support certified. Rescue vehicles include three structural engines, four aircraft firefighting vehicles, two ambulances, a hazmat truck and trailer, a technical rescue trailer, two utility pickup trucks, one tracked all-terrain vehicle, and one wheeled all-terrain vehicle (NASA, 2008a).

WFF maintains a security force that is responsible for the internal security of the base. The force provides 24-hour-per-day protection services for 2,428 hectares (6,000 acres) of real estate, 513 buildings and structures, and approximately 1,485 employees and tenants, with an average of 34,000 visitors per year (NASA, 2008a). On the Main Base, one entrance gate to WFF, one to NOAA, and one to the U.S. Navy are used to control and monitor daily employee and visitor traffic. One entrance gate serves as the control and monitoring point for Wallops Mainland and Wallops Island, combined. Other services provided by the security force include security patrols, employee and visitor identification, mail delivery, after-hours security checks, and police services.

Police protection for the surrounding areas is supplied by town, county, and State personnel. The Commonwealth of Virginia's police force employs 23 officers in the area, while the Accomack County Sheriff's Office has approximately 34 officers. Several towns also have their own police forces, including: Bloxom, Cape Charles, Chincoteague, Exmore, Ocean City, Onancock, Onley, Parksley, Pocomoke, Salisbury, Saxis, and Tangier (Eastern Shore Chamber of Commerce, 2007). The USCG and the Virginia Marine Police Officers of the VMRC provide law enforcement and investigation, search and rescue, and harbor and open seas patrol in the back bays around Wallops Island and on the Atlantic Ocean.

3.3.6 Cultural Resources

The National Historic Preservation Act (NHPA) of 1966, (P.L. 89-665; 16 U.S.C. 470 *et seq.*) as amended, outlines Federal policy to protect historic sites and values in cooperation with other nations, Tribal Governments, States, and local governments. Subsequent amendments designated the State Historic Preservation Officer as the individual responsible for administering State-level programs. The NHPA also created the Advisory Council on Historic Preservation, the Federal agency responsible for providing commentary on Federal activities, programs, and policies that affect historic resources.

Section 106 and Section 110 of the NHPA and its implementing regulations (36 CFR 800) outline the procedures to be followed in the documentation, evaluation, and mitigation of impacts for cultural resources. The Section 106 process applies to any Federal undertaking that has the potential to affect cultural resources. This process includes identifying significant historic properties and districts that may be affected by an action and mitigating adverse effects to properties listed, or eligible for listing, in the National Register of Historic Places (NRHP) (30 CFR 60.4). Section 110 of the NHPA outlines the obligations Federal agencies have in regard to historic resources under their ownership.

In November 2003, NASA prepared a *Cultural Resources Assessment of Wallops Flight Facility, Accomack County, Virginia* (CRA) that examined each of the three land areas of the facility within WFF's property boundaries: Wallops Main Base, Wallops Mainland, and Wallops Island (NASA, 2003c). The study was completed to assist NASA in meeting its obligations under Sections 106 and 110 of the NHPA. According to the NRHP, the age criterion for consideration of a historic property is 50 years. For planning purposes, this study evaluated properties constructed prior to 1955, using 1955–2005 as the youngest applicable 50-year period. Additionally, the CRA established a predictive model for understanding the archaeological potential over the entire WFF property.

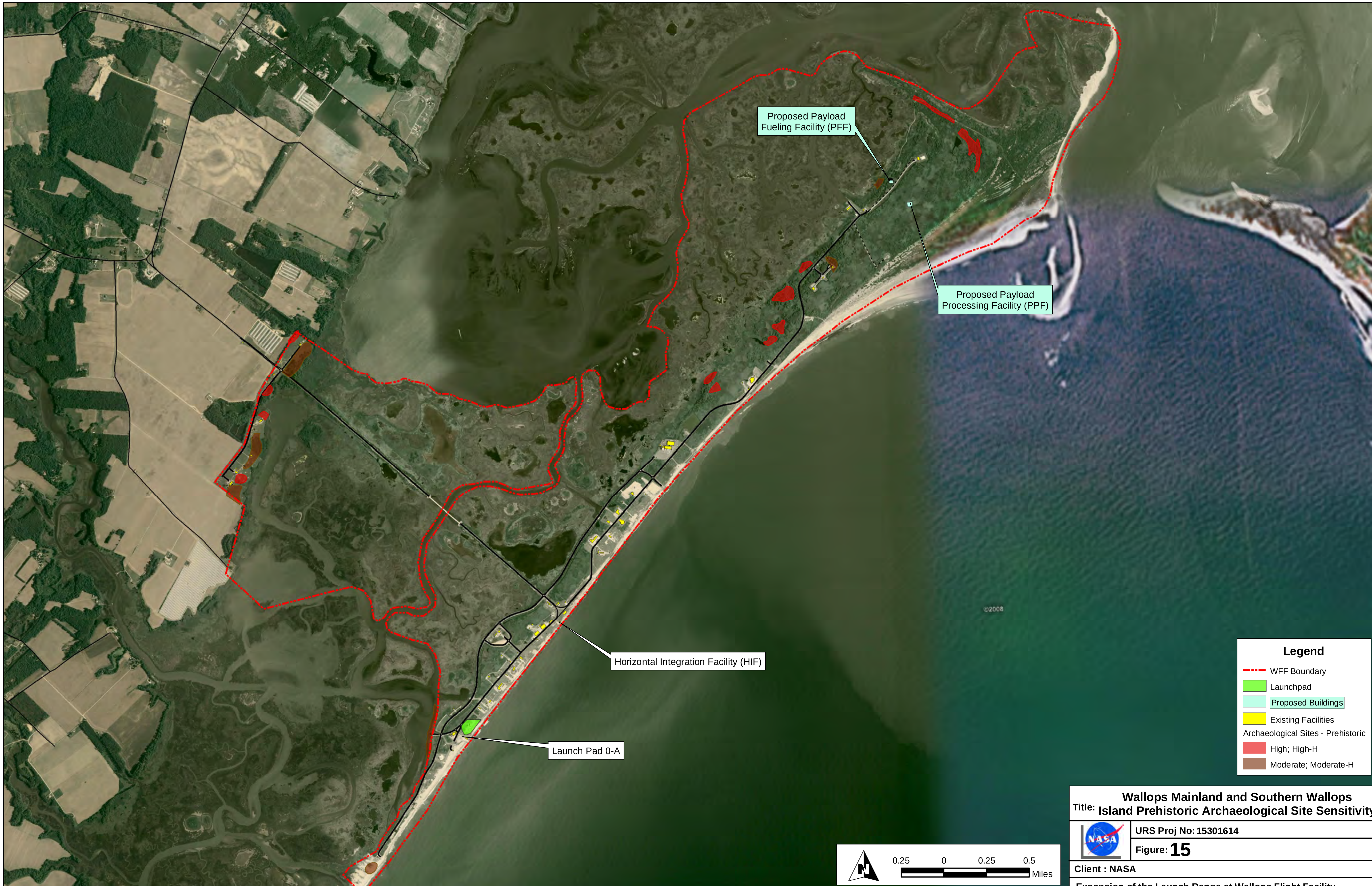
The CRA determined that among cultural resources at WFF are six archaeological sites, two of which are historic sites on Wallops Island (Figures 15 and 16), and a total of 166 structures that are at least 55 years old, 25 of which are located on Wallops Island. Comments from the Virginia Department of Historic Resources (VDHR) were received in a letter dated December 4, 2003 (NASA, 2003b). The letter concurred with the findings of the CRA. VDHR accepted the predictive model for archaeology at WFF, noting that many of the areas with moderate to high archaeological potential are unlikely to be disturbed by future construction or site use (NASA, 2008b).

Following the initial 2003 reconnaissance survey task, an intensive-level historic resource survey and historic research were conducted to develop a historic context for WFF. This context provided the necessary information with which to make NRHP eligibility determinations for the surveyed buildings and structures constructed prior to 1956. The findings were presented in the *Historic Resources Survey and Eligibility Report for Wallops Flight Facility* (NASA, 2004). The historic context developed for the report, in conjunction with field observations, served as the basis of evaluation for the buildings and structures determined to be (or soon to be) 50 years or older at Wallops. Of the 124 buildings assessed that pre-date 1956, 25 still exist on Wallops Island.

Two resources—the Wallops Coast Guard Lifesaving Station (VDHR #001-0027-0100; WFF# V-065) and its associated Coast Guard Observation Tower (001-0027-0101; WFF# V-070)—were determined to be eligible for listing in the NRHP and Virginia Landmarks Register (NASA, 2004). The other surveyed resources were determined not to be NRHP eligible because they lacked the historical significance or integrity necessary to convey significance.

In a letter dated November 4, 2004, the VDHR concurred with the findings and determinations in the *Historic Resources Survey and Eligibility Report*, confirming that the Wallops Coast Guard Lifesaving Station is eligible for listing in the NRHP, with the Observation Tower as a contributing structure to the historic property (NASA, 2004). NASA has determined that the Wallops Coast Guard Lifesaving Station is located inside the explosive hazard arc of a nearby rocket motor storage facility and as a result, is planning the demolition or removal of the Lifesaving Station and Observation Tower. In compliance with Section 106 of the NHPA, NASA and VDHR are currently negotiating a Memorandum of Agreement to resolve the effects of demolition or removal.

Since the 2004 report, no additional large-scale identification and evaluation of above-ground historic properties has been conducted at WFF. Accordingly, survey updates at WFF may reveal above-ground historic properties not identified in the 2004 report, including properties that have achieved 50 years of age since 2004 and properties that are less than 50 years of age.



Title: Wallops Mainland and Southern Wallops Island Prehistoric Archaeological Site Sensitivity

URS Proj No: 15301614

Figure: 15

Client : NASA

Expansion of the Launch Range at Wallops Flight Facility


Proposed Payload
Fueling Facility (PFF)
Proposed Payload
Processing Facility (PPF)
Horizontal Integration Facility (HIF)
Launch Pad 0-A
©2008
Legend
WFF Boundary
Launchpad
Proposed Buildings
Existing Facilities
Archaeological Sites - Historic
High; High-H
Moderate; Moderate-H
0.25 0 0.25 0.5
Miles
Title: Wallops Mainland and Southern Wallops Island Historic Archaeological Site Sensitivity
URS Proj No: 15301614
Figure: 16
Client : NASA
Expansion of the Launch Range at Wallops Flight Facility

3.3.7 Transportation

The Eastern Shore of Virginia is connected to the rest of the State by the Chesapeake Bay Bridge-Tunnel. The primary north-south route that spans the Delmarva Peninsula is U.S. Route 13, a four-lane divided highway. Local traffic travels by arteries branching off U.S. Route 13. Activities at Wallops Island and Wallops Mainland generate traffic along Route 803. Primary access to WFF is provided by Route 175, a two-lane secondary road. Traffic in the region varies with the seasons—during the winter and early spring, traffic is minimal; during the summer and early fall, traffic increases due to the number of tourists in the area.

Wallops Main Base and Wallops Mainland are connected by approximately 10 kilometers (6 miles) of the paved, two-lane Route 679. A NASA-owned road, bridge, and causeway link Wallops Mainland to Wallops Island. Hard surface roads provide access to most buildings at WFF and are maintained by NASA and its tenants. Most organizations at WFF own and maintain a variety of vehicles ranging from sedans and vans to trucks. There is no public transportation on the facility. Many WFF employees carpool to and from the facility.

Commercial air service to the area is provided through the Norfolk International Airport, about 145 kilometers (90 miles) to the south, and the Salisbury Regional Airport, about 64 kilometers (40 miles) to the north. Air service is also available approximately 40 kilometers (25 miles) south of WFF through the Accomack County Airport in Melfa, which normally provides flights during daylight hours. Surface transportation from the airports to WFF is by private rental vehicles, government vehicles, and commercial bus or taxi. In addition, ground transportation to the Salisbury Airport is occasionally provided by a WFF Shuttle Bus for WFF employees. Chartered and private aircraft that have the appropriate clearance may land at the WFF Airport for business purposes. Air-freight services are available from the Salisbury Regional Airport.

Rail freight service is provided to the Delmarva Peninsula by Bay Coast Railroad, although no rail freight service is available directly to WFF. No rail passenger service is available to WFF. Eleven motor freight carriers that serve the eastern United States are authorized to provide service to the Accomack-Northampton District, and therefore, WFF.

Ocean cargo shipments are typically offloaded at the Port of Baltimore, Maryland, or Cape Charles, Virginia, and transferred to commercial trucks or rail for transport to WFF. A sea-based option also exists utilizing Chincoteague Inlet and offloading cargo at the boat docks at WFF (one on Wallops Main Base and one on the north end of Wallops Island). Numerous small harbors are located throughout Accomack and Northampton Counties, which are used primarily for commercial or recreational fishing and boating.

3.4 DEPARTMENT OF TRANSPORTATION SECTION 4(F) LANDS

The DOT Act of 1966 (49 USC, Subtitle I, Section 303(c)), as amended, includes a special provision—Section 4(f)—that stipulates that DOT agencies cannot approve the use of land from publicly owned parks, recreational areas, wildlife and waterfowl refuges, or public and private historical sites unless the following conditions apply:

- There is no feasible and prudent alternative to the use of such land
- The project includes all possible planning to minimize harm to the land resulting from such use

Because the FAA Office of Commercial Space Transportation is a DOT agency with jurisdiction over the Proposed Action, this EA includes an evaluation of DOT Section 4(f) lands.

Section 4(f) includes guidelines for assessing the significance of an impact or the level of impairment that would occur when a proposed action involves either:

- More than a minimal physical use of a section 4(f) property; or,
- Deemed a "constructive use" substantially impairing the 4(f) property, and mitigation measures do not eliminate or reduce the effects of the use below the threshold of significance.

According to Section 4(f), substantial impairment would occur when impacts are sufficiently serious that the value of the site in terms of its prior significance and enjoyment are substantially reduced or lost.

3.4.1 National Historic Preservation Act of 1966, Section 106

Where historic sites are determined to be eligible for inclusion in the NRHP, NASA, MARS, and FAA are required to comply with all requirements of the NHPA prior to disturbance of a structure or site. Refer to the cultural resources discussion in Section 3 of this EA for further discussion regarding NHPA.

3.4.2 Public Lands and Refuges

Section 4(f) prohibits Federal lands or other public land holdings (e.g., State forests), park and recreation lands, and wildlife and waterfowl refuges from being converted to non-recreational use unless approval is received from the Secretary of the DOT. Although public land holdings surround WFF, Wallops Island is not a public land holding.

3.4.3 Land and Water Conservation Act, Section 6(f)

Section 6(f) of the Land and Water Conservation Act (LWCA) also applies to Section 4(f) lands. Section 6(f) prohibits recreational facilities funded under the LWCA from being converted to non-recreational use unless approval is received from the director of the National Park Service. No facilities on Wallops Island are funded under the LWCA.

SECTION FOUR ENVIRONMENTAL CONSEQUENCES

4.1 INTRODUCTION

Section 4 presents the potential impacts on existing resources at WFF described in Section 3 that may result from the alternatives described in Section 2. This section contains discussions on potential impacts on resources under the three main categories of Physical Environment, Biological Environment, and Social and Economic Environment. Land Use and Recreation will not be discussed further because no impacts to these resources are anticipated.

4.1.1 Definitions of Impacts

A major focus of Section 4 is to determine if any of the project-related environmental impacts could be classified as significant. The assessment of potential impacts and the determination of their significance are based on the requirements in 40 CFR 1508.27. Three levels of impact can be identified:

- No Impact – No impact is predicted
- No Significant Impact – An impact is predicted, but the impact does not meet the intensity/context significance criteria for the specified resource
- Significant Impact – An impact is predicted that meets the intensity/context significance criteria for the specified resource

Impacts that are not significant may still have an effect on the environment, and can be described in a variety of ways, such as:

- Type (beneficial or adverse)
- Context (site-specific, local, or regional)
- Intensity (negligible, minor, moderate, or substantial)
- Duration (short- or long-term)

The levels of these impacts and their specific definitions vary based on the resource that is being evaluated. For example, the scale at which an impact may occur (local, regional, etc.) would be different for wetland impacts as compared to economic resources.

Under NEPA (42 U.S.C. 4321 *et seq.*), significant impacts are those that have the potential to significantly affect the quality of the human environment. Human environment is a comprehensive phrase that includes the natural and physical environments and the relationship of people to those environments (40 CFR Section 1508.14). Whether an alternative significantly affects the quality of the human environment is determined by considering the context in which it would occur, along with the intensity of the action (40 CFR Section 1508.27).

During the discussion of impacts on each resource area, the type, context, intensity, and duration of the impact are presented.

4.2 PHYSICAL ENVIRONMENT

4.2.1 Land Resources

4.2.1.1 Topography and Drainage

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to topography and drainage.

Proposed Action

Site Improvements

Under the Proposed Action, land grading, excavation, and construction activities for the construction of a PPF, PFF, roads, Pad 0-A, and a LFF would cause land disturbances. Construction of these facilities would also result in increased impervious surfaces on Wallops Island. Because Wallops Island is essentially flat, the site improvement activities would not substantially alter topography; therefore, changes to natural drainage patterns would be minor. Although up to approximately 2.3 hectares (5.7 acres) of wetlands would be adversely affected for construction of the launch pad ramp, roads, and the PPF, only localized changes in drainage patterns would occur as a result.

Permanent stormwater control measures such as retention basins would be constructed and implemented in compliance with the Virginia Stormwater Management Regulations to provide adequate drainage for the new building sites, and to mitigate the effects of increased runoff from impervious surfaces. Therefore, with permanent stormwater measures incorporated into the site design, no significant impacts on topography and drainage are anticipated.

Transportation, Handling, and Storage of Materials

The transportation and handling of materials, launch vehicles, and the ES would not result in impacts on topography and drainage.

Launch Activities

Launch activities would not result in impacts on topography and drainage.

4.2.1.2 Geology and Soils

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to geology and soils.

Proposed Action

Site Improvements

Under the Proposed Action, construction activities, including grading, clearing, filling, and excavation, would result in disturbance of the ground surface and would have the potential to cause soil erosion. NASA and MARS would minimize adverse impacts to soils by acquiring VSMP permits as necessary, and developing and implementing site-specific SWPPPs and Erosion and Sediment Control Plans prior to ground disturbing activities. NASA and MARS would revegetate bare soils and incorporate landscaping measures in areas to be left as pervious surfaces (not paved) when construction is complete.

Construction of the pile foundation to support the Pad 0-A infrastructure would require driving precast concrete piles to depths of approximately 27 meters (90 feet) below ground surface. The piles are expected to penetrate the surficial coastal deposits and terminate in the Yorktown Formation. Although the driven piles would create long-term changes to the subsurface geology immediately around the driven piles, the changes would be limited in extent and are considered negligible. Therefore, construction of the pile foundation is not anticipated to result in an adverse impact on geologic resources.

Transportation, Handling, and Storage of Materials

Other potential impacts to soils include spills or leaks of pollutants from vehicles or equipment during construction activities and transportation of materials. NASA and MARS would minimize adverse impacts to soils by acquiring VSMP permits as necessary, and developing and implementing site-specific SWPPPs that would include best management practices for vehicle and equipment fueling and maintenance, and spill prevention and control measures to reduce potential impacts to soils during construction. The *Hazardous Materials and Hazardous Waste Management* discussion in Section 4.2.6 of this EA describes the procedures for transportation and handling of hazardous materials.

There is the potential for an accidental release of contaminants into soils resulting from ASTs, or during transportation of the ELV components and the ELV. Any accidental release of contaminants or liquid fuels would be addressed in accordance with existing WFF emergency management and response plans. All petroleum storage tanks would include spill containment measures such as impermeable berms that hold at least 110 percent of the tank's maximum capacity. The impacts of an accidental release would be adverse, although the likelihood of an accidental release would be low due to spill prevention and containment measures.

Launch Activities

Launch activities are not expected to impact soils because they would take place over the impervious surface at Pad 0-A.

4.2.2 Water Resources

4.2.2.1 Surface Water Including Wetlands

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to surface water including wetlands.

Proposed Action

Site Improvements

Under the Proposed Action, construction activities including grading, clearing, filling, and excavation would result in disturbance of the ground surface and would have the potential to cause soil erosion and the subsequent transport of sediment into waterways via stormwater.

Under the Proposed Action, up to 0.4 hectare (1 acre) of tidal wetlands would be filled for construction of the Pad 0-A ramp and road improvements. Up to 1.9 hectares (4.7 acres) of nontidal wetlands would be filled by construction of the PPF and its access road. No wetlands would be affected for construction of the PFF or LFF. The total area of wetland impacts under the Proposed Action is approximately 2.3 hectares (5.7 acres). Due to siting constraints, including available land and hazard arcs surrounding various facilities on Wallops Island, NASA has determined that there are no practicable alternatives for the location of the Pad 0-A ramps and road or the PPF.

Prior to construction, NASA and MARS would complete a jurisdictional wetland delineation in accordance with the USACE 1987 Wetland Delineation Manual (USACE, 1987) and regional guidelines to determine the precise location and size of the wetland area that would be adversely affected. NASA and MARS would notify the public and coordinate with applicable agencies including USACE, the VDEQ, VMRC, and the Accomack County Wetlands Board; these agencies would be notified of potential impacts to wetlands by VMRC through the JPA process. NASA and MARS would obtain necessary permits including Section 404 and/or Section 10 permits. NASA and MARS would implement wetland mitigation measures agreed upon through the JPA consultation process to offset the impacts and to ensure no net loss of wetlands.

Because the Proposed Action would involve federally funded and authorized impacts on jurisdictional wetlands, this EA serves as NASA's means for facilitating public review as required by EO 11990.

Transportation, Handling, and Storage of Materials

Other potential impacts to surface waters include contamination from spills or leaks of pollutants from vehicles or equipment during construction activities and transportation of materials. NASA and MARS would implement site-specific construction and industrial SWPPPs that would include best management practices for vehicle and equipment fueling and maintenance, and spill prevention and control measures to reduce potential impacts to surface water during construction. The *Hazardous Materials and Hazardous Waste Management* discussion in Section 4.2.6 of this EA describes the procedures for transportation and handling of hazardous materials.

There is the potential for an accidental release of contaminants into surface water resulting from ASTs, or during transportation of the ELV, ES, and components. Any accidental release of contaminants or liquid fuels would be addressed in accordance with the existing WFF ICP.

Launch Activities

Launch of a Taurus II rocket would result in the emission of CO at Pad 0-A. When CO combines with water vapor in the air, carbonic acid may form, which could result in the deposition of carbonic acid on the ground surface in the area surrounding the launch pad. The effects of carbonic acid deposition into the adjacent tidal wetland area would be minimal as carbonic acid is a weak acid normally found in rainwater; the natural buffering capacity of the nearby surface waters and wetlands would resist substantial changes in pH.

Any deluge water discharged to a retention basin would be tested for potential release to a newly constructed unlined infiltration and evaporation basin adjacent to Pad 0-A. If necessary, the deluge water would be treated (i.e., pH adjustment) before release, or removed for disposal if it does not meet the standards for discharge to surface water as permitted by VDEQ. If discharged to the pond, the release period may occur over a period of several days due to the large quantity of water to be discharged.

Launch failures could result in impacts on surface waters due to contamination from rocket propellant. In the unlikely occurrence of a launch failure, spilled liquid propellant could enter the tidal wetlands close to the launch pad. NASA and MARS would follow the emergency response and cleanup procedures in the WFF ICP to reduce the magnitude and duration of any impacts.

A release of unspent RP-1 from the ELV may create a thin film of petroleum on the water surface near the impact area. Due to the volume of this release into the nearby tidal wetlands, temporary impacts on water quality in the tidal wetlands may be adverse; however, because mitigation and cleanup measures would be implemented, the potential long-term impacts on tidal wetlands would not be significant.

If leaked into the ocean, the amount of water in comparison to the amount of propellant would allow the propellant to dilute so that impacts would be temporary and extremely localized. Dissipation into the ocean waters would occur within hours due to a combination of wave moment, oxygen exposure, and sunlight (USAF, 2007). Due to the small volume of this release into the open ocean, impacts on water quality in the ocean would be negligible.

4.2.2.2 Marine Waters

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to marine waters.

Proposed Action

Site Improvements

No impacts on marine waters are anticipated from implementation of the Proposed Action site improvements.

Transportation, Handling, and Storage of Materials

Marine waters would be affected if a barge or vessel were to spill its fuels or other substances that could contaminate the open ocean or estuary environment. Toxic concentrations are not anticipated in the open ocean due to the mixing and dilution rates associated with the wave movement and the vastness of the ocean environment. A spill within Chincoteague Inlet or the approach channel to the boat dock would likely result in short-term adverse impacts on the marine environment. Personnel would implement USCG-approved safety response plans or procedures outlined in WFF's ICP to prevent and minimize any impacts associated with a spill.

Launch Activities

The rockets launched from Pad 0-A would be multi-stage vehicles, so spent ELV stages would fall in the ocean during every launch event. Spent ELV stages falling into the ocean are a potential source of pollution to marine environments. Corrosion of hardware into toxic concentrations of metal ions is unlikely because the corrosion rates are slow in comparison to the mixing and dilution rates associated with marine environments (Detachment 12/RP, 2006; NASA, 2002b). Small quantities of unspent liquid propellants such as LOX and hydrazine could remain within the spent ELV stage, but they would pose little threat to the marine environment because they are water soluble and would be diluted by mixing with ocean water. However, liquid fuels such as RP-1 that are relatively insoluble in water pose a slight risk to the marine environment until evaporation occurs. The propellant would form a thin film that would be broken up by wave action, sunlight, and oxygen. All traces of propellant would quickly dissipate within 1 to 2 days. Due to the small quantities of liquid fuels remaining in reentered hardware, no substantial environmental effect is expected. The presence of miscellaneous materials such as battery electrolytes and hydraulic fluids are in such small quantities that only temporary effects would be expected (NASA, 1997).

If a launch failure were to occur, debris and unspent fuel would be removed from the near-shore ocean environment as practicable and disposed of in accordance with Federal, State, and local regulations. Short-term impacts on the near-shore environment may result, but long-term impacts would be negligible due to the buffering capacity of the Atlantic Ocean.

4.2.2.3 Floodplains

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to floodplains.

Proposed Action

Site Improvements

All facility construction and infrastructure improvements would take place within the 100-year and 500-year floodplains. NASA would ensure that its actions comply with EO 11988, *Floodplain Management*, and 14 CFR 1216.2 (NASA Regulations on Floodplain and Wetland Management). Because the Proposed Action would involve federally funded and authorized construction in the 100-year floodplain and jurisdictional wetlands, this EA also serves as NASA's means for facilitating public review as required by EO 11988.

Because Wallops Island is the location for WFF's core launch range functions, and is located entirely within the floodplain, no practicable alternatives to development in the floodplain exist. NASA and MARS would minimize floodplain impacts and protect and restore the natural and beneficial functions of floodplains to the maximum extent possible.

Transportation, Handling, and Storage of Materials

There would be no impacts on the floodplain as a result of transportation, handling, and storage of materials.

Launch Activities

There would be no impacts on the floodplain as a result of launch activities.

4.2.2.4 Coastal Zone Management

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to the coastal zone.

Proposed Action

All activities under the Proposed Action occur within Virginia's CMA as designated by Virginia's CZM Program. As the lead Federal agency for this project, NASA has determined that expansion of launch support facilities under the Proposed Action is consistent with the enforceable policies of the CZM Program. In a letter dated April 23, 2009, NASA submitted its determination to the VDEQ. NASA is currently awaiting VDEQ's response.

4.2.2.5 Stormwater

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to stormwater.

Proposed Action

Site Improvements

Under the Proposed Action, construction activities would result in permanent changes to stormwater conveyance due to disruptions of the natural drainage. NASA and MARS would obtain VSMP construction site stormwater permits and implement site-specific SWPPPs to minimize impacts to stormwater conveyance and stormwater quality during construction.

Up to approximately 2.3 hectares (5.8 acres) of new impervious area would be added to the existing 174.5 hectares (431.1 acres) of impervious surfaces on Wallops Island due to construction of buildings, roads, and expansion of the launch complex. These improvements would represent just over a 1 percent increase from existing conditions. To mitigate effects on surface waters due to increased runoff from impervious surfaces, permanent stormwater control measures such as onsite retention areas would be implemented in building and site design. All control measures would be designed and constructed in accordance with VSMP regulations, which include the incorporation of measures to protect aquatic resources from the effects of increased volume, frequency, and peak rate of stormwater runoff, and from increased nonpoint source pollution carried by stormwater runoff.

If required, MARS would obtain a VPDES industrial stormwater permit for the PPF and PFF, which requires that a SWPPP be developed for the permitted facilities. The SWPPP would identify all stormwater discharges at each facility, actual and potential sources of stormwater contamination, and would require the implementation of both structural and nonstructural best management practices to reduce the impact of stormwater runoff on the receiving stream to the maximum extent practicable, and to meet water quality standards. NASA would modify its existing industrial SWPPP to include the PPF and PFF that would generate industrial discharges.

Transportation and Handling of Materials

Other potential impacts to surface waters include accidental spills or leaks of pollutants that could be carried from vehicles or equipment via stormwater runoff during construction activities and transportation of materials. NASA and MARS would implement site-specific SWPPPs that would include best management practices for vehicle and equipment fueling and maintenance, and spill prevention and control measures to reduce potential impacts to surface waters during construction. The *Hazardous Materials and Hazardous Waste Management* discussion in Section 4.2.6 of this EA describes the procedures for transportation and handling of hazardous materials.

There is potential for an accidental release of contaminants (from ASTs or during transportation of the ELV, ES, and ELV components) that could be carried into surface waters via stormwater runoff. Any accidental release of contaminants or liquid fuels would be addressed in accordance with the WFF ICP.

Launch Activities

The tidal wetlands that occur approximately 213 meters (700 feet) west of Pad 0-A could be adversely be affected by exhaust products deposited in the area surrounding the pad and then transported by stormwater into the wetland; however, liquid propellant is rapidly combusted during a launch and almost completely burned. Also, the proposed launch complex stormwater control structures would contain nearly all pad runoff.

4.2.2.6 Wastewater

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to wastewater.

Proposed Action

Site Improvements

Wastewater generated by newly constructed facilities would discharge to existing WFF wastewater collection lines and would be sent to the WFF WWTP for treatment. The estimated volume of domestic wastewater that would be discharged to the WWTP from the Proposed Action is 9,464 liters (2,500 gallons) per day. The permitted maximum capacity of the wastewater facility is 1,135,625 liters (300,000 gallons) per day. The amount of wastewater that is currently treated is approximately 227,125 liters (60,000 gallons) per day (Bundick, pers. comm.); therefore, the WWTP has the capacity to treat the approximately 4 percent increase in wastewater from the new facilities, and the Proposed Action would not result in an adverse impact to the WWTP or wastewater.

To protect delicate electronic systems, the new facilities may use fire suppression foam instead of water to put out fires. The fire suppression foam could include chemicals that are harmful to aquatic systems and must be diluted prior to being discharged into the wastewater collection lines. Each building that uses a foam fire suppression system would be equipped with an adequate containment area to hold the foam prior to dilution and release to the WWTP.

Transportation, Handling, and Storage of Materials

No impacts to wastewater are anticipated due to transportation, handling, and storage of materials.

Launch Activities

No impacts to wastewater are anticipated due to launch activities.

4.2.2.7 Groundwater

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to groundwater.

Proposed Action

Site Improvements

Under the Proposed Action, NASA would provide potable water to the PPF and PFF for drinking water supply and industrial water use. The estimated maximum potable water demand of the Proposed Action facilities combined is approximately 293,369 liters (77,500 gallons) per month and 3,520,433 liters (930,000 gallons) per year. In addition to foam fire suppression, the PPF and PFF would include water-based fire suppression systems. These systems would require periodic flow testing that would utilize up to approximately 37,854 liters per year (10,000 gallons per year).

To minimize potable water consumption, NASA would encourage water use conservation practices in facility design and operation, such as the use of low-consumption water fixtures, the use of native plants in landscaping that are adapted to the local precipitation levels, and educating employees about water conservation methods.

Transportation, Handling, and Storage of Materials

Transportation, handling, and storage of hazardous materials could result in adverse impacts to groundwater if a spill were to occur that would contaminate groundwater. No contamination of groundwater in the Columbia-Yorkton aquifer due to a contaminant release from WFF has ever been documented. In order to minimize the potential for groundwater contamination, NASA and MARS would ensure that proper spill prevention, response, cleanup, and training procedures contained in the WFF ICP are implemented. Emergency response and cleanup procedures contained in the ICP would reduce the magnitude and duration of any impacts.

Launch Activities

Launch activities could potentially affect groundwater if fuels leach into the aquifer after an accidental release of RP-1 during ELV fueling at Pad 0-A. The impact would likely be minor and localized as the majority of the launch complex would be concrete and personnel performing fueling would be trained in the emergency response and cleanup procedures specified in the WFF ICP.

ELV testing and launches would require the use of deluge water (sound and vibration suppression water spray) that would be injected into the rocket exhaust plume and flame trench and sprayed on the pad deck. NASA’s existing potable water system would provide water for the 378,500-liter (100,000-gallon) elevated storage tank proposed at Pad 0-A. The entire tank would be emptied during each of the six proposed launches, equaling a total water usage of 2,271,000 liters (600,000 gallons) per year. Each static fire test would utilize the entire deluge water tank capacity, as well as up to an additional 683,266 liters (180,500 gallons). Prior to the test, water would be transferred from the elevated storage tank to the concrete-lined deluge retention basin. During the test, this water would be pumped into the rocket exhaust plume and flame trench. Any deluge water not vaporized by the ELV-generated heat would be collected in the retention basin and then recirculated until completion of the launch or test. Adding the groundwater usage for the deluge system during six launches and two static fire tests would result in 4,395,000 liters (1,161,000 gallons) of water use annually; assuming that only one static fire and one launch could occur in a given calendar month, a maximum Pad 0-A monthly usage of 1,061,800 liters (380,500 gallons) would result.

Combined Groundwater Withdrawal

NASA's groundwater withdrawal permit, issued by VDEQ for Wallops Island and Wallops Mainland, allows WFF to withdraw up to 6,813,741 liters (1,800,000 gallons) per month and 50,345,980 liters (13,300,000 gallons) per year from the Yorktown-Eastover Multiaquifer System. WFF has withdrawn an average of approximately 34,573,680 liters (9,133,400 gallons) per year during calendar years 2006–2008, with a maximum monthly withdrawal of 4,251,000 liters (1,123,000 gallons) during this same time (Bundick, pers. comm.). The combined water demand of the existing WFF uses and the Proposed Action (PPF, PFF, and Pad 0-A deluge system) would result in a monthly maximum of approximately 6,095,933 liters (1,610,375 gallons) and annual withdrawal of 43,324,132 liters (11,445,025 gallons). Although the implementation of the Proposed Action would increase the system's annual water use by approximately 25 percent and maximum monthly use by approximately 44 percent, it would not result in a significant impact on groundwater resources because withdrawal amounts would be within NASA's existing VDEQ-issued groundwater withdrawal permit.

4.2.3 Air Quality

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to air quality.

Proposed Action

Site Improvements

Construction activities would generate fugitive dust from clearing, trenching, backfilling, grading, and traffic on paved and unpaved areas, as well as combustion emissions from construction equipment. The internal combustion engines powering most of the construction equipment and vehicles would burn diesel fuel and the remaining vehicles would burn gasoline. Equipment that would be used for the construction activities is anticipated to include earthmoving equipment, pickup trucks, and compressors. To minimize impacts during construction, site-specific dust suppression methods would be implemented to minimize windblown and vehicular-borne fugitive dust generated from the construction site areas (e.g., daily watering of disturbed surfaces and soil stockpiles, covering stockpiles, implementing track-out controls). Construction-related impacts are expected to be short-term and limited to the duration and area of the construction activities.

The criteria pollutant emissions from the construction phase were estimated using the modeling tool developed for the U.S. Air Force, called Air Conformity Applicability Model (ACAM), version 4.3.3 (Air Force Center for Environmental Excellence, 2005). The No Action Alternative is the baseline for comparison of air quality impacts. The emissions summary is annotated in Table 18 and raw data with assumptions are provided in Appendix D.

Table 18: Emissions from Proposed Construction Activities in Metric Tonnes per Year (Tons per Year)

Year	CO	NO_X	SO_2	VOC	PM_{10}	$PM_{2.5}$
2009	0.11 (0.12)	0.41 (0.45)	0.05 (0.05)	0.05 (0.05)	11.9 (13.15)	0.00
2010	39.47 (43.51)	12.9 (14.2)	1.52 (1.68)	2.65 (2.92)	4.0 (4.4)	0.00
2011	0.14 (0.15)	0.17 (0.19)	0.00	0.01 (0.01)	0.01 (0.01)	0.00
TOTAL (2009–2011)	39.72 (43.78)	13.46 (14.84)	1.57 (1.73)	2.70 (2.98)	15.93 (17.56)	0.00

Stationary Source Operational Phase Activities

Stationary sources that may be installed and used during the operational phase of the Proposed Action to support launches are the following:

- Diesel fuel-fired internal combustion engines used as emergency generators
- Number 2 oil-fired external combustion units (e.g., domestic hot water heaters, space heaters, boilers)

Similar to estimating the criteria emissions from construction activities, emissions were also calculated for the stationary sources' first year of operation. Heating requirements for the new buildings were input to the same ACAM estimating model. The emissions summary is annotated in Table 19 and raw data with assumptions are provided in Appendix D. Since WFF is located in an attainment area (and therefore does not need to compare emissions from mobile sources to any thresholds) and the emissions estimated from the proposed stationary sources are negligible, impacts to the environment would be minor and short-term.

Table 19: Emissions from Stationary Source Operational Activities in Metric Tonnes per Year (Tons per Year)

Year	Source	CO	NO_X	SO_2	VOC	PM_{10}	$PM_{2.5}$
2009	Boilers	0.00	0.00	0.00	0.00	0.00	0.00
	Emergency Generators	0.00	0.00	0.00	0.00	0.00	0.00
2009 Total		0.00	0.00	0.00	0.00	0.00	0.00
2010	Boilers	0.00	0.00	0.00	0.00	0.00	0.00
	Emergency Generators	0.00	0.00	0.00	0.00	0.00	0.00
2010 Total		0.00	0.00	0.00	0.00	0.00	0.00
2011	Boilers	0.082 (0.09)	0.33 (0.36)	2.31 (2.55)	0.009 (0.01)	0.036 (0.04)	0.036 (0.04)
	Emergency Generators	0.39 (0.43)	1.48 (1.63)	0.027 (0.03)	0.045 (0.05)	0.027 (0.03)	0.027 (0.03)
2011 Total		0.47 (0.52)	1.81 (1.99)	2.34 (2.58)	0.054 (0.06)	0.064 (0.07)	0.064 (0.07)

Transportation, Handling, and Storage of Materials

During the loading operation, all propellant liquid and vapors would be contained; any propellant vapors left in the loading system would be routed to air emission scrubbers. Liquid propellant left in the loading system would be drained back to supply tanks or into dedicated waste tanks for treatment prior to disposal.

Based on current operations for other launches at WFF, emissions of VOCs would result from pre-launch activities in preparation of the launch vehicle and payloads. Although specific consumption rates and processing materials have not yet been identified specific to the Taurus II, information does exist for the Atlas V 500 launch vehicle. Material consumption data for the Atlas V 500 were used to derive consumption rates based on the surface area of the spacecraft and the payload. The surface area of the Atlas V 500 complete with the Centaur upper stage and payload fairing is approximately 3,530 square meters (38,000 square feet). The surface area of the Taurus II with payload fairing is approximately 3,620 square meters (38,960 square feet). Therefore, for the purpose of this analysis, the surface area of the two vehicles is essentially equivalent. Emissions of VOCs resulting from pre-launch preparation of the Taurus II would be similar to the Atlas V 500. Emissions from pre-launch activities are presented in Table 20.

Based on a launch schedule of six launches per year, approximately 6.4 metric tonnes (7 tons) of VOCs would be emitted. Although no information is currently available as to the HAP content of the various materials likely to be used, HAP emissions are expected to be low since many products have been reformulated to eliminate or reduce the HAP content. NASA and MARS personnel would utilize good operating practices to reduce evaporative losses of VOCs and HAPs during pre-launch preparation. Therefore minimal impact to the environment is anticipated.

Table 20: Quantification of VOCs from a Typical Taurus II Launch Preparation

Materials[1,2]	Usage Per Launch (kg [lbs]) or (liters [gallons])	Density (lbs per gallon)	VOC Content (percent by weight)	Percent Emitted	VOC Emissions Per Launch (kg [lbs])
Petroleum, Oils, Lubricants (POL)					
POL	2,177 kg (4,800 lbs)	Varies	Negligible	0.00%	0.00
Coatings					
VOC-based primers, topcoats, coatings	145 kg (320 lbs)	10.00	56.00%	100.00%	81.3 (179.20)
Non-VOC based primers, topcoats, coatings	86 kg (190 lbs)	10.00	13.00%	100.00%	11.2 (24.70)
Solvents, Cleaners					
VOC-based solvents, cleaners	623 kg (1,382 lbs)	N/A	100.00%	100.00%	626.9 (1,382.0)
Non-VOC based solvents, cleaners	432 kg (952 lbs)	N/A	0.00%	100.00%	0.00
Corrosives					
Corrosives	2,495 kg (5,500	N/A	0.00%	100.00%	0.00

Materials[1,2]	Usage Per Launch (kg [lbs]) or (liters [gallons])	Density (lbs per gallon)	VOC Content (percent by weight)	Percent Emitted	VOC Emissions Per Launch (kg [lbs])
	lbs)				
Adhesives, Sealants					
Adhesives, Sealants	1,036 kg (2,284 lbs)	N/A	25.00%	100.00%	259.0 (571.00)
Other					
Silicone RTV-88[3]	45.5 liters (12 gallons)	0.00	0.00%	100.00%	0.00
Electric insulating enamel	0.01 kg (0.22 lbs)	N/A	50.00%	100.00%	0.05 (0.11)
Acrylic primer	6 gallons	6.60	N/A	100.00%	18.0 (39.60)
Conductive paint	22. liters (12 gallons)	5.60	N/A	100.00%	30.5 (67.20)
Chemical conversion coating	0.30 kg (0.66 lbs)	N/A	50.00%	100.00%	0.15 (0.33)
Cork-filled potting compound	5.7 liters (1.5 gallons)	4.40	N/A	100.00%	3.0 (6.60)
Epoxy adhesive	5.7 liters (1.5 gallons)	4.40	N/A	100.00%	3.0 (6.60)
TOTAL		-	-		**1,035.20 (2,282.23)**
TOTAL Metric tonnes (tons) per year					**1.03 (1.14)**

Sources:
[1]Material quantities associated with an Atlas V 500 using five SRMs.
[2]All product data from FAA, 2001 (except where otherwise noted).
[3]Product VOC content based on MSDS (General Electric Corporation, 2001).

Launch Activities

WFF proposes to conduct up to two static firing test per year and up to six launches of suborbital and orbital class ELVs from Pad 0-A. Two scenarios, which include static test firing and launch, were evaluated to determine the impact of emissions on ambient air quality.

Rocket Exhaust Effluent Dispersion Model Results

The Rocket Exhaust Effluent Dispersion Model (REEDM) Version 7.13 was used to determine the ambient air impacts from static test firing and launching of Taurus II from Pad 0-A (USAF, 1999). A brief introduction on REEDM is provided in Appendix E. REEDM modeling analyses for 6,432 meteorological cases between 2000 and 2008 were conducted based on actual WFF weather balloon measurements.

The impacts of Stage I firing were considered to assess the impact resulting from launch activities; by the time Stages II and III are ignited, the altitude at which the exhaust from those stages is emitted (approximately 185 kilometers [115 miles]) is well above the Earth's atmosphere.

In the REEDM normal launch scenario, a fully configured launch vehicle with payload is ignited on the launch pad. The vehicle is held on the pad for approximately 2 seconds as the first stage engines build thrust. The hold-downs are then released, allowing the vehicle to begin its ascent to orbit. During ascent the vehicle velocity steadily increases, resulting in a time and altitude varying exhaust product emission rate. Initially the rocket engine exhaust is largely directed into and through the flame duct. As the vehicle lifts off from the pad and clears the launch tower, a portion of the exhaust plume impinges on the pad structure and is directed radially around the launch pad stand. The portion of the rocket plume that interacts with the launch pad and flame trench is referred to as the "ground cloud." As the vehicle climbs to an altitude several hundred feet above the pad, the rocket plume reaches a point where the gases no longer interact with the ground surface. The exhaust plume at that point is referred to as the "contrail cloud." Similar to static test firing, CO, CO_2, and H_2O are the primary exhaust products emitted during the Stage I flight. Emissions of CO from the proposed six Taurus II launches are approximately 374 metric tonnes per year (412 tons per year) (Nyman, pers. comm.). Only about 20 percent (74 tonnes per year [82 tons per year]) of these emissions would be released in the lower atmosphere (below 3,048 meters [10,000 feet]) (Nyman, pers. comm.).

As shown in Table 21 below, the maximum peak concentration for CO for a day or nighttime meteorology was 7.9 ppm at 7,000 meters (23,000 feet) from Pad 0-A. Similarly, the maximum 1-hour Time Weighted Average (TWA) concentration predicted by REEDM for a day or nighttime meteorology was 0.60 ppm at 7,000 meters (23,000 feet) from Pad 0-A. These are low concentrations that would have minimal or no impact on the population outside WFF property boundaries. The values predicted by the model are significantly below acute exposure guideline levels (AEGL-2 levels) and would occur for a very short duration. Appendix F contains detailed modeling results.

Table 21: Taurus II Normal Launch Predicted CO Ceiling and TWA Concentration Summary

Month	Daytime or Nighttime Meteorology	Peak Ceiling Concentration [ppm]	Distance to Peak Ceiling Concentration [meters (feet)]	Peak TWA Concentration [ppm]	Distance to Peak TWA Concentration [meters (feet)]
May	Daytime	7.9	7,000 (23,000)	--	--
May	Daytime	--	--	0.34	11,000 (36,000)
April	Nighttime	6.3	9,000 (30,000)	--	--
September	Nighttime	--	--	0.30	12,000 (40,000)

Source: NASA, 2009b

Static Testing

Static test firing of the Taurus II first stage would be conducted while the ELV is held stationary on the launch pad. In this scenario the two first stage engines are both ignited and are run through a 52-second thrust profile that ramps the engines up to full performance (112.9 percent) and back down. Exhaust from the rocket engine nozzles is directed downward into a flame trench and deflected through the flame duct such that the exhaust gases are diverted away from the launch vehicle and near by facilities. The exhaust plume exits the flame duct at supersonic velocity and its flow is approximately parallel to the ground and slightly above the ground.

Taurus II Stage I propellants consist of RP-1 and LOX as the oxidizer. The major constituents of combustion products resulting from static test firing of RP-1 and LOX are CO, CO_2, and H_2O. CO is the primary pollutant of concern as elevated concentrations can have serious health effects and it is regulated under the CAA. Emissions of CO from a single static test fire event per year would be approximately 14.4 tonnes (15.9 tons) (Nyman, 2009), and emissions if two tests were conducted would be 28.8 tonnes (31.8 tons).

As shown in Table 22 below, the maximum peak concentration for CO for a day or nighttime meteorology would be 18.9 ppm at 6,000 meters (20,000 feet) from Pad 0-A. Similarly, the maximum 1-hour TWA concentration predicted by REEDM for a day or nighttime meteorology is 0.30 ppm at 12,000 meters (40,000 feet) from Pad 0-A. These are low concentrations and would have minimal or no impact on the population outside WFF property boundaries. AEGL-2 concentration for a 1-hour exposure is 83 ppm for CO. This means that anyone who breathes CO at 83 ppm or above may experience irreversible or long-term damage. The values predicted by the model are significantly below AEGL-2 levels and would last for a very small duration. The AEGL-1 concentration for CO has not been determined and the AEGL-3 concentration for a 1-hour exposure is 330 ppm for CO. See Appendix F for a detailed explanation on AEGLs and detailed report on model runs.

Table 22: Taurus II Static Test Firing Predicted CO Ceiling and TWA Concentration Summary

Month	Daytime or Nighttime Meteorology	Peak Ceiling Concentration [ppm]	Distance to Peak Ceiling Concentration [meters (feet)]	Peak TWA Concentration [ppm]	Distance to Peak TWA Concentration [meters (feet)]
February	Daytime	--	--	0.27	8,000 (26,000)
March	Daytime	18.9	6,000 (20,000)	--	--
April	Nighttime	13.7	5,000 (16,000)	--	--
September	Nighttime	--	--	0.30	12,000 (40,000)

Source: NASA, 2009b

According to the final report summarizing the REEDM analysis for this EA, the far field CO concentration levels predicted for launching and static test firing the Taurus II ELV would be well below the published emergency exposure guidelines for humans and are considered to be benign to people, flora, and fauna (NASA, 2009b). Near-field CO concentrations (in the vicinity of Pad 0-A) may reach hazardous levels that exceed the AEGL-3 10-minute exposure threshold or the Immediately Dangerous to Life and Heath exposure threshold. Given the proximity of the near-field exposed region to the exhaust plume, other hazards, such as radiant heat transfer or direct exposure to the high temperature exhaust gas mixture, may be more severe than the hazard from CO exposure.

4.2.3.1 Halon

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no impacts from halon.

Proposed Action

Site Improvements

Halon would not be used during site improvements.

Transportation, Handling, and Storage of Materials

Halon would arrive at WFF enclosed within the Stage I of the Taurus II ELV; therefore, direct transportation, handling, and storage of halon would not occur. However, per the EPA regulation (40 CFR 82.270[c]) that requires trained technicians who test, maintain, service, repair, or dispose of halon-containing equipment, MARS would ensure that such technicians are trained and familiar with halon to ensure minimal loss of halon to the atmosphere. The ELV manufacturer would limit the supply of halon to recycled (non-virgin) sources only. MARS would ensure that any recovered halon is disposed of properly and all appropriate records would be maintained for a minimum of 3 years. With implementation of training and adherence to the EPA regulations regarding the transportation, handling, storage, and disposal of halon, the use of Halon-1301 under the Proposed Action would not result in substantial impacts on human health or the atmosphere.

Launch Activities

Approximately 20 kg (40 lbs) of Halon-1301 would be onboard the Taurus II within Stage 1 for use as a fire suppressant, all of which would be vented to the atmosphere in the aft bay of the ELV during a brief period beginning a few seconds immediately before main engine ignition. The maximum amount of Halon-1301 that would be released to the atmosphere by Taurus II launches at Wallops Island would be approximately 120 kg (265 lbs) annually. Many studies have been conducted on the cumulative environmental effects of launches worldwide. The American Institute for Aeronautics and Astronautics (AIAA) convened a workshop (AIAA, 1991) to identify and quantify the key environmental issues that relate to the effects on the atmosphere from launches. The conclusion of the workshop, based on evaluation of scientific studies performed in the United States, Europe, and Russia, was that the effects of launch vehicle propulsion exhaust emissions on stratospheric ozone depletion, acid rain, toxicity, air quality, and global warming were extremely small compared to other human activities (AIAA, 1991; FAA, 2001).

4.2.3.2 Regulatory Analysis

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no changes to regulatory requirements.

Proposed Action

The following regulatory requirements were reviewed for applicability to the Proposed Action:

- NSR/PSD (9 VAC 5-80-1605)
- Minor NSR (9 VAC 5-80-1100)
- Title V Operating Permits (9 VAC 5-80-50)
- NSPS (40 CFR 60)
- National Emission Standards for Hazardous Air Pollutants (NESHAPs) (40 CFR 61 and 40 CFR 63)

Prevention of Significant Deterioration

Under the NSR regulations, the Proposed Action would not be subject to the PSD requirements of 9 VAC 5-80-1605. WFF is not defined as a major source under the PSD program and the potential emissions from the proposed stationary sources would be less than the applicable major modification threshold for all criteria pollutants (see Table 23).

Table 23: Potential Emissions for Proposed Stationary Sources (metric tonnes per year [tons per year])

Pollutant	Boiler Emissions	Generator Emissions	Kerosene Storage Tank Emissions	Pre-Launch Preparation Emissions	Static Rocket Motor Testing/ Normal Launches[1]	Total Project Emissions	PSD Significant Modification Threshold
CO	0.60	2.10	0.00	0.00	15.90/82.0	2.70	100
NO_X	2.39	14.50	0.00	0.00	0.00	16.89	40
SO_2	0.25	0.20	0.00	0.00	0.00	0.45	40
VOC	0.04	0.26	Negligible	13.70	0.00	7.15	40
PM_{10}	0.13	0.18	0.00	0.00	0.00	0.31	15
$PM_{2.5}$	0.10	0.18	0.00	0.00	0.00	0.28	10

[1]Emissions are total for all 6 launches

Minor New Source Review

Prior to installing the proposed diesel-fired emergency generators at the PPF and PFF, NASA and MARS would prepare the necessary permit-to-construct applications with VDEQ. The aggregate kilowatt (kW) rating of the proposed emergency generators is anticipated to exceed the regulatory threshold of 1,125 kW (per 9 VAC 5-80-1320B).

To ensure the new stationary sources associated with the Proposed Action are accounted for on a facility-wide basis, NASA would modify its State operating permit, which would likely include adjusting its current permit limits for various sources. A modification is any change to the facility or process, including hours of operation, which increases the potential to emit an air pollutant or causes a pollutant to be emitted that was not previously emitted. The emergency generators and boilers, pre-launch activities, and static fire testing would all be included. This permit application modification would be submitted to VDEQ well in advance to enable receipt of the modified permit prior to the Proposed Action being implemented.

Title V Operating Permit

The Proposed Action would not require NASA or MARS to be subject to the Title V Operating Permit program, as per 9 VAC 5-80-50, as the emissions from the proposed stationary sources would not increase facility-wide emissions significantly to trigger a Title V permit. The proposed sources can be incorporated into the existing limits for criteria and hazardous air pollutants and the facility could remain a synthetic minor source; however, a modification of the existing limits would be necessary.

New Source Performance Standards

Based on maximum heat input and storage capacity, respectively, none of the external combustion sources or storage vessels would be subject to NSPS. However, the facility would be subject to Subpart IIII of 40 CFR 60 (Standards of Performance for Stationary Compression Ignition Internal Combustion Engines). This standard applies to diesel-fueled stationary compression ignition internal combustion engines of any size that are constructed, modified, or reconstructed after July 11, 2005. The rule requires manufacturers of these engines to meet emission standards based on engine size, model year, and end use. It also requires owners and operators to configure, operate, and maintain the engines according to specifications and instructions provided by the engine manufacturer. The facility would also be subject to the applicable recordkeeping and reporting requirements.

National Emission Standards for Hazardous Air Pollutants

The EPA has issued one NESHAP applicable to stationary internal combustion engines (40 CFR 63, Subpart ZZZZ – Reciprocating Internal Combustion Engines). This subpart became effective on March 18, 2008, and includes requirements to regulate emissions from new and reconstructed stationary reciprocating internal combustion engines (RICE) less than or equal to 370 kW (500 horsepower) at major sources of HAPs and all new and reconstructed stationary RICE at area sources (it does not address existing RICE). Owners and operators of compression ignition stationary engines less than or equal to 370 kW (500 horsepower) at HAP major and area sources that demonstrate compliance with the requirements of the NSPS Subpart III would be considered to be in compliance with Subpart ZZZZ. Owners/operators of these engines at HAP major and area sources can demonstrate compliance with the NESHAP recordkeeping and reporting requirements by meeting those requirements of the appropriate NSPS (Subpart IIII).

4.2.4 Noise

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to noise levels.

Proposed Action

Site Improvements

Under the Proposed Action, construction activities have the potential to generate temporary increases in noise levels from heavy equipment operations. Special precautions (such as noise suppression systems for heavy equipment) may be required when construction occurs near occupied facilities at Wallops Island. Noise impacts from the operation of construction equipment are usually limited to a distance of 305 meters (1,000 feet)—no residential areas or other noise-sensitive receptors occur close enough to Wallops Island to be affected by construction-related noise. NASA and MARS would comply with local noise ordinances and State and Federal standards and guidelines for potential impacts to humans caused by construction activities in order to mitigate potential impacts on NASA and MARS personnel.

OSHA limits noise exposure for workers to 115 dB for a period of no longer than 15 minutes in an 8-hour work shift, and to 90 dB for an entire 8-hour shift. Workers near activities producing unsafe noise levels, both during construction and after facilities are operational, would be required to wear hearing protection equipment. Therefore, impacts to the occupational health of construction workers as a result of construction noise are not expected.

Transportation, Handling, and Storage of Materials

Noise sources from transportation of materials include vehicles, airplanes (deliveries to the airport), and barges arriving at the Wallops Island boat dock.

According to a study done at WFF, the highest noise level for traffic near the Main Base during both peak and off-peak periods was 67 dB (NASA, 2003b). Transportation of materials for the Proposed Action activities is not anticipated to be outside the range of existing noise levels from vehicles, airplanes, and barges at WFF; therefore, no noise-related adverse effects to human health and safety or the environment from transportation of materials are anticipated under the Proposed Action.

Launch Activities

Taurus II would create loud instantaneous noise that may be heard for several miles from WFF. Impacts from engine noise and sonic booms are discussed below. Launch Pad 0-A is located approximately 4.02 kilometers (2.5 miles) from the Mainland. The marshland and water surrounding Wallops Island act as a buffer zone for noise generated during rocket launches. The noise levels generated during launches depend principally upon the thrust level of the rocket motors. Rocket noise has been part of the ambient noise levels at WFF for over 50 years.

<u>Engine Noise</u>

Calculations using a formula utilized by the WFF Range Safety Office estimate noise levels during static fires and launches of the Taurus II at specific distances away from Pad 0-A (NASA, 1973); Figure 17 shows the noise levels potentially generated by Taurus II in relation to noise receptors within the area. Ground level noise at various receptors during the launch of Taurus II is listed below:

- 114 dBA at the northern boundary of the piping plover habitat on south Wallops Island, approximately 1.46 kilometers (0.9 mile) from Pad 0-A
- 107 dBA in the community of Assawoman, approximately 3.2 kilometers (2.0 miles) from Pad 0-A
- 97 dBA in the town of Chincoteague, approximately 10.57 kilometers (6.57 miles) from Pad 0-A
- 96 dBA at the Main Base, approximately 12.28 kilometers (7.63 miles) from Pad 0-A

The OSHA level of exposure for worker safety is 115 dBA for 15 minutes and not to exceed 140 dBA peak sound pressure level for impulsive or impact noise (loud, short duration sounds). Noise levels immediately adjacent to the launch pad may reach over 140 dBA for a few seconds. MARS and WFF would be responsible for occupational safety of their personnel, and for determining the need for personal hearing protection for people working near the launch site. Exposure to noise would be minimized by personnel remaining inside a blast-proof building, called a blockhouse, or through the use of personal hearing protection (NASA, 2005). Personnel outside the hazard area may be restricted to their buildings depending on the size of the hazard area.

A noise level of 115 dBA would occur within a radius approximately 1.6 kilometers (1.0 mile) away from Pad 0-A during the launch of a Taurus II. The towns of Atlantic and Chincoteague, the community of Assawoman, and a few residences and businesses outside of the 1.6-kilometer (1.0-mile) radius would not be exposed to noise levels or durations that would exceed OSHA exposure standards during static firing or launches. Noise levels would exceed the Accomack County regulations for exposure to noise for a few seconds; however, while some observers may find the noise from a static fire or launch to be an annoyance, the noise would be maintained for only 30 to 60 seconds during launches and for up to 52 seconds during static fire testing and would attenuate after 1 to 2 seconds, would be of low frequency, and would occur no more than seven times per year (six launches and one static fire test). NASA and MARS personnel and the public would be notified in advance of launch dates and times.

The water deluge system at Pad 0-A would reduce the decibel levels of the engine noise during launches by blocking the sound pressure waves. The deluge system would therefore mitigate the sound levels during launches. Based on the above information, the Proposed Action is not expected to have noise impacts on the surrounding areas in excess of applicable thresholds of significance.

Sonic Booms

Because a sonic boom is not generated until an ELV reaches supersonic speeds some time after launch, the launch site itself would not experience a sonic boom. Therefore, with respect to human health and safety or structural damage, noise impacts due to sonic booms are not expected. Noise impacts on wildlife are discussed below.

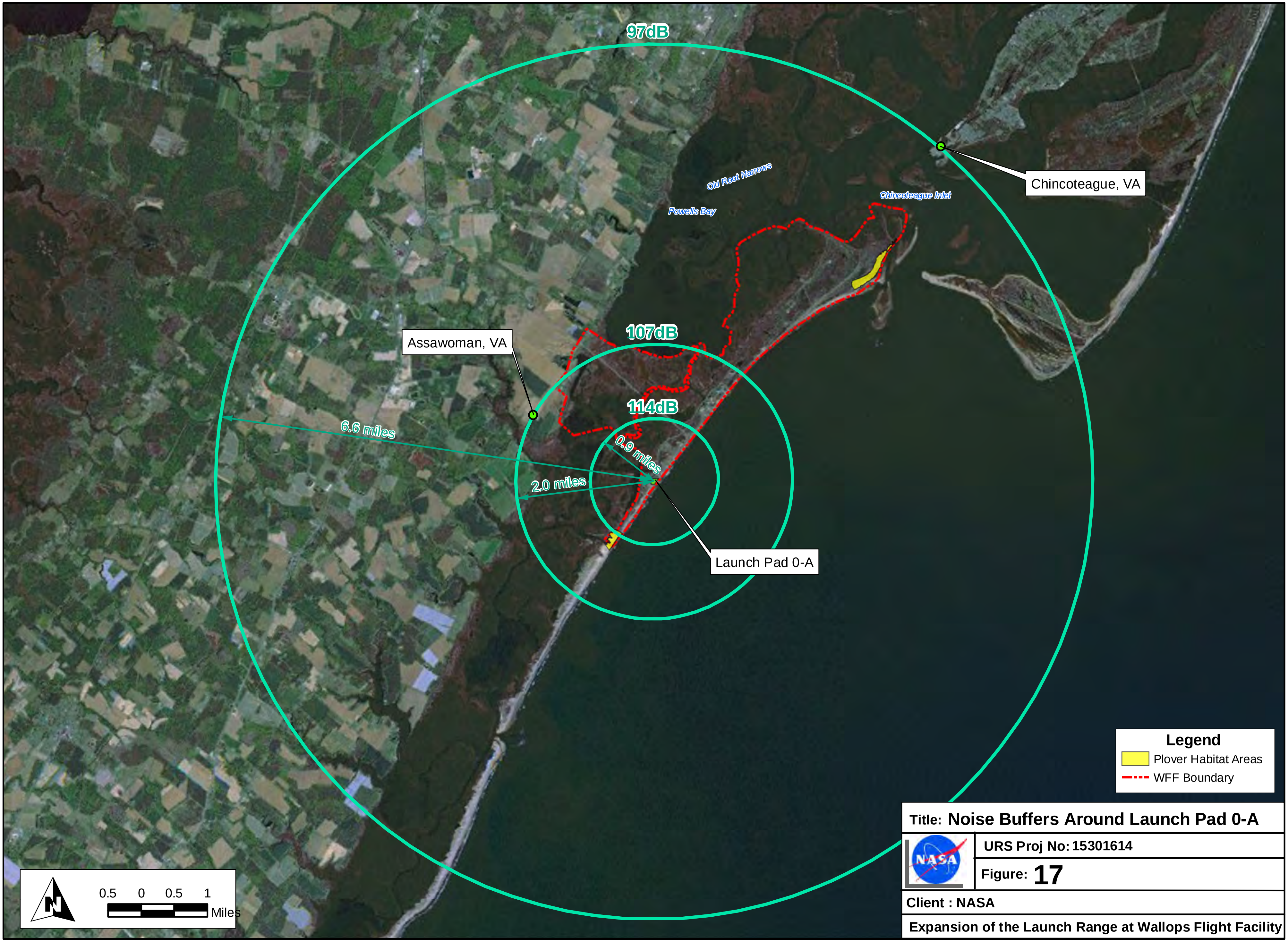
4.2.5 Orbital and Reentry Debris

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no change in orbital and reentry debris levels.

Proposed Action

The ES would comply with all requirements of NPR 8715.6, for limiting orbital debris, and NASA Standard 8719.14, which requires preparation of a debris assessment. If a malfunction causes an unplanned reentry of the spacecraft during launch, pieces of the spacecraft could survive reentry and strike the ground, resulting in injuries or fatalities. Over the period from 1958 to 1991, NASA reported that 14,831 payloads and debris objects reentered the atmosphere; however, there have been no reports of injuries or fatalities from reentering objects (NASA, 2007b).



Title: Noise Buffers Around Launch Pad 0-A

URS Proj No: 15301614

Figure: 17

Client : NASA

Expansion of the Launch Range at Wallops Flight Facility

Safety impacts resulting from the normal and errant burnout of launch vehicle stages would be controlled at MARS in accordance with the WFF Range Safety Manual, RSM-2002. That document requires that a trajectory analysis predict the Instantaneous Impact Point (IIP) at the surface at any moment during launch for either normal flight or debris from a flight terminated by range safety actions. This IIP would be overlaid on range maps indicating populated or environmentally sensitive areas, and a launch corridor would be developed.

This data would be developed for each mission (launch) well in advance of the launch activity. During the actual launch of the Taurus II, tracking data and IIP plots would be monitored to ensure the launch trajectory stays within the corridor. If a flight approaches corridor limits, the flight would be destroyed by Range Safety personnel. This ensures that spent stages or debris would only strike broad ocean areas cleared of shipping or air traffic. In rare cases, over-flight of land areas might be permitted if all Range Safety requirements are met.

Lower stages of the Taurus II would burn out and fall in the open ocean. Upper stages that achieve LEO would be programmed after spacecraft separation to burn residual propellants to depletion in a vector that would result in reentry in 2 to 3 months for a soft water landing. Upper stages going to higher orbits are not subject to controlled reentry, and contribute to orbital debris. Their location would be tracked to permit avoidance with future launch trajectories. However, the accumulation of such debris is of international concern and is the subject of international study. Typical measures discussed to assist in reducing debris include designing vehicles that are "litter free," whereby appendages or attachments do not separate into additional pieces, and designing vehicles with material that is more resilient to breakup (NASA, 2007b).

4.2.6 Hazardous Materials and Hazardous Waste Management

No Action Alternative

Under the No Action Alternative, activities would remain at present levels. Over an extended period of time, with no expansion of operations, WFF may experience a reduction in hazardous waste generation.

Proposed Action

The principal hazardous materials used under the Proposed Action would be liquid propellants (primarily LOX and RP-1), hypergolic propellants, pressurized gases, and various solvents and compounds used to process the ELV and spacecraft.

Site Improvements

Under the Proposed Action, construction activities would include the use of hazardous materials and hazardous waste generation (i.e., solvents, hydraulic fluid, oil, and antifreeze). With implementation of safety measures and proper procedures for the handling, storage, and disposal of hazardous materials and wastes during construction activities, no adverse impacts are anticipated during construction. In addition, NASA and MARS would develop a site-specific SWPPP to be developed prior to the start of construction activities for each facility. SWPPPs would contain best management practices related to spill prevention and cleanup procedures for hazardous materials and wastes.

All new petroleum facilities, tanks, and storage areas would be subject to VDEQ Storage Tank Program regulations. NASA must be notified of all portable ASTs brought into WFF. Spills or releases from temporary or permanent USTs or ASTs would be immediately reported to the WFF

Fire Department, which would contact the WFF Environmental Office. The WFF Environmental Office would properly characterize the spill or release, notify VDEQ if necessary, arrange for remediation, and dispose of contaminated soils and groundwater.

In addition, during existing building modifications NASA would comply with Federal and State regulations for asbestos containing materials and lead based paint, including Virginia Solid Waste Management Regulations (9 VAC 20-80-640), OSHA, and Virginia Lead Based Paint Activities Rules and Regulations. During construction, NASA and MARS would coordinate with the WFF Manager of Environmental Restoration for information concerning any Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) obligations at or near areas adjacent to WFF CERCLA sites or Formerly Used Defense Sites.

Transportation, Handling, and Storage of Materials

Implementation of the Proposed Action would result in the generation of domestic, industrial, and hazardous wastes. Fueling and payload processing operations would be the primary sources of hazardous waste and materials. Fueling of ELVs with LOX and RP-1, and pressurized gases would take place at the LFF adjacent to Pad 0-A. Loading of hypergolic propellants onto the ES would take place in the PFF. Hypergolic propellants would arrive at the PFF within DOT-approved shipping containers. Solid rocket propellants would arrive at WFF within the rocket motor casing—no loading of solid propellants would occur at WFF; however, solid propellants contained within the ELVs and ES would be temporarily located within each processing facility.

Liquid hypergolic propellants make up the largest proportion of hazardous materials used in processing the ES. Maximum quantities of propellants for the ES are listed in Table 4 of Section 2. An additional quantity of each propellant could be present at the processing facility. The PFF and PPF would be configured to manage hypergolic propellants and waste products. All propellants would be stored and used in compliance with Federal regulations for handling of solid propellants (14 CFR 420.65) and for storage or handling of solid propellants (14 CFR 420.67).

Spacecraft Processing

Payload processing may require limited use of chemicals considered toxic under CERCLA (NASA, 1997). A chemical inventory list would be provided to NASA's Safety and Environmental Offices prior to the arrival of such substances. The greatest risks associated with these substances are accidental leaks or spills. Mission-specific safety and environmental plans, as well as the WFF ICP would be in place to prevent and minimize any impacts associated with accidents involving toxic and or hazardous substances. Materials not used for fueling that may be used during processing of the ES are listed in Table 24. Any materials remaining after completion of processing would be properly stored for future use or disposed of in accordance with all applicable regulations.

Table 24: Payload Processing Materials of ES

Material	Purpose
Isopropyl Alcohol	Wash
Denatured Alcohol	Wash
Ink, White	Marking
Ink, Black	Marking
Epoxy adhesive	Part bonding
Epoxy, Resin	Repairs
Acetone	Epoxy cleanup
Paint, Enamel	Repair & marking
Paint, Lacquer	Repair & marking
Mineral Spirits	Enamel thinner
Lacquer Thinner	Thinning lacquer
Lubricant, Synthetic	Mechanism lube
Flux, Solder, MA	Electronics
Flux, Solder, RA	Electronics
Hypergolic propellants (MMH, N_2H_4, NTO)	Fuel
Chromate conversion coating	Metal Passivation

Source: NASA, 2007b

The hazardous materials used to process the ES could potentially generate hazardous waste. NASA and MARS would be responsible for identifying, containing, labeling, and accumulating the hazardous wastes in accordance with all applicable Federal, State, and local regulations. Liquid wastes would be generated almost exclusively from fuel and oxidizer transfer operations. Transfer equipment and lines would be flushed, first with potable water and then with an isopropyl alcohol (IPA) and demineralized water mixture. After hypergolic propellant has been loaded, equipment and lines used to transfer it would also undergo potable water flushes followed by an IPA/demineralized water flush. Similarly, potable water would be used to flush oxidizer transfer equipment and lines after the hypergolic oxidizer has been transferred to the satellite. The rinses resulting from the first three flushes of potable water for the propellant lines and equipment would be considered hazardous waste. Approximately 23 liters (6 gallons) of sodium hydroxide solution used for soaking small oxidizer transfer equipment parts (e.g., seals and fittings) would be added to the oxidizer rinse water. All five rinse-water waste streams would be collected in separate DOT-approved containers.

The fuel and oxidizer rinse-water wastes may or may not be hazardous depending on how the waste was generated and the characteristics of the wastes. Waste from each drum would be sampled and characterized based on laboratory analysis and the generation process. Based on the results of the waste characterization, drums would be labeled as hazardous or non-hazardous and disposed of according to applicable regulations.

The sodium hydroxide solution that could be used in the oxidizer scrubber would be changed about once every 5 to 10 years. NASA or MARS would pump the spent solution into approved containers, and then dispose of the waste according to its tested characteristics. The citric acid solution that could be used in the fuel scrubber would be collected and disposed of by NASA or MARS as non-hazardous waste.

During gaseous nitrogen purging of equipment and lines used to transfer anhydrous hydrazine and MMH to the satellite, a liquid separator would collect liquid droplets remaining in the equipment as the air streams pass through the hypergolic vent scrubber system. Prior to loading with NTO, approximately 23 liters (6 gallons) of a mixture of hydrazine and MMH would be transferred from the liquid separator to an approved container.

Solid hazardous wastes would also be generated almost exclusively from fuel and oxidizer transfer operations. Solids such as rags coming into contact with a fuel or oxidizer would be double-bagged and placed in a DOT-approved container. A separate container would be used for each fuel or oxidizer. Because solids contaminated with MMH and NTO are acutely toxic hazardous waste, these containers would be moved to a less-than-90-day waste accumulation facility within 72 hours if the amount exceeds 0.95 liter (1 quart).

The greatest potential impact to the environment due to the release of hazardous materials would result from an accident (e.g., leak, fire, or explosion) at a storage location or, to a lesser degree, from an accidental release during fueling, payload processing, or launch activities (e.g., spills or human exposure). The short- and long-term effects of an accident on the environment would vary greatly depending upon the type of accident and the substances involved. NASA has implemented various controls to prevent or minimize the effects of an accident involving hazardous materials on NASA property, including the following:

- Preparation of an ICP
- Preparation of emergency plans and procedures designed to minimize the effect an accident has on the environment
- Maintenance of an online database (MSDSPro) of hazardous materials and the associated buildings where they are stored or used, which would be updated to include the new facilities
- Annual training for all users of hazardous materials

Sources of hazardous wastes have the potential to adversely affect the environment and would be stored in accumulation areas for less than 90 days. NASA uses licensed contractors to transport and dispose of hazardous waste at permitted offsite facilities. NASA and MARS would implement the following list of controls for actions occurring on NASA property:

- Storing wastes in closed containers, and only using accumulation areas that have the capability of containing a leak or spill
- Inspecting containers for leaks on a scheduled basis
- Providing (and attending) training for all personnel who handle, or supervise those who handle, hazardous waste as part of their job
- Using the communication/alarm system that is in place to provide immediate emergency instructions to facility personnel in the event of an accident
- Employing fire extinguishers and fire control equipment available on site

- Following the ICP to control and mitigate the release of hazardous waste

Potential toxic corridors (transportation routes) are defined in mission-specific Operations and Safety Directives—further information is provided in the *Transportation* discussion in Section 4.4.5 of this EA. These hazard zones are designed to protect personnel, the environment, and the public. Fully fueled spacecraft or any other potentially hazardous material to be transported would be appropriately placarded and transported following Federal and State transportation regulations.

Hazardous materials would be managed according to standard safety procedures that include proper containment, separation of incompatible and reactive chemicals, worker warning and protection systems, and handling procedures to ensure safe operations. All personnel who transport, fuel, or otherwise work with ELVs (including launch or preparation activities such as payload processing) would receive training in hazardous waste management.

Launch Activities

The operation of ELVs would result in the use of hazardous materials and generation of hazardous wastes. Hazardous materials in use as part of flight operations include, but are not limited to, solvents, hydraulic fluid, oil, antifreeze, and paint. In addition, hazardous materials could exist within a payload or spacecraft for scientific research.

Hazardous wastes are unavoidable aspects of launch operations. Limited amounts of hazardous wastes, such as chemical solvents and some waste fuel and oxidizer, are necessarily associated with the preparation of launch vehicles. The small amount of waste generated would not substantially increase existing hazardous waste volumes, and would be segregated and handled through proper disposal. WFF is registered with EPA as a "large quantity generator" of hazardous waste. Mature programs for addressing hazardous waste and hazardous materials already exist. The incremental increase in hazardous waste requirements associated with the Proposed Action is well within the capabilities of the existing infrastructure for handling hazardous waste at WFF. In addition, WFF would continue to monitor existing and proposed activities and programs to ensure compliance with the pollution prevention program objectives.

Launch deluge wastewater generated by the Proposed Action would likely be categorized as industrial wastewater; however, this wastewater would be tested to ensure that it would not be considered a hazardous waste. If so, it would be properly handled and disposed of, typically by pumping it into a wastewater removal truck from the deluge water holding area onsite, and either transporting it to the WWTP on the Main Base or off-base to the appropriate hazardous waste treatment disposal site.

Because all applicable rules and regulations regarding hazardous waste (RCRA and non-RCRA) storage, treatment, disposal, and associated reporting requirements would be adhered to, less than significant impacts on hazardous waste management would occur under the Proposed Action. In addition, the hazardous waste streams likely to be generated by the Proposed Action are not anticipated to substantially increase the amount of hazardous waste currently generated by WFF.

A launch failure could result in a payload ground impact resulting in propellant tank rupture and spillage. The *Health and Safety* discussion in Section 4.4.3 of this EA addresses the potential impacts of spills during launch activities. It should be noted that during each launch, NASA coordinates with the local police and emergency personnel in anticipation of the need for evacuation of areas surrounding the launch site, up to the appropriate radius distance established by the WFF Range Safety Office at the time of launch.

4.2.7 Radiation

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts from radiation.

Proposed Action

Site Improvements

Construction activities are not anticipated to result in a potential source of radiation; therefore, no impacts to human health or the environment from radiation are expected to occur during construction or site improvement activities.

Transportation, Handling, and Storage of Materials

Radioactive Materials

Operation of the PPF/PFF and handling of the ES could result in a potential source of radiation. Spacecraft may carry small quantities of encapsulated radioactive materials for instrument calibration or similar purposes. The amount and type of radioactive material that can be carried on NASA or MARS missions is strictly limited by the approval authority level delegated to the NASA NFSAM (NASA, 2005). As part of the approval process, the spacecraft program manager must prepare a Radioactive Materials Report that describes all of the radioactive materials to be used on the spacecraft. The NFSAM would certify that preparation and launching of a payload that carries small quantities of radioactive materials would not present a substantial risk to public health or safety.

The amount of radioactive materials used on payloads would be limited to small quantities, typically a few millicuries, and the materials would be encapsulated and installed into the payload instruments prior to arrival at the launch site. Therefore, the use of radioactive materials in payloads would not present any significant impact or risk to the public or to the environment during normal or abnormal launch conditions (NASA, 2002a).

Lasers

The Proposed Action involves the use of lasers for science instrumentation on the ES. Lasers could also be used during launch vehicle or payload processing for miscellaneous tasks such as component alignment and calibration. Admissible safety analysis techniques are well established based on ANSI Z136.1-2007 and ANSI Z136.6-2005. The ANSI safety analysis applies to any laser that might be operationally or accidentally pointed toward people or wildlife on Earth or in an aircraft. To be covered within this EA, laser systems must be evaluated and found to be within ANSI standards for safe operations if they can be operated in an Earth-pointing mode.

According to ANSI standard Z136.6-2000, the maximum permissible exposure values are below known injury levels; therefore, use of lasers at WFF would be required to meet the safety standards set forth by ANSI, which would mitigate potential impacts to human health. Since the energy threshold for skin damage exceeds that for eye injury, any system found to be eye-safe would not present a substantial hazard to skin, structures, or plants.

Gases and particles in the atmosphere can absorb the energy from laser systems and cause changes in atmospheric chemistry by initiating various chemical reactions. However, for a typical laser system utilized by Earth-orbiting spacecraft, the mean beam power and, therefore, the maximum available atmospheric energy deposition rate is not substantial when compared to the mean solar energy deposition rate, so significant atmospheric impacts are not expected.

Radio Frequency Electromagnetic Fields

Most of the proposed spacecraft would be equipped with radar, telemetry, and tracking system transmitters. The ES is limited to a power of 10 kW for radar; a radar instrument of this size on a nadir-viewing satellite can provide useful information with no risk to people on the Earth or in aircraft above the Earth. A 2 kW radar (94 gigahertz with a 1.95-meter [6.4-foot] antenna) drops to safe levels in less than 2.5 kilometers (1.6 miles) from the satellite. Considering that LEO altitudes range from 200 to 800 kilometers (124 to 497 miles) above Earth, such a system presents no radiation hazard to populated regions of Earth or its atmosphere.

Launch Activities

Launch activities are not anticipated to result in a potential source of radiation; therefore, no impacts to human health or the environment from radiation are expected to occur during launches.

4.2.8 Munitions and Explosives of Concern

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no change in MEC levels.

Proposed Action

Site Improvements

Ground disturbances such as excavations and clearing may have the potential to encounter MECs on Wallops Island during construction. The 2005 Archive Search Report and other studies at WFF found potential MEC sites on Wallops Island (NASA, 2008a). A qualified MEC expert would evaluate the area proposed for ground disturbance and conduct a survey of the area if necessary prior to construction activities. WFF would continue to implement its MEC Safety Awareness Program to mitigate immediate risks to employees and the public at or around these sites (NASA, 2008a).

Transportation, Handling, and Storage of Materials

No impacts on MEC are anticipated from transportation, handling, and storage of materials.

Launch Activities

No impacts on MEC are anticipated from launch activities.

4.3 BIOLOGICAL ENVIRONMENT

4.3.1 Vegetation

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to vegetation.

Proposed Action

Site Improvements

Under the Proposed Action, construction activities including grading, clearing, filling, and excavation would result in disturbance of the ground surface and adverse impacts on vegetation. NASA and MARS would minimize adverse impacts to vegetation during construction by acquiring VSMP permits as necessary, and developing and implementing site-specific SWPPPs and Erosion and Sediment Control Plans prior to ground-disturbing activities. NASA and MARS would revegetate bare soils and incorporate landscaping measures in areas to be left as pervious surfaces (not paved) when construction is complete.

Long-term adverse impacts to vegetation would occur due to the loss of forest, shrub, and wetland plant communities due to the construction of the PPF, PFF, and Pad 0-A ramp and road improvements; however, these impacts would be localized and would not present a substantial adverse effect.

Transportation, Handling, and Storage of Materials

Vegetation could be adversely affected if a spill or leak were to occur where contaminants were released on the ground or into the terrestrial environment or surface waters. NASA and MARS would implement site-specific SWPPPs that would include best management practices for vehicle and equipment fueling and maintenance, and spill prevention and control measures to reduce potential impacts to vegetation during construction. The *Hazardous Materials and Hazardous Waste Management* discussion in Section 4.2.6 of this EA describes the procedures for transportation and handling of hazardous materials. Any accidental release of contaminants or liquid fuels would be addressed in accordance with the WFF ICP and other mission-specific response plans. All petroleum storage tanks would include spill containment measures such as berms that contain at least 110 percent of the tank's maximum capacity.

Launch Activities

NASA has conducted annual monitoring of the vegetation surrounding Pad 0-B since 2003 and observations were made directly after a launch in the spring of 2007. The monitoring results are mostly inconclusive as to the long-term effects on vegetation due to variation in perennial cover year to year; however, observers after the spring 2007 launch did note singeing and charring of vegetation immediately around the pad as a result of several small fires caused by the launch (Mitchell, pers. comm.). Heat and emissions from rocket exhaust under the Proposed Action may result in localized foliar scorching and spotting within the area immediately surrounding the launch pad.

Launch Pad 0-A would include a flame duct to direct heat and combustion products and the initial sound blast toward the ocean. The majority of the area in the combustion path of the flame duct is beach with little to no vegetation. In addition, the vegetation immediately around the launch pad is regularly mowed to minimize the risk of grass fires. Therefore, minor adverse effects on vegetation from launches would occur, and would be limited to a localized area around Pad 0-A.

4.3.2 Terrestrial Wildlife and Migratory Birds

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to terrestrial wildlife and migratory birds.

Proposed Action

Site Improvements

Short-term adverse impacts to wildlife and migratory birds may be anticipated during construction activities due to temporary noise disturbances, especially during spring and fall migrations; however, this would be similar to disruptions from daily operations at the Main Base and Wallops Island. The areas surrounding Pad 0-A, the PPF, and the PFF are currently affected by human-related noise. The launching of ELVs from Pad 0-A would causes noise disruption; however, noise disruptions already exist at WFF for existing flight and launch operations, and are infrequent and of short duration.

Long-term impacts to terrestrial wildlife or migratory birds may be anticipated due to the conversion of habitat to developed land. The impacts would be greatest on migratory birds during spring and fall migrations. The construction of the PPF and the launch ramp and road would result in the removal of approximately 2.3 hectares (5.7 acres) of wetlands that would permanently displace terrestrial wildlife and prevent migratory birds from utilizing those areas. Implementation of mitigation measures as agreed upon through the JPA consultation process, such as restoration of wetlands on Wallops Island, would minimize the impacts from loss of habitat at the PPF and Pad 0-A.

The removal of up to 0.8 hectares (2 acres) of trees to construct the PFF, PPF, and access roads would adversely affect wildlife due to the loss of habitat. No trees would be removed for construction of the Pad 0-A improvements.

Transportation, Handling, and Storage of Materials

Terrestrial wildlife could be adversely affected if a spill or leak were to occur where contaminants were released on the ground or into the terrestrial environment. NASA and MARS would implement site-specific SWPPPs that would include best management practices for vehicle and equipment fueling and maintenance and spill prevention and control measures. Section 4.2.6 describes the mitigation measures for transportation and handling of hazardous materials. Any accidental release of contaminants or liquid fuels would be addressed in accordance with WFF emergency management and response plans. All petroleum storage tanks would include spill containment measures such as berms that contain at least 110 percent of the tank's maximum capacity.

Launch Activities

Noise generated from rocket launches is generally low-frequency and of short duration (see Section 4.2.4 for more information on noise impacts); noise from static fire activities would be of longer duration, but infrequent (not more than two per year). Birds in the immediate area would be startled by rocket motor noise and are likely to temporarily leave the immediate area, which could disrupt foraging and nesting activities. Due to the short duration of the noise disturbances, impacts to birds are considered minimal (NASA, 1997). The continued presence of migratory, sea, and shore birds at WFF suggests that rocket launches over the past few decades have not significantly inhibited bird populations on the island.

During launch events, a bird strike could occur, although there would be an extremely low probability of such an event. Rockets launched from Pad 0-B have not resulted in a documented bird strike. In the unlikely event of a migratory or special status bird strike, the USFWS would be consulted.

Terrestrial mammals in close proximity to a launch might suffer startle responses; however, the launches are infrequent (approximately twice a month) and would have a minor adverse effect on wildlife.

Currently, all launches from Pad 0-B require closure of the southern end of Assateague Island. NASA has an established agreement with CNWR for such closures and coordinates with CNWR personnel during mission planning to ensure that closures do not adversely affect CNWR activities. The value of CNWR in terms of its significance and enjoyment is not substantially reduced or lost due to launch activities at WFF. CNWR has instead become a popular observation location for viewing NASA and MARS launches. Educational systems in the surrounding areas benefit from WFF's expertise. WFF offers educational tours for schools and other organizations, as well as WFF personnel lecturing at schools and judging school science fairs. The expansion of launch range operations is anticipated to introduce additional educational and recreational experiences for both local residents and tourists.

4.3.3 Threatened and Endangered Species

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to threatened and endangered species.

Proposed Action

Site Improvements

Construction activities are not anticipated to produce noise levels that would result in adverse impacts on the piping plover because of the distance of construction from their protected habitat on Wallops Island (see Figure 14). Because construction activities are planned outside of the piping plover habitat and would not occur on the beach or in the near-shore environment, no direct impacts on threatened and endangered species are anticipated as a result of construction.

Transportation, Handling, and Storage of Materials

An accidental release of hazardous materials during transportation via barge, rail, or road could occur. If a spill were to occur in the ocean, the vessel would notify the USCG and implement its approved spill response plan. Quantities of petroleum products transported over water would be no greater than are typically needed to fuel the vessel; any pollutants released would be cleaned up immediately; any remaining products would be diluted with sea water beyond a substantial impact. The piping plover habitat located at the northern end of Wallops Island is approximately 900 meters (2,950 feet) away from the proposed PPF, and the piping plover habitat at the southern end of Wallops Island is approximately 400 meters (1,300 feet) away from Pad 0-A. Therefore, the piping plover habitat is a sufficient distance from where a spill could occur, so it is not likely that piping plovers would be affected.

Launch Activities

Piping Plover

As with other avian populations, temporary interruption of foraging and nesting activities for piping plover may occur as a result of launch activities. The nesting area designated on the northern end of Wallops Island is approximately 6.7 kilometers (4 miles) from Pad 0-A, and is not expected to be affected by emissions or noise. The northernmost point of the designated plover habitat on the southern end of the island is approximately 1.46 kilometers (0.9 miles) from Pad 0-A. Noise generated from rocket launches is generally low-frequency, of short duration, and occurs infrequently, and naturally occurring background noises in the nesting area, such as wave action and thunderstorms, are more frequent and of longer duration than noise from a rocket launch. Formal ESA consultation with USFWS was conducted for the piping plover for the EA prepared for the launch expansion proposed at MARS Pad 0-B in 1997 (Appendix C). The USFWS issued a Biological Opinion stating that the Proposed Action in the 1997 Launch Range Expansion EA is not likely to jeopardize the continued existence of the piping plover on Wallops Island.

The 1997 USFWS guidance for managing fireworks near piping plover habitats recommends that a minimum 1.2-kilometer (0.75-mile) distance be established between the piping plover nests and the fireworks launch site. These same guidelines were referenced by USFWS in its July 14, 1997, Biological Opinion for construction of Pad 0-B. Fireworks noise outputs are comparable to the noise intensity at Pad 0-A during a Taurus II launch or static fire test and would likely last for a considerably longer period of time (USFWS, 1997). As launches and static fire tests under the Proposed Action would occur at a greater distance and shorter duration than those discussed in the 1997 USFWS guidance, no substantial effect on plover is anticipated.

Air quality modeling conducted for the launch of Taurus II at WFF (REEDM modeling described in Section 4.2.3 *Air Quality* discussion) showed that the limit of the near-field exhaust cloud ("near field" is defined as the region near the launch pad where the rocket exhaust cloud is formed) would extend approximately 200 meters (656 feet) away from Pad 0-A during static fire and approximately 100 meters (328 feet) away from Pad 0-A during launch, then begin to rise into the atmosphere where it would reach a "ceiling" due to an inversion, and then drift back down to the ground (NASA, 2009b). Because of wind and atmospheric mixing, the exhaust cloud is predicted to move a minimum of approximately 5,000 meters (3.1 miles) downwind from Pad 0-A before "touching down." By the time the exhaust cloud has moved downwind and resettled, the constituents from the rocket exhaust would be significantly dispersed and their concentrations significantly lowered.

The 1997 Launch Range Expansion EA assessed the peak concentrations of HCl, CO, and Al_2O_3 from a solid rocket motor (the Athena-3) at a distance of 1,400 meters (0.87 mile); this distance was selected because it is the boundary to the nearest sensitive receptor from Launch Pad 0-B, piping plover habitat. A comparison of the estimated peak concentrations of CO at a distance of 1,400 meters (0.87 mile) to the OSHA Threshold Limit Values (TLV)-TWA for Chemical Substances demonstrated that the levels of CO were well below exposure standards established to protect human worker health. TLV-TWA values were chosen for comparison purposes because these limits are more conservative than the TLV-Short Term Exposure Level exposure indices.

Human health exposure standards have been established well below levels shown to affect laboratory animals (NASA, 1997). Based on these comparisons, NASA determined that the launch of the Athena 3, a rocket utilizing solid propellants in its first stage and emitting higher launch concentrations of CO (0.9 to 1.1 ppm at 1,400 meters [0.87 mile] [NASA 1997]) than either Taurus II launch or static test firing CO concentrations (less than 0.04 ppm for far field 1-hour TWA concentrations to less than 1.0 ppm for far field instantaneous concentrations [NASA, 2009b]), would not have a substantial effect on humans or wildlife outside of the established hazard arc.

Open burning of rocket motors occurs approximately 400 meters (0.25 mile) north of the piping plover habitat on the southern end of Wallops Island. In a letter dated February 27, 1998, from NASA to USFWS, NASA summarized a telephone conference between USFWS, VDGIF, and NASA (Appendix C). The telephone conference discussed the 1997 USFWS Biological Opinion on impacts to the piping plover and the agreement that NASA could conduct year-round open burning of rocket motors at the open burning site located north of the southern piping plover habitat. Therefore, NASA has determined that the once a year static firing related to the Proposed Action also would not result in adverse impacts on the piping plover or its habitat.

Pad 0-A is 400 meters (1,312 feet) further away from the piping plover habitat on the southern end of Wallops Island than Pad 0-B. Also, the Taurus II-class rockets that would be tested and launched from Pad 0-A would be smaller and cleaner burning than the previously assessed Athena-3 launching from Pad 0-B. Finally, the burning of waste solid rocket fuel that takes place on south Wallops Island has not been documented to impact the piping plovers. Because of these reasons, coupled with the findings of the July 14, 1997, Biological Opinion (Appendix C) for construction of Pad 0-B, NASA has determined that the Proposed Action “may affect, but is unlikely to adversely affect” the piping plover. NASA has requested USFWS concurrence with this determination; NASA is currently awaiting USFWS response.

<u>Federally Protected Sea Turtles</u>

One sea turtle nest has been discovered in recent years on Wallops Island, approximately 5.1 kilometers (3.2 miles) north of Pad 0-A. There is no available beach for 4.2 kilometers (2.6 miles) along the Wallops Island Shoreline; the beach areas immediately adjacent to Pad 0-A are regularly inundated by the tides and wave energy, making these areas unsuitable for sea turtle nesting. Based on the low historical activity levels on Wallops Island and the lack of available habitat adjacent to the launch pad, NASA has determined that the Proposed Action would have “no effect” on the Leatherback, Hawksbill, Kemp’s Ridley, Loggerhead, and Atlantic Green sea turtles. If, in the future, sea turtle activity increases on Wallops Island or adjacent properties, this determination will be revisited in consultation with the NMFS and the USFWS.

4.3.4 Marine Mammals and Essential Fish Habitat

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to marine mammals and essential fish habitat.

Proposed Action

Site Improvements

Construction of facilities under the Proposed Action would occur in the estuary for modifications to the boat dock on the north end of Wallops Island. Temporary adverse impacts may occur to fish in the immediate area of construction due to suspension of sediment into the water column. The impacts from maintenance dredging that would occur are described in an existing REC (NASA, 2008d) and are currently permitted by the USACE.

No marine mammals have been documented or are known to inhabit the approach channel and boat dock area at Wallops Island; therefore, no impacts on marine mammals would occur in the estuary due to the Proposed Action. If this were to change in the future, NASA and MARS would consult with NMFS to ensure that its actions would not have an adverse impact on marine mammals.

Transportation, Handling, and Storage of Materials

An accidental release of onboard fuels (e.g., diesel, gasoline, etc.) during transportation via barge or boat could occur. If a spill were to occur, the vessel would notify the USCG and implement its approved spill response plan. Quantities of petroleum products transported over water would be no greater than are typically needed to fuel the vessel; any pollutants released would be cleaned up immediately; any remaining products diluted with sea water beyond a significant impact. If a spill were to occur within Chincoteague Inlet or the estuaries surrounding Wallops Island, adverse impacts on marine mammals and fish habitat might occur; however, due to the low probability of a large spill, the ability of marine mammals and fish to swim away, and the dilution of the pollutant with sea water, adverse impacts on marine mammals and fish are not anticipated to be significant.

Launch Activities

Spent stages would fall into the ocean many miles offshore. While a salvage boat may be used to recover the first stages of an ELV, the recovery efforts are likely to occur over 300 kilometers (500 nautical miles) from the coast. Stages that would not be recovered would sink to the ocean bottom. Due to the vastness of the ocean and the low density of marine mammals, it is extremely unlikely that a spent stage would strike a marine mammal or fish. Spent stages would not include propellants, and ES would not fall into the ocean under successful launches; therefore, no adverse effects on marine species are anticipated as a result of spent stages falling into the ocean.

In the unlikely event of a failure during launch, or an early termination of flight, the launch vehicle would most likely fall into the ocean, along with some scattered debris. Propellants and other chemicals could be released, although they would be quickly diluted within the ocean. Because the probability of an early flight termination is low, it is unlikely that a terminated launch vehicle or debris would strike a marine mammal, turtle, or fish; therefore, no significant adverse effects on marine species from the Proposed Action are expected from launch vehicle failure or early flight termination.

In the event of a launch failure, the ELV or ES may survive to strike the water essentially intact, presenting some potential for habitat impact. This potential arises from the fact that some stages of the ELV and the ES may carry hypergolic propellants, which are toxic to marine organisms. A lesser hazard may exist from small amounts of battery electrolyte (battery acid) carried aboard all spacecraft vehicles, but risk from the electrolyte is far smaller due to lesser quantities, lower toxicity, and more rugged containment.

Although it is unlikely that a fully fueled ELV or ES would fall in the ocean, several scenarios are possible if such an event did occur:

1. The entire spacecraft, with onboard propellants, is consumed in a destruct action.
2. The spacecraft is largely consumed in the destruct action, but residual propellant escapes and vaporizes into an airborne cloud.
3. The spacecraft survives to strike the water essentially intact, whereupon the propellant tanks rupture, releasing liquid propellants into surface waters.
4. The spacecraft survives water impact without tank rupture and sinks to the bottom, but leaks propellant into the water over time.

The probability of any one of these scenarios is unknown, but only the last two would potentially impact marine life or habitat.

The toxicology of hydrazine, MMH, and NTO with marine life is not well known. NTO almost immediately breaks down to nitric and nitrous acid on contact with water, and would be very quickly diluted and buffered by seawater; hence, it would offer negligible potential for harm to marine life. Hydrazine fuels are highly reactive substances that quickly oxidize to form amines and amino acids, which are beneficial nutrients to small marine organisms. Prior to oxidation, there is some potential for exposure of marine life to toxic levels, but for a very limited area and time. A half-life of 14 days for hydrazine in water is suggested based on the unacclimated aqueous biodegradation half-life (NASA, 2007b).

In summary, a mishap occurring downrange over the open ocean is improbable, and this event would not likely jeopardize any wildlife, given the relatively low density of species within the surface waters of these open ocean areas (NASA, 2007b). Debris from launch failures has a small potential to adversely affect managed fish species and their habitats in the vicinity of the project area.

Sonic booms created by launches from WFF could occur away from the Wallops Island shoreline over the open Atlantic Ocean. The effects of a sonic boom on whales or other open ocean species are not known. Because sonic booms are infrequent, and the marine species in the ocean's surface waters are present in low densities (although spring and fall migration would see periodic groups of migrating whales that follow the coastline), the sonic booms from launches are not expected to adversely affect the survival of any marine species (NASA, 2007b).

4.4 SOCIAL AND ECONOMIC ENVIRONMENT

4.4.1 Population, Employment, and Income

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to population, employment, and income.

Proposed Action

Site Improvements

Construction activities would result in a temporary increase in the number of workers at WFF; however, because local contractors would primarily be utilized, no long-term increase in population is anticipated due to construction activities. Some non-local construction workers are anticipated to require lodging in local motels and hotels. Construction activities would result in a benefit to the local economy due to employment opportunities for local construction workers and increased numbers of people in Accomack County during business hours resulting in a potential increase in the use of local stores and businesses for purchases.

Transportation, Handling, and Storage of Materials

Existing employees at WFF and MARS would assist in the transportation, handling, and storage of materials in support of launch activities. In addition, new employees specializing in the management of the materials, launch vehicles, and ES would be hired.

Launch Activities

Under the Proposed Action, the projected increase in newly hired permanent employees at MARS and WFF is approximately 125 people. Employment opportunities would be created in various areas of expertise (including the transportation, handling, and storage of materials along with those more directly involved with launch activities). In addition, private industries utilizing MARS Pad 0-A for a launch campaign may temporarily relocate a staff of approximately 15–20 personnel for periods of roughly 30 days, during which time food, lodging, and material goods would be needed. Taxes generated by this influx of personnel would directly benefit the local communities.

Expanded launch activities that would create 125 new jobs would bring approximately 385 people to the Lower Delmarva Peninsula (using the U.S. Census 2000 estimate of 3.04 people per household in Virginia and 3.12 people per household in Maryland [U.S. Census Bureau, 2000]). Employment opportunities within WFF would result in NASA continuing to be among the top five largest employers in Accomack County. The increase in population within the county would also result in increased tax revenues, thereby providing further growth for the local economy (NASA, 1997). The number of people moving to Accomack County under the Proposed Action would comprise less than 1 percent of the county's population of 39,345 in 2006.

The average salaries of new employees at WFF and MARS would likely be similar to the 2008 average NASA WFF civil servant salary of $83,462 (NASA, 2008a). Although Accomack County would likely continue to maintain lower income rates as compared with the Commonwealth of Virginia, the average income of people employed by WFF tenants and partners is expected to be well above the 2008 average county per capita income of $18,657 and median household income of $44,845 (NASA, 2008a). Due to greater average salaries of WFF employees, the Proposed Action would contribute positively to the local economy.

Educational systems in the surrounding areas benefit from WFF's expertise. WFF offers educational tours for schools and other organizations, as well as WFF personnel lecturing at schools and judging school science fairs. The expansion of launch range operations is anticipated to introduce additional educational and recreational experiences for both local residents and tourists.

4.4.2 Environmental Justice

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to low-income or minority populations.

Proposed Action

NASA complies with EO 12898 by incorporating Environmental Justice into their mission. WFF has prepared a site-specific EJIP that identifies programs and Federal actions that may disproportionately and adversely affect minority and low-income populations around WFF. Based upon the data presented in WFF's EJIP, Federal actions conducted at or by WFF do not disproportionately or adversely affect low-income or minority populations.

There are minority and low-income communities within Accomack County, but disproportionately high or adverse impacts to low-income or minority populations are not anticipated to occur under the Proposed Action because no displacement of residences or businesses would occur as a result of the implementation of the Proposed Action. In addition, the Proposed Action would include similar activities as those conducted at WFF, and the EJIP found that current WFF actions do not disproportionately affect low-income or minority populations (NASA, 1996).

4.4.3 Health and Safety

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to health and safety.

Proposed Action

The establishment of ground and flight safety guidelines is the responsibility of NASA. WFF's Range Safety Branch is responsible for implementing these safety guidelines. The *Range Safety Manual for Goddard Space Flight Center (GSFC)/Wallops Flight Facility (WFF)* (RSM-2002) outlines the Ground and Flight Safety Requirements, the Range User and Tenant Responsibilities, and the Safety Data Requirements to which all range users must conform.

To ensure the safety of personnel, property, and the public, WFF requires all range users to submit formal documentation pertaining to their proposed operations for safety review. Mission-specific safety plans will be prepared by WFF's Ground and Flight Safety Groups. These plans address all potential ground and flight hazards related to a given mission, in accordance with the Range Safety Manual. The Range Safety Branch is responsible for coordinating review of the proposed operations with all applicable organizations. Risks to human health and safety will be completely addressed and managed by these plans.

As a tenant, MARS and its clients would be required to comply with all of WFF's existing safety regulations. In addition, FAA licensing procedures require the Commercial Operator to prepare a Spaceport Explosives Site Plan, a Spaceport Safety Plan, and tailor Spaceport Operations for compliance with the WFF Range Safety Manual.

Site Improvements

Construction activities at the WFF site could result in short-term impacts to human health and safety and the increased usage of local fire, police, and medical services. Construction safety procedures and appropriate training would be implemented at WFF to ensure that events having the potential to adversely affect human health and safety are minimized.

Transportation and Handling of Materials

Transportation Routes

Public transportation routes would be utilized for the conveyance of a variety of materials to WFF. Transportation of all materials would be conducted in compliance with DOT regulations.

NASA and MARS would implement a Ground Safety Plan that outlines operational management procedures for minimizing risks to human health and the environment. These procedures are in addition to the Occupational Safety and Health Guidelines outlined in 29 CFR 1910. Guidelines that specifically pertain to Federal employees are outlined in 29 CFR 1960. Ground safety focuses on potential hazards associated with activities such as fueling, handling, assembly, and checkout for all pre-launch activities. System designs and safety controls are established to minimize the potential hazards associated with the operations of a launch range. The Ground Safety Plan addresses the following areas:

- Hazardous Materials Handling
- Explosive Safety
- Personal Protective Equipment
- Health and Safety Monitoring
- Training
- Operational Security, Controls, and Procedures

The majority of issues covered by the Ground Safety Plan deal with worker protection—to ensure the safety of personnel, property, and the public, the use of hazard quantity distances and other protective engineering controls would continue when dealing with explosives or other hazardous materials.

Handling of Liquid Propellants RP-1 and LOX

Along with the other issues addressed by ground safety, the handling of liquid fuels represents a potential environmental impact. Fueling launch vehicles with LOX and RP-1 would take place at Pad 0-A (Figures 5 and 6). Refilling LOX and RP-1 tanks would occur onsite by tank trucks. LOX and other cryogenic liquids, if spilled, could cause localized environmental damage such as grass kill due to the extreme cold associated with the liquid. LOX may explode if improperly mixed with combustible materials such as liquid hydrogen, and the gaseous oxygen evaporating from a liquid spill would intensify any existing fires. Long-term environmental impacts have not been reported due to spills of LOX (NASA, 1997). The cryogenic risk associated with the use of liquid hydrogen is similar to LOX.

The greatest risks associated with the use of RP-1 are attributable to spills or leaks. The procedures outlined in the ICP would be followed while fueling with RP-1 at Pad 0-A.

Handling of Hypergolic Propellants

Inadvertent releases of hypergolic propellants are possible from accidents during payload processing, transportation, and launches—hypergolic propellants would not be permanently stored at WFF. However, safeguarding the public, property, and the environment would be integrated at every step of the process, from design to construction to launch activities associated with this Proposed Action.

The proposed facilities would be designed and constructed specifically to meet several criteria to minimize the potential for accidents, as well as to minimize the potential impacts in the rare event an accident should occur. Facility designs would incorporate and meet criteria from the Uniform Building Code and Uniform Fire Code. Safety distance requirements would be implemented as part of the design process for storage and handling of propellants to protect personnel, other facilities, and the public. Integration of these safety criteria would also satisfy GDC requirements under the CAA. The proposed PFF and PPF would provide a completely controlled environment for critical operations.

Loading of hypergolic propellants would be performed either in the PFF or Building V-55. Each loading operation would be independent, sequential, and conducted using a closed-loop system. During the operation, all propellant liquid and vapors would be contained. If small leaks occur during propellant loading, immediate steps would be taken to stop loading, correct the leakage, and clean up leaked propellant with approved methods before continuing work. Personnel would wear protective clothing (Self-Contained Atmosphere Protective Ensemble suits) and would be closely monitored from a remote location during hazardous propellant operations. Leakage would be absorbed in an inert material for later disposal as hazardous waste, or aspirated into a neutralizer solution. Propellant vapors left in the loading system would be routed to air emission scrubbers, which are designed to remove more than 99 percent of propellant vapors. Liquid propellant left in the loading system would be either drained back to the supply containers or into waste drums for disposal as hazardous waste.

Prior to launch operations, only personnel with the appropriate clearance would be allowed access to various buildings. All other personnel are restricted from access by a security fence. Personnel are not present in the immediate vicinity of the ELV when fueling occurs. As with other launch vehicles, the fueling of Taurus II has been designed to preclude the release of fuels during normal operations.

WFF's Range Safety Manual states that bi-propellant systems shall be designed so that mixing cannot result if either the fuel or oxidizer subsystems malfunction. In general, liquid propellant systems shall be designed to prevent inadvertent mixing, especially where chemical reactions could lead to catastrophic consequences.

The likelihood of a hypergolic propellant release would be greatest during fueling operations. Under the Proposed Action, fueling would take place in the PFF or occasionally at Building V-55. During hypergolic fueling operations at WFF, the NASA Safety Office would employ weather data and computer models to predict the effects of an unintentional release. Based on the results of the analyses, access-controlled hazard areas would be established and maintained to ensure that public safety is not affected in the event of a mishap.

Spill response planning procedures are already in place to minimize spill size and duration, as well as any possible exposures to harmful air contaminants. In the event of an accident, the largest releases would result from the spillage of the entire quantity of liquid propellants. WFF's Hydrazine Contingency Plan would be followed in the event of an emergency or release. Lesser releases would result from fires or explosions that would consume significant fractions of the propellants. The magnitude of air releases from payload accidents would be relatively small compared to possible releases from accidents involving DOT shipping containers or launch vehicles. Therefore, payload accidents would have no substantial impact on the ambient air quality. Any impacts to public safety are anticipated to be minor and mitigatable as a result of integrating safety in the facility designs and siting of facilities, as well as maintaining a current preparedness and response plan.

Areal Locations of Hazardous Atmospheres Model (ALOHA) Results

The NASA Range Safety Office performed modeling using ALOHA, Version 5.3.1, to determine the extent of the area that could be affected during an accidental release of hypergolic propellants from ES. ALOHA is considered a very conservative model as it assumes complete evaporation of the propellant, no chemical degradation in the air, and no emergency response measures such as dilution. Background information on ALOHA is included in Appendix E.

Liquid propellant loads of 504.7 kg (1110.3 lbs) of hydrazine, 357.95 kg (787.5 lbs) of MMH, 321.7 kg (707.7 lbs) of NTO, and 268.8 kg (591.4 lbs) of MON-3 were the basis for the analysis. These quantities are based on the propellant loads that would be required for a three-stage Taurus II (with ORK motor as 3rd stage) carrying an ES (Moskios, personal comm.). Two spill scenarios were established by the WFF Range Safety Office to illustrate worst-case hazard distances. The first scenario was run for a small spill of 18.93 liters (5 gallons). The second scenario involved releasing the entire amount of liquid propellant that could be contained in the ELV and ES. A total of 36 runs were made for each propellant for small and large leaks during the day, afternoon and night time scenarios, as well as including/excluding low-level (305 meter [1,000 feet]) atmospheric inversions. According to the WFF Weather Office, morning and evening inversion levels typically occur at approximately 915 meters (3,000 feet); however, employing a lower altitude in the model presents a more conservative analysis as the inversion would trap the released propellant vapors closer to the ground surface. Detailed information regarding conditions used for each test case is located in Appendix E.

Threat zones, which radiate outward from a release site and are considered as areas where potential threats to human health may occur, were predicted using ALOHA. A threat zone's radius and area of influence changes along with changes in wind direction, which dictate the actual direction and distance that a substance would travel. The following concentrations were used to determine the maximum threat zone for each propellant:

- Hydrazine (0.12 ppm 1-hour average)
- MMH (0.26 ppm 1-hour average)
- NTO (1.0 ppm 1-hour average)
- MON- 3 (1.0 ppm, 1-hour average)

Table 25 presents the maximum threat zones for each of the propellants based on the levels of concern (LOC) presented below and various meteorological conditions. The maximum threat zones for each propellant based on the LOCs are for individual propellant spill scenarios. The large spill scenarios are based on the maximum amount of propellant that would be within the payload. ALOHA does not predict maximum threat zone distance based on the release of the combination of propellants. In the case of a spillage involving more than one propellant at the same time, the larger of the maximum threat zone distances would apply.

Spillage of the entire propellant load, while unlikely, could occur during the actual launch operation. A launch failure could result in a payload ground impact resulting in propellant tank rupture and spillage. The cases modeled by ALOHA are worst case since they assume that the spills are unconfined and evaporate to completion without dilution or other mitigating actions.

Table 25: Maximum Threat Zone Distances Predicted by ALOHA for Various Meteorological Conditions (Wind Speeds Constant at 4 meters/second)

Spill Size (small or large)	Spill Quantity L[1] (gallons) or kg[2] (lbs)	Atmospheric Inversion Yes or No (Y/N)	Maximum Threat Distance in kilometer (km) (mile [mi])			ALOHA Model Type Gaussian or Heavy Gas
			Morning	Afternoon	Night	
Hydrazine (0.12 ppm)						
Small	18.93 L (5.00 gallons)	Y	0.49 (0.30)	-	-	heavy gas
Small	18.93 L (5.00 gallons)	N	0.38 (0.24)	-	-	heavy gas
Small	18.93 L (5.00 gallons)	Y	-	NA[3]	-	NA
Small	18.93 L (5.00 gallons)	N	-	0.41 (0.26)	-	heavy gas
Small	18.93 L (5.00 gallons)	Y	-	-	0.70 (0.43)	gaussian
Small	18.93 L (5.00 gallons)	N	-	-	0.53 (0.33)	heavy gas
Large	504.7 kg (1,112 lbs)	Y	4.5 (2.8)	-	-	gaussian
Large	504.7 kg (1,112 lbs)	N	2.6 (1.6)	-	-	gaussian
Large	504.7 kg (1,112 lbs)	Y	-	NA	-	NA
Large	504.7 kg (1,112 lbs)	N	-	2.7 (1.7)	-	gaussian
Large	504.7 kg (1,112 lbs)	Y	-	-	4.5 (2.8)	gaussian
Large	504.7 kg (1,112 lbs)	N	-	-	2.6 (1.6)	gaussian

Spill Size (small or large)	Spill Quantity L[1] (gallons) or kg[2] (lbs)	Atmospheric Inversion Yes or No (Y/N)	Maximum Threat Distance in kilometer (km) (mile [mi])			ALOHA Model Type Gaussian or Heavy Gas
			Morning	Afternoon	Night	
MMH (0.26 ppm)						
Small	18.93 L (5.00 gallons)	Y	0.80 (0.50)	-	-	gaussian
Small	18.93 L (5.00 gallons)	N	0.61(0.38)	-	-	heavy gas
Small	18.93 L (5.00 gallons)	Y	-	NA	-	NA
Small	18.93 L (5.00 gallons)	N	-	0.64 (0.38)	-	heavy gas
Small	18.93 L (5.00 gallons)	Y	-	-	0.80 (0.50)	gaussian
Small	18.93 L (5.00 gallons)	N	-	-	0.61 (0.38)	heavy gas
Large	357.95 kg (789.15 lbs)	Y	5.1(3.2)	-	-	gaussian
Large	357.95 kg (789.15 lbs)	N	2.7 (1.7)	-	-	heavy gas
Large	357.95 kg (789.15 lbs)	Y	-	NA	-	NA
Large	357.95 kg (789.15 lbs)	N	-	2.9 (1.8)	-	heavy gas
Large	357.95 kg (789.15 lbs)	Y	-	-	5.1 (3.2)	gaussian
Large	357.95 kg (789.15 lbs)	N	-	-	2.7 (1.7)	heavy gas
NTO (1 ppm)						
Small	18.93 L (5.00 gallons)	Y	1.28 (0.80)	-	-	gaussian
Small	18.93 L (5.00 gallons)	N	1.03 (0.64)	-	-	heavy gas
Small	18.93 L (5.00 gallons)	Y	-	NA	-	NA
Small	18.93 L (5.00 gallons)	N	-	1.04 (0.65)	-	heavy gas
Small	18.93 L (5.00 gallons)	Y	-	-	1.28 (0.80)	gaussian
Small	18.93 L (5.00 gallons)	N	-	-	1.03 (0.64)	heavy gas
Large	321.7 kg (709.2 lbs)	Y	4.7 (2.9)	-	-	gaussian
Large	321.7 kg (709.2 lbs)	N	3.1 (1.9)	-	-	gaussian
Large	321.7 kg (709.2 lbs)	Y	-	NA	-	NA

Spill Size (small or large)	Spill Quantity L[1] (gallons) or kg[2] (lbs)	Atmospheric Inversion Yes or No (Y/N)	Maximum Threat Distance in kilometer (km) (mile [mi])			ALOHA Model Type Gaussian or Heavy Gas
			Morning	Afternoon	Night	
Large	321.7 kg (709.2 lbs)	N	-	3.1 (1.9)	-	gaussian
Large	321.7 kg (709.2 lbs)	Y	-	-	4.7 (2.9)	gaussian
Large	321.7 kg (709.2 lbs)	N	-	-	3.1 (1.9)	gaussian
MON-3 (1 ppm)						
Small	18.93 L (5.00 gallons)	Y	1.29 (0.80)	-	-	heavy gas
Small	18.93 L (5.00 gallons)	N	1.23 (0.76)	-	-	heavy gas
Small	18.93 L (5.00 gallons)	Y	-	NA	-	NA
Small	18.93 L (5.00 gallons)	N	-	1.24 (0.77)	-	heavy gas
Small	18.93 L (5.00 gallons)	Y	-	-	1.47 (0.91)	gaussian
Small	18.93 L (5.00 gallons)	N	-	-	1.23 (0.76)	heavy gas
Large	321.7 kg (709.2 lbs)	Y	2.9 (1.8)	-	-	gaussian
Large	321.7 kg (709.2 lbs)	N	2.1 (1.3)	-	-	heavy gas
Large	321.7 kg (709.2 lbs)	Y	-	NA	-	NA
Large	321.7 kg (709.2 lbs)	N	-	2.1 (1.3)	-	heavy gas
Large	321.7 kg (709.2 lbs)	Y	-	-	2.9 (1.8)	gaussian
Large	321.7 kg (709.2 lbs)	N	-	-	2.1 (1.3)	heavy gas

[1] L = liters
[2] kg = kg
[3] NA = data not available

The maximum threat distance for any of the propellants based on the small spill would be less than 1,473 meters (4,833 feet); this is well within WFF's property boundaries and would not impact offsite human population or properties outside WFF. The maximum threat distances for large spills range from 2 to 5 kilometers (1.3 to 3.2 miles). This would be the maximum downwind distance that would require evacuation and control by the NASA Range Safety Office in case of an accidental release. To reduce the risk to public safety and to ensure that evacuations could be executed if needed, NASA would coordinate with local emergency response agencies during mission planning to establish roadblocks and safety corridors. Also, this type of release would be highly unlikely to occur because trained personnel perform fueling operations, and emergency response measures (dilution, absorption, etc.) would be employed immediately following a release.

Launch Activities

Requirements for the Flight Safety Plan, found within WFF's Range Safety Manual, include flight management procedures for minimizing risks to human health and the environment. Flight safety focuses on the flight of the launch vehicle and ensures that safety criteria are met at all times. NASA coordinates all operations with the FAA, U.S. Navy, USCG, and other organizations as required in order to clear the potential hazard areas. Notices to mariners (called NOTMARS) and airmen (called NOTAMS) listing restricted or hazardous areas shall be made available at least 24 hours prior to launch. All launch limitations are published in the Flight Safety Plan.

WFF Range Safety Office uses models to predict launch hazards to the public and onsite personnel prior to every launch. These models calculate the risk of injury resulting from toxic gases, debris, and blast overpressure from both normal launches and launch failures. Launches are postponed if the predicted risk of injury exceeds acceptable limits.

A preliminary flight trajectory analysis is completed prior to each launch to define the flight safety limits. Vehicle systems with flight termination systems would be terminated by destruction of the vehicle if the flight is deemed erratic, or transverses the established destruct boundary. All stages are required to be equipped with flight termination systems unless the maximum range of the vehicle is less than the range to all protected areas, or the vehicle is determined to be inherently safe (NASA, 1997). Flight termination boundaries are designed to ensure that vehicle destruction occurs within a predetermined safety zone. This safety zone is established for the protection of the public, personnel, and the environment. In addition, while failures have occurred in the past, the history of WFF offers no evidence of acute or cumulative environmental impacts as a result of launch failures.

Under the Proposed Action, the estimated number of people moving to the Lower Delmarva Peninsula as a result of the Proposed Action is approximately 385. According to current distributions of WFF employee households among the five counties of the Lower Delmarva Peninsula, the 385 people anticipated to move to the Lower Delmarva Peninsula would be distributed as follows: 220 in Accomack County, 7 in Northampton County, 56 in Wicomico County, 20 in Somerset County, and 82 in Worcester County. The current capability of local medical, fire, and police services is sufficient to handle the additional people in the area.

With implementation of safety procedures, appropriate training, and oversight of activities under the Proposed Action by WFF's Range Safety Branch, events that have the potential to adversely affect human health and safety would be minimized or eliminated; therefore, no adverse impacts on health or safety are expected.

Probability of Launch Failure

When an ELV is launched, four outcomes can occur: successful launch, abort (abandoning the mission prior to takeoff), failure, and partial failures (defined as failures for which the payload is left by the launch vehicle in an incorrect orbit and lifespan is reduced because the payload expends fuel to reach its final orbit).

Rockets launched from MARS would be equipped with radio receivers and ordnance for in-flight destruction if the flight is determined to be erratic. The system is designed to terminate rocket motor thrust upon activation; however, it is possible that a portion of the ELV may fall into the ocean or in the Pad 0-A area. Toxic concentrations of contaminants would be quickly dissipated by the ocean currents.

A Programmatic EA completed by DOT in 1986 (USDOT, 1986) discusses the accidental release of an entire load of kerosene from an Atlas V rocket into the ocean. The Atlas is a liquid-fueled main stage rocket with a fuel capacity larger than the Taurus II. The thin film of liquid propellant released from an Atlas rocket evaporates quickly. While evaluating the accidental release from an Atlas, DOT determined that "due to the relatively small area involved and fleeting nature of the phenomena, no significant environmental effect is expected." The 1986 DOT Programmatic EA also addresses the near-shore (shallow water) accidental releases from Titan and Delta rockets, which both utilize liquid propellants, and concludes that although release of liquid propellant into the environment might be regarded as a substantial impact, such an extreme event is not considered likely. The 1986 DOT Programmatic EA determined that the probability of a launch failure is estimated at 1 percent.

For this EA, the FAA characterized the amount of orbital-class launch failures between 1989 and 2009, as shown in Table 26.

Table 26: Orbital Launch Attempt Failures 1989–2009*

	Failures and Total Orbital Attempts	Percent of launches that have failed
Department of Defense	9 of 164	5.5
NASA	2 of 173	<1.2
U.S. Government	11 of 337	3.3
Commercial**	11 of 147	7.5

Source: FAA, 2009a and FAA, 2009b

*Data does not include Sea Launch built by Ukraine and Russia (licensed by FAA) and does not include suborbital launches. Non-commercial launches were divided between the Department of Defense and NASA based on payload mission, not by the organization responsible for conducting the launch. The data does not include the 4 commercial and 10 non-commercial partial failures.

**Commercial launch is defined as a U.S. launch that is licensed by FAA.

Additionally, the Taurus II is designed to achieve 98 percent or greater launch capability (SpaceX, 2008). NASA evaluated the probability of launch failure for the Athena-3, which is a larger ELV than the Taurus II, in the 1997 Launch Range Expansion EA and concluded that "such an event [launch failure] should not pose a substantial environmental impact" (NASA, 1997). Therefore, impacts from launch failure events are not considered a significant adverse environmental impact.

4.4.4 Cultural Resources

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to threatened and endangered species.

Proposed Action

Section 106 of the NHPA requires Federal agencies take into consideration the effects of their undertakings on historic properties and to allow the Advisory Council on Historic Preservation (ACHP) the opportunity to comment on such undertakings. As defined in the Act, "historic properties" are one of five resource types—buildings, structures, object, sites, or districts—that are listed in or eligible for listing in the NRHP. Although buildings and archaeological sites are most readily recognizable as historic properties, a diverse range of resources are listed in the NRHP including roads, landscapes, and vehicles. As noted above, resources less than 50 years of age are not generally eligible for listing in the NRHP, but may be if they are of exceptional importance. Accordingly, to be in compliance with the NHPA, NASA must consider the effects of the proposed undertaking on all properties that are listed in or eligible for listing in the NRHP—both those owned by NASA within the boundaries of WFF, as well as those located outside of WFF that may be affected.

The geographical area within which an undertaking may affect historic properties is the Area of Potential Effects (APE). As stipulated in Section 106, Federal agencies must identify historic properties within the APE and consider the effects of the undertaking on these properties. The *Historic Resources Survey and Eligibility Report for Wallops Flight Facility* (NASA, 2004) referenced earlier in this report serves as the baseline for the identification of the above-ground historic properties at WFF, while the archaeological sensitivity model presented in the *Cultural Resources Assessment, NASA Wallops Flight Facility* (NASA, 2003c) serves as the baseline for identifying potential archaeological resources. Together these studies, addressed in the Cultural Resources Management Plan for WFF, likely account for many of the historic properties that are present at WFF and as such allow for a general assessment of the potential for an undertaking to affect historic properties.

The information contained within the cultural resources studies suggests that the Proposed Action would have a low potential to adversely affect either above-ground or archaeological historic properties. The Proposed Action would not have a direct effect on identified historic properties either within or outside of WFF. The Proposed Action may have indirect visual and auditory effects on identified historic properties in the APE, including the Coast Guard Lifesaving Station and Observation Tower, but these effects will not likely be adverse.

Site Improvements

<u>Modifications to Boat Dock</u>

In 2008, NASA carried out Section 106 consultation with VDHR on a project to make extensive alterations and improvements to the North Island Boat Basin and access road to accommodate the transport of the Max Launch Abort System (MLAS) vehicle, an undertaking that included components similar to those proposed for the MARS project. In documentation submitted to VDHR, NASA determined that the North Island Boat Basin no longer retained integrity necessary for listing in the NRHP, and that the undertaking would have no effect on above-ground and archaeological historic properties. In their response letter dated April 22, 2008, VDHR concurred with NASA's findings. As the scope of actions under the Proposed Action is analogous to the MLAS undertaking, it is unlikely that historic properties will be affected.

Payload Fueling Facility

Above-Ground Resources: The proposed PFF is new construction in an area at the north end of Wallops Island where there are few existing structures. However, the PFF will be located approximately 0.8 kilometer (0.5 mile) northeast of the NRHP-eligible Coast Guard Lifesaving Station and Observation Tower. The exact specifications of the PFF are not yet determined, but it is estimated that the building will occupy approximately 450 square meters (5,000 square feet) and be a maximum of 30.5 meter (100 feet) tall in the high bay. As such, the PFF will likely be visible from the Lifesaving Station and Observation Tower. However, the distance of the PFF, and the presence of other built resources related to the NASA presence on the island suggest that the construction of the PFF will have no adverse effect on the historic property. Moreover, NASA is currently negotiating a Memorandum of Agreement with VDHR for the disposition of this resource. As the Station and Tower are located within the hazard arc of the rocket motor storage facility, no personnel can occupy these structures. NASA is therefore seeking to donate both structures to an offsite property owner.

The community of Chincoteague is located approximately 3.5 kilometers (2.2 miles) northeast of the proposed PFF location, and Assateague Island is located approximately 5 kilometers (3.2 miles) northeast. Although the PFF may be visible from these sites, visibility at that distance is expected to be minimal.

Archaeological Resources: The proposed PFF is located on the northern portion of Wallops Island in an area that is not designated as having either high or moderate potential for prehistoric or historic archaeological resources. Therefore, NASA has determined that the proposed construction will have no effect on archaeological resources eligible for listing in the NRHP, and that no further archaeological investigations are warranted.

Payload Processing Facility

Above-Ground Resources: However, the PPF would be located approximately 0.6 kilometer (0.4 miles) northeast of the NRHP-eligible Coast Guard Lifesaving Station and Observation Tower, and 380 meters (1,250 feet) west of the PFF. The exact specifications of the PPF are not yet determined, but it is estimated that the building will be a maximum of 23 meters (75 feet) tall (high bay). As such, it is possible that the PPF will be visible from the Lifesaving Station and Observation Tower. However, the distance of the PPF from those structures, and the presence of other built resources related to the NASA presence on the island, suggest that the construction of the PPF will have no adverse effect on the historic property. Additionally, NASA is pursuing a Memorandum of Agreement with VDHR to donate these resources to an offsite property owner.

The community of Chincoteague is located approximately 3.9 kilometers (2.4 miles) northeast of the proposed PPF location, and Assateague Island is located approximately 5.5 kilometers (3.4 miles) northeast. Although the PPF may be visible from these sites, visibility at that distance is expected to be minimal.

Archaeological Resources: The proposed PPF is located on the northern portion of Wallops Island in an area that is not designated as having either high or moderate potential for prehistoric and historic archaeological resources. Therefore, NASA has determined that the proposed construction will have no effect on archaeological resources eligible for listing in the NRHP, and that no further archaeological investigations are warranted.

Transportation Infrastructure

Above-Ground Resources: New road construction and improvements to existing roads between the North Island Boat Dock, PFF, PPF, and HIF, are not expected to affect extant built resources and are, therefore, not likely to result in adverse effects to above-ground historic properties should they be present.

Archaeological Resources: The locations and specifications for existing road improvements, for the roads from the PFF or PPF to the HIF, would consist of either new construction or widening or straightening existing roads, resulting in up to 0.2 hectares (0.5 acres) of pavement. The exact locations and specifications have not yet been determined, but existing roads and proposed roads between the PFF, PPF, and HIF do not cross areas designated as having either high or moderate potential for prehistoric or historic archaeological resources. Therefore, NASA has determined that the proposed construction will have no effect on archaeological resources eligible for listing in the NRHP, and that no that further archaeological investigations are warranted.

Pad 0-A Improvements

Above-Ground Resources: Constructed in 1994 by the Virginia Commercial Space Flight Authority to support Commercial Experiment Transporter (COMET) launches, Launch Pad 0-A was not included in the 2004 *Historic Resources Survey and Eligibility Report for Wallops Flight Facility*. The structure was utilized for the launch of the Conestoga rocket on October 23, 1995. This was the only test conducted at Launch Pad 0-A and the facility has not been used since the Conestoga/COMET launch. Proposed work includes new construction of a pad access ramp and launch mount, liquid fuel storage tanks and piping, as well as a security fence and camera towers. A deluge system would be constructed, including an above-ground water tank not to exceed 38 meters (125 feet) in height. Additionally, four lightning protection towers, not to exceed 60 meters (200 feet) in height, would be constructed adjacent to the launch pad. Several resources in the vicinity of Launch Pad 0-A were included in the 2004 survey and were determined not eligible for listing in the NRHP, including Z-035 (Tracking Camera Turret, 1951), Z-065 (Blockhouse #1, 1952), and Z-70 (Launch Area 1, 1952). Properties outside of WFF on the mainland are located more than 2.4 kilometers (1.5 miles) from Pad 0-A, suggesting that the water tank and antenna towers would be minimally visible. The existence of other towers and water tanks within the WFF facility on Wallops Island further suggests that the new water tank would have no adverse effect on historic properties on the mainland should they be present.

Archaeological Resources: The proposed ramp and deluge system at Launch Pad 0-A are located outside of areas designated as having a moderate or high potential for archaeological resources and no archaeological survey is warranted.

Transportation, Handling, and Storage of Materials

Transportation, handling, and storage of materials are not anticipated to have an effect on historic properties.

Launch Activities

Because the launches would increase from 12 to 18 a year, the indirect auditory effects to historic properties in the APE are expected to be negligible; therefore, launch activities are not expected to have an adverse effect on historic properties.

4.4.5 Transportation

No Action Alternative

Under the No Action Alternative, activities would remain at present levels and there would be no additional impacts to transportation.

Proposed Action

Site Improvements

Temporary impacts to traffic flow would occur during construction activities due to an increase in the volume of construction-related traffic at roads in the immediate vicinity of Wallops Island. Traffic lanes may be temporarily closed or rerouted during construction, and construction equipment and staging could interfere with typical vehicle flow. NASA and MARS would coordinate all transportation activities, including closures, traffic control, safety issues, etc. with Accomack County and the Virginia DOT Accomack Residency Office. To mitigate potential delays, NASA and MARS would:

- Provide adequate advance notification of upcoming activities for all areas that would be affected by construction-related traffic, temporary closures, or re-routing
- Coordinate any traffic lane or pedestrian corridor closures with all appropriate officials
- Place construction equipment and vehicle staging so as to not hinder traffic and pedestrian flow
- Minimize the use of construction vehicles in residential areas

Transportation, Handling, and Storage of Materials

When payload processing is completed, the rocket (ELV and ES) would be encapsulated and transported to Pad 0-A. Accidents during transport would be extremely unlikely because movement of the rocket would be carefully controlled in convoys with security escorts. Several factors would minimize the consequences of an accident should one occur. The forces imparted to the encapsulated spacecraft during an accident would be small because of the low speeds involved during transport and the spacecraft would be protected from damage by the capsule and a protective blanket. Should the spacecraft be damaged, it would be unlikely that the propellant tanks would be damaged. In the unlikely event of a propellant leak, transport and security personnel would be protected by following emergency procedures developed in the project's ground safety plan and wearing appropriate protective clothing.

Transportation routes that may be utilized for the conveyance of ELVs, ELV components, payloads, fuels, and other materials necessary to support the Proposed Action include public roads, airplane delivery of materials to the airport at the Main Base, and barge deliveries that would either navigate from the boat basin at the Main Base or through Chincoteague Inlet and arrive at the boat dock on Wallops Island. Transportation of all materials would be in compliance with DOT regulations.

The largest load transported to Wallops Island under the Proposed Action would be the stage one core arriving by barge from the port of Newport News, Virginia, and would never be transported over a public road. All other components would consist of legal DOT loads, although approximately 30 loads arriving via truck would be characterized as oversize and would require a permit from the Virginia Department of Motor Vehicles for transportation. In 2008, 104,175 oversized load permits were issued by the Virginia Department of Motor Vehicles; the loads arriving at WFF would be a negligible amount compared to the total travelling on State roads.

The truck traffic arriving at WFF under the Proposed Action can be broken into two categories: recurring traffic that would be necessary for each launch event and non-recurring traffic that would be related to a one-time event. The lists below include an example of the types of loads that would be delivered via truck over public roads under the Proposed Action; other deliveries may also occur.

Recurring traffic:

- Stage 2 of ELV (Trucked from Promontory, Utah), Hazardous
- Main engines (Trucked from Stennis, Mississippi)
- Main engine Thrust Frame (Trucked from Dulles, Virginia), Oversized
- Interstage/motor cone (Trucked from Chandler, Arizona)
- Avionics shelf (Trucked from Chandler, Arizona)
- Fairing aft cylinder (Trucked from Chandler, Arizona), Oversized
- Fairing halves (Trucked from Chandler, Arizona), Oversized (two trucks)
- Payload service module (Trucked from Dulles, Virginia)
- Miscellaneous United Parcel Service, U.S. Postal Service, and Federal Express deliveries
- Cargo delivery (Trucked from various U.S. locations and arriving by aircraft)
- Cranes to support static fire test (up to twice per year)

Non-recurring traffic:

- Construction traffic
- Pad 0-A components (strongback and erector mechanism) (Trucked from California), Oversized
- Miscellaneous heavy mechanical ground support equipment deliveries, Oversized (some)

Launch Activities

Temporary traffic closures would occur on Wallops Island roads, the causeway going from Wallops Island to the Mainland, and potentially other public roads in the Wallops Island vicinity prior to and immediately after launches. NASA and MARS would coordinate all transportation activities including closures, traffic control, and safety issues with Accomack County, the Virginia State Police, and the Virginia DOT Accomack Residency Office. NASA and MARS would alert personnel and contractors of temporary closures.

NASA and MARS would coordinate all launch operations with the FAA, USCG, Virginia Capes Operating Area, the Fleet Area Control and Surveillance Facility, and other organizations as required in order to clear any areas of air and maritime traffic (including commercial and recreational boats); NOTMARS and NOTAMS listing restricted or hazardous areas shall be made available at least 24 hours prior to launch. All launch limitations would be established in the project's safety plans and would be conveyed to the public prior to the launch to minimize transportation interruptions.

4.5 CUMULATIVE EFFECTS

The CEQ defines cumulative effects as the "impact on the environment which results from the incremental impact of the action(s) when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR 1500). NASA has determined that the Proposed Action, in conjunction with the impacts of other WFF projects and operations, could result in cumulative impacts on some resources.

4.5.1 Past, Present, and Reasonably Foreseeable Projects

4.5.1.1 Wallops Research Park

The Wallops Research Park (WRP) project intends to create an integrated business park for aerospace research and development programs, scientific research, commercial space industries, and educational centers. Development of the WRP will take place adjacent to the Main Base at WFF over a 20-year period; some development has occurred, but the majority of the Proposed Action has not been constructed. WRP would consist of a multi-use development created for non-retail commercial, government space, science research, educational facilities, and public recreation areas. An EA was prepared for the construction of WRP, which resulted in a FONSI (NASA, 2008e).

4.5.1.2 North Unmanned Aerial Vehicle Airstrip

NASA is currently considering the construction of an unmanned aerial vehicle (UAV) airstrip on north Wallops Island. The purpose of the North UAV Airstrip is to provide a venue and infrastructure to support launch and recovery operations for UAVs. UAVs are small aircraft that serve as platforms for small science instruments. They are controlled remotely by a pilot on the ground and are powered by batteries or small model aircraft gasoline engines. The east-west orientation of this airstrip would provide an alternative to the north-south positioning of the current UAV airstrip on south Wallops Island. The airstrip is currently planned for late 2009 or early 2010; an EA is currently being prepared.

4.5.1.3 Shoreline Restoration and Infrastructure Protection Program

A Shoreline Restoration and Infrastructure Protection Program (SRIPP) is currently being planned at WFF to help reduce the risk of damage to existing NASA, U.S. Navy, and MARS assets on Wallops Island that are at risk due to extensive shoreline retreat. The proposed program includes: 1) dredging of approximately 3 million cubic yards of sand from a borrow site located in Federal waters, and subsequent sand placement on the Wallops Island shoreline with maintenance dredging to be performed every 5 years for the duration of the project's 50-year design life; 2) construction of one terminal groin structure perpendicular to the shoreline off the south end of Wallops Island; and 3) extension of the existing seawall a maximum of approximately 1,400 meters (4,500 feet) south. Implementation of this program is planned for 2010. An EIS is currently being prepared for the SRIPP.

Additionally, there have been many other beach restoration projects along the New Jersey, Maryland, and Virginia coastline due to beach and shoreline erosion. The end result of the combined effects of NASA's Proposed Action and other shoreline stabilization projects around the region would create a more natural topography due to many of the beaches being restored to a natural state.

4.5.1.4 Alternative Energy Project

The purpose of WFF's Alternative Energy Project is to generate clean, renewable energy from a technologically proven source that will be used by WFF in order to meet Federal renewable energy requirements. WFF plans to implement the use of wind turbines and solar panels in order to reduce the fossil fuels needed to create electricity while also reducing WFF's annual operation costs. NASA is currently preparing an EA for the project; implementation of this project is planned for 2010.

4.5.1.5 WFF Launch Range Activities

NASA can currently launch up to approximately 82 rockets a year from the launch areas on Wallops Island. These include a maximum of 50 from the Sounding Rocket Program, 12 from orbital rocket missions at Pad 0-B, and 20 from Navy missiles and drones (NASA, 2005).

Orbital Rockets

The Lockheed Martin Athena-3 class vehicle is the largest vehicle expected to be launched from WFF in terms of solid propellant weight for the first stage (approximately 133,120 kg [293,479 lbs]). The 1997 WFF Launch Range Expansion EA analyzed 12 annual launches of the Athena-3 class vehicle as an upper bound for environmental effects (NASA, 1997).

Sounding Rockets

Sounding rockets at WFF, managed under the NASA Sounding Rockets Program, carry research payloads with scientific instruments to altitudes up to 1,600 kilometers (994 miles). Scientific data are collected and returned to Earth by telemetry links. The NASA Sounding Rockets Program primarily operates for NASA, but serves other government agencies, universities, industry, and foreign countries as well. Several launch vehicles could be used to support the Sounding Rocket Program. The largest sounding rocket launched to date in terms of propellant weight is the Black Brant XII (approximately 3,350 kg [7,385 lbs]).

Since 2001, NASA has averaged six sounding rocket launches and one orbital launch per year from the launch areas on Wallops Island (NASA, 2008a).

Drones and Missiles

Drone targets are used at WFF as part of missile training exercises conducted by the U.S. Navy and supported by NASA. Targets are used to test the performance of shipboard combat systems, as well as to provide simulated real-world targets for ship defense training exercises. Drone targets are either launched from the WFF Range or air-launched from military aircraft in controlled airspace.

4.5.2 Potential Cumulative Effects by Resource

The environmental and socioeconomic resources that may experience cumulative impacts are discussed below.

4.5.2.1 Surface Waters Including Wetlands

The Proposed Action would have a minor and temporary impact on the water resources of the affected region; the incremental contribution to cumulative water resource impacts from the Proposed Action would not be significant.

The area surrounding MARS Launch Complex 0 has historically seen many rocket launches and local water resources have been exposed to launch impacts by many past actions. Impacts on water resources from other launches at WFF may result from incidental spills and release of propellants from on-pad accidents or emergencies, launch anomalies, or rocket stages falling in the ocean. Such spills or releases may affect surface water, including wetlands. Emergency response and cleanup procedures similar to those discussed under the Proposed Action would be employed to address on-pad accidents and emergency releases, and solid waste recovery and treatment would reduce the severity of launch anomalies.

The Proposed Action would result in the loss of 2.3 hectares (5.7 acres) of wetlands. The WRP will result in the loss of approximately 0.4 hectare (1 acre) of tidal wetlands and perennial stream to the west of the Main Base, the Alternative Energy project could result in the loss of up to 0.4 hectare (1 acre) of tidal wetlands in the central part of Wallops Island, and the UAV Airstrip project could result in the loss or conversion impacts to up to 8.5 hectares (21 acres) of tidal and nontidal wetlands on north Wallops Island. These impacts would result from both the construction of the airstrip and tree clearing activities required to provide a line of sight for UAV pilots. The SRIPP is not expected to affect wetlands. Water quality impacts from implementing the SRIPP would primarily include increased turbidity in the immediate project area due to dredging and placement of sand on the Wallops Beach. Such impacts would be temporary and are not anticipated to be substantial.

NASA would obtain necessary permits including Section 404 and Section 10 permits. Because NASA would implement compensatory wetland mitigation measures (agreed upon through the JPA consultation process) to offset any impacts and ensure no net loss of wetlands, no significant cumulative adverse impacts to wetlands are anticipated.

Additionally, NASA is currently preparing a Wetlands Inventory and Assessment Master Plan for the entire WFF. The goal of this effort is to provide strategic regulatory, environmental, and land use analysis of all wetlands on the Main Base, Wallops Mainland, and Wallops Island in order to develop a comprehensive long-term wetland management plan for the facility.

4.5.2.2 Groundwater

The SRIPP and Alternative Energy project are not expected to increase potable water demand at WFF. The estimated total potable water demand for the WRP is 4,156,382 liters (1,098,000 gallons) per month. Currently, WFF withdraws approximately 8,971,426 (2,370,000 gallons) per month (Bundick, pers. comm.). The Proposed Action is anticipated to result in the withdrawal of approximately 6,095,933 liters (1,610,375 gallons) per month. The combined water demand of WFF, WRP, and the Proposed Action would be approximately 19,223,741 liters (5,078,375 gallons) per month, which is below the 8,153,000 gallons per month authorized by VDEQ groundwater withdrawal permit; therefore, the Proposed Action, when combined with other WFF projects, is not anticipated to contribute to significant adverse cumulative impacts to the sole source aquifer. WFF would monitor groundwater withdrawal rates to ensure continued compliance with WFF’s Virginia DEQ groundwater withdrawal permit.

4.5.2.3 Air Quality

Construction-related activities under the Proposed Action and the other projects planned at WFF would occur at different locations and at different times over a period of several years. Such activities would result in fugitive particulate emissions (PM_{10} and $PM_{2.5}$) from site preparation (earth moving/soil disturbance) and wind erosion. The amount of fugitive dust would depend on numerous factors including: degree of vehicular traffic; amount of exposed soil; soil moisture content; and wind speed. The extent and duration of these projects would vary; however, best management practices (e.g., dust suppression and establishment of lower speed limits in construction areas) would be implemented on each project to minimize and mitigate those emissions.

Construction activities would also create combustion product (tailpipe) emissions (mostly PM, NO_X, and CO) from contractor personal vehicles, delivery trucks, heavy construction equipment, and temporary non-road equipment powered by internal combustion engines. Emissions from the mobile sources associated with these projects occurring at WFF would be short-term, negligible, and localized.

Cumulative emissions from these construction projects are unlikely to lead to a violation of the NAAQS as regional concentrations are already in attainment, with no indication that a re-designation for any criteria pollutant is imminent. Therefore, minimal and short-term cumulative impacts from construction-related activities are anticipated; there would not be a significant effect on local or regional air quality, or violation of NAAQS.

Launches in general would have only a localized impact on air quality. Long-term effects are not expected because the Taurus II launches would be infrequent and occur as independent events. Therefore, as the resulting emissions from all launch activities at WFF would be rapidly dispersed and diluted by winds, regional air quality would not be affected and the NAAQS are not expected to be exceeded by launches of the Taurus II launch vehicle when added to the air emissions from existing WFF activities. Since each launch is an independent event, no significant cumulative impacts to air quality are expected. In addition, the installation of two wind turbines planned on Wallops Island under the Alternative Energy Project would offset over 4,500 metric tonnes (5,000 tons) of CO_2 emissions per year.

4.5.2.4 Terrestrial Wildlife and Migratory Birds

Construction and launch noise could temporarily affect wildlife in the area (e.g., short-term disruption of daily/seasonal behavior). Some vegetative damage may occur from heat from the launch and acid deposition in the near-field areas. Potential cumulative impacts to terrestrial wildlife and migratory birds could result from habitat alteration and disturbance under the Proposed Action and other projects planned at WFF; however, since vast areas of habitat will remain on Wallops Island and the surrounding area, no significant cumulative impacts on wildlife or migratory birds are anticipated.

4.5.2.5 Marine Mammals and Essential Fish Habitat

For marine species, the potential exists for direct contact or exposure to underwater shock/sound waves from the splashdown of spent rocket motors and spacecraft. The likelihood for protected marine mammals or sea turtles to be located in close proximity to the impact points is extremely low, as launches from both Pad 0-A and Pad 0-B would occur only a few times per year, and impacts from each flight would not likely occur at the same locations.

4.5.2.6 Threatened and Endangered Species

A Programmatic EA was prepared for the SRIPP in 2007 and 2008 that evaluated effects to threatened and endangered species from shoreline restoration activities and dredging of sand in State waters. The Programmatic EA resulted in NASA's decision to prepare an EIS for the SRIPP, so the Programmatic EA was not finalized. However, USFWS and NMFS consultations were done for SRIPP actions. In a letter to USFWS dated March 1, 2007, NASA transmitted a Biological Assessment concluding that the SRIPP preferred action (similar to the SRIPP Proposed Action of the EIS) is "not likely to adversely affect" the piping plover. In a letter dated April 24, 2007, USFWS stated that the SRIPP Programmatic EA actions would not adversely affect threatened or endangered species. In a Biological Opinion issued on September 25, 2007, NMFS determined that dredging described in the SRIPP Programmatic EA is not likely to adversely affect right, humpback, or fin whales.

Additionally, in a Biological Opinion issued on September 25, 2007, NMFS determined that SRIPP dredging (conducted in State waters) may adversely affect, but is not likely to jeopardize the continued existence of, the loggerhead sea turtle; is not likely to adversely affect the Kemp's ridley, leatherback, or green sea turtles; and will not affect hawksbill turtles. NMFS issued an Incidental Take Statement for loggerhead sea turtles, which could be entrained in dredges. Although the SRIPP EIS Proposed Action is evaluating effects on threatened and endangered species for dredging in Federal waters instead of State waters, informal consultation with NMFS for the SRIPP EIS actions indicates that the effects are likely to be similar between the Programmatic EA and the EIS actions.

NASA has determined that the Proposed Action is also not likely to jeopardize the continued existence of the piping plover and that launch activities would have no effect on federally protected sea turtles. Therefore, the current range of operations on Wallops Island, when combined with the Proposed Action and other WFF projects including the SRIPP, is not anticipated to result in adverse cumulative effects to piping plover habitat or sea turtles. During the execution of all future projects, NASA would continue working with the USFWS and NMFS to ensure that its actions have minimal effect on protected species.

4.5.2.7 Population

The estimated number of people moving to the Lower Delmarva Peninsula as a result of the WRP is approximately 2,430; however, this would occur over a 20-year period due to gradual build-up of the WRP over 20 years. An EA done for the WRP concluded that impacts to population are not likely to occur due to the long lead time. Additionally, the population growth attributed to the WRP over a 10-year period (1.5 percent) compared to the "background" population growth in Accomack County over a 10 year period (between 1990 and 2000) does not indicate that the population growth from WRP would result in a significant impact on population within Accomack County. The WRP EA also stated that even if Accomack County schools do not increase student capacity, the WRP would not result in adverse impacts to public and private schools, and that in addition, the increase in taxes generated by the additional WRP-employed families would add to the county's ability to implement upgrades to schools.

The number of people moving to the lower Delmarva Peninsula under the Proposed Action would comprise less than 1 percent of the Accomack County's projected population of 37,350 in 2010 (VEC, 2008). The combination of additional population due to the Proposed Action and the WRP would not result in a significant increase in the population of Accomack County or the

Lower Delmarva Peninsula due to the reasons described in the WRP EA (stated above); therefore cumulative impacts are not expected to be significant.

4.5.2.8 Health and Safety

Due to an increase on the demand for medical, fire, and police services from development of the WRP (WRP would result in approximately 2,430 additional people in the Lower Delmarva Peninsula over a 20-year period) along with the Proposed Action, adverse cumulative impacts to human health and safety could occur if existing capacity of medial, fire, and police services are exceeded. However, the increase in taxes generated by the additional residents would add to the counties' ability to implement upgrades to emergency services. Also, safety procedures and appropriate training would be implemented to ensure that events that have the potential to adversely impact human health and safety are minimized. All operations at WFF must comply with applicable standards, policies, and procedures for health and safety. All rocket launches and other hazardous operations are closely reviewed and analyzed to ensure that there are no unacceptable risks to the public, WFF personnel including tenants (USCG, U.S. Navy, MARS), or contractors. Because implementation of the Proposed Action would also comply with these same requirements, no significant cumulative impacts to health and safety are expected to occur.

4.5.2.9 Climate Change

WWF would comply with Federal climate change policy including EO 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*, which instructs Federal agencies to conduct their environmental, transportation, and energy-related activities under the law in support of their respective missions in an environmentally, economically, and fiscally sound, integrated, continuously improving, efficient, and sustainable manner. EO 13423 also directs Federal agencies to implement sustainable practices for energy efficiency and reductions in greenhouse gas emissions, and for the use of renewable energy. The Federal Energy Policy Act requires Federal agencies to increase the usage of renewable sources by 3 percent between 2007 and 2009, 5 percent between 2010 and 2012, and by 7.5 percent for 2013 and beyond.

Greenhouse gases absorb the radiative energy from the Sun and the Earth. Some direct greenhouse gases (e.g., CO_2, chlorofluorocarbons, and H_2O) are emitted from processes, and other gases (e.g., NO_X and VOCs) emitted from these processes contribute indirectly by forming tropospheric (ground-level) ozone and other reactive species that photochemically react with the greenhouse gases and control the amount of radiation penetrating through the troposphere.

The principal source of carbon emissions that would be associated with the Proposed Action would be from NASA and MARS' energy use in support of the program (e.g., construction, transportation of materials/cargo, electricity for buildings). From fiscal year 1990 through fiscal year 2005, NASA reduced its total annual primary energy consumption by approximately 16 percent (DOE, 2006). NASA consumed energy primarily across four end-use sectors: 1) standard buildings; 2) industrial, laboratory, and other energy-intensive facilities; 3) exempt facilities; and 4) vehicles and equipment, including aircraft operations.

The effects of launch vehicle propulsion exhaust emissions on stratospheric ozone depletion, acid rain, toxicity, air quality, and global warming are extremely small compared to other human activities (AIAA, 1991; FAA, 2001).

WFF is currently planning an Alternative Energy Project that would utilize wind and solar energy to reduce greenhouse gas emissions by reducing the use of fossil fuels to generate electricity. Although the Proposed Action would result in additional energy demands at WFF, the installation of two wind turbines planned on Wallops Island under the Alternative Energy Project would offset over 4,500 metric tonnes (5,000 tons) of CO_2 emissions per year.

WFF is committed to complying with all of the Federal policies that address climate change, and as such, would implement measures to reduce greenhouse gas emissions and promote sustainable energy and resource use practices; therefore, significant cumulative impacts to the global climate from the Proposed Action, when added to other known and foreseeable regional actions, are not anticipated.

4.6 DEPARTMENT OF TRANSPORTATION SECTION 4(F) LANDS

This EA includes an investigation of impacts due to the Proposed Action upon parks, recreation areas, and wildlife refuges and historic structures that are on, or are eligible for inclusion on, the NRHP. The Proposed Action would not be considered a constructive or physical use of 4(f) properties; therefore, it would not result in impairment of 4(f) properties.

Closures of the southern end of Assateague Island including CNWR may occur for launches from Pad 0-A. NASA has an established agreement with CNWR for such closures and coordinates with CNWR personnel during mission planning to ensure that closures do not adversely affect CNWR activities. The value of CNWR in terms of its significance and enjoyment is not substantially reduced or lost due to launch activities at WFF. Instead, CNWR has become a popular observation location for viewing NASA and MARS launches.

4.7 PERMITS, LICENSES, AND APPROVALS

The following list of potential permits, licenses, and approvals are likely to be required for the Proposed Action. The agency responsible for each is included after the identified permit, license, or required consultation. Any required permits, licenses, or approvals would be obtained prior to construction.

- CWA Section 404 Dredge and Fill Permit, USACE
- Rivers and Harbors Act Section 10 Permit, USACE
- CWA Section 401 Water Quality Certification/Virginia Water Protection Permit, VDEQ
- Virginia Stormwater Management Program Permits, Virginia DCR
- Virginia Marine Resources Commission Permits, VMRC
- MEC Avoidance Plan and Health and Safety Plan, WFF
- Federal Consistency Determination, VDEQ
- Modification of State Operating Permit, VDEQ Division of Air Quality
- Air Quality Permit to construct proposed emission sources, VDEQ Division of Air Quality

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SECTION SEVEN PUBLIC PARTICIPATION

NASA is the lead Federal agency for conducting the NEPA compliance process for this EA at Wallops Flight Facility. The lead agency's goal is to expedite the preparation and review of NEPA documents while meeting the intent of NEPA and complying with all NEPA provisions including NHPA, EO 12114, EO 11988, EO 11990, CAA, CWA, and the Resource Conservation and Recovery Act.

The Draft EA was available for public review between April 24, 2009, and May 11, 2009, at the following locations:

NASA WFF Technical Library
Building E-105
Wallops Island, VA 23337
(757) 824-1065
Hours: Mon–Fri: 8 a.m. to 4:30 p.m.

Eastern Shore Main Public Library
23610 Front Street
P.O. Box 360
Accomac, VA 23301
Phone: (757) 787-3400
Monday, Tuesday, Wednesday, Friday:
9 a.m. to 6 p.m.
Thursday: 9 a.m. to 9 p.m.
Saturday: 9 a.m. to 1 p.m.

Island Library
4077 Main Street
Chincoteague, VA 23336
(757) 336-3460
Hours: Mon: 10 a.m. to 2 p.m.
Tues: 10 a.m. to 5 p.m.
Wed, Fri, Sat: 1 p.m. to 5 p.m.

NASA solicited public and agency review and comment on the environmental impacts of the proposed action through:

1. A notice of availability of the Draft EA published in the Eastern Shore News and the Chincoteague Beacon on April 25, 2009
2. Publication of the Draft EA on the WFF Environmental Office Web site
3. Consultations with local, State, and Federal agencies
4. Direct mailing of the Draft EA to interested parties

The Draft EA can be viewed on the WFF Environmental Office Web site:

http://sites.wff.nasa.gov/code250/docs/EWLR_DEA.pdf

A limited number of copies of the Draft EA are available by contacting:

NEPA Program Manager
NASA Wallops Flight Facility, Code 250.W
Wallops Island, VA 23337
Phone: (757) 824-1579
Fax: (757) 824-1819

Comments may also be sent electronically to Joshua.A.Bundick@nasa.gov; Subject: EWLR EA.

The following Public Notice advertising the availability of the Draft EA was placed in the *Eastern Shore News* and the *Chincoteague Beacon* newspapers on April 25, 2009.

PUBLIC NOTICE
Notice of Availability
DRAFT ENVIRONMENTAL ASSESSMENT FOR THE EXPANSION OF THE WALLOPS FLIGHT FACILITY LAUNCH RANGE

In accordance with the requirements of the National Environmental Policy Act (NEPA), NASA Goddard Space Flight Center's Wallops Flight Facility (WFF) invites public comment on the Draft Environmental Assessment (EA) for the Expansion of the Wallops Flight Facility Launch Range, Wallops Island, Virginia. NASA has analyzed and addressed the potential impacts of expanding NASA and Mid-Atlantic Regional Spaceport (MARS) facilities to support launching up to an additional six (6) medium large class suborbital and orbital Expendable Launch Vehicles from WFF. The Federal Aviation Administration Office of Commercial Space Transportation has served as a Cooperating Agency in preparing the Draft EA.

Under the Proposed Action, physical improvements to WFF may include any or all of the following:

On north Wallops Island, NASA would construct a dedicated payload fueling facility and MARS or a commercial entity would build a new payload processing facility. On south Wallops Island, MARS would construct a new launch complex including a liquid fueling facility, pad access ramp, launch pad, and deluge system in approximately the same location as the existing Pad 0-A. Transportation improvements would be made by NASA and MARS to allow the movement of cargo to the new facilities on Wallops Island. Such improvements could include construction of new roads and minor upgrades to existing roads. Several existing facilities could undergo minor interior modifications to support the additional launches; these facilities could include launch control buildings, communication support systems, radar, and antenna improvements.

As the Proposed Action would involve Federally-funded or authorized construction in the 100-year floodplain and jurisdictional wetlands, this Notice also serves as NASA's means for facilitating early public review as required by Executive Order 11988, *Floodplain Management* and Executive Order 11990, *Protection of Wetlands*.

The Proposed Action would have impacts to both environmental and socioeconomic resources, however most are minor and of short duration and none are considered significant. Impacts would be mitigated to the greatest extent practicable to minimize the effects on resource areas.

The Draft EA is available for review between April 25, 2009 and May 25, 2009,

Comments are requested by May 25, 2009.

Written comments should be submitted to:

NEPA Program Manager
NASA Wallops Flight Facility
Code 250.W/EWLR EA
Building F-160, Room W-160
Wallops Island, VA 23337
Fax – 757-824-1819

Comments may also be sent electronically to Joshua.A.Bundick@nasa.gov; Subject: EWLR EA.

The Draft EA may be viewed online at

http://sites.wff.nasa.gov/code250/docs/EWLR_DEA.pdf

The Draft EA is available for review at the following locations:

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Eastern Shore Public Library
23610 Front Street
Accomack, Virginia 23301
(757) 787-3400
Hours: Mon, Tues, Wed, Fri:
9 a.m.to 6 p.m.
Thurs: 9 a.m. to 9 p.m.
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Tues: 10 a.m. to 5 p.m.
Wed, Fri, Sat: 1 p.m. to- 5 p.m.

For further information or to request a copy of the Draft EA, please contact the Wallops Flight Facility Public Affairs Office at (757) 824-1579.

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Appendix A

ELV Specifications and Descriptions

SPECIFICATIONS AND DESCRIPTION OF FALCON EXPENDABLE LAUNCH VEHICLES (ELVS)

TAURUS II LAUNCH VEHICLE

Orbital Sciences Corporation is currently developing the Taurus II, which is designed to carry medium-class payloads into a variety of orbits (See Figure A-1). More information on Taurus II is provided below.

Taurus II is a two-stage launch vehicle designed to transport medium-class payloads weighing up to 5,750 kg (12,676 lbs) (Orbital, 2008). An optional third stage can be added. Taurus II incorporates both liquid and solid stages; the first stage uses liquid oxygen (LOX) and rocket propellant-1 (RP-1) as the propellant, the second stage is a solid motor propelled by hydroxyl-terminated polybutadiene (HTPB), and the optional third stage called Orbit Raising Kit (ORK) uses bipropellant hypergolics (nitrogen tetroxide [NTO] and monomethyl hydrazine [MMH]). For high-energy orbits, a Star 48V solid propellant kick motor could be used as a third stage.

Taurus II will stand roughly 40 meters (131 feet) tall, assuming a 9- to 10-meter- (30- to 33-foot-) long payload fairing. The 2.36-meter- (7.74-foot-) diameter Castor 30 second stage would fit within a 3.9-meter- (12.8-foot-) diameter, 4 to 5-meter- (13 to 16 foot-) tall "interstage" section.

Stage 1 will carry approximately 177,436 kg (391,179 lbs) of LOX and 65,000 kg (142,339 lbs) of RP-1 propellant, weigh 18,751 kg (41,253 lbs) empty, and stand 27 meters (88 feet) tall. The first stage structure features two AJ26-62 (Americanized Ukrainian NK33) engines.

Stage 2 will use a new Castor 30 motor fueled by a solid composite propellant with AP, aluminum, and HTPB. Propellant weight for the Castor 30 is 12,815 kg (28,252 lbs).

The optional third stage consists of a 3-engine bipropellant hypergolic pressure-fed propulsion system called an ORK. After completion of the second stage burn, the Castor 30 motor would be jettisoned from the ORK, allowing the third stage to provide the final precision orbit insertion burn and/or orbit raising maneuvers. The ORK will contain up to 322 kg (710 lbs) of NTO as oxidizer and 358 kg (789 lbs) of MMH as fuel. For higher energy missions, the Taurus II third stage could be a Star 48V solid propellant kick motor that would utilize 2,010 kg (4,431 lbs) of composite (AP, ammonium, and HTPB) propellant.

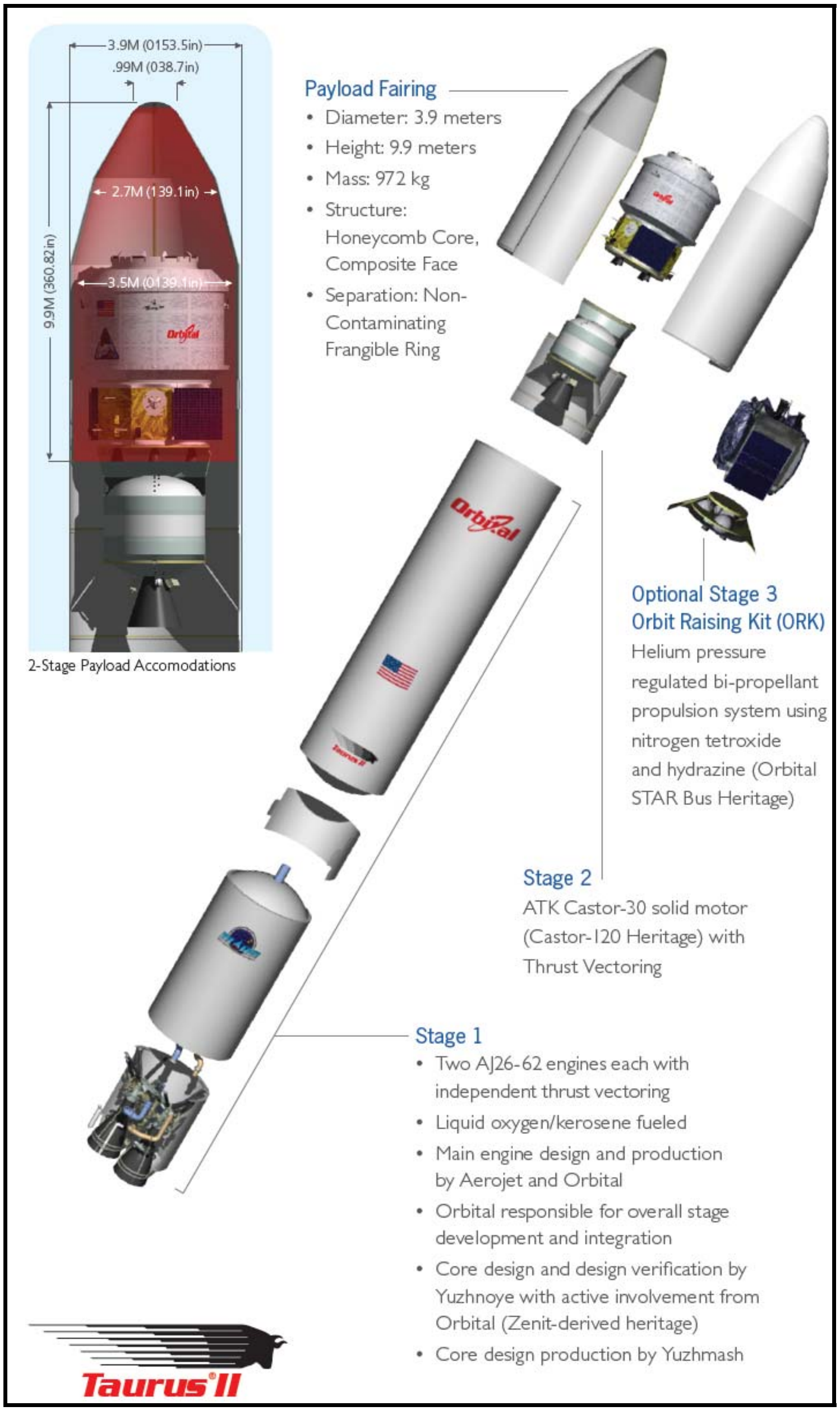


Figure A-1. Taurus II Rocket Configuration (*Source: Orbital Taurus II Fact Sheet, 2008)*

FALCON FAMILY OF LAUNCH VEHICLES

The Falcon family of launch vehicles utilizes a partially reusable launch system designed and manufactured by SpaceX. The two-stage-to-orbit rockets use LOX/RP-1 for both stages.

Falcon 1 and 1e

The Falcon 1 is a small, unmanned, light-lift, two-stage, liquid-fueled vehicle with a gross lift-off weight of approximately 27,273 kg (60,000 lbs) that can carry payloads between 125 kg (275 lbs) and 454 kg (1000 lbs) depending on the orbit. The Falcon 1 measures 21 meters (70 feet) in length with a diameter of 167 centimeters (66 inches), tapering to 152 centimeters (60 inches) on the second stage.

The Falcon 1e is based on the Falcon 1; however, it has an extended first stage tank. The Falcon 1e is also rated as a light-class launch vehicle with a gross lift-off weight of approximately 35,000 kg (77,000 lbs) and an overall length of approximately 27.4 meters (90 feet).

Both the first and second stages of the Falcon 1 and Falcon 1e use only liquid propellants (LOX and RP-1). The first stage uses a turbo pump to feed the propellant, while the second stage is pressure-fed using gaseous helium stored in high pressure, composite over-wrapped cylinders to pressurize the propellant tanks. Quantities of helium required for Falcon 1 processing are 16.5 kg (36.9 lbs) for first stage pressurization, engine spin start, and purging, and 9.8 kg (21.7 lbs) for second stage pressurization. The helium flow is controlled through solenoid valves. Propellant use and specifications for each stage are as follows.

<u>First and Second Stages</u>

The first stage uses a turbo pump to feed the propellant, while the second stage is pressure-fed using gaseous helium stored in high-pressure, composite over-wrapped cylinders to pressurize the propellant tanks.

The first stage consists of aluminum LOX and RP-1 tanks with a common bulkhead powered by a 40,823 kg (90,000 lbs) thrust Merlin LOX/RP-1 engine with Pintle Injector, a pump-fed gas generator cycle, turbine exhaust roll control, and hydraulic thrust vector control. The propellant tanks hold 15,586 kg (34,362 lbs) of LOX and 7,159 kg (15,782 lbs) of RP-1. The second stage consists of aluminum-lithium LOX and RP-1 tanks with a common bulkhead, and uses helium as a pressurant. The engine is a 3,402 kg (7,500 lbs) thrust Kestrel engine with Pintle injector, hot helium attitude control, and an electromagnetic actuator for thrust vector control. The propellant tanks hold 5,941 kg (5,941 lbs) of LOX and 1,142 kg (2,517 lbs) of RP-1. Please refer to Table 3 in Section 2.2.3 of this EA for amounts of LOX and RP-1 and engine specifications for Falcon 1e.

Falcon 9

The Falcon 9 is a medium class launch vehicle with a gross lift-off weight of approximately 315,000 kg (693,000 lbs) and an overall length of 54 meters (178 feet). The Falcon 9 uses LOX and RP-1 to carry payloads into orbit and is basically a scaled-up version of the Falcon 1 vehicle.

<u>First and Second Stages</u>

The first stage of the Falcon 9 is approximately 3.6 meters (12 feet) by 30.5 meters (100 feet), and includes 9 Merlin engines, the same engine used on the first stage of the Falcon 1. The second stage is approximately 3.6 meters (12 feet) by 12.5 meters (41 feet), not including the fairing and payload, and uses one or two Merlin engines. The fairing is 5.2 meters (17 feet) by 15.2 meters (50 feet), and a smaller version may also be used. The first stage consists of LOX and kerosene tanks that hold 146,000 liters (38,672 gallons) of LOX and 94,000 liters (24,840 gallons) of kerosene. The second stage consists of 27,600 liters (7300 gallons) of LOX and 17,400 liters (4600 gallons) of kerosene in tanks with a common bulkhead.

Appendix B

Payload Checklist

For a payload to be covered under this EA, it must meet specific limiting criteria, which are determined by evaluating a series of questions that serve as a payload checklist (checklist). The checklist should be evaluated following the format below as soon as the proposed payload and spacecraft subsystems are sufficiently defined (i.e., the end of Phase A/beginning of Phase B – during the Formulation Phase).

If responses to all checklist questions are negative (i.e., the condition is not present), the candidate mission would be considered covered by this EA. If answers to any of the checklist questions are positive, further NEPA analysis and documentation or clarification would be required. The nature and scope of the any incremental environmental review process, analysis, and documentation required would be determined in consultation with NASA Headquarters.

1. Would the candidate mission return a sample from an extraterrestrial body? (A1)

   Spacecraft that would return air, soil, or other materials from any extraterrestrial body or from interplanetary space are not covered by this EA. This includes spacecraft that would return a sample to the Earth's surface and spacecraft that would return a sample only to Earth orbit.

2. Would the candidate spacecraft carry radioactive sources such that launch could not be approved by the NASA Office of Safety and Mission Assurance (OSMA) Nuclear Flight Safety Assurance Manager (NFSAM) per NASA Procedural Requirement (NPR) 8715.3B (NASA Safety Manual)? (B1, B2)

   Spacecraft carrying any radioactive material for power, heat sources, instrument calibration, structural members, or any other purpose must be analyzed and reviewed for launch approval with the level of analysis and approval determined by the quantity of radioactive material. The NASA NFSAM may approve launch for small quantities of radioactive material that have been shown to present no substantial public hazard. Spacecraft that would carry radioactive sources requiring launch approval at the OSMA Associate Administrator level or above are not covered by this EA and would require further NEPA analysis per Table 6.1 of NASA's NPR 8715.3B Chapter 6, the type of radioactive material relates to its activity (A_1 and A_2)[2] (see Table 1 of Appendix D in NPR 8715.3B), and the amount of radioactive material determines the A_1 and A_2 multipliers. For the radioactive instrument calibration and measurement sources NPR payloads would launch, the sum of all of the A_2 values onboard the spacecraft contributes to a value known as the "A_2 mission multiple." For the purposes of this EA, the upper limit of the NFSAM's signature authority is less than 10 times the A_2 mission multiple.

3. Would the candidate spacecraft be launched on a vehicle and launch site combination other than those listed in this EA? (C1)

   The group of launch vehicles selected for routine payload spacecraft has been approved for launch from the launch sites listed. The environmental impacts of these vehicles have been reported in previous NEPA documentation.

[2] The A_2 multiplier for each radioactive source is based on the International Atomic Energy Agency (IAEA), Safety Series Number 6, Regulations for the Safe Transport of Radioactive Material, 1985 edition as amended in 1990, Section III, paragraphs 301 through 306, and summed to determine the A_2 mission multiple.

4. Would the proposed mission launch(es) cause the launch rate (per year) for a particular launch vehicle or total launches to exceed the launch rate previously approved and permitted at the proposed launch site? (C2)

   NEPA documentation for each launch vehicle has been approved assuming a particular number of annual launches from WFF. If adding the launch(es) required by the proposed spacecraft to the existing launch manifest would cause the number of launches to exceed the approved annual number for any year, further NEPA analysis would be required.

5. Would the candidate mission require the construction of any new facilities or substantial modification of existing facilities beyond the scope of this EA? (D1)

   Payload spacecraft would use only existing launch site facilities including roads, utilities, payload and launch vehicle processing facilities, and launch complexes. Minor modifications to existing facilities required for launch of the proposed spacecraft would be covered by this EA only if the associated activities remain within the scope of permitted operations at all proposed launch sites. Any non-covered modification or new construction would require further NEPA analysis.

6. Would the candidate spacecraft utilize any hazardous propellants, batteries, ordnance, radio frequency transmitter power, or other subsystem components in quantities or levels exceeding the ES in Table 4 of this EA? (E1)

   The routine payload Envelope Spacecraft defines the upper limits of quantities and levels of commonly used materials and systems that routine payload spacecraft may carry. These values are presented in Table 4 of this EA.

7. Would the candidate spacecraft utilize any potentially hazardous material as part of a flight system whose type or amount precludes acquisition of the necessary permits prior to its use or is not included within definition of the ES? (E2)

   Routine payload spacecraft may carry small quantities of hazardous materials that are not included as part of the ES description. If so, the required local permit(s) must be identified (if currently in force) or obtained (if new or renewed) before the material is used at the launch site.

8. Would the candidate spacecraft release material other than propulsion system exhaust or inert gases into the atmosphere? (E3)

   Routine payload spacecraft do not release or vent any material into the atmosphere that could present a hazard or substantial environmental impact either during launch preparations or launch.

9. Would launch of the candidate spacecraft suggest the potential for any substantial impact on public health and safety not covered by Chapter 4 of this EA? (E4)

   The environmental impact of routine payload spacecraft is bounded by the potential impact of preparation and launch of Envelope Spacecraft as presented in Chapter 4 of this EA. Changes in preparation, launch, or operation from standard practices described in this EA would require review to determine if the changes or associated environmental impacts are substantial enough to require further NEPA review.

10. Would the candidate spacecraft utilize an Earth-pointing laser system that does not meet the requirements for safe operations according to the analysis techniques in ANSI Z136.1-2000 and ANSI Z136.6-2005? (E5)

    Routine payload spacecraft may carry Earth-pointing laser systems as part of scientific instrumentation. Routine payload laser systems must meet performance criteria that eliminate the potential for the laser energy to present a health hazard for persons on the ground or in aircraft. Laser systems that would operate only in interplanetary space or in orbit around other planets are not required to meet the eye-safe requirement if they have systems that would prevent use when pointing toward the Earth. This EA documents not only the laser safety standards but also the required notifications and permits that must be obtained prior to use of Earth-pointing laser systems.

11. Would the candidate spacecraft contain pathogenic microorganisms (including bacteria, protozoa, and viruses) that could produce disease or toxins hazardous to human health? (E6)

    Spacecraft that would carry live or inactive disease-causing biological agents as part of an experiment package are not covered by this EA.

12. Would the candidate spacecraft have the potential for substantial effects on the environment outside the United States or on the global commons? (F1)

    If the launch or operation of the candidate spacecraft in the course of normal or anomalous operations might cause substantial effects outside of the United States, further analysis must be performed in accordance with Executive Order 12114, Environmental Effects Abroad of Major Federal Actions*, and NASA regulations (14 U.S.C. § 1216.321).*

13. Would launch and operation of the candidate spacecraft have the potential to create substantial public controversy related to environmental issues? (F2)

    Based on prior NASA experience and associated review, routine payload spacecraft are considered routine in that they would not present any environmental impacts that are new or unusual and would not raise or be likely to create substantial public controversy related to environmental concerns.

Appendix C

Agency Consultation

Appendix G
USFWS Section 7 Consultation

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
P.O. Box 99
6669 Short Lane
Gloucester, Virginia 23061

JUL 18 1997
NASA
GSFC/WALLOPS

July 14, 1997

Mr. Terry M. Potterton
National Aeronautics and Space Administration
Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, Virginia 23337-5099

Colonel Robert H. Reardon, Jr.
U.S. Army Corps of Engineers
803 Front Street
Norfolk, Virginia 23510-1096

Re: Range Operations Expansion at Wallops Flight Facility, Accomack County, Virginia

Gentlemen:

The U.S. Fish and Wildlife Service (Service) has reviewed the National Aeronautics and Space Administration's (NASA) proposal to expand range operations at Wallops Flight Facility, Accomack County, Virginia. NASA's April 22, 1997 request for formal consultation was received on April 22, 1997. This document represents the Service's biological opinion on the effects of that action on the piping plover (*Charadrius melodus*), federally listed threatened, in accordance with Section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.). A complete administrative record of this consultation is on file in this office.

I. CONSULTATION HISTORY

02-27-97 The Service received a copy of the Environmental Assessment for Range Operations Expansion at the NASA Goddard Space Flight Center's Wallops Flight Facility with a cover letter requesting our review regarding federally listed species.

04-09-97 The Service sent a letter to NASA providing comments on the Environmental Assessment and indicated that the project, as proposed, may affect the piping plover.

Mr. Potterton and Colonel Reardon 2

04-22-97 The Service met with NASA, the Virginia Department of Game and Inland Fisheries (VDGIF), and the Virginia Commercial Space Flight Authority to discuss the proposed project. NASA provided the Service with a letter regarding their estimate of the piping plover habitat to be impacted by the proposed project.

04-22-97 The Service received NASA's request to initiate formal consultation.

05-06-97 The Service sent a letter to the Corps indicating that NASA had requested formal consultation and no Corps' permits should be issued for this project until formal consultation has been completed.

II. BIOLOGICAL OPINION

DESCRIPTION OF PROPOSED ACTION

NASA proposes to enhance national launch capabilities through improvements to infrastructure and expansion of launch range capabilities. The major actions include: (1) establishment of a commercial Spaceport, (2) improvements to infrastructure to support a commercial Spaceport, (3) expanding launch operations to accommodate twelve orbital launches per year, and (4) restoration of the historical level and nature of operations at Wallops Flight Facility. The only action that may affect the piping plover is the use of launch pad 0-B. Construction of launch pad 0-B is proposed and will be used in conjunction with the existing launch pad 0-A to launch no more than twelve orbital launches per year from Wallops Flight Facility in Accomack County, Virginia (Figure 1). NASA has stated that a minimum of 60 to 90 days is required to prepare for a single launch event at one of the two pads.

Pad 0-B will be 19,000 square feet with a 170 foot high service tower. Other equipment will also be attached to this pad to facilitate launch operations. This facility would support the launching of expendable launch vehicles capable of placing small-to-medium payloads into orbit. Vehicle and payload handling within the pad and service tower area will be accomplished by a 75-ton capacity bridge crane. The proposed construction site will impact 1,315 square meters (m) (approximately 1/3 acre) of wetlands. The entire island is located within the 100-year flood plain. As part of the project, NASA has agreed to monitor piping plovers. The monitoring plan is in Appendix A.

Damage to local biological resources resulting from launch activities can be anticipated within a 1,000 m radius of the launch pad. The principal impacts radiate approximately 200 to 300 m within the combustion path. Searing of vegetation and injury or death to fauna can occur within this zone. Interruption of faunal activities is expected within a 1,000 m radius of the launch pad for 2 to 10 minutes during launch operations. The combustion products and initial sound blast will be directed toward the Atlantic Ocean. Launches may be conducted during any time of the year and any time of the day or night.

RANGEWIDE STATUS OF THE SPECIES

Life History

Piping plovers are small beige and white shorebirds with a black band across their breast and forehead. They typically feed on small invertebrates within intertidal surf zones, mud flats, tidal pool edges, barrier flats, and sand flats. The nesting season typically lasts from late April to late July. The nest is a shallow depression in the sand, typically lined with bits of broken seashells or fine pebbles. Incubation lasts for 26 to 30 days and is shared equally by both adults. The chicks leave the nest within hours of hatching and begin feeding on their own as soon as they can stand. Chicks are defended by the adults and can fly after 28 to 35 days. A more detailed and comprehensive description of the life history of the plover is provided in the recovery plan (U.S. Fish and Wildlife Service 1996).

Status of the Species Within its Range

Piping plovers occur in three disjunct populations in North America: Northern Great Plains, Great Lakes, and Atlantic Coast. The Atlantic Coast piping plover breeds on coastal beaches from Newfoundland to North Carolina (and occasionally South Carolina) and winters along the coast from North Carolina south, along the Gulf Coast and in the Caribbean (U.S. Fish and Wildlife Service 1996). The recovery plan divides the Atlantic Coast population into four recovery units: Atlantic Canada, New England, New York-New Jersey, and Southern (Delaware, Maryland, Virginia, and North Carolina).

Since 1986, the Atlantic Coast population has increased from 790 pairs to 1,347 pairs in 1996. However, most of the apparent increase between 1986 and 1989 is attributable to increased survey effort in two states. In addition, the population increase between 1989 and 1995 was very unevenly distributed. Between 1989 and 1995, the New England subpopulation increased by 346 pairs, while the New York-New Jersey and the Southern subpopulations gained 82 and 16 pairs, respectively, and the Atlantic Canada population decreased by 34 pairs. Substantially higher productivity rates have also been observed in New England than elsewhere in the Atlantic Coast population's range. In 1996, all recovery units either declined or increased less than expected based on 1995 productivity data. The Southern recovery unit declined 13% between 1995 and 1996. This is significant because the recovery plan ties recovery of the species to improved status of all four recovery units. The relative lack of recovery of the Southern subpopulation has heightened concern over any proposed activities which would further impede recovery in this area. Recovery of the Atlantic Coast piping plover population is occurring in the context of an extremely intensive protection effort now being implemented on an annual basis. Pressure on Atlantic Coast beach habitat from development and human disturbance is pervasive and unrelenting, and the species is sparsely distributed (U.S. Fish and Wildlife Service (1996).

In Virginia, piping plovers nest in Accomack and Northampton Counties on the barrier islands and on beaches in the Cities of Hampton and Portsmouth. Between 1989 and 1991, the number of piping plover pairs in Virginia increased from 100 to 131. In 1992, the number of nesting pairs was 97, and since then there have been serious population fluctuations. In 1996, only 87 pairs of plovers were documented. Annual productivity (numbers of chicks fledged/pair) has fluctuated widely, but was relatively high in 1996.

Threats to the Species

Loss and degradation of habitat due to development and shoreline stabilization have been major contributors to the species' decline. Disturbance by humans and pets often reduces the functional suitability of habitat and causes direct and indirect mortality of eggs and chicks. Predation has also been identified as a major factor limiting piping plover reproductive success at many Atlantic Coast sites. Substantial evidence shows that human activities are affecting types, numbers, and activity patterns of predators, thereby exacerbating natural predation (U.S. Fish and Wildlife Service 1996). A more detailed and comprehensive description of threats to the plover is provided in the recovery plan (U.S. Fish and Wildlife Service 1996).

Recovery Goals and Accomplishments

The Atlantic Coast population of the piping plover was listed at threatened in 1986. The primary recovery objective is to remove the Atlantic Coast plover population from the list of Endangered and Threatened Wildlife and Plants by achieving well-distributed increases in numbers and productivity of breeding pairs and providing for long-term protection of breeding and wintering plovers and their habitat. Delisting may be considered when the following criteria have been met: (1) increase and maintain for 5 years a total of 2,000 breeding pairs distributed among four recovery units as follows--Atlantic Canada, 400 pairs; New England 525 pairs; New York-New Jersey, 575 pairs; Southern, 400 pairs; (2) verify the adequacy of a 2,000-pair population to maintain heterozygosity and allelic diversity over the long-term; (3) achieve five-year average productivity of 1.5 fledged chicks per pair in each recovery unit, based on data from sites that collectively support at least 90% of the recovery unit's population; (4) institute long-term agreements to assure protection and management sufficient to maintain the population targets and average productivity in each recovery unit; and (5) ensure long-term maintenance of wintering habitat, sufficient in quantity, quality, and distribution to maintain survival rates for a 2,000-pair population. At the present time, these criteria are not close to being accomplished.

ENVIRONMENTAL BASELINE

As defined in 50 CFR 402.02 "action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies in the United States or upon the high seas. The "action area" is defined as all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action. The direct and indirect effects of the actions and activities resulting from the federal action must be considered in conjunction with the effects of other past and present federal, state, or private activities, as well as the cumulative effects of reasonably certain future state or private activities within the action area.

The Service has determined that the action area for this project is the portion of Wallops Island within 1,207 m (0.75 miles) south of launch pad 0-B.

Status of the Species in the Action Area - Piping plovers have nested at the north and south end of Wallops Island. The plover nesting area on the north end of the island is approximately 7 kilometers from the proposed project site. No impacts are expected to occur to the plovers at the north end of the island and only concerns related to plovers at the south end of the island will be addressed. Information about the plover at the southern end of the island is detailed below.

Wallops Island (Southern End) Piping Plover Data

Year	# Pairs	# Young Fledged	Comments
1986	2	0	
1987	2	3	
1988	0	0	
1989	5	unknown	
1990	5	unknown	
1991	3	unknown	
1992	4	5	1.25 young fledged/pair
1993	3	4	1.33 young fledged/pair
1994	3	2	0.67 young fledged/pair
1995	2	4	2.00 young fledged/pair
1996	1	0	Initial nest and renesting attempt both lost to predation by red fox.

Suitable plover nesting habitat at the southern end of the island was mapped and measured before and after the storms of 1991-1992. There was a 77% increase in the amount of nesting habitat available between years. Despite the increase in available habitat, there was no significant increase in numbers of nesting piping plovers, and their distribution throughout the available habitat remained similar to previous years, suggesting that birds were not available to colonize the newly created habitat (VDGIF 1992-1993). At the present time, the habitat at the southern end of Wallops is becoming less suitable due to encroaching vegetation (B. Cross, VDGIF, pers. comm. 1997; VDGIF 1995-1996).

The plover nesting and foraging area at the south end of the island is approximately 1,087 m from the proposed launch pad. Therefore, it is estimated that only the small portion (approximately

400 square meters) of existing plover habitat within the action area will be affected by launches at pad 0-B.

Effects of the Action - No information is available on the effects of rocket launches on foraging and nesting shorebirds. The most similar action for which Service has such information relates to fireworks displays (U.S. Fish and Wildlife Service 1997). Direct impacts to plovers from fireworks early in the breeding season may cause plovers to abandon their territories. Plovers will often abandon their nests and broods during fireworks displays, exposing eggs and chicks to weather and predators. If a flightless chick were to become permanently separated from its parents during the confusion, mortality is almost certain. Abandonment of colonies as a result of fireworks has been documented in other colonial-nesting birds. For example, a fireworks display in New Jersey caused permanent abandonment of a least tern (*Sterna antillarum*) colony located more than 250 m away. In addition, temporary abandonment and displays of distress were documented in a least tern colony located greater than 0.75 miles from a fireworks event. The Service's guidance (U.S. Fish and Wildlife Service 1997) recommends that fireworks launch sites be located at least 0.75 miles from the nearest piping plover nesting and/or foraging area.

Direct impacts to the piping plover from the construction of the proposed rocket launch facility are not anticipated because of the distance (1,087 m) from launch pad to the nesting/foraging area. The piping plover may be adversely affected by the noise and light associated with rocket launches. NASA has estimated actual launch operations will last from 2 to 10 minutes. Because no data specific to this type of activity is available, it is difficult to anticipate how plovers will be affected. The Service anticipates that between March 1 and September 15 of any year, depending on the time of year, time of day, and proximity to the launch site, plovers will temporarily abandon the area during migration and/or the breeding season. While temporary abandonment of eggs or chicks does increase the chances of predation and exposure to the elements, actual mortality or reduced productivity is very unlikely. Similarly, a brief interruption in foraging will not result in significant impacts. The Service anticipates minimal impacts to the plover because of the short duration of the disturbance, the long distance between the disturbance and the area used by plovers, the limited number of launches during the nesting season, and the lack of other disturbances (e.g., recreation) to the plovers at this site.

Cumulative Effects - Cumulative effects include the effects of future state, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA. The Service is not aware of any cumulative effects.

CONCLUSION

After reviewing the current status of the piping plover throughout its range and in the action area, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is the Service's biological opinion that construction and use of launch pad 0-

B, as proposed, is not likely to jeopardize the continued existence of the piping plover. No critical habitat has been designated for this species, therefore, none will be affected.

III. INCIDENTAL TAKE STATEMENT

Sections 4(d) and 9 of the ESA, as amended, prohibit taking (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct) of listed species of fish or wildlife without a special exemption. Harm is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns such as breeding, feeding, or sheltering. Harass is defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns, which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is any take of listed animal species that results from, but is not the purpose of, carrying out an otherwise lawful activity conducted by the federal agency or applicant. Under the terms of Section 7(b)(4) and Section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered a prohibited taking provided that such taking is in compliance with the terms and conditions of this incidental take statement.

AMOUNT OR EXTENT OF TAKE

The Service does not anticipate the proposed action will incidentally take any piping plovers due to the short duration of the disturbance, the distance between the launch pad and the plover nesting/foraging area, the limited number of launches that are likely to occur during the nesting season, and the lack of other disturbances (e.g., recreation).

IV. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to further minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans and other recovery activities, or to develop information to benefit the species. The Service recommends that following be implemented by NASA:

- Whenever possible, conduct launches during daylight hours.
- Provide more substantial fencing at the perimeter of piping plover use areas at the north and south ends of island to prevent human intrusion.
- Post the fenced areas with “sensitive wildlife area” signs.
- Close the piping plover use areas from March 1 through September 15 of every year to discourage human intrusion.

- o Piping plover nests should be protected with predator exclosures upon completion of the clutch.

In order for the Service to be kept informed of actions that minimize or avoid adverse effects or benefit listed species or their habitats, the Service requests notification of the implementation of any of these conservation recommendations by NASA.

V. REINITIATION - CLOSING STATEMENT

This concludes formal consultation on the action outlined in the NASA request. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

If this opinion does not contain national security or confidential business information, the Service will provide copies to the appropriate state natural resource agencies ten business days after the date of this opinion.

The Service appreciates this opportunity to work with NASA and the Corps in fulfilling our mutual responsibilities under the ESA. Please contact Cindy Schulz of this office at (804) 693-6694, extension 127, if you require additional information.

Sincerely,

Karen L. Mayne

Karen L. Mayne
Supervisor
Virginia Field Office

Enclosures

LITERATURE CITED

U.S. Fish and Wildlife Service. 1996. Piping plover (*Charadrius melodus*), Atlantic Coast Population, Revised Recovery Plan. Hadley, MA. 258pp.

U.S. Fish and Wildlife Service. 1997. Guidelines for managing fireworks in the vicinity of piping plovers and seabeach amaranth on the U.S. Atlantic Coast. Unpublished Report. Hadley, MA. 5pp.

Virginia Department of Game and Inland Fisheries. 1992-1993. Annual report nongame and endangered wildlife program. Richmond, VA.

Virginia Department of Game and Inland Fisheries. 1995-1996. Annual report nongame and endangered wildlife program. Richmond, VA.

APPENDIX A

NASA PIPING PLOVER MONITORING PLAN FOR ROCKET LAUNCHES FROM PAD 0-B WALLOPS ISLAND, VIRGINIA

1. Monitoring of piping plovers at the south end of Wallops Island will occur during the first three launches from launch pad 0-B that take place between March 1 and September 15. Depending on the results of the surveys, additional years of monitoring may be required at the discretion of the Service. Monitoring will be conducted daily for 7 consecutive days prior to a launch, during the launch (as dictated by human safety considerations), and for 7 consecutive days after the day of the launch. If it is not possible to monitor during the launch, monitoring will occur immediately before and after the launch. Monitoring should occur twice daily, early in the morning and late in the evening. Each monitoring event should be no longer than one hour and should only be as long as is required to collect the data listed below. A delay of the launch date may require additional monitoring. Each monitoring event will include:

   - A detailed, to scale, map indicating the location of plovers and their nests in relation to the launch pad.
   - Counts and locations of chicks.
   - Habitat description of the areas utilized by the plover and in immediate vicinity of each nest.
   - Dates for laying of each egg, if observed.
   - Dates for loss of any chicks.
   - Indices of predator abundance (presence or absence at the nest, track counts, etc.).
   - Documentation of any sources of additional disturbance.
   - Eggs counts per nest.
   - Behavior of individual plovers (e.g., foraging, brooding, leaving area). This will include determining the frequency of incubation and causes and duration of any interruption to incubation or chick foraging.
   - If pre-fledged young are present, their movements (foraging area and distance and direction moved from nest) should be plotted throughout the monitoring period.
   - Peck rates should be measured for pre-fledged young during five-minute observation periods conducted during each monitoring event. The number of observation periods sufficient for analysis should be determined by the observer.
   - On each data sheet, the following information should be recorded: date, start/stop time of observations, observer's name, weather conditions (e.g., raining, sunny), and temperature.
   - The above information should also be recorded for Wilson's plovers to increase the sample size.

2. A summary report along with copies of any field notes will be submitted to the Service, at the address provided below, within 10 days of the last day of monitoring for each launch event. Monitoring will be conducted by an individual approved by the Service and the

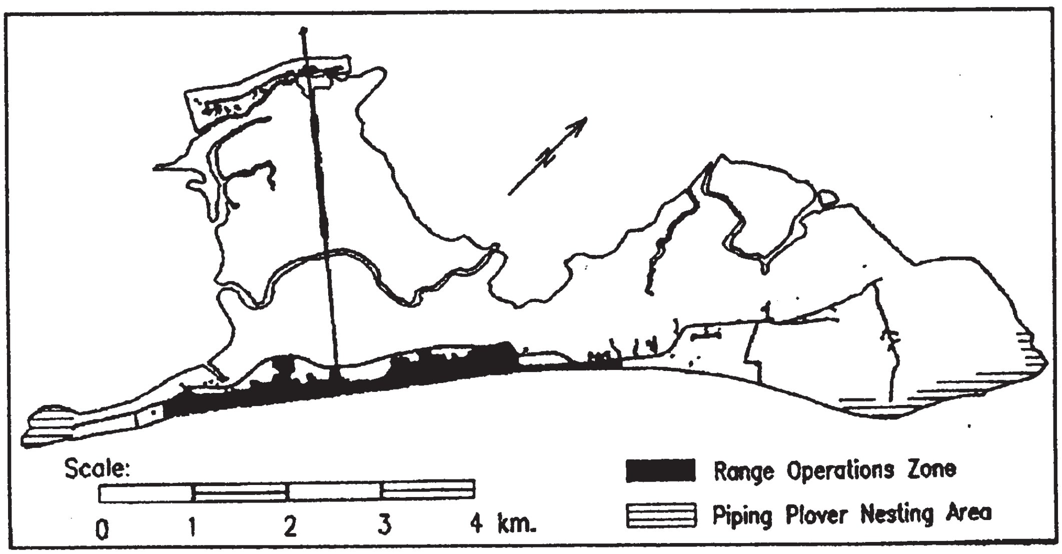
VDGIF. The name and qualifications of the individual must be provided to the Service at least 90 days before the first day of monitoring for the first launch event to be monitored.

3. Within 30 days of providing the Service with the monitoring report for the third launch taking place between March 1 and September 15, NASA will contact the Service to arrange a meeting to discuss the necessity, duration, and intensity of additional monitoring.

4. All information to be provided to the Service should be sent to:

Virginia Field Office
U.S. Fish and Wildlife Service
P.O. Box 99
6669 Short Lane
Gloucester, VA 23061
Phone (804) 693-6694
Fax (804) 693-9032

Figure 1. Location of the National Aeronautics and Space Administration's Proposed Launch Pad 0-B and Piping Plover Use Area on Wallops Island in Accomack County, Virginia.



National Aeronautics and
Space Administration
Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, VA 23337-5099

RECEIVED
GLOUCESTER

Reply to Attn of: 205.W

February 27, 1998

United States Department of the Interior
Fish and Wildlife Service
Ecological Services
Attn: Ms. Cindy Schulz
P.O. Box 99
Gloucester, VA 23061

Subject: **Beach Closure Dates for the Endangered Piping Plover at the National Aeronautics and Space Administration Goddard Space Flight Center's Wallops Flight Facility (NASA GSFC's WFF), Wallops Island, VA**

Ref: (a) Telecons between C. Schulz/U. S. Fish and Wildlife Service (USFWS), Bob Cross/Virginia Department of Game and Inland Fisheries (VDGIF), and John C.Brinton/NASA on 2/20/98, and 2/25/98
(b) USFWS Biological Opinion for Range Operations Expansion at WFF, dated 7/14/97

During reference (a) telephone conversations, it was agreed to close the north and south ends of Wallops Island's beaches from March 15 through September 15 to help protect the piping plover. This is a change to Section IV. Conservation Recommendations in the reference (b) Biological Opinion for Range Operations Expansion at WFF, which specifies "close the piping plover use areas from March 1 through September 15 of every year to discourage human intrusion." According to Bob Cross of the VDGIF, piping plover nesting activity should begin on Wallops Island after March 15.

It was also agreed that NASA could conduct year round open burn/open detonation (OB/OD) of rocket motors. The OB/OD facility is just north of the fencing, at the perimeter of the piping plover use area, at the south end of Wallops Island.

Please contact John C. Brinton, Environmental Protection Specialist, at 757-824-1327 with any questions or comments.

William B. Bott
Environmental Group Leader

Concurrence: Cindy Schulz
Cindy Schulz
USFWS Biologist

cc:
VDIGF/Mr. B. Cross

Approved: Karen L. Mayne
Supervisor
Virginia Field Office
3/10/98

Figure K-1 United States Fish and Wildlife Service Letter

Appendix D

Air Quality Background Information for Construction and Operational Emissions

USAF Air Conformity Applicability Model

Emissions Summary Information

Scenario: Wallops Island EA - Construction
Installation: NASA Wallops Island Flight Facility

Emissions Summary Report For 2009

SOURCE CATEGORY	Emissions, Ton/Year CO	NOX	SO2	VOC	PM10	PM2.5
Area Sources						
Other Phase II Const. - Workers Trips	0.00	0.00	0.00	0.00	0.00	0.00
Other Phase I Const. - Grading Ops.	0.00	0.00	0.00	0.00	13.11	0.00
Other Phase II Const. - Acres Paved	0.00	0.00	0.00	0.00	0.00	0.00
Other Phase II Const. - Mobile Equip.	0.00	0.00	0.00	0.00	0.00	0.00
Other Phase II Const. - Non-Res. Arch. Ctgs.	0.00	0.00	0.00	0.00	0.00	0.00
Other Phase II Const. - Res. Arch. Ctgs.	0.00	0.00	0.00	0.00	0.00	0.00
Other Phase II Const. - Stationary Equip.	0.00	0.00	0.00	0.00	0.00	0.00
Other Phase I Const. - Grading Equip.	0.12	0.45	0.05	0.05	0.04	0.00
Total	0.12	0.45	0.05	0.05	13.15	0.00
Grand Total	0.12	0.45	0.05	0.05	13.15	0.00

USAF Air Conformity Applicability Model

Emissions Summary Information

Scenario: Wallops Island EA - Construction
Installation: NASA Wallops Island Flight Facility

Emissions Summary Report For 2010

	Emissions, Ton/Year					
SOURCE CATEGORY	**CO**	**NOX**	**SO2**	**VOC**	**PM10**	**PM2.5**
Area Sources						
Other Phase I Const. - Grading Ops.	0.00	0.00	0.00	0.00	3.30	0.00
Other Phase II Const. - Acres Paved	0.00	0.00	0.00	0.00	0.00	0.00
Other Phase II Const. - Mobile Equip.	5.49	13.09	1.62	1.20	1.06	0.00
Other Phase II Const. - Non-Res. Arch. Ctgs.	0.00	0.00	0.00	0.28	0.00	0.00
Other Phase II Const. - Res. Arch. Ctgs.	0.00	0.00	0.00	0.00	0.00	0.00
Other Phase II Const. - Stationary Equip.	37.22	0.96	0.05	1.39	0.03	0.00
Other Phase II Const. - Workers Trips	0.77	0.04	0.00	0.04	0.01	0.00
Other Phase I Const. - Grading Equip.	0.03	0.11	0.01	0.01	0.01	0.00
Total	43.51	14.20	1.68	2.92	4.40	0.00
Point Sources						
Other Const. - Facility Heating	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	43.51	14.20	1.68	2.92	4.40	0.00

USAF Air Conformity Applicability Model

Emissions Summary Information

Scenario: **Wallops Island EA - Construction**
Installation: **NASA Wallops Island Flight Facility**

Emissions Summary Report For 2011

	Emissions, Ton/Year					
SOURCE CATEGORY	**CO**	**NOX**	**SO2**	**VOC**	**PM10**	**PM2.5**
Point Sources						
Other Const. - Facility Heating	0.15	0.19	0.00	0.01	0.01	0.00
Total	0.15	0.19	0.00	0.01	0.01	0.00
Grand Total	0.15	0.19	0.00	0.01	0.01	0.00

USAF Air Conformity Applicability Model

Emissions Summary Information

Scenario: Wallops Island EA - Boilers and Generators
Installation: NASA Wallops Island Flight Facility

Emissions Summary Report For 2011

SOURCE CATEGORY	Emissions, Ton/Year					
	CO	NOX	SO2	VOC	PM10	PM2.5
Point Sources						
Emergency Generators	0.43	1.63	0.03	0.05	0.03	0.03
Boilers	0.09	0.36	2.55	0.01	0.04	0.04
Total	0.52	1.99	2.57	0.06	0.07	0.07
Grand Total	0.52	1.99	2.57	0.06	0.07	0.07

Appendix E

Air Quality Modeling Background Information and Raw Data for Aloha Model

Background on REEDM

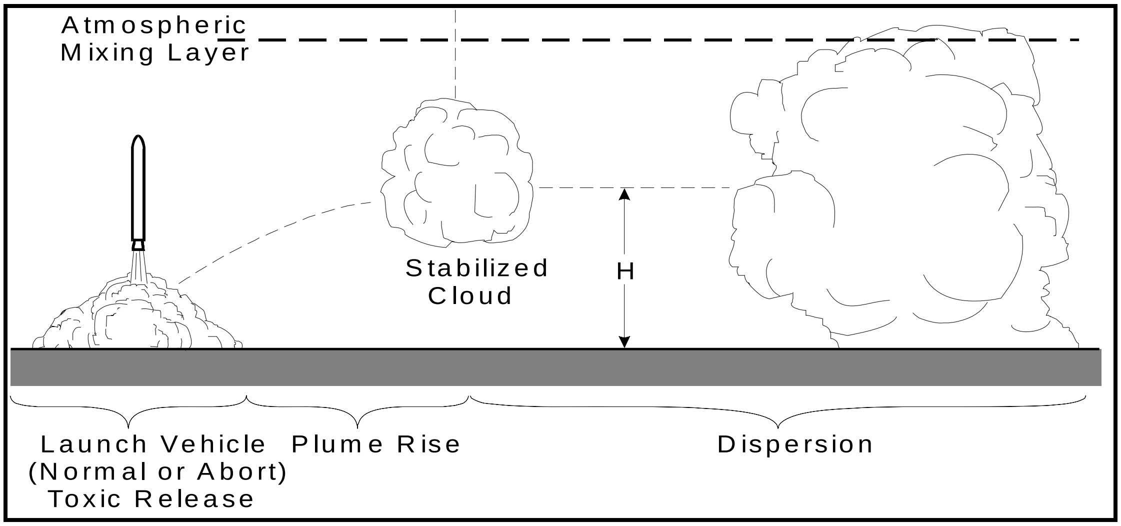
The REEDM model is a toxic dispersion model specifically tailored to address the large buoyant source clouds generated by rocket launches, test firings, and catastrophic launch vehicle explosions. REEDM falls in the category of "Gaussian puff" atmospheric dispersion models in that the initial mass distribution of toxic materials within the cloud at the time the cloud reaches thermal stabilization height in the atmosphere is assumed to be normally distributed. By making the Gaussian mass distribution assumption, the differential equation defining mass diffusion can be solved in closed form using exponential functions and may be readily implemented in a fast running computer program.

REEDM processes an emission event in the following sequence:

- Process vehicle related data
- Process meteorological data
- Define the initial size, shape, location, and heat content of the exhaust cloud
- Calculate the buoyant cloud rise rate and cloud growth rate to estimate the cloud stabilization height above ground, size, and downwind position
- Determine whether or not part of the stabilized cloud is above a capping atmospheric temperature inversion
- Transport the cloud disks downwind and grow the disk size using climatologic model estimates of atmospheric turbulence intensity
- Calculate concentrations at ground receptor points and determine the peak concentration as a function of downwind distance
- Report concentration as a function of distance from the source origin (e.g., launch pad)

REEDM was designed to primarily predict hazard conditions downwind from the stabilized exhaust cloud. REEDM does not directly calculate or report cloud concentrations during the buoyant cloud rise phase; however, advanced model users can manually extract sufficient pertinent cloud data from internal calculations to derive concentration estimates during the cloud rise phase. One assumption that REEDM makes about the nature and behavior of a rocket exhaust cloud is that it can be initially defined as a single cloud entity that grows and moves, but remains as a single cloud during the formation and cloud rise phases. A consequence of this assumption is that once the cloud lifts off the ground during the buoyant cloud rise phase, there will be no predicted cloud chemical concentration on the ground immediately below the cloud. Ground level concentrations will be predicted to remain at zero ppm until the some of the elevated cloud material is eventually brought back down to ground level by mixing due to atmospheric turbulence. This concept is illustrated in Figure E-1.

Figure E-1. Conceptual Illustration of Rocket Exhaust Source Cloud Formation, Cloud Rise, and Cloud Atmospheric Dispersion (NASA, 2009b).

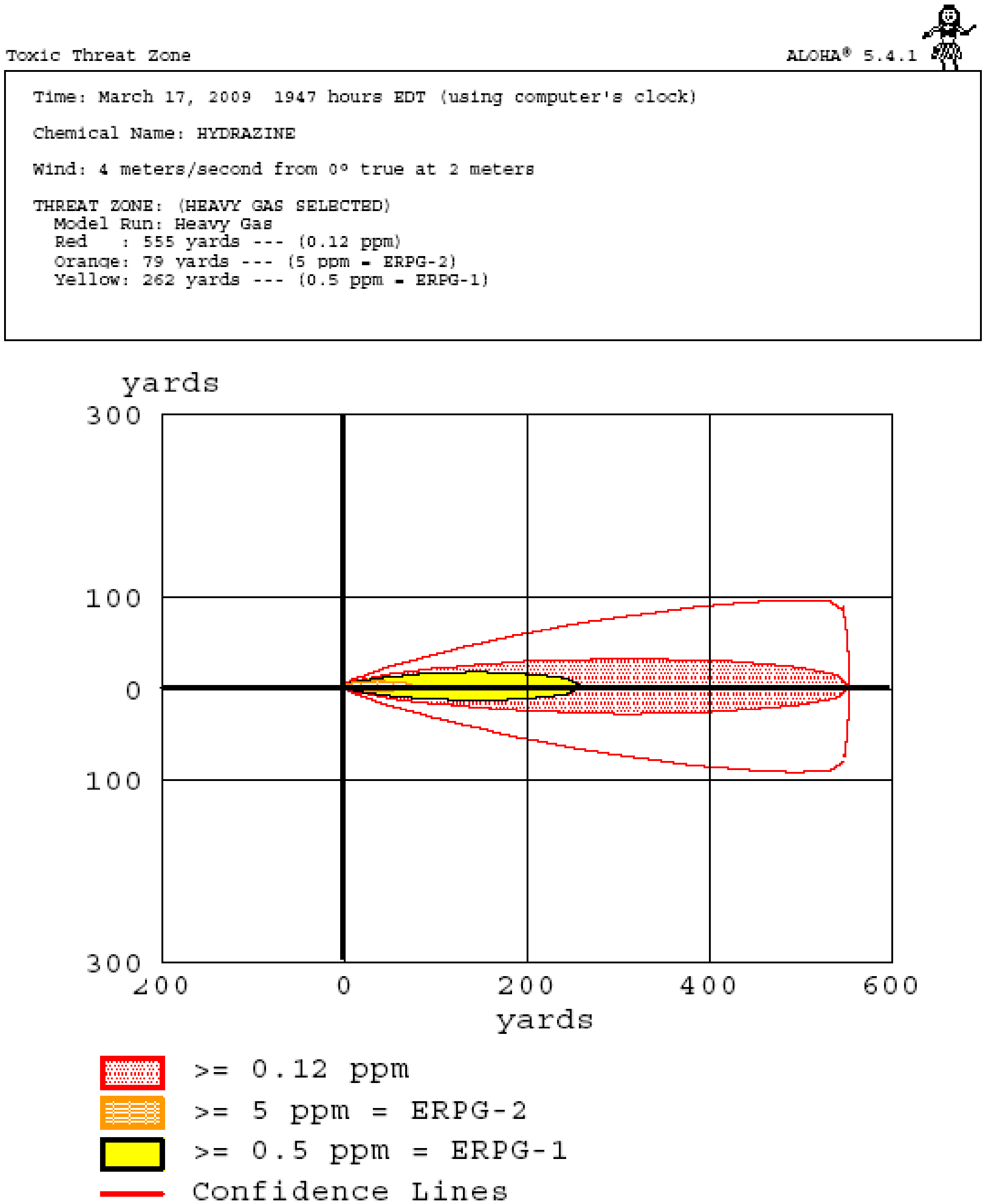


Background on ALOHA

The ALOHA model was designed with first emergency responders in mind. In particular, its air dispersion model is intended to be used to estimate the areas of impact near a short-duration chemical release where key hazards—toxicity, flammability, thermal radiation, or overpressure—may exceed user-specified Levels of Concern (LOCs).

ALOHA can model the dispersion of a cloud of pollutant gas in the atmosphere and display a diagram (i.e., a threat zone plot) that shows an overhead view of the regions, or threat zones, in which it predicts that key LOCs will be exceeded. To obtain a threat zone estimate, at least one LOC must be chosen. ALOHA will suggest default LOCs, and the user may keep those or choose up to three other LOCs. For toxic gas dispersion scenarios, an LOC is a threshold concentration of the gas at ground level—usually the concentration above which a hazard is believed to exist. The type of LOC will depend on the scenario. For each LOC chosen, ALOHA estimates a threat zone where the hazard is predicted to exceed that LOC at some time after a release begins. These zones are displayed on a single threat zone plot. If three LOCs are chosen, then ALOHA will display the threat zones in red, orange, and yellow. When ALOHA's default LOCs are selected, the red zone represents the worst hazard. Figure E-2 presents an example run from ALOHA indicating various threat zones.

Figure E-2: Example Threat Zone Plot in ALOHA Model



LOCs are usually based on one of the following parameters:

- Acute Exposure Guideline Levels (AEGLs) developed by the National Research Council's Advisory Committee.
- Emergency Response Planning Guidelines (ERPGs) developed by the ERPG committee of the American Industrial Hygiene Association. These were developed as planning guidelines to anticipate human adverse health effects caused by exposure to toxic chemicals.
- Temporary Emergency Exposure Limits (TEELs) are temporary toxic LOCs similar to ERPGs and are defined by the U.S. Department of Energy for use when ERPGs are not available.
- The Immediately Dangerous to Life or Health level is a limit established for selecting respirators for use in workplaces by the National Institute for Occupational Safety and Health (NIOSH). Immediately Dangerous to Life or Health is an estimate of the maximum concentration in the air to which a healthy worker could be exposed to without suffering permanent or escape-impairing health effects.

There are two separate dispersion models in ALOHA: Gaussian and heavy gas. ALOHA uses the Gaussian model to predict how gases that have a buoyancy equivalent to air will disperse in the atmosphere. The heavy gas dispersion calculations that are used in ALOHA are based on those used in the DEGADIS model, one of several well-known heavy gas models.

Like any model, ALOHA cannot be more accurate than the information entered during the modeling analysis. Therefore, it is important to enter the most accurate information. The modeler must choose a value that would give the worst-case scenario, or run multiple scenarios and compare the results. Additionally, ALOHA's models use atmospheric information to estimate the spread of the chemical release. If any of the atmospheric conditions (e.g., wind speed) change substantially during a response, it is recommended to correct the inputs and create a new threat zone plot, as the old plot may no longer be accurate.

Examples of conditions that can produce unreliable results during modeling runs using ALOHA include:

- Very low wind speeds;
- Very stable atmospheric conditions;
- Wind shifts and terrain steering effects; or
- Concentration patchiness, particularly near the release source.

SITE DATA INFORMATION:
Location: WALLOPS FLIGHT FACILITY, VIRGINIA
Building Air Exchanges Per Hour: 0.73 (sheltered single storied)
Time: February 4, 2009 2100 hours EST (user specified)

CHEMICAL INFORMATION:
Chemical Name: HYDRAZINE Molecular Weight: 32.05 g/mol
ERPG-3: 30 ppm ERPG-2: 5 ppm ERPG-1: 0.5 ppm
IDLH: 50 ppm
Carcinogenic risk - see CAMEO
Normal Boiling Point: 236.3° F Ambient Boiling Point: 236.3° F
Vapor Pressure at Ambient Temperature: 0.0050 atm
Ambient Saturation Concentration: 4,971 ppm or 0.50%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)
Wind: 4 meters/sec from 0° true at 3 meters
Inversion Height: 1000 feet
Stability Class: E (user override) Air Temperature: 40° F
Relative Humidity: 50% Ground Roughness: 10.0 centimeters
Cloud Cover: 5 tenths

SOURCE STRENGTH INFORMATION:
Puddle Area: 900 square feet Puddle Mass: 504.7 kilograms
Soil Type: Default Ground Temperature: 40° F
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Average Sustained Release Rate: 0.657 pounds/min
(averaged over a minute or more)
Total Amount Released: 37.6 pounds

FOOTPRINT INFORMATION: (GAUSS SELECTED)
Dispersion Module: Gaussian
Red LOC (0.12 ppm) Max Threat Zone: 1536 yards

SITE DATA INFORMATION:
Location: WALLOPS FLIGHT FACILITY, VIRGINIA
Building Air Exchanges Per Hour: 0.71 (sheltered single storied)
Time: February 4, 2009 2100 hours EST (user specified)

CHEMICAL INFORMATION:
Chemical Name: HYDRAZINE Molecular Weight: 32.05 g/mol
ERPG-3: 30 ppm ERPG-2: 5 ppm ERPG-1: 0.5 ppm
IDLH: 50 ppm
Carcinogenic risk - see CAMEO
Normal Boiling Point: 236.3° F Ambient Boiling Point: 236.3° F
Vapor Pressure at Ambient Temperature: 0.029 atm
Ambient Saturation Concentration: 28,929 ppm or 2.89%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)
Wind: 4 meters/sec from 0° true at 3 meters
No Inversion Height
Stability Class: D Air Temperature: 90° F
Relative Humidity: 50% Ground Roughness: 10.0 centimeters
Cloud Cover: 5 tenths

SOURCE STRENGTH INFORMATION:
Puddle Diameter: 7.2 feet Puddle Volume: 5 gallons
Soil Type: Default Ground Temperature: 90° F
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Average Sustained Release Rate: 0.172 pounds/min
(averaged over a minute or more)
Total Amount Released: 9.13 pounds

FOOTPRINT INFORMATION: (HEAVY GAS SELECTED)
Model Run: Heavy Gas
Red LOC (0.12 ppm) Max Threat Zone: 584 yards

SITE DATA INFORMATION:
Location: WALLOPS FLIGHT FACILITY, VIRGINIA
Building Air Exchanges Per Hour: 0.71 (sheltered single storied)
Time: February 4, 2009 0700 hours EST (user specified)

CHEMICAL INFORMATION:
Chemical Name: HYDRAZINE   Molecular Weight: 32.05 g/mol
ERPG-3: 30 ppm   ERPG-2: 5 ppm   ERPG-1: 0.5 ppm
IDLH: 50 ppm
Carcinogenic risk - see CAMEO
Normal Boiling Point: 236.3° F   Ambient Boiling Point: 236.3° F
Vapor Pressure at Ambient Temperature: 0.029 atm
Ambient Saturation Concentration: 28,929 ppm or 2.89%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)
Wind: 4 meters/sec from 0° true at 3 meters
No Inversion Height
Stability Class: D   Air Temperature: 90° F
Relative Humidity: 50%   Ground Roughness: 10.0 centimeters
Cloud Cover: 5 tenths

SOURCE STRENGTH INFORMATION:
Puddle Area: 900 square feet   Puddle Mass: 504.7 kilograms
Soil Type: Default   Ground Temperature: 90° F
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Average Sustained Release Rate: 3.22 pounds/min
(averaged over a minute or more)
Total Amount Released: 174 pounds

FOOTPRINT INFORMATION: (HEAVY GAS SELECTED)
Model Run: Heavy Gas
Red LOC (0.12 ppm) Max Threat Zone: 1.5 miles

SITE DATA INFORMATION:
Location: WALLOPS FLIGHT FACILITY, VIRGINIA
Building Air Exchanges Per Hour: 0.63 (sheltered single storied)
Time: February 4, 2009 0700 hours EST (user specified)

CHEMICAL INFORMATION:
Chemical Name: HYDRAZINE Molecular Weight: 32.05 g/mol
ERPG-3: 30 ppm ERPG-2: 5 ppm ERPG-1: 0.5 ppm
IDLH: 50 ppm
Carcinogenic risk - see CAMEO
Normal Boiling Point: 236.3° F Ambient Boiling Point: 236.3° F
Vapor Pressure at Ambient Temperature: 0.015 atm
Ambient Saturation Concentration: 14,958 ppm or 1.50%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)
Wind: 4 meters/sec from 0° true at 3 meters
No Inversion Height
Stability Class: D Air Temperature: 70° F
Relative Humidity: 50% Ground Roughness: 10.0 centimeters
Cloud Cover: 5 tenths

SOURCE STRENGTH INFORMATION:
Puddle Diameter: 7.2 feet Puddle Volume: 5 gallons
Soil Type: Default Ground Temperature: 70° F
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Average Sustained Release Rate: 0.0941 pounds/min
(averaged over a minute or more)
Total Amount Released: 5.23 pounds

FOOTPRINT INFORMATION: (HEAVY GAS SELECTED)
Model Run: Heavy Gas
Red LOC (0.12 ppm) Max Threat Zone: 417 yards

SITE DATA INFORMATION:
Location: WALLOPS FLIGHT FACILITY, VIRGINIA
Building Air Exchanges Per Hour: 0.62 (sheltered single storied)
Time: February 4, 2009 2100 hours EST (user specified)

CHEMICAL INFORMATION:
Chemical Name: NITROGEN TETROXIDE Molecular Weight: 92.01 g/mol
Normal Boiling Point: 70.1° F Ambient Boiling Point: 70.1° F
Vapor Pressure at Ambient Temperature: 0.99 atm
Ambient Saturation Concentration: 996,775 ppm or 99.7%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)
Wind: 4 meters/sec from 0° true at 3 meters
Inversion Height: 1000 feet
Stability Class: E (user override) Air Temperature: 70° F
Relative Humidity: 30% Ground Roughness: 10.0 centimeters
Cloud Cover: 5 tenths

SOURCE STRENGTH INFORMATION:
Puddle Diameter: 7.2 feet Puddle Volume: 5 gallons
Soil Type: Default Ground Temperature: 70° F
Initial Puddle Temperature: Ground temperature
Release Duration: 9 minutes
Max Average Sustained Release Rate: 13.5 pounds/min
(averaged over a minute or more)
Total Amount Released: 60.2 pounds

FOOTPRINT INFORMATION: (HEAVY GAS SELECTED)
Model Run: Heavy Gas
Red LOC (1.0 ppm) Max Threat Zone: 1,181 yards

SITE DATA INFORMATION:
Location: WALLOPS FLIGHT FACILITY, VIRGINIA
Building Air Exchanges Per Hour: 0.73 (sheltered single storied)
Time: February 4, 2009 2100 hours EST (user specified)

CHEMICAL INFORMATION:
Chemical Name: NITROGEN TETROXIDE Molecular Weight: 92.01 g/mol
Normal Boiling Point: 70.1° F Ambient Boiling Point: 70.1° F
Vapor Pressure at Ambient Temperature: 0.44 atm
Ambient Saturation Concentration: 438,008 ppm or 43.8%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)
Wind: 4 meters/sec from 0° true at 3 meters
Inversion Height: 1000 feet
Stability Class: E (user override) Air Temperature: 40° F
Relative Humidity: 30% Ground Roughness: 10.0 centimeters
Cloud Cover: 5 tenths

SOURCE STRENGTH INFORMATION:
Puddle Area: 472 square feet Puddle Mass: 321.7 kilograms
Soil Type: Default Ground Temperature: 40° F
Initial Puddle Temperature: Ground temperature
Release Duration: 16 minutes
Max Average Sustained Release Rate: 69.6 pounds/min
(averaged over a minute or more)
Total Amount Released: 709 pounds

FOOTPRINT INFORMATION: (GAUSS SELECTED)
Dispersion Module: Gaussian
Red LOC (1.0 ppm) Max Threat Zone: 1.8 miles

SITE DATA INFORMATION:
Location: WALLOPS FLIGHT FACILITY, VIRGINIA
Building Air Exchanges Per Hour: 0.73 (sheltered single storied)
Time: February 4, 2009 0700 hours EST (user specified)

CHEMICAL INFORMATION:
Chemical Name: NITROGEN TETROXIDE Molecular Weight: 92.01 g/mol
Normal Boiling Point: 70.1° F Ambient Boiling Point: 70.1° F
Vapor Pressure at Ambient Temperature: 0.44 atm
Ambient Saturation Concentration: 438,008 ppm or 43.8%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)
Wind: 4 meters/sec from 0° true at 3 meters
Inversion Height: 1000 feet
Stability Class: E (user override) Air Temperature: 40° F
Relative Humidity: 30% Ground Roughness: 10.0 centimeters
Cloud Cover: 5 tenths

SOURCE STRENGTH INFORMATION:
Puddle Area: 472 square feet Puddle Mass: 321.7 kilograms
Soil Type: Default Ground Temperature: 40° F
Initial Puddle Temperature: Ground temperature
Release Duration: 16 minutes
Max Average Sustained Release Rate: 69.6 pounds/min
(averaged over a minute or more)
Total Amount Released: 709 pounds

FOOTPRINT INFORMATION:
Dispersion Module: Gaussian
Red LOC (1.0 ppm) Max Threat Zone: 1.8 miles

SITE DATA INFORMATION:
Location: WALLOPS FLIGHT FACILITY, VIRGINIA
Building Air Exchanges Per Hour: 0.71 (sheltered single storied)
Time: February 4, 2009 2100 hours EST (user specified)

CHEMICAL INFORMATION:
Chemical Name: NITROGEN TETROXIDE Molecular Weight: 92.01 g/mol
Normal Boiling Point: 70.1° F Ambient Boiling Point: 70.1° F
Vapor Pressure at Ambient Temperature: greater than 1 atm
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)
Wind: 4 meters/sec from 0° true at 3 meters
No Inversion Height
Stability Class: D Air Temperature: 90° F
Relative Humidity: 50% Ground Roughness: 10.0 centimeters
Cloud Cover: 5 tenths

SOURCE STRENGTH INFORMATION:
Puddle Area: 472 square feet Puddle Mass: 321.7 kilograms
Soil Type: Default Ground Temperature: 90° F
Initial Puddle Temperature: 70.1° F
Release Duration: 7 minutes
Max Average Sustained Release Rate: 185 pounds/min
(averaged over a minute or more)
Total Amount Released: 709 pounds

FOOTPRINT INFORMATION: (GAUSS SELECTED)
Dispersion Module: Gaussian
Red LOC (1.0 ppm) Max Threat Zone: 1.9 miles

SITE DATA INFORMATION:
Location: WALLOPS FLIGHT FACILITY, VIRGINIA
Building Air Exchanges Per Hour: 0.73 (sheltered single storied)
Time: February 4, 2009 0700 hours EST (user specified)

CHEMICAL INFORMATION:
Chemical Name: NITROGEN TETROXIDE
Molecular Weight: 92.01 g/mol
Normal Boiling Point: 70.1° F
Ambient Boiling Point: 70.1° F
Vapor Pressure at Ambient Temperature: 0.44 atm
Ambient Saturation Concentration: 438,008 ppm or 43.8%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)
Wind: 4 meters/sec from 0° true at 3 meters
No Inversion Height
Stability Class: D
Air Temperature: 40° F
Relative Humidity: 30%
Ground Roughness: 10.0 centimeters
Cloud Cover: 5 tenths

SOURCE STRENGTH INFORMATION:
Puddle Diameter: 7.2 feet
Puddle Volume: 5 gallons
Soil Type: Default
Ground Temperature: 40° F
Initial Puddle Temperature: Ground temperature
Release Duration: 15 minutes
Max Average Sustained Release Rate: 6.33 pounds/min
(averaged over a minute or more)
Total Amount Released: 61.2 pounds

FOOTPRINT INFORMATION:
Dispersion Module: Gaussian
Red LOC (1.0 ppm) Max Threat Zone: 564 yards

SITE DATA INFORMATION:
Location: WALLOPS FLIGHT FACILITY, VIRGINIA
Building Air Exchanges Per Hour: 0.71 (sheltered single storied)
Time: February 24, 2009 2155 hours EST (user specified)

CHEMICAL INFORMATION:
Chemical Name: MON-3 Molecular Weight: 90.14 g/mol
Default LOC-3: 30 ppm Default LOC-2: 20 ppm Default LOC-1: 10 ppm
IDLH: 50 ppm
Normal Boiling Point: 49.4° F Ambient Boiling Point: 49.3° F
Vapor Pressure at Ambient Temperature: greater than 1 atm
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)
Wind: 4 meters/sec from 0° true at 3 meters
Inversion Height: 1000 feet
Stability Class: E (user override) Air Temperature: 90° F
Relative Humidity: 50% Ground Roughness: 10.0 centimeters
Cloud Cover: 5 tenths

SOURCE STRENGTH INFORMATION:
Puddle Diameter: 7.2 feet Puddle Volume: 5 gallons
Soil Type: Default Ground Temperature: 90° F
Initial Puddle Temperature: 49.3° F
Release Duration: 20 minutes
Max Average Sustained Release Rate: 24.4 pounds/min
(averaged over a minute or more)
Total Amount Released: 160 pounds

FOOTPRINT INFORMATION:
Dispersion Module: Gaussian
Red LOC (1 ppm) Max Threat Zone: 1612 yards

SITE DATA INFORMATION:
Location: WALLOPS FLIGHT FACILITY, VIRGINIA
Building Air Exchanges Per Hour: 0.71 (sheltered single storied)
Time: February 5, 2009 1207 hours EST (user specified)

CHEMICAL INFORMATION:
Chemical Name: MON-3 Molecular Weight: 90.14 g/mol
Default LOC-3: 30 ppm Default LOC-2: 20 ppm Default LOC-1: 10 ppm
IDLH: 50 ppm
Normal Boiling Point: 49.4° F Ambient Boiling Point: 49.3° F
Vapor Pressure at Ambient Temperature: greater than 1 atm
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)
Wind: 4 meters/sec from 0° true at 3 meters
No Inversion Height
Stability Class: D Air Temperature: 90° F
Relative Humidity: 50% Ground Roughness: 10.0 centimeters
Cloud Cover: 5 tenths

SOURCE STRENGTH INFORMATION:
Puddle Area: 149 square feet Puddle Mass: 268.8 kilograms
Soil Type: Default Ground Temperature: 90° F
Initial Puddle Temperature: 49.3° F
Release Duration: 20 minutes
Max Average Sustained Release Rate: 87.3 pounds/min
(averaged over a minute or more)
Total Amount Released: 593 pounds

FOOTPRINT INFORMATION: (HEAVY GAS SELECTED)
Model Run: Heavy Gas
Red LOC (1 ppm) Max Threat Zone: 1.3 miles

SITE DATA INFORMATION:
Location: WALLOPS FLIGHT FACILITY, VIRGINIA
Building Air Exchanges Per Hour: 0.73 (sheltered single storied)
Time: February 5, 2009 2107 hours EST (user specified)

CHEMICAL INFORMATION:
Chemical Name: MON-3 Molecular Weight: 90.14 g/mol
Default LOC-3: 30 ppm Default LOC-2: 20 ppm Default LOC-1: 10 ppm
IDLH: 50 ppm
Normal Boiling Point: 49.4° F Ambient Boiling Point: 49.3° F
Vapor Pressure at Ambient Temperature: 0.74 atm
Ambient Saturation Concentration: 743,692 ppm or 74.4%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)
Wind: 4 meters/sec from 0° true at 3 meters
No Inversion Height
Stability Class: D Air Temperature: 40° F
Relative Humidity: 50% Ground Roughness: 10.0 centimeters
Cloud Cover: 5 tenths

SOURCE STRENGTH INFORMATION:
Puddle Area: 149 square feet Puddle Mass: 268.8 kilograms
Soil Type: Default Ground Temperature: 40° F
Initial Puddle Temperature: Ground temperature
Release Duration: 52 minutes
Max Average Sustained Release Rate: 41.4 pounds/min
(averaged over a minute or more)
Total Amount Released: 593 pounds

FOOTPRINT INFORMATION: (HEAVY GAS SELECTED)
Model Run: Heavy Gas
Red LOC (1 ppm) Max Threat Zone: 1,645 yards

SITE DATA INFORMATION:
Location: WALLOPS FLIGHT FACILITY, VIRGINIA
Building Air Exchanges Per Hour: 0.71 (sheltered single storied)
Time: February 24, 2009 1200 hours EST (user specified)

CHEMICAL INFORMATION:
Chemical Name: METHYLHYDRAZINE   Molecular Weight: 46.07 g/mol
AEGL-3: 16 ppm   AEGL-2: 5.3 ppm
TEEL-3: 20 ppm   TEEL-2: 0.5 ppm   TEEL-1: 0.2 ppm
IDLH: 20 ppm
Carcinogenic risk - see CAMEO
Normal Boiling Point: 190.0° F   Ambient Boiling Point: 189.9° F
Vapor Pressure at Ambient Temperature: 0.087 atm
Ambient Saturation Concentration: 87,286 ppm or 8.73%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)
Wind: 4 meters/sec from 0° true at 3 meters
No Inversion Height
Stability Class: D   Air Temperature: 90° F
Relative Humidity: 50%   Ground Roughness: 10.0 centimeters
Cloud Cover: 5 tenths

SOURCE STRENGTH INFORMATION:
Puddle Area: 833 square feet   Puddle Mass: 357.95 kilograms
Soil Type: Default   Ground Temperature: 90° F
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Average Sustained Release Rate: 12.3 pounds/min
(averaged over a minute or more)
Total Amount Released: 658 pounds

FOOTPRINT INFORMATION: (HEAVY GAS SELECTED)
Model Run: Heavy Gas
Red LOC (0.24 ppm) Max Threat Zone: 1.8 miles

SITE DATA INFORMATION:
Location: WALLOPS FLIGHT FACILITY, VIRGINIA
Building Air Exchanges Per Hour: 0.62 (sheltered single storied)
Time: February 24, 2009 0700 hours EST (user specified)

CHEMICAL INFORMATION:
Chemical Name: METHYLHYDRAZINE Molecular Weight: 46.07 g/mol
AEGL-3: 16 ppm AEGL-2: 5.3 ppm
TEEL-3: 20 ppm TEEL-2: 0.5 ppm TEEL-1: 0.2 ppm
IDLH: 20 ppm
Carcinogenic risk - see CAMEO
Normal Boiling Point: 190.0° F Ambient Boiling Point: 189.9° F
Vapor Pressure at Ambient Temperature: 0.047 atm
Ambient Saturation Concentration: 46,839 ppm or 4.68%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)
Wind: 4 meters/sec from 0° true at 3 meters
Inversion Height: 1000 feet
Stability Class: E (user override) Air Temperature: 70° F
Relative Humidity: 50% Ground Roughness: 10.0 centimeters
Cloud Cover: 5 tenths

SOURCE STRENGTH INFORMATION:
Puddle Area: 803 square feet Puddle Mass: 357.95 kilograms
Soil Type: Default Ground Temperature: 70° F
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Average Sustained Release Rate: 6.65 pounds/min
(averaged over a minute or more)
Total Amount Released: 351 pounds

FOOTPRINT INFORMATION: (GAUSS SELECTED)
Dispersion Module: Gaussian
Red LOC (0.24 ppm) Max Threat Zone: 2.1 miles

SITE DATA INFORMATION:
Location: WALLOPS FLIGHT FACILITY, VIRGINIA
Building Air Exchanges Per Hour: 0.73 (sheltered single storied)
Time: February 24, 2009 0700 hours EST (user specified)

CHEMICAL INFORMATION:
Chemical Name: METHYLHYDRAZINE Molecular Weight: 46.07 g/mol
AEGL-3: 16 ppm AEGL-2: 5.3 ppm
TEEL-3: 20 ppm TEEL-2: 0.5 ppm TEEL-1: 0.2 ppm
IDLH: 20 ppm
Carcinogenic risk - see CAMEO
Normal Boiling Point: 190.0° F Ambient Boiling Point: 189.9° F
Vapor Pressure at Ambient Temperature: 0.016 atm
Ambient Saturation Concentration: 16,474 ppm or 1.65%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)
Wind: 4 meters/sec from 0° true at 3 meters
No Inversion Height
Stability Class: D Air Temperature: 40° F
Relative Humidity: 50% Ground Roughness: 10.0 centimeters
Cloud Cover: 5 tenths

SOURCE STRENGTH INFORMATION:
Puddle Diameter: 7.2 feet Puddle Volume: 5 gallons
Soil Type: Default Ground Temperature: 40° F
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Average Sustained Release Rate: 0.146 pounds/min
(averaged over a minute or more)
Total Amount Released: 8.25 pounds

FOOTPRINT INFORMATION: (HEAVY GAS SELECTED)
Model Run: Heavy Gas
Red LOC (0.24 ppm) Max Threat Zone: 293 yards

Appendix F

acta, inc. report: Evaluation of Taurus II Static Test Firing and Normal Launch Rocket Plume Emissions

Report No. 09-640/5-01

Evaluation of Taurus II Static Test Firing and Normal Launch Rocket Plume Emissions

Subcontract No.
Prime Contract No.
Task No. *5*

Prepared by

Randolph L. Nyman

ACTA
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Prepared for

National Aeronautics and Space Administration
Wallops Flight Facility, Environmental Office
Code 250
Wallops Island, VA 23337

Under Subcontract to:

Computer Sciences Corporation
7700 Hubble Drive
Lanham-Seabrook, MD 20706

March 18, 2009

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1. INTRODUCTION

The Taurus II launch vehicle is being designed and built by Orbital Sciences Corporation with the objective of launching missions from Wallops Flight Facility (WFF) to service the International Space Station. This report presents the findings of rocket exhaust plume emission and atmospheric dispersion analyses performed for the Taurus II first stage using a large archive of WFF weather balloon soundings. The report also explains the development of input data, describes the basic features of the modeling tools and identifies the assumptions made to support the analyses.

The Taurus II first stage uses liquid propellants commonly found in other modern U.S. built rockets. The first stage fuel is a refined form of kerosene known as RP-1 and the oxidizer is liquid oxygen (LOX). Although these propellants are burned in a fuel rich mixture the exhaust products can be considered environmentally friendly compared to solid propellant exhaust. The use of RP-1/LOX also avoids handling and spill toxic hazards associated with liquid hypergolic propellants. Consequently, the primary chemical exhaust constituent of concern from a toxicity standpoint is carbon monoxide (CO). The hazard associated with exposure to CO can be associated with several industry standard exposure criteria. Since rocket emissions from static test firings or rocket launches are relatively short duration events that only occur a few times a year over the course of the program, short duration or emergency exposure standards are more appropriate than long duration exposure standards designed for work place environments. One such emergency exposure standard is the National Institute for Occupational Safety and Health (NIOSH) definition of the Immediately Dangerous to Life or Health (IDLH) exposure threshold for an airborne chemical. The IDLH is intended to be used in conjunction with workers wearing respirators in contaminated areas, such that if the respirator fails the person could escape the contaminated area without being incapacitated given a maximum exposure of 30 minutes. Perhaps a more appropriate set of exposure guidelines are the Acute Exposure Guideline Levels (AEGLs) that are supported by the EPA. The development of Acute Exposure Guideline Levels (AEGLs) is a collaborative effort of the public and private sectors worldwide. AEGLs are intended to describe the risk to humans resulting from once-in-a-lifetime, or rare, exposure to airborne chemicals. The National Advisory Committee for the Development of Acute Exposure Guideline Levels for Hazardous Substances (AEGL Committee) is involved in developing these guidelines to help both national and local authorities, as well as private companies, deal with emergencies involving spills, or other catastrophic exposures. The recommended interim AEGLs for carbon monoxide are listed in Table 1-1.

Table 1-1: Interim Acute Exposure Guideline Levels (AEGLs) for Carbon Monoxide.

AEGL Level	10 min Exposure [ppm]	30 min Exposure [ppm]	60 min Exposure [ppm]	4 hr Exposure [ppm]
AEGL 1	NR	NR	NR	NR
AEGL 2	420	150	83	33
AEGL 3	1700	600	330	150

NR = No exposure level recommended due to insufficient or inconclusive data.

Definitions of the AEGL levels are as follows:

AEGL-1 is the airborne concentration, expressed as parts per million or milligrams per cubic meter (ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

AEGL-2 is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

AEGL-3 is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

The time duration that a receptor is exposed to a rocket exhaust plume emission depends upon the cloud transport wind speed and the size of the cloud. The cloud or plume grows in size as it transports downwind. Typical exposure durations are estimated to be in the 10 to 30 minute range but may approach one hour under very light wind conditions.

The report authors do not have toxicological expertise regarding hazardous CO thresholds for flora and fauna that may be of environmental concern. The selection of the most appropriate exposure level to apply to exposed flora and fauna is left to the judgment of others. It is however noted here that the vast majority of emission scenarios evaluated in this study predict far field maximum ground level CO concentrations below 10 parts per million (ppm), which is quite benign relative to all published human hazardous thresholds.

There are two emission scenarios of concern for the Taurus II environmental assessment:

1. Static test firing of the first stage while the stacked vehicle is held stationary on the launch pad. In this scenario the two first stage engines are both ignited and are run through a 52 second thrust profile that ramps the engines up to full performance (112.9%) and back down. Exhaust from the rocket engine nozzles is directed downward into a flame trench and deflected through the flame duct such that the exhaust gases are diverted away from the launch vehicle and nearby facilities. The exhaust plume exits the flame duct at supersonic velocity and the flow is approximately parallel to and slightly above the ground.

2. Normal launch of the Taurus II vehicle. In this scenario a fully configured launch vehicle with payload is ignited on the launch pad at time T-0. The vehicle is held on the pad for approximately 2 seconds as the first stage engines build thrust and then hold-downs are released allowing the vehicle to begin ascent to orbit. During ascent the vehicle velocity steadily increases resulting in a time and altitude varying exhaust product emission rate. Initially the rocket engine exhaust is largely directed into and through the flame duct. As the vehicle lifts off from the pad and clears the launch tower, a portion of the exhaust plume impinges on the pad structure and is directed radially around the launch pad stand. The portion of the rocket plume that interacts with the launch pad and flame trench is referred to as the "ground cloud". As the vehicle climbs to several hundred feet above the pad, the rocket plume reaches a point where the gases no longer interact with the ground surface and the exhaust plume is referred to as the "contrail cloud".

The concepts of the ground and contrail clouds are illustrated in Figure 1-1 using a Titan IV launch from Cape Canaveral as an example. For atmospheric dispersion analyses of rocket emissions that could affect receptors on the ground, it has been standard practice at the Federal Ranges (Cape Canaveral and Vandenberg Air Force Base) to simulate the emissions from the ascending launch vehicle from the ground to a vehicle altitude of approximately 3000 meters. The operational toxic dispersion analysis tool used by the Federal Ranges for launch support and public risk assessment is Version 7.13 of the Rocket Exhaust Effluent Diffusion Model (REEDM). This same computer program was used to perform the dispersion analyses for the Taurus II emission scenarios. The features of REEDM pertinent to this study are discussed in the next section.

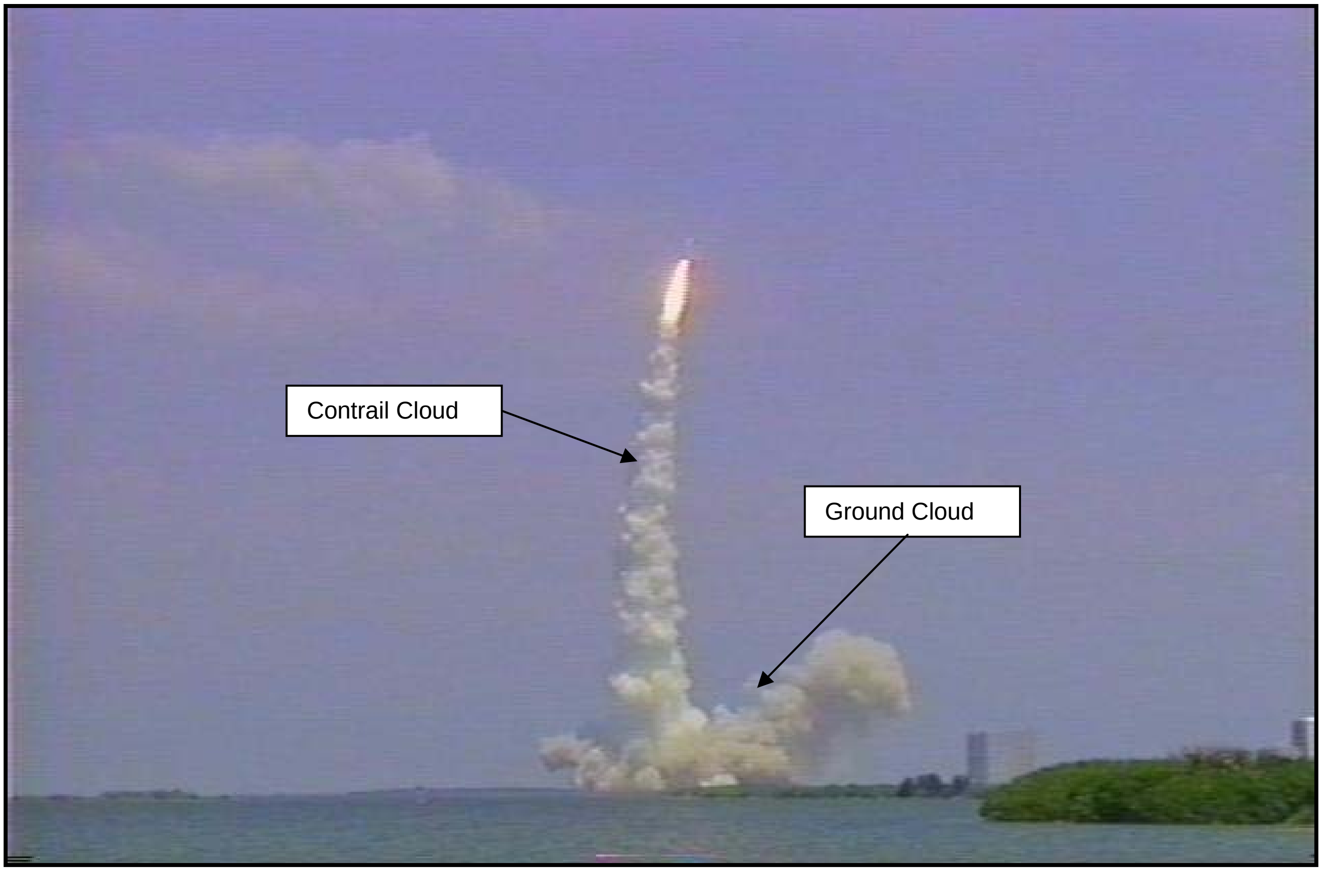

Figure 1-1. Illustration of the Ground Cloud and Contrail Cloud Portions of a Titan IV Rocket Emission Plume Associated With Normal Vehicle Launch.

2. THE ROCKET EXHAUST EFFLUENT DISPERSION MODEL (REEDM)

REEDM is a toxic dispersion model specifically tailored to address the large buoyant source clouds generated by rocket launches, test firings and catastrophic launch vehicle explosions. Under ongoing Air Force support, REEDM evolved from the NASA Multi-Layer Diffusion Model, which was written initially to evaluate environmental effects associated with the Space Shuttle, and has been generalized to handle a wide variety of launch vehicle types and propellant combinations. REEDM falls in the category of "Gaussian puff" atmospheric dispersion models in that the initial mass distribution of toxic materials within the cloud at the time the cloud reaches thermal stabilization height in the atmosphere is assumed to be normally distributed. By making the Gaussian mass distribution assumption, the differential equation defining mass diffusion can be solved in closed form using exponential functions and may be readily implemented in a fast running computer program. Gaussian puff models are still widely used by the EPA for environmental and permitting studies, by Homeland Security and the Defense Threat Reduction Agency for assessment of chemical, biological and radiological materials, and by the petrochemical industry for accidental releases of industrial chemicals.

REEDM processing of an emission event can be partitioned into the following basic steps:

1. Acquire and process vehicle related data from an input vehicle database file.

2. Acquire and process meteorological data, which in this study is a combination of archived weather balloon soundings used in conjunction with an internal REEDM climatological turbulence algorithm.

3. Acquire the chemical composition and thermodynamic properties of the rocket exhaust emissions and define the initial size, shape, location and heat content of the exhaust cloud (herein referred to as the "source term" or "source cloud"). REEDM has an internal propellant equilibrium combustion model that is used to compute these terms for vehicle catastrophic failure modes but for normal launch and static test firing scenarios this data is calculated external to REEDM and placed in the vehicle database file read by REEDM.

4. Iteratively calculate the buoyant cloud rise rate and cloud growth rate to achieve a converged estimate of the cloud stabilization height above ground, size and downwind position. The cloud rise equations evaluate both cloud thermodynamic state as well as the local atmospheric stability, which is defined by the potential temperature lapse rate.

5. Partition the stabilized cloud into disks and mark whether or not part of the stabilized cloud is above a capping atmospheric temperature inversion. Inversions (or other sufficiently stable air masses) act as a barrier to gaseous mixing and are treated in REEDM as reflective boundaries.

6. Transport the cloud disks downwind and grow the disk size using climatologic model estimates of atmospheric turbulence intensity. Turbulence intensity is a function of wind speed and solar radiation intensity. Turbulence varies with time of day and cloud cover conditions because these influence the solar radiation intensity.

7. Calculate concentrations at ground receptor points and determine the plume or cloud track "centerline" that defines the peak concentration as a function of downwind distance. Concentration at any given receptor point is computed as the sum of exposure contributions from each cloud disk. Concentration is solved using the closed form Gaussian dispersion equation and accounts for the effect of ground and capping inversion reflections.

8. Report concentration centerline values in table format as a function of distance from the source origin (e.g. launch pad)

There are other features and submodels of REEDM that are more fully described in the REEDM technical description manual and will not be reviewed in this report.

There are several important assumptions made in REEDM that have a bearing on this Environmental Assessment study. REEDM was designed to primarily predict hazard conditions downwind from the stabilized exhaust cloud. REEDM does not directly calculate or report cloud concentrations during the buoyant cloud rise phase, however, advanced model users can extract sufficient pertinent cloud data from internal calculations to derive concentration estimates during the cloud rise phase manually. One assumption that REEDM makes about the nature and behavior of a rocket exhaust cloud is that it can be initially defined as a single cloud entity that grows and moves but remains as a single cloud during the formation and cloud rise phases. A consequence of this assumption is that once the cloud lifts off the ground during the buoyant cloud rise phase, there will be no predicted cloud chemical concentration on the ground immediately below the cloud. Ground level concentrations will be predicted to remain at zero ppm until the some of the elevated cloud material is eventually brought back down to ground level by mixing due to atmospheric turbulence. This concept is illustrated in Figure 2-1 and it is noted that REEDM is designed to report concentrations downwind from the stabilized cloud position. The region downwind from the stabilized exhaust cloud is referred to as the "far field". It is also noted here that the most concentrated part of these rocket exhaust clouds remains at an altitude well above the ground level. REEDM is not able to model stochastic uncertainty in the source cloud and atmospheric flow such that if a gust of wind, small turbulence eddy or nuance of the launch pad flame duct structure causes a small portion of the main exhaust cloud to detach from the main cloud, the model will not correctly predict the transport, dispersion or concentration contribution from the detached cloud material. Likewise if there are strong atmospheric updrafts or down drafts, such as associated with development of thunderstorm cells or towering cumulus clouds, REEDM will not correctly model strong vertical displacements of the entire exhaust cloud or strong shearing forces that may completely breakup the cloud under such conditions (these are not favorable conditions for launch either and a planned launch would never be conducted with strong thunderstorm and cloud development activity in the launch area).

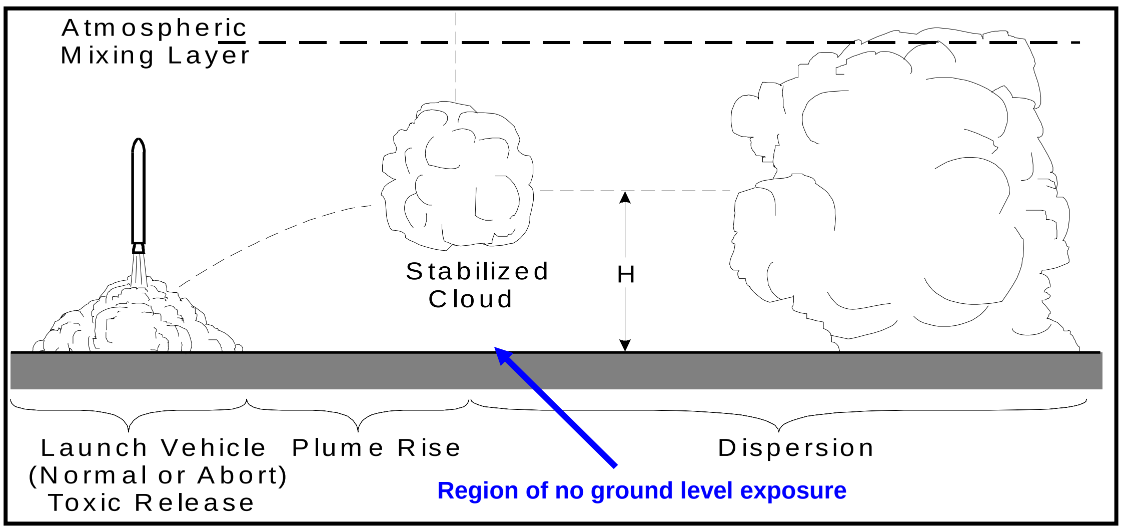

Figure 2-1. Conceptual Illustration of Rocket Exhaust Source Cloud Formation, Cloud Rise and Cloud Atmospheric Dispersion.

REEDM is also somewhat constrained by the Gaussian assumptions inherent in the model that require a single average transport wind speed and direction. The portion of the atmosphere selected for averaging the transport winds has been improved over the years of operational use at the Air Force ranges. Old versions of REEDM averaged the winds over the entire boundary layer, which in the absence of a capping inversion, was treated as being 3000 meters deep. The modern version of REEDM now selects the appropriate atmospheric layer based on the stabilization height of the cloud, the top of the cloud and the location of the reflective boundary layers. Comparison of REEDM predicted rocket exhaust cloud transport direction and speed with Doppler weather radar tracks of rocket exhaust clouds has indicated that the modern version of REEDM performs very satisfactorily in predicting the correct average cloud transport direction and speed. The "multi-layer" aspect of REEDM is still retained from its early development and refers to the partitioning of the stabilized rocket exhaust cloud into "disks" of cloud material assigned to meteorological levels at different altitudes. The altitude bands are typically 20 to 50 meters in depth. REEDM models the initial formation of a rocket exhaust cloud as either an ellipsoid or a sphere and predicts the buoyant could rise of the source as a single cloud entity. Once the cloud is predicted to have achieved a condition of thermal stability in the atmosphere, the cloud is partitioned into disks. The placement of each disk relative to the source origin (e.g. the launch pad) is determined based on the rise time of the cloud through a sequence of meteorological layers that are defined using the measurement levels obtained from a mandatory weather balloon input data file. Each meteorological layer may have a unique wind speed and direction that displaces the cloud disk in the down wind direction. The initial placement of cloud disks that are associated with the lower portion of the overall source cloud are not influenced by winds above their stabilized altitude level whereas disks near the top of the stabilized cloud will be displaced by the winds all the way from the ground level to the disk stabilization altitude. Thus the vertical stack of cloud disks can be displaced relative to each other due to the influence of wind speed and direction shears. The concept of the stabilized cloud partition into disks is illustrated in Figure 2-2.

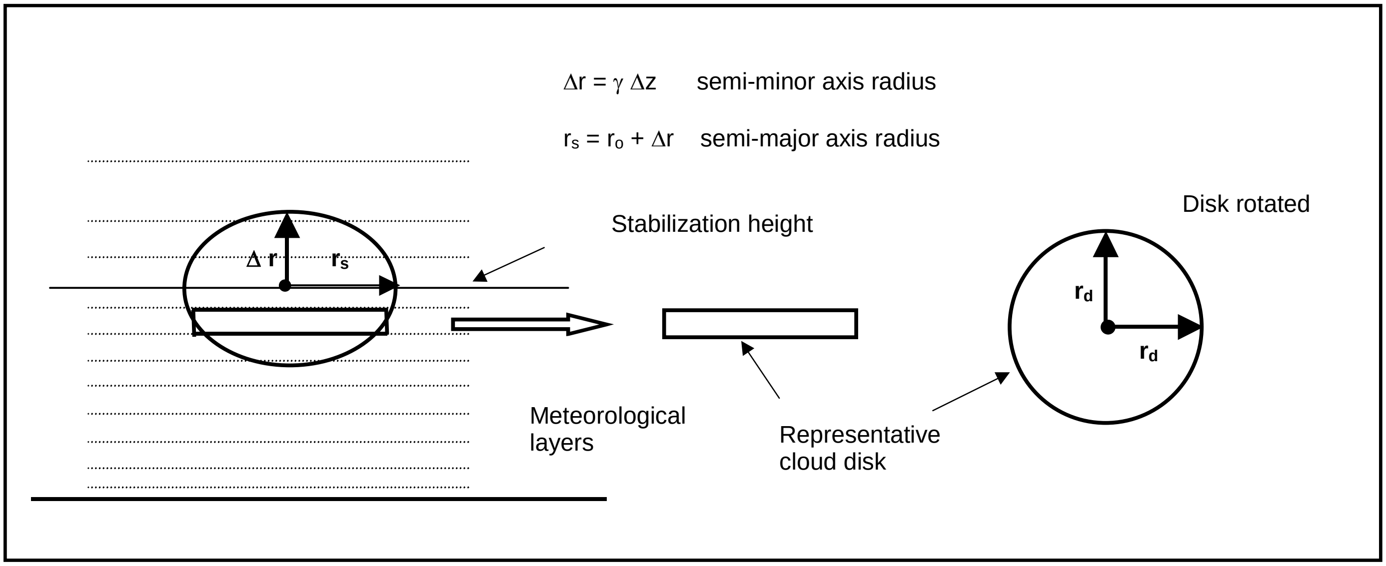

Figure 2-2. Illustration of REEDM Partitioning a Stabilized Cloud into Disks.

Once the cloud disks positions are initialized, future downwind transport applies the same average atmospheric boundary layer transport wind speed and direction to each cloud disk as illustrated in Figure 2-3.

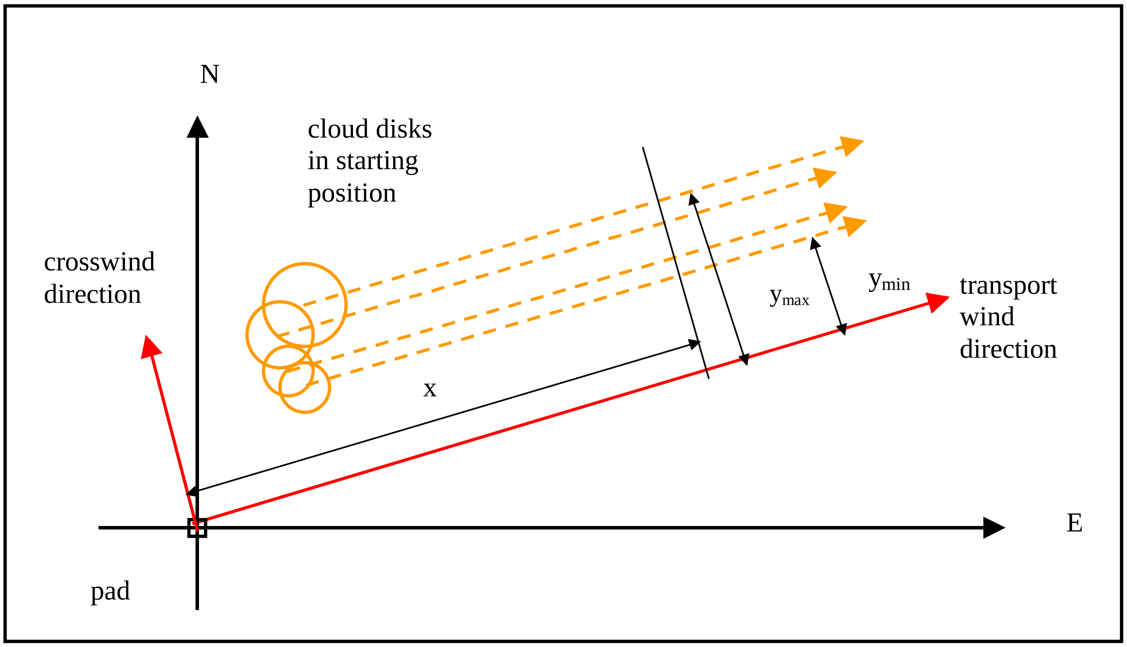

Figure 2-3. Illustration of Straight Line Transport of Stabilized Exhaust Cloud Disks Using Average Mixing Layer Wind Speed and Direction.

The assumption of straight-line transport used in REEDM during the cloud transport and dispersion phase ignores the possibility of complex wind fields that might arise in mountainous terrain or that could evolve during passage of a seabreeze front or synoptic scale weather front. It is recommended that the assumption of uniform winds be limited to plume transport distances of less that 20 kilometers. As will be shown in the analysis results section, REEDM predicted typical ranges of 5 to 10 kilometers from the launch pad to the location of the maximum far field ground level CO concentration point, thus the assumption of straight line transport should not be a problem.

In both Taurus II scenarios the exhaust emissions from the rocket combustion are at several thousand degrees Kelvin and are highly buoyant. The high temperature of these exhaust emissions causes the plume to be less dense than the surrounding atmosphere and buoyancy forces acting on the cloud cause it to lift off the ground and accelerate vertically. As the buoyant cloud rises, it entrains ambient air and grows in size while also cooling. In this initial cloud rise phase, the growth of the cloud volume is due primarily to internal velocity gradients and mixing induced by large temperature gradients within the cloud itself. Even though the cloud is entraining air and cooling by virtue of mixing hot combustion gases with cooler ambient air, the net thermal buoyancy in the cloud is conserved and the cloud will continue to rise until it either reaches a stable layer in the atmosphere or the cloud vertical velocity becomes slow enough to be damped by viscous forces. REEDM applies the following solution of Newton's second law of motion to a buoyant cloud in the atmosphere to iteratively predict cloud stabilization height:

$$z(t) = \left[\frac{3F_m}{u\gamma^2\sqrt{s}} \sin\left(t\sqrt{s}\right) + \frac{3F_c}{u\gamma^2 s}\left(1 - \cos\left(t\sqrt{s}\right)\right) + \left(\frac{r_o}{\gamma}\right)^3 \right]^{1/3} - \frac{r_o}{\gamma}$$

where:

s = atmospheric stability parameter = $\dfrac{g}{\theta_a} \dfrac{\Delta\theta_a}{\Delta Z}$ [sec^{-2}]

g = gravitational acceleration constant = 9.81 [m/sec^2]

θ_a = potential temperature of ambient air [K]

F_m = $r_o^2 w_o u$ = initial vertical momentum [m^4/sec^2]

u = mean ambient wind speed [m/sec]

w_o = initial vertical velocity [m/sec] (typically = 0.0)

r_o = initial plume cross-sectional radius [m]

F_c = initial buoyancy = $\dfrac{g\,\dot{q}}{\pi\,\rho_c\,C_p\,T_a}$ [m^4/s^3]

C_p = specific heat of exhaust cloud gases [cal/kg K]

γ = air entrainment coefficient (dimensionless)

z = plume height at time t [m]

$\dot{q}$ = initial plume heat flux [cal/sec]

T_a = ambient air temperature [K]

ρ_c = density of exhaust cloud gases [kg/m^3]

A critical parameter in the cloud rise equation is the rate of ambient air entrainment that is defined by the dimensionless air entrainment coefficient, γ. Cloud growth as a function of altitude is assumed to be linearly proportional and the air entrainment coefficient defines the constant of proportionality. REEDM's cloud rise equations have been compared with observations and measurements of Titan rocket ground clouds and a best-fit empirical cloud rise air entrainment coefficient has been derived from the test data, a sample of which is illustrated in Figure 2-4.

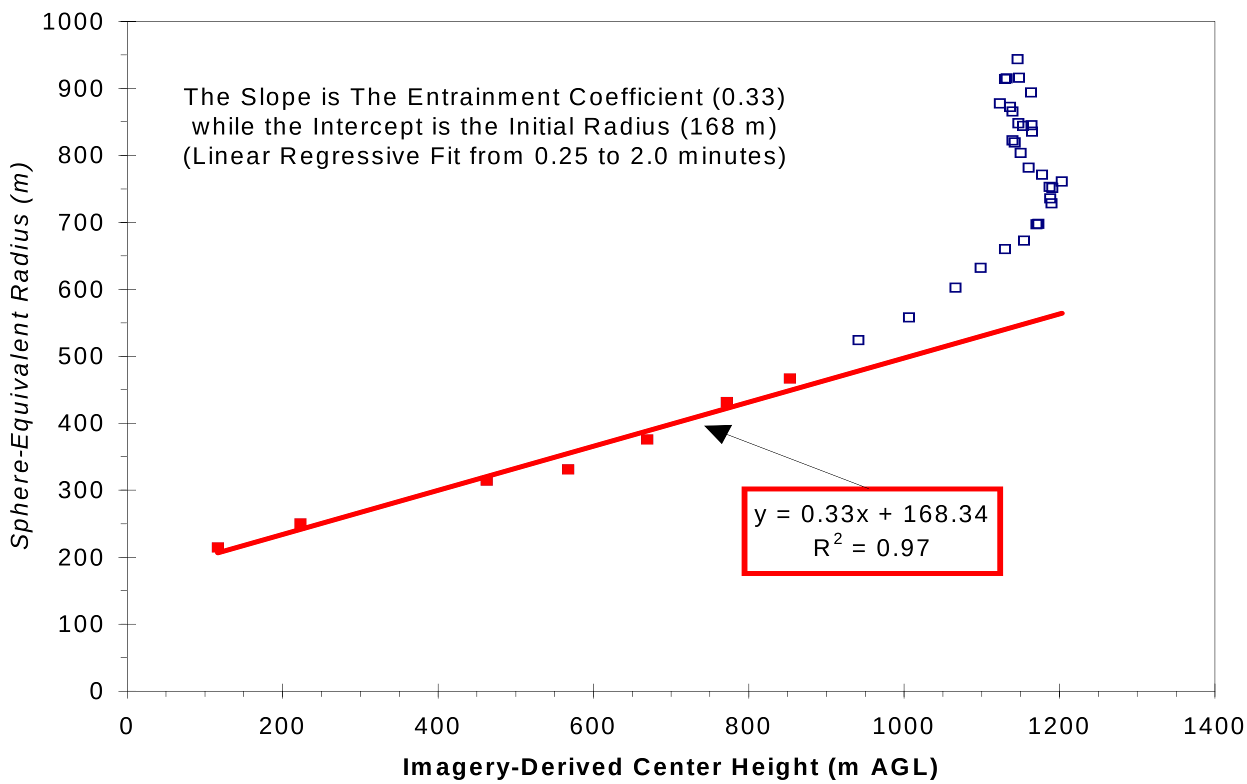

Figure 2-4. Observed Cloud Growth Versus Height for Titan IV A-17 Mission.

The Taurus II buoyant source clouds are predicted to rise from 500 to 1300 meters above the ground depending on atmospheric lapse rate conditions.

3. TAURUS II DATA DEVELOPMENT

Proper specification of vehicle characterization input data is critical to the overall toxic dispersion analysis problem. While many vehicle input parameters are straightforward and readily verifiable (e.g. types and amounts of propellants loaded on the vehicle), other parameters inherently involve greater uncertainty and are not readily verifiable (e.g. amount of ambient air entrained into the rocket plume at the flame duct inlet). In this report section the vehicle input data values used in the REEDM Taurus II normal launch and static test firing scenario analyses are itemized and explained. Input parameters that entail significant uncertainty were treated in a conservative fashion in the sense that choices were made to favor overestimating rather than underestimating the toxic chemical concentrations being evaluated for the Environmental Assessment study. Information pertaining to the vehicle propellant loads, burn rates and expected nominal launch flight trajectory were provided by WFF NASA or Orbital Sciences personnel and converted by ACTA into REEDM database format.

3.1 Normal Launch Vehicle Data

The following data items represent the vehicle data needed to characterize the normal launch scenario and are presented in the REEDM database format.

```
#05.00                       VEHICLE DATA SECTION
   VEHICLE TYPE = 4, NAME =     TAURUS-II,
   TIME HEIGHT COEFFICIENTS A,B,C =     0.967700,     0.471980,       2.2000,
#05.01 NORMAL LAUNCH ENGINE DATA FOR STAGES IGNITED AT LIFT-OFF:
   NUMBER OF IGNITED SRB'S           =   0,
   SOLID FUEL MASS             (LBM) =   0.0000000,
   SOLID FUEL BURN RATE      (LBM/S) =   0.0000000,
   LIQUID FUEL MASS            (LBM) =  142735.000,
   LIQUID FUEL BURN RATE     (LBM/S) =   645.90000,
   LIQUID OXIDIZER MASS        (LBM) =  390779.000,
   LIQUID OXIDIZER BURN RATE (LBM/S) =   1768.2000,
   AIR ENTRAINMENT RATE IN GROUND CLOUD       (LBM/S) =   0.0000000,
   TOTAL DELUGE WATER ENTRAINED IN GROUND CLOUD (LBM) =   0.0000000,
   AIR ENTRAINMENT RATE IN ROCKET CONTRAIL    (LBM/S) =   0.0000000,
   VEHICLE HEIGHT TO WHICH PLUME CONTRIBUTES TO GROUND CLOUD (FT) = 525,
   GROUND CLOUD INITIAL AVERAGE TEMPERATURE         (F) =  3487,
   GROUND CLOUD INITIAL HEAT CONTENT          (BTU/LBM) =  3475,
   INITIAL VERTICAL VELOCITY OF GROUND CLOUD     (FT/S) =   0.0,
   INITIAL RADIUS OF GROUND CLOUD                  (FT) = 160.0,
   INITIAL HEIGHT OF GROUND CLOUD                  (FT) =   0.0,
   INITIAL X DISPLACEMENT OF GROUND CLOUD FROM PAD (FT) =   0.0,
   INITIAL Y DISPLACEMENT OF GROUND CLOUD FROM PAD (FT) =   0.0,
   PLUME CONTRAIL INITIAL AVERAGE TEMPERATURE       (F) =  3487,
   PLUME CONTRAIL INITIAL HEAT CONTENT        (BTU/LBM) =  3475,
#05.02 NORMAL LAUNCH EXHAUST PRODUCT DATA:
 CHEMICAL NAME     MOL. WT.   MASS FRAC. GAS   MASS FRAC. COND  HAZARDOUS
 GROUND CLOUD:
   CO2              44.011        0.44824          0.00000          Y
   CO               28.011        0.25637          0.00000          Y
   H2O              18.015        0.28893          0.00000          N
```

```
  H2               2.016        0.00557         0.00000          N
  OH              17.007        0.00077         0.00000          N
  H                1.008        0.00006         0.00000          N
  O2              31.999        0.00005         0.00000          N
  O               15.999        0.00001         0.00000          N
  END
CONTRAIL:
  CO2             44.011        0.44824         0.00000          Y
  CO              28.011        0.25637         0.00000          Y
  H2O             18.015        0.28893         0.00000          N
  H2               2.016        0.00557         0.00000          N
  OH              17.007        0.00077         0.00000          N
  H                1.008        0.00006         0.00000          N
  O2              31.999        0.00005         0.00000          N
  O               15.999        0.00001         0.00000          N
  END
```

REEDM does not utilize the launch vehicle trajectory directly; instead a power law fit to the height of the vehicle above ground as a function of time is derived from the trajectory data. The fit achieved with the derived power law time-height coefficients is demonstrated in Figure 3-1

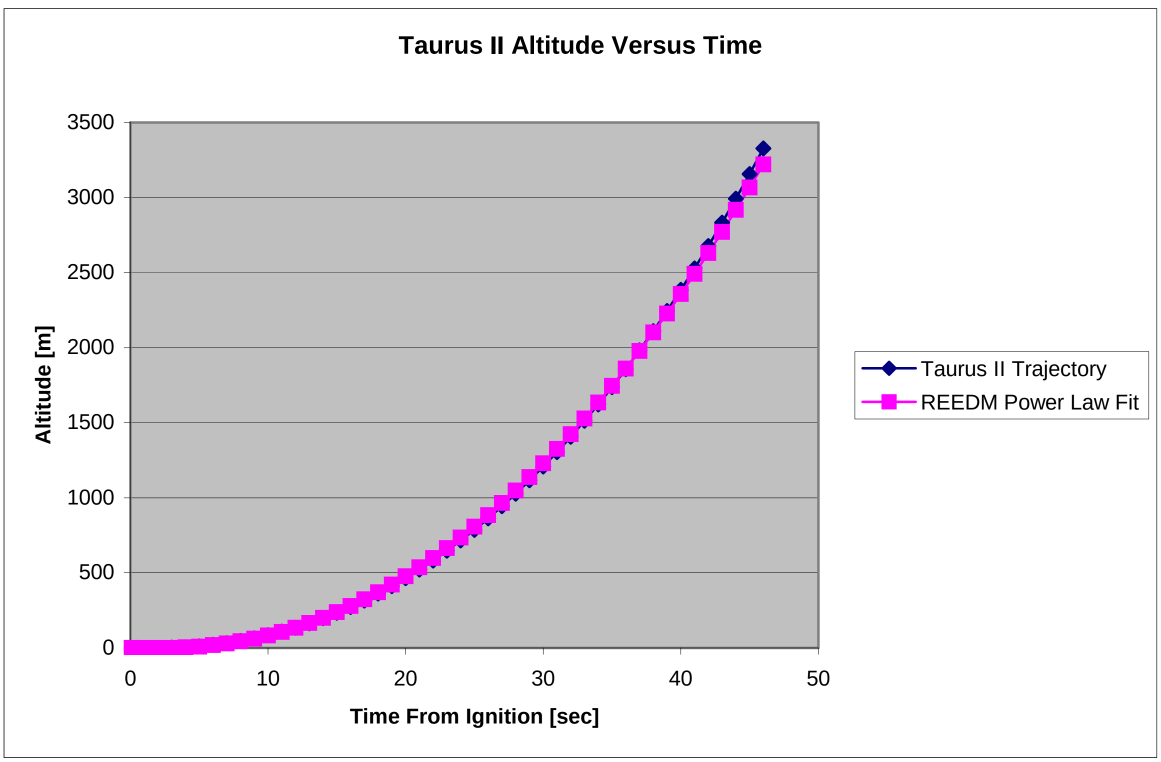

Figure 3-1. Plot of Vendor Taurus II Nominal Trajectory Compared with ACTA Derived Power Law Fit Used in REEDM.

REEDM allows for several chemical additions that may be included in the propellant exhaust of the normal launch ground cloud and the normal launch contrail cloud. In addition to specifying the nominal burn rates of the RP-1 fuel and the LOX oxidizer, the user may optionally consider adding deluge or sound suppression water and entrained ambient air. For these two items the REEDM database serves only as a source of documentation for the assumptions applied in deriving the chemical compositions of the exhaust specified in section #05.02 of the database. It is noted here that “air entrainment” as specified in this section represents the user assumption about the amount of air, if any, added as a ***reactant*** in the propellant combustion calculations. This “air entrainment” definition is not to be confused with the “air entrainment” process that takes place during the cloud rise calculations. REEDM assumes that all chemical combustion reactions are completed before the cloud rise process takes place and REEDM therefore does not attempt to recompute chemical composition and additional heat release during the cloud rise computations.

The REEDM database provides the chemical composition of the normal ground and contrail clouds. A mass fraction is assigned to each constituent and the total exhaust mass in the source cloud is multiplied by this fraction to determine the total mass of each chemical in the exhaust cloud. The molecular weight of each species is used to convert the concentration from mass per unit volume [e.g.mg/m^3] to parts per million. For this study ACTA computed the chemical composition of the Taurus II stage 1 RP-1/LOX exhaust using the NASA Lewis chemical equilibrium combustion model. The ACTA version of the NASA combustion model was modified slightly to output thermodynamic properties of the exhaust mixture that were needed to initialize the REEDM cloud rise equations. ACTA’s combustion results for the Taurus II first stage agreed within 2% for the major constituents (CO, CO_2, H_2O) compared with similar data provided by Orbital Sciences 0 as shown in Table 3-1. ACTA ran the NASA combustion model in “rocket” analysis mode using an oxidizer to fuel ratio of 2.7 and a combustion chamber pressure of 2194 PSIA. The Orbital analysis appears to have been conducted with a newer version of the NASA equilibrium combustion model and was executed with a slightly different nozzle to throat area ratio than the ACTA model. The supporting thermodynamic databases between the two versions of the combustion models may also differ slightly. ACTA considers the small chemical composition differences to have insignificant effect on the analysis results and conclusions of this study.

Table 3-1. Comparison of ACTA and Orbital Taurus II Stage-1 Combustion Model Nozzle Exit Results.

Chemical	ACTA Mole Fraction	Orbital Mole Fraction	Ratio ACTA/Orbital
CO_2	0.26632	0.27071	0.984
CO	0.23932	0.23532	1.017
H_2O	0.41938	0.41627	1.007
H_2	0.07231	0.07650	0.945
OH	0.00118	0.00048	2.458
H	0.00144	0.00072	2.000
O_2	0.00004	0.00001	4.000
O	0.00002	0.00000	--

Both ACTA and Orbital ran combustion for only RP-1 and LOX and the chemical compositions listed in Table 3-1 do not consider the shift in chemical equilibrium that takes place if ambient air or water are added to the nozzle exit exhaust mixture.

3.2 Static Test Firing Vehicle Data

The REEDM database also includes a data section used to define the parameters that characterize a static test firing scenario. The data developed for the Taurus II stage-1 static test firing is listed as follows:

```
#05.20 TEST FIRING ENGINE DATA:
   SOLID FUEL MASS                          (LBM) = 123552.,
   SOLID FUEL BURN RATE                   (LBM/S) =   2376.,
   AIR ENTRAINMENT RATE IN CLOUD          (LBM/S) =       0,
   TOTAL DELUGE WATER ENTRAINED IN CLOUD    (LBM) =       0,
   CLOUD INITIAL AVERAGE TEMPERATURE          (F) =    3487,
   CLOUD INITIAL HEAT CONTENT           (BTU/LBM) =    3475,
   INITIAL VERTICAL VELOCITY OF CLOUD      (FT/S) =     0.0,
   INITIAL RADIUS OF CLOUD                   (FT) =   151.1,
   INITIAL HEIGHT OF CLOUD                   (FT) =     0.0,
   INITIAL X DISPLACEMENT OF CLOUD FROM STAND (FT) =     0.0,
   INITIAL Y DISPLACEMENT OF CLOUD FROM STAND (FT) =     0.0,
#05.21 TEST FIRING PLUME CHEMISTRY  DATA:
 CHEMICAL NAME     MOL. WT.   MASS FRAC. GAS   MASS FRAC. COND  HAZARDOUS
   CO2              44.011        0.44824          0.00000          Y
   CO               28.011        0.25637          0.00000          Y
   H2O              18.015        0.28893          0.00000          N
   H2                2.016        0.00557          0.00000          N
   OH               17.007        0.00077          0.00000          N
   H                 1.008        0.00006          0.00000          N
   O2               31.999        0.00005          0.00000          N
   O                15.999        0.00001          0.00000          N
   END
```

The REEDM static test firing scenario was originally developed for burns of solid propellant motors and the nomenclature used in the database is outdated and somewhat misleading. In the case of the Taurus II first stage test firing the line items identified as "solid fuel mass" and "solid fuel burn rate" are set to represent the total quantity of RP-1 + LOX and the average burn rate of the RP-1 + LOX mixture consumed during a 52 second static burn. The chemical composition of the static test firing exhaust is set the same as the normal launch ground cloud. As with the normal launch scenario, the effects of plume afterburning and deluge water injection are ignored.

3.3 Conservative Assumptions Applied In Data Development

The REEDM atmospheric dispersion model has been used operationally by the Air Force to make range safety launch decisions since 1989. During that time vehicle databases have been developed for many vehicles (e.g. Space Shuttle, Titan II, Titan III, Titan IV, Delta II, Delta III, Delta IV, Atlas II, Atlas III, Atlas V, Taurus, TaurusXL, Taurus Lite, Minotaur, Peacekeeper, Minuteman II, Minuteman III, Athena, Lance, Scud, ATK-ALV-1). As noted at the beginning of this section, some vehicle data is easily obtained and verified, such as the stage propellant types, quantities and burn rates. Other model input parameters required by REEDM are based on derived values obtained from mathematical and physical models, empirical measurement data or engineering judgment from the vehicle designer or range safety experts.

An example of a derived value is the selection of how much pad deluge water to include with the rocket engine exhaust when defining the normal launch cloud heat content, mass and chemical composition. A typical pad deluge system is comprised of a series of pressure fed sprayers and sprinkers that wet the launch pad, the launch service tower and the flame duct. The deluge system is typically turned on several seconds before the rocket motors are ignited and continues until the rocket has ascended above the launch tower and the plume no longer impinges on the ground. As the vehicle ascends, the rocket plume interaction with the pad structures is time varying, such that the gas flow velocity ranges from supersonic to subsonic and involves multiple shock fronts, reflected shocks, deflected flow from the pad surface, partial flow ducting through the flame trench and plume temperatures that range from 300 to 3000 K. A simple energy balance between the amount of heat available in the plume and the amount of water released in the deluge system may suggest that there is ample energy to vaporize all of the deluge water, but actual observation of launches indicates that residual deluge water is often collected in a concrete containment basin designed to collect residual deluge water. Likewise the initial ignition impulse often blows standing water out of the flame trench or away from the pad and depositing it as droplets before they can be fully mixed with the combustion gases and vaporized. Some parts of the launch plume during vehicle liftoff may become saturated with water vapor and other portions may remain relatively "dry". Thus the task of selecting a specific deluge water inclusion amount for the REEDM database and setting the associated chemical and thermodynamic data for the exhaust products is challenging and typically not estimated by the launch agency or vehicle developer. This type of flow problem is extremely complex and would require advanced computational fluid dynamics analysis that is extremely costly and also constrained by modeling assumptions. Consequently, these types of detailed analyses are rarely performed or conducted only for limited specific design purposes.

Other examples of highly uncertain processes are the mixing of propellants from ruptured tanks in a vehicle explosion, and the fragmentation of a solid rocket motor propellant grain in the event of a case rupture. These latter events are related to vehicle failures that are not considered in this study, however, they illustrate the problem routinely faced by the launch community when attempting to set up REEDM database entries to model these scenarios. Historically the range safety community has taken a conservative approach in setting these uncertain database entries. The vast majority of vehicles characterized in the REEDM database ignore deluge water contributions (a notable exception being Shuttle). One reason for ignoring the deluge water effect is that it is known that water vapor and water droplets scrub hydrogen chloride (a common solid propellant toxic exhaust product) from the launch plume but the degree of the effect is difficult to quantify and verify, therefore ignoring this removal mechanism favors maximizing the downwind ground level concentrations of HCl at receptor sites of concern that must be protected.

The same philosophy of erring in favor of overestimating rather than underestimating potential emission hazards has been applied in this study of the Taurus II carbon monoxide emissions. There are two main factors to which conservative assumptions have been applied in this study; 1) ambient air entrainment and its effect on plume afterburning chemistry, and 2), deluge water injection into the plume. Both of these factors are discussed in further detail in the following paragraphs with an explanation for why it is believed that the REEDM modeling assumptions applied in this study are in fact conservative.

It is recognized that the Taurus II, like most rocket engines, is designed to run somewhat fuel rich for efficiency reasons and that the exhaust products will contain compounds (mainly CO and OH) that are not fully oxidized. Entrainment of ambient air into the superheated gases exiting from the rocket nozzle will allow for further oxidation in the plume, a process referred to as plume afterburning. The rate of air entrainment into the plume and the amount of additional oxidation that occurs in the plume downstream from the nozzle exit plane requires sophisticated computation fluid dynamic (CFD) solutions of the plume flow as it decelerates through multiple shock front to subsonic velocity that are beyond the design capabilities and run time requirements of REEDM. In this study ACTA has ignored the effect of air entrainment on the combustion products and heat content of the normal launch ground cloud and contrail cloud emissions. Ignoring air entrainment and after burning is assumed to be conservative for this study in that the ground level CO concentration predictions will err on the side of overestimating rather than underestimating the concentration for the following two reasons:

1. Ignoring ambient air entrainment in the combustion calculations will favor production of CO rather than CO_2 and CO is the more toxic species.

2. Ignoring ambient air afterburning reduces the total amount of heat released by the combustion process, which in turn leads to a lower stabilized cloud height prediction. Ground level concentrations of cloud chemicals vary approximately with the inverse cube of the stabilization height (e.g. doubling the cloud stabilization height reduces the ground concentrations by about a factor of 8, other factors being constant). Lower stabilization height therefore favors higher ground level CO predictions.

A deluge water system is planned for the Taurus II launch pad and serves to cool pad structures exposed to rocket engine exhaust as well as to suppress acoustic vibrations during motor ignition. An objective of the deluge water system design is to inject water into the plume just downstream of the nozzle exit plane at a rate of 2 lbm of water for every lbm of rocket propellant exhaust. Water is expected to chemically react with the high temperature rocket engine exhaust gases, which are fuel rich. In this situation water acts as an oxidizer and gives up oxygen to convert CO to CO_2 in the plume while simultaneously releasing hydrogen gas. The reaction between high temperature CO and H_2O is referred to as the "water-gas shift" reaction. ACTA evaluated the effect of 2:1 water to rocket exhaust mixing on the plume chemistry immediately downstream of the nozzle exit plane by running the NASA Lewis chemical equilibrium combustion model 0, 0 using the RP-1/LOX nozzle exit products as high temperature reactants at 2193 K mixed with liquid water at 298 K. The input reactant information entered into the combustion model is listed below:

NASA Lewis Combustion Model Input Reactants for RP-1/LOX Exhaust Products and Deluge Water Mixture.

```
THERMO
TRAN
REACTANTS
C 1.     O 2.0                            63.111  -69368.  G 2193.  F
C 1.     O 1.0                            36.096  -11178.  G 2193.  F
H 2.                                       0.784   14240.  G 2193.  F
H 1.                                       0.008   61472.  G 2193.  F
H 2.     O 1.0                            87.345  -68267.  L  298.  O
H 2.     O 1.0                            12.619  -37989.  G 2193.  O
O 2.                                       0.002   15877.  G 2193.  O
O 1.     H 1.0                             9.631   23759.  G 2193.  O
```

```
NAMELISTS
 &inpt2 kase=1,hp=t,p=1.000,of=t,mix=3.2239,siunit=t &end
```

The predicted combustion products and thermodynamic state properties for the exhaust plume + water mixture are listed below. Post combustion products are highlighted. Note that the plume is cooled from 2193 K to 856 K, but remains unsaturated. The predicted amount of CO in the exhaust has dropped from 25.6% to 0.3%, a reduction factor of approximately 100. CO_2 concentration is predicted to decrease from 44.8% to 27.9%. The total amount of CO_2 produced has actually increased but the percentage relative to the total exhaust mixture mass has decreased.

NASA Lewis Combustion Model Output Products for RP-1/LOX Exhaust and Deluge Water Mixture.

```
0                  O/F=   3.2239     PERCENT FUEL=   23.6748     EQUIVALENCE RATIO= 1.0383     PHI=
2.0181
0THERMODYNAMIC PROPERTIES

 P, MPA            0.10132
 T, DEG K           856.32
 RHO, KG/CU M    2.9654-1
 H, KJ/KG        -11095.9
 U, KJ/KG        -11437.6
 G, KJ/KG        -20674.8
 S, KJ/(KG)(K)    11.1861

 M, MOL WT          20.837
 (DLV/DLP)T      -1.00000
 (DLV/DLT)P         1.0000
 CP, KJ/(KG)(K)     1.9758
 GAMMA (S)          1.2531
 SON VEL,M/SEC       654.3
   trace =    0.000000000000000E+000
   npt   =             1
 total product molecular wt. (including condensed sp) = 20.837

0MOLE FRACTIONS

   oxidizer mass fraction =    0.7632520
   fuel mass fraction     =    0.2367480
  C O           -69368.0    44.010  F    0.6311
  C O           -11178.0    28.010  F    0.3610
  H              14240.0     2.016  F    0.0078
  H              61472.0     1.008  F    0.0001
  H O           -68267.0    18.015  O    0.7970
  H O           -37989.0    18.015  O    0.1151
  O              15877.0    31.999  O    0.0000
  O H            23759.0    17.007  O    0.0879

   oxfl =    3.22390007972717
   temperature =    856.317902340247
   Total reactant enthalpy [cal/g] =    -2651.987

   INJECTOR CONDITIONS
```

chemical	mole frac	mole wt	wt kg	wt frac	hval cal/gmole	hf298 cal/gmole	heat cal	heat@stag cal	hstag cal/gmole
H2O	0.82599	18.015	14.88037	0.71412	-52929.2	-57754.7	3985.8	3985.8	-52929.2
CO2	0.13216	44.010	5.81651	0.27914	-87837.4	-93983.8	812.3	812.3	-87837.4
H2	0.03969	2.016	0.08002	0.00384	3910.7	0.6	155.2	155.2	3910.7
CO	0.00215	28.010	0.06027	0.00289	-22342.6	-26398.0	8.7	8.7	-22342.6

```
  total kg products (per kgmole) =     20.83716
```

```
total heat of form. of prod. [cal/gmole] =   -60182.82
enthalpy of prod. at plume T [cal/gmole]=   -55220.72
heat content of prod. @ plume T & V [cal/gmole] =    4962.093
heat content of prod. @ plume T & V [cal/g] =    238.1358
total weight fractions of products =   0.9999962
total mole fractions of products =   0.9999994
gas velocity [m/sec] =   0.0000000E+00
stagnation enthalpy of prod. [cal/gmole]=   -55220.72
heat content of prod. @ stag T & V = 0 [cal/gmole] =    4962.093
heat content of prod. @ stag T & V = 0  [cal/g] =    238.1358
total heat of form. of reac. [cal/g] =   -2651.987
heat of combustion [cal/g] =    236.2465
```

The addition of deluge water has another effect in that it may reduce the net heat content of the cloud in proportion to the amount of liquid deluge water that is converted to gaseous phase and does not chemically react with other plume constituents. The amount of liquid water that is vaporized and then does not re-condense during the cloud rise phase reduces the cloud buoyancy. The effects of deluge water on the plume chemistry and plume rise where ignored in this study, in part because the normal launch plume has a time varying interaction with the deluge system and transitions from a high water injection condition to an essentially dry plume. Ignoring deluge or sound suppression water injection into the plume is expected to be conservative in that it should lead to model predictions that overestimate the downwind ground level CO concentrations. The reduction of in-cloud CO is expected to far outweigh the reduction in cloud stabilization height due to loss of thermal buoyancy.

4. ANALYSIS OF EMISSION SCENARIOS

The REEDM Taurus II database was used in conjunction with a large set of archived WFF weather balloon soundings to predict downwind concentrations of carbon monoxide and to achieve some statistical perspective of the potential toxic hazard corridors associated with normal launch and static test firing scenarios.

4.1 Meteorological Data Preparation

Gaseous dispersion of rocket exhaust clouds is extremely dependent upon the meteorological conditions at the time the source cloud is generated. The presence or absence of temperature inversions, the temperature lapse rate, wind speed and direction, wind shears and atmospheric turbulence are important factors that influence the cloud rise and rate of dispersion of the source cloud. Meteorological conditions that are adverse from a toxic chemical dispersion perspective are light winds with little wind speed or wind direction variation over the first several thousand feet of the atmosphere coupled with a capping temperature inversion just above the top of the stabilized source cloud. An additional adverse factor is suppression of atmospheric turbulence, as occurs at night or under cloudy or marine stratus and fog conditions.

ACTA acquired and ran REEDM analyses for 6432 meteorological cases based on actual weather balloon measurements made at Wallops Flight Facility between 2000 and 2008. The raw weather balloon data was not in a format usable by REEDM and needed to be preprocessed to reduce the number of measurement levels from several thousand to approximately one hundred, to quality control check the raw data, and to output the data in REEDM compatible format. A computer program written by ACTA and delivered to WFF for operational use in 2007 was used to perform the raw data file conversions. A critical part of the conversion process is to test for, and capture, inflection points where temperature, wind speed, wind direction or relative humidity reach minimum or maximum values and change slope as a function of altitude. An example of the weather profile testing algorithm capabilities is illustrated in Figure 4-1, which is contrived test data with positive, negative and infinite slopes and multiple inflection points. The resulting converted files were sorted into daytime and nighttime sets for each month of the year. Data was classified as "daytime" if the balloon release time was between 0600 and 1900 Eastern Standard Time.

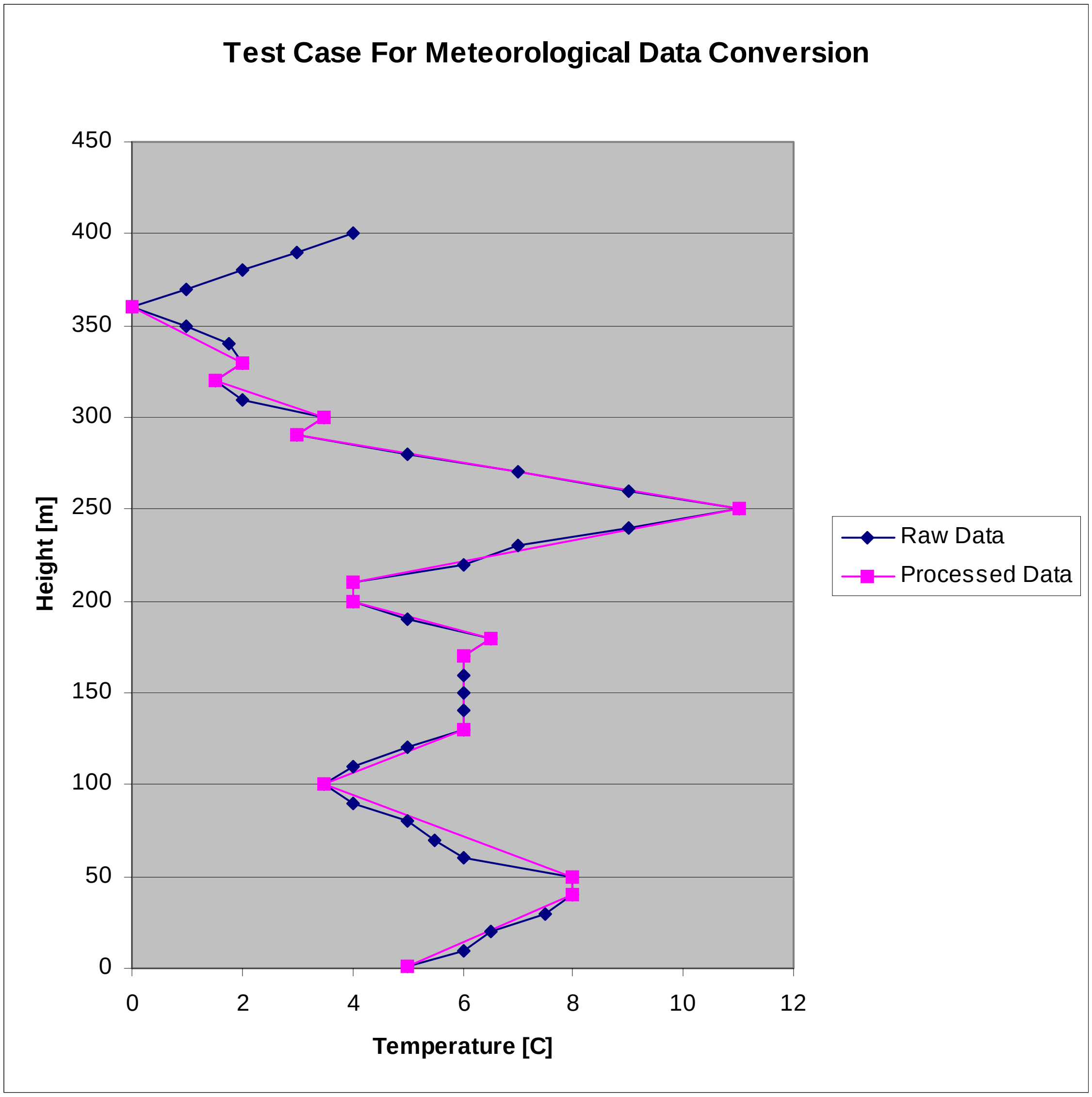

Figure 4-1. Illustration of Testing a Raw Data Profile to Capture Slope Inflection Points that Define Minimum and Maximum Values and Measure Inversions and Shear Effects.

4.2 <u>REEDM Far Field Results For Taurus II Normal Launch Scenario</u>

ACTA executed REEDM in batch processing mode to cycle through all archived meteorological cases and to extract key information to a summary table. Typically REEDM generates an output file for a single weather case that consists of 10 to 20 pages of information on the run setup, intermediate calculated value and tables of concentration versus downwind distance. When processing thousands of cases, saving the standard REEDM output file for each run results in an overwhelming amount of output data. ACTA developed a special batch version of REEDM for the Air Force that has been used over the years to execute thousands of scenarios and condense the REEDM output for all runs into a summary table containing the following critical analysis parameters:

1. Chemical being tracked in REEDM analysis.
2. Concentration threshold used to calculate concentration isopleth beginning and end distances.
3. Meteorological input file name.
4. Zulu time of balloon release.
5. REEDM computed mixing boundary depth.
6. REEDM predicted cloud stabilization height.
7. REEDM predicted average wind speed used to transport exhaust cloud.
8. REEDM predicted average wind direction used to transport exhaust cloud.
9. REEDM predicted maximum ground level concentration.
10. REEDM predicted distance from exhaust cloud source to location of maximum concentration.
11. REEDM predicted bearing from exhaust cloud source to location of maximum concentration.
12. REEDM predicted nearest distance from exhaust cloud source to the location where the ground concentration centerline first exceeds the user defined concentration threshold.
13. REEDM predicted farthest distance from exhaust cloud source to the location where the ground concentration centerline last exceeds the user defined concentration threshold.
14. REEDM predicted bearing from exhaust cloud source to location where the ground concentration centerline last exceeds the user defined concentration threshold.
15. REEDM derived average wind speed shear in the lower planetary boundary layer.
16. REEDM derived average wind direction shear in the lower planetary boundary layer.

17. REEDM derived average horizontal (azimuthal) turbulence intensity in the lower planetary boundary layer.

18. REEDM derived average vertical (elevation) turbulence intensity in the lower planetary boundary layer.

19. REEDM derived average wind speed shear in the region above the planetary boundary layer.

20. REEDM derived average wind direction shear in the region above the planetary boundary layer.

21. REEDM derived average horizontal (azimuthal) turbulence intensity in the region above the planetary boundary layer.

22. REEDM derived average vertical (elevation) turbulence intensity in the region above the planetary boundary layer.

The above list of parameters is provided for REEDM predictions of both peak instantaneous concentration and time weighted average (TWA) concentration. In the runs performed for this study a 1-hour averaging time was used to compute time weighted average concentrations. A fairly short averaging time is appropriate for rocket exhaust cloud exposures because the source cloud typically passes over a receptor with a time scale of tens of minutes rather than hours. The REEDM summary tables from the monthly batch runs were further condensed to identify the meteorological case that produced the highest peak concentration and record the range and bearing from the source location (WFF Taurus II launch Pad-0A). Table 4-1 presents the maximum far field CO peak instantaneous concentration predicted by REEDM for the hypothetical daytime launches of a Taurus II with subsequent dispersion of the normal launch ground and contrail clouds. The far field exposure is REEDM's prediction for concentrations at ground level downwind of the stabilized exhaust cloud. Far field peak CO concentrations ranged from 3 to 8 ppm with the maximum concentration predicted to occur from 5000 to 16000 meters downwind from the launch site. These values represent the maximum concentrations predicted over a sample set of 4704 WFF balloon soundings. Table 4-2 lists the maximum predicted far field 1-hour TWA concentrations of CO for daytime normal launch scenarios. The maximum TWA concentrations are all predicted to be less than 1 ppm. Table 4-3 and Table 4-4 show the REEDM predicted maximum peak and maximum TWA CO far field concentrations for 1728 nighttime cases for Taurus II normal launch scenarios. As with the daytime cases, the peak instantaneous CO concentrations are less than 10 ppm and the peak TWA CO concentrations are less than 1 ppm.

Table 4-1: Taurus II Normal Launch CO Concentration Summary – Daytime Meteorology.

Month	Number of Weather Cases	Peak CO Concentration [ppm]	Distance to Peak CO Concentration [m]	Bearing to Peak CO Concentration [deg]
January	344	4.7	8000	73
February	364	4.9	8000	158
March	397	5.1	7000	285
April	383	6.1	8000	249
May	398	7.9	7000	245
June	392	4.3	6000	258
July	416	5.4	5000	285
August	408	6.0	8000	226
September	413	4.7	9000	22
October	435	2.9	16000	240
November	382	4.0	11000	205
December	372	6.4	6000	83

Table 4-2. Taurus II Normal Launch CO TWA Concentration Summary – Daytime Meteorology.

Month	Number of Weather Cases	Peak CO Concentration [ppm]	Distance to Peak CO Concentration [m]	Bearing to Peak CO Concentration [deg]
January	344	0.22	7000	259
February	364	0.17	3000	23
March	397	0.19	11000	315
April	383	0.23	7000	228
May	398	0.34	11000	300
June	392	0.32	4000	51
July	416	0.32	7000	274
August	408	0.21	6000	133
September	413	0.18	7000	305
October	435	0.24	13000	108
November	382	0.20	28000	120
December	372	0.17	15000	127

Table 4-3: Taurus II Normal Launch CO Concentration Summary – Nighttime Meteorology.

Month	Number of Weather Cases	Peak CO Concentration [ppm]	Distance to Peak CO Concentration [m]	Bearing to Peak CO Concentration [deg]
January	93	5.5	8000	74
February	157	4.0	10000	74
March	162	3.7	10000	176
April	156	6.3	9000	226
May	158	6.2	11000	242
June	152	4.4	7000	114
July	153	4.4	8000	113
August	162	3.4	10000	82
September	163	2.7	9000	356
October	119	2.7	18000	259
November	125	3.8	9000	91
December	128	6.0	7000	149

Table 4-4. Taurus II Normal Launch CO TWA Concentration Summary – Nighttime Meteorology.

Month	Number of Weather Cases	Peak CO Concentration [ppm]	Distance to Peak CO Concentration [m]	Bearing to Peak CO Concentration [deg]
January	93	0.08	9000	74
February	157	.09	24000	77
March	162	0.10	13000	230
April	156	0.60	7000	46
May	158	0.17	16000	120
June	152	0.24	7000	210
July	153	0.15	14000	34
August	162	0.20	12000	223
September	163	0.16	12000	226
October	119	0.08	28000	59
November	125	0.20	7000	202
December	128	0.17	21000	146

The REEDM predicted CO concentrations for all daytime meteorological cases processed in the 8-year sample set was aggregated into bins to evaluate the peak far field concentration probability. This information is provided in Table 4-5 and it is noted that approximately 81% of all daytime meteorological cases resulted in REEDM maximum peak instantaneous ground level CO concentrations of less than 1 ppm.

Table 4-5. REEDM Predicted Maximum Far Field Ground Level Carbon Monoxide Concentrations For Daytime Taurus II Normal Launch Scenarios.

Concentration Bin	Count	Probability
0 - 1	3805	0.809
1 - 2	644	0.137
2 - 3	174	0.037
3 - 4	54	0.011
4 - 5	14	0.003
5 - 6	9	0.002
6 - 7	3	0.001
7 - 8	1	0.0002
8 - 9	0	0.0000
9 - 10	0	0.0000

The REEDM predicted CO 1-hour time weighted average concentrations for all daytime meteorological cases processed in the 8-year sample set was aggregated into bins to evaluate the peak far field TWA concentration probability. This information is provided in Table 4-6 and it is noted that approximately 88% of all daytime meteorological cases resulted in REEDM maximum 1-hour TWA ground level CO concentrations of less than 0.04 ppm. The fact that the TWA concentration is much less than the peak instantaneous concentration is consistent with the short cloud passage time.

The REEDM predicted cloud transport directions were also aggregated into bins representing 45-degree arc corridors around the compass (i.e. N, NE, E, SE, S, SW, W, NW). Table 4-7 indicates the predicted Taurus II normal launch plume direction probability of occurrence observed across the 4704 daytime balloon soundings. It is noted that for the daytime launch scenarios transport of the exhaust plume to the East is favored. The transport direction reflects the average airflow over a depth of approximately 1000 meters, hence the windrose observed for elevated rocket exhaust clouds may differ significantly from a windrose derived from a surface wind tower.

Table 4-6. REEDM Predicted Maximum Far Field Ground Level Carbon Monoxide TWA Concentrations For Daytime Taurus II Normal Launch Scenarios.

1-Hour TWA Concentration Bin	Count	Probability
0.00 – 0.02	1933	0.411
0.02 – 0.04	1464	0.311
0.04 - 0.06	735	0.156
0.06 - 0.08	285	0.061
0.08 - 0.10	126	0.027
0.10 - 0.12	66	0.014
0.12 - 0.14	35	0.007
0.14 - 0.16	18	0.004
0.16 - 0.18	17	0.004
0.18 – 0.20	10	0.002
0.20 – 0.22	3	0.001
0.22 – 0.24	3	0.001
0.24 – 0.26	2	0.0004
0.26 – 0.28	2	0.0004
0.28 – 0.30	2	0.0004
0.30 – 0.32	0	0.0000
0.32 – 0.34	2	0.0004
0.34 – 0.36	1	0.0002
0.36 – 0.38	0	0.0000
0.38 -0.40	0	0.0000

Table 4-7. REEDM Predicted Exhaust Cloud Transport Directions For Daytime Taurus II Normal Launch Scenarios.

Plume Transport Direction Bin	Count	Probability
337.5 – 22.5 (N)	363	0.077
22.5 – 67.5 (NE)	830	0.176
67.5 – 112.5 (E)	801	0.170
112.5 – 157.5 (SE)	976	0.207
157.5 – 202.5 (S)	515	0.109
202.5 – 247.5 (SW)	453	0.096
247.5 – 292.5 (W)	326	0.069
292.5 – 337.5 (NW)	440	0.094

Similar summary tables for the 1728 nighttime Taurus II normal launch simulations were compiled. Table 4-8 shows that the peak CO instantaneous concentration predictions for nighttime conditions continues with a high probability that the maximum far field concentration will be less than 1 ppm.

Table 4-8. REEDM Predicted Maximum Far Field Ground Level Carbon Monoxide Concentrations For Nighttime Taurus II Normal Launch Scenarios.

Concentration Bin	Count	Probability
0 - 1	1390	0.804
1 - 2	237	0.137
2 - 3	67	0.039
3 - 4	23	0.013
4 - 5	7	0.004
5 - 6	2	0.0012
6 - 7	2	0.0012
7 - 8	0	0.0000
8 - 9	0	0.0000
9 - 10	0	0.0000

The REEDM predicted CO 1-hour time weighted average concentrations for all nighttime meteorological cases is provided in Table 4-9 and it is noted that approximately 73% of all nighttime meteorological cases resulted in REEDM maximum 1-hour TWA ground level CO concentrations of less than 0.04 ppm.

Table 4-10 indicates the predicted Taurus II normal launch plume direction probability of occurrence observed across the 1728 nighttime balloon soundings. It is noted that for nighttime launch scenarios transport of the exhaust plume to the East is still favored as it was during the daytime.

Table 4-9. REEDM Predicted Maximum Far Field Ground Level Carbon Monoxide TWA Concentrations For Nighttime Taurus II Normal Launch Scenarios.

1-Hour TWA Concentration Bin	Count	Probability
0.00 – 0.02	817	0.473
0.02 – 0.04	449	0.260
0.04 - 0.06	264	0.153
0.06 - 0.08	114	0.066
0.08 - 0.10	52	0.030
0.10 - 0.12	12	0.007
0.12 - 0.14	6	0.0035
0.14 - 0.16	4	0.0023
0.16 - 0.18	5	0.0029
0.18 – 0.20	0	0.0000
0.20 – 0.22	3	0.0017
0.22 – 0.24	0	0.0000
0.24 – 0.26	0	0.0000
0.26 – 0.28	0	0.0000
0.28 – 0.30	0	0.0000
0.30 – 0.32	0	0.0000
0.32 – 0.34	0	0.0000
0.34 – 0.36	0	0.0000
0.36 – 0.38	0	0.0000
0.38 -0.40	0	0.0000

Table 4-10. REEDM Predicted Exhaust Cloud Transport Directions For Nighttime Taurus II Normal Launch Scenarios.

Plume Transport Direction Bin	Count	Probability
337.5 – 22.5 (N)	61	0.035
22.5 – 67.5 (NE)	315	0.182
67.5 – 112.5 (E)	296	0.171
112.5 – 157.5 (SE)	369	0.214
157.5 – 202.5 (S)	231	0.134
202.5 – 247.5 (SW)	215	0.124
247.5 – 292.5 (W)	106	0.061
292.5 – 337.5 (NW)	135	0.078

4.3 REEDM Far Field Results For The Taurus II Static Test Firing Scenario

REEDM was executed in batch mode using the same archived WFF meteorological soundings to evaluate the formation, transport and ground level concentration of CO from Taurus II static test firings on the launch stand. Table 4-11 presents the maximum peak instantaneous CO concentration predicted for the static test firing. It is noted that in general the static test firing is predicted to produce higher ground level CO concentrations than the normal launch scenario.

Table 4-11: Taurus II Static Test Firing CO Concentration Summary – Daytime Meteorology.

Month	Number of Weather Cases	Peak CO Concentration [ppm]	Distance to Peak CO Concentration [m]	Bearing to Peak CO Concentration [deg]
January	344	10.8	6000	53
February	364	15.5	6000	31
March	397	18.9	6000	34
April	383	13.5	6000	33
May	398	11.6	7000	16
June	392	6.1	8000	21
July	416	5.2	7000	75
August	408	5.2	11000	25
September	413	9.2	8000	249
October	435	5.9	6000	58
November	382	11.8	6000	92
December	372	13.6	8000	37

Table 4-12 lists the predicted daytime CO TWA concentrations for the Taurus II static test firing scenarios. The TWA concentrations are somewhat higher than the corresponding values predicted for the normal launch scenario, but the overall expectation is that the 1-hour TWA CO concentrations will be less than 1 ppm. Table 4-13 and Table 4-14 show the maximum predicted CO instantaneous and 1-hour TWA concentrations for the nighttime static test firing conditions.

Table 4-12. Taurus II Static Test Firing CO TWA Concentration Summary – Daytime Meteorology.

Month	Number of Weather Cases	Peak CO Concentration [ppm]	Distance to Peak CO Concentration [m]	Bearing to Peak CO Concentration [deg]
January	344	0.20	7000	53
February	364	0.27	8000	70
March	397	0.26	5000	46
April	383	0.23	9000	20
May	398	0.25	11000	251
June	392	0.16	5000	61
July	416	0.18	4000	181
August	408	0.14	14000	136
September	413	0.15	7000	241
October	435	0.17	14000	221
November	382	0.23	6000	92
December	372	0.25	9000	37

Table 4-13: Taurus II Static Test Firing CO Ceiling Concentration Summary – Nighttime Meteorology.

Month	Number of Weather Cases	Peak CO Concentration [ppm]	Distance to Peak CO Concentration [m]	Bearing to Peak CO Concentration [deg]
January	93	12.3	6000	100
February	157	8.7	7000	8
March	162	11.4	6000	40
April	156	13.7	5000	58
May	158	7.2	6000	80
June	152	5.9	6000	113
July	153	4.2	8000	83
August	162	4.7	9000	82
September	163	4.6	13000	72
October	119	6.1	8000	59
November	125	6.9	8000	92
December	128	13.6	8000	37

Table 4-14. Taurus II Static Test Firing CO TWA Concentration Summary – Nighttime Meteorology.

Month	Number of Weather Cases	Peak CO Concentration [ppm]	Distance to Peak CO Concentration [m]	Bearing to Peak CO Concentration [deg]
January	93	0.22	7000	100
February	157	0.24	16000	42
March	162	0.21	11000	29
April	156	0.28	7000	58
May	158	0.23	13000	100
June	152	0.15	7000	113
July	153	0.11	18000	83
August	162	0.12	10000	79
September	163	0.30	12000	226
October	119	0.13	12000	152
November	125	0.18	11000	66
December	128	0.25	9000	37

Histograms of REEDM predicted CO concentrations for Taurus II static test firings for all daytime meteorological cases were generated in a similar fashion to the normal launch scenario. Table 4-15 presents the maximum predicted CO concentrations and it is noted that approximately 76% of all daytime meteorological cases resulted in REEDM maximum peak instantaneous ground level CO concentrations of less than 1 ppm. The static test firing scenarios exhibited a trend toward somewhat higher concentrations than predicted for the normal launch.

Table 4-15. REEDM Predicted Maximum Far Field Ground Level Carbon Monoxide Concentrations For Daytime Taurus II Static Test Firing Scenarios.

Concentration Bin	Count	Probability
0 - 1	3568	0.759
1 - 2	632	0.134
2 - 3	195	0.041
3 - 4	125	0.027
4 - 5	51	0.011
5 - 6	48	0.010
6 - 7	21	0.004
7 - 8	18	0.004
8 - 9	14	0.003
9 +	12	0.003

Table 4-16 presents the REEDM predicted CO 1-hour time weighted average concentrations for all daytime meteorological cases processed for the Taurus II static test firing scenario. It is noted that approximately 60% of all daytime meteorological cases resulted in REEDM maximum 1-hour TWA ground level CO concentrations of less than 0.04 ppm.

The REEDM predicted cloud transport directions were also aggregated into bins for the static test firing scenario. Table 4-17 indicates the predicted Taurus II static test firing plume direction probability of occurrence observed across the 4704 daytime balloon soundings. It is noted that for the daytime launch scenarios transport of the exhaust plume to the East is favored.

Table 4-16. REEDM Predicted Maximum Far Field Ground Level Carbon Monoxide TWA Concentrations For Daytime Taurus II Static Test Firing Scenarios.

1-Hour TWA Concentration Bin	Count	Probability
0.00 – 0.02	1468	0.312
0.02 – 0.04	1372	0.292
0.04 - 0.06	863	0.183
0.06 - 0.08	446	0.095
0.08 - 0.10	230	0.049
0.10 - 0.12	138	0.029
0.12 - 0.14	74	0.016
0.14 - 0.16	40	0.009
0.16 - 0.18	29	0.006
0.18 – 0.20	17	0.004
0.20 – 0.22	15	0.003
0.22 – 0.24	6	0.0012
0.24 – 0.26	3	0.0006
0.26 – 0.28	2	0.0004
0.28 – 0.30	0	0.0000
0.30 – 0.32	0	0.0000
0.32 – 0.34	0	0.0000
0.34 – 0.36	0	0.0000
0.36 – 0.38	0	0.0000
0.38 -0.40	0	0.0000

Table 4-17. REEDM Predicted Exhaust Cloud Transport Directions For Daytime Taurus II Static Test Firing Scenarios.

Plume Transport Direction Bin	Count	Probability
337.5 – 22.5 (N)	397	0.084
22.5 – 67.5 (NE)	832	0.177
67.5 – 112.5 (E)	838	0.178
112.5 – 157.5 (SE)	955	0.203
157.5 – 202.5 (S)	489	0.104
202.5 – 247.5 (SW)	440	0.094
247.5 – 292.5 (W)	316	0.067
292.5 – 337.5 (NW)	437	0.093

Similar summary tables for the 1728 nighttime Taurus II static test firing simulations were compiled. Table 4-18 shows that the peak CO instantaneous concentration predictions for nighttime conditions continues with a high probability that the maximum far field concentration will be less than 1 ppm.

Table 4-18. REEDM Predicted Maximum Far Field Ground Level Carbon Monoxide Concentrations For Nighttime Taurus II Static Test Firing Scenarios.

Concentration Bin	Count	Probability
0 - 1	1231	0.712
1 - 2	279	0.161
2 - 3	99	0.057
3 - 4	42	0.024
4 - 5	33	0.019
5 - 6	15	0.009
6 - 7	9	0.005
7 - 8	9	0.005
8 - 9	3	0.002
9 +	3	0.002

The REEDM static test firing predicted CO 1-hour time weighted average concentrations for all nighttime meteorological cases is provided in Table 4-19 and it is noted that approximately 59% of all nighttime meteorological cases resulted in REEDM maximum 1-hour TWA ground level

CO concentrations of less than 0.04 ppm. Static test firing TWA CO concentrations trend higher than those observed in the normal launch simulations.

Table 4-20 indicates the predicted Taurus II static test firing plume direction probability of occurrence observed across the 1728 nighttime balloon soundings. It is noted that for nighttime launch scenarios transport of the exhaust plume to the East is still favored as it was during the daytime.

Table 4-19. REEDM Predicted Maximum Far Field Ground Level Carbon Monoxide TWA Concentrations For Nighttime Taurus II Static Test Firing Scenarios.

1-Hour TWA Concentration Bin	Count	Probability
0.00 – 0.02	605	0.350
0.02 – 0.04	407	0.236
0.04 - 0.06	293	0.170
0.06 - 0.08	197	0.114
0.08 - 0.10	84	0.049
0.10 - 0.12	58	0.034
0.12 - 0.14	31	0.018
0.14 - 0.16	9	0.005
0.16 - 0.18	19	0.011
0.18 – 0.20	11	0.006
0.20 – 0.22	7	0.004
0.22 – 0.24	3	0.002
0.24 – 0.26	2	0.001
0.26 – 0.28	0	0.000
0.28 – 0.30	1	0.001
0.30 – 0.32	1	0.001
0.32 – 0.34	0	0.0000
0.34 – 0.36	0	0.0000
0.36 – 0.38	0	0.0000
0.38 -0.40	0	0.0000

Table 4-20. REEDM Predicted Exhaust Cloud Transport Directions For Nighttime Taurus II Static Test Firing Scenarios.

Plume Transport Direction Bin	Count	Probability
337.5 – 22.5 (N)	72	0.042
22.5 – 67.5 (NE)	321	0.186
67.5 – 112.5 (E)	306	0.177
112.5 – 157.5 (SE)	378	0.219
157.5 – 202.5 (S)	221	0.128
202.5 – 247.5 (SW)	207	0.120
247.5 – 292.5 (W)	92	0.053
292.5 – 337.5 (NW)	131	0.076

4.4 REEDM Near Field Results For Taurus II Normal Launch Scenario

In REEDM terminology the "near field" is defined as the geographical region near the launch pad where the rocket exhaust cloud source is formed and undergoes vertical cloud rise due to buoyancy effects. REEDM is not specifically designed to predict cloud concentrations in this region because the area is typically evacuated during launches due to high risk from debris, blast, fire and toxics hazards. Emissions in this region are of interest for environmental considerations however; therefore ACTA modified the output of REEDM to report intermediate calculations of the exhaust cloud size, position and temperature during the cloud rise phase. Using information about the size and location of the exhaust cloud coupled with the known quantity of exhaust products emitted and the mass fractions of the exhaust chemical constituents allows an estimate to be made of chemical concentrations inside the cloud in the near field. When performing far field calculations, REEDM assumes that the mass distribution of exhaust products in the expanded and diluted exhaust cloud is Gaussian. In the near field, as the source cloud is initially formed, the exhaust products may be more uniformly distributed. ACTA computed in-cloud concentrations in the near field assuming both uniform and Gaussian mass distributions. For the Gaussian distribution the maximum concentration occurs at the cloud centroid and the edge of the cloud is defined as the point where the concentration is 10% of the centroid maximum values. This assumption defines the cloud radius as 2.14 standard deviations.

The size and shape of the near field ground level carbon monoxide concentration pattern depends upon several factors:

1. The dynamics of the exhaust flow emitted from the Taurus II Pad-0A flame duct.

2. The effects of thermal buoyancy that lifts the plume off the ground and imparts vertical acceleration to the hot plume gases.

3. The effect of local wind speed and direction after the jet momentum has dissipated and the plume is beginning to lift off the ground.

The jet dynamics of the high speed exhaust plume venting from the flame duct are largely independent of the weather conditions and are determined by the design of the flame duct and concrete ramp structure at the exit of the duct. These design features were still in development and evaluation at the time of this study. The vertical rise rate of the buoyant cloud after the jet dynamics have dampened are computed by REEDM and were used to estimate the vertical and horizontal cloud displacement from a point where the exhaust plume is assumed to become buoyancy dominated. For normal launches, only a portion of the main engine exhaust vents through the flame duct and some of the ground cloud forms around the launch pad. A detailed computational fluid dynamics flow analysis of the plume interaction with the flame duct and the launch pad surface is not available, however, based on photographs and video of other launch vehicle normal launch ground clouds, it is estimated that the center of the Taurus II normal launch ground cloud will be displaced about 100 meters from the vehicle liftoff position in the direction of the flame duct exit.

REEDM calculations for the near field normal launch cloud rise were processed for 6427 meteorological cases and summarized by month as shown in Table 4-21. REEDM approximates the Taurus II normal launch ground cloud as a sphere the radius of which grows linearly during the buoyant cloud rise phase according to the following relationship:

$$r(z) = r_0 + \gamma \Delta z$$

where:

$r(z)$	=	cloud radius at height z [m]
r_o	=	initial cloud radius [m] = 48.8 [m] (160 ft)
γ	=	air entrainment coefficient = 0.36
Δz	=	height of cloud centroid above the ground [m]

Based on the forgoing relationship, the spherical cloud will just touch the ground surface when the cloud centroid lifts to approximately 76 meters above the ground. This is also referred to in this report as the "cloud liftoff" point. Beyond this point the downwind ground CO concentration is assumed to be zero until the ground concentrations once again start to occur in the far field due to downward mixing from the stabilized normal launch cloud. The maximum distance from the point where the flame duct horizontal flow dynamics are dampened (REEDM initialization point) to the point where the wind driven normal launch plume lifts off the ground is estimated to be 144 meters. Average distance from the REEDM initialization point to the point of cloud liftoff is estimated to be about 25 meters. These distances are influenced by the initial amount of cloud "exhaust" materials as well as the air entrainment rate assumption. If deluge water injection and combustion air are added to the initial exhaust mass, then the initial cloud radius will be larger and the downwind distance to the liftoff point will be somewhat longer. Given uncertainties in the plume mass entrainment and other modeling assumptions, the maximum travel distance to Taurus II normal launch ground cloud liftoff is estimated at about 200 meters. Thus a circle with a radius of 200 meters centered 100 meters downstream from the flame duct exit would approximately define the region within which a toxic exposure to CO might occur under high surface wind conditions. The average potential toxic exposure zone is expected to be much smaller and is associated with moderate to light surface winds. Maximum ground level CO concentrations inside the near field toxic hazard zone could exceed 7000 ppm.

Table 4-21. Taurus II Normal Launch Near Field CO Concentration Summary.

Month	Number of Weather Cases	Ground CO Concentration at Cloud Liftoff Uniform Distribution [ppm]	Ground CO Concentration at Cloud Liftoff Gaussian Distribution [ppm]	Maximum Distance to Cloud Liftoff [m]	Average Distance to Cloud Liftoff [m]
January	435	7530	1980	78	22
February	521	7420	1950	86	23
March	559	7190	1890	99	25
April	538	8440	2220	93	25
May	556	7250	1910	86	23
June	544	7140	1880	55	21
July	569	6650	1750	62	20
August	570	7790	2050	61	18
September	576	7190	1890	144	21
October	554	7330	1930	98	19
November	507	7870	2070	101	20
December	498	8280	2180	76	22

An example of near field concentration calculations for a normal launch plume with a May meteorological case that produced a low cloud rise is listed below. As the ground cloud rises REEDM assumes it intersects and combines with the contrail cloud above it and the total amount of exhaust mass in the rising cloud continues to increase until the ground cloud stops rising at the stabilization altitude. As previously defined, when the predicted ground cloud radius just equals the height of the ground cloud centroid above the ground, the exhaust cloud is just at the point of lifting off the ground. In Table 4-22 this occurs as the cloud rises through the 8th meteorological layer where the top of the layer is 89.9 meters above the ground and the cloud radius is predicted to be 80.8 meters. At this point the cloud is predicted to have moved 20.6 meters in the downwind direction, has an average temperature of 329.5 Kelvin (133 F) and has an uniform CO concentration of 7615 ppm. As the cloud continues to move downwind it rises further above the ground and only flying birds or tall trees would be exposed to the concentrated cloud exhaust chemicals. This sample normal launch cloud is predicted to stabilize at 440 meters above the ground approximately 200 meters downwind from the initial source formation point and has a predicted radius of 206.9 meters. The bottom of the exhaust cloud would be approximately 233 meters above the ground. The centroid concentration, assuming the mass distribution has transitioned to Gaussian, is predicted to be 3881 ppm with the concentration at the edge of the cloud equal to 388 ppm (10% of the peak centroid concentration).

Table 4-22. Sample Near Field Taurus II Normal Launch Exhaust Cloud Concentration Estimates For a May WFF Meteorological Case.

```
     initial cloud radius          [m] =    48.76800
     initial cloud height          [m] =   0.0000000E+00
     initial cloud rise velocity [m/s] =   0.0000000E+00
```

met layer	cloud height [m]	cloud radius [m]	cloud volume [m**3]	exhaust mass [g]	downwind dist [m]	rise time [sec]	cloud temp [K]	uniform conc [ppm]	Gaussian conc [ppm]
1	11.0	52.4	.60123E+06	.17505E+08	2.3	1.295	590.5	6516.	17152.
2	20.6	55.8	.72845E+06	.23196E+08	5.8	0.632	498.6	7127.	18760.
3	30.2	59.3	.87234E+06	.30021E+08	8.0	0.580	443.6	7703.	20275.
4	39.8	62.7	.10341E+07	.37721E+08	10.1	0.573	407.6	8164.	21489.
5	49.4	66.2	.12148E+07	.46158E+08	12.2	0.584	382.5	8504.	22384.
6	59.3	69.8	.14221E+07	.55242E+08	14.4	0.622	363.7	8694.	22884.
7	69.2	73.3	.16517E+07	.64928E+08	16.7	0.647	349.6	8798.	23158.
8	89.9	80.8	.22091E+07	.75165E+08	20.6	1.451	329.5	7615.	20044.
9	108.5	87.5	.28051E+07	.86432E+08	26.0	1.423	317.9	6896.	18152.

10	126.5	94.0	.34754E+07	.98520E+08	31.5	1.490	310.0	6345.	16701.
11	144.5	100.4	.42446E+07	.11134E+09	37.3	1.605	304.2	5871.	15453.
12	176.0	111.8	.58536E+07	.12482E+09	46.4	3.091	297.9	4773.	12563.
13	207.6	123.2	.78254E+07	.13940E+09	59.1	3.425	294.1	3987.	10494.
14	222.5	128.5	.88963E+07	.15495E+09	69.4	1.734	292.7	3898.	10261.
15	240.2	134.9	.10285E+08	.17095E+09	77.2	2.141	291.2	3720.	9792.
16	295.4	154.8	.15530E+08	.18744E+09	96.9	7.536	288.8	2701.	7111.
17	339.9	170.8	.20869E+08	.20538E+09	127.3	7.224	287.6	2203.	5798.
18	386.5	187.6	.27649E+08	.22438E+09	158.3	9.055	286.9	1816.	4781.
19	440.1	206.9	.37099E+08	.24441E+09	198.2	14.517	286.9	1475.	3881.

4.5 REEDM Near Field Results For Taurus II Static Test Firing Scenario

REEDM calculations for the near field static test firing cloud rise were processed for 6427 meteorological cases and summarized by month as shown in Table 4-23. REEDM approximates the Taurus II static test firing cloud as a sphere the radius of which grows linearly during the buoyant cloud rise phase according to the following relationship:

$$r(z) = r_0 + \gamma \Delta z$$

where:

- $r(z)$ = cloud radius at height z [m]
- r_o = initial cloud radius [m] = 46.05 [m] (151 ft)
- γ = air entrainment coefficient = 0.5
- Δz = height of cloud centroid above the ground [m]

Based on the forgoing relationship, the spherical cloud will just touch the ground surface when the cloud centroid lifts to approximately 91 meters above the ground. The initial cloud radius is calculated using the ideal gas law and the principle of mass conservation applied to the engine RP-1 and LOX propellant consumed in the test firing. Inclusion of deluge water and combustion air injected beyond the nozzle exit plane would increase the cloud exhaust mass and therefore would also increase the estimated initial cloud radius.

Table 4-23. Taurus II Static Test Firing Near Field CO Concentration Summary.

Month	Number of Weather Cases	Ground CO Concentration at Cloud Liftoff Uniform Distribution [ppm]	Ground CO Concentration at Cloud Liftoff Gaussian Distribution [ppm]	Maximum Distance to Cloud Liftoff [m]	Cloud Transport Bearing Associated With Max Cloud Liftoff [deg]	Average Distance to Cloud Liftoff [m]
January	435	3990	1050	212	181	36
February	521	3980	1050	249	298	40
March	559	4010	1055	299	269	43
April	538	3960	1040	271	316	43
May	556	4050	1065	259	302	38
June	544	3980	1050	126	328	33
July	569	4020	1060	161	101	31
August	570	4020	1060	143	333	27
September	576	3970	1040	557*	298	36
October	554	3960	1040	296	309	30
November	507	4050	1065	307	310	33
December	498	4020	1060	211	283	36

* September case with 557-meter downwind distance was under storm conditions with 60 knot surface winds, an unlikely weather condition for conducting a test firing.

Given uncertainties in the static test firing plume mass entrainment and other modeling assumptions, the maximum travel distance to Taurus II static test firing cloud liftoff is estimated at about 350 meters. Thus a circle with a radius of 350 meters centered 200 meters downstream from the flame duct exit would approximately define the region within which a toxic exposure to CO might occur under high surface wind conditions. The average potential toxic exposure zone is expected to be much smaller and is associated with moderate to light surface winds. Maximum ground level CO concentrations inside the near field static test firing toxic hazard zone could exceed 4000 ppm.

5. CONCLUSIONS

A conservative analysis approach has been applied to estimate carbon monoxide concentrations associated with Taurus II normal launch and static test firing scenarios. The analysis is deemed to be conservative in the sense that certain modeling assumptions, such as discounting the effect of uncertain processes such as the plume chemical alterations due to deluge water injection and plume afterburning with ambient air, favor predicting higher carbon monoxide concentrations than are expected to actually occur. The study also evaluated maximum chemical concentrations predicted using a set of over 6000 historical Wallops Flight Facility weather balloon soundings. Thus reasonable worst-case weather conditions should have inherently been captured in the study. The Taurus II first stage propellants are the hydrocarbon based fuel RP-1 and liquid oxygen (LOX). Under design combustion conditions the oxidizer to fuel burn ratio is approximately 2.7, which represents a somewhat fuel rich mixture. The main combustion byproduct of concern is carbon monoxide, which is estimated to comprise approximately 25.6 percent of the exhaust mixture by mass at the rocket nozzle exit. The other main combustion byproducts are carbon dioxide and water vapor. Rocket emissions from both the a normal vehicle launch and a static test firing on the launch pad are extremely hot and therefore less dense than surrounding ambient air and are accelerated vertically due to buoyancy forces that act on the exhaust cloud gases. The effect of buoyancy is to loft the exhaust clouds above the ground to a point of neutral stability in the atmosphere at altitudes ranging from 400 to 1300 meters above the ground. From the stabilization altitude, exhaust cloud materials eventually mix back down to the ground due to atmospheric turbulence, unless the entire cloud is predicted to rise above a capping thermal inversion. The geographic region near the launch pad where the source cloud forms and begins its thermal rise process is referred to as the “near field”. Ground level CO concentrations in the near field region are estimate to be in the 4000 to 20000 ppm range, however the downwind transport distance before the cloud lifts off the ground is predicted to be relatively short—on the order of several hundred meters or less. The geographic region where the stabilized and neutrally buoyant cloud material mixes back to the ground is referred to as the “far field”. REEDM predicts that the peak instantaneous CO concentrations in the far field region are typically less than 1 ppm but have the potential to reach as high as 20 ppm. One-hour time weighted average CO concentrations are estimated to be very low, typically less than 0.04 ppm, and these low TWA values are due to the short cloud passage time over a receptor location (e.g. minutes rather than hours). The far field CO concentration levels are well below published emergency exposure guidelines for humans and are considered to be benign to people, flora and fauna. Near field CO concentrations may reach hazardous levels that exceed the AEGL-3 10-minute exposure threshold or the IDLH exposure threshold. Given the proximity of the near field exposed region to the plume point of origin, other hazards, such as radiant heat transfer or direct exposure to the high temperature exhaust gas mixture, may be more severe than the hazard from CO chemical concentration exposure.

6. REFERENCES

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