National Aeronautics and Space Administration

ENVIRONMENTAL RESOURCES DOCUMENT

Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, Virginia 23337

August 2017

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ABSTRACT: This Environmental Resources Document (ERD) has been developed to serve as the primary reference for current environmental conditions at the Wallops Flight Facility (WFF). This document has been prepared in accordance with NASA Procedural Requirement 8580.1A, *NASA National Environmental Policy Act Management Requirements*. This revision supersedes all previous editions of the WFF ERD.

August 2017

Introduction

The National Environmental Policy Act (NEPA) of 1969, Public Law 91-190, requires that all Federal agencies consider the environmental effects of proposed actions. The Act also specifies that Federal agencies shall adopt both administrative regulations and policies and procedures to ensure decisions are made in accordance with the provisions of NEPA. The regulations that Federal agencies must follow when implementing NEPA are promulgated by the President's Council on Environmental Quality (CEQ) and published in Title 40 of the Code of Federal Regulations (CFR) Parts 1500-1508 (40 CFR 1500-1508).

In accordance with the CEQ regulations, the National Aeronautics and Space Administration (NASA) has also developed Agency-specific NEPA Policy and Procedures (codified at 14 CFR Subpart 1216.3). Similarly, NASA has developed NASA Procedural Requirements (NPR) 8580.1A, *NASA National Environmental Policy Act Management Requirements*, to provide additional detail regarding roles and responsibilities of agency personnel at both the Headquarters and Center/Component Facility levels. One such requirement of the NPR is that each NASA Center or major Component Facility prepare and maintain an Environmental Resources Document (ERD).

An ERD is specific to NASA and not required by the NEPA statute or by CEQ regulations. It is a document intended to serve as a succinct baseline description of all environmental aspects of the operations of the facility at the time of the ERD's preparation. In effect, the ERD forms a baseline environment description against which the effects of subsequent proposed actions may be judged.

This ERD differs from an Environmental Assessment or Environmental Impact Statement in that it addresses the ongoing operations of Wallops Flight Facility (WFF) rather than a proposed project, and can be used as a management and planning tool to assist with ongoing management and planning decisions. The document is to be updated every 5 years to provide the most current and comprehensive environmental information available. The present document represents the fifth revision of the original ERD completed in 1980.

This document is organized into 13 sections according to the various environmental aspects or media related to WFF plus a section listing references used during preparation of the document. Appendices, exhibits, figures and tables are included to provide additional information, as needed.

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Table of Acronyms

AAOC	Administrative Agreement on Consent
AINS	Assateague Island National Seashores
AIRS	Aerometric Information Retrieval System
amsl	above mean sea level
ANSI	American National Standards Institute
AOC	Areas of Concern
APHIS	Animal and Plant Health Inspection Service
AR	Administrative Record
AST	Aboveground Storage Tank
AWQC	Ambient Water Quality Criteria
BA	Biological Assessment
BO	Biological Opinion
BTEX	Benzene Toluene Ethylbenzene Xylene
CAA	Clean Air Act
CBOD	Chemical Biological Oxygen Demand
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMP	Center Master Plan
CNAAS	Chincoteague Naval Auxiliary Air Station
CNWR	Chincoteague National Wildlife Refuge
CRA	Cultural Resources Assessment
CWA	Clean Water Act
CY	Calendar Year
CZMP	Coastal Zone Management Plan
DEQ	Department of Environmental Quality
DOD	Department of Defense
EA	Environmental Assessment
EFH	Essential Fish Habitat

EJIP	Environmental Justice Implementation Plan
EO	Executive Order
EPA	Environmental Protection Agency
ERD	Environmental Resources Document
ERP	Environmental Restoration Program
ESA	Endangered Species Act
ESV	Ecological Screening Value
ESVNWR	Eastern Shore of Virginia National Wildlife Refuge
FAA	Federal Aviation Administration
FACSFAC	Fleet Area Control and Surveillance Facility
FEMA	Federal Emergency Management Agency
FFTA	Former Fire Training Area
FINWR	Fisherman Island National Wildlife Refuge
FIRM	Flood Insurance Rate Maps
FMB	Facilities Management Branch
FOTW	Federally Owned Treatment Works
FUDS	Formerly Used Defense Sites
FY	Fiscal Year
GPR	Goddard Procedural Requirement
GSFC	Goddard Space Flight Center
HAP	Hazardous Air Pollutant
HRSER	Historic Resources Survey and Eligibility Report
ITS	Incidental Take Statement
JP	Jet Propellant
LIDAR	Light Detection And Ranging
M-area	Magazine Storage Area
MARS	Mid-Atlantic Regional Spaceport
MBTA	Migratory Bird Treaty Act
MEC	Munitions and Explosives of Concern

MMPA	Marine Mammal Protection Act
MMRP	Military Munitions and Response Program
MSA	Magnuson-Stevens Act
MSC	Marine Science Consortium
NA	Not Applicable
NAAQS	National Ambient Air Quality Standards
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NESDIS	National Environmental Satellite Data Information Service
NHPA	National Historic Preservation Act
NiCad	Nickel Cadmium
NL	No Limit
NMFS	National Marine Fisheries Services
NOAA	National Oceanic and Atmospheric Administration
NOHD	Nominal Ocular Hazard Distance
NPDES	National Pollutant Discharge Elimination System
NPR	NASA Procedural Requirement
NRC	Nuclear Regulatory Commission
NRHP	National Register of Historic Places
OB	Open Burn
OSHA	Occupational Safety and Health Administration
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
PPOA	Pollution Prevention Opportunity Assessment
PW	Parts Washer
RBC	Risk Based Concentration
RF	Radio Frequency
RSC	Radiation Safety Committee

SAA	Satellite Accumulation Area
SCS	Soil Conservation Service
SCSC	Surface Combat Systems Center
SHPO	State Historic Preservation Officer
SRIPP	Shoreline Restoration and Infrastructure Protection Program
SVOC	Semivolatile Organic Compounds
TKN	Total Kjeldahl Nitrogen
TPH	Total Petroleum Hydrocarbons
TPH-DRO	Total Petroleum Hydrocarbons-Diesel Range Organics
TPH-GRO	Total Petroleum Hydrocarbons-Gasoline Range Organics
TSCA	Toxic Substance Control Act
TSS	Total Suspended Solids
UAS	Unmanned Aerial Systems
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Services
UST	Underground Storage Tank
UV	Ultraviolet
UW	Universal Waste
VAC	Virginia Administrative Code
VACAPES OPAREA	Virginia Capes Operating Area
VCR	Virginia Coast Reserve
VDCR	Virginia Department of Conservation and Recreation
VDGIF	Virginia Department of Game and Inland Fisheries
VDH	Virginia Department of Health
VDHR	Virginia Department of Historic Resources
VIMS	Virginia Institute of Marine Science

VMRC	Virginia Marine Resources Commission
VOC	Volatile Organic Compound
VPDES	Virginia Pollutant Discharge Elimination System
W	Warning Areas
WEMA	Wallops Employee Morale Association
WFC	Wallops Flight Center
WFF	Wallops Flight Facility
WIA	Wallops Island Association
WIETC	Wallops Island Engineering Test Center
WINWR	Wallops Island National Wildlife Refuge
WRP	Wallops Research Park
WS	Wildlife Services

Table of Units

°F	Degrees Fahrenheit
µg/l	Micrograms per liter
cy	Cubic Yards
dBA	decibel, weighted to the A-scale
ft	Feet
gpd	gallons per day
gpm	gallons per minute
kHz	Kilohertz
lb	Pounds
mg/l	milligrams per liter
MGD	million gallons per day
N/CML	Number of Colonies per 100 milliliters
PM_{10}	Particulate Matter 10 micrometers or less
$PM_{2.5}$	Particulate Matter 2.5 micrometers or less
ppb	parts per billion
ppm	parts per million

Conversion Table

English Units	Metric Equivalent
1 acre	0.4 hectares
1 foot	0.305 meters
1 mile	1.6 kilometers
1 pound	0.45 kilograms
1 ounce	28 grams
1 gallon	3.8 liters
1 °F	-17.22 °C

Section 1. Facility Description

The National Aeronautics and Space Act of 1958 (as amended, also known as the Space Act) is the United States (U.S.) federal statute that created NASA. The Space Act gave the responsibility for planning, directing, and conducting the nation's civilian space program and aeronautics and aerospace research activities to NASA. It also gave NASA the authorization to enter into cooperative agreements, leases, and contracts with public and private entities in the use of NASA's services, equipment, and facilities in support of scientific research and discovery.

NASA Goddard Space Flight Center (GSFC) manages WFF; one of the oldest active launch ranges in the continental U.S. and the only rocket testing and launch range owned and operated by NASA. 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 of supporting scientific research through operation services and carrier systems (i.e., airplanes, balloons, rockets, and uninhabited aerial vehicles). Under the Wallops Strategic Implementation Plan, "Wallops Mission 2005," WFF assessed its current Mission Statement against the existing NASA and external environments and defined the overall Vision and Mission Elements of WFF priorities for the future (**NASA 2002; NASA 2015a**). The Vision and three key Mission Elements are:

1.1 Vision and Mission

Slogan

Reaching farther for science and technology.

Mission

Wallops powers scientific discovery and technology through unique access to space.

- *Wallops provided unique expertise, facilities, and carriers to enable rapid response, frequent, low-cost flight opportunities for a diverse customer base.*

Vision

Extending NASA's reach for science and technology.

- *Enhance capabilities and increase number of flight opportunities for science and technology development.*
- *Produce world-class science focused on earth science, sky-to-sea and coastal zone research.*
- *Advance high-quality STEM education using Wallops' unique flight capabilities.*
- *Serve as the nation's premier test and operation range offering safe, flexible, efficient access to suborbital and orbital flight operations at Wallops and around the world.*

For over 65 years, WFF has flown thousands of research vehicles in the quest for information on the flight characteristics of airplanes, launch vehicles, and spacecraft, and to increase the knowledge of the Earth's upper atmosphere and the near space environment. WFF supports aeronautical research, science technology, and education by providing other NASA centers and other U.S. government agencies access to resources such as special use (i.e., controlled/restricted) airspace, runways, and launch pads. WFF regularly provides launch support for the commercial launch industry, either directly or through the Mid-Atlantic Regional Spaceport (MARS), a commercial spaceport on Wallops Island. WFF facilitates a wide array of U.S. Department of Defense (DOD) research and development and training missions, including target and missile launches, and aircraft development. The flight programs and projects supported by WFF range from small sounding rockets, unmanned scientific balloons, unmanned aerial systems (UAS), manned aircraft, orbital tracking, next-generation launch vehicle development, expendable launch vehicles (ELVs), and small and medium classed orbital spacecraft. Many of these programs are conducted from the WFF research airport or the Wallops Island Launch Range.

Services provided by WFF include technical expertise, project oversight and management, engineering, fabrication, testing, meteorological studies, hydrospheric and biospheric sciences, and operational support. Additionally, WFF supports numerous aircraft companies that utilize the research airport for flight test and training activities. WFF also assists the scientific community with mobile campaigns, as well as providing commercial and other government activities with mobile range equipment.

1.2 Location and Boundaries

Wallops Flight Facility is located in northern Accomack County on the Eastern Shore of Virginia. Accomack County is bordered by Northampton County on the south, the state of Maryland on the north, the Atlantic Ocean on the east, and the Chesapeake Bay on the west (Figure 1-1). Accomack County is a part of the Delmarva Peninsula, which is also bordered on the east by the Atlantic Ocean, on the west by the Chesapeake Bay, and on the north by the Delaware Bay and River.

The facility is composed of three (3) separate land areas in close proximity to each other - the Main Base, Mainland, and Wallops Island (Figure 1-2). The Main Base encompasses approximately 2,230 acres and includes runways, aircraft hangars, office buildings, dormitories, and industrial shops. Most administrative, technical, and facility support functions occur on the Main Base. The Main Base is bordered on the east by extensive marshland and creeks, which lead into Chincoteague Bay and Chincoteague Inlet. Little Mosquito Creek and its tributaries define the north and west borders of the Main Base. State routes 175 and 798 border the Main Base on the south and southeast, respectively.

Approximately 5 miles of public roads through the unincorporated town of Atlantic, Virginia, separate the Main Base from the Mainland. The Mainland facilities include radar, antennas, and transmitter systems and associated buildings. The 100 acres of the Mainland area are bordered by extensive marshland to the east, and by farmland to the south, west, and north.

Figure 1-1 Regional Vicinity Map

Figure 1-2 WFF Locations and Boundaries

Wallops Island is a barrier island located along Virginia's coast. The 2-mile long Wallops causeway bridge, owned and maintained by NASA, connects Wallops Island to the Mainland. Encompassing approximately 4,200 acres and surrounded by water, the Island is approximately 7 miles long by ½ mile wide. The Atlantic Ocean borders Wallops Island to the east and Chincoteague Inlet delineates the northern coastline. Marshland, interlaced with small creeks, covers the entire western approach to Wallops Island. The north end of Assawoman Island abuts the southern tip of Wallops Island, resulting in the two being a single landmass. Testing and launch facilities, storage buildings, and office buildings, which are utilized by NASA and its partners, are located on Wallops Island.

1.3 Buildings and Structures

Numerous buildings and structures are dispersed throughout the Main Base, the Mainland and Wallops Island. Table 1-1 lists the building number, description, square footage, and environmental implications of buildings and structures located within WFF boundaries.

The Main Base at WFF includes management and administration buildings, maintenance and service facilities, engineering and design laboratories, research laboratories, airfield and associated support infrastructure and radar (Figure 1-3). In addition, there are water and sewage treatment plants, rocket motor storage magazines, U.S. Navy administration and housing, Coast Guard housing, National Oceanic and Atmospheric Administration (NOAA) buildings, and other miscellaneous structures.

The buildings on the Main Base are one to four stories in height with no single, dominant architectural theme. For example, aircraft hangars and a converted hangar (Building F-010) have metal panel exteriors with typical hangar roofs. The buildings in the E-area (Buildings E-104 through E-107) of the Main Base have been modernized by the addition of foam insulation with a stucco finish applied over the insulation. Many of the Main Base buildings were present in the 1940's when the facility was the Chincoteague Naval Auxiliary Air Station (CNAAS). The operations and maintenance facility (Building F-016) and some storage facilities have metal panel exteriors. Buildings around the antenna complex (Buildings N-161, N-162) have concrete-masonry or concrete-steel exteriors. The Visitor Information Center (Building J-020) has a steel-masonry exterior.

The Navy Housing Center includes residences for both bachelors and families. The Unaccompanied Housing in Building R-010 contains 5, 2-bedroom units. Navy Gateway Inns and Suites has 63 total rooms comprised of 29 private rooms, 14 shared bath rooms, 18 standard suites, and 2 family suites.. Each private room, shared bath sleeps up to 2 guests and suites can sleep up to 4 guests. In addition, dormitories in Buildings F-004 and F-005 are available to NASA researchers and other visiting personnel.

WFF is home to several specialized facilities including the Global Hawk East Command and Control Center and a research airport that collects experimental data on runway weather conditions, wind parameters, and radar/computer-determined velocity and trajectory information.

Wallops scientific aircraft can be used for surveillance of operational areas, instrumentation recovery, relay of radio signals, search and rescue mission functions, pilot proficiency training, and airborne science platforms for data acquisition. Other dedicated research facilities include a Hydrospheric and Biospheric Laboratory, an Atmospheric Sciences Research Facility, a Coastal Data Acquisition and Archive Center, a Bio-Optical Laboratory, and NASA Polarized S-Band Radar.

The Mainland and Wallops Island sites are associated with launch activities and Navy training and research facilities. Buildings on the Mainland and Wallops Island are in an area where an accelerated level of degradation can be expected to occur due to natural environmental conditions (e.g. saltwater, storms, humidity, etc.). The majority of these buildings are concrete block with concrete parging. Some of the newer buildings and a few of the refurbished buildings have prefabricated metal panels. Blockhouses are constructed of reinforced concrete. Many of the buildings at the facility have exceeded their design life. Extensive efforts have been made to rehabilitate buildings, both interior and exterior, and building upgrades are continuing.

The Mainland and southern Wallops Island facilities include radar antennas and transmitter systems and associated buildings (Figure 1-4 and Figure 1-5). Northern Wallops Island facilities include blockhouses, assembly shops, dynamic balancing facilities, tracking facilities, and other related support structures (Figure 1-6). Rocket motor storage facilities and the Navy's Aegis, Wallops Island Engineering Test Center (WIETC), and Ship Self Defense System Facilities are also located on northern Wallops Island. Southern Wallops Island includes the Open Burn (OB) area for the disposal of waste rocket motors, the launch complexes, 2 UAS runways, and associated structures.

Figure 1-3 WFF Main Base Buildings and Structures

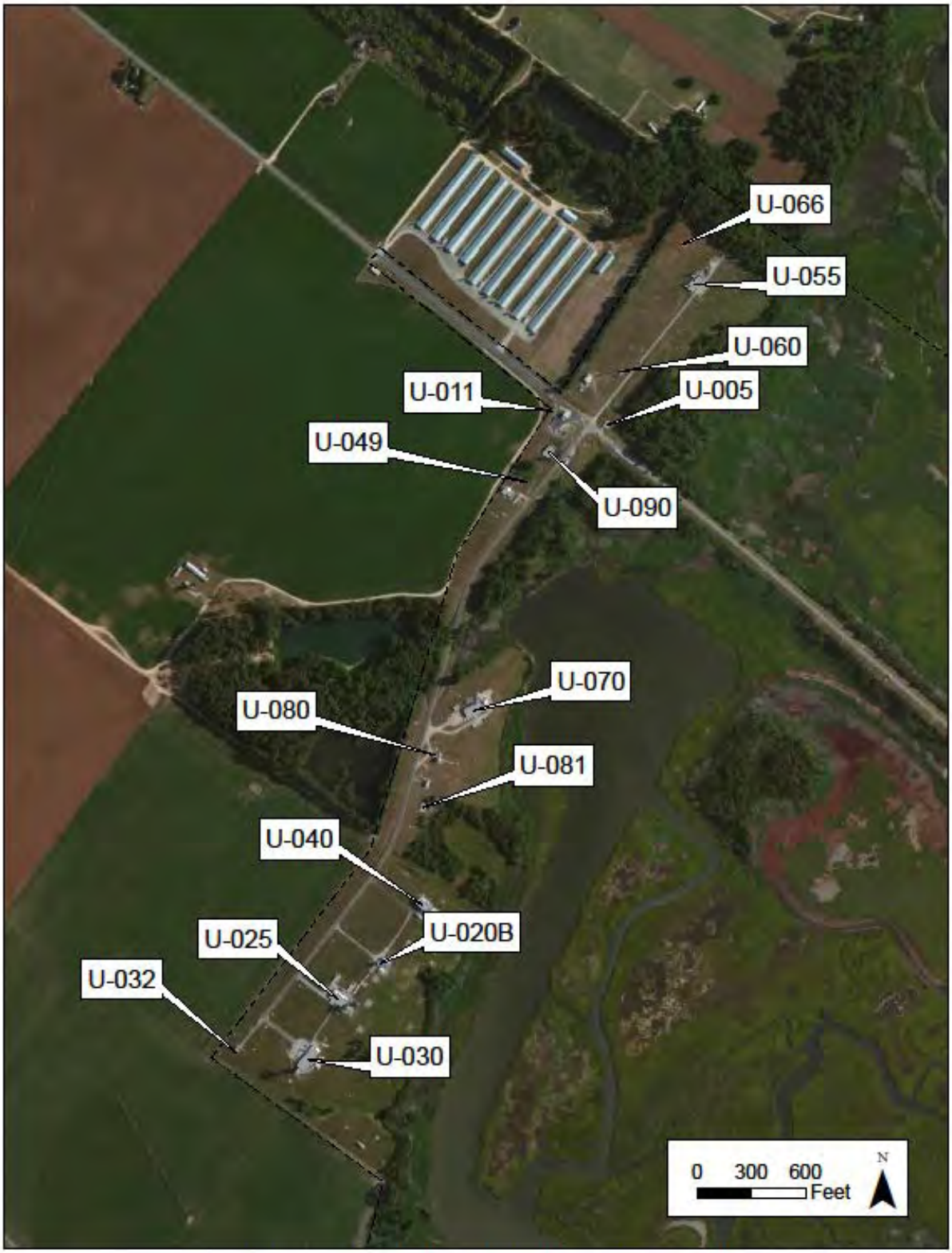


Figure 1-4 Wallops Mainland Buildings and Structures

Figure 1-5 Wallops Island South Buildings and Structures

Figure 1-6 WFF Island North Buildings and Structures

Table 1-1 Details for WFF Buildings and Structures

Building	Building Description	Size, ft²	Environmental Implications
A-001	ATC Operations Building	4,716	SAA: UW batteries
A-038	Liquid Oxygen Storage Facility	300	
A-041	Runway AN/FPS-16 Radar Op	4,760	SAA: solder, aerosol cans
A-041A	Radar Property Storage Facility	110	SAA: oily rags, used oil
A-044	AN/FPS-16(V) Radar Ant.	N/A	
A-131	Source Evaluation Board Building	864	
B-029	Hazardous Waste Staging Facility	3,100	< 90 day storage for hazardous waste
B-030	Hazardous Storage Facility	4,000	
B-031	Gen Warehouse Storage Bldg	7,662	SAA: used oil, oily rags
B-129	A/C Fire and Crash Building	9,614	SAA: oily rags, aerosols, batteries
C-015	Aircraft Support/Security Training Bldg	5,180	SAA: aerosol cans, flammable rags
C-016	Aircraft Parts Storage Building	110	
D-001	A/C Maintenance Hangar-Avionic	59,697	SAA: JP-8, Jet-A fuel, used oil, aerosol cans, solvent rags, batteries; Wash rack w/ oil water separator; AST: Jet Fuel
D-002	A/C Ground Support Equip Bldg	4,160	
D-004	Water Pumping Station	600	1 AST: diesel
D-008	Central Heating Plant	7,137	1 AST #2 fuel oil
D-009	Fuel Oil Storage Tank	40,000 gal	2 ASTs: #2 fuel oil
D-010	Gymnasium/Special Operations Office Bldg	15,594	
D-012	Waste Water Treatment Plant Headwork	955	
D-041	Fuel Handling/Dispensing/Pipeline Facility	600	
D-049	Packing and Crating Facility	3,200	
D-050	Wastewater Treatment Control Bldg	300	SAA: used oil, rags with methylene chloride, TCE, toluene, xylene; 1 AST: #2 fuel oil
D-053	Enclosed Sludge Drying Bed - Waste Water Treatment	N/A	
D-054	Open Air Sludge Drying Bed - Waste Water Treatment	N/A	
D-095	Water Reservoir	500,00 gal	
D-101	Balloon Laboratory	2,100	
D-137	FMB Materials Storage Facility	420	
E-002	Cafeteria and Photo Laboratory	30,520	SAA: UW batteries, alcohol rags, solder: 1 AST: Waste cooking oil
E-005	Contract Off and Storage Bldg	1,316	Slated for demolition

Table 1-1 Details for WFF Buildings and Structures

Building	Building Description	Size, ft²	Environmental Implications
E-007	Records Storage/Post Office/Mail and File	7,902	
E-010	Groundwater Remediation Facility	3,600	
E-100	Project Support Facility	9,250	
E-104	Mgmt. Education Center	22,270	SAA: UW batteries
E-105	Fiscal/Procurement Bldg	22,255	
E-106	Control Center And Range Operations Bldg	22,278	SAA: UW batteries
E-106A	Integrated Range Control Center - E-Area	6,020	
E-107	Sound Rocket/Balloon Project Bldg	22,278	SAA: UW batteries
E-109	Engineering Building	53,378	SAA: used Stratasys, solder, aerosols, alcohol rags, UW batteries
E-132	Cable Storage Building	4,000	
E-134	Mobile Radar Shop Office/Storage Bldg	11,380	
F-001	Reproduction Facility Building	5,940	
F-002	Telecommunications Facility Bldg	6,495	
F-003	Conference and Morale Activities Bldg	8,745	
F-004	Dormitory	10,320	
F-005	Dormitory	12,601	SAA: Alkaline Batteries
F-006	WFF Administration Bldg	14,613	SAA: Alkaline Batteries
F-007	Multi-Payload Processing Facility	28,347	SAA: methylene chloride, acetone and alcohol rags, MIBK rags, mercury rags, UW batteries, aerosol cans
F-007A	Hydraulic Support Equipment Shelter	48	
F-009	S.R. Materials Storage Bldg - WFF	4,000	
F-010	Tech Service Shops and Offices	100,213	SAA: acetone and alcohol rags, non-hazardous cutting fluid, solder, solder paste and wipes, UW batteries, sand blast grit, alcohol, Ionox BC, aerosol cans, used oil
F-010A	Tool and Equip Storehouse	280	
F-010B	Heat Treating Shop	1,605	SAA: Petroleum Naptha, Toluene, n-Butyl acohol
F-011	Mobile Generator Testing and Storage Shop	3,360	
F-013	Pump Facility (Payload Vacuum System)	210	
F-014	Empty Drum Storage Facility	960	
F-016	Facility Operations Shops Building	38,280	SAA: crushed fluorescent-UW tubes, UW batteries, refrigerant oil, thermostats, used oil, fuel filters, paint related materials, thinner, used oil, paint, paint

Table 1-1 Details for WFF Buildings and Structures

Building	Building Description	Size, ft²	Environmental Implications
			rags, lead weights, solder, lead acid batteries, aerosols, blast grit
F-017	Auto Parts Storage Facility	516	Oil drum storage
F-019	Supply Warehouse	22,400	
F-020	Welding/Sheet metal Shop	11,100	
F-022	Plant O & M Shops Suppt/Storage	7,980	
F-023	Magnetic Field Simulation Lab	1,635	
F-024	Mechanical Bldg (Mag Cal Sim Lab)	375	
F-025	Auxiliary Equip Storage	16,472	
F-026	Vehicle Service Facility	805	2 ASTs: Gasoline, Diesel
F-033	Salt Dome Storage Facility	1,400	
F-036	WEMA Storage Bldg - Wff	143	
F-044	Filter Storage Facility	1,073	
F-157	Supply Warehouse	6,060	
F-160	Health/Quality Verification Lab /Environmental/Chemistry Lab	25,054	SAA: Jet Fuel, UW batteries, solder, used oil, COD vials, nitric acid, alcohol and acetone rags, glycol, IPA,
F-162	Rain Simulation Facility	2,500	
F-163	Chemical Storage Building	120	
F-164	Rain Simulation Equipment Shelter	110	
F-165	Water Storage Tank - Elevated	150,000 gal	
H-030	Four Car Garage/WEMA	2,068	
H-100	Payload Processing Facility	17,980	SAA: UW batteries, flammables
J-017	VIC Exhibition Display Area Bldg	3,728	
J-020	Visitors Information Center	13,914	
J-219	VIC Storage Bldg	660	
M-001	Plant O & M Shops Support/Storage Bldg	7,600	
M-009	Underground Magazine	1,000	Explosives
M-010	Underground Magazine	1,000	Explosives
M-011	Underground Magazine	1,000	Explosives
M-012	Underground Magazine	1,000	Explosives
M-014	Underground Magazine	1,000	Explosives
M-015	Rocket Inspection and Storage Shelter	19,113	SAA: motors, acetone rags, aerosol cans, UW batteries
M-016	Rocket Storage and Inspection Shelter	20,289	SAA: acetone rags, aerosol cans
M-018	Rocket Vehicle Shelter	324	
M-020	Large Rocket Storage Bldg #3	12,000	

Table 1-1 Details for WFF Buildings and Structures

Building	Building Description	Size, ft²	Environmental Implications
M-022	Large Rocket Material Storage Bldg	5,115	
N-001	Badging Office	1,500	
N-116	Inactive Equip Storage Bldg	16,575	
N-117	Telecommunications Storage Building	4,000	
N-127	Security Visitor Control Bldg	2,100	
N-133	Credit Union Admin Office Bldg	1,446	
N-134	Vacant	535	
N-157	Plant Maintenance Shop	747	
N-159	Research Aircraft and Observational Science	100,515	SAA: paint waste, paint thinner, Jet A, used oil, Jet A rags, UW batteries, acetone, solder, aerosol cans, lead acid batteries
N-159E	ASR-7 Radar Ant/Pedestal and Tower	1	SAA: used oil, UW batteries, acetone, solder,
N-159F	Material Storage Building	160	
N-161	Facilities Engineering/Range and Mission Management	28,380	
N-162	Telecomm Facility Bldg	37,838	SAA: UW NiCad batteries, solder, alcohol rags
N-165	Hydraulic Systems Maintenance Facility	1,500	SAA: used oil from antenna changes, PW, solvent rags, aerosols
N-166	Flammable Storehouse	135	
N-169A	9 Meter S Band Ant Sys	1	
N-169C	Antenna Support Equip Shelter	110	
N-177	ADAS Pumps and Oil Storage Bldg	512	
N-179	Balloon Launch Shelter	488	
N-180	Flammable Material Storage Cubical	64	
N-183	Equip. Shelter - 11 Meter Antenna (Pedestal)	288	
N-218	Chemical Storage Building	63	
N-222	Surplus Utilities and Disposal Bldg	9,264	
N-223	Used Oil Storage Facility	300	used oil storage
Q-029	Facilities Management Division Building	2,016	
R-020	Bachelor's Enlisted Quarters	21,230	SAA: UW batteries; 2 USTs: #2 Fuel Oil
R-030	Navy SCSC Headquarters	36,215	AST and UST: #2 Fuel Oil
U-005	Mainland Terminal Bldg	460	
U-006	Mainland Terminal 2 Building	799	
U-012	Switchgear Shelter	N/A	2 ASTs: #2 fuel oil
U-020A	Radar Antenna Pedestal and Tower	N/A	
U-020C	Mobile Radar Spare Parts Storage Bldg	110	
U-025	Radar Operations Building	3,776	SAA: used oil

Table 1-1 Details for WFF Buildings and Structures

Building	Building Description	Size, ft²	Environmental Implications
U-025C	RARF Flammables Storage Bldg	110	
U-026	Projects Maintenance Shop	595	
U-027	Spare Parts Storage Bldg	960	
U-030	Spandar Radar Ops Bldg	6,845	SAA: UW batteries, oily rags, solder
U-030B	Fuel Oil Supply Tank Storage	5,000 gal	1 AST #2 Fuel Oil
U-040	Mobile Radar Laboratory	5,598	SAA: oily rags, grease, alcohol, solder, aerosols, UW and alkaline batteries
U-048	Water Supply Pump Facility	N/A	1 AST #2 Fuel Oil
U-049	Water Storage Tank	75,000 gal	
U-050	Water Pumping and Treat Bldg	5	
U-055	Transmitter Building	3,010	SAA: solder, alkaline batteries, oily rags
U-065	Small Generator Building	N/A	1 AST #2 Fuel Oil.
U-070	AN/FPQ-6 Radar Building	5,000	SAA: solder, oily rags, used oil from antenna changes, UW batteries
U-070B	Radar Parts Storage Building	400	
U-072	AN/FPQ 6 Radar Support Storage Bldg.	110	
U-080	Atmosphere Physics Measurement Lab	1,076	
U-081	Hazardous Waste Staging Facility	420	< 90 day storage for hazardous waste
U-090	Operations Support Building	2,016	SAA: UW batteries
V-003	Wallops Island Engineering Training Center	55,000	1 AST (indoor) #2 Fuel Oil and SAA
V-010	Aegis Engineering and Training Complex	53,600	< 90 day storage for hazardous waste SAA: various expired chemicals, oily rags, paint rags, AST: #2 fuel oil, UST: #2 fuel oil
V-018	Generator Pad	N/A	AST: #2 Fuel Oil (indoor)
V-020	Navy Cruiser Facility	51,970	UST: #2 fuel oil
V-021	Navy Aegis Training Building	2,764	1 AST: #2 Fuel Oil
V-024	Navy Ship Self-Defense Facility	36,400	SAA: oily rags 2 ASTs: #2 Fuel Oil
V-027	North Island Fire Station	16,900	
V-030	Ammunition Magazine	1,488	
V-045	Hypergolic Fueling Facility	5,305	
V-050	Hypergolic Fueling Control Facility	1,881	SAA: Alkaline batteries
V-052	Ready Service Chemical Storage Magazine	63	
V-055	Vertical Dynamics and Static Balance Facility	2,778	SAA: Alcohol rags
V-062	North Island Terminal 2 Building	414	
V-065	Coast Guard Lifesaving Station	4,140	

Table 1-1 Details for WFF Buildings and Structures

Building	Building Description	Size, ft²	Environmental Implications
V-066	ASR-8 Antenna Support Facility	96	SAA: used oil, oily rags
V-067	Rocket Motor Storage Facility	8,000	
V-070	Observation Tower for CG Lifesaving Station	1	
V-080	Rocket Motor Ready Storage	5,920	
V-090	Water Storage Tank - Elevated	50,000 gal	
W-005	Launch Area #3 Pad 3b	1	
W-010	Terminal Bldg Launch Area	713	
W-015	Assembly Shop #4	5,348	SAA: used oil
W-020	Blockhouse #3	4,442	-
W-022	Range Ground Support Equipment Bldg	9,692	
W-030	Launch Area #4	1	
W-032	Utility Building	360	
W-035	Term Bldg Launch Area #4	360	
W-040	Assembly Shop #5	5,602	SAA: UW batteries, aerosol cans, used oil, paint thinner, solder, solvent rags, acetone, 1 AST: #2 Fuel Oil
W-045	Launch Area #5	N/A	-
W-051	Flammables Storehouse	63	
W-055	Elevated Water Storage Tank	150,000 gal	
W-065	Assembly Shop #3	20,089	
W-065C	A/G Heat Fuel Oil Tank	5,000 gal	
W-067	Ready Issue Explosive Storage Cubical	63	
W-095	Launch Area No. 3	N/A	
X-005	Fire Department Support Bldg - Wff	1,024	
X-015	Payload Processing Facility and Fire Dept	17,265	SAA: Diesel rags and filters
X-016	Emergency Power Generator - (Diesel)	33	1 AST: Diesel
X-030	Paint Shop	2,410	SAA: paint thinner and paint rags
X-035	Launch Service Shop and Storage Facility	17,896	SAA: used oil and oily rags
X-046	Water Storage Tank - Elevated	150,000 gal	
X-055	Launch Support Service Bldg	3,960	
X-075	Island Terminal Building	1,365	
X-079	Horizontal Integration Facility	38,254	SAA: UW batteries, paints, epoxies, RP-1, acetone and alcohol rags, used oil

Table 1-1 Details for WFF Buildings and Structures

Building	Building Description	Size, ft²	Environmental Implications
X-080	330 foot Meteorological Tower	N/A	
X-085	Special Projects Building	3,042	
X-115	POMB Maintenance Shop	1,246	
X-140	POMB Materials Storage Bldg	1,000	
Y-010	Fuel Storage Magazine	2,500	
Y-015	Assembly Shop #1	10,447	
Y-025	Propellant Magazine	1,200	
Y-030	Blockhouse #2	5,307	
Y-035	Launch Area 2 (Pads A,B,C)	N/A	
Y-035A	Had Launcher Pad 2	N/A	
Y-045	Igniter Magazine	400	
Y-050	Rocket Flight Hardware Storage Facility	955	
Y-055	AN/FPS-16 Radar Station	3,510	SAA: solder, used oil, rags with alcohol and oil
Y-060	Island Radar Control Bldg	3,472	
Z-020	Liquid Propellant Storage	2,500	
Z-025	Liquid Propellant Storage	2,500	
Z-040	Launch Area 0 Service Bldg	2,625	SAA: aerosols, flammable rags, solder, blast grit
Z-041	Multi-Function Radar Facility	11,617	
Z-065	Blockhouse #1	3,300	UW batteries
Z-070	Launch Area No. 1 (Apron)	N/A	
Z-100	Camera Equip Pedestal W/12' Astrodome	N/A	
WCDAS	NOAA Office Of Satellite Data Processing And Distribution (OSDPD) Backup Facility	2,855	SAA: UW lamps 5 AST, 2 USTs: #2 Fuel Oil
WCDAS	NOAA Utility Building	4,405	SAA: used oil, oily rags, aerosol can crusher, paint thinner. 2 ASTs: Gasoline and Diesel fuel
WCDAS	NOAA Garage and Maintenance	5,610	SAA: UW batteries
WCDAS	NOAA Operations Building	13,475	
WCDAS	NOAA Flammable Storage Building		SAA: UW batteries, lead acid batteries

1.4 Tenant Facilities and other On-site Organizations

NASA has several long-term tenants and customers that use the WFF research airport and Wallops Island launch range, its facilities, and airspace. Each tenant relies on NASA for institutional and programmatic services, but also has its own missions. The activities of these tenants are described below.

1.4.1 United States Navy

The Surface Combat Systems Center (SCSC) is WFF's largest partner. Wallops Island is home to the unique replica of an Aegis cruiser and its combat systems. These systems are used to train naval officers and enlisted personnel in the operation and maintenance of sophisticated equipment used by the fleet onboard their Aegis cruisers and destroyers. The systems are also used to test concepts and solve operational problems. Other technical missions include Lifetime Support Engineering, In-Service Engineering, Systems Level operations, and maintenance training. The SCSC supports the Aegis Training Unit by providing equipment on which replacement crew training is held. The U.S. Navy Ship Self Defense System Facility on Wallops Island conducts research, development, testing, and evaluation elements of shipboard systems, integration, and demonstrations of new shipboard systems. WFF also provides missile launch support for the U.S. Navy. Drone vehicles are used for target tracking and are engaged by both the Aegis facility and operational naval forces.

In addition to the SCSC activities at WFF, the U.S. Navy's Fleet Forces Command maintains a presence at the WFF airfield. Conducting Field Carrier Landing Practice (FCLP), U.S. Navy pilots based in the Norfolk, Virginia area transit to WFF to rehearse landing on simulated aircraft carrier decks established on two of WFF's runways. Occasionally, FCLP detachments also base their operations at WFF for several weeks at a time to fulfill their training requirements. E/2 Hawkeye and C/2 Greyhound twin turboprop aircraft are utilized for this activity.

The Naval Air Warfare Center Aircraft Division (NAWCAD), from Patuxent River, Maryland, also maintains facilities and personnel at WFF and regularly utilizes the range for missile launches and aircraft development testing. Aircraft based at NAS PAX use the WFF Main Base in route to the Virginia Capes Operating Area (VACAPES OPAREA) and as an emergency divert field. Additionally, NAWCAD utilize radar and telemetry data from WFF. NAWCAD Atlantic Targets and Marine Operations Division has historically launched aerial targets from WFF to support fleet training in the VACAPES OPAREA.

Complementing the U.S. Navy activities that have a physical presence at WFF, the VACAPES OPAREA is a Navy surface and subsurface combat test and training operations area off the Virginia and North Carolina coasts (Figure 1-7). This approximately 28,000 square nautical miles (nm^2) area of the Atlantic Ocean extends from Rehoboth Beach, Delaware, to Cape Fear, North Carolina. The boundary starts 3 nm off the coast and terminates approximately 150 nm east in certain areas. It includes the area covered by FAA Warning Areas (W-) 386, W-387, W-72, W-50, W-110, and the Submarine Transit Lanes.

VACAPES OPAREA is managed by the U.S. Navy Fleet Area Control and Surveillance Facility (FACSFAC) VACAPES, located in Virginia Beach, Virginia. Restricted Area (R-) 6604, located west of W-386, is controlled by WFF. The VACAPES OPAREA is used by the Navy for air-to-air, air-to-surface, surface-to-air, and surface-to-surface missile, gunnery, and rocket exercises using conventional ordnance. As a designated air traffic control facility, it is required to provide air traffic separation consistent with the guidelines used by the FAA controllers, and provide for

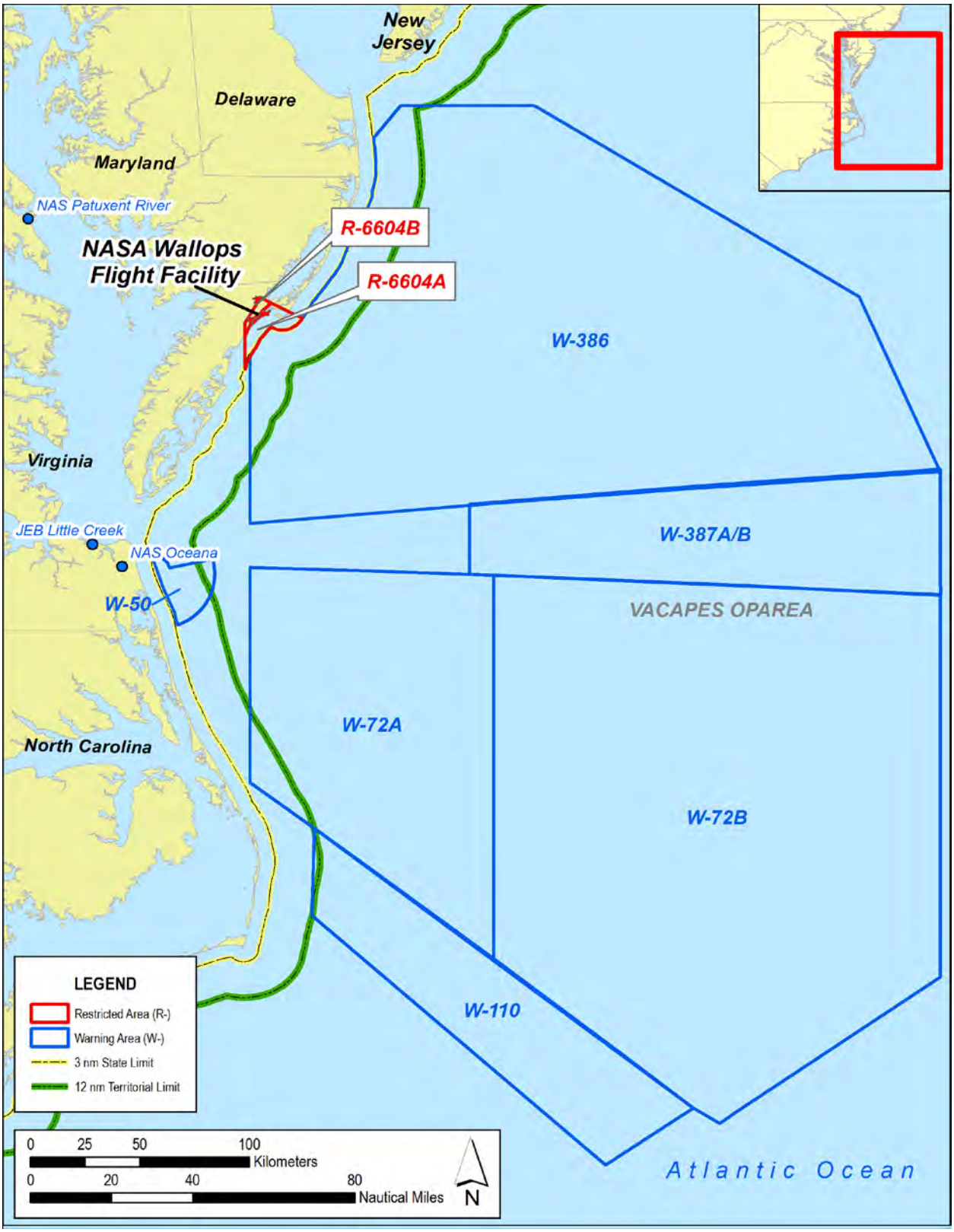


Figure 1-7 VACAPES OPAREA

the safe, efficient and expeditious flow of air traffic. W-386 is special use airspace over VACAPES OPAREA. W-386 extends from the surface to unlimited altitude, except a small portion of the area west of 75° 30'W which is surface to, but not including, 2,000 feet (ft) above mean sea level (MSL).

1.4.2 United States Coast Guard (USCG)

The USCG is represented by the Sector Field Office Station, Aids to Navigation Team, and Electronic Systems Detachment Chincoteague, all quartered on Chincoteague Island. Search and rescue helicopters and other aircraft use the WFF as a base of operations. During emergencies such as hurricanes or Chincoteague Island closure, the USCG is given space for a secondary command center and hangar space for boat/vehicle storage. The USCG maintains housing units, on 7 acres south of the Main Base entrance, for personnel assigned to the local Coast Guard units.

1.4.3 Mid-Atlantic Regional Spaceport (MARS)

The Virginia Commercial Space Flight Authority (Virginia Space) holds an active Launch Site Operator License with the Federal Aviation Administration (FAA) to operate the Mid-Atlantic Regional Spaceport (MARS). The license expires December 18, 2017, and authorizes Virginia Space to operate a launch site at the orbital Launch Complex 0, which includes Pads 0-A and 0-B, and to operate small and medium payload weight classes (less than or equal to 11,100 pounds [lbs]) of orbital Expendable Launch Vehicles (ELV). MARS provides facilities and services for NASA, Department of Defense (DoD), and commercial launches of payloads into space. Activities include launch vehicle and payload preparation, integration and testing, pre-launch operations, launch range integration, and launch and post-launch operations. Virginia Space manages the operations of the North Wallops Island UAS Airstrip for commercial testing. The airstrip measures approximately 3,000 feet long by 75 feet wide.

1.4.4 National Oceanic and Atmospheric Administration (NOAA)

The National Oceanic and Atmospheric Administration (NOAA) National Environmental Satellite Data Information Service (NESDIS) operates environmental satellites, which collect information on atmospheric, oceanic, and terrestrial environmental conditions. This data is distributed to various organizations to prepare short-term and long-range meteorological forecasts, monitor important environmental parameters, provide information critical to aviation and maritime safety, aid search and rescue missions, and assist in national defense and security. NOAA NESDIS satellites track the movement of storms, volcanic ash, and icebergs; measure cloud cover; measure temperature profiles in the atmosphere and temperature of the ocean surface; collect infrared and visual information; and measure atmospheric ozone (O_3) levels. The Wallops Command and Data Acquisition Station (CDAS), a 29-acre facility operated by NOAA NESDIS, gathers the data from the satellites via radio downlinks from 19 antennas (including one operated remotely from Wallops CDAS), 15 of which also transmit data.

1.4.5 Chincoteague Bay Field Station (of the Marine Science Consortium)

CBFS was founded as The Marine Science Consortium (MSC) in Cape May, New Jersey in 1968 by a consortium of three colleges. In 1971 MSC had expanded to fourteen member institutions and moved to its current location just outside the gate of the WFF Main Base. This consortium enacted a list of objectives that included the establishment and maintenance of a marine field station, promoting and encouraging learning and research in marine and environmental sciences, and promoting activities that create a broader understanding of marine and environmental sciences.

In 2013, The MSC undertook a name and brand review that resulted in a new name for the organization, Chincoteague Bay Field Station. Thirteen academic institutions now comprise CBFS, whose main campus adjacent to WFF consists of over 57 acres containing classrooms, wet and dry laboratories, a computer laboratory, residence buildings, faculty and staff residences, a cafeteria, library, recreational facilities, and an administrative building. CBFS maintains several boats that utilize a NASA-owned boat docking facility behind the WFF Visitor Information Center. The boats are necessary to conduct research in the nearby marshes. The second campus is located directly on Chincoteague Bay in Greenbackville, Virginia, approximately 12.5 miles north of WFF.

1.4.6 Wallops Research Park (WRP)

The WRP is currently in its initial development stages, and is under construction on approximately 200 acres of land owned by NASA, Accomack County, and CBFS. Currently, an office building, access roads, utilities, and a taxiway connecting the WRP to the WFF airfield have been constructed. Upon full build out, the WRP will consist of a multi-use development dedicated to non-retail commercial and government space and science research, educational facilities, and public recreational areas. Proposed land use categories within the WRP include:

- research and development/industrial use,
- aviation use,
- gateway research and development/industrial use, and
- Accomack County recreational park.

The WRP Site Plan Review Committee reviews all would-be tenants' proposals and site plans, and delivers recommendations to the WRP principals (NASA, Accomack County, and CBFS) regarding potential tenants. Accomack County provides overall WRP management and oversight of tenants, including implementation of the WRP Guiding Covenants and Restrictions.

Section 2. Air Resources

2.1 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 are typical of 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 air current, known as the Labrador Current, which originates in the arctic 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 2016 is presented in Table 2-1, along with record highs and lows for temperatures over a 50-year time frame.

2.2 State and Federal Air Quality Standards

The Clean Air Act (CAA), which was last amended in 1990, requires the Environmental Protection Agency (EPA) to set National Ambient Air Quality Standards (NAAQS) (40 CFR 50) for pollutants considered harmful to public health and the environment. The CAA established two types of national air quality standards: primary and secondary. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

The EPA Office of Air Quality Planning and Standards has set NAAQS for seven principal pollutants, which are called "criteria" pollutants. Virginia's ambient air quality standards mirror the NAAQS. Those standards are included in Table 2-2. The Commonwealth promulgates air quality standards through the State Air Pollution Control Board and implements them through the DEQ regulations in 9 VAC 30.

Table 2-1 50-Year Local Climatological Data

Month	Avg Max Temp °F	Avg Min Temp °F	Avg Precip in	Avg Wind Speed mph	Record Hi °F [Year]	Record Low °F [Year]
Jan	45	28	3.1	8.45	79 [2002]	-4 [1965]
Feb	46	29	2.9	9.08	79 [1997, 2002]	-4 [1971]
Mar	54	36	3.7	9.69	86 [1990]	14 [1980, 1996, 2009, 2014]
Apr	63	44	2.9	9.69	93 [1990]	24 [1969]
May	72	54	3.2	8.62	97 [1991]	34 [1974]
Jun	80	64	3.4	8.03	100 [2012]	40 [1967]
Jul	85	69	3.8	7.36	102 [2012]	51 [1965]
Aug	84	68	4.0	7.10	101 [1977]	47 [1982]
Sept	78	62	3.8	8.08	96 [1983]	40 [1970]
Oct	68	50	3.3	8.23	91 [2007]	26 [1976]
Nov	58	40	2.8	7.93	83 [1974]	19 [1967, 1974, 1976, 2014]
Dec	50	32	3.5	8.26	77 [1998, 2015]	4 [1989]

Source: **NASA 2016b**

Table 2-2 National Ambient Air Quality Standards

Pollutant	Primary Stds.	Averaging Times	Secondary Stds.
Carbon Monoxide	9 ppm	8-hour[1]	None
	35 ppm	1-hour[1]	None
Lead	0.15 ppb	Rolling 3-Month Average	Same as Primary
	1.5 ppb	Quarterly Average	Same as Primary
Nitrogen Dioxide	100 ppb	1-hour[2]	None
	53 ppb	Annual (Arithmetic Mean)	Same as Primary
Particulate Matter (PM_{10})	150 ppb	24-hour[3]	Same as Primary
Particulate Matter ($PM_{2.5}$)	12.0 ppb	Annual[4] (Arithmetic. Mean)	15 ppb
	35 ppb	24-hour[5]	Same as Primary
Ozone	0.075 ppm	8-hour[6]	Same as Primary
	0.12 ppm	1-hour[7] (Applies only in limited areas)	Same as Primary
Sulfur Oxides	75 ppb	1-hour[8]	None
	-------	3-hour[1]	0.5 ppm

[1] Not to be exceeded more than once per year.

[2] To attain this standard, the three-year average of the 98th percentile of 1-hour concentrations must not exceed 100 ppb.

[3] Not to be exceeded more than once per year on average over 3 years.

[4] To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 ppb.

[5] To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations within an area must not exceed 35 ppb (effective December 17, 2006).

[6] To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured within an area must not exceed 0.075 ppm.

[7] (a) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is ≤ 1.

(b) As of June 15, 2005 EPA revoked the 1-hour ozone standard in all areas except the fourteen 8-hour ozone nonattainment Early Action Compact Areas.

[8] To attain this standard, the 3-year average of the 99th percentile of 1-hour daily maximum concentrations, averaged over three years, must not exceed 75 ppb.

ppb = parts per billion (micrograms per cubic meter); ppm = parts per million (milligrams per cubic meter)

2.3 Air Quality at WFF

WFF is located in an attainment area for all six NAAQS listed criteria air pollutants. An attainment area is an area considered to have air quality that is as good as or better than the NAAQS as defined by the CAA.

WFF has two stationary source air permits. A stationary source refers to any building, structure, facility, or installation which emits or may emit any air pollutant from one, non-moving point (i.e., smoke stack or geographic area). A stationary source is considered a *major source* if it has the potential to emit pollutants greater than 100 tons per year of the listed criteria pollutants, or greater than 10 tons per year of a single Hazardous Air Pollutant (HAP), or more than 25 tons a year of combined HAPs.

At one point, the Main Base was thought to have the potential to emit over 100 tons a year of sulfur oxides and nitrogen oxides, which would have required a Title V permit. WFF accepted voluntary restrictions on its operating parameters to ensure that its potential to emit these pollutants would not exceed 100 tons per year. This made the Main Base a *synthetic minor source*, a stationary source that is subject to permit limits that keep emissions below major source thresholds. As such, the Main Base holds Virginia Synthetic Minor Source Permit Number 40217 Aerometric Information Retrieval System (AIRS) Facility Subsystem Identification Number (AFS Id. No.) 51-001-0005 (April 18, 2005, as amended).

The combined Wallops Island and Mainland area has the potential to emit over 10 tons of the HAP carbon monoxide during open burning activities and is an *actual minor source*, a stationary source with emissions less than major source thresholds. Wallops Island/Mainland holds Virginia State Operating Permit number 40909 AFS Id. No. 51-001-0031 (August 3, 2006, as amended).

Table 2 3 lists the primary sources of air pollutants for the NASA Main Base, Mainland, and Wallops Island. It should be noted that NASA tenants and partners, including NOAA, the U.S. Navy, and the Mid-Atlantic Regional Spaceport, hold air permits and report emissions separate from NASA.

Table 2-3 Selected Air Pollutant Sources at NASA WFF

Source	Location	Pollutants	Pollution Control
Sounding rockets	Wallops Island/Mainland	Al_2O_3, HCl, Pb	None
Orbital rockets	Wallops Island/ Mainland	Al_2O_3, HCl, Pb, CO, CO_2, NO_x	None
Spacecraft fueling	Wallops Island	Hydrazine	State Operating Permit
Airport operations	WFF Main Base	VOCs	None
Distillate oil fired boilers and heaters	WFF Main Base and Wallops Island/Mainland	SO_2, NO_x, VOCs, CO, CO_2	Efficient operation and maintenance
Distillate oil fired generators and pumps	WFF Main Base and Wallops Island/ Mainland	SO_2, NO_x, VOCs, CO, CO_2	Efficient operation and maintenance
Painting/coating operations	WFF Main Base and Wallops Island/ Mainland	VOCs	Particulate Filters in Paint Booths
Vehicle Fueling Facility	WFF Main Base	VOCs	Vapor Recovery
Construction –related activities	WFF Main Base and Wallops Island/ Mainland	Particulate Matter (PM)	None
OB Area	Wallops Island/ Mainland	Al_2O_3, HCl, Pb	Operating Restrictions
Rocket Motor Test Stand	Wallops Island/Mainland	Al_2O_3, HCl, Pb	None

Table 2-4 below summarizes the hazardous pollutants and lead found in the air above background and State Air Operating Permit limits at WFF.

Table 2-4 WFF State Air Operating Permit Limits

Area of Concern	Pollutant	Limit
Wallops Mainland/Island	Lead	0.9 tons/12 months
Wallops Mainland/Island	HCl	9.4 tons/12 months
Wallops Mainland and Island	Hydrazine	0.0176 lbs/30 minute (average time required per single fueling event) or 0.0185 tons/12 months
WFF Main Base	HAP	10 tons/12 months single or 25 tons/12 months combinations
Wallops Mainland/Island	HAP	9.4 tons/12 months single or 24.4 tons/12 months combinations

Table 2-5 compares WFF primary air pollutants emissions to those of Accomack County.

Table 2-5 Wallops Flight Facility Main Base Permit Limits and 2016 Annual Air Pollutant Emissions Compared to Accomack County

Location	Air Pollutant Emissions (Tons/Year)					
	VOCs	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$
Accomack County[a]	4,098.04	14,408.30	2,959.99	1,145.81	393.67	2,370.54
WFF Main Base Emissions[b]	3.28	5.05	16.95	0.24	0.67	1.9

Sources: [a]USEPA, 2016a; [b]NASA 2017; [c]U.S. Navy, 2013.

2.4 Conformity Analysis

As WFF is within an attainment area for all NAAQS criteria pollutants, a Conformity Analysis is not required.

Section 3. Water Resources

WFF is located in the Eastern Lower Delmarva and the Chincoteague watersheds. The portion of Wallops Mainland south of Route 803, and the portions of Wallops Island south of Route 803, and all along the eastern edge of the island are part of the Eastern Lower Delmarva watershed. The entire Main Base, portions of Wallops Mainland north of Route 803, and the western portion of Wallops Island north of Route 803, are part of the Chincoteague watershed.

There are no rivers in the vicinity of WFF that have been designated, or have the potential to be designated, as wild, scenic, or recreational under the Wild and Scenic Rivers Act. P.L. 90-542, as amended (16 U.S.C. 1271-1287).

3.1 Surface Water

Numerous inlets, marshes, bays, creeks, and tidal estuaries are found in and around all three installation areas of WFF. A section of the Virginia Inside Passage is located west of Wallops Island and east of the Main Base and Wallops Mainland. The Atlantic Ocean lies to the east of Wallops Island. Surface waters in the vicinity of WFF are saline to brackish and are influenced by the tides.

Through 9 Virginia Administrative Code (VAC) 25-260-520, the Virginia DEQ has designated the surface waters in the vicinity of WFF as Class II – Estuarine Waters and the Atlantic Ocean as Class I - Open Ocean. Surface Waters in Virginia must meet water quality criteria specified in 9 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 WFF, the saltwater numerical criterion is applied. Both sets of standards are used by Virginia DEQ to protect and maintain surface water quality.

The Main Base drains primarily into Little Mosquito Creek to the west and north, and borders Simoneaston Bay tidal marsh to the east. The southeastern portion of the Main Base includes stormwater swales and ditches that drain to Watts Bay. The surface water on the Mainland drains to and includes portions of Bogues Bay to the north, Cat Creek to the east, and Hog Creek to the south. Surface water on Wallops Island flows through numerous tidal tributaries that subsequently flow to the Atlantic Ocean. The northern boundary of Wallops Island is formed by Chincoteague Inlet and its western side is bounded by a series of water bodies that include (from north to south) Ballast Narrows, Bogues Bay, Cat Creek, and Hog Creek which separate the Island from the Mainland. No natural perennial streams or ponds exist on the Island; however, intermittent water bodies may form after storms or in response to other physical forces such as tides.

In 2006, the surface waters of Little Mosquito Creek were listed on Virginia 303(d) list as an impaired water body for beneficial uses including aquatic life due to low dissolved oxygen and are still identified as impaired in the draft 2013 list (**Virginia DEQ 2012**). Little Cat Creek is also listed in the draft 2013 report and is located just east of Wallops Island.

3.2 Virginia Pollutant Discharge Elimination System

Section 402 of the Clean Water Act (CWA) established the National Pollutant Discharge Elimination System (NPDES) to limit pollutant discharges into surface waters including streams, rivers, and bays. In Virginia, DEQ administers the program as the Virginia Pollutant Discharge Elimination System (VPDES). Though DEQ requires VPDES permits for all point source discharges to surface waters, the U.S. EPA maintains authority to review applications and permits for "major" dischargers, a distinction based on discharge quantity and content. A VPDES permit authorizes potential or actual discharge of pollutants from a point source to surface waters under prescribed conditions and limitations. VPDES Permit No. VA0024457 was issued to WFF by the DEQ on August 17, 1989, with the most recent renewal date being October 1, 2014 which expires September 30, 2019. Prior to the issuance of the August 1989, VPDES Permit, WFF referred to outfalls around the facility by common names; under the permits these names have been changed. VPDES Permit No. VA0024457 applies to 11 industrial storm water outfalls on the Main Base (Figure 3-1), including the Federally Owned Treatment Works (FOTW) process outfall and three industrial storm water outfalls on Wallops Island (Figure 3-2), including the deluge water storage pond at Launch Pad 0-A. Currently, there are no permitted storm water outfalls on the Mainland. Four non-industrial storm water outfalls are located on the Wallops Main Base (Figure 3-1) and five non-industrial storm water outfalls are located on Wallops Island (labelled WI-1 through WI-5 on Figure 3-2). A description the discharge from the two monitored outfalls on the Main Base and three monitored outfalls on Wallops Island along with their receiving stream is presented in Table 3-1. VPDES effluent limitations for the monitored outfalls (001 and 003) are presented in Table 3-2. The remaining nineteen outfalls, which are monitored but have no compliance limits established, are described in Table 3-3 along with their receiving stream and potential sources of pollutants.

In accordance with its VPDES permit, WFF has prepared and routinely updates a Storm Water Pollution Prevention Plan (**NASA 2014a**). This document describes current storm water management and documents revisions to the Facility storm water management systems and the associated outfalls, from each prior version. Through the use of best management practices, quarterly and annual inspections, and personnel training, WFF remains proactive in storm water pollution prevention.

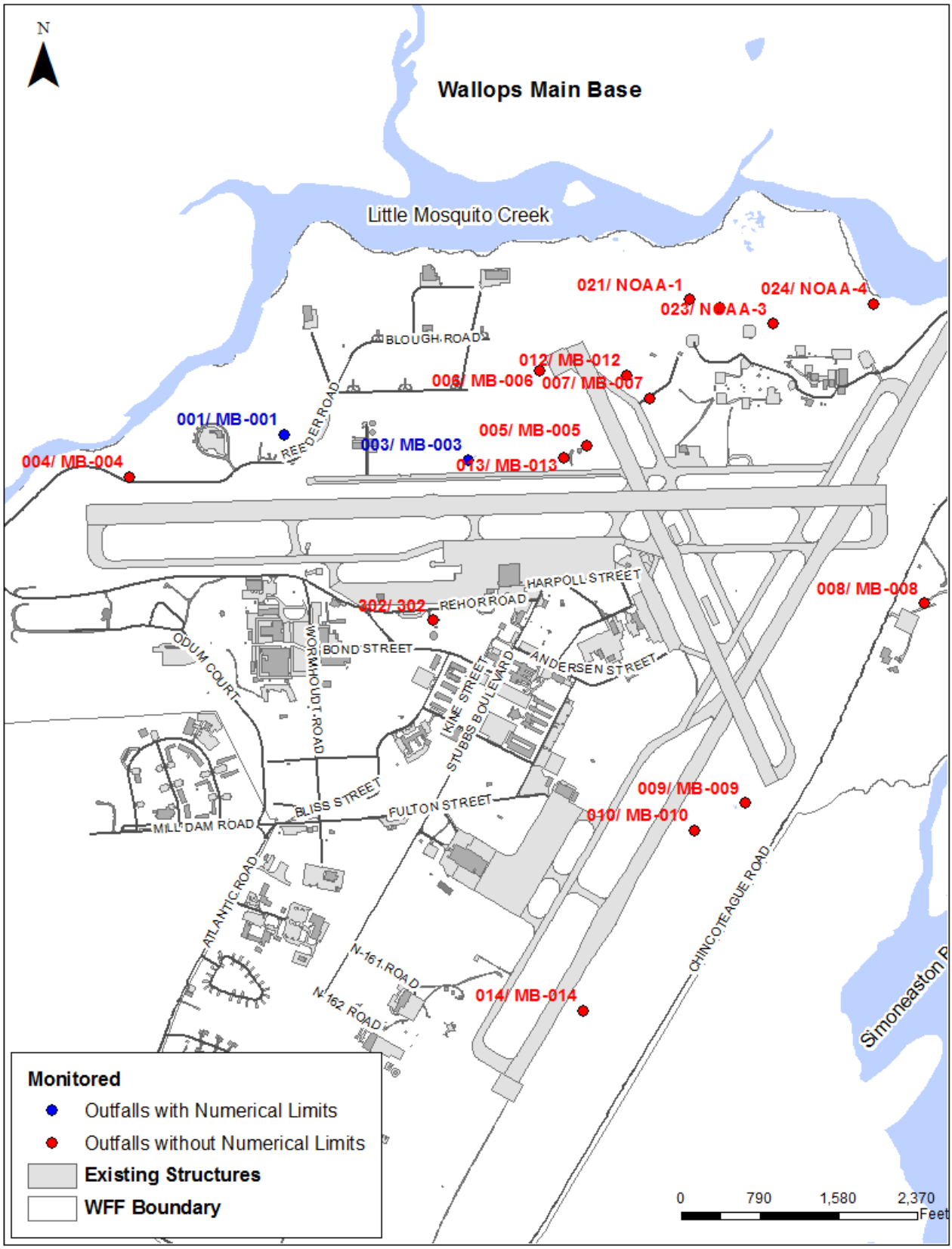


Figure 3-1 VPDES Main Base Permitted Outfalls

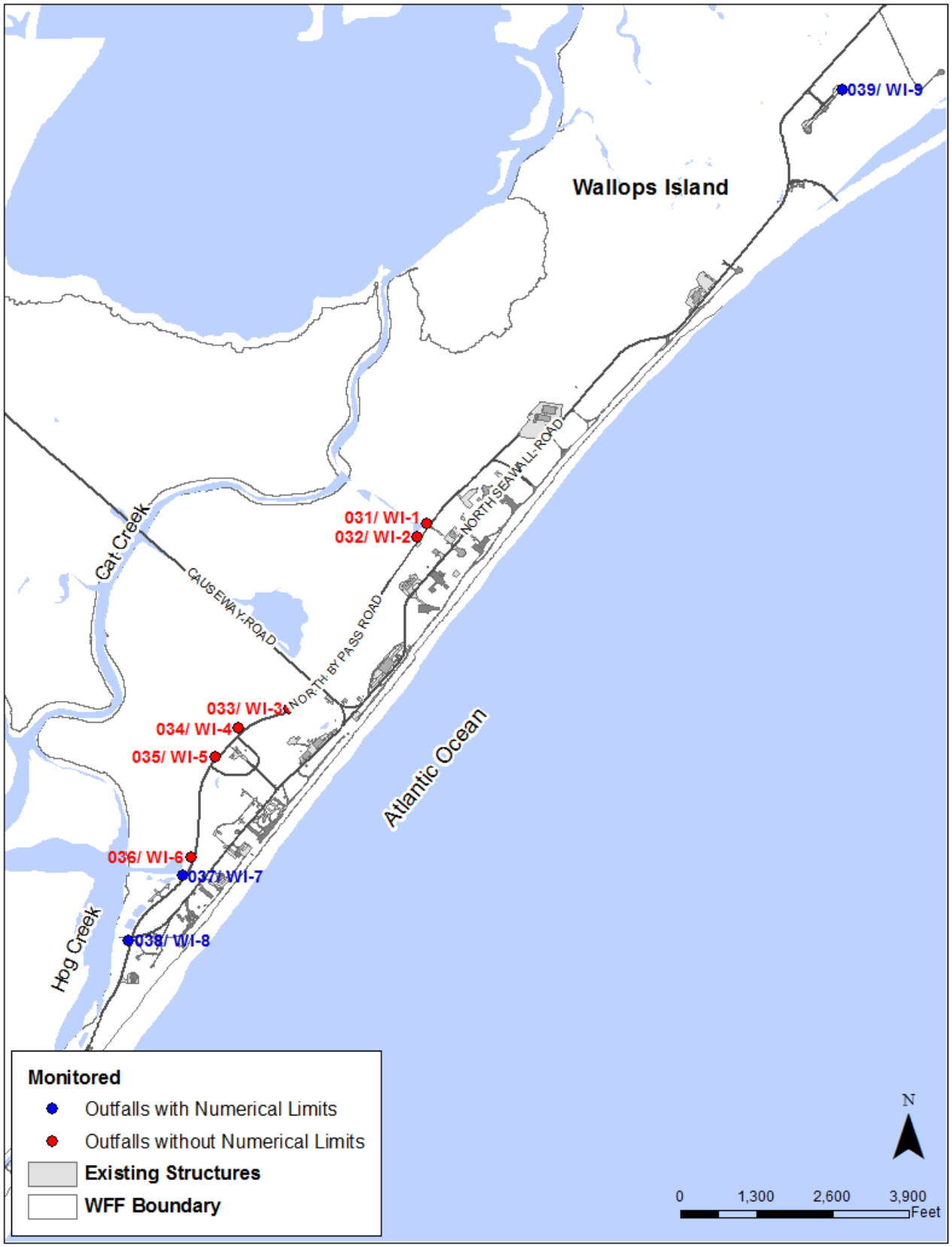


Figure 3-2 VPDES Wallops Island Permitted Outfalls

Table 3-1 Monitored Outfalls (VPDES Permit No. VA0024457)

Outfall Permit Number	Outfall Common Name	Description	Receiving Stream
001	MB-001	FOTW receives processed sanitary wastes.	Little Mosquito Creek
003	MB-003	Drains airfield runways, taxiways, aprons, and a hangar; satellite accumulation areas; aboveground fuel storage tanks; office buildings; roadways, parking areas, and grassy areas. This outfall discharges to Little Mosquito Creek. Potential sources of pollution include fuel spills from airfield activities or releases from fuel delivery vehicles or hazardous waste spills from a satellite accumulation area. A chance of storm water contamination from hazardous wastes exists; however, all satellite accumulation areas are required to have secondary containment and are located inside covered structures. This outfall drains approximately 204.6 acres and its weighted runoff coefficient is low at 0.39. During a 24-hour, 2-year storm event, approximately 8.03 million gallons per day (MGD) would discharge from this outfall.	Little Mosquito Creek
037 038	WI-7 WI-8	Drain orbital launch facilities, small launch facilities, office buildings, fuel storage tanks, RP-1 storage, roadways, parking areas, and grassy areas. Drainage involves retention basins with sluice gates and tidal flaps that drain to Hog Creek. Potential sources of pollution include orbital launch operations and fuel spills from delivery vehicles. To minimize the risk of storm water pollution, all orbital launch vehicle fueling is performed by highly trained personnel during closely controlled conditions. Also, all launch pad wash waters are tested prior to discharge. All tank fueling operations are performed by trained personnel. Additionally, spill kits are readily available. These outfalls drain approximately 27.9 acres and 22.5 acres, respectively. Weighted runoff coefficients are low at 0.23 and 0.17. During a 24-hour, 2-year storm event, approximately 0.64 MGD would discharge from WI-7 and 0.38 MGD would discharge from WI-8.	Hog Creek
039	WI-9	Deluge System – Discharge to containment basin, test for release to surface water structures. Release to surface water structures is anticipated based on similar operations at other NASA launch sites. If necessary water will be tested and treated (pH adjustment) before release, or collected and removed for disposal as necessary. The quantities may be significant requiring release over a period of days up to 200,000 gallons per launch.	Hog Creek

Table 3-2 Effluent Limitations for Monitored Outfalls with Reporting Requirements (VPDES Permit No. VA0024457)

Effluent Characteristics	Discharge Limitations for Outfall 001 (Design Flow 0.3 MGD)				Monitoring Requirements	
	Monthly Average	Weekly Average	Minimum	Maximum	Frequency	Sample Type
Flow (MGD)	NL[1]	NA[2]	NA	NA	Continuous	Totalizing, Indicating and Recording Equipment
pH (standard units)	NA	NA	6.0	9.0	1/day	Grab
$CBOD_5$ (mg/l; kg/d)	10; 11	15; 17	NA	NA	3 days/week	24-Hr Composite
Total Suspended Solids (TSS) (mg/l; kg/d)	10; 11	15; 17	NA	NA	3 days/week	24-Hr Composite
Dissolved Oxygen (mg/l)	NA	NA	5.5	NA	1/day	Grab
Fecal Coliform (colonies/100ml)	200	NA	NA	NA	3 days/week (10AM to 4PM)	Grab
E. coli (colonies/100ml)	126	NA	NA	NA	3 days/week (10AM to 4PM)	Grab
Total Kjeldahl Nitrogen (TKN) mg/l; kg/d)	3.0; 3.4	4.5; 5.1	NA	NA	3 days/week	24-Hr Composite
Total Recoverable Copper (µg/l)	19	19	NA	NA	1/month	24-Hr Composite

Effluent Characteristics	Discharge Limitations for Outfall 003		Monitoring Requirements	
	Minimum	Maximum	Frequency	Sample Type
Flow (MG)	NA	NL	1/3 months	Estimate
pH (standard units)	6.0	9.0	1/3 months	Grab
Total Suspended Solids (TSS) (mg/l)	NA	NL	1/3 months	Grab
Total Petroleum Hydrocarbons (TPH) (mg/l)	NA	NL	1/3 months	Grab

Table 3-2 Effluent Limitations for Monitored Outfalls with Reporting Requirements (VPDES Permit No. VA0024457)

Effluent Characteristics	Discharge Limitations for Outfalls 037 (WI-7) through 039 (WI-9)		Monitoring Requirements	
	Minimum	Maximum	Frequency	Sample Type
Flow (MG)	NA	NL	1/6 months	Estimate
pH (standard units)	6.0	9.0	1/6 months	Grab
Total Suspended Solids (TSS) (mg/l)	NA	NL	1/6 months	Grab
Total Petroleum Hydrocarbons (TPH) (mg/l)	NA	NL	1/6 months	Grab

MGD - million gallons per day; mg/l – milligrams per liter; kg/d – kilograms per day; µg/l – micrograms per day
NL - No Limit, however, reporting is required; NA - Not Applicable

Table 3-3 Monitored Outfalls with No Reporting Requirements (VPDES Permit No. VA0024457)

Outfall Permit Number	Outfall Common Name	Description
003	MB-003	Drains airfield runways, taxiways, aprons, and a hangar; satellite accumulation areas; aboveground fuel storage tanks; office buildings; roadways, parking areas, and grassy areas. This outfall discharges to Little Mosquito Creek. Potential sources of pollution include possible fuel spills from airfield activities or releases from fuel delivery vehicles or possible hazardous waste spills from a satellite accumulation area. A chance of storm water contamination from hazardous wastes exists; however, all satellite accumulation areas are required to have secondary containment and are located inside covered structures. This outfall drains approximately 204.6 acres and its weighted runoff coefficient is low at 0.39. During a 24-hour, 2-year storm event, approximately 8.03 million gallons per day (MGD) would discharge from this outfall.
004	MB-004	Drains airfield runways and taxiways, satellite accumulation areas, an enclosed salt storage facility, an automobile fueling facility and maintenance garage, aboveground fuel storage tanks, roadways, parking areas, office and storage buildings, and grassy areas. This outfall discharges to Little Mosquito Creek. Potential sources of pollution include possible fuel spills from automobile fueling and maintenance, releases from fuel delivery vehicles, or airfield activities. There is a possibility of hazardous waste spills from satellite accumulation areas; however, all satellite accumulation areas are required to have secondary containment and are located inside covered structures. This outfall drains approximately 54.1 acres and its weighted runoff coefficient is low at 0.31. During a 24-hour, 2-year storm event, approximately 1.72 MGD would discharge from this outfall.
005 006 007	MB-005 MB-006 MB-007	Drain airfield runways, taxiways, and grassy areas. These outfalls discharge to Little Mosquito Creek. Potential sources of pollution include possible fuel spills from airfield activities. These outfalls drain approximately 18.9 acres, 2.3 acres,

Table 3-3 Monitored Outfalls with No Reporting Requirements (VPDES Permit No. VA0024457)

Outfall Permit Number	Outfall Common Name	Description
008	MB-008	12.4 acres and 29.0 acres, respectively. Weighted runoff coefficients range from medium to high and are 0.52, 0.67, 0.40, and 0.46, respectively. During a 24-hour, 2-year storm event, discharges would be approximately 1.00 MGD from Outfall 005, 0.16 MGD from Outfall 006, 0.51 MGD from Outfall 007, and 1.36 MGD from Outfall 008.
009	MB-009	Drains airfield runways, taxiways, and grassy areas. This outfall discharges to Jenneys Gut. Potential sources of pollution include fuel spills from airfield activities. This outfall drains approximately 18.2 acres and its weighted runoff coefficient is medium at 0.46. During a 24-hour, 2-year storm event, approximately 0.85 MGD would discharge from this outfall.
010	MB-010	Drains airfield runways, taxiways, and aprons, satellite accumulation areas, a less-than-90-day accumulation area (Building B-29), one restoration site with petroleum related groundwater impacts, aboveground fuel storage tanks, office buildings, roadways, parking areas, and grassy areas. This outfall discharges to Jenneys Gut. Potential sources of pollution include fuel spills from airfield activities or releases from fuel delivery vehicles or hazardous waste spills from either a satellite accumulation area or a less-than-90-day accumulation area. The possibility of storm water contamination from hazardous wastes exists; however, all satellite accumulation areas are required to have secondary containment and are located inside covered structures. In addition, the less-than-90-day accumulation area is located in a concrete building that is protected by drains and troughs that would contain a spill within the area. The potential for contaminated runoff from the restoration sites exist, but due to site topography, is highly unlikely. This outfall drains approximately 127.7 acres and its weighted runoff coefficient is low at 0.34. During a 24-hour, 2-year storm event, approximately 4.43 MGD would discharge from this outfall.
012 013	MB-012 MB-013	Drain airfield runways, taxiways, and grassy areas. These outfalls discharge to Little Mosquito Creek. Potential sources of pollution include fuel spills from airfield activities. These outfalls drain approximately 3.2 acres and 2.6 acres, respectively. Their weighted runoff coefficients are medium at 0.54 and 0.52, respectively. During a 24-hour, 2-year storm event, approximately 0.17 MGD would discharge from outfall 012 and 0.14 MGD from outfall 013.
014	MB-014	Drains airfield runways, taxiways, one aircraft hangar, satellite accumulation areas, one aboveground fuel storage tank, roadways, parking areas, office and storage buildings, and grassy areas. This outfall discharges to Simoneaston Bay. Potential sources of pollution include fuel spills from runway activities, releases from fuel delivery vehicles, or hazardous waste spills from satellite accumulation areas. However, all satellite accumulation areas are required to have secondary containment and are located inside covered structures. This outfall drains approximately 113.1 acres with a low weighted runoff coefficient of 0.28. During a 24-hour, 2-year storm event, approximately 3.32 MGD would discharge from this outfall.
021 022	NOAA-1 NOAA-2	Drain spacecraft tracking facilities and grassy areas. These outfalls discharge to Little Mosquito Creek. Potential pollution sources include oils and lubricants; however, the equipment is regularly inspected and maintained by trained NOAA

Table 3-3 Monitored Outfalls with No Reporting Requirements (VPDES Permit No. VA0024457)

Outfall Permit Number	Outfall Common Name	Description
		personnel. These outfalls drain approximately 6.6 acres and 16.2 acres, respectively. Weighted runoff coefficients are low at 0.22 and 0.25. During a 24-hour, 2-year storm event, approximately 0.15 MGD would discharge from NOAA-1 and 0.41 MGD would discharge from NOAA-2.
023 024	NOAA 3 NOAA-4	Drain spacecraft tracking facilities, aboveground fuel storage tanks, office buildings, parking areas, and grassy areas. NOAA-4 also drains an airfield runway and taxiway. These outfalls discharge to Little Mosquito Creek. Potential sources of pollution include fuel spills from airfield activities, releases from fuel delivery vehicles, and radar oils and lubricants. To minimize storm water risk, tanks are surrounded by secondary containment, spill kits are readily available, and radar equipment is regularly inspected and maintained by trained NOAA personnel. These outfalls drain approximately 28.3 acres and 51.0 acres, respectively. Weighted runoff coefficients are low to moderate at 0.29 and 0.42. During a 24-hour, 2-year storm event, approximately 0.82 MGD would discharge from NOAA-3 and 2.15 MGD would discharge from NOAA-4.
031 032	WI-1 WI-2	Drain small launch facilities, office buildings, fuel storage tanks, roadways, parking areas, and grassy areas. WI-2 also drains a payload assembly, Building W-065. Drainage traverses retention basins with sluice gates and tidal flaps leading first to tidal marshland and then to Cat Creek. To minimize the risk of storm water pollution, all fueling and payload assembly operations are performed by trained personnel. Additionally, spill kits are readily available. These outfalls drain approximately 36.9 acres and 74.3 acres, respectively. Weighted runoff coefficients are low at 0.22 and 0.20. During a 24-hour, 2-year storm event, approximately 0.93 MGD would discharge from WI-1 and 1.49 MGD would discharge from WI-2.
033 034	WI-3 WI-4	Drain office buildings, fuel storage tanks, roadways, and parking areas. Drainage crosses retention basins with sluice gates and tidal flaps leading first to tidal marshland and then to Cat Creek. Potential sources of pollution include fuel spills from delivery vehicles. To minimize the risk of storm water pollution, trained personnel perform all fueling operations. Additionally, spill kits are readily available. These outfalls drain approximately 45.0 acres. Their weighted runoff coefficient is low at 0.19. During a 24-hour, 2-year storm event, approximately 0.86 MGD would discharge from these outfalls.
035	WI-5	Drains radar and tracking facilities, aboveground fuel storage tanks, office buildings, parking areas, and grassy areas. Drainage involves a culvert with tidal flaps leading first to tidal marshland and then to Cat Creek. Potential sources of pollution include fuel spills from delivery vehicles and radar oils and lubricants. To minimize storm water risks, tanks are surrounded by secondary containment, spill kits are readily available, and radar equipment is regularly inspected and maintained by trained personnel. This outfall drains approximately 7.7 acres. The weighted runoff coefficient is low at 0.19. During a 24-hour, 2-year storm event, approximately 0.15 MGD would discharge from this outfall.
036	WI-6	Drains small launch facilities, office buildings, fuel storage tanks, hypergols storage, roadways, parking areas, and grassy areas. Drainage involves retention basins with sluice gates and tidal flaps that drain to Hog Creek. Potential sources of

Table 3-3 Monitored Outfalls with No Reporting Requirements (VPDES Permit No. VA0024457)

Outfall Permit Number	Outfall Common Name	Description
		pollution include fuel spills from delivery vehicles. To minimize the risk of storm water pollution, all fueling operations are performed by trained personnel. Additionally, spill kits are readily available. This outfall drains approximately 47.8 acres. The weighted runoff coefficient is low at 0.23. During a 24-hour, 2-year storm event, approximately 1.1 MGD would discharge from this outfall.

3.2.1 Wastewater and Sludge

Main Base wastewater is primarily collected in gravity sewers and treated at the FOTW located in the northwest corner of the Main Base (Figure 3-1). Several lift stations also serve the Main Base. The FOTW has a design capacity of approximately 300,000 gallons per day (gpd). The current average daily discharge is approximately 50,000 to 60,000 gallons. Wallops Island is primarily served by gravity sewers, lift stations, and a force main that pumps wastewater to the Main Base FOTW.

As a result of Outfall 001 discharging to a tributary of Little Mosquito Creek, a portion of this waterway is closed for shellfish harvesting by the Virginia Department of Health (VDH). The closure serves as a buffer zone to ensure protection of human health. Buffer zone closures in the vicinity of point source discharges are a standard practice to provide protection of public health.

Buildings on the Mainland, the northern portion of Wallops Island, and remote areas of the Main Base are served by individual septic systems. The septic system locations are indicated on Figure 3-3 and Figure 3-4. A total of 13 septic systems are maintained by the Facilities Management Branch (FMB). The septic systems are pumped out semi-annually, and the septage is transported to D-098 (Old FOTW) sludge drying beds for dewatering, with ultimate disposal in the Accomack County North Landfill (**NASA 2014a**).

The original WFF wastewater treatment facility was constructed by the Navy in the 1940's. In the 1970's, a Trickling Filter Plant was constructed, which was replaced by the current system in 1999. The current treatment system provides preliminary, secondary, and tertiary treatment, ultraviolet disinfection, and sludge stabilization (Figure 3-5). Preliminary treatment includes grit removal, bar screens, and comminutors. Secondary treatment is accomplished by biological treatment, extended aeration activated sludge, and secondary clarification. Tertiary treatment is accomplished by sand filtration. Prior to discharge, an ultraviolet system provides disinfection and a post aeration system provides additional dissolved oxygen. Sewage sludge is aerobically digested, dried in Building D-053 on covered sludge drying beds, tested annually for Resource Conservation and Recovery Act (RCRA) metals, and disposed of at the Accomack County North Landfill in accordance with WFF's annually approved Sludge Management Plan. WFF disposes of approximately 10 tons of dried sewage sludge per calendar year.

Figure 3-3 Wallops Main Base Septic System Locations

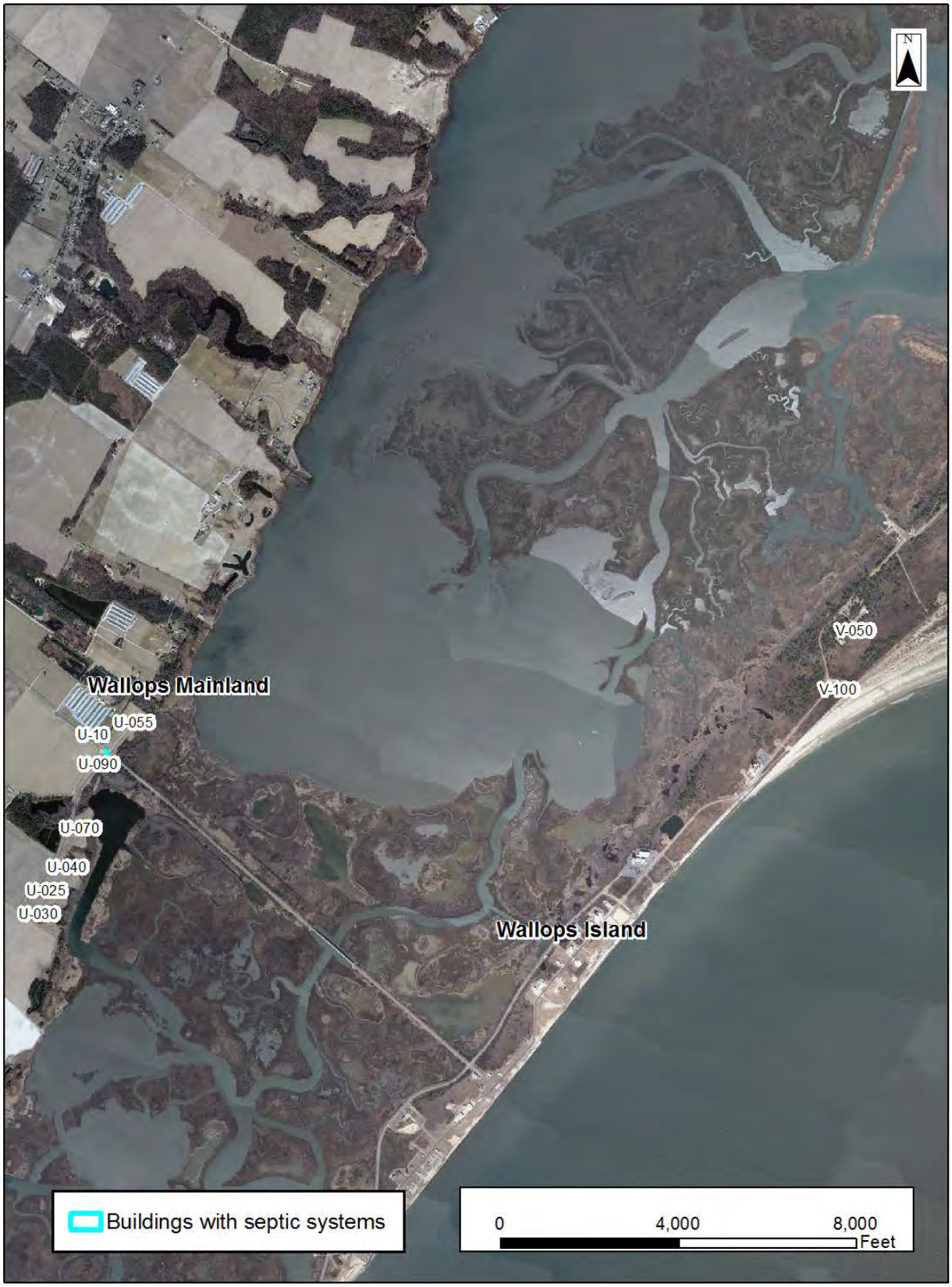


Figure 3-4 Wallops Mainland and Island Septic System Locations

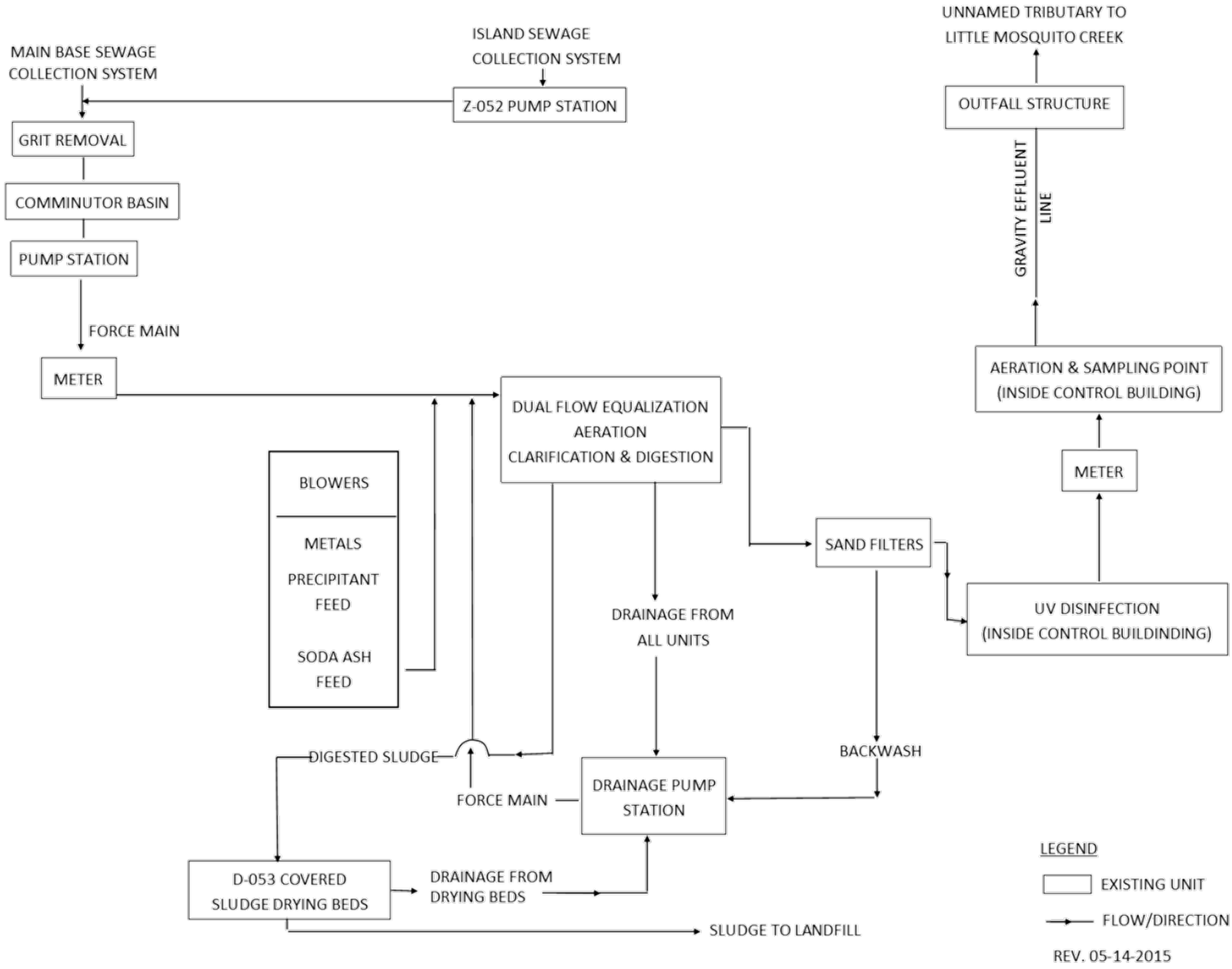


Figure 3-5 FOTW Flow Schematic Diagram

3.3 Marine Waters

Marine waters are those of the Atlantic Ocean in the vicinity of WFF. There are distinct differences in stratification of the mid-Atlantic Ocean between summer and winter. In the winter, the water column is vertically well mixed, with water temperatures averaging 57° Fahrenheit (°F) at the surface and 52°F at depths greater than 660 ft. In summer, the water column is vertically stratified with 77°F water near the surface and 50°F water at depths greater than 660 ft (**Paquette et al. 1995**). Among the large rivers and estuaries that discharge fresh water into the mid-Atlantic Ocean are the Hudson River, Delaware Bay, and Chesapeake Bay. The salinity over the continental shelf ranges from 28 to 36 parts per thousand (ppt), with lower salinities found near the coast and highest salinities found near the continental shelf break. Salinities are highest in continental shelf waters during winter and lowest in the spring. Variability in this area is due to the intrusion of saltier (greater than 35 ppt) water from the continental slope waters and freshwater input from coastal sources (**U.S. Navy 2009**).

Fresh or brackish plume water from the Chesapeake and Delaware Bays, flows out of these estuaries. This less dense (due to lower salinity) water flow turns south in response to the Coriolis force (Earth's rotation), resulting in southward flowing, coastally trapped currents. An increase in river flow and ebbing tides force more water out of the respective bays; predominant southwesterly winds cause a seaward expansion of the plume over the continental shelf, creating a well-stratified, two-layer system. The warm surface waters are constantly replaced by deeper, more saline, nutrient-rich water (**U.S. Navy 2009**).

3.4 Groundwater

The Virginia DEQ manages groundwater withdrawals in designated Groundwater Management Areas under the Groundwater Management Act of 1992. The WFF lies within the Eastern Shore Groundwater Management Area, which includes Accomack and Northampton counties.

3.4.1 Hydrogeology

The Virginia DEQ has identified four major aquifers on the Eastern Shore of Virginia: the Columbia aquifer and the three aquifers comprising the Yorktown-Eastover multi-aquifer system.

The Columbia aquifer is known as the water table aquifer, and primarily consists of Pleistocene sediments of the Columbia Group (**Richardson 1992**). It is unconfined and typically overlain by wind-deposited beach sands, silts, and gravel. The aquifer occurs between the depths of 5 and 60 ft below the ground surface, with the water table ranging between the depths of 0 and 30 ft below the ground surface. Groundwater generally flows east and north toward local tributaries and streams at the WFF, and also toward a marsh area that separates Chincoteague Island from the Eastern Shore mainland to the northeast of the WFF.

The Yorktown-Eastover system is a multi-aquifer unit consisting of late Miocene and Pliocene deposits and is composed of the sandy layers of the Yorktown and Eastover Formations (**Meng**

and Harsh 1988). The top of the shallowest confined Yorktown-Eastover aquifer in the area of WFF is found at depths of approximately 100 ft below the ground surface. It is separated from the overlying Columbia aquifer by a 20 to 30 ft 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.

In general, the water table (Columbia) aquifer on the Delmarva Peninsula is recharged by surface waters or infiltration of precipitation. The total recharge to the Columbia aquifer is estimated to be 257 MGD. Although most of this recharge is eventually discharged to either the Atlantic Ocean or the Chesapeake Bay, an estimated 11 MGD leaks through the first confining unit into the upper portion of the Yorktown- Eastover aquifer. Most of the recharge to the confined Yorktown-Eastover aquifer takes place in a narrow zone along the center of the Delmarva Peninsula called the spine (**EPA 1997**). The confined aquifers are recharged by the same process, but from areas located beyond the immediate vicinity of the WFF.

3.4.2 Groundwater Appropriation

Groundwater from the Columbia and Yorktown-Eastover multi-aquifer system is the sole source of potable water for the vicinity of the WFF. No major streams or other fresh surface water supplies are available as alternative sources of water for human consumption. The Columbia and Yorktown-Eastover multi-aquifer system is designated and protected by the EPA as a sole source aquifer (**EPA 1997**). A sole source aquifer is a drinking water supply located in an area with few or no alternative sources to the groundwater resource, and where if contamination occurred, using an alternative source would be extremely expensive. The 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, to ensure they do not endanger the water source.

Additionally, the Virginia DEQ and the Accomack-Northampton Planning District Committee established a groundwater management program for the entire Eastern Shore that included the development of the Eastern Shore of Virginia Groundwater Committee in 1990 to ensure 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. To implement these goals and track historic groundwater usage, Accomack and Northampton Counties have each drafted Regional Water Supply Plans. The Accomack County Regional Water Supply Plan (**Accomack County 2011**) lists conservation requirements for Groundwater Withdrawal Permits greater than or equal to 300,000 gallons per month; measures include use of water saving equipment and processes, water loss reduction programs, water use education programs, and water reuse programs.

NASA operates five supply wells on the WFF Main Base and two supply wells on the Mainland that serve both the Mainland and Wallops Island. These supply wells are several hundred feet deep (Table 3-4). Four wells withdraw water from the Middle Yorktown-Eastover aquifer and one well

withdraws water from the Upper Yorktown-Eastover aquifer. Eight supply wells are operated, through an easement agreement, by the Town of Chincoteague. Most of the Town of Chincoteague supply wells are several hundred feet deep and are constructed to withdraw water from one of the Yorktown aquifers. Three of the wells operated by the Town of Chincoteague (located near the eastern boundary of the Main Base) are 60 ft or less in depth and withdraw water from the Columbia aquifer on an as needed basis (e.g. times of high demand; summertime). In August 2006, NASA submitted two Ground Water Withdrawal Permit Applications, on for the Mainland (Island) System (Permit Number GW0039300) and the other for the Main Base System (Permit Number ES0038900). Both applications contain water conservation programs consistent with those specified in the Accomack County Regional Water Supply Plan (**NASA 2006a, NASA 2006b**).

However, as a Federal agency, NASA is not subject to the requirements of the Virginia Groundwater Management Act of 1992. Despite this fact, NASA voluntarily monitors its groundwater usage, provides monitoring data to Virginia DEQ, and strives to remain within the limits specified in its historic groundwater withdrawal permits that contain both monthly and annual maxima.

Actual Main Base withdrawals have averaged 1,614,488 gallons per month over the past five calendar years (2011 - 2015). Actual combined Mainland and Wallops Island withdrawals have averaged 1,084,174 gallons per month over the past five calendar years (2011 - 2015).

Table 3-4 NASA Operated Wells Located on Main Base and Wallops Island

Well#	DEQ Well#	Depth (ft)	Pump Capacity (gpm)	Pump Set (ft)	Well Type	Well Status	Screen Interval(s) (ft)
Main Base Wells							
1	100-966	260	171	200	Production	Active	190-200, 210-220, 230-255
2	100-967	150	55	120	Production	Active	100-145
3	100-968	253	214	200	Production	Active	198-218, 223-248
4	100-969	265	163	220	Production	Active	220-260
5	100-970	260	260	175	Production	Active	190-250
Mainland/Wallops Island Wells							
3	100-568	265	175	200	Production	Active	220-240, 245-255
4	100-844	260	275	180	Production	Active	195-215, 225-235

3.4.3 Groundwater Quality

Past contamination at three sites on the Main Base has affected groundwater quality in the Columbia aquifer. Chemical releases at the Former Fire Training Area (FFTA), the Waste Oil Dump, and the Old Aviation Fuel Tank Farm (Old AFTF) have resulted in contaminant plumes.

Water quality in the underlying Yorktown aquifer has not been affected by contamination due to the presence of an aquitard, the geologic layer that prevents groundwater movement from the Columbia aquifer downward into the Yorktown aquifer. WFF has actively treated the contaminant plumes which consist primarily of fuel and oil components.

The water supply wells located at WFF Main Base have not been affected by the contaminant plumes. All of the supply wells are located in the Yorktown aquifer, which is isolated from the overlying Columbia aquifer. The Town of Chincoteague wells located in the Columbia aquifer have not recorded sample results above the EPA-established Maximum Contaminant Levels (MCL). NASA regularly samples the water supply wells and area groundwater to ensure that there are no adverse effects on the drinking water supply. NASA is working with Federal and State environmental agencies to monitor the receding plumes and to restore groundwater to natural conditions.

3.5 Drinking Water Quality

Groundwater drawn from the seven wells shown in Table 3-1 is treated at the WFF water treatment plant in Building D-4. Raw groundwater is treated with liquid chlorine (for disinfection) and zinc orthophosphate (for corrosion control) prior to distribution in the drinking water system. The WFF water treatment plant provides drinking water to the Main Base, Wallops Island and Mainland, and NASA tenants, but not to the Town of Chincoteague. The Town of Chincoteague operates its own water treatment facility for the treatment of raw groundwater drawn from those wells located on the Main Base and operated by the Town. WFF's chemical laboratory performs routine analytical sampling of WFF's potable water systems in accordance with Federal and State requirements and submits the results to the Virginia Department of Health for review.

WFF is required to monitor for disinfection byproducts, specifically trihalomethanes (THM) and haloacetic acids (HAA5). THMs are produced as an incidental by-product during the chlorination of drinking water. As a result of the EPA lowering the total THM (TTHM) threshold levels in 2012, WFF temporarily exceeded the primary maximum contamination levels (MCL) of 80 parts per billion (ppb) for TTHMs. A corrective action was immediately prepared by WFF, and a solution was engineered and implemented to reduce the TTHM levels to less than the newly-established maximum allowable limits. On July 12, 2013 EPA determined that WFF resolved all outstanding issues regarding the drinking water supply.

Because the Main Base is classified as a "community" waterworks, WFF produces an annual Consumer Confidence Report regarding drinking water quality. This document is written in the EPA required format containing information about the levels of any contaminant detected, health related guidance, and sources to contact for additional information. The annual report is provided to all users of the WFF water system, including employees, tenants, and partners.

3.6 Wetlands

In general terms, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. Wetlands are transitional areas between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water (**Cowardin et al. 1979**). Freshwater, brackish and tidal wetland functions and values are based upon: 1) surface-water detention, 2) stream flow maintenance, 3) nutrient transformation, 4) sediment and other particulate retention, 5) coastal storm-surge detention, 6) shoreline stabilization, 7) providing fish and shellfish habitat, 8) providing waterfowl and water bird habitat, 9) providing other wildlife habitat, and 10) conservation of biodiversity (**Tiner 2005**).

Executive Order (EO) 11990, *Protection of Wetlands*, 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 Virginia, projects that impact wetlands may require permits from the U.S. Army Corps of Engineers (USACE), the Virginia Marine Resources Commission (VMRC), the Accomack County Wetlands Board, and/or Virginia DEQ. A Joint Permit Application (JPA) is filed with VMRC. The agency plays a central role as an information clearinghouse for Federal, state, and local levels of review where JPAs submitted to VMRC receive independent yet concurrent reviews by local wetland boards, VMRC, DEQ, and USACE. NASA wetland regulations (14 CFR Subpart 1216.2) outline the required procedures for evaluating actions of NASA that impact wetlands.

Primarily tidal and, to a lesser degree, non-tidal wetlands at WFF have been identified by the National Wetlands Inventory (NWI), a nation-wide wetlands mapping effort conducted by the U.S. Fish and Wildlife Service (USFWS). Wetlands at WFF have been remotely delineated using aerial imagery (**USFWS 2012a**). Additional site-specific delineations have been conducted in support of development activities (**Timmons Group 2009a, 2009b, 2009c**). Confirmed jurisdictional determinations have been obtained from the USACE for portions of the wetlands at WFF. The remaining delineations are for planning purposes only and must be verified by the USACE prior to conducting activities with the potential to impact wetlands. All of the wetland delineations at WFF prior to 2009 were conducted in accordance with the USACE *Wetlands Delineation Manual* (**USACE 1987**) and after 2009 using the new *Regional Supplement to the Wetland Delineation Manual: Atlantic and Gulf Coastal Plane Region* (**USACE 2010**).

Wetland classifications were assigned using the USFWS system: *Classification of Wetlands and Deepwater Habitats of the United States* (**Cowardin et al. 1979**). Under the USFWS system, wetlands are divided into five major systems: (1) marine, (2) estuarine, (3) riverine, (4) lacustrine, and (5) palustrine. A total of 3,940 ac of wetlands have been delineated at WFF: 1.6% are classified as marine, 83.6% as estuarine, and 14.8% as palustrine. No lacustrine or riverine wetlands have been identified.

Wetlands are also classified by the types of dominant vegetation that grow within them. Typical wetland vegetation types encountered on WFF are:

- ***Emergent***—dominated by erect rooted herbaceous, usually perennial plants;
- ***Scrub-shrub***—dominated by woody plants less than 20 ft in height; and
- ***Forested***—dominated by woody plants greater than 20 ft in height.

Figure 3-6, Figure 3-7, and Figure 3-8 illustrate the general locations of wetlands at the Main Base, the Mainland, and Wallops Island.

The Main Base has tidal and non-tidal wetlands along its perimeter in association with Little Mosquito Creek, Jenneys Gut, Simoneaston Bay, and Simoneaston Creek. The tidal wetlands are divided into high marsh, low marsh, and open water areas. The low marsh areas are located between the mean low and mean high tide elevations and are typically flooded twice daily. Low marsh habitat on the Main Base is predominantly covered by salt marsh cordgrass.

High marsh habitat is located just above the mean high tide elevation and is predominantly salt meadow hay (*Spartina patens*), salt grass (*Distichlis spicata*), common reed (*Phragmites australis*), and groundsel tree (*Baccharis halimifolia*) (**Timmons Group 2009a**). Much of the non-tidal wetlands in and around the Main Base are highly disturbed and dominated by species of low ecological value. The non-tidal wetlands areas are predominantly common reed at the lower elevations; thickets of common greenbriar (*Smilax rotundifolia*), poison ivy (*Toxicodendron radicans*), blackberry (*Rubus argutus*), and wax myrtle (*Morella cerifera*) found in higher elevation emergent/scrub shrub systems; and loblolly pine (*Pinus taeda*), red maple (*Acer rubrum*) and sweetgum (*Liquidambar styraciflua*) occurring at the higher forested areas (**Timmons Group 2009a**).

Extensive areas of tidal marsh wetlands also fringe the Mainland along Cat Creek, Hogs Creek, and Bogues Bay. Non-tidal wetlands have been identified in disturbed depressional areas on the Mainland. Vegetation cover of the Mainland wetland areas is very similar to the Main Base wetlands. Wallops Island has non-tidal wetlands located in depressional areas in its interior and extensive tidal marsh wetlands identified on the western edge along Cat Creek. No tidal wetlands have been identified along the eastern Atlantic Ocean side. The vegetative cover of the wetlands located on Wallops Island is very similar to the Main Base wetlands. The wetlands at WFF are part of an extensive ecological wetland network found within Accomack County. As part of their Comprehensive Plan, Accomack County has mapped approximately 109,510 ac of tidal wetlands located within the County. The 3,340 ac of tidal wetlands occurring at the WFF comprise 3.04 percent of the extensive tidal wetlands systems located in the entire County (**Accomack County 2014**).

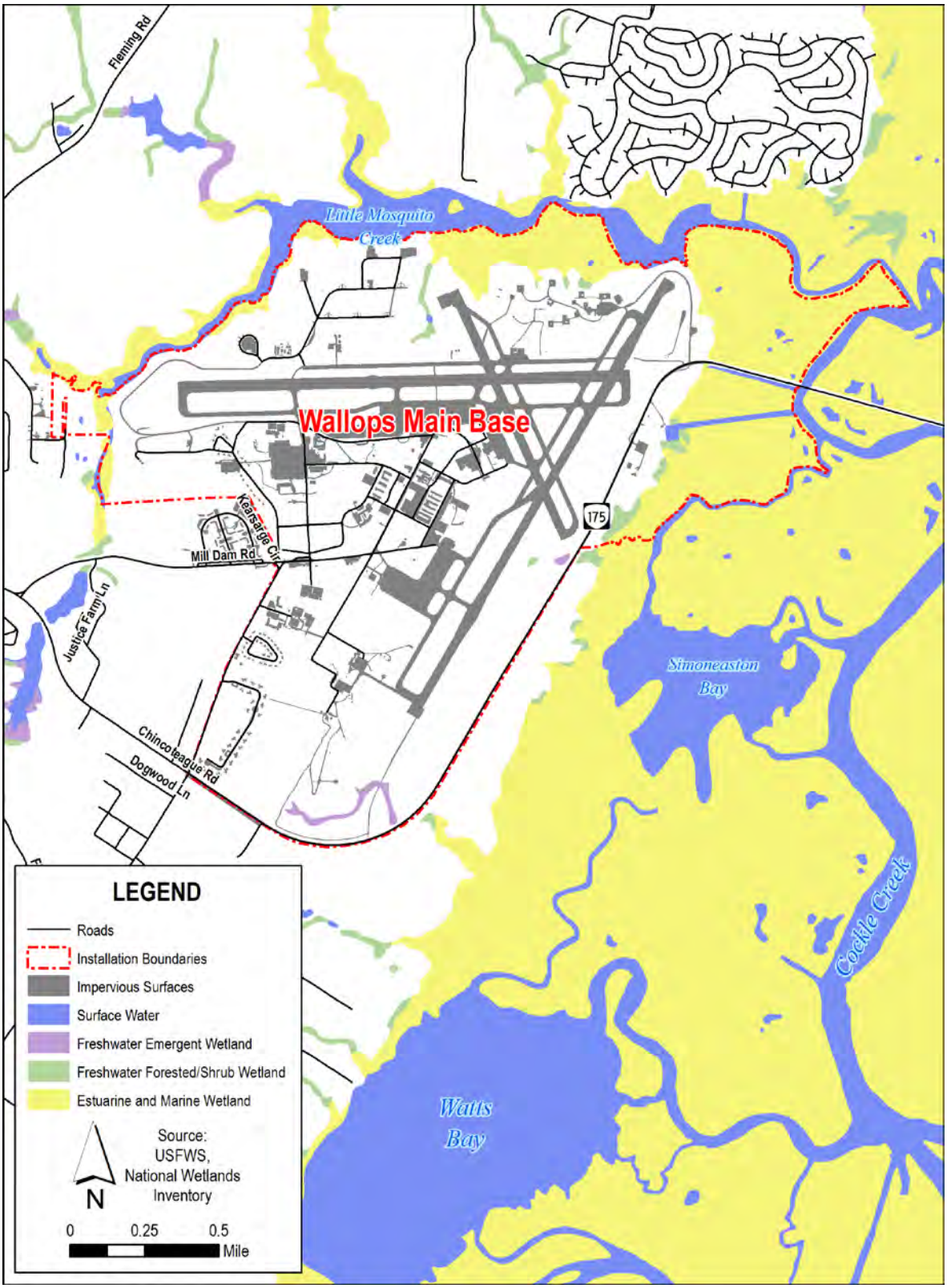


Figure 3-6 Location of Wetlands at the Main Base

Figure 3-7 Location of Wetlands at the Mainland and South Wallops Island

Figure 3-8 Location of Wetlands at North Wallops Island

3.7 Floodplains

Floodplains are lowland areas located adjacent to bodies of water in which the ordinary high water level fluctuates on an annual basis. Along streams and creeks the ordinary high water level may fluctuate as a result of a precipitation event. Tidally influenced waters may fluctuate due to spring tides or as a result of a large storm event (e.g., storm surge). When one of these events is large enough, it causes the water level to exceed the ordinary high water mark and enter the adjacent floodplain. As a result, functioning floodplains provide critical protection for surrounding communities because of their ability to dissipate energy and water from flooding. Any fill to floodplains results in the decrease of the effectiveness of a floodplain to mitigate flooding. Floodplains are often discussed in terms of the 100-year and 500-year floodplain zones. The 100-year flood is a flood having a 1% chance of occurring in any given year. The 100-year flood is also known as the base flood. The 500-year floodplain designates the area inundated during a storm having a 0.2% chance of occurring in any given year. Floodplains are valued for their natural flood and erosion control, enhancement of biological productivity, and socioeconomic benefits and functions.

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. NASA floodplain regulations (14 CFR Subpart 1216.2) outline the required procedures for evaluating actions of NASA that impact the floodplain. Flood Insurance Rate Maps (FIRMs) are produced by the Federal Emergency Management Agency (FEMA). Figure 3-9 and Figure 3-10 illustrate the 100- and 500-year flood zones at the Main Base, the Mainland, and Wallops Island (**FEMA 2013**). Zone A is defined as "areas subject to inundation by the 1-percent-annual-chance flood event. Because detailed hydraulic analyses have not been performed, no base flood elevations or flood depths are shown." Zone V is defined as "Areas along coasts subject to inundation by the 1-percent-annual-chance flood event with additional hazards associated with storm induced waves."

FIRM Community Panels 51001C0265G and 51001C0255G (**FEMA 2016**) show that the 100-year and 500-year floodplains along portions of the perimeter of the Main Base to the northwest, north and northeast and include lower elevation areas primarily defined by topographic ravines of Zone A. Large areas of tidal marsh located to the east are mapped as Zone V along Little Mosquito Creek, and Jenneys Gut. The same FIRM Community Panels indicate the 100-year and 500-year floodplains include much of the area identified as Wallops Mainland; however, these areas are primarily tidal marsh along Hog Creek, Oyster Bay and Bogues Bay. The developed portions of Wallops Mainland are mapped as no flood zone. Wallops Island is located entirely within the 100-year floodplain Zones A and V. Because detailed hydraulic analyses have not been performed, no base flood elevations or flood depths are shown.

The Zone A areas are primarily the more developed higher locations on the Island and the Zone V areas include the beaches and tidal marsh areas.

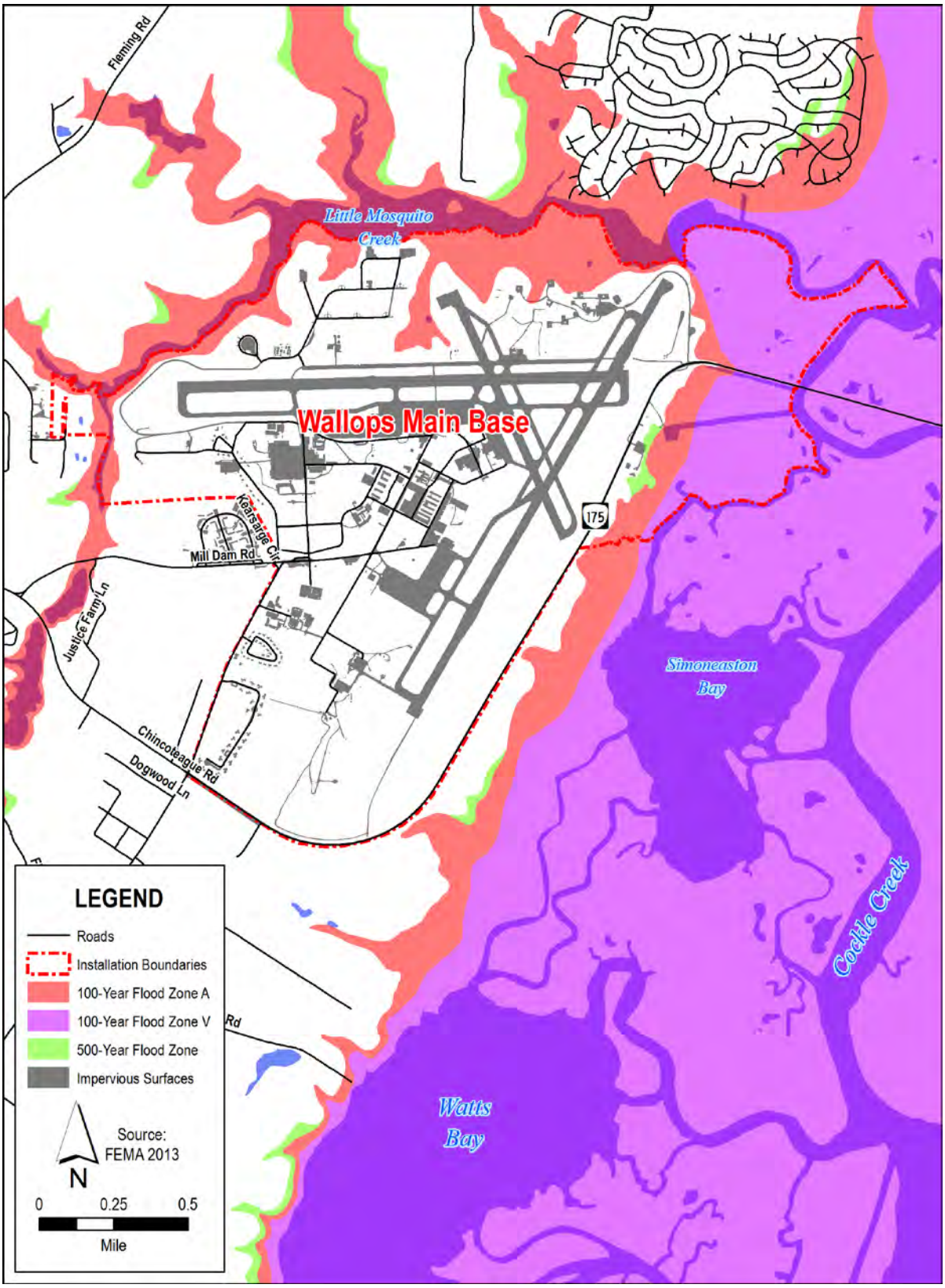


Figure 3-9 Flood Zones at the Main Base

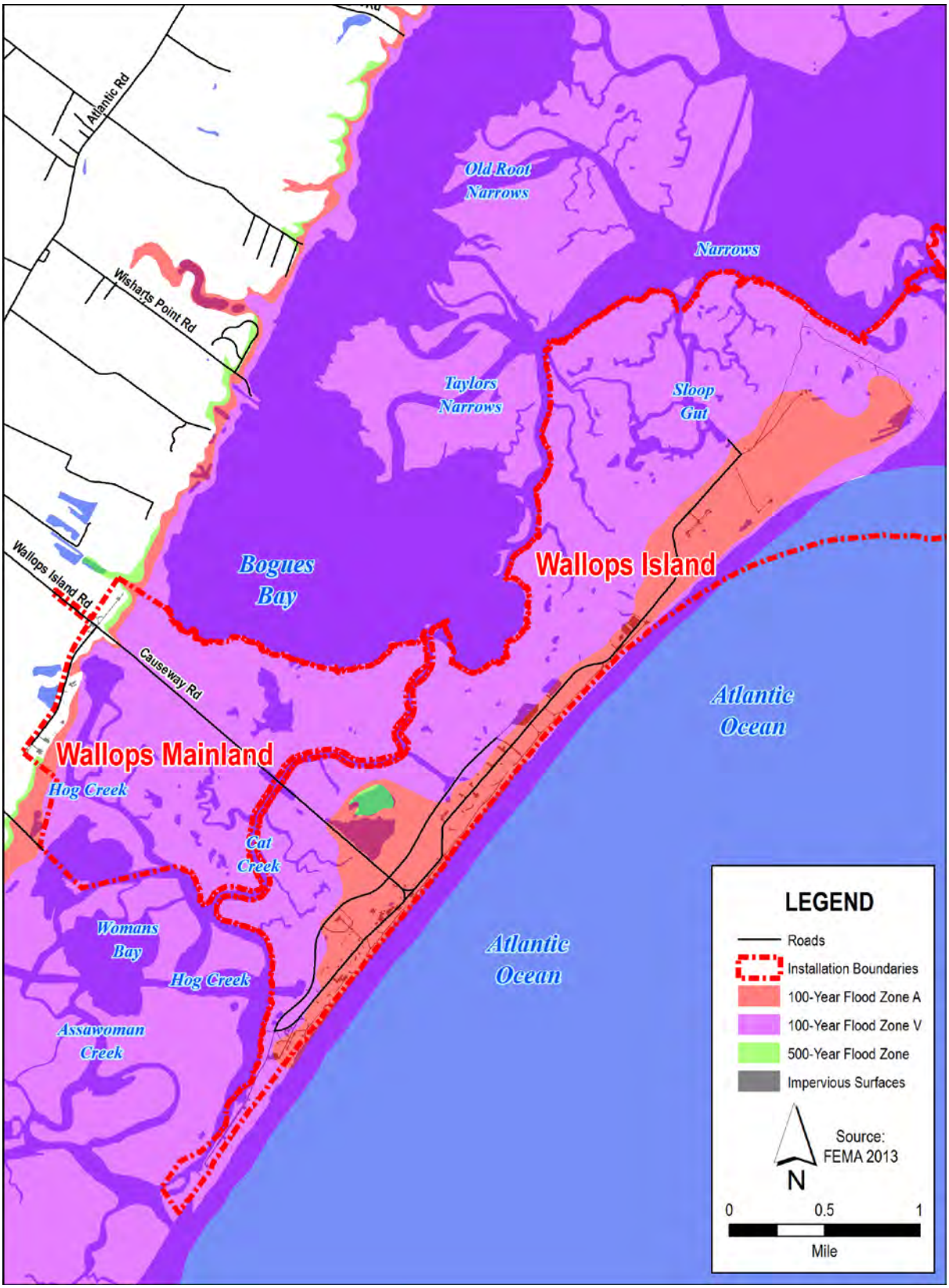


Figure 3-10 Flood Zones at the Mainland and Wallops Island

3.8 Coastal Zone

Under the Section 307 of the Coastal Zone Management Act (CZMA, 16 U.S.C. 1456), Federal agency activities that have coastal effects must be consistent to the maximum extent practicable with federally approved enforceable policies of a state's Coastal Management Program. Virginia DEQ is the lead agency for the Virginia CZM Program, which has been approved by NOAA in accordance with the CZMA. Although Federal lands are excluded from Virginia's Coastal Management Area (CMA), any activity on Federal land that has reasonably foreseeable coastal effects must be consistent with the enforceable policies of the CZM Program (**Virginia DEQ 2011**). Enforceable policies of Virginia's CZM Program that must be considered when making a Federal Consistency Determination include the following:

- **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 DEQ, 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 VDCR, 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 DEQ, the 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 DEQ, this program implements the Federal 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 many activities at WFF may affect the surrounding coastal areas, these actions are subject to the Federal Consistency requirement.

The Coastal Barrier Resources Act (Public Law 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 Coastal Barrier Resources Act does not apply.

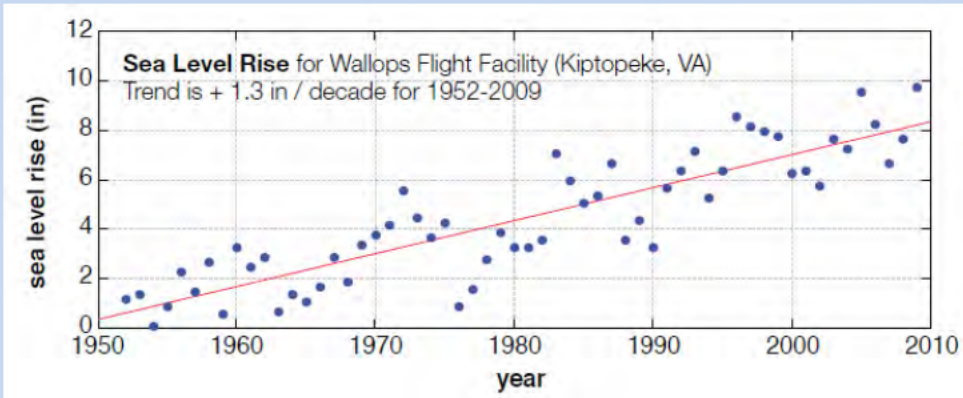
3.9 Sea Level Rise

Sea level is an indicator of the physical and climatic stability of the global environment. A number of factors affect sea level, including changes in sea temperature, salinity, and total water volume and mass. Sea level rises with warming sea temperatures and falls with cooling. Changes in the total volume and mass of ocean water also result from the melting or accumulation of Antarctic and Greenland ice sheets and non-polar glaciers and changes in the amount of water stored in lakes, rivers, and ground water (**EPA 2012a**). Rising sea levels may cause beach erosion, land submersion, wetland loss, coastal flooding, saltwater intrusion into estuaries and aquifers, and greater damages from hurricanes due to higher storm surge (**EPA 2012b**). A June 2012 report from the U.S. Geological Survey (USGS) states that since about 1990, sea level rise in the 600 mi stretch of Coastal Zone from Cape Hatteras, North Carolina to north of Boston, Massachusetts has increased 0.08 to 0.12 in per year whereas the global increase over the same period was 0.02 to 0.04 in per year (**Sallenger et al. 2012; USGS 2012**). This stretch of the Atlantic coast has been deemed a "hotspot" since the rate of sea level rise is increasing three-to-four times faster than globally. The increase in sea level rise is consistent with slowing of parts of the Atlantic Ocean circulation, suggesting that local sea level rise is not just an effect of melting glaciers and ice caps, but also regional changes in water temperature, salinity, and density (**Sallenger et al. 2012; USGS 2012).**

Coastal environments are highly dynamic and particularly vulnerable to climate change. The impacts at WFF would likely include rising sea levels, more frequent flooding, and increasingly intense, unevenly distributed rain events. Wallops Island has experienced shoreline changes throughout the six decades that NASA has occupied the site. Currently, the sandy portion of Wallops Island has an elevation of about 6.9 ft above MSL. The highest elevation on Wallops Island is approximately 15 ft above MSL. Most of the island is less than 10 ft above MSL (**NASA 2010a**). Along with sea level rise, storm surges from hurricanes and nor'easters may increasingly make natural and built systems vulnerable to disruption or damage.

NOAA collects MSL trend data for coastal states. Data collected from Kiptopeke, Virginia (approximately 68 mi from WFF) and Ocean City, Maryland (approximately 49 mi from WFF) are shown in Figure 3-11. The figure indicates that between 1951 and 2006, the average relative sea level rise for this location was 0.137 in per year +/- 0.017 in per year (**NOAA 2012a**). The 100-year projected local sea level rise at Kiptopeke is 1.14 ft (**NOAA 2012a**). Data collected from long-term tidal gauges in Ocean City indicate that between 1975 and 2006, the average relative sea level rise for this location was 5.48 mm per year 0.216 in per year +/- 0.066 in per year (**NOAA 2012b**). Cumulatively, data from Kiptopeke show that sea level has risen about 7 in during the

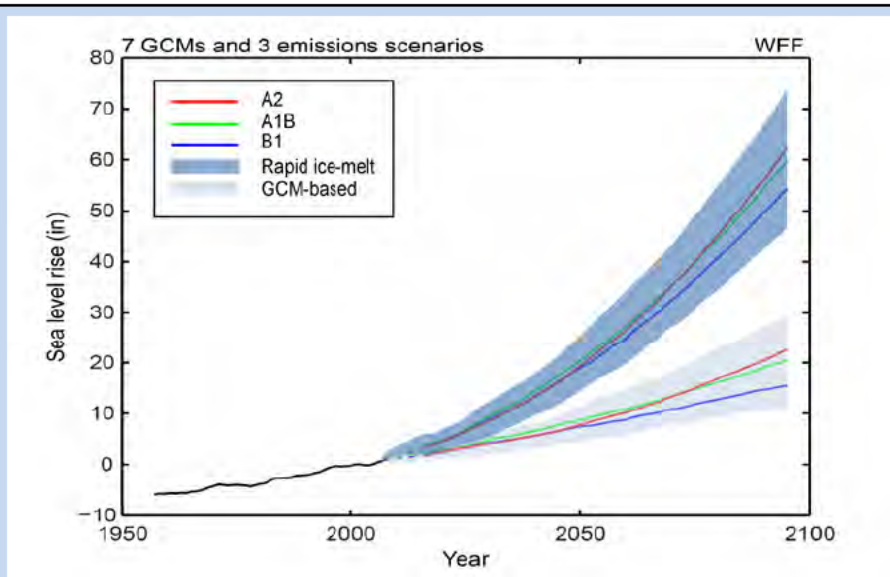
past 60 years. Climate models project continued sea level rise in the region. The 100-year projected local sea level rise at Ocean City is 1.80 ft (**NOAA 2012b**).



Source: NASA 2013.

Figure 3-11 Observed and Projected Sea Level Rise for Wallops Flight Facility

Scientists from NASA's Goddard Institute for Space Studies (GISS) used local data to refine global climate model (GCM) outputs, making the projections WFF-specific, as shown in Figure 3-12 (**NASA GISS 2013**). This "downscaling" process provides a more precise projection for a specific location (in this case the WFF area), than modeling for an entire region, such as the East Coast. Using these models, scientists project rising average sea levels for the Wallops area.



Source: NASA GISS 2013.

Figure 3-12 WFF-Specific Projected Sea Level Rise Scenarios

Figure 3-12 shows the combined observed (black line) and projected sea level rise for two future sea level rise scenarios. Local projections are joined to the observed historical data from Kiptopeke, Virginia. Dark blue shows the range of projections for the rapid ice-melt scenario while

light blue shows the range of projections for the GCM-based sea level rise approach. The three thick lines (green, red, and blue) within each sea level rise scenario show the average for each emissions scenario across 7 GCMs. A ten-year filter has been applied to the observed data and modeled output.

While little change is expected in average annual precipitation, heavy rainfall events may be more intense, leading to increased risks of flooding. Precipitation projections reflect a 30-year average centered on the specified decade; sea levels are averages for the specific decade (Table 3-5). Data for 1971-2000 from WFF provide a baseline for Annual Precipitation (40 in). Sea level data are for Gloucester Point and Kiptopeke, Virginia and include the impacts of subsidence in the area. Precipitation projections are rounded to the nearest 5%, and sea level rise to the nearest inch.

Table 3-5 Projected Changes in Climate Variables

	2020's	2050's	2080's
Average Annual Precipitation, percent	0 to +10	0 to +10	0 to +15
Sea Level, inches	+2 to +5	+7 to +11	+12 to +21
Sea Level-Rapid Ice Melt Scenario, inches	+5 to +9	+19 to +28	+42 to +56

Sources: **NOAA 2012b; NASA 2010a**.

During a storm damage reduction project designed by USACE for Wallops Island, the USACE took historical MSL trend data from Lewes, Delaware; Solomons Island, Maryland; and Portsmouth, Virginia. These locations are near Wallops Island but in widely different compass directions. During a storm damage reduction project designed by USACE for Wallops Island, the USACE took historical MSL trend data from Lewes, Delaware; Solomons Island, Maryland; and Portsmouth, Virginia. These locations are near Wallops Island but in widely different compass directions. Using this data, the 50-year projected local sea level rise was calculated to be 0.56 to 2.25 ft greater than a 2010 baseline condition (USACE 2010 [ERDC study September 2010]). Since the early 1990s, part of Wallops Island has been protected with a stone rubble mound seawall. However, because the seawall structure was being undermined and little or no protective sand beach remained, in 2012 NASA completed an approximately 3.2 million y3 beach replenishment program. As part of the beach renourishment planning process, the USACE estimated the 50-year projected sea level rise to be 1.91 ft greater than 2012 conditions and planned for renourishment sufficient to offset the effects of this rate of sea level rise on Wallops Island (King et al. 2011). Data provided by NASA's Goddard Institute for Space Studies (GISS; GISS 2012) indicated that the USACE estimates may not be sufficient for the upper 75th percentile of sea level rise scenarios which consider a rapid melting of land-based ice. On NASA's behalf, the USACE Norfolk District also oversaw the initial seawall extension between August 2011 and March 2012, with beach nourishment occurring between April and August 2012. Both during and after completing the initial phase of the project, multiple topographic and hydrographic surveys of the project site were conducted. The monitoring effort conducted in November 2012 following Hurricane Sandy (which made landfall in late October 2012), identified the need to repair a section of the seawall and to replace approximately 650,000 y^3 of the recently nourished beach. Between

July and September 2014, this material was dredged from the same location as the initial beach fill and placed along the southern 13,000 ft of Wallops Island.

NASA continues to implement an adaptive management and monitoring strategy for the shoreline restoration program. Throughout the 50 year term of the project, the beach profile in front of the present shoreline would be re-nourished with sand every five years, or as needed. To account for sea level rise impacts to the shoreline at Wallops Island, additional sediment volume would be placed during each beach renourishment event. Modifications would be made as needed to ensure the viability of the long-term project meant to reduce the potential for damage to, or loss of, NASA, U.S. Navy, and MARS assets on Wallops Island from storm-induced wave action and sea level rise impacts. Additionally, NASA established that only infrastructure with a demonstrated need would be allowed to be constructed on Wallops Island. For example, allowable Wallops Island infrastructure investments could include support systems essential for WFF's often hazardous launch site operations or those facilities that must be installed in a maritime environment, as in the case of many U.S. Navy operations.

3.10 Consideration of Climate Change

Because of its location on the Atlantic coast, climate change may be the greatest threat to WFF's long-term sustainability as a national launch asset. The area has always been subject to hurricanes and nor'easters, and the associated high winds and flooding. Accordingly, it is expected that without an adaptation strategy, the climate change-driven combination of rising sea level and severe storms may produce detrimental impacts on WFF and its high profile infrastructure, assets, human capital, and natural resources. Additionally, for any new construction on Wallops Island, climate change-related design considerations would apply, which include a requirement to elevate critical facility support systems (e.g., HVAC, electrical, etc.) such that they would not be subject to flooding, and in many cases, finished floor elevations of occupied facilities must be built at an elevation that is at least one foot above the 100-year flood zone elevation.

WFF is a member of the Eastern Shore of Virginia Climate Adaptation Working Group and in November 2012, held a climate change workshop engaging scientists, local leaders, agencies, and organizations to discuss climate change related issues with a particular focus on the WFF area. On a larger geographic scale, WFF, GISS, and GSFC have partnered with agencies and institutions in the Mid-Atlantic region, (i.e., USFWS, National Park Service, CBFS, the College of William and Mary's Virginia Institute of Marine Science [VIMS], the University of Virginia's Virginia Coast Reserve Long-Term Ecological Research Program, University of Maryland College Park, the University of Delaware's College of Earth Ocean and Environment, and The Nature Conservancy) to form the Mid-Atlantic Coastal Resilience Institute (MACRI). MACRI's mission is to "be the platform to combine and leverage the capabilities of participating institutions to provide an unprecedented integration of science and its applications to support local, state, and regional policy that promotes resilience for both human and natural coastal communities." Outputs of MACRI research are expected to be the most accurate and complete information to support applied science and policy related to coastal resilience in the context of sea level rise, extreme weather events, and

coastal ecosystem degradation in the Mid-Atlantic. Accordingly, the results of these research partnerships will be employed to guide decision making in the implementation of the WFF CMP.

Section 4. Land Resources

4.1 Topography

The topography at WFF is typical of the Mid-Atlantic coastal region, and is mostly flat without unusual features (Figure 4-1). Wallops Island is separated from the Mainland by various inlets, marshes, bays, creeks, and tidal estuaries. During storms, flood water from the Atlantic Ocean moves through these inlets and across the marshes to low-lying areas. The Main Base, Mainland, and Wallops Island lie within "the Tidewater region of the embayed section of the Atlantic Coastal Plain Physiographic Province" (**USDA 1994**). Three major landforms are found in the WFF project area: mainland, tidal marsh, and barrier island.

The majority of the WFF Main Base is located on a high terrace landform (25 to 40 ft above mean sea level [amsl]) with the northern and eastern portions located on low terrace (0 to 25 ft amsl) and tidal marsh. The Wallops Mainland is primarily located on low terrace and tidal marsh, and Wallops Island is a barrier island with extensive tidal marshes between the island and the Wallops Mainland. Presently, the highest elevation on Wallops Island is approximately 15 ft amsl. However, topography on barrier islands changes due to dynamics of ocean currents, wind erosion, and severe weather conditions.

The Wallops Mainland includes low and high terraces separated by a discontinuous escarpment at 25 ft amsl. Low terraces are found west of Route 13 and on the extreme eastern edge of the Mainland. The low terrace "consists of broad to narrow flats bordered by tidal marshes on the east and a discontinuous escarpment on the west" (**USDA 1994**). The high terrace ranges in elevation from 25 to 50 ft amsl. The high terrace topography is more complex than the low terrace, and "is generally characterized by broad, nearly level terraces that are broken by narrow elliptical ridges (Carolina Bay features), gentle escarpments, tidal creek, and drainage ways" (**USDA 1994**). Extensive tidal marshes are located between the mainland and barrier islands. The marshes flood regularly with the tides, are drained by an extensive system of meandering creeks, and have immature soils. Barrier islands are roughly parallel to the mainland and are generally less than 10 ft amsl. Topography varies from nearly level to steep, and soils are immature and vary widely from very poorly to excessively drained (**USDA 1994**).

4.2 Geology

Located within the Atlantic Coastal Plain Physiographic Province, WFF is underlain by approximately 7,000 ft of sediment. The sediment lies atop crystalline basement rock. The sedimentary section, ranging in age from Cretaceous to Quaternary, 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 sediments is to the east, toward the ocean. The two uppermost stratigraphic deposits at WFF 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. 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 60 to 140 ft in Accomack County (**Virginia Division of Minerals 1972**).

4.3 Seismology

Virginia is located centrally on the North American Plate (where the Earth's crust is thicker than at the edges) and has not had a history of seismic activity. Occurring earthquakes rarely measure above 4.5 on the Richter magnitude scale. The largest, at 6.0 magnitude, was recorded in 1897 in the southwestern corner of Virginia in the small town of Blacksburg (**USGS 2014**). In 1993, Texaco, Inc. and Exxon Exploration Company were exploring beneath the Chesapeake Bay for structures that might contain oil and gas. As part of their search, they created a seismic profile of the Chesapeake Bay Impact Center. These profiles showed clearly that a huge peak-ring impact crater is buried beneath the Bay and is centered near the town of Cape Charles on Virginia's Eastern Shore. The crater is approximately, 55 miles in diameter and about 0.8 miles deep (**USGS 2014**). The largest earthquake to recently strike Virginia occurred on August 23, 2011 and registered a magnitude of 5.8 at the epicenter near Mineral, Virginia. Most recently, a 3.2 magnitude earthquake with an epicenter near the town of Mineral, Virginia, was recorded on March 15, 2015, 2014 (**USGS 2015**).

4.4 Soils

The soil classifications for WFF (Table 4-1) are based on the 1988 Accomack County Soil Conservation Service (SCS) soil classification map (Figure 4-2). The Coastal Plain soils of the Eastern Shore are generally very level soils and many soil types are classified as prime farmland by the United States Department of Agriculture (USDA). Prime and unique farmlands in Accomack County are classified as the following soil types:

- 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

The dominant soils are high in sand content, resulting in a highly leached condition, an acidic pH, and a low natural fertility (**USDA 2013**).

Figure 4-1 Topography at Wallops Flight Facility

Table 4-1 Predominant Soil Types at Wallops Flight Facility

Location	Soil Type	Typical Slopes, %	Description
Main Base – inland Areas	Bojac fine sandy loam	0-2	Nearly level, very deep, well-drained soils. Suitable for agriculture.
Main Base – perimeter areas	Molena loamy sand	6-35	Very deep and somewhat excessively drained. The severe erosion potential and low availability of water make it unsuitable for cultivation.
Main Base – perimeter areas	Nimmo sandy loam	0-2	The parent material consists of poorly drained, hydric marine deposits. .
Main Base – around storm drainage and outfalls	Polawana loamy sand	0-2	This component is on marine terraces on coastal plains consisting of very poorly drained marine deposits. This soil is frequently flooded and ponded.
Wallops Mainland – western portion	Bojac loamy sand	2-6	Gently sloping, very deep, well-drained; can be used for cultivation; sloping and erodibility limit its productivity.
Wallops Mainland – middle portion	Magotha fine sandy loam	0-2	Nearly level, very deep, poorly drained hydric soils. This soil provides a suitable wildlife habitat.
Wallops Mainland – eastern and Wallops Island western portions	Chincoteague silt loam	0-1	Nearly level, very deep, very poorly drained hydric soils. This soil provides a suitable wildlife habitat.
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 marshes	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		Moderately sloping and used mainly for wildlife habitat.

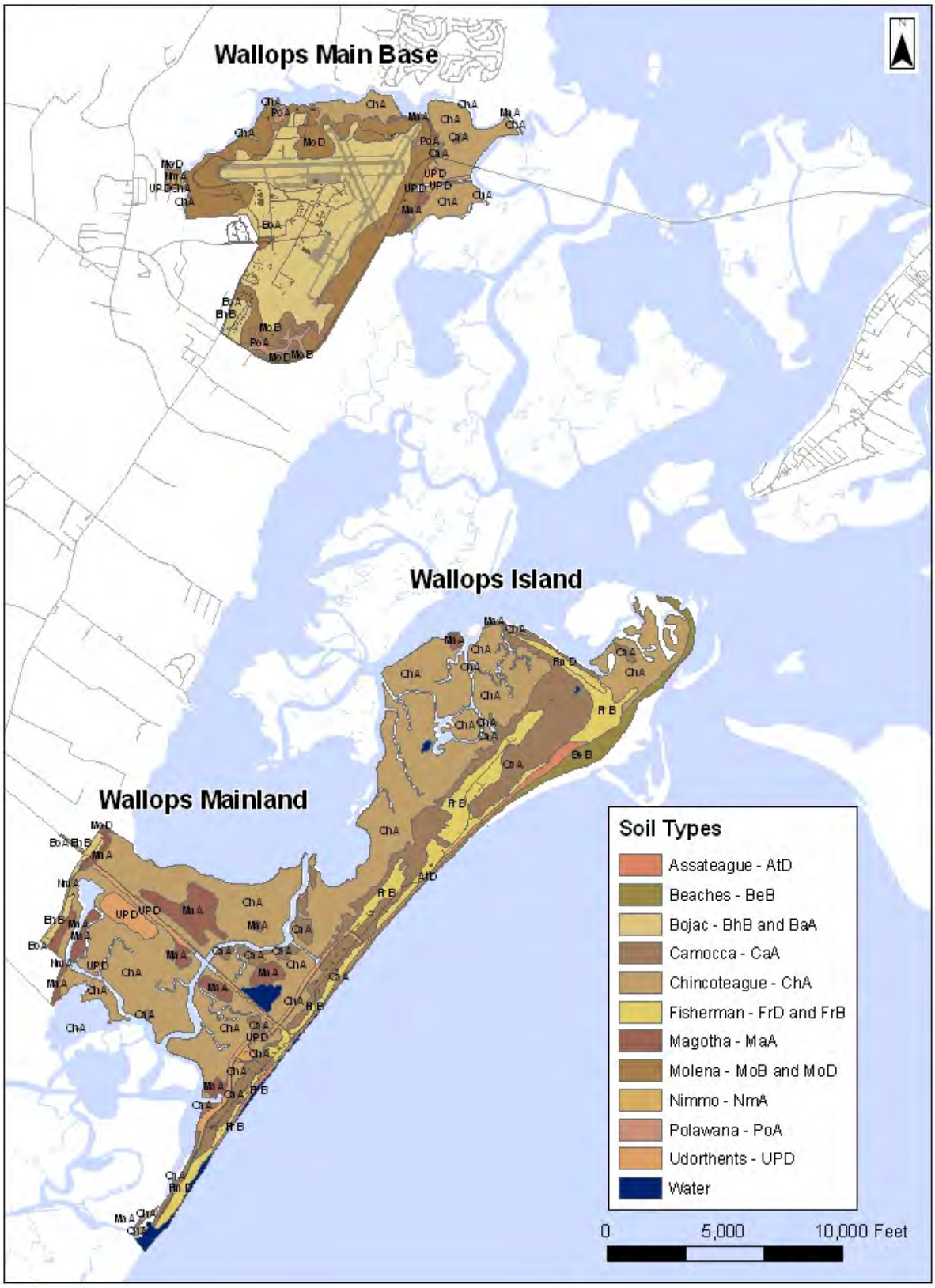


Figure 4-2 Soil Classification

4.5 Drainage

The Main Base has both natural drainage patterns and storm water swales and drains to intercept and divert flow. The natural drainage pattern on the northern portion of the Main Base drains to Little Mosquito Creek and eventually flows to the Atlantic Ocean. The eastern and southeastern portions of the Main Base have a natural drainage pattern that flows to Simoneaston Bay, then into Cockle Creek, Shelly Bay, and Chincoteague Bay, before draining to the Atlantic Ocean. The natural drainage pattern on the western and southwestern portion of the Main Base is toward Wattsville Branch, Little Mosquito Creek, and then on to the Atlantic Ocean. Storm water drains on the Main Base intercept natural drainage ditches and divert the flow to numerous discharge locations. Storm water drains are located throughout the developed portion of the Main Base; the majority of storm water discharges into the surrounding waterways, and eventually to the Atlantic Ocean (see Section 3.2).

On Wallops Mainland, the eastern sloping grade forms a natural drainage pattern that flows toward Hog Creek, and then to Oyster Bay, Assawoman Creek, and finally to the Atlantic Ocean. Surface water on Wallops Island flows east through numerous tidal tributaries and subsequently flows to the Atlantic Ocean. Additionally, Wallops Island has storm drains that divert the water flow to several individual discharge locations (see Section 3.2).

4.6 Landscaping

Fundamental landscaping principles at WFF are adhered to by using native plants whenever possible. In addition, minimal fertilizer, pesticides and/or herbicides are utilized in landscaping management. Watering is only as needed, utilizing a hose from a tank or truck containing water. No irrigation systems exist on the facility.

4.7 Current Land Use

4.7.1 Wallops Flight Facility

WFF is located in Accomack County, Virginia and encompasses approximately 6,030 ac in the northern area of Virginia's Eastern Shore on the Delmarva Peninsula. As shown on Figure 1-1, the facility is divided into three distinct land areas: the Main Base, Wallops Mainland, and Wallops Island. The Main Base is largely developed and consists of various land uses. Most acreage at the Main Base is dedicated to airfield operations. Wallops Mainland is home to long-range radar, communications, and optical tracking facilities. Wallops Mainland consists mostly of marshland. The area between Wallops Mainland and Wallops Island is separated by the Virginia Inside Passage (a public waterway); a causeway and bridge connects the two. In its Comprehensive Plan, Accomack County zoned Wallops Main Base as primarily agricultural with some small portions zoned industrial and general business. Wallops Mainland and Wallops Island are zoned as agricultural (**Accomack County 2014**). Figure 4-3 shows the land uses within WFF overlaying Accomack County Zoning.

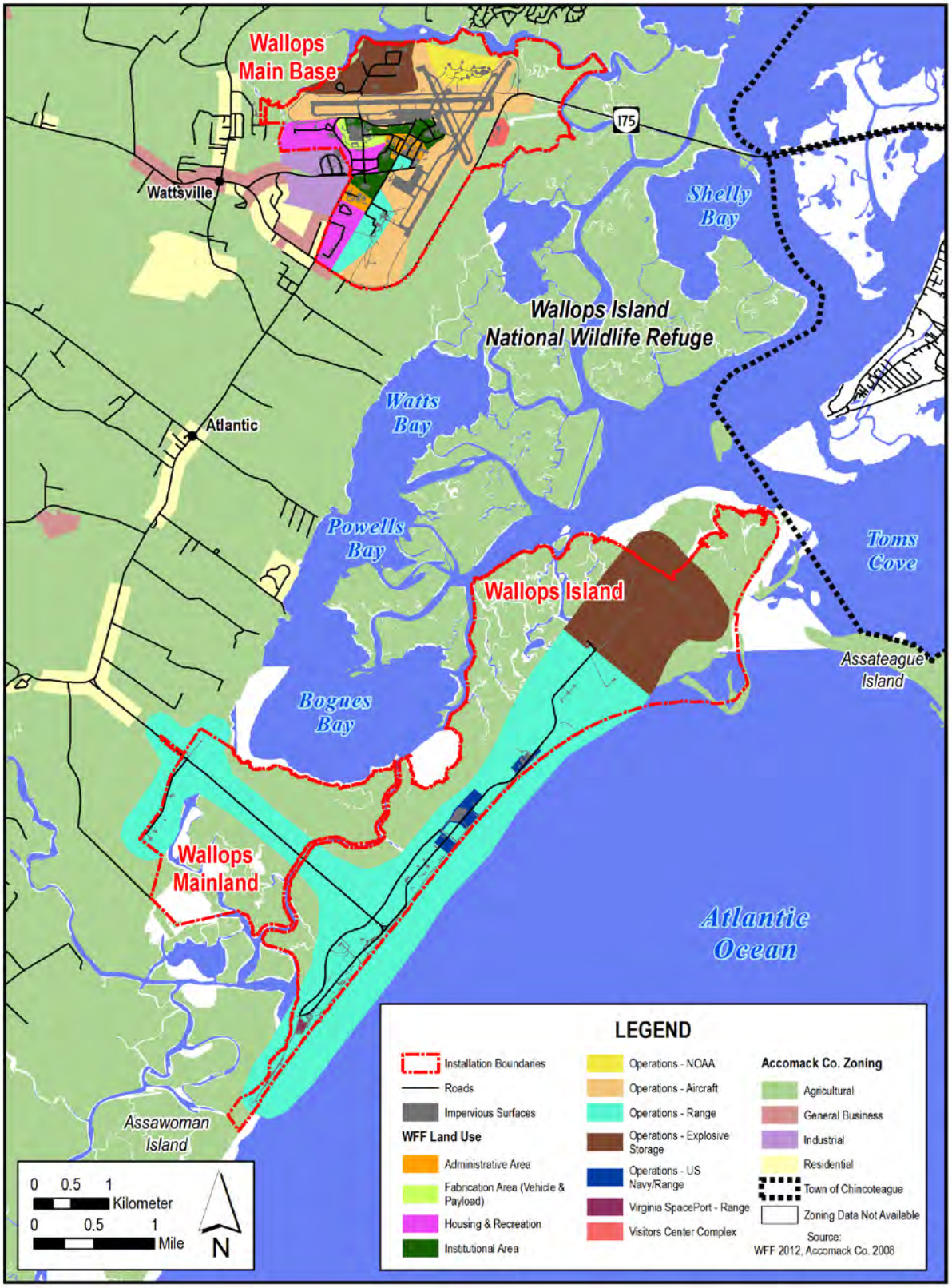


Figure 4-3 Existing Land Uses at WFF and in Accomack County

It should be noted that federal uses and buildings are exempt from local zoning requirements. Notwithstanding this fact, Federal projects, including those at WFF, must take into consideration all requirements (except procedural requirements) of the County's zoning laws (40 U.S.C. § 3312).

Wallops Island is a 6.5-square mile coastal barrier island separated from the Mainland by tidal marshes and waterways. WFF Wallops Island includes launch and testing facilities, blockhouses, rocket storage buildings, assembly shops, dynamic balancing facilities, tracking facilities, UAS airstrips, a Resource Conservation and Recovery Act-permitted open burning area for off-specification rocket motors, Navy SCSC facilities, and other related support structures.

There is one main area designated for recreational use on Wallops Island, a beach area north of the seawall and south of the beach cable barrier. This area is open after operational hours to permanently-badged WFF employees and their guests. The northern portion of this recreational area is closed annually from March through August during protected species (e.g., piping plover, loggerhead sea turtle) nesting season (**NASA 2014b**). A second area, the marsh under the Wallops Island Bridge, is open year round; however, it may only be accessed via boat. All other recreational resources are accessed either by vehicle or foot.

4.7.2 Surrounding Area

Land use surrounding WFF is predominately zoned agricultural, with rural farmland and small villages making up the majority of the surrounding areas (**Accomack County 2014**). Open farmland and forest dominate the landscape. Corn, wheat, soybeans, cabbage, potatoes, cucumbers, and tomatoes are examples of the commodities produced on the surrounding farms. Small tracts of land to the west, directly abutting WFF, are zoned industrial, residential, or general business by Accomack County; however, the majority of the adjacent land is zoned agricultural (**Accomack County 2014**). Towns near the facility are Wattsville, 1 mi west of the Main Base; Horntown, 2.5 mi north of the Main Base; and Atlantic, 2.8 mi southwest of the Main Base. Each of these towns has a population of fewer than 500 people. Area businesses include fuel stations, retail stores, markets, and restaurants.

The Town of Chincoteague, located approximately 5 mi east of the Main Base and 15 mi northeast of Wallops Island, on Chincoteague Island, is the largest community in the area, with approximately 4,300 permanent 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 in July. During the summer months, the Island population expands to approximately 15,000 people (**Town of Chincoteague 2010**). Numerous hotels and restaurants, as well as other seasonally based tourist businesses, can be found on Chincoteague Island.

Wallops Island is adjacent to a number of areas managed for conservation purposes. Located approximately 19 miles northeast of the boundary of Wallops Island is the Assateague Island National Seashore (Figure 1-1) which is managed by the National Park Service. Adjacent to Assateague Island and northeast of Wallops Island is the Chincoteague National Wildlife Refuge (NWR), managed by the USFWS. Immediately south of Wallops Island is Assawoman Island, a

1,420-acre parcel also managed as part of the Chincoteague NWR by the USFWS. A string of undeveloped barrier islands, managed by The Nature Conservancy as part of the Virginia Coast Reserve, extends southeasterly along the coast to the mouth of the Chesapeake Bay.

The Wallops Island NWR is located east of the Main Base and is under the jurisdiction of the USFWS. This refuge, which is not open to the general public, consists of approximately 373 acres of mostly salt marsh and some forested land across Route 175 from the Main Base. Additionally, the USFWS, through the Chincoteague NWR, has an agreement with NASA to use Wallops Island on a non-interference basis for research and management of declining wildlife species in need of special protection.

4.7.3 Land Use Plans

The Center Master Plan (CMP) for WFF is a 20-year plan, fiscal year (FY) 2007 to 2027, based on the strategic vision to maintain and strengthen WFF's role as a world-class launch facility and research institution (**NASA 2008a**). Per NPR 8810.1, *Master Planning Procedural Requirements*, the WFF is required to develop and maintain a CMP that addresses a planning horizon of not less than 20 years. The document is a living document and is meant to be revisited and updated every 5 years. The CMP serves as the framework for all future construction and demolition projects.

The primary purpose of the CMP is to guide the orderly management and future development of WFF's real property assets in a way that supports, sustains, and meets the needs of NASA's current and future missions and reflects its vision. The near-term implementation plans are used to evaluate the resource requirements for programs, projects, and assets required to move those projects forward and are used as tools for the development of WFF budgets as well as program and project planning. All planning activities refer to the CMP in order to ensure the efficient and effective use of real property resources. The CMP provides information needed to make well-informed business and planning decisions and facilitates coordination with Center supported programs, customers, and stakeholders, including local, state and other federal organizations. It also enables the development of plans that are safe, practical, and reflect the WFF's stewardship role towards its environment and cultural resources. All land disturbing activities are evaluated for consistency with the WFF CMP.

Encroachment is the location of any activities that will, today or over time, result in operational constraints, public safety problems, or public pressure to stop operations that are perceived as a nuisance to residents. The potential for encroachment (of many types) is a threat to future potential at WFF. Together, WFF and the Eastern Shore Defense Alliance have made the following recommendations to Accomack County for long-term growth and viability of WFF facilities (**Accomack County 2014**):

- Land Use – Intensive land development, particularly residential development, schools, stores, and offices, is incompatible with the Wallops operations due to operational safety issues. NASA has identified Airfield Accident Potential Zones and Launch Range

Hazardous Zones with go, no-go launch criteria to illustrate where these incompatible uses should not be located.

- Noise – A 'Noise Awareness Area" could be created to make prospective homebuyers aware of potential aircraft operation and electromagnetic issues.
- Radio Frequency (RF) and Electromagnetic (EM) – New homes and businesses built near WFF operational areas increases the potential for RF and EM interference. Home-based transmitters can interfere with WFF receivers and WFF emitters can interfere with sensitive radio and television systems. New cell phone towers may cause RF and EM interference, and tall towers may present a safety hazard to low-altitude aircraft flights.
- Offshore Drilling – Placing privately owned towers or other structures offshore would severely constrain or eliminate existing and future Wallops range operations.
- Offshore Wind Farms – Placing privately owned towers or other structures offshore would severely constrain or eliminate existing and future Wallops range operations.

The current *Accomack County Comprehensive Plan* was amended in February 2014 and is intended to guide the future social, economic and physical development of Accomack County to ensure the provision of adequate, quality, community facilities and the maintenance of a healthy, safe, orderly, and harmonious environment (**Accomack County 2014**). The following goals are presented in the comprehensive plan and are intended to shape and support growth, development, and quality of life in Accomack County:

- Have a strong, viable, rural community proud and supportive of its history, diversity, bountiful resources, traditional industries, and vision for the future.
- Have safe, clean, convenient, and efficient community services and facilities for transportation, recreational opportunities, government services, and disposal of wastes.
- Have a balanced, safe, and desirable patter of land use that protects and conserves agricultural land, forest land, groundwater, surface water, wetlands and other valuable resources, providing an excellent resource base for wildlife habitat, recreation, agriculture, seafood industries, and tourism.

With respect to land use, the comprehensive plan presents objectives and policies that are intended to guide future growth and development toward existing population centers and previously-developed areas so as to minimize the extension of public facilities (water, sewer, and other utilities), encroachment on natural areas, and inappropriate development (such as housing and schools) in proximity to WFF. In the *Comprehensive Plan*, Accomack County lists the following recommendations with regards to reducing and preventing encroachment of the surrounding community onto WFF missions:

- Explore the creation of airfield noise awareness areas for prospective home buyers.
- Explore the use of conservation easements on sensitive natural areas.

- Explore modifying the existing Accomack County zoning, including limiting the population density within the Red Accident Potential Zones of the airfield (**Figure 4-4**) and within 10,000 ft of Pad 0-B.
- Explore restricting storm water ponds that attract wildlife, types of lighting that interfere with pilot's vision, and Radio Frequency emitters that would require Federal Communication Commission licensing.

NASA has recently participated with Accomack County and the Navy's Surface Combat Systems Center in the Accomack County / Wallops Island Joint Land Use Study (JLUS). A primary input to the JLUS was WFF's range hazard areas within the County where special considerations (e.g., temporary relocation of residents) could be necessary to ensure both public safety and NASA's ability to meet mandatory range safety criteria. The principal objective of the JLUS was to identify land use issues that may impact the operational capabilities of WFF, and to identify actions participating agencies can pursue to ensure that incompatible development does not impact the facility's future mission requirements. Through the JLUS process, an action plan to guide future planning efforts was established. Below are the short-, mid-, long-term, and ongoing recommendations from the JLUS:

- Establish an Accomack-Wallops Working Group (AWWG)
- Amend/Update the Accomack County Comprehensive Plan
- Pursue available grants and/or supplemental funding sources for JLUS recommendations implementation
- Establish a process for identifying County strategies to address incompatibilities within the WFF aircraft clear zones
- Establish a collaborative review process for requests relating to development of wind turbines, cell towers, radio frequency emitters or structures
- NASA/Navy notify Accomack County and AWWG of offshore energy development to identify potential operational interference
- Establish a range hazard notification area and provide notifications of hazards associated with rocket launches
- Establish a WFF Aircraft Operations Overlay District and amend the Accomack County Zoning Ordinance and Subdivision Ordinance for compatible land use in Clear Zone, Accident Potential Zone (APZ)-1, APZ-2, and other affected areas
- Adopt measures for early and full real estate disclosure with respect to properties located within aircraft accident potential and noise zones including pursuing amending Virginia legislation 55-517/55-519 (required disclosures) to divulge WFF aircraft operations on the WFF Main Base airfield
- Provide information regarding incentives for retrofits to windows on existing buildings within the range hazard area
- Encourage the application of noise attenuation measures within the aircraft noise zones as part of the permitting process for new construction

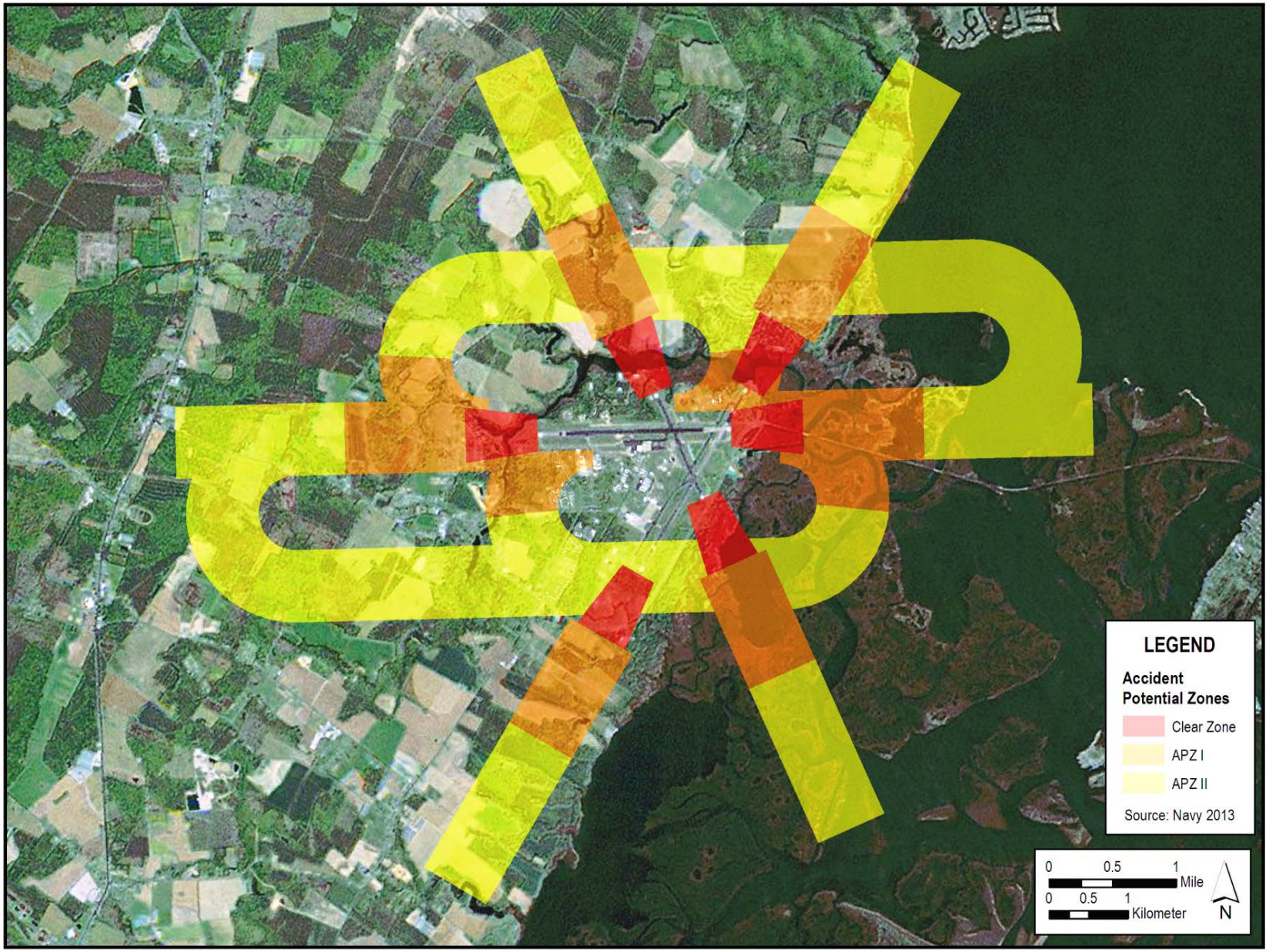


Figure 4-4 WFF Airfield Accident Potential Zones

- Develop a plan for mitigating and/or accommodating the effects of recurrent flooding, storm surge events, and sea level rise for the Navy, NASA, and MARS/VCSFA facilities on Wallops Island
- Develop a plan for mitigating and/or accommodating the effects of recurrent flooding, storm surge events, and sea level rise for the coastal areas of Accomack County within the study area
- Provide an annual update to the Accomack County Board of Supervisors regarding JLUS implementation progress
- Update the Accomack County GIS database with JLUS data following adoption by the County Board of Supervisors

While each of the aforementioned recommendations inherently requires collaboration among Accomack County, NASA, the U.S. Navy, and other related entities, the majority of the JLUS recommendations would require adoption by the Accomack County Board of Supervisors before they could be implemented.

4.8 Environmental Restoration Program

The WFF Environmental Restoration Program (ERP) is responsible for the planning, implementation and oversight of the Environmental Compliance and Restoration Program at WFF to ensure that contaminated sites from past activities are adequately addressed to protect human health and the environment. Formal environmental investigations on a facility-wide basis began in 1988 and continue today as an active program with the EPA and the DEQ providing oversight.

The ERP manages the investigation, response, and remedial activities of the historically contaminated NASA sites at WFF under the Administrative Agreement on Consent (AAOC) executed between NASA and U.S. EPA (**EPA 2004**). The AAOC was issued under the authority of the Resource Conservation and Recovery Act as amended by the Hazardous and Solid Waste Amendments, and by agreement integrates Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act, into meeting the obligations of the AAOC with NASA as the lead agency. The AAOC applies to Areas of Concern (AOCs) from past releases of hazardous substances, waste and/or constituents by NASA at WFF and identifies CERCLA response requirements, policies, and guidance as the primary process for planning for and performing the work necessary to complete remedial and corrective actions appropriate to those releases.

For sites involving only past petroleum contamination or releases, NASA manages the investigation, response, and remedial activities with oversight from Virginia DEQ, Tidewater Regional Office, located in Virginia Beach, Virginia. NASA follows guidelines in general accordance with the DEQ's May 10, 2011, *Guidance Document #01- 2024 Petroleum Storage Tank Program Technical Manual* and October 12, 2001, *Guidance Document #01-2025 Petroleum Storage Tank Program Compliance Manual.*

NASA has also established an Administrative Record (AR) that contains CERCLA and ERP related documents. Copies of the AR are located at the WFF Environmental Office (Building F-160), Eastern Shore Public Library in Accomack, Virginia and the Island Public Library in Chincoteague, Virginia. NASA will continue to maintain and update the AR as documents are generated during the ERP.

In addition to the NASA restoration programs at WFF, the USACE has an active ERP at WFF. NASA acquired the Main Base and northern Wallops Island from the Navy in 1959. From 1943 to 1945, the Navy operated an aviation training facility and coastal surveillance operations, housing a few hundred personnel. After World War II, the facility expanded to the present size as the Naval Air Station with several squadrons, and the Naval Aviation Ordnance Test Station for ordnance, weapons, and radar testing, with a combined housing of 1,500 to 2,000 personnel. Some of the AOCs identified in the initial surveys were identified as being associated with activities that solely took place during DoD ownership of the Former Chincoteague Naval Air Station, prior to NASA presence. Because of this finding, the USACE, in consultation with NASA, EPA, and DEQ, conducted a series of assessments and investigations to determine responsibility and eligibility for these AOCs under the Formerly Utilized Defense Sites (FUDS) program at the Former Chincoteague Naval Air Station. This program authorizes the USACE as the lead DoD agency for the environmental restoration of properties that were formerly under DoD control.

The FUDS program, which initially began at WFF in 1998 and increased investigation efforts in 2008, has evaluated over 200 Areas of Interest, within sixteen projects which are categorized by program type including: Hazardous, Toxic and Radioactive Waste (HTRW) Projects, Containerized HTRW Projects, Military Munitions Response Program (MMRP) Projects, and Potentially Responsible Party (PRP) Projects. Each project area may include several sites designated as potential Areas of Interest related to historic DoD activities conducted at the sites. The initial USACE documents that present the findings of these assessments include a Site Characterization Report, Site Investigation Report, and Desktop Audit and Site Screening Process Report (**USACE 1999; USACE 2003a; USACE 2003b**).

In addition to these reports, the USACE and the EPA each completed aerial photographic analysis of the facility. The purpose of the analysis was to review historical and current aerial photographic images along with facility environmental documents to evaluate the characteristics of known AOCs and to identify other potential AOCs (**USACE 2000; EPA 1996; EPA 2004**). In conjunction with an Inventory Project Report, identifying FUDS Projects, the USACE has prepared two Preliminary Assessment Reports, which serve three purposes: 1) eliminate AOCs that pose little or no threat to public health or the environment; 2) determine if there is any potential need for a removal action; and 3) set priorities for remedial site inspections. Preliminary Assessment I was finalized in September 2011 and the USACE began several Site Investigations within the FUDS Projects thereafter. Many of the Areas of Interest have been eliminated as AOCs during the Site Investigation phase; however, the USACE has initiated a Remedial Investigation at some of the project AOCs. Preliminary Assessment II, which addressed Areas of Interest not

included in Preliminary Assessment I, was provided to EPA, DEQ, and NASA in July 2013. Over 130 AOCs were determined as a result of the two Preliminary Assessment Reports.

In February 2015, NASA, USACE, and the Department of the Army signed a Memorandum of Agreement which divided responsibilities for response actions between NASA and USACE. NASA agreed to assume responsibility of 104 structures (buildings, tanks, substructures, etc.) and to assume responsibility for further investigations and actions for AOCs related to transformers left in place when the Navy ceased operations on Wallops Island. For Wallops FUDS, NASA agreed to complete the future investigation and response actions using Environmental Restoration, FUDS, (ER,F) funds appropriated to the Department of Defense and transferred to NASA. USACE will continue with current ER,F funded project activities while FUDS Projects are transitioned to NASA.

Several AOCs have been identified at WFF as a result of a series of assessments conducted under the oversight of EPA and DEQ (Figures 4-5- and 4-6). Projects include NASA sites, former Navy sites (FUDS), and petroleum-related sites contaminated from past operations. Projects are prioritized to ensure that sites with the highest priority are addressed first in order to protect human health and the environment and preserve natural resources for future missions. Currently, NASA has 27 AAOC CERCLA Sites (10 of which are active), 104 Former Navy Areas of Concern (three of which require site investigations), and 22 petroleum sites (one of which is active); 15 ER,F Projects (13 of which are active). In addition to the CERCLA and petroleum sites, potential Munitions and Explosives of Concern (MEC) sites were identified on Wallops Island and the WFF Visitor Center/Boat Basin area. WFF implemented an MEC Safety Awareness program to mitigate immediate risks to employees and the public at these sites while long-term action are evaluated.

NASA and USACE coordinates activities at the AOCs with EPA and DEQ, and has taken actions to address potential risks, on a priority basis, under the appropriate environmental and regulatory programs. Actions conducted at the AOCs include supplemental investigations, sampling programs, removals, product recovery, remedial investigations, feasibility studies, remediation, long term monitoring, and closeout. As such, land use restrictions and institutional controls currently exist at some of these sites to prevent future development and groundwater usage. The current status of each AOC is summarized in **Error! Reference source not found.**, Table 4-3 and Table 4-4.

Table 4-2 WFF Areas of Concern

Site Name	Location	Site Description: Nature and Extent of Contamination and Current Status
Maintenance Facility Building E-52	Main Base	Former Navy carpool and maintenance shop. Soils: PAH, metals, and pesticide concentrations exceed RBC. Groundwater: No contaminant of concern. **Site closed under AAOC with a No Further Action determination in 2006.**
Island Debris Pile	Wallops Island	Former debris pile from historic Navy and NASA operations. Soil: Metals, pesticides, SVOC, PCBs, and TPH levels above background levels. Groundwater: Metals present above human-health screening levels but similar to background levels. Debris removal and Non-Time Critical Removal Action Completed. **Site closed under AAOC with a No Further Action determination in 2012.**
Paint Stain and Former Wind Tunnel Sites (Sites 5 and 12)	Wallops Island	Soil and Sediments: Metals, pesticides, PAH, and PCB above RBC and ESV. Surface Water: Contaminant levels below AWQC. Note: Removal action for PAH contaminated soils completed in 2003. Remedial Investigation/Feasibility Study and Proposed Remedial Action Plan finalized in 2009. Record of Decision signed in December 2011. Remedial Action including the excavation and offsite disposal of soils and sediments and the demolition and removal of Building X-115 and associated concrete was completed in July 2013. **Site closed under AAOC with a No Further Action determination in June 2014.**
Former Transformer Pads	Main Base, Mainland, Wallops Island	Past use of electrical transformers containing PCB dielectric fluids. Soil: PCB below regulatory action levels. **Site closed under TSCA with a No Further Action determination in 2005.**
Advanced Data Acquisition System (ADAS Radar Tower)	Main Base	Former antenna and support structures associated with leaking hydraulic fluid. No unacceptable CERCLA risk to human health or environment. **Site closed with a No Further Action determination in 2003.**
Former Transformer Storage Areas	Main Base, Wallops Island	Past temporary storage of out-of-use electrical transformer containing PCB dielectric fluids. Soil: PCB below regulatory action levels. **Site closed under TSCA with a No Further Action determination in 2005.**
Waste Oil Dump	Main Base	Past surface and subsurface disposal of waste oils and flammable liquids. Soils: No unacceptable risks to human health or the environment. Groundwater: Solvent and petroleum-related contaminant levels exceed RBC and present an unacceptable risk to human health under residential scenario risk. Final remedy (biostimulation, institutional controls, and monitoring) documented in ROD and implemented. Long-term monitoring and reporting is ongoing.
Former Fire Training Area	Main Base	Past fire-fighting training exercises. Soils: No unacceptable risks to human health or the environment. Groundwater: Solvent and petroleum-related contaminant levels exceed RBC and present an unacceptable risk to human health and the environment under the residential scenario. Final remedy (biostimulation, institutional controls, and monitoring) documented in ROD and implemented. Long-term monitoring and reporting is ongoing.

Table 4-2 WFF Areas of Concern

Site Name	Location	Site Description: Nature and Extent of Contamination and Current Status
M-15 Photographic Tank	Main Base	Former wastewater processing tank and drain field. Soils and sediments: Metals present at levels above ESVs but site-specific toxicity and contaminant distribution indicated a low probability of ecological risks above background levels. **Tank was demolished and the Site closed with a No Further Action determination in 2007.**
N-222 Scrapyard	Main Base	Soils: PCB and radioisotope contaminated soils removed in 2003. No unacceptable site-related risks. Groundwater: Low-level VOC in groundwater similar to background levels. No unacceptable site risks. No Further Action Record of Decision in March 2008. **Site closed with a No Further Action determination in 2008.**
Main Base Firing Range	Main Base	Former pistol, rifle, skeet, and aircraft firing ranges. Soils and sediment: Target areas at Pistol and Rifle Ranges contain metals and nitroglycerin above residential and ecological risk-based screening levels. Skeet Range soils contain lead shot and lead and PAH concentrations present a potential risk to residential users and ecological receptors. Sediment/soil downgradient from the Skeet Range contains lead above residential action levels. Skeet Range actions addressed under FUDS Project 9. Groundwater: No unacceptable risk to human health or the environment. NASA completed a Non-Time Critical Removal Action at the Pistol and Rifle Ranges in FY16. No Further Action decision anticipated for FY 17.
South End Disposal Area	Wallops Island	Miscellaneous debris and military MEC deposition within berm. Limited Response Action conducted including removal of the berm, concrete, and MEC items. Soils, sediment, and groundwater: Elevated metal concentrations detected during Site Screening. **Site closed with a No Further Action determination in 2014.**
Area of Interest-20	Wallops Island	Pole-mounted transformer identified as abandoned remnant from 1950s. Soils: PCBs detected above regulatory action levels. Site Screening activities conducted in FY 15 and Time Critical Removal Action completed in FY15. **Site closed with a No Further Action determination in 2016.**
North Island Transformer Sites	Wallops Island	North Island Transformer Sites includes 17 former electrical poles/transformers. Site Screening activities completed; transformer and soil removal planned for 4 of 17 locations. Soils, Sediments: PCBs detected above regulatory action levels. Time Critical Removal Action completed for North Island Transformer locations NIT-1, NIT-7, NIT-14, and NIT-17 in FY 16. A No Further Action determination is anticipated in FY17.
Site 6 – Former Island Fueling Station	Wallops Island	Former service station and petroleum storage tanks. Soils: TPH-DRO above Virginia DEQ Soil Saturation Levels. Bioventing system installed in 2006. Quarterly monitoring was conducted per Corrective Action Plan. **Site closed in August 2008.**

Table 4-2 WFF Areas of Concern

Site Name	Location	Site Description: Nature and Extent of Contamination and Current Status
Old Aviation Fuel Tank Farm	Main Base	Former Aviation Fuel Tank Farm. Soils: TPH-DRO Groundwater: BTEX, lead Air Sparging/Soil Vapor Extraction system installed December 2004. System was decommissioned in 2010; Currently annual groundwater monitoring is conducted for source, sentry, and Town of Chincoteague wells.
Site U-48 – Former Fuel Spill and Landfarm	Mainland	Former spill site and landfarm cell. Soil: TPH-DRO Groundwater: TPH-DRO **Site closed with a No Further Action determination in December 2004.**
Site U-30 – Former Bioventing System	Wallops Island	Former AST with associated petroleum contamination. Bioventing system installed in 1993. **Site closed with a No Further Action determination in 2006.**
Site D-8 – Fuel Oil Spill	Main Base	Site of two 20,000 gallon ASTs where historic spills have occurred. Soils and Groundwater: TPH-DRO. **Site closed with a No Further Action determination in January 2008.**
Site 8 – Main Base Fueling System	Main Base	Site of former fueling station. Soils: TPH-DRO and TPH-GRO – below regulatory guidance. **Site closed with a No Further Action determination in 1999.**
Former Power Generating Plant	Wallops Island	Former power generating plant utilized for wind tunnel operations. Soils: TPH-DRO **Site closed with a No Further Action determination in August 2008.**
D-37 Aviation Fuel Tank Farm	Main Base	Former Aviation Fuel Tank Farm – contained five 20,000-gallon single-walled USTs, three 10,000-gallon double-walled USTs, and one 12,000-gallon spill containment tank. Removal of tanks and soil conducted in 2011. **Site closed with a No Further Action determination in February 2012.**
D-102/D-103 ASTs	Main Base	Former 125,000-gallon steel tanks used for the storage of No. 6 fuel oil for the Main Base boilers (D-8). Historic spills were documented at the site. Soils: TPH-ORO **Site closed with a No Further Action determination in November 2012. Tanks removed in July 2013.**
A-7 Auxiliary Power Building Underground Storage Tank	Main Base	Former unknown 5,000-gallon underground storage tank identified following construction of a storm drain line. Aboveground vent pipe was cut allowing rain water to enter the tank and displace residual fuel. Soils: TPH-DRO Removal of tank, contents, and impacted surface soils completed in 2015. **Site closed with a No Further Action determination in May 2015.**
FUDS Project 3 (MMRP) – Gunboat Point, Strafing Target, Target Center, and Explosive Ordnance Disposal Area	Wallops Island	Multiple MMRP Sites located on Northern Wallops Island. Contaminants of Potential Concern (COPCs): MEC, metals Site Investigation completed in 2011; MEC institutional controls in place. NASA Remedial Investigation planned for Fiscal Year 2020 with ER,F funding.

Table 4-2 WFF Areas of Concern

Site Name	Location	Site Description: Nature and Extent of Contamination and Current Status
FUDS Project 4 (MMRP) – Machine Gun Rocket Firing Area	Wallops Island	MMRP Site used to test aircraft machine guns and cannons. Included a 175-yard, a 500-yard, and a 750-yard range. COPCs: MEC, metals Site Investigation completed in 2011; MEC institutional controls in place. NASA Remedial Investigation planned for Fiscal Year 2021, with ER,F funding.
FUDS Project 5 (MMRP) – Grebe Range and Explosive Ammunition Test Facility	Wallops Island	MMRP Site included a Grebe/Kingfisher missile range, 20-mm gun, ammunition testing facility, and associated structures. COPCs: MEC, metals, VOCs, SVOCs Site Investigation completed in 2011; MEC institutional controls in place. NASA Remedial Investigation planned for Fiscal Year 2022, with ER,F funding.
FUDS Project 6 (HTRW) – Wallops Island NAOTS Cantonment Area	Wallops Island	Former NAOTS cantonment area which included maintenance and power generating areas, paint, electric and plumbing shops, and additional support buildings. COPCs: Metals, VOCs, SVOCs Site Investigation completed in 2011; supplemental field work conducted in 2011 and 2014. Final Site Investigation Report planned for FY 16.
FUDS Project 7 (MMRP) – Boat Basin/Visitor Center	Main Base	MMRP Site includes a Pyrotechnics Dump, Gun Butts 1 and 2, and South Bank Boat Basin ammunition disposal area. COPCs: MECs, metals Site Investigation completed in 2012; Remedial Investigation fieldwork conducted in FY 13-16. A Feasibility Study is anticipated to begin in FY 17 pending completion of the Remedial Investigation.
FUDS Project 8 (HTRW) – Boat Basin Area	Main Base	Former location of CNAS maintenance and storage structures. COPCs: Metal, VOCs, SVOCs Site Investigation completed in 2012; No further actions planned.
FUDS Project 9 (MMRP) – Main Base Ranges	Main Base	Former CNAS Skeet Range COPCs: Metals, PAHs Site Investigation completed in 2009 and 2012; NASA anticipates Supplemental Site Investigation in FY 17. A Non-Time Critical Removal Action is anticipated following the Supplemental Site Investigation.
FUDS Project 10 (MMRP) – Practice Bombing Target	Main Base	Practice Bombing Target southeast of the Boat Basin and Visitor Center. COPCs: MEC, metals Site Investigation completed in 2012; additional sampling completed in 2013. No Further Action required.
FUDS Project 11 (HTRW) – Main Base Areas of Interest	Main Base	Several Areas of Interest from historic CNAS maintenance activities throughout the Main Base. COPCs: Metals, VOCs, SVOCs Site Investigation activities conducted in 2012-2014; Remedial Investigation anticipated in FY 17 pending completion of the Site Investigation.
FUDS Project 12 (Con-HTRW) Petroleum, Oil, and Lubricants (POL)	Main Base	Former transformer and tank sites on Main Base and Wallops Island. COPCs: Metals, VOCs, SVOCs, PCBs Site Investigation field work conducted in 2012. Additional sampling and monitoring conducted in 2014. Transformer sites were transferred to NASA.

Table 4-2 WFF Areas of Concern

Site Name	Location	Site Description: Nature and Extent of Contamination and Current Status
Storage and Distribution		Con-HTRW (Tanks and Pipelines): Includes former CNAS tanks and associated pipelines; **Site closed with a No Further Action determination in January 2016.** Con-HTRW: Two 600,000-gallon underground storage tanks; **Site closed with a No Further Action determination in November 2014.**
FUDS Project 13 (HTRW) – Sewage Treatment Facilities	Main Base	Former Wastewater Treatment Plant COPCs: Metals, PAHs Interim Removal Action completed in 2006, Site Investigation completed in 2007, Remedial Investigation initiated in 2008; additional sampling completed in 2012; Final Remedial Investigation completed in 2013; Focused Feasibility Study completed in 2015. Proposed Plan and Record of Decision completed in FY 17. Remedial Design and Remedial Action planned for FY 17.
FUDS Project 14 (MMRP) – Regulus Launch Area	Main Base	MMRP Former Regulus Launch Area COPCs: MEC, BTEX, perchlorate Site Investigation completed in 2013; **No Further Action Decision.**
FUDS Project 15 (HTRW) – Active Remediation Projects	Main Base	Includes Active FUDS Projects initiated prior to Preliminary Assessment and Inventory Project Report. COPCs: Metals, VOCs, SVOCs Site 9 – Abandoned Drum Dump - Removal Action completed in 2005; Remedial Investigation completed; Proposed Plan completed in 2016 and No Action Record of Decision for soils, sediment, and surface water planned for FY 17. Groundwater will be addressed separately. Sites 14 and 15 –Proposed Plan completed in 2016 and No Action Record of Decision will be finalized in FY 17. Construction Debris Landfill – Site Investigation completed in 2004; Remedial Investigation completed in 2006; Focused Feasibility Study sampling and additional investigations conducted in FY 15; additional investigations completed in FY 16-17. A Feasibility Study is planned for FY 17-18. M-Area, Runway 10-28, Runway 17-35, Main Base Boat Dock Disturbed Soil Sites, Airport Parts Disposal Area – Site Investigation completed 2013; No Further Actions planned. Route 175 Landfill – Site Investigation completed in FY 15. No further actions planned.
FUDS Project 17 – Potentially Responsible Party/Hazardous, Toxic, Radioactive Waste Main Base	Main Base	Study Area Screening Evaluation completed in FY 16; No further actions anticipated.

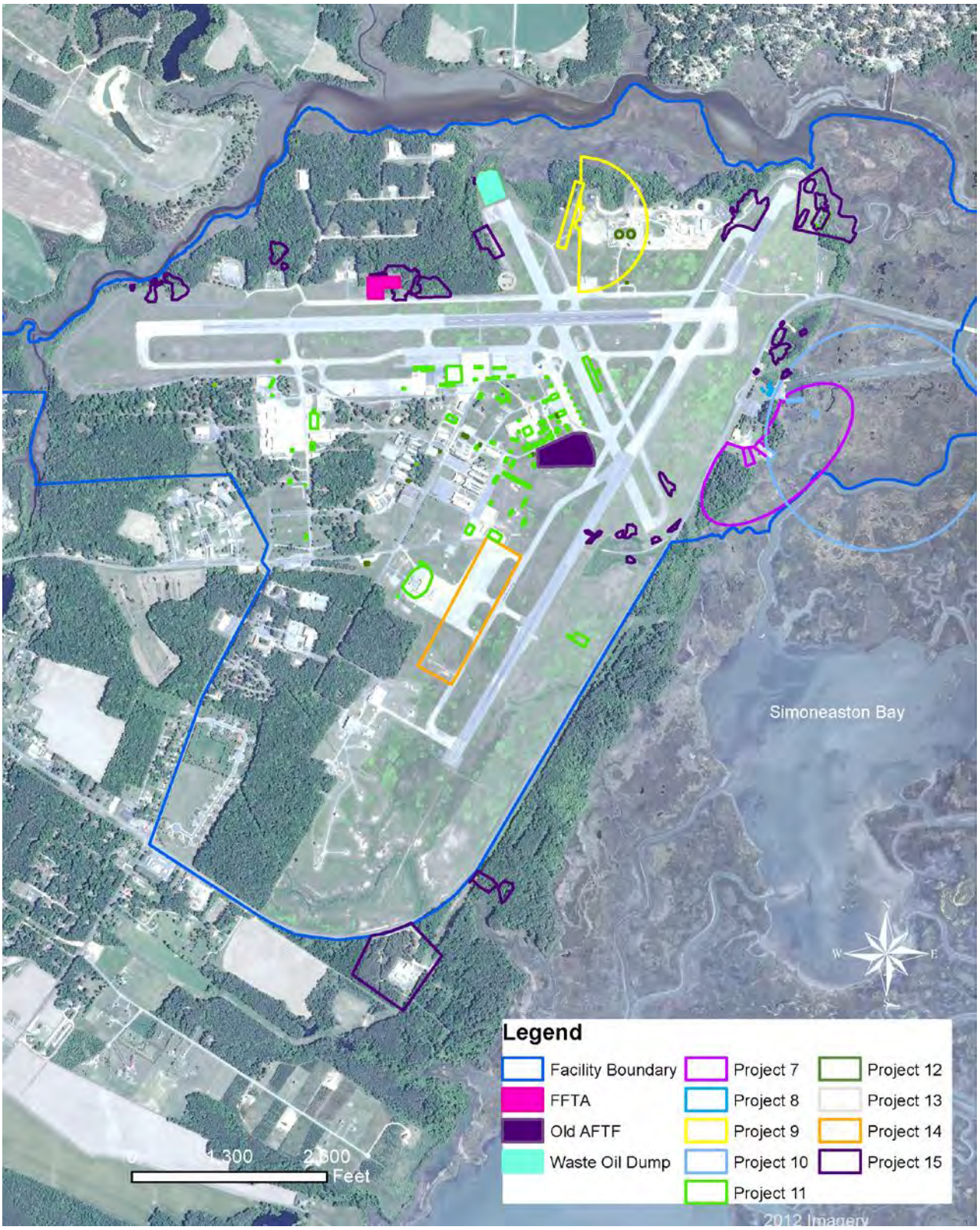


Figure 4-5 Main Base Area of Concern

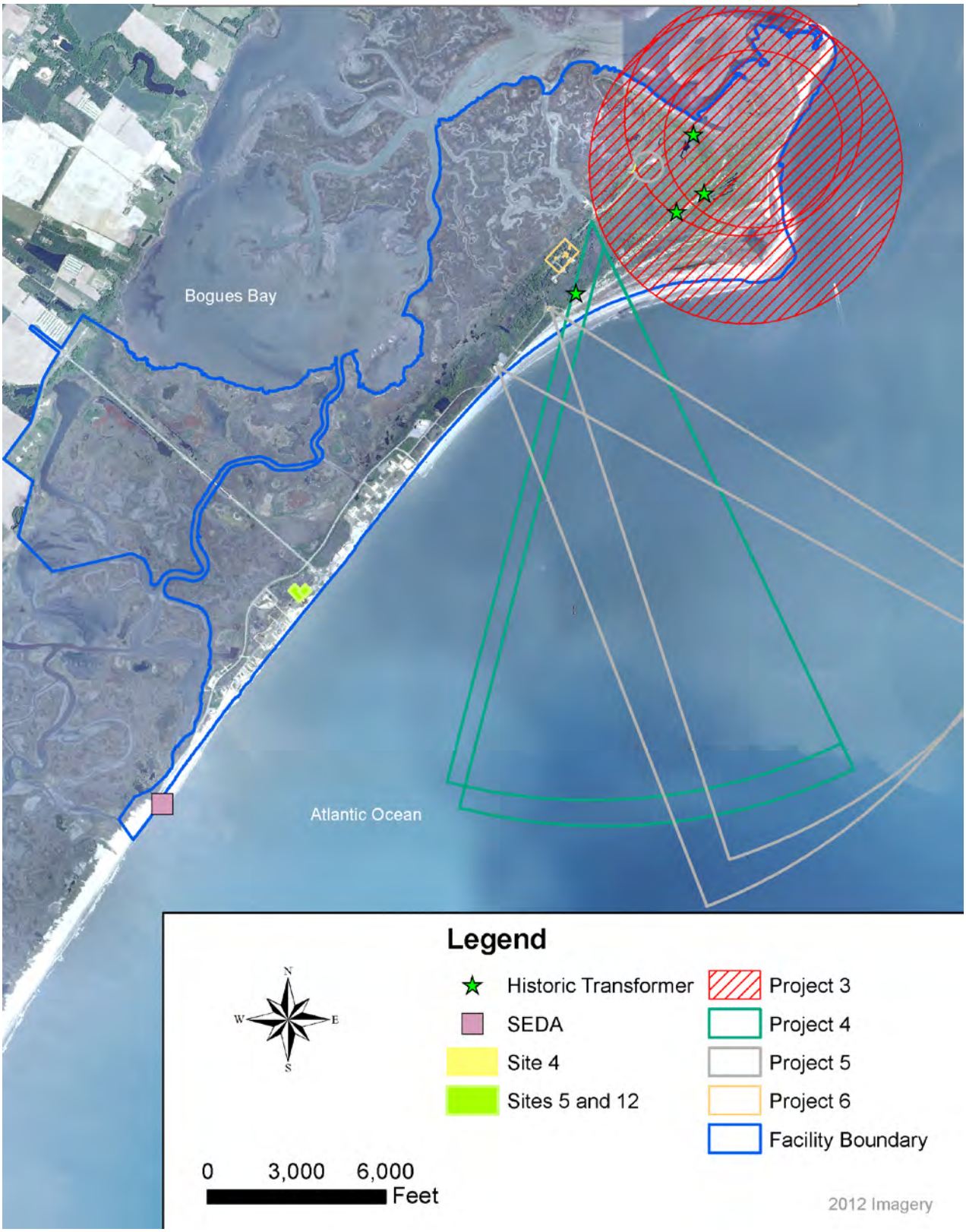


Figure 4-6 Mainland and Wallops Island Areas of Concern

Section 5. Biotic Resources

5.1 Vegetation

Habitats within the WFF area include dune systems, maritime forests, salt marshes, swamps, thickets, upland grasslands, and upland forests. Specifically, dune systems, maritime forests, and salt marshes are found on Wallops Island, and salt marshes, swamps, thickets, upland grasslands, and upland forests are found on Wallops Mainland and the Main Base.

5.1.1 Main Base

The 1,924 ac Main Base is composed of three main vegetation communities: managed/maintained, forests, and wetlands (Table 5-1 and Figure 5-1). The Main Base is dominated by vegetation classified as managed/maintained or anthropogenic/planted vegetation. The majority of these areas are maintained as open grassland necessary for the mission; however, some areas are landscaped. In addition, there are approximately 255 ac of impervious surfaces consisting of roads, parking lots, airfield runways, buildings, and unpaved parking areas and roads with no vegetation (**NASA 2012a**). Forested areas cover 22% of the Main Base and vary in composition based on historical land use and site conditions, but three main classifications prevail: hardwood, pine, and mixed pine-hardwood. The remaining area is comprised of wetlands which include emergent and scrub-shrub wetland areas; wetland vegetation and wetland impacts are discussed in detail in Section 3.6, Wetlands will not be further discussed in this section.

Table 5-1 Vegetation Communities at WFF Main Base

Community	Main Base
Managed/Maintained	849 ac
Forests	432 ac
Wetlands (Emergent estuarine and Scrub Shrub)	387 ac
Impervious Surfaces and Unpaved Roads/Parking*	256 ac
Total	**1,924 ac**

Note: *This line item was included so that the total acreage for the Main Base was taken into account.
Source: **NASA 2012a.**

Managed/maintained vegetation at the Main Base occurs in areas that are either mission critical (i.e., runway clear zones) or are landscaped for aesthetic or stormwater management purposes. Common species that occur in areas maintained by mowing are crabgrass (*Digitaria sanguinalis*), Bermuda grass (*Cynodon dactylon*), meadow fescue (*Schedonorus pratensis*), bluegrasses (*Poa* spp.), sheep sorrel (*Rumex acetosella*), chickweeds (*Cerastium* spp.), and other non-native weedy species. A variety of landscape and ornamental trees and shrubs are utilized in areas that are maintained for aesthetic purposes. Commonly used native species are loblolly pine (*Pinus taeda*) and American holly (*Ilex opaca*). Non-native species used for landscaping include Bradford pear (*Pyrus calleryanal*), autumn olive (*Elaeagnus umbellata*), thorny olive (*Elaeagnus pungens*), ornamental cherry (*Prunus sp.*), and privet (*Ligustrum spp.*). There are three areas of wetlands on the Main Base that function as part of the stormwater management system around the airfield.

These semi-natural communities are classified as managed/maintained vegetation because they are within the runway clear zones; therefore, the vegetation height is maintained by mowing or brush cutting (**NASA 2008b**).

Forested areas on the Main Base can be broken down into hardwood forests and mixed pine-hardwood forests. The species composition of hardwood forests in the area varies by specific location. Hardwood forests that occur on upland ridges and slopes contain red oak (*Quercus rubra*), southern red oak (*Q. falcate*), white oak (*Q. alba*), hickories (*Carya* spp.), yellow poplar (*Liriodendron tulipifera*), black cherry (*Prunus serotina*), sweetgum (*Liquidambar styraciflua*), and scattered loblolly pine. Mid-story species include dogwood (*Cornus florida*) and American holly. Under-story shrub species include dwarf huckleberry (*Gaylussacia dumosa*) and strawberry bush (*Euonymus americanus*). Herbaceous vegetation in these areas can vary greatly between sites and by season but some common species for the area are mayapple (*Podophyllum peltatum*), partridgeberry (*Mitchella repens*), Christmas fern (*Polystichum acrostichoides*), Solomon's seal (*Polygonatum biflorum*), bellwort (*Uvularia perfoliata*), and false lily of the valley (*Maianthemum racemosum*) (**VDCR 1996**).

Hardwood forests that are found in floodplains and other wet areas contain a different set of species than upland hardwood forests; however, some species are common to both habitat types. The over-story in these areas contains blackgum (*Nyssa sylvatica*), sweetgum, red maple (*Acer rubrum*), black willow (*Salix nigra*), and willow oaks (*Quercus phellos*). Smaller trees and shrubs in this habitat include American hornbeam (*Carpinus caroliniana*), spice bush (*Lindera bezoin*), blue huckleberry (*Gaylussacia frondosa*), viburnums (*Viburnum* spp.), and sweet pepperbush (*Clethra alnifolia*). Herbaceous under-story vegetation in this habitat includes sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmunda cinnamomea*), sedges (*Cyperaceae*), rushes (*Juncaceae*), and other grasses and forbs. Robin's plantain (*Erigeron pulchellus*) was also observed in one hardwood stand on WFF Main Base (**VDCR 1996**).

Pine forests at the Main Base are composed mostly of loblolly pine, but can also contain Virginia pine (*Pinus virginiana*) and hardwood species. Common hardwood species in pine forests are yellow poplar and sweetgum and older pine stands can contain oaks and hickories. Mid-story and under-story cover in dense pine stands is usually sparse; however, the species composition is variable, as it is with hardwood forests. One site at the Main Base contains a large population of pink ladyslippers (*Cypripedium acaule*). Other under-story species found in pine stands include vines like muscadine grape (*Vitis rotundifolia*) and trumpet creeper (*Campsis radicans*) (**VDCR 1996**).

The mixed pine-hardwood forests at the Main Base mostly contain a mix of the species described above for the hardwood and pine forests and are usually transitional between pine and hardwood.

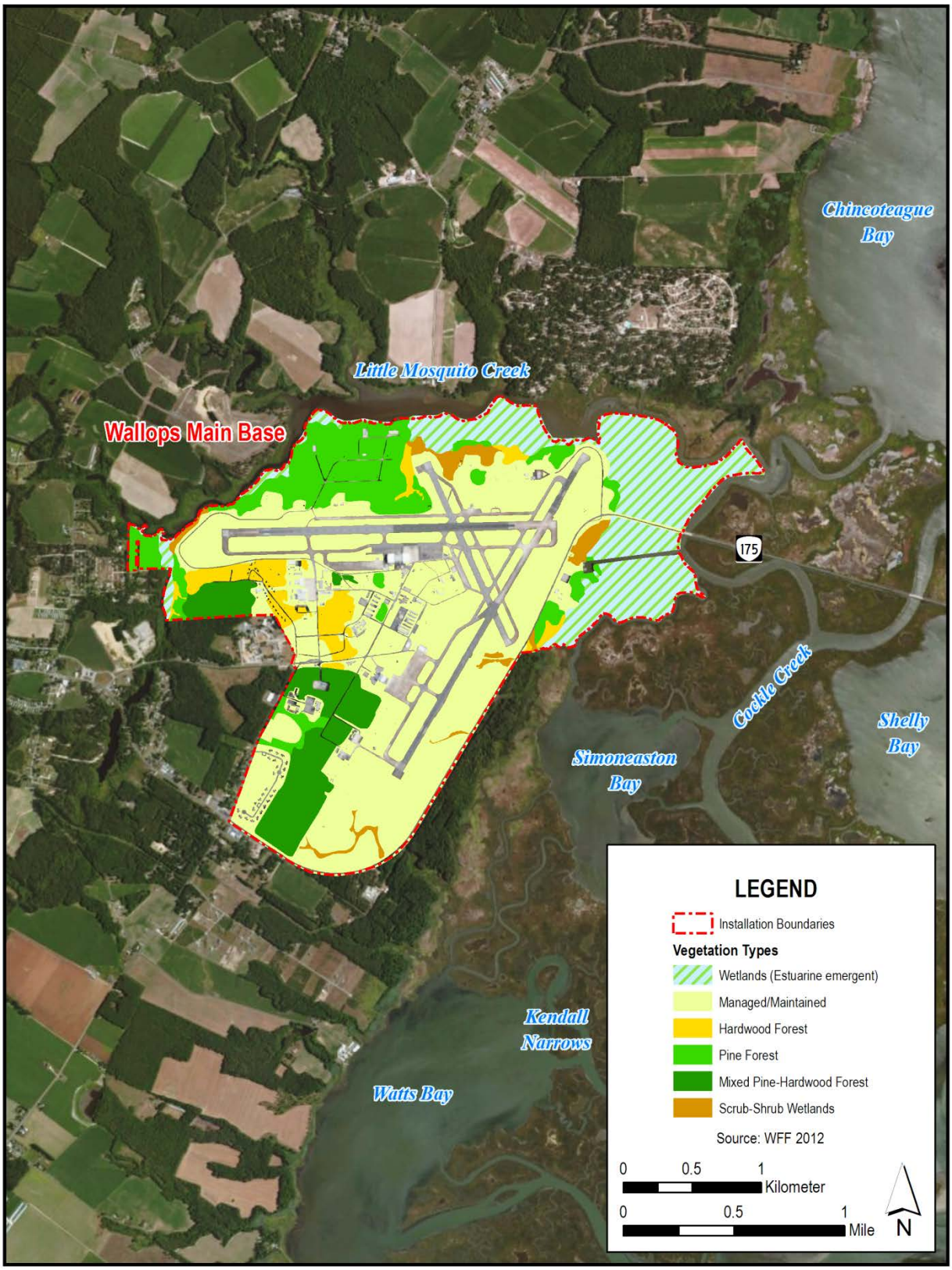


Figure 5-1 Vegetation Communities at WFF Main Base

Succession usually favors hardwoods unless there is disturbance in the area. Wet areas contain a mix of sweetgum, red maple, yellow poplar, and loblolly pine. Under-story species in wet areas include northern bayberry (*Morella pensylvanica*), southern bayberry (*Morella cerifera*), groundsel tree (*Baccharis halimifolia*), and devil's walkingstick (*Aralia spinosa*). Drier sites are usually first colonized by pine but over time red oak and white oak develop and become co-dominants. Under-story species in dry areas include mountain laurel (*Kalmia laurifolia*), fetterbush (*Leucothoe racemosa*), and male berry (*Lyonia ligustrina*) (**VDCR 1996**).

5.1.2 Mainland

The Mainland contains a different mix of habitats than those found at the Main Base. The majority (90%) of the Mainland consists of estuarine emergent wetland vegetation with some managed/maintained areas, scrub-shrub, and hardwood forests (Table 5-2 and Figure 5-2). Wetland vegetation is discussed in detail in Section 3.6 Wetlands.

Table 5-2 Vegetation Communities at WFF Mainland

Community	Mainland, acres
Managed/Maintained	72
Hardwood Forest	13
Wetlands(Estuarine emergent)	1,135
Scrub-Shrub	36
Impervious Surfaces*	2
Total	**1,258**

Note: *This line item was included so that the total acreage for the Mainland was taken into account.
Source: **WFF 2012**.

The managed/maintained vegetation at the Mainland consists of grass fields and lawns. These areas are maintained by mowing and are required for mission support. Plant species that exist in these areas are similar to those mentioned for managed/maintained at the Main Base (**VDCR 1996**).

The forests at the Mainland are composed of upland and swamp forests. Upland forests are composed of mixed pine-hardwood species in the over-story. These include loblolly pine, black cherry, and red maple. The under-story consists mostly of sassafras (*Sassafras albidum*) and bayberries. The swamp forests at the Mainland have hardwoods such as black willow and red maple in the over-story. The under-story of the swamp forests contains similar species as those listed above for the floodplain hardwood forests at WFF Main Base. A major invasive species that occurs in the forests at the Mainland is Asiatic tearthumb (*Polygonum perfoliatum*), which is also referred to as mile-a-minute (**VDCR 1996**).

5.1.3 Wallops Island

Wallops Island is a coastal barrier island that contains some similar vegetation communities found on the Main Base and Mainland; however, there are a variety of habitat types found on Wallops Island that do not occur in other areas of WFF. The approximately 3,300 ac Wallops Island consists

of beaches, maritime grassland, maritime scrub, maritime woodland, maritime forest, wetlands (estuarine emergent), and managed/maintained areas (Table 5-3 and Figure 5-2). There are also interdune ponds also referred to as sea swales, on Wallops Island, which are seasonally flooded or semi permanently flooded areas of herbaceous wetland (**VDCR 1996**). There are roughly 100 ac of impervious surface making up the remaining land area on Wallops Island. The majority of Wallops Island is wetlands (predominately estuarine emergent) vegetation and is discussed in detail in Section 3.6, Wetlands.

Table 5-3 Vegetation Communities at Wallops Island

Community	Wallops Island, acres
Managed/Maintained	251
Beach	74
Maritime Grassland	79
Maritime Scrub	182
Maritime Woodland	30
Maritime Forest	42
Wetlands (Estuarine Emergent)	2,511
Roads/Impervious Surfaces*	131
Total	**3,300**

Note: *This line item was included so that the total acreage for Wallops Island was taken into account.
Source: **WFF 2012**.

Managed/maintained vegetation on Wallops Island is composed mostly of meadows, lawn, and open roadside. Species found in the meadows include bushy bluestem (*Andropogon glomeratus*), little bluestem (*Schizachyrium scoparium*), thoroughworts and bonesets (*Eupatoriums* spp.), and goldenrods. Invasive species found in the meadows are similar to those found in managed/maintained communities at WFF Main Base and WFF Mainland, but may also include sericea lespedeza (*Lespedeza cuneata*) and clovers (*Trifolium* spp.). There are also a few man-made ponds on Wallops Island that are dominated by widgeon grass (*Ruppia maritima*) and duck weed (*Lemna minor*) (**VDCR 1996**).

Beach habitat at Wallops Island consists of upper beaches and overwash flats. Overwash flats are areas above the high tide line that are occasionally flooded by storm surges and high spring tides. These areas have sparse vegetation, which includes American searocket (*Cakile edentula*) and seabeach orach (*Atriplex arenaria*). Russian thistle (*Salsola kali*) is an invasive species that is also common in these areas (**VDCR 1996**). Though not shown in Figure 5-2, beach habitat has expanded through the Shoreline Restoration and Infrastructure Protection Program (SRIPP); a long-term project to maintain an elevated beach within the approximately 3.7 mi long area of Wallops Island that was previously rock seawall. This effort began in 2010 and will continue for the next 50 years (**NASA 2010a**). As part of the stabilization of the new beach and berm, American beachgrass (*Ammophila breviligulata*) has been and will continue to be planted on constructed dunes.

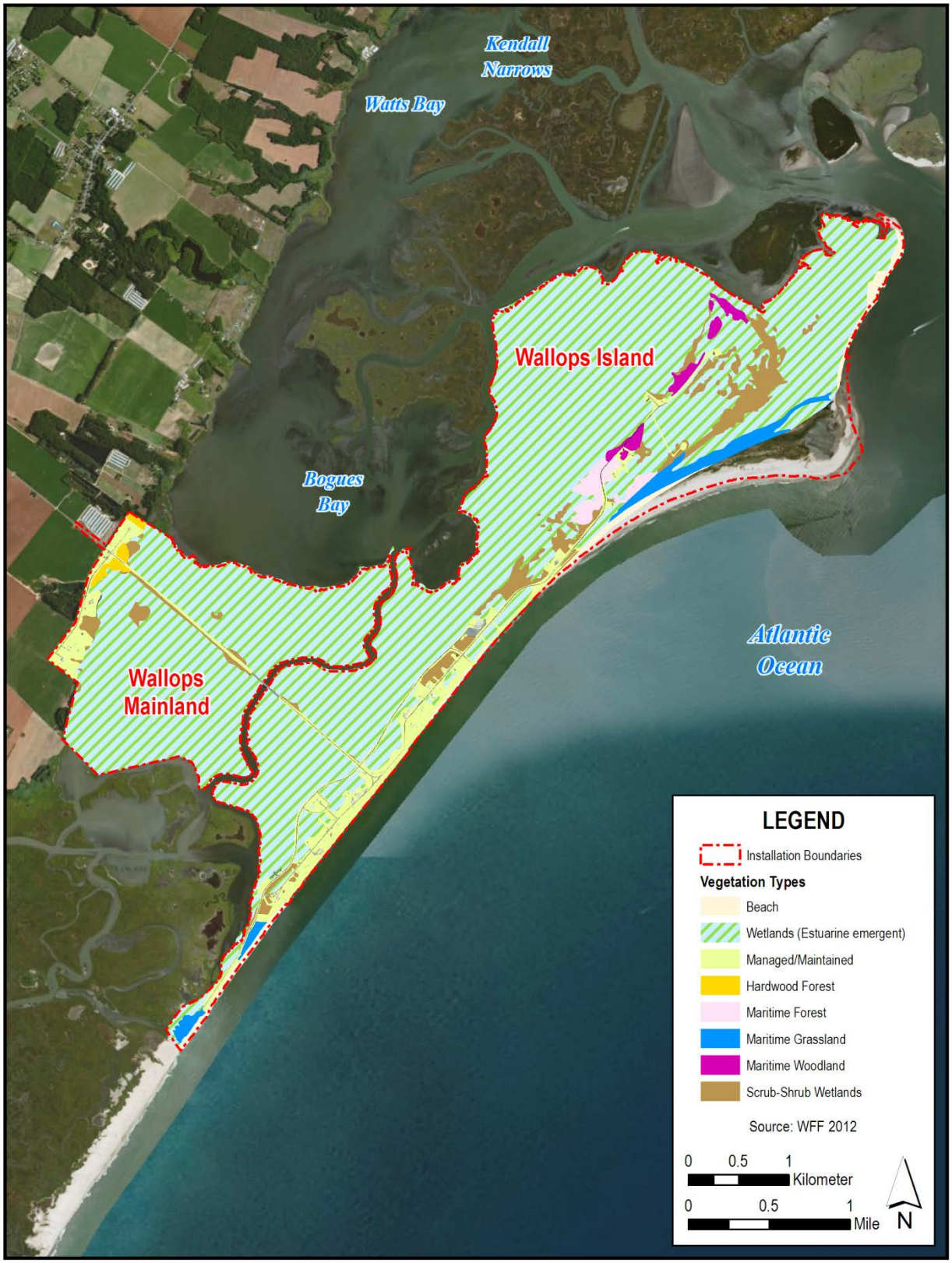


Figure 5-2 Vegetation Communities at WFF Mainland and Wallops Island

Maritime grasslands occur on the foredunes and secondary dunes of Wallops Island. Vegetation in these areas includes American beachgrass, saltmeadow cordgrass (*Spartina patens*), beach panic grass (*Panicum amarum*), and seaside goldenrod (*Solidago sempervirens*). The northern end of Wallops Island contains some areas of relatively pristine maritime grasslands. Dixie sandmat (*Chamaesyce bombensis*), also known as southern beach spurge, is a relatively rare plant species that has been documented in these more pristine areas (**VDCR 1996**).

Maritime scrub on Wallops Island occurs on secondary dunes and is sometimes mixed with maritime grasslands. The scrub communities are composed mostly of bayberry, marsh elder (*Iva frutescens*), and poison ivy (*Toxicodendron radicans*). Species that are less dominant include winged sumac (*Rhus copallina*), groundsel tree, stunted black cherry, and stunted loblolly pine (**VDCR 1996**).

An isolated area of maritime woodlands is found on a secondary dune on Wallops Island. Tree species in this habitat include scattered black cherry, loblolly pine, and scrubby oaks (*Quercus nigra* and *Quercus falcata*). Species found in sandy openings in this area include prickly-pear (*Opuntia humifusa*), yellow thistle (*Cirsium horridulum*), seaside needlegrass (*Aristida tuberculosa*), eastern jointweed (*Polygonella articulate*), and seaside little bluestem (*Schizachyrium littorale*) (**VDCR 1996**). A recent re-inventory of the North Wallops Island Conservation Area also identified 4 ac of *Maritime Dune Woodland*, more specifically, black cherry xeric dune woodland communities within the areas designated as Maritime Woodland in Figure 5-2. This re-inventory also identified the occurrence of *Eupatorium anamolum*, a state listed rare plant species (**VDCR 2012**). This species is discussed further in Section 5.4, Special-Status Species.

There are a few small patches of maritime forest on Wallops Island that occur in isolated stands or are inter-mixed with the maritime scrub habitat. The over-story of the maritime forests consists almost entirely of loblolly pine. The under-story is composed of trees like red maple, black cherry, and sassafras, and common vines in this habitat include greenbrier (*Smilax* spp.), poison ivy, Japanese honeysuckle (*Lonicera japonica*), Virginia creeper (*Parthenocissus quinquefolia*), and grapes (*Vitis* spp.) (**VDCR 1996**). Interdune ponds primarily occur in the northern and north-central parts of Wallops Island. Typical vegetation in these areas includes common threesquare (*Schoenoplectus pungens = Scirpus pungens*), sedges, switchgrass (*Panicum virgatum*), saltmeadow cordgrass, rushes (*Juncus* spp.), sea pink (*Sabatina stellaris*), saltmarsh fimbristylis (*Fimbristylis spadicea*), and seaside goldenrod. State rare species that have been documented in this habitat include Carolina fimbry (*Fimbristylis caroliniana*), long-awned prangletop (*Leptochloa fusca* ssp. *Fascicularis*), and big-headed rush (*Juncus megacephalus*) (**VDCR 1996**).

5.1.4 Submerged Aquatic Vegetation (SAV)

Grasses that grow to the surface of, but do not emerge from, shallow water are called submerged aquatic vegetation. SAV beds are an important component of the estuarine ecosystem. SAV is a diverse assemblage of marine and bay grasses that occur in shallow areas of the Chesapeake Bay,

Delmarva Peninsula bays, and the Atlantic Ocean. SAV beds are an important resource that provide habitat for juvenile and adult fish and shellfish grant protection from predators for fish and shellfish; produce food for waterfowl, fish, and mammals; absorb wave energy and nutrients; produce oxygen and improve water clarity; and help settle suspended sediments in the water and stabilize bottom sediments (**NOAA 2012c**).

The VIMS has been mapping SAV in the Chesapeake Bay and Delmarva Peninsula Bays since the 1970s using aerial photo-interpretation and ground surveys. The most recent report of SAV mapping was 2011 and shows that eel grass and widgeon grass are both dominant SAV species in the Delmarva Peninsula bays that can be found in waters near WFF (**VIMS 2013**). According to the VIMS aerial surveys, SAV beds throughout the Chesapeake and Delmarva Peninsula Bays are in decline (**VIMS 2013**). SAV beds are present in the waters north of the Mainland, near the mouth of Little Mosquito Creek, and farther east in the waters of Chincoteague Bay but none are located in the waterways on or adjacent to WFF.

5.1.5 Invasive Species

Invasive species are any species that are not native to a given ecosystem and whose introduction causes, or is likely to cause, economic or environmental harm and/or harm to human health (EO 13112 on Invasive Species 1999). Because of their ability to alter natural ecosystems and diminish the abundance or survival of native species, aggressive non-native species can readily displace native species and can create monoculture habitats. Due to the extensive historic disturbance, land use history, and landscaping practices that occurred at all WFF locations, invasive species have colonized large areas of the facility.

Although a variety of nonnative species occur at WFF, including landscape and groundcover plants such as privet (*Ligustrum spp.*), English ivy (*Hedera helix*), Japanese honeysuckle (*Lonicera japonica*), multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), and ornamental cherry (*Prunus sp.*) (**VDCR 1996**), some pose a greater threat to biodiversity and NASA's assets than others; and not all are problematic and warrant control. Therefore, assessing the extent of damage caused by the presence of invasive species and prioritizing management activities are important steps to ensure the greatest environmental and safety benefits and the success of the invasive species control program. The primary considerations for prioritizing actions are: the potential impact of invasive species to the NASA mission; the severity of threat to natural ecosystems and rare, threatened, and endangered species; and the feasibility of control.

In 2007 and 2008, a combination of field surveys and aerial photograph interpretation were employed to estimate the areal extent of invasive species infestation at WFF. Of the approximately 790 ac of invasive species identified, *Phragmites australis* (common reed) accounted for 88 percent of the acreage with a total of 687 ac on Wallops Island, 1 ac on the Mainland, and 11 ac at the Main Base (**NASA 2008b**). A Natural Heritage Survey of North Wallops Island conducted in the summer and fall of 2011 by the Natural Heritage Division of VDCR came to a similar

conclusion, noting that large portions of the study area were dominated by *Phragmites* (**VDCR 2012**).

NASA has worked with the VDCR in an effort to map, control, and monitor *Phragmites* at WFF as part of an ongoing project on Virginia's Eastern Shore (**VDCR 2011**). The 2011 VDCR report, summarizing these activities, indicated that from 2006 to 2008 a total of 322 ac of *Phragmites* on Wallops Island was aerially treated with an herbicide. Furthermore, with the goal of reducing the spread of *Phragmites* and of lessening the hazards that *Phragmites*-fueled wildfires present to flight-related infrastructure, fragile marsh ecosystems, wildlife, property owned by WFF and its neighbors, and, human life, WFF has recently developed a *Phragmites Control Plan* (**NASA 2014c**). The control methods outlined in the Plan include a combination of the following:

- Aerial application of an imazapyr[1] -based herbicide in late summer to early fall (August – September);
- Hand herbicidal spraying, to treat small stands of *Phragmites* or stands in locations inaccessible to aerial spraying (e.g., close to structures, underneath the Pad 0-A ramp, or in small patches surrounded by non-*Phragmites* plants);
- Post-herbicide application controlled burning;
- Mowing of small infestations;
- Requiring special considerations for operating heavy equipment in *Phragmites* infested areas (e.g., restricting construction equipment from areas prone to invasion, cleaning of construction equipment of all visible dirt and plant debris prior to leaving the construction site, and post construction monitoring and mowing); and
- Annual monitoring and reporting of *Phragmites* growth.

In accordance with the Plan, approximately 15 acres of *Phragmites* was subjected to controlled burning (**Mitchell 2017**).

Though the primary goal of this Control Plan is to protect NASA's launch infrastructure assets, consistent with EO 13112 it will also protect marsh ecosystems and native plant and animal species from invasive species.

5.2 Terrestrial Wildlife

Terrestrial wildlife includes all common animal species, with the exception of those identified as special-status species (see Section 5.4). The terrestrial wildlife category includes amphibians, reptiles, mammals, and birds, including native bird species protected under the Migratory Bird Treaty Act (MBTA). Virtually all native birds are protected under the MBTA. The MBTA was

[1] Imazapyr is an EPA-approved, non-selective, broad-spectrum herbicide marketed under various trade names including *Chopper*, *Arsenal*, *Stalker*, and *Assault*. It was first registered for use in the U.S. in 1984.

designed to protect migratory birds and birds of conservation concern (BCC), including their eggs, nests, and feathers. BCC birds are species that, without additional conservation measures, are likely to become candidates for listing under the Endangered Species Act (ESA). If an agency determines that implementation of a Proposed Action may result in a significant adverse effect on a population of a migratory bird species or BCC, they must confer and cooperate with the USFWS to develop appropriate and reasonable conservation measures to minimize or mitigate identified significant adverse effects. USFWS recommends that BCC lists be reviewed in accordance with Executive Order 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds* so that proactive management and conservation actions may be implemented.

5.2.1 Invertebrates

Wallops Island, particularly the tidal marsh area, has an extensive variety of invertebrates. Salt marsh cordgrass marshes have herbivorous insects such as the salt marsh grasshopper (*Orchelimum fidicinium*) and the tiny plant hopper (*Megamelus spp*). Plant hopper eggs are in turn preyed upon by a variety of arthropods. 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 found in dead smooth cordgrass (*Spartina alterniflora*). Salt marsh mosquitoes (*Ochlerotatus sollicitans*) and greenhead flies (*Tabanus nigrovittatus*) are prevalent insects at WFF (**VDCR 1996**).

Species inhabit different areas of the marsh depending on their ability to adapt to the fluctuating tides. Many insects and arachnids 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 (**VDCR 1996**).

Coastal invertebrates in the Wallops Island area include ghost crabs (*Ocypode quadrata*), calico crabs (*Ovalipes ocellatus*), fiddler crabs (*Uca spp*.), sand shrimp (*Crangon septemspinosa*), moon jelly (*Aurelia aurita*), and coffee bean snails (*Melampus bidentatus*). Crab distributions are limited by high salinities. Squid (*Lolliguncula brevis*) are prevalent during the winter (**VDCR 1996**).

Common insects found at WFF include the salt marsh grasshopper (*Orchelium fidicinium*), planthoppers (*Prokelisia* spp.), salt marsh mosquitoes (*Ochlerotatus* spp.), greenhead flies (*Tabanus nigrovittatus*), and various wasps, and parasitic flies. Spiders and mites are also common invertebrates at WFF (**VDCR 1996**). Special-status species are discussed in Section 5.4.

5.2.2 Fish

Common fish in the waters near WFF 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*). During summer months, salinity and water depths play a major role in determining if a coastal fish species is present in the bays and inlets. An example of this is the sandbar shark (*Carcharhinus plumbeus*), which is one of the most common sharks in the coastal and estuarine waters near WFF. If the channels located between Wallops Mainland and Wallops Island are at least 12 ft deep and the salinity is at least 30 parts per thousand, then the sandbar shark can thrive in the channels (**Ellis 2003**).

The tidal marsh areas of WFF act as nursery grounds for a variety of fish species due to the protection the marsh grasses provide and the abundance of food. Marsh grasses, for example, provide protection to the spot *(Leiostomus xanthurus),* the northern pipefish *(Syngnathus fuscus),* the dusky pipefish *(Syngnathus floridae),* and bay anchovy *(Anchoa mitchilli)* (**VDCR 1996**).

Essential Fish Habitat (EFH) is regulated under the Magnuson-Stevens Fishery Conservation and Management Act (MSA) of 1976. The MSA established eight regional Fishery Management Councils (FMCs), which are responsible for the management and protection of marine fishes. The Sustainable Fisheries Act of 1996, which amended the MSA, created a new mandate for the regional FMCs to identify and provide protection to important marine and anadromous fisheries habitat or EFH. The eight regional FMCs, with assistance from National Marine Fisheries Service (NMFS), are required to delineate EFH for all federally managed fisheries in an effort to conserve and enhance those habitats. EFH may be applied to an individual species or an assemblage of species and is defined in the MSA as “those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity.” NMFS and the FMCs also identify habitat areas of particular concern. These are considered high priority areas for conservation, management, or research because they are rare, sensitive, stressed by development, or important to ecosystem function.

The NOAA Greater Atlantic Regional Field Office provides species lists with designated EFH divided into 10-minute by 10-minute (10’ x 10’) geographic squares (Figure 5-3). The waters near WFF fall within two of these 10’ x 10’squares of latitude and longitude. One or more life stages of 26 federally managed fish species have designated EFH within the area depicted in Figure 5-3. The list of the species and life-stages with designated EFH is provided in Table 5-4.

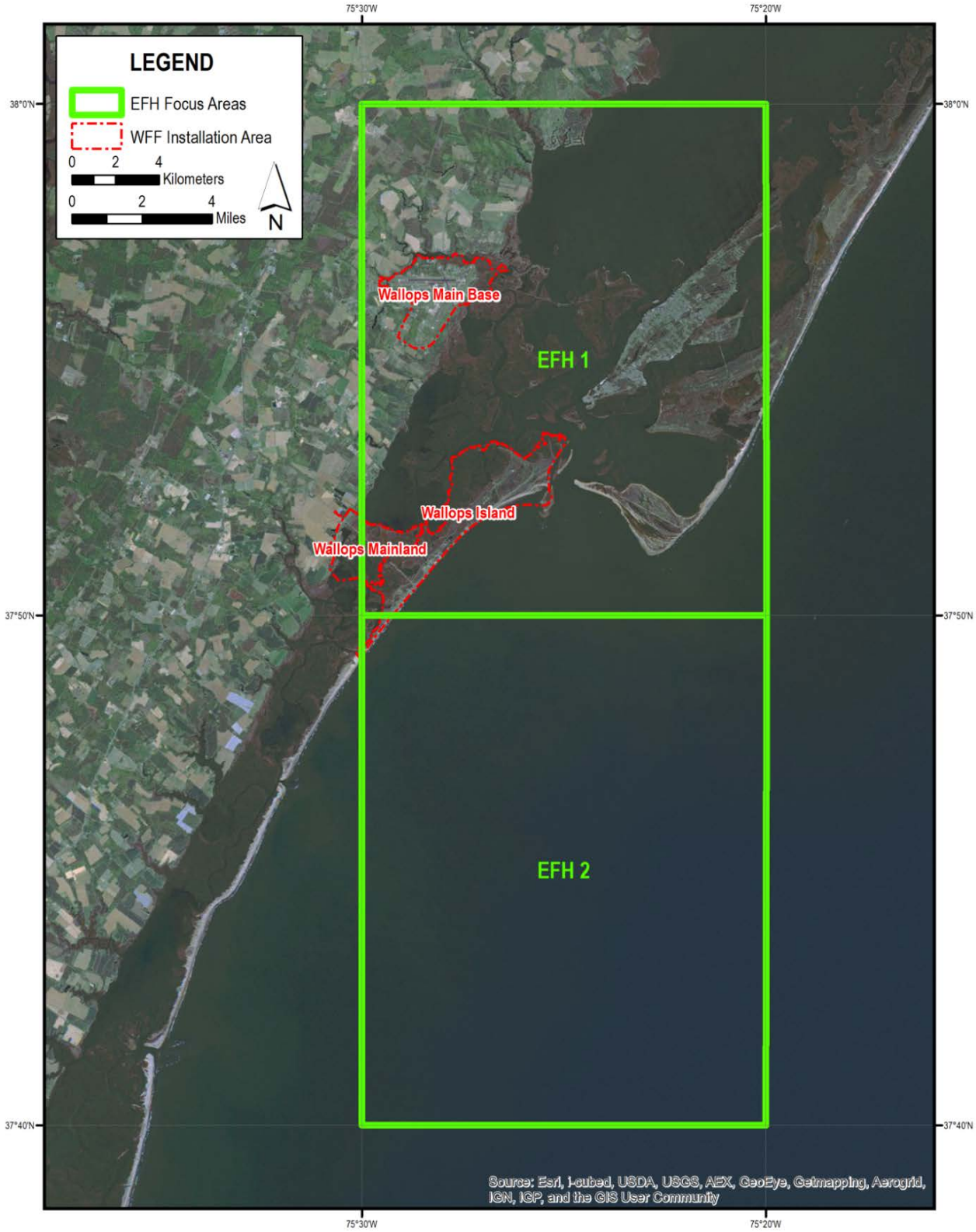


Figure 5-3 EFH Management Squares Adjacent to WFF

Table 5-4 Species and Life-Stages with Designated EFH in Waters Surrounding WFF

Species	Eggs	Larvae	Juveniles	Adults
Atlantic Butterfish (*Peprilus triacanthus*)			X	X
Atlantic sea herring (*Clupea harengus*)				X
Atlantic sharpnose shark (*Rhizopriondon terraenovae)*				X
Black sea bass (*Centropristus striata)*			X	X
Bluefish (*Pomatomus saltatrix*)		X	X	X
Clearnose skate (*Raja eglanteria*)			X	X
Cobia (*Rachycentron canadum*)	X	X	X	X
Dusky shark (*Charcharinus obscurus*)		X	X	
King mackerel (*Scomberomorus cavalla*)	X	X	X	X
Little skate (*Leucoraja erinacea*)			X	X
Monkfish (*Lophius americanus*)	X	X		
Red drum (*Sciaenops occelatus*)	X	X	X	X
Red hake (*Urophycis chuss*)	X	X	X	
Sand tiger shark (*Odontaspis taurus*)		X		X
Sandbar shark (*Charcharinus plumbeus*)		X	X	X
Scalloped hammerhead shark (*Sphyrna lewini*)			X	
Scup (*Stenotomus chrysops*)			X	X
Spanish mackerel (*Scomberomorus maculatus*)	X	X	X	X
Spiny dogfish (*Squalus acanthias*)				X
Surf clam (*Spisula solidissima*)			X	
Summer flounder (*Paralicthys dentatus*)			X	X
Tiger shark (*Galeocerdo cuvieri*)		X		
Windowpane flounder (*Scopthalmus aquosus)*			X	X
Winter flounder (*Pleuronectes americanus*)	X	X	X	X
Winter skate (*Leucoraja ocellata*)			X	X
Witch flounder (*Glyptocephalus cynoglossus*)	X			

Note: "X" indicates that EFH has been designated within the square for a given species and life stage.
Source: **NMFS 2012a**.

5.2.3 Amphibians and Reptiles

Amphibians and reptiles use the dune and backdune of Wallops Island for forage. Fowler's toad (*Bufo woodhousei*) can be found under stands of bayberry. The green tree frog (*Hyla cinerea*) can be found in the freshwater depressions in the northern portion of Wallops Island. Some species of reptiles such as the black rat snake (*Elaphe 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 (**VDCR 1996**).

5.2.4 Mammals

Mammals such as white-tailed deer (*Odocoileus virginianus*), opossum (*Didelphis marsupialis*), raccoon (*Procyon lotor*), and grey squirrel (*Sciurus carolinensis*) are plentiful at WFF. Raccoon and red fox (*Vulpes fulva*) are occasionally found in the upper beach zone and the inter-tidal beach

zone. The grey 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 backdune (**VDCR 1996**).

5.2.5 Avifauna

During spring and fall migrations, approximately 15 species of shorebirds feed on small plants and animals in the inter-tidal zone. Abundant among these are the sanderling (*Calidris alba*), semi-palmated plover (*Charadrius semipalmatus*), short-billed dowitcher (*Limnodromus griseus*), and dunlin (*Calidris alpina*). The willet (*C. semipalmatus*) is very common during the breeding season. Royal tern (*Sterna maxima*), least tern (*S. antillarum*), and common tern (*S. hirundo*) can be observed during the summer months.

Laughing gulls (*Larus atricilla*), herring gulls (*L. argentatus*), and great black-backed gulls (*L. marinus*) commonly forage in the upper beach zone and the inter-tidal beach zone. Forster's terns (*S. foresteri*) are common in the marshes and on occasion may winter in the WFF area. 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*). Additional birds common in the shrub zone include the song sparrow (*Melospiza melodia*), gray catbird (*Dumetella carolinensis*), yellowthroat (*Geothlypis trichas*), and mourning dove (*Zenaida macroura*) (**VDCR 1996**).

Numerous songbirds and other avian species can be found on the Main Base and Wallops Mainland. Some of these, such as barn swallows (*Hirundo rustica*), are migratory and occur only during the spring, summer, and early fall. Northern mockingbirds (*Mimus polyglottos*), robins (*Turdus migratorius*), and starlings (*Sturnus vulgaris*) are prevalent throughout the year (**VDCR 1996**).

Herring gulls and laughing gulls occasionally can be a problem on the runways, especially during inclement weather (e.g., birds gathering in pooled water). Raptors, including 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 WFF. There is an active bald eagle nest just north of the WFF Main Base (**VDCR 1996**).

5.3 Wildlife Management

Another important component of aviation safety at WFF is the ongoing wildlife hazard management program, sometimes referred to as the Bird/Wildlife Aircraft Safety Hazard (BASH) program. Performed on NASA's behalf by the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service's Wildlife Services Division, the purpose of the program is to

mitigate both short- and long-term hazards to aviation. Since the development of WFF's Wildlife Hazard Management Plan in 2001, USDA has maintained a full-time presence at WFF to disperse and remove birds and mammals from the aircraft operating area. Under the WFF BASH program, the WFF Aviation Safety Working Group consisting of the USDA, Airport Management, Airport Operations, Aviation Safety Office, and Senior Management meets quarterly to identify, manage, and monitor wildlife-related hazards at WFF. Program objectives include reducing the attractiveness of WFF to birds and wildlife by minimizing food sources, nesting sites, and roosting habitat within the airfield clear zones. The USDA at WFF holds the following Federal and State depredation permits: U.S. Fish and Wildlife Service (USFWS) Migratory Bird Depredation Permit at Airports, USFWS Eagle Depredation Permit (Harassment Only), and Virginia Department of Game and Inland Fisheries Kill Permit. In accordance with these permits, USDA personnel may use a variety of lethal and non-lethal methods to disperse wildlife within and adjacent to the WFF airfield. These methods may include: identifying and manipulating species habitat and roosts; employing techniques to disperse species; and, if deemed necessary, lethal or non-lethal removal of birds and/or mammals that pose a hazard to human health and aviation safety. Additionally, Section 15.2-2204 of the Code of Virginia directs the Accomack County Planning Commission to consult with WFF prior to changing the zoning of, or approving certain uses of, properties within 3,000 ft of the WFF boundary. Related to BASH, WFF works with Accomack County to ensure that aviation safety is considered when siting water reservoirs, parks and golf courses with artificial ponds, waste handling facilities, animal processing facilities, and landfills that would attract birds and wildlife, potentially creating an aircraft strike hazard.

5.4 Special Status Species

Special-status species include any species which is listed, or proposed for listing, as threatened or endangered by the USFWS or NMFS under the provisions of the Federal ESA; species protected under other Federal laws including the Bald and Golden Eagle Protection Act (BGEPA) or the Migratory Bird Treaty Act (MTBA); species considered to be threatened or endangered under Virginia's ESA; or those species or habitats of conservation concern identified by the Commonwealth of Virginia. Marine mammals are also protected under Federal regulations and are discussed later in this section.

5.4.1 Federal Regulatory Framework

Under Section 7 of the Federal ESA, as amended (16 U.S.C. 1531-1544), Federal agencies, in consultation with the USFWS and NMFS, are required to evaluate the effects of their actions on federally listed species of fish, wildlife, plants and designated critical habitat and to take steps to conserve and protect these species and habitat. Species that are protected under the Federal ESA include plants or animals that are candidates for, proposed as, or listed as threatened or endangered by USFWS. Bald eagles, which have been delisted under the Federal ESA, are still federally protected under the BGEPA (16 U.S.C. 668-668c).

The MBTA, as amended (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. 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. The coastal route of the Atlantic Flyway, which in general follows the shoreline, 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, using WFF as a stopover between wintering and nesting ranges and also as an over-wintering area.

5.4.2 State Regulatory Framework

The Virginia ESA (29 VAC 1-563 – 29.1-570) is administered by VDGIF and prohibits the taking, transportation, processing, sale, or offer for sale of any federally or state-listed threatened or endangered species. As a Federal agency, NASA cooperates with VDGIF to ensure that its activities are conducted in a manner which minimizes potential adverse effects on species listed under Virginia's ESA. Similarly, NASA works with VDGIF and other agencies to further the recovery efforts of Virginia ESA-listed species. An example of such cooperation is NASA's monitoring of the nesting of Peregrine falcon, a species no longer Federally-listed but still protected by Virginia's ESA.

Both the VDCR and VDGIF place emphasis on species considered to be "Species of Greatest Conservation Need" within the Commonwealth of Virginia's *Comprehensive Wildlife Conservation Strategy* (**VDGIF 2005**).

The strategy/action plan breaks down species of greatest conservation need into four Tiers, as follows:

- **Tier I – Species of Critical Conservation Need** face an extremely high risk of extinction or extirpation.
- **Tier II – Species of Very High Conservation Need** have a high risk of extinction or extirpation.
- **Tier III – Species of High Conservation Need** for which extinction or extirpation is possible.
- **Tier IV – Species of Moderate Conservation Need** that may be rare in parts of their range, particularly on the periphery.

The VDCR's Division of Natural Heritage (DCR-DNH) is the state agency responsible under the Virginia Natural Area Preserves Act (Section 10.1-209 through 217, Code of Virginia) for inventory, protection, and management of Virginia's natural heritage resources. One of DCR-DNH's responsibilities is to designate conservation sites for the Commonwealth of Virginia. A conservation site may include one or more rare plants, animals, or natural

communities. Conservation sites are given a biodiversity significance ranking based on rarity, quality, or number of element occurrences they contain; on a scale of 1 to 5, 1 being most significant.

5.4.3 Special Status Species in the Vicinity of WFF

Special-status species that may occur on or within the vicinity of WFF are summarized in Table 5-5. Figure 5-4 shows the known location of bald eagle nest sites around the Main Base. Figure 5-5 shows the past five years (2011 to 2015) of protected species nesting sites on Wallops Island and near the Mainland; however, the entire beach area is suitable nesting and/or foraging habitat for a number of special-status species that are described in more detail below.

Table 5-5 Special-Status Species That May Occur on or within the Vicinity of WFF

Common Name	Scientific Name	Status†	Expected Occurrence*	Notes
PLANTS				
Seabeach Amaranth	*Amaranthus pumilus*	FT, ST	Assateague Island beach	No documented occurrences on Wallops Island (**NASA 2016**); closest documented occurrence has been at Assateague Island (**USFWS 2012**),
Florida Thouroughwort	*Eupatorium anomolum*	SGCN	Northern Wallops Island	Documented on north end of Wallops Island (**NASA 2012a**; **VDCR 2011**)
BIRDS				
Red knot	*Calidris canutus rufa*	FT, ST	Wallops, Assateague, Assawoman Island beaches	Red knots regularly forage on Wallops, Assateague, and Assawoman Island beaches during northerly spring migration (**NASA 2016**).
Piping Plover	*Charadrius melodus*	FT, ST	Wallops, Assateague, Assawoman Island beaches	Regularly nests and forages on Wallops, Assateague, Assawoman Island beaches (**NASA 2016**).
Wilson's Plover	*Charadrius wilsonia*	SE	Assawoman Island beach	No active nests detected on Wallops Island (**NASA 2013**); active nests on Assateague Island and two adjacent islands to the south (**Boettcher 2013**).
Upland Sandpiper	*Bartramia longicauda*	ST	Wallops Main Base, Wallops Mainland	Rare in Virginia; breed in Northern Virginia counties with possible post-breeding presence within ROI (**Bazuin 1991b**).
Bald Eagle	*Haliaeetus leucocephalus*	BGEPA, ST	Main Base, Wallops Island	Active nests on Wallops Main Base and Island (**(B. Watts, personal communication, 2016).**)
Peregrine Falcon	*Falco peregrinus*	ST	Wallops Island	Regularly nests on hacking tower on west side of north Wallops Island (**NASA 2008b**).
Gull-billed Tern	*Gelochelidon nilotica*	ST	Assateague Island beach	No active nests detected on Wallops Island; active nests on Assateague Island (**NASA 2013; USFWS 2012b**).

Table 5-5 Special-Status Species That May Occur on or within the Vicinity of WFF

Common Name	Scientific Name	Status†	Expected Occurrence*	Notes
American Oystercatcher	*Haematopus palliatus*	SGCN	Wallops Island beaches	Nesting success on some Virginia barrier islands has been relatively high when compared to other coastal breeding sites (**Denmon, Watts, & Smith 2013**). In 2015, three nests, each nest containing eight eggs were found. None of the eggs hatched (**NASA 2015b**).
TERRESTRIAL MAMMALS				
Northern long-eared bat	*Myotis septentrionalis*	FT	Wallops Main Base, Wallops Mainland, Wallops, Assateague, Assawoman Island beaches	During 2008 acoustic bat surveys conducted in the marshes on Wallops Island, 0.3 percent of the calls identified were attributed to myotids (**Stantec Consulting, 2008**).
SEA TURTLES				
Loggerhead Sea Turtle Northwest Atlantic Ocean Distinct Population Segment	*Caretta caretta*	FT, ST	Coastal and offshore ocean waters; Wallops, Assateague Island beaches	Most prevalent sea turtle species in ROI; regularly nests on Wallops and Assateague Island beaches (**NASA 2013; USFWS2012b**); greatest in- water concentrations over continental shelf (**Shoop and Kenney 1992**), however species is also found in deeper waters (**Mansfield et al. 2009**).
Leatherback Sea Turtle	*Dermochelys coriaces*	FE, SE	Coastal and offshore ocean waters	Nesting unlikely; only one individual demonstrating nesting behavior documented on Assateague Island in 1996 (**Rabon et al. 2003**); generally considered oceanic, however will forage in coastal areas if prey species are available in high densities (**Eckert et al. 2006**).
Hawksbill Sea Turtle	*Eretmochelys imbricate*	FE, SE	Coastal ocean waters	Most unlikely sea turtle species in ROI; only two observations in Virginia since 1979 (**Mansfield 2006**).

Table 5-5 Special-Status Species That May Occur on or within the Vicinity of WFF

Common Name	Scientific Name	Status†	Expected Occurrence*	Notes
Kemp's Ridley Sea Turtle	*Lepidechelys kempi*	FE, SE	Coastal ocean waters	Second most prevalent sea turtle species in ROI; traditionally nests in Mexico, however first Virginia nest discovered in 2012 at Virginia Beach (**USFWS 2012c**); generally found in more sheltered, shallower water habitats than other sea turtle species (**Ogren 1989**).
Atlantic Green Sea Turtle	*Chelonia mydas*	FT, ST	Coastal ocean waters	Nesting unlikely; only one nest documented nest in Virginia at Virginia Beach in 2005 (**MTN 2006**).
FISH				
Atlantic Sturgeon	*Acipenser o. oxyrinchus*	FE, SCGN II	Coastal ocean waters	Most likely found in water depths less than 50 m (**Stein et al. 2004**).
MARINE MAMMALS				
Fin Whale	*Balaenoptera physalus*	FE, SE	Coastal ocean waters	In ROI when migrating between breeding and foraging grounds (**Waring et al. 2013**).
Humpback Whale	*Megaptera novaeangliae*	FE, SE	Coastal ocean waters	In ROI when migrating between breeding and foraging grounds (**Waring et al. 2013**); possibly some foraging in ROI during winter (**Swingle et al. 1993**).
North Atlantic Right Whale	*Eubalaena glacialis*	FE, SE	Coastal ocean waters	In ROI when migrating between breeding and foraging grounds (**Waring et al. 2013**).
Sperm Whale	*Physeter macrocephalis*	FE, SE	Offshore ocean waters	In ROI when migrating between breeding and foraging grounds (**Perry et al. 1999**).
Sei Whale	*Balaenoptera borealis*	FE, SE	Offshore ocean waters	In ROI when migrating between breeding and foraging grounds (**Mizroch et al. 1984**).

Table 5-5 Special-Status Species That May Occur on or within the Vicinity of WFF

Common Name	Scientific Name	Status†	Expected Occurrence*	Notes
Blue Whale	*Balaenoptera musculus*	FE, SE	Offshore ocean waters	In ROI when migrating between breeding and foraging grounds (**Perry et al. 1999**)
Florida Manatee	*Trichechus manatus latirostis*	FE, SE	Coastal ocean waters	Occasionally observed in Virginia waters; nearest observation approximately 8 mi south of Wallops Island (**Cummings et al. 2014**)

Notes: †FC = Federal Candidate; FT = Federally Threatened; FE = Federally Endangered; ST = State Threatened; SE = State Endangered; BGEPA = Bald & Golden Eagle Protection Act; SGCN = species of greatest conservation need.

*For in-water species, the term "coastal ocean waters" in this Table generally corresponds with the neritic zone, which in standard oceanographic terms is between water depths of 0-200 m and usually includes the continental shelf; "offshore ocean waters" generally corresponds with the oceanic zone beyond the 200 m depth contour.

Figure 5-4 Bald Eagle Nest Sites at WFF Main Base

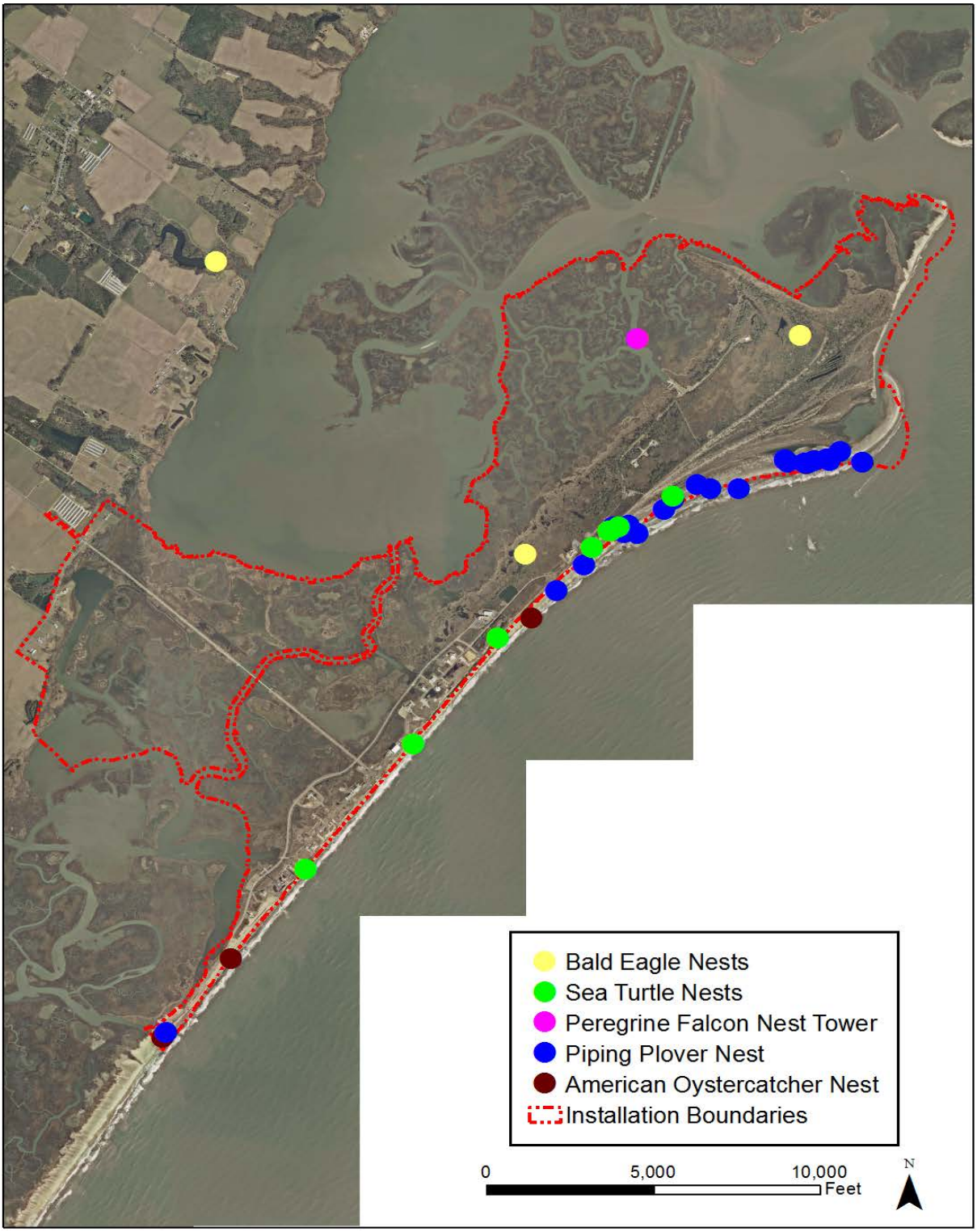


Figure 5-5 Special-Status Species at WFF Mainland and Wallops Island

5.4.3.1 Plants

5.4.3.1.1 Seabeach Amaranth

The federally and state threatened seabeach amaranth is an herbaceous plant, which colonizes on barrier islands and beaches and stabilizes the areas seaward of the primary dunes, growing closer to the high tide line than any other coastal plant. An annual plant and fugitive species, seabeach amaranth appears to need extensive beach and inlet areas that function in a relatively natural and dynamic manner with its primary habitat consisting of over-wash flats at the accreting ends of islands, and the lower foredunes and upper strands of non-eroding beaches. This species appears to be intolerant of competition and does well on sites with low vegetative cover. It often grows in the same areas selected for nesting by shorebirds such as plovers, terns, and skimmers.

Seabeach amaranth stems are fleshy and pinkish-red or red, with small rounded leaves that are 0.5 to 1 inch in diameter. The leaves, with indented veins, are clustered toward the tip of the stem and have a small notch at the rounded tip. Flowers and fruits are relatively inconspicuous, borne in clusters along the stems. Its distribution varies from year to year, influenced by seed dispersal and locally favorable conditions for germination, growth, and flowering. Germination occurs over a relatively long period of time, generally from April to July. Upon germination, the species forms a small unbranched sprig, but soon begins to branch profusely into a clump. This clump often reaches 12 inches in diameter and consists of five to 20 branches. Occasionally, a clump may get as large as a yard or more across, with 100 or more branches Germination usually begins in early summer. Flowering begins as soon as plants are mature, sometimes as early as June, but more typically beginning in July and continuing into late fall. Seed production begins in July or August and peaks in September (**USFWS 2012d**). The species has not been observed at WFF since NASA began surveying for it on an annual basis in 2010 (**NASA 2014e**).

5.4.3.1.2 Florida Thoroughwort

WFF commissioned field surveys to be conducted in 2011 by VDCR staff botanists and zoologists. During this survey, VDCR botanists discovered a plant that they tentatively identified as Florida thoroughwort. This perennial forb prefers flat, wet, low ground exposed to full or partial sunlight. VDCR discovered plants of this species alongside the road that traverses east to west across northern Wallops Island. The Wallops specimens represent the northernmost occurrence of the plant, found to date (**Van Alstine 2011**); typically its habitat extends from Florida to Alabama, Georgia, South and North Carolina, and most recently to Virginia. Florida thoroughwort is commonly thought to be a hybrid of two other plants in the Eupatorium genus, *Eupatorium mohrii* and *Eupatorium semiserratum*. However, DNA analysis suggests that examples of the plant in Virginia and North Carolina are actually hybrids of *E. mohrii* and *E. serotinum*. This could lead to reclassification of the plants in Virginia and North Carolina into a separate species from those in the deep south. Reclassification would make the Wallops Island plant even rarer than presently considered (**Van Alstine 2011**).

5.4.3.2 Birds

5.4.3.2.1 Red Knot

The rufa subspecies of red knot (*Calidris canutus rufa*) are federally and state threatened (**79 FR 73706**). It is a medium sized sandpiper and one of the longest-distance migrants known in the world. Red knots have a red head and breast during breeding plumage and are grey during the rest of the year. These small birds have wingspans of approximately 20 inches and fly more than 9,300 mi from south to north each spring and in reverse each autumn. They feed on small mussels and other mollusks for a large percentage of the year and horseshoe crab eggs during migration (**USFWS 2005**). Based on survey data, during the mid-1990s, 8,000 to 10,000 individuals would migrate through the barrier islands of coastal Virginia. Regional surveys conducted in 2005 and 2006 recorded similar numbers (**NASA 2014b**).

Red knots do not breed in the vicinity of Accomack County, although they have been appearing regularly during spring migration on Wallops Island beaches, mostly during the second half of May (**NASA 2014e**). Since 2010, NASA has been monitoring the flocks of red knot on Wallops Island. Survey data for 2010 indicate that approximately 900 individuals were observed on the northern end of Wallops Island in May (**NASA 2010b**). Monitoring data for 2011 indicate that a total of 1,167 red knots were counted throughout the survey period with the largest flock comprised of 216 individuals (**NASA 2011a**). Approximately 3,516 red knots were observed throughout the 2012 monitoring season with the largest flock of 672 individuals observed in mid-May (**NASA 2012b**). In late May 2013, a flock of 1,162 individuals was seen; 2,681 red knots were observed over the 2013 monitoring season (**NASA 2013**). Survey data indicate some change in red knot population with only 87 red knots observed throughout during the 2014 monitoring season (**NASA 2014e**). In 2015, a total of 1,091 red knots, including one banded bird, were observed on Wallops Island. (**NASA 2015b**).

5.4.3.2.2 Piping Plovers

Piping plovers are federally and state threatened. Piping plovers are small, beige and white shorebirds with a black band across their forehead and the base of the neck. They typically feed on invertebrates such as marine worms, beetles, fly larvae, crustaceans, and mollusks. Habitat generally consists of ocean beaches, sand, or algal flats in protected bays, while breeding occurs mainly on gently sloping foredunes or blow-out areas behind dunes. In late March or early April, after they have established territories and conducted courtship rituals, plover pairs form shallow depressions for nests where they lay their eggs in the sand. Nests can be found above the high tide line on coastal beaches, sandflats at the end of spits and barrier islands, gently sloping foredunes, blowout areas behind dunes, and over-wash areas between dunes. Nest site substrates may include a range of materials from fine grained sands up to shells and cobbles. Nests are typically found in areas with little or no vegetation; however, occasionally nests have been found under beach grass and other vegetation (**NASA 2014b**).

The piping plover is a common transient and summer resident of the upper Virginia barrier islands and is known to inhabit the coastal beaches from Newfoundland to North Carolina. Piping plovers are known to nest and forage on the sandy beaches and tidal flats along the coast of Wallops Island (Figure 5-6). They were first identified on northeast Wallops Island in a survey in June 1995. In 2008, two pairs of piping plovers began nesting attempts at the north end of Wallops Island but no eggs were laid. In 2009, three pairs nested successfully on the northern beaches (**NASA 2009a**). In 2010, there were three nesting attempts, including one that was successful (**NASA 2010b**). In 2011, there were three documented piping plover nesting attempts on Wallops Island with 11 eggs laid and three chicks fledged, between them (**NASA 2011a**). Six piping plover nests were attempted in 2012. Of the 16 eggs laid, 3 chicks successfully fledged. Monitoring efforts in 2013 identified four piping plover nests on north Wallops Island, resulting in 8 chicks fledged (**NASA 2013**). Between the five piping plover nests found in 2014, 16 eggs were documented and 5 chicks successfully fledged (**NASA 2014e**). In 2015, 6 nests were observed, each nest containing 4 eggs. 23 of the eggs hatched, with 8 chicks fledged. (**NASA 2015b**).

5.4.3.2.3 Wilson's Plover

Wilson's plover is considered endangered by VDGIF. Wilson's plover is a small to medium sized plover and is a coastal wader. Its range is both the east and west coasts of the U.S., with abundant breeding populations along the Gulf Coast. Wilson's plover have been documented as occurring on south Wallops Island, and, although no nests have been documented on Wallops Island, they are historically known to nest with piping plover (**NASA 2014b**).

5.4.3.2.4 Upland Sandpiper

The upland sandpiper is listed state threatened. The adult upland sandpiper measures approximately 12 in long with a 26 in wingspan. Upland sandpipers forage in fields; they are frequently sighted on fence posts and telephone poles. The bird's breeding season is from early-to-late summer. During the migratory season, the upland sandpiper may occur in large grassy areas such as those adjacent to the runways on the Main Base (**NASA 2008c**).

5.4.3.2.5 Bald Eagle

The bald eagle was formerly federally listed as endangered but has been de-listed and is now considered recovered; however, bald eagles are provided protection under the Federal BGEPA. Bald eagles also remain listed in Virginia as a threatened species. Active bald eagle nests are located within or adjacent to all three portions of WFF (**NASA 2012b**). Nesting activities typically begin in November and conclude in the summer when the young fledge.

On March 26, 2015, the College of William and Mary's Center for Conservation Biology flew a raptor survey over Virginia's eastern shore. They observed an active bald eagle nest on northern Wallops Island, another active nest mid-Wallops Island, a third active nest on the Little Mosquito Creek, and one across Route 175 from the airfield (Figure 5-6) (**CCB 2015**). The northern Wallops Island nest is located approximately 700 ft from the east end of the proposed UAS airstrip; a

660 ft buffer around the bald eagle's nest would be observed during construction of the airstrip and UAS operations. The mid-Island nest is located in the wetlands between Buildings V-020 and V-024. Near the Main Base, there is one active eagle nest in the Wallops National Wildlife Refuge, across Route 175 from the airfield and the other is across Little Mosquito Creek from the M-Area.

5.4.3.2.6 Peregrine Falcon

Peregrine falcons were formerly listed as endangered but have been de-listed and are now considered recovered; however, they remain listed in Virginia as a threatened species. One man-made peregrine falcon nesting tower is located on Wallops Island, and has been historically utilized by a pair of falcons. Peregrine falcons are also known to occur on Wallops Island during migration (**NASA 2008c**).

5.4.3.2.7 Gull-billed Tern

The gull-billed tern is state threatened and is a medium sized, black-capped, heavy-billed, and long-legged tern, now placed by most authorities in the monotypic genus *Gelochelidon,* but was formerly placed in the larger genus *Sterna*. It has a broad distribution breeding in scattered localities in Europe, Asia, northwest Africa, Australia, and the Americas. In the U.S. it nests only in coastal colonies along the Atlantic and Gulf coasts; in California it is restricted to one coastal location and one location in the interior of the state. North American gull-billed terns winter along the Gulf Coast, Pacific coast of Mexico, and into Central and South America. Breeding and nesting takes place on sandy beaches in spring and summer (**Molina et al. 2009**). Gull-billed terns are possible summer residents along Virginia's Eastern Shore; uncommon transients on the coast south of Cape Henry; and rare in the Lower Chesapeake Bay. Breeding activity has been recorded on the coast of the Eastern Shore but not on Wallops Island (**VDGIF 2012**).

5.4.3.2.8 American Oystercatcher

The American oystercatcher (AMOY, *Haematopus palliatus*) is a very large shorebird with an unmistakable long orange bill. The AMOY has been designated as a species of high conservation concern in the U.S. Shorebird Conservation Plan. Virginia is considered to be a key American Oystercatcher breeding area along the east coast of the United States with the highest number of breeding pairs in any state. Nesting success on some Virginia barrier islands has been relatively high when compared to other coastal breeding sites (**Denmon, Watts, & Smith 2013**). In 2015, three nests, each nest containing eight eggs were found. None of the eggs hatched (**NASA 2015b**).

5.4.3.3 Terrestrial Mammals

5.4.3.3.1 Northern Long-eared Bat

The northern long-eared bat (also known as northern Myotis) is federally threatened throughout its range (**80 FR 17974**). This species is typically dull yellow/brown above with a pale gray belly. Weighing only 0.2 to 0.3 ounces with a wingspan of 9 to 10 inches, adult northern long-eared bats

can live up to 19 years. During summer months, northern long-eared bats roost singly or in colonies underneath bark, in cavities, or in crevices of both live and dead trees. Northern long-eared bats emerge at dusk to fly through the understory of forested areas, feeding on moths, flies, leafhoppers, and beetles. This bat also feeds by gleaning motionless insects from vegetation and water surfaces. Northern long-eared bats do not spend the winter near WFF as they prefer hibernating in caves and mines (**USFWS 2015a**). During the fall months, individuals enter hibernacula and remain in a hibernative state until spring or early summer. Breeding occurs prior to winter hibernation, and females give birth to a single pup the following summer (**Caceres & Barclay 2000**).

White-nose syndrome, a fungal disease known to affect bats, is currently the predominant threat to this bat, especially throughout the northeast where the species has declined by up to 99 percent from pre-white-nose syndrome levels at many hibernation sites. The northern long-eared bat is one of the species of bats most impacted by this disease (**USFWS 2015a**).

The species' range includes Accomack County. During 2008 acoustic bat surveys conducted in the marshes on Wallops Island and between the island and the Mainland, in conjunction with the WFF Alternative Energy EA, 0.3 percent of the calls identified were attributed to myotids (**Stantec Consulting 2008**). While northern long-eared bats were not separated from the rest of the guild, it is reasonable to assume that this species could occur in the vicinity of WFF. The Final ESA 4(d) Rule for the NLEB (81 Federal Register 1900-1922) prohibits maternal roost tree removal is planned between June 1 and July 31.

5.4.3.4 Sea Turtles

5.4.3.4.1 Loggerhead Sea Turtle

Both USFWS and VDGIF consider loggerhead sea turtles *(Caretta caretta)* a threatened species. In 2011 the loggerhead sea turtle was divided into nine distinct population segments (DPSs), listed as threatened or endangered under the ESA (**76 FR 58868**). This revision replaced the previous global listing of loggerheads with these nine new "species," of which the threatened Northwest Atlantic Ocean DPS occurs offshore of Wallops Island.

On average, adults in the Northwest Atlantic Ocean DPS weigh 250 lbs and grow to a length of 3 ft. Loggerhead sea turtles feed on hard-shelled prey such as whelks and conch. Current threats to the species include incidental capture in fishing gear, direct harvest, disease, consumption of marine debris, and environmental contamination. Threats to nesting include loss or degradation of nesting habitat, beach armoring, artificial lighting, and non-native vegetation on beaches (**NMFS 2012b**).

The species spends the majority of its life in the open ocean or nearshore coastal areas but nests on beaches and occasionally on estuarine shorelines (**NMFS 2013a**). In the southeastern U.S., they mate from March to early June and females lay eggs between late April and early September. Female sea turtles leave the ocean only to lay eggs and, for most of the species, nest only at night. A female may nest every two to three years. Nesting can take between one and three hours. After

a female turtle drags herself up the beach, she hollows out a pit with her back legs and deposits from fifty to two hundred eggs. When the last egg is laid, the turtle covers the eggs with sand, tamps down the sand with her plastron, flings more sand about with her flippers to erase any signs of the nest, and crawls back out to sea. After about two months, typically between late June and mid-November, the hatchling turtles emerge at night. The moon and starlight reflected off the water guides them to the sea.

The major nesting sites in the U.S. are concentrated between North Carolina and southwest Florida; however, the species has been known to range northward to Virginia and westward to Texas. On July 9, 2014, NMFS and USFWS finalized the ruling respectively designating marine and terrestrial critical habitat units for loggerhead sea turtles (**NMFS 2013b**). Specific areas in the ocean east of Wallops Island that contain *Sargassum* were designated as critical habitat for the loggerhead sea turtle (**79 FR 35896**). The most northerly designated nesting beach is Bogue Banks, North Carolina.

One loggerhead sea turtle nest was observed on Wallops Island in 2008 (**Mitchell 2011**). In 2010, four loggerhead turtle nests were observed on Wallops Island (**NASA 2010b**). In 2012, two loggerhead nests were observed including one on the re-nourished beach near Buildings V-010 and V-020; the first nest was predated during the hatch window while the second nest had a 78 percent hatch rate, with 5 hatchlings directly observed by WFF personnel. In 2013, two loggerhead nests were identified farther south on the Wallops Island beach between Building X-079 and Launch Pad 0-A. The southernmost nest had a hatch rate of 79 percent whereas the more northern nest was less successful (hatch rate approximately 4 percent due to its relatively lower elevation on the beach, which resulted in its exposure to storm-induced flooding (**NASA 2013**). No loggerhead nests were observed in 2014 (**NASA 2014e**) or 2015 (**NASA 2015b**). The area where loggerhead sea turtle nests have been observed on Wallops Island is depicted in Figure 5-6.

5.4.3.4.2 Leatherback Sea Turtle

The leatherback sea turtle is federally and state endangered and is the largest sea turtle, and the largest living reptile, reaching up to 6.5 ft in length and weighing up to 2,000 lbs. Leatherbacks are the only sea turtle that lack a bony shell, with the carapace being made up of thick, leathery, oil saturated connective tissue overlaying loosely interlocking dermal bones. The carapace has seven distinctive longitudinal ridges and tapers to a blunt point. The front flippers lack both claws and scales and are proportionally longer than those of other sea turtles and the rear flippers are paddle shaped. Leatherback morphology makes the species uniquely suited to long distance foraging migrations. They feed on soft bodied pelagic prey, such as jelly fish and salps (**NMFS 2012b**). Leatherbacks are commonly known as oceanic creatures but they also forage in coastal waters. They are the most migratory and wide ranging of all sea turtle species. Nesting typically occurs in tropical waters. After nesting, females migrate to more temperate waters that support high densities of jellyfish (**NMFS 2012b**). Live leatherbacks have never been sighted on WFF but are known to occur in the waters offshore of Accomack County; a deceased leatherback was stranded on Wallops Island in 2006 (**NASA 2008c**).

5.4.3.4.3 Hawksbill Sea Turtle

The hawksbill sea turtle is federally and state endangered; it can reach up to 3 ft in length and weigh up to 180 lbs. Hawksbills have an elongated head that tapers to a point with a beak-like mouth that gives the species its name. The morphology of the head and mouth allows the hawksbill to reach into holes and crevices of coral reefs to find sponges, their primary food source, and other invertebrates. Hawksbills are unique among sea turtles in that they have two pairs of prefrontal scales on the top of the head and each of the flippers typically has two claws. Females return to natal beaches to lay their eggs every 2 to 3 years. A female will typically lay 3 to 5 nests per season, laying one every 14 to 16 days. They typically nest high up on the beach under beach/dune vegetation. Hawksbills are a circumtropical species typically occurring between 30°S latitude and 30°N latitude in the Atlantic; however, they have been sighted as far north as Massachusetts (**NMFS 2012b**). Hawksbills have never been directly observed by WFF personnel (**NASA 2008c**). They may occur in offshore waters, but the preferred tropical habitat does not exist off WFF. Therefore, they are unlikely to occur.

5.4.3.4.4 Kemp's Ridley Sea Turtle

Kemp's Ridley sea turtles are federally and state endangered. Adult Kemp's Ridley sea turtles are considered the smallest of all sea turtles, growing to 28 inches long and weighing up to 100 lbs. They have a relatively round shape, with five pairs of costal scutes. Each front flipper has one claw, while back flippers may have one or two claws. Kemp's Ridleys feed on crabs, fish, jellyfish, and mollusks. They range from the Gulf of Mexico to the U.S. Atlantic seaboard from Florida to Maine. They are found in the neritic zone; that is, in areas that typically contain muddy or sandy bottoms where their prey can be found. Kemp's Ridley turtles nest from May to July, laying two to three clutches of about 100 eggs. These turtles utilize synchronized nesting techniques, where many females come ashore to nest along the same beach at the same time. Large groups are known to nest in the state of Tamaulipas, Mexico, where 95 percent of the worldwide nesting of Kemp's Ridley turtles occurs. Occasional nests have been documented in North Carolina, South Carolina, and Gulf and Atlantic Coasts of Florida (**NMFS 2012b**), and most recently, Virginia (**USFWS 2012c, Martin 2014**). The Kemp's Ridley sea turtle has never been directly observed at WFF (**NASA 2008c**). It may occur offshore in relatively shallow waters (less than 160 ft) where habitat exists for prey species (**NMFS 2012b**).

5.4.3.4.5 Atlantic Green Sea Turtle

Atlantic Green sea turtles are federally and state threatened. These sea turtles are the largest of all the hard shelled marine turtles, growing to a length of 3 ft and weighing up to 350 lbs. Green sea turtles are unique among marine turtles in that they feed exclusively on plants, primarily sea grasses and algae. Nesting locations vary in the southeastern U.S. but nesting generally occurs between June and July. Females lay an average of five nests per season. In the U.S., green sea turtles primarily nest along the central and southern coast of Florida. They have a global distribution and are generally found in tropical and subtropical waters along continental coasts and

islands between 30°S latitude and 30°N latitude. The species utilize open ocean convergence zones and coastal areas for benthic feeding on sea grasses and algae (**NMFS 2012b**). Atlantic Green sea turtles have been directly observed in waters off WFF (**NASA 2008c**). These turtles are likely to inhabit the waters off WFF during the warmer months when sea grasses and algae are plentiful. However, nesting habitat occurs farther south in tropical waters.

5.4.3.5 Fish

5.4.3.5.1 Atlantic Sturgeon

The Atlantic sturgeon is a federally and state endangered (state Tier II SGCN), long-lived, estuarine dependent, anadromous fish that can grow to approximately 14 ft in length and weigh up to 800 lbs. They are similar in appearance to shortnose sturgeon but are distinguished by their larger size, smaller mouth, different snout shape, and scutes. These fish range from Newfoundland to the Gulf of Mexico and are highly migratory. Adults migrate to natal rivers and spawn in flowing waters between the salt front and fall line. Adults spawn in freshwater in the spring and early summer and migrate into estuarine and marine waters where they spend the majority of their lives. Atlantic sturgeon are benthic feeders and typically forage on benthic invertebrates (crustaceans, worms, mollusks, etc.). Though historically abundant, the slow reproducing populations have been depleted due to overfishing, water pollution, and commercial bycatch. Atlantic sturgeon are known to occur and have been documented in the deeper waters off WFF **(NMFS 2012c**).

5.4.3.6 Marine Mammal Densities

The Navy has undertaken a large-scale modeling effort to determine the density of marine mammals within Navy training ranges and OPAREAS in the Atlantic and Pacific Oceans and the Gulf of Mexico. Included in this modeling are the offshore waters east of WFF. The modeling effort is referred to as "Navy at-sea Operating Area Density Estimates" and has recently been used to create the Navy's Marine Species Density Database (**U.S. Navy 2012**). The Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations, which is a spatially referenced online database aggregating marine mammal, seabird, and sea turtle observation data from across the globe (**OBIS SEAMAP 2012**), was used to generate marine mammal densities by season in the 10' x 10' EFH 2 area shown in Figure 5-4. The results are shown in Table 5-5. Modeled densities are reported in the number of animals per 0.4 nmi^2. The densities vary by season but for the most part are extremely low (all significantly less than 1).

Table 5-6 Marine Mammal Densities in Waters off WFF

Common Name	Scientific Name	Modeled Density in Geographic Range (animals per 0.4 nmi^2)			
		Spring	Summer	Fall	Winter
Atlantic Spotted Dolphin	*Stenella frontalis*	0.112	0.112	0.112	0.112
Atlantic White-sided Dolphin	*Lagenorhynchus acutus*	0	0	0	0
Blainville's Beaked Whale	*Mesoplodon densirostris*	0.001032	0.000943	0.001032	0.001032
Blue Whale*	*Balaenoptera musculus*	no data	no data	no data	no data
Bottlenose Dolphin	*Tursiops*	0.04616	0.05087	0.04616	0.04616
Bryde's Whale	*Balaenoptera brydei*	GOMEX ONLY[1]	GOMEX ONLY[1]	GOMEX ONLY[1]	GOMEX ONLY[1]
Clymene Dolphin	*Stenella clymene*	0.009137	0.009137	0.009137	0.009137
Common Dolphin	*Delphinus*	0.2973	0.2973	0.2973	0.2973
Cuvier's Beaked Whale	*Ziphius cavirostris*	0.001032	0.000943	0.001032	0.001032
Dwarf Sperm Whale	*Kogia sima*	no data	no data	no data	no data
False Killer Whale	*Pseudorca crassidens*	GOMEX ONLY[1]	GOMEX ONLY[1]	GOMEX ONLY[1]	GOMEX ONLY[1]
Fin Whale*	*Balaenoptera physalus*	0.00044	0.00044	0.00044	0.00044
Fraser's Dolphin	*Lagenodelphis hosei*	GOMEX ONLY[1]	GOMEX ONLY[1]	GOMEX ONLY[1]	GOMEX ONLY[1]
Gervais' Beaked Whale	*Mesoplodon europaeus*	0.001032	0.000943	0.001032	0.001032
Gray Seal	*Halichoerus grypus*	0	0	0	0
Harbor Porpoise	*Phocoena phocoena*	0	0	0	0
Harbor Seal	*Phoca vitulina*	0	0	0	0
Harp Seal	*Pagophilus groenlandicus*	no data	no data	no data	no data
Humpback Whale*	*Megaptera novaeangliae*	0.000998	0	0.000998	0.000499
Killer Whale	*Orcinus orca*	GOMEX ONLY[1]	GOMEX ONLY[1]	GOMEX ONLY[1]	GOMEX ONLY[1]
Long-finned Pilot Whale	*Globicephala melas*	0.04326	0.04814	0.04326	0.04326
Melon-headed Whale	*Peponocephala electra*	GOMEX ONLY[1]	GOMEX ONLY[1]	GOMEX ONLY[1]	GOMEX ONLY[1]
Common Minke Whale	*Balaenoptera acutorostrata*	0.000034	0.000034	0.000034	0.000034
North Atlantic Right Whale*	*Eubalaena glacialis*	0.0003	0	0	0.0003
Pantropical Spotted Dolphin	*Stenella attenuata*	0.01913	0.01913	0.01913	0.01913
Pygmy Killer Whale	*Feresa attenuata*	GOMEX ONLY[1]	GOMEX ONLY[1]	GOMEX ONLY[1]	GOMEX ONLY[1]
Pygmy Sperm Whale	*Kogia brevicep*	no data	no data	no data	no data
Risso's Dolphin	*Grampus griseus*	0.02188	0.02188	0.02086	0.02188
Rough-toothed Dolphin	*Steno bredanensis*	0.000413	0.000413	0.000413	0.000413

Table 5-6 Marine Mammal Densities in Waters off WFF

Common Name	Scientific Name	Modeled Density in Geographic Range (animals per 0.4 nmi^2)			
		Spring	Summer	Fall	Winter
Sei Whale*	*Balaenoptera borealis*	0	0	0	0
Short-finned Pilot Whale	*Globicephala macrorhynchus*	GOMEX ONLY[1]	GOMEX ONLY[1]	GOMEX ONLY[1]	GOMEX ONLY[1]
Sowerby's Beaked Whale	*Mesoplodon bidens*	0.001032	0.000943	0.001032	0.001032
Sperm Whale*	*Physeter macrocephalus*	0.01113	0.01845	0.01113	0.01113
Spinner Dolphin	*Stenella longirostris*	GOMEX ONLY[1]	GOMEX ONLY[1]	GOMEX ONLY[1]	GOMEX ONLY[1]
Striped Dolphin	*Stenella coeruleoalba*	0.284	0.284	0.284	0.284
True's Beaked Whale	*Mesoplodon mirus*	0.001032	0.000943	0.001032	0.001032
Florida Manatee*	*Florida Manatee*	no data	no data	no data	no data

Notes: * Federally threatened or endangered.
[1]GOMEX = species only modeled for Gulf of Mexico not Western Atlantic.
Source: **OBIS SEAMAP 2012**.

5.4.3.7 Marine Mammals in the Off-shore Environment

5.4.3.7.1 Fin Whale

The fin whale is federally and state endangered and is considered depleted under the Marine Mammal Protection Act (MMPA) of 1972. Fin whales are the second largest species of whale, grow to a maximum length of approximately 75 ft in the Northern Hemisphere, and can weigh from 40 to 80 tons. This species is found in social groups that range from two to seven individuals. They feed on krill, small schooling fish, and squid in the summer and fast during the winter migration. Little is known about fin whale migration patterns. Fin whales are found in deep, offshore waters primarily in temperate and polar latitudes and less commonly in the tropics. Currently, the minimum population estimate for fin whales in the North Atlantic Ocean is 1,678 individuals. Historically, the fin whale population was diminished through commercial whaling. Current threats to the species include collision with vessels, entanglement in fishing gear, reduced prey abundance due to overfishing, habitat degradation, and disturbance from low-frequency noise (**NMFS 2012d**). Fin whales may be found in ocean waters over the continental shelf off the coast of WFF (**Waring et al. 2009**) and have been documented as close as 1 mi offshore when following prey species such as rockfish (**Whealton 2013**).

5.4.3.7.2 Humpback Whale

The humpback whale is federally and state endangered and is considered depleted under the MMPA. Humpback whales grow to lengths of up to 60 ft and have long pectoral fins that can grow to 15 ft in length. Humpback whales spend summer months in high-latitude feeding grounds building fat reserves by feeding on krill, plankton, and small fish. The species migrates seasonally

and spends the winter months in tropical or subtropical waters where they congregate and engage in mating activities. Humpback whales stay near the surface of the ocean during migration and prefer shallow waters for feeding and calving. The best available population estimate for humpback whales in the North Atlantic Ocean is currently 11,570 individuals; however, the species is believed to be increasing in abundance in much of its range. Threats to humpback whales include entanglement in fishing gear, collision with vessels, whale watch harassment, and habitat impacts (**NMFS 2012d**). Humpback whales may be found in ocean waters off the coast of WFF during migration and recent data suggests that habitat off the mid-Atlantic states (Virginia and North Carolina) may be important for juvenile humpbacks (**Waring et al. 2009**). A juvenile humpback whale stranded on north Wallops Island beach in September 2012.

5.4.3.7.3 North Atlantic Right Whale

The North Atlantic right whale is federally and state endangered and is considered depleted under the MMPA. North Atlantic right whales grow to lengths of 45 to 55 ft and weigh up to 70 tons. The species spends winter months in lower latitudes and coastal water, where calving occurs. There is still much uncertainty about the exact whereabouts of much of the population during winter months. North Atlantic right whales migrate to higher latitudes during the spring and summer to feed on zooplankton. Current estimates indicate that there are between 300 and 400 North Atlantic right whales and there is evidence to suggest a slight growth in the population size. Threats to North Atlantic right whales include entanglement in fishing gear, collision with vessels, whale watch harassment, habitat impacts, and noise from industrial activities (**NMFS 2012d**). No North Atlantic right whales have been observed adjacent to WFF (**NASA 2008c**). However, they have the potential to occur in shallow coastal waters within VACAPES.

5.4.3.7.4 Sperm Whale

The sperm whale is federally and state endangered and is considered depleted under the MMPA. Sperm whales are the most sexually dimorphic cetaceans, with males growing to 52 ft in length and weighing up to 45 tons, and females growing to 36 ft in length and weighing up to 15 tons. Sperm whales generally inhabit areas with a water depth of 2,000 ft or more and are uncommon in waters less than 1,000 ft. The North Atlantic stock of sperm whales concentrates east and northeast of Cape Hatteras during the winter. During the spring, the population shifts northward to the east of Delaware and Virginia, and is widespread throughout the central portion of the Mid-Atlantic Bight and the southern portion of Georges Bank. During the summer, there is a similar distribution, which also includes areas east and north of Georges Bank, into the Northeast Channel region and the continental shelf south of New England. In the fall, occurrences south of the New England continental shelf are at their highest and there are occurrences along the continental shelf edge of the Mid-Atlantic Bight. The best available estimate for the North Atlantic population of sperm whales is 4,702 individuals. Historic threats to the species were mainly from whaling, but current threats include collision with vessels, fishing gear entanglement, anthropogenic noise, and

pollution (**NMFS 2012d**). Sperm whales have not been observed near WFF; however, they could potentially occur at the edge of the continental shelf in VACAPES.

5.4.3.7.5 Sei Whale

The sei whale is federally and state endangered and is considered depleted under the MMPA. Sei whales grow to lengths of 40 to 60 ft and weigh up to 50 tons. Sei whales are usually observed in deep waters along continental shelf edges in sub-tropical and sub-polar latitudes; however, it is believed that they prefer temperate waters in the mid-latitudes. Distribution and movement of the species is not well known, but it is believed that they seasonally migrate to lower latitudes during winter and higher latitudes during summer. Sei whales opportunistically feed on plankton, small schooling fish, and cephalopods. There are no current estimates for the western North Atlantic stock of sei whales but the current worldwide estimate is 80,000 individuals. Threats to sei whales include collision with vessels and fishing gear entanglement (**NMFS 2012d**). Sei whales have not been observed near WFF; however, they could potentially occur at the edge of the continental shelf in VACAPES.

5.4.3.7.6 Blue Whale

The blue whale is federally and state endangered and is considered depleted under the MMPA. Blue whales are the largest whales in the world. In the North Atlantic, blue whales grow to lengths of up to 88 ft and can weigh more than 165 tons. Blue whales inhabit sub-polar and sub-tropical latitudes. The species migrates to higher latitudes during the spring in order to feed on krill during the summer and then migrates back to the sub-tropics in the fall. Blue whales can be found in coastal waters but are generally believed to occur offshore. The current minimum estimate for the blue whale population in the western North Atlantic is 308 individuals and there is insufficient data to determine an overall population trend. Threats to blue whales include ship strikes, fishing gear entanglement, anthropogenic noise, competition for prey, and habitat degradation (**NMFS 2012d**). Blue whales have not been observed near WFF; however, they could be found in the coastal and deeper waters in VACAPES.

5.4.3.7.7 Florida Manatees

Florida manatees (*Trichechus manatus latirostris*) are listed as endangered under the ESA and protected under the MMPA. Manatees are large, slow moving herbivores with a low metabolic rate and high thermal conductance, which limits their ability to maintain core body temperatures in cold waters. Manatees depend on seagrass and other aquatic vegetation for food. In the winter, they congregate around warm water springs and man-made sources of warm water such as power plant discharges. Manatees can live for several decades. Adult females give birth to a calf about once every three years. The current best available population count for the Florida manatee is 4,834 individuals, with a modeled long-term decline in population and a change in their regional distribution throughout Florida (**Cummings et al. 2014**). Manatees are known to range north into the mid-Atlantic during warmer summer and fall months. Of the 112 Florida manatee sightings in

Virginia between 1991 and 2012, most occurred between June and October in rivers and creeks followed by sightings in the open ocean, sounds and bays, Intracoastal Waterway, and marinas (**Cummings et al. 2014**). The most northerly-recorded Virginia sighting noted by **Cummings et al.** (**2014**) was from Metompkin Island, approximately 7.5 miles southwest of Wallops Island.

5.4.3.8 Marine Mammals in WFF Nearshore Environment

Nearshore waters extend from the shoreline out to 3 nm. Several marine mammal species have been identified in the waters around Virginia's Eastern Shore/Accomack County including: fin whale, humpback whale, Florida manatee, bottlenose dolphin (*Tursiops truncatus),* harbor seal *(Phoca vitulina),* and harbor porpoise (*Phocoena phocoena*). The fin whale, humpback whale, and Florida manatee are listed as endangered under the Federal ESA and have been discussed previously in Section 5.4.3.6 of this ERD.

5.4.3.8.1 Bottlenose Dolphin

The Western North Atlantic coastal stock of bottlenose dolphin is considered depleted under the MMPA. Bottlenose dolphins range in length from 6 to 12.5 ft and can weigh between 300 and 1,400 lbs. The species is found in temperate and tropical waters around the world. Inshore bottlenose dolphins are smaller and lighter in color, and are commonly found in groups of 2-15 individuals. Offshore individuals are larger, darker in color, have smaller flippers, and can be found in pods that contain several hundred dolphins. Coastal populations of bottlenose dolphins migrate into bays, estuaries, and river mouths and offshore populations inhabit pelagic waters along continental shelves. Bottlenose dolphins are considered generalists and eat a variety of prey species that are endemic to their habitat. Coastal populations generally feed on benthic invertebrates and fish, and offshore populations feed on pelagic squid and fish. Bottlenose dolphins in the Western Atlantic Ocean face threats from incidental injury and mortality from fishing gear, exposure to pollutants and biotoxins, and viral outbreaks (**NMFS 2012d**). The primary habitat for the coastal morphotype of the bottlenose dolphin extends from New Jersey south to Florida during summer months and in waters less than 65 ft in depth; this includes estuarine and inshore waters (**Waring et al. 2009**).

5.4.3.8.2 Harbor Seal

Harbor seals range from 5.6 to 6.3 ft in length and weigh up to 245 lbs. The species eats a variety of prey including fish, shellfish, and crustaceans. Harbor seals live in temperate coastal habitats and use rocks, reefs, and beaches as haul out sites. These sites are utilized for rest, thermal regulation, social interaction, and pupping. In the West Atlantic Ocean, harbor seals are found from the Canadian Arctic to southern New England and New York, although they are occasionally spotted as far south as the Carolinas. The harbor seal population in the New England area is believed to be increasing, and there are an estimated 91,000 seals in this population. Threats to harbor seals include incidental capture in fishing gear, boat strikes, oil spill exposure, chemical contaminants, power plant entrainment, and human harassment (**NMFS 2012d**). Harbor seals

would be considered a rare visitor to WFF and the only reports of the species occurring from New Jersey south to Cape Hatteras, North Carolina are from strandings (**Waring et al. 2009**).

5.4.3.8.3 Harbor Porpoise

Harbor porpoises range from 5 to 5.5 ft in length and weigh between 135 and 170 lbs. Harbor porpoises are found in northern temperate and subarctic coastal and offshore waters, and are commonly found in bays, estuaries, and harbors less than 650 ft deep. The species is usually seen in groups composed of two to five individuals. In the Western North Atlantic, harbor porpoises range from West Greenland south to Cape Hatteras. The main threat to this species is by-catch in fishing gear, specifically gillnets and trawls (**NMFS 2012d**). In winter months (January through March), intermediate densities of harbor porpoises can be found in coastal ocean waters from New Jersey to North Carolina (**Waring et al. 2009**).

5.4.3.9 Virginia Natural Heritage Sites

VDCR-DNH has identified five Conservation Sites at WFF –Little Mosquito Creek and Wallops Main Base Airfield Swale on the Main Base; Wallops Island Causeway Marshes on the Mainland and west side of central Wallops Island; and North Assawoman/South Wallops Island and North Wallops Island on Wallops Island (**Fleming 1996**).

The approximately 500 ac Little Mosquito Creek site includes the marshes and adjacent uplands along the south side of Little Mosquito Creek at the north end of the Wallops Main Base Airfield. This site has been assigned a biodiversity significance ranking of B4, representing a site of moderate significance/globally rare community (**Fleming 1996**). The natural heritage resources of concern at this site are a rare plant community (Estuarine herbaceous vegetation); the state-critically imperiled plant species brown-fruited rush (*Juncus pelocarpus*), and three state-vulnerable to critically imperiled animal species the delta-spotted spiketail (*Cordulegaster diastotops),* bald eagle, and furtive forktail (*Ischnura prognota)* (**Fleming 1996**).

Wallops Main Base Airfield Swale site is approximately 170 ac and includes the open field at the southwest end of Wallops Main Base Airfield, along with a portion of the adjoining wooded tract to the west. This site has been assigned a biodiversity significance ranking of B4, representing a site of moderate significance/globally rare community. The natural heritage resources of concern at this site are a rare plant community (Oligotrophic saturated scrub) and the state-critically imperiled plant species low frostweed (*Helianthemum propinquum*) (**Fleming 1996**).

The approximately 100 ac North Assawoman/South Wallops Island site was assigned a biodiversity significance ranking of B3, representing a site of high significance/globally imperiled community. The site contains the beaches and dunes at the south end of Wallops Island and the north end of Assawoman Island, on either side of the now-closed Assawoman Inlet. Its species of concern are piping plover, Wilson's plover, and least tern (**Fleming 1996**).

The Causeway Marshes site is approximately 1,600 ac and has been assigned a biodiversity significance ranking of B5, representing a site of general biodiversity interest. This site includes

Marshes on both sides of the Wallops Island Causeway, bordered by Arbuckle Neck on the west, Wallops Island on the east, Hog and Little Cat Creeks on the south, and the NASA property boundary on the north. The natural heritage resources of concern at this site are the state-imperiled to critically imperiled Saltmarsh Sharp-tailed sparrow (*Ammodramus caudacutus*) and Northern Harrier (*Circus cyaneus*) (**Fleming 1996**).

In 1996**, Fleming** assigned the 1,100 ac North Wallops Island site a biodiversity significance ranking of B3, representing a site of high significance/globally imperiled community. The site encompasses the northeast portion of Wallops Island, southwest of Chincoteague Island and east of Arbuckle Neck on the Mainland. The natural heritage resources of concern for the site at that time were the piping plover, peregrine falcon, five rare plant communities, and five state-rare plant species. Subsequent to its 1994 and 1995 natural heritage survey at WFF (**Fleming 1996**), in 2011 VDCR performed an inventory of rare plant species and habitats in the northern portion of Wallops Island. This inventory found occurrences of Florida thoroughwort (*Eupatorium anomalum*) and Maritime Dune Woodland habitat in northern Wallops Island. Although not listed as threatened or endangered by the Commonwealth or USFWS, Florida thoroughwort is considered critically imperiled in Virginia and globally very rare (**VDCR 2012**). In coordination with VDCR, WFF created the *Rare Species and Community Action Plan for Northern Wallops Island* (**NASA 2012c**). This plan stipulates that WFF will maintain open areas to promote the growth of Florida thoroughwort near the planned UAS airstrip. The plan also states that after UAS airstrip construction, all remaining areas of Maritime Dune Woodland will be protected.

5.4.4 Consultations and Biological Opinions

Section 7 of the ESA states that any action by a Federal agency which "may affect" a listed species or its habitat will require the agency to consult with the USFWS or the NMFS. If the proposed action is likely to adversely affect the listed species, a formal consultation with USFWS or NMFS is mandatory. As a result of the consultation, a Biological Opinion (BO) is provided to inform the agency of reasonable and prudent measures to minimize the impacts of the action and to identify ways in which the agency can conserve listed species and habitat. If the proposed action is not likely to adversely affect listed species or their habitat, informal consultation with USFWS or NMFS is required. These consultations may result in a letter of concurrence with the agency's determination or a request for formal consultation as discussed above. WFF currently has multiple consultations with USFWS and NMFS which have resulted in BOs and letters of concurrence; the most current of which remain on file with the WFF Environmental Office.

5.4.5 Special Status Species Management at WFF

In accordance with these consultations and Biological Opinions, WFF administers a Protected Species Monitoring Plan in an effort to manage special-status species. The plan is updated annually and maintained by the WFF Environmental Office. Due to lack of special-status species habitat on the Main Base and Mainland, the *Protected Species Monitoring Plan* only applies to Wallops Island. Wallops Island is further divided into four distinct monitoring areas: North End,

Recreational Beach, Constructed Beach, and South End. Procedures are outlined for monitoring a number of protected species that are likely to occur at Wallops Island including: seabeach amaranth (*Amaranthus pumilus)*, red knot (*Calidris canutus)*, piping plover (*Charadrius melodus)*, American oystercatcher (AMOY, *Haematopus palliatus*), and sea turtles. Processes for marine mammal stranding monitoring and coordination are also specified.

Section 6. Solid Waste Generation

6.1 Solid Waste Management Control System

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 and Wallops Island/Mainland are separated by approximately 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 Island, WFF has its own hazardous waste transporter license. Both the Main Base and the Island/Mainland are classified as Large Quantity Generators because each has the potential to generate more than 2,205 pounds of hazardous waste per month. Building B-029 is the less-than-90-day hazardous waste accumulation area for the Main Base. Additionally, used oil is stored in Building N-223 on the Main Base. Wastes generated on the Mainland and on Wallops Island are stored on the Mainland at Building U-081, a less-than-90-day accumulation area. Hazardous waste may be stored at an accumulation area for up to 90 days from the date of initial accumulation. WFF uses licensed hazardous waste transporters to transport hazardous waste to licensed Treatment, Storage, and Disposal Facilities.

On October 20, 2005, WFF was issued a "Permit for Open Burning Treatment of Hazardous Waste" by the Virginia DEQ. This permit limits WFF to treatment of 75 tons net explosive weight of propellant per year. WFF operates an Open Burn Area on the south end of Wallops Island, for the treatment of hazardous waste rocket motors and igniters.

6.1.1 Hazardous Waste Disposal

The regulations that govern hazardous waste management are found in 40 CFR 260-270 and 9 VAC 20-60. In addition, GPR 8500.3, Waste Management, contains detailed policies and procedures related to solid waste generation, treatment, storage, and disposal for GSFC facilities.

WFF 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 55 gallons of hazardous waste or less than 1 quart of acute hazardous waste are accumulated at or near the point of generation; and
- Properly completing and transferring GSFC Form 23-54, Hazardous Waste Disposal Inventory, to the Environmental Office.

The Environmental Office manages hazardous waste generation, including inspection, onsite transportation, storage, shipment of all hazardous waste as well as annual training to all

contractor and civil service employees who handle hazardous wastes. This office is responsible for tracking manifests and certificates of disposal for hazardous wastes that leave the facility. Individuals wishing to dispose of property considered to be hazardous must complete GSFC Form 20-9, Report of Excess Property, before transferring the property to Wallops Disposal Office. If the hazmat box on the form is checked, the Environmental Office is notified and involved in the disposition of the article.

WFF biennially reports volumes of both hazardous and non-hazardous waste generated. According to the 2015 biennial report, 50,779 pounds of hazardous waste were generated on the Main Base, and 5,240 pounds were generated on Wallops Island and Wallops Mainland. Both hazardous and non-hazardous wastes reported in 2015 are shown in Table 6-1.

Table 6-1 Hazardous and Non-hazardous Waste Generation at WFF

Waste Disposed Or Recycled	2015 Reporting Main Base VA8800010763 (lbs)	2015 Reporting Island VA7800020888 (lbs)
Waste Flammable Aerosols	2185	345
Waste Aerosols, Poison	40	0
Waste Barium Oxide	2	0
Waste Corrosive Liquid; Alondine	10	5
Waste Corrosive Liquid Lab Packs	95	960
Waste Corrosive Liquid Test Kits, PCB Kits	8	2
Waste Corrosive Toxic, Used COD Vials	10	0
Waste Dichloromethane Expired	2	0
Waste Flammable Liquid, Jet A	23500	1200
Waste Flammable Rags	16232	1448
Waste Flammable Liquids, Lab Packs	5750	0
Waste Gasoline	400	0
Hazardous Waste Oil	1200	0
Waste Flammable Magnesium	5	0
Waste Paint Related Material	800	0
Waste Corrosive Sodium Hydroxide	160	0

Table 6-1 Hazardous and Non-hazardous Waste Generation at WFF

Waste Disposed Or Recycled	2015 Reporting Main Base VA8800010763 (lbs)	2015 Reporting Island VA7800020888 (lbs)
Hazardous Waste Solid, Lamps	800	0
Hazardous Waste Solid, Carbon Filter	600	0
Hazardous Waste Liquid, R11	40	0
Waste Combustible Liquid, Naptha	200	0
Waste Toxic Rags, Payload Fueling	0	17
Waste Articles Explosive, 1.4E	0	365
Waste Explosive Cartridges, 1.4C	0	90
Waste Explosive Fuses, 1.4D, 1.4S	0	85
Waste Flammable Diesel and Water	0	400
Waste Reactive Lithium Batteries	0	210
Waste Reactive Spin Motors	0	8
Waste Reactive Propellant	0	100
Waste Reactive Propellant Rags	0	10

6.1.2 Solid Waste Disposal

Several types of receptacles are maintained throughout the facility for the collection of solid waste and recyclable materials. Non-hazardous or regulated solid waste is disposed of through a contract with an offsite vendor. A member of FMB routinely inspects the solid waste containers to ensure that both recyclables and hazardous waste are not present. Single-stream recycling containers located throughout WFF allow for the disposal of plastic, paper, cardboard, aluminum cans, and glass to provide added convenience and encourage recycling. Scrap metal is also recycled by an offsite vendor.

6.2 Pollution Prevention Plan

EO 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*, by combining and replacing several previous EOs, directs Federal agencies to implement sustainable practices. GPR 8500.2, *Pollution Prevention and Green Procurement,* requires a Pollution Prevention Plan. WFF maintains a Pollution Prevention Plan that is reviewed annually.

A very important element in the Pollution Prevention Program is the Pollution Prevention Opportunity Assessment (PPOA). A PPOA is a project-specific systematic evaluation of a process

or operation to characterize all aspects of the process or operation, define the environmental impacts of the process, associate impacts and wastes with specific unit operations, and assign related costs and liabilities to specific wastes and management practices. Alternative products, processes, and operations that reduce environmental impacts, plus health and safety hazards, are identified. Vendor information is included to facilitate rapid implementation of the PPOA. Considerations used to rank PPOAs for possible implementation include environmental compliance, facility mission impact, environmental benefits, ease of implementation, and cost savings.

The long-term goals of WFF are to minimize the use of hazardous materials, minimize the generation of wastes, and minimize emissions of pollutants to the environment. WFF Pollution Prevention Goals were most recently updated in 2017 and include the following:

- Reduce quantity of virgin chemicals disposed,
- Achieve nonhazardous solid waste diversion rate (recycling, donation, reuse, repair),
- Achieve construction and demolition materials solid waste diversion rate (recycling, donation, reuse, repair),
- Increase purchase of green products and services, and
- Increase the number of waivers for products that require them.

Section 7. Toxic Substances

7.1 Toxic Substances Management

The regulations that govern the management of toxic substances are the 15 USC § 2601 Toxic Substance Control Act of 1976 (TSCA) and 40 CFR 761, Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibition. In addition, GPR 8500.3, *Waste Management*, contains detailed policies and procedures related to disposal of asbestos, lead, and PCB-containing material. GPR 1840.1, *Asbestos Program Management at GSFC*, establishes general policy and procedures for an Asbestos Management Program. Furthermore, WFF has an Asbestos Working Group which meets regularly to discuss asbestos-related issues and has performed a survey entitled *Suspect Asbestos Material Inventory*, dated August 2007, which inventoried existing and suspected asbestos locations. Asbestos removal is performed by licensed asbestos removal professionals and is typically disposed of by the removal contractor.

Only one location on the Main Base has PCB items or contamination from previous releases. All other releases have been remediated and PCB-containing items have been removed from the facility. The only remaining PCB-containing item on the facility is located in the transformer room of Building E-106. This site is known to have experienced a previous release of PCB-containing oil. The floor has been triple-washed and encapsulated with a double coat of paint, the room is locked with limited access, and PCB warning signs are posted.

Approximately 18 potential PCB items or contamination sites have been identified on Wallops Island. Area of Interest (AI) – 20, a historic pole-mounted transformer, was identified on the north end of Wallops Island during a Preliminary Assessment conducted by the USACE. Elevated PCB concentrations were detected in the surrounding soils and the transformer pole. A Time Critical Removal Action was completed at AI-20 by NASA in 2015. The investigation of AI-20 prompted NASA to conduct additional reviews of historic maps, aerial photos, and site reconnaissance in order to determine if other transformers remained on the northern portion of Wallops Island. The analysis identified 17 additional former transformer locations. Site screening activities at these North Island Transformer (NIT) sites determined that 4 of the 17 the locations still contain transformers. Analytical data from these four transformer locations identified PCB impacted soils at two of the locations. A Time Critical Removal Action at the four PCB impacted NIT sites will was completed in 2016.

Each July, a PCB log is prepared which details the PCB items that were disposed of during the previous year. No PCB items were removed from the facility between 2011 and 2013. One small PCB transformer was removed from the facility in 2014.

As buildings are renovated or demolished, lead paint issues are resolved. Known lead paint areas are marked. Lead-based paint abatement is performed by licensed lead removal professionals and

is typically disposed of by the removal contractor. The evaluation of suspect lead-containing materials is coordinated by the FMB and the WFF Safety Office.

Radon-222 is a colorless, odorless, radioactive gas. It forms from the decay of naturally occurring uranium-238, which is found in soil and rock throughout the world. Radon is present both outdoors and indoors. Exposure in buildings mostly results from radon-contaminated gas rising from the soil. The potential of the soil to release radon and contaminate buildings depends on the concentration of uranium and the characteristics of the earth. As a result, radon levels vary greatly in different parts of the United States, even within small geographic regions (**American Cancer Society 2006**). The USGS map indicates that Accomack County has a predicted average indoor radon screening level that is approximately one half of the EPA's action level.

Section 8. Pesticides

8.1 Pest Management

WFF uses off-site contractors for mosquito and indoor pest control. Every effort is made to use an integrated pest management system which includes using the least hazardous alternative, such as using sticky traps, mowing grass, limiting outside containers which could collect rainwater, maintaining good drainage, and regularly removing trash.

8.2 Pesticide Application, Storage, and Disposal

The application of herbicides is supervised by an onsite trained and licensed individual. NASA onsite contractor applied herbicides are stored in a locked and labeled storage shed between Buildings B-031 and B-029. Empty herbicide containers are triple rinsed, with the rinseate returned to the sprayer. The rinsed containers are cut to prevent reuse and disposed of as solid waste. In the event an herbicide would be unusable, it would be turned over to the Environmental Office to be properly disposed.

The U.S. Navy, one of WFF's tenants, has taken this system one step further by fully implementing their Integrated Pest Management Plan. "Black cows" and bird boxes have been installed to control the greenhead fly population and to attract mosquito eating birds, respectively. The "black cows" are constructed with screens and baffles which allow the flies to enter, but prevent their escape. Nontoxic materials such as diatomaceous earth to control spiders; Victor Pro®, a mint-oil based product, to control wasps and hornets; lemon grass oil to control mosquitoes; Japanese beetle traps; and boric acid to control ants are used instead of hazardous chemicals.

The Navy has licensed onsite pesticide supervisors and applicators who apply their own pesticides and herbicides. The Navy also has an offsite contractor on retainer. Pesticides are stored in the locked Hazardous Waste Minimization Center outside Building R-030. Unusable pesticides, herbicides, and their empty containers are turned over to the Navy Hazardous Materials Manager for proper disposal.

8.2.1 Commonly Used Pesticides at WFF

Table 8-1 lists the herbicides and pesticides which are used at WFF. The regulated pesticides do not require a permit but a licensed applicator must administer the pesticides.

Table 8-1 Regulated Pesticides at WFF

Name	User	Active Ingredient	Manufacturer	Use
Advance 388B	Navy	Borate	Whitmore Micor-Gen Prescription Treatment	Ants
Altosid XRG pellets	NASA Contractor	Methoprene isopropyl 2e 4e7s 11 methoxy3711 trimethyl24 dodecadiene Calcium sulfate	Zoecon	Mosquito larva
AquaNeat	Navy	Sodium Glyphosate	Nufarm Americas Inc.	Weeds
Bait Max Force Gel FC	NASA Contractor, Navy	Fipronil	Bayer Environmental Sciences	Ants
Contrac Rat and Mouse Bait	NASA Contractor, Navy	Bromadiolene	Bell Laboratories, Inc	Rats and mice
Demand	Navy Contractor	Pyrethroid	Syngenta Professional Products	Crawling
Drax Ant Gel	Navy	Boric Acid	Waterbury Companies	Ants
Eaton's Bait Blocks	Navy	Diphacinone	J.T. Eaton and Co.	Baits in Mouse traps
Habitat	VDCR	Isopropylamine salt of Imazapyr	BASF Specialty Products	Weed Control (*phragmites*)
Hyvar	NASA	Bromacil	DuPont E I De Nemours	Weeds, only on airfield
Mistocide	Navy Contractor	Pyrethrin	Summit	Mosquitoes
Phantom	NASA Contractor, Navy Contractor	Chlorfenapyr, CL 303,630	BASF Corporation	Cockroaches/ Termites
Prevail FT Termiticide	Navy Contractor	Cypermethrin	FCM Corporation	Termites
Pyrenone 50	NASA Contractor, Navy Contractor	Pyrethrins Piperonyl Butoxide	Van Waters and Rogers	Mosquitoes/ Termites
Sodium Glyphosphate	NASA Navy	Sodium Glyphosate	Various	Weeds
Suspend SC	Navy Contractor	Deltamethrin	Bayer Environmental Sciences	Ants
Talstar	Navy Contractor	Bifenthrin	FMC Corporation	Ants/ Cockroaches
Tempo SC	Navy Contractor	Cyfluthrin	Bayer Environmental Sciences	Spiders
Medal EC	NASA Navy Contractor	S-metolachlor	Syngenta Crop Protection	Pre-emerge herbicide
Rejex-it Fog Force	USDA	Methyl Anthranilate	Ceannard, Inc.	Bird repellant for airfield

Section 9. Radioactive Materials and Non-Ionizing Radiation

9.1 Radiation Protection Program

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/or stored at WFF under a comprehensive radiation protection program. GSFC has issued the following mandatory compliance GPRs for radiation protection and safety:

- GPR 1860.1C, *Ionizing Radiation Protection*
- GPR 1860.2C, *Laser Radiation Protection*
- GPR1860.3B, *Radio Frequency Radiation Safety*
- GPR 1860.4B, *Ultraviolet and High Intensity Light Radiation Protection*

WFF's Code 803 Safety Office administers the program at WFF, and the GSFC Radiation Safety Officer, Goddard Non-Ionizing Radiation Safety Committee (NIRSC), and Goddard Ionizing Radiation Safety Committee (IRSC) provide oversight. The GPRs are reviewed and updated every 5 years at a minimum, and sooner if needed.

The 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.

9.2 Ionizing Radiation

The Federal Nuclear Regulatory Commission (NRC) licenses use and storage of ionizing source material, special nuclear material, and byproduct material. The NRC has issued license number 19-05748-02 to GSFC for NRC regulated radioactive materials in use at WFF. 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 at WFF include instruments, experiments, and calibration sources. All sources of ionizing radiation are used and/or stored at WFF under the radiation protection program overseen by GSFC's IRSC. Because protection guidelines must be followed for all radiation-emitting sources and equipment, the potential for human overexposure to ionizing radiation is minimal.

Radiation safety is maintained by employing monitoring devices and performing periodic inspections of radioactive sources, personnel, and the areas where radioactive sources are used and stored. In the event an area or item is found to be above the regulatory limits, proper

decontamination methods are performed. The IRSC surveys ionizing radiation devices, and, if necessary, properly disposes of the devices (**NASA 2005**). Ionizing radiation sources at WFF and control techniques are provided in Table 9-1.

Table 9-1 Ionizing Radiation Sources and Control Techniques at WFF

Source of Radiation	Potential Population Exposed	Degree of Hazard	Control Techniques
Used for Package Receiving X-Ray (electric, no associated isotope) F-019 Receiving	Occupational User	Low	Proper Handling Techniques; User Safety Training required and updated every 3 yrs.
Used in Explosives Handling X-ray (electric, no associated isotope) M-016 Magazine Area	Occupational User	Low	Proper Handling Techniques; User Safety Training required and updated every 3 yrs.
Used in Instrument Calibration (building varies depending on current projects) Source: Americum-241, Carbon-14, Caesium-137, Technetium-99	Occupational User	Low; Exempt from NRC License (Ref: 10CPR30.18(a))	Proper Handling Techniques; Periodic Wipe Testing; User Safety Training required and updated every 3 yrs.

9.3 Non-ionizing Radiation

The GSFC NIRSC oversees the use of non-ionizing radiation sources to ensure personnel protection. Prior to the arrival of a non-ionizing radiation source at WFF, information on the source is obtained and reviewed by the WFF Safety Office and the NIRSC. Hazard evaluations are conducted and controls are established based on the hazards to ensure a safe working environment. Equipment in use at WFF that produces non-ionizing radiation includes lasers, radars, microwaves, and ultraviolet and high-intensity lamps. Non-ionizing radiation sources at WFF and control techniques are provided in Table 9-2.

Laser radiation sources include pulsed or continuous wave systems capable of producing laser light from ultraviolet to the far infrared. The lasers at WFF are used for research and testing, as well as communication and atmospheric research. Laser devices are used in a variety of experiments at WFF in both laboratories, aircraft mounted instruments, and payloads. Outdoor laser tests are also conducted. The hazards of lasers are well known, and proper handling techniques have been developed and implemented.

All of NASA's laser operators must be trained in the proper use of the class of lasers they use. NASA classifies all lasers into one of four categories based on use and light intensity in compliance with American National Standards Institute (ANSI) Standard Z136.6:

Table 9-2 Non-Ionizing Radiation Sources and Control Techniques at WFF

Source of Radiation	Potential Population Exposed	Degree of Hazard	Control Techniques
Class III b and IV Lasers: Such as- NASA Airborne Topographical Mapper. NASA Airborne Oceanographic LIDAR.	Occupational User, General Public, and Aircraft	Low	Ground Testing: area restrictions established, warning signs and lights used, safety observer posted to warn transients. During flight, laser is not activated until aircraft altitude is greater than the NOHD; laser is terminated if another aircraft approaches the hazard area. FAA Letter of Non-Objection is obtained prior to flight operations. Flight plans are approved prior to mission. User Safety Training required and updated every 3 yrs.
Radars: (such as those located at A-41, E-134, N-162, U-25, U-30, U-40, U-70, U-55, Y-55, V-100)	Occupation User and General Public	Low, within ANSI Limit 30kHz-300GHz (GPR 1860.3)	Annual Hazard Evaluation Performed by WFF Safety Office in Accordance with GPR 1860.3. User Safety Training required and updated every 3 yrs.
Microwave Ovens	User	Low, within ANSI Limit 30kHz-300GHz (GPR 1860.3)	Required UL listing
Ultraviolet and High-Intensity Lamps	User	Low	Hazard analysis performed by user

NOHD = Nominal Ocular Hazard Distance; UL = Underwriters Laboratories

(1) Class I lasers

- considered exempt
- typically enclosed in a protective device
- control measures not required for operation

(2) Class II lasers

- low-power visible continuous wave and high pulse-rate frequency lasers
- incapable of producing eye injury within the duration of a blink
- eye injury can occur if user stares directly into laser beam

(3) Class III lasers

- medium-power lasers
- can cause serious eye injury if user looks directly into laser beam

(4) Class IV lasers

- are high-power lasers
- can present serious skin and eye hazards
- can ignite flammable targets
- can create hazardous airborne contaminants
- can have a potentially lethal, high-current, high-voltage power supply

Other sources of non-ionizing radiation include high intensity light sources such as compact arc lamps, tungsten-halogen lamps, and electronic flash lamps. Some high-intensity light sources may produce ultraviolet, visible, and/or infrared radiation.

Sources of radio-frequency radiation that produce power densities greater than 645 milliwatts per square inch are also potentially hazardous. Sources of radio frequency at WFF that fall into this category include radar units, microwave ovens, diathermy units, induction heating devices, and radio-frequency generators. Radio frequency is managed by the WFF Code 500 Spectrum Manager and the WFF Safety Office.

Section 10. Noise, Sonic Boom, and Vibration

Sound, expressed in decibels, is created by vibrations travelling through a medium such as air or water. A-weighting (dBA) provides a good approximation of the response of the average human ear and correlates well with the average person's judgment of the relative loudness of a noise event. Table 10-1 provides typical noise levels. A sound level of 0 dBA is the approximate threshold of human hearing and is barely audible under extremely quiet conditions. By contrast, normal speech has a sound level of approximately 60 dBA. Sound levels above 100 dBA begin to be felt inside the human ear as discomfort. Sound levels between 110 and 130 dBA are felt as pain; levels exceeding 140 dBA could involve tissue damage to the ear (**Berglund and Lindvall 1995**).

Table 10-1 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 ft	130		
Jet takeoff at 200 ft Auto horn at 3 ft	120		
Chain saw or noisy snowmobile	110		
Lawn mower at 3 ft Noisy motorcycle at 50 ft	100	Very Loud	
Heavy truck at 50 ft	90		
Pneumatic drill at 50 ft Busy urban street, daytime	80	Loud	
Normal automobile at 50 mph Vacuum cleaner at 3 ft	70		Speech interference
Air conditioning unit 20 ft Conversation at 3 ft	60	Moderate	
Quiet residential area Light auto traffic at 100 ft	50		Sleep interference
Library or quiet home	40	Faint	
Soft whisper at 15 ft	30		None
Slight rustling of leaves	20	Very Faint	
Broadcasting studio	10		
Threshold of Human Hearing	0		

Note: [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 minimum change in the sound level of individual noise events that an average human ear can detect is about 3 dB. On average, a person perceives a doubling (or halving) of a sound's loudness when there is a 10 dB change in sound level. In the Noise Control Act of 1972 and as amended by the Quiet Communities Act of 1978, Congress declared that it is the policy of the United States to promote an environment for all Americans that is free from noise that jeopardizes their health or welfare.

Noise is often defined as any sound that is undesirable because it interferes with communication, is intense enough to damage hearing, diminishes the quality of the environment, or is otherwise annoying. Noise may be intermittent or continuous, steady or impulsive, and may be generated by stationary or mobile sources. The individual response to similar noise events can vary widely and is influenced by the type and characteristics of the noise source, distance between source and receptor, receptor sensitivity, and time of day.

10.1 Noise Metrics

The impact of noise is described through the use of noise metrics which depend on the nature of the event and who or what is affected by the sound. The following sections provide metrics for airborne noise (includes criteria regarding sonic booms and how sound overpressures are assessed to evaluate structural impacts) and underwater acoustics.

10.1.1 Airborne Noise

Airborne noise is represented by a variety of metrics that are used to quantify the noise environment. Human hearing is more sensitive to medium and high frequencies than to low and very high frequencies, so it is common to use maximum dBA metrics (also shown as dB L_{Amax}) representing the maximum A-weighted sound level over a duration of an event such as an aircraft overflight. A-weighting provides a good approximation of the response of the average human ear and correlates well with the average person's judgment of the relative loudness of a noise event. "Unweighted" (dB or dB L_{max}) metrics represent low frequency sound levels used to analyze structural response to noise. A-weighted Sound Exposure Level (SEL) represents both the magnitude of a sound and its duration. SEL is greater than the dB L_{max} because an individual event (i.e., rocket launch) can take several minutes while the dB L_{max} occurs instantaneously. The Day Night Average Sound Level (DNL)[2] is a cumulative noise metric that accounts for all noise events over an average 24-hour period. This is often shown as dB DNL. DNL is used to predict human annoyance and community reaction to unwanted sound (i.e., noise).

[2] DNL combines the levels and durations of noise events, and the number of events over a 24-hour time period; it is the community noise metric recommended by the EPA (**EPA 1974**).

10.1.2 Sonic Booms, Sound Overpressures, and Low Frequency Sounds

A sonic boom is created when an object (e.g., rocket) travels faster than the speed of sound. A sonic boom differs from other sounds in that it is impulsive and very brief, lasting less than one second. Shock waves, or sound overpressures, associated with sonic booms (boom load) have the potential to cause structural damage. Most damage claims from sonic booms are for brittle objects such as glass and plaster. There is a large degree of variability in damage experience, and the degree of damage depends on the pre-existing condition of an object or structure. Breakage data for glass, for example, spans a range of two to three orders of magnitude at a given overpressure. At 1 pound per square foot (psf), the probability of a window breaking ranges from one in a billion (**Sutherland 1990**) to one in a million (**Hershey and Higgins 1976**). These damage rates are associated with a combination of boom load and glass condition. At 10 psf, the probability of breakage is between one in a 100 and one in a 1,000 (**Haber and Nakaki 1989**). Laboratory tests of glass have shown that properly installed window glass will not break at overpressures below 10 psf, even when subjected to repeated booms (**White 1972**). FAA regulations prohibit civil supersonic aircraft flight over land. For a rocket launch, a sonic boom occurs over the ocean, downrange of the launch site, after the rocket reaches supersonic speeds; therefore, the launch site itself does not experience a sonic boom.

10.1.3 Underwater Acoustics

Underwater acoustics behave much like sound in the air but, due to the denser medium, the sound waves can propagate much farther in water. Unlike airborne noise, underwater noise is not weighted to match frequencies that can be heard by the human ear. Two common descriptors of underwater noise are instantaneous peak sound pressure level (dB_{peak}) and the Root Mean Square (dB_{RMS}) pressure level during the impulse. The dB_{peak} is the instantaneous maximum overpressure or underpressure observed during each sound pulse and can be presented in Pascals (Pa) or sound pressure level in dB, referenced to a pressure of 1 micropascal at one meter (dB re:1μPa-m). The dB_{RMS} is the square root of the energy divided by the duration of the sound pulse. This level is often used by the NMFS to describe disturbance related effects to marine mammals from underwater impulse sounds. Potential injury to fish from noise is estimated using the dB_{peak} metric (**WSDOT 2011**).

10.2 Noise Thresholds and Guidelines

Noise in the U.S. is regulated under a number of different statutes and regulations. The Noise Control Act of 1972, and as amended by the Quiet Communities Act of 1978, set forth the policy of the U.S. to promote an environment for all citizens that is free from noise that jeopardizes human health and welfare. Specific noise regulations can be imposed by Federal agencies and state and local governments. Thresholds and guidelines for airborne noise and underwater acoustics applicable to activities at WFF along with standard thresholds are provided below.

10.2.1 Accomack County Noise Ordinance

The Accomack County Code provides noise threshold guidelines based on the different zoning districts within the county. The County Code provides noise levels for both day and nighttime activities, and activities that will exceed these thresholds are generally prohibited. Article 38-35 of the Code states that the thresholds shown in Table 10-2 do not apply to commercial or industrial operations except if noise from those operations emanates beyond the boundaries of the commercial or industrial site and affect persons who are not working onsite. No specific noise thresholds have been established for any sensitive receptors but the Code states that noise would be deemed excessive if 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" (**Accomack County 2001**).

Table 10-2 Accomack County Noise Guidelines by Land Use

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

10.2.2 OSHA Noise Guidance

The Occupational Safety and Health Act of 1970 assures safe and healthy working conditions by enforcing standards and by providing training, education, outreach, and assistance. OSHA regulates noise impacts to workers, and establishes thresholds for a safe work environment. OSHA standard (29 CFR 1910.95) provides noise exposure limits for employees in noisy environments or workplaces. According to OSHA, an employee should not be subjected to continuous noise exceeding 90 dBA for durations lasting more than 8 hours per day (Table 10-3). As the level increases, the allowed duration of exposure decreases. The maximum limit is 115 dBA for duration of 15 minutes or less.

OSHA standards are the most well documented requirements in regards to long-term human noise exposure. Although they are not specifically designed to assess the impact of intermittent launch noise, the OSHA limit of 115 dBA appears to be the most appropriate standard available for human exposure to launch noise levels. A maximum noise level of 115 dBA is used to identify potential locations where hearing protection should be considered for a rocket launch.

10.2.3 Federal Interagency Committee on Urban Noise

In June 1980, an ad hoc Federal Interagency Committee on Urban Noise (FICUN) published guidelines relating DNL to compatible land uses (**FICUN 1980**). This committee was composed of representatives from DOD, Department of Transportation, Department of Housing and Urban Development, EPA, and Veterans Administration. Since their issuance, Federal agencies have generally adopted the guidelines for their noise analyses. According to a study conducted by FICUN, noise levels between 65 and 70 dB DNL are compatible with educational services, such as schools, provided that measures are taken to provide noise level reduction of 25 dB in the buildings (**FICUN 1980**).

Table 10-3 OSHA Permissible Noise Exposures

Duration per Day (hours)	Sound Level (dBA)
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25	115

Source: **OSHA 2012**.

10.2.4 NMFS Guidance

Underwater thresholds have been established by NMFS for behavioral disruption and potential injury for marine wildlife, specifically, marine mammals and fish. NMFS is currently developing comprehensive guidance on sound characteristics likely to cause injury and behavioral disruption in the context of the MMPA, ESA, and other statutes. Until formal guidance is approved and available, NMFS uses conservative thresholds for underwater sound pressure levels from broad band sounds that may cause behavioral disturbance and/or injury to marine organisms. The thresholds shown in Table 10-4 are those used for MMPA permitting activities and ESA Section 7 consultations by NMFS. NMFS also uses conservative in-air noise thresholds for marine mammals, specifically pinnipeds. These thresholds are for behavioral disruption and are 90 dB_{RMS} for harbor seals and 100 dB_{RMS} for non-harbor seal pinnipeds (**NMFS 2012d**).

Table 10-4 Underwater Acoustic Thresholds for Cetaceans, Pinnipeds, and Fish

Functional Hearing Group	Underwater Threshold
Cetaceans and Pinnipeds[a, d]	
Injury	190 dB re: 1 µPa (RMS) pinnipeds 180 dB re: 1 µPa (RMS) cetaceans
Behavior Disruption (Impulsive Noise)	160 dB re: 1 µPa (RMS)
Behavior Disruption (Non-pulse Noise)	120 dB re: 1 µPa (RMS)
Fish	
Injury[b]	
All	206 dB re: 1 µPa (Peak)
Fish ≥ 2 grams	187 dB re: 1 μPa^2 -s (SEL)
Fish < 2 grams	183 dB re: 1 μPa^2 -s (SEL)
Behavioral Disruption[c]	150 dB re: 1 µPa (RMS)

Sources: **[a] Southall et al. 2007; [b] Fisheries Hydroacoustic Working Group 2008; [c] Hastings 2002; [d] NMFS 2012d.**

10.3 Airborne Noise

In October 2011, Blue Ridge Research and Consulting (BRRC) collected monitored noise data for WFF. The effort focused mainly on the baseline acoustic environment of the Mainland and Wallops Island (**BRRC 2011**). Generally, the noise environments at the Mainland and Wallops Island are relatively quiet with the dominant noise sources being naturally occurring wind and wave action, due to their coastal location. Ambient noise is below 52 dB DNL (**BRRC 2011**). Those activities that generate noise above ambient conditions include aircraft flight operations, Navy target launches, and NASA and MARS rocket launch activities.

Rocket activities generate the greatest noise levels on Wallops Island. Noise generated by these activities is short-term in duration lasting less than 10 minutes. Large rockets have the potential to produce sonic booms. Trajectories for rockets launched from WFF follow a predominantly southeastern course over the Atlantic Ocean. The boom footprint or "carpet", if generated, would occur over the open ocean (**NASA 2009b**). Rocket operations that have the potential to create sonic booms must be coordinated through the Navy's FACSFAC VACAPES (**NASA 2009b**).

Aircraft operations generate the greatest noise levels around the Main Base. According to the WFF Public Affairs Office and Navy's Region Mid Atlantic, between November 2013 and February 2016, a total of 124 noise complaint calls were received from 39 callers with 62 of these complaint calls originating from five callers; 20 of the 39 callers and 84 of the 124 noise complaint calls were from residential areas within 0.75 nautical miles west of the approach end of Runway 10. All complaints focused on FCLP operations. The majority of calls were received by the hotline that the Navy established solely for the purpose of WFF FCLP complaint calls. The Navy has directly contacted all callers to further discuss the caller's concerns (**Eggers 2016**).

10.4 Underwater Acoustics

The ambient underwater acoustic environment is affected by many natural and man-made activities. Generally, the waters surrounding WFF would be relatively quiet, with the major human generated noise sources coming from commercial fishing vessels, recreational boats, and personal watercraft. During the initial SRIPP beach fill in summer 2012, NASA partnered with BOEM and USACE to record background in-water sound levels at the both offshore borrow area (11 mi northeast of Wallops Island) and the nearshore pump-out area (between 1.2 and 2.4 mi) east of Wallops Island). Data were collected at two listening depths at each site; approximately 10 ft and 30 ft depths at the offshore shoal and 10 ft and 20 ft at the nearshore sites. During the study, the majority of data collected when winds were at least 4 to 7 mi per hour and wave heights were at least 1 to 2 ft. Therefore, the data do not reflect "calm" sea conditions.

Background sound pressure levels (SPLs) averaged 117 dB across all sampling days, sites, water depths and weather conditions. Minimum measured sound levels ranged from 91 dB to 107 dB depending on sampling location and water depth; maximum levels ranged from approximately 128 dB to just under 148 dB (**Reine et al. 2014**). Highest SPLs were found at frequencies of less than 200 hertz.

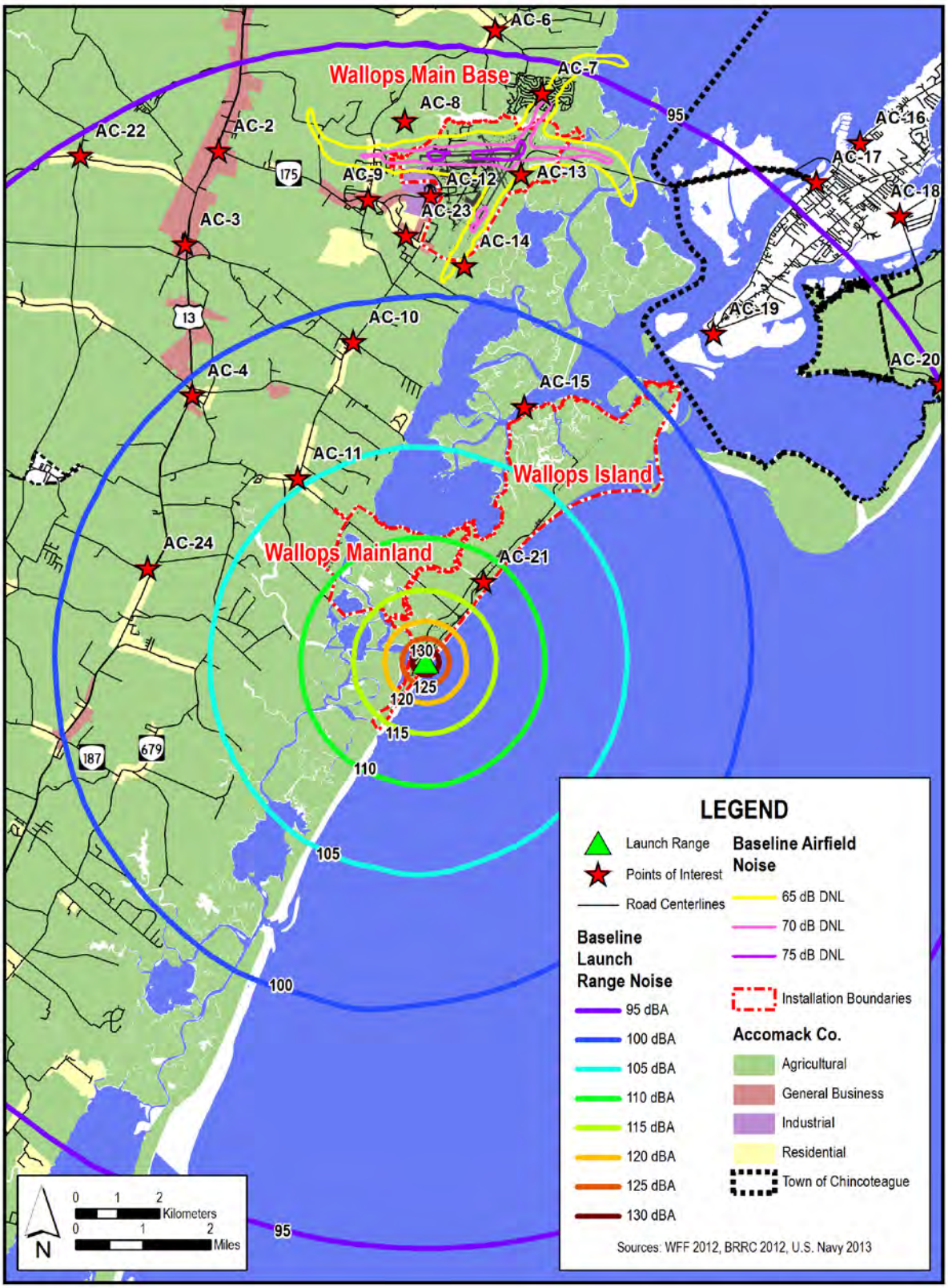


Figure 10-1 Baseline Noise Environment and Points of Interest at WFF

10.5 Airfield Operations

In July 2012, BRRC, modeled aircraft noise around the WFF airfield. The model was based on various aircraft including the A-10, Super King Air C-12, C-40 transport, E-2/C-2, F/A-18E Jet Fighters, and the P-3C (**BRRC 2012**). Noise generated from airfield operations are shown as contours in Figure 10-1. The 65 dB DNL noise contour extends beyond the Main Base boundary, mostly over lands zoned for agricultural use. The 65 dB DNL contour does extend over a residential area to the west, but 65 dB is within the daytime noise ordinance limits for Accomack County (**Accomack County 2001**).

The 70 dB DNL contour extends only slightly beyond the base boundary at the terminal end of Runways 10, 22, and 28 and the 75 dB DNL noise contour is confined to the Main Base boundary. Figure 10-1 also indicates the numerous points of interest surrounding WFF. As shown in Table 10-5, 24 points of interest were identified during a baseline noise monitoring survey, as comparisons; baseline dB DNL values (i.e., normally occurring background levels) are presented for 22 of the points. With an average DNL of approximately 50 dB, none of the points of interest had DNL values that exceeded 64 dB DNL.

Table 10-5 DNL Values for Points of Interest around WFF

Location ID	Description	Latitude	Longitude	Baseline dB DNL
AC-1	Intersection of U.S. 13 and SR 709	37.979862	75.530116	<45
AC-2	T's Corner (east of intersection of U.S. 13 and Chincoteague Road)	37.945590	75.539688	49.1
AC-3	Arcadia High School	37.925653	75.549588	48.2
AC-4	Temperanceville at Intersection of U.S. 13 and SR 695	37.892998	75.548880	<45
AC-5	Captain's Cove Community Pool	37.990629	75.421811	<45
AC-6	Horntown at Intersection of SR 679 and SR 709	37.969714	75.463103	52.8
AC-7	Trail's End Campground/Community Pool	37.955769	75.450846	62.4
AC-8	Olde Mill Pointe Traffic Circle	37.950772	75.488573	56.1
AC-9	Wattsville at Intersection of SR 679 and Chincoteague Road	37.934026	75.499244	61.2
AC-10	Atlantic at Intersection of SR 679 and Nocks Landing Road	37.903404	75.504567	45.1
AC-11	Assawoman at Intersection of SR 670 and Wallops Island Road	37.874388	75.520869	<45
AC-12	CBFS	37.934410	75.482184	55
AC-13	NASA Visitor Center	37.938484	75.457344	63.5
AC-14	USFWS Maintenance Yard at Wallops Island National Wildlife Refuge	37.919021	75.473680	62.4
AC-15	Ballast Narrows at Wallops Island National Wildlife Refuge	37.888266	75.458558	<45
AC-16	Chincoteague High School	37.942804	75.364619	<45
AC-17	Chincoteague Waterfront Park	37.934675	75.376869	<45
AC-18	Chincoteague Chamber of Commerce on Piney Island	37.926754	75.354520	<45

Table 10-5 DNL Values for Points of Interest around WFF

Location ID	Description	Latitude	Longitude	Baseline dB DNL
AC-19	Curtis Merritt Harbor, Chincoteague Island	37.902697	75.406283	<45
AC-20	Tom's Cove Visitor Center	37.890114	75.344757	<45
AC-21	MARS	37.850806	75.471128	<45
AC-22	Withams at Intersection of SR 693 and SR703	37.945463	75.577460	<45
AC-23*	Emma's World Daycare and Preschool	37.926485	75.489265	No data
AC-24*	Kegotank Elementary School	37.855931	75.562478	No data

Note: *Points not included in BRRC's noise modeling effort, therefore no baseline data exists in DNL.
Source: **U.S. Navy 2013**.
Legend: SR=State Route.

10.6 Launch Vehicle

The Antares launch vehicle has been analyzed for operations at WFF and is the envelope launch vehicle; therefore, baseline conditions have been modeled with the Antares. The 2009 *EA for the Expansion of the Wallops Flight Facility Launch Range* and the 2015 *Supplemental EA for the Antares 200 Configuration Expendable Launch Vehicle* presented conservative noise predictions for either Antares launch vehicle. The 2009 predictions were based on a methodology that equated noise to the overall thrust of the rocket motor with the assumption that the noise levels would be evenly distributed radially (**NASA 2009b**). In 2015, the Antares ELV was modeled using the latest technology for assessing rocket launch noise, the RUMBLE model (**BRRC unpubl. data**). Additionally, to help assess the community impact, BRRC modeled the noise impact at the nearest house location approximately 1.9 mi west of the WFF launch range, as a specific point of interest (**BRRC 2013**). The results of the Antares ELV noise modeling are presented below.

10.6.1 Methodology

To determine the number of occupied structures (i.e., homes, business, etc.), including the nearest house, and population that could be affected by noise generated by rockets and projectiles launched from Wallops Island, 2010 Census data was used in combination with 911 emergency address Geographic Information System (GIS) data obtained from Accomack, Northampton, Somerset, Wicomico, and Worcester counties (**USCB 2010**). As part of a ground-truthing effort, WFF plotted all homes within a 3 mi radius of the launch range.

10.6.2 Results for A-weighted Noise (dBA)

Figure 10-1 provides the dBA noise contours for the baseline noise environment at Wallops Island. Table 10-6 provides the total land area, occupied structures, and estimated population under the noise contours ranging from 115 dBA (the OSHA threshold for 15 minute exposure) to 130 dBA, within Accomack County. A total of 1,018 ac of land area is within the 115 to 130 dBA contours; however, there are no occupied structures or people located within the 115 dBA and greater noise contours. No land area, occupied structures, or people in Northampton, Somerset, Wicomico, or

Worcester counties are located within the 115 to 130 dBA noise contours. From the noise modeling study for impacts on the nearest home to the launch range, noise from the event is modeled to attenuate to the background average of 50 dBA in approximately 8.3 minutes (500 seconds) with peak noise levels dropping drastically in the first 1.6 minutes (100 seconds) (refer to Figure 10-2) (**BRRC 2013**).

Table 10-6 Antares Sound Pressure Levels at Selected Locations

Location Description	Distance from Pad 0-A (Approximate)	2015 Modeled Maximum OASPL	
	(km)	(dB)	(dBA)
Estimated Sound Pressure Levels			
Northern boundary of the piping plover habitat on south Wallops Island	1.5	126	109
Community of Assawoman	3.2	119	98
Town of Chincoteague	10.6	108	80
Wallops Main Base	12.3	107	78
Distance to OSHA Hearing Conservation Criterion (km)			
Distance to 115 dBA Hearing Conservation Criterion	N/A	0.9	

Key: N/A = Not Applicable SPL = Sound Pressure Level OASPL = Overall Sound Pressure Level
Source: **BRRC unpubl. data; USCB 2010**.

The modeled A-weighted Overall Sound Pressure Level (OASPL) at the nearest house to the launch range is shown in Figure 10-2 with respect to time, where zero seconds represents the beginning of the launch event. The nearest house does not receive noise from the launch event until close to 9 seconds after the event has started due to the time it takes the noise to travel from the rocket to the receiver. The received OASPL is a result of the distance between the house (receiver) and the launch vehicle (source) as well as the vehicle's orientation. Although the vehicle is always moving farther away from the house, its orientation to the ground is shifting so that more acoustic energy is directed towards the house based on the angle from the source to receiver.

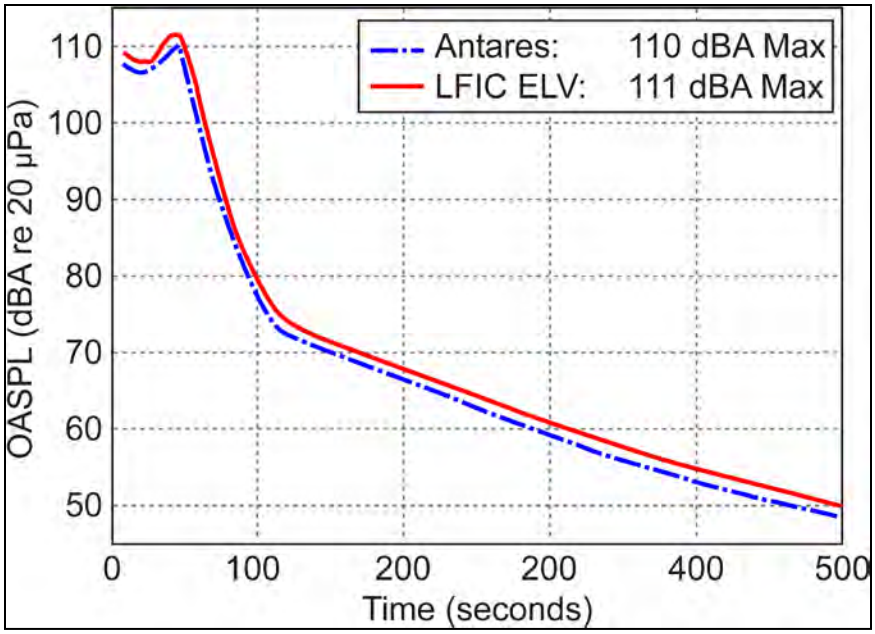


Figure 10-2 Time History of Noise (dBA OASPL) at Nearest House to Launch Range

This explains why the maximum sound may not occur at the beginning of the launch event. In addition, as the launch vehicle moves away from the house, the time required for a doubling of distance (equating to a decrease of 6 dB) increases, resulting in a reduced slope. A maximum predicted A-weighted OASPL of 110 dBA that would drop to approximately 75 dBA in 100 seconds, would be perceived at the nearest house for the Antares launch (**BRRC 2013**).

Time above OASPL 66 dBA is a supplemental metric that estimates the noise that can potentially interfere with speech. Outdoor speech interference can be expressed as a percentage of sentence intelligibility between two people speaking in normal voices at approximately 3 ft apart. The model results indicate that sentence speech intelligibility will drop below 95% for a time period of up to 4 minutes per launch for the Antares. Ninety-five percent sentence intelligibility usually permits reliable communication because of the redundancy in normal conversation (**BRRC 2013**).

10.6.3 Results for Unweighted Noise (dB)

Rocket launches also produce low frequency sounds. Low frequency sounds would be perceived as vibration and rumbling. These noise levels are reported in un-weighted dB. From the noise modeling study for impacts on the nearest home to the launch range (approximately 1.9 mi) noise from the event is modeled to attenuate to between 75 and 80 dB in approximately 8.3 minutes (500 seconds) with peak noise levels dropping drastically in the first 1.6 minutes (100 seconds) (refer to Figure 10-3) (**BRRC 2013**).

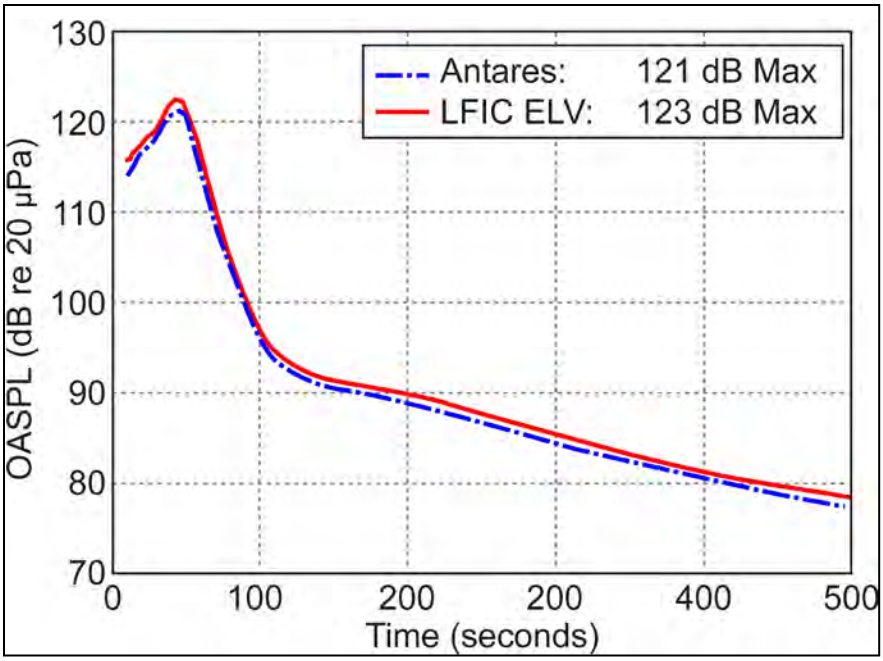


Figure 10-3 Time History of Noise (dB OASPL) at Nearest House to Launch Range

10.7 Typical Construction and Demolition Noise

Typical construction assumes standard construction and demolition practices include the use of heavy equipment during construction and demolition, but assumes that no explosives or exceedingly loud practices would be needed for construction or demolition. These construction efforts would generally be non-hardened buildings to house administrative or similar activities. Construction/demolition noise would be temporary over the course of the individual projects and would be confined to within the WFF boundaries. Construction-related noise can range from 74 to 101 dBA when measured 50 ft from the respective piece of equipment. The noise associated with construction and demolition activities at WFF is confined to general working hours (8:00 a.m. to 5:00 p.m.) and are unlikely to adversely alter the surrounding noise environment.

Section 11. Historical, Archaeological, and Cultural Factors

11.1 History of Wallops Flight Facility

In 1664, the year following the formation of Accomack County, John Wallop received his first land patent of 1,000 acres from King Charles II of England. In that same year, Wallop was appointed deputy Surveyor-General, and "soon the local maps were labeled with the names Wallop's Neck, Wallop's Island, and Wallop's Creek". Wallop laid out the original town of Port Scarburgh (Onancock) and the Old Wallop's Road (which later became Route 13). Wallop received an additional land patent of 700 acres in 1666, and added 2,000 additional acres to his holdings in 1672 (**NASA 2003**).

In 1693, John Wallop divided the island, which is now known as Wallops Island, and gave it to his two children. The United States Government has had a presence on the island since 1883. In that year, a small amount of land was purchased from the Wallops family by the United States Life Saving Service (which in 1915 became the USCG) establishing a Life Saving Station on the northern end of Wallops Island. The remainder of the land seems to have remained in the family until it was sold in 1889 along with island acreage to Wesley K. Woodbury of Wrightsville, Pennsylvania, a trustee for what was known as the Wallops Island Association (WIA).

In 1933, the WIA incorporated and became known as the Wallops Island Club (**NASA 1994**). In 1942, the U.S. Navy established the Naval Auxiliary Air Station on what is now the Main Base. Beginning in 1943, the Civil Air Patrol used the airfield to operate PB4Y aircraft (converted B-24 Liberators) engaged in anti-submarine patrol along the Atlantic Coast. The airfield was commissioned that same year and was originally known as the CNAAS. The airfield was used as a training facility for naval aviation units. On 1 January 1950, the CNAAS was re-designated as a Naval Air Facility. Modifications to the air facility to accommodate Field Carrier Landing Practice were completed during July 1950. The US Navy ceased training flight operations and declared the air facility excess in 1959 (**USACE 2005**).

The National Advisory Committee for Aeronautics (NACA) Langley Field Research Center established a base on Wallops Island in 1945 and in June of that year launched its first rocket from the facility. Naval use of Wallops Island commenced in 1946 when the Naval Aviation Ordinance Test Station was established to provide a test range and training for personnel to test, modify, and develop guided missiles, aircraft weapons, and aviation fire control equipment. The types of tests conducted by the Navy included and involved advanced jet aircraft, pilotless propeller-driven and jet drones, flights with live ammunition, aviation ordnance test flights, and various methods of bombing. Naval use of the northern half of Wallops Island to test and proof Navy aerial ordnance continued until 1959 (**USACE 2005**).

In 1958 President Dwight D. Eisenhower signed the Space Act, Public Law (PL) 85-568. This act created NASA and NACA was absorbed into the new agency. NASA was officially given organizational life on October 1, 1958 **(NASA 1994**). The fledgling NASA acquired the facility

on June 30, 1959, along with the Mainland area. The entire Wallops complex consisting of the Main Base, the Mainland, and Wallops Island became known as Wallops Station in 1959 (**NASA 1994**). The name of the facility was changed on April 26, 1974, from Wallops Station to Wallops Flight Center (WFC). WFC was consolidated with GSFC in October 1981, and the name was again changed to WFF (**NASA 1994**). The consolidation objectives were to improve the overall effectiveness of the centers through institutional reconfiguration and to focus both centers' resources in their areas of expertise.

11.2 Programmatic Agreement

The National Historic Preservation Act (NHPA) of 1966, 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 (SHPO) 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 impact 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. The Section 106 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 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 accordance with Sections 106 and 110 of the NHPA, NASA has entered into a Programmatic Agreement with the Virginia SHPO and the Advisory Council on Historic Preservation to outline how WFF will manage its cultural resources as an integral part its operations and missions (**NASA 2014f**). As part of this process, NASA identified a number of parties who have an interest in, or knowledge of, cultural resources at WFF, including the Pocomoke Indian Nation and the Catawba Indian Nation, and have included them in development of the terms of the Programmatic Agreement. The Programmatic Agreement establishes the parameters for managing cultural resources at WFF including:

- Roles and responsibilities;
- Updates and requirements for the WFF ICRMP;
- Activities not requiring review;
- Review process for potential impacts including professional qualifications, documentation, curation, etc;
- Requirements for the treatment of the Wallops Beach Live Saving Station;
- Resolution of adverse effects and disputes; and
- Emergency actions.

11.3 Archaeological Resources

In order to assess possible impacts to archaeological sites, a predictive model was prepared for the WFF and accepted by the VDHR in 2003 (**NASA 2003**). This predictive model includes both prehistoric and historic models and indicates areas of low, moderate, and high archaeological potential, as explained in Table 11-1 nd Table 11-2. Archaeological sensitivity maps (Figure 11-1) have been created based on the predictive model, incorporated into GIS geodatabases, and are available for the entire WFF facility for planning purposes. The model is used to help identify potential archaeological impacts of WFF projects and is used in WFF's NHPA Section 106 consultation with the Virginia SHPO. For ground-disturbing activities in moderate or high probability areas, or that will disturb unevaluated archaeological sites, the WFF Historic Preservation Officer (HPO) consults with the SHPO to determine whether further archaeological surveys or evaluations are warranted. If during consultation with the SHPO, the WFF HPO determines that further efforts are needed to identify or evaluate archaeological sites, the WFF HPO ensures that an archaeological testing program is developed and implemented. The testing program must be sufficient to identify any potentially eligible sites present within the area of disturbance and determine conclusively their eligibility for listing in the NRHP. These investigations are then used to re-evaluate and refine the predictive model in the geodatabases.

Table 11-1 Prehistoric Site Predictive Model for the Virginia Interior Coastal Plain

Sensitivity	Landform	Soil Drainage Type	Slope, %	Distance to Water, ft
Low	Tidal Marsh, Topographically low areas	Poorly-drained	< 2	NA
	Terrace, knoll, ridge, and bluff edges	All types	> 10	NA
	Terrace, knoll, ridge, bluff	All types	NA	> 500
Moderate	Terrace, knoll, ridge, bluff, barrier island	Moderately-drained	2–10	< 500
High	Terrace, knoll, ridge, bluff, barrier island	Well-drained	2–10	< 500
	Hummock or knoll in tidal marsh	Moderately-to well-drained	2–10	NA

Source: **NASA 2003**.

Table 11-2 Historic Site Predictive Model for the Virginia Interior Coastal Plain

Sensitivity	Landform	Slope, %	Distance to Water, ft
Low	Any	> 20	NA
Moderate	Ridges	10–20	NA
High	Stream terraces, floodplains, ridges	0–10	+/- 900

Source: **NASA 2003**.

Over the years, several studies have been conducted identifying and evaluating cultural resources at WFF. Currently, eleven archaeological sites have been identified on WFF (Table 11-3). Five sites have been recommended as ineligible for listing on the NRHP. Four sites have not been the subject of further archaeological inquiry as these sites are located in protected areas not planned for development. In order to protect these archaeological sites, only general location information is included in the table.

Table 11-3 Known Archaeological Sites on WFF

Site Number	Site Type	Location	National Register Eligible?	Cultural Period
44AC0089	Military Earthworks	Wallops Island/north	Recommended Eligible[1]	Revolutionary War
44AC0103	Matthews House and associated grave/cemetery	Main Base south airfield	Not Evaluated	18th Century (ca. 1788)
44AC0159	Shell Pile	Wallops Island/south	Determined Not Eligible	Unknown Historic
44AC0405	Artifact Scatter	Main Base/Navy housing	Recommended Not Eligible	19th Century
44AC0437	Artifact Scatter	Main Base/across Wattsville from Runway 10	Not Evaluated	18th and 19th Centuries
44AC0459	Trash scatter associated with U.S. Coast Guard Station	Wallops Island/north	Determined Not Eligible	Late 19th and 20th Centuries
44AC0556	Trash pit and Funerary, single grave	Main Base/NOAA	Determined Not Eligible	Late Woodland and 19th Century
44AC0558	Temporary Camp	Mainland	Recommended Eligible; Have not sought concurrence	Possible Middle Archaic; Woodland; possible Historic
44AC0562	Artifact Scatter	Mainland	Recommended Not Eligible; Have not sought concurrence	18th and 19th Centuries
44AC0563	Artifact Scatter	Mainland	Recommended Not Eligible; Have not sought concurrence	18th and 19th Centuries
44AC0567	Trash Dump	Mainland	Determined Not Eligible	20th Century

Note: Site 44AC0089 was recommended eligible for listing in the National Register (**Espenshade and Lockerman 2009**), but a formal determination of eligibility, in consultation with the Virginia SHPO, has not been conducted. However, Site 44AC0089 is identified in the PA among NASA WFF, the Virginia SHPO, and the ACHP as a property that is eligible for inclusion in the National Register.

Sources: **NASA 2015c**

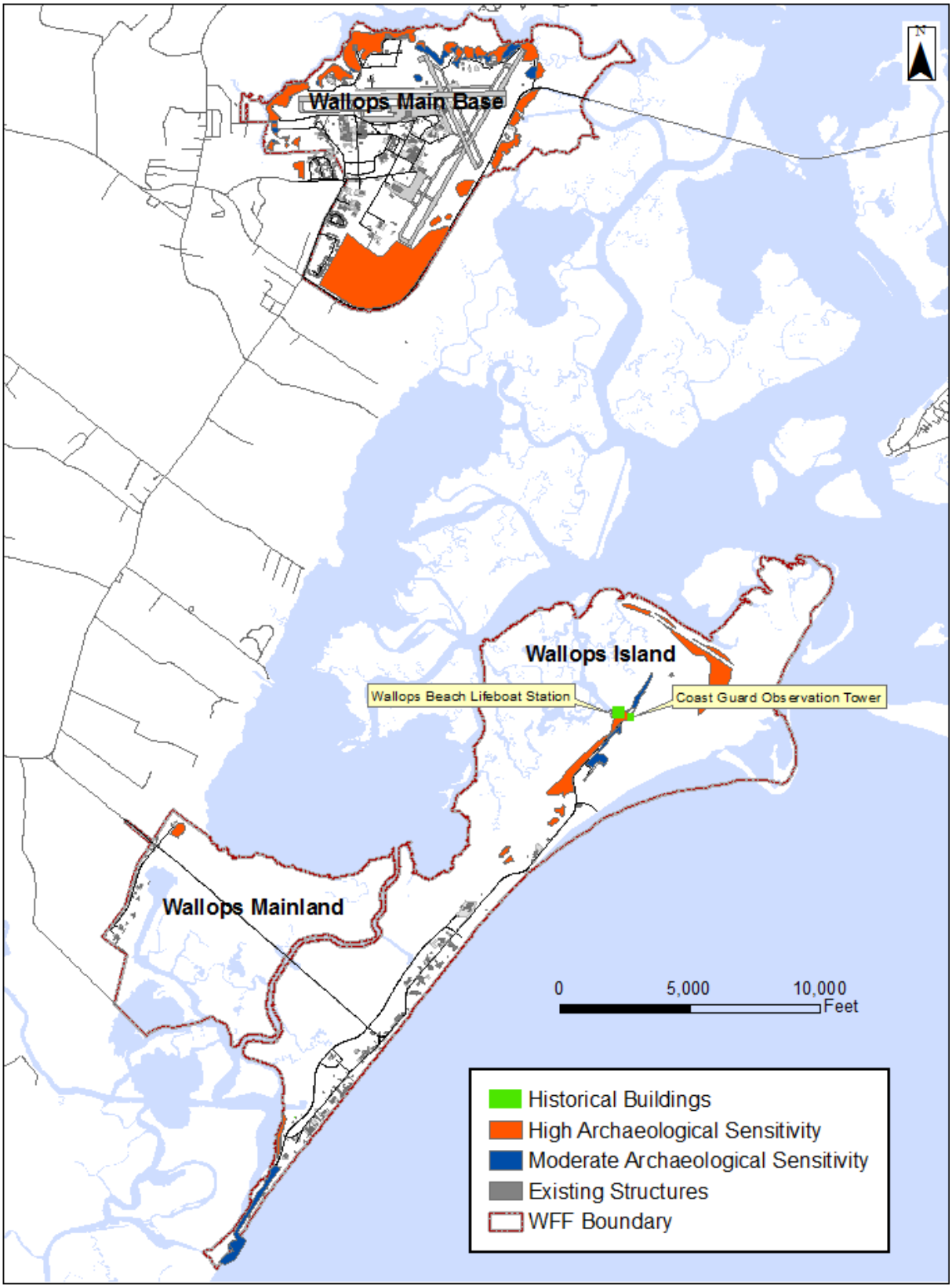


Figure 11-1 Historic and Archaeological Sensitivity

11.4 Architectural Resources

In 2004, a comprehensive architectural survey and National Register eligibility evaluation of the WFF was conducted. The study consisted of a reconnaissance level architectural survey of 124 buildings, structures, and objects at WFF built before 1956, as well as a historic context of the facility. The *Historic Resources Survey and Eligibility Report for Wallops Flight Facility, Accomack County, Virginia* was prepared from the 2004 survey (NASA 2004). As part of the Section 106 process, following the research and field work tasks, the illustrated HRSER for WFF was submitted to the WFF and the VDHR for review and comment. The VDHR concurred with the survey findings, recommending that the Wallops Beach Lifeboat Station is potentially eligible for the National Register, with the Observation Tower as a contributing structure.

In consultation with the VDHR, which is the Virginia SHPO, it was determined that there are no eligible historic districts within WFF and that all of the 124 resources surveyed were not eligible except for the Wallops Beach Lifesaving Station (Station) (V-065) and the associated steel frame Observation Tower (V-070). Since the Station and Observation Tower are located within a designated explosive hazard zone for an adjacent rocket motor storage facility, WFF is considering various options for their disposition including adaptive reuse at another location on Wallops Island or removal from WFF and transfer from Federal ownership. These plans, however, are on indefinite hold pending studies of the various alternatives. Once a final course of action has been determined.

In 2010, WFF performed a Phase 1 Archaeological Investigation for the proposed north Wallops Island UAS airstrip. Based upon findings of the investigation and subsequent consultation with VDHR, WFF has determined that a Revolutionary War earthworks (44AC0089) on the Island is eligible for listing on the NRHP and, as such, NASA and VDHR have established a plan to protect this resource during construction and operation of the airstrip.

In 2011, a supplemental historic context study and comprehensive architectural survey of 76 buildings and structures with dates of construction between 1956 and 1965 were completed for WFF. The *Historic Resources Eligibility Survey, Wallops Flight Facility, Accomack County, Virginia* (**NASA 2011b**) used the historic context of the 2004 survey; however, the 2011 survey augmented the context with additional history pertinent to the period (1956 to 1965). In consultation with VDHR, it was determined that there are no eligible historic districts within WFF and that the 76 buildings and structures are not individually eligible for NRHP listing.

11.5 Traditional Cultural Properties

WFF does not possess or manage Native American collections or cultural items, Native American remains, or Native American sacred sites or traditional cultural properties. The installation is not located within the lands of any state or federally recognized Native American tribe (**NASA 2003**). During this process of developing the Programmatic Agreement, WFF contacted a variety of tribal councils around the country to invite their participation in the Programmatic Agreement process. During the development of the Programmatic Agreement, two Native American tribes requested

to be involved in further consultation: the Pocomoke Indian Nation and the Catawba Indian Nation. In September 2016, NASA initiated government-to-government consultation with the newly federally-recognized Pamunkey Indian Tribe as well as simultaneously entering into formal government-to-government consultation with the Catawba Indian Nation. Although WFF routinely consults with the Pocomoke Indian Nation, no formalized government-to-government consultation can be undertaken with this non-federally-recognized tribe.

11.6 Cultural Factors

11.6.1 Schools

Accomack County public schools have an enrollment of approximately 5,247 students, while the Northampton County public school system consists of approximately 1,685 students (**Home Town Locator 2016**). The majority of the Navy SCSC employees' school-age children are enrolled in Accomack County schools, while others are in schools in Worcester, Somerset and Wicomico Counties in Maryland. Table 11-4 indicates the number and level of Accomack County and Northampton county schools versus the lower three Maryland counties.

Table 11-4 Lower Delmarva Peninsula Schools

County	Elementary	Middle	High School	Private
Accomack	5	3	4	1
Northampton	2	1	1	4
Wicomico	25	3	5	13
Worcester	6	4	4	5
Somerset	6	2	3	3

***Source*: Private School Review 2016, Home Town Locator 2016**

For higher education, the Eastern Shore Community College in Melfa, Virginia offers courses in several disciplines. The Eastern Shore Community College is a 2-year college with an enrollment of almost 1,131 students (**ESCC 2015**). Other neighboring facilities for post-secondary education include Wor-Wic Community College, a 2-year educational institution in Salisbury, Maryland with a total enrollment of more than 1,900 full-time equivalent students. Salisbury University, a 4-year college, also located in Salisbury, Maryland has a total enrollment of more than 8,670, students. Another four-year academic facility is the University of Maryland Eastern Shore, located in Princess Anne, Maryland, with a total enrollment of more than 4,500 students. Refer to Table 11-5 for descriptions of degrees offered by neighboring colleges and universities.

Table 11-5 Lower Delmarva Peninsula Colleges and Universities

County	University	Degrees Offered
Accomack	Eastern Shore Community College	Associate of Applied Science Associate in Arts and Sciences Small Business Management Certificate Career Studies Certificate
Wicomico	Wor-Wic Community College	Continuing Education credits Associate of Applied Science Associate of Science Associate of Arts Associate of Arts In Teaching Certificate of Proficiency
Wicomico	Salisbury University	Bachelors of Arts Bachelors of Science Bachelors of Arts Social Work Bachelors of Fine Arts Master of Business Administration Master of Science Master of Education Master of Art Master of Social Work Master of Arts in Teaching Doctor of Nursing Practice Doctor of Education
Somerset	University of Maryland Eastern Shore	Bachelors of Arts Bachelors of Science Bachelors of General Studies Master of Science Master of Arts in Teaching Master of Education Doctor of Philosophy Doctor of Education Doctor of Physical Therapy Doctor of Pharmacy

***Source*: Wor-Wic 2015; Salisbury University 2015; UMES 2015**

11.6.2 Health Facilities and Hospitals

Three local emergency medical service facilities are located in the vicinity of WFF. 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 Emergency Medical Services staff of the WFF Fire Department. The Chincoteague Community Health Center and the

Chincoteague Island Medical Center, both located on Chincoteague Island, and the Atlantic Community Health Center in Oak Hall, Virginia, also provide emergency assistance, and are all located within close proximity to WFF.

Accomack and Northampton County Health Departments offer clinical services. Worcester, Somerset, and Wicomico Counties also have health departments.

Four surgical hospitals are also located in the region, all within 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; and
- Riverside 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 Riverside Shore Memorial Hospital in Nassawadox. Additionally, numerous nursing homes, rehabilitation centers, and urgent care facilities are available to the surrounding communities on Virginia's Eastern Shore and Maryland's Lower Eastern Shore.

11.6.3 Churches

The Delmarva Peninsula is home to several religious denominations. Religious structures are broken down by county in Table 11-6.

Table 11-6 Lower Delmarva Peninsula Houses of Worship

County	Churches
Accomack	47
Northampton	37
Wicomico	137
Worcester	95
Somerset	73

***Source*: Home Town Locator 2016**

11.6.4 Social and Recreational Opportunities and Facilities

WFF is located on Virginia's Eastern Shore, which is a popular tourist destination. The surrounding counties offer numerous recreational opportunities, including the WFF Visitor Information Center. For most of the year the Visitor Information Center is open to the public Thursday through Monday, from 10:00 a.m. to 4:00 p.m., free of charge. The Visitor Information

Center is open seven days a week from July 4 through Labor Day. All Visitor Information Center buildings and facilities are wheelchair accessible, and interpreters are available for the hearing impaired for all tours and events.

The Visitor Information Center houses a variety of educational exhibits and displays including a moon rock, scale models of space probes, satellites, and aircraft, as well as displays of current and future NASA projects and full-scale aircraft and rockets. Other special activities sponsored by the Visitor Information Center include weekly and monthly educational programs such as games, films on space, and model rocket demonstrations.

Many other activities and facilities are offered to WFF employees and their families through the Wallops Employee Morale Association (WEMA). There are numerous clubs (e.g., Aerobics Club, Black History Club, Eco Club, Fitness Club, Music Club, and Prayer Club) and recreational facilities. A full-scale gymnasium including cardiovascular machines, weight machines, free-weights, a basketball court, and an aerobics area is available to all employees. Baseball fields, a volleyball court, tennis courts, and an outdoor basketball court are located at WFF along with exercise trails and an outdoor pavilion where various events are held throughout the year.

WEMA also sponsors numerous dinners and social events. The Morale Activities Building, referred to as the "Rocket Club" by employees, houses holiday social events and provides for after-hours social interaction. As part of the Federal Women's Program, the Women of Wallops sponsor speakers and lunches on a semi-annual basis. WEMA also sponsors seasonal events such as Oktoberfest, an Easter egg hunt, and children's and employee's holiday parties. WFF sponsors Earth Day events, a Health Fair, and recreational use of the Wallops Island beach.

As a result of the increased rocket launches at WFF, the region is experiencing an increase in tourism related to launches. Many tourists and vacationers visit the Eastern Shore throughout the late spring, summer, and early fall. The coast of Virginia is a popular area for recreational and sport fishing. Winter hunting season draws people to hunt local game including dove, quail, deer, fox, and many types of geese and ducks.

Local county park facilities support many recreational programs, including softball, volleyball, and basketball leagues, as well as youth football, soccer, and little league baseball programs. Tennis courts, ball fields, public beaches, and privately-owned indoor movie theaters also provide sources of recreation and entertainment throughout the area.

Additionally, there are multiple festivals held on the Eastern Shore throughout the year involving local seafood, art, and crafts. Local vineyards offer tours during peak season and seasonal farmers markets are widespread. Local convention centers offer plays and concerts as well as frequent art events.

Section 12. Economic, Population, and Employment Factors

12.1 Population Density, Distribution and Composition

WFF is located in Accomack County, Virginia. The majority of WFF employees (civil servants and contractors) are residents of Accomack County as well as for four additional counties: Northampton County in Virginia; and Somerset, Wicomico, and Worcester counties in Maryland (Table 12-1). Population distribution, density, and composition data is included for five counties (Table 12-2 and Table 12-3).

Table 12-1 NASA WFF Employee Geographic Distribution by County of Residence

Location	NASA Support Contractor	NASA Civil Servants	Tenant	Total
Accomack County, VA	500	138	328	966
Northampton County, VA	10	5	6	21
Somerset County, MD	34	17	20	71
Wicomico County, MD	101	48	48	197
Worcester County, MD	117	52	95	264
Other Locations	82	15	55	152
Total	844	275	552	1671

***Source*: Lopez 2015**

Table 12-2 Population in the Affected Region

Location	2010	2016	Growth Rate 2010-2016 (%)
Accomack County, Virginia	33,164	32,947	-0.7
Northampton County, Virginia	12,389	12,139	-2.0
Somerset County, Maryland	26,470	25,928	-2.0
Wicomico County, Maryland	98,733	102,577	3.7
Worcester County, Maryland	51,451	51,444	0.1
Regional Total	***222,207***	***225,035***	***1.2***
Virginia	8,001,041	8,411,808	4.8
Maryland	5,773,785	6,016,447	4.2

***Source*: USCB 2017**

Table 12-3 Population Composition of Lower Delmarva Peninsula Residents

Ethnicity	Accomack County (%)	Northampton County (%)	Somerset County (%)	Wicomico County (%)	Worcester County (%)
White Persons	68.8	61.6	53.6	68.7	82.7
Black Persons	28.1	35.2	42.8	25.2	13.7
Persons of Hispanic or Latino Origin	8.9	8.5	3.7	5.2	3.5
American Indian and Alaska Native Persons	0.7	0.2	0.3	0.5	0.4
Asian Persons	0.7	0.9	1.0	3.0	1.4
Native Hawaiian and Other Pacific Islander	0.2	0.1	0.0	0.1	0.0
Persons reporting two or more races	1.6	1.8	2.1	2.4	1.8

***Source*: USCB 2016**

12.2 Environmental Justice Implementation Plan

Executive Order (EO) 12898, entitled *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* tasks "each federal agency [to] make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health and environmental effects of its programs, policies, and activities on minority populations and low-income populations." EO 12898, dated February 11, 1994, seeks to: 1) focus the attention of federal agencies on the environmental and human health conditions in minority communities and low-income communities with the goal of achieving environmental justice; 2) foster non-discrimination in federal programs that substantially affect human health or the environment; and 3) give minority communities and low-

income communities greater opportunities for public participation in, and access to public information on, matters relating to human health and the environment.

The United States (U.S.) Environmental Protection Agency (EPA) describes environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people should bear a disproportionate share of the negative environmental consequences resulting from the execution of industrial, governmental, and commercial operations or policies." The goal of fair treatment is not to shift risks among populations but to identify potential disproportionately high and adverse effects and identify alternatives that may mitigate these effects. Government agencies must provide minority and low-income communities with access to information on matters relating to human health or the environment.

In 1996, WFF prepared an Environmental Justice Implementation Plan (EJIP) that considered the then programs, policies and activities at WFF with impacts that extended beyond the boundaries of the facility. The EJIP was updated in 2014 to include NASA WFF's missions that have evolved during the past 18 years, most notably the expansion of the Wallops Island Launch Range and the Mid-Atlantic Regional Spaceport, which provide facilities and services for NASA, the Department of Defense, academia, and commercial customers including the launching of payloads into space and to the International Space Station (**NASA 2014g**). These changes in mission operations and activities have been evaluated in accordance with NEPA. Each of the NEPA documents prepared for WFF since the 1996 EJIP has included an evaluation of environmental justice.

The process for determining if activities at WFF would disproportionately affect minority and low-income populations include the following steps:

- Evaluating the location of minority and low-income populations adjacent to and within the radius of WFF off-site noise impacts;
- Determining if the magnitude of the potential impact to minority and low-income populations would be disproportionately high and adverse;
- Developing mitigation measures, if necessary; and
- Implementing a community outreach program to affected minority and low-income populations, as appropriate.

12.3 Income

Table 12-4 shows the income and poverty rates for Accomack and neighboring counties. Accomack and Northampton Counties are both on the lower end of income measures in the region. Correspondingly, both counties are also on the higher end of poverty levels in the region based on 2014 Census estimates using 2014 dollars.

This data highlights some important income and poverty data for the area surrounding WFF. All five counties have a lower per capita income than their respective states as a whole; however,

none of these counties includes major urban centers. The poverty data indicate that all five counties also have a higher percentage of the population living in poverty than their respective states. Northampton County has the highest percentage of population living in poverty, at more than double the Virginia average.

Table 12-4 Income and Poverty Statistics

Location	Median Household Income (2015$)	Per Capita Income (2015$)	Percentage of All Ages in Poverty
Accomack County, VA	39,412	23,231	11.2
Northampton County, VA	35,055	22,490	20.5
State of Virginia	65,015	34,152	11.2
Somerset County, MD	35,154	16,631	25.8
Wicomico County, MD	52,278	26,241	14.7
Worcester County, MD	56,773	32,419	11.3
State of Maryland	74,551	36,897	9.7

***Source*: USCB 2017**

NASA employment categories at WFF consist largely of managerial, professional, and technical disciplines with higher than regional average salaries. The 2015 average salary for Civil Servants at WFF was $100,450.98. The range for the middle 50% of the Civil Servants' Salary was between $91,814 and $115,072 (**Billger 2015**). WFF mean annual income exceeded the median family income of $39,389 for Accomack County and $34,656 for Northampton County in 2014. Due to the wide gap between salaries of WFF employees and most area residents, the facility contributes significantly to the local economy.

12.4 Employment Opportunities and Labor Force

Table 12-5 shows the labor force and unemployment rates of Accomack and neighboring counties. Accomack and Northampton Counties are both approximately average in the region in terms of unemployment rates. It is also notable that employment fluctuates seasonally in this region (due to farm labor and summer tourism labor), with lower unemployment during the months of June through October.

Table 12-5 Total Labor Force and Unemployment Rates by County

County	Total Labor Force	Unemployment Rate (%)
Accomack, VA	15,972	6.0
Northampton, VA	6,103	7.2
Somerset, MD	9,438	8.4
Wicomico, MD	50,820	7.3
Worcester, MD	26,029	12.7

***Source*: U.S. Bureau of Labor and Statistics 2017**

Table 12-6 illustrates the labor force trend over the past thirty-four years by facility; with NASA steadily increasing its labor force, and both the Navy and NOAA showing a steady-state in their labor force.

Table 12-6 Employee Trends at WFF by Facility

Facility	1981	1999	2008	2015	2016
NASA (including contractors)	732	963	1,027	1,119	1,097
Tenants	136	486	458	552	561

***Source*: NASA 1981; NASA 1999; NASA 2008c; Billger 2015, Massey 2016**

The Eastern Shore of Virginia has several well-established industries that form the basis of its economic strength. Some of the major employers in the region can be found in Table 12-7. The majority of businesses in the area are small businesses with fewer than 100 employees. The most important industries to the Eastern Shore are agriculture, seafood, and tourism.

Table 12-7 Top Twenty-five Employers in Accomack County

Top Employers in Accomack County	
1. Perdue Products	14. URS Federal Services
2. Tyson Farms	15. Royal Farms 79
3. Accomack County School Board	16. Eastern Shore Community College
4. County of Accomack	17. Intrepid USA Inc
5. Nat'l Aeronautics & Space Admin.	18. Arcadia Nursing Center
6. WalMart	19. McDonalds
7. LJT Associates Inc	20. Integrated Microcomputer System, Lockheed Martin
8. Eastern Shore Community Services	21.The Hermitage
9. Eastern Shore Rural Health System	22.U.S. Department of Defense
10. Integrated Microcomputer System, Lockheed Martin	23. Postal Service
11. Therapeutic Interventions	24. Town of Chincoteague
12. Food Lion	25. A&N Electric Co-op
13. Pay Admin LLC	

***Source*: Virginia Employment Commission 2017**

Table 12-8 lists the distribution by broad occupational categories for Accomack and Northampton Counties as reported by the **Virginia Employment Commission (2016)**.

Table 12-8 Eastern Shore of Virginia Broad Occupational Categories

Category	Percent of Labor Force	Workers
Agriculture, Forestry, Fishing, Hunting		2,183
Construction	2.4	473
Manufacturing	18.5	3,654
Wholesale Trade	1.4	291
Retail Trade	9.6	1,894
Transportation and Warehousing	0.7	156
Information, Finance, and Insurance	2.1	417
Real Estate	0.6	134
Professional, Scientific, and Technical Services	5.1	1,020
Management of Companies	0.3	71
Administrative Support	1.5	302
Education and Health Care Services	11.8	2,332
Arts and Entertainment	1.2	251
Food Services and Accommodation	11.5	2,271
Government	18.8	3,718
Other Services	2.4	481
Unclassified	0.1	37
Total		19,685

***Source*: Virginia Employment Commission 2017**

Table 12-9 lists the employee distribution by category for WFF civil service employees as of April 2014.

Table 12-9 Civil Service Employees by Profession

Category	Civil Service Employees (%)
Scientist	3
Engineer	56
Professional/Administrative	28
Technical	9
Secretarial/Clerical	4
Crafts/Trades	0

***Source*: Billger 2014**

12.5 Services

12.5.1 Fire Protection

Fire company personnel are housed in two buildings on the facility, one on Wallops Island and one on the Main Base. There is 24-hour protection, and personnel are also trained as first responders for hazardous materials, waste, and oil spills.

The fire-fighting personnel maintain three shifts of 12 employees: two officers and 10 fire fighters. All are Emergency Medical Technicians and two per shift are Advance Life Support certified. Rescue vehicles include 3 structural engines, 3 aircraft firefighting vehicles, 3 ambulances, one hazmat truck, 2 hazmat trailers, one technical rescue trailer, one utility pickup truck, one ARGO tracked vehicle and one brush truck. Additionally, one pickup truck is on loan from the Protective Services office and is located at Station 2.

The WFF Fire Department has a Mutual Aid Agreement with the Accomack-Northampton Fireman's Association for any outside assistance needed at the facility (NASA, 1999). There are 21 existing Fire and Rescue stations in Accomack County. The local fire companies nearest WFF are in Atlantic, Chincoteague, and New Church.

12.5.2 Security

WFF maintains a security force that is responsible for the internal security of the Facility. The force provides 24-hour-per-day protection services for 6,000 acres of real estate, all buildings and facilities, as well as all WFF personnel and visitors. Two entrance gates to WFF are used to control and monitor daily employee and visitor traffic. All civil servants and contractors must wear a visible photo identification badge that is received after a thorough background investigation. All visitors must be badged and escorted. Other services provided by the security force include security patrols, after-hours security checks, and police services.

12.5.3 Public Transportation

Public transportation is provided for the Eastern Shore of Virginia by the Star Transit system. The service began in 1996 and is headquartered in Tasley, Virginia. Star Transit serves both Accomack and Northampton counties under the auspices of the Accomack-Northampton Transportation District Commission. Star Transit offers fixed route and demand/response services to over fifteen towns across the Eastern Shore of Virginia. This public service benefits Eastern Shore residents by proving a reliable means of transportation to and from work. Star Transit does not currently offer a route which includes WFF.

The Eastern Shore of Virginia is connected to the rest of the state by the double span of 17.6 mi long 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. 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.

The Main Base and Wallops Mainland are connected by approximately 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 all buildings on WFF. NASA maintains all roads within the facility. Additionally, the Main Base has extensive sidewalks.

NASA and most organizations at WFF own and maintain a variety of fleet vehicles ranging from sedans and vans to trucks.

Many WFF employees carpool to and from the facility. Employees commute from all over the Delmarva Peninsula, however, the majority of civil service and contractor employees commute to and from points within Accomack County, Virginia.

Commercial air service is provided by the Norfolk International Airport, about 90 mi to the south, and the Salisbury-Ocean City-Wicomico Regional Airport, about 40 mi to the north. Air service is also available through the Accomack County Airport in Melfa, which normally provides flights during daylight hours. Surface transportation from the airports to WFF is by private rentals, government vehicles, and commercial bus or taxi.

Chartered and private aircraft that have the appropriate clearance may land at WFF Airport for business purposes. Air-freight services are available from the Salisbury-Ocean City-Wicomico Regional Airport.

Rail freight service is provided to the peninsula by the Eastern Shore Railroad. 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.

Section 13. Special Land Uses in the Vicinity

13.1 Wildlife Refuges

13.1.1 Wallops Island National Wildlife Refuge

WINWR was created on July 10, 1975 when 373 acres of land were transferred to the USFWS from NASA. The refuge, comprised mainly of salt marsh and woodlands, is located east of Wattsville in Accomack County, Virginia and contains habitat for a variety of trust species, including upland- and wetland-dependent migratory birds. Additionally, the USFWS has an agreement with NASA to use the NASA-owned portion of Wallops Island on a non-interference basis for research and management of declining wildlife in special need of protection. The agreement with NASA covers approximately 3,000 acres of Wallops Island and is primarily salt marsh. WINWR and the agreement with NASA are administered by the staff at CNWR (**USFWS 2015b**).

13.1.2 Chincoteague National Wildlife Refuge

The CNWR is under the jurisdiction of the USFWS and is located 6 miles to the northeast of WFF. The CNWR includes more than 14,000 acres of beach, dunes, marsh, and maritime forest. Most of the refuge is located on the Virginia end of Assateague Island; however, 418 acres are on the Maryland side of the island, 427 acres are found on Morris Island, and 546 acres comprise Wildcat Marsh on the northern tip of Chincoteague Island. Additionally, CNWR boundaries extend south and encompass all or part of Assawoman, Metompkin, and Cedar Islands. The refuge's location along the Atlantic Flyway makes it a vital resting and feeding spot for a large number and diversity of birds. Within close proximity to millions of people, CNWR is one of the most visited refuges in the United States, providing visitors with outstanding opportunities to learn about and enjoy wildlands and wildlife. Most notably, the refuge is home to the world famous Chincoteague Ponies which take part in the annual pony swim, a major tourist attraction for the region.

Chincoteague is also one of the top five shorebird migratory staging areas in the United States, east of the Rocky Mountains. In 1990, the barrier islands which make up CNWR along with other barrier islands of the Eastern Shore of Virginia and Maryland, were designated an International Shorebird Reserve. This coastal barrier island/lagoon system has also been designated a World Biosphere Reserve by the United Nations Educational, Scientific, and Cultural Organization in recognition of its great ecological value. Moreover, the Department of the Interior designated the area a National Natural Landmark in recognition of its outstanding natural values (**USFWS 2015c**).

13.1.3 Eastern Shore of Virginia National Wildlife Refuge

The Eastern Shore of Virginia National Wildlife Refuge (ESVNWR), formerly Cape Charles Air Force Base, is located at the southern tip of the Delmarva Peninsula between the Atlantic Ocean and the Chesapeake Bay, approximately 68.8 miles south of WFF. It was established in 1984 for migratory and endangered species management and for wildlife oriented recreation. This area is one of the most important avian migration funnels in North America. The 1,393 acres of maritime forest, myrtle and bayberry thickets, grasslands, croplands, and fresh and brackish ponds provide important habitat for wildlife. Available activities include wildlife observation, photography, nature study and trail hiking (**USFWS 2015d**).

13.1.4 Fisherman Island National Wildlife Refuge

The Virginia barrier island chain, which includes Fisherman Island National Wildlife Refuge (FINWR), is one of only 17 sites in the United States classified as a "Wetland of International Importance." The refuge is the southernmost island in the chain, separated from ESVNWR by approximately one-half mile of sea called Fisherman's Inlet (**USFWS 2015e**). The FINWR is approximately 68.8 miles south of WFF.

The FINWR was established in 1969 to protect critical habitats for coastal species such as royal terns and brown pelicans. This 1850-acre island includes upland forests, brackish ponds, expansive salt marshes and miles of sandy beaches and grass-covered dunes. Herons, egrets, ibis, songbirds, osprey, and shorebirds all make their homes here while thousands of other species depend on the island as a resting and feeding stop along their migration route (**USFWS 2015e**).

13.2 National Seashores and Reserves

13.2.1 Assateague Island National Seashore

Assateague Island National Seashore (AINS) is under the jurisdiction of the National Park Service and is located north of CNWR. The AINS has 15 miles of undeveloped shoreline in Virginia and Maryland. There are two entrances to AINS; the southern (Virginia) entrance is approximately 6 miles northeast of WFF, and the northern (Maryland) entrance is approximately 46.8 miles northeast of WFF.

Recreational activities such as camping, fishing, crabbing, clamming, canoeing, birding, wildlife viewing, hiking, swimming, off road vehicle use and hunting are available. The island is perhaps most famous for the wild horses that continue to roam the beaches since the late 17th century. Two herds of wild ponies make their home on Assateague Island, separated by a fence at the Maryland-Virginia line. The Virginia herd is owned by the Chincoteague Volunteer Fire Company and allowed by permit to graze on the CNWR. In July of each year, the Virginia herd is rounded up for the internationally recognized Pony Penning and Auction. The auction provides revenue to the fire department and controls the herd population. To retain the permit to graze on the refuge, the herd must not exceed 150 ponies. The Maryland herd is managed by using contraceptive

vaccines for females. Both of these management techniques reduce the impact the horses pose to their natural environment and help provide a sustainable resource for the future (**AINS 2008**).

13.2.2 Virginia Coast Reserve

The Nature Conservancy's Virginia Coast Reserve (VCR) encompasses over 38,000 acres, running for more than sixty miles south, from the Maryland border to the Chesapeake Bay. It is comprised of 14 undeveloped barrier islands, thousands of acres of pristine salt marshes, vast tidal mudflats, shallow bays, and productive forested uplands. Situated at the lower end of the Delmarva Peninsula, VCR is one of the most important migratory bird stopover sites on Earth (**The Nature Conservancy 2008**). Together, the islands shelter more than 250 species of raptors, songbirds, and shorebirds.

Focusing on science and comprehensive planning, the VCR has worked with partners for over three decades to advance local conservation strategies and preserve the Eastern Shore's natural heritage. Conservation strategies include land and water protection, science-based conservation through partnership with NASA, habitat enhancement and restoration, education and outreach, and shaping public policies (**The Nature Conservancy 2008**).

13.3 State Parks

13.3.1 Kiptopeke State Park

Located in lower Northampton County, three miles from the northern terminus of the Chesapeake Bay Bridge Tunnel, Kiptopeke State Park offers recreational access to the Chesapeake Bay and the chance to explore a unique coastal habitat featuring a major flyway for migratory birds. This state park offers lodging in family size cabins, bunkhouses, yurts, or personal recreational vehicles. Recreational opportunities include swimming, hiking, biking, fishing, boating and hunting. There is also an environmental education center that provides both nature and history programs (**VDCR 2014**).

13.3.2 Pocomoke River State Park

The park is located in southern Worcester County, Maryland along the Pocomoke River and is divided into two sections. The Shad Landing area is 3.5 miles south of Snow Hill, MD. The Milburn Landing area is 7 miles northeast of Pocomoke City, MD. Located within 15,000 wooded acres of Pocomoke State Forest, the park provides outdoor and tourist activities. The forest is famous for its stand of loblolly pine and for its cypress swamps. Pocomoke River State Park offers boat launch, boat rental, camp fire programs, camp sites, park store, dump station, food and beverage, fishing, flat water canoeing, hiking trails, electrical hook ups, picnic areas, playgrounds, picnic shelters, swimming pool, and nature center.

13.3.3 Saxis Wildlife Management Area (Virginia)

Located on the bayside of Virginia's Eastern Shore in Accomack County, the Saxis Wildlife Management Area offers the opportunity to hunt the marshes, fish the surrounding waters or view a vast array of water and shore birds. The Saxis Wildlife Management Area is predominately tidal marshland, divided into three tracts totaling approximately 5,678 acres. All three tracts are peninsulas, bordered by the brackish waters of Beasley Bay, Pocomoke Sound or Messongo Creek, or several smaller fresh water creeks. Maintained primarily in its natural state, there is little in the way of active management or development on the area.

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