ENVIRONMENTAL RESOURCES DOCUMENT

March 2015

National Aeronautics and Space Administration
John F. Kennedy Space Center

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DOCUMENT

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National Aeronautics and Space Administration
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Environmental Resources Document

(KSC-PLN-1911/Revision F, dated March 2015)

The purpose of the Environmental Resources Document for KSC is to fulfill the requirements of the National Aeronautics and Space Administration (NASA) Procedural Requirement NPR 8580.1, Implementing the National Environmental Policy Act (NEPA) and Executive Order (EO) 12114, as specifically stipulated in 14 Code of Federal Regulations (CFR), Section 1216.319. That directive states in part: Each Field Installation Director shall ensure that there exists an Environmental Resources Document which describes the current environment at that field installation, including current information on the effects of NASA operations on the local environment.

Record of Revisions/Changes

REV LTR	CHANGE NO.	DESCRIPTION DATE
	Basic Issue	November 1986
A	General Revision (Updated)	March 1992
B	General Revision (Updated)	October 1994
C	General Revision (Updated)	February 1997
D	General Revision (Updated)	January 2003
E	General Revision (Updated)	March 2010
F	General Revision (Updated)	March 2015

List of Effective Pages

Insert latest changes; destroy superseded pages

NOTE

THIS IS A GENERAL REVISION OF THE ENTIRE DOCUMENT CONSEQUENTLY
ALL
PAGES OF THE ISSUE ARE EFFECTIVE

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Abbreviations/Acronyms	
^oC	Degrees Celsius
^oF	Degrees Fahrenheit
45SW	45^{th} Space Wing/Patrick Air Force Base
ABC	American Broadcasting Company
Ac	Acre
ACHP	Advisory Council on Historic Preservation
ACI	Archaeological Consultants, Inc.
ACM	Asbestos Containing Material
AET	Actual Evapotranspiration
AF	Air Force
Ag	Silver
Al	Aluminum
Al_2O_3	Aluminum oxide
a.m.	Ante Meridian
AP	Associated Press
ARPA	Archaeological Resources Protection Act
As	Arsenic
AST	Aboveground Storage Tank
Ba	Barium
BCMCD	Brevard County Mosquito Control District
BCNRMO	Brevard County Natural Resources Management Office
Be	Beryllium
BFF	Booster Fabrication Facility
BTL	Biomass to liquid
BTU	British Thermal Units
C&D	Construction and Demolition
Ca	Calcium
CAA	Clean Air Act
CBS	Columbia Broadcasting System

Abbreviations/Acronyms (cont.)	
CCAFS	Cape Canaveral Air Force Station
CCF	Components Cleaning Facility or Corrosion Control Facility
Cd	Cadmium
cDCE	cis-1,2-dichloroethene
CDP	Census Designated Place
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQ	Council on Environmental Quality
CFC	Combined Federal Campaign
CFR	Code of Federal Regulations
CG	Cloud to Ground
CI	Compression Ignition
CIF	Central Instrumentation Facility
CITES	Convention on International Trade in Endangered Species of Wild Fauna and
Cl, Cl2	Chlorine
cm	Centimeter
cm^2	Square centimeter
cm^3	Cubic centimeter
CMS	Corrective Measures Study
CNG	Compressed Natural Gas
CNN	Cable News Network
CNS	Canaveral National Seashore
Co	Cobalt
CO	Carbon monoxide
CO2	Carbon dioxide
CPG	Comprehensive Procurement Guideline
CPUE	Catch per unit effort
Cr	Chromium
CRCA	Component Refurbishment and Chemical Analysis
CRF	Canister Rotation Facility
CS	Confirmatory Sampling
CTL	Coal to liquid

Abbreviations/Acronyms (cont.)	
Cu	Copper
Cu ft	Cubic Foot
cu yd	Cubic Yard
CUP	Consumptive Use Permit
CVLC	Commercial Vertical Launch Complex
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DARCY	Diverted Aggregate Reclamation and Collection Yard
dB	Decibel
dBA	Decibels (A-weighted)
DEM	Digital Elevation Model
DESC	Defense Energy Support Contractor
DHR	Division of Historical Resources
DNA	Deoxyribonucleic Acid
DO	Dissolved Oxygen
DOD	Department of Defense
DOT	Department of Transportation
Dth	Dekatherms
E	Endangered
E&O	Engineering and Operations
EA	Environmental Assessment
EAB	Environmental Assurance Branch
EAOR	Electronic Annual Operating Report
ECS	Engineering Control System
ECS	Environmental Control System
EDL	Engineering Development Laboratory
EELV	Evolved Expendable Launch Vehicle
EFSC	Eastern Florida State College
EHS	Extremely Hazardous Substances
EIS	Environmental Impact Statement
ELV	Expendable Launch Vehicles
EMB	Environmental Management Branch

Abbreviations/Acronyms (cont.)	
EMS	Environmental Management System
ENSO	El Nino Southern Oscillation
EO	Executive Order
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know Act
EPNdBA	Effective Perceived Noise Level
ERD	Environmental Resources Document
ERP	Environmental Resource Permit
EU	Emission Units
EUL	Enhanced Use Lease
EWG	Energy Working Group
FAA	Federal Aviation Administration
FAAQS	Florida Ambient Air Quality Standards
FAC	Florida Administrative Code
FAR	Federal Acquisition Regulations
FAWPCA	Florida Air and Water Pollution Control Act
FCREPA	Florida Committee on Rare and Endangered Plants and Animals
FDA	Food and Drug Administration
FDCA	Florida Department of Community Affairs
FDEP	Florida Department of Environmental Protection
Fe	Iron
FFDCA	Federal Food, Drug, and Cosmetics Act
FEMA	Federal Emergency Management Agency
FFWCC	Florida Fish and Wildlife Conservation Commission
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FIRM	Flood Insurance Rate Maps
FLUCCS	Florida Land Use Cover and Forms Classification System
FMSF	Florida Master Site File
FNAI	Florida Natural Areas Inventory
FONSI	Finding of No Significant Impact
FP	Fibropapillomatosis

Abbreviations/Acronyms (cont.)	
FPL	Florida Power and Light Company
FPO	Federal Preservation Officer
FR	Federal Register
F.S.	Florida Statutes
FSA	Fuel Storage Area
ft	Feet
FWPCA	Federal Water Pollution Control Act
FY	Fiscal Year
gal	Gallon
GH_2	Gaseous hydrogen
GN_2	Gaseous nitrogen
GIS	Geographic Information System
GISS	Goddard Institute for Space Studies
GO	Governor's Office
GO_2	Gaseous oxygen
GODU	Ground Operations Demonstration Unit
GPD	Gallons per day
gpm	Gallons per minute
GCTL	Groundwater Cleanup Target Level
GSA	General Services Administration
GTL	Gas to liquid
H	Hurricane
Ha	Hectare
HAP	Hazardous Air Pollutants
H_2	Hydrogen
H_2O	Water
HCl	Hydrochloric acid, hydrochloride
Hg	Mercury
HMCA	Hypergolic Maintenance Checkout Area
HMF	Hypergol Maintenance Facility
HMTA	Hazardous Materials Transportation Act

Abbreviations/Acronyms (cont.)	
HPO	Historic Preservation Officer
HQ	Headquarters
Hr	Hour
HSWA	Hazardous and Solid Waste Amendments
HVAC	Heating, Ventilation and Air Conditioning
ICRMP	Integrated Cultural Resources Management Plan
In	Inches
IPA	Isopropyl alcohol
IRL	Indian River Lagoon
ISS	International Space Station
IWW	Industrial Wastewater
J	Joule
JTU	Jackson Turbidity Units
K	Potassium
KARS	Kennedy Athletic, Recreational and Social Organization
KDP	Kennedy Documented Procedures
kg	Kilogram
KHB	Kennedy Handbook
kl	Kiloliter
km	Kilometer
km^2	Square kilometer
KNPD	Kennedy NASA Policy Directive
KNPR	Kennedy NASA Procedural Requirements
KSC	Kennedy Space Center
Kts	Knots
KV	Kilovolt
l	Liter
lbs	Pounds
lbs/hr	Pounds per hour
LC	Launch Complex
LCC	Launch Control Center
L_{dn}	Day-night noise level

Abbreviations/Acronyms (cont.)	
LEPC	Local Emergency Planning Committee
LETF	Launch Equipment Test Facility
LH_2	Liquid hydrogen
LN_2	Liquid nitrogen
LOC	Launch Operations Center
LOX	Liquid Oxygen
LUC	Land Use Controls
LUCIP	Land Use Control Implementation Plan
m	Meter
m^3	Cubic meter
M&O	Maintenance and Operations
MACT	Maximum Achievable Control Technology
max	Maximum
Mbtu	Million British thermal units
MCC	Mission Control Center
MDD	Mate/Demate Device
MESC	Medical and Environmental Support Contract
MFL	Missile Firing Laboratory
Mg	Magnesium
MGD	Million gallons per day
mg/L	Milligrams per liter
mg/m^3	Milligrams per cubic meter
mi	Mile
mi^2	Square mile
MILA	Merritt Island Launch Area
Min	Minimum, Minute
MINWR	Merritt Island National Wildlife Refuge
MLP	Mobile Launcher Platform
mm	Millimeter
MMBtu/hr	Million British Thermal Units per hour
MMH	Monomethyl Hydrazine
Mn	Manganese

Abbreviations/Acronyms (cont.)	
MOA	Memorandum of Agreement
MOSB	Multi-Operation Support Building
MSBLS	Microwave Scanning Beam Landing System
MSDS	Material Safety Data Sheets
MSL	Mean sea level
MSS	Mobile Service Structure
MSFC	Marshall Space Flight Center
mt	Metric ton
MWh	Megawatt-hours
N	Newton
N_2	Nitrogen
N/m^2	Newtons per square meter
Na	Sodium
NaOH	Sodium hydroxide
NAAQS	National Ambient Air Quality Standards
NADP	National Air Deposition Program
NASA	National Aeronautics and Space Administration
NBC	National Broadcasting Company
NDEL	Non-Destructive Evaluation Laboratory
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NETS	NASA Environmental Tracking System
NGVD	National Geodetic Vertical Datum
NHB	NASA Handbook
NHL	National Historic Landmark
NHPA	National Historic Preservation Act
Ni	Nickel
NMFS	National Marine Fisheries Service
No.	Number
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxides
NOTU	Naval Ordnance Test Unit

Abbreviations/Acronyms (cont.)	
NPD	NASA Policy Directive
NPDES	National Pollutant Discharge Elimination System
NPG	NASA Procedures and Guidelines
NPR	NASA Procedural Requirement
NPS	National Park Service
NRHP	National Register of Historic Places
NSPS	New Source Performance Standards
NSR	New Source Review
NUI	National Utility Investors
NVCS	National Vegetation Classification System
NW	Northwest
O_3	Ozone
O&C	Operations & Checkout
O&M	Operations and Maintenance
ODC	Ozone-Depleting Chemical
ODS	Ozone-Depleting Substances
OFW	Outstanding Florida Waters
OMRF	Orbiter Modification and Refurbishment Facility
OPF	Orbiter Processing Facility
OSHA	Occupational Safety and Health Administration
P2	Pollution Prevention
pH	Measure of Acidity (Log of Hydrogen Ions)
PAFB	Patrick Air Force Base
PAH	Polyaromatic Hydrocarbons
PAMS	Permanent Air Monitoring System
Pb	Lead
PCB	Polychlorinated Biphenyls
PET	Potential Evapotranspiration
PGOC	Payload Ground Operations Contract
PHSF	Payload Hazardous Servicing Facility
PIR	Pollution Incident Report

Abbreviations/Acronyms (cont.)	
PL	Public Law
p.m.	Post Meridian
PM	Particulate matter
PO_4	Phosphate
POL	Paint and oil locker
ppb	Parts per billion
ppm	Parts per million
ppt	Parts per thousand
PRL	Potential Release Location
PSD	Prevention of Significant Deterioration
psf	Pound(s) per square foot
PTE	Potential to Emit
QD	Quantity Distance
qt	Quart
RACM	Regulated Asbestos Containing Material
R&D	Research and Development
RCRA	Resource Conservation and Recovery Act
REEDM	Rocket Exhaust Effluent Diffusion Model
REV	Revision
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RICE	Reciprocating Internal Combustion Engines
RHA	Rivers and Harbors Act of 1899
RMP	Risk Management Program or Plan
ROD	Record of Decision
RPSF	Rotation, Processing and Surge Facility
RRMF	Reutilization, Recycling and Marketing Facility
R-SCTL	Residential Soil Cleanup Target Level
RSS	Rotating Service Structure
SA	Single Artifacts
SAV	Submerged Aquatic Vegetation
Sal	Salinity

Abbreviations/Acronyms (cont.)	
Sb	Antimony
SDWA	Safe Drinking Water Act
Se	Selenium
SE	Southeast
SERC	State Emergency Response Commission
SFOC	Shuttle Facility Operations Contract
SHPO	State Historic Preservation Officer
SI	Spark ignition
SIC	Standard Industrial Classification
SIP	State Implementation Plan
SJRWMD	St. Johns River Water Management District
SLF	Shuttle Landing Facility
SLS	Space Launch System
SLSL	Space Life Sciences Laboratory
SNAP	Significant New Alternatives Policy
SO_2	Sulfur dioxide
SPCC	Spill Prevention, Control and Countermeasures Plan
SR	State Road
SRB	Solid Rocket Booster
SRB-ARF	Solid Rocket Booster Assembly & Refurbishment Facility
SSC	Species of Special Concern
SSP	Space Shuttle Program
SSPF	Space Station Processing Facility
STEM	Science, Technology, Engineering and Math
STP	Sewage (Wastewater) Treatment Plant
STS	Space Transportation System
SWIM	Surface Water Improvement and Management
SWMU	Solid Waste Management Unit
T	Threatened
T(S/A)	Threatened because of similarity of appearance to another protected species
TCE	Trichloroethene
TD	Tropical depression

Abbreviations/Acronyms (cont.)	
TDS	Total Dissolved Solids
THPO	Tribal Historic Preservation Office
Tl	Thallium
tpy	Tons per year
TRI	Toxic Release Inventory
TRMM	Tropical Rainfall Mesoscale Monitoring
TPS	Thermal Protection System
TS	Tropical storm
TSCA	Toxic Substances Control Act
TSDF	Transportation, Storage and Disposal Facility
µ	Micro-, micron
µg/L	Micrograms per liter
µg/m3	Micrograms per cubic meters
URTD	Upper Respiratory Tract Disease
U.S.	United States
USACE	U.S. Army Corps of Engineers
USAF	United States Air Force
U.S.C.	U.S. Code
USDA	U.S. Department of Agriculture
USDI	U.S. Department of Interior
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	Underground Storage Tank
V	Vanadium
VAB	Vehicle Assembly Building
VAFB	Vandenberg Air Force Base
VC	Vinyl Chloride
VOC	Volatile Organic Compound
VPF	Vertical Processing Facility
Yr	Year
ZAP	Zone of Archaeological Potential
Zn	Zinc

SECTION I. ENVIRONMENTAL RESOURCES DOCUMENT INTRODUCTION

1.1 PURPOSE OF THE ENVIRONMENTAL RESOURCES DOCUMENT

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 prepared by the Council on Environmental Quality (CEQ) and published in 40 CFR 1500-1508.

The National Aeronautics and Space Administration (NASA) developed Agency-specific guidance in accordance with the CEQ regulations. The policies and procedures are published in 14 CFR 1216. NASA requirements mandate the preparation of a resource document as follows:

> Each Field Installation Director shall ensure that there exists an Environmental Resources Document (ERD), which describes the current environment at that field installation, including current information on the effects of NASA operations on the local environment. This document shall include information on the same environmental effects as included in an Environmental Impact Statement (EIS) (reference 14 CFR 1216.307). This document shall be coordinated with the Associate Administrator for Management and shall be published in an appropriate NASA report category for use as a reference document in preparing other environmental documents [14 CFR 1216.319].

The ERD provides the current status and a description of the different environmental areas and operations at the Center. The document serves as a baseline against which the effects of proposed actions can be judged to determine a possible environmental impact. The KSC ERD is programmed to be updated continually as required by changing conditions (by page change or other simple technique) and to be reviewed thoroughly at 5-year intervals (and revised if necessary) to ensure adequacy. The present document represents the sixth revision of the original KSC ERD completed in 1986.

1.2 ENVIRONMENTAL RESOURCES DOCUMENT ORGANIZATION

This document is organized into 15 sections according to the various environmental aspects or media related to the Center. Appendices, exhibits, figures and tables are included to provide additional information, as needed. Most chapters have the following structure:

Regulatory Overview – Review of applicable regulations, Executive Orders, and other guidance as they relate to that media at KSC including both federal and state information.

Operations – Review of the operational and physical aspects of that media at KSC.

1.3 KENNEDY SPACE CENTER ENVIRONMENTAL PROGRAM

KSC environmental policies are contained in the KSC Environmental Policy Document, Kennedy NASA Policy Directive ([KNPD] 8500.1). KSC environmental requirements are contained in the KSC Environmental Requirements, (Kennedy NASA Procedural Requirements [KNPR] 8500.1). The KNPR describes requirements, procedures and responsibilities for each environmental program area.

The NASA Environmental Assurance (EAB) and Management (EMB) Branches manage the environmental program and environmental compliance at KSC. These offices are responsible for obtaining and maintaining the Center's environmental permits, assuring compliance with environmental laws, regulations, executive orders, and ensuring conservation and stewardship issues are considered for all NASA activities at KSC. The Center frequently undergoes both internal and external environmental audits and inspections. All onsite regulatory reviews are coordinated through the EAB and EMB with minimum impact to Center operations. The Environmental Assurance and Management Branches support and are actively involved with the Space Coast Inter-Agency Environmental Partnership working group to ensure long-term regulatory compliance and to provide a conflict resolution forum between the Center, onsite contractors, and the regulatory community. This working group, comprised of the Florida Department of Environmental Protection (FDEP) office in Orlando, Brevard County Natural Resources Management Department, NASA, United States Air Force (USAF), St. Johns River Water Management District (SJRWMD), and representatives of onsite contractors, meets on a regular basis to discuss issues and concerns associated with planned or proposed regulatory changes, unique actions and findings at the federal facilities, and development of mutually agreeable solutions.

The EMB has developed and conducted the Ecological Program since 1982 to address current and future environmental issues associated with operations and management of the 140,000 acre (56,000 ha) Kennedy Space Center. The program strives to anticipate and deal comprehensively with regulatory and environmental stewardship concerns focusing heavily on ecological health and natural resource management issues. KSC management has the highest level of commitment to the program, and strongly encourages frequent interactions with other agencies, organizations, and universities concerned with ecosystem science and management at local, regional, and global scales. Over the last 33 years, program scientists and university and agency partners have developed national and international recognition for the Ecological Program and the NASA commitment to protect, preserve, and enhance the unique natural resources in and around KSC.

The EAB and EMB have primary responsibility for ensuring all activities at KSC are conducted in accordance with federal, state, and local environmental laws and regulations such as the National Environmental Policy Act (NEPA), Clean Water Act, Clean Air Act, Resource Conservation and Recovery Act (RCRA), and the Endangered Species Act (ESA). NASA's policy and commitment to excellence in stewardship is defined in the Code of Federal Regulations (14 CFR, Chapter V, "NASA", Part 1216.102). These commitments state NASA will:

- Use all practicable means, consistent with NASA's statutory authority, available resources, and the national policy, to protect and enhance the quality of the environment;
- Provide for proper attention to and ensure that environmental amenities and values are given appropriate consideration in all NASA actions, including those performed under contract, grant, lease, or permit;
- Recognize the worldwide and long-range character of environmental concerns and, when consistent with the foreign policy of the United States and its own responsibilities, lend appropriate support to initiatives, resolutions, and programs designed to maximize international cooperation in anticipating and preventing a decline in the quality of the world environment;
- Pursue research and development, within the scope of NASA's authority or in response to authorized agencies, for application of technologies useful in the protection and enhancement of environmental quality;
- Initiate and utilize ecological and other environmental information in the planning and development of resource-oriented projects; and
- Invite cooperation, where appropriate, from federal, state, local, and regional authorities and the public in NASA planning and decision making processes.

Information collected by the EMB Ecological Program is utilized to fulfill NASA stewardship and regulatory goals while providing input for a variety of natural resource management decisions in support of KSC, the overlaying Merritt Island National Wildlife Refuge (MINWR), Canaveral National Seashore (CNS), Cape Canaveral Air Force Station (CCAFS), the St. Johns River Water Management District (SJRWMD), the Florida Fish and Wildlife Conservation Commission (FFWCC), and others with management authority or requirements at the local and regional level. A comprehensive description of the Ecological Program activities, data, reports, publications, GIS data sets, management tools, and other information can be found at the EMB Ecological Program Earth Systems Modeling and Data Management Laboratory web page.

SECTION II. DESCRIPTION OF INSTALLATION

2.1 FACILITY BACKGROUND

Early in 1962, NASA began acquiring property for a space center as a base for launch operations in support of the Manned Lunar Landing Program. Approximately 34,000 hectares (ha) (84,000 acres [ac]) were purchased on Merritt Island in the northern part of Brevard County extending into the southernmost tip of Volusia County. An additional 22,660 ha (56,000 ac) of state-owned submerged land (Mosquito Lagoon and part of Indian River Lagoon) were negotiated with the State of Florida for exclusive rights dedicated to the United States. This total area of nearly 56,660 ha (140,000 ac), together with the adjoining water bodies, was considered extensive enough to provide adequate safety for the surrounding communities from the planned vehicle launches.

2.2 LOCATION DESCRIPTION

KSC is located on the east coast of Florida. The Center itself is situated approximately 242 km (150 miles [mi]) south of Jacksonville and 64 km (40 mi) due east of Orlando on the north end of Merritt Island adjacent to Cape Canaveral (Figure 2-1).

KSC is relatively long and narrow, being approximately 56 km (35 mi) in length and varying from 8 to 16 km (5 to 10 mi) in width. It is bordered on the west by the Indian River, a brackish-water lagoon, and on the east by the Atlantic Ocean and the Cape Canaveral Air Force Station (CCAFS). The northernmost end of the Banana River (another brackish-water lagoon) lies between Merritt Island and CCAFS and is included as part of KSC submerged lands. The southern boundary of KSC runs east west along the Merritt Island Barge Canal, which connects the Indian River with the Banana River and Port Canaveral at the southern tip of Cape Canaveral. The northern border lies in Volusia County near Oak Hill across Mosquito Lagoon. The Indian River, Banana River and the Mosquito Lagoon collectively make up the Indian River Lagoon system.

Only a very small part of the total acreage of KSC has been developed or designated for NASA operational and industrial use (Figure 2-2). Merritt Island consists of prime habitat for unique and endangered wildlife; therefore, in 1972 NASA entered into an agreement with the U.S. Fish and Wildlife Service (USFWS) to establish a wildlife preserve known as the Merritt Island National Wildlife Refuge (MINWR) within the boundaries of KSC. Public Law 93-626 created the Canaveral National Seashore (CNS); thereby, an agreement with the Department of the Interior (USDI) was also formed in 1975 due to the location of a portion of CNS within KSC boundaries (Figure 2-2).

2.3 NASA VISION AND MISSION

NASA's vision is to reach for new heights and reveal the unknown for the benefit of humankind. The NASA mission is to drive advances in science, technology, aeronautics, and space exploration to enhance knowledge, education, innovation, economic vitality, and stewardship of Earth (Ref. 1).

NASA's Strategic Goals as outlined in the 2014 Strategic Plan are as follows:

- Expand the frontiers of knowledge, capability, and opportunity in space.
- Advance understanding of Earth and develop technologies to improve the quality of life on our home planet.
- Serve the American public and accomplish our Mission by effectively managing our people, technical capabilities, and infrastructure.

NASA has four core values which support its commitment to technical excellence and express the ethics that guide our behavior. These shared values are the underpinnings of NASA's spirit and resolve (KDP-KSC-S-1863).

- Safety
- Teamwork
- Integrity
- Excellence

2.4 KSC MISSION

KSC's vision is to be the world's preeminent launch complex for government and commercial space access, enabling the world to explore and work in space. The Center's mission is to safely manage, develop, integrate and sustain space systems through partnerships that enable innovative, diverse access to space and inspire the nation's future explorers (Ref. 2).

KSC Core Competencies:

- Acquisition and management of launch services and commercial crew development
- Launch vehicle and spacecraft processing, launching, landing and recovery
- Payload and flight science experiment processing, integration and testing

- Designing, developing, operating, and sustaining flight and ground systems, and supporting infrastructure
- Development, test and demonstration of advanced flight systems and transformational technologies to advance exploration and space systems

2.5 KSC MASTER PLAN

The KSC Master Plan defines and communicates the Center's concept for orderly future development and management of real property assets. The previous Master Plan was based on the Constellation Program, which has since been cancelled. The current Master Plan was developed in a programmatical transitional phase between Shuttle and Space Launch System (SLS). It aims to provide the necessary framework and steps to achieve a sustainable end state, supporting both NASA and commercial launch operations. The KSC Master Plan is prepared in accordance with Master Planning for Real Property (NPD 8810.2). It describes how KSC will transform over the next 20 years to become a multi-user spaceport supporting government, commercial and other space launch users and providers. The Plan documents developmental possibilities for KSC's future state and describes the implementation and operating framework necessary for the transformation (Ref. 3).

The Future Land Use Plan outlines areas where development can occur, how land can be used, and how strategic capabilities can be expanded to support the Center's evolution to a multi-user spaceport. Future Land Use classifications are as follows:

- Vertical Launch and Landing– includes all facilities and land area directly related to vertical launch and landing operations, inclusive of launch pads 39A, 39B, and 41
- Horizontal Launch and Landing - includes pavement, infrastructure, facilities and land area directly related to horizontal launch and landing operations
- Launch Operations and Support – includes facilities and associated and areas essential to supporting a mission during launch and flight, including command, control and compilation, evaluation and communication of the data associated with launch vehicle activities. Storage of propellants and munitions is also included in this classification
- Assembly, Testing and Processing – includes facilities, operations and land areas that are essential to space vehicle component assembly, integration and processing prior to launch
- Central Campus – a consolidation of NASA operations into a smaller more cost-effective operational footprint with uses to predominately include non-hazardous NASA operations that will continue to occur in support of NASA missions and

programs

- Administration - includes facilities supporting operations management and oversight activities. Administrative functions/uses associated with management are more focused in the Industrial area. A subset of administration applies to administrative functions that are adjacent to and in support of assembly, integration and processing operations
- Support Services - includes all functions other than administration that provide management and oversight of KSC operations and services provided for overall KSC benefit, including operations and maintenance
- Operational Buffer/Conservation - areas corresponding to land areas in the southern portion of KSC that may never have been developed, or sites that may have reverted to a natural environment over the years
- Operational Buffer/Public Use - areas corresponding to publicly accessible areas of Merritt Island National Wildlife Refuge and the Cape Canaveral National Seashore for recreational use in the northern portion of KSC, as a conditional use subject to the operational activities associated with KSC's mission
- Utility Systems - includes land and facilities associated with KSC utilities infrastructure and systems (e.g., water, wastewater, gas, electrical, chilled water, communications and sewer systems)
- Public Outreach - includes facilities and associated land areas that promote an educational, research or informational connection between the community and KSC
- Research and Development - includes non-program specific laboratories, related facilities and associated land areas that perform research, experimentation and testing in support of developing new technologies, procedures and products to enhance existing and future programs at KSC
- Seaport - includes port, harbor, wharves, docks and associated land areas to accommodate delivery or embarkation of materials, equipment or people via access to the mainland through means of sea going vessels. Land areas contiguous to wharves and docks that are used for the staging, off-loading, transfer and storage/processing of materials, equipment or people are also classified as Seaport land use. Currently the Turn Basin is classified as a Seaport. Future Seaports are shown at Buck Creek (south of Industrial Area) and Cedar Hammock Creek (west of the SLF and north of Banana Creek).
- Renewable Energy – includes land areas designated to accommodate varying forms of renewable energy; and research and production facilitating KSC's goal for achieving increased on-site generation of its power from renewable sources.
- Recreation - includes parks, outdoor fitness, athletic fields, and recreation buildings such as the KARS Park I and II complexes.

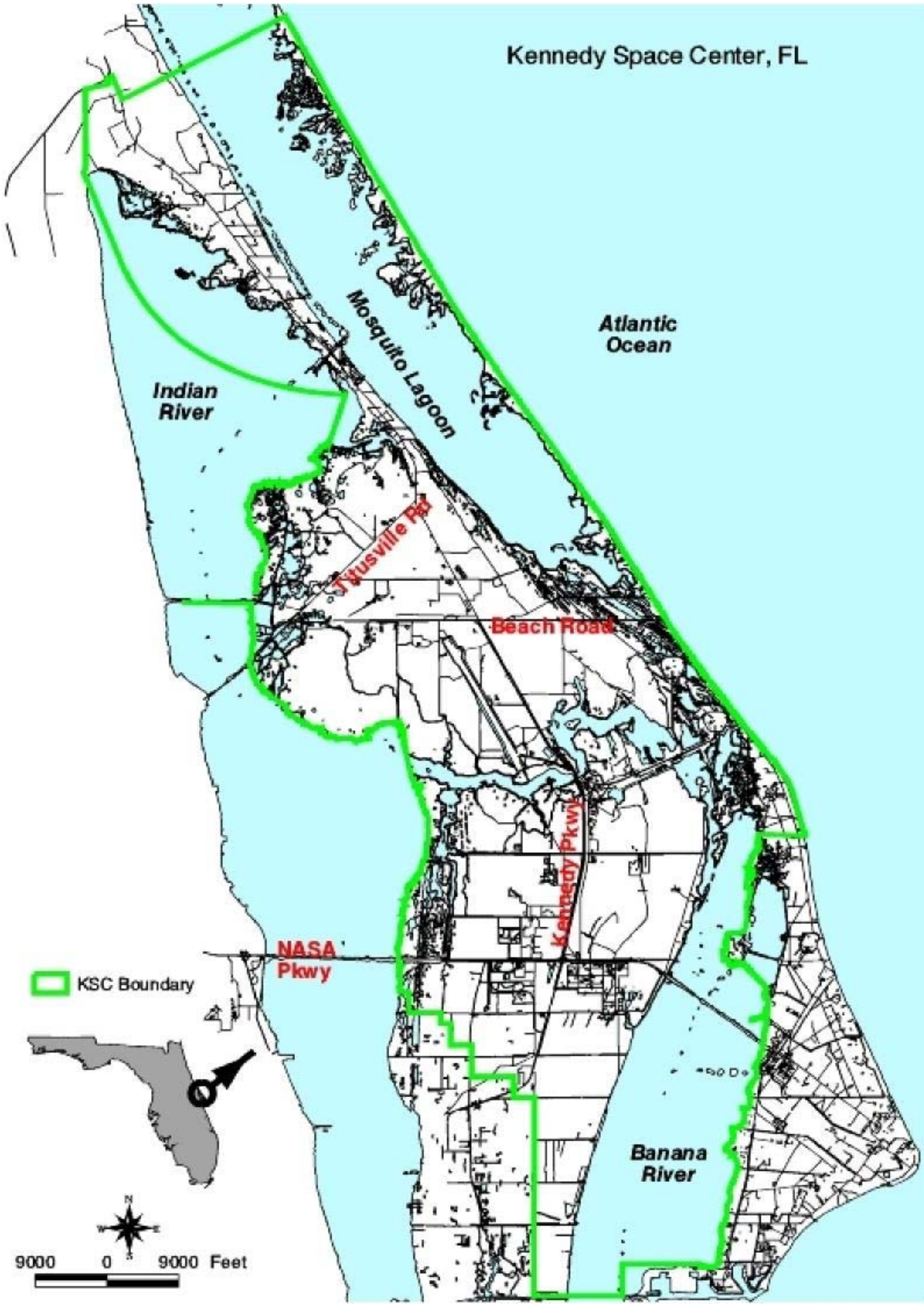


Figure 2-1. KSC Location.

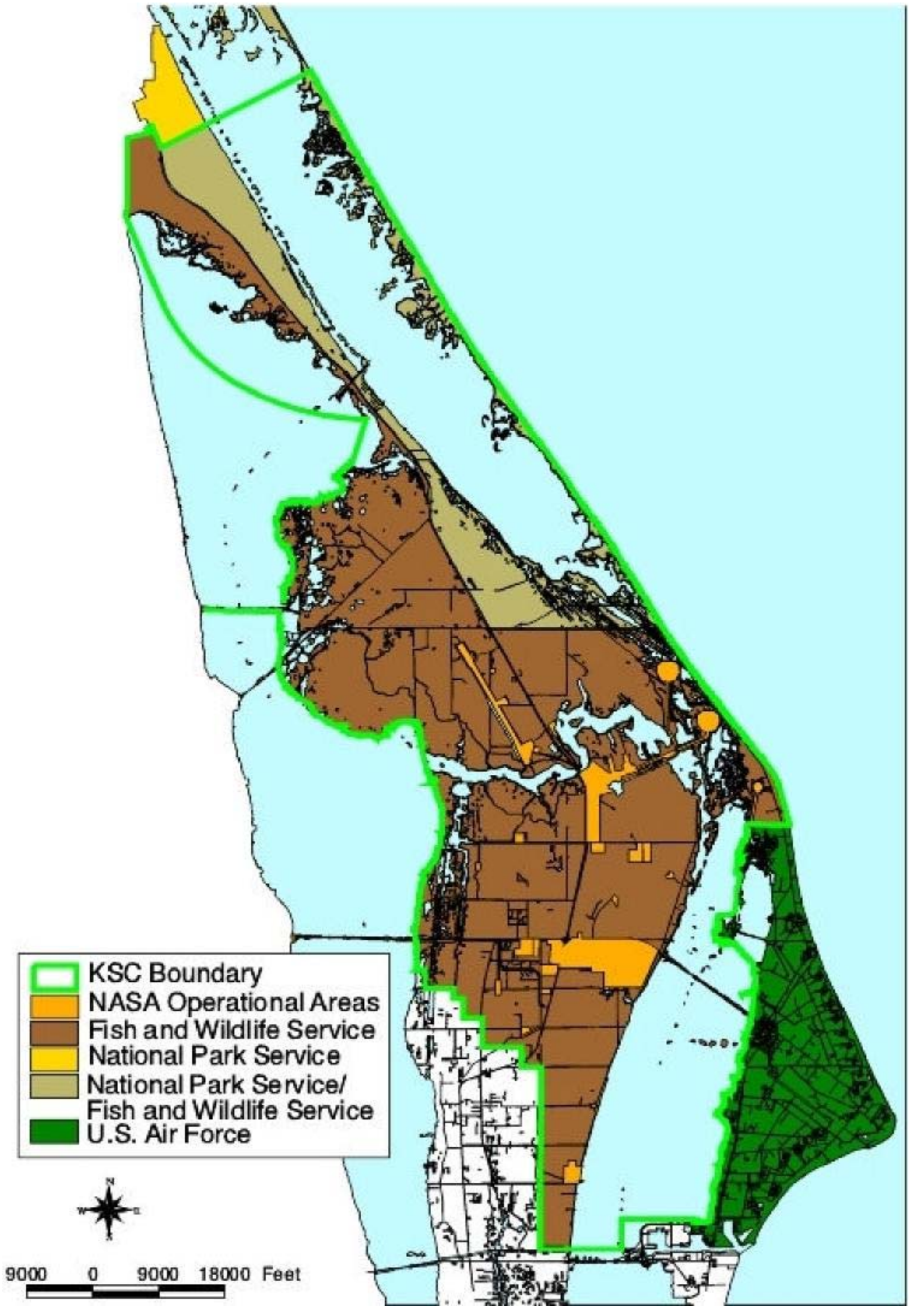


Figure 2-2. KSC Administrative Areas.

2.6 FACILITIES INFORMATION

KSC facilities, equipment and personnel provide a variety of functions in support of the NASA/KSC mission:

- Assemble, integrate, and validate launch vehicle elements along with associated payloads including International Space Station experimental and supply payloads
- Conduct launch operations
- Design, develop, construct, operate, and maintain launch and associated support facilities
- Maintain ground support equipment required to process launch vehicle systems and their associated payloads
- Serve as the NASA point of contact for DOD launch activities and provide logistics support to NASA activities at KSC, Cape Canaveral Air Force Station (CCAFS), Patrick Air Force Base (PAFB), Vandenberg Air Force Base (VAFB), and various contingency and secondary landing sites around the world
- Research and develop new technologies to support space launch and ground processing activities
- Provide government oversight and approval authority for commercial expendable vehicle launch operations.

2.6.1 LAUNCH VEHICLE PROCESSING FACILITIES

Launch vehicle and spacecraft processing activities are primarily performed within Launch Complex 39 (LC-39). This area contains the Vehicle Assembly Building (VAB), Launch Control Center (LCC), Orbiter Processing Facilities (OPF), Launch Complexes 39A and 39B, and other operational and support facilities. Facilities at KSC are classified according to how they are being used.

Assembly and Checkout Buildings
These facilities house equipment and activities utilized in assembling and checking out (inspecting and checking for proper functioning) spacecraft and launch vehicles:

- Vehicle Assembly Building (VAB) – K6-0848
- Rotation/Processing Building (K6-0494)

Vehicle Assembly Buildings
These buildings are utilized in the specialized assembly of vehicles for launching spacecraft, satellites or other payloads into earth orbit or outer space.

- Orbiter Processing Facility (OPF) High Bays 1 & 2, K6-0894

- OPF 3, K6-0696
- Manufacturing Building – Booster Fabrication Facility (BFF) Complex, L6-0247
- Service Building – BFF Complex, L6-0248
- Aft Skirt Test Building – BFF Complex, L7-0251

Launch Pad

A facility consisting of a concrete pad type base usually with a flame deflector and the structures and systems required to service, monitor and launch the launch vehicle and its payload.

- Launch Complex 39A, J8-1708
- Launch Complex 39B, J7-0337

2.6.2 PAYLOAD PROCESSING FACILITIES

ISS elements and payloads are processed primarily in the Space Station Processing Facility, on the east end of the KSC Industrial Area. Other payload processing activities take place within facilities in the KSC Industrial Area.

Spacecraft and Vehicle R&D Test Buildings

These buildings house equipment and activities involved in spacecraft and launch vehicle theoretical and/or applied science research, development, test and evaluation operations such as control systems, crew vehicle systems, avionics systems, systems integration, and structural dynamics.

- Neil Armstrong Operations and Checkout Facility (O&C), M7-0355
- Space Station Processing Facility (SSPF), M7-0360
- Launch Abort System Facility (LASF), M7-0777
- Multi-Payload Processing Facility (MPPF), M7-1104
- Payload Hazardous Servicing (PHSF), M7-1354
- Multi-Operation Support Building (MOSB), M7-1357
- Radiothermalisotopic Generator Facility (RTG), M7-1472
- Missile Assembly Building AE, 60680
    - Launch Vehicle Data Center (LVDC)
    - Telemetry Lab (TMLAB)
    - Mission Director's Center (MDC)

2.6.3 TECHNOLOGY DEVELOPMENT FACILITIES

The complexity of electrical, mechanical, and biological systems support required at KSC demands unique computerized facilities. Specialized laboratories, personnel, and equipment provide resources for solving design and operational problems. A variety of facilities, launch systems, payload-processing facilities, and laboratories support diverse technology projects.

Physical Science

This category includes scientific structures and facilities, as well as research and development (R&D) buildings used for physical science direct research, development, testing, and evaluation activities in theoretical and/or applied research, development, test and evaluation operations.

- Launch Equipment Test Facility (LETF), M7-0505A
- LETF Cryogenics Support Facility, M7-0505E
- Cryogenics Test Lab, M7-0557
- Cone Calorimeter Building, M7-1509
- Ground Operations Demonstration Unit (GODU) LH2 Test Site, M7-0915

Life Science

These facilities are used in research, development, test and evaluation in terrestrial and marine biology as related to structure capabilities, functioning habitat, health, growth environmental indicators, ecological relationships, etc. of living organisms and association of biological phenomenon onto man's existence and operations in the land, ocean and space environment

- Space Life Sciences Laboratory (SLSL), M6-1025
- Engineering Development Lab (EDL) Building, M7-0409

The EDL houses the Swamp Works Engineering and Development Lab. Capabilities of this technology and innovation lab include the Granular Mechanics and Regolith Operations Laboratory, Electrostatics and Surface Physics Laboratory, Regolith Activities Testbed and the Robotics Integration, Checkout and Assembly Area.

Materials (R&D & Test Buildings)

These facilities are used for research, development, test and evaluation of static, pneumatic non-destructive as well as destructive testing of components and assemblies for vehicles, engines, non-destructive testing of metals, plastics, etc. This facility also supports research in the areas of physical, mechanical, chemical and structural metallurgy.

- Prototype Shop, M7-0581
- Component Refurbishment and Chemical Analysis (CRCA) Facility, K6-1696
- Corrosion Atmospheric Exposure Facility and Test Area (K8-0600, K8-0237)

2.7 UTILITIES

2.7.1 REGULATORY OVERVIEW

2.7.1.1 Drinking Water

The Safe Drinking Water Act (SDWA) was established to protect the quality of drinking water and its surface water and groundwater sources. The SDWA authorizes EPA to establish standards and require all owners and operators of public water systems to comply with these health-related standards. In August 1996, amendments to the SDWA were passed to tighten drinking water standards and provide funding to the states to improve water treatment systems. The objectives of the 1996 Amendments focused on:

- Identification, monitoring, and control of drinking water contaminants as identified by EPA and the SDWA
- Enforcement of the regulations
- Collection of treated water data and distribution to the public
- Providing consumer right-to-know information and
- Provide funding to the states for necessary treatment system upgrades

The legislature of Florida has enacted the "Florida Safe Drinking Water Act," sections 403.850- 403.864, F.S. This chapter and chapters 62-550, 62-555, and 62-560, Florida Administrative Code (FAC), are promulgated to implement the requirements of the Florida Safe Drinking Water Act and to acquire and maintain primacy for Florida under the Federal Act. Under these laws, the State of Florida has delegated the FDEP to promulgate regulations and administer programs for the enforcement of the state and federal laws concerning our drinking water. FDEP has developed standards and operating practices to protect the health and safety of the public and is responsible for enforcing these regulations and permitting treatment and distribution systems.

The Safe Drinking Water Act gives the EPA the responsibility for setting national drinking water standards that protect the health of the 250 million people who get their water from public water systems. Since 1974, EPA has set national safety standards for over 80 contaminants that may occur in drinking water. While EPA and state governments set and enforce standards, local governments and private water suppliers have direct responsibility for the quality of the water that is delivered to the tap. The KSC water distribution system is maintained, tested, and treated to ensure that the quality of water delivered measures up to the federal and state standards. These actions are continuously documented due to permitting and reported to the regulatory agencies governing the KSC Potable Water System.

2.7.1.2 Domestic Wastewater

State regulatory authority over wastewater treatment facilities was established by the Florida Air and Water Pollution Control Act (FAWPCA) Chapter 403 F.S., of 1967. The directives of the FAWPCA were implemented through Chapter 62-3, 62-4, and 62-6 of the FAC. Chapters 62-3 FAC and 62-4 FAC deal with effluent quality standards and with permitting requirements, respectively. Chapter 62-600 FAC addresses wastewater facility design and construction criteria. Under these laws, the State of Florida has delegated the FDEP to promulgate regulations and administer programs for the enforcement of the state and federal laws concerning the disposal of domestic wastewater. FDEP has developed the Domestic Wastewater Program to set treatment standards and operating practices to protect the health and safety of the public, to protect aquifers, lakes and rivers from harm, and to promote reuse of reclaimed water. FDEP and State Health Departments are responsible for enforcing these regulations and permitting treatment systems.

2.7.1.3 Industrial Wastewater

In an effort to restore and maintain the chemical, physical, and biological integrity of the nation’s waters, the Federal Government enacted the Federal Water Pollution Control Act (FWPCA), commonly known as the Clean Water Act (CWA) amended in 1977. The Clean Water Act gives the EPA responsibility for regulating point source discharges of pollutants. The Clean Water Act also has provisions for states to administer the federal legislation after approval from the EPA. Under these provisions, the State of Florida has enacted The Florida Safe Drinking Water Act, Chapter 403, Florida Statute and Water Resources, Chapter 373, F.S., to promote the conservation, replenishment, recapture, enhancement, development, and proper utilization of the State’s water resources. These chapters and Chapters 62-660, FAC, are promulgated to implement the requirements of the Florida Safe Drinking Water Act.

The State of Florida has delegated the FDEP to promulgate regulations and administer programs for the enforcement of the state and federal laws concerning the disposal of industrial wastewater. FDEP is responsible for issuing permits that authorize the discharge of properly treated wastewater to the land or to waters of the State. Due to the variability of waste streams, industrial waste treatment requirements must be developed on a case-by-case or industry-by-industry basis rather than under a uniform treatment standard such as the minimum secondary treatment requirement for domestic wastewater facilities. Most industrial wastewater discharges are regulated by specific federal requirements at a minimum. However, if additional treatment is necessary to protect Florida's water quality standards, the industries must provide it.

2.7.1.4 Consumptive Use Permitting

A Consumptive Use Permit (CUP) is required by the SJRWMD for each consumptive use of ground or surface water which:

- Exceeds more than 100,000 gpd, annual average; or
- Is from a facility (wells, pumps, etc.) or facilities which are capable of withdrawing one million gallons or more of water per day; or
- Is from a well where the outside diameter of the largest permanent water bearing casing is six inches or greater.

All permits include certain limiting conditions set forth in Chapters 40C-2.381, FAC. The SJRWMD prohibits significant adverse impacts on offsite land uses and legal uses of water existing at the time of permit application.

Permitting authority is granted to SJRWMD under Section 373.216, F.S. In so doing, the State is attempting to conserve and promote the proper utilization of Florida's ground and surface waters. KSC is located in the District's Upper St. Johns River Administrative Basin and currently does not meet criteria requiring a CUP.

2.7.1.5 Stormwater

Rain is an inevitable part of living in Florida. Rainfall is soaked up by the soil, collected by streams, rivers, and ponds, and utilized by vegetation. However, as Florida becomes more developed and natural areas are replaced by buildings, roads, and parking lots, we reduce the areas available to store rainfall. When this happens, the volume of rainfall flowing offsite increases and creates possible flooding issues in downstream areas. Rainfall runoff from parking lots, buildings, roads, and other manmade structures also collects a wide variety of pollutants such as grease and oils, nutrients, and suspended solids. These pollutants are carried offsite into rivers and streams contaminating water sources used for drinking water, habitat for aquatic species, and recreational activities.

In an effort to conserve and protect our water and land resources, the Federal Government enacted the Rivers and Harbors Act of 1899 and the Federal Water Pollution Control Act, commonly known as the Clean Water Act (amended 1977). The Rivers and Harbors Act gives responsibility to the U.S. Army Corps of Engineers (USACE) to regulate activities in the Nation's waterways, including the building of structures and all dredge and fill activities. The Clean Water Act gives responsibility for permitting dredge and fill activities to the USACE and also to the EPA. The Clean Water Act also has provisions for states to administer the federal legislation after approval from the EPA. Under these provisions, the State of Florida has enacted the Florida Safe Drinking Water Act, Chapter 403, F.S. and Water Resources, Chapter 373, F.S., to promote the conservation, replenishment, recapture, enhancement, development, and proper utilization of the State's water resources. These chapters and Chapter40C-44 FAC are promulgated to implement the requirements of the Florida Safe Drinking Water Act.

To manage the issues of flooding and water contamination, the State of Florida created a program that requires the construction of surface water management systems to control stormwater runoff. The Environmental Resource Permit (ERP) program was developed with two main goals. The first is to ensure that any type of new development or changes in land use will not cause flooding by adversely affecting the natural flow and storage of water. The second purpose is to prevent stormwater pollution in lakes and streams and to protect wetland environments. This program is administered by the SJRWMD, and the FDEP. These two agencies are responsible for reviewing stormwater system designs and issuing permits for their construction and operation. On October 1, 2013, the "statewide ERP rule", Chapter 62-330 FAC, became effective combining the previously diverse program under one set of instructions.

2.7.1.6 NPDES Stormwater

In October 2000, the U.S. EPA authorized the FDEP to implement the National Pollutant Discharge Elimination System (NPDES) stormwater permitting program in the State of Florida (in all areas except Tribal Indian lands). FDEP's authority to assume delegation of the NPDES program is set forth in Section 403.0885, F.S. and is undertaken pursuant to a Memorandum of Agreement with EPA. The NPDES stormwater program regulates point source discharges of stormwater into surface waters of the U.S. and the State. Regulated sources must obtain an NPDES stormwater permit and implement a stormwater management plan that includes pollution prevention techniques to reduce contamination of stormwater runoff.

EPA developed the federal NPDES stormwater permitting program in two phases. Phase I, promulgated in 1990, addresses the sources of stormwater runoff with the greatest potential to degrade water quality. These sources include:

- "Medium" and "large" municipal separate storm sewer systems (MS4s) located in incorporated places and counties with populations of 100,000 or more
- Eleven categories of industrial activity, one of which is large construction activity that disturbs 5 or more acres of land.

Phase II, promulgated in 1999, addresses additional sources of concern, including certain "small" MS4s and small non-point source construction activity disturbing between 1 and 5 acres, that must be permitted by March 10, 2003. Phase II also revised the Phase I industrial no exposure conditional exclusion to broaden its applicability.

The NPDES stormwater permitting program is separate from the State's stormwater ERP programs and local stormwater/water quality programs which have their own regulations and permitting requirements.

2.7.2 KSC UTILITIES

2.7.2.1 Drinking Water

At KSC, we use tap water for a wide variety of purposes. Some of these are for personal use such as drinking, cooking, and bathing, while others are for public activities such as lawn irrigation, fire-fighting, air conditioning, and construction. Commercial and industrial operations also place heavy demands on the public water supply. These include launch operations such as sound suppression and deluge/wash operations, and shuttle and launch vehicle processing operations. KSC uses an average of 0.8 million gallons per day with a maximum daily average usage of 2.2 million gallons.

KSC is subject to regulation under the Safe Drinking Water Act as a supplier since it operates a Non-Transient, Non-Community "Public Water System" as defined by state and federal regulations. The source of KSC's drinking water supply is surface water from the Taylor Creek Reservoir and groundwater from wells located in east Orange County. The City of Cocoa operates the Claude H. Dyal Water Treatment Plant that treats the raw water from these sources. Water from this plant is transmitted to KSC via a 24" water main to KSC's south boundary at Gate #2. At this interface point, the flow rate of water is maintained by booster pumps at the Water Pump Station (N6-1007), while chlorine and ammonia are added to maintain the proper chlorine residual within the distribution system. Water flows through a 24" primary distribution system from the South Gate to the VAB area. Throughout KSC there are various storage systems and secondary pump systems to supply water needs for fire suppression, launch activities, and potable water.

2.7.2.2 Domestic Wastewater

Two domestic wastewater collection/transmission systems, one located in the Industrial Area and one in the VAB Area, provide service for approximately 80 percent of NASA and contractor personnel at KSC. These systems transport raw wastewater to the CCAFS Regional Plant located on the Cape Canaveral Air Force Station. There are a number of septic tank systems throughout KSC that typically support small offices or temporary facilities. Of the existing septic tanks, only a few are permitted under Chapter 64E-6, FAC. The remaining septic tanks were constructed prior to the implementation of construction permitting regulations and are therefore grandfathered in under these rules. Two septic tanks at facilities K6-1091 and P6-1789 require OSTDS Operating Permits from the Florida Department of Health as serving Industrial or Manufacturing facilities.

2.7.2.3 Industrial Wastewater

KSC currently maintains operating permits for one facility treating Industrial Wastewater (IWW), the Seawater Immersion Facility at the Beach Corrosion Test Laboratory which is located near Complex 40 along the Atlantic Ocean. The facility is used for testing the resistance of materials and coatings to the natural elements. The IWW is generated when seawater is withdrawn from the ocean and passed over test materials before being discharged back to the ocean. Previous IWW permits held at Launch Complexes 39A and 39B were surrendered and will be reestablished prior to reestablishment of launch operations.

2.7.2.4 Stormwater

The Kennedy Space Center (KSC) has over one hundred surface water management systems to control stormwater runoff. The four largest stormwater systems at KSC are the Region I system that serves the Industrial Area, the Sub-basin 11 system that serves the western VAB Area, the VAB South system that serves the south VAB area, and the Shuttle Landing Facility (SLF) system that serves the entire SLF area (Figure 2-3).

2.7.2.5 NPDES Stormwater

In addition to those stormwater management systems permitted by the SJRWMD, KSC manages an NPDES Stormwater permit for industrial activities. This permit covers six industrial operations at KSC, which include the Contractors Road Locomotive Yard, the SLF, the Ransom Road Reclamation Yard, the Transportation, Storage and Disposal Facility (TSDF), and the Visitors Center Fleet Maintenance Facility. No Exposure exemptions have been received for the Locomotive Yard, SLF, TSDF and Fleet Maintenance Facility.

KSC does not meet the criteria established by FDEP that would categorize it as an urban area and is therefore not required to obtain a permit as a municipal separate storm sewer system (MS4).

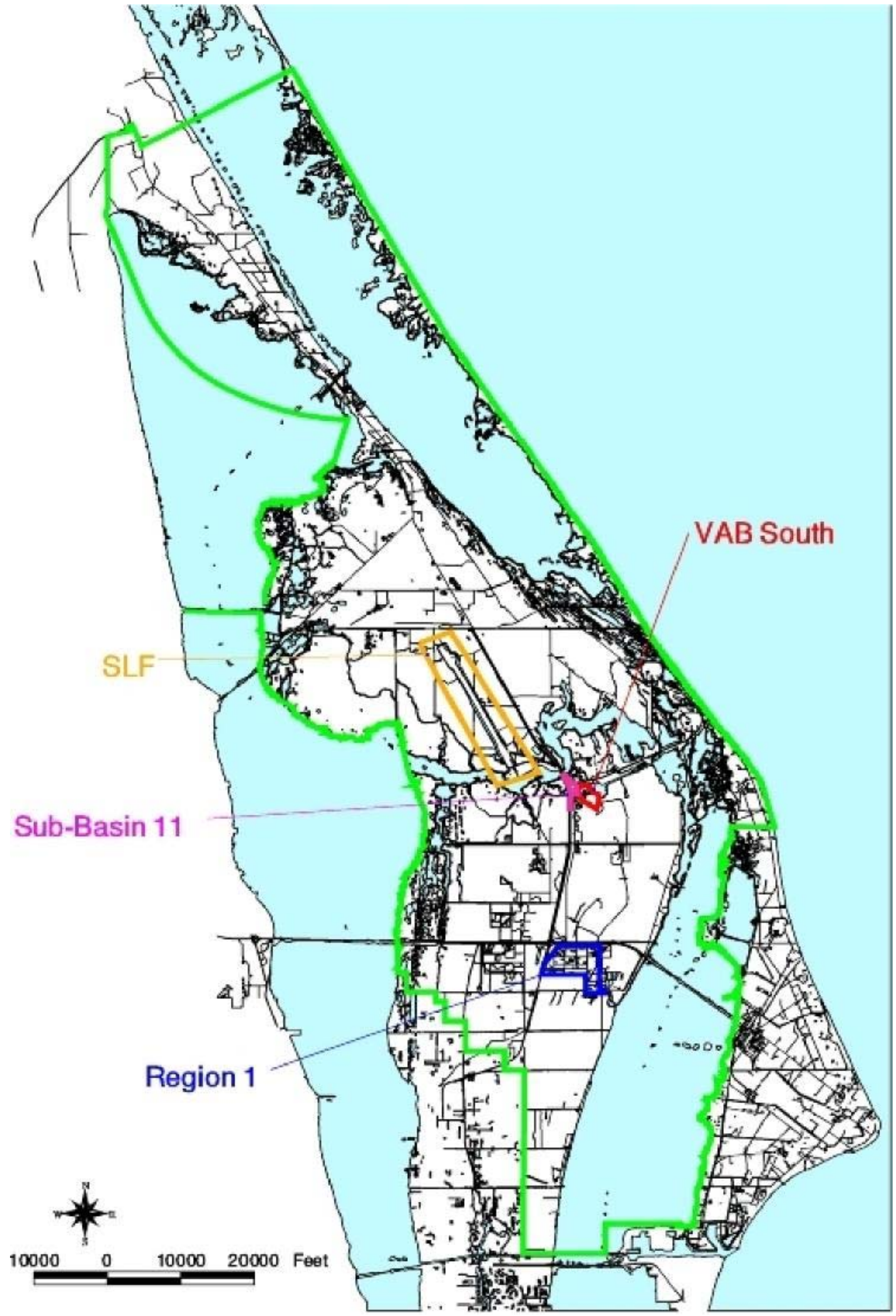


Figure 2-3. Regional Stormwater Systems at KSC.

2.8 REFERENCES

1. NASA. 2014. NASA Strategic Plan. 68 pp.

2. NASA. 2013. Launching the Future. KSC Annual Report. 57 pp

3. KSC Master Plan. 2012.

SECTION III. AIR RESOURCES

3.1 AIR QUALITY

3.1.1 REGULATORY OVERVIEW

3.1.1.1 Federal Regulations

The federal regulation of air pollution begins with the Clean Air Act (CAA) 42 U.S.C. 7401-7642, Public Law 88-206, which has been amended several times since originally enacted in 1963. Titles IV, V, and VI were added in the most recent amendments enacted in November 1990. The CAA authorizes the EPA to adopt regulations for the control and abatement of air pollution. The EPA regulations are contained in 40 CFR 50 through 87. As the CAA relates to KSC, the requirements of Titles I (including Title III of the 1990 Clean Air Act Amendments), V and VI are of primary concern.

Title I of the CAA is the basis for the EPA's air quality and emission limitations, the Prevention of Significant Deterioration (PSD) program, and the New Source Review (NSR) program. This Title establishes the requirements for the National Ambient Air Quality Standards (NAAQS), the Florida State Implementation Plan (SIP), the New Source Performance Standards (NSPS), the National Emission Standards for Hazardous Air Pollutants (NESHAP), as amended through Title III of the 1990 Clean Air Act Amendments, and the requirements for federal facilities to comply with all federal, state, and local air pollution regulations.

Title V establishes the federal operating permit program which includes reporting and fee requirements based on emission levels. The federal operating permit replaces all previous state air pollution operating permits at KSC. The program is delegated to the State of Florida and is administrated by the FDEP.

Title VI initiates protection of the stratospheric ozone layer. The CAA mandates the phase out of production and consumption of Class I and II substances, the initiation of recycling and emission reduction programs, the implementation of a federal procurement program, and requires federal facilities to comply with its requirements. Additionally, programs targeting the service of motor vehicle air conditioners and halon emissions reduction are required.

Compliance with the NAAQS for an area is the primary objective of the regulations currently being developed and enforced by the EPA and the FDEP. KSC is located within an area, which is classified as attainment for all the pollutants listed in Table 3-1. This classification means that pollutant concentrations within the KSC boundary are below the NAAQS established by the EPA, which triggers the requirements of the PSD program versus the much more stringent requirements of the NSR program.

The CAA requires each state to develop and submit a SIP to the EPA for approval. The purpose of the SIP is to provide a framework by which each state will ensure compliance with the NAAQS or achieve compliance within a reasonable time. The majority of the regulations adopted by the FDEP are incorporated in Florida's SIP. This allows the EPA to enforce these regulations, including the state requirements for construction and operating permits, should FDEP fail to do so.

The CAA requires the EPA to identify source categories which significantly contribute to air pollution, and to adopt regulations that reflect the best system of continuous emission reduction for new sources. This is the basis for the New Source Performance Standards (NSPS) program. The EPA is expected to periodically re-examine these NSPSs and revise them, when necessary.

The EPA is required by the CAA to adopt regulations for the control of hazardous air pollutants (HAP) from both major and area sources through the application of the Maximum Achievable Control Technology (MACT) to major sources. The recent CAA amendments defined and listed 189 HAPs. The amendments also require case-by-case MACT determinations for any source for which the EPA fails to adopt regulations. The EPA has listed the source categories potentially subject to regulation under the NESHAP program. The EPA must develop an accident prevention program to control the release of hazardous air pollutants. Section 112(r) of the CAA established the Chemical Accident Prevention Provisions. These regulations require facilities that manufacture, process, store, or handle regulated substances in amounts greater than threshold quantities to have a Risk Management Program (RMP). The RMP requirements have been delegated to the state level and are administrated by the Florida Department of Community Affairs (FDCA).

Table 3-1. State and Federal Ambient Air Quality Standards.

	Federal Primary Standards		Federal Secondary Standards		State of Florida Standard
Pollutant	**Level**	**Averaging Time**	**Level**	**Averaging Time**	**Level**
Carbon Monoxide	**9 ppm**	8-hour (1)	None		**9 ppm (10 mg/m³)**
	35 ppm (40 mg/m³)	1-hour (1)			**35 ppm (40 mg/m³)**
Lead	**0.15 µg/m³** (2)	Rolling 3-Month Average	Same as Primary		**0.15 µg/m³ (2)**
	1.5 µg/m³	Quarterly Average	Same as Primary		**1.5 µg/m³**
Nitrogen Dioxide	**0.053 ppm (100 µg/m³)**	Annual (Arithmetic Mean)	Same as Primary		**0.053 ppm (100 µg/m³)**
Particulate Matter (PM_{10})	**150 µg/m³**	24-hour (3)	Same as Primary		**150 µg/m³**
Particulate Matter ($PM_{2.5}$)	**12.0 µg/m³**	Annual (4) (Arithmetic Mean)	Same as Primary		**12.0 µg/m³**
	35 µg/m³	24-hour (5)	Same as Primary		**35 µg/m³**
Ozone	**0.075 ppm (2008 std)**	8-hour (6)	Same as Primary		**0.075 ppm (2008 std)**
	0.12 ppm	1-hour (7) (Applies only in limited areas)	Same as Primary		**0.12 ppm**
Sulfur Dioxide	**0.03 ppm**	Annual (Arithmetic Mean)	**0.5 ppm (1300 µg/m³)**	**3-hour (1)**	**Annual (Arithmetic Mean) 0.02 ppm**
	0.14 ppm	24-hour (1)			**24-hour 0.1ppm** **3-hour 0.5 ppm (1300 µg/m³)**

(1) Not to be exceeded more than once per year.
(2) Final rule signed October 15, 2008.
(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 PM2.5 concentrations from single or multiple community-oriented monitors must not exceed 12.0 µg/m3.
(5) To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m3 (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 at each monitor within an area over each year must not exceed 0.075 ppm. (effective May 27, 2008)
(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 8-hour ozone nonattainment Early Action Compact (EAC) Areas.

The CAA requires the EPA to address air pollution from new major stationary sources and major modifications to major stationary sources in both attainment and non-attainment areas. The EPA has addressed this requirement through the PSD (attainment areas) and NSR (non-attainment areas) regulations and Title V operating permitting programs. A stationary source generally includes all pollutant-emitting activities, which are located on contiguous or adjacent properties, and are under common control. Implementation of these programs in Florida is through the SIP process. The EPA develops and implements the federal operating permit program or Title V permit program for all major stationary air pollution sources. This permitting process is different than the PSD and NSR permitting programs. Those programs require a one-time-only permit generally considered as a construction permit. The 1990 amendments have greatly expanded the requirements of the CAA, specifically in non-attainment areas, hazardous air pollutants, permits, and ozone depleting substances.

3.1.1.2 State Regulations

The state regulation of air pollution in Florida begins with the "Florida Air and Water Pollution Control Act" and the "Florida Environmental Reorganization Act of 1975", (Chapter 403, F.S.). These laws established the FDEP and authorized the development and enforcement of air pollution regulations. Florida air pollution regulations applicable to KSC are summarized as follows:

Permits (Chapters 62-4, 62-210, 62-212, 62-213, FAC) are required for all operations, which have the potential to emit air pollutants to the atmosphere. This includes state construction, PSD and NSR permits and Title V operating permits. Section 62-4.040(1)(b), FAC, allows the FDEP the discretion to exempt certain operations from the need for a permit on a case-by-case basis. Additionally, Section 62-210.300(3), FAC, lists operations for which the FDEP does not require air pollution permits.

Ambient air quality standards and area designations are contained in Chapters 62-272 and 62-275, FAC. Within Florida, the NAAQS are incorporated as well as the more stringent Florida Ambient Air Quality Standards (FAAQS) as listed in Table 3-1. Currently, FDEP considers the area within KSC's boundary to be in attainment for all pollutants.

Emission standards and monitoring requirements are specified in Chapters 62-296 and 62-297, FAC. The emission standards contain both general and specific requirements related to stationary sources, the NSPS program, and the NESHAP program.

Open burning regulations are contained in Chapter 62-256, FAC. The FDEP and the Florida Department of Forestry are the primary agencies regulating open burning at KSC and the Merritt Island National Wildlife Refuge.

3.1.2 KSC TITLE V OPERATING PERMIT

The Title V operating permit (No. 0090051-028-AV), issued by the FDEP Central District, is valid for a period of five years and requires a renewal application to be submitted six months prior to the date of expiration. Based on the Title V permit, KSC is designated as a major source as the potential to emit (PTE) for the criteria pollutants oxides of nitrogen (NOx), volatile organic compounds (VOCs) and carbon monoxide (CO) each exceed the 100 tons per year (tpy) Title V major source threshold.

KSC is considered a minor source for:

- Particulate matter (PM), sulfur dioxide (SO_2), and lead (Pb) emissions as the PTE is less than the 100 tpy Title V major source threshold,
- The Prevention of Significant Deterioration (PSD) permitting program as the PTE for PSD pollutants is less than the PSD major source threshold (e.g. 250 tpy for CO and NOx), and
- Hazardous Air Pollutants (HAP) for which KSC was previously considered a major source of HAP. Pollution prevention initiatives taken by the facility have allowed it to reduce HAP emissions to less than the major source thresholds of 10 tpy for individual HAP, and 25 tpy for combined HAP.

The emission units (EUs) and/or activities are divided into three-types: permitted, unregulated, and insignificant. Table 3-2 summarizes the Title V EUs with the types of EU, identification numbers, and limited pollutant, if any. The only units that have limitations for pollutants are surface coating operations. All other operations are not subject to any limiting standard or work practice. However, they do have usage rate limitations which limit the capacity of the unit and therefore, limit the emissions. Facility-wide permit conditions include: visible emissions at KSC must be less than 20% opacity; KSC must comply with RMP regulations; and KSC must comply with procedures to minimize VOC emissions.

Table 3-2. KSC Title V Emission Units (EU) Summary.

EU Description	EU Identification Number	Limited Pollutant
Permitted – Subsection A		
Vehicle Assembly Building Utility Annex Hot Water Generators/Boilers	001	Not Applicable
Permitted – Subsection B		
Emergency Stationary Compression Ignition (CI) RICE (Diesel)	086	Not Applicable
Permitted – Subsection C		
Emergency Stationary Spark Ignition (SI) RICE (Gasoline)	087	Not Applicable
Permitted – Subsection D		
Launch Complex-39 Non-Emergency Stationary CI RICE	088	Not Applicable
Permitted – Subsection E		
Non-Emergency Existing Stationary CI RICE with Installed Controls	093	Not Applicable
Permitted – Subsection F		
Non-Emergency Stationary NSPS CI RICE	094	Not Applicable
Permitted – Subsection G		
Surface Coating Operations	091	HAP/VOC
Permitted – Subsection H		
Hypergol Servicing Operations & Activities	089	Not Applicable
Permitted – Subsection I		
Portable Aggregate Material Crushing Operations	092	Not Applicable
Unregulated		
Fog Fluid (Special Effects) at KSC Visitors Center Complex	090	Not Applicable
Insignificant Units and/or Activities (See Appendix I in permit for detailed descriptions)		
External Combustion Equipment	I-1	Not Applicable
Miscellaneous Internal Combustion Engines Units that are not subject to the NSPS/NESHAP.	I-2	Not Applicable
Fueling Related Activities	I-3	Not Applicable

Table 3-2. KSC Title V Emission Units (EU) Summary (cont.).

EU Description	EU Identification Number	Limited Pollutant
General Chemical and Solvent Use	I-4	Not Applicable
Surface Coating	I-5	Not Applicable
Blast Cleaning/Abrasive Blasting	I-6	Not Applicable
Aircraft (e.g., fixed or rotor wing) Servicing Operations	I-7	Not Applicable
Document Destruction	I-8	Not Applicable
Maintenance and/or Machining Activities (inside or outside of maintenance shops)	I-9	Not Applicable
Facilities and Building Maintenance Related Activities	I-10	Not Applicable
Waste Related Operations	I-11	Not Applicable
Laboratory Operations	I-12	Not Applicable
Outdoor Fugitive Particulate Matter Sources	I-13	Not Applicable
Ventilation Systems	I-14	Not Applicable
Water Treatment	I-15	Not Applicable
Fire and Safety Equipment	I-16	Not Applicable
Cleaning Activities	I-17	Not Applicable
Sampling and Compressed Gases	I-18	Not Applicable
Process Tanks	I-19	Not Applicable
Animal Kennels	I-20	Not Applicable
Application of identification numbers such as to facilities, equipment, structures, and components.	I-21	Not Applicable

Table 3-2. KSC Title V Emission Units (EU) Summary (cont.).

EU Description	EU Identification Number	Limited Pollutant
Blowdown of compressors or other vessels containing natural gas or liquid hydrocarbons for the purpose of maintenance due to emergency	I-22	Not Applicable
Cable fabrication operations	I-23	Not Applicable
Controlled/prescribed burning, including vegetative burning	I-24	Not Applicable
Construction activities	I-25	Not Applicable
Cooling towers provided no chromium containing water treatment chemicals are used	I-26	Not Applicable
Distillation equipment with PTE less than 5 tpy (e.g., Vertrel still)	I-27	Not Applicable
Electrical power transmission equipment which do not involve fuel burning activities, including transformers and substations	I-28	Not Applicable
Fiberglass cutting and bonding	I-29	Not Applicable
Flare Stacks	I-30	Not Applicable
Film processing labs and x-ray processing, including developing and cleaning with non-halogenated solvents, and associated ventilation systems	I-31	Not Applicable
Firing range operations, including both indoor and outdoor activities	I-32	Not Applicable
Indoor fugitive emissions, including particulate matter from vacuum cleaning, building material, interior furnishings	I-33	Not Applicable
Industrial battery recharging and maintenance operations for batteries utilized within the facility only. Includes back up batteries.	I-34	Not Applicable
Laser engraving	I-35	Not Applicable
Marina activities, including fueling and vessel maintenance	I-36	Not Applicable

Table 3-2. KSC Title V Emission Units (EU) Summary (cont.).

EU Description	EU Identification Number	Limited Pollutant
Office activities, including office supplies, such as photographic processes, photocopying, and blueprint copiers.	I-37	Not Applicable
Ordnance disposal	I-38	Not Applicable
Portable toilets	I-39	Not Applicable
Recovered materials recycling systems, including bulb crushers, solvent stills, and aerosol can puncturing.	I-40	Not Applicable
Relocatable screening-only operations (e.g., aggregate screening/sizing	I-41	Not Applicable
Sterilizers, including those using ethylene	I-42	Not Applicable
Warehouse activities, including the storage of packaged raw materials and finished	I-43	Not Applicable
Sewage/Wastewater treatment emissions from tanks, vessels, and equipment used for storage and dispensing of inorganic salts, bases (caustics), or acids which contain no volatile organic compounds, **excluding**: (a) 99% or greater sulfuric acid; (b) 99% or greater phosphoric acid; (c) 70% or greater nitric acid; (d) 30% or greater hydrochloric acid; and (e) air conditioning units.	I-44	Not Applicable
Operations using ozone depleting compounds (ODS). Cold storage refrigeration systems and air conditioning systems which contain less than 50 pounds of ozone depleting Class I or Class II substances, Also ODSs used in recharging automobile air conditioning systems, cleaning parts, cleaning instruments, and sterilization of medical equipment.	I-45	Not Applicable

Table 3-2. KSC Title V Emission Units (EU) Summary (cont.).

EU Description	EU Identification Number	Limited Pollutant
Vehicle repair facilities (e.g., automotive and truck) emitting less than five tons per year of volatile organic materials. Includes vehicular exhaust emissions associated with maintenance activities.	I-46	Not Applicable
Remediation activities provided actual air emissions from each activity are less than 1,000 pounds per year of any individual HAP; 2,000 pounds per year of total HAP;	I-47	Not Applicable
Any emissions unit, operation or activity that has a potential to emit no more than the lesser of either one ton per year or the de minimis of any 112(b) hazardous air pollutant listed in the US EPA document "Documentation of De Minimus Rates for proposed 40 CFR 62, Subpart B", EPA-453/R-93-035.	I-48	Not Applicable
Individual emissions points of any regulated pollutant (criteria pollutant, excluding lead and HAP) having uncontrolled potential emissions less than 5 tons per year source per any one emission unit.	I-49	Not Applicable

All administrative, insignificant or minor modifications to the permit that occur before the renewal application is submitted must be proposed in a written letter with supporting information or calculations to the FDEP for consideration. If FDEP concurs, the modification is automatic. If the desired modification is major, an application for an air construction permit must be submitted with a PSD determination included in the application. Once the construction and the compliance testing are complete, the new source or modification of the existing source is added to the Title V operating permit.

Requirements of the Title V operating permit include an annual operating report, an annual emission fee, and an annual certification of compliance. The report, which is due to the

FDEP each March, calculates the actual emissions from all of the permitted and unregulated EUs. The FDEP has developed a computer program for the annual report called the Electronic Annual Operating Report (EAOR). The reported emissions then become part of a database maintained by the FDEP. The annual operating fee is also due each March to the FDEP. The fee amount is based on the usage of the emission-limited units, of which KSC has ten. The certification of compliance is submitted each March to the FDEP and the EPA. This is signed by the responsible person to certify that KSC has remained in compliance with the Title V permit requirements over the previous year. The level of KSC compliance is also documented.

3.2.2.1 Hot Water Generators/Boilers

The Hot Water Generator EUs are described in Subsection A of the KSC Title V operating permit. There are three hot water generators permitted within EU 01. The hot water generators are located at the Vehicle Assembly Building (VAB) Utility Annex (EU 001). The VAB Utility Annex has three units. Records are maintained at the location of the hot water generators for the fuel usage for this EU and hours of each fuel burned. Each unit is allowed to fire no. 2 fuel oil, diesel fuel, natural gas, propane (including liquid propane), biodiesel, jet fuel, synthetically derived fuel (e.g. produced by the Fischer-Tropsch process). Synthetically derived fuels include coal-to-liquid (CTL), gas-to-liquid (GTL), biomass-to-liquid (BTL), and syngas (e.g. mixture of carbon monoxide and hydrogen). Each unit is allowed to operate continuously. Gas-fired boilers are limited to less than 48 hours per year firing fuel oil for non-emergency purposes.

3.2.2.2 EU 086, 087, 088, 093

EUs 086 (Emergency Stationary CI RICE [diesel]), 087 (Emergency Stationary SI RICE [gasoline]), 088 (Launch Complex [LC] 39 Non-Emergency Stationary CI RICE) and 093 (Non-Emergency Existing Stationary CI RICE with install controls) are found in Subsections B, C, D, and E of the Title V operating permit. Fuel usage records are maintained for all of these units by totaling the diesel and gasoline delivered to KSC for use in these permitted units over a consecutive twelve-month period. It is assumed that the fuel that is delivered equals the amount used by the units. For EU 088, records are maintained for both fuel and hours of operation usage. EU 088 consists of five two-megawatt diesel generators that are used at KSC as backup power for the LC 39 area. Florida Power and Light was involved in the construction of the facility and has the capacity to access the generators for emergency power also.

Each EU has an annual fuel usage limitation based on a consecutive twelve-month period. There is also a limit placed on the hours of operation per consecutive twelve-month period. The total combined generator units fuel usage and hours of operation limitations for the miscellaneous operations are as follows: 305,000 gallons diesel shared for EU 086 and EU 093; 38,000 gallons gasoline usage per consecutive twelve months for EU 087; and 170,000 gallons diesel and operations of 1,250 hours per consecutive twelve months for EU 088 for combined generator units operations. The annual usage, hours of operation, and emissions are reported to the FDEP using the EAOR each year for all of the units in this subsection.

3.2.2.3 EU 094

EU 094 is found in Subsection F of the Title V operating permit and includes Non-Emergency NSPS Stationary CI RICE. Fuel usage records are maintained for all of the units included in EU 094 by totaling the fuel delivered over a consecutive twelve-month period. It is assumed that the fuel delivered equals the amount used by the units. Records are maintained for both fuel and hours of operation usage.

3.2.2.4 Surface Coating Operations

The Surface Coating Operations EUs are found in Subsection G of the Title V operating permit. There are a total of twelve units that are permitted within EU 091. The surface coating operations are as follows: two drive-through paint booths at the Corrosion Control Facility (CCF), a top coat application cell at the SRB-ARF, Thermal Protection System (TPS) north spray cells number 1 and 2 at the SRB-ARF, TPS south spray cells number 1 and 2 at the SRB-ARF, east and west paint booths at Hanger AF at the Cape Canaveral Air Force Station (CCAFS), a small parts paint booth at Hangar AF at CCAFS, an isopropyl alcohol (IPA) vent hood at building K6-1696, and the LES Paint Booth at K6-1397. Records are maintained for the usage of all solvents and coatings used in any of the surface coating operations at all of the facilities that encompass this EU.

The permitted VOC emission rate for EU 091 is limited to less than 69.0 tons per consecutive twelve months, including the emissions from the air drying of empty cans and excess two-part epoxy paints prior to their disposal. The permitted HAP emission rate from EU 091 is combined HAP emissions are limited to less than 20.0 tons per any twelve consecutive months and individual HAP emissions are limited to less than 8.0 tons per any twelve consecutive months.

KSC employs a variety of activities that result in emissions of VOCs and HAPs. These emissions are directly related to the types and quantities of the products utilized. Chemical tanks and trays are housed in multiple locations for purposes of cleaning, etching and coating metal parts. Spray, hand painting, and touchup applications are also performed in many locations. Assembly and refurbishment operations are responsible for producing the majority of total VOC emissions at KSC. Assembly and refurbishment operations involve cleaning, surface preparation, painting, and thermal coating applications.

3.2.2.4 Emission Unit 089

EU 089 is comprised of hypergol servicing operations and activities and is found in Subsection H of the Title V operating permit. These operations include fueling operations, purging, fume hoods and scrubbers (Table 3-3). Each unit is allowed to operate continuously. The visible emission limitation for hypergol servicing operations and activities shall be 100 % opacity. Given the 100% visual emission limitation for this EU, compliance is inherent, therefore visual emission testing is not required.

Table 3-3. Hypergol Servicing Operations and Activities (EU 089).

Unique ID	Location/Building	Description
CM-07	PHSF	Fuel Vapor Scrubber
CM-08	PHSF	Oxidizer Vapor Scrubber
IM-53	FSA-1	Hypergol Fueling Operations

3.2.2.5 Unregulated Emission Units

Unregulated EUs are defined in Appendix U-1 of the Title V operating permit. Unregulated EUs are over the threshold for insignificant units or activities, but emit no “emissions-limited pollutant” which is subject to no unit-specific work practice standard. The EUs may still be subject to regulations that apply on a facility-wide basis, such as unconfined emissions, odor, or general opacity regulations, or to regulations that require the ability to prove exemption from unit-specific emissions or work practice standards. The unregulated EU includes EU 090 Fog Fluid (Special Effects) at the KSC Visitor Center. This unit has no limitations for usage, hours of operations, or emissions, but this information is reported to the FDEP as part of the EAOR.

3.2.2.6 Insignificant Emission Units and/or Activities

The insignificant EUs and/or activities are described in Appendix I-1 of the KSC Title V operating permit. Insignificant EUs and/or activities are facilities, EUs, and/or pollutant-emitting activities that are exempt from permitting requirements because the potential emissions from the units and/or activities are below the threshold amounts or they are listed as a categorical exemption in F.A.C Rule 62-210.300(3)(a). The thresholds found in FAC Rule 62-213.430(6)(b) for insignificant units or activities to emit or have the potential to emit are: less than 500 pounds per year of lead and lead compounds, less than 1,000 pounds per year of any individual HAP, less than 2,500 pounds per year of the total HAPs, or 5 tons per year of any other regulated pollutant.

All EUs and/or activities have been classified by categories instead of listing individual sources. The insignificant EUs and/or activities are listed in Section 3.3.2. These units have no limitations for usage, hours of operations, or emissions, and this information is not required to be maintained or reported to the FDEP.

3.1.3 OZONE DEPLETING SUBSTANCES

The CAA amendments established a deadline of 2000 for the phase-out of the production of the Class I Ozone Depleting Substances (ODS) chlorofluorocarbons (CFCs), halons, and carbon tetrachloride, and 2002 for methyl chloroform. In 1992, these deadlines were accelerated in response to scientific findings that significant ozone depletion is underway in the Northern Hemisphere. The accelerated schedule required the phase-out of Class I ODCs by December 31, 1995. Also in 1992, the United States and other parties to the Montreal Protocol agreed to accelerate the phase-out of CFCs, carbon tetrachloride and methyl chloroform to the end of 1995 and halons to the end of 1993. Under the Montreal Protocol, the U.S. must also phase-out its use of Class II ODCs (hydrochlorofluorocarbons or HCFCs) by 2030.

In 1993, EO 12843 directed federal agencies to minimize the procurement of products containing Ozone-Depleting Substances (ODS). NASA issued NPG 8820.3 in response to the Executive Order. The NASA policy requires that NASA minimize the procurement of Ozone-Depleting Substances in anticipation of the phase-out of ODS production. In April 2000, EO 13148 was issued. This new Executive Order directs federal agencies to develop a plan by April 2001 to phase out the procurement of Class I ODS for all non-excepted uses by December 31, 2010.

EO 13148 also requires federal agencies to ensure that its facilities: (1) maximize the use of safe alternatives to Ozone-Depleting Substances, as approved by the EPA's Significant New Alternatives Policy (SNAP) program; (2) evaluate the present and future uses of Ozone-Depleting Substances, including making assessments of existing and future needs for such materials, and evaluate use of, and plans for recycling, refrigerants, and halons; and (3) exercise leadership, develop exemplary practices, and disseminate information on successful efforts in phasing out Ozone-Depleting Substances.

3.1.4 RISK MANAGEMENT PROGRAM

Section 112(r) of the CAA establishes chemical accident prevention provisions. These regulations, located in 40 CFR 68, require facilities that manufacture, process, store, or handle certain regulated substances in amounts greater than threshold quantities to conduct risk management planning and develop risk management plans (RMPs). RMPs identify the hazardous substances and locations at a facility; the hazards associated with each substance; the processes and chemical accident prevention steps employed to prevent an accidental release; and the response/mitigation plans in the event of an accidental release. The EPA has delegated its authority to oversee and enforce chemical accident prevention regulations in Florida to the Florida Division of Emergency Management (FDEM).

Historically KSC maintained a RMP for certain hazardous chemicals (such as monomethylhydrazine) stored in quantities above the regulatory thresholds. The KSC RMP was deactivated in 2012 when chemical inventory levels dropped below the regulatory thresholds.

KSC organizations and contractors shall contact the EAB to discuss proposed operational, process, or chemical storage changes involving RMP chemicals. An RMP may need to be developed and submitted to the EPA and FDEM prior to implementing those changes. The EAB conducts periodic audits of KSC operations to ensure compliance with chemical accident prevention regulations.

3.1.5 NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS

The CAA amendments requires EPA to regulate emissions of toxic air pollutants from a published list of industrial sources referred to as "source categories" by promulgating National Emission Standards for Hazardous Air Pollutants (NESHAP). As required under the CAA amendments, EPA has developed a list of source categories that must meet control technology requirements for these toxic air pollutants. The EPA is required to develop regulations or rules for all industries that emit one or more of the HAPs in significant quantities. Currently, KSC is applicable to only one promulgated source category in the NESHAP. KSC is exempt from following the MACT standards of the Aerospace NESHAP. As new proposed and promulgated NESHAPs are published in the Federal Register, applicability and impact analysis are preformed to determine the optimal approach to comply with the regulations.

Section 112(j) of the CAA amendments requires operators of major sources within a listed source category to apply for a Title V permit or renew the current Title V permit should the EPA fail to promulgate emission standards for that source category by the date specified in the regulatory schedule established through Section 112(e) of the CAA amendments. The Title V permit that is issued must require the major source's ability to achieve a maximum achievable control technology (MACT) emission limitation for all HAP emissions. Regulations to implement Section 112(j) will be published in 40 CFR 63, Subpart B. The EPA has delegated the permitting authority to the FDEP for complying with these regulations by identifying and evaluating control technology options to determine the MACT emission limitation. In April of 2002, the FDEP requested that a Part 1 Notification Submittal for a MACT Determination be completed as required under 40 CFR 63.52 for stationary sources located on facilities that are major sources of HAPs for which the EPA failed to finalize a MACT Standard by May 15, 2002. KSC informed the FDEP and the EPA that it is a major source of HAPs and is required to submit this notification.

The notification information consists of the name, address, and brief description of KSC; an identification of the relevant industry type source categories applicable to KSC when the final regulation is promulgated; a list of the EUs, sources, processes, and/or activities that belong to the relevant industry type source categories; and an identification of any affected sources for which a section 112(g) MACT determination has already been made, which is none in the case of KSC. Of the over 40-affected industry type source categories, KSC submitted information on 8 categories. They are: Industrial, Commercial and Institutional Boilers and Indirect-fired Process Heaters, Miscellaneous Metal Parts and Products (Surface Coating), Organic Liquids Distribution (non-gasoline), Paint Stripping Operations, Plastic Parts (Surface Coating), Reciprocating Internal Combustion Engines (RICE), Site Remediation, and Large Appliance (Surface Coating). The list of the EUs, sources, processes, and/or activities included permitted EUs, insignificant activities, or general KSC operations that are possibly affected activities.

KSC must also comply with the Asbestos NESHAP (Subpart M) and the FDEP regulations covered by FAC 62-257 for notification of asbestos renovation or demolition. KSC must quantify all planned asbestos abatement projects in an annual notification submittal, if the total of all projects exceeds the threshold of at least 260 linear feet on pipes, at least 160 square feet on other facility components, or at least 35 cubic feet off facility components where the length or area could not be measured. KSC must also report all demolition of any load-supporting structural member using the same FDEP Form 62-257.900(1). This requirement is mandatory whether the project contains regulated asbestos-containing material (RACM) or not and regardless of any threshold amount. All unplanned asbestos abatement projects must also be reported using the same process 10 days prior to exceeding the threshold quantity of RACM.

KSC must comply with the Plating and Polishing NESHAP (Subpart WWWWWW). The initial notification and the notification of compliance status were submitted as required by 40 CFR 63.9, 63.11509(a), and 63.11509(b). An initial notification and Notice of Compliance Status was submitted to the Environmental Protection Agency (EPA). Additionally an annual Compliance Certification is required to be signed by the KSC RO. The Compliance Certification is not submitted to FDEP or EPA unless requested, or if there is a deviation or noncompliance.

KSC must also comply with the Reciprocating Internal Combustion Engine (RICE) NESHAP (Subpart ZZZZ) which regulates emissions from stationary diesel and gasoline engines (such as electric power generators and fire extinguishing pump engines). The RICE NESHAP applies to all engines at KSC. Because most of the existing stationary engines at KSC are only used for emergency purposes, these engines are either exempt from the RICE NESHAP or have minimal RICE NESHAP requirements. Prior to the installation, modification, or rebuilding of any stationary engine, KSC organizations and contractors shall coordinate with the NASA EAB to determine RICE NESHAP requirements.

3.2 KSC AMBIENT AIR QUALITY

Ambient air quality at KSC is influenced by NASA operations, land management practices, vehicle traffic, and emission sources outside of KSC. Daily air quality conditions are most influenced by vehicle traffic, utilities fuel combustion, standard refurbishment and maintenance operations, controlled burning operations, and wildfires. Air quality at KSC is also influenced by emissions from one regional power plant, which is located within a 16.1 km radius of KSC, and cruise ship activity at Port Canaveral. Space launches and vegetation fuel load reduction controlled burns influence air quality as episodic events. One of the most influential air quality fluctuations on a routine basis is created by the emissions from automobiles entering and departing KSC each day. Mobile sources and the control of the emissions are regulated under Title II of the Clean Air Act, but the regulations have no applicability to the environmental requirements of KSC. A summary of air source emissions from KSC is provided in Table 3-2. These calculations are based on emission factors in the EPA's AP-42 manual.

Ambient air quality at KSC is monitored at one Permanent Air Monitoring System (PAMS) station. The PAMS A station is located approximately 0.4 km (0.25 mi) southeast of the former Environmental Health Facility site, and approximately 1.6 km (1.0 mi) north of the KSC Headquarters Building (Figure 3-1). PAMS A includes continuous analyzers for monitoring sulfur dioxide (SO_2), nitrogen dioxide (NO_2), CO, ozone (O_3), total inhalable (10-micron) particulates and a meteorological tower with instrumentation for wind speed, wind direction, solar radiation, high (30 m) temperature, and relative humidity (Ref. 1).

A summary of air quality parameters collected from the PAMS A facility from January, 2014 through December, 2014 is provided in Table 3-4. There were no exceedances of either the primary or secondary air quality standards for O_3, CO, NO_2, or SO_2 for the entire year. The maximum eight-hour average value for O_3 was 71.0 ppb and it occurred on May

17, 2014, and was 94.7% of the current primary standard of 75.0 ppb. The maximum hourly average value for O_3 was 77.5 ppb and it occurred on May 23, 2014. The maximum 24-hour average value for SO_2 was 11.3 ppb, which occurred on September 28, 2014. The maximum hourly average value for NO_2 was 30.4 ppb, which occurred on April 2, 2014. The maximum hourly average value for CO was 1.017 ppm, which occurred on September 27, 2014. The maximum 24-hour PM-10 inhalable particulates were 28.94 ug/m^3.

The maximum hourly value for the last twelve months was 71.0 ppb in May 2014. The maximum 8-Hour O_3 value occurring in May is typical when the "Bermuda High" sets up a stagnant weather condition. The maximum CO level was probably the result of either the use of a vehicle motor running in the area, or center-wide wildfire or controlled burns. NO_2 and SO_2 emissions are related to utilities fuel combustion and mobile sources. Strong correlation between elevated NO_2 and SO_2 levels and prevailing westerly winds suggest that power plants to the west of KSC could be the primary source of these emissions (Ref. 2).

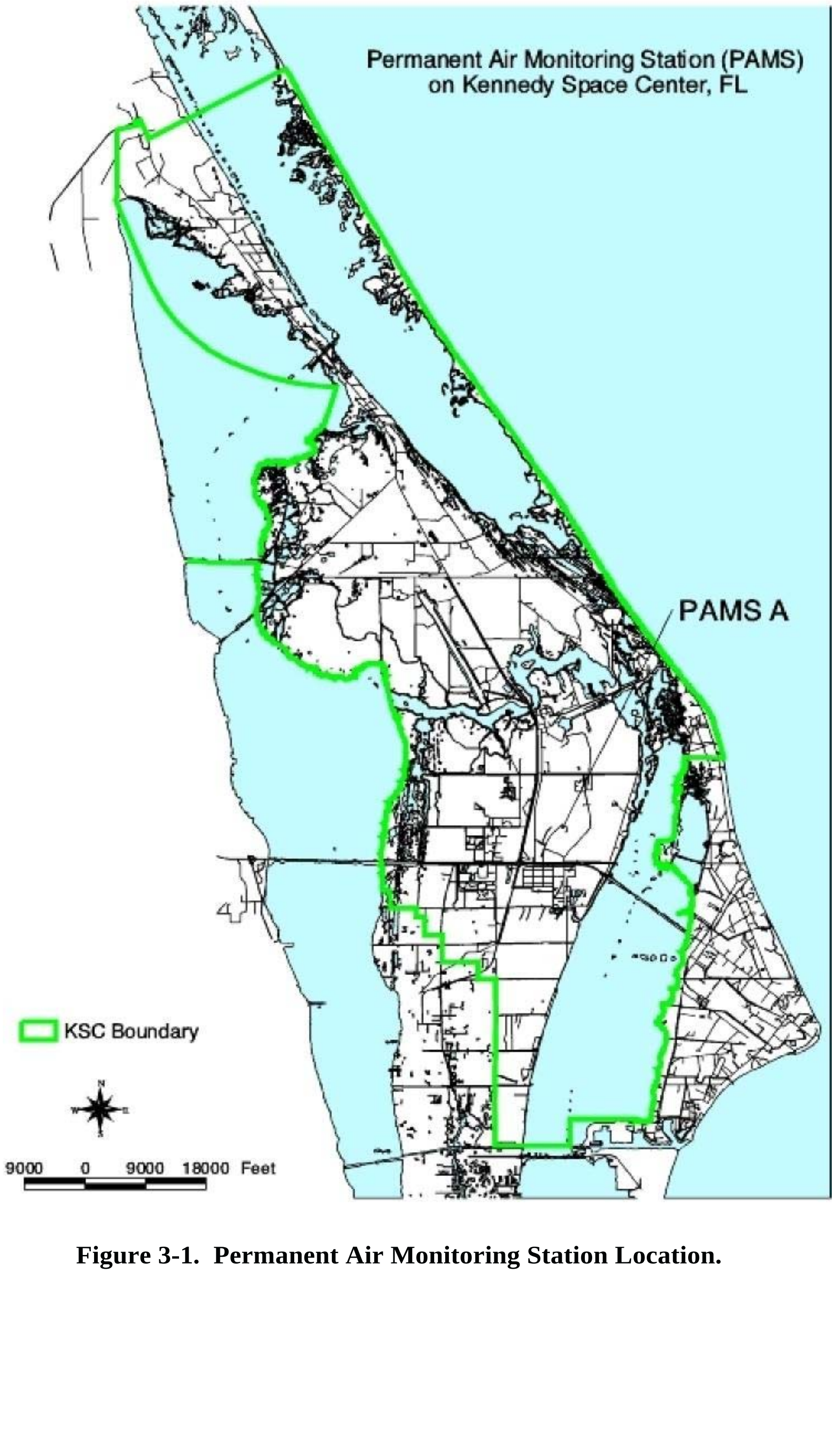


Figure 3-1. Permanent Air Monitoring Station Location.

Table 3-4. KSC Air Quality Data Summary PAMS A, 2014.

Parameter	Federal [4] and State Standard	Jan	Feb	Mar	Apr	May	June
Ozone (ppb)	Primary 75 (8-HR) [1]** Secondary 75 (8-HR-AVG)	35.4 33.9 (99.9%)	39.4 38.5 (98.2%)	41.7 39.2 (99.7%)	62.6 56.1 (89.4%)	71.0 70.2 (100.0%)	57.0 53.0 (100.0%)
Sulfur Dioxide (ppb)	Primary 140 (24-HR) [2,4] Secondary 500 (3-HR) [3]	5.8 5.1 (99.3%)	4.3 3.6 (81.4%)	5.0 3.4 (99.3%)	4.1 4.0 (100.0%)	4.7 4.5 (100.0%)	4.5 4.3 (100.0%)
Nitrogen Dioxide (ppb)	(1 HR-AVG) 50 (ANNUAL-AVG) [3]	8.6 1.78 (92.2%)	7.0 1.62 (86.5%)	20.7 1.48 (88.2%)	30.4 1.34 (65.6%)	4.8 1.23 (100.0%)	6.2 1.11 (100.0%)
Carbon Monoxide (ppm)	35 (HR-AVG) [1] 9 (8-HR) [2]	0.642 0.607 (99.9%)	0.767 0.725 (98.1%)	0.708 0.469 (99.2%)	0.600 0.571 (99.9%)	0.475 0.407 (100.0%)	0.417 0.342 (100.0%
Carbon	Minimum					387	361
Dioxide	Mean					477	490
(ppm)	Maximum			999	899	911	911
				(71.2%)	(100.0%)	(100.0%)	(100.0%)
Parameter	**Federal [4] and State Standard**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Ozone (ppb)	Primary 75 (8-HR) [1]** Secondary 75 (8-HR-AVG) [1]	51.4 39.9 (100.0%)	45.2 44.1 (96.4%)	34.6 33.8 (95.6%)	51.1 48.4 (100.0%)	47.4 44.7 (99.9%)	37.6 35.9 (99.1%)
Sulfur Dioxide (ppb)	Primary 140 (24-HR) [2, 4] Secondary 500 (3-HR) [3]	3.4 3.1 (100.0%)	3.5 3.2 (96.4%)	11.3 8.3 (95.4%)	4.4 4.3 (100.0%)	7.4 7.3 (99.9%)	11.3 11.0 (99.1%)
Nitrogen Dioxide (ppb)	(1 HR-AVG) 50 (ANNUAL-AVG) [3]	5.3 1.030 (98.7%)	3.4 0.950 (76.9%)	27.9 0.890 (14.2%)	7.5 0.880 (76.6%)	13.7 0.790 (99.9%)	4.9 0.770 (94.9%)
Carbon Monoxide	35 (HR-AVG) [1] 9 (8-HR) [2]	0.808 0.399 (100.0%)	0.808 0.399 (99.5%)	1.017 0.482 (92.2%)	0.500 0.402 (99.2%)	0.783 0.745 (100.0%)	0.658 0.547 (99.2%)
Carbon	Minimum	354	252	254	229	282	282
Dioxide	Mean	434	398	493	498	371	366
(ppm)	Maximum	965	869	949	904	730	672
		(100.0%)	(96.4%)	(95.8%)	(100.0%)	(100.0%)	(99.2%)

[1] Maximum hourly average concentration (not to be exceeded more than once per year).
[2] Maximum time-period average concentration (not to be exceeded more than once per year).
[3] Annual arithmetic mean.
[4] Federal and state standards are identical except for SO2; State Primary (24-hour) is 100 ppb.
Twenty-one days are required to yield a valid month.
(%) = Percentage of validation the month.
SOURCES: References 2, 3, 4, and 5.

3.2.1 OZONE

Ozone is the most consistently "elevated" criteria pollutant at KSC (Ref. 1). Ozone is formed in a series of chemical reactions between oxidant precursors such as VOCs and NO_x in the presence of sunlight. Local sources, as well as distant metropolitan areas can contribute to elevated ozone levels. Ozone precursors generated over land are directed offshore by prevailing evening winds. Morning sunlight catalyzes the conversion to ozone and onshore breezes can return ozone to the land mass. There have been 6 exceedances of the primary and/or secondary ambient air quality standards for O_3 recorded at KSC since 1988. However, the levels have been below these standards for the last ten years.

Figure 3-2 displays a plot of the maximum monthly 8-hr and 1-hr O_3 values from January 2014 to December 2014 and the last 10-year means for comparison. The 8-hr monthly values were above the 10-year mean all year with the exception of March & September 2014. The maximum 8-Hour Average was 71.0 ppb (0.071 ppm), which was 94.7 percent of the proposed 8-hr standard of 75 ppb (0.075 ppm). The 1-hr data was above the associated 10-year mean for most of the year with the exception of February, March, September, and December 2014. This is consistent with the “typical” bi-annual peaks found with ozone. The 77.5 ppb (0.077 ppm) in May 2014 was 64.6 percent of the old 1-hr standard of 120 ppb (0.120 ppm). However, the new secondary standard for Ozone is the same as the Primary one (75 ppb, 8-hour), and is being proposed to be lowered to 70.0 ppb, 8-hour).

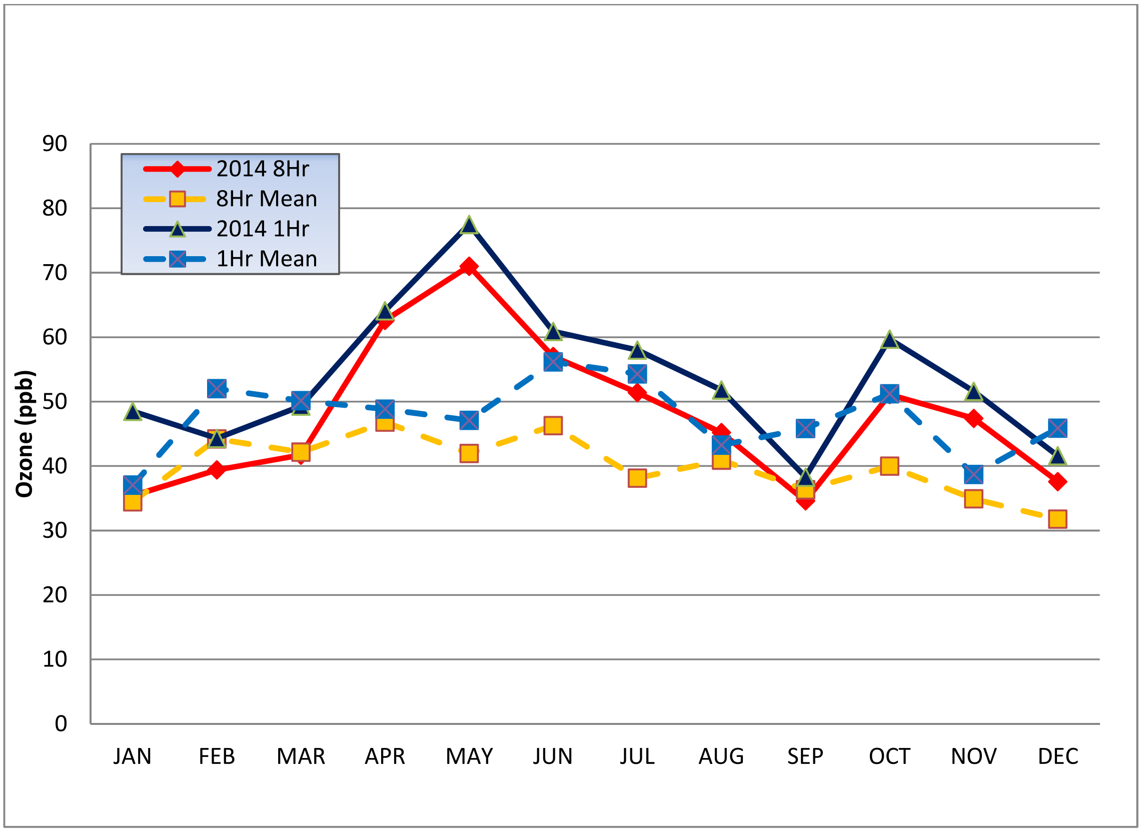


Figure 3-2. Jan. 2014 through Dec. 2014 vs. 10-Year Mean for Ozone

3.2.2 SULFUR DIOXIDE

Figure 3-3 displays a plot of the maximum monthly 24-hr and 3-hr and 1-hr mean SO_2 values from January 2014 to December 2014 and the last 10-year means for comparison. The 24-hr data was above the associated 10-year mean for September, 2014, and below the remaining 11 months. The highest 24-hr average was 11.3 ppb in September and December, 2014, which was 8.1 percent of the primary standard of 140 ppb. The 3-hr values were above the 10-year mean in two months: June and December, 2014. The highest 3-hr average was 11.0 ppb in December, 2014, which was 2.2 percent of the primary standard of 500 ppb. The 1-hr values were below the Primary Standard of 75 ppb. The highest 1-hr average was 11.3 ppb in September and December, 2014, which was 2.3 percent of the primary standard of 500 ppb.

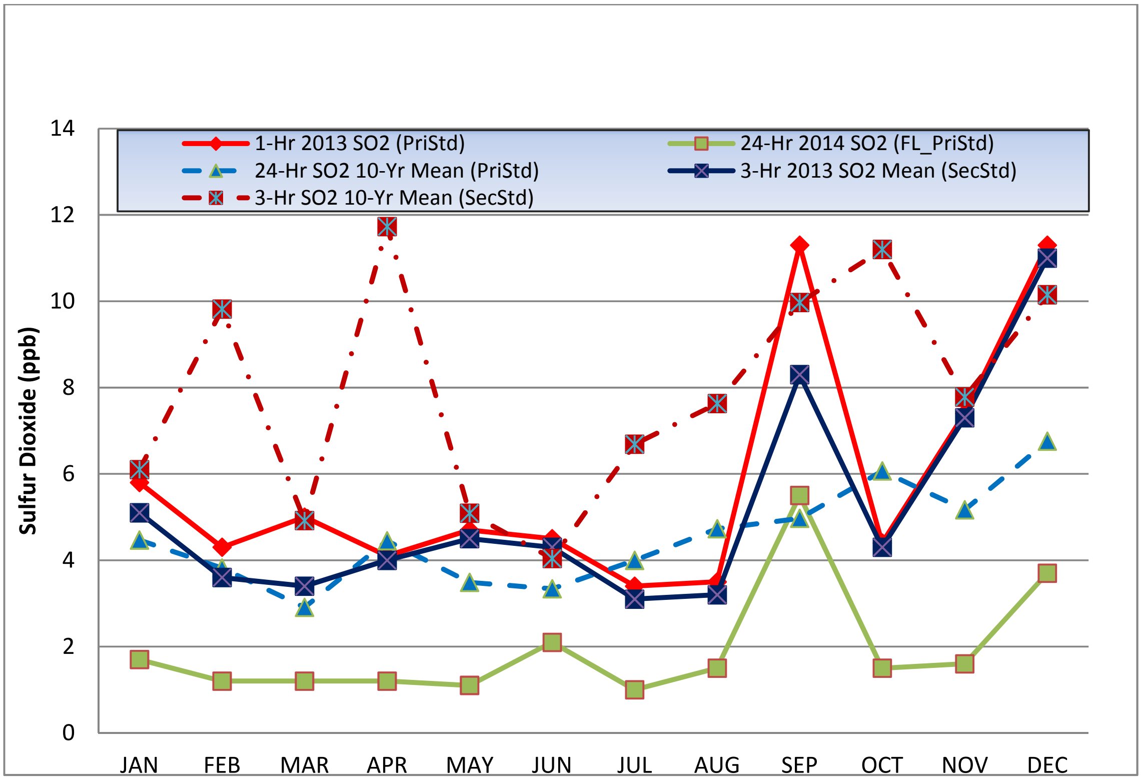


Figure 3-3. 10-Year Mean for Sulfur Dioxide

3.2.3 NITROGEN DIOXIDE

Figure 3-4 displays a plot of the maximum monthly annual average and the 1-hr NO_2 values from January 2014 to December 2014 and the last 10-year means for comparison. The annual average values were below the 10-year mean for all of the year. The highest annual average value was 1.03 ppb for July, 2014, which was 2.1 percentage of the standard of 50 ppb (100 ug/m^3). The 1-hr data was at or above the associated 10-year mean for 5 months of the year, March, April, June, July, and September 2014. The highest 1-hr NO_2 value was 30.4 ppb in April, 2014.

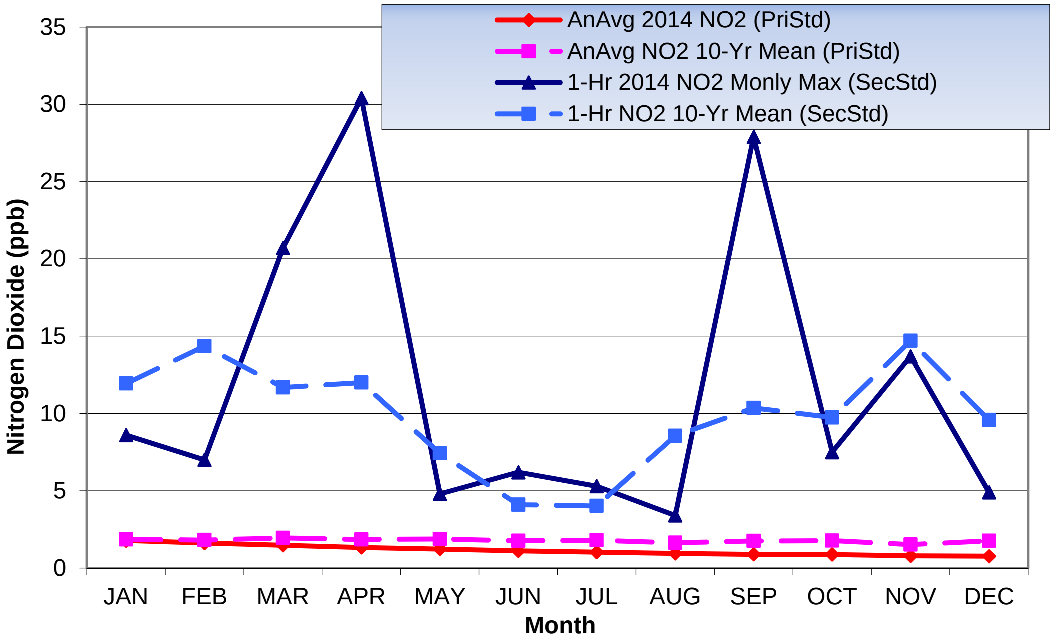


Figure 3-4. 10-Year Mean for Nitrogen Dioxide

3.2.4 CARBON MONOXIDE

Figure 3-5 displays a plot of the maximum monthly 1-hr and 8-hr CO values from January 2014 to December 2014 and the last 10-year means for comparison. The 1-hr data was below the associated 10-year mean for most of the year with the exception of July and September 2014. The highest 1-hr average of 1.017 ppm on September 27, 2014 was 2.9 percent of the primary 1-hr standard of 35 ppm. The 8-hr monthly values were below the 10-year mean all year with the exception of March, July, and November 2008. The highest 8-hr value of 0.745 ppm occurred in November 2014 and was 8.3 percent of the proposed 8-hr standard of 9.0 ppm.

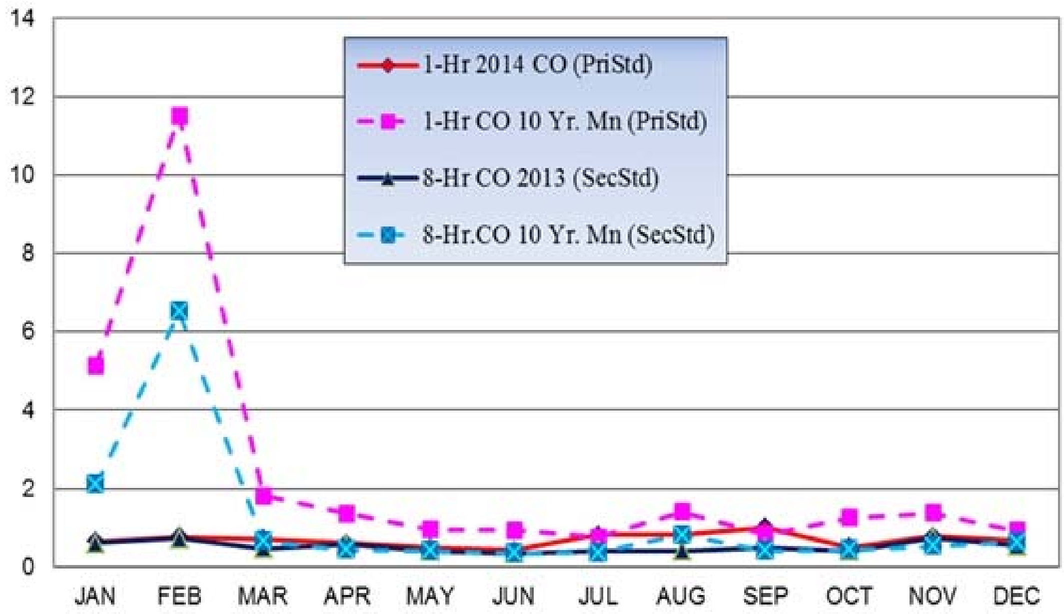


Figure 3-5. 2014 vs. 10-Year Mean for Carbon Monoxide.

3.2.5 CARBON DIOXIDE

Figure 3-6 displays a plot of the minimum, mean, and maximum monthly 1-hr CO_2 values from May 2014 to December 2014. The data reflect a range of 229 to 965 PPM with a mean value of 441 PPM and standard deviation of 56.1 PPM. The largest value (965 PPM) occurred on July 18. The data reflect a lowering trend throughout the year with three peak months (March, July, and September).

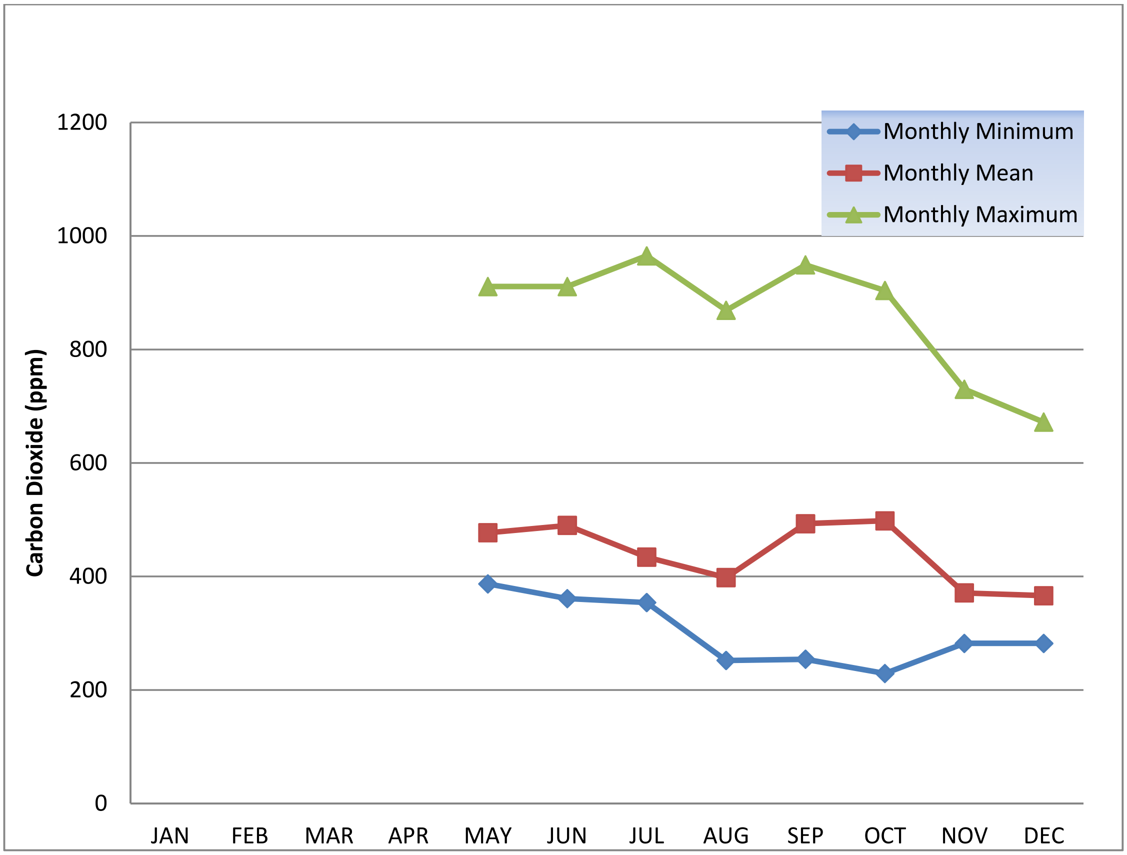


Figure 3-6. 2014 Monthly Minimum, Mean, and Maximum for Carbon Dioxide.

3.3 CLIMATIC CONDITIONS

The climate of KSC is subtropical with short, mild winters and hot, humid summers, with no recognizable spring or fall seasons. Summer weather, usually beginning in April, prevails for about 9 months of the year. Typically, dawns are slightly cloudy or hazy, with little wind and temperatures near 70 degrees Fahrenheit (F). During the day the temperature rises into the 80s and 90s F. A typical day is mostly sunny, with scattered white clouds. Often dark clouds in the afternoon foreshadow a storm. Thundershowers frequently lower local temperatures and an ocean breeze usually appears. Occasional cool days occur in November, but winter weather starts in January and extends through February and March. These last two months are usually windy and temperatures range from about 40^{o}F at night to 75^{o}F during the daytime (Ref. 3).

The dominant weather pattern (May to October) is characterized by southeast winds, which travel clockwise around the Bermuda High. The southeast wind brings moisture and warm air, which help produce almost daily thundershowers creating a wet season.

Approximately 70 percent of the average annual rainfall occurs during this period. Weather patterns in the dry season (November to April) are influenced by cold continental air masses. Rains occur when these masses move over the Florida peninsula and meet warmer air. In contrast to localized, heavy thundershowers in the wet season, rains are light and tend to be uniform in distribution in the dry season (Ref. 4).

The main factors influencing climate at KSC are latitude and proximity to the Atlantic Ocean and the Indian and Banana Rivers, which moderate temperature fluctuations (Ref. 9). Results of the Cape Atmospheric Boundary Layer Experiment found that wind direction, especially the sea breeze front, is controlled by thermal differences between the Atlantic Ocean, Banana River, Indian River, and Cape Canaveral Land Mass. Heat is gained and lost more rapidly from land than water. During a 24-hour period, water may be warmer and again cooler than adjacent land. Cool air replaces rising warm air creating offshore (from land to ocean) breezes in the night and onshore (from ocean to land) breezes in the day. These sea breezes have been recorded at altitudes of 3,281 feet and higher, and reach further inland during the wet season. Seasonal wind directions are primarily influenced by continental temperature changes. In general, the fall winds occur predominantly from the east to northeast. Winter winds occur from the north to northwest shifting to the southeast in the spring and then to the south in the summer months (Ref. 4).

3.3.1 RAINFALL

Rainfall data are gathered from several collecting stations in the KSC area (Ref. 5). These stations (Figure 3-7) provide both long-term records (Merritt Island and Titusville) and site-specific data of special interest to KSC. Mean annual rainfall for Merritt Island and Titusville are 51.6 in and 53.8 in, respectively. Annual rainfall varies widely; values for Merritt Island range from 30.5 in to 85.7 in, and for Titusville range from 33.4 in to 81.7 in. Distribution of rainfall is bimodal, with a wet season occurring from May to October, and the remainder of the year being relatively dry. There is noticeable variation in mean monthly rainfall amounts among the wet season months (June through October) with little variation during the dry season (Table 3-5 and Figure 3-8).

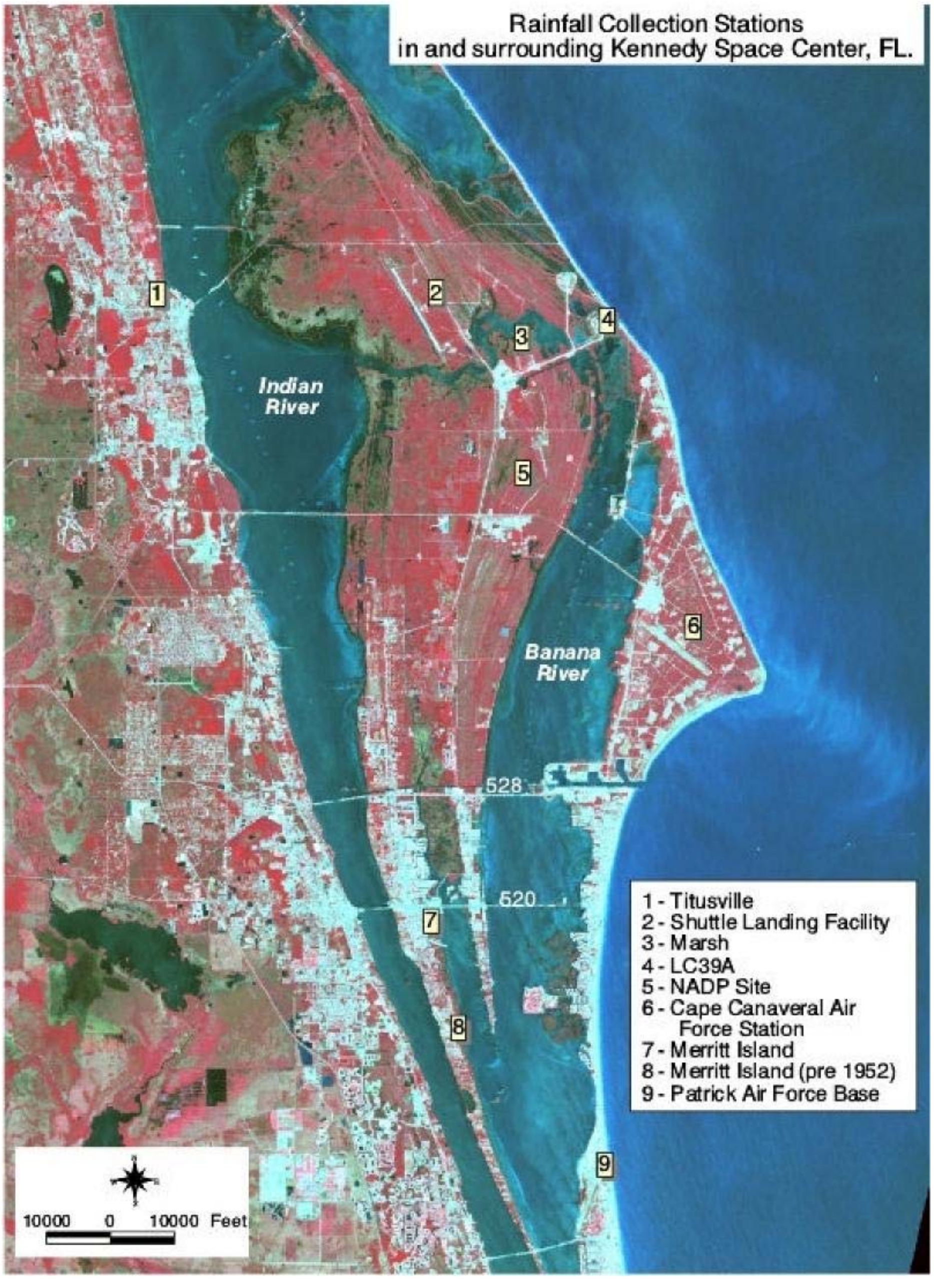


Figure 3-7. Rainfall Collection Stations In and Around KSC.

Table 3-5. Monthly Mean Rainfall for KSC Area Collecting Stations.

Station	Titusville *	Merritt Island*	CCAFS *	NADP Site	LC-39A	Shuttle 1	Patrick *
Length of Records (yrs)	86	75	21	25	12	12	2
January	2.22	2.68	2.39	2.60	2.39	3.21	2.72
February	2.80	2.56	2.91	2.49	2.10	2.43	1.98
March	3.06	2.79	3.41	3.66	2.49	4.28	6.12
April	2.53	2.77	1.30	2.33	2.41	2.38	0.74
May	4.09	3.70	2.77	2.24	2.11	2.54	4.58
June	7.12	6.65	5.74	6.81	4.92	7.14	4.16
July	7.52	5.99	5.17	5.20	2.87	6.23	6.27
August	6.69	5.52	5.41	5.77	4.91	5.67	2.46
September	7.96	7.76	6.48	7.92	6.11	8.03	6.97
October	5.41	6.14	4.32	4.81	4.57	5.29	5.56
November	2.52	2.52	3.24	3.14	2.47	2.75	8.80
December	2.32	0.30	2.00	3.02	2.04	2.16	2.56
Total	54.24	51.38	45.14	49.99	39.39	52.12	52.92
Reference: *Source 88							

On average, measurable precipitation occurs 148 days per year, with about 60 percent of these being in the wet season (Figure 3-8). Year to year variability in precipitation is high with drought conditions (high temperatures and low groundwater table) being somewhat common. These occurrences are usually associated with La Nina conditions. The total annual precipitation for 2000 was only 32.60 inches, which is the lowest recorded in twenty-five years at the NADP site. The total annual precipitation for 2008 was 55.87 inches, which was the seventh highest amount in the last twenty-five years.

A comparison of the NADP rainfall for 2014 vs the last 28-year mean shows the rainfall at the NADP site was drier than normal during the winter and spring, and wetter than normal during the summer and fall of 2014, except for the month of October (Figure 3-8).

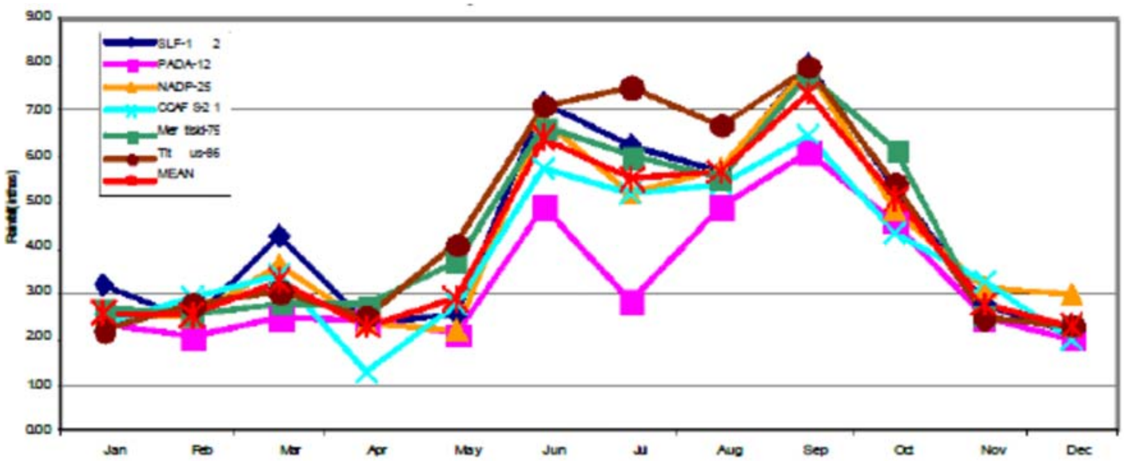


Figure 3-8. Mean Monthly Rainfall at KSC Area Sites.

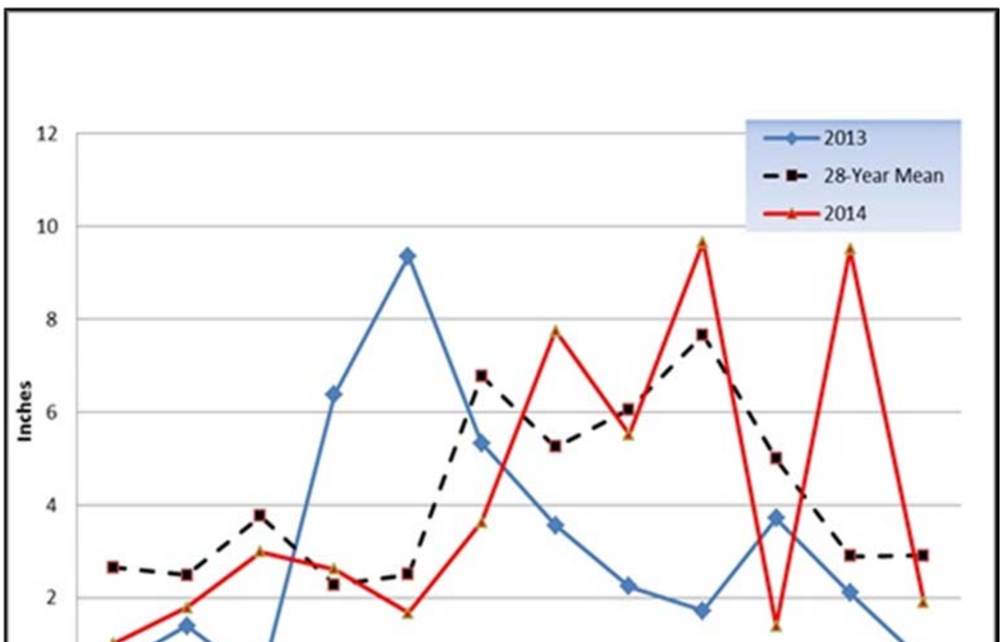


Figure 3-9. Monthly NADP Rainfall Totals (inches).

There is a spatial component to rainfall at KSC and CCAFS as can be seen in a 23-

year composite figure of data from the Tropical Rainfall Mesoscale Monitoring (TRMM) network (Figure 3-10). There is an east-to-west and north-to-south trend from drier-to-wetter sites across the domain. The wettest site on KSC is usually site 18, 20, or 22, while the drier sites are usually along the coastline, sites 8, 16, 26, 27, 28, and 29. As previously mentioned, there is some degree of year-to-year variability, which is somewhat driven by the El Nino Southern Oscillation (ENSO).

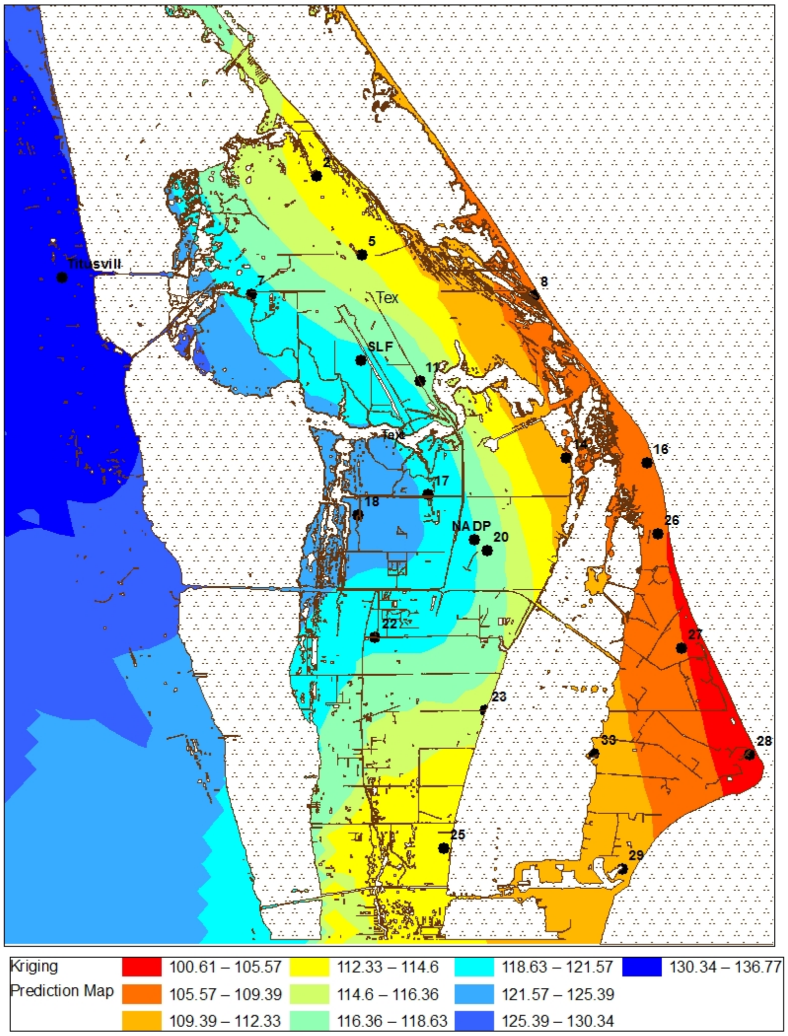


Figure 3-10. 23-Year Mean Rainfall at KSC.

3.3.2 TEMPERATURE

Monthly temperature variations for 1998, 2013, 2014, and the 28-year mean at PAMS A are shown in Figure 3-11. June was the warmest month of 2014 with an average temperature of 25.7ºC (78.2 ºF), and had the highest maximum temperature of 34.4ºC (93.9ºF). January is the coldest month, on average, with a mean temperature of 14.8ºC (58.7ºF) for 2014 and a 26-year mean temperature of 15.7ºC (60.3ºF). A plot of monthly minimum, mean, and maximum temperatures from 1984 through 2014 at PAMS A shows that there has been little change over this period (Figure 3-12).

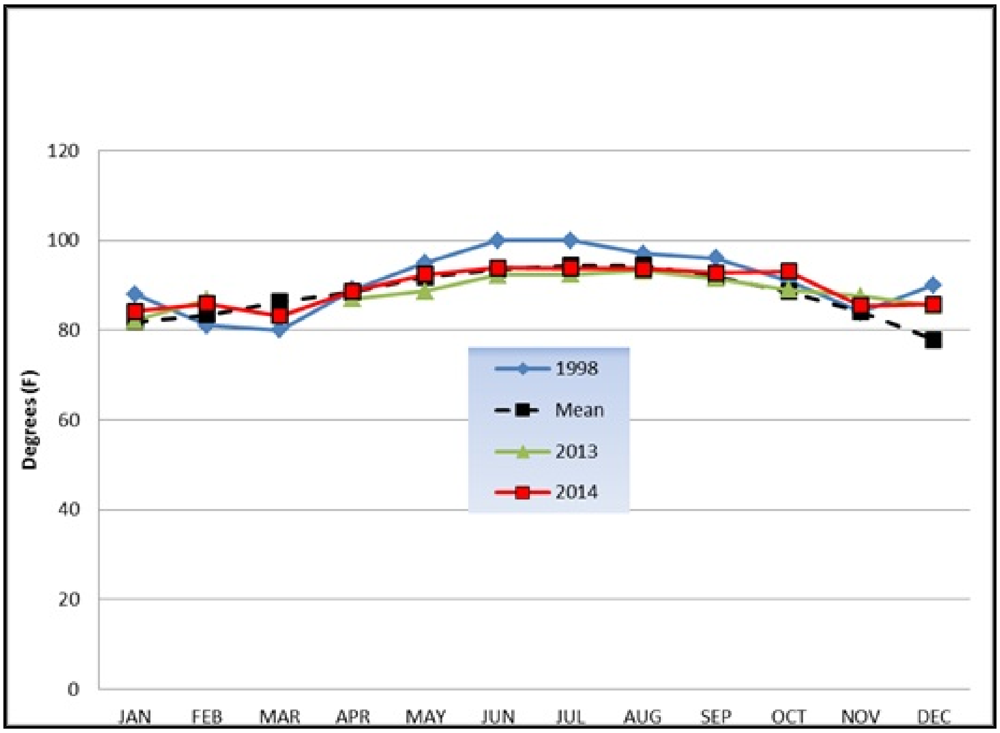


Figure 3-11. 2013 and 2014 Monthly Mean Temperature vs. 28-Year Monthly Mean.

Freezing temperatures in the KSC area have been analyzed for the Titusville and Merritt Island stations. Titusville has more recorded days of freezing temperatures than does Merritt Island and the freezing events are more severe. Cold air originates in the north or northwest and Merritt Island (including KSC) and has the Indian River to moderate temperatures before cold air reaches the Island. For a 40-year period of concurrent records for Merritt Island and Titusville, Titusville shows 121 days with temperatures below freezing while Merritt Island has only 30 such days. Titusville records lower temperatures than Merritt Island for the same freeze event as well as more frost occurrence. Over half of the Titusville freeze events lasted only one day with no record of the daytime high temperature during a freeze event being below freezing.

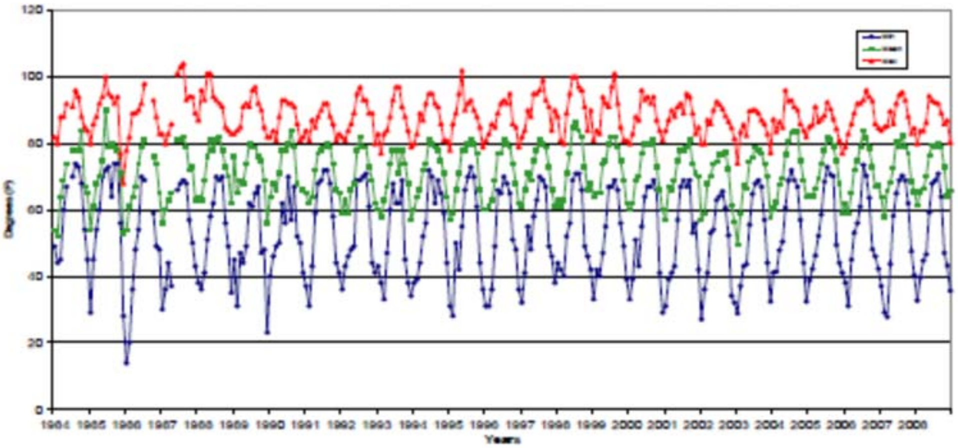


Figure 3-12. Ambient Minimum, Mean, and Maximum Temperatures (1984 - 2008).

3.3.3 WIND

A summary of monthly prevailing wind data along with data on peak gusts is given in Table 3-6. Wind conditions over short time periods are variable, depending on local convectional forces or land/sea breeze effects. Average monthly wind speeds range from 6 kts (July and August) to 9 kts (March). Monthly maximum recorded gusts for the period of record (1950-1952 and 1957- 1989) range from 40 kts to 68 kts. The highest wind speeds are encountered during tropical storms and hurricanes, which can produce sustained wind speeds over 87 kts. The prevailing wind direction is from the north or northeast during the dry season.

A series of seasonal wind roses are presented for wind direction data measured at Happy Creek Wind Tower 313 from 1998 to 2015 (Figures 3-13). The primary wind direction in the winter is from the NW, in the spring from the N and SE, in the summer from the SE-S, and in the fall from the N and ENE-E. Annually, predominate winds are from the N, E, and the SE-S. Calm winds are prevalent, about three percent for the entire year.

Table 3-6. Wind and Humidity Values for KSC/CCAFS.

	Wind			Humidity
	Prevailing (Dir. + KTS)	Peak Gust (KTS.)	Direction of Peak Gust	Mean Percent Relative Humidity
January	NW8	46	270	80
February	N8	60	240	79
March	N9	48	180	77
April	E8a	53	200	75
May	E8	46	270	77
June	E7	50	160	81
July	S6	50	220	83
August	E6	60	-0-	84
September	E7	68	160	82
October	E8	40	30	78
November	NW8	46	190	78
December	NW7	40	310	79

Source: Ref. 10

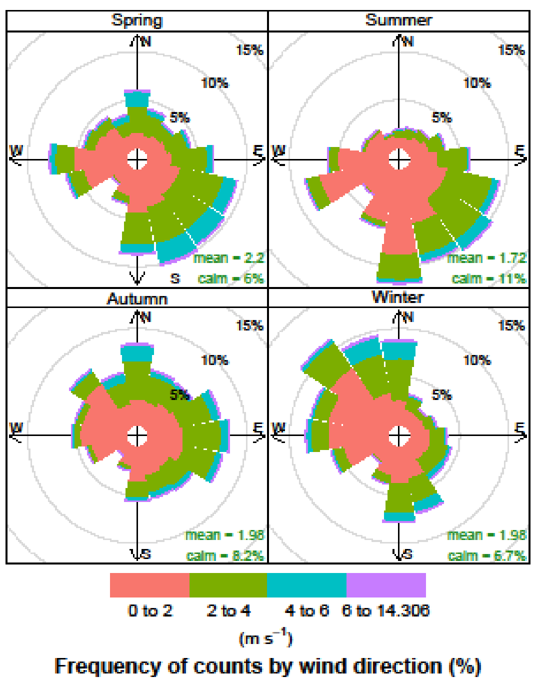


Figure 3-13. Seasonal Wind Patterns Based on Data from Happy Creek Wind Tower 313.

3.3.4 HUMIDITY

Humidity is high year round with a seasonal fluctuation less than the diurnal fluctuation of 30%. Mean monthly relative humidity values for the CCAFS and the SLF range from 75% in April to 84% in August. Seasonally, humidity tends to be approximately 3% higher in the summer months. On a diurnal basis, humidity values range from 50-65% during afternoon hours to 85-95% during night and early morning hours. Mean monthly days with fog (visibility less than 11 km [7 mi]) ranges from 3 km (2 mi) in June through September to 14 km (9 mi) in January. Most fog occurs from November to March and is light, usually burning off by midmorning. Figure 3-14 shows that the monthly mean humidity levels for 2014 were elevated above the mean for most of the year. The minimum RH was 21.0% in January 2014 ranging to 100.0% RH for most of the year with a mean value of 79.2%.

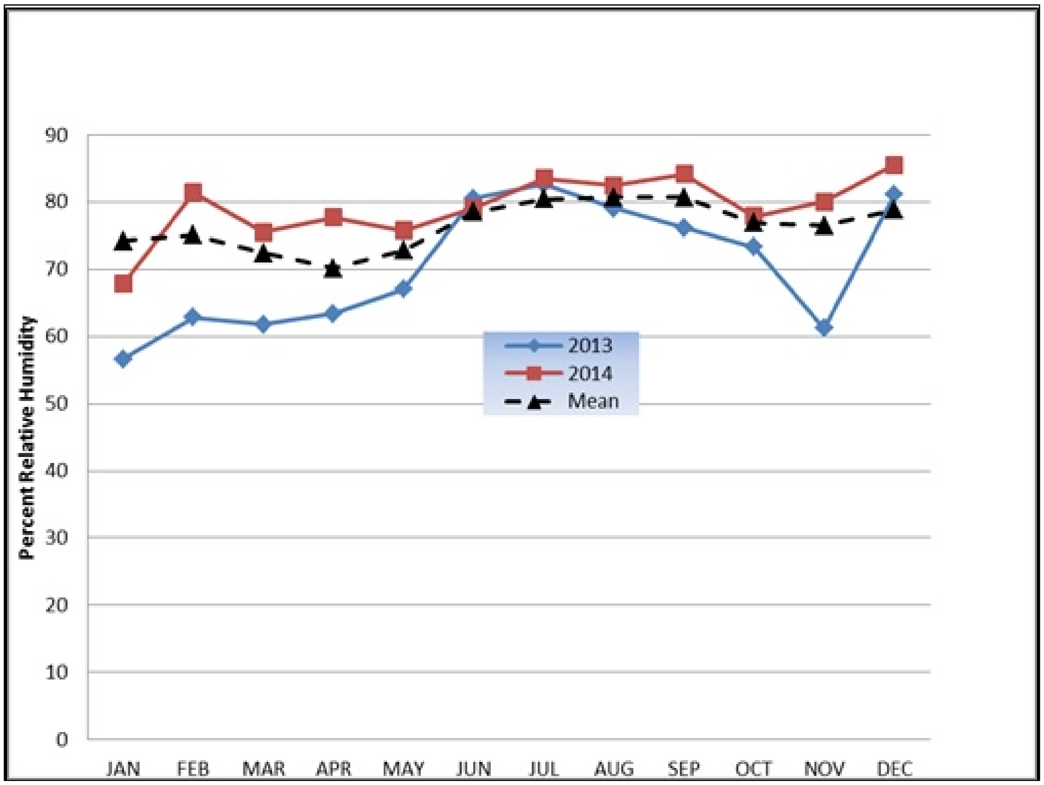


Figure 3-14. 2013 and 2014 Monthly Mean Relative Humidity vs. 28-Year Monthly Mean.

3.3.5 SOLAR RADIATION

Incident solar radiation that is not reflected is either transmitted or absorbed. The absorbed radiation generally increases the temperature of the absorbing medium; this is then released to the environment as heat as the medium cools. Absorbed radiation can also cause a number of photic reactions with the materials it encounters; photosynthesis is an example of such a reaction in nature. Due to KSC's location in the "sun-belt" and the nature of the operations occurring there, solar radiation measurements are taken daily. Fourteen years of solar radiation data taken at the Florida Solar Energy Center at CCAFS are averaged by month and presented in Table 3-7. The monthly hourly solar radiation averages show that the maximum radiation occurred in May, April, June, and August in decreasing order (Figure 3-15). The rest of the months have less with the minimum occurring in January, December, November and February.

Table 3-7. Mean Daily Solar Radiation, January 1977 through December 1990.

	DIRECT NORMAL INSOLATION			TOTAL NORMAL NSOLATION			TOTAL INSOLATION ON A HORIZONTAL SURFACE			A TILTED SURFACE (INCIDENT ANGLE <5 DEG AT SOLAR NOON)		
	WATT	DAYS	BTU/SQ FT	WATT	DAYS	BTU/SQ FT	WATT	DAYS	BTU/SQ FT	WATT	DAYS	BTU/ FT
JAN	3960.2	375	1256.2	5691.0	133	1805.5	3285.9	331	1042.3	4833.0	392	1533.
FEB	4144.9	367	1314.8	6675.1	118	2117.7	3964.8	371	1257.7	5071.6	367	1608.
MAR	4760.0	389	1509.9	7290.2	135	2312.9	5237.8	392	1661.5	5738.6	394	1820.
APR	5809.3	348	1842.8	8830.3	131	2801.5	6274.5	350	1990.3	6206.6	381	1968.
MAY	5612.9	336	1780.5	8898.0	129	2823.0	6627.3	330	212.2	6396.8	358	2029.
JUN	5209.3	330	1652.5	8430.5	128	2674.6	6439.0	329	2042.5	6282.4	331	1992.
JUL	5357.6	330	1699.5	8514.6	133	2701.3	6377.9	341	2023.1	6308.7	332	2001.
AUG	4892.9	372	1552.1	8048.5	137	2553.3	5954.9	372	1888.9	5915.9	372	1876.
SEP	4288.2	361	1360.3	7225.3	133	2292.2	5168.9	368	1639.6	5469.3	365	1734.
OCT	4097.2	355	1299.7	6552.9	142	2079.0	4431.5	351	1405.7	5382.2	358	1707.
NOV	4139.3	350	1313.0	6249.3	138	1982.6	3496.4	332	1109.1	5095.0	350	1616.
DEC	3541.9	366	1123.5	5381.9	136	1707.5	308.7	341	954.4	4691.2	374	1488.
ANNUAL MEAN DAILY SOLAR RADIATION												
4645.1		4279	1473.5	7315.6	1593	2320.9	5043.0	4208	1599.7	5600.0	4374	1776.
Source: Ref. 10												

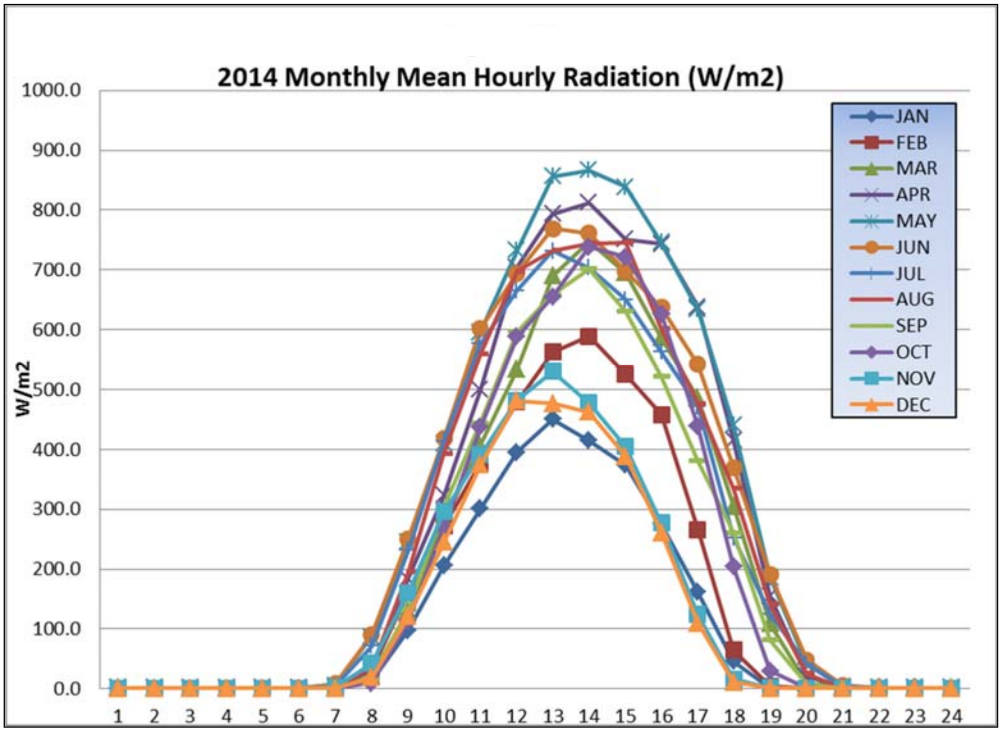


Figure 3-15. 2014 Monthly Mean Hourly Radiation (W/m2).

3.3.6 EVAPORATION

An important part of the hydrological cycle is the return of some of the precipitation reaching the earth's surface to the atmosphere as vapor. The evaporation of water from water bodies and the transpiration of water vapor from plants is combined into one term and measured as evapotranspiration. The term potential evapotranspiration (PET) is defined as the evapotranspiration that would occur if there were an adequate moisture supply at all times. Evapotranspiration is thus referred to as actual evapotranspiration (AET) in order to differentiate it from PET. The difference between precipitation and AET yields surplus. The AET values for CCAFS and Cocoa Beach are approximately 93 cm (37 in), and using an average annual precipitation of 140.7 cm (55.4 in), there is an annual surplus of roughly 45 cm (18 in) of water for the KSC area in an average year (Ref. 6). However, despite the overall surplus, two periods of moisture deficit occur in an average year: a two-month period between mid-March and mid-May and a one-month period between mid-November and mid-December (Ref. 5, Figure I-15).

3.3.7 WEATHER HAZARDS

3.3.7.1 Fog

The weather phenomena of the area of KSC is characterized by occasional fog which results from the cooling of air that remains at the earth's surface, and usually appears in the early morning. Fog causes hazardous driving conditions particularly when combined with smoke from fires in woods or swamps (Ref. 3). Fog is defined as visibility less than 11.3 km (7 mi) and typically occurs two days in June through September and nine days in January. Most fogs occur from November to March and are light, usually burning off by mid-morning.

3.3.7.2 Temperature

Abrupt or extreme temperatures are not uncommon in the area and may effect operations at KSC, with the potential for heat exhaustion if working outdoors. While KSC's annual temperatures are moderated by its proximity to the Atlantic Ocean and Gulf Stream, recent winters have had longer cold periods. Although snow flurries have occurred in very light amounts at KSC, none were measurable. Sleet seldom occurs, but skim ice may form occasionally (Ref. 3).

3.3.7.3 Thunderstorms

Eighty percent of the storms at KSC occur in the months of May through September, with an average maximum of 16 thunderstorm days in July (Ref. 9). Thunderstorms most often occur from 2:00 to 6:00 p.m., with a peak occurrence at 4:00 p.m. The storm duration usually is brief; however, cloudbursts sometimes cause adverse driving conditions (Ref. 3). The frequency of regional thunderstorms ranges from a low in January of a 2% probability to a high of a 50% probability in July. Storms passing directly over the KSC area happen more commonly in the summer months with a relative frequency of approximately every nine days (Ref. 3).

3.3.7.4 Lightning

Data have been collected and analyzed for 79 summer storms that produced ten or more electrical discharges (lightning) during the years 1976 through 1980. The analysis indicates that cloud and cloud to ground (CG) discharges occur at a mean rate of 2.4 discharges per min. per storm. The maximum flashing rate over a 5-min interval was 30.6 discharges per min on July 14, 1980 (Ref. 3). Estimates of the monthly area density of all discharges during the summers of 1974 through 1980, range from 0.8 to 3.8 discharges per km^2 (2 to 10 per mi^2) per month. The main area density of CG flashes alone is estimated to be 0.4 flashes per km^2 (1 per mi^2) per month (Ref. 3).

3.3.7.5 Hail

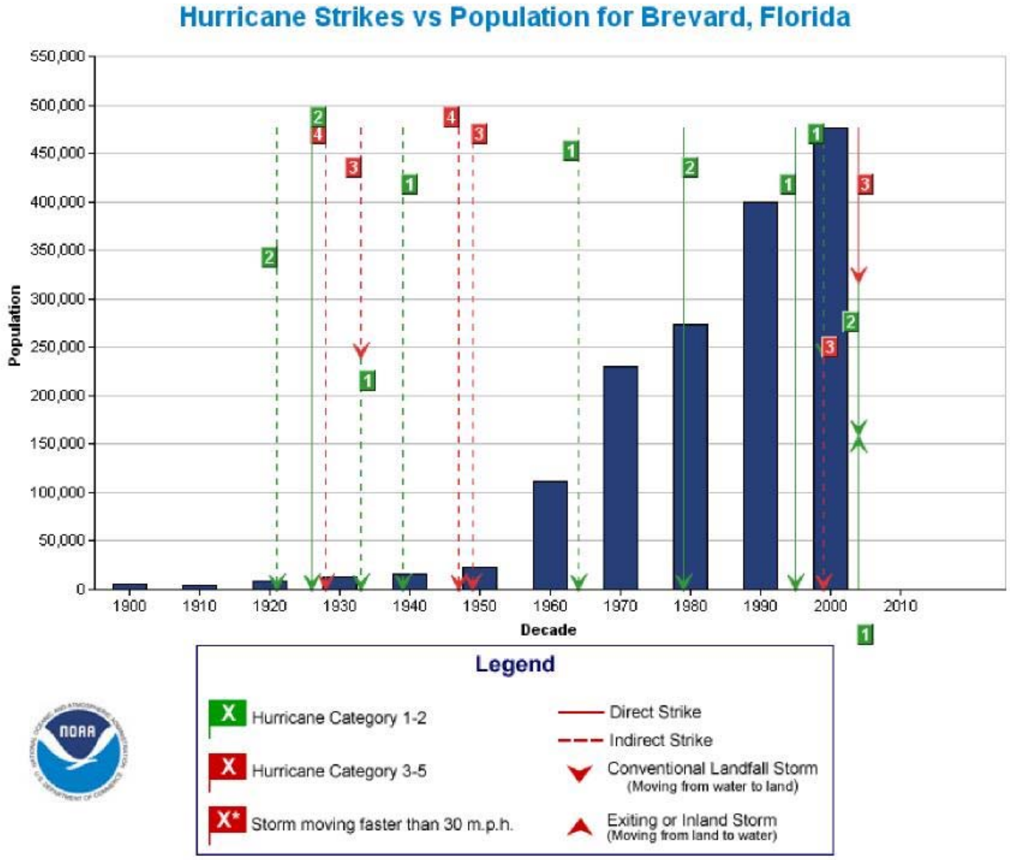
Hailstorms are an infrequent occurrence at KSC; however, there is potential for significant damage and thus they may affect KSC operations if severe.

3.3.7.6 Tornadoes

Tornado statistics show a relatively high frequency for Florida with maximum activity in July, but the state ranks relatively low in tornado-related property damage and casualties. Tornadoes have occurred at KSC, buy they are rare and damage has been slight (Ref. 3).

3.3.7.7 Hurricanes

All of Florida is susceptible to hurricanes, but some parts of the state, namely southern Florida and the panhandle, experience more hurricanes than other areas. Hurricanes have wind speeds of 119 km/hr (74 mi/hr) or greater, while tropical storm winds are slower, ranging from 63 to 117 km/hr (39 to 73 mi/hr. These storms often have rain areas as large as 560 km (300 mi) across and are relatively slow-moving so that a station could remain under the influence of an individual storm for three days or longer. Tropical depressions (TD), tropical storms (TS), and hurricanes (H 1-5) mainly occur throughout the wet season in Florida, and a total of 57 such storms have passed within 50 nm of KSC and CCAFS since 1851: TD (9), TS (34), H1 (12), H2 (4), H3 (3), H4 (0), H5 (0). Hurricane Charley (8/14/2004) was the last hurricane (H1) to affect the KSC area. However, Tropical Storm Fay (8/2008) caused a significant amount of rain-caused flooding in Brevard County, including KSC. Figure 3-16 gives the occurrence of hurricane landfalls in Brevard County, Florida, from 1900 through 20010. The most activity was in the 1920s through the 1940s and from 2000 to present (http://hurricane.csc.noaa.gov/hurricanes/index.htm Coastal Population). Figure 3-17 shows hurricane strikes in Florida by county from 1900 to 2010.



Hurricane Strike Data: National Hurricane Center
Population Data: U.S. Census Bureau
NOTE:Population values may be missing in some counties, particularly for earlier periods. This is most often attributable to the fact that the county had not yet been established.
NOTE:There may be discrepancies between the strike data shown in this chart and the HURDAT strike data used in the Historical Hurricanes Tracks Tool. The National Hurricane Center is currently updating the strike data used for these charts. For more information visit http://www.aoml.noaa.gov/hrd/data_sub/re_anal.html
NOTE:Population data is current as of 2000 U.S. Census. X-axis on graphs depict years through 2010 to illustrate storms that have occurred from 2000-2006.

Figure 3-16. Occurrence of Hurricanes in Brevard County from 1900 through 2010.

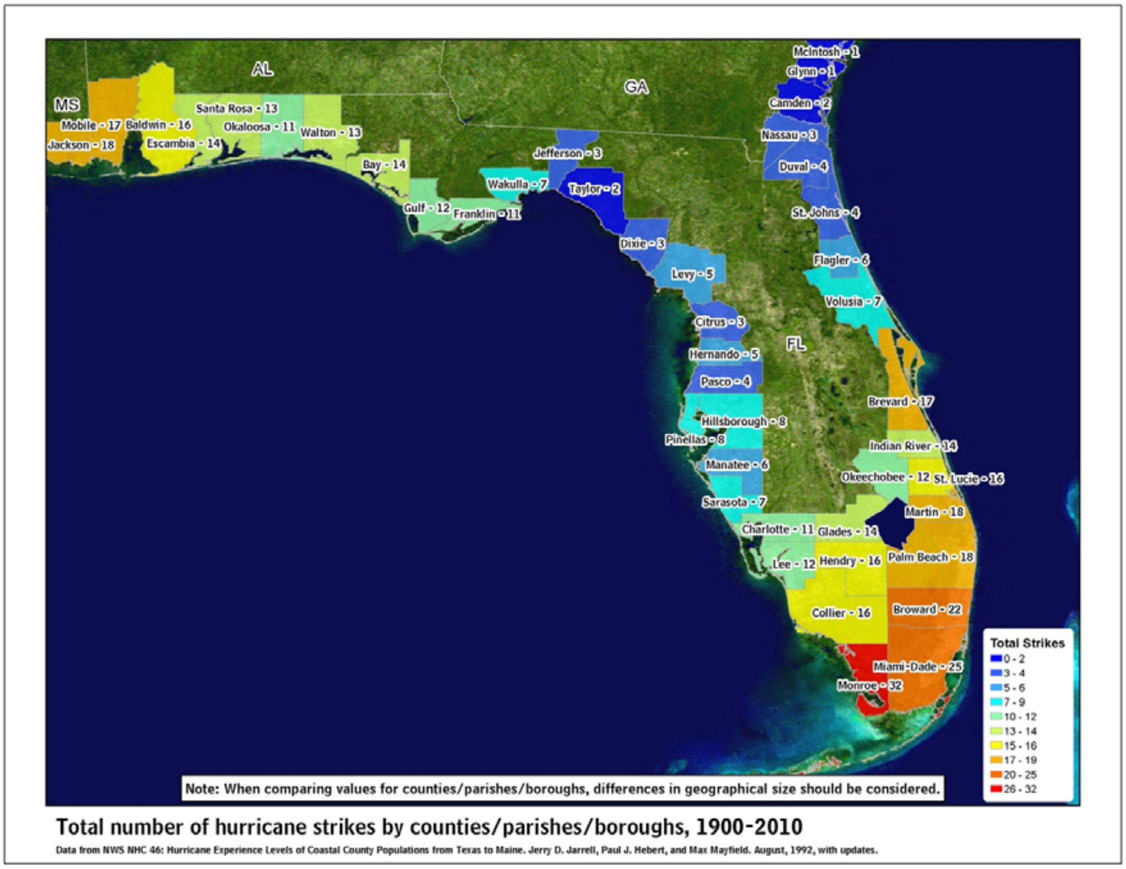


Figure 3-17. Occurrence of Hurricanes in Florida from 1900 through 2010.

3.4 CLIMATE CHANGE PROJECTIONS

In 2009, President Obama issued EO 13514 entitled "Federal Leadership in Environmental, Energy and Economic Performance," which mandated that all U.S. agencies "evaluate agency climate-change risks and vulnerabilities to manage the effects of climate change on the agency's operations and mission in both the short and long-term." This EO was revoked in March 2015 with the publication of EO 13693, "Planning for Federal Sustainability in the Next Decade." In 2010, NASA Headquarters initiated an agency-wide Climate Adaptation Science Investigators (CASI) program to assess and incorporate climate change predictions into the facility planning and decision process (Ref. 6). The NASA Goddard Institute for Space Studies (GISS) in conjunction with Columbia University climate scientist provide periodic downscaled climate change forecast data to each of the NASA field centers to support the CASI program. A summary of these predictions for climatic conditions between now and the 2080 time frame are presented in

Tables 3-8 and 3-9. The likelihood of extreme events occurring through the later part of the 21st century is given in Table 3-10.

Table 3-8. Estimated Climate Conditions for Air Temperature and Rainfall for KSC. Shown are the low-estimate (10th percentile), middle range (25th percentile to 75th percentile), and high-estimate (90th percentile).

a. Temperature

Baseline (1971 - 2000) 72.2°F	**Low Estimate (10th Percentile)**	**Middle Range (25th to 75th Percentile)**	**High Estimate (90th Percentile)**
2020s	+ 1.0 °F	+ 1.5 to + 1.9 °F	+ 2.3 °F
2050s	+ 2.2 °F	+ 2.7 to + 3.9 °F	+ 4.5 °F
2080s	+ 2.8 °F	+ 3.2 to + 6.1 °F	+ 7.2 °F

b. Precipitation

Baseline (1971 - 2000) 52.8 inches	**Low Estimate (10th Percentile)**	**Middle Range (25th to 75th Percentile)**	**High Estimate (90th Percentile)**
2020s	- 5 percent	- 1 to + 8 percent	+ 12 percent
2050s	- 7 percent	- 2 to + 8 percent	+ 17 percent
2080s	- 11 percent	- 3 to + 10 percent	+ 16 percent

Based on 33 GCMs and two Representative Concentration Pathways. Baseline data are for the 1971 to 2000 base period for Titusville, Florida and are from the NOAA National Climatic Data Center (NCDC).

Table 3-9. Estimated Changes in Numbers of Days of Extreme Hot or Cold Temperatures, Extreme Rainfall Events and Heat Wave Numbers and Duration for KSC.

a. 2020s

	Low Estimate (10th Percentile)	**Middle Range (25th to 75th Percentile)**	**High Estimate (90th Percentile)**
Number of days per year with maximum temperature at or above over 90°F (85 days)	101	103 to 115	125
Number of days per year with minimum temperature at or below 40°F (20 days)	12	14 to 15	16

Table 3-9. Estimated Changes in Numbers of Days of Extreme Hot or Cold Temperatures, Extreme Rainfall Events and Heat Wave Numbers and Duration for KSC (cont.).

	Low Estimate (10th Percentile)	**Middle Range (25th to 75th Percentile)**	**High Estimate (90th Percentile)**
Number of days per year with rainfall at or above 1 inch (17 days)	15	16 to 18	19
Number of days per year with rainfall at or above 2 inches (4 days)	3	4 to 5	6
Numbers of heat waves per year (8 heat waves)	10	10 to 10	11
Average heat wave duration in days (8 days)	8	9 to 10	11

b. 2050s

	Low Estimate (10th Percentile)	**Middle Range (25th to 75th Percentile)**	**High Estimate (90th Percentile)**
Number of days per year with maximum temperature at or above over 90°F (85 days)	120	127 to 147	162
Number of days per year with minimum temperature at or below 40°F (20 days)	9	10 to 12	14
Number of days per year with rainfall at or above 1 inch (17 days)	14	16 to 18	21
Number of days per year with rainfall at or above 2 inches (4 days)	3	4 to 5	6
Numbers of heat waves per year (8 heat waves)	10	10 to 10	11
Average heat wave duration in days (8 days)	10	11 to 13	15

Table 3-9. Estimated Changes in Numbers of Days of Extreme Hot or Cold Temperatures, Extreme Rainfall Events and Heat Wave Numbers and Duration for KSC (cont.).

c. 2080s

	Low Estimate (10^{th} Percentile)	Middle Range (25^{th} to 75^{th} Percentile)	High Estimate (90^{th} Percentile)
Number of days per year with maximum temperature at or above over 90°F (85 days)	125	138 to 182	200
Number of days per year with minimum temperature at or below 40°F (20 days)	5	7 to 12	14
Number of days per year with rainfall at or above 1 inch (17 days)	13	15 to 19	20
Number of days per year with rainfall at or above 2 inches (4 days)	3	4 to 5	6
Numbers of heat waves per year (8 heat waves)	9	9 to 10	11
Average heat wave duration in days (8 days)	11	12 to 18	20

Projections for temperature and precipitation are based on 33 GCMs and 2 RCPs. Baseline data (shown in parenthesis) are for the 1971 to 2000 base period for Titusville, FL and are from the NOAA National Climatic Data Center (NCDC). Shown are the low-estimate (10^{th} percentile), middle range (25^{th} to 7^{t5h} percentile), and high-estimate (90^{th} percentile) 30-year mean values from model-based outcomes. Decimal places are shown for values less than 1, although this does not indicate higher precision/certainty. Heat waves are defined as three or more consecutive days with maximum temperatures at or above 90 °F.

Table 3-10. Projected Likelihood of Extreme Events through the Later Part of the 21st Century, Based on Global Climate Simulations, Published Literature, and Expert Judgment.

Event	Trend	Likelihood
Heat Stress	up	Very Likely (>90%)
Downpours	up	Likely (>66%)
Intense Storms	up	More likely than not (>50%)
Extreme Winds	up	More likely than not (>50%)

Adapting Now to a Changing Climate, NP-2010-11-687-HQ, NASA

These model projections support the idea that global climate change will produce a more tropical climate pattern in the central Florida region, reducing the number of cool days in winter and increasing the number of hot days in summer. Increased days of summer weather have the potential to increase energy use for cooling and the number of convective thunder storms that form with heavy rains and lightning. These changes represent increased risk to Center operations associated with construction projects, launch processing, fueling operations, land management, and other work conducted outdoors.

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SECTION IV. WATER RESOURCES

4.1 SURFACE WATERS

Kennedy Space Center is surrounded by the Indian River Lagoon System (IRL) and the Atlantic Ocean. The Indian River Lagoon System extends along the East Coast of Florida from Ponce de Leon Inlet to St. Lucie Inlet near Stuart, Florida. The Indian River lagoon System (IRL) surrounding KSC consists of the Mosquito Lagoon to the north, Banana River to the south, and Indian River to the west. This system was formed by changing sea levels and its prominent features are the southern barrier islands, the Cape Canaveral foreland formation, the western mainland ridges, and the valleys and sloughs between the ridges (Ref. 1). These basins are shallow, aeolian lagoons with depths averaging 1.5 m and maximums of 9 m generally restricted to dredged basins and channels.

The Indian River Lagoon proper runs along the entire western boundary of KSC. The western boundary of KSC is undeveloped and is part of the MINWR. Most of the shoreline on KSC/MINWR is impounded with no direct runoff into the lagoon. The western shore of the IRL is highly developed in the area from Titusville south with many areas of point and non-point runoff.

Mosquito Lagoon and the Indian River are connected by Haulover Canal and the Intracoastal Waterway. Water flow between these two systems is primarily wind-driven. Because of the various man-made modifications related to the space program and mosquito control, circulation between Mosquito Lagoon and the Banana River was blocked in the earlier 1960s.

The Indian and Banana Rivers mix in the southern region near Eau Gallie and through a man-made canal located just south of KSC. This navigation canal accesses the Atlantic Ocean through the Port Canaveral Locks, whose oceanic waters influence surface water quality in the northern Banana River. The northern-most Banana River is inside KSC property and closed to motorized boat traffic. It is part of the Merritt Island National Wildlife Refuge and its water quality is one of the best in the Indian River Lagoon System (Ref. 2). The region of the Banana River north of the NASA Causeway includes Pintail Creek and Max Hoeck Back Creek. Very little tidal fluctuation occurs, and the water movement in this location is influenced primarily by wind, freshwater inputs and evaporation.

Within KSC property is Banana Creek, which drains the area adjacent to the LC39 launch pads via a canal located northwest of the Vehicle Assembly Building to the Indian River. Salinity usually increases in a westward direction, but depending on wind direction, the Indian River system can have a greater or lesser effect on the Banana Creek water quality. Freshwater inputs to the estuarine system surrounding KSC include direct precipitation, stormwater runoff, discharges from impoundments, and groundwater seepage (Ref. 3).

This area is very biologically diverse as it includes the temperate Carolinian and the subtropical Caribbean zoogeographic Provinces. The lagoonal waters surrounding KSC are shallow flats that support dense growths of submerged aquatic vegetation including manatee grass (*Syringodium filiformis*), shoal grass (*Halodule wrightii*), widgeon grass (*Ruppia maritima*), Gulf halophila (*Halophila engelmanii*) and various macroalgae such as *Gracilaria*, *Caulerpa*, *Sargassum*, *Laurencia*, *Penicillus*, *Acetabularia* and *Acanthophora*. Cool winter temperatures preclude the growth of turtle grass (*Thalassia testudinum*) in the KSC area (Ref. 4). Shorelines of the system near KSC are dominated by white mangrove (*Laguncularia racemosa*) and black mangrove (*Avicennia germinans*) with red mangrove (Rhizophora mangle) occurring in small patches; however, this region represents the northern limit of their range, and the winter freezes of 1983, 1984, and 1989 significantly impacted their populations (Ref. 5). Fauna in the lagoon system near KSC represents both the Carolinian and subtropical provinces. Most common species mullet (*Mugil cephalus*), spotted sea trout (*Cynoscion nebulosus*), red fish (*Sciaenops ocellatus*), sea catfish (*Arius felis*), and blue crabs (*Callinectes sapidus*). Subtropical species are present but become more prevalent to the south of KSC. This unique environmental setting makes the KSC one of the most diverse areas in the United States (Ref. 4, 6-10). Refer to Section 6 for further information on biotic resources.

4.1.1 REGULATORY OVERVIEW

Surface waters at KSC include "Waters of the United States", "Navigable Waters" and "Waters of the State", activities in which are subject to numerous federal, state and regional regulations. The EPA regulates the discharge of pollutants into navigable waters of the United States under the Federal Clean Water Act of 1977 (CWA), as amended by the Water Quality Act of 1987. EPA has adopted numerous regulations to implement the CWA found in Title 40 CFR. The USACE administers Dredge and Fill activities in navigable waters through the authority of the Rivers and Harbors Act of 1899 (RHA), and in waters of the United States (including isolated wetlands) through Section 404 of the CWA.

4.1.1.1 Water Quality Standards

The CWA required each state to adopt water quality standards. These standards are established on the use and values of waters for public water supplies, propagation of fish and wildlife, recreation, agriculture, industry and navigation.

The EPA was designated under the CWA as the federal agency with regulatory jurisdiction over discharges of pollutants into the waters of the United States. Their regulatory authority is vested in the National Pollutant Discharge Elimination System (NPDES) permit program. NPDES permits are operating permits, which ensure compliance with state and federal water quality standards.

State compliance with the CWA has been delegated to the FDEP. Today, Florida surface waters are designated according to five classifications based on their potential use and value:

- Class I Potable Water Supplies
- Class II Shellfish Propagation and Harvesting
- Class III Recreation and Fish and Wildlife Propagation
- Class IV Agricultural Water Supplies
- Class V Navigation and Utility and Industrial Use

Minimum water quality standards for surface and ground waters have been established by the FDEP. A complimentary water quality classification is provided by the designation of Outstanding Florida Waters (OFW). Regulatory criteria established for activities in OFW are designed to prevent is no lowering of the existing ambient water quality. Additionally, numeric criteria for nutrients in the form of Total Maximum Daily Loadings (TMDLs) have been established for segments of the Indian River and Banana River Lagoons adjoining KSC. The site-specific nature of the OFW water quality standard and TMDL is designed to ensure against any surface water degradation.

4.1.1.2 Water Use Permitting

A Consumptive Use Permit (CUP) is required by the (SJRWMD in accordance with the rule criteria set forth in Chapter 40C-2, FAC as amended on August 12, 2008. The rule requires a CUP for the consumptive use of ground or surface water for any of the following:

- Average annual daily withdrawal exceeding one hundred thousand (100,000) gallons average per day; or
- Withdrawal equipment or facilities which have a capacity of more than one million (1,000,000) gallons per day (GPD); or
- Withdrawals from a combination of wells or facilities having a combined capacity of more than one million (1,000,000) GPD; or
- Withdrawals from a well in which the outside diameter of the largest permanent water bearing casing is six inches or greater

All permits will include certain limiting conditions set forth in Rule 40C-2.381. The District prohibits significant adverse impacts on offsite land uses and legal uses of water existing at the time of permit application. Permitting authority is granted to SJRWMD under Section 373.216, F.S. by Rule 40C-2, FAC. In so doing the state is attempting to conserve and promote the proper utilization of Florida's surface and ground waters. KSC is located in the District's Upper St. Johns River Administrative Basin.

In 2014, the St. Johns River Water Management District rescinded the KSC CUP, Permit 50054, based on a determination that type and quantity of water use at KSC did not meet permitting thresholds; but, indicated that should type of use or quantity change in the future, permitting could again be required.

4.1.1.3 Wetland Resource Management (Dredge and Fill) Permitting

The discharge of pollutants to surface waters is regulated by the wetland resource regulatory authority granted to federal and state agencies. The permitting of dredge and fill activities in Florida is subject to independent review and action by state and federal regulatory agencies. Despite differing jurisdictional parameters between these agencies, a common joint form permit application has been developed. The joint form application notifies all regulatory authorities of a proposed action. Federal authority over dredge and fill operations is established by the CWA of 1977, the RHA of 1899, the NEPA, the U.S. Fish and Wildlife Coordination Act, the Safe Drinking Water Act, and the Endangered Species Act of 1973.

The USACE administers the federal dredge and fill permitting program (referred to as environmental resource permitting or ERP by FDEP) with assistance and review from other federal agencies including the USFWS, the National Marine Fisheries Service (NMFS), and the EPA.

The USACE exerts jurisdiction over all coastal and inland waters, lakes, tributaries to navigable waters, and adjacent wetlands to the above. In addition, as a result of a ruling by the EPA regarding interpretation of the "interstate commerce connection", the USACE has been authorized regulatory jurisdiction over all isolated wetlands and surface waters. Consequently, virtually any activity within wetlands or surface waters is subject to the USACE permit authority. The USACE 1987 Wetland Delineation Manual was updated in December 2008. The Florida Wetlands Delineation Manual was published in 1995 to assist in the implementation of the state wetland delineation rule Delineation of the Landward Extent of Wetlands and Surface Waters Chapter 62-340, FAC. The landward extent of wetlands as determined by the state and federal agencies is generally the same or very similar. However, differences may occur and it is prudent not only to apply each delineation methodology to the field demarcation of the wetland edge but to also have the delineations verified by a representative of each agency.

FDEP is the principle agency for administering the State ERP process (Chapter 62-312

FAC). Under the provisions of The Warren S. Henderson Wetlands Protection Act of 1984, the FDEP authority to regulate dredge and fill activities was largely consolidated under Chapter 403, F.S. FDEP jurisdiction extends over the "Waters of the State" which are defined to include, but not limited to, rivers, lakes, streams, springs, impoundments, and all other waters or bodies of water including fresh, brackish, saline, tidal, surface or underground. The Henderson Act clarified FDEP jurisdiction over wetlands by establishing indicator wetland species and soil types. In addition, the Act establishes provisions for the special consideration of OFW in the permit application review process.

FDEP ERP authority is supported by the FFWCC, which is responsible for the management, protection, and conservation of wild animal life and aquatic freshwater life; and the Florida Department of Environmental Protection-State Lands (formerly Florida Department of Natural Resources), which processes requests for the use of State-owned lands including submerged bottoms.

SJRWMD received delegation for the ERP process within the District effective October 1, 1988. The operating agreement between SJRWMD and FDEP concerning regulation under Part IV, Chapter 373, F.S. was amended on July 1, 2007.

SJRWMD reviews all ERP applications when an activity also requires a stormwater discharge permit, with the following exceptions:

- All ERP applications for solid, industrial, domestic and hazardous waste treatment facilities will be reviewed by FDEP
- District projects will be permitted by FDEP
- Power plant siting will be processed by FDEP
- Corps of Engineers water resources projects will be permitted by FDEP
- Marinas (ten or more boat slips)
- Other activities listed in the delegation agreement

4.1.1.4 Stormwater Runoff

Stormwater runoff control and management programs have become increasingly important in recent years and will continue to grow in importance to KSC. The Water Quality Control Act of 1987 required EPA to permit industrial and municipal stormwater discharges. On November 16, 1990, EPA issued the final rule for the National Pollutant Discharge Elimination System (NPDES) permit application regulations for stormwater discharges (40 CFR 122-124). Applications for stormwater discharges associated with industrial activity were required by March 18, 1991, for a permit through a group application or by November 18, 1991, for an individual permit. In addition, NPDES stormwater permits are required for all construction projects that impact an area equal to, or greater than 1 acre. Construction sites are covered under the Generic Permit for Stormwater Discharge from Large and Small Construction Activities (62-621.300(4)(a) FAC).

FDEP has stormwater permit authority for discharges to surface water as defined in Chapter 40C-42 FAC (as administered by SJRWMD) and groundwater as defined in 62-4 FAC. The stormwater rule is designed to minimize permit requirements for stormwater designs which utilize best management practices. FDEP has been authorized to delegate stormwater permitting authority to the State Water Management Districts or Local Governments and several districts have assumed this regulatory function including SJRWMD.

4.1.1.5 Surface Water Management

The Florida Water Resource Act (Chapter 373 FS) enacted in 1972 created five Water Management Districts. The districts were assigned to the major watersheds within the state and were provided with the authority to manage and regulate surface waters. Regulated activities include any construction, alteration, maintenance, or operation of any dam, impoundment, reservoir or works including ditches, canals, conduits, channels, culverts, pipes and other construction that connects to, draws water from, drains water into, or is placed in or across open waters or wetlands. Each water management district has established thresholds, which trigger permit application requirements. KSC is located within the watershed area administered by the SJRWMD. The SJRWMD has a comprehensive surface water management permitting program in place.

4.1.1.6 Outstanding Florida Waters

A special classification has been established for certain water bodies which possess demonstrated exceptional recreational or ecological significance. Outstanding Florida Waters (OFW) include waters within National and State parks, wildlife refuges, aquatic preserves, and other state and federal areas. Areas designated as OFW are afforded the highest protection of any surface waters in the State of Florida. Water quality standards for OFW are established to prevent the lowering of existing water quality. The FDEP is the principle State agency responsible for the administration of OFW.

4.1.1.7 Aquatic Preserves

The Aquatic Preserve Act of 1975 (Chapter 258 F.S.) set aside certain state-owned submerged lands and associated coastal waters in areas which have exceptional biological, aesthetic, and scientific values. The aquatic preserve designation substantially restricts or prohibits activities requiring dredge and fill permits, drilling or gas or oil wells, and the discharge of wastes or effluents. The FDEP is the state agency responsible for the administration of the Aquatic Preserve Program. As the administering agency the FDEP is required to develop and implement management plans for the preservation, protection, and enhancement of the natural resources of each aquatic preserve. Table 4-1 provides physical characteristics of the major surface water bodies at KSC. Figure 4-1 shows the locations of these water bodies and Figure 4-2 gives their classifications.

Table 4-1. Surface Water Segments Physical Characteristics.

Surface Water Segment	Area (Acres)	Drainage Area (Acres)	Average Depth (Feet)
Indian River	10,091	46,409	3.3
Banana River	18,096	33,950	2.3
Mosquito Lagoon	25,121	25,378	2.0
Total	53,308	105,737	

4.1.1.8 Oceanic and Tidal Influence

The Ponce de Leon Inlet is an oceanic connection to Mosquito Lagoon located approximately 31 mi north of KSC. Port Canaveral provides an oceanic connection to the Banana River approximately 7.5 mi south of KSC. Navigation locks within Port Canaveral virtually eliminate any significant oceanic influence on the Banana River. The Sebastian Inlet, located 50 mi south of KSC is the next southerly oceanic connection to the Indian River. The remoteness of the estuarine waters from oceanic influence and the restrictions imposed by constructed causeways, minimize water circulation within the lagoon basins. Surface water movement and flushing are primarily a function of wind driven forces and salinity regimes are mostly controlled by precipitation, upland runoff, evaporation, and groundwater seepage. Much information on water resources of the Indian River Lagoon have been compiled under the SWIM plan (Ref. 4) and a bibliography has been published by the Marine Resources Council of East Central Florida (Ref. 11).

4.1.1.9 Navigation

Navigable channels including the Intracoastal and the Turning Basin access channel are excavated waterways. The Intracoastal Waterway follows the Indian River through Haulover Canal and proceeds north through Mosquito Lagoon. Dredged material from the construction of the Intracoastal Waterway and the Turning Basin access channel was typically deposited along the waterways as small islands. The Intracoastal Waterway has a variable width and a design depth of 3.7 m (12 ft).

The Turning Basin access channel extends from Port Canaveral north through the

Banana River to the VAB area. South of the NASA Parkway a channel spur extends to the east and provides navigable access for vessels to Hangar AF, previously used by SRB retrieval ships. The Banana River, north of KARS Park, is designated as a manatee sanctuary and has been closed to powered vessels except for KSC-related activities. Public navigational access is prohibited north of the NASA Parkway.

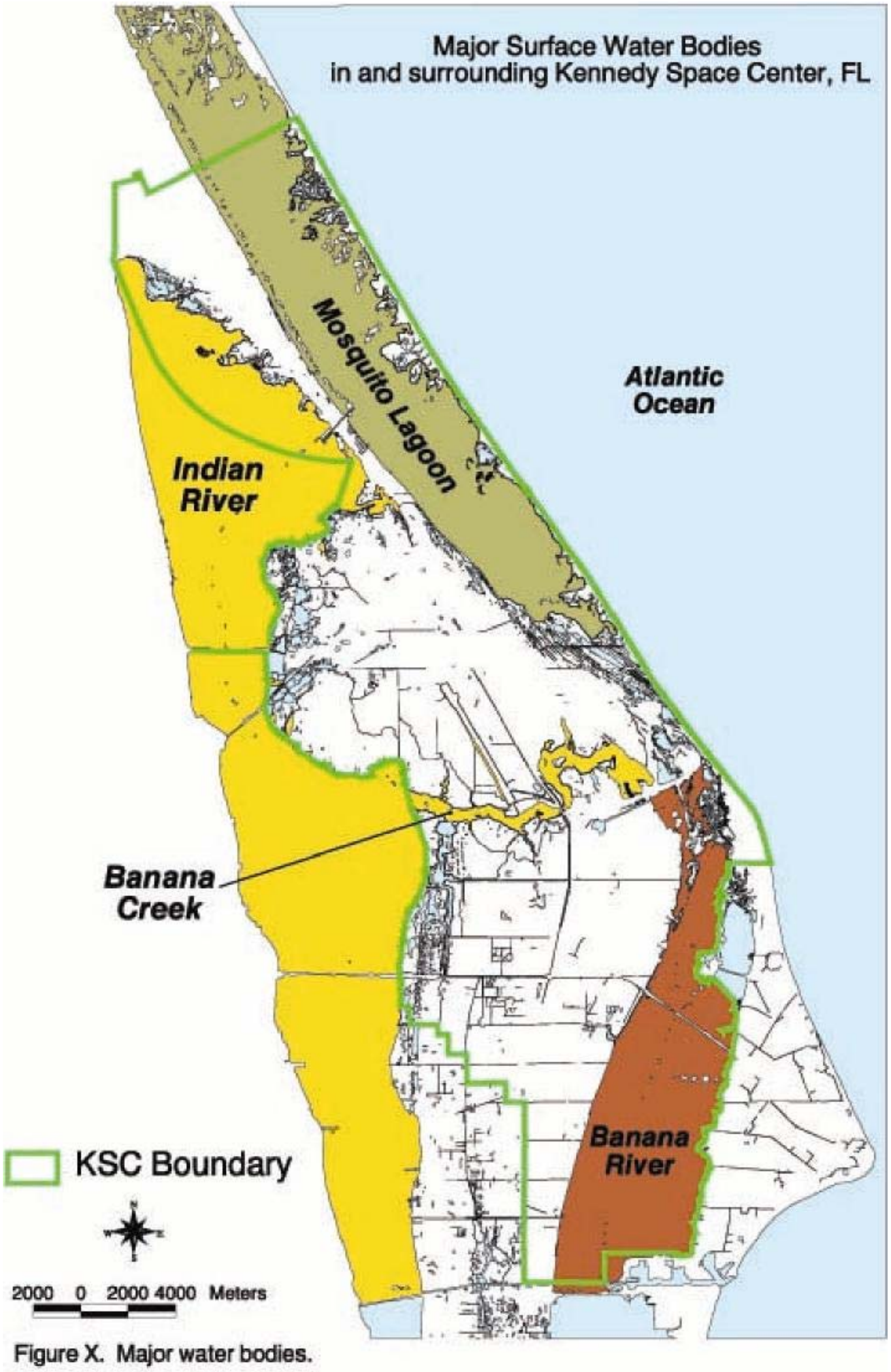

Figure 4-1. Major Water Bodies around KSC.

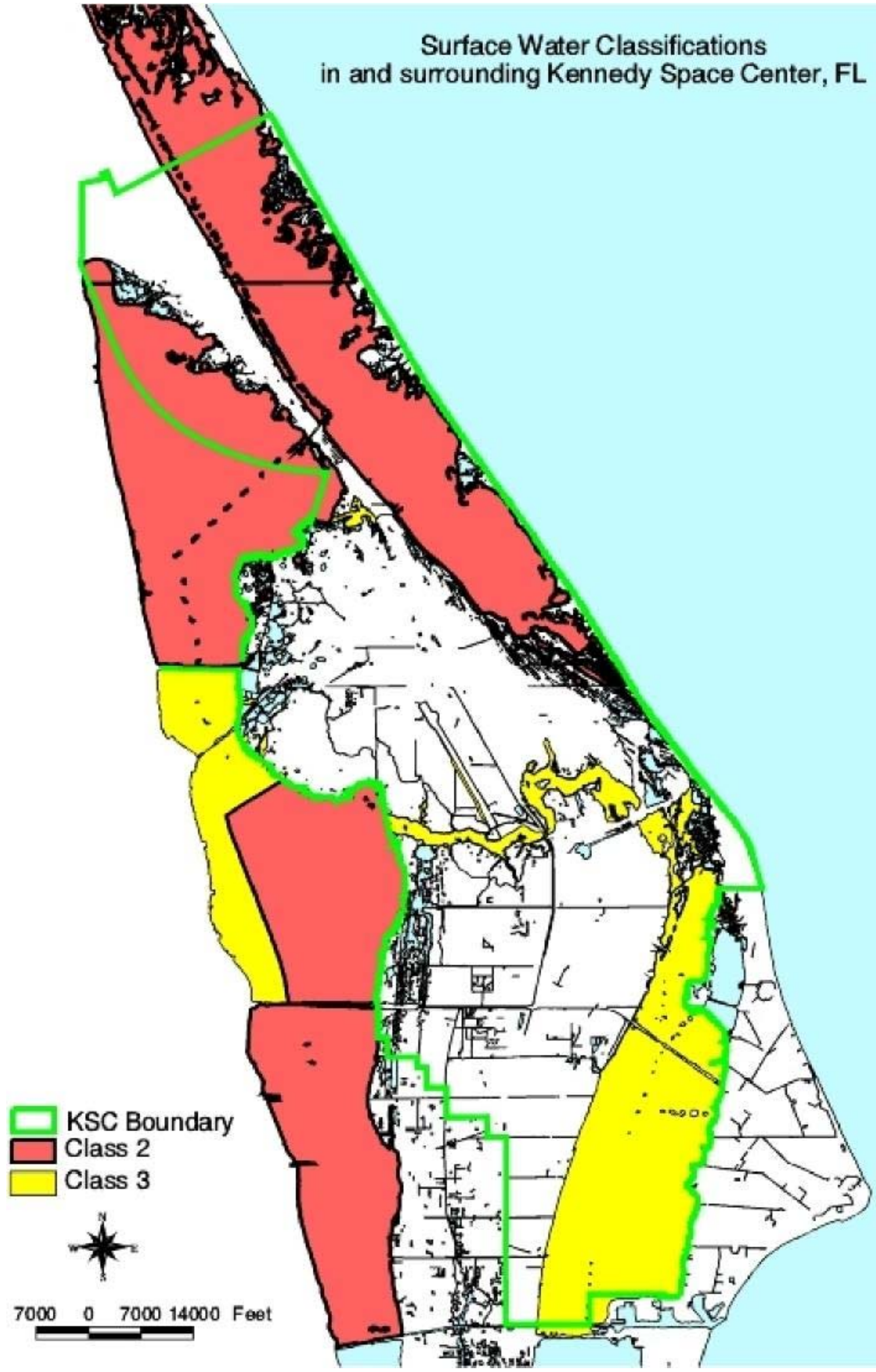

Figure 4-2. Classification of Water Bodies around KSC.

4.1.2 KSC SURFACE WATERS CLASSIFICATION

In compliance with the CWA, the State has classified water surrounding the Kennedy Space Center.

4.1.2.1 Class II

All of the area of Mosquito Lagoon within KSC boundaries and the northern-most segment of the Indian River extending from the NASA Railway spur crossing, is designated as Class II - Shellfish Propagation or Harvesting (see Figure 4-2). Class II waters establish more stringent limitations on bacteriological and fluoride pollution and the discharge of treated wastewater effluent are prohibited. Dredge and fill projects in Class II waters require a plan of procedure to adequately protect the project area from significant damage.

4.1.2.2. Class III

The remainder of surface waters surrounding KSC is designated as Class III (Recreation-Propagation and Management of Fire and Wildlife). Class III water standards (reference Table 4-1) are intended to maintain water quality suitable for body contact sports and recreation and the production of diverse fish and wildlife communities.

4.1.2.3 KSC Outstanding Florida Waters

The surface waters within the Merritt Island National Wildlife Refuge (Figure 2-2) have been designated as OFW. The OFW designation supersedes other surface water classifications and water quality standards are based on ambient conditions. These waters cannot be degraded below their existing water quality.

4.1.2.4 Aquatic Preserves

The entire Mosquito Lagoon has been designated by the Board of Trustees of the Internal Improvement Trust Fund as an Aquatic Preserve. The Mosquito Lagoon aquatic preserve management plan has been published (Ref. 12), but it has no jurisdiction in federal waters based on agreements with the state that turn their management over to the federal agencies.

The Banana River Aquatic Preserve begins at SR 528 (Bennett Causeway) and extends south to Mathers Bridge and includes that entire section of the Banana River and portions of Sykes Creek and Newfound Harbor. A management plan has been developed for this aquatic preserve (Ref. 13). The Banana River Aquatic Preserve does not extend to KSC and NASA operations are not affected by the implementation of the management plan.

4.1.3 KSC SURFACE WATER QUALITY MONITORING PROGRAMS

4.1.3.1 Long-Term Programs

Surface water quality at KSC is considered to be generally good; however, the Indian River Lagoon and Banana River Lagoon are both identified by FDEP as impaired for nutrients including total nitrogen and total phosphorus; and Indian, Banana and the Mosquito Lagoons are identified as impaired for mercury. The best areas of water quality are adjacent to undeveloped areas of the lagoon, such as the north Banana River Lagoon, Mosquito Lagoon, and the northernmost portion of the Indian River Lagoon (Ref. 14).

In order to document the surface water quality of waters surrounding KSC several different monitoring programs are used. NASA, SJRWMD and Brevard County have previously maintained water quality monitoring stations around and within KSC boundaries. The SJRWMD lagoon wide water quality monitoring network maintains several surface water quality monitoring stations within KSC for incorporation into a region-wide data management system (Figure 4-3). The surface water quality data from this program is used for long-term trend analysis and offers a supportive role in land use planning for the entire Indian River Lagoon. The KSC long-term monitoring program collected data from 1984 to 2010, at eleven long-term sites within the boundary of KSC. These sites were monitored quarterly until 2000 and bi annually to 2010 (Figure 4-3). The purpose of this monitoring program was to maintain a baseline ecological database of basic surface water quality parameters.

Most of the monitoring sites were located away from major facilities and operational areas for comparison to several sites located near launch complexes to monitor any short term or long-term impacts. Parameters collected include nutrients, phenols, grease and oil, color, total suspended solids, total dissolved solids, chlorophyll, turbidity and metals. Additionally, KSC maintains two, basic surface water parameter stations. These stations continuously collect basic environmental parameters such as salinity, dissolved oxygen (DO), pH, temperature and conductivity. Most of these basic surface water parameters follow seasonal and diurnal patterns typical of the IRL.

For specific water quality events, such as plankton blooms and low dissolved oxygen resulting in fish kills that occur outside of the framework of the ongoing monitoring programs, established sampling protocols are followed to document these events and report information to other agencies as needed or required. An example of such an event occurred starting in 2011 when the overall water quality of the waters surrounding KSC markedly declined. The likely cause for the dramatic decrease can be related to the presence of two separate large persistent plankton blooms in the area. The first bloom consisted mostly of a chloro-microflagellate, *Pedinophyceae sp.*, which occurred from early spring through late fall of 2011 (Ref. 37). This bloom covered a large portion of the northern Indian River

Lagoon basin, mainly the IRL proper and Banana River including the waters surrounding KSC. The second large bloom, consisting mostly of a "Brown Tide" species, *Aureoumbra lagunensis*, occurred during the summer and fall of 2012. This bloom not only covered them same extent as the 2011 bloom but also extended into the Mosquito Lagoon. These blooms resulted in a marked decrease in water clarity and quality in the waters surrounding KSC. Both of these factors impact incident light penetration which in turn influences seagrass growth and distribution. The drastic decline of seagrass distribution during these bloom events was documented at KSC's long-term seagrass monitoring sites and the SJRWMD long-term seagrass sites (L. Morris 2011 and 2012, SJRWMD, pers. comm.).

KSC also monitors surface water in compliance with NPDES stormwater permitting under Multi-Sector Generic Permit for Stormwater Discharge Associated with Industrial Activity (MSGP) facility identification number FLR05F574-003. Sectors L and N, landfills and scrap recycling facilities respectively, are assigned to KSC for the KSC Landfill and Ransom Road Recycling Yard. Stormwater is observed quarterly at these facilities during the 5 year permit cycle. Qualifying stormwater events are sampled for chemical analysis during the second and fourth years of the permit for parameters specific to the Sector. Data are reported annually to FDEP. Conditions for sampling are rare for the landfill and monitored parameters are within compliance limits. Sampling at the Ransom Road Recycling Yard is more common and Chemical Oxygen Demand (COD) and concentrations of metals aluminum, lead, iron and zinc intermittently exceed established cut-off concentrations. KSC has several other potential Sectors and sites of industrial stormwater activity that are not sampled due to No-Exposure Exemptions granted through FDEP.

In addition to the NPDES stormwater permitting, KSC monitors surface water at the KSC Class III Schwartz Road Landfill in compliance with permit FDEP SO05-0150308-006 (active landfill) and SF05-0150308-005 (closed landfill). Two locations within the landfill water collection and treatment system are monitored twice annually for chemical and physical conditions required by the permits.

4.1.3.2 1998 Background Centerwide Monitoring

In 1998 a comprehensive study to document background chemical composition of soils, groundwater, surface water, and sediments of John F. Kennedy Space Center was conducted. In addition to the long-term surface water quality monitoring sites forty additional locations were examined. Location of the surface water sampling stations was determined based on the watershed basins. Forty stations were selected to incorporate samples from open lagoonal water, rivers, creeks, ditches, borrow pits, and impoundments. Samples were collected using standard sampling protocols. Basins included Banana Creek, Banana River, Indian River Lagoon, Mosquito Lagoon, saline ditches (salinity> 6 ppt), and freshwater ditches (salinity < 6 ppt) (see Figure 4-3) (Ref. 3).

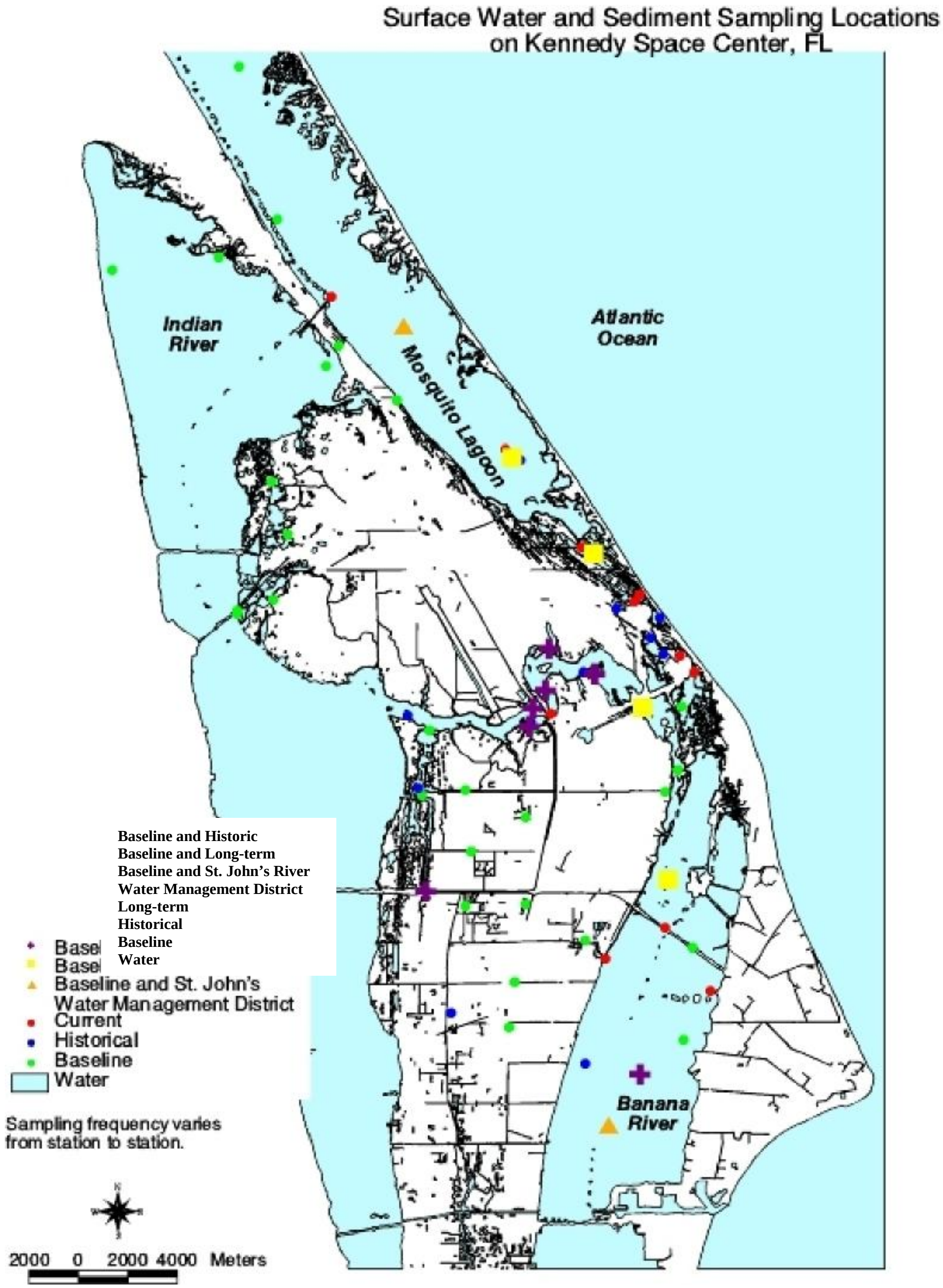

Figure 4-3. Water Quality and Sediment Sampling Stations on KSC.

Surface water was analyzed for organochlorine pesticides, aroclors, chlorinated herbicides, polyaromatic hydrocarbons (PAH), and metals. Field parameters such as pH, temperature, turbidity, DO, and conductivity were also measured at each sampling location.

All of the aroclors (6) and chlorinated herbicides (18) were below detection. One of 25 organochlorine pesticides (dieldrin) was above detection as were five of 17 PAHs. The occurrence of dieldrin is probably related to past agricultural use. Concentrations of PAHs were low; these may result from natural sources or regional deposition. Sixteen of 24 metals were above detection limits; eight (barium [Ba], cadmium [Cd], chromium [Cr], cobalt [Co], mercury [Hg], nickel [Ni], vanadium [V], and zinc [Zn]) were always below detection. Nine metals (antimony [Sb], arsenic [As], beryllium [Be], copper [Cu], Pb, manganese [Mn], selenium [Se], silver [Ag], and thallium [Tl]) were above detection in too few samples to test for differences among watershed basins. Seven metals commonly above detection limits (aluminum [Al], calcium [Ca], chlorine [Cl], magnesium [Mg], iron [Fe], potassium [K], and sodium [Na]) differed among basins (ANOVA, $p<0.05$).

Patterns of differences varied among metals. For Al, Banana Creek was higher than the other basins. Iron was higher in Banana Creek, saline ditches, and freshwater ditches compared to Banana River, Indian River Lagoon, and Mosquito Lagoon. Values of Ca, Cl, and Mg occurred in three classes with Banana Creek, Mosquito Lagoon, and Indian River Lagoon the highest, Banana River and saline ditches intermediate, and freshwater ditches low. Potassium was highest in Mosquito Lagoon, intermediate in Banana Creek, Indian River Lagoon, Banana River, and saline ditches, and lowest in freshwater ditches. Sodium was highest in Mosquito Lagoon and the Indian River Lagoon, intermediate in Banana Creek, Banana River, and saline ditches, and lowest in freshwater ditches (Ref. 3). Table 4-2 lists parameters, EPA methods, and detection limits used to analyze surface water samples collected for the 1998 KSC Background Study. (Note: * = measurement made with a calibrated field instrument (YSI) (Ref. 3).

Table 4-2. 1998 KSC Background Study Surface Water Contaminant Levels.

	EPA Method	Lab Reporting Limit for Surface Water
Organochlorine Pesticides		
4,4' – DDD	8081	0.05 µg/L
4,4' – DDE	8081	0.05 µg/L
4,4' – DDT	8081	0.05 µg/L
Aldrin	8081	0.05 µg/L

Table 4-2. 1998 KSC Background Study Surface Water Contaminant Levels (cont.).

Alpha–BHC	8081	0.05 µg/L
Beta – BHC	8081	0.05 µg/L
Chlordane (alpha)	8081	0.05 µg/L
Chlordane (Gamma)	8081	0.05 µg/L
Chlordane (Total)	8081	0.05 µg/L
Delta – BHC	8081	0.05 µg/L
Dieldrin	8081	0.05 µg/L
Endosulfan I	8081	0.05 µg/L
Endosulfan II (Beta)	8081	0.05 µg/L
Endosulfan Sulfate	8081	0.05 µg/L
Endrin	8081	0.05 µg/L
Endrin Aldenhyde	8081	0.05 µg/L
Endrin Ketone	8081	0.05 µg/L
Gamma – BHC (Lindane)	8081	0.05 µg/L
Heptachlor	8081	0.05 µg/L
Heptachlor Epoxide (a)	8081	0.05 µg/L
Heptachlor Expoxide (b)	8081	0.05 µg/L
Isodrin	8081	0.05 µg/L
Methoxychlor	8081	0.05 µg/L
Mirex	8081	0.05 µg/L
Toxaphene	8081	2 µg/L
Aroclors		
PCB – 1016/1242	8082	1 µg/L
PCB – 1221	8082	1 µg/L
PCB – 1232	8082	1 µg/L
PCB – 1248	8082	1 µg/L
PCB – 1254	8082	1 µg/L
PCB – 1260	8082	1 µg/L
Chlorinated Herbicides		
2 – (2, 4, 5 – Trichlorophenoxy) propionic acid (2, 4, 5 – TP) (Silvex)	8151	0.5 µg/L
2, 4, 5 – Trichlorophenoxy acetic acid (2, 4, 5 – T)	8151	0.5 µg/L
2, 4 – Dichlorophenoxy acetic acid (2, 4 – D)	8151	0.5 µg/L
3,5–DCBA	8151	0.5 µg/L
4 (2, 4 – Dichlorophenoxy) butyric acid (2, 4 – DB)	8151	0.5 µg/L
4 – Nitrophenol	8151	0.5 µg/L
Acifluorfen	8151	0.5 µg/L
Bentazon	8151	0.5 µg/L
Chloramben	8151	0.5 µg/L
Dacthal	8151	0.5 µg/L

Table 4-2. 1998 KSC Background Study Surface Water Contaminant Levels (cont.).

Dalapon	8151	0.5 µg/L
Dicamba	8151	0.5 µg/L
Chlorinated Herbicides (continued)		
Dichloroprop [2 – (2, 4 – Dichlorophenoxy) proponic acid]	8151	0.5 µg/L
Dinoseb	8151	0.5 µg/L
MCPA		
MCPP	8151	5 µg/L
Pentachlorophenol	8151	0.5 µg/L
Picloram	8151	0.5 µg/L
Polyaromatic Hydrocarbons		
1 – Methylnaphthalene	8310	0.5 µg/L
2 – Methylnaphthalene	8310	0.5 µg/L
Acenaphthene	8310	0.5 µg/L
Acenaphthylene	8310	0.1 µg/L
Anthracene	8310	0.5 µg/L
Table 4-2. (cont.).		
Benzo (a) anthracene	8310	0.5 µg/L
Benzo (a) pyrene	8310	0.5 µg/L
Benzo (b) fluoranthene	8310	0.1 µg/L
Benzo (g, h, I) perylene	8310	0.1 µg/L
Benzo (k) fluoranthene	8310	0.05 µg/L
Chrysene	8310	0.05 µg/L
Dibenzo (a, h) anthracene	8310	0.1 µg/L
Fluoranthene	8310	0.1 µg/L
Fluorene	8310	0.1 µg/L
Indeno (1, 2, 3 – cd) pyrene	8310	0.05 µg/L
Naphthalene	8310	0.5 µg/L
Phenanthrene	8310	0.05 µg/L
Pyrene	8310	0.05 µg/L
Metals		
Aluminum	200.7	0.05 mg/L
Antimony	200.7/ 204.2	0.006 mg/L
Arsenic (as carcinogen)	200.7	0.01 mg/L
Barium	200.7	0.01 mg/L
Beryllium	200.7	0.001 mg/L
Cadmium	200.7	0.001 mg/L
Calcium	200.7	0.5 mg/L
Chloride, Total	325.3	1 mg/L
Chromium (Total)	200.7	0.01 mg/L
Cobalt	200.7	0.05 mg/L
Copper	200.7/7211	0.05 mg/L

Table 4-2. 1998 KSC Background Study Surface Water Contaminant Levels (cont.).

Iron	200.7	0.05 mg/L
Lead	200.7	0.005 mg/L
Metals (continued)		
Magnesium	200.7	0.5 mg/L
Manganese	200.7	0.01 mg/l
Mercury (inorganic)	7470	0.0002 mg/L
Nickel	200.7	0.01 mg/L
Potassium	200.7/ 258.1	0.5 mg/L
Selenium	200.7	0.01 mg/L
Silver	200.7/ 7761	0.01 mg/L
Sodium	7770	0.5 mg/L
Thallium	279.2	0.004 mg/L
Vanadium	200.7	0.01 mg/L
Zinc	200.7	0.1 mg/L
Other Parameters		
Dissolved Oxygen	*	N/A
PH	*	N/A
Specific Conductivity	*	N/A
Temperature	*	N/A
Total Dissolved Solids	160.1	N/A
Total Organic Carbon	415.1	1 mg/L
Turbidity	180.1	N/A

4.2 GROUNDWATER

KSC is a relatively flat, coastal area characterized by a near-surface water table. KSC is surrounded by brackish to saline surface water. Nearly all groundwater at KSC originates as precipitation that infiltrates through soil into flow systems in the underlying hydrogeologic units. Of the approximate 55 in (140 cm) of precipitation annually, approximately 75% is claimed by evapotranspiration. The remainder is accounted for by runoff, base flow, and recharge of the Surficial Aquifer.

4.2.1 HYDROGEOLOGIC UNITS

There are three aquifer systems underlying KSC: the Surficial aquifer system, the Intermediate aquifer system and the Floridan aquifer system (Figure 4-5, Table 4-3). The Surficial aquifer system contains fresh water but is less extensive than the Floridan, the principal artesian aquifer in east-central Florida. These two main aquifers are separated by nearly impermeable confining units that contain three shallow aquifers referred to as the Intermediate aquifer system (Ref. 15).

The Surficial aquifer can be divided into several subsystems (Figure 4-6). The Dune (Barrier Island) subsystem has a lens of freshwater less than 3 m thick on top of intruded saline water. The primary dune acts as the prime recharge area. Shallow groundwater flows east of the ridge to the Atlantic Ocean and west to Banana River, Mosquito Lagoon, or swales; at depth (> 6.1 m) flow is to the Atlantic Ocean. The Dune-Swale subsystem includes high ridges with permeable sand that favor recharge. This is the only area where the freshwater recharge of the deeper layers of the Surficial aquifer occurs. During most of the year, shallow groundwater discharges to the swales. At the beginning of the rainy season after the spring drought, swales collect water and remain flooded; and lateral and downward seepage from the swales helps to recharge the groundwater. In areas of pine flatwoods and swales, topography is lower and most soils have well-developed humic hardpans (spodic horizon, Bh layer) that restrict infiltration. During heavy rains, water perches above the hardpan and infiltrates slowly into the Surficial aquifer. This increases evapotranspiration and reduces recharge relative to the prime recharge areas. In the West Plain and Marsh (Lowland) subsystems, the water table is typically within 0.9 m of the land surface, evapotranspiration losses are high, and the dispersed saline water interface renders water quality variable. In the West Plain south of Banana Creek, a limerock "hardpan" replaces the humic hardpan of the Dune-Swale flatwoods. Along the coastlines, the Surficial aquifer contacts the saline water of the Atlantic Ocean and the brackish lagoons. Seawater intrusion occurs as a wedge at the base of the Surficial aquifer since seawater is denser than fresh water. The position of the fresh-saline water interface fluctuates; when water levels are low, saline water moves inland, and when water levels are high, saline water is forced out, producing a dynamic system (Ref. 15).

4.2.2 GROUNDWATER FLOW PATTERNS

Recharge to the Surficial aquifer system primarily comes from the direct infiltration of precipitation. Recharge potential differs across KSC with the greatest recharge potential in the ridges of eastern Merritt Island and north of Haulover Canal (Figure 4-7).

Groundwater mounds at the prime recharge areas. Groundwater flows from these recharge areas east toward the Banana River, Mosquito Lagoon, and the Atlantic Ocean and west toward the Indian River (Ref. 15) (Figure 4-8). Recharge to the Intermediate aquifer system is dependent on leakage through the surrounding beds of lower permeability (Ref. 15). In general, water in the Surficial aquifer system near the groundwater divide of the island has potential gradients which tend to carry some of the water vertically downward to the deepest part of the Surficial aquifer system and potentially to the upper units of the Intermediate aquifer system (Ref. 15) (Figure 4-8). Recharge to the Intermediate aquifer system is dependent on leakage through the surrounding beds of lower permeability (Ref. 15). Major discharge points for the Surficial aquifer system are the estuary lagoons, shallow seepage occurring to troughs and swales, and evapotranspiration (Ref. 15).

Internal fresh surface waters are primarily derived from surficial groundwater; shallow groundwater supports fresh water wetlands; groundwater discharge to surrounding saltwater bodies contributes to the maintenance of lagoon salinity; and groundwater underflow is a major factor in establishing the equilibrium of the fresh-saltwater interface in the surficial aquifer system (Ref. 15).

Groundwater under artesian and semi-artesian conditions, the Floridan and Intermediate aquifer systems, have upward flow potentials. The great elevation differential between the Floridan aquifer system recharge areas (e.g., Polk and Orange Co.) and discharge areas along the Atlantic coast provides the potential for the flowing artesian pressure experienced at KSC. Upward flow is limited by the thickness and the relatively impermeable nature of the confining units. Some upward flow may occur in the northwestern areas of KSC where the Hawthorn Formation thins. In addition, there are cases of free-flowing and abandoned artesian wells that have allowed the deeper saline ground waters to impact the fresh Surficial aquifer system. The general horizontal direction of flow in the Floridan aquifer system is northerly and northwesterly (Ref. 15).

4.2.3 GROUNDWATER QUALITY

The quality of water in an aquifer is dependent upon the lithology of the aquifer, the proximity of the aquifer to highly mineralized waters, the presence of residual saline waters in the aquifer, and the presence of chemical constituents in the aquifer and overlying soils.

4.2.3.1 Surficial Aquifer System

Unconsolidated, surficial aquifers are subject to contamination from point sources and from general land use; and contaminants may include trace elements, pesticides, herbicides, and other organics (Ref. 16-20). Urban and agricultural land uses have affected some Florida aquifers (Ref. 21, 22). Point source contamination to the KSC Surficial aquifer has occurred at certain facilities (Ref. 23, 24, 25). See Section X Remediation for more information on contaminated sites.

Groundwater surveys conducted to ascertain baseline conditions of the Surficial Aquifer were completed in 2000 (Ref. 3, 26). In that study, six sample sites were located in each subsystem of the Surficial Aquifer, 24 total sites. The sampling plan designated that a shallow well (4.6 m) was to be installed at each site. Intermediate wells (10.7 m) were to be installed at four sites per subsystem (16 total); deep wells (15.2 m) were to be installed at three sites per subsystem (12 total). A total of 52 wells were planned. Due to the depth of the confining unit at one location, the deep well was not installed there. Therefore, a total of 51 wells were installed at varying depths. Groundwater samples were collected using standard protocols. Groundwater samples were analyzed for organochlorine pesticides, aroclors, chlorinated herbicides, polycyclic aromatic hydrocarbons (PAH), total metals, dissolved oxygen (DO), turbidity, pH, specific conductivity, temperature, total dissolved solids (TDS), and total organic carbon (TOC).

The baseline data, summarized in Table 4-6, suggest that widespread contamination of the Surficial aquifer on KSC has not occurred. No organochlorine pesticides, aroclors, or chlorinated herbicides occurred above laboratory detection limits. Although pesticide residues or degradation products and chlorinated herbicides occurred in some soils, those concentrations were low and migration into the aquifer either has not occurred or has not been widespread. Some PAHs occurred in the shallow wells. PAHs occur in a variety of KSC soils at relatively low concentrations. Some occurrence of PAHs in shallow wells is not surprising since PAHs have both natural and anthropogenic sources (Ref. 27-30).

Most trace metals were in low concentrations in KSC groundwater, if they occurred above detection levels. This is consistent with the low concentrations of most trace metals in KSC soils and the primarily quartz composition of the terrigenous deposits comprising the surficial sediments of Merritt Island (Ref. 31, 32, 33). Aluminum, Fe, and Mn occurred above detection limits more frequently than other trace metals. Al and Fe are abundant crustal components and are present in KSC soils. Intense leaching, particularly in acid scrub and flatwoods soils, mobilizes Al and Fe (Ref. 34). Iron is a typical constituent of groundwater in the Surficial aquifer in Florida (Ref. 35).

Manganese is one of the most abundant trace elements (Ref. 36); it is present in KSC soils but the concentrations are relatively low. Solution and precipitation of Fe and Mn are affected by pH and oxidation-reduction conditions.

The chemical parameters varying most with subaquifer and depth were Ca, Cl^-, Mg, K, and Na, as well as conductivity and TDS that are related to these cations and anions. The trends were generally consistent among these; the shallow wells in the Dune-Swale subaquifer had the lowest values. Concentrations increased with depth within a subaquifer. At a given depth, concentrations in the Dune-Swale and West Plain subaquifers were lower than in the Dune and Marsh subaquifers. These trends reflect increased mineralization with depth and differences between the fresh water Dune-Swale and West Plain subaquifers and the more saline Dune and Marsh systems. The Dune and Marsh subaquifers interact with saline water of the Atlantic Ocean and Indian River Lagoon system, respectively (Ref. 15). These data are consistent with earlier work by Clark (Ref. 15) (Figure 4-8).

The surficial aquifer is monitored under permit at two locations across KSC. The KSC landfill operates under FDEP permit SO05-0150308-006, and the Seawater Immersion Facility, located at the Beach Corrosion Test Site, operates under permit 05-FLA168645-004. Groundwater monitoring at each of these locations occurs at a frequency and for parameters specific to each permit. The permits at LC 39 A and B were surrendered to FDEP in 2012 and no monitoring was occurring at the date of this document revision; however, it is expected that these permits will be renewed or new permits obtained when launch operations begin again and monitoring will resume at that time.

4.2.3.2 Intermediate Aquifer System

The groundwater quality in the intermediate aquifer system varies from moderately brackish to brackish due to their recharge by upward leakage from the highly mineralized and artesian Floridan aquifer system and in some cases from lateral intrusion from the Atlantic Ocean (Ref. 15). Groundwater in the Semi-artesian Sand and Shell aquifer is brackish (Ref. 15). Groundwater in the Shallow Rock aquifer is brackish with some sites receiving seawater intrusion (Ref. 15). The limited data that exists for the relatively thin Hawthorn Limestone Aquifer indicates that it is moderately brackish (Ref. 15).

4.2.3.3 Floridan Aquifer System

The Floridan aquifer system at KSC contains highly mineralized water with high concentrations of chlorides due to connate seawater in the aquifer, and to a lesser degree induced lateral intrusion (due to inland pumping), and a lack of flushing due to distant freshwater recharge areas (Ref. 15).

4.3 CLIMATE CHANGE

Climate change forced alterations of water resources will result from rising sea levels, alterations of rainfall and evapotranspiration rates, and anthropogenic adaptation strategy implementation such as dike construction or removal, alterations of stormwater management systems, and dune construction to control rates of shoreline retreat. In the vicinity of KSC these changes will influence the surficial aquifer and vados zone by altering water elevations and saltwater intrusion potential, surface water body depths, volumes, and distributions by flooding low lying areas adjacent to lagoons, coastal barrier beach and dune erosion, facilities, infrastructure and natural resources. Downscaled rising sea level estimates, as projected by GISS using 24 Global Climate Models as part of the CASI program (Ref. 38), are presented in Table 4-3.

Table 4-3. Projected Sea Level Rise in the Vicinity of KSC through the Latter Part of the 21st Century.

Baseline (2000 - 2004) 0 inches	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
2020s	5 cm (2 inches)	7.5 to 15 cm (3 to 6 inches)	20 cm (8 inches)
2050s	15 cm (6 inches)	23 to 43 cm (9 to 17 inches)	64 cm (25 inches)
2080s	25 cm (10 inches)	38 to 84 cm (15 to 33 inches)	125 cm (49 inches)

Projections are based on a 4-component approach that incorporates both local and global factors. The model-based components are from 24 GCMs and two Representative Concentration Pathways. Shown are the low-estimate (10th percentile), middle range (25th percentile to 75th percentile), and high-estimate (90th percentile). Projections are relative to the 2000-2004 base period.

A comprehensive assessment of potential impacts of rising sea leaves on the following subjects has been conducted using LiDAR derived elevation data (see Section 6.6) and GIS modeling using three sea level rise scenarios (0.2, 0.4 and 1.2 m NAVD88).

- Facilities and structures
- Roads
- Septic systems
- Storm water systems
- Waste water systems
- Water distribution systems
- Electrical distribution systems
- Solid waste management units (SWMU)
- Potential release locations (PRL)
- Natural gas distribution lines
- Communications lines
- Land use and land cover
- Archaeological sites
- Wetlands vegetation
- Protected species habitats

Results of these assessments, including maps and summary data tables are available through the EMB Ecological Program, Earth Systems Modeling and Data Management laboratory (http://kltep.ksc.nasa.gov). As an example, Figure 4-4 shows the spatial distribution of potential sea level rise impacts to different road categories. Major impacts are focused on the tertiary roads in outlying areas. Table 4-4 provides an example of the summary table results for the Roads assessment.

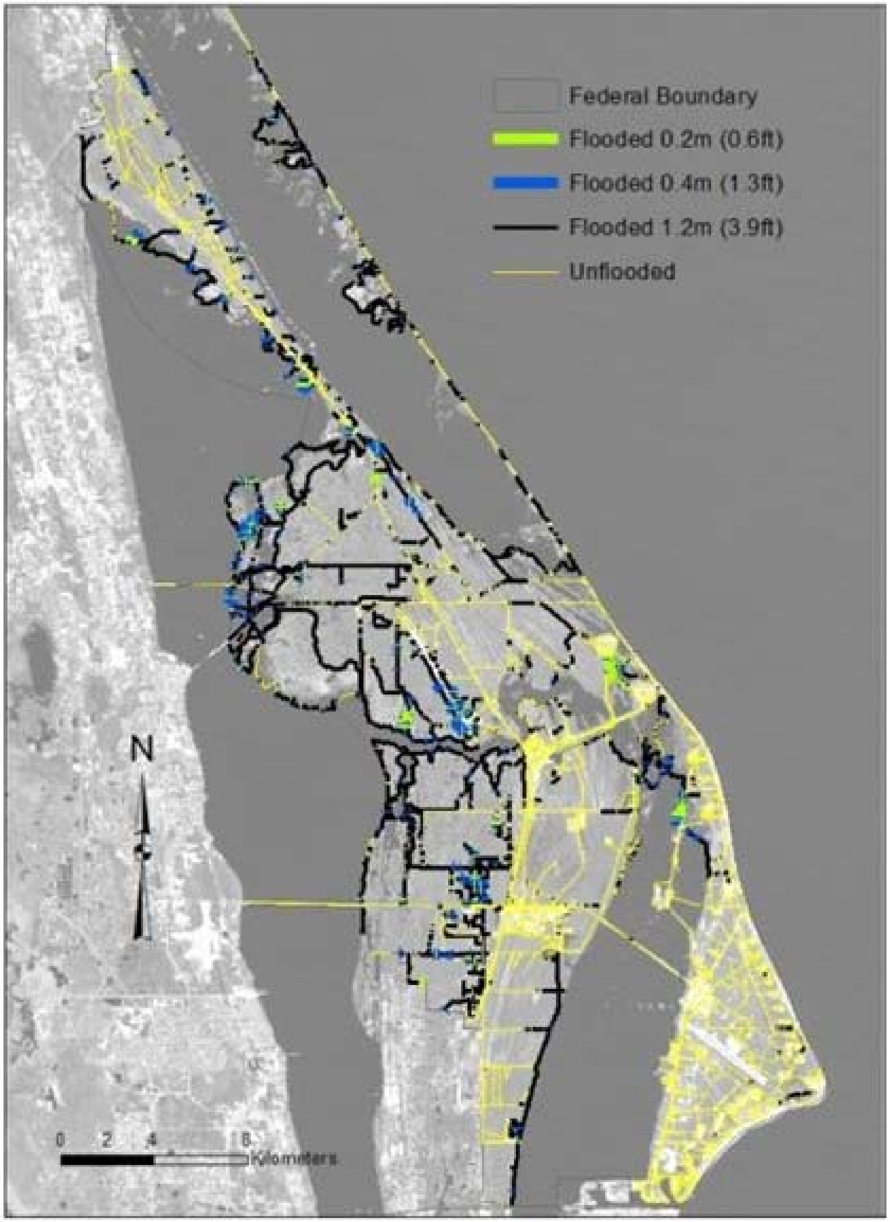

Figure 4-4. Impact of Sea Level Rise (0.2, 0.4 and 1.2 m) on Roads within the Federal Property Boundary of KSC, CCAFS, and CNS.

Table 4-4. Summary of Sea Level Rise (0.2, 0.4 and 1.2 m) Impacts on Roads at KSC and the Surrounding Federal Properties.

Road Category (mi)	SLR1 (0.2)	SLR2 (0.4)	SLR3 (1.2)	Total Length
Primary	0.1	0.6	34.1	294.3
Secondary	0.9	3.1	46.1	152.0
Tertiary	2.7	10.8	159.4	268.7
Sum	3.7	14.4	239.6	715.0
Road Category (km)				
Primary	0.2	0.9	54.8	473.6
Secondary	1.4	4.9	74.3	244.6
Tertiary	4.4	17.3	256.5	432.5
Sum	6.0	23.2	385.6	1150.7
Road Category	% of total	% of total	% of total	
Primary	0.03	0.2	11.6	
Secondary	0.6	2.0	30.4	
Tertiary	1.0	4.0	59.3	

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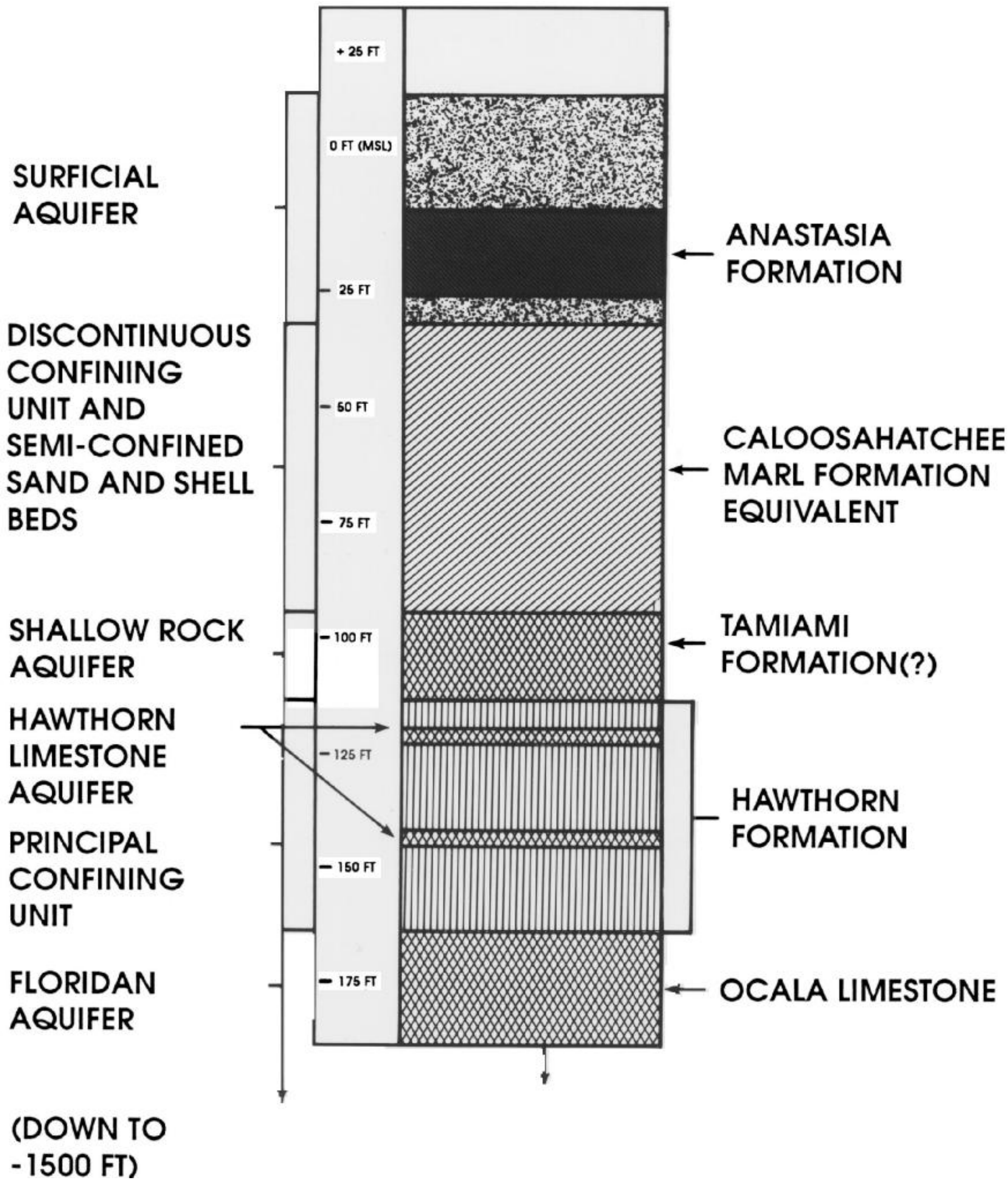

Figure 4-5. Geohydrological Units on Kennedy Space Center (Ref. 15).

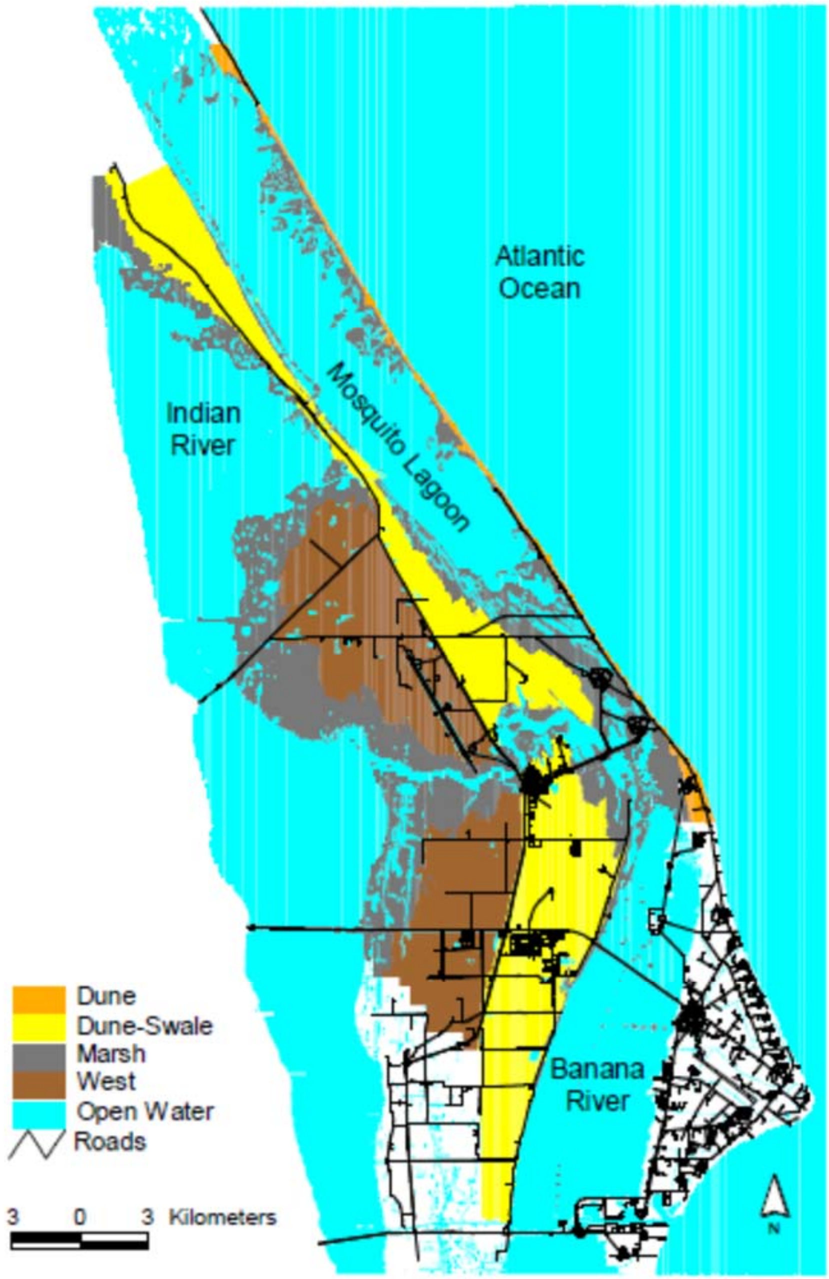

Figure 4-6. Subaquifers of the Surficial Aquifer on KSC.
(Ref. 3 modified from Ref. 15)

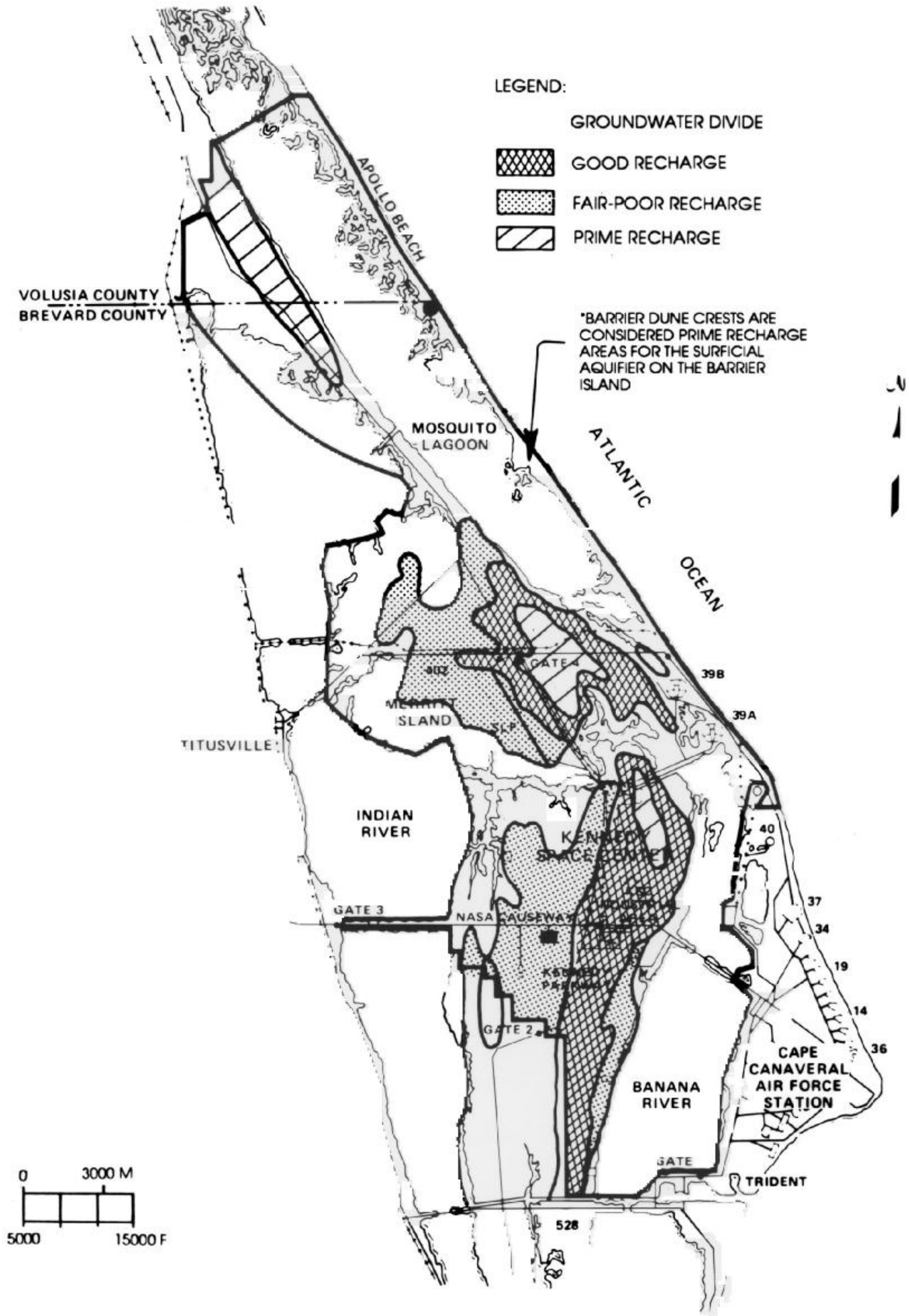

Figure 4-7. Potential for Recharge of the Surficial Aquifer (redrafted from Ref.A

Table 4-5. General Characteristics of the Aquifers on KSC.

Aquifer	Geologic Strata	Recharge Area	Discharge Area	Water Quality
Unconfined Water Table Aquifer				
Surficial Aquifer	Pleistocene and Recent deposits – sand, shell, coquina, silt, and marl	Rainfall and direct infiltration, particularly that on central sand ridges of island	Drainage canals and ditches; evapotranspiration including losses from swales; seepage to impoundments, lagoons, and ocean	Fresh in center of island, becomes mineralized toward lagoons and ocean
Secondary Artesian Aquifers				
Semi-artesian Shell and Sand Beds	Little freshwater recharge, may act as conduits for seawater intrusion		(?)	Moderately brackish, generally poorer than Florida aquifer
Shallow Rock Aquifer	Leakage upward from Florida aquifer	Tamiami Formation – shelly, partially consolidated quart sand and some limestone	(?)	Brackish
Hawthorn Limestone Aquifer	Leakage upward from Florida aquifer	Thin beds of weathered limestone, sandstone, and sand within the Hawthorn Formation	(?)	Moderately brackish
Principal Artesian Aquifer				
Floridan Aquifer	Eocene limestones, Ocala Group, Avon Park Formation	Central Florida- West Osceola, South Orange, and Polk Counties; Mims-Titusville ridge	Atlantic Ocean via offshore submarine springs, upward leakage where Hawthorn Formation thins	Highly mineralized, primarily chlorides

Data from Clark Ref. 15, table modified from Schmalzer and Hinkle (1990b)

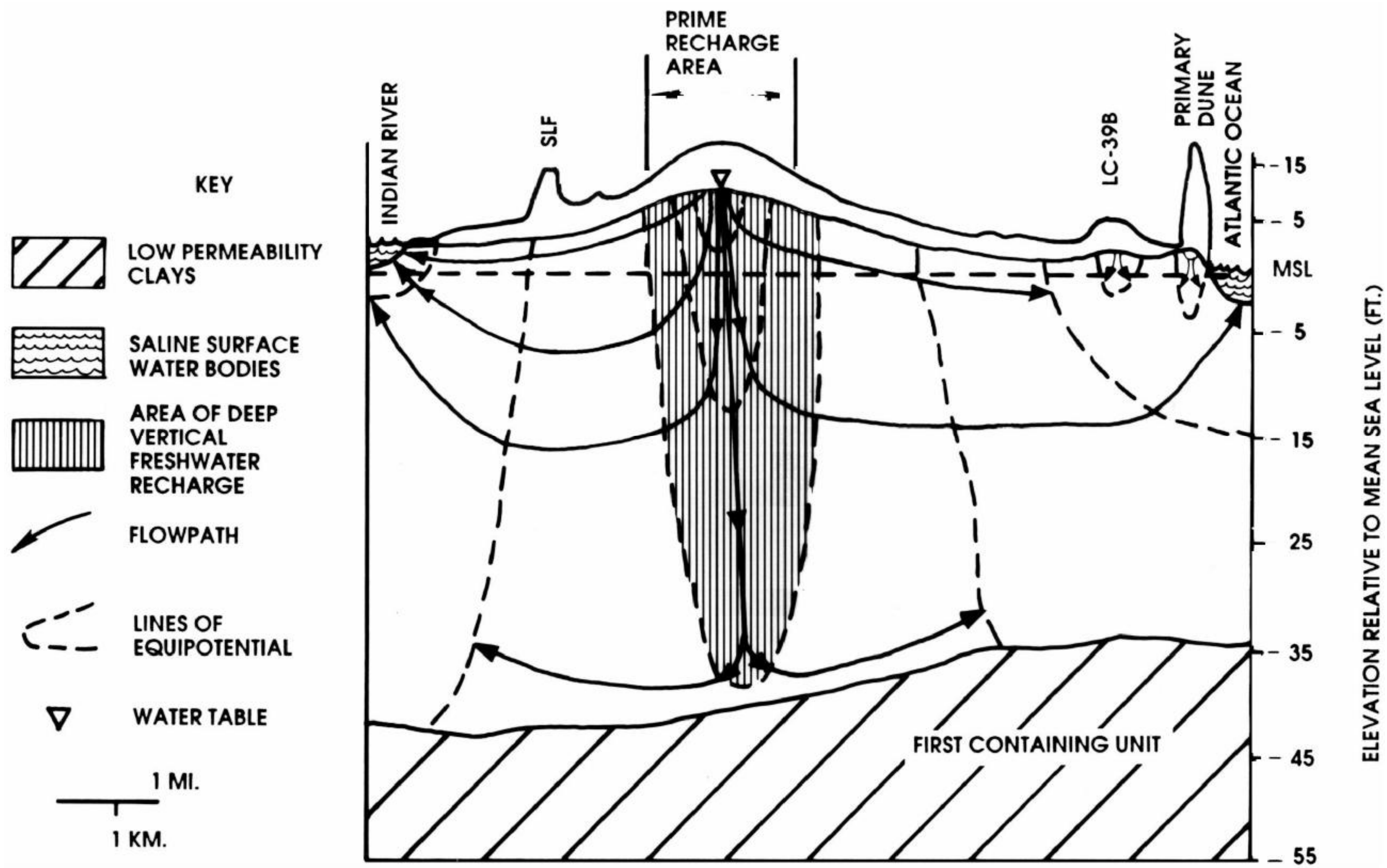

Figure 4-8. Groundwater Circulation in the Surficial Aquifer (redrafted from Ref. 15).

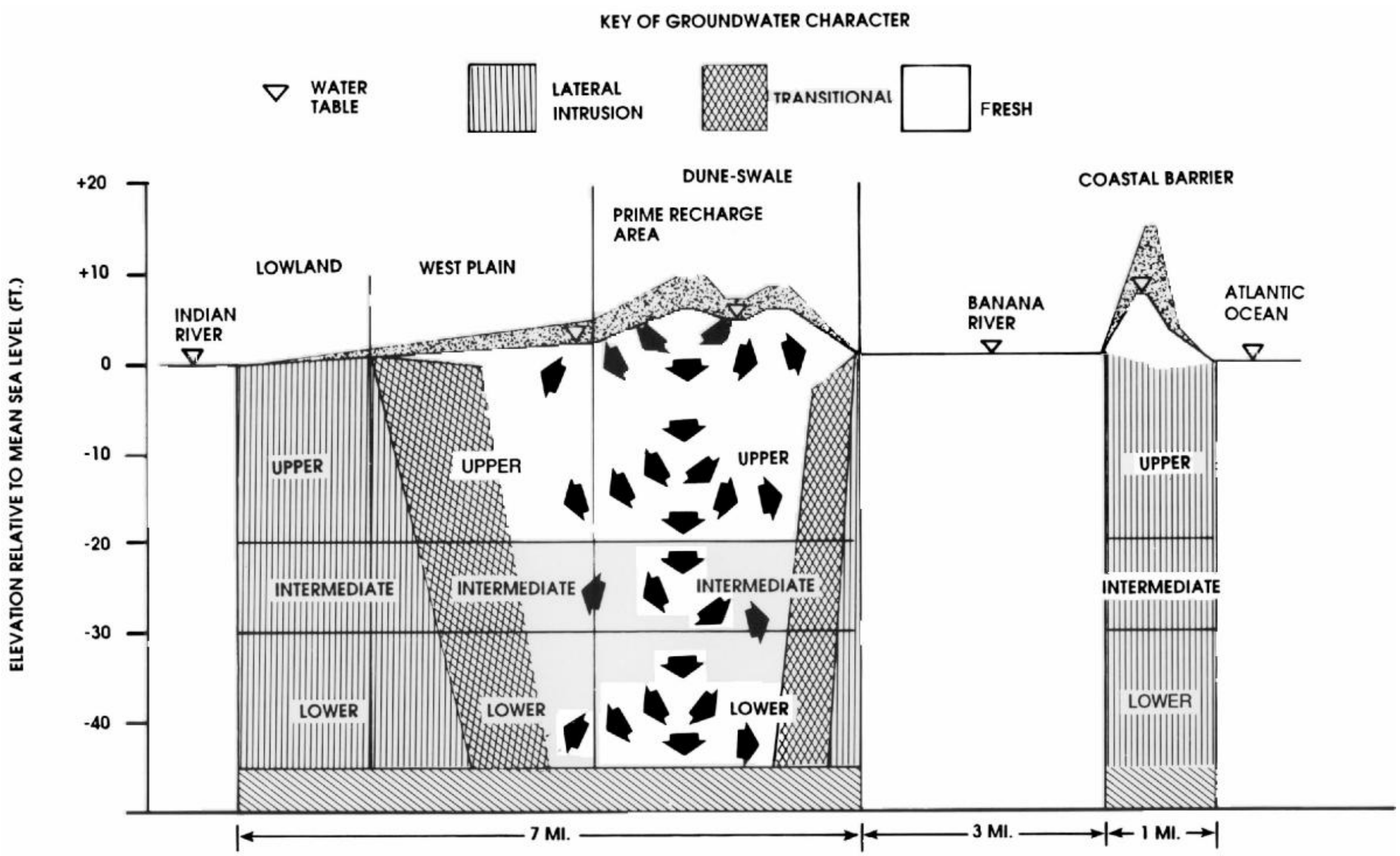

Figure 4-9. Chemical Evolution of Groundwater in the Surficial Aquifer (redrafted from Ref. 15).

Table 4-6. Chemical Parameters in Groundwater by Subaquifer and Depth.
Data are means with standard deviations in parentheses. Field parameters were not measured on replicate samples. Note: "nd" indicates all samples below detection limits (Ref. 3, 26).

Parameter	All Ground-water	Dune Shallow	Dune Intermediate	Dune Deep	Dune-Swale Shallow	Dune-Swale Intermediate	Dune-Swale Deep	West Shallow	West Intermediate	West Deep	Marsh Shallow	Marsh Intermediate	Marsh Deep
Sample Size	57	6	5	3	7	4	3	7	5	3	7	5	2
PAHs													
Benzo(a)anthracene (ug/L)	0.035 (0.02)	0.047 (0.041)	0.03 nd	0.03 nd	0.036 (0.015)	0.03 nd	0.03 nd	0.051 (0.048)	0.03 nd	0.03 nd	0.03 nd	0.03 nd	0.03 nd
Benzo(a)pyrene (ug/L)	0.029 (0.017)	0.031 (0.014)	0.025 nd	0.025 nd	0.031 (0.013)	0.026 nd	0.027 nd	0.048 (0.044)	0.025 nd	0.025 nd	0.025 nd	0.025 nd	0.025 nd
Benzo(b)fluoranthene (ug/L)	0.05 (0.02)	0.05 nd	0.05 nd	0.05 nd	0.051 nd	0.053 nd	0.053 nd	0.067 (0.045)	0.05 nd	0.05 nd	0.05 nd	0.05 nd	0.05 nd
Benzo(k)fluoranthene (ug/L)	0.028 (0.019)	0.037 (0.019)	0.025 nd	0.025 nd	0.026 nd	0.026 nd	0.027 nd	0.036 (0.028)	0.025 nd	0.025 nd	0.025 nd	0.025 nd	0.025 nd
Chrysene (ug/L)	0.03 (0.03)	0.05 (0.06)	0.025 nd	0.025 nd	0.031 (0.013)	0.026 nd	0.027 nd	0.046 (0.055)	0.025 nd	0.025 nd	0.025 nd	0.025 nd	0.025 nd
Fluoranthene (ug/L)	0.06 (0.08)	0.05 nd	0.05 nd	0.05 nd	0.06 (0.03)	0.053 nd	0.053 nd	0.14 (0.23)	0.05 nd	0.05 nd	0.05 nd	0.05 nd	0.05 nd
Indeno(1,2,3-cd)pyrene (ug/L)	0.03 (0.01)	0.04 (0.03)	0.025 nd	0.025 nd	0.026 nd	0.026 nd	0.027 nd	0.034 (0.025)	0.025 nd	0.025 nd	0.025 nd	0.025 nd	0.025 nd

Table 4-6. Chemical Parameters in Groundwater by Subaquifer and Depth (cont.).

Parameter	All Ground-water	Dune Shallow	Dune Intermediate	Dune Deep	Dune-Swale Shallow	Dune-Swale Intermediate	Dune-Swale Deep	West Shallow	West Intermediate	West Deep	Marsh Shallow	Marsh Intermediate	Marsh Deep
Elements													
Aluminum (mg/L)	0.16 (0.27)	0.083 (0.098)	0.105 (0.025)	0.05 (0.04)	0.298 (0.481)	0.117 (0.136)	0.049 (0.041)	0.143 (0.175)	0.057 (0.054)	0.033 (0.014)	0.44 (0.50)	0.15 (0.08)	0.066 (0.020)
Antimony (mg/L)	0.003 (0.002)	0.003 nd	0.007 (0.004)	0.0025 nd	0.0025 nd	0.0025 nd	0.0053 (0.0049)	0.0025 nd	0.0025 nd	0.0025 nd	0.0038 (0.0025)	0.0045 nd	0.0025 nd
Arsenic (as carcinogen) (mg/L)	0.011 (0.016)	0.015 (0.02)	0.028 (0.039)	0.021 (0.014)	0.005 nd	0.005 nd	0.005 nd	0.006 (0.002)	0.008 (0.007)	0.005 nd	0.025 (0.029)	0.005 nd	0.005 nd
Barium (mg/L)	0.06 (0.05)	0.05 nd	0.05 nd	0.05 nd	0.05 nd	0.05 nd	0.05 nd	0.05 nd	0.05 nd	0.05 nd	0.11 (0.13)	0.06 (0.03)	0.05 nd
Beryllium (mg/L)	0.0005 (0.0003)	0.0005 nd	0.001 (0.001)	0.0005 nd	0.0005 nd	0.0005 nd	0.0005 nd	0.0005 nd	0.0005 nd	0.0005 nd	0.0005 nd	0.0005 nd	0.0005 nd
Cadmium (mg/L)	0.0007 (0.0011)	0.0008 (0.0006)	0.002 (0.004)	0.0007 (0.0003)	0.0006 (0.0002)	0.0005 nd	0.0005 nd	0.0005 nd	0.0005 nd	0.0005 nd	0.0005 nd	0.0005 nd	0.0005 nd
Calcium (mg/L)	242.4 (201.2)	148.8 (75.5)	322.4 (189.2)	336.7 (200.3)	56.1 (43.6)	97.6 (74.4)	254.0 (265.7)	144.3 (51.3)	192.0 (47.6)	246.7 (73.7)	262.7 (238.9)	594.0 (98.4)	620.0 (70.7)
Chloride (mg/L)	4545 (7272)	2995 (4114)	12340 (8322)	7433 (7420)	27 (33)	102 (139)	3707 (6316)	404 (669)	1099 (618)	1127 (1016)	4251 (3293)	14860 (11870)	14800 (15839)
Chromium (total) (mg/L)	0.006 (0.003)	0.005 nd	0.006 (0.002)	0.005 nd	0.005 nd	0.005 nd	0.005 nd	0.005 nd	0.005 nd	0.005 nd	0.009 (0.007)	0.005 nd	0.005 nd
Copper (mg/L)	0.031 (0.035)	0.025 nd	0.04 (0.03)	0.025 nd	0.025 nd	0.025 nd	0.025 nd	0.025 nd	0.025 nd	0.110 (0.147)	0.022 (0.006)	0.028 (0.006)	0.025 nd
Iron (mg/L)	1.12 (1.76)	0.058 (0.08)	0.77 (0.99)	2.06 (3.24)	0.36 (0.59)	1.28 (0.53)	1.21 (1.50)	0.81 (0.94)	1.60 (0.20)	2.00 (0.97)	1.60 (3.71)	2.31 (2.38)	1.21 (1.68)

Figure 4-6. Chemical Parameters in Groundwater by Subaquifer and Depth (cont.).

Parameter	All Ground-water	Dune Shallow	Dune Intermediate	Dune Deep	Dune-Swale Shallow	Dune-Swale Intermediate	Dune-Swale Deep	West Shallow	West Intermediate	West Deep	Marsh Shallow	Marsh Intermediate	Marsh Deep
Elements (cont.)													
Lead (mg/L)	0.004 (0.005)	0.0025 nd	0.009 (0.10)	0.004 (0.003)	0.0025 nd	0.0025 nd	0.0025 nd	0.0025 nd	0.0025 nd	0.011 (0.015)	0.003 (0.001)	0.006 (0.005)	0.0025 nd
Magnesium (mg/L)	307.4 (493.8)	201.1 (267.6)	847.6 (571.1)	1036.7 (845.6)	2.2 (2.6)	10.0 (13.5)	244.9 (420.1)	32.6 (31.7)	73.0 (19.4)	98.7 (28.7)	248.6 (211.6)	796.8 (734.0)	782.5 (1014.7)
Manganese (mg/L)	0.068 (0.098)	0.02 (0.023)	0.075 (0.072)	0.114 (0.162)	0.015 (0.026)	0.022 (0.02)	0.057 (0.08)	0.024 (0.095)	0.046 (0.019)	0.070 (0.007)	0.062 (0.079)	0.284 (0.146)	0.141 (0.112)
Nickel (mg/L)	0.006 (0.004)	0.005 nd	0.006 (0.003)	0.007 (0.003)	0.005 nd	0.005 nd	0.005 nd	0.005 nd	0.005 nd	0.015 (0.014)	0.005 nd	0.005 nd	0.005 nd
Potassium (mg/L)	89.2 (150.6)	66.0 (91.3)	274.2 (177.6)	316.7 (211.3)	1.1 (0.6)	1.2 (1.7)	31.5 (54.1)	8.1 (8.1)	17.0 (13.2)	13.3 (0.6)	74.8 (63.7)	215.6 (241.7)	239.4 (326.2)
Selenium (mg/L)	0.006 (0.007)	0.005 nd	0.01 (0.01)	0.02 nd	0.007 (0.003)	0.005 nd	0.005 nd	0.005 nd	0.005 nd	0.005 nd	0.005 nd	0.005 nd	0.005 nd
Silver (mg/L)	0.005 (0.007)	0.005 nd	0.005 nd	0.007 (0.003)	0.005 nd	0.005 nd	0.005 nd	0.005 nd	0.005 nd	0.005 nd	0.005 nd	0.005 nd	0.005 nd
Sodium (mg/L)	2670 (4011)	1510 (2011)	6720 (4342)	8167 (6526)	13.1 (11.9)	53.6 (59.5)	1875 (3226)	240 (318)	560 (399)	883 (196)	3121 (3030)	7360 (5280)	6650 (7566)
Thallium (mg/L)	0.001 (0.0005)	0.001 nd	0.001 nd	0.001 nd	0.001 nd	0.001 nd	0.001 (0.0006)	0.001 nd	0.001 (0.0005)	0.001 nd	0.001 (0.0008)	0.001 (0.002)	0.002 (0.001)
Vanadium (mg/L)	0.005 (0.002)	0.005 nd	0.007 (0.004)	0.005 nd	0.005 nd	0.005 nd	0.005 nd	0.006 (0.002)	0.005 nd	0.005 nd	0.007 (0.003)	0.005 nd	0.005 nd
Zinc (mg/L)	0.053 (0.024)	0.05 nd	0.05 nd	0.05 nd	0.05 nd	0.05 nd	0.05 nd	0.05 nd	0.05 nd	0.11 (0.10)	0.05 nd	0.05 nd	0.05 nd

Table 4-6. Chemical Parameters in Groundwater by Subaquifer and Depth (cont.).

Parameter	All Ground-water	Dune Shallow	Dune Intermediate	Dune Deep	Dune-Swale Shallow	Dune-Swale Intermediate	Dune-Swale Deep	West Shallow	West Intermediate	West Deep	Marsh Shallow	Marsh Intermediate	Marsh Deep
Other Parameters													
Total Dissolved Solids (mg/L)	8066 (11275)	5455 (6845)	21564 (13441)	22133 (19535)	156 (86)	608 (463)	6987 (11270)	1164 (1298)	2760 (1228)	3900 (1375)	8214 (5227)	19020 (13951)	21050 (22557)
Total Organic Carbon (mg/L)	18.9 (23.4)	1.8 (1.3)	4.7 (7.5)	11.8 (15.1)	19.1 (18.0)	6.5 (4.1)	12.3 (2.5)	31.4 (30.0)	9.2 (8.9)	7.3 (3.5)	51.3 (35.5)	26.4 (18.9)	15.5 (6.4)
Sample Size (field)	51	6	4	3	6	4	3	6	4	3	6	4	2
Hydrogen Ion	8.80E-6 (5.46E-5)	3.49E-8 (2.46E-8)	4.41E-8 (4.27E-8)	7.34E-8 (8.35E-	7.40E-5 (1.55E-4)	1.25E-7 (4.91E-8)	1.06E-7 (7.97E-8)	1.09E-7 (4.29E-8)	6.16E-8 (4.93E-8)	1.04E-7 (1.38E-9)	2.13E-7 (2.62E-7)	1.55E-7 (4.00E-8)	5.20E-8 (2.89E-8)
pH	5.06	7.46	7.36	7.13	4.13	6.90	6.97	6.96	7.21	6.98	6.67	6.80	7.28
Dissolved Oxygen (mg/L)	1.82 (1.44)	2.79 (1.24)	1.97 (1.10)	2.88 (2.78)	1.57 (0.83)	2.23 (1.42)	3.27 (2.55)	1.00 (0.64)	0.51 (0.37)	1.18 (0.16)	2.21 (1.48)	0.76 (0.50)	1.79 (2.40)
Temperature (C)	25.7 (1.3)	26.8 (0.8)	26.2 (0.6)	26.0 (0.3)	26.7 (1.1)	24.8 (0.5)	26.1 (1.4)	25.7 (1.1)	24.1 (0.9)	23.1 (0.2)	26.9 (0.5)	24.9 (0.2)	24.9 (1.8)
Specific Conductivity (umhos/cm)	10012 (13156)	6607 (7368)	24875 (18001)	22507 (18314)	267 (171)	872 (620)	7037 (10880)	2242 (2119)	3715 (1482)	5770 (1440)	11897 (7147)	27210 (18546)	25955 (23257)

SECTION V. LAND RESOURCES

5.1 SOILS

Soils differ through the interaction of several factors: climate, parent material, topography, organisms, and time (Ref. 1 and 2). The soils of KSC are mapped in the soil surveys for Brevard County (Ref. 3) and Volusia County (Ref. 4), and the resulting soil pattern is complex. Numerous soil series and land types are represented even though Merritt Island is a relatively young landscape and one formed from coastal plain deposits. Some differences in soil parent material do occur. In particular, soils that formed in deposits over limestone, coquina, or other alkaline material differ greatly in properties from those formed in sand. Textural differences in parent material such as that between loam or clay material and sand also influence soil properties.

The primary source of parent material for KSC soils is sands of mixed terrestrial and biogenic origin. The terrestrial material originated from southern rivers carrying sediments eroded from highly weathered Coastal Plain and Piedmont soils; these sediments are quartzose with low feldspar content (Ref. 5). These sediments moved south through long-shore transport and may have been reworked repeatedly. The biogenic carbonate fraction of the sand is primarily of mollusk or barnacle origin with lesser contributions of coralline algae and lithoclasts; some may be reworked from offshore deposits of coquina and oolitic limestone (Ref. 5).

The Cape Canaveral-Merritt Island complex is not all of the same age. Soils on Cape Canaveral, False Cape, and the barrier island section on the east side of Mosquito Lagoon are younger than those of Merritt Island and therefore have had less time to weather. Well drained soil series (e.g., Palm Beach, Canaveral) in these areas still retain shell fragments in the upper layers, while those inland on Merritt Island (e.g., Paola, Pomello) do not. The presence of shell fragments influences soil nutrient levels, particularly calcium and magnesium, and pH. The eastern and western sections of Merritt Island differ in age. The eastern section of Merritt Island inland to about State Route 3 has a marked ridge-swale topography presumably retained from its formation as a barrier island; west of State Route 3, the island is flatter, without obvious ridges and swales probably due to the greater age of this topography.

Differences in age and parent material account for some soil differences, but on landscapes of Merritt Island with similar age, topography has a dramatic effect on soil formation. Relatively small elevation changes cause dramatic differences in the position of the water table that, in turn, affect leaching, accumulation of organic matter, and formation of soil horizons. In addition, proximity to the lagoon systems influences soil salinity.

Fifty-eight soil series and land types have been mapped at KSC (Ref. 3, 4). These are listed and described in Appendix A.

Five general soil associations have been identified in the Brevard County section of KSC (Ref. 3). These associations are: Paola-Pomello-Astatula, Canaveral-Palm Beach-Welaka, Myakka-EauGallie-Immokalee, Copeland-Wabasso, and Salt Water Marsh-Salt Water Swamp. The Paola-Pomello-Astatula association consists of nearly level to strongly sloping, excessively to moderately drained soils that are sandy throughout the profile. In the KSC area, these soils are found on long, narrow ridges between the Indian River and the Banana River and along the Kennedy Parkway. The Canaveral-Palm Beach-Welaka Association includes soils that are nearly level to gently sloping, moderately well drained to excessively drained, and sandy throughout that occur primarily on the outer barrier island and Cape Canaveral. The Myakka-EauGallie-Immokalee association consists of nearly level, poorly drained soils, sandy throughout to a depth of 40 in (102 cm) and loamy below; these soils are associated with flatwoods vegetation. The Copeland-Wabasso association includes soils that are nearly level, very poorly drained to poorly drained, sandy to depth of 40 in (102 cm) and loamy below; these soils are associated with hammock vegetation. The Salt Water Marsh-Salt Water Swamp association consists of nearly level, very poorly drained, saline to brackish soils of variable textures; these soils are associated with salt marsh and mangrove vegetation. Similar, but differently named, soil associations have been mapped in the Volusia County section of KSC (Ref. 4).

These soil associations are too generalized for many purposes, but there are too many soil series and land types to treat each individually. As part of the recent baseline characterization of soil, groundwater, surface water and sediment of KSC, ten soil classes were developed (Ref. 6, 7). First soils were divided into four groups: Upland, Wetland, Agricultural, and Disturbed. Upland soils are not flooded for substantial periods, while Wetland soils have standing water for substantial periods. Flooding affects organic matter accumulation, oxidation-reduction conditions, and other chemical properties of soils (Ref. 8). Upland soils were then divided into well-drained and poorly drained categories. Poorly drained soils accumulate more organic matter, which forms the cation exchange capacity in these soils retaining nutrients and metals (Ref. 9, 10, 11). Well-drained, upland soils were divided into three classes: 1) geologically recent, alkaline, sandy soils of coastal dunes where the vegetation is coastal dunes, coastal strand, or coastal scrub; 2) old, inland, leached, acid, sandy soils where the vegetation is oak-saw palmetto scrub or scrubby flatwoods; and 3) inland, circumneutral soils formed over coquina where the vegetation is oak-saw palmetto scrub or xeric hammock. Poorly-drained, upland soils were divided into two classes: 1) acid, sandy soils with flatwoods vegetation; and 2) circumneutral to alkaline soils formed over coquina or limestone where the vegetation is mesic hammock (Table 5-1).

The primary division of wetland soils was between: 1) inland, freshwater wetlands where the vegetation was freshwater marshes or hardwood swamps; and 2) coastal, brackish to saline wetlands where the vegetation was salt marshes or mangroves (Table 5-1).

Agricultural soils were of two types: 1) active or abandoned citrus on scrub soils; and 2) active or abandoned citrus on hammock soils (Table 5-1). Disturbed soils included various types modified by construction (Table 5-1). This group could be heterogeneous, but there was no apparent division into homogeneous subgroups.

Table 5-1. Soil Classification for Kennedy Space Center.
(Soils are grouped into ten classes based on similarities[1]).

Division	Subdivision	Description	Class
Upland	Well-drained	Recent, coastal, alkaline soils – vegetation is coastal dunes, coastal strand, or coastal scrub	Coastal
		Old, inland, acid soils – vegetation is scrub or scrubby flatwoods	Acid Scrub
		Inland, circumneutral soils over coquina – vegetation is scrub or xeric hammock	Coquina Scrub
	Poorly-drained	Acid, sandy soils – vegetation is flatwoods	Flatwoods
		Circumneutral to alkaline soils over coquina or limestone – vegetation is hammock	Hammocks
Wetland	Freshwater	Inland, freshwater soils – vegetation is freshwater marshes or hardwood swamps	Freshwater Wetland

Table 5-1. Soil Classification for Kennedy Space Center (cont.).

Division	Subdivision	Description	Class
	Saline	Coastal, brackish to saline soils – vegetation is saltmarsh or mangroves	
Agricultural	Scrub soil	Active or abandoned citrus on acid or coquina scrub soils	Citrus Scrub
	Hammock soil	Active or abandoned citrus on hammock soils	Citrus Hammock
Disturbed		Soils modified by construction or filling	Disturbed

[1]Ref. 7

The division of soil series and land types into these classes is given in Appendix A, Table A-2. There are clear landscape patterns to these soil classes (Figure 5-1). Flatwoods, Salt Water Wetlands, and Freshwater Wetlands were the largest categories (Table 5-2). These soil classes were shown to be significantly different for many chemical and physical parameters (Ref. 6, 7).

Table 5-2. Area of Soil Classes.[1]

Soil Class	Area (hectares)	Percent of Soil Area
Coastal	1098.3	3.30
Acid Scrub	1556.9	4.76
Coquina Scrub	270.4	0.81
Flatwoods	10432.6	31.32
Hammocks	1990.1	5.97
Freshwater Wetlands	6154.3	18.48
Saltwater Wetlands	9626.2	28.90
Citrus Scrub	349.3	1.05
Citrus Hammock	640.0	1.92
Disturbed	1192.4	3.58

[1]Ref. 7

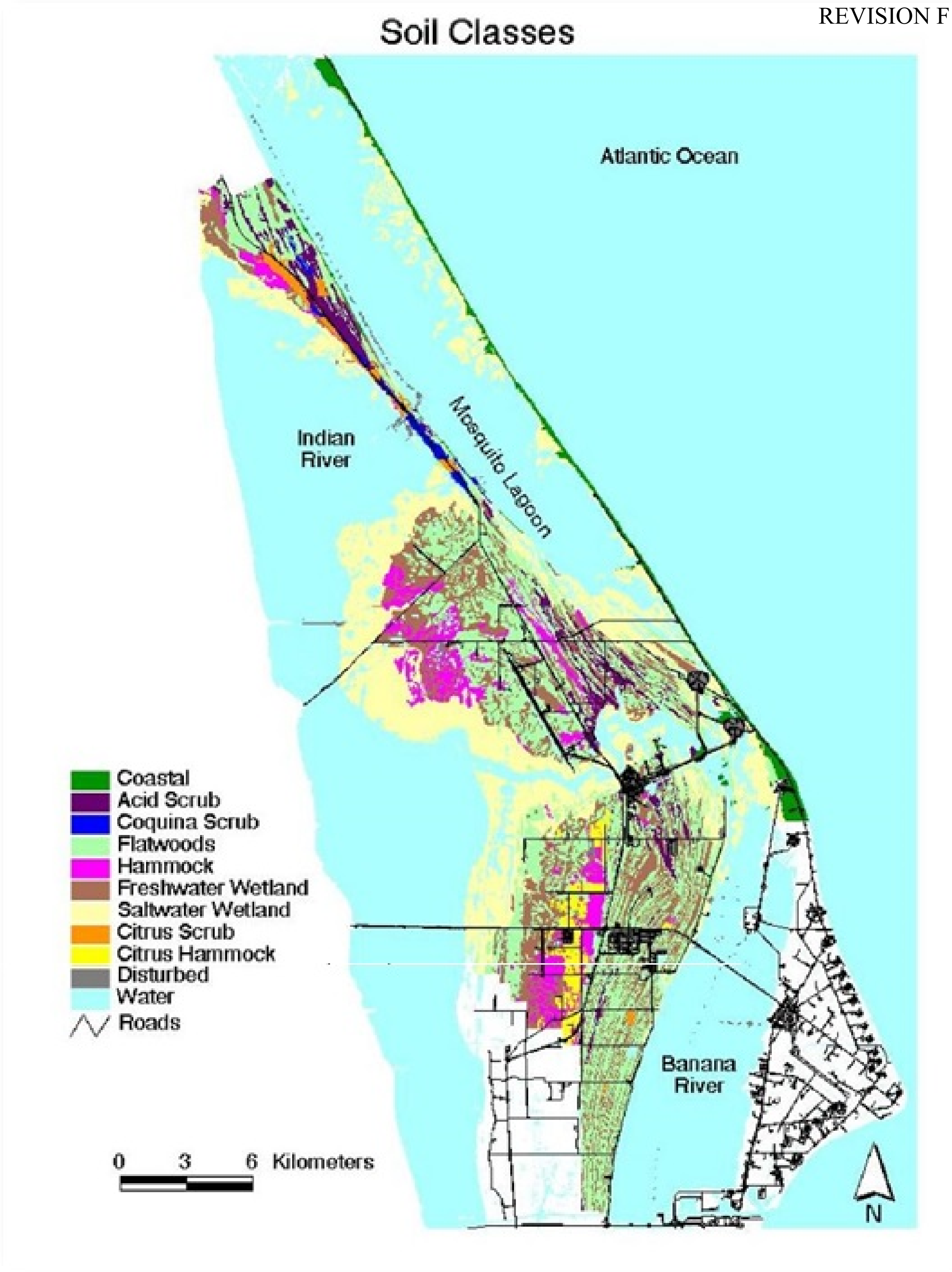

Figure 5-1. Distribution of Soil Classes on KSC (Ref. 7).

5.2 GEOLOGY AND GEOLOGICAL HISTORY

Florida has a complex geologic history with repeated periods of deposition when the Florida Plateau was submerged and erosion when the seas recessed (Ref. 12, 13). The oldest formations known to occur beneath Brevard County and KSC were deposited in the early Eocene in an open ocean (Ref. 14). This was followed by a withdrawal of the sea and a period of erosion. In the late Eocene, the seas advanced and limestones of the Ocala group were deposited (Ref. 14). Following another period of recession of the sea and erosion of the land surface, the Hawthorn formation of calcareous clay, phosphatic limestone, phosphorite, and radiolarian clay was deposited in the late Miocene (Ref. 14, 15). Overlying this are unconsolidated beds of fine sand, shells, clay, and calcareous clay of late Miocene or Pliocene age (Ref. 15). Surface strata in Brevard County are primarily unconsolidated white to brown quartz sand containing beds of sandy coquina of Pleistocene and Holocene age (Ref. 15).

During the Pleistocene (ca. 1.6 million years before present year B.P. to 13,000 year B.P.) repeated glaciation of the northern hemisphere produced fluctuations in sea level (Ref. 16). At the maximum of the Wisconsinan glaciation (ca. 18,000 yr B.P.), sea levels were on the order of 100 m lower than at present, and substantial additional areas were exposed along the Atlantic and Gulf coasts, including Florida (Ref. 17, 18).

The alternating high and low sea stands of the Pleistocene and Holocene (since ca. 13,000 yr B.P.) shaped the surface of Brevard County. The outer barrier island and Cape Canaveral formed after sea levels rose when the Wisconsinan glaciers retreated (Ref. 19). Cape Canaveral is mapped as Holocene in age (Ref. 20). Brooks (Ref. 21) suggested that the formation of the Cape Canaveral peninsula began about 7,000 years ago. Cape Canaveral is part of a prograding barrier island complex, the result of southward growth of an original cape at the site of the present False Cape (Ref. 22, 23). Multiple dune ridges on Cape Canaveral suggest that periods of deposition and erosion alternated (Ref. 24). The barrier island separating Mosquito Lagoon from the Atlantic Ocean also originated about 7,000 years ago (Ref. 25). However, its history has been marked by erosion, overwash, and landward migration rather than progradation; these processes continue today (Ref. 25). Some areas of the barrier island south of Cape Canaveral have a history of overwash, while others have been more stable (Ref. 26).

Merritt Island also formed as a prograding barrier island complex; the eastern edge of Merritt Island at its contact with the Mosquito Lagoon and the Banana River forms a relict cape aligned with False Cape (Ref. 22, 23). Multiple dune ridges apparently represent successive stages in this growth. Brooks (Ref. 21) suggested that the geologic history of the Merritt Island-Cape Canaveral barrier island was complex. The western portion of Merritt Island is substantially older than the east (Ref. 21, 27). Erosion has reduced the western side to a nearly level plain (Ref. 15).

5.2.1 STRATIGRAPHY

Lithology, stratigraphy, and geologic structure are important controls of (1) groundwater quality, (2) distribution of aquifers and confining beds, and (3) the availability of groundwater. Four distinct geologic units are characteristic of the coastal area of East-Central Florida and lie beneath KSC (Table 5-3). In descending order these are: Pleistocene and Recent age sands with interbedded shell layers, Upper Miocene and Pliocene silty or clayey sands, Central and Lower Miocene compacted silts and clays, and Eocene limestones (Ref. 28). North-south and east-west geological cross sections (Figures 5-2, 5-3, 5-4) were developed by Edward E. Clark Engineers-Scientists, Inc (Ref. 28) based on data collected during the construction phase of facilities for the Manned Lunar Landing Program at Merritt Island and Cape Canaveral, Florida.

Table 5-3. Generalized Stratigraphy at Kennedy Space Center.[1]

Geologic Age	Formation Name	Aquifer	Physical and Water Bearing Characteristics
Holocene Pleistocene Pliocene Miocene Oligocene Eocene	Anastasia Formation Tamiami Formation Hawthorn Formation Suwanee Limestone Ocala Limestone	Surficial Aquifer System Intermediate Confining Unit Floridan Aquifer System	Highly variable and undifferentiated deposits. Sand, shell, clay, coquina, and mixtures. Yields moderate amounts of water, depending on permeability of deposits. Interbedded limestone, coquina, sand and clay (eastern). Shell, sand, clay and cemented zones (western). Sand clay, green and brown clays, and some limestones. Generally impermeable; poor water yield except for some thin shell and limestone beds. Gray to cream colored, clayey, granular limestone. Poor water yields.
	Avon Park Limestone		Cream colored to tan, porous, chalky, and hard crystalline limestone and dense dolomite.
	Lake City Limestone		Cream colored to tan, porous, chalky, and hard crystalline limestone and dense dolomite.
	Oldsmar Limestone		Not commonly tapped by wells.

[1]Ref. 29

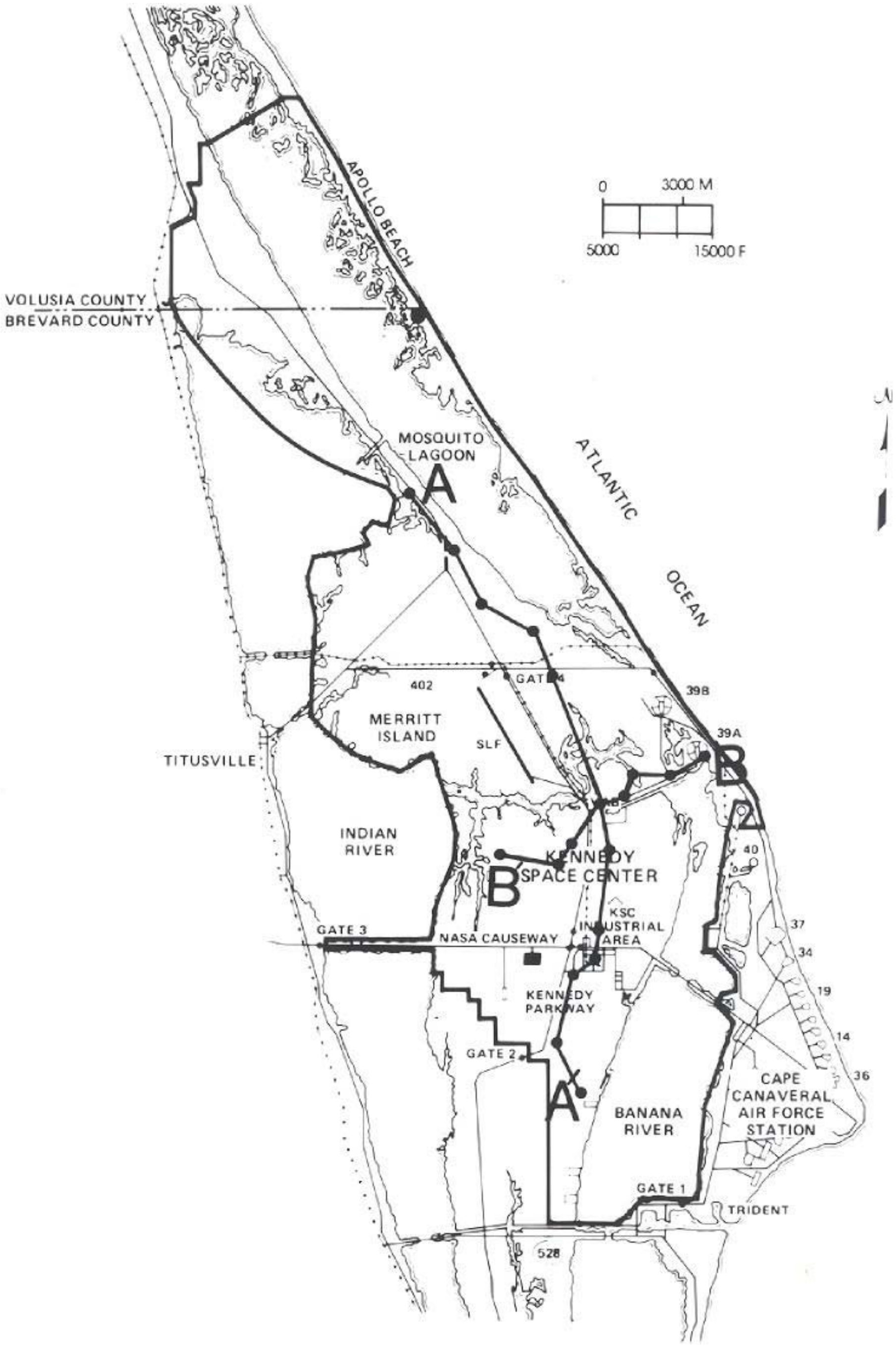

Figure 5-2. Location of North-South and East-West Geologic Cross Sections on KSC (redrafted from Ref 28).

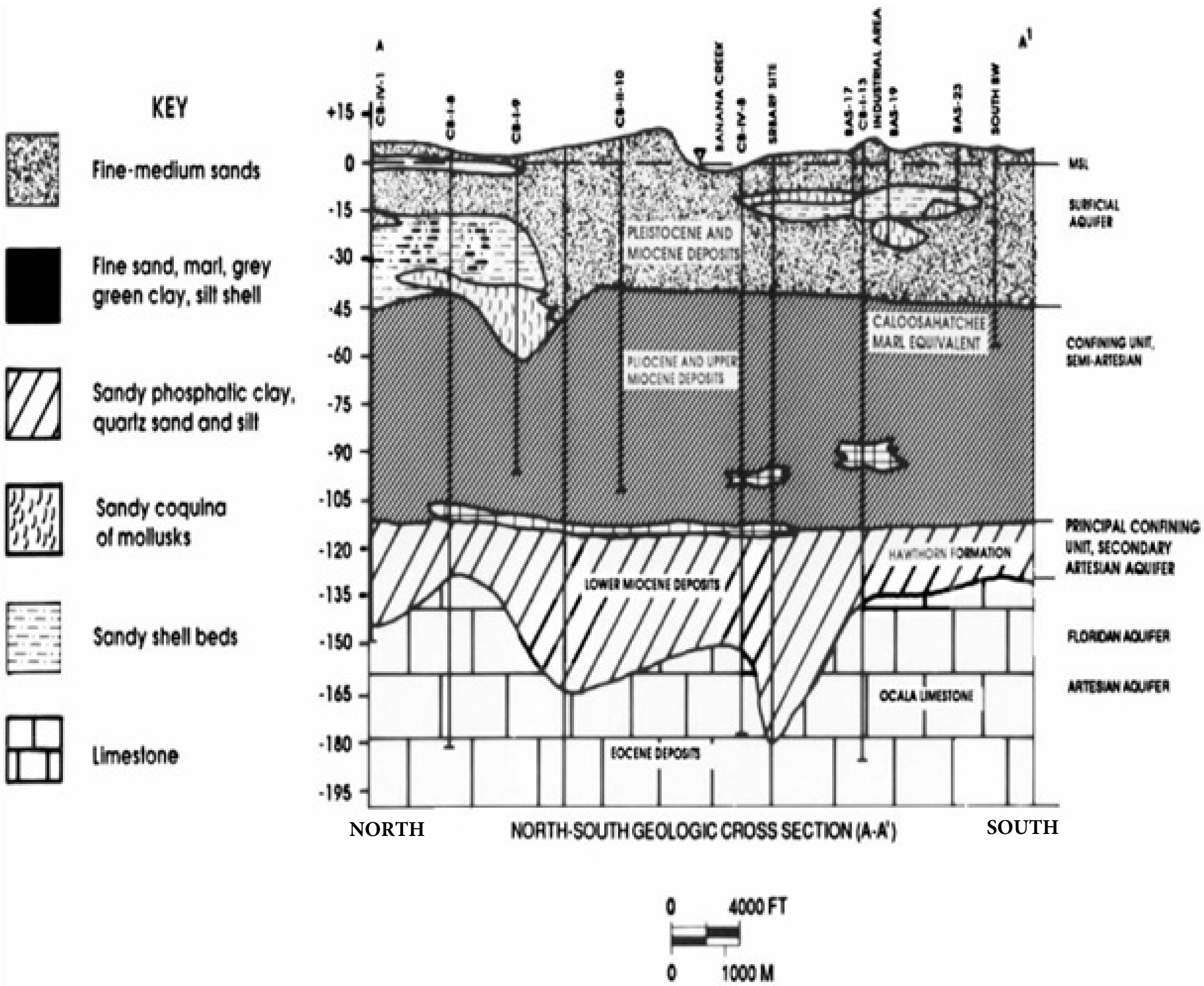

Figure 5-3. North-South Geologic Cross Section for Kennedy Space Center (redrafted from Ref. 28). Vertical scale is elevation in feet relative to mean sea level.

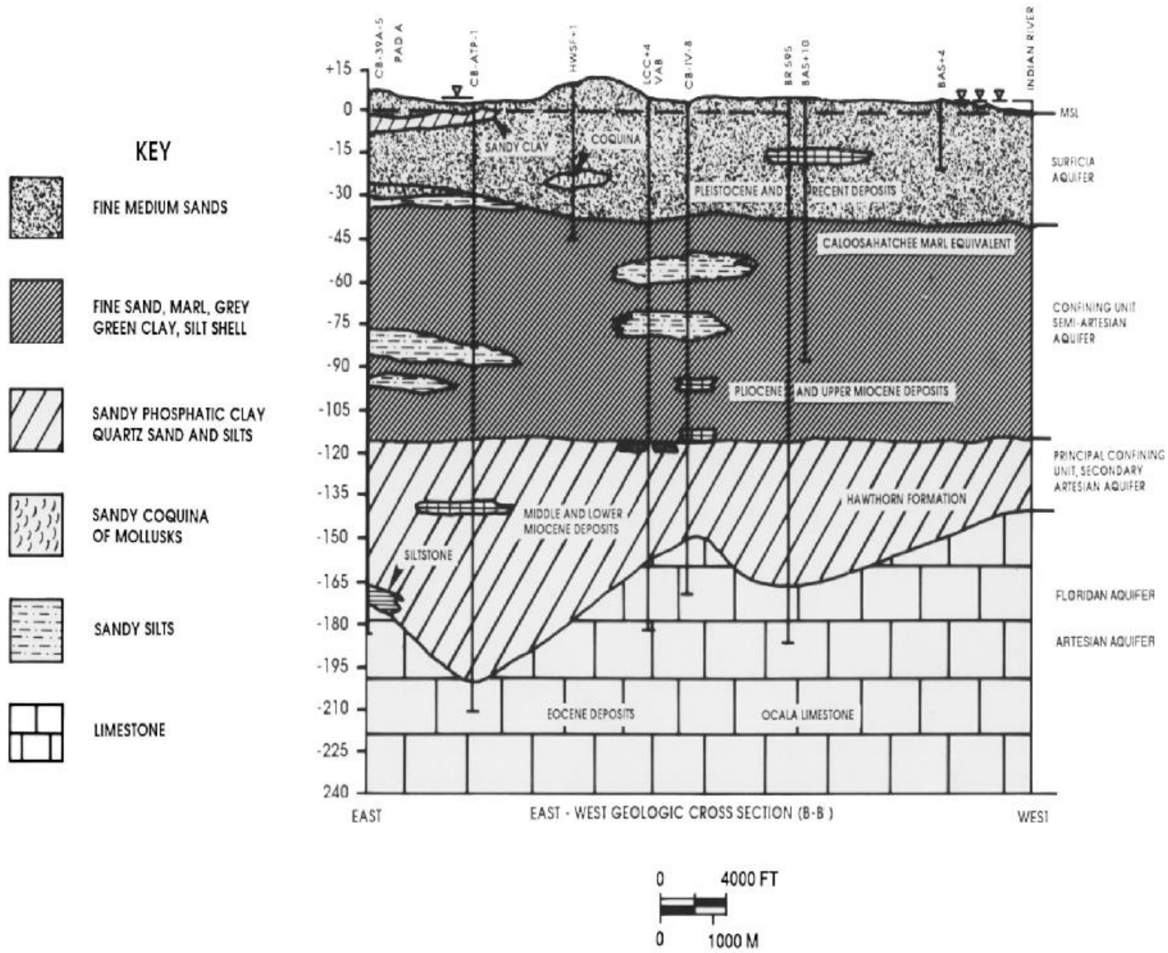

Figure 5-4. East-West Geologic Cross Section for KSC (redrafted from Ref. 28). Vertical scale is elevation in feet relative to mean sea level.

5.2.2 PLEISTOCENE AND RECENT DEPOSITS

The Pleistocene period was characterized by a wide range of sea level fluctuations. These deposits are, therefore, characterized by 35 to 45 stratigraphic feet (10.7-13.7 m) of fine-medium sands with varying amounts of shell and interbedded layers of shell deposited by longshore currents and wave action (high energy environments) and subjected to varying degrees of oxidation. The upper limits of Pleistocene deposits range from 5 to 8 ft (1.5-2.4 m) above mean sea level (MSL) or the elevation of the Silver Bluff terrace, the youngest terrace formed as the result of the Pleistocene age sea level fluctuation (Ref. 15). The characteristics of these Pleistocene deposits have been altered by cementation and compaction; in the upper horizons discontinuous layers of limerock hardpan, dark brown humic sandstone hardpan, silt, and clay can be found (Ref. 28).

5.2.3 UNDIFFERENTIATED UPPER MIOCENE AND PLIOCENE SILTS, SANDS, AND CLAYS

Visually there is little difference between the upper Hawthorn and Upper Miocene deposits. These deposits, generally occurring between a top elevation of -30 ft (9.1 m) MSL and a base elevation of -115 feet (35.0 m) MSL, consist primarily of sands, silts, and clays with minor occurrences of limestone and shelly sands. They were deposited in shallow marine and lagoonal environments subjected to numerous sea level fluctuations resulting in numerous interbedded, discontinuous strata of local area extent. The upper limits of these undifferentiated deposits are equivalent to the Caloosahatchee Marl Formation and, in the northern extremities of Merritt Island; the top of the Pliocene Tamiami Formation is at approximately -87 ft (26.5 m) MSL. Within the Tamiami Formation lies a narrow band of shelly conglomerate or medium hard limestone. The contact between the undifferentiated sediments and the overlying surficial sands is conformable and gradational over approximately three stratigraphic feet (0.9 m), but is nonetheless distinct (Ref. 28).

5.2.4 LOWER AND MIDDLE MIOCENE SILTS AND CLAYS

The Ocala limestone was submerged during the Miocene Epoch at which time the Hawthorn Formation was uniformly deposited on the karst Ocala limestone surface. The top of the Hawthorn Formation is located approximately -115 ft (35.0 m) MSL and extends down to the Ocala limestone. It consists of calcareous clays and silts, sandy phosphatic limestone, and phosphatic clays. These massive beds of marine clays and silts are identified by varying amounts of phosphatic material (formed from residue of shallow marine life) and a dramatically high natural gamma ray signature on geophysical well logs. Associated with this formation are at least two thin (approximately 2-3 ft [0.6-0.9 m]), discontinuous conglomerate limestone/ sandstone beds. The upper bed, although not always present, is located near the -120 ft (36.6m) MSL mark and the location of the lower bed ranges between approximately -130 ft (39.6 m) MSL and -140 ft. (42.7 m) MSL depending on the presence or absence of faulting. Its thickness depends on the extent to which the Ocala limestone surface has been eroded. The top of the Hawthorn Formation gradually changes to Upper Miocene silts and clays. The exact upper limits of the formation have not been described; however, it is assumed to be the change from firm compact sediments to looser, less consolidated materials. Numerous geophysical logs (natural gamma) indicate the diagnostic signatures of the Hawthorn Formation beginning approximately -110 ft (33.5 m) MSL to -120 ft (36.6 m) MSL (Ref. 28).

5.2.5 EOCENE LIMESTONES

At least four limestone formations from the Eocene Epoch make up the Floridan aquifer system in the KSC area (Table 5-6). The upper limestones, the Ocala group, are the best defined as they have been test drilled numerous times for the design of facilities for the Manned Lunar Landing Program and have been utilized for an artesian water source. The Ocala limestone is of late Eocene age and was formed in a shallow sea environment. This limestone was later exposed to subaerial processes above sea level where it developed a karst topography with sinks, cavities, and solution channels (Ref. 28).

5.2.6 TEST DRILLING AND OTHER GEOLOGIC RELATED STUDIES

During the construction phase of facilities for the Manned Lunar Landing Program at Merritt Island and Cape Canaveral, Florida, the U.S. Army Corps of Engineers (USACE) documented numerous geology and soils reports with emphasis on general and detailed foundation information. These reports can be found in the KSC Technical Documents Library.

5.2.7 SEISMOLOGY

Seismological investigations of the Cape Canaveral area included refraction surveys and well logs. The investigations were conducted by the Seismological Branch of the U.S. Coast and Geodetic Survey and showed that the Cape Canaveral underground structure is normal and free of voids or anomalies. The Florida Platform exhibits high seismologic stability with very few confirmed earthquakes (Ref. 30).

5.3 VEGETATION AND LAND COVER

Table 5-4 and Figure 5-5 present a summary of land cover and vegetation on KSC. These data follow the nomenclature of the Florida Land Use Cover and Forms Classification System (FLUCCS). A more detailed description and corresponding map of KSC natural habitats can be found in Section VI, Natural Resources.

Table 5-4. Land Cover Classes on Kennedy Space Center.

Land Cover Class	Area (ac)	Area (ha)
Upland Vegetation	41083	16625
Wetland Vegetation	36183	14642
Urban and Developed	3800.3	1537.9
Water	54228.1	21945.4

Derived from 1995 St. Johns River Water Management District map with modifications.

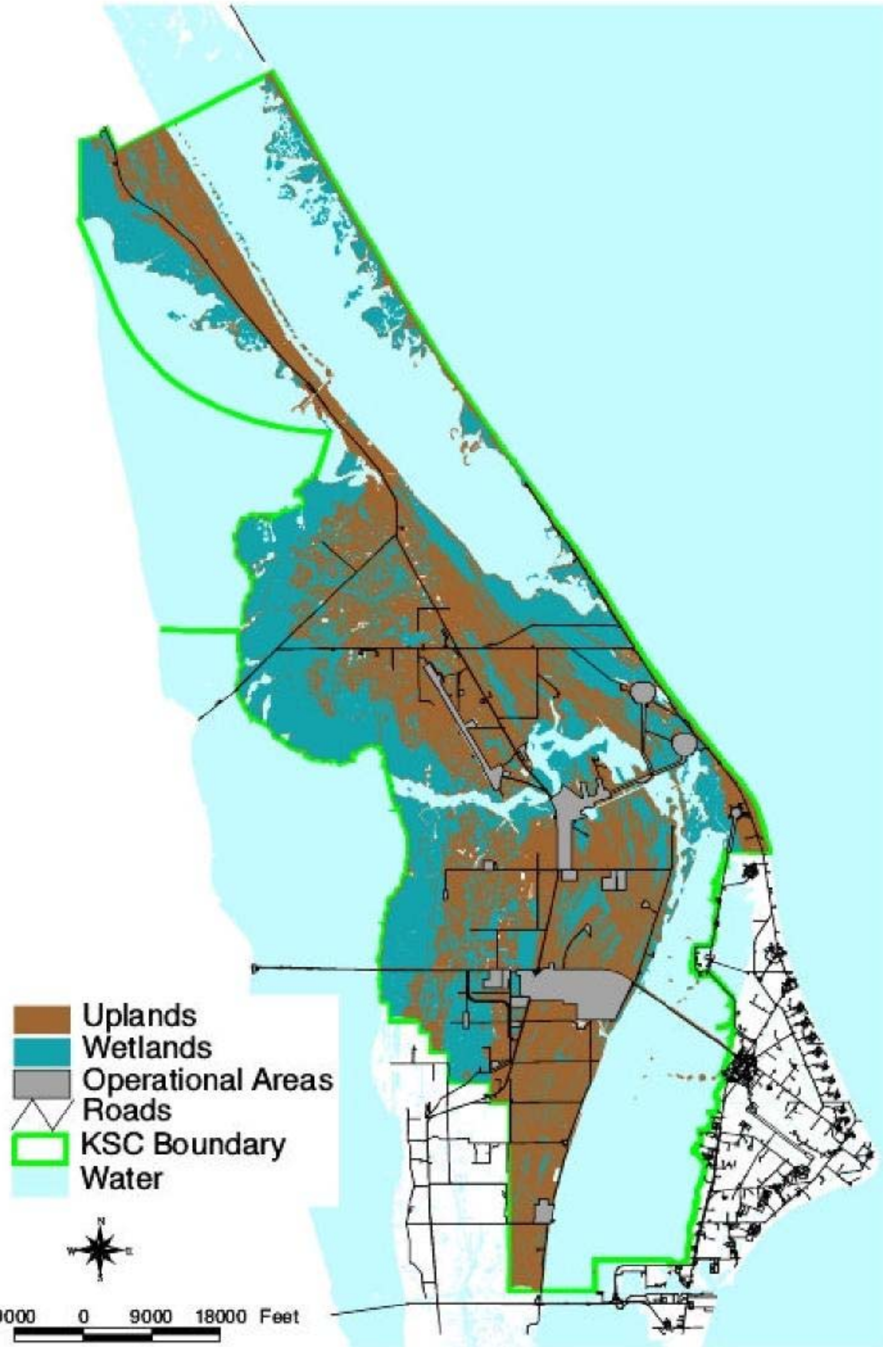

Figure 5-5. General Land Cover on KSC.

5.3.1 UPLAND VEGETATION

These are natural communities occurring on sites that are not flooded for extended periods. Minor areas of wetlands may be included in these mapping units. The types of habitats found in these areas include: scrub, flatwoods and hardwoods and mixed forests.

5.3.2 WETLAND VEGETATION

These are natural communities that occur on sites that are flooded for short to long periods in most years. Minor areas of uplands may be included in these mapping units. The types of habitats that are found in these areas include: freshwater marshes, hardwood and mixed swamps, wetlands shrub, saltwater marshes, and mangrove swamps.

5.4 LAND USE, MANAGEMENT, AND PLANNING

NASA exercises control over the 56,510 ha (139,639 ac), which comprise KSC. The overall land use categories and land management objectives of NASA and KSC are to maintain the nation's space mission operations while supporting alternative land uses which are in the nation's best interest. All zoning and land use planning is under NASA directive for implementation of the nation's space program. Land use at KSC is carefully planned and managed to provide required support for missions and to maximize protection of the environment. Essential safety zones, clearance areas, lines-of-sight, and other such elements have been developed as guides to master planning and, where applicable, as mandatory operational requirements. All facility sitings and projects are reviewed extensively with attention to items described in this section. For areas not directly utilized for NASA operations, land planning and management responsibilities have been delegated to the USFWS at MINWR and the National Park Service (NPS) (see Figure 5-5). These agencies exercise management control over agricultural, recreational, and environmental programs at KSC.

Impacts to wetland areas and scrub habitat as a result of development of facilities at KSC, often requires mitigation. In order to provide assurance that wetland and scrub mitigation areas are preserved, KSC is in the process of establishing a Conservation Area Layer in the KSC Master Planning Institutional GIS. This will ensure review and concurrence from all directorates and programs during the site plan review process and help to avoid any impacts to restored or constructed wetlands and Scrub-jay habitat.

5.4.1 LAND USE

KSC is dominated by undeveloped lands. Uplands, wetlands, mosquito control impoundments, and open water areas, comprise approximately 95 percent of the total KSC area (see Figure 5-6). Nearly 40 percent of KSC consists of open water areas of the Indian River Lagoon system including portions of the Indian River, the Banana River, Mosquito Lagoon and all of Banana Creek.

NASA maintains dedicated operational control over approximately 1,787 ha (4,415 ac) of KSC (Figure 5-6). The NASA operational areas contain currently developed facility sites, roads, lawns, and maintained right-of-ways. The remaining undeveloped operational areas are dedicated as safety zones around existing facilities or are held in reserve for planned and future expansion.

Developed facilities within the NASA operational area are dominated by the SLF, the Industrial Area and the VAB Area (Figure 5-6).

These facilities comprise more than 70 percent of the NASA operational area. The remainder of the NASA operational area is divided among smaller facilities spread throughout KSC.

The 54,723 ha (135,225 ac) outside of NASA operational control are managed by the NPS and the USFWS. The NPS administers a 2,693 ha (6,655 ac) area of the CNS, while the USFWS administers the remaining 52,030 ha (128,570 ac) of the CNS and the MINWR.

Major municipalities outside of, but near, KSC include the City of Titusville, which is approximately 9.5 mi from the KSC Industrial Area and the City of Cape Canaveral, which is approximately 8.5 mi from the KSC Industrial Area.

5.4.2 LAND USE CATEGORIES

NASA has devised land use categories to describe the regions within which various types of operational or support activities are conducted (Ref. 38).

5.4.2.1 Vertical Launch

Vertical launch includes all facilities and land area directly related to vertical launch operations, inclusive of launch pads 39A and 39B. It also includes immediately adjacent launch support facilities required to be operational at the time of launch. Quantity Distance

(QD) arcs, launch hazard impact limit lines, other safety setbacks, and exposure limits are considered restrictions on the use of land adjacent to the Vertical Launch area. Land within these QD arcs is not designated part of the vertical launch land use.

5.4.2.2 Horizontal Launch and Landing

Horizontal Launch and Landing includes pavements, infrastructure, facilities and land area directly related to horizontal launch and landing operations. Horizontal Launch and Landing includes all paved runway surfaces, aprons, or similar runway features primarily associated with the Shuttle Landing Facility. Imaginary surfaces related to airfield safety clearances consistent with FAA clearance criteria and requirements, Quantity Distance (QD) arcs, launch and landing hazard impact lines, other safety setbacks, and exposure limits are considered restrictions on the use of land in and adjacent to Horizontal Launch and Landing areas. Land covered by QD arcs is not designated as part of the Horizontal Launch and Landing land use classification.

5.4.2.3 Launch Operations and Support

Launch Operations and Support includes facilities and associated land areas essential to supporting a mission during launch and flight, including command, control and compilation, evaluation and communication of the data associated with launch vehicle activities. Storage of propellants and munitions is also included in this classification. QD arcs, other safety setback, and exposure limits are considered restrictions on the use of land adjacent to the Assembly, Testing and Processing Area.

5.4.2.4. Assembly, Testing and Processing

Assembly, Testing and Processing includes facilities, operations and land areas that are essential to space vehicle component assembly, integration and processing prior to launch. Laboratories, material support and interface testing to achieve final assembly, test and closeout to prepare and test payloads, space systems and systems components for flight and integration, which may include hazardous commodities, are also included in this clarification. Primary uses and facilities support both government and commercial capabilities for payload assembly, integration, and processing; the development and testing of launch vehicle or spacecraft equipment at the component or system level; post-flight servicing and refurbishment activities; and spaceport operations. Secondary uses and facilities include associated and compatible manufacturing, logistics, or technical support functions. QD arcs, other safety setback, and exposure limits are considered restrictions on the use of land adjacent to the Assembly, Testing and Processing Area. Land within these restricted areas is not designated as part of the Assembly, Testing and Processing land use.

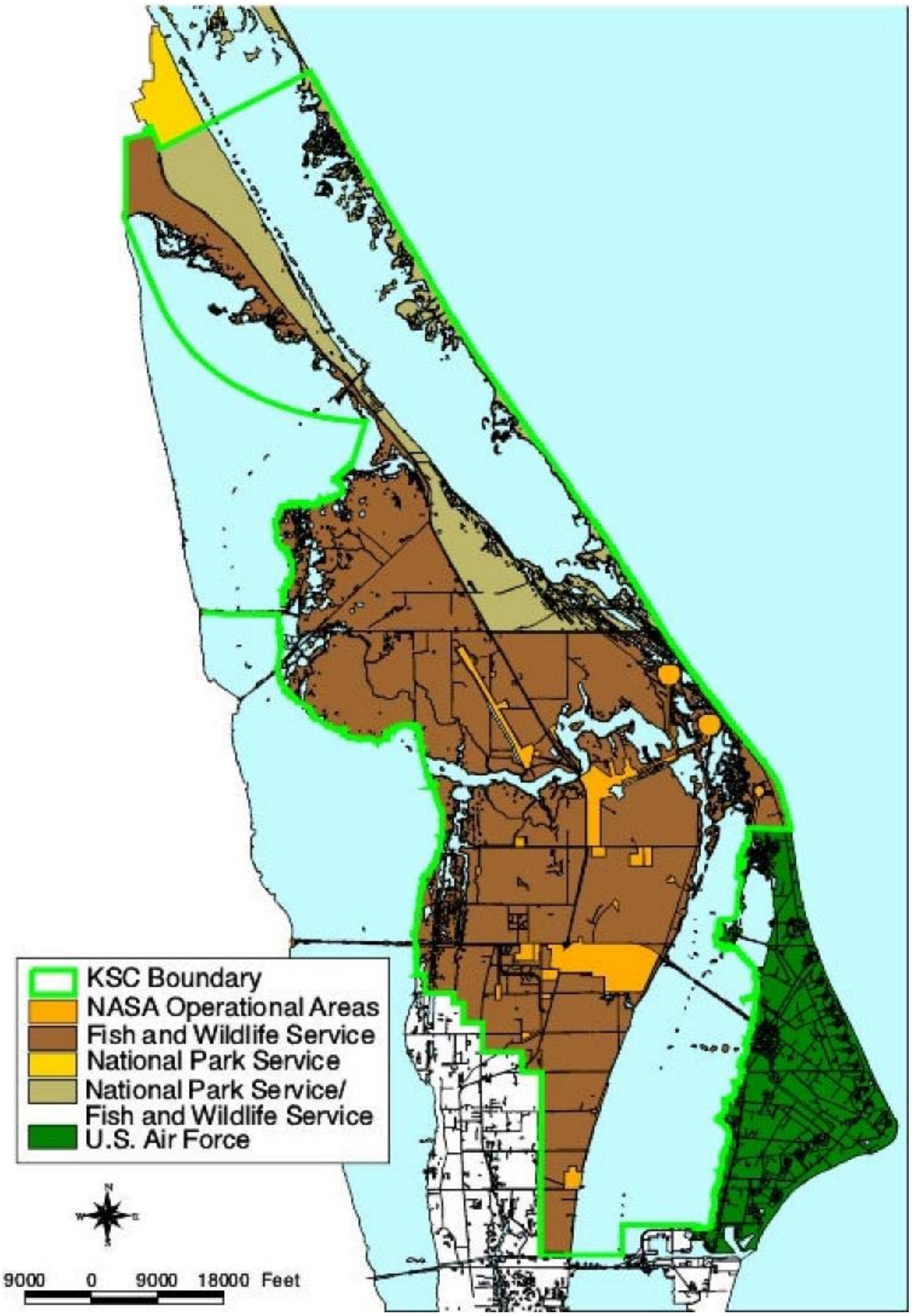

Figure 5-6. KSC Administrative Areas.

5.4.2.5 Utilities Systems

The Utilities Systems land use classification includes land and facilities associated with KSC utilities infrastructure and systems (e.g., water, wastewater, gas, electrical, chilled water, communications and sewer systems). Utility easements help to define patterns and impacts associated with the development of utility systems and the overall land use pattern.

5.4.2.6 Administration

Administration includes facilities supporting operations management and oversight activities. Administrative functions/uses associated with management are more focused in the Industrial area. A subset of administration applies to administrative functions that are adjacent to and in support of assembly, integration and processing operations.

5.4.2.7 Support Services

Support Services includes all functions other than administration that provide management and oversight of KSC operations and services provided for overall KSC benefit, including operations and maintenance. Operations and maintenance land uses include supply, storage, facilities maintenance, motor pool, service stations, railroad, reclamation areas, roads and grounds maintenance and sanitary landfill facilities. Service land uses include: access control and entry gates; fire protection facilities and training areas; security facilities and related training areas; child development and care; training and conference; dispensary; data processing; environmental and occupational health; food service and photo operations facilities.

5.4.2.8 Public Outreach

The Public Outreach land use classification includes facilities and associated land areas that promote an educational, research or informational connection between the community and KSC. Examples of Public Outreach use include public reception/welcome centers, tour facilities, display and education areas, museums, memorials, launch viewing areas, recreation areas and conference centers.

5.4.2.9 Recreation

Recreation areas include parks, outdoor fitness, athletic fields, recreation buildings, centers and clubs. Examples of recreation land uses include KARS Park and KARS Park II complex. Coastal beaches and supporting facilities are part of the Cape Canaveral National Seashore and are classified as Operational Buffer/Public Use. Camping, fishing, picnic and related outdoor activity areas associated with the Merritt Island National Wildlife Refuge are also classified as Operational Buffer/Public Use.

5.4.2.10 Research and Development

The Research and Development (R&D) land use classification includes non-program specific laboratories, related facilities and associated land areas that perform research, experimentation and testing in support of developing new technologies, procedures and products to enhance existing and future programs at KSC. Light industrial and manufacturing functions, as well as commercial uses may also be accommodated within R&D land use areas. Integration of educational institutions offering advanced degrees in disciplines supporting space-related research and development activities provide added enhancement and support reinforcing R&D collaboration between KSC, private industry and the educational community. Examples of R&D land uses include chemical, physical standards and laser testing laboratories; missile research and testing facilities; centers for experimentation; innovative science and technology; and life science activities accommodated in Exploration Park.

5.4.2.11 Seaport

The Seaport land use classification includes port, harbor, wharves, docks and associated land areas to accommodate delivery or embarkation of materials, equipment or people via access to the mainland through means of sea going vessels. Land areas contiguous to wharves and docks that are used for the staging, off-loading, transfer and storage / processing of materials, equipment or people are also classified as Seaport land use. Existing Seaport use includes waterside facilities adjacent to the existing turning basin near the Vehicle Assemble Building. The turn basin was originally built to allow barges to off load rocket vehicle stages where they were then rolled into the Vehicle Assembly Building for processing and stacking. The turning basin was also used to receive and off load the Space Shuttle's external tank.

5.4.2.12 Renewable Energy

Land areas identified to accommodate varying forms of renewable energy are designated Renewable Energy and comprise this land use. Corresponding to fallow agricultural land and other underutilized property, land areas designated as Renewable Energy also includes research and production, facilitating KSC’s goal for achieving increased on-site generation of its power from renewable sources. This includes current and future accommodation of solar array fields, as well as other emerging renewable energy technologies that may be developed in the future.

5.4.2.13 Operational Buffer

The Operational Buffer land use classification includes designated land areas intended to serve as operational safety and security buffers for space launch and landing activities, balanced with conserving KSC's natural environment. A majority of the Operational Buffer land area is either submerged, vulnerable to inundation by rising water (whether the result of storm event or climate change) or consists of high-value uplands habitat for species of critical concern, particularly the Florida scrub jay. Two sub-categories of Operational Buffer are designated:

<u>Operational Buffer/Public Use</u>
Operational Buffer/Public Use areas correspond to publicly accessible areas of Merritt Island National Wildlife Refuge and the Cape Canaveral National Seashore for recreational use in the northern portion of KSC, as a conditional use subject to the operational activities associated with KSC's mission.

<u>Operational Buffer/Conservation</u>
Operational Buffer/Conservation areas correspond to land areas in the southern portion of KSC that may never have been developed, or sites that may have reverted to a natural environment over the years. Development in Operational Buffer areas may include infrastructure, operations of low impact, or small footprint facilities that may be required for support of space launch or landing operations.

5.4.2.14 Open Space

The Open Space land use classification includes undeveloped open land, not designated as Operational Buffer, within existing land areas. Open Space land areas include existing land that is primarily cleared of natural vegetation, level, and/or located in or immediately adjacent to developed areas where future development may be anticipated. Areas of fallow orange groves are also designated as open space.

5.4.2.15 Industrial Area and Central Campus

Future development in the Industrial Area is characterized as redevelopment and enhancement of the Central Campus area, and expansion of Research and Development and Assembly, Testing and Processing functions. The Central Campus expansion is a means to consolidate NASA operations into a smaller more cost-effective operational footprint with uses to include predominately non-hazardous NASA operations in support of NASA missions and programs.

Facilities that will be relocated to Central Campus through recapitalization efforts are NASA facilities being utilized for Administration, R&D, and Support Services functions that have aging-related operational inefficiencies and excessive maintenance requirements whose relocation would support decreased operations and maintenance costs. Expanded payload processing functions will be accommodated in an expanded Assembly, Testing and Processing area. Additional land area is designated to accommodate expanded R&D activities in Exploration Park and other newly developed R&D areas adjacent to Central Campus.

5.4.3 SPECIFIC EASEMENTS AND RIGHTS-OF-WAY

Easements are provided to utility suppliers such as Florida Power and Light Company for power lines, and the right-of-way for AT&T communication cables. Others include the easement used until 1983 by Florida East Coast Railroad and easements for high pressure and natural gas lines. The Center has also granted easements for cellular communication towers to improve cell phone service.

5.4.4 SPECIFIC ZONES AND CLEARANCES

KSC has been zoned to protect personnel and facilities from launch hazards such as blast forces, acoustic pressures, radio frequency radiation, and laser beams. In addition, restrictions on the development and use of facilities are established based on required clearances for flight hazards, instrumentation lines-of-sight, instrumentation quiet zones, and security. Buildings and structures are sited to provide necessary safety distances. These safety zones or clearances are developed by considering constraints as discussed in the following subdivisions.

5.4.4.1 Radio Frequency Radiation

Radio frequency radiation is a hazard emanating from certain electronic apparatus and is evaluated by measurements taken from operational equipment. It is necessary to rely on separation distance for protection of the public and personnel assigned to work at KSC. This has resulted in the establishment of special radio frequency zones.

5.4.4.2 Blast Forces

Blast hazards are caused by explosion of launch vehicles or ordnance items. The resulting overpressures, expressed in Newtons per square centimeter (N/cm2), vary with distance from the point of explosion. These overpressures can cause damage to structures or other launch vehicles, depending upon their design and the distance separating them from the explosion. Although all blast overpressures are of concern, overpressures of most concern to Master Planning at KSC are regulated as: ordinary building overpressure limit, launch vehicle overpressure limit, and property overpressure limit.

5.4.4.5 Acoustic Pressures

Acoustic hazards are a result of sound pressure levels generated by high-thrust booster engines. Overall sound pressure levels of 120 and 135 decibels (dB) are the most important sound pressure levels considered in zoning. Damage to buildings of ordinary construction may occur at sound pressure levels of 135 dB, particularly at the lower frequencies. General support structures will normally be sited at distances to comply with this criterion, or they will be designed to suit the acoustic environment involved. Personnel without ear protection should not be exposed to overall sound pressure levels equaling or exceeding 120 dB (threshold of pain).

5.4.4.6 Toxic Vapors

Toxic vapors from the propellants used in space vehicles may be released into the atmosphere from vehicle explosions, equipment failure during fueling, or similar accidents. If this happens, people in the immediate and downwind areas from the accident will be exposed to toxic fumes. The maximum concentration of toxic fumes to which personnel may safely be exposed depends upon the propellant involved. Buildings not designed to protect occupants from toxic hazards will be evacuated during hazardous operations.

5.4.4.7 Lines-of-Sight

KSC has many transmitters, receivers, camera pads, and visual observation points that result in the requirements for lines-of-sight between various points. Several of these points are on CCAFS. Others are or could be placed on non-government property. Lines-of-sight from optical and electronic instrumentation are considered during the process of reviewing site plans. Special attention is paid to electronic line-of-sight requirements that may be complicated by structures causing multi path interferences even when they are outside the line-of-sight.

5.4.4.8 Quantity/Distance Radii

Quantity/Distances (Q/Ds) show radii for Intraline, Inhabited Buildings, and other related criteria. These Q/Ds are based on the greatest allowable amount of explosives, solid rocket motors, liquid propellants, or other hazardous materials that may be stored at a facility.

The radius distances are calculated from the formulas and tables in the Air Force Regulation 127-100. This regulation implements the Department of Defense Ammunition and Explosives Safety Standards outlined in DOD Directive 5154.4-S. These standards also agree with OSHA Standards 1910.109.

5.4.4.9 Airspace

The USAF and the Federal Aviation Administration (FAA) have designated special airspace zones over and around the SLF and the skid strip on CCAFS to ensure aircraft safety when landing or taking off. For increased safety, obstructions to flying units are also identified.

5.4.5 LAND USE PERMITS

Special land use permits are considered during review of facility siting requests. Both duration of permit and assignment of permit vary. Three examples of current special land use permits are KARS Park, USACE spoil site, and LC-39 press site. A permit has been obtained for a recreation area (KARS Park I and II) located on Center property. KSC personnel and their families use these parks. The USACE has a permit for a spoil area located on the north bank of the Barge Canal at the southern boundary of KSC. The Florida Inland Navigation District uses a spoil disposal area south of Schwartz Road. Many of the news media lease areas in the Press Site for news gathering and broadcasting facilities. Major media leaseholders include Associated Press (AP), American Broadcasting Company (ABC), Columbia Broadcasting System (CBS), National Broadcasting Company (NBC), Cable News Network (CNN), Spaceflight Now, and Nikon. Several newspaper organizations including Orlando Sentinel and Florida Today also use Press Site property.

The Center formed a partnership with the State of Florida to develop a 161 ha (400 ac), campus-like and ecologically friendly research park with a balanced mix of academic and commercial tenants. In order to take advantage of this established partnership, the Center constructed a 9,290 m^2 (100,000 ft^2) facility, the Space Life Sciences Lab containing state-of-the-art laboratories with the capability and systems necessary to host International Space Station experiment processing as well as life sciences and microgravity-related research. This research site, now known as Exploration Park, provides its tenants an opportunity to conduct research and develop new technologies and applications in close proximity to KSC and its launch sites.

Enhanced Use Leases (EUL) and Space Act Agreements allow NASA to recover asset values, reduce operating costs, improved facility conditions, and therefore improve mission effectiveness. NASA encourages the use of its property and facilities by other governmental agencies, commercial space and related industries, and universities. NASA-KSC and Florida Power and Light (FPL) have entered into an EUL for the purpose of developing and operating a photovoltaic facility to generate renewable energy for use and distribution by both parties. Phase 1 is a 30 year lease of 24 ha (60 ac) for construction/operation of a 10 MW facility, commissioned in April 2010. A second phase would be a lease option for 19 additional ha (48 ac) contingent upon an FPL proposal being accepted by NASA-KSC.

Other property agreements at KSC include one with Johnson Space Center for the processing of the Orion vehicle by Lockheed Martin for the SLS Program in the Neil Armstrong O&C High Bay. And Boeing, through Space Florida, has a 15 year lease agreement for OPF 3 for the manufacture and testing of the CST-100 spacecraft. A 20 year Commercial Space Launch Act agreement between NASA and Space Exploration Technologies (SpaceX) gives them access to LC 39A for processing and launch of their Falcon vehicles. A 15 year agreement with the USAF will allow continued development of their classified X-37B Program in OPF High Bays 1 and 2.

5.4.6 LAND USE AGREEMENTS

KSC has entered into agreements with the U.S. Department of the Interior regarding property management concerning MINWR and CNS.

KSC has an agreement with the FWS of the U.S. Department of the Interior to:

- Manage KSC property that is not used specifically for Space Program activities
- Manage KSC property that is not assigned to the NPS to manage as part of the CNS

This area, the MINWR, is managed by the FWS, which sponsors or directs many wildlife programs, administers the apiary permits, and regulates hunting, fishing, and non-consumptive public use activities. Land management directives are identified in the Comprehensive Conservation Plan prepared and periodically updated for the Refuge (Ref. 45).

A significant program, relative to NASA operations, is the fire management program administered by the USFWS, discussed in detail in Section 5.4.9. The fire management program controls vegetative fuel loads at KSC to reduce the potential of wildfires seriously damaging NASA facilities. A secondary management objective of controlled burning is to maintain and perpetuate scrub, slash pine forests and herbaceous wetlands for their habitat and wildlife values. Each year prior to burning, prescribed fire management plans are prepared which identify burn areas, provide site descriptions, burn objectives and burn parameters (Ref. 32). All site specific limitations to burning and smoke management considerations are addressed in the plan.

Mosquito control at KSC is jointly administered by the USFWS and the Brevard County Mosquito Control District (BCMCD). The USFWS maintains and operates approximately 75 mosquito control impoundments at KSC totaling 21,422 acres. The USFWS performs dike maintenance operations and regulates water elevations within the impoundments. The BCMCD retains the responsibility of monitoring mosquito populations at KSC and the spraying of mosquito larvicides and adulticides.

KSC has an agreement with the U.S. Department of the Interior for management of a part of the CNS by the NPS and a part by the FWS. The NPS administers a 6,655 acre area of the CNS including a 24-mile long beachfront (see Figure 2-3). Management functions include law enforcement, visitor access, and ecological projects. Among the most significant environmental programs initiated by the NPS are efforts to stabilize and protect dune vegetation, sea turtle protection, and exotic species eradication programs. The NPS has developed a Resource Management Plan, which summarizes the Service's immediate and long-term resource management objectives (Ref. 33).

5.4.7 COASTAL ZONE MANAGEMENT

Federal activity in a coastal zone requires preparation of a Coastal Zone Consistency Determination in accordance with the Coastal Zone Management Act (CZMA) of 1972 as implemented by NOAA through State coastal zone management offices. Any activities, which directly affect the State's coastal zone are subject to a determination of consistency with the State's Coastal Management Program (15 CFR 930.30-44). NASA and other federal agencies are required to review their activities with regard to direct effects on the coastal zone and are responsible for making the final coastal zone consistency determinations. Florida’s statewide coastal management program, executed by the FDEP, oversees activities occurring in or affecting the coastal zone and is based on a network of agencies implementing 24 statutes protecting coastal resources. The State of Florida’s coastal zone is the area encompassed by the entire state and its territorial seas.

The CZMA provides for management of our Nation’s coastal uses and resources. CZMA encourages coastal states to develop and implement comprehensive management programs that balance the need for coastal resource protection with the need for economic growth and development in the coastal zone. Once a management program is developed and approved by NOAA, the state is authorized to review certain federal activities affecting the land or water uses or natural resources of its coastal zone for consistency with the program. This authority is referred to as “federal consistency”. The Florida Coastal Management Program was approved by NOAA in 1981 and is codified in Chapter 380, Part II, F.S.

NASA activities at KSC, which are likely to require consistency determinations include:

- Any project subject to state or federal dredge and fill permitting review
- Any point or new non-point source discharge to surface waters
- Major industrial expansion or development projects

The review of consistency with the Coastal Zone Management Program is coordinated through the Florida State Clearinghouse. Because any action at KSC, which directly affects the coastal zone would also be subject to NEPA, consistency review is typically addressed in the NEPA documentation which is submitted to the Clearinghouse for review.

5.4.8 FLOODPLAIN AND WETLAND MANAGEMENT

In accordance with EO 11988 "Floodplain Management" and EO 11990 "Protection of Wetlands", KSC has established procedures and planning policies to minimize federal project and operations impacts on floodplain and wetland resources. Any NASA activity, including those which significantly impact floodplains or wetlands, is subject to NEPA documentation requirements. The requirement to prepare an Environmental Assessment (EA) ensures that all practicable alternatives to the proposed action have been reviewed and that all project impacts have been minimized to the extent possible. Preparation of an EA also invites outside agency review and comment on the proposed action.

The 100-year floodplain at KSC has been established by the Federal Emergency Management Agency (FEMA), which has published Flood Insurance Rate Maps (FIRM) for Brevard County. FEMA maps indicate the 100-year and 500-year floodplain, and serve as the baseline for floodplain delineation at KSC.

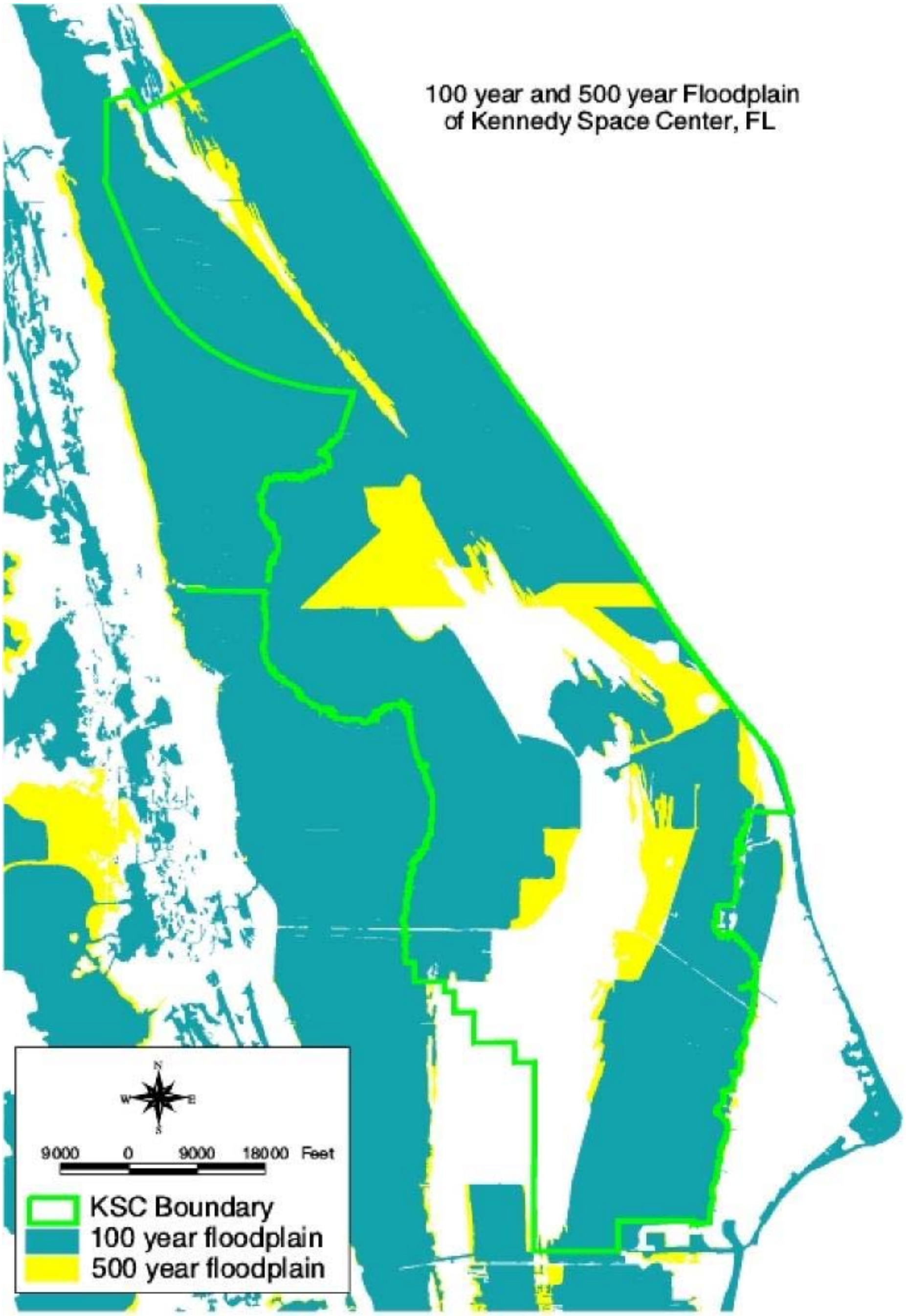

Figure 5-7. 100-Year and 500-Year Floodplain on Kennedy Space Center.

5.4.9 FIRE MANAGEMENT ON KSC/MINWR

5.4.9.1 General

Fire management on KSC is done under an Interagency Agreement with Merritt Island National Wildlife Refuge (MINWR). The history of fire management done by MINWR can be divided into three phases. The first phase lasted from 1963 to 1980. It was characterized by no comprehensive fire planning, very little prescribed fire, and few wildfire actions. In 1981, the KSC/MINWR experienced a severe fire season. During this year, almost 17,000 6880 ha (17,000 ac) were burned in wildfires, and two refuge employees were killed. This started the next stage in the development of fire management on the refuge that involved a concerted effort to upgrade the fire management program. Extensive training of fire personnel was done, and new fire equipment was purchased. Prescribed burning objectives during this time were directed primarily towards the reduction of hazardous fuels. During the last phase, from the early 1990's to the present, efforts were made to change the emphasis of prescribed fire. Instead of a single objective of fuel reduction management, using fire to modify and restore wildlife habitats became more important.

5.4.9.2 The Early Fire Years

Fire management began slowly on Merritt Island National Wildlife Refuge. Reporting of wildfires was spotty from 1975 until 1981, and the only documentation of prescribed burns was found in Refuge's annual narratives. The refuge's first formal Fire Management Plan was approved in 1979 (Ref. 34). Although simplistic by today's standards for fire management planning, it marks the change from a haphazard approach to fire to a more sophisticated decision making and planning process. Based on this plan, fire prescriptions for 20 burn units were developed in 1980.

5.4.9.3 The 1980-1981 Fire Season

There were dry conditions in 1980, and these continued into 1981. This led to a severe fire season with 41 wildfires burning a total of 6770.8 ha (16,731 ac). More importantly, the dry conditions, heavy fuel loads, less than satisfactory equipment, and lack of training led to two fatalities on the 8th of June 1981.

5.4.9.4 1982-1992

Beginning in 1982, efforts began in earnest to rectify some of the problems that led up to the catastrophe of 1981. Funds became available for the purchase of new equipment, firefighter positions, and training. A contract was let for a light helicopter with a bucket for suppression work. Prescribed burning objectives during this time period were directed towards reducing the heavy fuel loads on the refuge. Thirty-one Aerial Ignition Units were developed for the refuge, based on existing natural and manmade barriers. They ranged in size from 293 acres to 4,406 acres (118.6-1783.1 ha), and had a variety of vegetation types in each unit. In the years from 1982 through 1992, there were 113 prescribed burns averaging 1,334 acres (539.9 ha) each. Most of these burns were aerially ignited using a contract helicopter. During this same time period, KSC/MINWR had 214 wildfire suppression actions. These fires averaged only 6.7 acres (2.7 ha) in size. The contract helicopter was essential in managing these wildfires.

5.4.9.5 Ecological Burning

About 1990, the emphasis for prescribed burning began to change. Concern for habitat for threatened and endangered species, notably the Florida scrub jay (*Aphelocoma coerulescens)*, caused the objectives of burning to move from solely fuels reduction to habitat maintenance and enhancement. Prescribed burning, along with other vegetation management techniques, was used to improve scrub habitat quality (Ref. 35, 36, 37). Likewise, fire was used along with water management to improve the quality of wetlands. Many of the large burn units in the uplands were subdivided. Smaller burn units reduced the number of different kinds of vegetation in each unit, which gave Fire Managers the ability to tailor burns to meet specific habitat requirements. This also provided additional benefits including reduced smoke management problems. Currently, there are 141 units on KSC/MINWR for prescribed burning (Figure 5-8) including impoundments. These units range in size from 14 to 1,128 ha (35 to 2,787 ac).

Between 1993 and 2000, a total of 151 prescribed fires were conducted. The average size was 181.7 ha (449 ac) a significant reduction in area from the prescribed burns in the 1980s. Much of these burns were done to support a joint effort between the Refuge and Kennedy Space Center to restore overgrown Florida scrub-jay habitat. Money was provided by KSC for mechanical treatment of scrub. Refuge personnel did the actual treatment and the burning. Many of the scrub habitat burns were less than 40.5 ha (100 ac) and were concentrated in the areas that supported the three main jay population centers on the Refuge. Larger burns were done in other areas of the refuge to maintain habitat and manage hazardous fuels. Burning continued in the impoundments to enhance habitat for wading birds, shore birds, and migratory waterfowl. Currently, an average of 6070 to 8093 ha (15,000 to 20,000 ac) are burned each year on MINWR (G. Stratton, May 27, 2009, pers. comm.).

In 2011 an interdisciplinary group called the Fire Action Team was formed with members from NASA KSC, MINWR, CCAFS, NPS, and KSC's Ecological Program. The group's purpose was to advance the ecological benefit of fire management by combining credible scientific information and the application of specific fire treatments on the terrestrial landscapes of KSC/MINWR. Fire treatments begun in 2012 and the results of these treatments look favorable initially, but their effectiveness is being monitored (Ref. 39). The group's activities largely build on a wealth of recent scientific research focused on understanding natural and managed fire regimes and optimization of fire management for ecological benefit on KSC/MINWR (Ref. 40 - 44).

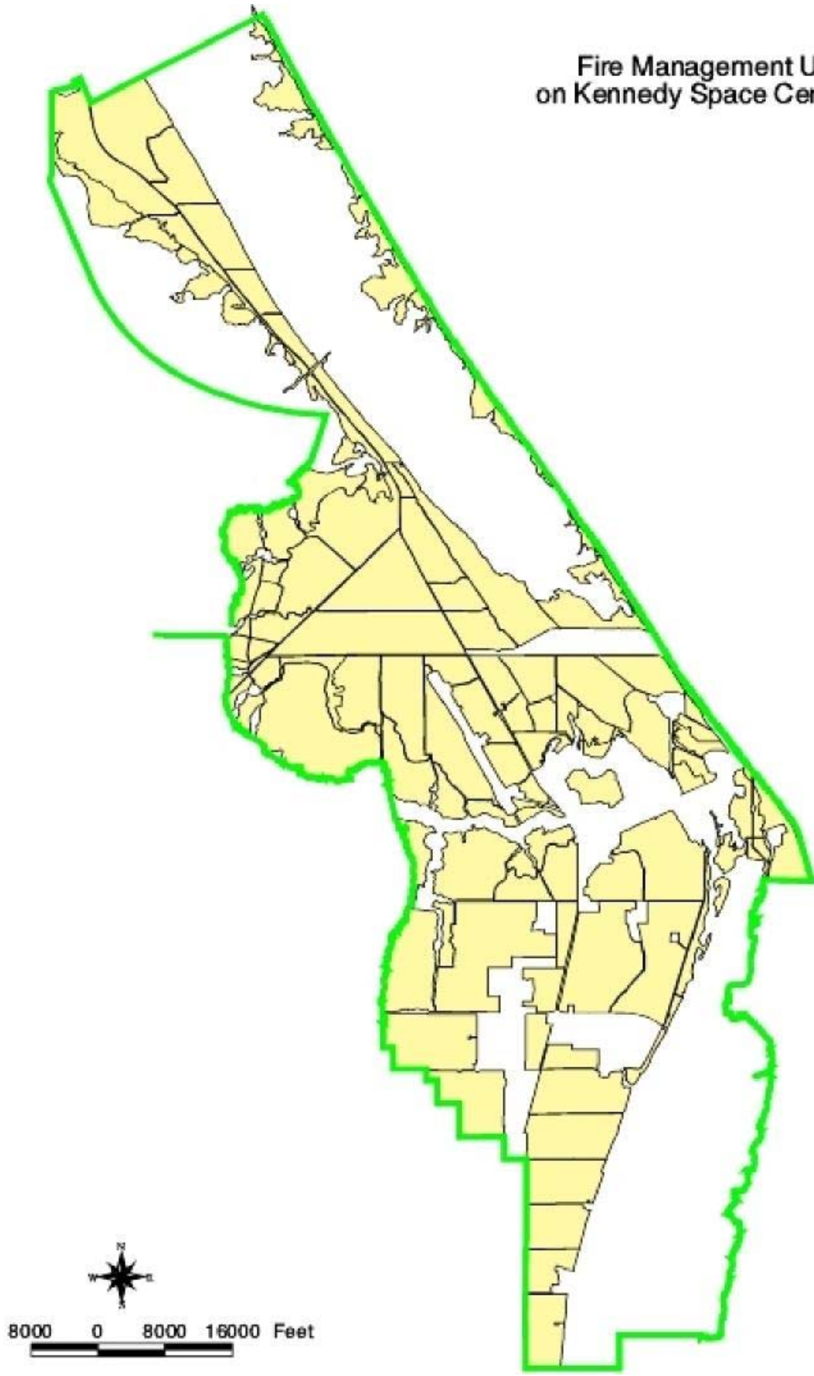

Figure 5-8. Fire Burn Units on MINWR.

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SECTION VI. NATURAL RESOURCES

6.1 GENERAL

KSC, which contains within its boundaries MINWR and most of CNS, is located on the northern part of Merritt Island on the east coast of central Florida (Figure 6-1) and consists of approximately 57,400 ha (142,000 acres) of land and lagoon waters.

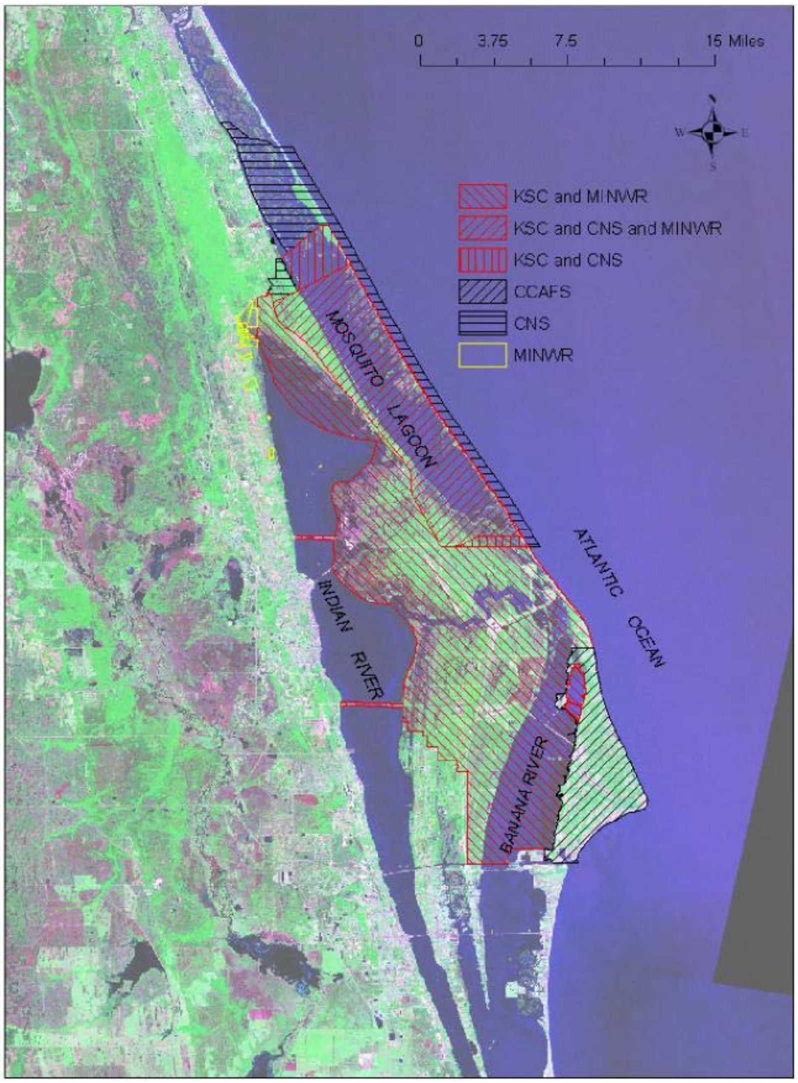

Figure 6-1. KSC and Neighboring Federal Administrations.

Merritt Island and the adjacent Cape Canaveral form a barrier island complex of Pleistocene and Recent Age (Ref. 1, 2). The topography is marked by a series of ridges and swales derived from relict dunes deposited as the barrier islands were formed. Erosion has reduced the western side of Merritt Island to a nearly level plain (Ref. 3). Elevation ranges from sea level to about 3 m (10 ft) in the inland areas and to 6 m (20 ft) on the recent dunes. Soils of the area have been derived primarily from deposits of sand and sandy coquina but vary greatly with landscape position, drainage, and age of parent material (Ref. 4, 5).

The designated Merritt Island land mass is bordered on the west by the Indian River, on the southeast by the Banana River and on the north by Mosquito Lagoon. This land mass has a maximum east-west width of about 11.3 km (7 mi.) and a north-south length of about 50 km (31 mi.), of which KSC occupies about 19.3 km (12 mi.). Merritt Island is composed of relict beach ridges on the eastern side of the island and thus the land surface is undulating. The troughs are near sea level, and the ridges rise to a maximum of about 3m (10 ft) above sea level. The western side of Merritt Island is a near-level land surface with an elevation of 1.2m (4 ft.) above sea level near the center of the island, to about 0.2m (0.5 ft.) above sea level at the Indian River shoreline. This plain is a result of erosional forces smoothing out the beach ridges as the Island's deposition progressed from west to east. Surface deposits on Merritt Island are of Pleistocene and Recent ages consisting primarily of sand and sandy coquina (a course grained, porous limestone composed principally of mollusk shell and coral fragments). Differences in landscape position, drainage, and age have produced a wide variety of soils (Ref. 5).

The surface drainage pattern of Merritt Island is multi-basinal. Surface drainage is typically internal, being trapped in the ponds, lakes, sloughs, burrows and man-made canals on the Island. External drainage is conducted primarily by man-made drainage systems (i.e., KSC Industrial Area to the Banana River via Buck Creek) and by way of grove management pumps to the Indian River. These drainage systems are most prevalent in the developed areas, and surrounding uplands adjacent to the bordering water bodies previously mentioned.

The adjacent Cape Canaveral is a barrier island about 7.2 km (4.5 mi) wide. The land surface of Cape Canaveral is typical coastal strand with a shoreline elevation at sea level and dune peaks up to about 3m (10 ft.) above sea level. Drainage of Cape Canaveral is typically internal with any external drainage discharging into the Banana River and the Atlantic Ocean.

6.2. REGULATORY OVERVIEW

6.2.1 FEDERAL PROGRAMS AND POLICIES ON UPLANDS

The USFWS has been given the responsibility of protecting wildlife habitat. There are no direct references to protecting uplands in the Endangered Species Act of 1973, although many species on this list do require uplands habitat. The regulation of uplands results from the regulation of habitat for protected animals and plants.

6.2.2 STATE REGULATION OF UPLANDS

The State Comprehensive Plan sets forth a goal of protecting and acquiring unique natural habitats and ecological systems such as uplands. Local comprehensive plans must be consistent with the State Comprehensive Plan. These comprehensive plans provide an outline for regulating habitats while land development regulations are the instruments, which require upland habitat preservation. As a federal property, KSC is excluded from coverage under these rules.

6.2.3 FEDERAL PROGRAMS AND POLICIES ON WETLANDS

Most wetlands are considered waters of the U.S. and are under the jurisdiction of the Clean Water Act (CWA). A number of federal agencies administer programs that can potentially affect wetlands and their likelihood for utilization. Six of these are briefly discussed below.

The USACE administers the Section 404 Dredge and Fill Permit Program of the CWA. The federal dredge and fill regulations are codified in 33 CFR 290.320. The program may be delegated to the states. Any action involving discharges of dredged or fill material in Waters of the U.S. including wetlands, requires a permit under Section 404 of the Clean Water Act (Section 4.1.1.3

The FDEP and Water Management Districts developed a streamlined ERP, which was adopted on July 1, 1994. This permit repealed the FDEP dredge and fill statute in Chapter 403, F.S. and incorporated it into Part IV, Chapter 373, F.S., Management and Storage of Surface Waters. This combined the FDEP and Water Management Districts' wetland permitting programs into one process (Section 4.1.1.3).

The USFWS has been delegated the responsibility of protecting wetlands and wildlife habitat. The USDI, which administers the USFWS, has been given responsibility to identify threatened and endangered species through the Endangered Species Act. A number of species protected by the Endangered Species Act are dependent on wetlands during some part of their life. The Act emphasizes the need to preserve critical habitats upon which protected species depend (Ref. 6).

EO 11990 was issued in May 1977 to emphasize the need for wetlands protection. Federal agencies are required to develop policies for enhancing wetlands protection and minimizing wetlands impacts. The EO suggested that federal assistance or financial support be withheld from any activity not in keeping with its goals. EO 11988 was issued to curtail developmental activities in floodplains. It is similar to the wetlands EO in its goals and means for obtaining those goals (Ref. 6). The Orders are codified for NASA in 14 CFR 1216.205. They are also incorporated into the NASA Management Directives System.

The EPA policy to protect the nation's wetlands issued in 1973 recognizes the inherent values of wetlands. The policy has four major elements:

(1) To evaluate a proposal's potential to degrade wetlands and preserve and protect them in decision processes.

(2) To minimize alterations and prevent violation of applicable water quality standards.

(3) In compliance with NEPA, withhold Construction Grants funds for municipal wastewater treatment facilities except where no other alternative of lesser environmental damage is found to be feasible.

(4) Advise applicants who install waste treatment facilities under a federal grant program or federal permit to select the most environmentally protective alternatives.

6.2.4 ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

Florida is divided into five water management districts to preserve and manage Florida’s precious water resources. The SJRWMD is responsible for managing groundwater and surface water resources in all or part of 18 counties in northeast and east central Florida, including KSC. Regulatory, planning and management programs are maintained by the SJRWMD and focus on water supply, flood protection, water quality and natural systems. The regulatory program includes stormwater management, consumptive use and wetlands protection. Briefly, the SJRWMD uses three indices to identify wetlands; 1) reliable hydrologic records, 2) vegetative index, and 3) soils index.

6.2.5 STATE REGULATION OF WETLANDS

The State Of Florida enacted a unified Wetland Delineation Rule, F. A. C. Chapter 62-340 on July 1, 1994 which replaced the previous rule under Chapter 17-340, FAC. The rule established a statewide unified methodology for the delineation of wetlands and surface waters. Wetlands are defined by the State as areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support and under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soils. Simply stated, the landward extent of wetlands is determined by three indicators: wetland vegetation, hydric soils, and presence of hydrologic indicators. Florida wetlands generally include swamps, marshes, bayheads, bogs, cypress domes and strands, sloughs, wet prairies, riverine swamps and marshes, hydric seepage slopes, tidal marshes, mangrove swamps, and other similar areas. Florida wetlands do not generally include longleaf (*Pinus palustris*) or slash (*Pinus elliotii*) pine flatwoods with an understory dominated by saw palmetto (*Serenoa repens*).

6.3 LAND COVER

The most recent land cover map for KSC is based on high-resolution imagery acquired during November 2010 with additional source data including imagery acquired during February of 2007 and February of 2009, planimetrics from KSC Master Planning, and light detection and ranging data acquired 2007 (LIDAR) for ground elevations and height profiles. The classification scheme is partly derived from the Florida Land Use, Cover and Forms Classification System (FLUCCS) (Ref. 7) with site specific descriptions of class composition from Schmalzer and Hinkle (Ref. 8). The land cover map does not identify features (e.g., wetlands) at a scale suitable for jurisdictional delineation or mitigation assessments for permitting. The total land cover area defined in Figure 6- 2 is 901 ha (2226 ac) larger than the area inside the KSC boundary as described in Section 5.4. This difference is comprised of contiguous brackish and estuarine aquatic habitats that are under management jurisdiction of the USFWS at MINWR.

6.3.1 LAND COVER CATEGORIES

The 2010 land cover map identifies 37 cover types on KSC (Figure 6-2 and Table 6-1). Types 1 through 19 are found in upland areas. Types 20 through 31 are wetlands and open waters.

6.3.1.1 Upland Cover Types

These types are natural communities occurring on sites that are not flooded for extended periods. Minor areas of wetlands may be included in these mapping units.

KSC infrastructure includes:

1. Infrastructure - primary = structures and all paved surfaces.
2. Infrastructure - secondary = unpaved roads, parking and staging areas.
3. Natural uplands devoid of vegetation include:
4. Beach = Zone of sparse or no vegetation between the ocean and coastal dune.
5. Disturbed areas with exotic/invasive vegetation include:

6. Ruderal - herbaceous = Herbaceous areas with sparse and/or widely scattered woody vegetation and/or bare soil that is often the result of disturbance.
7. Ruderal - herbaceous with trees = Mowed grass with scattered trees.
8. Citrus = Includes orange and grapefruit groves.
9. Citrus to Brazilian pepper = Citrus groves that are transitioning to Brazilian pepper.
10. Ruderal - woody = Disturbed areas of dense woody vegetation generally with a closed canopy but may be mixed with ruderal - herbaceous. The dominant vegetation is often Brazilian pepper but may include willow, wax myrtle, and vines (i.e.: grape vine, green briar). Mangroves may occur along the inundated edge of levees (classified as ruderal - woody).
11. Ruderal_herbaceous/woody mix = Mixture of ruderal herbaceous and ruderal woody vegetation.
12. Brazilian pepper = Dense stands of Brazilian pepper. Generally occurs where native vegetation has been removed or disturbed.
13. Australian pine = Australian pine is a hardwood. Its name is derived from its needle-like leaves and its characteristic cone shaped crown structure. Australian pine was introduced to Florida from Australia and occurs on disturbed sites, forming dense thickets. Used to form wind breaks and area extent may be linear in configuration. Generally more than 5m tall, with interlocking canopy.
14. Upland scrub and pine flatwoods includes:
15. Coastal strand = Includes saw palmetto, sea grape and other species.
16. Oak scrub = Includes scrub oak species (i.e.: sand live oak, myrtle oak, Chapman oak), with scattered saw palmetto, wax myrtle, gallberry, lyonias, other shrub and brush species, intermixed with various types of herbs and grasses. Generally less than 5m tall, with interlocking canopy but may also contain small areas with little or no vegetation.
17. Planted oak scrub = Planted oak scrub – see oak scrub above.
18. Scrubby flatwoods = oak scrub with scattered pine trees, primarily slash pine.
19. Palmetto scrub = Includes saw palmetto, wax myrtle, gallberry, lyonias, other shrub and brush species, intermixed with various types of herbs and grasses. Generally less than 5m tall, with interlocking canopy but may also contain small areas with little or no vegetation.
20. Pine flatwoods = Palmetto scrub with scattered pine trees, primarily slash pine.

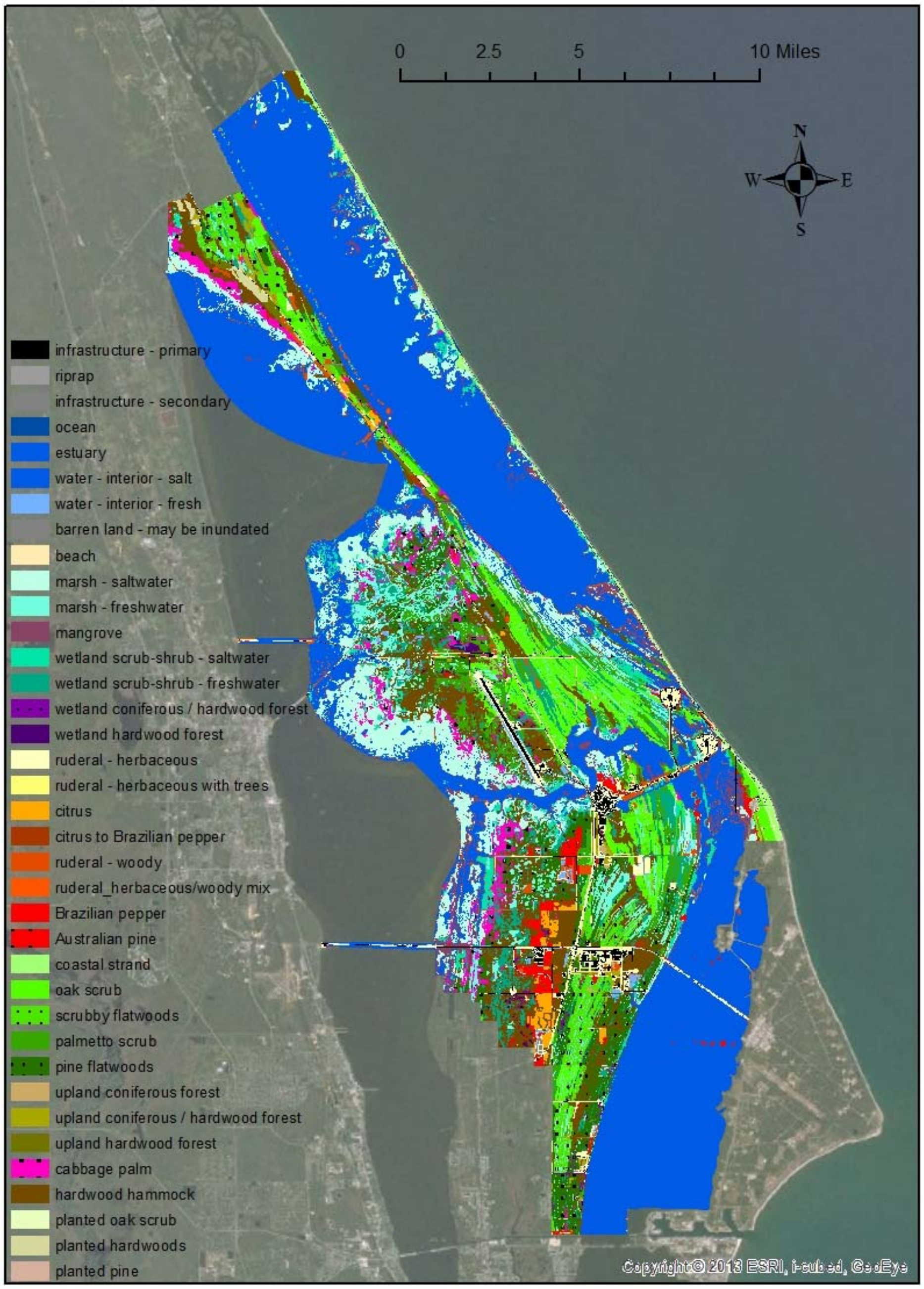

Figure 6-2. Land Cover Types within KSC during 2010.

Table 6-1. Land Cover Types within KSC.

Community	Land Cover Class	Hectares	Acres
upland	infrastructure - primary	614.79	1,519.1
upland	infrastructure - secondary	195.66	483.49
	infrastructure	810.45	2,002.6
upland	beach	61.46	151.86
	natural uplands devoid of vegetation	61.46	151.86
upland	ruderal - herbaceous	1,496.16	3,697.1
upland	ruderal - herbaceous with trees	7.85	19.41
upland	ruderal - herbaceous/woody mix	13.96	34.49
upland	ruderal - woody	689.97	1,704.9
upland	citrus	310.66	767.67
upland	citrus to Brazilian pepper	50.75	125.39
upland	Brazilian pepper	572.83	1,415.4
upland	Australian pine	41.05	101.42
	disturbed areas with exotic/invasive vegetation	3,183.23	7,865.9
upland	coastal strand	412.76	1,019.9
upland	oak scrub	2,637.50	6,517.4
upland	scrubby flatwoods	1,395.17	3,447.5
upland	palmetto scrub	1,856.77	4,588.1
upland	pine flatwoods	2,537.11	6,269.3
upland	planted oak scrub	9.83	24.28
	upland scrub	8,849.14	21,866.
upland	upland coniferous forest	46.93	115.97
upland	upland coniferous / hardwood forest	325.55	804.45
upland	upland hardwood forest	128.72	318.08
upland	hardwood hammock	4,847.18	11,977.
upland	planted hardwoods	125.67	310.53
upland	planted pine	10.14	25.06
	upland forest	5,484.20	13,551.
wetland	ocean	80.77	199.60
wetland	estuary	22,377.09	55,294.
wetland	riprap	2.08	5.13
wetland	water - interior - salt	3,394.09	8,386.9
wetland	water - interior - fresh	367.01	906.91
wetland	barren land - may be inundated	108.82	268.90
wetland	marsh - saltwater	4,585.84	11,331.
wetland	marsh - freshwater	1,936.61	4,785.4
wetland	mangrove	1,216.41	3,005.8
wetland	wetland scrub-shrub - saltwater	1,384.88	3,422.1

Table 6-1. Land Cover Types within KSC (cont.).

Wetland	wetland scrub-shrub - freshwater	2,066.36	5,106.0
wetland	wetland coniferous / hardwood forest	78.66	194.38
wetland	wetland hardwood forest	92.41	228.36
	cabbage palm	1,317.15	3,254.7
	wetland - water, marsh, shrub, forest	39,008.19	96,391.
	TOTAL	57,396.66	141,830

Upland forest includes:

21. Upland coniferous forest = Dense stands of slash pines (some planted), generally greater than 5 m tall with interlocking canopy. May contain an upland scrub sub-canopy.
22. Upland coniferous / hardwood forest = Contains tall oaks and pine trees generally greater than 5 m tall with interlocking canopy. Composition may include redbay, laurel cherry, and cabbage palm.
23. Upland hardwood forest = Contains tall oaks generally greater than 5 m with interlocking canopy and an understory that includes saw palmetto. Composition may include red bay, slash pines, laurel cherry, and cabbage palm.
24. Cabbage palm = A forest community predominantly cabbage palm and is commonly found as hammock communities on shallow rises within wetland communities generally greater than 5 m with interlocking canopy.
25. Hardwood hammock = A forest community commonly found on shallow rises within wetland communities. Greater than 5 m with interlocking canopy and predominantly composed of Virginia live oak with laurel oak, cabbage palm, and American elm.
26. Planted oak scrub = Planted oak scrub - oak scrub above.
27. Planted hardwood = Planted hardwoods - see upland hardwood forest above.
28. Planted pine = Planted slash pines.

6.3.1.2 Wetland Cover Types

These types are natural communities that occur on sites that are flooded for short to long periods in most years. Minor areas of uplands may be included in these mapping units.

Wetlands – estuary, marsh, shrub, forest includes:

29. Estuary = Includes the Indian River, Banana River, Mosquito Lagoon, Banana Creek, and connected navigable waters. Does not include waters that may be connected via underground culverts.
30. Water - interior - salt = Waters surrounded by levees that may be connected to estuarine waters via underground culverts and other more isolated waters that are salt or brackish.

31. Water - interior - fresh = Isolated waters and drainage areas, some may be inundated for only brief periods.
32. Barren land - may be inundated = Lowland areas devoid of vegetation that may be periodically inundated – occurs in salt water zones only.
33. Marsh - saltwater = Herbaceous wetlands that includes impounded and non-impounded systems. Species composition includes sand cord grass, black rush, salt-tolerant grasses (including salt grass, seashore paspalum, and seashore drop seed), and other species.
34. Marsh - freshwater = Herbaceous wetlands that include beard grass, sand cord grass, saw grass, cattail, and other species.
35. Mangrove = Includes white mangrove, black mangrove, red mangrove, and buttonwood. Woody vegetation along levees (classified as ruderal - woody) may contain mangroves along the inundated edge mixed with Brazilian pepper.
36. Wetland scrub - shrub - saltwater = Vegetation composition consists of low height, generally less than 5m, woody species including sea oxeye, saltwort, glasswort, and other species.
37. Wetland scrub - shrub - freshwater = Vegetation composition consists of low height, generally less than 5m, woody species including Carolina willow intermixed with other species.
38. Wetland coniferous / hardwood forest = Mix of conifers, primarily slash pines, and assorted hardwood trees including laurel oak, Virginia live oak, cabbage palm, red maple, American elm, and bay; generally greater than 5m tall, with interlocking canopy.
39. Wetland hardwood forest = Hardwood trees including red maple, American elm, laurel oak, live oak, cabbage palm, and bay, generally greater than 5m tall, with interlocking canopy.
40. Cabbage palm = A forest community predominantly cabbage palm and is commonly found as hammock communities on shallow rises within wetland communities generally greater than 5m with interlocking canopy.
41. Hardwood hammock = A forest community commonly found on shallow rises within wetland communities. Greater than 5m with interlocking canopy and predominantly composed of Virginia live oak with laurel oak, cabbage palm, and American elm.
42. Riprap = rock and other materials used as armor to reduce erosion.
43. Ocean = Atlantic Ocean – ocean occurs because of erosion within the KSC boundary.

6.4 IMPOUNDED WETLANDS

On KSC the vast majority of the estuarine wetlands have been impounded for mosquito control and isolated from the estuary since the late 1950s and 1960s (Figure 6-3). Salt marsh mosquitoes (*Aedes* sp.) need moist exposed substrate for oviposition sites and then flooding to produce a brood. The intertidal shorelines and tidal wetlands and marshes along the Indian River lagoon system (including the Banana River, and Mosquito Lagoon) are ideal for mosquito production. These conditions are present throughout the year with peak conditions occurring during the summer wet season, May-September (Ref. 11, 12, 13).

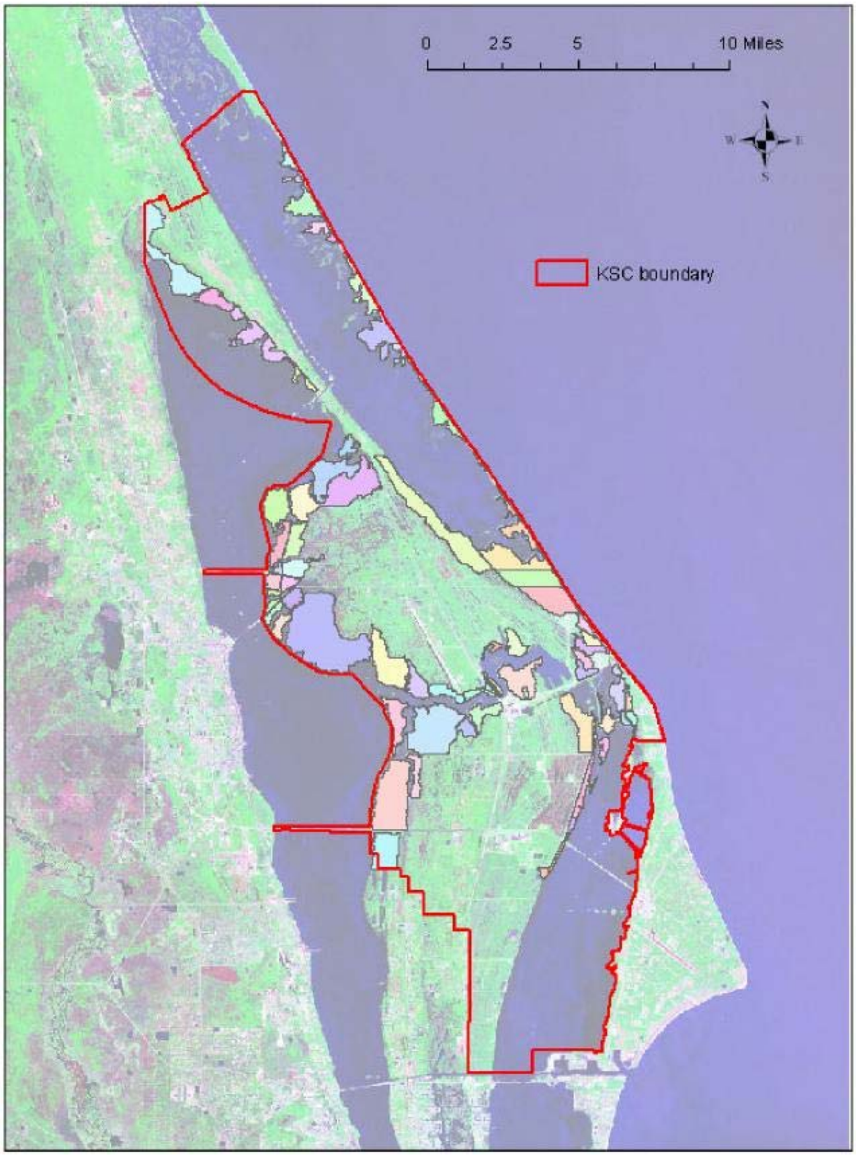

Figure 6-3. Impounded Wetlands within KSC.

To control the salt marsh mosquitoes, managers can use chemical agents (pesticides) or use a biological control to interrupt part of the mosquito's life cycle. The portion of the life cycle easiest to interrupt is the oviposition site. This can be accomplished by either drying out or keeping dry the exposed moist substrate needed for oviposition or by keeping this substrate flooded. In the 1950-1960s, mosquito control managers set about to control mosquitoes by interrupting the oviposition portion of the life cycle. To achieve this goal, the wetlands and exposed intertidal areas along the coastal and estuarine shorelines were impounded. This was done by digging steep ditches and using the excavated soil to build earthen dikes around the marshes. These areas were then flooded. This worked well for controlling mosquitoes (Ref. 11-13); however, it removed not only tidal access, but any type of water connection between the estuary and the wetlands. These habitats that were once accessible to fish and macro-crustaceans were removed from the ecosystem which was changed dramatically (Ref. 14-19).

Beginning in the early 1980s the SJRWMD refocused their efforts into restoring these impounded saltmarshes in an attempt to regain those habitats for both fish and bird use. The impoundment method of mosquito control had been effective in reducing the mosquito populations but at the same time, radically altered the saltmarsh habitat. Hypersaline and hyposaline conditions diminished saltmarsh vegetation, freshwater input altered the saltmarsh habitat into freshwater marsh and scrub-shrub habitats. Efforts now are focused on restoring these marshes and introducing normal connections to the Indian River Lagoon, primarily through water control structures.

The initial restoration efforts focused on reconnecting impoundments using culverts placed in the dikes. This provided the flexibility to use these culverts to control water levels in the marshes if needed. The culverts had flap gates installed which allowed water to enter and exit the marsh, but could be closed if mosquito breeding increased. This method proved to allow better flushing of the marsh and allowed limited access to the marshes by fish. It became evident that keeping these culverts open did not create the mosquito populations that were expected. And it helped restore a more natural water quality condition in the marsh. However, this impoundment reconnection method limited aquatic organism access to the marsh at the culvert locations only.

Follow-on restoration efforts involved complete removal of the dikes in a subset of impoundment marshes on KSC. This was accomplished by placing the fill material that had been dredged from the interior of the marsh, back into the perimeter ditch and leveling the dike areas down to existing marsh elevation. This allowed for natural inundation of the marsh. This method of marsh restoration has shown to be successful in both restoring natural hydrology to the marsh, as well as allowing natural recruitment of native saltmarsh vegetation, fish and wading bird populations.

Over the past twenty years, NASA and the USFWS have reconnected over 7,031 ha (17,376 ac) of impoundments and restored over 972 ha (2,403 ac) of impoundments.

6.5 SEAGRASS

During the last thirty years, attention has focused on the role of seagrasses in ecosystem productivity and the associated documentation of human influence on the worldwide decline in abundance and distribution (Ref. 20, 21). Numerous recreational and commercial fish that are found offshore spawn and grow in shallow seagrass beds in the IRL system. Seagrasses and submerged aquatic vegetation (SAV) are currently considered the ecological foundation of the IRL (Ref. 22).

The decline of SAV in various estuaries has been attributed to increases in stormwater runoff associated with urbanization of watersheds, industrial discharges, agricultural herbicides, increased nutrient loads, suspended, sediments, and other noxious discharges. Any factor that negatively influences the underwater light field has the potential to causes a major effect on production, biomass, and morphology (Ref. 22, 23). Seagrass beds are found in varying sizes along the IRL shoreline (Figure 6-4) and KSC has been known to support vast acreages of seagrasses and SAV within its boundaries.

KSC began supporting baseline ecological studies in the 1970s in preparation for the Space Transportation System (STS) EIS and operations. In 1983, Brevard County and KSC began a cooperative project to set up transects in various seagrass beds that would provide ground truth sites to coordinate with aerial photography. These sites became the KSC Long-Term Seagrass Monitoring Program which has continuously collected data since 1983 to the present. Additional sites were added in 1994 as part of the cooperative and lagoon-wide, Indian River Lagoon Seagrass Monitoring Network established by SJRWMD (Ref. 84). The objective for all of these programs was to create a baseline dataset from each transect to provide descriptive information regarding species composition, percent cover, and frequency of occurrence. Collected over the long-term, these data provide a benchmark that has been and continues to be used by researchers and managers in comparing patterns observed elsewhere in the lagoon and determining if these are site specific or regional trends (Ref. 35).

There are seven seagrass species with distributions that vary along the north-south axis of the IRL. All seven species occur in the southern third (Ref. 24). Three of the seven (*Thalassia testudinum* and *Halophila johnsonii*, and *Halophila dicipiens*) are not found in the northern IRL including KSC, where *Halodule wrightii*, *Syringodium filiforme*, *Ruppia maritima*, and *Halophila engelmannii* do occur.

Assessments of long-term trends of seagrass beds in waters of KSC, using aerial photography from the 1940s through 2011 suggest little or no change in bed distributions (Figure 6.4). An in depth analyses of KSC data collected between 1983 and 1996 evaluated local trends in more detail. These analyses included 8,150 samples collected along 37 transects (Ref. 34). Four seagrass species and one attached algae are typically the most commonly occurring submerged aquatic vegetation in KSC waters. The overall frequency of occurrence for each species, indicated the following dominance: *Halodule wrightii* (71.9%), *Ruppia maritima* (23.7%), *Syringodium filiforme* (9.4%), *Halophila engelmannii* (2.3%) and *Caulerpa prolifera* (5.4%). *H. wrightii* and *R. maritima* are represented on most transects. Primary production and habitat/species interactions research has been predominantly conducted in the southern part of the lagoon (Ref. 24-26).

The seagrass beds in Mosquito Lagoon provide direct forage for marine turtles (*Chelonia mydas*) and manatees (*Trichechus manatus*). The Banana River portion of KSC provides habitat for large numbers of manatees (Ref. 27, 28) and sea turtles are also observed there (Ref. 124). Several studies have begun to explore the relationships between this large herbivore and its seagrass forage (Ref. 29-33).

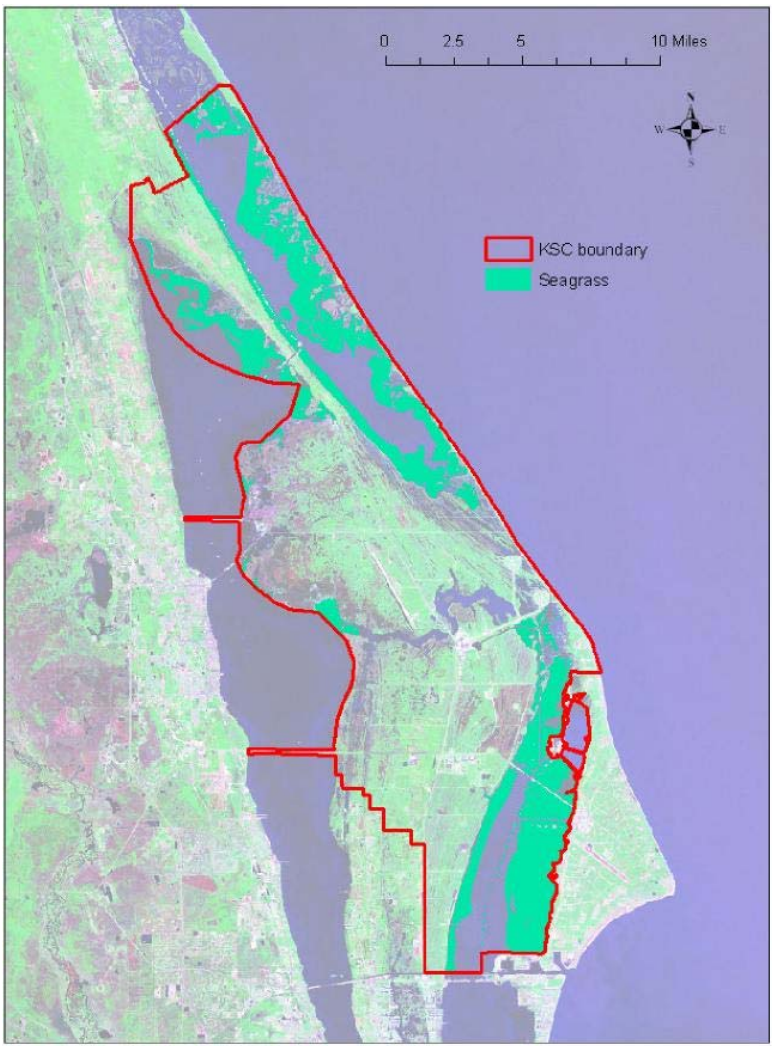

Figure 6-4. Typical Distribution of Seagrass Beds (dark green) within the Waters of KSC Prior to 2011.

In 2011, water quality in the waters surrounding KSC were impacted by the presence of two large and persistent algal blooms in the area. The first bloom consisted mostly of an unidentified chloro-microflagellate which occurred from early spring through late fall of 2011 (Ref. 125). This bloom covered a large portion of the northern Indian River Lagoon basin, mainly the IRL proper and Banana River, including the waters surrounding KSC. The second large bloom, consisted mostly of a "Brown Tide" pelagophyte species, occurred during the summer of 2012 (T. Rice/SJRWMD, 2012, pers. comm.). Unlike the bloom of 2011, which began in the Banana River Lagoon before spreading to the northern IRL and Mosquito Lagoon, the 2012 bloom started in the southern Mosquito Lagoon in July then spread into the northern IRL. These blooms resulted in an unprecedented decline in water clarity and overall quality that negatively impacted seagrass growth and distribution in sections of the Indian and Banana Rivers (Figure 6.5). Losses in the Mosquito Lagoon ranged from minor to no change in most areas. The marked decline of seagrass during this bloom was documented at both KSC and SJRWMD long-term seagrass sites (L. Morris/SJRWMD, 2012, pers. comm.). In 2013 and 2014 seagrass beds within KSC and other nearby waters showed strong recovery, particularly in Banana River where beds appeared nearly decimated in the previous two years. The seagrass beds at the extreme northern end of the Banana River near the LC 39 Area were still extremely sparse in 2014.

Seagrass is also now a monitored indicator organism for compliance with Clean Water Act numeric nutrient criteria. In implementing numeric criteria for nutrients, FDEP has adopted a Total Maximum Daily Load (TMDL) system for the Indian River, Banana River and Mosquito Lagoons that uses seagrass as the standard for compliance. Under this system, compliance with nutrient criteria is met if seagrass meets a predetermined "deep edge" growth requirement. Models developed by SJRWMD and FDEP relate nutrient levels in the Lagoons to water clarity and hence to seagrass growth at depth. Monitoring occurs by aerial mapping every third year and compliance is based on results of aerial maps which are compared to field transect surveys described previously. Allocations of nutrient reduction goals are made every fifth year of the 15 year Basin Action Management Plan (BMAP) for each Lagoon segment until deep edge seagrass cover goals are met.

6.6 ELEVATION

A digital elevation model (DEM) was constructed for the KSC region based on LIDAR for KSC and CCAFS topography, soundings within the IRL collected by SJRWMD, and oceanographic soundings provided by NOAA (Figure 6-5). KSC includes a central ridge with a gradual decline in elevation approaching the IRL. The IRL within KSC is generally no more than 3 meters deep with the exception of areas dredged for the Intracoastal Waterway in the Indian River and Mosquito Lagoon and passage channels for movement of space program assets in the Banana River. Oceanic shoal formations are conspicuous primarily off of False

Cape and Cape Canaveral.

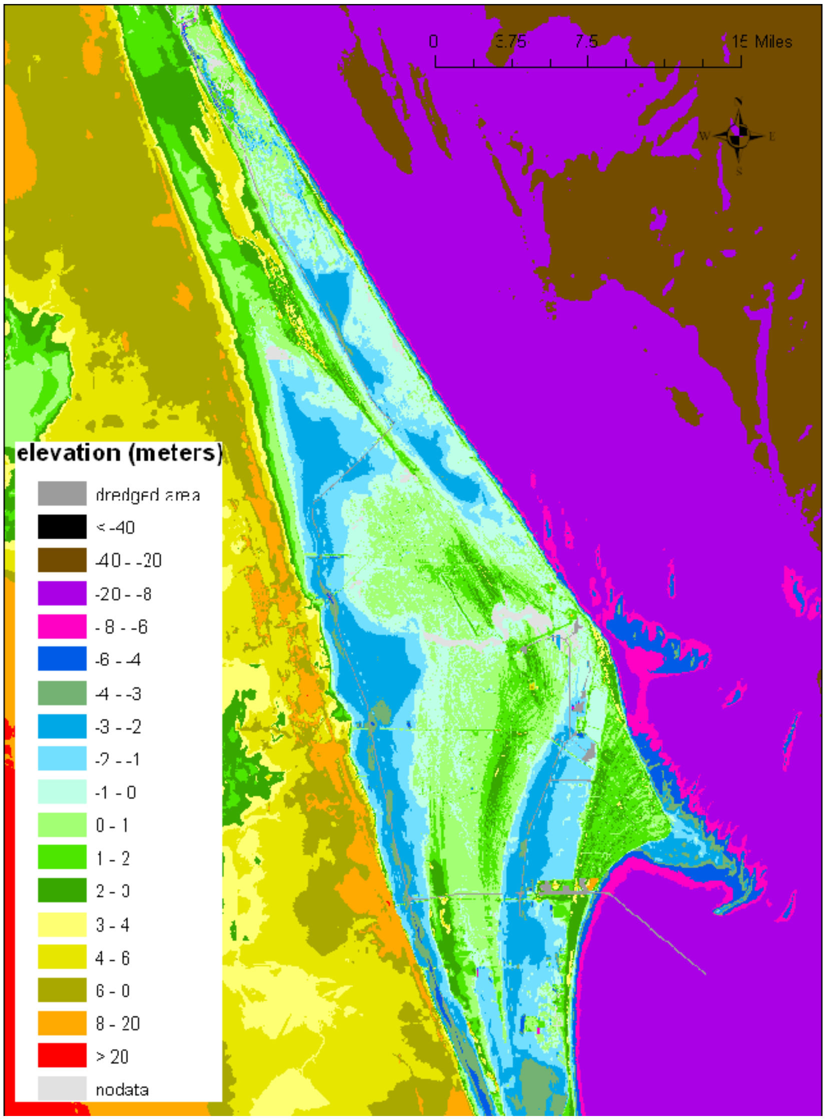

Figure 6-5. Elevations of the KSC Region.

6.7 FLORA

The vascular flora of the KSC area was first studied in the 1970s (Ref. 36, 37). The first study of threatened and endangered plants was conducted in 1981 (Ref. 38). Subsequent nomenclatural and taxonomic changes (Ref. 39) and additional collections required revision of this species list (Ref. 40). Further changes in taxonomy and nomenclature (Ref. 41, 42-45) and new collections and studies required additional revision to the list (Ref. 46).

An extensive floristic study of Canaveral National Seashore (Ref. 47) and several surveys for rare plants (Ref. 48-51) have now been conducted. There have been additional changes in taxonomy and nomenclature (Ref. 52-61, 126-128). This has required further revision of the floristic list for Kennedy Space Center-Merritt Island National Wildlife Refuge and adjoining federal properties (CNS, CCAFS).

The revised list (Appendix D, Table D-1) includes 1133 taxa of which 883 are native and 250 are introduced. This total appears to be a substantial proportion of the regional flora. Fifty-eight taxa (Appendix D, Table D-2) are endemic or nearly endemic to Florida (Ref. 62, 126), a level of endemism that appears high for the east coast of central Florida. Of the 250 introduced plants, 37 are Category I invasive exotics and 29 are Category II invasive exotics (Ref. 63) (Appendix D, Table D-3). The bryophyte flora of the KSC area includes 23 mosses and 20 liverworts and hornworts (Ref. 64) (Appendix D, Table D-4). The lichen flora is currently unknown (Ref. 46).

6.8 FAUNA

This section discusses in general terms the rich biodiversity of fish and wildlife associated with KSC and the MINWR. Protected species are described in more detail in Chapter 7.0.

6.8.1 GENERAL

By virtue of its geologic history and physical location, KSC is comprised of many diverse plant communities. The close proximity of uplands and wetlands, and the mixing of temperate and subtropical flora provide habitat for a large number of wildlife species. MINWR is home to more federally protected species than any other national wildlife refuge in the continental U.S. The conservation and management responsibilities for these natural resources are shared by NASA, the USFWS, and the NPS.

6.8.2 FISH

The IRL system is a biogeographic transition zone, possessing numerous aquatic habitat types and supporting, the highest biodiversity of any estuary in North America (Ref. 76, 129). Over 400 fish species have been identified in the lagoon system (Ref. 76). The IRL has been the subject of several studies concerning ecology and habitat preservation and protection (Ref. 65 - 75). Species diversity is generally elevated near tidal inlets, resulting in higher fish diversity at the southern end of the IRL where inlets are more closely spaced. It is lower near cities, where turbidity is high and where large areas of habitat has been modified or destroyed. Seagrass and mangrove habitats have proven extremely important in supporting diverse fish species (Ref. 76); much of this habitat has been lost as the result of shoreline development, navigational improvements, and marsh management practices. Relative to the southern Indian River system, the KSC area supports fewer tropical, oceanic and freshwater species (Ref. 77). A latitudinal temperature gradient, the absence of hard bottom and reef-like habitats and reduced oceanic inlet influences are factors in limiting species diversity in the KSC area (Ref. 77). The absence of permanent fresh water habitats prior to the presence of man on Merritt Island is responsible for a limited fresh water fish fauna (Ref. 77) and many of the freshwater fish species now found on Merritt Island were introduced by man (Ref. 77). A summary of fish species found in KSC waters, their general habitat requirements and relative abundance is provided in Appendix B.

On KSC there are at least 41 species of fish found in natural wetlands and impounded wetlands (Ref. 18, 19, 68, 76, 78, 130). In the impounded wetlands, the fish fauna is numerically dominated by resident fish species. Residents spend their entire life cycle within the marsh and are physiologically adapted to handle the wide variation in environmental conditions such as temperature, salinity, and dissolved oxygen, and commonly occur in a variety of habitats. These species include sailfin molly (*Poecilia latipinna*), eastern mosquitofish (*Gambusia holbrooki*), and sheepshead minnow (*Cyprinodon variegatus*) which can reach densities of several dozen individuals per square meter. Transient fish are species that utilize the marsh habitat during a portion of their life cycle, primarily as juveniles. These fish may use this area for a source of forage or as a refuge from predators. Transient fish are not as well adapted physiologically to handle the harsh or extreme conditions that exist in the wetlands year-round (Ref. 79). Examples of common transient fish at KSC include striped mullet (*Mugil cephalus*), ladyfish (*Elops saurus*), and common snook (*Centropomus undecimalis*). These species are typically excluded from marshes whose connection to the IRL has been severed.

The IRL system surrounding KSC sustains a robust recreational and charter guide fishery with anglers primarily targeting red drum (*Sciaenops ocellatus*), spotted seatrout (*Cynoscion nebulosus*), black drum (*Pogonias cromis*), common snook (*Centropomus undecimalis*), and tarpon (*Megalops atlanticus*). These fisheries are of substantial economic value and directly or indirectly support many jobs in the region. Commercial fisheries also exist for certain fish, blue crab (*Callinectes sapidus*), and quahog clam (*Mercenaria* spp.) but are much smaller than historically. The upper Banana River Lagoon, and all of Banana Creek, are within the KSC Security Zone. Public access including fishing has been prohibited here since 1962, creating a de-facto marine reserve older than any other marine reserve in the United States. Studies have demonstrated that sportfish within the KSC Reserve are both more common, and larger on average, than in adjacent public waters (Ref. 131). More recent acoustic tracking studies show that red drum, black drum, and seatrout repeatedly traverse the reserve boundary, most commonly during spawning months, with some individuals moving several hundred kilometers (E. Reyier, 2015, pers. comm.). This behavior suggests that KSC helps sustain fish populations, and the fisheries dependent on them, throughout a wide area of east Florida.

Due to the shallow nature of the inshore water bodies, fish kills are not uncommon. Abrupt drops in temperature during the winter months with passage of strong cold fronts can lead to mortality in some of the fish species. During summer months, fish kills stem from low levels of dissolved oxygen as a result of high rates of respiration and decomposition during nighttime and cloudy conditions.

6.8.3 AMPHIBIANS AND REPTILES

Seventy-four species of amphibians and reptiles, collectively called “herps”, have been documented to occur on KSC (Table 6-2; Ref. 80). Herpetological research on KSC began in the mid-1970s as part of the environmental monitoring associated with the Space Shuttle Program (Ref. 80). Efforts were focused on marine turtles, diamondback terrapins, and general herp presence/absence surveys. During the 1980s and early 1990s, most herpetological work was species-specific for gopher tortoises and eastern indigo snakes. In 1992, a long-term herpetological monitoring program was established. The objectives of the program were to continue adding to the database of herp knowledge on KSC, to allow comparisons of herp populations between the 1970s and present, and to concentrate on specific herp-related issues as they arise. This long-term data collection program was discontinued in 2011 due to lack of funding.

Several discoveries came to light during and since the long-term monitoring program. Eighteen species have been added to the KSC herp list (Table 6.2). Five of these were added because of different trapping techniques that were used in the 1990s and not in the 1970s. Two species occur in very low abundance and might not have been documented in the 1970s merely because they were never found. Six species are introduced exotics as described in Section 6.9. It is not clear why the remaining five species were not documented in the earlier studies. One species, the eastern hognose snake, was seen in the 1970s and has not been seen since. Only one specimen was found, and was possibly a human-released animal that does not naturally occur on KSC.

Two species have experienced population declines since the 1970s. A survey technique called road cruising (driving the same exact route for multiple sampling periods) found a significant difference in the numbers of cottonmouths between the 1970s and the current studies. One hypothesis explaining this decline is the decrease in freshwater habitats from the reconnection of impoundments to the brackish water estuary. Diamondback terrapin populations have also declined. Areas where they were once abundant no longer support large populations. Several hypotheses have been forwarded to explain the decline: incidental deaths in crab traps, too much predation pressure from an increased raccoon population, road mortality, and loss of food resources due to increased water turbidity (Ref. 80).

Table 6-2. Amphibians, Reptiles, and Mammals of KSC.

Amphibians		
Salamanders		
two-toed amphiuma	*Amphiuma means*	rarely seen
red-spotted newt	*Notophthalmus viridescens*	common, but rarely seen
lesser siren	*Siren intermedia*	very common, but rarely seen
greater siren	*Siren lacertina*	very common, but rarely seen
Frogs		
oak toad	*Anaxyrus quercicus*	occasionally seen, commonly heard
southern toad	*Anaxyrus terrestris*	commonly seen and heard
cricket frog	*Acris gryllus*	rarely seen, commonly heard
green treefrog	*Hyla cinerea*	commonly seen and heard
pinewoods treefrog	*Hyla femoralis*	occasionally heard at night, rarely
barking treefrog	*Hyla gratiosa*	occasionally heard at night, rarely
squirrel treefrog	*Hyla squirella*	commonly seen and heard
Cuban treefrog	*Osteopilus septentrionalis*	occasionally seen
chorus frog	*Pseudacris nigrita*	rarely seen, commonly heard
little grass frog	*Pseudacris ocularis*	rarely seen, occasionally heard
greenhouse frog (E)	*Eleutherodactylus planirostris*	occasionally seen
narrow-mouthed toad	*Gastrophryne carolinensis*	occasionally seen, commonly heard
eastern spadefoot toad	*Scaphiopus holbrookii*	occasionally seen and heard
gopher frog	*Lithobates capito*	rarely seen or heard
pig frog	*Lithobates grylio*	rarely seen, commonly heard
southern leopard frog	*Lithobates sphenocephalus*	commonly seen and heard
Reptiles		
American alligator	*Alligator mississippiensis*	commonly seen
Turtles		
loggerhead	*Caretta caretta*	commonly seen while nesting
Atlantic green turtle	*Chelonia mydas*	occasionally seen while nesting
snapping turtle	*Chelydra serpentina*	occasionally seen
leatherback sea turtle	*Dermochelys coriacea*	rarely seen
chicken turtle	*Deirochelys reticularia*	rarely seen
diamondback terrapin	*Malaclemys terrapin*	rarely seen
Florida cooter	*Pseudemys peninsularis*	commonly seen
Florida redbelly turtle	*Pseudemys nelsoni*	occasionally seen
box turtle	*Terrapene carolina*	occasionally seen
striped mud turtle	*Kinosternon baurii*	occasionally seen
common mud turtle	*Kinosternon subrubrum*	occasionally seen

Table 6-2. Amphibians, Reptiles, and Mammals of KSC (cont.).

common musk turtle	*Sternotherus odoratus*	occasionally seen
gopher tortoise	*Gopherus polyphemus*	commonly seen
Florida softshell turtle	*Apalone ferox*	commonly seen
Lizards		
slender glass lizard	*Ophisaurus attenuatus*	rarely seen
island glass lizard	*Ophisaurus compressus*	rarely seen
eastern glass lizard	*Ophisaurus ventralis*	occasionally seen
Indo-Pacific gecko (E)	*Hemidactylus garnotii*	rarely seen
cosmopolitan house gecko (E)	*Hemidactylus mabouia*	rarely seen
Mediterranean gecko (E)	*Hemidactylus turcicus*	rarely seen
green anole	*Anolis carolinensis*	commonly seen
brown anole (E)	*Norops sagrei*	commonly seen
mole skink	*Eumeces egregious*	rarely seen
southeastern five-lined skink	*Eumeces inexpectatus*	commonly seen
ground skink	*Scincella lateralis*	occasionally seen
six-lined racerunner	*Cnemidophorus sexlineatus*	commonly seen
Snakes		
scarlet snake	*Cemophora coccinea*	rarely seen
black racer	*Coluber constrictor*	commonly seen
ring-necked snake	*Diadophis punctatus*	rarely seen
eastern indigo snake	*Drymarchon corais*	occasionally seen
corn snake	*Elaphe guttata*	occasionally seen
yellow rat snake	*Elaphe obsoleta*	occasionally seen
mud snake	*Farancia abacura*	rarely seen
eastern hog-nosed snake	*Heterodon platirhinos*	rarely seen
common kingsnake	*Lampropeltis getula*	rarely seen
scarlet kingsnake	*Lampropeltis triangulum*	rarely seen
coachwhip	*Masticophis flagellum*	occasionally seen
Atlantic saltmarsh snake	*Nerodia clarkii*	rarely seen
banded water snake	*Nerodia fasciata*	commonly seen
green water snake	*Nerodia floridana*	occasionally seen
rough green snake	*Opheodrys aestivus*	occasionally seen
pine snake	*Pituophis melanoleucus*	rarely seen
striped crayfish snake	*Regina alleni*	common, but rarely seen
pine woods snake	*Rhadinaea flavilata*	rarely seen
black swamp snake	*Seminatrix pygaea*	common, but rarely seen
brown snake	*Storeria dekayi*	rarely seen
coastal dunes crowned snake	*Tantilla relicta*	rarely seen
ribbon snake	*Thamnophis sauritus*	commonly seen
garter snake	*Thamnophis sirtalis*	commonly seen
coral snake (V)	*Micrurus fulvius*	rarely seen
cottonmouth (V)	*Agkistrodon piscivorus*	rarely seen
diamondback rattlesnake (V)	*Crotalus adamanteus*	occasionally seen
pygmy rattlesnake (V)	*Sistrurus miliarius*	rarely seen

Table 6-2. Amphibians, Reptiles, and Mammals of KSC (cont.).

Mammals		
Virginia opossum	*Didelphis virginiana*	commonly seen
least shrew	*Cryptotis parva*	rarely seen
eastern mole	*Scalopus aquaticus*	rarely seen
southeastern bat	*Myotis austroriparius*	occasionally seen
Brazilian free-tailed bat	*Tadarida brasiliensis*	commonly seen
nine-banded armadillo (E)	*Dasypus novemcinctus*	commonly seen
eastern cottontail	*Sylvilagus floridanus*	commonly seen
marsh rabbit	*Sylvilagus palustris*	occasionally seen
gray squirrel	*Sciurus carolinensis*	rarely seen
hispid cotton rat	*Sigmodon hispidus*	commonly seen
marsh rice rat	*Oryzomys palustris*	rarely seen
Florida mouse	*Podomys floridanus*	rarely seen
southeastern beach mouse	*Peromyscus polionotus niveiventris*	commonly seen
cotton mouse	*Peromyscus gossypinus*	commonly seen
golden mouse	*Ochrotomys nuttalli*	rarely seen
round-tailed muskrat	*Neofiber alleni*	rarely seen
black rat (E)	*Rattus rattus*	rarely seen
raccoon	*Procyon lotor*	commonly seen
long-tailed weasel	*Mustela frenata*	rarely seen
eastern spotted skunk	*Spilogale putorius*	occasionally seen
river otter	*Lutra canadensis*	occasionally seen
gray fox	*Urocyon cinereoargenteus*	rarely seen
red fox (E)	*Vulpes vulpes*	rarely seen
coyote (E)	*Canis latrans*	occasionally seen
bobcat	*Felis rufus*	occasionally seen
bottle-nosed dolphin	*Tursiops truncates*	commonly seen
manatee	*Trichechus manatus*	commonly seen
wild hog (E)	*Sus scrofa*	commonly seen
white-tailed deer	*Odocoileus virginianus*	occasionally seen

E=exotic; V=venomous

6.8.4 BIRDS

Three hundred eighteen species of birds have been documented as occurring on KSC, and MINWR is considered to be one of the top ten birding spots in the U.S. Eighty-seven species nest at KSC; some of these are year-round residents while others come specifically to nest. Over 100 species are winter visitors and do not nest here, and over 100 species are considered to be transients or accidentals. The Bird Checklists of the United States website (http://www.npwrc.usgs.gov/resource/birds/chekbird/r4/merritt.htm) provides seasonal occurrence and abundance information for birds present on MINWR.

The extensive wetlands on KSC provide habitat for many species of aquatic birds, several of which are protected by state or federal laws. The herons, egrets, ibises, and other birds in the Order Ciconiiformes are collectively called wading birds. Thirteen species of wading birds are year-round residents on KSC, and due to the large numbers of waders using the habitats here for feeding and nesting, KSC is crucial for the conservation of several species (Ref. 85). The impounded saltmarsh habitat and shallow areas along the estuarine shorelines are extensively used by wading birds (Ref. 85, 86). While the roadside ditches and natural freshwater swales are not used by as many wading birds as are the impoundments, they are also an important component of the overall feeding habitat. This is particularly true in the winter (Oct. – Jan.) when the number of waders feeding in roadside ditches increases**.** KSC is also important for breeding sites for several species of wading birds including White Ibis, Great Egret, Snowy Egret, and Tricolored Heron.

For example, species and numbers of nests of wading birds were monitored yearly from 1987 through 2014, excluding 1991 (Ref. 85). The number of nests and islands used for nesting was variable between years with White Ibis nests accounting for 53% of the total nests counted. Reddish Egrets and Roseate Spoonbills, two species of wading birds mostly found in the Caribbean and South America, have the northern limits of their ranges in the KSC region. The Reddish Egret is a tropical heron that nests at only a few estuaries in Florida (Florida Bay, Tampa Bay and the IRL). Similarly, the Roseate Spoonbill has a limited range in Florida due to extirpations during the plume hunting era (around the late 1800s). The Roseate Spoonbill population on KSC has been expanding over the two decades since they have returned to nesting in the IRL (Ref. 87).

KSC also supports a large wintering waterfowl population, and hunting takes place each year on the MINWR portion from November through January for 25 days. Twenty-nine species of waterfowl have been documented on KSC, with 23 species regularly occurring, and one, the mottled duck, a year-round resident. Mottled ducks inhabit estuarine edges, impoundments, freshwater wetlands, and occasionally roadside ditches. Important waterfowl species wintering on KSC include: Blue-wing Teal, American Widgeon, Northern Pintail, Lesser Scaup, Redhead, Red-breasted Mergansers and Hooded mergansers. KSC and the adjacent estuarine areas support up to 2/3 of the Lesser Scaup wintering along the Atlantic Flyway (Ref. 88). Other species of waterbirds which are important components of the KSC avifauna include the numerous shorebirds that migrate through and overwinter on KSC. These birds use the beaches (Ref. 89) and impounded wetland habitats. It has been estimated that as much as 5% of the Dunlin using the Atlantic flyway overwinter on KSC (Ref. 90). The Piping Plover, a federally Threatened bird is occasionally found using KSC beach habitat during migration. Least Terns and Black Skimmers are two state listed species of beach nesting birds that also nest on gravel rooftops; colonies of these birds exist on KSC. Much of the natural beach and sandbar habitat for these birds is no longer suitable, due to habitat alteration and introduced or natural predators. In recent years most nesting attempts on KSC have occurred on rooftops. However, changing construction materials is causing most gravel rooftops to be replaced with other materials on KSC, thus reducing the available nesting habitat for these species.

Of the several species of rails found in the salt marshes on KSC, the Black Rail is perhaps the most important as an indicator of ecosystem health. This species is cryptic and little is known about its population status in Florida. It is noteworthy that the Black Rail inhabits habitat very similar to that which the now extinct Dusky Seaside Sparrow preferred.

A recent addition to the KSC bird list is the sandhill crane, a state-protected Threatened species. These beautiful, large birds inhabit and nest in freshwater marsh. The first reported sighting was of a pair with a flightless chick near the VAB circa 2010. Since that time, several pairs have been observed, and one pair was a regular visitor at the KSC Headquarters building (Becky Bolt, 2015, pers. comm.).

6.8.5 MAMMALS

Twenty-nine species of mammals have been documented on KSC (Table 6-2); this number includes five introduced species (see non-native wildlife discussion below). It does not include the numerous species of dolphins (other than the common bottle-nosed dolphins) and whales that occur offshore and occasionally wash up dead on KSC beaches, or feral house cats (*Felis domesticus*) that are occasionally seen around facilities.

A large bat colony exists in the SR 405 bridge crossing over SR 3. Two species, the Brazilian free-tailed bat and the southeastern bat, have been identified using the bridge as a roosting site. The bridge is a maternity colony site and pre-fledgling bats have been observed. Routine maintenance and repair operations on the bridge have been done on several occasions with no apparent impacts to the colony. In recent years, bat roosts have been identified in five other buildings/structures and may very likely occur elsewhere on KSC. Fourteen bat houses have been installed; one near a pavilion at KARS Park I, five near the Logistics Facility, and eight near the intersection of SR 405 and SR 3.

A black bear population no longer occurs on KSC, even though an occasional individual will wander in from areas north of the property. Habitat fragmentation leading to smaller patches of suitable habitat and increased road mortality are probable causes for the loss of black bears on KSC.

Raccoons are a native that is common in most habitats on KSC, but particularly abundant near water sources of all kinds. Raccoons have been documented as predators on wildlife and eggs of any kind that are available to them. In the 1970s, raccoons took nearly 100% of the marine turtle eggs that were deposited on the beaches of KSC, CNS, and CCAFS (Ref. 91). This trend continued until the responsible agencies implemented various raccoon predation control strategies on their respective beaches. Raccoons have also been implicated in the apparent decline of diamondback terrapin populations on KSC because they have been observed eating adults and destroying nests to obtain eggs (Ref. 80).

Although there are no historical data on raccoon densities on KSC, it is thought that populations may have become unnaturally high when mosquito control impoundments were built in the early 1960s. The sudden access to marsh interiors and all of the resources within them may have contributed to a raccoon population expansion. Raccoons are also an animal that coexists well with people and can flourish in situations that might inhibit population growth of other more sensitive species.

The largest mammalian predators remaining on KSC are the bobcat and river otter. There are no population estimates available for these animals, and although they are commonly observed in many areas, the status of their populations is unknown. In data collected between 1992 and 1995, 31 bobcats and 17 otters were documented road mortalities on KSC. Many of the bobcats were juveniles, but all of the otters were adults. Loss of large predator populations can lead to increased densities of prey populations and a proliferation of smaller predators, such as the raccoon.

6.9 NON-NATIVE WILDLIFE

At least 15 species of non-native wildlife have been documented on KSC. These fall into three basic categories: introduced exotics, non-native species extending their ranges, and feral populations of domesticated species.

6.9.1 INTRODUCED EXOTICS

The greenhouse frog (*Eleutherodactylus planirostris*) is native to the West Indies, but has become well established throughout peninsular Florida. It is nocturnal and prefers moist conditions, even within uplands habitats. It is one of KSC's most common frogs. The Cuban treefrog (*Osteopilus septentrionalis*) has a well-established breeding population in Florida. Its native range is Cuba, the Cayman Islands, and the Bahamas. Cuban treefrogs are found in a variety of natural and human-altered habitats including pine forests, hardwood hammocks, swamps, orange groves, plant nurseries, and around buildings in gardens and landscape plants.

Four species of lizards, the Cuban anole (*Anolis sagrei*), Indo-Pacific gecko (*Hemidactylus garnoti*), cosmopolitan house gecko (*Hemidactylus mabouia*), and Mediterranean gecko (*Hemidactylus turcicus*) were never reported in herpetological surveys done in the 1970s. All four species are now found around buildings and other facilities on KSC. The Cuban anole is native to Cuba, Jamaica, and the Bahamas, but is now well established in Florida, with populations also occurring in Texas, Louisiana, and Georgia. They probably were imported into the U.S. accidentally on landscaping plants. The Indo-Pacific gecko came to the U.S. from Southeast Asia and has spread throughout central and south Florida. One reason that these lizards are successful colonizers is that they are all self-fertilizing females. It only takes the introduction of one lizard into a new area to start a population. The Mediterranean gecko was introduced from the Mediterranean and is found in the Gulf States, Mexico, and Cuba. It is nocturnal, feeding on insects attracted to facility lighting. The most recent invader is the cosmopolitan house gecko, a small lizard native to Africa.

The rock dove (*Columba livia*) or pigeon was introduced to North America from Eurasia in the 1800s. They are extremely common around human habitations and are often considered pests. On KSC and CCAFS, rock doves are year-round residents and may take up residence in hangars and other open buildings, causing safety and sanitation concerns. Occasionally, the bodies of banded pigeons are retrieved, and these birds typically have traveled thousands of miles from the northeastern U.S.

Sixty European starlings (*Sturnus vulgaris*) were intentionally introduced into New York City's Central Park in 1890 as a tribute to William Shakespeare. By 1950, they had become established across the entire U.S. Starlings are an ecological concern because they often usurp cavities for nesting that are being used, or could be used, by native species such as screech owls, woodpeckers, and wrens. On KSC, there is a population of year-round residents and also an influx of migrant starlings in winter. Starlings often gather in huge flocks which are capable of devouring large quantities of food resources.

The English house sparrow (*Passer domesticus*) is the most widely introduced bird species in the world. They were purposely imported from Europe to Brooklyn, New York, in 1850, and within 20 years, they had spread in all directions across the continent. House sparrows are extremely aggressive and will extricate even larger birds from their nest sites. On KSC, they are extremely common around buildings and often get into buildings and hangars, causing safety and sanitation problems.

Originally native to South America, the nine-banded armadillo (*Dasypus novemcinctus*) extended its range into the U.S. through Texas in the late 1800s. It was intentionally introduced into Florida in the 1920s. Armadillos are extremely abundant, more so than is immediately evident because they are generally crepuscular or nocturnal. They eat a variety of insects and other invertebrates, carrion, and eggs, and dig burrows for den and nesting sites. Nine-banded armadillos are not well studied, and their impacts on native wildlife are not known. They could potentially compete with gopher tortoises for burrows, and may eat eggs of native birds, amphibians, and reptiles.

Black rats (*Rattus rattus*) were stowaways on the ships of European explorers to the U.S. in the mid-1500s. They are found primarily associated with buildings. However, during beach mouse surveys occurring from 1996 to 1998 on the dunes near the Space Shuttle launch pads, nine black rats were captured in traps. They have subsequently been captured on the dunes as recently as 2012. Because these animals constituted a threat to the federally protected southeastern beach mouse, they were humanely destroyed. The extent to which black rats occur in natural habitats on KSC is not known, but could be a significant concern.

The red fox (*Vulpes vulpes*) was brought from England to the U.S. in the mid-18th century by hunters. They were released in the northeast U.S. and have since spread throughout most of the U.S. and Canada. Hunting kept populations in check for many years, but the devaluation of the fur market has caused red foxes to become more common. In some urban areas, they are considered to be pests and potential sources of rabies. The occurrence of red fox on KSC was documented from a single road mortality on SR 405 in front of the SSPF.

Typically associated with the southwest U.S., coyotes (*Canis latrans*) have taken advantage of human activities and impacts to increase their range to include every state in the U.S. except Hawaii. Although coyotes were introduced into Florida in the 1920s for hunting with dogs, their natural range expansion was probably inevitable. The coyote's great success can be attributed to several factors. They are generalists in their habitat and food requirements, and they produce large litters that mature quickly. Several of the other large predators that were competitors with the coyote (e.g., red wolf and panthers) have been extirpated from many areas. Most importantly, coyotes are able to capitalize on and benefit from human activities such as farming, ranching, and urbanization in general. Coyote numbers have been increasing in Florida during the last 20 years, and the impacts on native wildlife are not well studied. They have been documented depredating marine turtle nests on KSC and CCAFS. Coyotes may directly compete with bobcats for food resources. However, they may also help mitigate the loss of other large predators that once kept prey populations of raccoons, rodents, rabbits, etc., in check.

6.9.2 RANGE EXTENSIONS

The cattle egret (*Bubulcus ibis*) and brown-headed cowbird (*Molothrus ater*) are both examples of species that have managed to colonize Florida on their own (i.e., not introduced); both of these range extensions have occurred because of habitat changes caused by humans. The cattle egret reached Florida in the 1940s, via South America from Africa. Their entry was facilitated by deforestation, irrigation, and the cattle industry, all of which provided ample food resources. They may compete with native herons for food and nesting resources. The brown-headed cowbird is native to the Great Plains and was originally associated with the American bison. The proliferation of the cattle industry and the conversion of land to agriculture have allowed the cowbird to occupy the entire U.S. mainland. Cowbirds have completely abandoned nest building and deposit their eggs in the nests of other birds, often destroying the host birds' eggs in the process. Not all species of birds are susceptible to brown-headed cowbird parasitism, and as of yet, they have not been documented using Florida scrub-jay nests.

6.9.3 FERAL POPULATIONS OF DOMESTICATED SPECIES

Free-ranging feral house cats (*Felis domesticus*) are known to pose a significant threat to native species of wildlife. There is overwhelming evidence to show that feral cats eat adult birds, amphibians, and reptiles, their young, and eggs. They are also vectors for diseases infecting other wildlife (e.g., feline leukemia and distemper) and humans (e.g., rabies). In 1996, KSC workers concerned for the welfare of cats formed the Space Cats Club. By 1999, 100 feral cats had been trapped, neutered, and vaccinated, and were either adopted or housed in a closed facility on KSC. After 1999, operations were moved off KSC into Brevard County. At this time, feral cat populations do not appear to be large or constitute a major impact to KSC wildlife. However, it is against federal regulations to feed or house feral cats on KSC.

Before NASA took control of the property that is now KSC, the area was home to many people who owned livestock and/or citrus groves. As the people relocated to surrounding towns, their domestic hogs (*Sus scrofa*) were occasionally left behind. The mild central Florida winters and abundance of food resources made it possible for feral hog populations to explode. Hogs constitute an environmental problem for a number of reasons. They eat plants, small species of wildlife, and any eggs deposited on or below the ground. Their method of foraging is very destructive because they turn over large amounts of dirt and cause significant soil disturbance, allowing increased opportunity for exotic and pest vegetation germination (e.g., cogon grass, *Imperata cylindrica*). Hogs can seriously damage the shallow freshwater marshes that are crucial breeding habitat for amphibians, and feeding habitat for a large number of species, including gopher tortoises, indigo snakes, and several waterbirds (ducks, wading birds, shorebirds). Feral hogs also pose a safety concern because they are often killed by vehicles on KSC roads each year, causing property damage and potential injury to the KSC workforce (Ref. 93).

6.10 LAUNCH IMPACTS

The Kennedy Space Center was established adjacent to the USAF Eastern Test Range in 1962 to serve as the launch site for manned spaceflight. A summary of Shuttle launch effects can be found in (Ref. 132). A comprehensive programmatic review of local NASA operational and launch effects in the context of land use change and development over the last 50 - 60 years can be found in Hall et al., 2014 (Ref. 133). Environmental effects of unmanned vehicles were documented by Schmalzer et al., 1998 (Ref. 134).

Through the 30 year flight history of the Space Shuttle Program there were 135 launches, 82 from Pad 39A and 53 from Pad 39B. The three shuttle main engines (SME) burned liquid oxygen and liquid hydrogen producing an exhaust of water vapor. The Solid Rocket Booster (SRB) exhaust, composed primarily of aluminum, hydrogen, nitrogen, carbon, oxygen, and chloride compounds including hydrochloric acid (HCl), was directed northward from the launch pads by the split flame trench. At each pad, a water based sound suppression system was utilized to protect the shuttle and payloads from damage by acoustic energy reflected from the mobile launch platform during launch. At launch minus 12 seconds, the sound suppression system was activated, starting flow of roughly 300,000 gallons of water onto the launch pad and structure. At minus nine seconds, the three shuttle main engines were ignited and throttled toward full power. At zero, the two SRBs are ignited. The initial blast hit the sound suppression water that has been pouring onto the pad, instantly vaporizing and atomizing it. The resulting mixture of deluge water, debris, and exhaust chemicals exploded from the flame trench at a velocity of approximately 85-100 meters per second. During the first 10-12 seconds of flight, as the shuttle rose from the launch pad, the exit velocity and percent of SRB exhaust exiting the flame trench decayed to zero. At this point, the exhaust ground cloud formation ceased and column cloud formation predominated. The typical ground cloud was approximately $1.4x10^6$ m^3 in volume. This cloud was composed of the complex mixture of gases and dissolved and particulate exhaust products formed by SRB fuels, sound suppression water, and materials ablated from the physical surfaces on and around the launch pad.

Near-field deposition was created by the ground cloud sweeping turbulently across the ground, vegetation, and lagoon waters to the north of the launch pads in line with the SRB flame trench. For each launch, the area impacted by near-field deposition was mapped based on the visible effects on vegetation and structures. The area of cumulative near-field impacts at Pad 39A was about 90 ha (221 ac), and the area of cumulative near-field impacts at Pad 39B was 62 ha (154 ac). The solid rocket motors produce a fine particulate mixture of aluminum compounds that were generally less than 63 µ in diameter. These fine particulates made up roughly 40% of the deposition found in the near-field area, but in background soils only about three percent of particles occurred in this silt and clay fraction. Near-field deposition greater than 63 µ was composed in large part of fine silica sand, shell fragments, and other debris entrained in the exhaust cloud from the pad surface north of the flame trench.

Different size classes of particulates were analyzed for aluminum (Al), Cu, Fe, lead (Pb), manganese (Mn), and Zn content. As expected, Al concentrations were highest in the launch derived fine fraction of the deposition while larger size classes displayed values similar to background soils. Copper deposition displayed a peak in the 63-125 µ size class, but the source was not readily apparent. Two metals, Fe and Mn, were observed well above background levels, primarily in the largest particle size class. These two metals are associated with steel structures. Examination with a microscope revealed the presence of numerous metal flakes in this fraction and exposure to a magnet indicated they contained iron. These metal flakes were blown off of Apollo era railroad tracks that were used to position the flame splitter beneath the mobile launch platform inside each launch pad flame trench. These railroad tracks were removed from the pad surfaces during renovations and upgrades. Lead levels were consistently low but were higher than background soils in the 63-250 μ range. Zinc concentrations were above background levels and the source was believed to be the large amount used in corrosion control on the pad and mobile launch platform surfaces. SRB exhaust blasts were known to strip the coating off of these exposed surfaces.

Soils in the most frequently impacted area north of Pad 39A were sampled after nine launches and again after 24 launches from the same sites. These soils near the launch complexes are heterogeneous but can be divided into saline and non-saline groups. Within these groups, changes between conditions after nine launches and after 24 launches differed. In the non-saline soils, there were increases in conductivity, calcium (Ca), potassium (K), sodium (Na), and Zn and decreases in phosphorus (P), nitrate nitrogen (NO_3-N), and ammonium as N (NH_4-N). In the saline soils, there were increases in Ca, K, Na, Zn, and P but not conductivity, and decreases in NH_4-N but not NO_3-N. Increases in conductivity, Ca, K, and Na between nine and 24 launches may be due to leaching of soil material including shell fragments. Increases in Zn could be from soil leaching or from deposition of material derived from paint or plating on pad structures. Soils in the impact area remained well buffered; even after 24 launches, soil pH was still alkaline.

Background pH in the estuarine system generally ranges between 7.8 and 8.8 units. At launch, the surface layer of the lagoon receives up to 1700 kg (3748 lbs [pounds]) of hydrochloride (HCl) from deposition. This acid mixed downward into the water column through advection and diffusion, eventually impacting approximately the upper 1.5 m (4 ft). The rate of mixing is driven primarily by wind speed and direction across the lagoon. Levels of impact were highly variable spatially and temporally depending on meteorological conditions at the time of launch. Maximum pH reductions (about six to seven units) were found at the surface and in the area adjacent to the storm water drainage ditch in line with the flame trench at each pad. In these areas, pH depression may be acute and lethal to organisms utilizing gills for respiration. Minimal effects were observed around the edges of the near-field ground cloud footprint and at depth where buffering and dilution minimize chemical impacts.

For most launches, a fish kill was observed in the shallow surface waters immediately north of each launch complex in line with the flame trench. This fish kill was the direct result of surface water acidification. The rapid drop in pH produced severe damage to the gill lamella of fish exposed to the near-field launch deposition. Field surveys conducted after each launch indicated that this event was generally limited to the shallow shoreline closest to the pad and the stormwater ditches leading away from the north side of the pad surface. In every event, the fish kill occurred in direct relation to the spatial pattern of the near-field deposition footprint.

Cumulative impacts to vegetation in the most frequently exposed area north of Pad 39A included reduction in the number of plant species present, and reduction in total cover. The reduction in total species number included both loss of sensitive species and invasion of more weedy ones, but losses exceeded new invasion. Vegetation effects differed by strata; shrubs and small trees were eliminated by repeated defoliation more rapidly than forbs and graminoids. The community level effects consisted of retrogressive changes however, during the post-Challenger period of no launches vegetation recovered to near pre-launch conditions. Aerial photography was collected before and throughout the Space Shuttle program to document vegetation community changes that might result from launch impacts as recommended by AIBS. At Pad 39A the general pattern was an expansion of disturbance tolerant wax myrtle (*Myrica cerifera*), Brazilian pepper (*Schinus terebinthifolius*), and mangroves filling bare ground and some areas of wetland and herbaceous cover. At Pad 39B mangroves have increased in abundance in the impounded areas northwest of the pad, and wax myrtle, Brazilian pepper and other disturbance tolerant taxa have expanded in coverage. At both pads the amount of bright reflective bare ground has been greatly reduced by expansion of vegetation communities.

Far-field deposition occurred outside of the near-field plume zone, as a result of movement of the launch cloud with prevailing meteorological conditions at cloud stabilization height. The ground tracks of deposition from every launch were mapped for each pad and a cumulative far-field map was prepared for all areas of KSC receiving deposition. Spots of acid or dry deposition on leaves of plants or on structures indicated the area received far-field deposition. The geographic distribution of far-field deposition was far more variable than that of near-field deposition, and much of KSC received deposition from at least one launch. After 135 launches, 23,124.7 ha (57,142.2 ac) received far-field deposition at least once, but 14,065 ha (34,755.2 ac) were impacted no more than two times. No changes in plant community composition or structure due to cumulative effects of far-field deposition were observed.

The highest acoustic noise levels generated by launch are recorded within the first two minutes. In the launch pad vicinity, noise levels could exceed 160 dBA. Noise levels recorded at the Launch Impact Line near the VAB area did not exceed the 115 dBA maximum level established for short exposure by the Department of Labor standards. For maximum protection, observer areas and security zones were set at distances beyond which the 115 dBA sound level is not exceeded.

Acute impacts of Space Shuttle launches to wildlife populations were minimal. Birds in the vicinity of the launch pad flee the area in a fright response to the ignition of the shuttle main engines prior to the ignition of the SRBs. On occasion, some individuals were caught in the exhaust blast and were killed or injured. Examples of species observed included frogs, alligators, armadillo, marsh rabbits, snowy egret, and killdeer. No federally listed threatened or endangered species were observed killed based on post launch surveys conducted in the area.

Results of monitoring launch impacts have shown no long-term macro-scale negative responses. Ecological communities persisted through the duration of the Space Shuttle Program with no dramatic change in species composition or spatial distribution based on launch rates achieved. Ongoing assessments of potential launch impacts include a comprehensive Ecological Risk Assessment being conducted by the KSC Remediation Program Office in response to preliminary RCRA Facility Investigation findings. This project will evaluate the likelihood that sub-lethal adverse ecological effects are occurring, or may potentially occur, as a result of site-specific constituents including metals, semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and organochlorine pesticides (OCPs), perchlorate, and total petroleum hydrocarbons (TRPH).

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SECTION VII. PROTECTED SPECIES

7.1 REGULATORY OVERVIEW

The Endangered Species Act of 1973 (PL-93-205) provides guidance regarding the management and protection of certain species based on determinations made regarding their relative ability to survive. The U.S. Fish and Wildlife Service is responsible for determining which species are listed as either Threatened or Endangered and for maintaining this listing. In addition, Section 7 of the statute provides for a consultation process between the Service and any federal agency that may, through one of its proposed actions, impact one of these species or their critical habitat.

The State of Florida also develops and maintains its own list of species suffering threats to populations and habitats. The FFWCC Endangered Species Coordinator is responsible for the review of species, designating their status and formally listing them in the State's Official List of Endangered and Potentially Endangered Fauna and Flora in Florida. This official list provides a comprehensive directory of the biota requiring special consideration in the State of Florida.

A list of the 30 federally and state-protected animals which have been documented at KSC and MINWR is given in Table 7-1. Protected plant taxa at KSC are described in detail in Section 7.2 and Sections 7.3, 7.4, and 7.5 discuss amphibians and reptiles, birds, and mammals, respectively. Wildlife species accounts are provided in Appendix C.

Table 7-1. Wildlife Species Known to Occur on KSC that are Protected Federally and/or by the State of Florida.

SCIENTIFIC NAME	COMMON NAME	LEVEL OF PROTECTION	
		STATE	FEDERAL
Amphibians and Reptiles			
Lithobates capito	Florida gopher frog	SSC	
Alligator mississippiensis	American alligator		T(S/A)
Caretta caretta	loggerhead		T
Chelonia mydas	Atlantic green turtle		E
Dermochelys coriacea	leatherback sea turtle		E
Gopherus polyphemus	gopher tortoise	T	C
Drymarchon couperi	eastern indigo snake		T
Pituophis melanoleucus mugitus	Florida pine snake	SSC	
Birds			
Pelecanus occidentalis	brown pelican	SSC	

Table 7-1. Wildlife Species Known to Occur on KSC that are Protected Federally and/or by the State of Florida (cont.).

Birds (cont'd)			
Egretta caerulea	little blue heron	SSC	
Egretta rufescens	reddish egret	SSC	
Egretta thula	snowy egret	SSC	
Egretta tricolor	tricolored heron	SSC	
Mycteria americana	wood stork		E
Eudocimus albus	white ibis	SSC	
Ajaia ajaja	roseate spoonbill	SSC	
Haliaeetus leucocephalus	bald eagle		P
Falco sparverius paulus	Southeastern American kestrel	T	
Aramus guarauna	limpkin	SSC	
Grus canadensis pratensis	Florida sandhill crane	T	
Charadrius melodus	piping plover		T
Haematopus palliatus	American oystercatcher	SSC	
Calidris canutus rufa	rufa red knot		T
Sterna antillarum	least tern	T	
Sterna dougallii	roseate tern		T
Rynchops niger	black skimmer	SSC	
Aphelocoma coerulescens	Florida scrub-jay		T
Mammals			
Peromyscus polionotus niveiventris	Southeastern beach mouse		T
Podomys floridanus	Florida mouse	SSC	
Trichechus manatus	West Indian manatee		E
Key: SSC = Species of Special Concern; T(S/A) = threatened because of similarity of appearance to another protected species; T = threatened; E = endangered; P = Bald and Golden Eagle Protection Act.			

7.2 PLANTS

Forty taxa occurring on KSC are listed as threatened, endangered, or of special concern on state lists (Ref. 1, 2, 3, 44) (Table 7-2).

Two taxa have been added from recent work on Canaveral National Seashore. A population of *Harrisia fragrans* was identified by Woodmansee et al. (Ref. 45) at the northern end of Canaveral National Seashore, and that identification has been confirmed by A. R. Franck (University of South Florida, pers. comm.). Recent studies of *Harrisia* (Ref. 46-48) indicate that the Florida east coast populations of *Harrisia* all should be considered *H. fragrans*. *Cereus eriphorus* var. *fragrans* (now *Harrisia fragrans*) was reported from KSC (Ref. 6). *Cereus gracilis* var. *simpsonii* was reported at Turtle Mound (Ref. 7) but was eliminated by freezes (Ref. 8); following the studies of Franck, this reported taxa should also be considered *Harrisia fragrans*. *Harrisia* also once occurred in south Brevard County (Ref. 5, 9). A survey in 2003 (Ref. 10) did not locate any extant populations in southern Brevard County.

Argusia gnaphalodes was reported from Canaveral National Seashore by Poppleton et al. (Ref. 49); however, Poppleton (Ref. 6) reported that the one individual known had been destroyed by a severe freeze in 1977. Krakow (Ref. 50) examined the historic location, and the plant was not present. It was not located on the Seashore during the 2002-2004 survey (Ref. 4). Recently, one individual was found on coastal dunes in a remote section of the seashore, whether it persisted there or established from a disjunct population is not known.

Taxa of special concern occur in all major habitats, but many are restricted to hammocks and hardwood swamps that constitute a minor proportion of the terrestrial vegetation (Table 7-3). For some of the listed taxa (e.g., *Calamovilfa curtissii*), populations on KSC appear to be important for their regional and global survival. Spatial location data are available for some of these species; these are summarized in Figure 7-1.

Table 7-2. Status of Endangered and Threatened Plants of the KSC Area Including Adjacent Federal Property.

		Designated Status[1]			
Scientific Name	Common Name	USFWS[2]	FDA[3]	FCREPA[4]	FNAI[5]
Asclepias curtissii[6,8,9,12]	Curtiss milkweed		E	T	
Argusia gnaphalodes[6,7]	Sea rosemary		E		G4S3
Avicennia germinans[6,7,8,11]	Black mangrove			SP	
Calamovilfa curtissii[6,7]	Curtiss reedgrass	FC2	T		G3,S3
Calopogon multiflorus	Many-flowered grass pink		T		G2S3, S2S3
Chamaesyce cumulicola[9,11,12]	Sand dune spurge	FC2	E		G2,S2
Chrysophyllum oliviforme[6,7,9]	Satinleaf		T		
Encyclia tampensis[11]	Butterfly orchid		C		
Epidendrum canopseum[11]	Greenfly orchid		C		
Glandularia maritima[6,7,9,11]	Coastal vervain	FC2	E		G3, S3
Scientific Name	Common Name	USFWS	FDA	FCREPA	FNAI
Glandularia tampensis[6,7]	Tampa vervain	FC1	E		G2, S2
Gonolobus suberosus[11]	Angle-pod		T		
Harrisella filiformis	Threadroot orchid		T		
Harrisia fragrans[6,13]	Indian River prickly-apple	E	E		G1S1
Hexalectris spicata	Crested coralroot		E		
Lantana depressa	East coast lantana	FC2	E		G2T1, S1
Lechea cernua[6,9]	Nodding pinweed	FC2	T		G3, S3
Lechea divaricata[7,11,12]	Pine pinweed	FC2	E		G2, S2
Lilium catesbaei	Catesby lily		T		
Myrcianthes fragrans[6,7,11]	Nakedwood	FC2	T		
Nemastylis floridana[11]	Fall-flowering ixia		E	T	G2, S2

Table 7-2. Status of Endangered and Threatened Plants of the KSC Area Including Adjacent Federal Property (cont.).

Scientific Name	Common Name	USFWS	FDA	FCREPA	FNAI
Ophioglossum palmatum[6,8,9,11] *(= Cheiroglossa palmata)*	Hand fern		E	E	G4, S2
Opuntia stricta[7,11]	Shell mound prickly-pear		T		
Osmunda cinnamomea[7,11]	Cinnamon fern		C		
Osmunda regalis var. *spectabilis*[7,11]	Royal fern		C		
Pavonia spinifex[9,11]	Yellow hibiscus				G4G5, S2
Pecluma plumula *(=Polypodium plumula)*	Plume polypody		E		G5, S2
Peperomia humilis	Peperomia		E		G5, S2
Peperomia obtusifolia[8]	Florida peperomia		E		G5, S2
Persea borbonia var. *humilis*[6,7,11]	Scrub bay				G3, S3
Pogonia ophioglossoides	Rose pogonia		T		
Pteroglossaspis ecristata[11,12] (= *Eulophia ecristata*)	False coco		T		G2G3, S2
Remirea maritima[7,9,10] (=*Cyperus pedunculatus*)	Beach-star		E	E	
Rhizophora mangle[6,7,8,11]	Red mangrove			SP	
Scaevola plumieri[7,10,11]	Scaevola		T		
Spiranthes laciniata	Lace-lip ladies'-tresses		T		
Tephrosia angustissima var. *curtissii*[11]	Narrow-leaved hoary pea; coastal	FC2	E		G1T1, S1
Tillandsia fasciculata[11]	Common wild pine		E		
Tillandsia utriculata[11]	Giant wild pine; giant air plant		E		
Zamia pumila [6,8,11] (= *Zamia umbrosa*)	East coast coontie		C	T	

Table 7-2. Status of Endangered and Threatened Plants of the KSC Area Including Adjacent Federal Property (cont.).

	USFWS	FDA	FCREPA	FNAI
TOTALS	E-1	E-18	E-2	19
	FC1-1	T-13	T-3	
	FC2-8	C-5	SP-2	
	10	36	7	
GRAND TOTAL-40				

[1] E = Endangered
T = Threatened
SP = Special Concern
C = Commercially Exploited
[2] United States Fish and Wildlife Service. FC1 and FC2 indicate species that were formerly under consideration for listing.
[3] Florida Department of Agriculture and Consumer Services (Ref. 3, 44).
[4] Florida Committee on Rare and Endangered Plants and Animals (Ref. 1).
[5] Florida Natural Areas Inventory (Ref. 2, tracking list updated 2013). FNAI assigns two ranks for each element. The global element rank is based on an element's worldwide status; the state element rank is based on the status of the element in Florida. Element ranks are based on factors including estimated number of element occurrences, estimated abundance, range, estimated adequately protected element occurrences, relative threat of destruction, and ecological fragility.

Global Element Rank:
G1 = Critically imperiled globally because of extreme rarity (5 or fewer occurrences or less than 1000 individuals) or because of extreme vulnerability to extinction due to some natural or man-made factor.
G2 = Imperiled globally because of rarity (6 to 20 occurrences or less than 3000 individuals) or because of vulnerability to extinction due to some biological or man-made factor.
G3 = Either very rare and local throughout its range (21-100 occurrences or less than 10,000 individuals), or found locally in a restricted range, or vulnerable to extinction because of other factors.
G4 = Apparently secure globally (may be rare in parts of range)
G5 =Demonstrably secure globally
G#T# = Rank of taxonomic subgroup such as subspecies or variety; numbers have same definition as above

State Element Rank:

Definitions parallel global element ranks: substitute “S” for “G” in global ranks, and “in state” for “globally” in global rank definitions..
[6] Sites or populations identified by Poppleton (Ref. 6)
[7] Sites or populations identified by Kennedy Space Center Ecological Program (1982-2014) (Ref. 5, 62)
[8] Listed in Final Environmental Impact Statement for Kennedy Space Center (Ref. 11)
[9] Sites or populations identified by Chafin et al. (Ref. 12 1996) on Cape Canaveral Air Force Station
[10] Sites or populations identified by Schmalzer and Oddy (Ref. 13 1995) on Cape Canaveral Air Force Station
[11] Sites or populations identified by Schmalzer and Foster (Ref. 4 2005a) on Canaveral National Seashore
[12] Sites or populations identified during rare plant surveys by Schmalzer and Foster (Ref. 10, 14, 15, 16).
[13] Sites or populations identified by Woodmansee et al. (new ref 2007) on Canaveral National Seashore

Table 7-3. Common Habitats of Endangered and Threatened Plants of the KSC Area Including Adjacent Federal Property.

Scientific Name	Common Name	Habitat	Population Status	Threats to Existence
Asclepias curtissii[1,3,4,7]	Curtiss milkweed	Oak scrub	Several small populations	Habitat loss, fire exclusion
Argusia gnaphalodes[1,2]	Sea rosemary	Coastal dunes	Two small populations	Habitat loss, freezes
Avicennia germinans[1,2,3,6]	Black mangrove	Mangrove swamps	Common within habitat	Habitat loss, freezes
Calamovilfa curtissii[1,2]	Curtiss reedgrass	Shallow swales in pine	Several populations	Habitat loss, fire
Calopogon multiflorus	Many-flowered grass	Pine flatwoods	Unknown	Habitat loss
Chamaesyce cumulicola[4,6,7]	Sand dune spurge	Coastal dunes, strand and scrub	Several small populations	Habitat loss, fire exclusion
Chrysophyllum oliviforme[1,2,4]	Satinleaf	Hammocks	Unknown	Habitat loss
Encyclia tampensis[6]	Butterfly orchid	Hammocks, hardwood swamps - epiphytic	One small population	Habitat loss
Epidendrum canopseum[6]	Greenfly orchid	Hammocks, hardwood swamps - epiphytic	Two small populations	Habitat loss
Glandularia maritima[1,2,4,6] (=*Verbena maritima*)	Coastal vervain	Coastal dunes and strand - openings	Common within habitat	Habitat loss
Glandularia tampensis[1,2]	Tampa vervain	Edge of hammocks	A few small populations	Habitat loss
Gonolobus suberosus[6]	Angle-pod	Hammocks	One population	Habitat loss
Harrisella filiformis	Threadroot orchid	Hardwood swamps - epiphytic	Unknown	Habitat loss
Harrisia fragrans[1,8]	Indian River prickly-apple	Coastal hammocks and shell beds	Several small populations	Habitat loss, freezes
Hexalectris spicata	Crested coralroot	Hammocks	Unknown	Habitat loss

Table 7-3. Common Habitats of Endangered and Threatened Plants of the KSC Area Including Adjacent Federal Property (cont.).

Scientific Name	Common Name	Habitat	Population Status	Threats to Existence
Lantana depressa var. *floridana*[2,4,6,7]	East coast lantana	Coastal strand and scrub, coquina scrub	Several populations	Habitat loss, hybridization with *L.*
Lechea cernua[1,4]	Nodding pinweed	Scrub openings	Not relocated on KSC/MINWR	Habitat loss, fire exclusion
Lechea divaricata[2,6,7]	Pine pinweed	Scrub openings	Several small populations	Habitat loss, fire exclusion
Lilium catesbaei	Catesby lily	Pine flatwoods	Unknown	Habitat loss
Myrcianthes fragrans[1,2,6]	Nakedwood	Hammocks, coastal strand	Common within habitat	Habitat loss
Nemastylis floridana[6]	Fall-flowering ixia	Hammocks, wet flatwoods	One population	Habitat loss
Ophioglossum palmatum[1,3,4,6] *(=Cheiroglossa palmata)*	Hand fern	Hammocks - epiphytic on cabbage palm	3 extant, 1 historic populations	Habitat loss, freezes
Opuntia stricta[2,6]	Shell mound prickly-pear	Coastal dunes and strand	Common within habitat	Habitat loss, introduced insect
Osmunda cinnamomea[2,6]	Cinnamon fern	Hardwood swamps	Common within habitat	Habitat loss, collection
Osmunda regalis var. *spectabilis*[2,6]	Royal fern	Hardwood swamps	Common within habitat	Habitat loss, collection
Pavonia spinifex[4,6]	Yellow hibiscus	Hammocks	Several populations	Habitat loss
Pecluma plumula	Plume polypody	Hammocks - epiphytic	Unknown	Habitat loss
Peperomia humilis	Peperomia	Hammocks	Unknown	Habitat loss
Peperomia obtusifolia[3]	Florida peperomia	Hammocks - epiphytic	Unknown	Habitat loss
Persea borbonia var. *humilis*[1,2,6]	Scrub bay	Scrub	A few small populations	Habitat loss, fire exclusion
Pogonia ophioglossoides	Rose pogonia	Marshes and wet pine flatwoods	Unknown	Habitat loss

Table 7-3. Common Habitats of Endangered and Threatened Plants of the KSC Area Including Adjacent Federal Property (cont.).

Scientific Name	Common Name	Habitat	Population Status	Threats to Existence
Pteroglossaspis ecristata[6,7] (=*Eulophia ecristata*)	False coco	Scrub and dry flatwoods	One population	Habitat loss, fire exclusion
Remirea maritima[2,4,5] (=*Cyperus pedunculatus)*	Beach-star	Coastal dunes	Occasional within habitat	Habitat loss
Rhizophora mangle[1,2,3,6]	Red mangrove	Mangrove swamps	Occasional within habitat	Habitat loss, freezes
Scaevola plumieri[2,5,6]	Scaevola	Coastal dunes and strand	Occasional within habitat	Habitat loss
Spiranthes laciniata	Lace-lip ladies'-tresses	Marshes	Unknown	Habitat loss
Tephrosia angustissima var.	Narrow-leaved hoary	Coastal dunes and strand	Two small populations	Habitat loss, fire
Tillandsia fasciculata[6]	Common wild pine	Hammocks and hardwood	Five small populations	Exotic insect, habitat
Tillandsia utriculata[6]	Giant wild pine; giant air plant	Hammocks and hardwood swamps - epiphytic	Three small populations	Exotic insect, habitat loss
Zamia pumila[1,3,6] (= *Zamia umbrosa*)	East coast coontie	Coastal hammocks	Several populations	Habitat loss, collection

[1] Sites or populations identified by Poppleton (Ref. 6)
[2] Sites or populations identified by Kennedy Space Center Ecological Program (1982-2014) (Ref. 5, 62)
[3] Listed in Final Environmental Impact Statement for Kennedy Space Center (Ref. 11 NASA 1979)
[4] Sites or populations identified by Chafin et al. (Ref. 12) on Cape Canaveral Air Force Station
[5] Sites or populations identified by Schmalzer and Oddy (Ref. 13) on Cape Canaveral Air Force Station
[6] Sites or populations identified by Schmalzer and Foster (Ref. 4) on Canaveral National Seashore
[7] Sites or populations identified during rare plant surveys by Schmalzer and Foster (Ref 10, 14, 15, 16)
[8] Sites or populations identified by Woodmansee et al. (Ref. 45) on Canaveral National Seashore

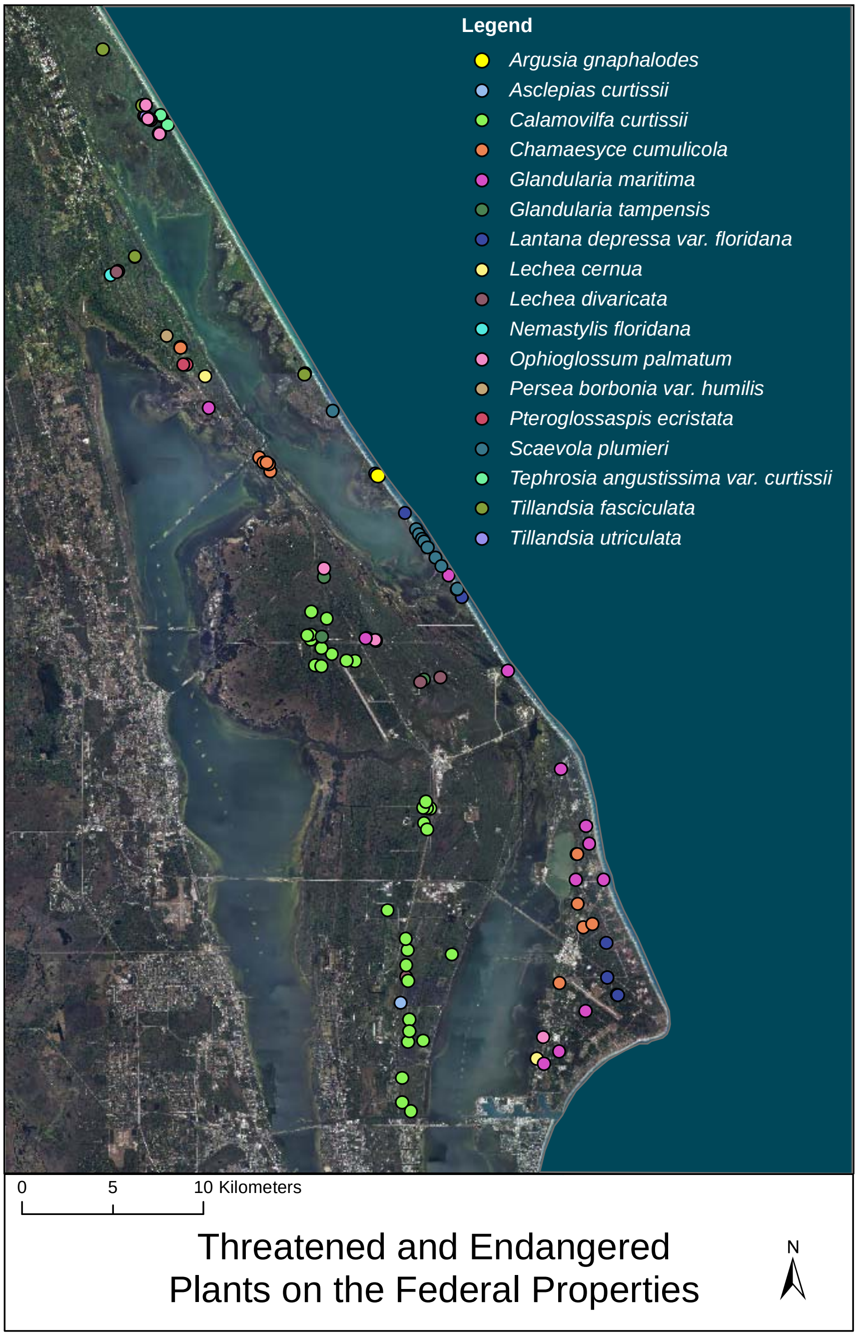

Figure 7-1. Locations of Selected Threatened and Endangered Plants in the KSC area.

7.3 AMPHIBIANS AND REPTILES

The Florida gopher frog is a state-listed Species of Special Concern. The gopher frog lives in the dry upland scrub and pine habitats where it typically shelters in gopher tortoise burrows. During the breeding season, gopher frogs migrate to seasonally flooded freshwater swales that are found adjacent to the uplands habitats. Although gopher frogs have been documented from three sites on KSC, they are not thought to be very common and little is known about the population's distribution or abundance.

The KSC Atlantic shoreline provides nesting habitat for three species of marine turtles: loggerheads, green turtles, and leatherbacks. In addition, the IRL complex (Mosquito, Indian River, and Banana River lagoons) provides developmental habitat for a large population of juvenile green and loggerhead sea turtles. Historic documents provide evidence that green turtles were once abundant and temporarily supported commercial harvesting in the late 1800s. Anecdotal statements and early reports, (Ref. 17, 18) contend that in the year 1879 alone, as many as 150 green turtles were exported from Mosquito Lagoon for consumption. However, the turtle fishing industry was more concentrated in the southern end of the IRL near Sebastian and Ft. Pierce. By 1895, green turtle populations in the lagoon were so heavily exploited, captures dropped sharply, and the industry neared collapse (Ref. 18).

Sea turtle nesting activity along the 41-km (25-mi) shoreline owned by NASA at KSC is managed by MINWR (10 km [6.2 mi]; southern section; within the KSC security area) and CNS (31 km [19 mi]; northern section; CNS Park Service). The boundaries of the KSC security area are the CCAFS-managed beach to the south and the CNS-managed beach to the north. Species nesting on this stretch of shoreline are primarily loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and leatherback (*Dermochelys coriacea*) sea turtles, which are federally protected under the Endangered Species Act of 1973 (Ref. 81, 82). The average annual number of sea turtle nests within this entire area often exceeds 4,000 nests.

For the period 2010 to 2014, the average number of loggerhead nests annually deposited on the KSC security beach ranged between 1080-1582 (average 1201.2 ± SD 215.5; Figure 7-2). The number of loggerhead nests in 2012 (1582) was significantly higher than the other four years (ANOVA; df = 4, F = 44.44, p = 0.004). Spatial distribution of loggerhead nesting among the 5-year period (Figure 7-3) was significantly different for only the beach kilometers 27 vs. 28 km (Kruskal-Wallis; H = 25.76, p = 0.004). Similar annual nesting trends were previously described by Provancha and Ehrhart (Ref. 51) and patterns remain comparatively similar over the past 3 decades. Green turtles exhibit strong bi-modal patterns in nest numbers (averages substantially rise and fall in 2-3 year cycles). However, the overall number of green turtle nests has steadily increased through time. During the last 5 years, the average number of green turtle nests was 212.8 (± SD 169.3). The spatial distribution of green turtle nests on the KSC security beach is heavily skewed toward the north (Figure 7-3).

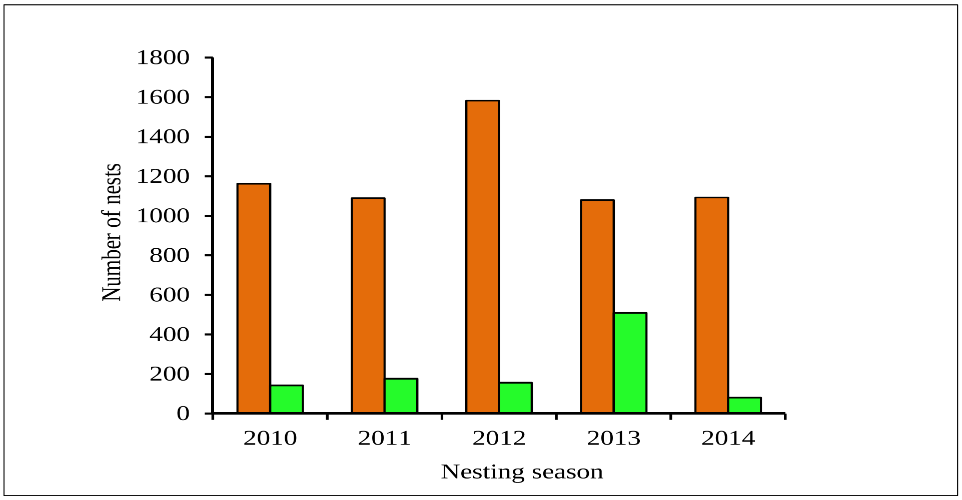

Figure 7-2. Number of Loggerhead (orange bars) and Green (green bars) Nests per Nesting Season Based on Index Nesting Beach Surveys (INBS; May 15 - August 31).

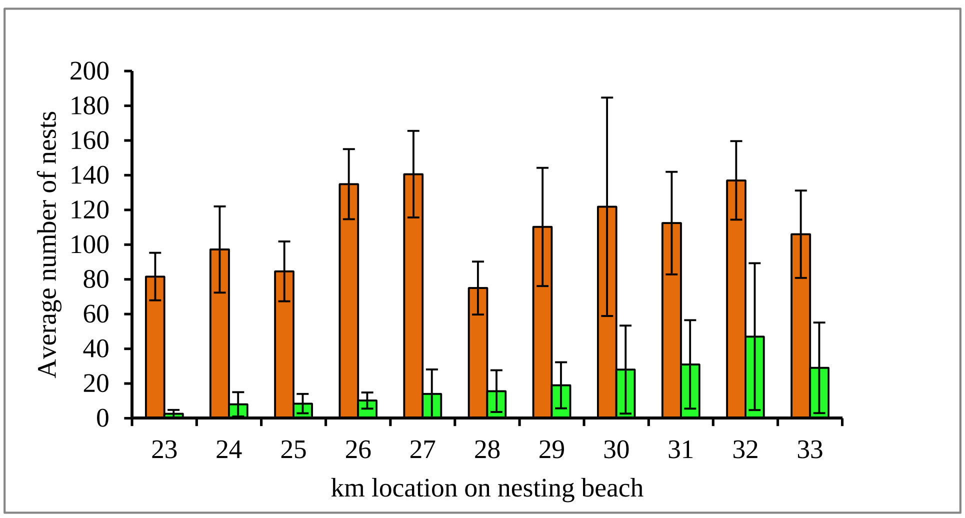

Figure 7-3. Spatial Distribution of Sea Turtle Nests within each Kilometer Zone on Beach. Vertical bars are the average number of loggerhead (orange) and green (green) turtle nests from 2010-2014. Error bars are ± SD.

Over the past two decades hurricane, tropical storms, and other high-energy storm events (e.g., nor'easter storms) have increased in number and/or intensity which has led to shoreline recession and the removal of the previously existing primary dune and vegetation. The loss of suitable nesting habitat is critical for sea turtles as well as other shoreline-dependent species (e.g., Wilson's plovers). Areas most heavily impacted by dynamic changes in dune profile and the greatest loss of shoreline are located within the 28-32 km. Two primary impacts from dune and shoreline erosion are the loss of viable nests during storm or extreme high tide activity and hatchling disorientations caused by the loss of dunes that once prevented inland facility lighting from illuminating the beach. With the end of the Space Shuttle Program, KSC has been in transition during the past 5 years with a new focus on commercial flight. Light trespass on the beach from facility and launch pad construction and operations present new challenges for reducing sea turtle disorientations. Several measures, large-scale (dune restoration) and small-scale (light shielding), have been implemented to reduce the impact of lighting on sea turtles. In 2006, the labor-intensive tracking of nests and installation of temporary light shields prior to hatchling was the primary method to protect hatchlings from disorienting upon emergence. This was initially a measure used for protecting nests prior to scheduled shuttle launch operations. In subsequent years, however, due to the substantial loss of the primary dune, landward lighting illuminated the beach within the 29-31 km areas so intensely that it was necessary to monitor and shield the majority of nests within these areas throughout the nesting season. Disorientation rates, however, remain variable and subject to anticipated as well as unanticipated events that occur each nesting season (Table 7-4). Dynamic changes in the dune profile, launch schedules for both CCAFS and KSC, and an ever-increasing cumulative sky glow from facilities at KSC and further inland remain challenges to reducing hatchling disorientation rates.

Both passive (metal screening over nests) and active (trapping, hunting) methods to prevent or reduce predation on sea turtle nests are implemented as necessary by MINWR. On the KSC beach, trapping for raccoons, hogs, and/or coyotes is periodically required when nest disturbance and/or destruction of nests by predators approaches 10% loss of the total nests *in situ*.

Table 7-4. Historical Summary of Activity, Effort, and Outcome Related to Sea Turtle Hatchling Emergences from 2010 to 2014.

Year	Total Survey Days	Observed Nests	Disorient-ation Rate %	Light Shields Deployed	Conditions of beach, lighting or operations related to observed disorientation
2010	46	307	2.4	107	KSC EMB rapid responses to problem lighting; construction for Constellation Program daytime only; temporary light shields installed at nests
2011	53	332	4.2	75	USFWS cut & burned coastal acreage adjacent to the beach, reducing vegetation screen; temporary light shields installed at nests; last shuttle LC 39A in 2011; temporary light shields installed at nests
2012	40	479	2.4	0	Repurposing of LC39A underway during daylight only; KSC wide photopollution education outreach
2013	45	481	8.6	215	Damaged dune from Hurricane Sandy in 2012 caused more exposure to KSC lighting; no emergence surveys or light shielding in October due to government furlough; temporary light shields installed at nests.
2014	56	347	6.1	0	Construction of an inland dune expanded in the region of Km 29 and 30 utilizing Hurricane Sandy funds

Scientific research on the status of marine turtles in Mosquito Lagoon began in 1975 (Ref. 19) and a near-continuous database on capture rates has been maintained over the past 20 years. Green turtles and loggerheads are the most frequently encountered species, however, there has been occasional captures of Kemp’s ridley (n=2) and hawksbill (n=1) turtles. The size-class of turtles captured within ML in recent years has ranged from small juveniles (30 cm carapace length) to sub-adult and, occasionally, a reproductively mature adult. The average capture rate of marine turtles in Mosquito Lagoon is 0.67 turtles/day; comparatively much lower than turtle captures reported near Sebastian Inlet in the IRL (Ref. 20, 21).

The relative abundance, distribution, and status of the marine turtle population inhabiting Mosquito Lagoon has been monitored since 1994 as part of EMB conservation and stewardship activities. Objectives are to monitor and compare present-day marine turtle populations to baseline data collected in the 1970’s, prior to the implementation of the Space Shuttle Program (Ref 21, 52). This work provides data for federal and state agencies on the status of marine turtles within KSC-owned areas of the IRL complex. Data collected include: population abundance (catch per unit effort [CPUE]), species and sex ratio compositions, population genetics, foraging, habitat-use, long-range movement, and disease (FP population ratios).

Using CPUE (a standardized method for calculating capture rates) for KSC turtles allows our efforts to be compared worldwide. Recent capture rates within ML indicate green turtles are much more abundant today than they were in the 1970s (Ref 19, 21, 52). In contrast, rates for loggerhead turtles show a slight decline in their numbers since the 1970s. Green turtles appear to be more abundant within ML than loggerheads. The increased number of green turtles in ML mirrors the present trend observed elsewhere in the US and western Atlantic of a growing green turtle population. Sex ratios of KSCs juvenile sea turtles appear to be skewed towards females, with 94.4% and 66.6% female in the population for greens and loggerheads, respectively. DNA analyses reveal that our sea turtles originate from beaches in Florida, and as far away as Mexico, Aves Island, Surinam, and Costa Rica.

Seagrass beds on KSC provide vast acres of forage for green turtles and habitat for the prey items of loggerhead turtles (i.e., crabs, mollusks). Previous foraging data indicate that juvenile green turtles in ML forage primarily of *Halodule wrightii* (shoal grass) and *Syringodium filiforme* (manatee grass). Foraging on gelatinous prey (i.e., ctenophores, cnidarians) occurred but was relatively uncommon and the percentage of macroalgae in samples was comparatively low (Ref. 53). The foraging habits of loggerhead sea turtles are assumed to be similar to other loggerhead populations within the lagoon with soft-bottom, seagrass-dominated habitats.

Tagging and recapture data show evidence that large-scale habitat movements occur in some individual juvenile turtles. Turtles originally tagged in Mosquito Lagoon have been recaptured as far away as Cuba. Acoustic tracking data for KSC juvenile turtles show that while they may take up a multiple-year residency, they use the entire Mosquito Lagoon with small-scale movements in and out of the northern IRL (Ref. 54).

Changes in the observed health of ML green turtles since the 1970s include the occurrence of fibropapillomatosis (FP), a potentially debilitating disease that is transmitted by a retrovirus and manifests as tumors. These tumors can grow to a considerable size (>10 cm), and are typically attached to soft-tissues such as the eyes and flippers. If tumors occlude the sea turtle’s vision, they indirectly lead to starvation as turtles are generally sight feeders. The current rate of FP in the ML juvenile green turtle population is 50%. FP has also been observed in loggerhead sea turtles but at a much lower incidence. Occasionally, recaptured turtles have shown signs of regressed FP tumors.

Information on marine turtles residing in Mosquito Lagoon has also been gathered opportunistically during cold-stunning events, particularly in 1977, 1978, 1989, 2003, and 2010. When the water temperatures are sustained for several days below 10°C, marine turtles may become lethargic and float to the surface, and can die if not rescued and rehabilitated (Ref. 20, 55). During the 1989 freeze, 246 green turtles and ten loggerheads were recovered from Mosquito Lagoon and nearby waters of the northern Indian River, representing the largest recorded cold-stunning event in this region. Approximately 27% of those turtles were found dead or moribund. In 2003 a smaller event occurred with 28 turtles found over a two day period and five (17%) died later at rehabilitation facilities (Ref. 55).

In 2010 there were two sea turtle cold stun events; one in January that lasted over a ten day period and one in December over a three day period (Ref. 56). While the December event involved about 300 turtles, the January event had over 1800 turtles from KSC waters. These large numbers of turtles (mostly greens) rescued from of Mosquito Lagoon (53%), northern IRL (15%) and Banana River (32%) surprised the scientific and conservation community. The volume of turtles found in the KSC northern Banana River was particularly remarkable as very few are sighted during other surveys or operations in that water body. An additional 500 turtles were discovered in waters just south of KSC during the January 2010 cold stun. Most were initially brought to KSC/MINWR to a make-shift processing and command center as wildlife agencies grappled with providing adequate rehabilitation facilities across Florida and Georgia. These large sea turtle numbers are another indication of the importance of these water bodies. Interestingly, several January 2010 cold stunned turtles were transported and released approximately 220 km south into the warmer Atlantic Ocean near Juno Beach. Several turtles carried KSC sonic tags and were discovered back in the IRL and Mosquito Lagoon several months later.

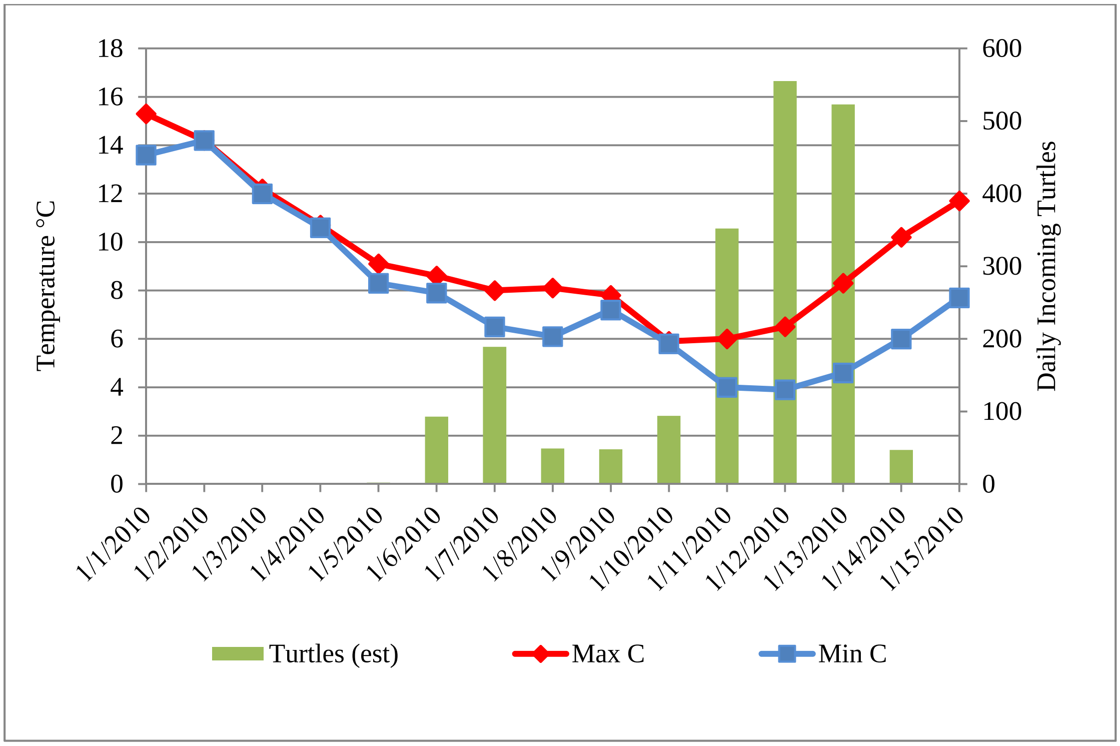

Figure 7-4. January 2010 Sea Turtle Cold Stun Results with Number of Turtles Rescued Each Day Plotted with Relative Low and High Water Temperatures Recorded in the Vicinity.

Gopher tortoises are a state-protected Threatened species and are a candidate for federal listing. They are long-lived terrestrial animals that dig burrows to use as refuge from inclement weather, fire, and predators. The burrow provides important habitat for hundreds of invertebrate and vertebrate species, earning the gopher tortoise the distinction of being a "keystone species". Several of the animals that use tortoise burrows are also state or federally protected, and the value of healthy, reproductive gopher tortoise colonies cannot be overstated from a conservation perspective. Several studies of gopher tortoises have been conducted on KSC. In the mid-1980s, 112 plots were established in tortoise habitats to determine burrow and tortoise densities, and to develop corrections factors to correlate the number of burrows seen to the number of tortoises in the population (Ref. 22).

From 1989 – 1991, tortoises were radio-tracked to determine home range sizes and numbers of burrows used (Ref. 23). Tortoise burrows were found in the typical high, dry habitats, but radio-tracking showed that they also utilize wetter habitats, such as the freshwater swales, for feeding. Work began in 1998 to determine if the deadly bacterial disease, Upper Respiratory Tract Disease (URTD), was present in KSC gopher tortoise populations. Antibodies for URTD were found in several populations spread across KSC and CCAFS

(Ref. 23) and several sites may potentially have had die-offs that could be contributed to URTD (Ref. 24).

Gopher tortoises are being monitored on recently constructed (2010 and 2014) dunes located east of LC 39A and LC 39B. Burrow and tortoise surveys conducted post-construction found that tortoises readily moved into the new available habitat, establishing burrows within a few weeks of the dunes being planted. Radiotracking also confirmed that the tortoises cross the dunes and use them for feeding and burrowing. Tortoises frequently construct their burrows in previously disturbed areas including mowed, ruderal areas with artificial slopes such as camera mounds and constructed earthen embankments.

Much of the work with gopher tortoises at KSC involves moving them from harm's way for operational requirements. New construction, renovations, repairs, and environmental cleanup efforts often occur in areas occupied by tortoises. In these instances, the sites are surveyed to determine the locations of all burrows, which are marked. The interiors of the burrows are examined with an infrared burrow camera to determine occupancy. When tortoises are found, they are removed from the burrow either by bucket trapping or excavation with a backhoe. In most instances, the tortoises are relocated a short distance away, out of harm's way, but still within their home range and familiar surroundings. When the occasional longer distance relocation is required, suitable recipient sites are identified, ideally in newly restored habitat that is capable of supporting an increased tortoise population.

The eastern indigo snake is the longest snake in the U.S., reaching lengths greater than 2.5 m (8 ft). They are federally listed as a threatened species, but protection and conservation are difficult due to the lack of knowledge regarding their biology and their reclusive nature. There is little life history information available, and no reliable survey techniques exist to determine presence, absence, or abundance at a site. Eastern indigo snake radio-tracking first took place on KSC between 1990 and 1992. A small number of snakes were tagged to determine home range sizes and habitat use. From 1998 to 2002 in a studied funded by a private wildlife foundation with support from NASA and the USFWS, more than 70 eastern indigo snakes were captured from throughout Brevard County and radio-tracked. Home range sizes were variable, with males generally using a larger area than females. It was found that indigo snakes used a wide variety of habitats, including suburban areas where they regularly come into contact with people. Road mortality and intentional killing by humans were two major sources of mortality. Land development, resulting in the fragmentation of habitat, is the greatest threat to indigo snake populations for a number of reasons: snakes are forced to cross more roads in their daily travels, are more likely to be seen and possibly killed by people, and the fire-maintained habitats that they use are degraded due to lack of naturally occurring fire.

7.4 BIRDS

The wood stork, piping plover, rufa red knot, roseate tern, and Florida scrub-jay are protected under the Endangered Species Act, and 13 additional species are protected by the State of Florida (Table 7-1; see discussions below). All birds, except exotics that have been introduced, receive federal protection under the Migratory Bird Treaty Act (16 U.S.C., pp. 703-712, July 3, 1918, as amended), and the bald eagle is additionally protected under the federal Bald and Golden Eagle Protection Act (16 U.S.C. 668-668c, 1940).

The wood stork is federally listed as endangered, and six other species of wading birds are protected by the State (Table 7.1). Long-term monthly monitoring of feeding sites began in 1987. Sites surveyed include a sample of mosquito control impoundments, a portion of the edge of the estuary and associated creeks, and a sample of roadside ditches. Results showed that wading birds prefer feeding in open water over other available habitats, but will feed in marsh grasses, particularly when the water level is high (Ref. 57). More detailed analysis of habitat preference showed that wading birds feeding in impounded salt marsh on KSC preferred areas within 1 m (3.3 ft) of the boundary between marsh vegetation and unvegetated open water (Ref. 58).

Wood stork nesting occurred in large numbers prior to 1985, and then again in smaller numbers from 1988 - 1990, but has not been documented since 1990. Roseate spoonbills were first documented nesting on KSC in 1987 (Ref. 87), and their numbers have increased steadily since that time. A study of foraging habitat preference by nesting great egrets and snowy egrets showed some evidence for a slight preference for impounded wetlands over other available wetland types on KSC (Ref. 59. Brown pelicans and double-crested cormorants also frequently nest in the wading bird colonies in large numbers.

Bald eagles arrive each year on KSC in the fall, nest during the winter, and leave KSC in early spring after the young have fledged. Records of bald eagle nesting have been kept on KSC continuously since 1978 by MINWR and/or FFWCC. The numbers of nests have increased steadily over the years, in keeping with the general recovery of bald eagle populations in the U.S. since the banning of the pesticide DDT. Between 1998 and 2014, the average number of nests was 11, and the average number of known fledglings per year was 15. Eagle nest trees are protected from disturbance within zones of no activity or permitted-only activity. One nest located on KSC is very well known locally as it has been used almost continuously for at least 40 years. The nest measures 0.2 m (7 ft) in diameter and is 3 m (10 ft) deep. It is a regular stop for KSC tour buses, and has been equipped with video and still cameras during different time periods, providing an incredible up-close look at life in the nest. In March 2013, two eaglets were rescued when their nest was blown down in a storm. Both birds were rehabilitated at the Audubon Center for Birds of Prey in Maitland. One was returned to KSC and released into an artificial nest box near its original nest tree; it was accepted by its parents and later fledged successfully. The second bird could not be released due to a problem with one of its eyes. The female eaglet was treated, trained, and sent to Sea World in San Antonio, Texas to be an education bird.

The piping plover, rufa red knot, and roseate tern (all federally Threatened) are rare to occasional visitors to the KSC shoreline, mostly during migration seasons. None of these birds are documented nesting here.

The Florida scrub-jay is a federally protected Threatened species that was elevated from subspecies status in 1997. The four largest remaining populations of scrub-jays occur on KSC, CCAFS, Ocala National Forest, and the mainland of Brevard County and Indian River County (Ref. 28). Kennedy Space Center has a potential population size of 700 breeding pairs, but the population is currently less than half this number because of habitat degradation (Ref. 29, 30, 31). Monitoring of color-banded scrub-jay populations on KSC began in 1987 and showed that territory sizes averaged 10 ha (25 ac) (Ref. 32). Major sources of mortality for adults are hawk predation and road mortality (Ref. 33), although annual survival is considered high (Ref. 38). A large number of nests (between 80 % and 43% of the total, depending on the site) are depredated, resulting in a decreasing population in some areas (Ref. 34, 39). Two years of remote recording of egg and nestling predation events found that 13 of 19 were due to yellow rat snakes (*Elaphe alleghaniensis*). Radiotracking data showed that small mammals, other birds, and snakes readily eat the fledgling scrub-jays before they become efficient fliers.

Florida scrub-jays live in stable territories with a long-term bonded pair of breeders; the young delay breeding for a few years after hatching to remain in the territory as helpers (Ref. 40). Scrub-jays are restricted to shrub lands that have many scrub oaks and few trees (Ref. 28) and have their greatest demographic success when territories include a matrix of recently burned scrub (<3 years since fire) and patches of scrub oaks that are 120-170 cm (47-67 in) tall with many open sandy areas (Ref. 35, 36,37, 41). Fragmentation of scrub habitat and isolation of small patches of scrub result in habitat degradation from fire suppression, increased predation, and increased road mortality (Ref. 29, 31, 42). Major Scrub-jay populations on KSC are found in zones shown in Figure 7-2. Most core habitat represents habitat of greatest importance to the Florida Scrub-jay population and is essential for achieving recovery. Support habitat has lesser importance although it is necessary for connecting population cores and providing a population with high persistence probabilities. Auxiliary habitat is of lower habitat quality regardless of management history. Florida scrub-jays have been the topic of adaptive resource management studies intended to optimize fire management (Ref. 43, 44, 45). Knowledge gained from these studies has been incorporated into a NASA Scrub-jay mitigation plan and USFWS Biological Opinion.

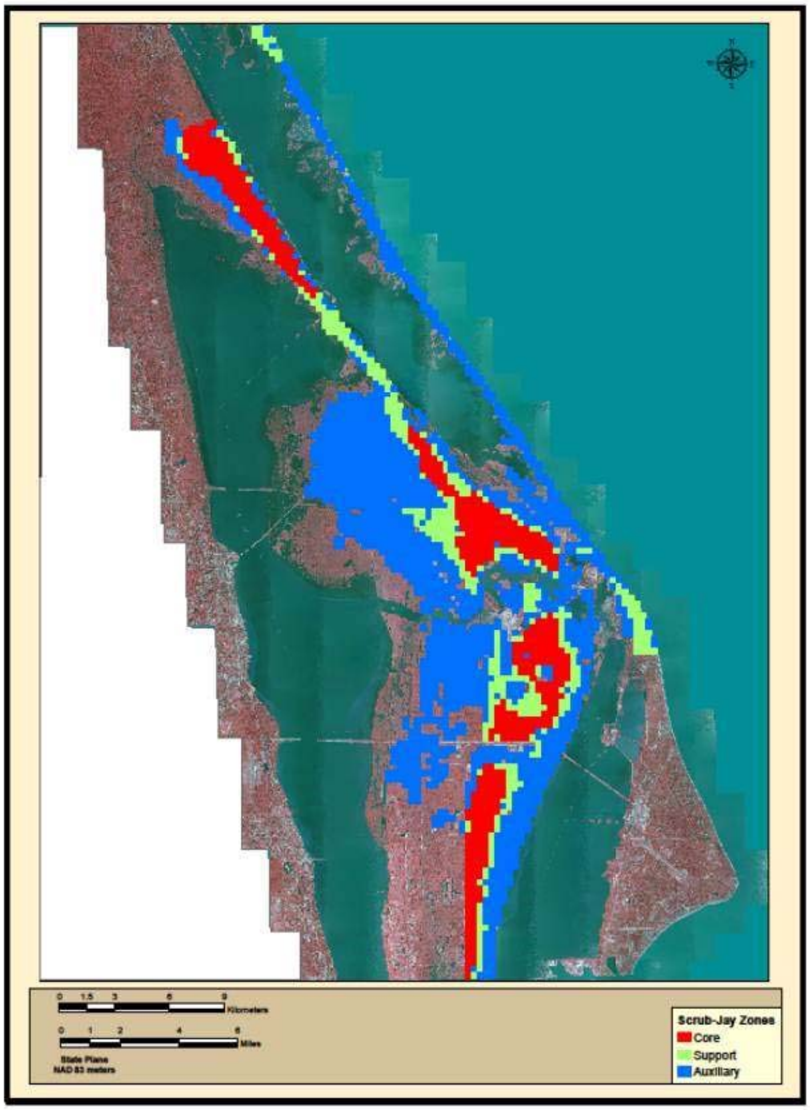

Figure 7-5. Scrub and Major Scrub-jay Populations on KSC.

7.5 MAMMALS

Three species of mammals occurring on KSC are legally protected, the Southeastern beach mouse, Florida mouse and West Indian manatee.

The southeastern beach mouse is federally listed as Threatened and the Florida mouse is protected by the State of Florida as a Species of Special Concern (Table 7-1). The USFWS at MINWR ranks management issues associated with the conservation of southeastern beach mice as one of their highest priorities due to the mouse's limited range and lack of remaining habitat outside of the Refuge.

Small mammal trapping, primarily done in coastal habitats, has provided data on several rodent species, including beach mice, cotton mice (*Peromyscus gossypinus*), cotton rats (*Sigmodon hispidus*), Florida mice, and golden mice (*Ochrotomys nuttalli*). In the mid-1970s, southeastern beach mice were trapped along the dunes at MINWR/KSC and were considered abundant with 771 captures in 2,256 trap nights (Ref. 38, 39). In 1990-1991, a baseline distribution survey (29 transects) was conducted in the coastal dunes, strand, and scrub, and resulted in 539 beach mouse captures over 3,937 trap nights (Ref. 40). In 1996-1998, surveys were conducted to evaluate space shuttle impacts on southeastern beach mice at four sites in the vicinity of the shuttle pads. Two areas (one near LC 39A and one near LC 39B) with the most frequent occurrence of near-field deposition were selected as treatment sites, and two areas not impacted by near-field deposition were selected as reference sites. A total of 479 beach mice were captured, 64% of which were adults, 28% were juveniles, and 4% were dependent young. No effects of launch could be inferred from the data collected.

Southeastern beach mouse trapping and radiotracking projects have been conducted associated with the construction of two inland dunes. During the summer of 2010, a pilot dune was built behind the primary dune between LC 39A and LC 39B, east of Phillips Parkway. The dune is 221 m (725 ft) long, 24 m (80 ft) wide, and 4.6 m (15 ft) tall. During five trapping events from Nov. 2011 through Nov. 2012, totaling 720 trap nights, there were 126 captures of 53 individual beach mice from the pilot dune. Beach mice were captured in the first sampling event, less than four months after the bare dune sand was planted. There was movement of mice between the pilot dune and the nearby natural primary dune.

A second inland dune was constructed beginning in December 2013; it was also located east of Phillips Parkway and the LC 39 launch pads. The dune repair project, referred to as Sandy dune, incorporated the pilot dune and is approximately 1,829 m (7,000 ft) long. Three small mammal trapping events were conducted, two preconstruction and one post-construction. The first preconstruction event (2 – 4 December 2013) involved trapping in two areas outside the construction footprint for consideration as recipient sites for beach mice removed from the construction area. There were 356 trap nights with 10 individual beach mice captured. The second preconstruction trapping effort was conducted to collect beach mice inhabiting the construction footprint and adjacent habitat. Traps were set linearly for approximately 2 km (1.2 mi) from 5 – 9 December 2013, resulting in 1,009 trap nights. There were a total of eight beach mice captured and relocated to a recipient site. The first post-construction trapping was conducted 25 – 27 June 2014, just over two months after construction. A total of 412 trap nights yielded 46 different southeastern beach mice, all captured from the Sandy dune.

In addition to the post-construction trapping, ten mice (5 females and 5 males) were radio tracked from 22 – 25 April 2014. The mice were tracked from 3 to 15 days, with an average of 9.8 tracking days per mouse. Two of the mice were tracked directly on the new Sandy dune within a few days of being radio collared, even though the dune vegetation had been planted for less than a month and was still sparse [46 cm (18 in) between plants]. Two other mice crossed the dune at least once during the radio tracking surveys. It was clear that mice began using the newly created dune very quickly, including establishing burrows.

Overall, surveys indicate that the number of southeastern beach mice has remained relatively stable since 1990-1991, although year-to-year variation at a specific site can be high. The use of artificially created dune habitat is encouraging for the future stability of the southeastern beach mouse populations.

Since 2008, biologists have monitored habitat occupancy of the southeastern beach mouse on the federal lands encompassing KSC/MINWR/CCAFS/CNS, with the goal of sampling habitat occupancy annually each fall/winter throughout the entire area of suitable coastal habitat. This monitoring program utilizes habitat occupancy surveys based on rapid assessment techniques (i.e., tracking tubes or live-traps) to detect beach mouse occurrence at sampling stations, with repeated samples providing the information needed to estimate detectability. A pilot study of the feasibility of such an occupancy study was conducted in December 2008 along the 10 km (6.2 mi) beach on KSC/MINWR (Ref. 60). In February 2010, a full-scale implementation of the habitat occupancy monitoring project was initiated at 114 sites across the nearly 70 km (43 mi) of beaches extending from the north jetty of the Port Canaveral inlet on CCAFS to the northern boundary of the CNS. In March of 2011, a second year of data was collected from these same locations. In February 2012 a third year of sampling was performed at a subset (71) of the original sample points (43 sites on the CNS were not sampled), but for a longer number of sampling days. In February-March 2013, a fourth year of data was collected from the same subset of locations as in 2012 using the same number of days. In February-March 2014, all 114 sample locations were sampled. Results show that beach mice occupy suitable habitat throughout the entire region sampled, with the range of estimated probability of habitat occupancy being 0.43 – 0.93 over the sampling period.

Beach mice are thought to be somewhat habitat specific, relying on coastal dune and scrub areas for persistence. However, they are occasionally found inside and around facilities (A. Chambers, Jan. 2015, pers. comm.) and specimens have been captured as far inland as State Road 3 west of Happy Creek, approximately 4 km (2.5 mi) from the nearest coastal habitat.

Live trapping for Florida mice was conducted four times between July 2001 and July 2002 at Happy Creek, a large inland scrub site. Trapping grids were set in scrub habitat that was interspersed with shallow freshwater swale marshes. The July 2001 sample period consisted of six consecutive nights, and the remaining sample periods consisted of two consecutive nights each. There were 24 captures of 17 individual Florida mice. Eight were males and 9 were females. Of these, 12 were adults and 5 were juveniles. There are no long-term consistent trapping surveys done for Florida mice.

The manatee (*Trichechus manatus*) is federally listed as endangered (Table 7-1). In 1977, KSC supported baseline inventory studies to determine the abundance and distribution of the endangered manatee throughout Florida including the KSC property. Those surveys concluded that a large number of manatees were utilizing the Banana River where NASA intended to continue Space operations and use barges for the Shuttle Program. During the spring each year, as much as 25 percent of the total US manatee population can be found within the waters immediately surrounding KSC property (Ref. 42). Monitoring the distribution and abundance of manatees at KSC has been primarily performed through routine aerial surveys funded by KSC intermittently from 1977 - 1983 and almost continuously since 1984 (Ref. 61). The number of surveys per year has varied over time. Since 1991 KSC aerial surveys have also been conducted during cold periods in conjunction with the FFWCC's population census referred to as the Statewide Manatee Synoptic Survey.

The data collected are shared with the FFWCC, USFWS, universities, and others as requested. Data have been presented at scientific meetings and published in peer-reviewed journals. The raw aerial survey data for 1977-1990 were made available to the public on a CD-ROM in a joint venture with the FFWCC through the Manatee GIS Working Group. KSC maintains a position on the Manatee GIS Working Group. Data sets were submitted (with restricted use) to FFWCC for their evaluation of speed zone regulations as they were being developed. KSC data have also been shared through invited presentations to environmental and educational audiences, marine industry groups, the Brevard County Commission, US Marine Mammal Commission, the USFWS and the USACE.

In 1990, to further protect this endangered species, the USFWS created a sanctuary for manatees covering the majority of the KSC boundary within the Banana River. This precludes non-KSC motorized boats from entering into these waters. The USFWS officially designated the following areas at KSC as Critical Habitat: (1) the entire inland section of water known as the Indian River, from its northernmost point immediately south of the intersection of U.S. Highway 1 and Florida State Road 3 (2) the entire inland section of water known as the Banana River, north of KARS park; (3) and all waterways between the Indian and Banana Rivers (exclusive of those existing manmade structures or settlements which are not necessary to the normal needs of survival of the species). Critical habitat and areas of manatee concentration are delineated in Figure 7-6.

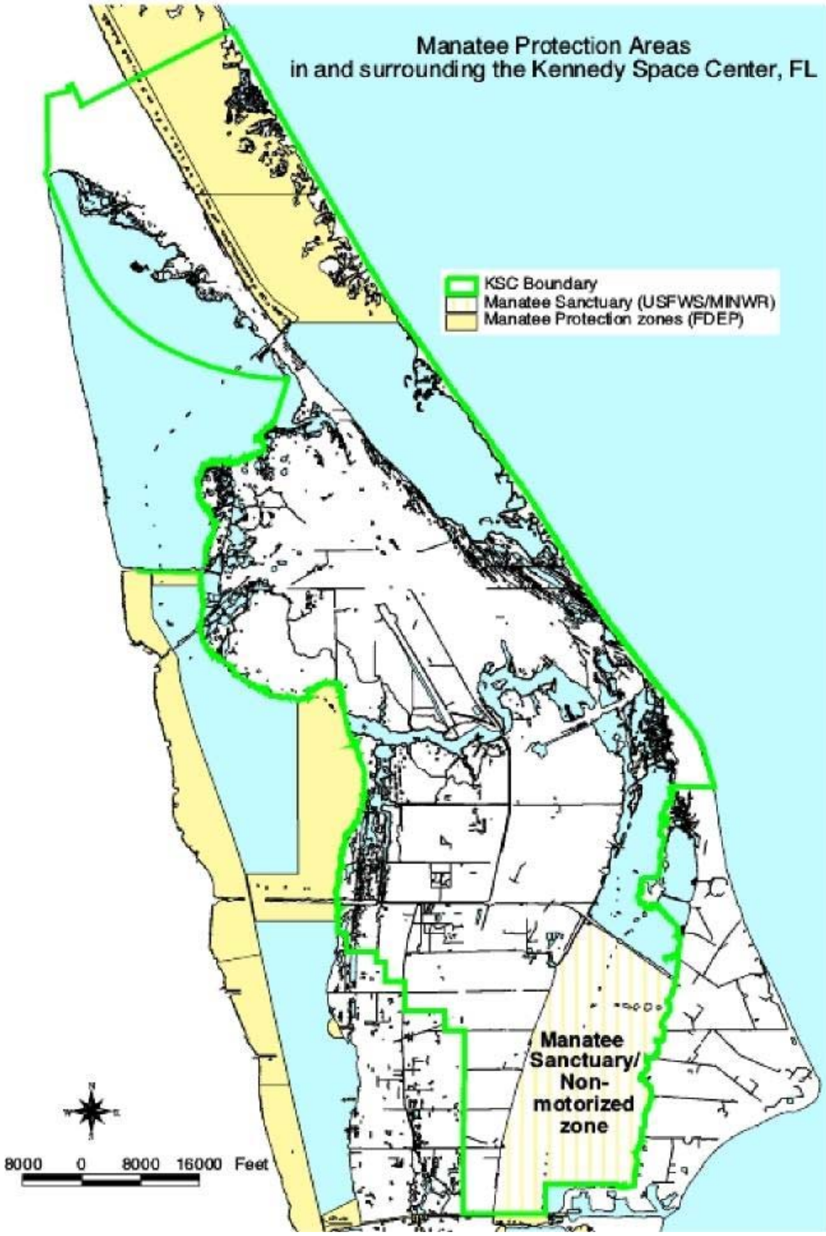

Figure 7-6. Manatee Protection Zones at Kennedy Space Center.

As mentioned above, monitoring the distribution and abundance of manatees at KSC was conducted through aerial surveys. Manatee aerial survey data analyses lead to the understanding that the season with the least variation in manatee numbers (presence) was summer. In contrast, spring and fall are times of high migration activity at KSC and widely ranging counts between weeks. To reduce the "data noise" of the highly migratory period it was determined that minimum monitoring for trends would entail a commitment to a series of flights conducted during the summer season each year. A summary of the KSC summer aerial survey data since 2002 is presented in Figure 7-7. Mean numbers of manatees observed in KSC waters during summer have used to fluctuate between 100 and 160 but in the last six years range from 250 to 650 manatees. High numbers in spring have exceeded 1200 manatees within this small 75-km^2 (29-m^2) area in recent years.

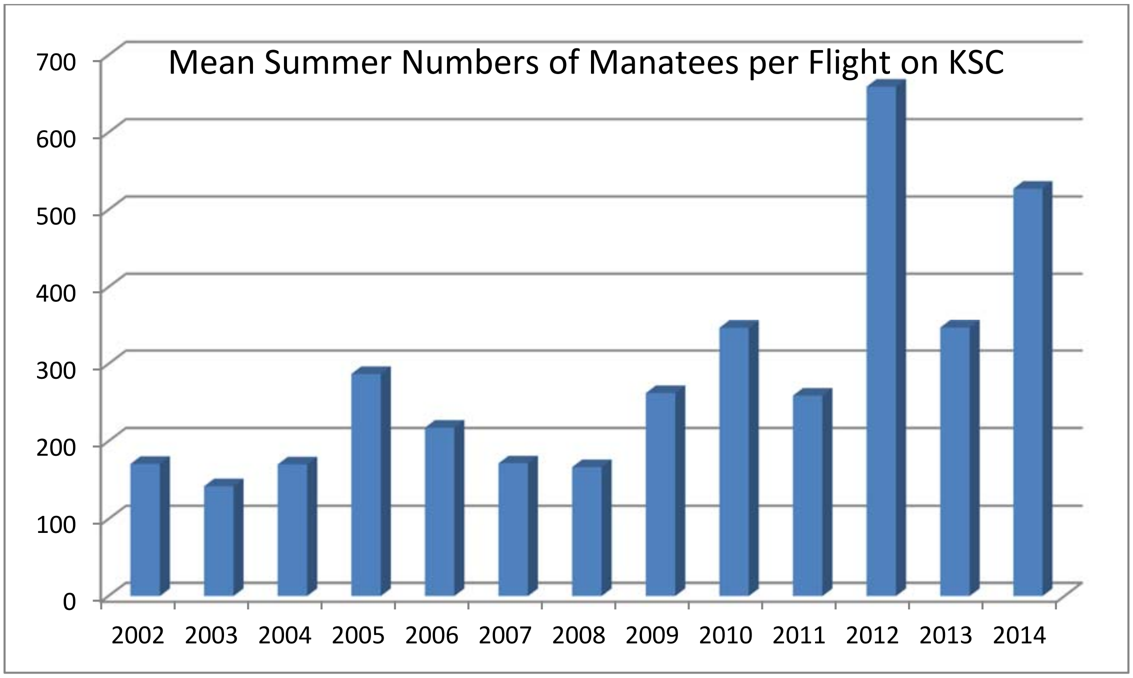

Figure 7-7. Manatee Counts Averaged for Each Summer in the Banana River on KSC between 2002 and 2014.

Manatees have experienced several remarkable challenges in the last 5 years in the Banana and Indian Rivers. The winter of 2010 was extremely cold both in January and in December and led to some related manatee deaths. The cold may have affected the abundance of seagrass shoots to some degree, and algae cover in many areas beginning a shift in the balance. The remarkable losses of seagrasses in 2011 and 2012 were associated with several persistent plankton blooms that reduced light penetration through the water, reducing or eliminating seagrass growth. This raised concerns for the ever increasing local and KSC manatee population (Figure 7-3) that clearly relies on this forage resource. KSC Ecological program scientists expected to see a problem for manatees and/or a large shift away from the upper Banana River in 2011 and 2012. There was in fact an unexplained manatee mortality event covering much of the IRL in spring through fall of 2011. Interestingly, manatees continued to visit and spend much time in KSC waters during this period feeding in ever shallower waters on the remaining sparse SAV. This leads to the next concern of the impact that manatees may have on the recovery of SAV in the area. To determine impacts, KSC will continue to monitor manatee distribution and seagrass cover within the surrounding waters.

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SECTION VIII. HAZARDOUS AND SOLID MATERIALS AND WASTES

8.1 REGULATORY OVERVIEW - FEDERAL

Federal statutes have been promulgated that address hazardous materials, hazardous wastes, potential impacts to the environment and handling from manufacture to disposal. These federal statutes are administered by a variety of government agencies that specifically address the generation, handling, transport, and proper disposal of hazardous materials and wastes. Those most applicable to activities at KSC are outlined in Table 8-1 below.

Table 8-1. Federal Statutes Governing Toxic Wastes and Substances.

Statute	U.S. Code
Comprehensive Environmental Response, Compensation, and Liability Act	42 U.S.C. 9601
Resource Conservation and Recovery Act	42 U.S.C. 6901
Toxic Substances Control Act	15 U.S.C. 2601
Clean Water Act	33 U.S.C. 1251
Clean Air Act	42 U.S.C. 7401
Safe Drinking Water Act	42 U.S.C. 300(f)
Federal Insecticide, Fungicide, and Rodenticide Act	7 U.S.C. 136
Occupational Safety and Health Act	29 U.S.C. 651
Hazardous Materials Transportation Act	49 U.S.C. 1801

8.1.1 PESTICIDES

Pesticides, which are chemical or biological substances used to control undesirable plants, insects, fungi, rodents or bacteria, can be extremely toxic and can cause serious harm if spilled on the skin, inhaled, or otherwise misused. EPA regulates pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Pesticide Amendment to the Federal Food, Drug, and Cosmetic Act (FFDCA).

8.1.2 RADIATION

Ionizing Radiation

Ionizing radiation can be a source of environmental contamination. Sources of this form of radiation include uranium mining and milling, nuclear power wastes, and radioactive materials used in medicine. The health effects of non-ionizing radiation - such as microwaves and radiation from high voltage power lines - are not as well understood, but they, too, are considered potentially hazardous.

A number of federal agencies, including EPA, are responsible for regulating emissions of ionizing radiation. The EPA derives its ionizing radiation regulations from the Atomic Energy Act of 1954, Public Health Service Act of 1962, Safe Drinking Water Act of 1974, Clean Air Act Amendments of 1977, the Uranium Mill Tailings Radiation Control Act of 1978, the Marine Protection and Sanctuaries Act, the Clean Water Act, the Nuclear Waste Policy Act of 1982, and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980. The Agency's major responsibilities are to set radiation guidelines, to assess new technology, and to monitor radiation in the environment. Use of ionizing radiation sources on KSC must comply with KNPR 1860.1, KSC Ionizing Radiation Protection Program.

Nonionizing Radiation

FDEP has established requirements to reasonably protect the public health, safety, and welfare from electric and magnetic fields of future electric transmission lines. Use of ionizing radiation sources on KSC must comply with KNPR 1860.2, KSC Nonionizing Radiation Protection Program.

8.1.3 TOXIC SUBSTANCES CONTROL ACT

Toxic substances include a number of manufactured chemicals, as well as naturally occurring heavy metals and other materials. In 1976, Congress passed the Toxic Substances Control Act (TSCA) to provide regulations against the introduction to the environment of contaminants such as polychlorinated biphenyls (PCBs), dioxin, and asbestos.

TSCA requires the EPA to develop and keep current a comprehensive chemical inventory, which presents an overall picture of the chemicals used for commercial purposes in the U.S. TSCA is applicable only to chemicals in commercial use, and not those used for research and development.

8.1.4 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) - WASTE MANAGEMENT

In 1965 Congress passed the Solid Waste Disposal Act. It was replaced in 1976, when

Congress enacted the RCRA, which authorized EPA to regulate current and future waste management and disposal practices. In 1984 the Hazardous and Solid Waste Amendments (HSWA) to RCRA were enacted (see Section 8.2.1 of this document).

8.1.5 COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT (CERCLA)

The Act authorizes EPA to respond to a danger that may pose a threat to public health or the environment as a result of abandoned hazardous waste disposal sites, improperly operated industries or catastrophic spillage of hazardous materials. The agency is also authorized to take long-term remedial action to achieve a permanent cleanup of these sites.

8.1.6 HAZARDOUS MATERIALS TRANSPORTATION ACT (HMTA)

The EPA is required by RCRA to be consistent with the Department of Transportation (DOT) under HMTA. To meet this mandate, EPA has incorporated the DOT regulations, which are outlined in 49 CFR 170-179, assuring consistency of coverage under the two programs. Generally, the DOT covers the packaging, labeling, and proper identification of hazardous materials in accordance with the DOT Hazardous Materials Table. EPA and DOT issued a joint Memorandum of Understanding delineating their respective enforcement and compliance responsibilities. EPA monitors compliance by hazardous waste generators and treatment, storage, and disposal facilities while DOT conducts inspections and applies RCRA standards to transporters. Unlike many of the DOT transportation regulations, these apply to both interstate and intrastate transport of hazardous waste.

8.1.7 PRIORITY POLLUTANTS AND HAZARDOUS CONSTITUENTS

The result of the Clean Water Act (CWA) and many of those acts mentioned above has been the establishment of effluent standards and the regulation of toxic substances released to the Nation's surface and ground waters. In 1976, a Consent Decree required EPA to establish a list of specific pollutants and their effluent limitations. A primary listing was initiated with additional compounds being added after screening water supplies. This procedure resulted in the priority pollutant list. The priority pollutants represent the subset of EPA's Hazardous Constituent List (40 CFR 261), which is most likely to impact water quality. Required methods for analyzing these pollutants are specified in 40 CFR 136.

8.1.8 STORAGE FACILITY STANDARDS

The EPA does not allow surface impoundments or land storage facilities for the temporary storage of hazardous waste. All hazardous wastes must be stored in appropriately labeled containers and tanks.

90-Day Storage Provision. 40 CFR 262.34 allows for the accumulation of hazardous waste on-site for a period of up to 90 days without having to obtain a permit as a storage facility. Additionally, generators can accumulate hazardous waste at interim staging areas before removing the material to a central storage facility. Up to 55 gallons of hazardous waste, or one (1) quart of acutely hazardous waste listed in 40 CFR 261.33(e), may be accumulated at or near any point of generation which is under control of the operator of the process. In the case of multiple waste streams generated at the same point of generation from the same process under control of the same operator, 55 gallons of hazardous waste (or one (1) quart of acutely hazardous waste) may be accumulated for each waste stream. This is the FDEP Central District interpretation of 40 CFR 262.34 (c)(1).

8.2 REGULATORY OVERVIEW - STATE

8.2.1 HAZARDOUS WASTE PERMITTING

Hazardous waste permitting has been delegated to the state by the EPA. Permitting programs are in place for hazardous waste disposal, storage and treatment facilities. Federal hazardous waste regulatory programs were established by RCRA P.L. 94-580 and parallel state permitting criteria contained in Chapter 403 F.S. and Chapter 62-730 FAC. The EPA still retains overview authority and certain permitting functions.

The Hazardous and Solid Waste Amendments (HSWA) to RCRA were enacted into law on November 8, 1984. One of the major provisions (Section 3004(u)) of these amendments requires corrective action for releases of hazardous waste or constituents from Solid Waste Management Units (SWMUs) at hazardous waste treatment, storage, or disposal facilities. Under this provision, any facility that has a RCRA hazardous waste management facility permit will be subject to a RCRA Facility Assessment (RFA).

8.2.2 TRANSPORTING HAZARDOUS WASTE

Vehicles which transport hazardous waste are subject to the U.S. DOT requirements of 49 CFR 170-179 which the Florida DOT has adopted and incorporated by reference in

Section 316.302, F.S. Similarly, FDEP has adopted the federal hazardous waste transporter regulations in 40 CFR 263 by reference in Chapter 62-730, FAC.

8.3 KSC HAZARDOUS WASTE MANAGEMENT PROGRAM

8.3.1 KSC HAZARDOUS WASTE MANAGEMENT ORGANIZATION

In compliance with the provisions of the RCRA of 1976, and the implementing regulations adopted by the State of Florida (62-730, FAC). NASA has developed a program of managing and handling hazardous and controlled wastes at KSC.

The organizational and procedural requirements of the KSC hazardous waste management program are contained in KNPR 8500.1 KSC Environmental Requirements and EVS-P-0001 Spaceport Waste Services Guidance Manual. These documents clearly delineate the procedures and methods to obtain/provide hazardous waste support, establish and approve operations and maintenance instructions, and provide instructions to maximize resource recovery and minimize costs (Table 8-2). Additionally, the Center utilizes the Medical and Environmental Services Contract (MESC) in providing contractor support for the management and storage of waste to be disposed of off-site from the Center's permitted TSDF. Contractor support includes the development of waste specific management guidance that is provided to the Center's waste generators to assist in managing the waste for off-site disposal. The support contractor directs and documents relevant actions associated with hazardous and controlled waste handling, including sampling, storage, transportation, treatment, disposal and recovery to ensure compliance with all applicable federal, state, and local regulations.

Table 8-2. KSC Hazardous Waste Management Directives.

KNPR 8500.1	Kennedy Environmental Requirements
KNPR 8830.1	Facility Asset Management Procedural Requirements Management
KNPR 8715.3	KSC Safety Procedural Requirements
KNPR 1840.19	KSC Industrial Hygiene Programs
KNPR 4000.1	Supply and Equipment System Manual
KNPR 8720.2	KSC Reliability & Maintainability Procedural Requirements
KSC-PLN-1919	Spill Prevention, Control, and Countermeasures (SPCC) Plan
KSC-PLN-1920	Appendix B: KSC Site-Specific SPCC Plans
EVS-P-0001	Spaceport Waste Services Guidance Manual
KNPR 8553.1	NASA-KSC Sustainable Environment Management System (SEMS)

To promote consistency, minimize risk, and ensure compliance with federal and state regulatory requirements, the NASA EAB utilizes a center-wide methodology for management of hazardous and controlled waste. This is accomplished by utilizing the KSC MESC for hazardous and controlled waste evaluation, pickup, and disposal services. The hazardous waste management process has been reviewed and approved by FDEP. MESC Waste Operations provides waste pick-up and transportation for all the Center's waste generators to long-term storage at the TSDF and eventual off-site disposal. In addition, Waste Operations provides other services such as bulk accumulation of used oil and industrial wastewater, including material generated in association with post-spill clean-up activities. The number of hazardous waste collection sites maintained at the Center is dynamic. KSC contractors are continually reviewing processes to reduce the amount of hazardous waste being generated which in turn reduces the number of sites required to manage the waste. This waste reduction/minimization effort is also associated with the requirements of EO 13693, "Planning for Federal Sustainability in the Next Decade."

8.3.2 KSC HAZARDOUS WASTE OPERATING PERMITS

KSC has an FDEP operating permit for the storage, treatment and disposal of hazardous waste. The main facilities operating under this permit are the Hazardous Waste Storage Building, Solids (K7-0164) and Hazardous Waste Storage Building, Liquids (K7-0165) in the LC-39 area, which handles liquid and solid hazardous wastes. There are four cells at these facilities each of which is designated and designed for the storage of specific hazardous wastes. Wastes permitted to be stored at the facilities include the following: flammable, organic, toxic waste; caustic, toxic, reactive wastes; acidic waste; and solid hazardous and controlled wastes. Treatment of inorganic zinc paint waste at the PCB Waste Storage Building (K7-0115) is also allowed under the hazardous waste operating permit. The MESC Waste Operations group operates these facilities and maintains records and reports associated with waste activities at the TSD facility to ensure Center compliance.

8.3.3 HAZARDOUS AND CONTROLLED WASTE GENERATION

KSC maintains a comprehensive inventory of all RCRA defined hazardous wastes, and controlled waste not regulated by RCRA. This inventory is maintained by a manifest records system, which tracks the generation, on-site storage, treatment, and reclamation of hazardous and controlled wastes. Various types of waste being managed include used oil, which is recycled, used antifreeze which is recycled, and fluorescent

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lamps that are managed as universal waste and are also recycled. The manifest records system is integrated with an automated data processing system, which provides the capability to generate current waste status reports as well as quarterly and annual summary reports. The MESC contractor is responsible for the maintenance of the hazardous and controlled waste database inventory including the KSC Biennial Hazardous Waste Disposal Report.

The quantity of hazardous and controlled waste generated at KSC depends on launch processing, construction and associated support activities. As part of KSC's waste management and pollution prevention programs, opportunities for waste prevention and reduction are continually assessed and implemented where cost-effective. Examples of waste reduction through material substitution and alternative treatment include the materials tetrachloroethylene and methyl hydrazine. Tetrachloroethylene was a key ingredient in the composition of a two-part paint used in Space Shuttle processing. This process generated a significant amount of hazardous waste at the Center. The paint was reformulated by substituting a more environmentally preferable source material for tetrachloroethylene, rendering the resulting waste stream non-hazardous. A second hazardous waste stream was eliminated through the treatment of methyl hydrazine by ultraviolet exposure. The resulting non-hazardous waste is discharged to the Center's sewer system.

8.4 SOLID WASTE

8.4.1 KSC/SCHWARTZ ROAD CLASS III OPERATIONAL LANDFILL

The KSC/Schwartz Road Class III Landfill is located in the restricted access area at the Kennedy Space Center on Merritt Island, southeast quarter of Section 20, Township 22 South, and Range 37 East. The landfill is located at latitude 28 degrees 33' 30" North and longitude 80 degrees 38' 36" West. The site is located adjacent to and east of the closed Schwartz Road Landfill, directly south of Schwartz Road and approximately 2.2 km (1.4 mi) east of Kennedy Parkway. Construction began in August 1994, with completion prior to physical closure of the Schwartz Road Landfill in January 1996. The facility is expected to handle the solid waste disposal needs of KSC for an estimated 13 to 49 years, based on assumed disposal rate scenarios of 350 tons per day (13 years) and 90 tons per week (49 years).

The permitted Class III landfill is unlined and does not accept putrescible household waste. NASA contractor personnel who are trained in accordance to FDEP and federal regulatory requirements operate the landfill. Operating reports are generated and forwarded to the EAB on a monthly basis and submitted to the State annually, and include the amount of daily wastes received by media type and weight.

These wastes consist of construction, demolition and maintenance debris, approved blast media, unserviceable furniture, wood and plastic products and yard waste.

The landfill is permitted to take asbestos, but currently at this time does not accept regulated asbestos containing material (ACM). However the landfill does accept non-regulated asbestos which is managed as regulated. Records are maintained at the scale house for incoming wastes documenting the transporters, contractor and debris being placed into the landfill.

The working face of the landfill is monitored by trained spotters to protect against unauthorized waste disposal. These spotters also conduct the load-checking program and traffic control as required by FDEP. The weekly cell construction is built from the deposited refuse and then compacted. The cell has to be a minimum of 1.9 m (6.5 ft) thick across the row to conform to requirements. The first row is constructed east to west and the next row will be west to east alternating on each row. Initial cover to minimize the adverse environmental health hazards resulting from birds, animals, waste, blowing litter and fires, is applied a minimum 15 cm (6 in) thick and is compacted on a weekly basis. Areas inactive for 180 days or more will receive additional cover of 30 cm (12 Stormwater discharge is routed to the perimeter drainage ditches that surround the landfill. The stormwater ditches, culverts and wet detention pond are designed to convey, retain, and discharge all stormwater runoff from a 25 year, 24-hour duration storm event.

The landfill has a Groundwater Monitoring Plan, with a well field consisting of 43 wells and 2 surface water sample points. Regulatory groundwater monitoring reporting requirements are met on semi-annual and bi-annual schedule. The Gas Monitoring Plan requires quarterly reporting on a field of 11 monitoring wells. All water and gas sample analysis is performed by a State certified laboratory and forwarded to the NASA Environmental Assurance Branch for review prior to submittal to FDEP.

8.4.2 KSC/SCHWARTZ ROAD CLASS III CLOSED LANDFILL

The Schwartz Road Closed Landfill was the primary land disposal site at KSC until December 1995. The landfill was placed in operation in 1968, and operated initially as a Class II facility until 1982. Beginning in 1982, the landfill accepted only Class III waste material, which included trash and paper products, plastic, glass, and debris as a result of land clearing, construction, or demolition activities. The landfill site encompasses approximately 25 ha (64 ac), with about 20 ha (51 ac) being utilized for waste disposal. Renewal of the facility operations permit in March 1993 resulted in completion of a site-specific hydrogeologic investigation and in the construction of a new network of groundwater monitoring wells. Waste disposal consisted of excavated cells to depths of 0.9 to 1.8 m (3 to 6 ft) below original grade, with cell dimensions being roughly 15 m (50 ft) in width and 106 m (350 ft) in length. Trenching began along the east side of the site and progressed westward, with trenches generally oriented in the east and west direction. The closed trenches were covered with approximately 0.6 m (2 ft) of sandy soil. Final physical closure or capping of the Schwartz Road Landfill occurred in January 1996. Long-term site closure monitoring will continue for 30 years from the date of closure. The official date of closure filed with FDEP was June 2001.

SECTION IX. KSC STORAGE TANK SYSTEMS MANAGEMENT PROGRAM - UNDERGROUND STORAGE TANKS (UST), ABOVEGROUND STORAGE TANKS (AST) AND HAZARDOUS WASTE TANKS

9.1 REGULATORY OVERVIEW

Storage tanks systems can be aboveground (ASTs) or underground (USTs). A tank system includes the storage or treatment tank and its associated ancillary equipment and containment system. The regulations define an AST as a tank situated in such a way that its entire surface area (including the bottom) is above the plane of the adjacent surrounding surface and can be visually inspected; and define USTs as tanks with 10 percent of their volume underground (including connective piping).

9.1.1 UNDERGROUND STORAGE TANKS

In 1984, Congress added Subtitle I to RCRA, establishing a comprehensive regulatory program for USTs containing regulated substances. EPA regulates this program under Title 40 CFR 280. In addition to the federal regulation, many states have enacted UST regulations.

For more than 50 years, USTs have been widely used throughout the nation to store petroleum products, chemicals, and wastes. Most of these tanks contain petroleum products such as gasoline, diesel or oil. The State of Florida regulates the UST program under FAC Part 62-761. Specific requirements vary depending on the contents of tanks. Generally, tanks must meet specific installation standards and requirements for corrosion protection, spill/overfill prevention, and leak detection.

9.1.2 ABOVEGROUND STORAGE TANKS

Aboveground systems incorporate the National Fire Protection Association standards (NFPA-30 and 30A), and for oil and/or petroleum storage tanks, Title 40 CFR 112, Spill Prevention, Control and Countermeasures Plan (SPCC). The State of Florida regulates the AST program under FAC Part 62-762. Specific requirements vary depending on the contents of the tanks. Generally, aboveground tanks must meet specific installation standards and requirements for corrosion protection, spill/overfill prevention, fire protection, and leak detection.

9.1.3 HAZARDOUS WASTE TANKS

Subtitle C of RCRA establishes requirements for managing hazardous wastes. The requirements for tank systems storing hazardous wastes are detailed in Title 40 CFR 264, Subpart J and 265, Subpart J. The regulations for these tank systems apply to both underground and aboveground hazardous waste tank systems. The Florida Department of Environmental Protection's Central District is the local administering agency for the hazardous waste tank regulations affecting KSC.

Table 9-1 lists the existing hazardous waste tanks in operation on KSC. The 2,500 gallon alodine tank in the Small Parts Area at Hangar AF is not closed but is not currently in service.

Table 9-1. Regulated Hazardous Waste Tanks at KSC for 2015.

Facility/ Building #	Stored Material	Capacity (gallons)	Construction
ARF/L6-0247	Waste Alcohol (IPA)	200	Stainless Steel
ARF/L6-0247	Waste Alcohol (IPA)	200	Stainless Steel
Surface Prep Facility/66310	Waste Alodine	1,000	Fiberglass
Hangar AF/66250	Waste Alodine	2,500	Fiberglass

9.2 REGULATED SUBSTANCE TANKS

9.2.1 REGULATORY OVERVIEW

Separate from the hazardous waste tank program and regulations, 40 CFR 280 sets forth requirements pursuant to Subtitle I of HSWA for USTs. Tanks regulated under Part 280 contain "regulated substances," which are defined in Section 280.12 to include petroleum products and CERCLA hazardous substances. The primary distinction between the two regulatory sections is based on tank content (hazardous wastes vs. regulated substances). Program requirements for tanks vary significantly between Title 40 CFR 264, 265 and 280.

9.2.2 KSC UNDERGROUND STORAGE TANKS

In the early 1980s, the State of Florida first began addressing the serious threat to groundwater posed by USTs by establishing a rigorous regulatory and remediation program. The state requirements for USTs that contain petroleum products and CERCLA hazardous substances include permitting, construction design, monitoring, record keeping, inspection, accidental releases, financial responsibility, and tank closure. The state program underwent modifications after US/EPA adopted federal regulations for

USTs in late 1988 under the provisions of RCRA. The Brevard County Natural Resource Management Office (BCNRMO) is the local administering agency for the UST regulations affecting KSC.

Various tank removal projects throughout KSC and at KSC-operated facilities at Cape Canaveral Air Force Station (CCAFS) were initiated and performed throughout the mid- to late-1990s. Approximately 90 tank systems were removed or closed in place. As a result of this initiative, only one registered UST remains in service at KSC. This UST is located at the NASA Gas Station (currently a Mobil station), facility M6-0596. In July 2009, NASA Exchange entered into a concessionaire's agreement with a new vendor for the KSC Service Station. As a part of that agreement, the vendor replaced the old single-walled USTs with a new double-walled compartmented UST in March 2010. This tank contains 22,000 gal of unleaded regular, unleaded premium, and diesel fuel in a double-walled steel/fiberglass compartmented tank. The underground tank is a double-wall design, consisting of a single-walled steel tank surrounded by a fiberglass outer shell. The UST system is monitored by a continuous liquid level detection system designed to detect a release from either of the three primary tank compartments.

9.2.3 KSC ABOVEGROUND STORAGE TANKS

The aboveground storage tank (AST) regulatory requirements are from FAC 62-762, which provides standards for the construction, installation, maintenance, registration, removal and disposal of stationary aboveground storage tank systems, which consist of aboveground tanks and their on-site integral piping system and associated release detection, which store pollutants and have storage capacities of greater than 550 gallons. This rule implements the requirements of Chapter 376, Florida Statutes.

In Brevard County, FDEP has contracted annual compliance inspections associated with FAC 62-762 to the BCNRMO. The NASA Environmental Assurance Branch and MESC personnel conduct audits, prepare registrations and coordinate all FDEP compliance inspections. Table 9-2 lists the registered aboveground tank systems in operation on KSC.

Table 9-2. Regulated Aboveground Storage Tank Systems at KSC for 2015.

Facility/ Building #	Stored Material	Capacity (gallons)	Construction	Year Installed
VAB Utility Annex/K6-947	Diesel	30,000	DW Steel	2007
VAB Utility Annex/K6-947	Diesel	30,000	DW Steel	2008
VAB Utility Annex/K6-947	Diesel	30,000	DW Steel	2008
MCAR/E3-1133	Diesel	2,000	Concrete Vaulted Steel	2006
C5 Substation/K6-1091	Diesel	10,000	Concrete Vaulted Steel	1999
C5 Substation/K6-1091	Diesel	10,000	Concrete Vaulted Steel	1999
NASA Press Site/K7-1203	Diesel	2,000	Concrete Vaulted Steel	2005
M&O Bldg./M6-0486	Gasoline	4,000	Concrete Vaulted Steel	2006
M&O Bldg./M6-0486	Diesel	4,000	Concrete Vaulted Steel	2006
NASA Citgo.M6-0596	Ethanol	5,000	DW Steel	2005
North Area Fuels/K6-1345	Ethanol	10,000	DW Steel	2005
Visitor’s Center/M6-0510	Diesel	12,000	Concrete Vaulted Steel	2007
Kennedy Data Center/M6-0547	Diesel	8,000	Concrete Vaulted Steel	2015
HMF Firex/M7-1362	Diesel	1,500	DW Steel	2000
HMF Firex/M7-1362	Diesel	1,500	DW Steel	2000
HMF Firex/M7-1362	Diesel	1,500	DW Steel	2000
OPF Firex/K6-895	Diesel	1,500	DW Steel	2002
OPF/Firex/K6-895	Diesel	1,500	DW Steel	2002
OPF/Firex K6-895	Diesel	1,500	DW Steel	2002
Pad B Firex/J7-1388	Diesel	1,000	DW Steel	2000
Pad B Firex/J7-1388	Diesel	1,000	DW Steel	2000
Pad B Firex/J7-1388	Diesel	1,000	DW Steel	2000
Pad B Firex/J7-1388	Diesel	1,000	DW Steel	2000
Pad B Firex/J7-1388	Diesel	5,000	DW Steel	2002
PHSF/M7-1354	Diesel	2,500	Concrete Vaulted Steel	2011
SSPF/M7-0360	Diesel	1250	DW Steel	1998
SSPF/M7-0360	Diesel	1000	DW Steel	1999
Hangar AE/60690	Diesel	4,000	Concrete Vaulted Steel	2011

9.3 KSC SPILL PREVENTION CONTROL AND COUNTERMEASURES (SPCC) PROGRAM

9.3.1 BACKGROUND AND REGULATORY REQUIREMENTS

Oil pollution prevention regulations in 40 CFR 112 require the preparation and implementation of SPCC Plans for all non-transportation related facilities that store oil in excess of specific quantities (an aggregate aboveground container capacity greater than 1,320 gals [only containers greater than or equal to 55 gals are counted], or completely buried storage capacity greater than 42,000 gals) and that have discharged or could reasonably be expected to discharge oil into navigable waters of the U.S. or its adjoining shorelines. Because KSC stores more than 1,320 gals of oil above ground and a spill could reach a navigable U.S. waterway, the facility is subject to the SPCC regulations.

In accordance with the requirements in 40 CFR 112.5, SPCC Plans shall be reviewed and evaluated every 5 years. Technical changes to an SPCC Plan must certified by a registered Professional Engineer. In addition, SPCC Plans must be amended within 6 months of a change in facility design, construction or operation that materially affects the potential for an oil discharge. For this purpose, the NASA EAB office conducts bi-annual data calls to all KSC contractor organizations for the purpose of amendment to the contractor's individual site specific SPCC Plans.

9.3.2 OBJECTIVE AND PLAN ORGANIZATION

The KSC SPCC Plan (KSC-PLN-1919) outlines the criteria established by KSC to prevent, respond to, control, and report spills of oil. Various types and quantities of oil are stored, transported, and handled throughout the installation to support the operations of KSC. The KSC SPCC Plan describes both the facility-wide and site-specific approach for preventing and addressing spills. This plan serves as a guide for personnel and organizations to ensure that appropriate measures are taken to prevent and contain spills and leaks of oil in accordance with all applicable state and federal regulations.

In conjunction with the facility-wide SPCC Plan, site-specific SPCC plans (KSC-PLN-1920) were developed for each individual building or area at KSC where oil is stored or used in containers or processing equipment equal to or greater than 55 gals. The range of bulk storage containers includes aboveground tanks, drums and oil-filled process equipment used for various purposes on KSC. The site-specific plans are also located in Appendix B-1 thru B-10 of the SPCC Plan and contain the following information:

- An inventory of oil that is located at storage, handling, and transfer facilities;
- A detailed description of countermeasures and equipment available for diversion and containment of spills for each facility listed in the inventory; and
- Site-specific guidelines for spill prevention, response, and control.

A copy of the SPCC Plan is maintained at the EAB Office and is available to the U.S. EPA Regional Administrator for on-site review during normal working hours.

SECTION X. REMEDIATION

10.1 RESOURCE CONSERVATION AND RECOVERY ACT OF 1976

Under RCRA, the U.S EPA developed strict regulations that require facilities that treat, store, or dispose of hazardous wastes to identify potential waste release sites and to take actions to eliminate any hazards in an environmentally responsible manner. For hazardous waste this program is commonly referred to as the RCRA Corrective Action Program, which in Florida is overseen by the FDEP, with support from the USEPA. For petroleum, which is also regulated under RCRA, this program is regulated under the FDEP petroleum cleanup regulation, FAC Chapter 62-770.

10.2 REGULATORY OVERVIEW

10.2.1 HAZARDOUS WASTE PERMITTING

Hazardous waste permitting has been delegated to the State of Florida by EPA. Permitting programs are in place for hazardous waste disposal, storage, and treatment facilities. Federal hazardous waste regulatory programs were established by RCRA P.L. 94-580 and parallel state permitting criteria contained in Chapter 403 F.S. and FAC Chapter 62-730. EPA still retains overview authority and certain permitting functions.

The Hazardous and Solid Waste Amendments (HSWA) to RCRA were enacted into law on November 8, 1984. One of the major provisions (Section 3004(u)) of these amendments requires corrective action for releases of hazardous waste or constituents from solid waste management units (SWMUs) at hazardous waste treatment, storage, or disposal facilities. Under this provision, any facility that has a RCRA hazardous waste management facility permit will be subject to a RCRA Facility Assessment (RFA). The HSWA portion of RCRA was delegated to the state in 2002.

10.2.2 TRANSPORTING HAZARDOUS WASTE

Vehicles which transport hazardous waste are subject to the U.S. DOT requirements of 49 CFR 171-178, which the Florida DOT has adopted and incorporated by reference in Section 316.302, F.S. Similarly, FDEP has adopted the federal hazardous waste transporter regulations in 40 CFR 263 by reference in Chapter 62-730, FAC.

10.2.3 SOLID WASTE MANAGEMENT UNITS (SWMUs)

EPA has conducted a RCRA Facility Assessment (RFA) at KSC that was designed to identify SWMUs, which are, or are suspected to be, the source of releases to the environment. For the units identified, KSC was directed to perform a RCRA Facility Investigation (RFI) to obtain information on the nature and extent of the release so that the need for interim corrective measures or a Corrective Measures Study can be determined. Information collected during the RFI can also be used by KSC to aid in formulating and implementing appropriate corrective measures. Such corrective measures may range from stopping the release through the application of a source control technique to a full-scale cleanup of the affected area. In cases where releases are sufficiently characterized, the EPA may require KSC to collect specific information needed to implement corrective measures during the RFI.

Since the time of the initial RFA, the list and status of sites has changed significantly. A listing of individual SWMU and Potential Release Location (PRL) sites requiring investigation is found in the HSWA portion of the KSC RCRA facility permit dated January 2009. The list is periodically updated through a permit modification process. Tables 10-1 through 10-4 list SWMU and PRL sites and status.

Table 10-1. SWMUs and PRLs Requiring Confirmatory Sampling.

SWMU/ PRL Number	SWMU/PRL Name	Comment and Basis for Determination	Dates of Operation
SWMU #36	GSA Reclamation Yard West	Collecting representative GW samples now; complete SAR after 2010	2000 - present
PRL #122	Fire Station #4, M6-695	CS Work Plan approved by FDEP June 6, 2005	1964 - present
PRL #144	Fire Rescue Training Area, L7-940	CS Work Plan approved by FDEP October 3, 2006	1969 -1994
PRL #148	Base Operations Building, M6-339	CS Work Plan approved by FDEP April 12, 2007	1965 -present
PRL #149	Child Development Center, M6-883	CS Work Plan Approved by FDEP January 10, 2007	1997 - present
PRL #150	Sewage Treatment Plant #1, M6-895	CS Work Plan approved by FDEP April 11, 2007	1996 -present
PRL #153	Property Disposal Office, M6-1723	CS Work Plan approved by FDEP June 13, 2007	1963 - present
PRL #154	Equipment Buildings Static Test Road, M7- 0335/M7-0286	CS Work Plan approved by FDEP May 5, 2007	1964 - present
PRL #155	Banana River Repeater Station, M7-0531	CS Work Plan approved by FDEP June 15, 2007	1964 - present
PRL #160	Fire Department Staging Building #1, L6-1563	CS Work Plan approved by FDEP December 19, 2007	1965-1975
PRL #161	Fire Station #6, J7-1339	CS Work Plan approved by FDEP January 10, 2008	1965 – present
PRL #163	Fire Station #2, K6-1198	CS Work Plan approved by FDEP April 23. 2008	1967 - 2007

Table 10-1. SWMUs and PRLs Requiring Confirmatory Sampling (cont.).

SWMU/PRL Number	SWMU/PRL Name	Comment and Basis for Determination	Dates of Operation
PRL #164	Paint Shop Area, K6- 1397	CS Work Plan approved by FDEP September 12, 2008	1984 - present
PRL #166	Instrumentation Facility Building Area, K7-1557	CS Work Plan approved by FDEP June 5, 2008	1965 - present
PRL #167	Launch Control Center Area, K6-900	CS Work Plan approved by FDEP November 29, 2007	1966 - present
PRL #168	Mission Support Building Area, K6-1298	CS Work Plan approved by FDEP November 30, 2007	1985 - present
PRL #169	Ordnance Operations Building Area, K7-0558	CS Work Plan approved by FDEP May 16, 2008	1970 - present
PRL #170	Operations Support Building Area, K6-1096	CS Work Plan approved by FDEP April 7, 2008	1964 - present
PRL #171	Area 1 Rechlorination Buildings, L6-0043 & M7-0433	CS Work Plan approved by FDEP April 21, 2008	1964 - present

Table 10-2. SWMUs and PRLs Requiring a Site Assessment (a/k/a RCRA Facility Investigation [RFI] or a Risk Assessment).

SWMU/PRL Number	SWMU/PRL Name	Comment and Basis for Determination	Dates of Operation
SWMU#41	Components Refurbishment & Chemical Analysis Facility, K6-1964	CS Report/RFI Work Plan approved by FDEP October 5, 2005	1996 - present
SWMU#77	Vertical Processing Facility (VPF), M7-1469, (formerly PRL # 109)	RFI Report/CMS Work Plan delivered to FDEP January 31, 2005	1965 - 2007
SWMU#78	SRB Rotation, Processing, & Storage Facility, K6-345, K6- 494 (formerly PRL # 104)	RFI Work Plan approved by FDEP May 11, 2004	1984 - present

Table 10-2. SWMUs and PRLs Requiring a Site Assessment (a/k/a RCRA Facility Investigation [RFI] or a Risk Assessment) (cont.).

SWMU/ PRL Number	SWMU/PRL Name	Comment and Basis for Determination	Dates of Operation
SWMU#89	Convertor/ Compressor Building, K7-468 (formerly PRL # 60)	CS Report/RFI Work approved FDEP July 8, 2005	1965 - present
SWMU#91	LETF/M7-0505 Area (formerly PRL #126 & includes PRL#96 VC Plume	RFI Work Plan approved by FDEP September 21, 2006	1976 - present
SWMU #97	Agricultural Sheds (formerly PRLs#57a, 57b, & 143)	CS Report/RFI Work approved FDEP January 24, 2007	1960's - present
SWMU#98	Space Station Processing Facility, M6-360, (formerly PRL#142)	SAR/CS Work Plan delivered to FDEP February 28, 2006	1992 - present
SWMU#99	Visitor Complex Maintenance Area, M6-504, (formerly PRL#139)	CS Report/RFI Work Plan approved by FDEP April 20, 2007	1960's – present
SWMU#100	Area South of K7-516	RFI Work Plan approved by FDEP May, 2008	Unknown
SWMU#101	Processing Control Center Area, K6-1094, (formerly PRL#145)	RFI Work Plan approved by FDEP February 18, 2008	1992 - present
SWMU#102	Propellants Support Building Area, K7-416B (formerly PRL #162)	CS Report/RFI Work Plan Work approved by FDEP July 29, 2008	1967 - present
SWMU#103	Transporter/Canister Rotation Facility, M7-777 (formerly PRL #158)	CS Report/RFI Work Plan Work approved by FDEP October 8, 2008	1993 - present
SWMU #104	KSC Headquarters Building Area, M6-399 (formerly PRL #146)	CS Work Plan approved by FDEP August 16, 2006	1965 - present
PRL#157	Fuel Storage Area #1 Underground Storage Tank (1044)	Petroleum Site regulated under Chapter 62-770, F.A.C	1985 - present

Table 10-3. SWMUs and PRLs Requiring a Remedial Action Plan or Natural Attenuation with Monitoring Plan (a/k/a Corrective Measures Study [CMS]).

SWMU/PRL Number/	SWMU/PRL Name	Dates of Operation	Potentially Affected Media
SWMU #8	Launch Complex 39A(includes SWMUs 46, 47, 48, 49, 50, and 51)	1966 - present	Groundwater, soil, and sediment
SWMU #37	Former Drum Storage Area, J7-2112	1965 -present	Groundwater
SWMU #82	Communications, Maintenance & Storage (M6- 0791)	1964 - present	Groundwater
SWMU #84	KARS Park 1 (formerly PRL#117)	1963 - present	Soil and Groundwater
SWMU #88	Supply Warehouse #3 (M6- 0891)	1967 - present	Groundwater
SWMU #90	Hypergol Module Facility North, M7-0961, (formerly PRL#118)	1964 - present	Soil & Groundwater
SWMU #93	Citgo Service Station (M6- 0596)	1967 - present	Groundwater
SWMU #95	General Services Administration Seized Property, M6-0880, (formerly PRL #130)	1989 - present	Groundwater
SWMU #CC054	Launch Complex 34 (Facility 21934)	1961 - 1998	Groundwater

Table 10-4. SWMUs and PRLs Implementing a Remedial Action Plan or Natural Attenuation with Monitoring Plan (a/k/a CMS).

SWMU/PRL Number	SWMU/PRL Name
SWMU #1	Wilson Corners (H5-1633)
SWMU #3	Ransom Road Landfill
SWMU #4	Orsino Storage Yard (M6-895)
SWMU #7	Hydrocarbon Burn Facility
SWMU #9	Launch Complex 39B - Includes SWMUs 32 (formerly PRL # 46), 52, 53, 61, and 62
SWMU #10	General Storage Area Reclamation Yard
SWMU #13	General Service Administration Vehicle Maintenance Facility - includes Battery Acid Dump Site #1
SWMU #14	M&O Building (M6-0486) - includes Battery Acid Dump Site #2 and SWMU # 24a
SWMU #15	Contractors Road Acid Dump Site – made part of SWMU#55
SWMU #16	Sewage Treatment Plant, K6-1996E #15 – made part of SWMU #55
SWMU #21	Ransom Road Sandblast Yard, M6-1625 - includes STP-14, PRL #86b
SWMU #30	Component Cleaning Facility, K7-516
SWMU #31	Printed Circuit Board Shop, K6-1696 - made part of SWMU#55
SWMU #32	LC-39B Compressor Building, J7-338 – made part of SWMU#9
SWMU #33	LC 39B MEK Spill, J7-288 – made part of SWMU#9
SWMU #35	VAB Utility Annex, K6-0947
SWMU #39	Payload Support Building, M7-0505
SWMU #43	East Crawler Park Site, K7-0188e
SWMU #44	West Crawler Park Site, K6-0743 - includes South Crawler Park Site, PRL # 84
SWMU #45	Central Heat Plant, M6-0595 - includes Cooling Tower Discharge Area, PRL #69
SWMU #46	LC-39A Deluge Basin (Tank) - made part of SWMU #8
SWMU #47	LC-39A Compressor Building, J8-1659 - made part of SWMU #8
SWMU #48	LC-39A Fuel Farm, J8-1906 - made part of SWMU #8
SWMU #49	LC-39A Oxidizer Farm, J8-1862 - made part of SWMU #8
SWMU #50	LC-39A ECS Site, J8-1708C - made part of SWMU #8
SWMU #51	LC-39A HVAC Facility, J8-1708G - made part of SWMU #8
SWMU #52	LC-39B ECS Site, J7-286 - made part of SWMU #9
SWMU #53	LC-39B HVAC Facility, J7-337C - made part of SWMU #9
SWMU #55	Contractors Road Heavy Equipment Area (Includes SWMUs #15, #16, #31)
SWMU #56	Mobile Launch Platform Park Sites/Vehicle Assembly Building Area – includes SWMUs # 80, #83; groundwater from SWMUs #72 and #74, and PRL #24c.
SWMU #50	LC-39A ECS Site, J8-1708C - made part of SWMU #8
SWMU #51	LC-39A HVAC Facility, J8-1708G - made part of SWMU #8
SWMU #52	LC-39B ECS Site, J7-286 - made part of SWMU #9
SWMU #53	LC-39B HVAC Facility, J7-337C - made part of SWMU #9
SWMU #55	Contractors Road Heavy Equipment Area (Includes SWMUs #15, #16, #31)

Table 10-4. SWMUs and PRLs Implementing a Remedial Action Plan or Natural Attenuation with Monitoring Plan (a/k/a CMS) (cont.).

SWMU/PRL Number	SWMU/PRL Name
SWMU #56	Mobile Launch Platform Park Sites/Vehicle Assembly Building Area – includes SWMUs # 80, #83; groundwater from SWMUs #72 and #74, and PRL #24c.
SWMU #61	LC-39B Fuel Farm, J7-534 - made part of SWMU #9
SWMU #62	LC-39B Oxidizer, J7-490 - made part of SWMU #9
SWMU #64	Suspect Rail Car Siding
SWMU #65	Hypergol Support Bldg, M7-1061 (formerly PRL#79)
SWMU #66	C-5 Electrical Substation Facility, K6-1141 (formerly PRL #75)
SWMU #67	POL Area, M6-894 (formerly PRL #90)
SWMU #68	Jay-Jay Railroad Yard, H2-1245
SWMU #69	Firex Water Tank, M7-1362A, (formerly PRL#82)
SWMU #70	Hypergol Module Facility South Hazardous Waste Staging Area, M7-1410 (formerly PRL #94)
SWMU #71	Wilson's Railroad Yard (formerly PRL # 91) - includes PRL#38
SWMU #72	Orbiter Processing Facilities 1 & 2, K6-0894 (formerly PRL # 103) – groundwater made part of SWMU #56
SWMU #74	KSC Press Site, K7-1205 (formerly PRL # 102) - groundwater made part of SWMU #56
SWMU #75	Former Engineering Development Bldg, L5-683, L5-734 (formerly PRL# 88)
SWMU #76	Operations and Checkout Bldg (O & C), M7-355, (formerly PRL
SWMU #79	Environmental Health Facility, L7-1557, (formerly PRL #105)
SWMU #81	SFOC Generator Maintenance Facility, (formerly PRL #80)
SWMU #85	Engineering Development Laboratory, M7-0409, (formerly PRL
SWMU #86	Spaceflight Tracking and Data Network Station, M5-1494, (formerly PRL #73)
SWMU #88	Supply Warehouse #3, M6-0891 (formerly part of SWMU #82)
SWMU #92	Central Supply Warehouse ,M6-0744 (formerly PRL #121)
SWMU #94	Payload Hazardous Servicing Facility, M7-1354, (formerly PRL #116)
SWMU #96	Orsino Power Substation, M6-0996, (formerly PRL#131)
PRL #51	Launch Equipment Shop, K6-1247

10.2.4 LAND USE CONTROLS (LUC)

By separate Memorandum of Agreement (MOA), effective February 23, 2001, with the EPA and FDEP, KSC on behalf of NASA, agreed to implement Center-wide, periodic site inspection, condition certification and agency notification procedures designed to ensure the maintenance of any site-specific LUCs deemed necessary for future protection of human health and the environment. A fundamental premise underlying execution of that agreement was the Center’s substantial good faith compliance with the procedures called for within each Land Use Control Implementation Plan (LUCIP).

Although the terms and conditions of the MOA are not specifically incorporated or made enforceable within each LUCIP by reference, it is understood and agreed by

NASA KSC, EPA and FDEP that the contemplated permanence of the remedy reflected within each LUCIP shall be dependent upon the Center's substantial good faith compliance with the specific LUC maintenance commitments. Reasonable assurances would be provided to EPA and FDEP as to the permanency of those remedies, which included the use of specific LUCs. Should such compliance not occur or should the MOA be terminated, it is understood that the protectiveness of the remedy may be reconsidered and that additional measures may need to be taken to adequately ensure necessary future protection of human health and the environment. LUCIPs are generally prepared for sites undergoing some type of corrective action and will remain in place until the site conditions requiring land use controls are eliminated.

SECTION XI. NOISE

11.1 REGULATORY OVERVIEW

The Congress enacted the Federal Noise Control Act in 1972 (42 USC §4901 et. seq.). This act was designed to promote an environment that is free from noise that might jeopardize the health and welfare of the population of the United States. The Act provided a means for coordinating federal research and activities in noise control, to authorize the establishment of noise emission standards for products distributed in commerce, and to provide information to the public respecting the noise emission and noise reduction characteristics of such products. In 1978, the Quiet Communities Act (42 USC §4913) was enacted to direct the federal government to develop and disseminate noise control information and educational materials to the public, conduct research into the effects of noise on humans, domestic animals, wildlife, and property, and investigate the economic impact of noise on property and human activities.

Both of these acts have resulted in the promulgation of regulations regarding the noise produced by transportation related equipment such as locomotives, trucks, and construction equipment (40 CFR 201-211). However, federal regulations governing low noise emission requirements for products exclude any rockets or equipment which are designed for research, experimental, or developmental work to be performed by NASA (40 CFR 203.1).

The Noise Control Act directed the EPA to publish information about the effects of different qualities and quantities of noise. It also defined acceptable levels of noise under various conditions that would protect public health and welfare. The noise guidelines published by the EPA identify a day/night sound level (Ldn) of less than 55 dBA as adequate to protect outdoor activities against interference and annoyance due to noise (Ref. 1).

The L_{dn} parameter is preferred by the EPA for assessing environmental noise impacts (Ref. 1). It is the energy average of all the noise occurring throughout the 24-hour day but with a 10- dB penalty added to the nighttime hours between 10 p.m. and 7 a.m. to account for the greater sensitivity of people to noise at night. This guideline level is commonly used as a basis for judging the acceptability of facility noise at residential and other sensitive receptors. Other governmental agencies such as the Department of Housing and Urban Development (HUD) and the Department of Defense (DOD) define outdoor L_{dn} levels up to 65 dBA as acceptable for residences.

11.2 AMBIENT NOISE

The 24-hour average ambient noise level on KSC is appreciably lower than the EPA recommended upper level of 65 decibels (dBA). This is on a scale ranging from approximately 10 dBA for the rustling of grass or leaves to 115 dBA, the unprotected hearing upper limit for exposure to a missile or space launch. The areas of KSC/MINWR away from operational areas are exposed to relatively low ambient noise levels, in the range of 35 to 40 dBA.

11.3 MAN-MADE SOURCES OF NOISE

Noise generated at KSC by day-to-day operations, and space vehicle launches can be attributed to five general sources: (1) launches, (2) aircraft movements, (3) industrial operations, (4) construction, and (5) traffic noise. Table 11-1 lists measured noise levels at KSC while Tables 11-2 and 11-3 are provided for reference.

11.3.1 AIRCRAFT MOVEMENTS

A number of aircraft are utilized at KSC for payload delivery, ferry support, NASA executives, security and astronaut training. Typically, noise levels are expected to be no greater than those experienced by a small commercial airport. See Tables 11-2 and 11-3 for noise levels generated by typical aircraft.

11.3.2 INDUSTRIAL ACTIVITIES

The loudest noise generated by industrial activities at KSC is produced by hydraulic pumps operating within the confines of their enclosures. Operators are required by Occupational Safety and Health Administration (OSHA) regulations to be equipped with ear protection devices when exposed to these levels. Other intermittent raised levels of noise occur during operation of lifting equipment, diesel-powered generators and locomotives, heavy-duty service vehicles, and the Crawler Transporter; by certain sheet metal forming and cutting processes. Even the highest levels of noise from industrial activities will have minor impact on the environment and none will affect areas beyond the KSC boundaries (see Table 11-3 for construction noise sources).

11.3.3 VEHICULAR TRAFFIC

The intermittent noise of arriving and departing vehicles (including visitors to the Space Center, the Merritt Island National Wildlife Refuge, and the Canaveral National Seashore) is expected to be no greater than that experienced in a major shopping center parking lot. Table 11-1 presents typical noise levels at the KSC Industrial Area.

11.3.4 NOISE ABATEMENT

A number of permanent and/or temporary measures may be taken to reduce noise levels at KSC. Potential noise abatement measures for any facility or operation include:

- Property acquisition for use as a buffer zone
- Landscaping with high, dense vegetation or earthen berm
- Noise insulation of buildings
- Erect permanent noise barriers
- Proper scheduling of a specified activity might eliminate or alleviate noise impacts during critical periods

During periods of construction, noise attenuation is generally not possible. Decreases in efficiency due to such efforts would increase construction costs and the time period over which the impacts would occur. However, with a little planning, the use of portable sound screens, and the strategic placement of stationary machinery, noise impacts can be significantly minimized.

Table 11-1. Measured Noise Levels at KSC.

Source	DBA Low	Range High	Remarks
Re-Entry Sonic Boom [1]			
Orbiter			101 N/m2 max. (2.1 psf)
SRB Casing			96 to 144 N/m2 (2 to 3 psf)
External Tank			96 to 192 N/m2 (2 to 4 psf)
Launch Noise			
Titan IIIC	[2]	94	21 Oct 165 (9,388 m)
Saturn I	[2]	89	Avg. of 3 (9,034 m)
Saturn V	[2]	91	15 Apr 1969 (9,384 m)
Atlas	[2]	96	Comstar (4,816 m)
Space Shuttle [1]		90	1.4 dBA Down from Saturn V (9,384 m)
Aircraft			
F4 Jet	[2]	107	18 km from Ground Zero
F Jet	[2]	158	Calculated at Ground Zero
NASA Gulfstream	87	109	Takeoff (Marker 14)
NASA Gulfstream	87	100	Landing (Marker 14)
Industrial Activities			
Complex 39A	71	78	Transformers
LETF	89	92	Hydraulic Charger Unit
Machine Shop	89	112	Base Support Building M6-486
Computer Room	85	88	VAB – Room 2K11
Snack Bar	[2]	60	CIF – Room 154
Laboratories	45	58	CIF – Rooms 139 and 282
Elevator	[2]	62	Central Instrumentation Fac.
VAB High Bay	75	108	Welding, Cutting, etc.
VAB High Bay	106	116	Chipping
Hangar AE	[2]	77	Room 125 During Test
Headquarters Office	58	75	Room 2637 and Printers
O&C Office	[2]	57	Room 2063
Mobile Launcher Platform	70	94	Room 2063
Mobile Launcher Platform	82	199	2 Pumps Operating 5K Load
Industrial Area	55	66	15 m from Traffic Light
Undisturbed Areas			
Seashore	50	69	Medium Waves (Nice Day)
Riverbank	48	48	Light Gusts (No Traffic)
150 m Tower	50	64	Light Gusts of Wind

[1] Estimated.
[2] Not measured or not applicable. SOURCE: Ref. 2

Table 11-2. Aircraft and Weapons Noise Levels.

Type Aircraft	Takeoff		Landing	
	DBA	(EPNdBA) [1]	DBA	(EPNdBA)
727, 737, DC9, BAC111	94-100	92-96	85-90	97-104
707, 720, DC8	100-105	-	94-100	-
747, Widebody	103	107-115	92	104-114
DC10, L1011	90	95-106	84	99-108
DC3, Propeller	85-90	-	75-82	-
Single-Engine Propeller	76-90	77-78	67-77	87-88
Multipropeller	76-90	-	67-77	-
Executive Jet	93-97	83-94	70-80	92-101
OH58 (Ranger Helicopter)	84	-	81-87	-
UH1 (Huey Helicopter)	77	-	2	-
C141 (Cargo Plane)	134	-	77	-

[a] EPNdBA: Effective Perceived Noise Level.

[b] Assume atmospheric absorption of 1dB/100 ft.

Table 11-3. Construction and Vehicular Noise Sources, dBA.

Source	Noise Level	Distance from Source [a]			
	(Peak)	50 ft	100 ft	200 ft	400 ft
Construction					
Heavy Trucks	95	84-89	78-83	72-77	66-71
Pickup Trucks	92	72	66	60	54
Dump Trucks	108	88	82	76	70
Concrete Mixer	105	85	79	73	67
Jackhammer	108	88	82	76	70
Scraper	93	80-89	74-82	68-77	60-71
Dozer	107	87-102	81-96	75-90	69-84
Paver	109	80-89	74-83	68-77	60-71
Generator	96	76	70	64	58
Shovel	111	91	85	79	73
Crane	104	75-88	69-82	63-76	55-70
Loader	104	73-86	67-80	61-74	55-68
Grader	108	88-91	82-85	76-79	70-73

Table 11-3. Construction and Vehicular Noise Sources, dBA (cont.).

Source	Noise Level (Peak)	Distance from Source [a]			
		50 ft	100 ft	200 ft	400 ft
Caterpillar	103	88	82	76	70
Dragline	105	85	79	73	67
Shovel	110	91-107	85-101	79-95	73-89
Dredging	89	79	73	66	60
Pile Driver	105	95	89	83	77
Ditcher	104	99	93	87	81
Fork Lift	100	5	89	83	77
Vehicles					
Diesel Train	98	80-88	74-82	68-76	62-70
Mack Truck	91	84	78	72	66
Bus	97	82	76	70	54
Compact Auto	90	75-80	69-74	63-68	57-62
Passenger Auto	85	69-76	63-70	57-64	51-68
Motorcycle	110	82	76	70	64
[1] Assume 6 dBA decrease for every doubling of distance.					
Source: Ref. 3					

11.3.5 ENVIRONMENTAL IMPACTS OF NOISE

Wildlife. Studies have been conducted on the noise impacts on wood storks from launch operations. During the 1990 nesting season, studies were made on the Bluebill Creek colony before and after the April 24, 1990 launch from Pad B and a Titan IV launch from CCAFS Pad 41 on June 12, 1990. A startle response occurs during launches from either shuttle pad but within 10 minutes the colony appeared to be functioning normally and no young were observed to be injured or killed from startle effects. Experts consulted on the subject concluded that noise levels in the frequency and power range observed may be harmful to birds, but very little information is available. Site visits made before and after the launches did not indicate any obvious adverse effects. Bluebill Creek was also often used as a roost site by wading birds, cormorants, and brown pelicans. Freezes destroyed the mangroves in this area and it is no longer a rookery area.

A noise survey was performed by the Base Operations Contractor Industrial Hygiene Office on March 14, 1990, to assess the noise levels in the habitat of scrub jays and beach mice during a Titan 34D launch from Complex 40. Noise levels are reported for four sampling sites. No conclusions can be drawn from the field data; however, ongoing observations of the scrub jays do not indicate any adverse impact (Ref. 4).

Studies were conducted on wading bird colonies subjected to military overflights 152 m (500 ft) altitude) with noise levels up to 100 dBA. No productivity limiting responses were observed (Ref. 5). Nesting birds are apparently more startled by human presence in the vicinity of the nest than by noise impacts.

Bald eagles utilizing a nest adjacent to the Kennedy Parkway at KSC have received episodic sound exposures of 102 dBA during STS launches. Observation showed that the startle response to such high noise levels was short-term and caused no significant impact (Ref. 6).

Studies of reproductive success and survival of Florida scrub jays have been conducted surrounding USAF Titan IV launch pads 40 and 41 (Ref. 7). No acute or obvious direct impacts have been found resulting from several launches where noise levels approached 140 dB.

Man. The effects of noise on man are outlined in Table 11-4. To ensure the protection of employees' hearing OSHA has outlined permissible noise exposures (see Table 11-5). 29 CFR Section 1019.95 states personnel exposed to an 8-hour time-weighted average of 85 dBA or greater must be issued hearing protection.

Table 11-4. Effects of Noise on Humans.

DBA Level	Potential Effect
20	No sound perceived
25	Hearing threshold
30	--
35	Slight sleep interference
40	--
45	--
50	Moderate sleep interference
55	Annoyance (mild)
60	Normal speech level
65	Communication interference
70	Smooth muscles/glands react

Table 11-4. Effects of Noise on Humans (cont.).

DBA Level	Potential Effect
75	Changed motor coordination
80	Moderate hearing damage
85	Very annoying
90	Affect mental and motor behavior
95	Severe hearing damage
100	Awaken everyone
105	--
110	--
115	Maximum vocal effort
120	--
125	Pain threshold
130	Limit amplified speech
135	Very painful
140	Potential hearing loss high

Source: Ref. 3

Table 11-5. Permissible Noise Exposures [1] (29 CFR 1910.95).

Duration per day, hours	Sound Level dBA Slow Response
8	90
6	92
4	95
3	97
2	100
1-1/2	102
1	105
1/2	110
1/4 or less	115

[1] When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: C/T + C/T + Cn/Tn exceeds unity, then the mix of exposure should be considered to exceed the limit value. Cn indicates the total time of exposure at a specific noise level, and Tn indicates the total time of exposure. Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

11.4 REFERENCES

1. EPA/ONAC 550/9-74-004, March 1974. "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety."

2. Environmental Impact Statement: Space Shuttle Program. 1978. NASA, Washington, D.C.

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SECTION XII. CULTURAL RESOURCES

KSC has a stewardship responsibility for managing cultural resources on all NASA-owned lands, as well as the NASA facilities and structures located within the CCAFS. To this end, KSC has developed an Integrated Cultural Resource Management Plan (ICRMP) (KSC-PLN-1733, Ref. 1) that reflects the Agency's commitment to protect significant archaeological sites and historic facilities. NPR 8510.1, NASA Cultural Resources Management (Ref. 2), addresses the Center Director's roles and responsibilities for cultural resources. The Center has designated a Historic Preservation Officer (HPO) under the Environmental Management Branch to manage the Cultural Resources Management Program and to report to NASA Headquarters, Federal Preservation Officer (FPO), as required. It is the goal of KSC to balance historic preservation considerations with the Agency's missions and mandates and to avoid conflict with ongoing operational requirements. Historic preservation is an integral part of KSC's environmental mission and is part of the decision-making process for activities at KSC. The ICRMP provides an inventory of significant cultural resources and a plan of action to identify, assess, manage, preserve, and protect. It also includes a guide for impact analysis review and a set of Standard Operating Procedures for ongoing cultural resource management activities. The ICRMP is also consistent with KSC's environmental policies stated in KNPD 8500.1, which promulgates compliance "through a proactive, systematic approach that integrates environmental management system elements into KSC's operations and practices to comply with all environmental laws, regulations, policies, Executive Orders, and NASA environmental directives, procedures, and requirements."

12.1 HISTORY OF LAND ACQUISITION

NASA became a resident of Cape Canaveral in 1958 when the Army Missile Firing Laboratory (MFL) was designated as the Launch Operations Directorate, led by Kurt Debus to manage NASA's overall integration, testing, and launch operations. Several Army facilities, various offices, and hangars at CCAFS were given to NASA including Launch Complexes 5/6, 26, and 34.

When President John F. Kennedy began the Man-to-the-Moon project, CCAFS land was insufficient to house further rocket facilities. New land was required to support expanded launch structures. Merritt Island, an undeveloped area west and north of the Cape, was selected for acquisition, and in 1961, the Merritt Island Launch Area (MILA) was created. In that same year, NASA requested from Congress authority to purchase 32,380.0 ha (79,999.7 ac) of property. The land was formally granted in 1962. The USACE acted as the agent for purchasing land. NASA began gaining title to the land in late 1962, taking over 33,955.9 ha (83,903.9 ac) by outright purchase. Much of the land deeded to NASA by the State of Florida was located south of the Old Haulover Canal and north of the Barge Canal. The purchase of KSC land included several small towns (such as Orsino, Wilson, Heath and Audubon), many farms, citrus groves, and fish camps. In 1963, LOC and MILA were renamed the John F. Kennedy Space Center to honor the late President.

In 1962, the Air Force requested more land to build new Titan rocket facilities (Launch Complexes 40 and 41) at the south end of KSC's newly purchased land. Negotiations between NASA and the Air Force resulted in the purchase of an additional 5,960.0 ha (14,719.9 ac) of land in 1963, lying north and east of the Old Haulover Canal, including the towns of Allenhurst and Shiloh. This land was purchased by the USACE with Air Force money in compensation for 140.4 ha (346.9 ac) taken by CCAFS for the two Titan launch facilities. The State of Florida provided an additional 259 ha (640 ac), bringing the total of donated submerged land to 22,580 ha (55,795 ac). In 1983, KSC increased its holdings when the Florida East Coast Railway requested a buy-out of its property east of Titusville, including the Jay-Jay rail yard. KSC acquired 74.9 ha (185.1 ac) as the result of this purchase. Total holdings of KSC-owned land increased to nearly 56,660 ha (140,000 ac), including the adjacent water bodies.

12.2 PRECONTACT AND HISTORIC CONTEXTS

Archaeologically, KSC lies within the East and Central Florida culture area, which is composed of the "lower (northern) and central portions of the St. Johns River, its tributaries, adjacent portions of the coastal barrier island-salt marsh-lagoon system, and the Central Florida Lake District" (Ref. 3). This region was home to the St. Johns culture, which developed out of the late Archaic period Orange culture. The primary trait, common throughout the culture area, is the distinctive chalky St. Johns' pottery.

The KSC area was previously included in the Indian River culture area, which begins at the northern headwaters of the coastal IRL and extends south to the St. Lucie Inlet. Archaeologically, the Indian River area differs from the northern St. Johns area primarily by the inclusion of significant amounts of sand-tempered pottery in the ceramic assemblages. The sequence of pre-columbian cultures within this zone, first described by Irving Rouse (Ref. 4), parallels that of the St. Johns region. Rouse's Malabar I period is equivalent to the St. Johns I period and Malabar II is the temporal equivalent of St. Johns II (Ref. 4). A chronological sequence of precontact cultures for the Indian River culture area is summarized in Chapter 2 of the ICRMP.

12.3 REGULATORY OVERVIEW

The principal federal legislation governing the management of cultural resources or historic properties on federal and tribal lands include:

- Antiquities Act of 1906
- Historic Sites Act of 1935
- National Historic Preservation Act (NHPA) of 1966, as amended
- National Environmental Policy Act of 1969,
- EO 13287: Preserve America (2003)
- EO 11593: Protection and Enhancement of the Cultural Environment (1971)
- Archaeological and Historic Preservation Act of 1974
- American Indian Religious Freedom Act of 1978
- Archaeological Resources Protection Act of 1979
- Native American Graves Protection and Repatriation Act of 1990

Other federal authorities, which address Native American cultural resources, include EO13007: Indian Sacred Sites (1996) and EO 13175: Consultation and Coordination with Indian Tribal Governments (2000). Chapter 267 F.S. contains legislation, which parallels the federal requirements on the state level.

The following rules in the CFR also address cultural resources:

- 36 CFR 60, National Register of Historic Places (NRHP)
- 36 CFR 61, Procedural for Approved State and Local Government Historic Preservation Program
- 36 CFR 63, Determinations of Eligibility for Inclusion in the NRHP
- 36 CFR 65, National Historic Landmarks (NHLs) Program
- 36 CFR 68, The Secretary of the Interior's Standards for Treatment of Historic Properties
- 36 CFR 79, Curation of Federally-Owned and Administered Archeological Collections
- 36 CFR 800, Protection of Historic Properties
- 43 CFR 3, Preservation of American Antiquities; 43 CFR 7, Subpart A, Protection of Archaeological Resources, Uniform Regulations
- 43 CFR 10, Native American Graves Protection and Repatriation Act

Regulations, Final Rule

Two flow charts have been developed to assure compliance of KSC projects with guidelines for historic or archaeological sites: KDP-P-1733, Revision D-1, Historic and Review of Potential Effects to Historic Properties Flowchart and KDP-KSC-P-1295, Processing of KSC Real Property Agreements. Several NASA policies and directives are also followed:

- NPR 8510.1, NASA Cultural Resources Management
- NPD 8500.1C, NASA Environmental Management
- NPR 8580.1A, NASA National Environmental Policy Act Management Requirements
- EO 12114, Environmental Effects Abroad of Major Federal Actions
- NPD 4300.1B, NASA Personal Property Disposal Policy
- NPR 4310.1A, Artifact Identification and Disposition
- KNPR 8500.1 Rev C-1, KSC Environmental Requirements

KSC's compliance with all of these is accomplished by adherence to the Section 106 process on the federal level and the historic preservation compliance review program of the Florida Department of State, Division of Historical Resources (DHR) at the state level. Since the DHR has incorporated the Section 106 process into the State's uniform compliance review program, the two processes are identical.

12.3.1 NATIONAL HISTORIC PRESERVATION ACT OF 1966, AS AMENDED (PUBLIC LAW [PL] 89-665)

The National Historic Preservation Act of 1966, as amended, is the keystone of federal historic preservation laws. Among the fundamental provisions of the Act is the Section 106 Process, described in 12.4. The NRHP is administered by the Secretary of the Interior through the National Park Service (NPS) under authority of Section 101(a)(1)(A) of the NHPA, as amended. The NRHP is a list of districts, sites, buildings, structures, and objects significant in American history, architecture, archaeology, engineering, or culture.

Section 110 of the NHPA (as amended in 1992) obligates federal agencies to establish a historic preservation program for the identification, evaluation, and nomination to the NRHP of historic properties under their jurisdiction and to ensure that such properties are managed and maintained in a way that considers their historic, archaeological, architectural, and cultural values. Section 110(a) requires federal agencies to give priority to the use of historic properties for agency purposes. Section 110(a)(2)(D) requires that the federal agency's preservation-related activities are carried out in consultation with other federal, state, and local agencies, Indian tribes, and other stakeholders, including the private sector. Section 110(b) mandates that federal agencies document historic properties that may be destroyed or altered as a result of federal actions or assistance. It also calls for such records (i.e., HABS [Historic American Building Survey] and HAER [Historic American Building Record]) to be deposited in the Library of Congress or other designated repository for “future use and reference.” Section 110(d) calls for agencies to integrate historic preservation concerns into their plans and programs and Section 110(f) addresses impacts to NHLs.

Section 111 of the NHPA addresses the lease or exchange of historic properties owned by federal agencies provided such actions “will adequately ensure the preservation of the historic property” (Section 111(a)). Under Section 111(b), the proceeds of the lease may be used by the agency to defray the costs of administering and maintaining its historic properties.

Section 112 addresses both professional standards for agency personnel and contractors responsible for historic resources (Section 112(a)(1)(A)), as well as records and data management (Section 112(a)(2)).

Section 304 discusses the confidentiality regarding the locations of historic resources, which stipulates that disclosure shall be withheld from the public, if it has the potential to cause “significant invasion of privacy,” harm to the historic resources, or “impede the use of a traditional religious site by practitioners.”

12.3.2 EO 13287: PRESERVE AMERICA

EO 13287, signed by President George W. Bush on May 3, 2003, establishes the federal government’s leadership role in preserving America’s heritage through promotion of the protection and continued use of historic properties owned by the federal government. It advocates intergovernmental cooperation, as well as public-private partnerships to promote local economic development. Section 3 of EO 13287 requires federal agencies with real property management responsibilities “to prepare an assessment of the current status of its inventory of historic properties required by Section 110(a)(2) of the NHPA, the general condition and management needs of such properties, and the steps underway or planned to meet these management needs.” The Section 3 Report includes the evaluation of the suitability of the historic properties to contribute to community economic development, including heritage tourism. Since September 2004, federal agencies are required to submit triennial progress reports to the Advisory Council on Historic Preservation (ACHP).

12.4 THE SECTION 106 PROCESS

The Section 106 process is a review procedure established by Congress in 1966. It is implemented by federal regulations entitled "Protection of Historic Properties," also known as CFR 800 (as amended in August 5, 2004). Section 106 represents the principal federal review process that looks at the potential effects that federal or federally funded undertakings may have on historic properties. In essence, Section 106 requires federal agencies to: (1) consider the effects of their action (or actions they may assist, permit or license) on NRHP-listed or eligible historic properties, and (2) seek comments from the ACHP. This is critical to KSC since it is the responsibility of the federal agency involved to identify historic properties and ascertain their potential NRHP eligibility following procedures outlined in the ACHP and NPS regulations, 36 CFR 800 and 48 FR 44716, respectively. KSC is ultimately responsible for coordination and consultation with the Florida State Historic Preservation Office (SHPO) and the ACHP. Section 106 also recognizes that it is not realistic, nor in the public interest to preserve every historic resource. Therefore, Section 106 does not require preservation of a resource, nor does it give the ACHP veto power over a federal agency's action. It does, however, require full consideration of measures to avoid, minimize, or mitigate effects of federal activities. Consulting parties in the Section 106 process include the SHPO, Tribal Historic Preservation Officers (THPO) or representatives, the ACHP, representatives of local governments, and the public. The review process, which implements Section 106, is divided into four steps: (1) Initiate Section 106 Process, (2) Identify Historic Properties, (3) Assess Adverse Effects, and (4) Resolve Adverse Effects. The steps are described in the ICRMP.

12.5 MEMORANDA OF AGREEMENTS AND PROGRAMMATIC AGREEMENTS

An agreement document is prepared when an undertaking will have an adverse effect on those characteristics of a historic property that qualify it for the National Register and embodies the ways to reduce, avoid, minimize, or mitigate such effects decided by the consulting parties. A three-party Memorandum of Agreement (MOA) is signed by the federal agency, the SHPO, and the ACHP; a two-party MOA occurs when the ACHP has not been involved in the consultation, but receives the MOA after the federal agency and SHPO/THPO has executed it. NASA has executed a number of agreement documents: (1) MOA for the LC-39 Site among KSC, the ACHP, and the Florida SHPO permitted KSC to proceed with the design and development of Space Shuttle facilities including modifications to existing facilities and new construction (1974); (2) MOA between NASA and the Smithsonian Institution Concerning the Transfer and Management of NASA Historical Artifacts (2008). NASA must offer all personal property including historic artifacts to the Smithsonian after

NASA programs/projects and other federal agencies have screened the property for government use. The Smithsonian Institute is responsible for preserving the artifacts that represent aviation and spaceflight; (3) MOA between KSC and the SHPO addresses the removal of the sun louvers and replacement of the window framing unit from the LCC (2008); (4) MOA for the Demolition of LC-34 Environmental Support Building between KSC and the SHPO (2006); (5) a Non-Reimbursable Space Act Agreement between KSC and the Board of County Commissioners in Brevard County regarding the Clifton Schoolhouse for the removal of the remaining schoolhouse structure (2006); and (6) MOA for the Demolition of the Mission Control Center between KSC, the SHPO, and the ACHP (2009). KSC executed a Programmatic Agreement for the Management of Historic Properties in 2009 between KSC, ACHP, and the SHPO. This agreement streamlines the Section 106 process and documentation for "like" multiple assets (such as two launch pads, three mobile launcher platforms, and two crawler transporters) by conducting recordation of only one of those assets. It also allows KSC to do normal maintenance and minor modifications, reuse historic properties, and ensures that historic, engineering, and architectural values are recognized and considered in the course of ongoing KSC programs.

12.6 INTEGRATING NEPA AND SECTION 106

In accordance with 36 CFR 800, federal agencies are encouraged to coordinate studies and documents prepared under Section 106 with those completed under NEPA. Section 800.8(a) of the regulations provides guidance on how NEPA and Section 106 processes can be coordinated. NEPA documents (i.e., EA/Finding of No Significant Impact [FONSI] or an EIS/Record of Decision [ROD]) prepared by KSC will include appropriate scoping, identification of historic properties, assessment of effects upon them, and consultation leading to resolution of any adverse effects. In the case of an action categorically excluded from NEPA review (36 CFR 800.8(b)), KSC will determine if it qualifies as an undertaking requiring review under Section 106 (Section 800.3(a)), then proceed accordingly. KSC also will conform to the consultation, identification, and documentation standards set forth in 36 CFR 800.8(c), and will notify in advance, the SHPO and ACHP where it intends to use the NEPA process to comply with Section 106 (Ref. 5).

12.7 ARCHAEOLOGICAL PREDICTIVE MODEL, SURVEYS, RESULTS, AND COLLECTIONS

12.7.1 KSC-WIDE PREDICTIVE MODEL SURVEY

Between 1990 and 1996, a KSC-wide archaeological survey was conducted by Archaeological Consultants, Inc. (ACI) to establish differential Zones of Archaeological Potential (ZAPs) within all areas of KSC. These were defined as low, medium, and high probability zones based upon the anticipated potential for containing significant or potentially significant archaeological sites. The determination of these ZAPs resulted in a KSC-specific archaeological site location predictive model. A set of U.S. Geological Survey (USGS) quadrangle maps were prepared showing the ZAPs defined by this effort, as well as the locations of known archaeological sites. These baseline maps are used to create layers in the KSC GIS database.

In 2007-2008, ACI completed a study of the last 200 years of KSC history, including the development of a historic context and expansion of the predictive model to include historic period archaeological sites, circa 1700 to 1958. Work included field reconnaissance to ground-truth the predictive model. A total of 126 historic ZAPs were identified within KSC (ACI 2008). In addition, a new layer of the GIS database was prepared. These maps were developed as management tools for the Center and HPO when planning for new construction and evaluating projects. As funds become available, potential historic period archaeological sites will be surveyed, evaluated, and recorded in the Florida Master Site File (FMSF).

12.7.2 SURVEY AND RESULTS

As of January 2014, KSC manages 187 archaeological sites. The general area, including CNS, MINWR, and CCAFS, has been the focus of archaeological investigations and studies by many investigators for over 100 years. Most of these projects focused upon parcels of land proposed for facility development. Details of the surveys can be found in the ICRMP. Four recorded sites and one historic district is listed in the NRHP (Table 12-1).

Table 12-1. NRHP-listed archaeological sites at KSC.

FMSF No.	Name
8BR0188	Old Haulover Canal
8VO0130	Ross Hammock Midden
8VO0131	Ross Hammock Indian Mounds
8VO0213	Ross Hammock Salt Rendering Plant

Note: Technically, 8VO130, -131, and -213 are components of a single site complex, assigned the FMSF number 8VO2569 for the Ross Hammock Archaeological District.

The remaining archaeological sites, those determined eligible, ineligible, or those that require further investigation may be found within Appendix D of the ICRMP or by contacting the KSC HPO.

12.7.3 COLLECTIONS

As part of its mandate under federal historic preservation laws and regulations, KSC has a responsibility to ensure that archaeological collections, including material remains (i.e., artifacts, objects, specimens, and other physical evidence that are excavated or removed) and associated documentation, are managed and preserved in accordance with the regulations set forth in 36 CFR 79, Curation of Federally-Owned and Administrative Collections. All artifacts, field notes, maps, and data generated or collected during a survey or excavation project on NASA-owned land, whether conducted by a contractor or cooperating federal agency, is the property of KSC. The majority of KSC's collections are stored at the NPS Southeast Archeological Center, located in Tallahassee, Florida, which meets the federal curation standards contained in 36 CFR 79. The collections are coordinated through a loan agreement with CNS, which is updated every five years. Table 12-2 details KSC's archaeological site collections, location, and size.

Table 12-2. Location and volume of archaeological collections from sites at KSC.

Repository	Total Sites	Cubic m/ft
Florida Bureau of Archaeological Research (Tallahassee)	8	.03/1.0
Florida Museum of Natural History(Gainesville)	23	.07/2.5
SEAC (pre-2001)	17	.07/2.5
SEACH (2001) 8BR170 Phase II and III ACI 1990-1992 Surveys ACI 1996 Surveys	 1 39 27	 *1.2/44.0 *.06/2.0 *.08/3.0
TOTAL	115	1.5/55.0

*Measurements are rough estimates made in 1998; they do not accurately reflect the actual volume.

12.8 SIGNFICANT HISTORIC BUILDINGS, STRUCTURES, OBJECTS, AND HISTORIC DISTRICTS SURVEYS AND RESULTS

As of January 2014, KSC manages approximately 105 historic buildings, structures or objects and eight historic districts. The districts consists of (1) LC-39: Pad A Historic District, (2) LC-39: Pad B Historic District, (3) SLF Area Historic District, (4) Orbiter Processing Historic District, (5) NASA-owned CCAFS Industrial Area Historic District, (6) NASA KSC Railroad System Historic District, (7) SRB Disassembly and Refurbishment Complex Historic District, and (8) Hypergolic Maintenance and Checkout Area (HMCA) Historic District. The HMCA Historic District name was removed later in 2014 due to the fact that two of the three properties have been demolished (Hypergol Module Processing North and Hypergol Support Building). Many surveys were conducted from 1973 to 2013 and are described in Chapter 3 of the ICRMP. Below is a summary of some of the surveys performed at KSC.

LC-39 Site

In May 1973, LC-39 became the first KSC site to be listed in the NRHP for its association with the Apollo Manned Lunar Landing Program. LC-39, built between November 1962 and October 1968, was evaluated as significant in the areas of architecture, communications, engineering, industry, science, transportation, and space exploration. As originally defined, the boundaries of the NRHP site encompassed a rectangle measuring approximately 2,833 ha (7,000 ac) in areal extent with a total of 322 associated facilities. It included the VAB, LCC, Crawlers, Crawlerway, and the LC 39 Launch Complexes A and B, the latter of which included the elevated launch pads, storage tanks, and associated servicing facilities.

LC-39 Site Reassessment

In 1996-1997, a site reassessment for the LC-39 Site was conducted by ACI along with an inventory of the Industrial, VAB, and SLF areas (Ref. 6). The reassessment found that the majority of individual facilities within the existing LC-39 Site were not associated with the historically important events of the Apollo Program; were not dated to the period of significance for the historic property (1961-1975); were not distinguished for their historical, engineering and/or architectural values; and/or had suffered a substantial loss of integrity, which made them no longer eligible for NRHP listing. The original LC-39 nomination was amended and the boundary of the LC-39 Site was removed. A new NRHP Multiple Property nomination for a number of buildings, structures, districts, and objects considered to be of exceptional national importance within the context of the Apollo Program was prepared. Consequently, the survey and reassessment focused on the facilities of exceptional importance to the Apollo Program, from 1961 through 1975, including three subcontexts: Apollo Manned

Lunar Landing Program, 1961-1972; Skylab Space Station, 1973-1974; and Apollo-Soyuz Test Project, 1975. The 322 resources located within the original NRHP site were reduced to eight individually eligible resources and 34 facilities considered as contributing to newly identified NRHP historic districts at LC-39 Pads A and B. The VAB, LCC, the Crawlers, Crawlerway, and Launch Pads A and B were retained from the original nomination. The Headquarters Building, Neil Armstrong O&C Building, Central Instrumentation Facility, and the Press Site: Clock and Flag Pole were added as NRHP-eligible properties as a result of this survey. The three Mobile Launcher Platforms/Launch Umbilical Towers (MLPs/LUTs), included in the original nomination, were no longer considered independently eligible for the NRHP due to a loss of integrity. The Mobile Service Structure (MSS), also included in the original nomination, is no longer extant. Thus, the MLPs/LUTs and the MSS were suggested for delisting and it was recommended to the SHPO that the new Multiple Property submission be accepted to supersede the original nomination.

SSP Survey

Prior to the end of the Space Shuttle Program (SSP), ACI conducted a survey and determined 26 new assets were considered to individually meet the criteria of eligibility for listing in the NRHP, including 11 buildings, 14 structures, and one object (Ref. 7.) All meet NRHP Criterion A for their exceptional significance in the context of the SSP and most meet Criterion C in the area of Engineering. The 26 facilities include six NRHP-listed properties: the VAB, LCC, Crawlerway, 2 Crawler Transporters, and the Press Site: Clock and Flag Pole. Twenty additional properties were newly assessed as individually eligible. These include LC-39 Pad A, LC-39 Pad B, the SLF Runway, the Landing Aids Control Building, the Mate-Demate Device, the OPF High Bays 1 and 2, the OPF High Bay 3, the Thermal Protection System Facility, the Rotation/Processing Facility, the Manufacturing Building, the Parachute Refurbishment Facility, the Canister Rotation Facility, the Hypergol Module Processing North, two Payload Canisters, two Retrieval Ships, Freedom Star and Liberty Star, and 3 MLPs. Two previously listed historic districts, the LC-39 Pad A Historic District and the LC-39 Pad B Historic District, originally listed for their exceptional significance in the context of the Apollo Program, were also assessed as significant within the context of the Space Shuttle Program. In addition, four new historic districts were identified: (1) the SLF Area Historic District; (2) the Orbiter Processing Historic District; (3) the Solid Rocket Booster (SRB) Disassembly and Refurbishment Complex Historic District; and (4) the HMCA Historic District. Thus, of the 112 SSP-related facilities identified and evaluated at KSC, 76 are NRHP-listed or eligible, including 26 individually listed or eligible properties and 50, which are contributing to a historic district, but are not considered individually eligible. Of the 76 significant properties, 36 were previously determined NRHP-eligible and 40 were newly evaluated.

45-50 Years Survey
In 2012, New South Associates conducted background research, performed an architectural survey, and prepared historic context development and NRHP evaluation of 45 facilities located on KSC or CCAFS that are owned by NASA and have reached 45-50 years of age (Ref. 8). Of these, six are eligible for individual listing in the NRHP including the EDL, Missile Assembly Building AE, Beach House, Banana River Bridge, Indian River Bridge, and Haulover Canal Bridge. The Barge Terminal Facility is eligible as a contributing resource to the NRHP-eligible VAB. These six facilities possess exceptional significance at the local and national levels and meet the NRHP Criteria for Eligibility in the areas of Space Exploration, Community Planning and Development, Transportation, and Engineering. Table 12-3 is a summary of KSC's listed historic properties. Chapter 4 of the ICRMP contains more information on these properties (e.g., historic significance and descriptions). Appendix E of the ICRMP consists of a complete listing of the NRHP-listed, eligible, and contributing resources and those which have been demolished, transferred, or leased. For the most current listing, contact the KSC HPO or visit the CRM website at http://environmental.ksc.nasa.gov/projects/cultural.htm.

National Historic Landmarks
In September 1983, a revised NHL Federal Agency Nomination was prepared by the NPS History Division at the direction of the Secretary of the Interior's Advisory Board to reflect an agreement between the NPS, the U.S. Air Force, and the Board. The nomination highlighted the national significance of those principal facilities associated with the manned and unmanned space program of the United States, which included Launch Complexes 5/6, 13, 14, 19, 26, 34, and the original Mission Control Center (MCC). Currently NASA manages only LC 5/6. LC 19 was transferred back to the Air Force and the MCC and LC 34 Engineering Support Building were both demolished by NASA. At the direction of the Secretary of the Interior's Advisory Board, the boundary of the NHL District includes only the area immediately surrounding the seven launch pads and the MCC. The NHL Cape Canaveral Air Force Station Historic District was listed on April 16, 1984.

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Table 12-3. NRHP-Listed Historic Properties at KSC

Facility No.	Facility	Built	FMSF No.	NRHP Resource Type	NRHP Status – Listed, Eligible, Individual (I), Contributing (C)	Significant Historic Context(s)	Criterion/ Criteria Consideration[1]
M6-0399	Headquarters Building	1965	8BR1691	Building	Listed (I)	Apollo	A, C, and G
M6-0342	Central Instrumentation Facility	1965	8BR1692	Building	Listed (I)	Apollo	A, C, and G
M7-0355	Neil Armstrong Operations and Checkout (O&C) Building	1964	8BR1693	Building	Listed (I)	Apollo	A, C, and G
K6-0848	Vehicle Assembly Building (VAB)	1962-66	8BR1684	Building	Listed (I)	Apollo	A, C, and G
K6-0947	VAB Utility Annex	1966	None	Building	Listed (C to VAB)	Apollo	A, C, and G
K6-0900	Launch Control Center	1966	8BR1685	Building	Listed (I)	Apollo	A, C, and G
	Crawler Transporters (2)	1965	8BR1688	Structure	Listed (I)	Apollo	A, C, and G
UK-0008	Crawlerway	1963-65	8BR1689	Structure	Listed (I)	Apollo	A, C, and G
	Press Site: Clock and Flag Pole	1969	8BR1690	Object	Listed (I)	Apollo	A and G

Table 12-3. NRHP-Listed Historic Properties at KSC (cont.).

Facility No.	Facility	Built	FMSF No.	NRHP Resource Type	NRHP Status – Listed, Eligible, Individual (I), Contributing (C)	Significant Historic Context(s)	Criterion/ Criteria Consideration[1]
	LC 39: Pad A Historic District[1]	1967-85	8BR1686	District	Listed	Apollo/SSP	A, C, and G
J8-1708	LC 39 Pad A	1963-65	8BR1995	Structure	Listed (I)	Apollo	A, C, and G
J8-1564	Foam Building	1965	None	Building	Listed (C)	Apollo	A, C, and G
J8-1565	Pump House	1964	None	Structure	Listed (C)	Apollo	A, C, and G
J8-1659	Compressed Air Building	1965	None	Building	Listed (C)	Apollo	A, C, and G
J8-1753	Remote Air Intake Building	1965	None	Building	Listed (C)	Apollo	A, C, and G
J8-1858	Azimuth Alignment Station	1965	None	Structure	Listed (C)	Apollo	A, C, and G
J8-1462	High Pressure GH2 Facility	1968	8BR2094	Structure	Listed (C)	Apollo	A, C, and G
J8-1502	LOX Facility	1966	8BR2095	Structure	Listed (C)	Apollo	A, C, and G
J8-1503	Operations Support Building A-1	1966	8BR2096	Building	Listed (C)	Apollo	A, C, and G
J8-1512	Camera Pad A No. 1	1966	8BR2097	Structure	Listed (C)	Apollo	A, C, and G
J8-1513	LH2 Facility	1966	8BR2098	Structure	Listed (C)	Apollo	A, C, and G

Table 12-3. NRHP-Listed Historic Properties at KSC (cont.).

Facility No.	Facility	Built	FMSF No.	NRHP Resource Type	NRHP Status – Listed, Eligible, Individual (I), Contributing (C)	Significant Historic Context(s)	Criterion/ Criteria Consideration[1]
J8-1553	Electrical Equipment Building No. 2	1965	8BR2099	Building	Listed (C)	Apollo	A, C, and G
J8-1554	Camera Pad No. 6	1965	8BR2100	Structure	Listed (C)	Apollo	A, C, and G
J8-1563	Electrical Equipment Building No. 1	1965	8BR2101	Building	Listed (C)	Apollo	A, C, and G
J8-1614	Operations Support Building A-2	1966	8BR2102	Building	Listed (C)	Apollo	A, C, and G
J8-1703	Slidewire Termination Facility	1965	8BR2103	Structure	Listed (C)	Apollo	A, C, and G
J8-1707	Water Chiller Building	1968	8BR2104	Building	Listed (C)	Apollo	A, C, and G
J8-1714	Camera Pad A No.2	1965	8BR2105	Structure	Listed (C)	Apollo	A, C, and G
J8-1956	Camera Pad A No. 4	1965	8BR2106	Structure	Listed (C)	Apollo	A, C, and G
J8-1961	Camera Pad A No. 3	1965	8BR2107	Structure	Listed (C)	Apollo	A, C, and G
	LC 39: Pad B Historic District	1967-85	8BR1687	District	Listed	Apollo/SSP	A, C, and G
J7-0242	Foam Building	1968	None	Structure	Listed	Apollo	A, C, and G

Table 12-3. NRHP-Listed Historic Properties at KSC (cont.)

Facility No.	Facility	Built	FMSF No.	NRHP Resource Type	NRHP Status – Listed, Eligible, Individual (I), Contributing (C)	Significant Historic Context(s)	Criterion/ Criteria Consideration[1]
J7-0338	Compressed Air Building	1967	None	Structure	Listed (C)	Apollo	A, C, and G
J7-0432	Remote Air Intake Building	1967	None	Building	Listed (C)	Apollo	A, C, and G
J7-0537	Azimuth Alignment Station	1967	None	Structure	Listed (C)	Apollo	A, C, and G
J7-0132	Operations Support Building B-1	1967	8BR2114	Building	Listed (C)	Apollo	A, C, and G
J7-0140	High Pressure GH2 Facility	1967	8BR2115	Structure	Listed (C)	Apollo	A, C, and G
J7-0182	LOX Facility	1967	8BR2116	Structure	Listed (C)	Apollo	A, C, and G
J7-0183	Camera Pad B No. 6	1968	8BR2117	Structure	Listed (C)	Apollo	A, C, and G
J7-0191	Camera Pad B No. 1	1968	8BR2118	Structure	Listed (C)	Apollo	A, C, and G
J7-0192	LH2 Facility	1967	8BR2119	Structure	Listed (C)	Apollo	A, C, and G
J7-0231	Electrical Equipment Building No. 2	1967	8BR2120	Building	Listed (C)	Apollo	A, C, and G
J7-0241	Electrical Equipment Building No. 1	1967	8BR2121	Building	Listed (C)	Apollo	A, C, and G
J7-0243	Operations Support Building B-2	1967	8BR2122	Building	Listed (C)	Apollo	A, C, and G

Table 12-3. NRHP-Listed Historic Properties at KSC (cont.)

Facility No.	Facility	Built	FMSF NO.	NRHP Resource Type	NRHP Status – Listed, Eligible, Individual (I), Contributing (C)	Significant Historic Context(s)	Criterion/ Criteria Consideration[1]
J7-0331	Slidewire Termination Facility	1967	8BR2123	Structure	Listed (C)	Apollo	A, C, and G
J7-0342	Camera Pad B No. 2	1967	8BR2124	Structure	Listed (C)	Apollo	A, C, and G
J7-0385	Water Chiller Building	1968	8BR2125	Building	Listed (C)	Apollo	A, C, and G
J7-0584	Camera Pad B No. 4	1968	8BR2126	Structure	Listed (C)	Apollo	A, C, and G
J7-0589	Camera Pad B No. 3	1968	8BR2127	Structure	Listed (C)	Apollo	A, C, and G

1- Criterion A: Event, Criterion B: Person, Criterion C: Design/Construction; Criteria Consideration G: Properties that have achieved significance within the last 50 years.

SECTION XIII. SOCIOECONOMICS

13.1 WORKFORCE

KSC is one of Brevard County's largest employers and a major source of revenue for local firms. KSC operations cause a chain of economic effects throughout the region. It is estimated that each job created within Brevard County's space industry generates an additional job within the Florida economy (Ref. 1). KSC's reciprocal relationship with Brevard County has far-reaching effects. KSC is directly and indirectly involved in many Florida industries that supply goods and services to the space program and various other NASA projects. Additionally, KSC supports two industries generated by KSC's own resources:

- *Agriculture and Aquaculture*: In the past NASA managed approximately 325 hectares (800 acres) of citrus groves on the Merritt Island National Wildlife Refuge (MINWR), an integral part of the Indian River fruit industry. Active grove operations declined after the 1990s and in 2008 all grove leases at KSC expired. Abandoned groves may be targeted for future development or for restoration to natural habitat. Commercial fishing for oysters, shrimp, and other river fish species is permitted within MINWR and Canaveral National Seashore (CNS) areas.
- *Tourism*: KSC's Visitor Center Complex is a popular tourist attraction drawing thousands of people every day, providing the public with a first-hand look at the latest technology. MINWR and CNS areas are additional attractions and popular parks for swimming, hunting, fishing, bird watching, boating and other forms of eco-tourism.

Few places experienced such sudden and far-reaching impacts as did Brevard County, when the Federal Government decided to establish the Eastern Test Range in this locale. There were approximately 7,864 personnel employed at KSC at the end of September 2013. This population includes contractor, construction, tenant, and permanent civil service employees. Approximately 26 percent of the total workforce is considered civil service employees. A summary of KSC personnel levels since 1964 is provided in Table 13-1.

The highest employment levels at KSC were recorded during the Apollo Program. In 1968 a peak population of 25,895 was recorded and an estimated one in four workers in Brevard County were employed by operations at KSC. Employment levels dropped precipitously following the Apollo Program to a low of 8,441 personnel employed in 1976. Employment levels rose sharply in 1979 when KSC was designated as the launch and operations support center for the STS (Table 13-1). Employment levels gradually rose through 1985 following the increasing number of launch events. Another sharp drop in employment levels was seen in 1986 as a result of the loss of the Space Shuttle Challenger. The retirement of the Shuttle Program in 2011 resulted in another major drop in the KSC workforce (Ref. 2).

KSC personnel are dedicated to supporting the nation's space program and NASA's future explorations and missions. The workforce is currently employed in ground and base support, unmanned launch programs, financial and resources management, engineering and technology development, safety, health, and independent assessment, research and development, and administrative positions.

Table 13-1. History of Workforce at KSC.

End Fiscal Year (Sept.)	Number of People	Year Change
1964	11,230	4,879
1965	16,819	5,589
1966	18,482	1,663
1967	24,404	5,922
1968	25,895	1,491
1969	23,620	-2,275
1970	16,235	-7,385
1971	14,470	-1,765
1972	14,642	172
1973	12,841	-1,801
1974	9,246	-3,595
1975	10,368	1,122
1976	8,441	-1,927
1977	9,376	935
1978	10,352	976
1979	13,002	2,650
1980	13,688	686
1981	14,004	316
1982	14,391	387
1983	14,665	274
1984	15,133	468
1985	16,067	934
1986	13,664	-2,403
1987	15,307	1,643
1988	16,559	1,252

Table 13-1. History of Workforce at KSC (cont.).

End Fiscal Year (Sept.)	Number of People	Year Change
1989	18,151	1,592
1990	18,522	401
1991	19,088	536
1992	18,696	-392
1993	18,253	-443
1994	16,585	-1668
1995	16,413	-172
1996	16,208	-205
1997	14,593	-1,615
1998	14,200	-393
1999	13,123	-1.077
2000	14,716	1,593
2001	13,499	-1,217
2002	13,720	221
2003	13,259	-461
2004	13,816	557
2005	14,045	229
2006	14,678	633
2007	13,858	-820
2008	14,181	323
2009	15,248	1,067
2010	13,631	-1,617
2011	9,011	-4,620
2012	8,319	-692
2013	7,864	-455

*Does not include Off-site workforce

13.2 TRANSPORTATION RESOURCES

13.2.1 ROADS

Highway transportation routes are shown in Figure 13-1. KSC is serviced by over 340 km (211 mi) of roadway with 263 km (163 mi) of paved roads and 77 km (48 mi) of unpaved roads. Of the five access roads onto KSC, NASA Parkway West serves as the primary access road for cargo, tourists, and personnel entering and leaving. This four-lane road originates in Titusville as State Road 405 and crosses the Indian River Lagoon onto KSC. Once passing through the Industrial Area, the road reduces to two lanes of traffic. It then crosses the Banana River and enters the Cape Canaveral Air Force Station (CCAFS). The third point of entry onto KSC is from the south via South Kennedy Parkway, which originates on north Merritt Island as State Road 3. This road is the major north-south artery for KSC and is also a four-lane highway. The fourth entry point is accessible from Titusville along Beach Road, which connects to North

Kennedy Parkway. The final access point is south of Oak Hill at the intersection of U.S.1 and North Kennedy Parkway. All roads to KSC have control access points which are manned 24 hours per day, seven days per week. Design standards for primary roads and highways mandate 24-ft widths and for two-lane roads, a 40-ft wide median strip. All paved roads conform to the American Association of State Highway and Transportation specification H20-S16. This specification establishes a load bearing capacity of 20 tons for a tractor truck and a gross single axle weight of 16 tons (8 tons/wheel).

13.2.2 RAIL

A railroad spur runs from the Florida East Coast rail line to KSC (Figure 13-1). The spur spans the Indian River and Intracoastal Waterway via a causeway and bascule bridge from Wilson, on the mainland, to Merritt Island. Approximately 65 km (40 mi) of rail track provide heavy freight transport to KSC. The portion of the railroad that runs parallel to Phillips Parkway on the beach side has been often washed out by storms, making it nearly impossible to maintain. This section of railroad is no longer operational and approximately 2 km (6500 ft) of the railroad and rail bed were removed from the shorefront between LC 39A and 39B in Spring 2014 during construction of the Post-Hurricane Sandy dune reparations.

13.2.3 WATERWAYS

Port Canaveral is the nearest navigable oceanic connection to KSC. Navigable access from Port Canaveral to KSC docking facilities at Hangar AF (CCAFS) and the Barge Turn Basin is provided by 31 km (19.3 mi) of maintained channels. The docking facilities at Hangar AF Wharf were used primarily for the retrieval of the SRB motors following launches. The Turn Basin Wharf was used to unload the external fuel tanks of the STS and other heavy equipment suited to waterway transport. The largest element of SLS hardware, the Core Stage, will arrive at the Turn Basin via barge. A total of 481 m (1,578 ft) of dockage is available at the existing wharf facilities.

13.3 SERVICES

13.3.1 SECURITY

KSC has internal security operations which include access control, personnel identification, traffic control, law enforcement, investigations, classified material control, and national resource protection. The security forces maintain road access control gates and patrol the KSC/CCAFS perimeter boundary.

KSC security forces have coordination agreements to support local municipalities in the event of an emergency or disaster. Requests for emergency support are directed through the Brevard Civil Defense Coordinator to the KSC Emergency Preparedness Office.

13.3.2 FIRE PROTECTION

Fire protection at KSC/CCAFS includes a comprehensive program of fire protection engineering, fire prevention, fire suppression and emergency response operations. Specialized equipment and training, suited to the potential fire and emergency hazards of operations at KSC are provided. Three fire stations, one located in the SLF/VAB Area, one at Pads 39A and B, and the other located in the Industrial Area provide effective coverage for all of KSC/CCAFS. Coordination support agreements between KSC/CCAFS and local municipalities provide for reciprocal support in the event of an emergency or disaster.

13.3.3 HEALTH

An Occupational Health Facility and an Emergency Aid Clinic provide medical services to KSC. These facilities are staffed by medical personnel specially trained in the hazards and treatment associated with the facilities and operations at KSC. The medical facilities are equipped to provide first-care treatment of injuries. Ambulance service and a medically equipped helicopter are available to transfer injured personnel to full-care medical facilities. KSC has established Memoranda of Understanding for emergency treatment with the following medical facilities: Jess Parish Medical Center, Cape Canaveral Hospital, Wuesthoff Memorial Hospital, Brevard County Civil Defense and Emergency Medical Services, Patrick Air Force Base Hospital, Orlando Regional Health Systems, Florida Hospital, and Holmes Regional Medical Center.

13.4 SURROUNDING COMMUNITIES

Brevard County was established in 1844 from a portion of Mosquito County and was originally named St. Lucie. In 1855 the name was changed in honor of Theodore Washington Brevard (1804-77) of North Carolina. Brevard came to Florida in 1847 and became the State Comptroller. Brevard County is bordered by the Atlantic Ocean and by Volusia, Orange, Osceola, and Indian River counties. The county has 774 km^2 (299 mi^2) of water. Most of Brevard County's population resides along the Indian River and the Atlantic Ocean. In 2010 the most populous incorporated areas were Palm Bay (103,190 persons), followed by Melbourne (76,068 persons), and Titusville (43,761 persons). Cocoa, Rockledge, and Cocoa Beach all had populations in excess of 10,000 in the year 2013. The unincorporated area of Merritt Island, sparsely populated in 1960, had a population of 34,743 in 2013. During the 1980s, Port St. John, located between Titusville and Cocoa, and Micco, south of Melbourne, developed rapidly.

The U.S. Bureau of the Census has designated Brevard County as the Melbourne-Titusville-Palm Bay Metropolitan Statistical Area. In 2013, 84 percent of Brevard County's population was white and 10.6 percent was African American. In 2013, 9 percent of the population was Hispanic. The 2013 birth rate for the county was 9.2 live births per 1,000 persons, and the 2013 death rate was 753.4 deaths per 100,000 persons. In 2013 the infant mortality rate was 6.8 per 1,000. The leading causes of death in 2000 were cancer, heart disease, and respiratory disease.

The per capita income for 2013 was $39,420. The median household income in 2013 was $48,039. In 2012, 14.9% of families had incomes below the poverty level. In 2012 there were 513 farms in Brevard County, totaling 111,925 hectares (146,470 ac) with an average size of 137 ha (338 ac). Leading agricultural products include cattle and citrus. In 2013, 963,983 kg (2,125,218 lbs) of fin fish and 680,795 kg (1,500,896 lbs) of shellfish were landed in Brevard County (Ref. 3). Construction, professional, scientific and technical services, and transportation equipment were the most common industries for males. Healthcare, education services, and accommodations and food services were the most common industries for females.

The KSC Environmental Justice Plan (KSC-PLN-1917) was updated by the Environmental Management Branch in 2010 with another minor revision released in 2012. The purpose of the Environmental Justice Plan is to ensure KSC identifies and addresses activities which have disproportionately high adverse human health or environmental effects on minority or low-income populations in the surrounding Kennedy community and that the community participates in developing policies to prevent these effects.

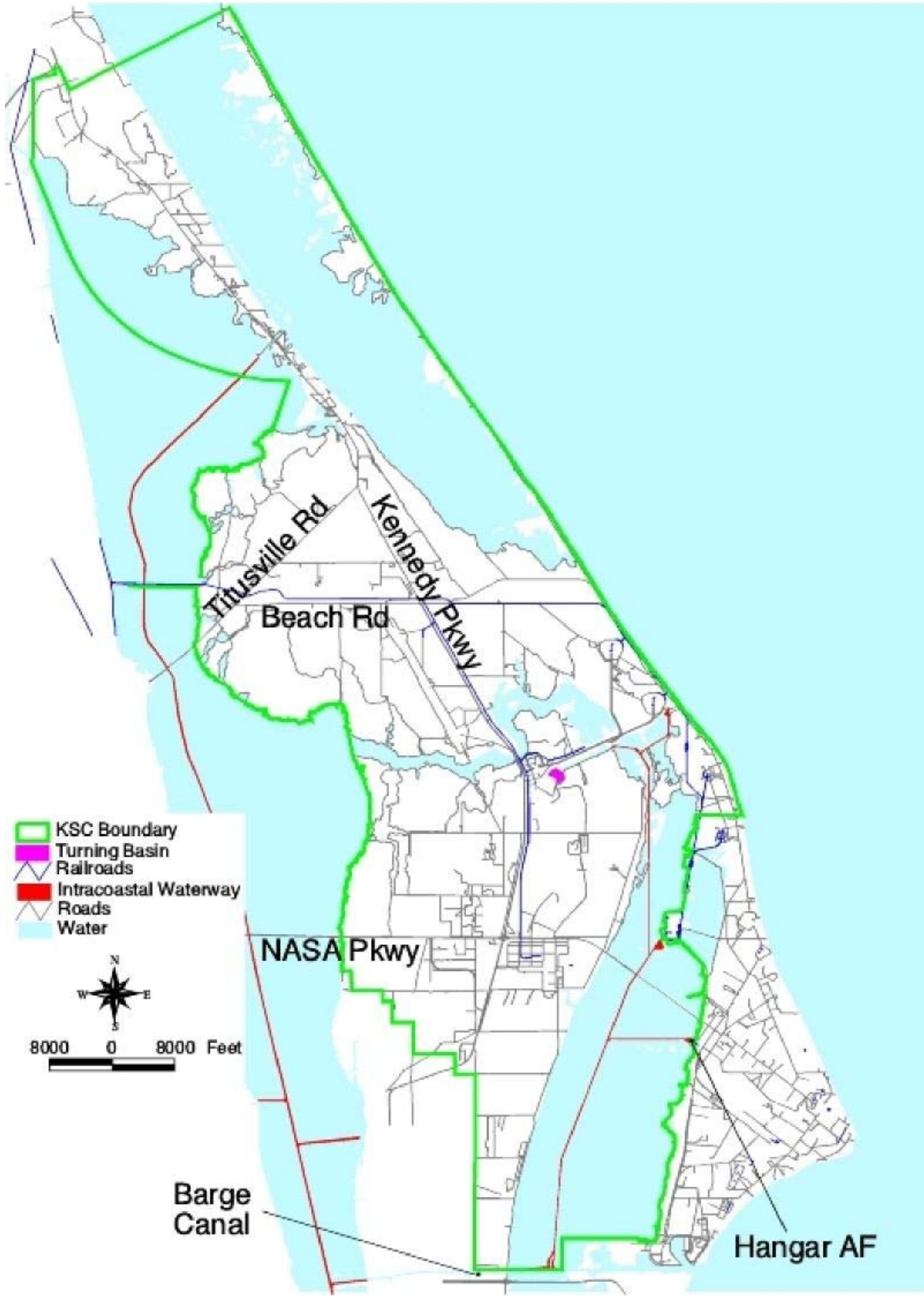

Figure 13-1. Transportation routes on KSC.

City of Cape Canaveral

A small 4.9 km^2 (1.9 mi^2) town sandwiched between the Atlantic Ocean and the Banana River, Cape Canaveral has a population of 9,912. Ample housing, shopping and other amenities complete the area. Capeview Elementary School serves the area's children. Port Canaveral, to the north of the city is the third largest cruise-passenger port in the country. Port Canaveral is a vital import/export shipping center. The port has the largest dockside refrigerated storage facility in the country. As Foreign Trade Zone #136, Port Canaveral encompasses 1684 ha (4,160 ac). The foreign trade zone status lowers U.S. production costs and offers savings to export companies. The port is a major deep-water port of entry with nine cargo berths, 46,452 m^2 (500,000 ft^2) of warehouse and dry cargo storage, and commercial fishing fleets.

City of Cocoa.

Bordered by the Indian River to east, Cocoa extends west to the undeveloped St. Johns River floodplain. An old established city, Cocoa features large restored, southern homes along scenic river roads. Cocoa is an old city with a historic downtown area. The city, first settled in the 1860s, derived its name from a shipment of baker's cocoa to the local store in the 1880s, and has grown into a bustling community with a population of 17,140 according to the 2010 census data. Cocoa is home to some of Florida's major fruit shippers and the Eastern Florida State College (EFSC) main campus. Courses are offered in academics, technical, vocational, continuing education and adult community education subject. The University of Central Florida, which maintains a branch at EFSC, offers graduate and upper division courses as well. Students can earn bachelors and masters degrees in engineering, nursing, education and technical areas without leaving the county. Schools and housing are conveniently located near one another. There are seven elementary schools and Cocoa Jr./Sr. High School in the city. Two causeways connect Cocoa with Merritt Island and the beaches. West Cocoa includes the St. Johns River, a freshwater fisherman's delight. Commercial and private boaters launch their water vehicles from this waterway.

City of Cocoa Beach.

An island community known for its attractive beaches, Cocoa Beach offers 12 miles of public beaches complete with hotels, boat rentals, deep-sea fishing opportunities and other water sports. The population in 2000 was 11,231. The city's residential areas house many of the space program's engineers and technicians. There are two elementary schools and Cocoa Beach Jr./Sr. high school serving Cocoa Beach. Single-family homes, condominiums and apartments are available on the ocean, river and in between.

City of Rockledge

Rockledge was first settled in 1837, making it the oldest resort on Florida's east coast, and Brevard County's oldest city. In the late 1800s, Rockledge was a popular resort town, featuring three stores, two sawmills, several schools and a church. It is named for the coquina rock formations extending into the Indian River. In 2010, Rockledge had a population of 24,926. It is known for both its restored riverfront homes and new housing developments. A comprehensive Land Use Plan adopted in 1975 limits development in the city to five single-family or 14 multi-family units per acre. Growth in Rockledge was fairly slow until the space program in the 1950s. Since then, the economy has diversified into such areas as manufacturing and building supply industries. Schools include Rockledge High, John F. Kennedy Middle, Ronald McNair Middle, and three elementary schools.

City of Titusville
Situated on the Indian River, near the Atlantic Ocean, Titusville is the "Gateway" to KSC. The greater Titusville area population is 43,761. Titusville is home for many of the employees and contractors of NASA. Because of the many highly trained professionals including, engineers and technicians, Titusville has one of the highest median incomes in Central Florida. The Space Center Executive Airport, with access for private and corporate aircraft is situated between the Space Center and Spaceport Florida Industrial Park. In addition to its industrial and technological centers, Titusville has numerous residential areas. Housing prices range from moderate to high. Titusville receives high marks for its educational and cultural offerings. Serving the area are ESFC Titusville campus, Astronaut and Titusville High Schools, plus two middle schools and five elementary schools.

Merritt Island Community
Merritt Island is 40 miles long and varies from seven miles wide at the north to two miles wide at the south. Most of the island's population, 34,743 residents in 2010, occupies a suburban area of middle-class homes between State Roads 528 and 520. Merritt Island is the home of hundreds of businesses, stores, restaurants, real estate and mortgage companies, banks and government offices. There is a light industrial section and an airport south of SR 520. To the south of SR 520, the island's width thins and the area is again residential. The area north of SR 528 and south of KSC is largely small subdivisions, commercial/light industrial, agricultural, and rural residential. Merritt Island recreational areas include MINWR, Kiwanis Park, Rotary Park, Kelly Park East and West, a County golf course and Mitchell Ellington Sports Complex. Merritt Island High School, Edgewood Jr./Sr. High and Thomas Jefferson Middle School as well as five elementary schools serve the area.

Port St. John Community
Port St. John is a relatively new community situated midway between Titusville and Cocoa. The population in 2010 was 12,267. New and existing home median value was $79,200, making the area an affordable choice for both retirees on fixed incomes and

young families working in nearby cities. The business district in Port St. John includes mortgage companies, a bank, several restaurants, family medical centers and convenience stores. Three elementary schools, Atlantis, Challenger 7 and Enterprise, and Space Coast Jr./Sr. High School serve residents.

13.5 KSC COMMITMENT TO SURROUNDING COMMUNITIES

KSC is committed to ensuring that the goals of EO 12898 and NASA's Environmental Justice Strategy are met. Moreover, KSC will continue to communicate with local communities and seek input through public meetings, material distributions, information repositories, community events, open houses, press releases and public education campaigns. To ensure that members of the community are well informed of potential adverse environmental impacts from KSC activities, a mailing list with the names of local officials, community leaders, public interest groups, interested individuals, media, and community organizations was compiled. The mailing list is updated as changes are reported.

Table 13-2. 2010 Population Census Data of KSC Surrounding Communities.

	2010 Population Census Data					
Place Name	**Total**	**Caucasian**	**African American**	**Native American**	**Asian Pacific Islanders**	**Hispanic**
United States of America	308,745,538	223,553,265	38,929,319	2,932,248	15,214,265	50,477,594
State of Florida	18,801,310	14,109,162	2,999,862	71,458	467,107	4,223,806
Brevard County	543,376	450,927	54,799	2,118	11,863	7,071
Cape Canaveral City	9,912	9,208	237	33	191	562
Cocoa City	17,140	10,141	5,369	94	228	1,931
Cocoa Beach City	11,231	10,741	86	40	175	354
Merritt Island CDP	34,743	30,832	1,696	169	821	2,129
Mims CDP	7,058	5,923	873	31	48	216
Oak Hill City	1,792	1,490	249	8	9	31
Port St. John CDP	12,267	10,977	674	64	158	737
Rockledge City	24,926	19,614	3,608	84	633	1,590
Titusville City	43,761	35,375	5,909	206	649	2,825
Source: U.S. Census Bureau, American FactFinder, Table Viewer, Profile of General Demographic Characteristics: 2010; Data Set: Census 2010, factfinder.census.gov.						

There are several outreach programs in which KSC is involved, thus furthering KSC's commitment to the community. These programs also involve outreach to KSC employees and contractors. Such programs include:

- KSC Pathways Intern Employment Program – The objective of this program is to provide students valuable work experience related to their academic studies and knowledge of KSC's mission.

- Motivating Undergraduates in Science and Technology (MUST) – This scholarship program is designed to attract and retain students in science, technology, engineering, or mathematics disciplines, and is led by the Hispanic College Fund with the support of the Society of Hispanic Professional Engineers and the United Negro College Fund Special Programs Corporation.
- Science, Technology, Engineering and Math (STEM)
- Undergraduate Student Research Program (USRP) – This program offers undergraduates in science, math, and engineering, mentored internship experiences at KSC.
- Annual Day of Caring Program - This program allows KSC employees four hours off to help and provide assistance in the community work.
- Combined Federal Campaign (CFC)
- A teacher-resource center which provides extensive information about NASA and KSC on the Internet and enables users to obtain material on science, math and related topics.
- Annual Earth Day
- Family Day
- African-American Heritage Month
- Hispanic Heritage Month
- Asian Pacific Islanders Heritage Month
- Native American Heritage Month
- National Disability Employment Awareness Month.

13.6 REFERENCES

1. NASA. 2012. Kennedy Space Center's Annual Report FY12. 54 pp.

2. NASA. 2013. Launching the Future. KSC Annual Report. 57 pp.

3. FFWCC. 2013 Annual Landings Summary. Myfwc.com.

SECTION XIV. ENERGY

14.1 REGULATORY OVERVIEW

The following list includes relevant federal statutes and support programs, Executive Orders, Presidential Memorandums, NASA directives, and KSC requirements documents:

- Energy Policy and Conservation Act (42 U.S.C. 6361(a)(1)) and Resource Conservation and Recovery Act of 1976 (42 U.S.C. 6901, *et seq*.).
- National Energy Conservation Policy Act (42 U.S.C. 8253, 8259b, 8262g, and 8287).
- EO 13221 of July 31, 2001, Energy-Efficient Standby Power Devices.
- EO 13693 of March 19, 2015, Planning for Federal Sustainability in the Next Decade
- 10 CFR 436, Federal Energy Management and Planning Programs
- Presidential Memorandum, Federal Leadership on Energy Management of 2013
- NPD 8500.1, NASA Environmental Management
- NPR 8570.1, Energy Efficiency and Water Conservation
- NPR 8820.2, Facility Project Requirements
- KNPD 8500.1, KSC Environmental Management
- KNPR 8500.1, KSC Environmental Requirements

The above directives drive energy and water conservation as well as infrastructural evaluations that confirm progress of facility and utility efficiencies. KNPR 8500.1 documents the NASA Agency Energy Mission Statement and KSC Energy Policy:

- NASA Agency Energy Mission Statement: Improving energy efficiency to save taxpayer dollars, reduce emissions contributing to air pollution and global climate change, and conserve precious natural resources for future generations.
- KSC Energy Policy: Energy efficiency is everyone's responsibility. All KSC organizations shall comply with federal requirements and perform day-to-day activities as energy efficient as possible. For example, designing efficient equipment and facilities, buying efficient products, operating/maintaining equipment and facilities at peak efficiency, and turning off systems when not in use.

To this end, KSC established an Energy Working Group (EWG) in 1991, which is chartered as follows: "Ensure KSC makes continual progress towards compliance with federal energy efficiency mandates and reducing energy and water consumption. Regarding energy matters, provide a forum to develop policies and plans, report progress and accomplishments, increase awareness, advocate/pursue initiatives and technology applications, forecast consumption/cost, and foster consistency across all Center elements."

14.2 PROGRAM OVERVIEW

KSC is a retail electricity, natural gas, and fuel oil customer. The Institutional Services Contractor (ISC) provides a monthly energy utilization/cost report that feeds NASA's accounting process to "direct charge" facility energy costs to the appropriate KSC program or tenant according to facility use. Each major program has its own facility engineering and operations & maintenance (O&M) contractor, but these contractors do not pay the energy bills. The ISC report also feeds the NASA Environmental Tracking System for energy metrics reporting to Department of Energy, Office of Management and Budget, and Congress. Table 14.1 summarizes KSC's main facility energy sources and their costs for fiscal year 2014. Tables 14-2 and 14-3 summarize the electric and natural gas utility structures at KSC, respectively.

Table 14-1. FY 2014 Energy Summary.

Source	Consumption	MBtu	%	$M
Electricity	187,793 MWh	2,140,192	90.5	12.84
Natural Gas	212,464 Dth	222,449	9.4	1.74
#2 Fuel Oil	19,488 gal	1,135	0.1	0.03
	TOTAL	**2,363,776**		**14.61**

Includes approximately 3.29M reimbursable tenants (Visitor Complex, Air Force, etc.). Also includes payments to utility companies for energy conservation services provided.

Table 14-2. KSC Electric Distribution Summary.

Source	Electricity
% of KSC energy	91%
Contracts	Air Force 45th Space Wing (45SW) contracts with Florida Power & Light (FPL).
Metering/ billing	FPL meters/bills KSC directly for eleven accounts: Two major 115 kV substations on FPL's Commercial/Industrial Load Control rate (LC-39 Area, Industrial Area), and nine small accounts for remote loads. FPL meters/bills 45SW for CCAFS substations, and NASA reimburses 45SW for NASA facilities in the CCAFS Industrial Area.

Table 14-2. KSC Electric Distribution Summary (cont.).

Source	Electricity
Ownership	KSC owns/maintains 13.2 and 13.8 kV distribution systems.
Submetering	KSC has about 240 submeters for energy/cost management. These meters cover 82% of consumption, but not at the facility level; the remaining usage is calculated by subtracting metered values from totals or estimating. KSC is pursuing networking meters for more automated input into an information management system.
Central plants	Both the Industrial Area and LC-39 Area have a central utility plant that produces air conditioning chilled water and distributes to various buildings. KSC is pursuing metering plant production and facility usage.
Backup	Diesel generation and uninterruptible power supply units backup critical loads. Portions of the generation capability participate in FPL's load control program and qualify the substations for a cheaper rate.

Table 14-3. KSC Natural Gas Distribution.

Source	Natural Gas
% of KSC energy	9.4%
Contracts	NASA contracts with National Utility Investors (NUI)/City Gas for local delivery service, and utilizes a Defense Energy Support Center (DESC) contractor for gas commodity.
Metering/billing	City Gas meters/bills NASA directly for local delivery to 47 accounts at KSC and CCAFS: Four large accounts and 43 smaller loads. The DESC contractor bills NASA for the commodity and its transportation across the interstate pipeline into City Gas's local system.
Ownership	City Gas owns the distribution pipes/meters.
Sub-metering	No KSC sub-metering because City Gas meters each load.
Central plants	The LC-39 Area central utility plant produces heating/reheating high temperature hot water and distributes to various buildings.
Backup	KSC's largest boiler plants have fuel oil back up and qualify for cheaper interruptible rates from City Gas. New modular boilers use liquid petroleum gas backup fuel.

The Transportation Office under the Center Operations Logistics and Services Branch coordinates KSC response to transportation mandates with General Services Administration.

14.3 INITIATIVES

The EWG updated the KSC Energy and Water Management Five-Year Plan, and will obtain Center Director approval in February, 2015. Due to the frequent changes in the Energy Law and the issuance of a new Executive Order (EO), the plan has recently experienced a major revision that revealed new categories of emphasis such as an increased requirement for renewable energy production. KSC tracks progress towards energy and water efficiency goals using energy metrics for all Goal Subject facilities as defined by energy law identified previously in section 14.1. Previous energy reduction initiatives include lighting retrofits, HVAC control conversions from pneumatic to digital, conversion to variable speed motor drives, decentralization of an inefficient high temperature hot water distribution system, and minimal renewable energy technology applications as warranted by life cycle cost effectiveness. Project funding sources include NASA Construction of Facilities appropriations, NASA Construction and Environmental Compliance and Restoration appropriations, Enhanced Use Lease (EUL) residuals, facilities O&M contracts (performance requirements), self-funding projects (repay third-party loan with savings), Department of Energy grants, Strategic Institutional Investment (SII) funding, and utility rebates from previous energy projects

SECTION XV. POLLUTION PREVENTION, GREEN PURCHASING, RECYCLING/WASTE DIVERSION AND SUSTAINABLE ENVIRONMENT MANAGEMENT SYSTEM

15.1 REGULATORY OVERVIEW

Section 3002(b) of RCRA, as amended by the Hazardous and Solid Waste Amendments of 1984, Section 6602(b) of the Pollution Prevention Act and EO 13693 "Planning for Federal Sustainability in the Next Decade" direct federal agencies to:

- Reduce the quantity of toxic and hazardous chemicals and materials acquired, used, or disposed of by the agency,
- Increase diversion of solid waste as appropriate,
- Maintain cost-effective waste prevention and recycling programs in facilities, and
- Use sustainable practices in the acquisition of biobased, environmentally preferable, energy efficient, water-efficient and recycled-content products (Green Purchasing).

EO 13693 also requires federal agencies to implement Environmental Management Systems (EMS) to ensure use of the EMS as the primary management approach for addressing environmental aspects of agency operations and activities.

15.2 KSC POLLUTION PREVENTION (P2) PROGRAM

15.2.1 KSC POLLUTION PREVENTION GOALS

KSC's goals are to reduce the volume and toxicity of solid and hazardous waste to the extent economically practicable through the following program elements:

Source Reduction

Prevention through source reduction is the practice of reducing the amount of hazardous substances, pollutants, or contaminants entering any waste stream or otherwise released into the environment before recycling, treatment, or disposal. Source reduction reduces or eliminates the hazards to employees, the public, and the environment along with the liability of regulatory compliance. Source reduction techniques employed by KSC are listed below.

- Initial Environmental Design**:** Incorporation of environmental considerations into the initial process or facility design to limit or prevent pollution or waste generation from occurring.
- Process Efficiency Improvements**:** Changes to a process or facility to reduce requirements for hazardous substances, pollutants, or contaminants.

- Material Substitution**:** Substitution of non-hazardous or less hazardous materials into a process to reduce the toxicity of the resulting waste stream.
- Inventory Control**:** Control of hazardous materials in inventories to promote efficient use and to avoid shelf-life expiration and waste generation.
- Preventive Maintenance**:** Designing equipment for maintainability to result in detection and avoidance of equipment problems before failures and associated spills and leaks of hazardous materials occur.
- Improved Housekeeping**:** Maintaining clean, well-organized facilities and awareness by personnel regarding proper management and use of toxic and hazardous materials to reduce the frequency and amount of accidental spills, releases, and subsequent waste generation.

Recycling and Waste Diversion

Recycling is the most preferred method of waste minimization for those hazardous substances, pollutants, or contaminants that cannot be reduced at the source. Recycling is the practice of using, reusing or reclaiming a waste material. A waste material is used or reused if it is employed as an ingredient in an industrial process to make a product, or employed in a particular function or application as an effective substitute for a commercial product. A waste material is reclaimed if it is processed to recover a usable product, or regenerated.

Treatment

Treatment options should only be employed when wastes cannot be prevented or recycled. Treatment is any method that physically, chemically or biologically changes the character or composition of the waste; recovers energy or material resources from the waste; renders the waste non-hazardous or less hazardous; reduces the volume of the waste; renders the waste safer for transport, storage, or disposal; or makes the waste amenable for recovery or storage. Treatment opportunities for hazardous wastes at KSC may be referenced in Technical Response Package instructions (example: neutralization of corrosive wastes).

Disposal

Disposal is the discharge, deposit, injection, dumping, spilling, leaking, or placing of a waste into or on land or water or into the air so that hazardous constituents may enter the environment. No hazardous wastes may be disposed of at KSC; offsite disposal of hazardous waste is managed through specific documented processes. Disposal is utilized when the waste can’t be prevented, recycled, or treated.

15.2.2 KSC POLLUTION PREVENTION (P2) PROGRAM ELEMENTS

The KSC P2 Program addresses source reduction, waste minimization, recycling and reuse. The program encourages the use of environmentally preferable materials and the minimization of all wastes generated at KSC. Pollution prevention includes developing and implementing practices that reduce the use of hazardous and non-hazardous materials and minimize the generation of and/or treatment and disposal of wastes. The P2 Program also supports the Center's purchasing decisions, operations, maintenance, and waste management and disposal methods.

The main components of the KSC P2 Program include:

- P2 opportunity assessments
- Partnering with contractors and regulators
- Emergency Planning and Community Right to Know (EPCRA) Tier II data tracking and reporting
- EPCRA Toxic Releases Inventory tracking and reporting, and
- Green purchasing, recycling and solid waste reporting

The KSC Environmental Management Branch leads, coordinates and communicates this strategy for the Center. The Branch collects and analyzes data, performs trend analysis, communicates lessons learned, shares information with partnering teams, and submits reports to NASA HQ and regulatory agencies.

15.2.3 KSC EMERGENCY PLANNING AND COMMUNITY RIGHT TO KNOW ACT PLAN

EPCRA is intended to improve local community access to information about chemical hazards and to improve state and local emergency response capabilities.

EPCRA has three main objectives:

- To bolster local emergency planning efforts
- To improve emergency notification in the event of a release of hazardous chemicals, and
- To develop a baseline on routine chemical releases into the environment

To meet these objectives, EPCRA created four types of reporting obligations for facilities that store or manage specified listed chemicals. All information submitted pursuant to EPCRA regulations is publicly accessible, unless protected by a trade secret claim.

Notification of Extremely Hazardous Substances

EPCRA §302 requires facilities to notify the State Emergency Response Commission (SERC) and the Local Emergency Planning Committee (LEPC) of the presence of any "extremely hazardous substance" if it has the substance in excess of the specified "threshold planning quantity." It also directs the facility to appoint an emergency response coordinator. KSC utilizes extremely hazardous substances and reports to the SERC and LEPC accordingly.

Notification of Releases

EPCRA §304 requires facilities to notify the SERC and the LEPC in the event of a release exceeding the "reportable quantity" of a CERCLA hazardous substance or an EPCRA extremely hazardous substance. EPCRA extremely hazardous substances and reportable quantities are listed in 40 CFR 355. KSC keeps track of all "reportable quantity" releases and any other "non-reportable quantity" releases annually by using the Pollution Incident Report (PIR).

Emergency Planning (EPCRA Tier II)

EPCRA §311 and §312 require facilities to notify SERC, LEPC, and the local fire department of all hazardous chemicals for which the Occupational Health and Safety Administration requires material safety data sheets (MSDSs). The facility must submit either the MSDS or a list of the substances for which an MSDS is maintained. If a list is submitted, hazardous chemical inventory forms (also known as Tier I and II forms) must also be submitted. A Tier I form provides information about hazardous chemicals grouped by hazard category. A Tier II form provides information about each specific hazardous chemical. This information helps the local government respond in the event of a spill or release of the chemical. These requirements are found at 40 CFR 370, Hazardous Chemical Reporting: Community Right-to-Know. On March 1st of each year, KSC submits the EPCRA Tier II Report to the EPA, the SERC, the LEPC and the KSC Fire Department.

Toxic Release Inventory (Form R)

EPCRA §313 of Title III requires manufacturing facilities included in SIC codes 20 through 39, which have ten or more employees, and which manufacture, process, or use specified chemicals in amounts greater than threshold quantities, to submit an annual toxic chemical release report to EPA. This program is called the Toxic Release Inventory (TRI). The report, commonly known as Form R, 1) covers releases and transfers of toxic chemicals to various facilities and environmental media, 2) allows EPA to compile the national TRI database, and 3) assists in research and development of regulations, guidelines, and standards. The TRI data are used nationally to track pollution prevention progress by industry. These requirements can be found at 40 CFR 372, Toxic Chemical Release Reporting: Community Right-to-Know. On July 1st of each year, KSC submits the TRI Report to the EPA and the SERC.

15.3 GREEN PURCHASING AND RECYLING/WASTE DIVERSION

15.3.1 REGULATORY OVERVIEW

Section 6002 of RCRA, Section 9002 of the Farm Security and Rural Investment Act of 2002 (FSRIA), EO 13693, *Planning for Federal Sustainability in the Next Decade*, and the Federal Acquisition Regulations (FAR 23.4) direct federal agencies to maintain cost-effective waste prevention and recycling programs and to use sustainable environmental practices in acquisitions. These practices include acquisition of biobased, environmentally preferable, energy-efficient, water-efficient and recycled-content products, collectively referred to as Green Purchasing. NASA implements the federal agency Green Purchasing requirements through NASA Procedural Requirement NPR 8530.1, Affirmative Procurement Program and Plan for Environmentally Preferable Products.

In response to RCRA, the U.S. EPA developed the Comprehensive Procurement Guideline (CPG). The CPG designates recycled-content products in eight product categories for which federal procuring agencies are required to develop Green Purchasing programs. The eight product categories are: 1) Paper and paper products, 2) Vehicular products, 3) Construction products, 4) Landscaping products, 5) Transportation products, 6) Park and recreation products, 7) Non-paper products, and 8) Miscellaneous products. In response to the FSRIA, the U.S. Department of Agriculture (USDA) has developed one proposed and four final rounds of designated biobased items. Additional rounds of biobased items will be finalized in future years.

EO 13693 also requires that the Agency submit an annual report to the Office of the Federal Environmental Executive and the Office of Management and Budget on the progress of its Green Purchasing and waste diversion program. To help with tracking this data, NASA utilizes an automated, web-based tracking system, the NASA NETS.

15.3.2 NASA GREEN PURCHASING AND RECYCLING/WASTE DIVERSION GOALS

Agency goals to increase waste prevention, recycling/waste diversion, and use of recycled content, biobased and environmentally preferable products and services encompass the following principals:

- Improve and expand the diversion of solid waste from landfills and incinerators through waste prevention, reuse, and recycling
- Facilitate development and expansion of markets for recycled content and environmentally preferable products through acquisition of products and services, research and development programs, assistance programs, and other appropriate programs

- Facilitate development and expansion of technologies for waste prevention, recycling (including design for disassembly), and manufacture of recycled content, biobased and environmentally preferable products
- Expand waste prevention and recycling in the daily operation of NASA, and
- Implement cost-effective procurement programs favoring the purchase of environmentally preferable products and services.

15.3.3 RECYCLING/WASTE DIVERSION AND GREEN PURCHASING GOALS

KSC is committed to maximize Green Purchasing opportunities, maximize the amount of materials recycled, reduce the amount of recyclable material going to either KSC's onsite landfill or the Brevard County Landfill, and to meet the Agency's 50% waste diversion goal. KSC encourages NASA civil service workforce and contractors to maximize recycling and Green Purchasing through contract requirements, policy, processes and procedures, and through educational and awareness activities.

15.3.4 KSC RECYCLING AND WASTE DIVERSION PROGRAM

KSC's recycling program consists of the following main components:

- Excess/sale of non-construction and demolition materials through KSC's Property Disposal Office at KSC's onsite Reutilization, Recycling and Marketing Facility (RRMF),
- Service contract for paper, toner cartridges, cardboard, plastic, glass, steel and aluminum containers,
- Diversion of wood, land clearing debris and non-hazardous blast media to the KSC onsite Class III Construction and Demolition (C&D) landfill for use as landfill cover,
- Diversion of recyclable construction and demolition material, and
- Diversion of clean concrete from onsite construction activities for reuse in onsite construction projects.

The RRMF accepts materials, commodities and equipment only if they meet the following criteria:

- Items must be drained of all fluids with no leakage of any type of fluid from equipment or containers.
- There must be no visible indication of old spills/releases on the outside of equipment or containers that could be washed off from rainfall.
- All items must be accompanied by required documentation, KSC Form 7-652 or KSC Form 7-49, and identified with a full, written commercial description.
- The RRMF will not accept treated lumber (arsenic, chromated copper arsenate, etc.), explosive materials/ordnance, blast media, hazardous materials (PCBs, asbestos, etc.), leaking equipment, radioactive wastes, uncrushed drums, intact

compressed gas cylinders, intact flex hoses, or biomedical wastes. Any equipment found to be leaking during initial inspection upon delivery to RRMF will be reported as a spill. It is the financial and environmental responsibility of the organization sending the equipment to the RRMF to ensure appropriate clean up and disposition of the equipment and any other contamination caused by it.

- Liquid-containing items which are delivered to the RRMF with the intent of resale, but which are at some point re-designated for sale as scrap metal, must be properly drained (into impermeable containment sufficient to collect and contain 100% of all liquids in the equipment) by RRMF personnel and thereafter be managed under the requirements for scrap metal.

In addition to commodities recycled through the RRMF, KSC utilizes the onsite Diverted Aggregate Reclamation and Collection Yard (DARCY) to provide a temporary staging area for clean concrete generated from onsite construction activities that would otherwise be disposed of at KSC's Class III C&D landfill. The concrete is reused in onsite construction and maintenance projects.

Public Law Number 103-329, Section 608, allows federal agencies to retain funds generated from the sale of excess commodities designated as recyclable through the Government Surplus Sales Program. At KSC, the Government Surplus Sales Program is managed by the Property Disposal Office at the RRMF. The KSC Environmental Management Branch manages the recycling funds for the Center. These funds can be expended for Green Purchasing, Waste Reduction and Prevention, and Recycling projects and activities; other Federal Agency Environmental Management Programs, including but not limited to, development and implementation of Hazardous Waste Management and Pollution Prevention Programs; and other employee programs as authorized by law or as deemed appropriate by the head of the federal agency**.**

15.4 SUSTAINABLE ENVIRONMENT MANAGEMENT SYSTEM

15.4.1 REGULATORY OVERVIEW

The following Executive Orders and regulations direct NASA to implement an EMS at all appropriate organizational levels.

- EO 13693, *Planning for Federal Sustainability in the Next Decade*
- NPD 8500.1, *NASA Environmental Management*
- NPR 8553.1, *NASA Environmental Management System (EMS)*

15.4.2 KSC SUSTAINABLE ENVIRONMENT MANAGEMENT SYSTEM (SEMS)

In response to the requirements, KSC implemented its SEMS, which:

- Incorporates organizational elements, procedures, and work practices in a formal structure to ensure that the important environmental impacts and benefits of KSC's operations and activities are identified and addressed,
- Promotes continual improvement including periodically evaluating environmental performance,
- Increases awareness of the Center's sustainability goals from the KSC Sustainability Plan and ensures the continual improvement of sustainability programs and projects,
- Involves all members of the organizations and contracts as appropriate, and
- Involves Senior Management in support of the environmental management program.

KSC's SEMS is documented in KNPR 8553.1: *NASA-Kennedy Space Center Sustainable Environment Management System (SEMS).*

Appendix A

Areas and Descriptions of Soil Series on KSC

APPENDIX A

AREAS AND DESCRIPTIONS OF SOIL SERIES ON KSC

Descriptions of the Soil Series and Land Types on KSC modified form Schmalzer and Hinkle 1990 (Ref. 1).
Anclote sand is a nearly level, very poorly drained, sandy soil in marshy depressions in flatwoods, broad areas on floodplains, and in poorly defined drainageways. In most years the water table is <10" (25 cm) for >6 months and seldom >40" (102 cm). These soils are occasionally flooded for 2-7 days after heavy rain (Ref. 2). On KSC, Anclote soils are primarily in swales of flatwoods and scrub and along drainage ways.

Arents are nearly level soils made up of heterogeneous material removed form other soils and used in land leveling, as fill material or as the final cover of a sanitary landfill (Ref. 3).
Astatula fine sand is a nearly level to gently sloping, excessively drained, sandy soil on high, undulating ridges. It has low organic matter content and low natural fertility. The water table is typically below 120" (305 cm). This series is better drained than Pomello and lacks the A2 and B horizons of Paola (Ref. 2). On KSC, this series is found primarily on the higher ridges north of Haulover Canal. The Astatula-Urban land complex map unit is made up of nearly level to sloping Astatula soils that have been used for urban development (Ref. 3). The soil coverage from the St. Johns River Water Management District considers these Candler series (Table A-1).

Basinger sand is a nearly level, poorly drained, sandy soil in sloughs of poorly defined drainageways and depressions in flatwoods. In most years, the water table is <10" (25 cm) for 2-6 months, between 10-40" (25-102 cm) for 6 months, and >40" (102 cm) for short periods in the dry season. This series is better drained than Anclote and lacks the weakly cemented Bh horizon of Immokalee (Ref. 2). On KSC, Basinger sand occurs primarily in swales in flatwoods and scrub.

Beaches are the narrow sandy strips along the Atlantic coast composed of fine to coarse sand mixed with multicolored shells and shell fragments. Seawater regularly over washes the larger part of these areas at high tide but the higher areas only at equinoctal or storm-driven tides (Ref. 2).

Bradenton fine sand, shallow variant is a nearly level, poorly drained soil with limestone at a depth of ca. 40" (102 cm). The water table is <10" (25 cm) for 2-6 months, between 10-30" (25-76 cm) for >6 months, and >30" (76 cm) for short periods in the dry season. These soils may be flooded for 2-7 days once in 1-5 years. This series is better drained than Copeland (Ref. 2). On KSC, this series occurs mainly in the central and western parts of Merritt Island near areas mapped as the Copeland complex.

Bulow sand is a gently sloping, well drained, moderately deep, sandy soil underlain by differentially weathered coquina on narrow sand ridges. The water table is typically below 72" (183 cm) (Ref. 3). Bulow sand occurs only to a minor extent on KSC (Table A-1) and is found on ridges north of Haulover Canal.

Canaveral sand is a nearly level and gently undulating, moderately well drained, sandy soil mixed with shell fragments. The map unit consists of 60% Canaveral sand and 30% a more poorly drained Canaveral sand in sloughs between ridges with a thicker, darker surface layer and the water table closer to the surface for longer periods. Canaveral sand is not as well drained as Palm Beach but better drained than Anclote (Ref. 2). On KSC, Canaveral sand is found primarily on the coastal strip inland from Palm Beach sand. It is of modest extent on KSC (Table A-1) but occupies most of Cape Canaveral. The Canaveral-Urban land complex consist of about 20-40% urban development; the remaining areas are a mixture of sand and shell dredged from the Indian and Banana Rivers, deposited on tidal marshes and swamps, and then leveled and smoothed (Ref. 2).

Canova peat is a nearly level, very poorly drained soil with a peat surface layer and a loamy subsoil occurring on broad floodplains. The water table is <10" (25 cm) for 9-12 months, continuously flooded for 3-6 months, and >10" (25 cm) for short periods in the dry season. This series is more poorly drained than Felda and Winder soils and has an organic surface layer (Ref. 2). Canova peat is of minor extent on KSC (Table A-1).

Cassia fine sand is a nearly level, somewhat poorly drained but moderately permeable soil that occurs on low sandy swells slightly higher than the adjacent flatwoods. The water table is between 15-40" (38-102 cm) during rainy seasons. This series is less well drained than Orsino but better drained than Myakka soils (Ref. 3).

Chobee fine sandy loam is a nearly level, very poorly drained, loamy soil with a thick black surface layer that occurs in marshy depressions and floodplains. The water table is <10" (25 cm) for 6-9 months, between 10-40" (25-102 cm) for 3-6 months, >40" (102 cm) for short periods in the dry season, and may be flooded continuously for 1-6 months. This series is more poorly drained than Felda (Ref. 2). On KSC, a minor acreage (Table A-1) of this series occurs on the central and western part of Merritt Island.

Cocoa sand is a nearly level and gently sloping, well drained, sandy soil over coquina. The water table is >72" (183 cm) all year (Ref. 2). On KSC, this series occurs primarily on low ridges north and south of Haulover Canal.

Copeland is a nearly level, sandy to loamy, very poorly drained soil on low flats underlain by limestone. The Copeland complex map unit consists of several nearly level, very poorly drained soils where the water table is <10" (25 cm) for >6 months, between 10-30" (25-76 cm) in the dry season, and flooded 7-30 days once in 5-20 years. Soils in the complex differ in depth to the limestone layer (Ref. 2). On KSC, this complex occurs mainly in the central and western part of Merritt Island west of State Route 3.

Daytona sand is a moderately well drained, nearly level to gently sloping soil on undulating sandhills or slightly elevated places in the flatwoods. The water table is between 40-50" (102-127 cm) for 1-4 months per year in the wet season and >72" (183 cm) in the dry season (Ref. 3). On KSC, small areas of this series (Table A-1) are mapped on ridges north of Haulover Canal in Volusia County.

Felda sand is a nearly level, poorly drained soil on broad low flats, in sloughs, depressions, and poorly defined drainageways. The water table is <10" (25 cm) for 2-6 months and between 10-40" (25-102 cm) for the rest of the year. Water may be above the surface for 2-7 days in 1-3 months per year. Depressions are flooded for >6 months per year (Ref. 2). The soil coverage from the St. Johns River Water Management District combines Felda soils into the Riviera series (Table A-1).

Felda and Winder soils consist of poorly drained soils in low sloughs and slightly higher hammocks. The map unit consists of about 65% sloughs and 35% hammocks. In the sloughs, the soils are 35% Felda, 30% Winder, and <20% Chobee, Floridana, and/or Wabasso. In the hammocks, the soils are 55% a soil similar to Wabasso but over limestone and the remainder a soil similar to Copeland (Ref. 2). These soils occur in low areas in flatwoods on the east side of Merritt Island and on low flats on the west side of the island. The soil coverage from the St. Johns River Water Management District combines Felda soils into the Riviera series (Table A-1).

Felda and Winder soils, ponded are the landward areas of former high tidal marsh impounded for mosquito control and now continuously flooded for >6 months per year. About 50% of the soils are Felda and 25% Winder (Ref. 2). These soils are also mapped in some of the large interior wetlands on KSC. The soil coverage from the St. Johns River Water Management District combines Felda soils into the Riviera series (Table A-1).

Floridana sand is a nearly level, very poorly drained soil in broad areas of floodplains and small to large marshy depressions. The water table is <10" (25 cm) for 6-9 months and between 10-30" (25-76 cm) for the rest of the year. This series is more poorly drained than Felda or Winder (Ref. 2). Only minor areas of this soil occur on KSC (Table A-1).

Holopaw sand is a nearly level, poorly drained soil of broad low flats and depressions (Ref. 3).

Hydraquents are variable, silty, clayey, or loamy tidal deposits in mangrove swamps and islands. The outer edges experience tidal overwash daily, while the inner parts are slightly elevated and are inundated only during storms and equinoctial tides. Hydraquents are mapped in Volusia County (Ref. 3); in Brevard County, the map unit of Tidal swamp is apparently equivalent (Ref. 2).

Immokalee sand is a nearly level, poorly drained, sandy soil in broad areas in flatwoods, low ridges between sloughs, and in narrow areas between sand ridges and lakes or ponds. The water table is <10" (25 cm) for 1-2 months, between 10-40" (25-102 cm) for >6 months, and >40" (102 cm) for short dry periods. It may be flooded for 2-7 days once in 1-5 years (Ref. 2). Immokalee is one of the major soil series in flatwoods and scrub on KSC (Table A-1).

Malabar sand is a nearly level, poorly drained soil in broad low areas, sloughs, and poorly defined drainageways (Ref. 2). It is of minor extent on KSC (Table A-1).

Montverde peat is a nearly level, very poorly drained, thick organic soil in depressions, marshes, and swamps (Ref. 2). It is of minor extent on KSC (Table A-1).

Myakka sand is a nearly level, poorly drained, sandy soil in broad areas in flatwoods, low ridges between sloughs, and in narrow areas between sand ridges and lakes or ponds. The water table is <10" (25 cm) for 1-4 months, between 10-40" (25-102 cm) for >6 months, and >40" (102 cm) for short dry periods. It may be flooded for 2-7 days once in 1-5 years (Ref. 2). Myakka is an important series in flatwoods and wetter scrub on KSC (Table A-1) where it is in lower areas than Immokalee. Myakka-Urban land complex consists of Myakka soil, Myakka soil that has been altered for use as building sites, and urban development (Ref. 2).

Myakka sand, ponded is a nearly level, poorly drained, sandy soil in shallow depressions in flatwoods. It is similar to Myakka but is flooded for 6-12 months per year (Ref. 2). Only minor areas of this series occur on KSC (Table A-1).

Myakka variant fine sand is a nearly level, poorly drained, sandy soil in swells in flatwoods and in slightly higher areas in hardwood hammocks near the coast. The water table is <10" (25 cm) in the rainy season. This series differs form Myakka in the fine sand texture and the presence of a neutral to alkaline IIC horizon with shell fragments (Ref. 3). Small areas of this series (Table A-1) occur in the northern section of KSC in Volusia County.

Orsino fine sand is a nearly level, moderately well drained, sandy soil on moderately low ridges and between high ridges and poorly drained areas. The water table is between 40-60" (102-152 cm) for >6 months, during dry periods it is >60" (152 cm), and during wet periods between 20-40" (51-102 cm) for 7 days to 1 month (Ref. 2). Small areas of this soil (Table A-1) occur on ridges in the central part of Merritt Island.

Palm Beach sand is a nearly level and gently sloping, excessively drained soil on dune-like ridges that roughly parallel the Atlantic Ocean and consists of mixed sand and shell fragments. The water table is >120" (305 cm). This series is better drained than Canaveral sand (Ref. 2). On KSC, it occurs on the recent dunes inland from the beaches.

Paola fine sand is a nearly level to strongly sloping, excessively drained, sandy soil of the tops and sides of ridges. This series is better drained than Orsino and much better drained than Immokalee or Myakka (Ref. 2). On KSC, this series occurs on the higher ridges in the center of Merritt Island and on ridges north of Haulover Canal.

Parkwood fine sand is a nearly level, poorly drained soil with a loamy subsoil occurring in hammocks along streams, poorly defined drainageways, and depressions. The water table is <10" (25 cm) for 2-4 months per year in wet periods, and between 10-30" (25-76 cm) the rest of the year. The soil may be flooded for 7 days to 1 month once in 1-5 years (Ref. 2). Small areas of this series (Table A-1) occur on KSC, generally near the Copeland complex. The soil coverage from the St. Johns River Water Management District considers these Hilolo series soils (Table A-1).

Pineda fine sand is a nearly level, poorly drained, sandy soil in broad low flats in the flatwoods, in poorly defined drainageways, and at the edges of sand ponds and swamps. The water table is <10" (25 cm) for 1-6 months; some areas have standing water for 7 days to 6 months in some years (Ref. 2).

Pineda sand, dark surface variant is a nearly level, poorly drained, sandy soil in broad hammock and low sloughs. The water table is within 10” (25 cm) for 1-2 months most years. The soil is flooded for 2-7 days every 1-5 years (Ref. 2). The soil coverage from the St. Johns River Water Management District considers these Delray sand-commonly flooded (Table A-1).

Pits are excavations from which soil and geologic material have been removed for use in road construction or development (Ref. 3).

Placid fine sand, depressional is a very poorly drained, nearly level soil in wet depressions. The water table is above the surface for >6 months per year. This series is lower and more poorly drained than Myakka or St. Johns (Ref. 3). Minor areas of this series occur on KSC (Table A-1).

Pomello sand is a nearly level, moderately well drained, sandy soil on broad low ridges and low knolls in the flatwoods. The water table is between 30-40" (76-102 cm) for 2-4 months per year and between 40-60" (102-152 cm) for >6 months per year. This series is better drained than Immokalee or Myakka but more poorly drained than St. Lucie (Ref. 2). On KSC, Pomello sand is primarily on the broader ridges of central Merritt Island.

The Pomona-St. Johns complex consists of nearly level, poorly drained Pomona and St. Johns soils that are covered with standing water for long periods. These soils occur in drainageways and broad depressions in flatwoods (Ref. 3).

Pompano is a nearly level, poorly drained, sandy soil on broad flats, in shallow depressions, and in sloughs. The water table is <10" (25 cm) for 2-6 months per year, between 10-40" (25-102 cm) for >6 months per year, and >40" (102 cm) in the dry season (Ref. 2).

The Pompano-Placid complex map unit consists of nearly level, poorly drained Pompano soils and very poorly drained Placid soils in depressions in flatwoods. The soils are too intermingled on the landscape to map separately at the scale of the soil survey (Ref. 3).

Quartzipsamments are nearly level to steeply sloping soils reworked by earthmoving equipment. The soil material is derived from a variety of sandy soils (Ref. 2).

Riviera fine sand is a poorly drained, nearly level soil in broad low flats. The water table is <10" (25 cm) for 2-6 months per year and >40" (102 cm) for ca. 6 months per year (Ref. 3). Minor areas of this series were mapped in the northern part of Merritt Island in Volusia County. The soil coverage from the St. Johns River Water Management District combines Felda soils into the Riviera series (Table A-1).

St. Johns sand is a nearly level, poorly drained, sandy soil on broad low ridges in the flatwoods. The water table is <10" (25 cm) for 2-6 months per year and between 10-40" (25-102 cm) the rest of the time. During extended dry periods it may be >40" (102 cm), and the soils may be flooded for 2-7 days following heavy rain (Ref. 2). This series occurs in low swales in the flatwoods and scrub on the eastern part of Merritt Island and in low flats on the western part of the island.

St. Johns soils, ponded are in sloughs, poorly defined drainageways, and shallow intermittent ponds in the flatwoods. The water table is <10" (25 cm) for 6-12 months per year, and they may be flooded for >6 months per year (Ref. 2). On KSC, this series is primarily in swales in flatwoods and scrub.

St. Lucie fine sand is a deep, nearly level to strongly sloping, excessively drained, sandy soil on high dune-like ridges and isolated knolls. The water table is >120" (305 cm) (Ref. 2). Only minor areas of this soil occur on KSC (Table A-1).

Satellite sand is a somewhat poorly drained but rapidly permeable soil found on low and moderately high sandy hills in flatwoods. It is better drained than the associated Immokalee and Myakka soils but not as well drained as Daytona soils (Ref. 3).

Smyrna fine sand is a nearly level, poorly drained, moderately permeable soil of broad, nearly level terraces in flatwoods. It is less well drained than the associated Cassia soils but better drained than Basinger soils (Ref. 3).

Spoil banks are piles of soil material dug from large ditches and canals or dredged from ship channels in the Indian River. On the mainland, spoil banks occur as long, narrow areas adjacent to the ditches and canals from which they were dug. In the Indian River, they occur as scattered islands near the ship channel from which they were dredged. Properties of spoil banks vary depending on the material from which they were taken (Ref. 2). The soil coverage from the St. Johns River Water Management District uses Arents and Udorthents for this material.

Swamp includes nearly level, poorly drained and very poorly drained areas of soils with dense cover of wetland hardwoods, vines, and shrubs in poorly defined drainageways, depressions, and large bay heads. They are flooded with freshwater most of the time. The soil pattern is intricate, varied, and impractical to map separately and includes Anclote, Basinger, Pompano, Terra Ceia, and Tomoka soils (Ref. 2).

Submerged marsh is the mapping unit used for areas on the lagoonward side of marshes impounded for mosquito control (Ref. 2). These are now flooded for much of the year; they may be primarily open water or may still support some marsh vegetation. The soil coverage from the St. Johns River Water Management District uses Turnbull and Riomar soils–tidal for these soils.

Tavares fine sand is a nearly level and gently sloping, well drained, sandy soil on narrow to broad, moderately low ridges. The water table is between 40-60" (102-152 cm) for >6 months per year and >60" (152 cm) in the dry season. This series is better drained than Immokalee or Myakka but less well drained than Astatula, Paola, or St. Lucie (Ref. 2). Only minor areas of this series occur on KSC (Table A-1).

Tequesta muck is a nearly level, very poorly drained soil of low flats and freshwater marshes and swamps where conditions favor the accumulation of plant remains. The soil consists of about 12” (30.5 cm) of sapric muck over sand (Ref. 3).

Tidal marsh includes nearly level areas of soils covered with salt or brackish waters at high tide. Soils are highly variable and include shallow mucky sands over marl or limestone, irregularly stratified mixed sand and shell fragments, silty or clayey layers over sand and shells, and deep organic material (Ref. 2). Tidal marsh is mapped in Brevard County for marsh areas adjacent to the lagoon systems (Indian River, Banana River, Mosquito Lagoon) that are not impounded.

Tidal swamp includes nearly level areas at about mean sea level covered with dense tangled growth of mangrove trees and roots. Soil material ranges from mixed sand and shells to organic material (Ref. 2). This type is mapped in Brevard County for mangrove islands in Mosquito Lagoon and the Banana River and for other unimpounded areas of mangroves adjacent to the lagoon systems. The soil coverage from the St. Johns River Water Management District labels these soils Bessie muck.

Turnbull muck is a very poorly drained soil formed in clayey and sandy estuarine deposits near sea level and periodically flooded by tidal overwash (Ref. 3). This series is mapped in marshes bordering the Indian River and Mosquito Lagoon in the Volusia County section of KSC.

Turnbull variant sand consists of mixed sandy and shelly material dredged from the Intracoastal Waterway and placed in narrow strips along it over underlying material of organic deposits and layers of clayey and sandy estuarine deposits (Ref. 3). Minor areas (Table A-1) of this soil are mapped in the Volusia County section of KSC. It appears to be similar or identical to the Spoil bank type in Brevard County (Ref. 2).

Tuscawilla fine sand is a nearly level, poorly drained soil in broad hammocks near the coast. The water table is <10" for 2-6 months per year (Ref. 3). Areas of this soil are mapped in the northern part of Merritt Island in Volusia County.

Urban land consists of areas that are 60 to >75% covered with streets, buildings, parking lots, and similar structures (Ref. 2).

Valkaria fine sand is a nearly level, poorly drained soil of sloughs, depressions, and low areas bordering swamps (Ref. 3).

Wabasso loamy sand is a nearly level, poorly drained, sandy soil on broad areas in the flatwoods and on low ridges of floodplains. The water table is <10" (25 cm) for 1-2 months per year and <30" (76 cm) most of the time; during the dry season it may be >30" (76 cm) for short periods. These soils may be flooded for 2-7 days once in 1-5 years (Ref. 2). On KSC, this series occurs on broad flats on the western side of Merritt Island.

Winder sand is a nearly level, poorly drained, sandy soil in low areas and on low ridges. The water table is <30" (76 cm) most of the time and <10" (25 cm) for 2-6 months per year. During short, dry periods it may be >30" (76 cm); these soils may be flooded occasionally for 2-7 days (Ref. 2). Only small areas of this soil are mapped separately on KSC (Table A-1); others are included in the Felda and Winder class.

Table A-1. Areas of Soil Series on Kennedy Space Center. Areas Derived from a Soil Coverage Provided by St. Johns River Water Management District from the Original Soil Maps of Brevard and Volusia Counties.

Soil Series or Land Type	Area (acres)	Area (ha)
Anclote sand	2282.6	923.8
Arents (includes some spoil)	286.0	115.7
Astatula fine sand (Candler)	584.7	236.6
Astatula (Candler)-Urban land complex	1.3	0.5
Basinger sand	1094.1	442.8
Beaches	577.3	233.6
Bradenton fine sand	714.0	288.9
Bulow sand	58.1	23.5
Canavera sand	390.3	158.0
Canaveral – Urban land complex	457.3	185.1
Canova peat	18.0	7.3
Chobee fine sandy loam	203.1	82.2
Cocoa sand	925.0	374.4
Copeland complex	4605.4	1863.7
Daytona sand	95.1	38.5
Felda (Riviera) and Winder	4072.7	1648.2
Felda (Riviera) and Winder, ponded	4402.2	1781.5
Floridana	75.6	30.6
Hydraquents	1082.0	437.9
Immokalee sand	14409.1	5831.2
Malabar sand	1.8	0.7
Montverde peat (Everglades mucky peat)	2.5	1.0
Myakka sand	4300.9	1740.5
Myakka, ponded	26.4	10.7
Myakka, variant	69.1	28.0
Myakka-Urban land complex	9.9	4.0
Orsino fine sand	104.1	42.1
Palm Beach sand	1765.7	714.6
Paola fine sand	1262.8	511.0
Parkwood (Hilolo) fine sand	147.3	59.6
Pineda fine sand	484.8	196.2
Pineda sand, dark surface variant (Delray sand – commonly flooded)	170.9	69.2
Pits	6.0	2.3
Placid fine sand, depressional	83.1	33.6
Pomello sand	2048.3	828.9
Pomona-St. Johns complex	5.8	2.3
Pompano	298.1	120.6

Note: Names in parentheses differ in the coverage from those in the original maps.

Table A-1. (cont.).

Soil Series or Land Type	Area (acres)	Area (ha)
Pompano-Placid complex	540.3	218.6
Quartzipsamments	345.2	139.7
Riviera fine sand (includes Felda)	572.0	231.5
St. Johns fine sand	3080.8	1246.7
St. Johns, ponded	1424.3	576.4
St. Lucie fine sand	16.7	6.8
Samsula muck	304.2	123.1
Spoil banks (Udorthents)	15.3	6.2
Submerged marsh and Tidal marsh (Turnbull and Riomar soils – tidal)	21911.0	8867.1
Swamp (Anclote sand-frequently flooded)	167.6	67.8
Tavares fine sand	44.6	18.1
Tequesta muck	?	?
Tidal swamp (Bessie muck)	225.5	91.3
Turnbull muck	570.4	230.8
Turnbull variant sand	86.5	35.0
Tuscawilla fine sand	413.1	167.2
Urban land	1771.1	716.7
Wabasso fine sand	3704.2	1499.0
Winder sand loam	6.7	2.7

Note: Names in parentheses differ in the coverage from those in the original maps.

Table A-2. Soil Classes with the Series and Land Types in Each[1].

Soil Class and Series	Soil Subgroup
Coastal	
Canaveral	Aquic Udipsamment
Palm Beach	Typic Udipsamment
Welaka	Spodic Quartzipsamment
Acid Scrub	
Astatula	Typic Quartzipsamment
Cassia	Typic Haplohumod
Daytona	Entic Haplohumod
Orsino	Spodic Quartzipsamment
Paola	Spodic Quartzipsamment
Pomello	Arenic Haplohumod
St. Lucie	Typic Quartzipsamment
Satellite	Aquic Quartzipsamment
Tavares	Typic Quartzipsamment
Coquina Scrub	
Bulow	Typic Hapludalf
Cocoa	Psammentic Hapludalf
Flatwoods	
Holopaw	Grossarenic Ochraqualf
Immokalee	Arenic Haplaquod
Myakka	Aeric Haplaquod
Myakka variant	Aeric Haplaquod
Pompano	Typic Psammaquent
Smyrna	Aeric Haplaquod
St. Johns	Typic Haplaquod
Wabasso	Alfic Haplaquod
Winder	Typic Glossaqualf
Hammocks	
Bradenton, shallow variant	Typic Orchaqualf
Copeland	Typic Argiaquoll
Parkwood	Mollic Orchaqualf
Tuscawilla	Typic Orchaqualf

[1] Schmalzer et al. (2001)

Table A-2. (cont.).

Soil Class and Series	Soil Subgroup
Freshwater Wetlands	
Anclote	Typic Haplaquoll
Basinger	Spodic Psammaquent
Canova	Typic Glossaqualf
Chobee	Typic Argiaquoll
Felda & Winder	Arenic Orchaqualf/Typic Glossaqualf
Felda & Winder, ponded	Arenic Orchaqualf /Typic Glossaqualf
Floridana	Arenic Argiaquoll
Immokalee, depressional	Arenic Haplaquod
Myakka, ponded	Aeric Haplaquod
Pineda	Arenic Orchaqualf
Riviera	Arenic Glossaqualf
Samsula muck	Terric Medisaprists
St. Johns, ponded	Typic Haplaquod
Swamp	N/A
Tequesta muck	Arenic Glossaqualf
Valkaria	Spodic Psammaquent
Saltwater Wetlands	
Submerged Marsh	N/A
Tidal Marsh	Hydraquents
Tidal Swamp	Hydraquents
Hydraquents	Hydraquents
Citrus Scrub	Acid Scrub and Coquina Scrub types
Citrus Hammock	Hammock types
Disturbed	
Canaveral-urban land	Entisol
Galveston-urban land	Entisol
Urban land	Entisol
Quartzipsamments	Entisol
Arents	Entisol
Spoil Banks	Entisol
Dikes	Entisol
Made land	Entisol
Turnbull variant	Aquic Udipsamment

[1] Schmalzer et al. (2001)

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Appendix B

Fish Fauna of the KSC Area

APPENDIX B

FISH FAUNA OF THE KSC AREA [1]

I. Salinity Regime:

- (M) – Mesohaline > 15 ppt
- (0) – Oligohaline 1-14 ppt
- (F) – Fresh < 1 ppt

II. Habitat Types:

- Open Lagoon (OL) – Depths > 0.5 M
- Lagoon Fringe (FL) – Depths < 0.5M around shores and spoil islands
- Marsh (MR) – Marshes, creeks and bays with shallow water, silt substrates, fringe-mangroves or marsh grasses
- Ditches (D) – Man-made ditches and canals
- Impoundments (I) – Mosquito control impoundments
- Ponds (P) – Man-made borrow ponds, flooded swales

III. Relative Abundance:

- R - Rare: 5 or fewer specimens
- O -Occasional: Collected or observed at irregular intervals
- F - Frequent: Observed or collected on numerous occasions or recorded in large percentage of collections from the appropriate habitat
- C -Common: Present in virtually every collection from the appropriate habitat
- A - Abundant: Common species present in large numbers

[1] Adapted from: Snelson, F. F., Jr. 1983. Ichthyfauna of the Northern Part of the Indian River Lagoon System, Florida. Florida Scientist. 46 : 187-206

Table B-1. Fishes of KSC Waters.

Habitat						
	OL	FL	M	D	I	P
Carcharhinidae – Requium Sharks						
1. Bull Shark (M) *Carcharhinus leucas*	F					
2. Blacktip Shark (M) *Carcharhinus limbatus*	0					
3. Sandbar Shark (M) *Carcharhinus plumbeus*	R					
4. Lemon Shark (M) *Negaprion brevirostris*	0					
Sphyrnidae – Hammerhead Sharks						
5. Scalloped Hammerhead (M) *Sphyrna lewini*	0					

Table B-1. Fishes of KSC Waters (cont.).

Habitat						
	OL	FL	M	D	I	P
Pristidae – Sawfishes						
6. Smalltooth Sawfish (M) *Pristis pectinata*	R					
Dasyatidae – Stingrays						
7. Southern Stingray (M) *Dasyatis americana*	0					
8. Atlantic Stingray (M) *Dasyatis sabina*	C					
9. Bluntnose Stingray (M) *Dasyatis sayi*	C					
10. Smooth Butterfly Ray (M) *Gymnura micrura*	0					
Myliobatidae – Eagle Rays						
11. Spotted Eagle Ray (M) *Aetobatus narinari*	0					
12. Cownose Ray (M) *Rhinoptera bonasus*	F					
Lepisosteidae – Gars						
13. Florida Gar (F, O) *Lepisosteus platyrhincus*				F	F	F
Amiidae – Bowfins						
14. Bowfin (F) *Amia calva*					0	
Elopidae – Tarpons						
15. Ladyfish (O, M) *Elops saurus*	F	F	F	F	F	
16. Tarpon (M, O) *Megalops atlanticus*	0		0	0	0	
Albulidae – Bonefishes						
17. Bonefish (M) *Albula vulpes*	R					
Anguillidae – Freshwater Eels						
18. American Eel (M, O) *Anguilla rostrata*	0			0		
Ophichthidae – Snake Eels						
19. Speckled Worm Eel (M) *Myrophis unctatus*	F					
20. Shrimp Eel (M) Ophichthus gomesi	R					
Clupeidae – Herrings						
21. Yellowfin Menhaden (M) *Brevoortia smithi*	C					
22. Atlantic Menhaden (M) *Brevoortia tyrannus*	F					
23. Gizzard Shad (M, O) *Dorosoma cepedianum*	0		0	0		
24. Scaled Sardine (M) *Harangula jaguana*	A					
25. Atlantic Thread Herring (M) *Opisthonema oglinum*	C					
Engraulidae – Anchovies						
26. Cuban Anchovy (M) *Anchoa cubana*	0					
27. Striped Anchovy (M) *Anchoa hepsetus*	F					
28. Bay Anchovy *Anchoa mitchilli*	A	A				
29. Longnose Anchovy *Anchoa nasuta*	R					
Synodontidae – Lizardfishes						
30. Inshore Lizardfish (M) *Synodus foetens*	0					
Cyprinidae – Minnows						
31. Golden Shiner (F) *Notemigonus crysoleucas*				F	F	F
Catostomidae – Suckers						
32. Lake Chubsucker (F) *Erimyzon sucetta*				F	F	F

Table B-1. Fishes of KSC Waters (cont.).

Habitat						
	OL	FL	M	D	I	P
Ictaluridae - Bullhead Catfishes						
33. Yellow Bullhead (F) *Ictaluris natalis*				0	0	0
Ariidae – Sea Catfishes						
34. Hardhead Catfishes (M) *Arius felis*	C					
35. Gafftopsail Catfish (M) *Bagre marinus*	F					
Batrachoididae – Toadfishes						
36. Oyster Toadfish (M) O*psanus tau*	F	F				
Gobiesocidae – Clingfishes						
37. Skilletfish (M) *Gobiesox strumosus*	F					
Ophidiidae – Cusk Eels						
38. Striped Cusk Eel (M) *Ophidion marginatum*	R					
Exocoetidae – Flyingfishes						
39. Atlantic Flyingfish (M) *Cypselurus melanurus*	R					
40. Halfbeak (M) *Hyporhamphus unifasciatus*	O					
Belanidae – Needlefishes						
41. Atlantic Needlefish (O, M) *Strongylura marina*	O	O	O	O	O	
42. Redfin Needlefish (O, M) *Strongylura notata*	C	C	C	C	C	
43. Timucu (M) *Strongylura timucu*	R	R				
Cyprinodontidae Killifishes						
44. Sheepshead Minnow (O, M) *Cyprinodon variegates*	O	A	A	A		
45. Goldspotted Killifish (M, O) *Floridichtyhys carpio*	O	A	A			
46. Golden Topminnow (F) *Fundulus chrysotus*				F	F	F
47. Marsh Killifish (O, M) *Fundulus confluentus*			F	F	F	
48. Gulf Killifish (M, O) *Fundulus grandis*		C	C	C	C	
49. Mummichog *Fundulus heteroclitus*	R					
50. Seminole Killifish (F, O) *Fundulus seminolis*				O	O	O
51. Longnose Killifish (M) *Fundulus similes*			O			
52. Flagfish (F) *Jordinella floridae*				F	F	F
53. Bluefin Killifish (F) *Lucania goodie*				C	C	C
54. Rainwater Killifish (O, M) *Lucania parva*	A	A	A	A	A	
Poeciliidae – Livebearers						
55. Mosquitofish (F, O, M) *Gambusia affinis*		A	A	A	A	A
56. Least Killifish (F) *Heterandria formosa*				F	F	F
57. Sailfin Molly (M, O, F) *Poecilia latipinna*	R	A	A	A	A	R
Atherinidae – Silversides						
58. Rough Silverside (M) *Membras martinica*		O				
59. Inland Silverside (M) *Menidia beryllina*					O	O
60. Tidewater Silverside (M, O) *Menidia peninsulae*			A	A	A	A
Syngnathidae – Pipefishes						
61. Lined Seahorse (M) *Hippocampus erectus*	O	O				
62. Dwarf Seahorse (M) *Hippocampus zosterae*	F	F				

Table B-1. Fishes of KSC Waters (cont.).

Habitat						
	OL	FL	M	D	I	P
63. China Pipefish (M) *Syngnathus louisianae*	O					
64. Gulf Pipefish (M, O) *Syngnathus scovelli*	C	C	C			
Centropomidae – Snooks						
65. Snook (M, O) *Centropomus undecimalis*	F	F	F	O		
Serranidae – Sea Basses						
66. Rock Sea Bass (M) *Cetropristis philadelphica*	R					
67. Gag (M) *Mycteroperca microlepis*	O					
Centrarchidae – Sunfishes						
68. Warmouth (F) *Lepomis gulosus*				F	F	F
69. Bluegill (F) *Lepomis macrochirus*				C	C	C
70. Dollar Sunfish (F) *Lepomis marginatus*				O	O	O
71. Redear Sunfish (F) *Lepomis microlophus*				F	F	F
72. Spotted Sunfish (F) *Lepomis punctatus*				R		
73. Largemouth Bass (F, O) *Micropterus salmoides*				F	F	F
74. Black Crappie (F) *Pomoxis nigromaculatus*					R	
Pomatomidae – Bluefishes						
75. Bluefish (M) *Pomatomus saltatrix*	O					
Echeneidae – Remoras						
76. Sharksucker (M) *Echeneis naucrates*				R		
77. Whitefin Sharksucker (M) *Echeneis neucratoides*	R					
78. Blue Runner (M) *Caranx crysos*	R					
79. Crevalle Jack (M) *Caranx hippos*	C					
80. Horse-eye Jack (M) *Caranx latus*	O					
81. Atlantic Bumper (M) *Chloroscombrus chrysurus*	O					
82. Leatherjacket (M) *Oligoplites saurus*	F	F				
83. Atlantic Moonfish (M) *Selene setaphinnis*	R					
84. Lookdown (M) *Selene vomer*	O					
85. Florida Pompano (M) *Trachinotus carolinus*	O					
86. Permit (M) *Trachinotus falcatus*	O					
Lutjanidae – Snapper						
87. Gray Snapper (M) *Lutjanus griseus*	F	F				
Lobotidae – *Tripletails*						
88. Tripletail (M) *Lobotes surinamensis*	R					
Gerreidae – Mojarras						
89. Irish Pompano (M) *Diapterus auratus*	F					
90. Striped Mojarra (M) *Diapterus plumieri*	R					
91. Spotfin Mojarra (M) *Eucinostomus argenteus*	C	C				
92. Silver Jenny (M) *Eucinostomus gula*	C	C				
93. Pigfish (M) *Orthopristis chrysoptera*	F					
Sparidae – Porgies						
94. Sheepshead (M) *Archosargus probatocephalus*	C					
95. Pinfish (M) *Lagodon rhomboides*	C	C				

Table B-1. Fishes of KSC Waters (cont.).

Habitat						
	OL	FL	M	D	I	P
Sciaenidae – Drums						
96. Silver Perch (M) *Bairdiella chrysoura*	A					
97. Spotted Seatrout (M) *Cynoscion nebulosus*	C					
98. Weakfish (M) *Cyoscion regalis*	F					
99. Spot (M) *Leiostomus xanthurus*	C					
100. Southern Kingfish (M) *Menticirrhus americanus*	F					
101. Atlantic Croaker (M) *Micropogonias undulates*	F					
102. Black Drum (M) *Pogonias cromis*	F	F	F			
103. Red Drum (M) *Sciaenops ocellata*	F	F	F			
Ephippidae – Spadefish						
104. Atlantic Spadefish (M) *Chaetodipterus faber*	F					
Scaridae – Parrotfishes						
105. Emerald Parrotfish (M) *Nicholsina usta*	R					
Mugilidae – Mullets						
106. Striped Mullet (M, O) *Mugil cephalus*	C	C	C	C	C	
107. White Mullet (M) *Mugil curema*	C	C	C			
Sphyraenidae – Barracudas						
108. Great Barracuda – (M) *Sphyraena barracuda*	R					
109. Northern Sennet (M) *Sphyraena borealis*	R					
Uranoscopidae – Stargazers						
110. Southern Stargazer (M) *Astroscopus y-graecum*	R					
Blenniidae – Combooth Blennnies						
111. Florida Blenny (M) *Chasmodes saburrae*	C	C				
112. Crested Blenny (M) *Hypleurochilus geminatus*	R					
Eleotridae – Sleepers						
113. Fat Sleep (O, F) *Dormiator maculates*				O	O	
Gobiidae – Gobies						
114. Frillfin Gobyh (M) *Bathygobius soporator*		R				
115. Lyre Goby (M) *Evorthodus lyricus*		R	R			
116. Violet Goby (M) *Gobioides brousonneti*		R				
117. Darter Gobie (M) *Gobinellus boleosoma*		R				
118. Highfin Goby (M) *Gobionellus oceanicus*		O				
119. Emerald Goby (M) *Gobionellus smaragdus*		R				
120. Naked Goby (O) *Gobioides bosci*			F	F	F	
121. Code Goby (M, O) *Gobiosoma robustum*	A	A	A			
122. Clown Goby (M, O) *Microgobius gulosus*	C	C	C	C	C	
123. Green Goby (M) *Microgobius thalassinus*	O					
Trichiuridae – Cutlassfishes						
124. Atlantic Cutlassfish (M) *Trichirus lepturus*	O					
Scombridae – Mackerels						
125. Spanish Mackerel (M) *Scomberomorus maculates*	O					
Scorpaenidae – Scorpionfishes						

Table B-1. Fishes of KSC Waters (cont.).

Habitat						
	OL	FL	M	D	I	P
126. Barbfish (M) *Scorpaena brasiliensis*	R					
Triglidae – Searobins						
127. Leopard Searobin (M) *Prionotus scitulus*	O					
128. Bighead Searobin (M) *Prionotus tribulus*	F					
Bothidae – Lefteye Flounders						
129. Bay Whiff (M) *Citharichthys spilopterus*	O					
130. Fringed Flounder (M) *Etropus crossotus*	R					
131. Gulf Flounder (M) *Paralichthys albigutta*	F					
132. Southern Flounder (M) *Paralichthys lethostigma*	O					
Soleide – Soles						
133. Lined Sole (M, O) *Achirus lineatus*	C	C	C	C		
134. Hogchoker (O) *Trinectes maculates*		F	F	F	F	
Cynoglossidae – Tonguefishes						
135. Blackcheek Tonguefish (M) *Symphurus plagiusa*	O					
Balisstidae – Leatherjackets						
136. Orange Filefish (M) *Aluterus schoepfi*	R					
137. Planehead Filefish (M) *Monacanthus hispidus*	C					
Tetraodontidae – Puffers						
138. Southern Puffer (M) *Sphoeroides nephelus*	C	C				
139. Bandtail Puffer (M) *Sphoeroides spengleri*	R					
140. Checkered Puffer (M) *Sphoeroides testudineus*	R					
Diodontidae – Porcupinefishes						
141. Striped Burrfish (M) *Chilomycterus schoepfi*	C	C				

Appendix C

Protected Species Descriptions

APPENDIX C

PROTECTED SPECIES DESCRIPTIONS

The Florida gopher frog (*Rana capito aesopus*) is a medium-sized, chunky frog with short legs, a large head and mouth, and prominent eyes. These frogs are typically creamy white to brownish with irregular dark markings. This species is found in dry upland habitats, where it is highly dependent on the burrows of another protected species, the gopher tortoise, for refuge. During the breeding season these frogs will migrate long distances to seasonally flooded wetlands to breed. The call of breeding males, heard mostly in the winter months in Florida, is a distinctive sound resembling a deep snore. This frog's diet consists primarily of insects, but it is also known to prey upon toads. The xeric habitat required by the Florida gopher frog and the gopher tortoise has been declining due to development. The Florida gopher frog is protected in the state of Florida as a Species of Special Concern.

The American alligator (*Alligator mississippiensis*) is a large crocodilian with a broadly rounded snout. Adult males commonly reach lengths of 3 m (10 ft) or more, while adult females rarely exceed 3 m (10 ft). Individuals over 1.2 m (4 ft) long are mostly black, while younger alligators are black with yellow cross bands on the back, tail, and sides. The American alligator is known to occupy a wide variety of brackish and freshwater wetland habitats. It is able to tolerate human-altered habitats, often occurring in lakes and canals in urban settings. Alligators feed primarily on fish, birds, and reptiles. Females construct large mound nests near water in which they lay 20 to 50 eggs; they guard their nests throughout the 9-week incubation period. Upon hatching, the young are assisted out of the nest by their mother and will remain with her for at least one year. Until the 1960s, alligators were hunted for their hides, reducing populations drastically. In 1967 the American alligator was listed as a protected species by the federal government. Populations have since been increasing and, in some cases, restored. Current threats include destruction and pollution of wetlands, and confrontations with man. The American alligator is currently protected as a Threatened species by the federal government, not because its population is in danger, but due to its similar appearance to the federally Endangered crocodile.

The loggerhead sea turtle (*Caretta caretta*) is a medium to large turtle reaching adult carapace lengths of 70-125 cm (2.3-4.1 ft) and adult weights of 70-180 kg (155-400 lbs). Its limbs are modified as flippers for its mainly aquatic habits. It is distinguished from other Florida sea turtles by its large head, powerful jaws, and reddish-brown carapace. Loggerheads are found in temperate and subtropical waters worldwide, with major nesting beaches in eastern Australia, southeastern Africa, Oman, and the southeastern United States. This species can be found hundreds of miles out to sea, as well as in inshore areas such as bays, lagoons, estuaries, and mouths of large rivers. The diet of loggerheads consists primarily of mollusks, crustaceans, and horseshoe crabs (Ref. 1). Nesting in Florida occurs from late April to September, when females briefly leave the water to deposit an average of 110-120 eggs per nest. Most females will nest 2-6 times per season, but only nest every 2-4 years (Ref. 1). Hatching occurs about 50-75 days later, when the young typically emerge at night. The major nest predators include raccoons, feral hogs, coyotes, and ghost crabs. Beach lighting can disorient emerging hatchlings, causing the young to head toward the lights and away from the water. Lighting also causes females to avoid nesting habitat or may disorient females on the beach. Other threats include beach erosion, oceanfront development, and drowning of turtles in fishing/shrimping gear. The loggerhead sea turtle is protected as a Threatened species by the federal government.

The Atlantic green turtle (*Chelonia mydas*) is a medium to large turtle, with adult females reaching carapace lengths of 88-117 cm (35-46 in) and weights of 104-177 kg (220-389 lbs). Its limbs are modified as flippers for its mainly aquatic habits. The top of the shell is generally olive with numerous black spots in adults, and solid black in hatchlings. The green turtle is found throughout the world, but predominantly in tropical seas. Nearly all of the species' nesting in the United States occurs on the beaches of eastern Florida, where nesting females emerge briefly to lay their eggs from May to September. Females typically return to the same stretch of beach every two years, where they will deposit up to six clutches averaging 136 eggs each in one season. Hatchlings emerge from nests, immediately swim offshore, and become associated with floating vegetation until reaching one to three years of age when they will return to Florida coastal waters (Ref. 2). Historically, the green turtle was exploited commercially as food more than any other sea turtle. Current threats include mortality due to drowning in fishing/shrimping gear and the development of nesting beaches. The Atlantic green turtle is protected as an Endangered species by the federal government.

The leatherback turtle (*Dermochelys coriacea*) is the largest of all living turtles, with adults reaching carapace lengths of 1.2-2.4 m (4-8 ft) and weights of 295-590 kg (650-1300 lbs). The species can be distinguished from all other marine turtles by its smooth, scaleless dorsal surface, which is black with variable white spotting and has seven narrow, longitudinal ridges. The leatherback turtle is widely distributed throughout the world. Nesting in the United States, however, is confined almost exclusively to the east coast of Florida, where females emerge briefly to deposit up to 10 clutches of 80-85 eggs each in one season. They will typically wait 1-2 years before returning to nest again. Leatherbacks feed primarily on jellyfish either at the surface or in the water column. The leatherback turtle is protected as an Endangered species by the federal government.

The gopher tortoise (*Gopherus polyphemus*) is a large terrestrial turtle averaging 23-28 cm (9-11 in) in carapace length. It has stumpy, elephantine hind limbs and flattened, shovel-like forelimbs adapted for digging. Gopher tortoises typically inhabit areas with dry, sandy soils in which they excavate burrows averaging 4.5 m (14.8 ft) in length and 2 m (6.6 ft) in depth. These burrows provide protection from temperature extremes and predators for the tortoises, as well as a wide variety of other animals. Over 300 species of invertebrates are known to utilize tortoise burrows for refuge, including several obligate species. More than 60 vertebrate species also occupy gopher tortoise burrows, including such protected species as the eastern indigo snake, the Florida pine snake, the Florida gopher frog, and the Florida mouse. Gopher tortoises feed on a variety of foods, and serve as an important seed dispersal agent for native grasses and forbs (Ref. 3). Gopher tortoises exhibit long life spans, with an estimated life expectancy in the wild of 40-60 years. Female tortoises do not reach sexual maturity until 10-20 years of age, and one clutch of 3-12 eggs is produced annually, typically laid in the mound at the mouth of a burrow. Nests and hatchling tortoises are often depredated by raccoons, armadillos, snakes, and other predators. Although the gopher tortoise is widely distributed throughout its range, its numbers have declined and continue to decline due mostly to habitat loss and fragmentation. The gopher tortoise is protected in the state of Florida as Threatened, and is a Candidate for federal listing under the Endangered Species Act.

The eastern indigo snake (*Drymarchon couperi*) is the longest snake in North America, with a maximum recorded length of 2.63 m (8.6 ft). It is a heavy-bodied snake with smooth, shiny scales. Adults are uniformly iridescent black, with the throat often tinged with red, coral, or white. Indigo snakes occupy large home ranges including a variety of upland and lowland habitats. The indigo snake is not a constrictor, and its prey is usually swallowed alive (Ref. 4). It is known to feed on virtually any type of vertebrate, including fish, frogs, turtles, birds, small mammals, and other snakes, including venomous species. In certain portions of its range, the indigo snake spends a considerable amount of time in the burrow of gopher tortoises, allowing it to escape temperature extremes. This has led to indirect killings of indigos through gassing of tortoise burrows by rattlesnake collectors, a practice that is now illegal. The indigo has also been heavily collected for the pet trade in the past, due partially to its handsome appearance and docile demeanor. Currently, the biggest threat to eastern indigo snakes is habitat loss and habitat fragmentation, which increasingly exposes this species to road mortality and other conflicts with humans. The eastern indigo snake is protected as a Threatened species by the federal government.

The Florida pine snake (*Pituophis melanoleucus mugitus*) is a large, stocky snake reaching a maximum length of 2.3 m (7.5 ft). Its dorsal surface is typically a light sandy color saddled with dark brown to reddish blotches. It has a cone-shaped head and snout, and a muscular body that allows it to push its way through loose soil and into the burrows of rodents and reptiles (Ref. 5). The Florida pine snake is a constrictor, known to feed on ground-dwelling birds and their eggs, mice, and pocket gophers. When alarmed, the snake will swell up and hiss loudly by exhaling. These snakes typically occupy dry, upland habitats, although during drought conditions, they may seek out open habitats bordering wetlands. There have been serious declines in the numbers of Florida pine snakes throughout their range in the last 20 years due to collection for the pet trade, road mortality, and habitat loss and fragmentation (Ref. 5). The Florida pine snake is protected in the state of Florida as a Species of Special Concern.

The snowy egret (*Egretta thula*) is a small wading bird, standing 60 cm (24 in) tall with a wingspan of 1 m (40 in). It is all white with a thin black bill, black legs, and bright yellow feet. During the breeding season, adults have prominent white plumes on the head, neck, and back. The snowy egret is widely distributed in both freshwater and coastal wetlands throughout most of Florida. This species typically nests in large colonies over standing water, often with other species of water birds. The most common food sources are aquatic invertebrates, fish, and insects. The number of snowy egrets nesting in Florida was seriously reduced during the plume-hunting era at the turn of the 20th century. Although the species recovered quite rapidly once granted protection in 1910, the numbers have declined again, possibly due to the alteration and destruction of wetland habitats. The snowy egret is protected in the state of Florida as a Species of Special Concern.

The little blue heron (*Egretta caerulea*) is a small wading bird, standing 60 cm (24 in) tall with a wingspan of 1 m (40 in). Adults are slate blue with a reddish head and neck, and have a bluish bill with a black tip. The legs are dark. During the breeding season, adults have long plumes on the back and head. The plumage of juveniles is white with slate-gray wingtips. Molting one-year birds are mottled with slate blue and white. The little blue heron is distributed widely throughout Florida, breeding in freshwater, brackish, and saltwater habitats, and often nesting in large colonies with other species of birds. They seem to prefer foraging in freshwater habitats, feeding on fish, amphibians, aquatic invertebrates, and insects. Population estimates in Florida indicate a decrease in numbers over the past few decades, probably associated with the loss and alteration of Florida's wetlands. The little blue heron is protected in the state of Florida as a Species of Special Concern.

The tricolored heron (*Egretta tricolor*) is a medium-sized heron, standing 66 cm (26 in) tall with a wingspan of 1 m (40 in). It is slate-blue on the head, neck, and upper wings and body. The chest is purplish, in sharp contrast to a white belly. During the breeding season, adults have distinctive yellow-brown plumes across the lower back. The tricolored heron is closely associated with wetlands throughout Florida, but is most common in estuarine habitats. Like most wading birds, tricolored herons nest on islands or in woody vegetation over standing water, often in large groups with other species of birds. They feed primarily on small fish and, to a lesser extent, on amphibians and aquatic invertebrates. Although the tricolored heron remains a commonly seen bird in Florida, data suggest that total numbers are declining. This is likely due to the loss and alteration of Florida's wetlands. The tricolored heron is protected in the state of Florida as a Species of Special Concern.

The reddish egret (*Egretta rufescens*), Florida's least common egret, is a medium-sized wading bird standing 76 cm (30 in) tall with a wingspan of 1.2 m (4 ft). It is a dark heron with deep reddish brown on the head and neck, and slate blue on the body. During the breeding season, adults have long plumes on the back, head, and neck. The bill is pink with a black tip and the legs are slate blue. The reddish egret is almost entirely a coastal species, nesting on mangrove islands and feeding in the surrounding shallows. This species has a unique foraging behavior in which it dashes about rapidly with wings open, feeding on fish, aquatic invertebrates, and small vertebrates that is scares up with its dancing. It appears that the Florida population of this species has never recovered from the impact of plume-hunting that occurred at the turn of the 20^{th} century. Despite encouraging signs in certain parts of its range, it remains a rare bird. The reddish egret is protected in the state of Florida as a Species of Special Concern.

The white ibis (*Eudocimus albus*) is a medium-sized wading bird, standing 64 cm (25 in) tall. It is mostly white with black wingtips and a down-curved bill. During the breeding season, adults have a bright red face, bill, and legs. Immature birds are brown with white underparts. White ibises nest in large colonies in freshwater marshes, shallow lakes, and estuaries throughout the state of Florida. They may be seen in large numbers when moving between feeding and roosting areas. They feed primarily on aquatic invertebrates including crabs, crayfish, and snails, as well as on snakes and insects, but will also forage on small fish, especially when these are abundant. The Florida population of this species has experienced drastic declines and fluctuations due to destruction and disturbance of habitat. The white ibis is protected in the state of Florida as a Species of Special Concern.

The roseate spoonbill (*Ajaja ajaja*) is a long-legged wading bird, standing 81 cm (32 in) tall. Adults are bright pink with a featherless head. The species' most distinguishing characteristic is its broad, flattened bill. The spoonbill feeds by sweeping its bill through shallow water, and snapping it shut on fish, crustaceans, and insects detected by feel. Spoonbills often feed in small groups at night wherever concentrations of prey occur in shallow, coastal habitats. Tremendous numbers of spoonbills were killed for their plumage and wings during the late 1800's and early 1900's. Although their numbers have since increased in suitable habitat, much of their natural habitat has been altered and destroyed for the development of coastal areas. Breeding of the roseate spoonbill in Florida is restricted to a few areas. The roseate spoonbill is protected in the state of Florida as a Species of Special Concern.

The wood stork (*Mycteria americana*) is the only true stork native to North America. It is white except for black wing tips and a short black tail. Its head and long legs are unfeathered, and the heavy black bill is slightly down-curved. It stands at 102 cm (40 in) tall. Wood storks inhabit freshwater and brackish wetlands, primarily nesting in cypress and mangrove swamps, and feeding in freshwater marshes and seasonally flooded areas. Typical feeding sites are depressions where fish become concentrated during periods of drought. Wood storks feed by moving their open bills through shallow water. When the bill comes into contact with a fish or other prey item, an extremely rapid bill-snap reflex is triggered. The speed with which the wood stork snaps its bill shut is one of the fastest known reflexes in the animal kingdom. Wood storks have been identified as one of the most endangered wading birds in Florida due to almost routine nesting failures brought on by poor feeding conditions in the much manipulated wetlands of southern Florida (Ref. 6). As a result, the breeding range of the wood stork has moved north, and colonies are now found in Georgia and South Carolina. The wood stork is protected as an Endangered species by the federal government.

The bald eagle (*Haliaeetus leucocephalus*) is a large raptor with a total length of 79-94 cm (31-37 in) and a wingspan of nearly 2 m (6.6 ft). Adults have a white head and tail, a dark brown body and wings, and yellow eyes, bill, and feet. Juveniles are brown, often with white mottling on the tail, belly, and wings. The bald eagle is distributed throughout much of North America and northern Mexico. Bald eagle habitat is primarily riparian, typically associated with the coast or with the shores of rivers and lakes. They usually nest near bodies of water where they feed primarily on fish, as well as waterfowl and small mammals. Historically, the bald eagle suffered reproductive failures from the use of pesticides that have since been banned in the United States. Other threats include nesting habitat loss and disturbance. The bald eagle is protected under the Bald and Golden Eagle Protection Act.

The southeastern American kestrel (*Falco sparverius paulus*), a subspecies of the American kestrel, is a small falcon measuring 25 cm (10 in) in length. Both sexes have a rust-colored back and tail, two black facial stripes, and a yellow bill and feet. The male's wings are slate gray, while the female's wings are rust-colored. This subspecies is restricted to an area from South Carolina south to southern Alabama and Florida, and is nonmigratory. It feeds mainly on large insects, as well as small rodents, birds, and reptiles. The preferred habitat in Florida is essentially open pine forests and clearings, where these cavity nesters lay their eggs in dead trees. There has been a significant decline in the numbers of southeastern kestrels in Florida. Although the cause of this decline is undetermined, destruction of nesting habitat is a likely cause (Ref. 6). The southeastern American kestrel is protected in the state of Florida as a Threatened species.

The limpkin (*Aramus guarauma*) is a large bird measuring around 67 cm (26 inches) in length. It is light brown with white streaks above and has a long, slightly down-curved bill, and dull grayish-green unwebbed feet. Limpkins inhabit freshwater marshes and the edges of lakes and rivers. They also use banks of man-made canals and irrigation ditches for foraging. The limpkin feeds extensively on apple snails and other freshwater mussels, usually by probing in the mud with its long bill, or occasionally wading or swimming. It will also feed on small vertebrates and other species of freshwater invertebrates. Limpkins have a unique loud “kur-r-eeow” call which is given at all times of the day. The limpkin is designated as a Species of Special Concern in Florida.

The piping plover (*Charadrius melodus*) is a small sand-colored shorebird that nests and feeds along sand and gravel beaches. The adult has yellow-orange legs, a black band across the forehead from eye to eye, and a black ring around the neck. This ring is usually thicker in males during the breeding season, and is the only reliable way to tell the sexes apart. These shorebirds forage for food along the edge of beaches and large lakes, usually by sight, moving in short bursts. They eat mainly insects, marine worms, and crustaceans. Piping plovers occur in Florida only during the winter. They are federally protected as a Threatened species.

The rufa red knot (*Calidris canutus rufa*) is an occasional visitor to the KSC shoreline, mostly during migration seasons. They have not been documented nesting in Florida. The body shape and size is typical for the sandpipers, with a small head and eyes, a short neck, a slightly tapering bill that is no longer than its head, and short dark legs. The winter plumage that is observed in Florida is uniformly pale grey, and is similar between the sexes, in much contrast to the bright breeding colors. The rufa red knot became federally listed as Threatened in 2014.

The least tern (*Sterna antillarum*) is a small tern measuring 23 cm (9 in) in length, with a 50 cm (20 in) wingspan. It is a mostly white bird with a black crown and nape, and black wingtips. The bill is yellow with a black tip, and the legs and feet are yellow to orange. The top of the wings and back are light gray. Least terns feed by plunge diving and dipping for small fish and aquatic invertebrates. The natural nesting habitat of this species is open, flat beach with coarse sand or shell. The development of Florida’s beaches for human recreation and housing has caused destruction and alteration of the natural least tern nesting habitat. As a result, least terns will also use spoil islands, various rooftops, runways, and other gravel-covered surfaces for nesting, although changing construction practices are making rooftop nesting less common. The reproductive success of terns nesting in these artificial situations is not as high as for birds nesting on undisturbed beaches. Other threats include accidental destruction of nests by boaters and fishermen who frequent spoil islands during the breeding season, and the destruction of nests on the ground by predators, including house cats, dogs, and feral pigs. The least tern is protected in the state of Florida as a Threatened species.

The roseate tern (*Sterna dougallii*) is a federally protected Threatened species. It is similar in appearance and size to several other tern species. Its thin sharp bill is black, with a red base which develops through the breeding season. It is shorter-winged and has faster wing beats than other terns. The upper wings are pale grey and the under parts are white; this tern looks very pale in flight. The adults have very long, flexible tail streamers and orange-red legs. In summer, the underparts of adults take on the pinkish tinge which gives this bird its name. Roseate terns do not nest in Florida and are present only during the winter or when they pass through during migration seasons.

The black skimmer (*Rynchops niger*) is a tern-like bird measuring 46 cm (18 in) in length. It has black upperparts, a white forehead and underparts, red feet, and a bright red, black-tipped bill. The black skimmer is unique among birds in having the lower half of the bill longer than the upper half. Skimmers feed by cutting the water's surface with the lower bill and snatching up their fish or shrimp prey with a quick, downward snap. Their preferred habitat is coastal beaches and salt marshes where they usually nest in small colonies, often with other species of shorebirds. Development of Florida's coastline has decreased the quantity and quality of nesting sites for this unique bird. As a result, black skimmers are becoming more common nesters on artificial spoil islands, rooftops, runways, and other gravel-covered surfaces where their reproductive success is lower than on natural beach habitat. Changing construction practices are making rooftop nesting less common. Black skimmer nests are also susceptible to ground predators such as house cats, dogs, and feral pigs. The black skimmer is protected in the state of Florida as a Species of Special Concern.

The Florida scrub-jay (*Aphelocoma coerulescens*) is the only species of bird unique to Florida. Florida scrub-jays mate for life and live in family groups where young stay with their parents for one to several years, helping raise new offspring, defend territory boundaries, and ward off predators. Florida scrub-jays are 25 to 30 cm (12 in) long and are similar in size and shape to the more common and widespread blue jay (*Cyanocitta cristata*). Males and females look alike and are crestless, with a necklace of blue feathers separating a white throat from grayer underparts. There is a white line over the eye blending into a whitish forehead. Juveniles have dull or dark brown upperparts. Insects comprise the majority of the animal diet throughout most of the year, but acorns are also an important plant food in fall and winter, and surplus acorns are frequently cached in the ground. The Florida scrub-jay lives in scrub and scrubby flatwoods; these unique habitats occur on well drained soils of relict sand dunes . Their optimal habitat is dominated by evergreen oaks less than two meters in height with sparse ground cover dominated by saw palmetto (*Serenoa repens*) , and bare sand patches which are essential for foraging and acorn-caching. Slash pines (*Pinus elliottii*) and sand pines (*P. clausa*) are widely scattered with less than 15 percent cover. Florida scrub-jays are listed as Threatened under the Endangered Species Act. Florida scrub-jays are threatened with extinction because of habitat destruction, fragmentation, and habitat degradation (Ref. 8). Lack of natural fire has caused their optimal habitat conditions to become increasingly rare across the state, thereby triggering greatly reduced population sizes. (Ref. 9 and 10). Optimal habitat conditions can sometimes be recreated via active habitat management primarily focused on controlled burning.

The Florida mouse (*Podomys floridanus*) is brownish to brownish-gray on the back and upper sides, with bright orange-buff on the shoulders and lower sides and a white abdomen. It has large eyes, ears, and hind feet. Adults measure 179 - 197 mm (7 - 8 in) in total length, with a tail of 70-90 mm (3-3.5 in), and weighs 25 - 49 g (0.9 – 1.7 oz). The Florida mouse has one of the smallest geographical ranges of any North American mammal, and is the only genus of mammal endemic to the state of Florida (Ref. 12). The species requires a very specific habitat type of deep, sandy soils that support fire-maintained, upland vegetation. It is thought to be an exclusively burrow-dwelling species, often excavating its burrows and nest chambers off the main burrow of a gopher tortoise. The biggest threat to populations of the Florida mouse is the destruction and fragmentation of its restricted habitat for residential development and agriculture. The Florida mouse is protected in the state of Florida as a Species of Special Concern.

The southeastern beach mouse (*Peromyscus polionotus niveiventris*) is a light, buffy-colored coastal subspecies of the oldfield mouse. It has a strikingly white venter and a bicolored tail. It is the largest of the beach mice, averaging 139 mm (5 in) in total length and 52 mm (2 in) in tail length. Its principal habitat is the sea oat zone of primary coastal dunes, although it may also occupy adjoining scrub habitats. They have also been documented occurring in scrub habitats several miles from the nearest coastal dune habitat. Major threats to existing populations include habitat loss and fragmentation, invasion of non-native animals (especially house cats), and beach erosion (Ref. 13). The southeastern beach mouse is protected as a Threatened species by the federal government.

The Florida manatee (*Trichechus manatus latirostris*), a subspecies of the West Indian manatee, is a massive, fusiform, thick-skinned, nearly hairless aquatic mammal. Florida manatees are gray to gray-brown with a horizontally flattened tail. They possess paddle-like forelimbs and lack hind limbs. Adults range in length from 2.8 - 3.5 m (9 - 11.5 ft), and weigh from 400-900 kg (882 – 1,984jlbs). Newborn calves are 1.0 - 1.5 m (3.3 - 5 ft) in length and weigh 20-30 kg (44 – 66 lbs). The maximum weight recorded for a Florida manatee is 1,620 kg (3,571 lbs) for a 3.75 m (12 ft) long female. The diet is strictly herbivorous but highly diverse, ranging from algae and sea grass to terrestrial plants (Ref. 14). Florida manatees inhabit sluggish rivers, shallow estuaries, and saltwater bays. The only year-round population of Florida manatees in the U.S. occurs in the state of Florida, where they often congregate in the warm waters of many natural springs during the winter months. Manatee habitat in Florida has been and continues to be greatly altered by residential and commercial development of coastal land (Ref. 15). Additional threats include water pollution, the obstruction of migration routes by dams, dredging of food resources, and direct mortality by the propellers of powerboats. The Florida manatee is protected as an Endangered species by the federal government.

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Appendix D

Flora of Kennedy Space Center

Table D-1. Vascular flora of the Kennedy Space Center area including adjoining federal properties.

CLASS	FAMILY	GENUS	SPECIES	VARIETY	AUTHORITY	INTRODUCED	ENDEMIC	KSCHERB
p	Aspleniaceae	Asplenium	platyneuron		(L.) Britton et al.	No	0	Yes
p	Azollaceae	Azolla	filiculoides		Lam.	No	0	Yes
p	Blechnaceae	Blechnum	serrulatum		Rich.	No	0	Yes
p	Blechnaceae	Woodwardia	areolata		(L.) T. Moore	No	0	Yes
p	Blechnaceae	Woodwardia	virginica		(L.) Sm.	No	0	Yes
p	Dennstaedtiaceae	Pteridium	aquilinum (L.) Kuhn	var. pseudocaudatum	(Clute) Clute ex A. Heller	No	0	Yes
p	Dryopteridaceae	Dryopteris	ludoviciana		(Kunze) Small	No	0	Yes
p	Lycopodiaceae	Lycopodiella	alopecuroides		(L.) Cranfill	No	0	No
p	Lycopodiaceae	Lycopodiella	appressa		(Chapm.) Cranfill	No	0	No
p	Lycopodiaceae	Lycopodiella	caroliniana		(L.) Pic. Serm.	No	0	No
p	Nephrolepidaceae	Nephrolepis	biserrata		(Sw.) Schott	No	0	No
p	Nephrolepidaceae	Nephrolepis	cordifolia		(L.) C. Presl	Yes	0	Yes
p	Nephrolepidaceae	Nephrolepis	exaltata		(L.) Schott	No	0	Yes
p	Ophioglossaceae	Ophioglossum	palmatum		L.	No	0	Yes
p	Ophioglossaceae	Ophioglossum	petiolatum		Hook.	No	0	Yes
p	Osmundaceae	Osmunda	cinnamomea		L.	No	0	Yes
p	Osmundaceae	Osmunda	regalis L.	var. spectabilis	(Willd.) A. Gray	No	0	Yes
p	Polypodiaceae	Campyloneurum	phyllitidis		(L.) C. Presl	No	0	Yes
p	Polypodiaceae	Pecluma	plumula		(Humb. & Bonpl. ex Willd.) M. G. Price	No	0	No
p	Polypodiaceae	Phlebodium	aureum		(L.) J. Sm.	No	0	Yes
p	Polypodiaceae	Pleopeltis	polypodioides (L.) E. G. Andrews & Windham	var. michauxiana	(Weatherby) E. G. Andrews & Windham	No	0	Yes
p	Psilotaceae	Psilotum	nudum		(L.) P. Beauv.	No	0	Yes
p	Pteridaceae	Acrostichum	danaeifolium		Langsd. & Fisch.	No	0	Yes
p	Pteridaceae	Ceratopteris	thalictroides		(L.) Brongn.	Yes	0	Yes
p	Salviniaceae	Salvinia	minima		Baker	Yes	0	Yes
p	Schizaeaceae	Lygodium	microphyllum		(Cav.) R. Br.	Yes	0	No

p	Selaginellaceae	Selaginella	arenicola		Underw.	No	0	Yes
p	Thelypteridaceae	Macrothelypteris	torresiana		(Gaudich.) Ching	Yes	0	Yes
p	Thelypteridaceae	Thelypteris	dentata		(Forssk.) E. P. St. John	Yes	0	Yes
p	Thelypteridaceae	Thelypteris	hispidula (Decne.) C. F. Reed	var. versicolor	(R. P. St. John) Lellinger	No	0	No
p	Thelypteridaceae	Thelypteris	interrupta		(Willd.) K. Iwats.	No	0	No
p	Thelypteridaceae	Thelypteris	kunthii		(Desv.) C. V. Morton	No	0	Yes
p	Thelypteridaceae	Thelypteris	ovata		R. P. St. John	No	0	Yes
p	Thelypteridaceae	Thelypteris	palustris Schott	var. pubescens	(G. Lawson) Fernald	No	0	Yes
p	Vittariaceae	Vittaria	lineata		(L.) J. Sm.	No	0	Yes
g	Cupressaceae	Juniperus	virginiana		L.	No	0	Yes
g	Cupressaceae	Taxodium	ascendens		Brongn.	No	0	No
g	Cycadaceae	Cycas	revoluta		Thunb.	Yes	0	No
g	Pinaceae	Pinus	clausa		(Chapm. ex Engelm.) Vasey ex Sarg.	No	2	Yes
g	Pinaceae	Pinus	elliottii Engelm.	var. densa	Little and Dorman	No	1	Yes
g	Pinaceae	Pinus	palustris		Mill.	No	0	No
g	Pinaceae	Pinus	serotina		Michx.	No	0	Yes
g	Podocarpaceae	Podocarpus	macrophyllus		(Thunb.) D. Don	Yes	0	No
g	Podocarpaceae	Podocarpus	nagi		Makino	Yes	0	No
g	Zamiaceae	Zamia	pumila		L.	No	0	No
a	Acanthaceae	Asystasia	gangetica		(L.) T. Anderson	Yes	0	No
a	Acanthaceae	Dicliptera	sexangularis		(L.) Juss.	No	0	Yes
a	Acanthaceae	Justicia	brandegeeana		Wassh. & L. B. Sm.	Yes	0	No
a	Acanthaceae	Odontonema	cuspidatum		(Nees) Kuntze	Yes	0	No
a	Acanthaceae	Ruellia	caroliniensis		(J. F. Gmel.) Steud.	No	0	Yes
a	Acanthaceae	Ruellia	simplex		C. Wright	Yes	0	No
a	Acanthaceae	Thunbergia	alata		Bojer ex Sims	Yes	0	Yes

a	Acanthaceae	Thunbergia	fragrans		Roxb.	Yes	0	No
a	Adoxaceae	Sambucus	nigra L.	subsp. canadensis	(L.) R. Bolli	No	0	Yes
a	Adoxaceae	Viburnum	obovatum		Walter	No	0	Yes
a	Agavaceae	Agave	decipiens		Baker	No	1	Yes
a	Agavaceae	Agave	sisalana		Perrine	Yes	0	No
a	Agavaceae	Yucca	aloifolia		L.	No	0	Yes
a	Agavaceae	Yucca	filamentosa		L.	No	0	Yes
a	Aizoaceae	Sesuvium	maritimum		(Walter) Britton et al.	No	0	Yes
a	Aizoaceae	Sesuvium	portulacastrum		(L.) L.	No	0	Yes
a	Aizoaceae	Trianthema	portulacastrum		L.	No	0	No
a	Alismataceae	Sagittaria	filiformis		J. G. Sm.	No	0	Yes
a	Alismataceae	Sagittaria	lancifolia		L.	No	0	Yes
a	Alismataceae	Sagittaria	subulata		(L.) Buchenau	No	0	Yes
a	Alliaceae	Allium	cuthbertii		Small	No	0	No
a	Altingiaceae	Liquidambar	styraciflua		L.	No	0	Yes
a	Amaranthaceae	Alternanthera	flavescens		Kunth	No	0	No
a	Amaranthaceae	Alternanthera	philoxeroides		(Mart.) Griseb.	Yes	0	Yes
a	Amaranthaceae	Amaranthus	australis		(A. Gray) J. D. Sauer	No	0	Yes
a	Amaranthaceae	Amaranthus	cannabinus		(L.) J. D. Sauer	No	0	No
a	Amaranthaceae	Amaranthus	hybridus		L.	Yes	0	No
a	Amaranthaceae	Amaranthus	spinosus		L.	Yes	0	No
a	Amaranthaceae	Atriplex	pentandra		(Jacq.) Standl.	No	0	Yes
a	Amaranthaceae	Blutaparon	vermiculare		(L.) Mears	No	0	Yes
a	Amaranthaceae	Chenopodium	album		L.	Yes	0	No
a	Amaranthaceae	Chenopodium	ambrosioides		L.	Yes	0	Yes
a	Amaranthaceae	Chenopodium	berlandieri		Moq.	No	0	Yes
a	Amaranthaceae	Froelichia	floridana		(Nutt.) Moq.	No	0	Yes
a	Amaranthaceae	Gomphrena	serrata		L.	Yes	0	Yes
a	Amaranthaceae	Iresine	diffusa		Humb. & Bonpl. ex Willd.	No	0	Yes
a	Amaranthaceae	Salicornia	bigelovii		Torr.	No	0	Yes

a	Amaranthaceae	Salsola	kali L.	subsp. pontica	(Pall.) Mosyakin	Yes	0	Yes
a	Amaranthaceae	Sarcocornia	ambigua		(Michx.) M. A. Alonso & M. B. Crespo	No	0	Yes
a	Amaranthaceae	Suaeda	linearis		(Elliott) Moq.	No	0	Yes
a	Amaryllidaceae	Crinum	americanum		L.	No	0	No
a	Amaryllidaceae	Crinum	zeylanicum		(L.) L.	Yes	0	Yes
a	Amaryllidaceae	Hymenocallis	crassifolia		Herb.	No	0	No
a	Amaryllidaceae	Hymenocallis	latifolia		(Mill.) M. Roem.	No	0	Yes
a	Amaryllidaceae	Hymenocallis	palmeri		S. Watson	No	1	Yes
a	Anacardiaceae	Mangifera	indica		L.	Yes	0	Yes
a	Anacardiaceae	Rhus	copallinum		L.	No	0	Yes
a	Anacardiaceae	Schinus	terebinthifolia		Raddi	Yes	0	Yes
a	Anacardiaceae	Toxicodendron	radicans		(L.) Kuntze	No	0	Yes
a	Annonaceae	Annona	glabra		L.	No	0	No
a	Annonaceae	Asimina	obovata		(Willd.) Nash	No	2	Yes
a	Annonaceae	Asimina	parviflora		(Michx.) Dunal	No	0	Yes
a	Annonaceae	Asimina	pygmea		(W. Bartram) Dunal	No	0	Yes
a	Annonaceae	Asimina	reticulata		Shuttlew. ex Chapm.	No	2	Yes
a	Apiaceae	Cicuta	maculata		L.	No	0	Yes
a	Apiaceae	Cyclospermum	leptophyllum		(Pers.) Sprague ex Britton & P. Wilson	Yes	0	Yes
a	Apiaceae	Eryngium	aromaticum		Baldwin	No	0	Yes
a	Apiaceae	Eryngium	baldwinii		Spreng.	No	0	Yes
a	Apiaceae	Eryngium	yuccifolium		Michx.	No	0	Yes
a	Apiaceae	Oxypolis	filiformis		(Walter) Britton	No	0	Yes
a	Apiaceae	Ptilimnium	capillaceum		(Michx.) Raf.	No	0	Yes
a	Apiaceae	Sanicula	canadensis		L.	No	0	No
a	Apiaceae	Spermolepis	divaricata		(Walter) Raf.	No	0	No
a	Apiaceae	Spermolepis	echinata		(Nutt. ex DC.) A. Heller	No	0	Yes

a	Apocynaceae	Allamanda	cathartica		L.	Yes	0	Yes
a	Apocynaceae	Apocynum	cannabinum		L.	No	0	No
a	Apocynaceae	Asclepias	curtissii		A. Gray	No	1	Yes
a	Apocynaceae	Asclepias	incarnata		L.	No	0	No
a	Apocynaceae	Asclepias	lanceolata		Walter	No	0	Yes
a	Apocynaceae	Asclepias	pedicellata		Walter	No	0	Yes
a	Apocynaceae	Asclepias	tomentosa		Elliott	No	0	Yes
a	Apocynaceae	Asclepias	tuberosa		L.	No	0	Yes
a	Apocynaceae	Carissa	macrocarpa		(Eckl.) A. DC.	Yes	0	Yes
a	Apocynaceae	Catharanthus	roseus		(L.) G. Don	Yes	0	Yes
a	Apocynaceae	Cynanchum	angustifolium		Pers.	No	0	Yes
a	Apocynaceae	Cynanchum	scoparium		Nutt.	No	0	Yes
a	Apocynaceae	Echites	umbellatus		Jacq.	No	0	No
a	Apocynaceae	Gonolobus	suberosus		(L.) R. Br.	No	0	Yes
a	Apocynaceae	Morrenia	odorata		(Hook. & Arn.) Lindl.	Yes	0	No
a	Apocynaceae	Nerium	oleander		L.	Yes	0	No
a	Apocynaceae	Sarcostemma	clausum		(Jacq.) Roem. & Schult.	No	0	Yes
a	Apocynaceae	Tabernaemontana	divaricata		(L.) R. Br. ex Roem. & Schult.	Yes	0	No
a	Apocynaceae	Thevetia	peruviana		(Pers.) K. Schum.	Yes	0	No
a	Apocynaceae	Vinca	minor		L.	Yes	0	No
a	Aquifoliaceae	Ilex	ambigua		(Michx.) Torr.	No	0	Yes
a	Aquifoliaceae	Ilex	cassine		L.	No	0	Yes
a	Aquifoliaceae	Ilex	glabra		(L.) A. Gray	No	0	Yes
a	Aquifoliaceae	Ilex	vomitoria		Aiton	No	0	Yes
a	Araceae	Arisaema	dracontium		(L.) Schott	No	0	No
a	Araceae	Arisaema	triphyllum		(L.) Schott	No	0	Yes
a	Araceae	Colocasia	esculenta		(L.) Schott	Yes	0	No
a	Araceae	Landoltia	punctata		(G. Mey.) Les & D.J. Crawford	Yes	0	Yes
a	Araceae	Lemna	aequinoctialis		Welw.	No	0	No

a	Araceae	Lemna	obscura		(Austin) Daubs	No	0	Yes
a	Araceae	Peltandra	virginica		(L.) Schott	No	0	No
a	Araceae	Pistia	stratiotes		L.	Yes	0	No
a	Araceae	Spirodela	polyrhiza		(L.) Schleid.	No	0	No
a	Araceae	Syngonium	podophyllum		Schott	Yes	0	No
a	Araceae	Wolffiella	gladiata		(Hegelm.) Hegelm.	No	0	No
a	Araliaceae	Centella	asiatica		(L.) Urb.	No	0	Yes
a	Araliaceae	Hydrocotyle	bonariensis		Comm. ex Lam.	No	0	Yes
a	Araliaceae	Hydrocotyle	umbellata		L.	No	0	Yes
a	Araliaceae	Hydrocotyle	verticillata	var. verticillata	Thunb.	No	0	Yes
a	Araliaceae	Hydrocotyle	verticillata Thunb.	var. triradiata	(A. Rich.) Fernald	No	0	Yes
a	Araliaceae	Tetrapanax	papyriferus		(Hook.) K. Koch	Yes	0	No
a	Arecaceae	Cocos	nucifera		L.	Yes	0	No
a	Arecaceae	Phoenix	canariensis		Chabaud	Yes	0	No
a	Arecaceae	Phoenix	dactylifera		L.	Yes	0	No
a	Arecaceae	Phoenix	reclinata		Jacq.	Yes	0	No
a	Arecaceae	Phoenix	sylvestris		Roxb.	Yes	0	No
a	Arecaceae	Sabal	palmetto		(Walter) Lodd. ex Schult. & Schult. f.	No	0	Yes
a	Arecaceae	Serenoa	repens		(W. Bartram) Small	No	0	Yes
a	Arecaceae	Syagrus	romanzoffiana		(Chapm.) Glassman	Yes	0	No
a	Arecaceae	Washingtonia	robusta		H. Wendl.	Yes	0	No
a	Aristolochiaceae	Aristolochia	littoralis		Parodi	Yes	0	Yes
a	Asparagaceae	Asparagus	aethiopicus		L.	Yes	0	Yes
a	Asparagaceae	Asparagus	setaceus		(Kunth) Jessop	Yes	0	No
a	Asteraceae	Acmella	oppositifolia (Lam.) R. K. Jansen	var. repens	(Walter) R. K. Jansen	No	0	Yes
a	Asteraceae	Ageratina	jucunda		(Greene) Clewell & Wooten	No	0	Yes
a	Asteraceae	Ambrosia	artemisiifolia		L.	No	0	Yes

a	Asteraceae	Ambrosia	hispida		Pursh	No	0	No
a	Asteraceae	Arnoglossum	floridanum		(A. Gray) H. Rob.	No	1	Yes
a	Asteraceae	Arnoglossum	ovatum		(Walter) H. Rob.	No	0	No
a	Asteraceae	Baccharis	angustifolia		Michx.	No	0	Yes
a	Asteraceae	Baccharis	glomeruliflora		Pers.	No	0	Yes
a	Asteraceae	Baccharis	halimifolia		L.	No	0	Yes
a	Asteraceae	Balduina	angustifolia		(Pursh) B. L. Rob.	No	0	Yes
a	Asteraceae	Berlandiera	subacaulis		(Nutt.) Nutt.	No	1	Yes
a	Asteraceae	Bidens	alba		(L.) DC.	No	0	Yes
a	Asteraceae	Bidens	bipinnata		L.	No	0	No
a	Asteraceae	Borrichia	frutescens		(L.) DC.	No	0	Yes
a	Asteraceae	Brickellia	eupatorioides		(L.) Shinners	No	0	Yes
a	Asteraceae	Calyptocarpus	vialis		Less.	Yes	0	Yes
a	Asteraceae	Carphephorus	corymbosus		(Nutt.) Torr. & A. Gray	No	0	Yes
a	Asteraceae	Carphephorus	odoratissimus	var. odoratissimus	(J. F. Gmel.) H. Hebert	No	0	Yes
a	Asteraceae	Carphephorus	odoratissimus (J. F. Gmel.) H. Hebert	var. subtropicanus	(DeLaney et al.) Wunderlin & B. F. Hansen	No	1	Yes
a	Asteraceae	Carphephorus	paniculatus		(J. F. Gmel.) H. Hebert	No	0	No
a	Asteraceae	Chrysopsis	gossypina		(Michx.) Elliott	No	0	No
a	Asteraceae	Chrysopsis	linearifolia Semple	subsp. dressii	Semple	No	1	Yes
a	Asteraceae	Chrysopsis	mariana		(L.) Elliott	No	0	Yes
a	Asteraceae	Chrysopsis	scabrella		Torr & A. Gray	No	0	Yes
a	Asteraceae	Chrysopsis	subulata		Small	No	1	Yes
a	Asteraceae	Cirsium	horridulum		Michx.	No	0	Yes
a	Asteraceae	Cirsium	nuttallii		DC.	No	0	No
a	Asteraceae	Conoclinium	coelestinum		(L.) DC.	No	0	Yes
a	Asteraceae	Conyza	canadensis		(L.) Cronquist	No	0	Yes
a	Asteraceae	Coreopsis	floridana		E. B. Sm.	No	1	Yes

a	Asteraceae	Coreopsis	gladiata		Walter	No	0	No
a	Asteraceae	Coreopsis	leavenworthii		Torr. & A. Gray	No	1	Yes
a	Asteraceae	Eclipta	prostrata		(L.) L.	No	0	Yes
a	Asteraceae	Elephantopus	elatus		Bertol.	No	0	Yes
a	Asteraceae	Emilia	fosbergii		Nicolson	Yes	0	Yes
a	Asteraceae	Erechtites	hieraciifolius		(L.) Raf. ex DC.	No	0	Yes
a	Asteraceae	Erigeron	quercifolius		Poir.	No	0	Yes
a	Asteraceae	Erigeron	strigosus		Muhl. ex Willd.	No	0	No
a	Asteraceae	Erigeron	vernus		(L.) Torr. & A. Gray	No	0	Yes
a	Asteraceae	Eupatorium	capillifolium		(Lam.) Small ex Porter & Britton	No	0	Yes
a	Asteraceae	Eupatorium	compositifolium		Walter	No	0	Yes
a	Asteraceae	Eupatorium	leptophyllum		DC.	No	0	No
a	Asteraceae	Eupatorium	leucolepis		(DC.) Torr. & A. Gray	No	0	Yes
a	Asteraceae	Eupatorium	mikanioides		Chapm.	No	1	Yes
a	Asteraceae	Eupatorium	mohrii		Greene	No	0	Yes
a	Asteraceae	Eupatorium	rotundifolium		L.	No	0	Yes
a	Asteraceae	Eupatorium	serotinum		Michx.	No	0	Yes
a	Asteraceae	Euthamia	caroliniana		(L.) Greene ex Porter & Britton	No	0	Yes
a	Asteraceae	Euthamia	graminifolia		(L.) Nutt.	No	0	No
a	Asteraceae	Flaveria	linearis		Lag.	No	0	Yes
a	Asteraceae	Gaillardia	pulchella		Foug.	No	0	Yes
a	Asteraceae	Gamochaeta	antillana		(Urb.) Anderb.	No	0	Yes
a	Asteraceae	Gamochaeta	purpurea		(L.) Cabrera	No	0	No
a	Asteraceae	Helenium	amarum		(Raf.) H. Rock	No	0	No
a	Asteraceae	Helenium	pinnatifidum		(Schwein. ex Nutt.) Rydb.	No	0	Yes
a	Asteraceae	Helianthus	angustifolius		L.	No	0	Yes
a	Asteraceae	Helianthus	annuus		L.	Yes	0	No
a	Asteraceae	Helianthus	debilis	subsp. debilis	Nutt.	No	1	Yes
a	Asteraceae	Helianthus	floridanus		A. Gray ex	No	0	Yes

					Chapm.			
a	Asteraceae	Heterotheca	subaxillaris		(Lam.) Britton & Rusby	No	0	Yes
a	Asteraceae	Hieracium	gronovii		L.	No	0	No
a	Asteraceae	Hieracium	megacephalon		Nash	No	1	Yes
a	Asteraceae	Iva	frutescens		L.	No	0	Yes
a	Asteraceae	Iva	imbricata		Walter	No	0	Yes
a	Asteraceae	Iva	microcephala		Nutt.	No	0	Yes
a	Asteraceae	Krigia	virginica		(L.) Willd.	No	0	Yes
a	Asteraceae	Lactuca	canadensis		L.	No	0	Yes
a	Asteraceae	Lactuca	floridana		(L.) Gaertn.	No	0	No
a	Asteraceae	Lactuca	graminifolia		Michx.	No	0	Yes
a	Asteraceae	Liatris	chapmanii		Torr. & A. Gray	No	0	No
a	Asteraceae	Liatris	elegans		(Walter) Michx.	No	0	No
a	Asteraceae	Liatris	elegantula		(Greene) K. Schum.	No	0	No
a	Asteraceae	Liatris	gracilis		Pursh	No	0	No
a	Asteraceae	Liatris	pauciflora		Pursh	No	0	Yes
a	Asteraceae	Liatris	tenuifolia	var. tenuifolia	Nutt.	No	0	Yes
a	Asteraceae	Liatris	tenuifolia Nutt.	var. quadrifolia	Chapm.	No	1	Yes
a	Asteraceae	Lygodesmia	aphylla		(Nutt.) DC.	No	0	Yes
a	Asteraceae	Melanthera	nivea		(L.) Small	No	0	Yes
a	Asteraceae	Mikania	cordifolia		(L. f.) Willd.	No	0	Yes
a	Asteraceae	Mikania	scandens		(L.) Willd.	No	0	Yes
a	Asteraceae	Oclemena	reticulata		(Pursh) G. L. Nesom	No	0	Yes
a	Asteraceae	Packera	glabella		(Poir.) C. Jeffrey	No	0	Yes
a	Asteraceae	Palafoxia	feayi		A. Gray	No	1	No
a	Asteraceae	Palafoxia	integrifolia		(Nutt.) Torr. & A. Gray	No	2	Yes
a	Asteraceae	Phoebanthus	grandiflorus		(Torr. & A. Gray) S. F. Blake	No	1	No
a	Asteraceae	Pityopsis	graminifolia		(Michx.) Nutt.	No	0	Yes
a	Asteraceae	Pluchea	baccharis		(Mill.) Pruski	No	0	Yes

a	Asteraceae	Pluchea	camphorata		(L.) DC.	No	0	No
a	Asteraceae	Pluchea	foetida		(L.) DC.	No	0	Yes
a	Asteraceae	Pluchea	longifolia		Nash	No	1	No
a	Asteraceae	Pluchea	odorata		(L.) Cass.	No	0	Yes
a	Asteraceae	Pseudognaphalium	obtusifolium		(L.) Hilliard & B. L. Burtt	No	0	No
a	Asteraceae	Pseudogynoxys	chenopodioides		(Kunth) Cabrera	Yes	0	No
a	Asteraceae	Pterocaulon	pycnostachyum		(Michx.) Elliott	No	0	Yes
a	Asteraceae	Pyrrhopappus	carolinianus		(Walter) DC.	No	0	Yes
a	Asteraceae	Rudbeckia	hirta		L.	No	0	Yes
a	Asteraceae	Sericocarpus	tortifolius		(Michx.) Nees	No	0	Yes
a	Asteraceae	Smallanthus	uvedalia		(L.) Mack. ex Small	No	0	No
a	Asteraceae	Solidago	arguta Aiton	var. caroliniana	A. Gray	No	0	No
a	Asteraceae	Solidago	fistulosa		Mill.	No	0	Yes
a	Asteraceae	Solidago	leavenworthii		Torr. & A. Gray	No	0	No
a	Asteraceae	Solidago	odora Aiton	var. chapmanii	(A. Gray) Cronquist	No	1	Yes
a	Asteraceae	Solidago	sempervirens		L.	No	0	Yes
a	Asteraceae	Solidago	stricta		Aiton	No	0	Yes
a	Asteraceae	Solidago	tortifolia		Elliott	No	0	No
a	Asteraceae	Sonchus	asper		(L.) Hill	Yes	0	Yes
a	Asteraceae	Sonchus	oleraceus		L.	Yes	0	Yes
a	Asteraceae	Sphagneticola	trilobata		(L.) Pruski	Yes	0	Yes
a	Asteraceae	Symphyotrichum	bahamense		(Britton) G. L. Nesom	No	0	Yes
a	Asteraceae	Symphyotrichum	carolinianum		(Walter) Wunderlin & B. F. Hansen	No	0	Yes
a	Asteraceae	Symphyotrichum	dumosum		(L.) G. L. Nesom	No	0	Yes
a	Asteraceae	Symphyotrichum	elliottii		(Torr. & A. Gray) G. L. Nesom	No	0	Yes
a	Asteraceae	Symphyotrichum	simmondsii		(Small) G. L. Nesom	No	1	Yes
a	Asteraceae	Symphyotrichum	subulatum		(Michx.) G. L.	No	0	Yes

					Nesom			
a	Asteraceae	Symphyotrichum	tenuifolium		(L.) G. L. Nesom	No	0	Yes
a	Asteraceae	Tridax	procumbens		L.	Yes	0	Yes
a	Asteraceae	Verbesina	virginica		L.	No	0	Yes
a	Asteraceae	Vernonia	angustifolia		Michx.	No	0	No
a	Asteraceae	Vernonia	gigantea		(Walter) Trel. ex Branner & Coville	No	0	Yes
a	Asteraceae	Xanthium	strumarium		L.	No	0	No
a	Asteraceae	Youngia	japonica		(L.) DC.	Yes	0	Yes
a	Avicenniaceae	Avicennia	germinans		(L.) L.	No	0	Yes
a	Bataceae	Batis	maritima		L.	No	0	Yes
a	Betulaceae	Carpinus	caroliniana		Walter	No	0	No
a	Bignoniaceae	Bignonia	capreolata		L.	No	0	No
a	Bignoniaceae	Campsis	radicans		(L.) Seemann	No	0	No
a	Bignoniaceae	Jacaranda	mimosifolia		D. Don	Yes	0	No
a	Bignoniaceae	Kigelia	africana		(Lam.) Benth.	Yes	0	No
a	Bignoniaceae	Podranea	ricasoliana		(Tanfani) Sprague	Yes	0	Yes
a	Bignoniaceae	Pyrostegia	venusta		(Ker Gawl.) Miers	Yes	0	Yes
a	Bignoniaceae	Spathodea	campanulata		P. Beauv.	Yes	0	No
a	Bignoniaceae	Tecoma	capensis		(Thunb.) Lindl.	Yes	0	Yes
a	Bignoniaceae	Tecoma	stans		(L.) Juss. ex Kunth	Yes	0	No
a	Boraginaceae	Argusia	gnaphalodes		(L.) Heine	No	0	Yes
a	Boraginaceae	Argusia	gnaphalodes		(L.) Heine	No	0	No
a	Boraginaceae	Heliotropium	angiospermum		Murray	No	0	Yes
a	Boraginaceae	Heliotropium	curassavicum		L.	No	0	Yes
a	Boraginaceae	Heliotropium	polyphyllum		Lehm.	No	0	No
a	Boraginaceae	Tournefortia	volubilis		L.	No	0	No
a	Brassicaceae	Cakile	lanceolata		(Willd.) O. E. Schulz	No	0	Yes
a	Brassicaceae	Capparis	flexuosa		(L.) L.	No	0	Yes

a	Brassicaceae	Capparis	jamaicensis		Jacq.	No	0	No
a	Brassicaceae	Descurainia	pinnata		(Walter) Britton	No	0	No
a	Brassicaceae	Lepidium	virginicum		L.	No	0	Yes
a	Brassicaceae	Nasturtium	floridanum		(Al-Shehbaz & Rollins) Al-Shehbaz & R. A. Price	No	1	Yes
a	Brassicaceae	Polanisia	tenuifolia		Torr. & A. Gray	No	0	Yes
a	Brassicaceae	Raphanus	raphanistrum		L.	Yes	0	No
a	Bromeliaceae	Tillandsia	fasciculata		Sw.	No	0	Yes
a	Bromeliaceae	Tillandsia	recurvata		(L.) L.	No	0	Yes
a	Bromeliaceae	Tillandsia	simulata		Small	No	1	Yes
a	Bromeliaceae	Tillandsia	usneoides		(L.) L.	No	0	Yes
a	Bromeliaceae	Tillandsia	utriculata		L.	No	0	Yes
a	Buddlejaceae	Buddleja	madagascariensis		Lam.	Yes	0	Yes
a	Burseraceae	Bursera	simaruba		(L.) Sarg.	No	0	Yes
a	Cabombaceae	Brasenia	schreberi		J. F. Gmel.	No	0	Yes
a	Cactaceae	Harrisia	fragrans		Small ex Britton & Rose	No	1	No
a	Cactaceae	Hylocereus	undatus		(Haw.) Britton & Rose	Yes	0	No
a	Cactaceae	Opuntia	cochenillifera		(L.) Mill.	Yes	0	No
a	Cactaceae	Opuntia	humifusa		(Raf.) Raf.	No	0	Yes
a	Cactaceae	Opuntia	stricta		(Haw.) Haw.	No	0	Yes
a	Cactaceae	Pereskia	aculeata		Mill.	Yes	0	No
a	Cactaceae	Selenicereus	pteranthus		(Link & Otto) Britton & Rose	Yes	0	No
a	Campanulaceae	Campanula	floridana		S. Watson ex A. Gray	No	1	Yes
a	Campanulaceae	Lobelia	feayana		A. Gray	No	1	Yes
a	Campanulaceae	Lobelia	glandulosa		Walter	No	0	No
a	Campanulaceae	Lobelia	paludosa		Nutt.	No	0	Yes
a	Campanulaceae	Lobelia	puberula		Michx.	No	0	Yes
a	Cannaceae	Canna	flaccida		Salisb.	No	0	Yes

a	Cannaceae	Canna	xgeneralis		L. H. Bailey	Yes	0	No
a	Caprifoliaceae	Lonicera	japonica		Thunb.	Yes	0	No
a	Caricaceae	Carica	papaya		L.	Yes	0	Yes
a	Caryophyllaceae	Arenaria	lanuginosa		(Michx.) Rohrb.	No	0	No
a	Caryophyllaceae	Drymaria	cordata		(L.) Willd. ex Schult.	Yes	0	No
a	Caryophyllaceae	Paronychia	americana		(Nutt.) Fenzl ex Walp.	No	0	Yes
a	Caryophyllaceae	Stellaria	media		(L.) Vill.	Yes	0	No
a	Caryophyllaceae	Stipulicida	setacea		Michx.	No	0	No
a	Casuarinaceae	Casuarina	cunninghamiana		Miq.	Yes	0	Yes
a	Casuarinaceae	Casuarina	equisetifolia		L.	Yes	0	Yes
a	Casuarinaceae	Casuarina	glauca		Sieber ex Spreng.	Yes	0	Yes
a	Celtidaceae	Celtis	laevigata		Willd.	No	0	Yes
a	Ceratophyllaceae	Ceratophyllum	demersum		L.	No	0	Yes
a	Ceratophyllaceae	Ceratophyllum	muricatum		Cham.	Yes	0	No
a	Chrysobalanaceae	Chrysobalanus	icaco		L.	No	0	Yes
a	Chrysobalanaceae	Licania	michauxii		Prance	No	0	Yes
a	Cistaceae	Helianthemum	corymbosum		Michx.	No	0	Yes
a	Cistaceae	Helianthemum	nashii		Britton	No	2	Yes
a	Cistaceae	Lechea	cernua		Small	No	1	No
a	Cistaceae	Lechea	deckertii		Small	No	0	Yes
a	Cistaceae	Lechea	divaricata		Shuttlew. ex Britton	No	1	Yes
a	Cistaceae	Lechea	minor		L.	No	0	Yes
a	Cistaceae	Lechea	mucronata		Raf.	No	0	Yes
a	Cistaceae	Lechea	sessiliflora		Raf.	No	0	Yes
a	Cistaceae	Lechea	torreyi		(Chapm.) Legg. ex Britton	No	0	Yes
a	Clusiaceae	Hypericum	brachyphyllum		(Spach) Steud.	No	0	Yes
a	Clusiaceae	Hypericum	cistifolium		Lam.	No	0	Yes
a	Clusiaceae	Hypericum	crux-andreae		(L.) Crantz	No	0	No
a	Clusiaceae	Hypericum	fasciculatum		Lam.	No	0	No

a	Clusiaceae	Hypericum	galioides		Lam.	No	0	Yes
a	Clusiaceae	Hypericum	gentianoides		(L.) Britton et al.	No	0	Yes
a	Clusiaceae	Hypericum	hypericoides		(L.) Crantz	No	0	Yes
a	Clusiaceae	Hypericum	mutilum		L.	No	0	Yes
a	Clusiaceae	Hypericum	tenuifolium		Pursh	No	0	Yes
a	Clusiaceae	Hypericum	tetrapetalum		Lam.	No	0	Yes
a	Combretaceae	Conocarpus	erectus		L.	No	0	Yes
a	Combretaceae	Laguncularia	racemosa		(L.) C. F. Gaertn.	No	0	Yes
a	Combretaceae	Quisqualis	indica		L.	Yes	0	No
a	Commelinaceae	Callisia	ornata		(Small) G. C. Tucker	No	1	Yes
a	Commelinaceae	Commelina	benghalensis		L.	Yes	0	Yes
a	Commelinaceae	Commelina	communis		L.	Yes	0	Yes
a	Commelinaceae	Commelina	diffusa	var. diffusa	Burm.f.	Yes	0	Yes
a	Commelinaceae	Commelina	erecta		L.	No	0	Yes
a	Commelinaceae	Murdannia	nudiflora		(L.) Brenan	Yes	0	Yes
a	Commelinaceae	Tradescantia	ohiensis		Raf.	No	0	Yes
a	Commelinaceae	Tradescantia	zebrina		Bosse	Yes	0	No
a	Convolvulaceae	Calystegia	sepium (L.) R. Br.	subsp. limnophila	(Greene) Brummitt	No	0	No
a	Convolvulaceae	Cuscuta	compacta		Juss. ex Choisy	No	0	No
a	Convolvulaceae	Cuscuta	exaltata		Engelm.	No	0	Yes
a	Convolvulaceae	Cuscuta	indecora		Choisy	No	0	Yes
a	Convolvulaceae	Cuscuta	pentagona		Engelm.	No	0	Yes
a	Convolvulaceae	Dichondra	caroliniensis		Michx.	No	0	No
a	Convolvulaceae	Ipomoea	alba		L.	No	0	Yes
a	Convolvulaceae	Ipomoea	cairica		(L.) Sweet	Yes	0	No
a	Convolvulaceae	Ipomoea	cordatotriloba		Dennst.	No	0	No
a	Convolvulaceae	Ipomoea	hederacea		Jacq.	Yes	0	No
a	Convolvulaceae	Ipomoea	hederifolia		L.	No	0	No
a	Convolvulaceae	Ipomoea	imperati		(Vahl) Griseb.	No	0	Yes
a	Convolvulaceae	Ipomoea	indica		(Burm.) Merr.	No	0	Yes
a	Convolvulaceae	Ipomoea	pandurata		(L.) G. Mey.	No	0	Yes

a	Convolvulaceae	Ipomoea	pes-caprae (L.) R. Br.	subsp. brasiliensis	(L.) Ooststr.	No	0	Yes
a	Convolvulaceae	Ipomoea	purpurea		(L.) Roth	Yes	0	Yes
a	Convolvulaceae	Ipomoea	sagittata		Poir.	No	0	Yes
a	Convolvulaceae	Ipomoea	violacea		L.	No	0	Yes
a	Convolvulaceae	Merremia	dissecta		(Jacq.) Hallier. f.	Yes	0	Yes
a	Cornaceae	Cornus	foemina		Mill.	No	0	Yes
a	Crassulaceae	Kalanchoe	daigremontiana		Raym.-Hamet & H. Perrier	Yes	0	No
a	Crassulaceae	Kalanchoe	delagoensis		Eckl. & Zeyh.	Yes	0	Yes
a	Crassulaceae	Kalanchoe	fedtschenkoi		Raym-Hamet & Perrier	Yes	0	No
a	Crassulaceae	Kalanchoe	pinnata		(Lam.) Pers.	Yes	0	Yes
a	Cucurbitaceae	Citrullus	lanatus		(Thunb.) Matsum & Nakai	Yes	0	No
a	Cucurbitaceae	Melothria	pendula		L.	No	0	Yes
a	Cucurbitaceae	Momordica	charantia		L.	Yes	0	Yes
a	Cymodoceaceae	Halodule	wrightii		Asch.	No	0	Yes
a	Cymodoceaceae	Syringodium	filiforme		Kutz.	No	0	Yes
a	Cyperaceae	Bulbostylis	barbata		(Rottb.) C. B. Clarke	Yes	0	Yes
a	Cyperaceae	Bulbostylis	ciliatifolia		(Elliott) Fernald	No	0	Yes
a	Cyperaceae	Bulbostylis	stenophylla		(Elliott) C. B. Clarke	No	0	Yes
a	Cyperaceae	Bulbostylis	warei		(Torr.) C. B. Clarke	No	0	Yes
a	Cyperaceae	Carex	alata		Torr.	No	0	Yes
a	Cyperaceae	Carex	digitalis		Willd.	No	0	Yes
a	Cyperaceae	Carex	fissa Mack	var. aristata	F. J. Herm.	No	0	Yes
a	Cyperaceae	Carex	gigantea		Rudge	No	0	Yes
a	Cyperaceae	Carex	lupulina		Muhl. ex Willd.	No	0	No
a	Cyperaceae	Cladium	jamaicense		Crantz	No	0	Yes
a	Cyperaceae	Cyperus	articulatus		L.	No	0	No
a	Cyperaceae	Cyperus	compressus		L.	No	0	No

a	Cyperaceae	Cyperus	croceus		Vahl	No	0	Yes
a	Cyperaceae	Cyperus	distinctus		Steud.	No	0	Yes
a	Cyperaceae	Cyperus	echinatus		(L.) A. W. Wood	No	0	No
a	Cyperaceae	Cyperus	erythrorhizos		Muhl.	No	0	Yes
a	Cyperaceae	Cyperus	esculentus		L.	Yes	0	Yes
a	Cyperaceae	Cyperus	filiculmis		Vahl	No	0	No
a	Cyperaceae	Cyperus	flavescens		L.	No	0	No
a	Cyperaceae	Cyperus	haspan		L.	No	0	Yes
a	Cyperaceae	Cyperus	ligularis		L.	No	0	Yes
a	Cyperaceae	Cyperus	odoratus		L.	No	0	Yes
a	Cyperaceae	Cyperus	ovatus		Baldwin	No	0	Yes
a	Cyperaceae	Cyperus	pedunculatus		(R. Br.) J. Kern	No	0	Yes
a	Cyperaceae	Cyperus	planifolius		Rich.	No	0	Yes
a	Cyperaceae	Cyperus	polystachyos		Rottb.	No	0	Yes
a	Cyperaceae	Cyperus	strigosus		L.	No	0	Yes
a	Cyperaceae	Cyperus	surinamensis		Rottb.	No	0	No
a	Cyperaceae	Cyperus	tetragonus		Elliott	No	0	Yes
a	Cyperaceae	Eleocharis	albida		Torr.	No	0	Yes
a	Cyperaceae	Eleocharis	atropurpurea		(Retz.) J. Presl & C. Presl	No	0	No
a	Cyperaceae	Eleocharis	baldwinii		(Torr.) Chapm.	No	0	Yes
a	Cyperaceae	Eleocharis	cellulosa		Torr.	No	0	Yes
a	Cyperaceae	Eleocharis	geniculata		(L.) Roem. & Schult.	No	0	Yes
a	Cyperaceae	Eleocharis	montevidensis		Kunth	No	0	No
a	Cyperaceae	Eleocharis	parvula		(Roem. & Schult.) Link ex Bluff et al.	No	0	No
a	Cyperaceae	Fimbristylis	caroliniana		(Lam.) Fernald	No	0	Yes
a	Cyperaceae	Fimbristylis	cymosa		R. Br.	No	0	Yes
a	Cyperaceae	Fimbristylis	dichotoma		(L.) Vahl	No	0	Yes
a	Cyperaceae	Fimbristylis	puberula		(Michx.) Vahl	No	0	Yes
a	Cyperaceae	Fimbristylis	spadicea		(L.) Vahl	No	0	Yes

a	Cyperaceae	Fuirena	breviseta		(Coville) Coville	No	0	Yes
a	Cyperaceae	Fuirena	pumila		(Torr.) Spreng.	No	0	Yes
a	Cyperaceae	Fuirena	scirpoidea		Michx.	No	0	Yes
a	Cyperaceae	Fuirena	squarrosa		Michx.	No	0	No
a	Cyperaceae	Kyllinga	brevifolia		Rottb.	Yes	0	No
a	Cyperaceae	Lipocarpha	micrantha		(Vahl) G. C. Tucker	No	0	No
a	Cyperaceae	Rhynchospora	caduca		Elliott	No	0	No
a	Cyperaceae	Rhynchospora	ciliaris		(Michx.) C. Mohr	No	0	No
a	Cyperaceae	Rhynchospora	colorata		(L.) H. Pfeiff.	No	0	Yes
a	Cyperaceae	Rhynchospora	debilis		Gale	No	0	No
a	Cyperaceae	Rhynchospora	divergens		Chapm. ex M. A. Curtis	No	0	No
a	Cyperaceae	Rhynchospora	fascicularis		(Michx.) Vahl	No	0	Yes
a	Cyperaceae	Rhynchospora	fernaldii		Gale	No	0	Yes
a	Cyperaceae	Rhynchospora	filifolia		A. Gray	No	0	Yes
a	Cyperaceae	Rhynchospora	globularis		(Chapm.) Small	No	0	Yes
a	Cyperaceae	Rhynchospora	grayi		Kunth	No	0	Yes
a	Cyperaceae	Rhynchospora	intermedia		(Chapm.) Britton	No	1	No
a	Cyperaceae	Rhynchospora	inundata		(Oakes) Fernald	No	0	Yes
a	Cyperaceae	Rhynchospora	latifolia		(Baldwin) W. W. Thomas	No	0	No
a	Cyperaceae	Rhynchospora	megalocarpa		A. Gray	No	0	Yes
a	Cyperaceae	Rhynchospora	microcarpa		Baldwin ex A. Gray	No	0	Yes
a	Cyperaceae	Rhynchospora	microcephala		(Britton) Britton ex Small	No	0	Yes
a	Cyperaceae	Rhynchospora	miliacea		(Lam.) A. Gray	No	0	Yes
a	Cyperaceae	Rhynchospora	odorata		C. Wright ex Griseb.	No	0	Yes
a	Cyperaceae	Rhynchospora	plumosa		Elliott	No	0	Yes
a	Cyperaceae	Rhynchospora	pusilla		Chapm. ex M. A. Curtis	No	0	No
a	Cyperaceae	Rhynchospora	sulcata		Gale	No	0	Yes
a	Cyperaceae	Rhynchospora	tracyi		Britton	No	0	Yes

a	Cyperaceae	Rhynchospora	wrightiana		Boeck.	No	0	Yes
a	Cyperaceae	Schoenoplectus	americanus		(Pers.) Volkart ex Schinz & R. Keller	No	0	Yes
a	Cyperaceae	Schoenoplectus	pungens		(Vahl) Palla	No	0	Yes
a	Cyperaceae	Schoenoplectus	robustus		(Pursh) M. T. Strong	No	0	Yes
a	Cyperaceae	Schoenoplectus	tabernaemontani		(C. C. Gmel.) Palla	No	0	Yes
a	Cyperaceae	Scleria	ciliata	var. ciliata	Michx.	No	0	Yes
a	Cyperaceae	Scleria	ciliata Michx.	var. pauciflora	(Muhl. ex Willd.) Kuk.	No	0	Yes
a	Cyperaceae	Scleria	oligantha		Michx.	No	0	No
a	Cyperaceae	Scleria	reticularis		Michx.	No	0	Yes
a	Cyperaceae	Scleria	triglomerata		Michx.	No	0	Yes
a	Cyperaceae	Scleria	verticillata		Muhl. ex Willd.	No	0	Yes
a	Cyperaceae	Websteria	confervoides		(Poir.) S. S. Hooper	No	0	Yes
a	Cyrillaceae	Cyrilla	racemiflora		L.	No	0	Yes
a	Dioscoreaceae	Dioscorea	bulbifera		L.	Yes	0	Yes
a	Droseraceae	Drosera	brevifolia		Pursh	No	0	Yes
a	Droseraceae	Drosera	capillaris		Poir.	No	0	Yes
a	Ebenaceae	Diospyros	kaki		L. f.	Yes	0	No
a	Ebenaceae	Diospyros	virginiana		L.	No	0	Yes
a	Ericaceae	Bejaria	racemosa		Vent.	No	0	Yes
a	Ericaceae	Ceratiola	ericoides		Michx.	No	0	No
a	Ericaceae	Gaylussacia	dumosa		(Andrews) Torr. & A. Gray	No	0	Yes
a	Ericaceae	Gaylussacia	frondosa (L.) Torr. & A. Gray ex Torr.	var. tomentosa	A. Gray	No	0	No
a	Ericaceae	Lyonia	ferruginea		(Walter) Nutt.	No	0	Yes
a	Ericaceae	Lyonia	fruticosa		(Michx.) G. S. Torr.	No	0	Yes
a	Ericaceae	Lyonia	lucida		(Lam.) K. Koch	No	0	Yes
a	Ericaceae	Monotropa	uniflora		L.	No	0	Yes

a	Ericaceae	Vaccinium	arboreum		Marshall	No	0	Yes
a	Ericaceae	Vaccinium	corymbosum		L.	No	0	Yes
a	Ericaceae	Vaccinium	darrowii		Camp.	No	0	Yes
a	Ericaceae	Vaccinium	myrsinites		Lam.	No	0	Yes
a	Ericaceae	Vaccinium	stamineum		L.	No	0	Yes
a	Eriocaulaceae	Eriocaulon	compressum		Lam.	No	0	Yes
a	Eriocaulaceae	Lachnocaulon	anceps		(Walter) Morong	No	0	No
a	Eriocaulaceae	Lachnocaulon	beyrichianum		Sporl. ex Korn.	No	0	Yes
a	Eriocaulaceae	Lachnocaulon	minus		(Chapm.) Small	No	0	No
a	Eriocaulaceae	Syngonanthus	flavidulus		(Michx.) Ruhland	No	0	Yes
a	Euphorbiaceae	Acalypha	gracilens		A. Gray	No	0	Yes
a	Euphorbiaceae	Acalypha	ostryifolia		Riddell ex J. M. Coult	No	0	No
a	Euphorbiaceae	Chamaesyce	blodgettii		(Engelm. ex Hitchc.) Small	No	0	No
a	Euphorbiaceae	Chamaesyce	bombensis		(Jacq.) Dugand	No	0	Yes
a	Euphorbiaceae	Chamaesyce	cumulicola		Small	No	1	Yes
a	Euphorbiaceae	Chamaesyce	hirta		(L.) Millsp.	No	0	Yes
a	Euphorbiaceae	Chamaesyce	hypericifolia		(L.) Millsp.	No	0	Yes
a	Euphorbiaceae	Chamaesyce	hyssopifolia		(L.) Small	No	0	Yes
a	Euphorbiaceae	Chamaesyce	maculata		(L.) Small	No	0	Yes
a	Euphorbiaceae	Chamaesyce	mesembrianthemifolia		(Jacq.) Dugand	No	0	Yes
a	Euphorbiaceae	Chamaesyce	ophthalmica		(Pers.) D. G. Burch	No	0	No
a	Euphorbiaceae	Chamaesyce	thymifolia		(L.) Millsp.	No	0	Yes
a	Euphorbiaceae	Cnidoscolus	stimulosus		(Michx.) Engelm. & A. Gray	No	0	Yes
a	Euphorbiaceae	Croton	glandulosus	var. glandulosus	L.	No	0	Yes
a	Euphorbiaceae	Croton	punctatus		Jacq.	No	0	Yes
a	Euphorbiaceae	Euphorbia	polyphylla		Engelm. ex Chapm.	No	1	Yes
a	Euphorbiaceae	Euphorbia	trichotoma		Kunth	No	0	No
a	Euphorbiaceae	Jatropha	curcas		L.	Yes	0	No
a	Euphorbiaceae	Pedilanthus	tithymaloides (L.)	subsp. smallii	(Millsp.) Dressler	No	0	No

			Poit.					
a	Euphorbiaceae	Poinsettia	cyathophora		(Murray) Bartl.	No	0	Yes
a	Euphorbiaceae	Poinsettia	heterophylla		(L.) Klotzsch & Garcke ex Klotzsch	No	0	Yes
a	Euphorbiaceae	Ricinus	communis		L.	Yes	0	Yes
a	Euphorbiaceae	Sapium	sebiferum		(L.) Roxb.	Yes	0	No
a	Euphorbiaceae	Stillingia	aquatica		Chapm.	No	0	No
a	Euphorbiaceae	Stillingia	sylvatica		L.	No	0	Yes
a	Euphorbiaceae	Tragia	urens		L.	No	0	Yes
a	Fabaceae	Abrus	precatorius		L.	Yes	0	Yes
a	Fabaceae	Acacia	farnesiana		(L.) Willd.	No	0	Yes
a	Fabaceae	Aeschynomene	americana		L.	No	0	No
a	Fabaceae	Albizia	julibrissin		Durazz.	Yes	0	Yes
a	Fabaceae	Albizia	lebbeck		(L.) Benth.	Yes	0	No
a	Fabaceae	Alysicarpus	ovalifolius		(Schumach. & Thonn.) J. Leonard	Yes	0	No
a	Fabaceae	Amorpha	fruticosa		L.	No	0	Yes
a	Fabaceae	Apios	americana		Medik.	No	0	Yes
a	Fabaceae	Baptisia	lecontei		Torr. & A. Gray	No	0	No
a	Fabaceae	Bauhinia	variegata		L.	Yes	0	Yes
a	Fabaceae	Caesalpinia	bonduc		(L.) Roxb.	No	0	Yes
a	Fabaceae	Calliandra	haematocephala		Hassk.	Yes	0	Yes
a	Fabaceae	Canavalia	rosea		(Sw.) DC.	No	0	Yes
a	Fabaceae	Centrosema	virginianum		(L.) Benth.	No	0	Yes
a	Fabaceae	Chamaecrista	fasciculata		(Michx.) Greene	No	0	Yes
a	Fabaceae	Chamaecrista	nictitans (L.) Moench	var. aspera	(Muhl. ex Elliott) H. S. Irwin & Barneby	No	0	Yes
a	Fabaceae	Clitoria	mariana		L.	No	0	Yes
a	Fabaceae	Crotalaria	lanceolata		E. Mey.	Yes	0	Yes
a	Fabaceae	Crotalaria	pallida Aiton	var. obovata	(G. Don) Polhill	Yes	0	Yes
a	Fabaceae	Crotalaria	pumila		Ortega	No	0	Yes

a	Fabaceae	Crotalaria	purshii		DC.	No	0	Yes
a	Fabaceae	Crotalaria	retusa		L.	Yes	0	No
a	Fabaceae	Crotalaria	rotundifolia		J. F. Gmel.	No	0	Yes
a	Fabaceae	Crotalaria	spectabilis		Roth	Yes	0	No
a	Fabaceae	Dalbergia	ecastaphyllum		(L.) Taub.	No	0	Yes
a	Fabaceae	Dalea	carnea		(Michx.) Poir.	No	0	No
a	Fabaceae	Dalea	feayi		(Chapm.) Barneby	No	0	Yes
a	Fabaceae	Dalea	pinnata (J. F. Gmel.) Barneby	var. adenopoda	(Rydb.) Barneby	No	1	Yes
a	Fabaceae	Desmodium	floridanum		Chapm.	No	0	Yes
a	Fabaceae	Desmodium	incanum		DC.	Yes	0	Yes
a	Fabaceae	Desmodium	paniculatum		(L.) DC.	No	0	Yes
a	Fabaceae	Desmodium	strictum		(Pursh) DC.	No	0	Yes
a	Fabaceae	Desmodium	tenuifolium		Torr. & A. Gray	No	0	No
a	Fabaceae	Desmodium	tortuosum		(Sw.) DC.	Yes	0	Yes
a	Fabaceae	Desmodium	triflorum		(L.) DC.	Yes	0	Yes
a	Fabaceae	Enterolobium	contortisiliquum		(Vell.) Morong	Yes	0	Yes
a	Fabaceae	Erythrina	herbacea		L.	No	0	Yes
a	Fabaceae	Galactia	elliottii		Nutt.	No	0	Yes
a	Fabaceae	Galactia	volubilis		(L.) Britton	No	0	Yes
a	Fabaceae	Indigofera	caroliniana		Mill.	No	0	Yes
a	Fabaceae	Indigofera	hirsuta		L.	Yes	0	Yes
a	Fabaceae	Indigofera	miniata Ortega	var. leptosepala	(Nutt. ex Torr. & A. Gray) B. L. Turner	No	0	Yes
a	Fabaceae	Indigofera	spicata		Forssk.	Yes	0	Yes
a	Fabaceae	Indigofera	suffruticosa		Mill.	Yes	0	Yes
a	Fabaceae	Kummerowia	striata		(Thunb.) Schindl.	Yes	0	No
a	Fabaceae	Leucaena	leucocephala	subsp. Leucocephala	(Lam.) de Wit	Yes	0	Yes
a	Fabaceae	Lupinus	diffusus		Nutt.	No	0	Yes
a	Fabaceae	Macroptilium	atropurpureum		(Moc. & Sesse ex DC.) Urb.	Yes	0	Yes

a	Fabaceae	Macroptilium	lathyroides		(L.) Urb.	Yes	0	Yes
a	Fabaceae	Medicago	lupulina		L.	Yes	0	Yes
a	Fabaceae	Melilotus	albus		Medik.	Yes	0	Yes
a	Fabaceae	Melilotus	indicus		(L.) All.	Yes	0	Yes
a	Fabaceae	Mimosa	strigillosa		Torr. & A. Gray	No	0	Yes
a	Fabaceae	Parkinsonia	aculeata		L.	Yes	0	Yes
a	Fabaceae	Phaseolus	polystachios	var. polystachios	(L.) Britton et al.	No	0	Yes
a	Fabaceae	Phaseolus	vulgaris		L.	Yes	0	Yes
a	Fabaceae	Pueraria	montana (Lour.) Merr.	var. lobata	(Willd.) Maesen & S. M. Almeida ex Sanjappa & Predeep	Yes	0	Yes
a	Fabaceae	Rhynchosia	cinerea		Nash	No	1	Yes
a	Fabaceae	Rhynchosia	difformis		(Elliott) DC.	No	0	No
a	Fabaceae	Rhynchosia	minima		(L.) DC.	No	0	Yes
a	Fabaceae	Senna	alata		(L.) Roxb.	Yes	0	Yes
a	Fabaceae	Senna	obtusifolia		(L.) H. S. Irwin & Barneby	Yes	0	Yes
a	Fabaceae	Senna	occidentalis		(L.) Link	Yes	0	No
a	Fabaceae	Senna	pendula (Humb. & Bonpl. ex Willd.) H. S. Irwin & Barneby	var. glabrata	(Vogel) H. S. Irwin & Barneby	Yes	0	Yes
a	Fabaceae	Sesbania	herbacea		(Mill.) McVaugh	No	0	Yes
a	Fabaceae	Sesbania	punicea		(Cav.) Benth.	Yes	0	Yes
a	Fabaceae	Sesbania	vesicaria		(Jacq.) Elliott	No	0	Yes
a	Fabaceae	Sophora	tomentosa L.	var. truncata	Torr. & A. Gray	No	0	Yes
a	Fabaceae	Strophostyles	umbellata		(Muhl. ex Willd.) Britton	No	0	No
a	Fabaceae	Stylosanthes	hamata		(L.) Taub	Yes	0	Yes
a	Fabaceae	Tephrosia	angustissima Shuttlew. ex Chapm.	var. curtissii	(Small ex Rydb.) Isely	No	1	Yes
a	Fabaceae	Trifolium	repens		L.	Yes	0	Yes
a	Fabaceae	Vicia	acutifolia		Elliott	No	0	Yes
a	Fabaceae	Vicia	floridana		S. Watson	No	2	No
a	Fabaceae	Vigna	luteola		(Jacq.) Benth.	No	0	Yes

a	Fabaceae	Wisteria	sinensis		(Sims) Sweet	Yes	0	No
a	Fagaceae	Quercus	chapmanii		Sarg.	No	0	Yes
a	Fagaceae	Quercus	geminata		Small	No	0	Yes
a	Fagaceae	Quercus	incana		W. Bartram	No	0	No
a	Fagaceae	Quercus	laevis		Walter	No	0	Yes
a	Fagaceae	Quercus	laurifolia		Michx.	No	0	Yes
a	Fagaceae	Quercus	minima		(Sarg.) Small	No	0	Yes
a	Fagaceae	Quercus	myrtifolia		Willd.	No	0	Yes
a	Fagaceae	Quercus	nigra		L.	No	0	Yes
a	Fagaceae	Quercus	pumila		Walter	No	0	Yes
a	Fagaceae	Quercus	virginiana		Mill.	No	0	Yes
a	Gelsemiaceae	Gelsemium	sempervirens		(L.) W. T. Aiton	No	0	Yes
a	Gentianaceae	Bartonia	verna		(Michx.) Raf. ex Barton	No	0	No
a	Gentianaceae	Eustoma	exaltatum		(L.) Salisb. ex G. Don	No	0	Yes
a	Gentianaceae	Sabatia	brevifolia		Raf.	No	0	Yes
a	Gentianaceae	Sabatia	campanulata		(L.) Torr.	No	0	Yes
a	Gentianaceae	Sabatia	difformis		(L.) Druce	No	0	No
a	Gentianaceae	Sabatia	grandiflora		(A. Gray) Small	No	0	Yes
a	Gentianaceae	Sabatia	stellaris		Pursh	No	0	Yes
a	Geraniaceae	Geranium	carolinianum		L.	No	0	Yes
a	Geraniaceae	Pelargonium	hortorum		Bailey	Yes	0	No
a	Goodeniaceae	Scaevola	plumieri		(L.) Vahl	No	0	Yes
a	Goodeniaceae	Scaevola	taccada (Gaertn.) Roxb.	var. sericea	(Vahl) H. St. John	Yes	0	Yes
a	Haemodoraceae	Lachnanthes	caroliana		(Lam.) Dandy	No	0	Yes
a	Haloragaceae	Proserpinaca	palustris		L.	No	0	Yes
a	Haloragaceae	Proserpinaca	pectinata		Lam.	No	0	No
a	Hydrocharitaceae	Halophila	engelmannii		Asch. ex Neumayer	No	0	Yes
a	Hydrocharitaceae	Limnobium	spongia		(Bosc) Rich. ex Steud.	No	0	Yes
a	Hydrocharitaceae	Najas	guadalupensis		(Spreng.)	No	0	Yes

					Magnus			
a	Hydrocharitaceae	Najas	marina		L.	No	0	No
a	Hydrocharitaceae	Najas	wrightiana		A. Braun	No	0	No
a	Hydrocharitaceae	Thalassia	testudinum		Banks & Sol. ex J. Konig	No	0	No
a	Hypoxidaceae	Hypoxis	juncea		Sm.	No	0	Yes
a	Iridaceae	Gladiolus	x gandavensis		Van Houtte	Yes	0	No
a	Iridaceae	Iris	hexagona		Walter	No	0	Yes
a	Iridaceae	Nemastylis	floridana		Small	No	1	Yes
a	Iridaceae	Sisyrinchium	angustifolium		Mill.	No	0	Yes
a	Iridaceae	Sisyrinchium	nashii		E. P. Bicknell	No	0	Yes
a	Iridaceae	Sisyrinchium	xerophyllum		Greene	No	0	Yes
a	Juglandaceae	Carya	aquatica		(F. Michx.) Nutt.	No	0	No
a	Juglandaceae	Carya	floridana		Sarg.	No	1	Yes
a	Juglandaceae	Carya	glabra		(Mill.) Sweet	No	0	Yes
a	Juglandaceae	Carya	illinoinensis		(Wangenh.) K. Koch	Yes	0	No
a	Juncaceae	Juncus	acuminatus		Michx.	No	0	Yes
a	Juncaceae	Juncus	dichotomus		Elliott	No	0	No
a	Juncaceae	Juncus	effusus L.	subsp. solutus	(Fernald & Wiegand) Hamet-Ahti	No	0	Yes
a	Juncaceae	Juncus	elliottii		Chapm	No	0	Yes
a	Juncaceae	Juncus	marginatus		Rostk.	No	0	Yes
a	Juncaceae	Juncus	megacephalus		M. A. Curtis	No	0	Yes
a	Juncaceae	Juncus	polycephalos		Michx.	No	0	No
a	Juncaceae	Juncus	repens		Michx.	No	0	Yes
a	Juncaceae	Juncus	roemerianus		Scheele	No	0	Yes
a	Juncaceae	Juncus	scirpoides		Lam.	No	0	Yes
a	Lamiaceae	Callicarpa	americana		L.	No	0	Yes
a	Lamiaceae	Clerodendrum	indicum		(L.) Kuntze	Yes	0	Yes
a	Lamiaceae	Clerodendrum	xspeciosum		Dombain	Yes	0	No
a	Lamiaceae	Hyptis	alata		(Raf.) Shinners	No	0	Yes

a	Lamiaceae	Hyptis	mutabilis		(Rich.) Briq.	Yes	0	Yes
a	Lamiaceae	Mentha	sp.			Yes	0	No
a	Lamiaceae	Monarda	punctata		L.	No	0	Yes
a	Lamiaceae	Physostegia	purpurea		(Walter) S. F. Blake	No	0	Yes
a	Lamiaceae	Piloblephis	rigida		(W. Bartram ex Benth.) Raf.	No	1	Yes
a	Lamiaceae	Prunella	vulgaris		L.	Yes	0	No
a	Lamiaceae	Salvia	coccinea		Buc'hoz. ex Etl.	No	0	Yes
a	Lamiaceae	Salvia	lyrata		L.	No	0	Yes
a	Lamiaceae	Salvia	serotina		L.	No	0	Yes
a	Lamiaceae	Scutellaria	integrifolia		L.	No	0	Yes
a	Lamiaceae	Teucrium	canadense		L.	No	0	Yes
a	Lamiaceae	Trichostema	dichotomum		L.	No	0	Yes
a	Lamiaceae	Vitex	trifolia		L.	Yes	0	Yes
a	Lauraceae	Cassytha	filiformis		L.	No	0	Yes
a	Lauraceae	Cinnamomum	camphora		(L.) J. Presl	Yes	0	No
a	Lauraceae	Ocotea	coriacea		(Sw.) Britton	No	0	Yes
a	Lauraceae	Persea	americana		Mill.	Yes	0	No
a	Lauraceae	Persea	borbonia	var. borbonia	(L.) Spreng.	No	0	Yes
a	Lauraceae	Persea	borbonia (L.) Spreng.	var. humilis	(Nash) L. E. Kopp	No	1	Yes
a	Lauraceae	Persea	palustris		(Raf.) Sarg.	No	0	Yes
a	Lentibulariaceae	Pinguicula	caerulea		Walter	No	0	No
a	Lentibulariaceae	Pinguicula	lutea		Walter	No	0	No
a	Lentibulariaceae	Pinguicula	pumila		Michx.	No	0	Yes
a	Lentibulariaceae	Utricularia	foliosa		L.	No	0	Yes
a	Lentibulariaceae	Utricularia	gibba		L.	No	0	Yes
a	Lentibulariaceae	Utricularia	inflata		Walter	No	0	Yes
a	Lentibulariaceae	Utricularia	purpurea		Walter	No	0	Yes
a	Lentibulariaceae	Utricularia	radiata		Small	No	0	Yes
a	Lentibulariaceae	Utricularia	subulata		L.	No	0	Yes
a	Liliaceae	Lilium	catesbaei		Walter	No	0	No

a	Liliaceae	Lilium	longiflorum		Thunb.	Yes	0	No
a	Loasaceae	Mentzelia	floridana		Nutt. ex Torr. & A. Gray	No	0	Yes
a	Loganiaceae	Mitreola	petiolata		(J. F. Gmel.) Torr. & A. Gray	No	0	Yes
a	Loganiaceae	Mitreola	sessilifolia		(J. F. Gmel.) G. Don	No	0	No
a	Lythraceae	Ammannia	latifolia		L.	No	0	Yes
a	Lythraceae	Lagerstroemia	indica		L.	Yes	0	No
a	Lythraceae	Lythrum	alatum Pursh	var. lanceolatum	(Elliott) Torr. & A. Gray ex Rothr.	No	0	Yes
a	Lythraceae	Lythrum	lineare		L.	No	0	No
a	Lythraceae	Rotala	ramosior		(L.) Koehne	No	0	No
a	Magnoliaceae	Magnolia	grandiflora		L.	No	0	Yes
a	Magnoliaceae	Magnolia	virginiana		L.	No	0	No
a	Malvaceae	Dombeya	wallichii		(Lindl.) Benth. & Hook. ex K. Schum.	Yes	0	No
a	Malvaceae	Hibiscus	furcellatus		Desr.	No	0	No
a	Malvaceae	Hibiscus	grandiflorus		Michx.	No	0	No
a	Malvaceae	Hibiscus	rosa-sinensis	var. rosa-sinensis	L.	Yes	0	No
a	Malvaceae	Hibiscus	rosa-sinensis L.	var. schizopetalus	Dyer.	Yes	0	No
a	Malvaceae	Kosteletzkya	pentacarpos		(L.) Ledeb.	No	0	Yes
a	Malvaceae	Malvastrum	corchorifolium		(Desr.) Britton ex Small	No	0	Yes
a	Malvaceae	Malvastrum	coromandelianum		(L.) Garcke	Yes	0	No
a	Malvaceae	Malvaviscus	arboreus Cav.	var. drummondii	(Torr. & A. Gray) Schery.	Yes	0	No
a	Malvaceae	Pavonia	spinifex		(L.) Cav.	No	0	Yes
a	Malvaceae	Sida	cordifolia		L.	Yes	0	No
a	Malvaceae	Sida	rhombifolia		L.	No	0	Yes
a	Malvaceae	Sida	ulmifolia		Mill.	No	0	Yes
a	Malvaceae	Talipariti	tiliaceum		(L.) Fryxell	Yes	0	No

a	Malvaceae	Urena	lobata		L.	Yes	0	Yes
a	Marantaceae	Thalia	geniculata		L.	No	0	Yes
a	Melanthiaceae	Schoenocaulon	dubium		(Michx.) Small	No	1	No
a	Melastomataceae	Rhexia	mariana		L.	No	0	Yes
a	Melastomataceae	Rhexia	nuttallii		C. W. James	No	0	Yes
a	Melastomataceae	Rhexia	petiolata		Walter	No	0	Yes
a	Meliaceae	Melia	azedarach		L.	Yes	0	Yes
a	Molluginaceae	Mollugo	verticillata		L.	Yes	0	Yes
a	Moraceae	Broussonetia	papyrifera		(L.) Vent.	Yes	0	Yes
a	Moraceae	Ficus	aurea		Nutt.	No	0	Yes
a	Moraceae	Ficus	carica		L.	Yes	0	No
a	Moraceae	Ficus	elastica		Roxb.	Yes	0	No
a	Moraceae	Maclura	pomifera		(Raf.) C. K. Schneid.	Yes	0	No
a	Moraceae	Morus	alba		L.	Yes	0	No
a	Moraceae	Morus	rubra		L.	No	0	Yes
a	Musaceae	Musa	x paradisiaca		L.	Yes	0	No
a	Myricaceae	Myrica	cerifera		L.	No	0	Yes
a	Myrsinaceae	Ardisia	escallonioides		Schiede & Deppe ex Schltdl. & Cham.	No	0	Yes
a	Myrsinaceae	Myrsine	cubana		A. DC.	No	0	Yes
a	Myrtaceae	Eucalyptus	robusta		Sm.	Yes	0	No
a	Myrtaceae	Eugenia	axillaris		(Sw.) Willd.	No	0	Yes
a	Myrtaceae	Eugenia	foetida		Pers.	No	0	Yes
a	Myrtaceae	Eugenia	uniflora		L.	Yes	0	Yes
a	Myrtaceae	Melaleuca	quinquenervia		(Cav.) S. T. Blake	Yes	0	Yes
a	Myrtaceae	Myrcianthes	fragrans		(Sw.) McVaugh	No	0	Yes
a	Myrtaceae	Psidium	cattleianum		Sabine	Yes	0	No
a	Myrtaceae	Psidium	guajava		L.	Yes	0	Yes
a	Myrtaceae	Syzygium	cumini		(L.) Skeels	Yes	0	No
a	Myrtaceae	Syzygium	jambos		(L.) Alston	Yes	0	No

a	Nartheciaceae	Aletris	lutea		Small	No	0	Yes
a	Nelumbonaceae	Nelumbo	lutea		Willd.	No	0	Yes
a	Nyctaginaceae	Boerhavia	diffusa		L.	No	0	Yes
a	Nyctaginaceae	Bougainvillea	glabra		Choisy	Yes	0	No
a	Nyctaginaceae	Guapira	discolor		(Spreng.) Little	No	0	No
a	Nyctaginaceae	Mirabilis	jalapa		L.	Yes	0	No
a	Nymphaeaceae	Nuphar	advena		(Aiton) Aiton f.	No	0	No
a	Nymphaeaceae	Nymphaea	capensis Thunb.	var. zanzibariensis	(Casp.) Conard.	Yes	0	Yes
a	Nymphaeaceae	Nymphaea	elegans		Hook.	No	0	Yes
a	Nymphaeaceae	Nymphaea	mexicana		Zucc.	No	0	Yes
a	Nymphaeaceae	Nymphaea	odorata		Sol.	No	0	Yes
a	Oleaceae	Forestiera	segregata		(Jacq.) Krug & Urb.	No	0	Yes
a	Oleaceae	Fraxinus	pennsylvanica		Marshall	No	0	No
a	Oleaceae	Jasminum	sambac		(L.) Aiton	Yes	0	No
a	Oleaceae	Ligustrum	japonicum		Thunb.	Yes	0	No
a	Oleaceae	Olea	europeae		L.	Yes	0	No
a	Oleaceae	Osmanthus	americanus		(L.) Benth. & Hook. f. ex A. Gray	No	0	Yes
a	Onagraceae	Gaura	angustifolia		Michx.	No	0	Yes
a	Onagraceae	Ludwigia	alata		Elliott	No	0	Yes
a	Onagraceae	Ludwigia	arcuata		Walter	No	0	No
a	Onagraceae	Ludwigia	curtissii		Champ.	No	0	Yes
a	Onagraceae	Ludwigia	decurrens		Walter	No	0	Yes
a	Onagraceae	Ludwigia	erecta		(L.) H. Hara	No	0	Yes
a	Onagraceae	Ludwigia	hirtella		Raf.	No	0	No
a	Onagraceae	Ludwigia	lanceolata		Elliott	No	0	Yes
a	Onagraceae	Ludwigia	maritima		R. M. Harper	No	0	Yes
a	Onagraceae	Ludwigia	microcarpa		Michx.	No	0	No
a	Onagraceae	Ludwigia	octovalvis		(Jacq.) Raven	No	0	Yes
a	Onagraceae	Ludwigia	palustris		(L.) Elliott	No	0	No

a	Onagraceae	Ludwigia	peruviana		(L.) H. Hara	Yes	0	Yes
a	Onagraceae	Ludwigia	repens		J. R. Forst.	No	0	Yes
a	Onagraceae	Ludwigia	suffruticosa		Walter	No	0	Yes
a	Onagraceae	Oenothera	humifusa		Nutt.	No	0	Yes
a	Onagraceae	Oenothera	laciniata		Hill	No	0	Yes
a	Orchidaceae	Calopogon	barbatus		(Walter) Ames	No	0	Yes
a	Orchidaceae	Calopogon	multiflorus		Lindl.	No	0	No
a	Orchidaceae	Calopogon	tuberosus		(L.) Britton et al.	No	0	Yes
a	Orchidaceae	Encyclia	tampensis		(Lindl.) Small	No	0	Yes
a	Orchidaceae	Epidendrum	conopseum		R. Br.	No	0	Yes
a	Orchidaceae	Eulophia	alta		(L.) Fawc. & Rendle	No	0	No
a	Orchidaceae	Habenaria	floribunda		Lindl.	No	0	Yes
a	Orchidaceae	Habenaria	repens		Nutt.	No	0	No
a	Orchidaceae	Harrisella	porrecta		(Rchb. f.) Fawc. & Rendle	No	0	No
a	Orchidaceae	Hexalectris	spicata		(Walter) Barnhart	No	0	No
a	Orchidaceae	Malaxis	spicata		Sw.	No	0	No
a	Orchidaceae	Pogonia	ophioglossoides		(L.) Ker Gawl.	No	0	No
a	Orchidaceae	Ponthieva	racemosa		(Walter) C. Mohr	No	0	No
a	Orchidaceae	Pteroglossaspis	ecristata		(Fernald) Rolfe	No	0	Yes
a	Orchidaceae	Spiranthes	laciniata		(Small) Ames	No	0	No
a	Orchidaceae	Spiranthes	odorata		(Nutt.) Lindl.	No	0	Yes
a	Orchidaceae	Spiranthes	praecox		(Walter) S. Watson	No	0	Yes
a	Orchidaceae	Zeuxine	strateumatica		(L.) Schltr.	Yes	0	No
a	Orobanchaceae	Agalinis	fasciculata		(Elliott) Raf.	No	0	Yes
a	Orobanchaceae	Agalinis	filifolia		(Nutt.) Raf.	No	0	Yes
a	Orobanchaceae	Agalinis	linifolia		(Nutt.) Britton	No	0	No
a	Orobanchaceae	Agalinis	maritima		(Raf.) Raf.	No	0	Yes
a	Orobanchaceae	Agalinis	setacea		(J. F. Gmel.) Raf.	No	0	No
a	Orobanchaceae	Buchnera	americana		L.	No	0	Yes

a	Orobanchaceae	Seymeria	pectinata		Pursh	No	0	Yes
a	Oxalidaceae	Oxalis	corniculata		L.	No	0	Yes
a	Oxalidaceae	Oxalis	violacea		L.	Yes	0	No
a	Papaveraceae	Argemone	mexicana		L.	No	0	No
a	Passifloraceae	Passiflora	incarnata		L.	No	0	Yes
a	Passifloraceae	Passiflora	lutea		L.	No	0	No
a	Passifloraceae	Passiflora	suberosa		L.	No	0	Yes
a	Phyllanthaceae	Phyllanthus	abnormis		Baill.	No	0	Yes
a	Phyllanthaceae	Phyllanthus	tenellus		Roxb.	Yes	0	No
a	Phytolaccaceae	Agdestis	clematidea		Moc. & Sesse ex DC.	Yes	0	No
a	Phytolaccaceae	Phytolacca	americana		L.	No	0	Yes
a	Phytolaccaceae	Rivina	humilis		L.	No	0	Yes
a	Piperaceae	Peperomia	humilis		A. Dietr.	No	0	No
a	Piperaceae	Peperomia	obtusifolia		(L.) A. Dietr.	No	0	No
a	Plantaginaceae	Bacopa	caroliniana		(Walter) B. L. Rob.	No	0	No
a	Plantaginaceae	Bacopa	monnieri		(L.) Pennell	No	0	Yes
a	Plantaginaceae	Gratiola	hispida		(Benth. ex Lindl.) Pollard	No	0	Yes
a	Plantaginaceae	Gratiola	ramosa		Walter	No	0	Yes
a	Plantaginaceae	Linaria	canadensis		(L.) Chaz.	No	0	Yes
a	Plantaginaceae	Linaria	floridana		Chapm.	No	0	No
a	Plantaginaceae	Mecardonia	acuminata (Walter) Small	subsp. peninsularis	(Pennell) Rossow	No	1	Yes
a	Plantaginaceae	Micranthemum	glomeratum		(Chapm.) Shinners	No	1	No
a	Plantaginaceae	Penstemon	multiflorus		(Benth.) Chapm. ex Small	No	0	Yes
a	Plantaginaceae	Plantago	lanceolata		L.	Yes	0	Yes
a	Plantaginaceae	Plantago	virginica		L.	No	0	Yes
a	Plantaginaceae	Russellia	equisetiformis		Schltdl. & Cham.	Yes	0	No
a	Plantaginaceae	Scoparia	dulcis		L.	No	0	Yes
a	Plumbaginaceae	Limonium	carolinianum		(Walter) Britton	No	0	Yes

a	Plumbaginaceae	Plumbago	auriculata		Lam.	Yes	0	No
a	Plumbaginaceae	Plumbago	zeylanica		L.	No	0	Yes
a	Poaceae	Amphicarpum	muhlenbergianum		(Shult.) Hitchc.	No	0	Yes
a	Poaceae	Andropogon	brachystachyus		Chapm.	No	2	Yes
a	Poaceae	Andropogon	floridanus		Scribn.	No	2	Yes
a	Poaceae	Andropogon	glomeratus	var. glomeratus	(Walter) Britton et al.	No	0	Yes
a	Poaceae	Andropogon	glomeratus (Walter) Britton et al.	var. glaucopis	(Elliott) C. Mohr	No	0	Yes
a	Poaceae	Andropogon	glomeratus (Walter) Britton et al.	var. hirsutior	(Hack.) C. Mohr	No	0	Yes
a	Poaceae	Andropogon	glomeratus (Walter) Britton et al.	var. pumilus	(Vasey) Vasey ex L. H. Dewey	No	0	Yes
a	Poaceae	Andropogon	gyrans	var. gyrans	Ashe	No	0	Yes
a	Poaceae	Andropogon	gyrans Ashe	var. stenophyllus	(Hack.) C. S. Campb.	No	0	Yes
a	Poaceae	Andropogon	longiberbis		Hack.	No	0	Yes
a	Poaceae	Andropogon	ternarius		Michx.	No	0	Yes
a	Poaceae	Andropogon	virginicus	var. virginicus	L.	No	0	Yes
a	Poaceae	Andropogon	virginicus L.	var. decipiens	C. S. Campb.	No	0	Yes
a	Poaceae	Andropogon	virginicus L.	var. glaucus	Hack.	No	0	Yes
a	Poaceae	Aristida	patula		Chapm. ex Nash	No	1	No
a	Poaceae	Aristida	purpurascens	var. purpurascens	Poir.	No	0	Yes
a	Poaceae	Aristida	purpurascens Poir.	var. tenuispica	(Hitchc.) Allred	No	0	Yes
a	Poaceae	Aristida	purpurascens Poir.	var. virgata	(Trin.) Allred	No	0	No
a	Poaceae	Aristida	spiciformis		Elliott	No	0	Yes
a	Poaceae	Aristida	stricta Michx.	var. beyrichiana	(Trin. & Rupr.) D. B. Ward	No	0	Yes
a	Poaceae	Arundinaria	gigantea		(Walter) Walter ex Muhl.	No	0	No
a	Poaceae	Arundo	donax		L.	Yes	0	Yes
a	Poaceae	Axonopus	fissifolius		(Raddi) Kuhlm.	No	0	Yes
a	Poaceae	Axonopus	furcatus		(Flugge) Hitchc.	No	0	Yes
a	Poaceae	Bambusa	multiplex		(Lour.) Raeusch.	Yes	0	No

					ex Schult. & Schult. f.			
a	Poaceae	Bambusa	vulgaris		Schrad. ex J. C. Wendl.	Yes	0	No
a	Poaceae	Bothriochloa	ischaemum (L.) Keng	var. songarica	(Rupr.) ex Fisch. & C. A. Mey.) Celarier & J. R. Harlan	Yes	0	Yes
a	Poaceae	Bothriochloa	pertusa		(L.) A. Camus	Yes	0	Yes
a	Poaceae	Calamovilfa	curtissii		(Vasey) Scribn.	No	1	Yes
a	Poaceae	Cenchrus	echinatus		L.	No	0	Yes
a	Poaceae	Cenchrus	spinifex		Cav.	No	0	Yes
a	Poaceae	Chasmanthium	laxum (L.) H. A. Yates	var. sessiliflorum	(Poir.) Wipff & S. D. Jones	No	0	Yes
a	Poaceae	Coelorachis	rugosa		(Nutt.) Nash	No	0	Yes
a	Poaceae	Cynodon	dactylon		(L.) Pers.	Yes	0	Yes
a	Poaceae	Dactyloctenium	aegyptium		(L.) Willd. ex Asch. & Schweinf.	Yes	0	Yes
a	Poaceae	Dichanthelium	aciculare		(Desv. ex Poir.) Gould & C. A. Clark	No	0	Yes
a	Poaceae	Dichanthelium	acuminatum		(Sw.) Gould & C. A. Clark	No	0	Yes
a	Poaceae	Dichanthelium	commutatum		(Schult.) Gould	No	0	Yes
a	Poaceae	Dichanthelium	dichotomum		(L.) Gould	No	0	Yes
a	Poaceae	Dichanthelium	ensifolium	var. ensifolium	(Baldwin ex Elliott) Gould	No	0	Yes
a	Poaceae	Dichanthelium	ensifolium (Baldwin ex Elliott) Gould	var. breve	(Hitchc. & Chase) B. F. Hansen & Wunderlin	No	1	Yes
a	Poaceae	Dichanthelium	ensifolium (Baldwin ex Elliott) Gould	var. unciphyllum	(Trin) B. F. Hansen & Wunderlin	No	0	No
a	Poaceae	Dichanthelium	laxiflorum		(Lam.) Gould	No	0	Yes
a	Poaceae	Dichanthelium	leucothrix		(Nash)	No	0	No

					Freckmann			
a	Poaceae	Dichanthelium	oligosanthes		(Schult.) Gould	No	0	Yes
a	Poaceae	Dichanthelium	ovale		(Elliott) Gould & C. A. Clark	No	0	No
a	Poaceae	Dichanthelium	portoricense		(Desv. ex Ham.) B. F. Hansen & Wunderlin	No	0	Yes
a	Poaceae	Dichanthelium	scabriusculum		(Elliott) Gould & C. A. Clark	No	0	Yes
a	Poaceae	Dichanthelium	scoparium		(Lam.) Gould	No	0	Yes
a	Poaceae	Dichanthelium	sphaerocarpon		(Elliott) Gould	No	0	Yes
a	Poaceae	Dichanthelium	strigosum (Muhl. ex Elliott) Freckmann	var. glabrescens	(Griseb.) Freckmann	No	0	No
a	Poaceae	Dichanthelium	strigosum (Muhl. ex Elliott) Freckmann	var. leucoblepharis	(Trin.) Freckmann	No	0	Yes
a	Poaceae	Digitaria	ciliaris		(Retz.) Koeler	No	0	Yes
a	Poaceae	Digitaria	filiformis		(L.) Koeler	No	0	Yes
a	Poaceae	Distichlis	spicata		(L.) Greene	No	0	Yes
a	Poaceae	Echinochloa	colona		(L.) Link	Yes	0	No
a	Poaceae	Echinochloa	crus-galli		(L.) P. Beauv.	Yes	0	No
a	Poaceae	Echinochloa	muricata		(P. Beauv.) Fernald	No	0	Yes
a	Poaceae	Echinochloa	walteri		(Pursh) A. Heller	No	0	Yes
a	Poaceae	Eleusine	indica		(L.) Gaertn.	Yes	0	Yes
a	Poaceae	Eragrostis	ciliaris		(L.) R. Br.	Yes	0	Yes
a	Poaceae	Eragrostis	elliottii		S. Watson	No	0	Yes
a	Poaceae	Eragrostis	hirsuta		(Michx.) Nees	No	0	Yes
a	Poaceae	Eragrostis	pectinacea	var. pectinacea	(Michx.) Nees ex Jedwabn.	No	0	No
a	Poaceae	Eragrostis	secundiflora J. Presl	subsp. oxylepis	(Torr.) S. D. Koch	No	0	Yes
a	Poaceae	Eragrostis	spectabilis		(Pursh) Steud.	No	0	Yes
a	Poaceae	Eragrostis	virginica		(Zuccagni) Steud.	No	0	No
a	Poaceae	Eremochloa	ophiuroides		(Munro) Hack.	Yes	0	Yes

a	Poaceae	Eriochloa	michauxii		(Poir.) Hitchc.	No	0	Yes
a	Poaceae	Eustachys	glauca		Chapm.	No	0	Yes
a	Poaceae	Eustachys	petraea		(Sw.) Desv.	No	0	Yes
a	Poaceae	Heteropogon	melanocarpus		(Elliott) Elliott ex Benth.	Yes	0	Yes
a	Poaceae	Imperata	cylindrica		(L.) P. Beauv.	Yes	0	Yes
a	Poaceae	Leersia	hexandra		Sw.	No	0	No
a	Poaceae	Leersia	virginica		Willd.	No	0	No
a	Poaceae	Leptochloa	fusca (L.) Kunth	subsp. fascicularis	(Lam.) N. Snow	No	0	Yes
a	Poaceae	Lolium	arundinaceum		(Schreb.) Darbysh.	Yes	0	Yes
a	Poaceae	Melinis	repens		(Willd.) Zizka	Yes	0	Yes
a	Poaceae	Monanthochloe	littoralis		Engelm.	No	0	Yes
a	Poaceae	Muhlenbergia	capillaris (Lam.) Trin.	var. filipes	(M. A. Curtis) Chapm. ex Beal	No	0	Yes
a	Poaceae	Oplismenus	hirtellus		(L.) P. Beauv.	No	0	Yes
a	Poaceae	Panicum	amarum		Elliott	No	0	Yes
a	Poaceae	Panicum	anceps		Michx.	No	0	Yes
a	Poaceae	Panicum	dichotomiflorum	var. dichotomiflorum	Michx.	No	0	No
a	Poaceae	Panicum	dichotomiflorum Michx.	var. bartowense	(Scribn. & Merr.) Fernald	No	0	Yes
a	Poaceae	Panicum	hemitomon		Schult.	No	0	Yes
a	Poaceae	Panicum	hians		Elliott	No	0	Yes
a	Poaceae	Panicum	longifolium		Torr.	No	0	Yes
a	Poaceae	Panicum	maximum		Jacq.	Yes	0	Yes
a	Poaceae	Panicum	repens		L.	Yes	0	Yes
a	Poaceae	Panicum	rigidulum		Bosc ex Nees	No	0	Yes
a	Poaceae	Panicum	tenerum		Beyr. ex Trin.	No	0	No
a	Poaceae	Panicum	verrucosum		Muhl.	No	0	Yes
a	Poaceae	Panicum	virgatum		L.	No	0	Yes
a	Poaceae	Paspalum	bifidum		(Bertol.) Nash	No	0	No
a	Poaceae	Paspalum	botterii		(E. Fourn.) Chase	No	0	No

a	Poaceae	Paspalum	caespitosum		Flugge	No	0	Yes
a	Poaceae	Paspalum	conjugatum		Bergius	No	0	Yes
a	Poaceae	Paspalum	floridanum		Michx.	No	0	Yes
a	Poaceae	Paspalum	laeve		Michx.	No	0	No
a	Poaceae	Paspalum	notatum Flugge	var. saurae	Parodi	Yes	0	Yes
a	Poaceae	Paspalum	plicatulum		Michx.	No	0	Yes
a	Poaceae	Paspalum	praecox		Walter	No	0	No
a	Poaceae	Paspalum	setaceum		Michx.	No	0	Yes
a	Poaceae	Paspalum	urvillei		Steud.	Yes	0	Yes
a	Poaceae	Paspalum	vaginatum		Sw.	No	0	Yes
a	Poaceae	Pennisetum	glaucum		(L.) R. Br.	Yes	0	Yes
a	Poaceae	Pennisetum	purpureum		Schumach.	Yes	0	Yes
a	Poaceae	Phragmites	australis		(Cav.) Trin. ex Steud.	No	0	Yes
a	Poaceae	Polypogon	monspeliensis		(L.) Desf.	Yes	0	Yes
a	Poaceae	Saccharum	giganteum		(Walter) Pers.	No	0	Yes
a	Poaceae	Sacciolepis	striata		(L.) Nash	No	0	Yes
a	Poaceae	Schizachyrium	sanguineum		(Retz.) Alston	No	0	Yes
a	Poaceae	Schizachyrium	scoparium		(Michx.) Nash	No	0	Yes
a	Poaceae	Setaria	corrugata		(Elliott) Schult.	No	0	Yes
a	Poaceae	Setaria	macrosperma		(Scribn. & Merr.) K. Schum.	No	0	Yes
a	Poaceae	Setaria	magna		Griseb.	No	0	Yes
a	Poaceae	Setaria	parviflora		(Poir.) Kerguelen	No	0	Yes
a	Poaceae	Sorghastrum	elliottii		(C. Mohr) Nash	No	0	No
a	Poaceae	Sorghastrum	secundum		(Elliott) Nash	No	0	Yes
a	Poaceae	Sorghum	bicolor	subsp. bicolor	(L.) Moench	Yes	0	No
a	Poaceae	Sorghum	halepense		(L.) Pers.	Yes	0	Yes
a	Poaceae	Spartina	alterniflora		Loisel.	No	0	Yes
a	Poaceae	Spartina	bakeri		Merr.	No	0	Yes
a	Poaceae	Spartina	cynosuroides		(L.) Roth	No	0	No
a	Poaceae	Spartina	patens		(Aiton) Muhl.	No	0	Yes
a	Poaceae	Spartina	spartinae		(Trin.) Merr. ex	No	0	Yes

					Hitchc.			
a	Poaceae	Sphenopholis	filiformis		(Chapm.) Scribn.	No	0	No
a	Poaceae	Sphenopholis	obtusata		(Michx.) Scribn.	No	0	Yes
a	Poaceae	Sporobolus	domingensis		(Trin.) Kunth	No	0	No
a	Poaceae	Sporobolus	floridanus		Chapm.	No	0	No
a	Poaceae	Sporobolus	indicus	var. indicus	(L.) R. Br.	Yes	0	Yes
a	Poaceae	Sporobolus	virginicus		(L.) Kunth	No	0	Yes
a	Poaceae	Stenotaphrum	secundatum		(Walter) Kuntze	No	0	Yes
a	Poaceae	Tridens	flavus (L.) Hitchc.	var. chapmanii	(Small) Shinners	No	0	Yes
a	Poaceae	Triplasis	purpurea		(Walter) Chapm.	No	0	Yes
a	Poaceae	Tripsacum	dactyloides		(L.) L.	No	0	Yes
a	Poaceae	Uniola	paniculata		L.	No	0	Yes
a	Poaceae	Urochloa	adspersa		(Trin.) R. D. Webster	No	0	Yes
a	Poaceae	Urochloa	distachya		(L.) T. Q. Nguyen	Yes	0	Yes
a	Poaceae	Urochloa	fusca (Sw.) B. F. Hansen & Wunderlin	var. reticulata	(Torr.) B. F. Hansen & Wunderlin	Yes	0	Yes
a	Poaceae	Urochloa	mutica		(Forssk.) T. Q. Nguyen	Yes	0	Yes
a	Poaceae	Zea	mays		L.	Yes	0	No
a	Poaceae	Zoysia	pacifica		(Goudswaard) M. Hotta & Kuroki	Yes	0	No
a	Polemoniaceae	Ipomopsis	rubra		(L.) Wherry	No	0	Yes
a	Polemoniaceae	Phlox	drummondii		Hook.	Yes	0	Yes
a	Polygalaceae	Polygala	balduinii		Nutt.	No	0	No
a	Polygalaceae	Polygala	cruciata		L.	No	0	Yes
a	Polygalaceae	Polygala	incarnata		L.	No	0	Yes
a	Polygalaceae	Polygala	lutea		L.	No	0	No
a	Polygalaceae	Polygala	nana		(Michx.) DC.	No	0	Yes
a	Polygalaceae	Polygala	polygama		Walter	No	0	No
a	Polygalaceae	Polygala	rugelii		Shuttlew. ex Chapm.	No	1	Yes

a	Polygalaceae	Polygala	setacea		Michx.	No	0	Yes
a	Polygalaceae	Polygala	violacea		Aubl.	No	0	Yes
a	Polygonaceae	Antigonon	leptopus		Hook. & Arn.	Yes	0	Yes
a	Polygonaceae	Coccoloba	diversifolia		Jacq.	No	0	No
a	Polygonaceae	Coccoloba	uvifera		(L.) L.	No	0	Yes
a	Polygonaceae	Polygonella	ciliata		Meisn.	No	1	No
a	Polygonaceae	Polygonella	gracilis		Meisn.	No	0	Yes
a	Polygonaceae	Polygonella	polygama	var. polygama	(Vent.) Engelm. & A. Gray	No	0	Yes
a	Polygonaceae	Polygonum	hirsutum		Walter	No	0	No
a	Polygonaceae	Polygonum	hydropiperoides		Michx.	No	0	Yes
a	Polygonaceae	Polygonum	persicaria		L.	Yes	0	No
a	Polygonaceae	Polygonum	punctatum		Elliott	No	0	Yes
a	Polygonaceae	Polygonum	scandens		L.	No	0	Yes
a	Polygonaceae	Polygonum	setaceum		Baldwin	No	0	No
a	Polygonaceae	Rumex	hastatulus		Baldwin	No	0	Yes
a	Polygonaceae	Rumex	pulcher		L.	Yes	0	No
a	Polygonaceae	Rumex	verticillatus		L.	No	0	Yes
a	Pontederiaceae	Eichhornia	crassipes		(Mart.) Solms	Yes	0	No
a	Pontederiaceae	Pontederia	cordata		L.	No	0	Yes
a	Portulacaceae	Portulaca	oleracea		L.	No	0	Yes
a	Portulacaceae	Portulaca	pilosa		L.	No	0	Yes
a	Proteaceae	Grevillea	robusta		A. Cunn.	Yes	0	Yes
a	Putranjivaceae	Drypetes	lateriflora		(Sw.) Krug & Urb.	No	0	No
a	Ranunculaceae	Clematis	baldwinii		Torr. & A. Gray	No	1	No
a	Ranunculaceae	Clematis	crispa		L.	No	0	No
a	Rhamnaceae	Berchemia	scandens		(Hill) K. Koch	No	0	Yes
a	Rhamnaceae	Colubrina	asiatica		(L.) Brongn.	Yes	0	Yes
a	Rhamnaceae	Krugiodendron	ferreum		(Vahl) Urb.	No	0	Yes
a	Rhamnaceae	Sageretia	minutiflora		(Michx.) C. Mohr	No	0	Yes
a	Rhizophoraceae	Rhizophora	mangle		L.	No	0	Yes
a	Rosaceae	Eriobotrya	japonica		(Thunb.) Lindl.	Yes	0	Yes

a	Rosaceae	Prunus	angustifolia		Marshall	No	0	Yes
a	Rosaceae	Prunus	caroliniana		(Mill.) Aiton	No	0	Yes
a	Rosaceae	Prunus	persica		(L.) Batsch	Yes	0	Yes
a	Rosaceae	Prunus	serotina		Ehrh.	No	0	Yes
a	Rosaceae	Pyrus	communis		L.	Yes	0	No
a	Rosaceae	Rubus	cuneifolius		Pursh	No	0	No
a	Rosaceae	Rubus	pensilvanicus		Poir.	No	0	Yes
a	Rosaceae	Rubus	trivialis		Michx.	No	0	Yes
a	Rubiaceae	Cephalanthus	occidentalis		L.	No	0	Yes
a	Rubiaceae	Chiococca	alba		(L.) Hitchc.	No	0	Yes
a	Rubiaceae	Diodia	teres		Walter	No	0	Yes
a	Rubiaceae	Diodia	virginiana		L.	No	0	Yes
a	Rubiaceae	Ernodea	littoralis		Sw.	No	0	No
a	Rubiaceae	Galium	hispidulum		Michx.	No	0	Yes
a	Rubiaceae	Galium	pilosum		Aiton	No	0	Yes
a	Rubiaceae	Galium	tinctorium		L.	No	0	Yes
a	Rubiaceae	Houstonia	procumbens		(J. F. Gmel.) Standl	No	0	Yes
a	Rubiaceae	Mitracarpus	hirtus		(L.) DC.	Yes	0	Yes
a	Rubiaceae	Morinda	royoc		L.	No	0	No
a	Rubiaceae	Oldenlandia	corymbosa		L.	Yes	0	Yes
a	Rubiaceae	Oldenlandia	uniflora		L.	No	0	Yes
a	Rubiaceae	Pentodon	pentandrus		(Schumach. & Thonn.) Vatke	No	0	Yes
a	Rubiaceae	Psychotria	nervosa		Sw.	No	0	Yes
a	Rubiaceae	Psychotria	sulzneri		Small	No	0	Yes
a	Rubiaceae	Randia	aculeata		L.	No	0	No
a	Rubiaceae	Richardia	brasiliensis		Gomes	Yes	0	Yes
a	Rubiaceae	Richardia	grandiflora		(Cham. & Schltdl.) Schult. & Schult. f.	Yes	0	Yes
a	Rubiaceae	Spermacoce	remota		Lam.	No	0	Yes
a	Rubiaceae	Spermacoce	verticillata		L.	Yes	0	Yes

a	Ruppiaceae	Ruppia	maritima		L.	No	0	Yes
a	Ruscaceae	Sansevieria	hyacinthoides		(L.) Druce	Yes	0	Yes
a	Rutaceae	Amyris	elemifera		L.	No	0	Yes
a	Rutaceae	Citrus	reticulata		Blanco	Yes	0	No
a	Rutaceae	Citrus	X aurantium		L.	Yes	0	Yes
a	Rutaceae	Zanthoxylum	clava-herculis		L.	No	0	Yes
a	Rutaceae	Zanthoxylum	fagara		(L.) Sarg.	No	0	Yes
a	Salicaceae	Salix	babylonica		L.	Yes	0	No
a	Salicaceae	Salix	caroliniana		Michx.	No	0	Yes
a	Samolaceae	Samolus	ebracteatus		Kunth	No	0	Yes
a	Samolaceae	Samolus	valerandi L.	subsp. parviflorus	(Raf.) Hulten	No	0	Yes
a	Sapindaceae	Acer	negundo		L.	No	0	No
a	Sapindaceae	Acer	rubrum		L.	No	0	Yes
a	Sapindaceae	Cardiospermum	microcarpum		Kunth	No	0	Yes
a	Sapindaceae	Dodonaea	viscosa		Jacq.	No	0	Yes
a	Sapindaceae	Exothea	paniculata		(Juss.) Radlk.	No	0	Yes
a	Sapindaceae	Koelreuteria	elegans (Seemann) A. C. Sm.	subsp. formosana	(Hayata) F. G. Mey.	Yes	0	No
a	Sapindaceae	Litchi	chinensis		Sonn.	Yes	0	No
a	Sapindaceae	Sapindus	saponaria		L.	No	0	No
a	Sapotaceae	Chrysophyllum	oliviforme		L.	No	0	Yes
a	Sapotaceae	Sideroxylon	foetidissimum		Jacq.	No	0	Yes
a	Sapotaceae	Sideroxylon	reclinatum		Michx.	No	0	Yes
a	Sapotaceae	Sideroxylon	tenax		L.	No	0	Yes
a	Schoepfiaceae	Schoepfia	chrysophylloides		(A. Rich.) Planch.	No	0	No
a	Simaroubaceae	Simarouba	glauca		DC.	No	0	No
a	Smilacaceae	Smilax	auriculata		Walter	No	0	Yes
a	Smilacaceae	Smilax	bona-nox		L.	No	0	Yes
a	Smilacaceae	Smilax	glauca		Walter	No	0	No
a	Smilacaceae	Smilax	laurifolia		L.	No	0	Yes
a	Smilacaceae	Smilax	tamnoides		L.	No	0	Yes

a	Solanaceae	Capsicum	annuum L.	var. glabriusculum	(Dunal) Heiser & Pickersgill	No	0	No
a	Solanaceae	Capsicum	frutescens		L.	No	0	Yes
a	Solanaceae	Cestrum	nocturnum		L.	Yes	0	No
a	Solanaceae	Lycium	carolinianum		Walter	No	0	Yes
a	Solanaceae	Physalis	pubescens		L.	No	0	No
a	Solanaceae	Physalis	walteri		Nutt.	No	0	Yes
a	Solanaceae	Solanum	americanum		Mill.	No	0	Yes
a	Solanaceae	Solanum	chenopodioides		Lam.	No	0	Yes
a	Solanaceae	Solanum	erianthum		D. Don	No	0	Yes
a	Solanaceae	Solanum	seaforthianum		Jacks.	Yes	0	No
a	Surianaceae	Suriana	maritima		L.	No	0	No
a	Tetrachondraceae	Polypremum	procumbens		L.	No	0	Yes
a	Turneraceae	Piriqueta	cistoides (L.) Griseb.	subsp. caroliniana	(Walter) Arbo.	No	0	Yes
a	Typhaceae	Typha	domingensis		Pers.	No	0	Yes
a	Typhaceae	Typha	latifolia		L.	No	0	Yes
a	Ulmaceae	Ulmus	americana		L.	No	0	Yes
a	Urticaceae	Boehmeria	cylindrica		(L.) Sw.	No	0	Yes
a	Urticaceae	Parietaria	floridana		Nutt.	No	0	Yes
a	Urticaceae	Parietaria	praetermissa		Hinton	No	0	Yes
a	Verbenaceae	Citharexylum	spinosum		L.	No	0	No
a	Verbenaceae	Glandularia	maritima		(Small) Small	No	1	Yes
a	Verbenaceae	Glandularia	tampensis		(Nash) Small	No	1	No
a	Verbenaceae	Lantana	camara		L.	Yes	0	Yes
a	Verbenaceae	Lantana	depressa Small	var. floridana	(Moldenke) R. W. Sanders	No	1	Yes
a	Verbenaceae	Lantana	involucrata		L.	No	0	No
a	Verbenaceae	Lantana	montevidensis		(Spreng.) Briq.	Yes	0	No
a	Verbenaceae	Phyla	nodiflora		(L.) Greene	No	0	Yes
a	Verbenaceae	Verbena	scabra		Vahl	No	0	Yes
a	Violaceae	Viola	lanceolata		L.	No	0	No
a	Violaceae	Viola	primulifolia		L.	No	0	Yes

a	Violaceae	Viola	sororia		Willd.	No	0	Yes
a	Viscaceae	Phoradendron	leucarpum		(Raf.) Reveal & M. C. Johnst.	No	0	Yes
a	Vitaceae	Ampelopsis	arborea		(L.) Koehne	No	0	Yes
a	Vitaceae	Cissus	trifoliata		(L.) L.	No	0	Yes
a	Vitaceae	Parthenocissus	quinquefolia		(L.) Planch.	No	0	Yes
a	Vitaceae	Vitis	aestivalis		Michx.	No	0	Yes
a	Vitaceae	Vitis	rotundifolia		Michx.	No	0	Yes
a	Vitaceae	Vitis	shuttleworthii		House	No	0	Yes
a	Ximeniaceae	Ximenia	americana		L.	No	0	Yes
a	Xyridaceae	Xyris	brevifolia		Michx.	No	0	Yes
a	Xyridaceae	Xyris	caroliniana		Walter	No	0	Yes
a	Xyridaceae	Xyris	elliottii		Chapm.	No	0	Yes
a	Xyridaceae	Xyris	fimbriata		Elliott	No	0	Yes
a	Xyridaceae	Xyris	flabelliformis		Kral	No	0	Yes
a	Xyridaceae	Xyris	jupicai		Rich.	No	0	Yes
a	Xyridaceae	Xyris	platylepis		Chapm.	No	0	Yes
a	Xyridaceae	Xyris	smalliana		Nash	No	0	Yes
a	Zingiberaceae	Alpinia	zerumbet		(Pers.) B. L. Burtt & R. M. Sm.	Yes	0	No
a	Zygophyllaceae	Tribulus	cistoides		L.	Yes	0	No
a	Zygophyllaceae	Tribulus	terrestris		L.	Yes	0	No

Table D-2. Plants endemic or nearly endemic to Florida occurring in the Kennedy Space Center area flora.

Gymnosperms

Pinaceae
Pinus clausa (Chapm. ex Engelm.) Vasey ex Sarg.
Pinus elliottii Engelm. var. *densa* Little & Dorman

Angiosperms

Agavaceae
Agave decipiens Baker

Amaryllidaceae
Hymenocallis palmeri S. Wats.

Annonaceae
Asimina obovata (Willd.) Nash
Asimina reticulata Shuttlew. ex Chapm.

Apocynaceae
Asclepias curtissii A. Gray

Asteraceae
Arnoglossum floridana (A. Gray) H. Rob.
Berlandiera subacaulis (Nutt.) Nutt.
Carphephorus odoratissimus (J.F. Gmel.) H. Hebert var. *subtropicanus* (Delaney et al.) Wunderlin & B.F. Hansen
Chrysopsis linearifolia Semple subsp. *dressii* Semple
Chrysopsis subulata Small
Coreopsis floridana E.B. Sm.
Coreopsis leavenworthii T. & G.
Eupatorium mikanioides Chapm.
Helianthus debilis Nutt. subsp. *debilis*
Hieracium megacephalum Nash
Liatris tenuifolia Nutt. var. *quadrifolia* Chapm.
Palafoxia feayi A. Gray
Palafoxia integrifolia (Nutt.) T. & G.
Phoebanthus grandiflora (T. & G.) Blake
Pluchea longifolia Nash
Solidago odora Ait. var. *chapmanii* (A. Gray) Cronq.
Symphyotrichum simmondsii (Small) G.L. Nesom

Brassicaceae
*Nasturtium floridana (*Al-Shehbaz & Rollins) Al-Shehbaz & R. A. Price

Bromeliaceae
Tillandsia simulata Small

Cactaceae
Harrisa fragrans Small ex Britton & Rose

Campanulaceae
Campanula floridana S. Wats. ex A. Gray
Lobelia feayana A. Gray

Cistaceae
Helianthemum nashii Britt.
Lechea cernua Small
Lechea divaricata Shuttlew. ex Britton

Commelinaceae
Callisia ornata (Small) G.C. Tucker

Cyperaceae
Rhynchospora intermedia (Chapm.) Britt.

Euphobiaceae
Chamaesyce cumulicola Small
Euphorbia polyphylla Engelm. ex Chapm.

Fabaceae
Dalea pinnata (J.F. Gmel.) Barneby var. *adenopoda* (Rydb.) Barneby
Rhynchosia cinerea Nash
Tephrosia angustissima Shuttlew. ex Chapm. var. *curtissii* (Small ex Rydb.) Isely
Vicia floridana S. Wats.

Iridaceae
Nemastylis floridana Small
Sisyrinchium xerophyllum Greene

Juglandaceae
Carya floridana Sarg.

Lamiaceae
Piloblephis rigida (Batr. ex Benth.) Raf.

Lauraceae
Persea borbonia (L.) Spreng. var. *humilis* (Nash) Koop

Melanthiaceae
Schoenocaulon dubium (Michx.) Small

Plantaginaceae
Mecardonia acuminata (Walter) Small subsp. *peninsularis* (Pennell) Rossow
Micranthemum glomeratum (Chapm.) Shinners

Poaceae
Andropogon brachystachyus Chapm.
Andropogon floridanus Scribn.
Aristida patula Chapm. ex Nash
Calamovilfa curtissii (Vasey) Scribn.
Dicanthelium ensifolium (Bald. ex Ell.) Gould var. *breve* (Hitchc. & Chase) Hansen & Wunderlin

Polygalaceae
Polygala rugelii Shuttlew. ex Chapm.

Polygonaceae
Polygonella ciliata Meisn.

Ranunculaceae
Clematis baldwinii T. & G.

Verbenaceae
Glandularia maritima (Small) Small
Glandularia tampensis (Nash) Small
Lantana depressa Small var. *floridana* (Moldenke) R.W. Sanders

Table D-3. Introduced plants in the Kennedy Space Center area flora. Status of invasive exotic plants is indicated following Florida Exotic Pest Plant Council (EPPC) Category I (CI) and Category II (CII) classifications.

Pteriodophytes

Nephrolepidaceae
Nephrolepis cordifolia (L.) Presl EPPC-CI

Pteridaceae
Ceratopteris thalictroides (L.) Brongn.

Salviniaceae
Salvinia minima Baker EPPC-CI

Schizaeaceae
Lygodium microphyllum (Cav.) R. Br. EPPC-CI

Thelypteridaceae
Macrothelypteris torresiana (Gaudich.) Ching
Thelypteris dentata (Forssk.) E.P. St. John

Gymnosperms

Cycadaceae
Cycas revoluta Thunb.

Podocarpaceae
Podocarpus macrophyllus D. Don .
Podocarpus nagi Makino

Angiosperms

Acanthaceae
Asystasia gangetica (L.) T. Anderson EPPC-CII
Justicia brandegeeana Wassh. & L.B. Smith
Odontonema cuspidatum (Nees) Kuntz
Ruellia simplex C. Wright. EPPC-CI
Thunbergia alata Bojer ex Sims
Thunbergia fragrans Roxb.

Agavaceae
Agave sisalana Perrine EPPC-CII

Amaranthaceae
Alternanthera philoxeroides (Mart.) Griesb. EPPC-CII

Amaranthus hybridus L.
Amaranthus spinosus L.
Chenopodium album L.
Chenopodium ambrosioides L.
Gomphrena serrata L.
Salsola kali L. subsp. *pontica* (Pall.) Mosyakin

Amaryllidaceae
Crinum zeylanicum (L.) L.

Anacardiaceae
Mangifera indica L.
Schinus terebinthifolia Raddi EPPC-CI

Apiaceae
Cyclospermum leptophyllum (Pers.) Sprague ex Britton & WIlson

Apocynaceae
Allamanda cathartica L.
Carissa macrocarpa (Eckl.) A. DC.
Catharanthus roseus (L.) G. Don
Morrenia odorata (Hook. & Arn.) Lindl.
Nerium oleander L.
Tabernaemontana divaricata (L.) R. Br. ex Roem. & Schult.
Thevetia peruviana (Pers.) Schum.
Vinca minor L.

Araceae
Colocasia esculenta (L.) Schott EPPC-CI
Landoltia punctata (G. Mey.) Les & D.J. Crawford
Pistia stratiotes L. EPPC-CI
Syngonium podophyllum Schott EPPC-CI

Araliaceae
Tetrapanax papyriferus (Hook.) K. Koch

Arecaceae
Cocos nucifera L. EPPC-CII
Phoenix canariensis Chabaud
Phoenix dactylifera L.
Phoenix reclinata Jacq. EPPC-CII
Phoenix sylvestris Roxb.
Syagrus romanzoffiana (Cham.) Glassman EPPC-CII
Washingtonia robusta Wendl. EPPC-CII

Aristolochiaceae
Aristolochia littoralis Parodi EPPC-CII

Asparagaceae
Asparagus aethiopicus L. EPPC-CI`
Asparagus setaceus (Kunth) Jessop

Asteraceae
Calyptocarpus vialis Lees.
Emilia fosbergii Nichols.
Helianthus annuus L.
Pseudogynoxys chenopodioides (Kunth) Cabrera
Sonchus asper (L.) Hill
Sonchus oleraceus L.
Sphagneticola trilobata (L.) Pruski EPPC-CII
Tridax procumbens L.
Youngia japonica (L.) DC.

Bignoniaceae
Jacaranda mimosifolia D. Don
Kigelia africana (Lam.) Benth.
Podranea ricasoliana (Tanfani) Sprague
Pyrostegia venusta (Ker-Gaw.) Miers.
Spathodea campanulata Beauv.
Tecoma capensis (Thunb.) Lindl.
Tecoma stans (L.) Juss. ex Kunth

Brassicaceae
Raphanus raphanistrum L.

Buddlejaceae
Buddleja madagascariensis Lam.

Cactaceae
Hylocereus undatus (Haw.) Britton & Rose
Opuntia cochenillifera (L.) Mill.
Pereskia aculeata Mill.
Selenicereus pteranthus (Link & Otto) Britton & Rose

Cannaceae
Canna x generalis Bailey

Caprifoliaceae
Lonicera japonica Thunb. EPPC-CI

Caricaceae
Carica papaya L.

Caryophyllaceae
Drymaria cordata (L.) Willd. ex Schult.
Stellaria media (L.) Vill.

Casuarinaceae
Casuarina cunninghamiana Miq. EPPC-CII
Casuarina equisetifolia L. EPPC-CI
Casuarina glauca Sieb. ex Spreng. EPPC-CI

Ceratophtllaceae
Ceratophyllum muricatum Cham.

Combretaceae
Quisqualis indica L.

Commelinaceae
Commelina benghalensis L.
Commelina diffusa Burm. f. var. *diffusa*
Murdannia nudiflora (L.) Brenan
Tradescantia zebrina Bosse.

Convolvulaceae
Ipomoea cairica (L.) Sweet
Ipomoea hederacea Jacq.
Ipomoea purpurea (L.) Roth.
Merremia dissecta (Jacq.) Hall. f.

Crassulaceae
Kalanchoe daigremontiana Ham. & Perr.
Kalonchoe delagoensis Eckl. & Zeyh.
Kalanchoe fedtschenkoi Ham. & Perr.
Kalanchoe pinnata (Lam.) Pers. EPPC-CII

Cucurbitaceae
Citrullus lanatus (Thunb.) Mats. & Nakai.
Momordica charantia L. EPPC-CII

Cyperaceae
Bulbostylis barbata (Rottb.) Clarke
Cyperus esculentus L.
Kyllinga brevifolia Rottb.

Dioscoreaceae
Dioscorea bulbifera L. EPPC-CI

Ebenaceae
Diospyros kaki L. f.

Euphorbiaceae
Jatropha curcas L.
Ricinus communis L. EPPC-CII
Sapium sebiferum (L.) Roxb. EPPC-CI

Fabaceae
Abrus precatorius L. EPPC-CI
Albizia julibrissin Durazz. EPPC-CI
Albizia lebbeck (L.) Benth. EPPC-CI
Alysicarpus ovalifolius (Shum. & Thonn.) J. Leonard
Bauhinia variegata L. EPPC-CI
Calliandra haematocephala Hassk.
Crotalaria lanceolata E. Mey.
Crotalaria pallida Aiton var. *obovata* (G. Don) Polhill
Crotalaria retusa L.
Crotalaria spectabilis Roth
Desmodium incanum DC.
Desmodium tortuosum (Sw.) DC.
Desmodium triflorum (L.) DC.
Enterolobium contortisiliquum (Vell.) Morong
Indigofera hirsuta L.
Indigofera spicata Forssk.
Indigofera suffruticosa Mill.
Kummerowia striata (Thunb.) Schindler
Leucaena leucocephala (Lam.) de Wit. var. *leucocephala* EPPC-CII
Macroptilium atropurpureum (Moc. & Sesse ex DC.) Urban
Macroptilium lathyroides (L.) Urban EPPC-CII
Medicago lupulina L.
Melilotus albus Medik.
Melilotus indicus (L.) All.
Parkinsonia aculeata L.
Phaseolus vulgaris L.
Pueraria montana (Lour.) Merr. var. *lobata* (Willd.) Maesen & S.M. Almeida EPPC-CI
Senna alata (L.) Roxb.
Senna obtusifolia (L.) H.S. Irwin & Barneby
Senna occidentalis (L.) Link
Senna pendula (Humb. & Bonpl. ex Willd.) H.S. Irwin & Barneby var. *glabrata* (Vogel) H.S. Irwin & Barneby EPPC-CI
Sesbania punicea (Cav.) Benth. EPPC-CII
Stylosanthes hamata (L.) Taub.

Trifolium repens L.
Wisteria sinensis (Sims) Sweet EPPC-CII

Geraniaceae
Pelargonium hortorum Bailey

Goodeniaceae
Scaevola taccada (Gaertn.) Roxb. var. *sericea* (Vahl) H. St. John EPPC-CI

Iridaceae
Gladiolus x gandavensis Van Houtte

Juglandaceae
Carya illinoinensis (Wang.) K. Koch

Lamiaceae
Clerodendrum indicum (L.) Kuntze
Clerodendrum xspeciosum Dombrain
Hyptis mutabilis (A. Rich.) Briq.
Mentha sp.
Prunella vulgaris L.
Vitex trifolia L. EPPC-CII

Lauraceae
Cinnamonum camphora (L.) J. Presl EPPC-CI
Persea americana Mill.

Liliaceae
Lilium longiflorum Thunb.

Lythraceae
Lagerstroemia indica L.

Malvaceae
Dombeya wallichii (Lindl.) Benth. & Hook. ex K. Schum.
Hibiscus rosa-sinensis L.
Hibiscus rosa-sinensis L. var. *schizopetalus* Dyer.
Malvastrum coromandelianum (L.) Garcke
Malvaviscus arboreus Cav. var. *drummondii* (Torr. & A. Gray) Schery
Sida cordifolia L.
Talipariti tiliaceum (L.) Fryxell EPPC-CII
Urena lobata L. EPPC-CI

Meliaceae
Melia azedarach L. EPPC-CII

Molluginaceae
Mollugo verticillata L.

Moraceae
Broussonetia papyrifera (L.) Vent. EPPC-CII
Ficus carica L.
Ficus elastica Roxb.
Maclura pomifera (Raf.) Schneid.
Morus alba L.

Musaceae
Musa x paradisiaca L.

Myrtaceae
Eucalyptus robusta Smith
Eugenia uniflora L. EPPC-CI
Melaleuca quinquenervia (Cav.) Blake EPPC-CI
Psidium cattleianum Sabine EPPC-CI
Psidium guajava L. EPPC-CI
Syzygium cumini (L.) Skeels EPPC-CI
Syzygium jambos (L.) Alston EPPC-CII

Nyctaginaceae
Bouganvillea glabra Choisy
Mirabilis jalapa L.

Nymphaeaceae
Nymphaea capensis Thunb. var. zanzibariensis (Casp.) Conrad

Oleaceae
Jasminum sambac (L.) Aiton
Ligustrum japonicum Thunb.
Olea europeae L.

Onagraceae
Ludwigia peruviana (L.) Hara EPPC-CI

Orchidaceae
Zeuxine strateumatica (L.) Schltr.

Oxalidaceae
Oxalis violacea L.

Phyllanthaceae
Agdestis clematidea Moc. & Sesse. ex DC.
Phyllanthus tenellus Roxb.

Plantaginaceae
Plantago lanceolata L.
Russellia equisetiformis Schlecht. & Cham.

Plumbaginaceae
Plumbago auriculata Lam.

Poaceae
Arundo donax L.
Bambusa multiplex (Lour.) Raeusch. ex Schult. & Schult. f.
Bambusa vulgaris Schrad. ex J.C. Wendl.
Bothriochloa ischaemum (L.) Keng var. *songarica* (Rupr. ex Fisch & C.A. Mey.) Celarier & J.R. Harlan
Bothriochloa pertusa (L.) A. Camus
Cynodon dactylon (L.) Pers.
Dactyloctenium aegyptium (L.) Willd. ex Asch. & Schweinf. EPPC-CII
Echinochloa colona (L.) Link
Echinochloa crus-galli (L.) P. Beauv.
Eleusine indica (L.) Gaertn.
Eragrostis ciliaris (L.) R. Br.
Eremochloa ophiuroides (Munro) Hack.
Heteropogon melanocarpus (Elliott) Elliott ex Benth.
Imperata cylindrica (L.) Beauv. EPPC-CI
Lolium arundinaceum (Schreb.) Darbysh.
Melinis repens (Willd.) Zizka. EPPC-CI
Panicum maximum Jacq. EPPC-CII
Panicum repens L. EPPC-CI
Paspalum notatum Fluegge var. *saurae* Parodi
Paspalum urvillei Steud.
Pennisetum glaucum (L.) R. Br.
Pennisetum purpureum Schum. EPPC-CI
Polypogon monspeliensis (L.) Desf.
Sorghum bicolor (L.) Moench subsp. *bicolor*
Sorghum halepense (L.) Pers.
Sporobolus indicus (L.) R. Br.
Urochloa distachya (L.) T.Q. Nguyen
Urochloa fusca (Sw.) B.F. Hansen & Wunderlin var. *reticulata* (Torr.) B.F. Hansen & Wunderlin
Urochloa mutica (Forssk.) T.Q. Nguyen EPPC-CI
Zea mays L.
Zoysia pacifica (Goudswaard) M. Hotta & Kuroki

Polemoniaceae
Phlox drummondii Hook.

Polygonaceae
Antigonon leptopus Hook. & Arn. EPPC-CII
Polygonum persicaria L.
Rumex pulcher L.

Pontederiaceae
Eichhornia crassipes (Mart.) Solms EPPC-CI

Proteaceae
Grevillea robusta A. Cunn.

Rhamnaceae
Colubrina asiatica (L.) Brongn. EPPC-CI

Rosaceae
Eriobotrya japonica (Thunb.) Lindl.
Prunus persica (L.) Batsch
Pyrus communis L.

Rubiaceae
Mitracarpus hirtus (L.) DC.
Oldenlandia corymbosa L.
Richardia brasiliensis Gomes
Richardia grandiflora (Cham. & Schltdl.) Schult. & Schult. f. EPPC-CII
Spermacoce verticillata L.

Ruscaceae
Sansevieria hyacinthoides (L.) Druce EPPC-CII

Rutaceae
Citrus x aurantium L.
Citrus reticulata Blanco

Salicaceae
Salix babylonica L.

Sapindaceae
Koelreuteria elegans (Seemann) A.C. Sm. subsp. *formosana* (Hayata) F. G. Mey.
EPPC-CII
Litchi chinensis Sonn.

Solanaceae
Cestrum nocturnum L.
Solanum seaforthianum Jacks.

Verbenaceae
Lantana camara L. EPPC-CI
Lantana montevidensis (Spreng.) Briq.

Zingiberaceae
Alpinia zerumbet (Pers.) B.L. Burtt & R.M. Sm.

Zygophyllaceae
Tribulus cistoides L. EPPC-CII
Tribulus terrestris L.

Table D-4. Bryophytes of the Kennedy Space Center area (Whittier and Miller 1975).

Musci

Amblystegium serpens (Hedw.) B.S.G. var. *juratzkanum* (Schimp.) Ren. & Card.
Amblystegium varium (Hedw.) Lindb.
Anomodon rostratus (Hedw.) Schimp.
Barbula cruegeri Sond. ex C. Muell.
Brachmenium ?systylium (C. Meull.) Jaeg. & Sauerb.
Bryum argenteum Hedw.
Bryum ?capillare Hedw.
Desmatodon sprengeli (Schw.) Williams
Entodon macropodus (Hedw.) C. Meull.
Fissidens garberi Lesq. & James
Forsstroemia trichomitria (Hedw.) Lindb.
Haplocladium microphyllum (Hedw.) Broth.
Isopterygium micans (Sw.) Broth.
Leptodictyum riparium (Hedw.) Warnst ssp. *sipho* (P. Beauv.) Grout.
Leucobryum albidum (P. Beauv.) Lindb.
Octoblepharum albidum Hedw.
Oxyrrhynchium hians (Hedw.) Loesk.
Papillaria nigrescens (Hedw.) Jaeg. & Sauerb.
Rhynchostegium serrulatum (Hedw.) Jaeg.
Sematophyllum adanatum (Michx.) E.G. Britt.
Sphagnum strictum Sull.
Syrrhopodon texanus Sull.
Thuidium recognitum (Hedw.) Lindb. var. *delicatulum* (Hedw.) Warnst

Hepaticae and Anthocerotae

Anthoceros carolinianus Michx.
Cololejeunea cardiocarpa (Mont.) Steph.
Frullania kunzei (Lehm. & Lindenb.) Lehm. & Lindenb.
Frullania squarrosa (R.B.N.) Nees
Lejeunea cf. cladogyna Evans
Lejeunea flava (Sw.) Evans
Lejeunea floridana Evans
Lejeunea laetevirens Nees & Mont.
Lejeunea minutiloba Evans
Lophocolea martiana Nees
Microlejeunea ulicina (Tayl.) Evans ssp. *bullata* (Tayl.) Schust.
Odontoschisma denundatum (Nees) Dum.
Odontoschisma prostratum (Sw.) Trev.
Pallavicinia lyelli (Hook.) S.F. Gray
Radula australis Aust.
Radula obconica Sull.

Hepaticae and Anthocerotae

Rectolejeunea maxonii Evans
Riccardia multifida (L.) S.F. Gray
Riccia aff. fluitans L.
Telaranea nematodes (Aust.) Howe