KSC-PLN-1911
REVISION E

ENVIRONMENTAL RESOURCES DOCUMENT

MARCH 2010

National Aeronautics and
Space Administration
John F. Kennedy Space Center

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Environmental Resources Document

(KSC-PLN-1911/Revision E, dated March 2010)

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 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

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Insert latest changes; destroy superseded pages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

Table of Contents

List of Tables

List of Illustrations

Abbreviations/Acronyms

^{o}C	Degrees Celsius
^{o}F	Degree Fahrenheit
45SW	45th Space Wing/Patrick Air Force Base
Ac	Acre
ACHP	Advisory Council on Historic Preservation
ACI	Archaeological Consultants, Inc.
ACM	Asbestos Containing Material
ADP	Area Development Plans
AET	Actual Evapotranspiration
AF	Air Force
Ag	Silver
Al	Aluminum
Al_2O_3	Aluminum oxide
ABC	American Broadcasting Company
a.m.	Ante Meridian
AOC	Areas of Concern
AP	Associated Press
ARPA	Archaeological Resources Protection Act
AS	Artifact Scatters
As	Arsenic
AST	Aboveground Storage Tank
Ba	Barium
BCC	Brevard Community College
BCMCD	Brevard County Mosquito Control District
BCNRMO	Brevard County Natural Resources Management Office
Be	Beryllium
BOD	Biochemical Oxygen Demand
BTU	British Thermal Units
Ca	Calcium
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CBS	Columbia Broadcasting System
CCAFS	Cape Canaveral Air Force Station

Abbreviations/Acronyms (cont.)	
CCF	Components Cleaning Facility or Corrosion Control Facility
Cd	Cadmium
cDCE	cis-1,2-dichloroethene
CDP	Census Designated Place
CEM	Cemeteries
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQ	Council on Environmental Quality
CEV	Crew Exploration Vehicle
CFC	Combined Federal Campaign
CFR	Code of Federal Regulations
CG	Cloud to Ground
CIF	Central Instrumentation Facility
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
Cl, Cl_2	Chlorine
CLV	Crew Launch Vehicle
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
CO_2	Carbon dioxide
CPG	Comprehensive Procurement Guideline
CPUE	Catch per unit effort
Cr	Chromium
CRCA	Component Refurbishment and Chemical Analysis
CRF	Canister Rotation Facility
CRMP	Cultural Resources Management Plan
CS	Confirmatory Sampling
Cu	Copper

Abbreviations/Acronyms (cont.)	
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
DEM	Digital Elevation Model
DESC	Defense Energy Support Center
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
EHS	Extremely Hazardous Substances
EIS	Environmental Impact Statement
ELV	Expendable Launch Vehicles
EMB	Environmental Management Branch
EMS	Environmental Management System
ENSO	El Nino Southern Oscillation
EO	Executive Order
EPA	Environmental Protection Agency

Abbreviations/Acronyms (cont.)	
EPCRA	Emergency Planning and Community Right to Know Act
EPNdBA	Effective Perceived Noise Level
EPPC	Exotic Pest Plant Council
ERD	Environmental Resources Document
ERP	Environmental Resource Permit
ET	External Tank
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
FDAC	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
Fe	Iron
FEC	Florida East Coast
FFDCA	Federal Food, Drug, and Cosmetics Act
FEMA	Federal Emergency Management Agency
FFWCC	Florida Fish and Wildlife Conservation Commission
FGFWFC	Florida Game and Fresh Water Fish Commission
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FIRM	Flood Insurance Rate Maps
FLUCCS	Florida Land Use Cover and Forms Classification System
FM	Fathoms
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
FR	Federal Register
F.S.	Florida Statutes
FSA	Fuel Storage Area
FSS	Fixed Service Structure
ft	Feet
ft/day	Feet per day
FWPCA	Federal Water Pollution Control Act
FY	Fiscal Year
g-cal	Gram-calorie
gal	Gallon
GC/MS	Gas Chromatography/Mass Spectroscopy
GH_2	Gaseous hydrogen
GN_2	Gaseous nitrogen
GIS	Geographic Information System
GO	Governor's Office
GO_2	Gaseous oxygen
GPD	Gallons per day
GPD/ft	Gallons per day per foot
gpm	Gallons per minute
GCTL	Groundwater Cleanup Target Level
GSA	General Services Administration
GSFC	Goddard Space Flight Center
Ha	Hectare
HAP	Hazardous Air Pollutants
HCFC	Hydrochlorofluorocarbons
H_2	Hydrogen
H_2O	Water
H_2S	Hydrogen sulfide
HC	Hydrocarbons
HCl	Hydrogen Chloride
HD	Historic District
Hg	Mercury

Abbreviations/Acronyms (cont.)	
HMCA	Hypergolic Maintenance Checkout Area
HMF	Hypergol Maintenance Facility
HMTA	Hazardous Materials Transportation Act
HPO	Historic Preservation Officer
HQ	Headquarters
Hr	Hour
HSWA	Hazardous and Solid Waste Amendments
HVAC	Heating, Ventilation and Air Conditioning
IE	Individually Eligible
In	Inches
INSPIRE	Interdisciplinary National Science Project Incorporating Research and Education Experience
IRL	Indian River Lagoon
ISS	International Space Station
IWW	Industrial Wastewater
J	Joule
JP	Jet Propellant
JTU	Jackson Turbidity Units
K	Potassium
KARS	Kennedy Athletic, Recreational and Social Organization
KDP	Kennedy Documented Procedures
kg	Kilogram
KHB	Kennedy Handbook
kl	Kiloliter
KMI	Kennedy Management Instruction
km	Kilometer
km^2	Square kilometer
KNPR	Kennedy NASA Procedural Requirements
KSC	Kennedy Space Center
Kts	Knots
KV	Kilovolt
L	Liter
Lb	Pound

Abbreviations/Acronyms (cont.)	
lbs/hr	Pounds per hour
LC	Launch Complex
LCC	Launch Control Center
LEPC	Local Emergency Planning Committee
LETF	Launch Equipment Test Facility
LH_2	Liquid hydrogen
LN_2	Liquid nitrogen
LOC	Launch Operations Center
LOD	Launch Operations Directorate
LOX	Liquid Oxygen
LS	Lithic Scatters
LUC	Land Use Controls
LUCIP	Land Use Control Implementation Plan
LUT	Launch Umbilical Tower
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

Abbreviations/Acronyms (cont.)	
MLP	Mobile Launcher Platform
mm	Millimeter
MMBtu/hr	Million British Thermal Units per hour
MMH	Monomethyl Hydrazine
Mn	Manganese
MNA	Monitored Natural Attenuation
MOA	Memorandum of Agreement
MOSB	Multi-Operation Support Building
MS4s	Municipal Separate Storm Sewer Systems
MSBLS	Microwave Scanning Beam Landing System
MSDS	Material Safety Data Sheets
MSL	Mean sea level
MSS	Mobile Service Structure
MSFC	Marshall Space Flight Center
m.t.	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

Abbreviations/Acronyms (cont.)	
Ni	Nickel
NMFS	National Marine Fisheries Service
NMI	NASA Management Instruction
No.	Number
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxides
NOTU	Naval Ordnance Test Unit
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
OSB	Operations Support Building
OSHA	Occupational Safety and Health Administration
OZ	Ounce
P2	Pollution Prevention
pH	Measure of Acidity (Log of Hydrogen Ions)
PAFB	Patrick Air Force Base
PAH	Polyaromatic Hydrocarbons

Abbreviations/Acronyms (cont.)	
PAMS	Permanent Air Monitoring System
Pb	Lead
PCB	Polychlorinated Biphenyls
PCR	Payload Changeout Room
PET	Potential Evapotranspiration
PGOC	Payload Ground Operations Contract
PHSF	Payload Hazardous Servicing Facility
PIR	Pollution Incident Report
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
PRF	Parachute Refurbishment Facility
PRL	Potential Release Location
PSD	Prevention of Significant Deterioration
psf	Pound(s) per square foot
PSM	Process Safety Management
PTE	Potential to Emit
QD	Quality Distance
Qt	Quart
RACM	Regulated Asbestos Containing Material
RADL	Robotics Applications Development Laboratory
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

Abbreviations/Acronyms (cont.)	
RHA	Rivers and Harbors Act of 1899
RMP	Risk Management Program
ROD	Record of Decision
RP	Rocket Propellant
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
Sb	Antimony
SDWA	Safe Drinking Water Act
Se	Selenium
SE	Southeast
SERC	State Emergency Response Commission
SFOC	Shuttle Facility Operations Contract
SGS	Space Gateway Support
SHPO	State Historic Preservation Officer
SIC	Standard Industrial Classification
SIP	State Implementation Plan
SJRWMD	St. Johns River Water Management District
SLF	Shuttle Landing Facility
SLSL	Space Life Sciences Laboratory
SNAP	Significant New Alternatives Policy
SO_2	Sulfur dioxide
SPC	Shuttle Processing Contract
SPCC	Spill Prevention, Control and Countermeasure 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

Abbreviations/Acronyms (cont.)	
SSPF	Space Station Processing Facility
STDN	Spaceflight Tracking and Data Network
STP	Sewage (Wastewater) Treatment Plant
STS	Space Transportation System
SWCTL	Surface Water Cleanup Target Levels
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
TDS	Total Dissolved Solids
Temp	Temperature
Ti	Titanium
TKN	Total Kjeldahl Nitrogen
TRI	Toxic Release Inventory
TRMM	Tropical Rainfall Mesoscale Monitoring
TPS	Thermal Protection System
TPSF	Thermal Protection System Facility
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
UAV	Unmanned Aerial Vehicle
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 & Wildlife Service
USGS	U.S. Geological Survey

Abbreviations/Acronyms (cont.)	
UST	Underground Storage Tank
UV	Ultraviolet
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	Zones of Archaeological Potential
Zero G	Zero Gravity Corporation
Zn	Zinc

Conversion Factors

Area

1 acre = 0.4047 ha
1 ft3 = 0.0283 m3
1 ft2 = 0.0930 m2
1 hectare = 2.4710 acres
1 in2 = 6.4516 cm2
1 mi2 = 2.5900 km2
1 square centimeter = 0.1550 square inch
1 square kilometer = 0.3861 square mile
1 square meter = 10.7527 square feet

Energy

joule = 0.0009 British thermal unit
joule = 0.2392 gram-calorie
1 BTU = 1060.4 j
1 g-cal = 4.181 j

Linear

1 centimeter = 0.3937 inch
1 centimeter = 0.0328 foot
1 ft = 30.48 cm
1 ft = 0.3048 m
1 in = 2.54 cm
1 kilometer = 0.6214 mile
1 kilometer = 0.5396 nautical mile
1 meter = 3.2808 feet
1 meter = 0.0006 mile
1 mi = 1609.3440 m
1 mi = 1.6093 km
1 NM = 1.8520 km

Pressure

Newton/square meter = 0.0208 pound/square foot
1 psf = 48 N/m2

Thrust

pound (of thrust) = 4.4 Newtons
1 N (of thrust) = 0.2273 lbs

Volume

1 cubic centimeter = 0.0610 cubic inch
1 cubic meter = 35.3357 cubic feet
1 gal = 3.7844 l
1 gal = 0.0038 kl
1 in3 = 16.3934 cm3
1 in3 = 16.3934 cm3
1 kiloliter = 264.2 gallons
1 liter = 1.0567 quarts
1 liter = 0.2642 gallon
1 qt = 0.9463 l

Weight

gram = 0.0353 ounce
kilogram = 2.2046 pounds
metric ton = 1.1023 tons
1 lb = 0.4536 kg
1 oz = 28.3286 g
1 ton = 0.9072 m.t.

SECTION I

ERD 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 Parts 1500-1508.

The National Aeronautics and Space Administration (NASA) has developed Agency-specific guidance in accordance with the CEQ regulations. The policies and procedures are published in 14 CFR Part 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 fifth revision of the original 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, KNPD 8500.1. KSC environmental requirements are contained in the KSC Environmental Requirements, KNPR 8500.1. The KNPR describes requirements, procedures and responsibilities for each environmental program area, including air, water, and NEPA.

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 insuring 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, NASA, United States Air Force (USAF), St. Johns River Water Management District (SJRWMD), Environmental Protection Agency (EPA), 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.

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) south of Jacksonville and 64 km (40 mi.) due east of Orlando on the north end of Merritt Island adjacent to Cape Canaveral (see 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. 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 (see 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 CNS within KSC boundaries (see Figure 2-2).

2.3 NASA VISION AND MISSION

NASA's vision is: To improve life here; to extend life to there; and to find life beyond. NASA's mission is: To pioneer the future in space exploration, scientific discovery, and aeronautics research (KDP-KSC-S-1863, Center Planning Guidance for the Kennedy Space Center). NASA is organized along five basic mission driven areas:

- Space Science
- Earth Science
- Biological and Physical Science
- Aeronautics
- Education

In addition, NASA functions using four basic Enabling Capabilities:

- Space Flight
- Crosscutting Technology
- Safety and Mission Assurance
- Institutional Support

2.4 KSC MISSION

Liftoff at the Kennedy Space Center! These words inspire people around the world as another space mission begins to explore our limitless universe. The primary functions at KSC are the processing and launching of the Space Shuttle and future generations of space vehicles, the assembly, integration, and processing of ISS elements and flight experiments, and the processing of payloads for launch aboard the various Expendable Launch Vehicles processed and launched from the CCAFS.

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
- Mission Success

KSC is coordinating activities associated with remaining flights and closeout of the Shuttle program, ramping down ISS ground processing operations, and developing future programs.

2.5 KSC MASTER PLAN

The KSC Master Plan provides a long range concept for orderly management and future development of real property assets of the Center while ensuring proper stewardship of these assets including facilities and natural resources, and achieving agency policy under NEPA. It facilitates coordination with Center supported programs, customers, and stakeholders, including local, state and other federal organizations. Area Development Plans (ADP) are conceptual plans for long term development of functional areas consistent with the Master Plan. These areas include:

- Central Campus
  - Renovate and enhance administrative space to improve efficiency, occupant density, and working environment, allowing for a centralized campus.
  - Expand and renovate support services to improve operational efficiency and extend facilities' useful life.
  - Renovate program related facilities to meet future program requirements.
  - Demolish underutilized and deteriorated vacated buildings to reduce operation and maintenance costs.
- Payload Processing
  - Utilize the Multi-Payload Processing Facility for future programs.
  - Reserve sites for future processing operations.
  - Renovate the Multi-Operation Support Building in response to potential processing operations.
  - Demolish processing facilities no longer required for the Shuttle Program or otherwise abandoned.
  - Renovation and reuse of the Hypergol Processing North and Hypergol Support Building to accommodate relocation of laboratory and shop functions from the Central Campus.
- Vertical Launch
  - Provide a feasible transition from the Shuttle to future programs by reutilizing launch facility capabilities and providing adequate safety buffers between operations.
  - Enable commercial launch activity.
  - Eliminate structures in poor condition and/or considered surplus.
- Horizontal Launch (Shuttle Landing Facility (SLF) Support Facilities)
  - Provide for limited operations required by future programs with potential to add new facilities that include medium and heavy payloads handling, astronaut and flight crew training and preparation, mission management, and helicopter support.
  - Potentially add new facilities that include Department of Defense (DOD) and military ramps and support, Federal Aviation Administration (FAA) new/experimental aircraft certification, Unmanned Aerial Vehicle (UAV) ramp and related support, and weather studies and sensor development.
  - Provide for option to develop controlled access or public access operational sites to facilitate commercial utilization of SLF facilities.
- Exploration Park (Developed by private entities on enhanced use lease basis)
  - The first phase proposed is 60 acres adjacent to the Space Life Sciences Laboratory (SLSL) to provide office, flex space and processing/light manufacturing facilities for industry, academia, and Government users.
  - Additional phases would be developed as the need for facilities is identified.

  - NASA participation is currently envisioned to be limited to making the land available for development, providing limited site earth fill, and funding the extension of utilities to the project sites.
- Public Outreach
  - Renovate current venues and add new ones to reorganize the presentation and portray the past, present, and future of the NASA story through an array of active participation experiences and educational opportunities.
  - Develop an educational complex devoted to interactive educational programs and seminars.
  - Relocate Press Site from LC-39 area due to impending safety concerns.
  - Renovate or replace deteriorated maintenance support facilities, construct a new administration building, and expand infrastructure to support new facilities.
- Miscellaneous
  - Address projects indicated by the USFWS as pending, including a new Refuge headquarters building and improvements to maintenance facilities.
  - Demolish Merritt Island Launch Area (MILA) Facility consistent with planned abandonment at conclusion of the Shuttle Program.
  - Provide for renovation and addition of paint and reclamation facilities necessary to maintain operations.
  - Kennedy Athletic, Recreational and Social Organization (KARS) Park I and II – Provide for renovation or construction of restrooms, recreation buildings, handball and racquetball courts, marina boat ramp, snack bar, and demolition of the pistol/rifle/skeet range.

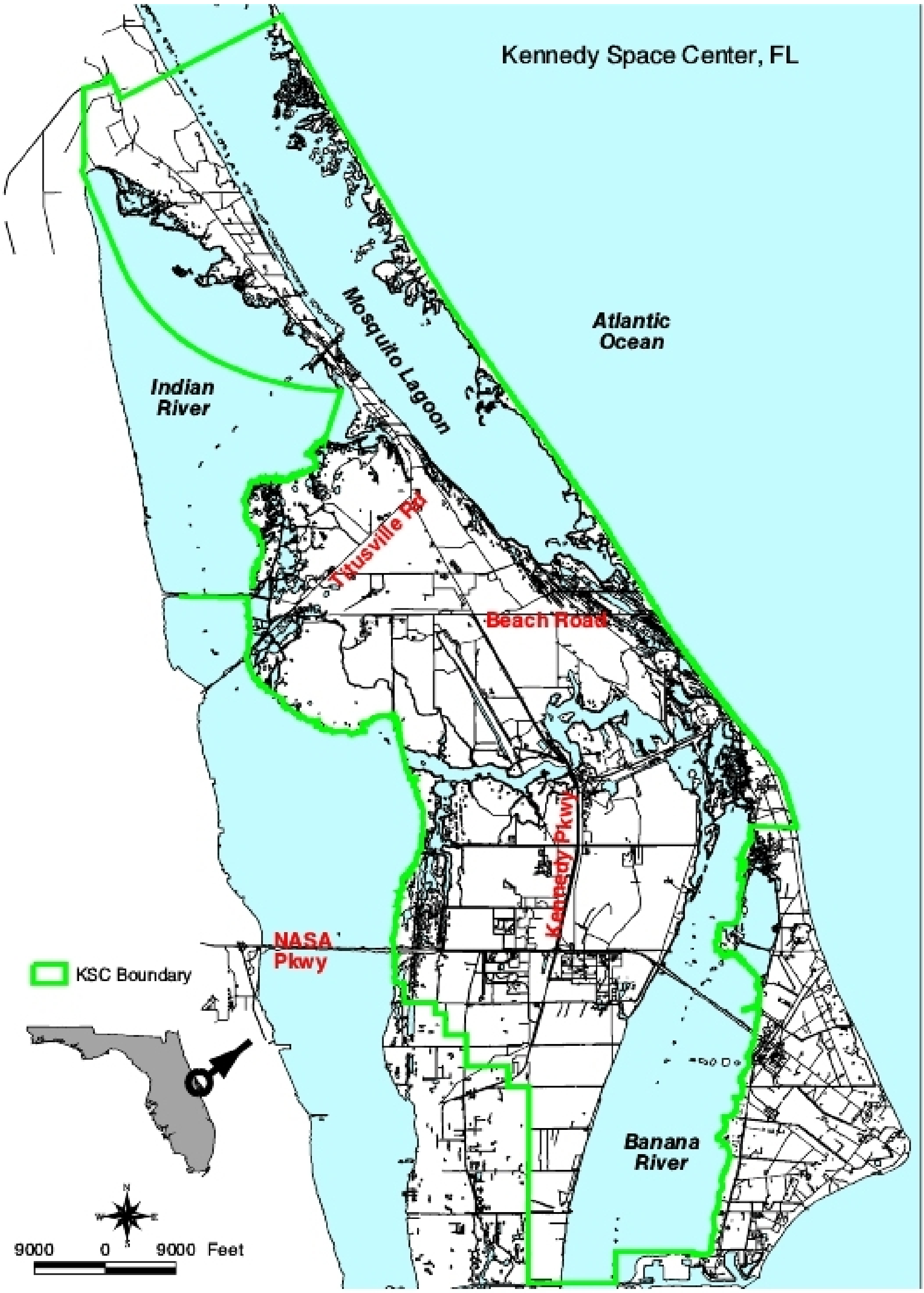


Figure 2-1. KSC Location.

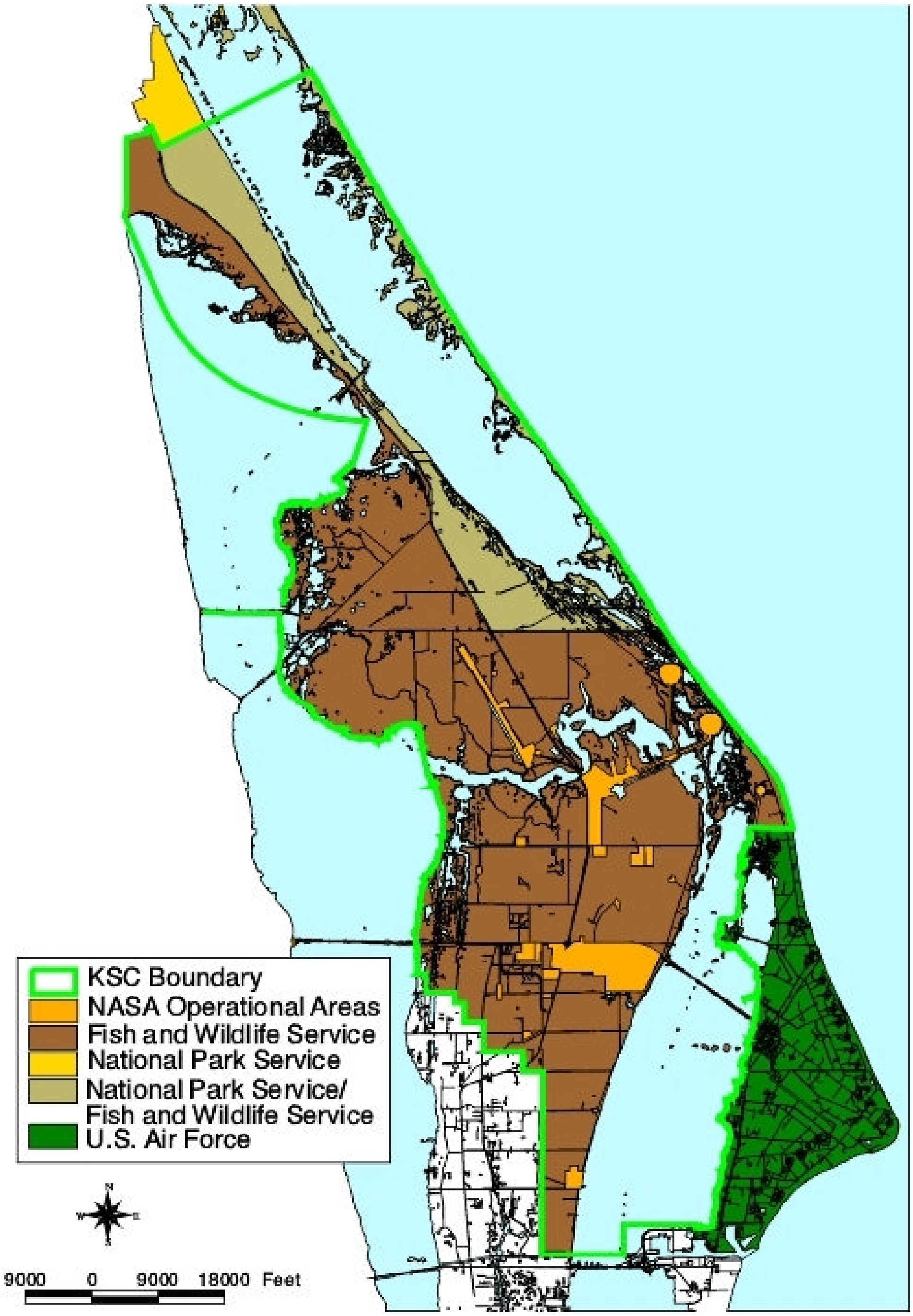


Figure 2-2. KSC Administrative Areas.

2.6 FACILITIES INFORMATION

KSC facilities, equipment and personnel provide a variety of functions in support of their mission:

- Assemble, integrate, and validate Space Shuttle elements along with associated payloads including International Space Station elements and upper stage boosters
- Conduct launch, recovery, and landing operations
- Design, develop, construct, operate, and maintain each launch and landing facility and the 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 Station (CCAFS), Patrick Air Force Base (PAFB), Vandenberg Air Force Base (VAFB), and various contingency and secondary landing sites around the world
- Manage Shuttle flight hardware logistics
- 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 SPACE SHUTTLE PROCESSING FACILITIES

Space Shuttle 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 facilities, as well as support facilities. In the KSC Industrial Area, the Hypergolic Maintenance Facility and associated support buildings provide capability for Space Shuttle component processing. In addition, some facilities on Cape Canaveral Air Force Station support Space Shuttle processing and logistics requirements.

- Vehicle Assembly Building (VAB) – K6-848
- Launch Control Center (LCC) – K6-900
- Orbiter Processing Facility High Bays 1, 2, and 3, including the Space Shuttle Main Engine Facility (OPF HB’s 1, 2, and 3) – K6-894, K6-696
- Thermal Protection System Facility (TPSF) - K6-794
- Crawler Maintenance Facility - K6-743
- LC-39A and LC-39B – J8-1798(A) and J7-337(B)
- Hypergol Maintenance Facilities (HMF) – M7-1061, M7-961, M7-1212, and HMF Support Building #2 (M7-1059)
- Shuttle Landing Facility (SLF)
- Operations Support Building (OSB) – K6-1096
- Component Refurb and Chemical Analysis (CRCA) (K6-1696)

- Logistics Facility – K7-1547
- Rotation, Processing and Surge Facility (RPSF)
- Hangar AF
- Hangar S Annex
- Hangar N

2.6.2 PAYLOAD AND INTERNATIONAL SPACE STATION (ISS) ELEMENT PROCESSING FACILITIES

ISS elements 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 and on Cape Canaveral Air Force Station.

- Space Station Processing Facility (SSPF)
- Operations and Checkout Facility (O&C)
- Payload Hazardous Servicing Building (PHSF)
- Multi-Operation Support Building (MOSB)
- Canister Rotation Facility (CRF)
- Spin Test Facility
- Hangar Little L
- Space Life Sciences Laboratory (SLSL)

2.6.3 EXPENDABLE LAUNCH VEHICLE PROGRAM FACILITIES

The Expendable Launch Vehicle (ELV) Program Office at KSC provides the ELV launch services acquisition and management functions for NASA and its customers. These activities are carried out in facilities based in NASA facilities on Cape Canaveral Air Force Base.

- E&O Building
- Launch Vehicle Data Center

2.6.4 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.

- Launch Equipment Test Facility (LETF)
- Robotics Applications Development Laboratory (RADL)
- Prototype Laboratory
- Artificial Intelligence Laboratory
- Microchemical Analysis Laboratory
- Biomedical Laboratory
- Non-Destructive Evaluation Laboratory (NDEL)

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 sources (both surface and ground water). 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, F.A.C., 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 Florida Department of Environmental Protection (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 Environmental Protection Agency (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 F.A.C. Chapters 62-3 F.A.C. and 62-4 F.A.C. deal with effluent quality standards and with permitting requirements, respectively. Chapter 62-600 F.A.C. addresses wastewater facility design and construction criteria. Under these laws, the State of Florida has delegated the Florida Department of Environmental Protection (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 Environmental Protection Agency (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, F.A.C., are promulgated to implement the requirements of the Florida Safe Drinking Water Act.

The State of Florida has delegated the Florida Department of Environmental Protection (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, F.A.C. 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.

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 that flows 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 to contaminate 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 Environmental Protection Agency (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 Chapters 40C-4, 40C-42, 40C-44, and 40C-400, F.A.C., 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 St. Johns River Water Management District, and by the Florida Department of Environmental Protection. These two agencies are responsible for reviewing stormwater system designs and issuing permits for their construction and operation.

2.7.1.6 NPDES Stormwater. In October 2000, the U.S. Environmental Protection Agency (EPA) authorized the Florida Department of Environmental Protection (FDEP) to implement the National Pollutant Discharge Elimination System (NPDES) stormwater permitting program in the State of Florida (in all areas except Indian country 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, and
- 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 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 1.2 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 flowrate of water is maintained by booster pumps at the Water Pump Station (N6-1007), while chlorine and a corrosion inhibitor are added to maintain the proper chlorine residual and to maintain the integrity of the distribution system. Water flows through a 24” primary distribution system from the South Gate to the VAB area. At the intersection of Schwartz Road and S.R. 3, the water can be chlorinated again to maintain the residual concentration. 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, F.A.C. The remaining septic tanks were constructed prior to the implementation of permitting regulations and are therefore grandfathered in under these rules.

2.7.2.3 Industrial Wastewater. KSC currently maintains operating permits for three facilities treating Industrial Wastewater (IWW).

- Seawater Immersion Facility at Beach Corrosion Test Laboratory - The Beach Corrosion Test Laboratory 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.

- Launch Complex 39 - Launch Complexes 39A and 39B utilize holding tanks to treat IWW waste streams generated by sound suppression water, Firex water, SRB exhaust and post-launch washdown. The IWW generated during launch is collected in deluge tanks and is neutralized with Sodium Hydroxide or Phosphoric Acid. The effluent is discharged to a percolation pond using supplementary sprayfield disposal. The system is operated on a "per launch" basis. Diversion gates direct stormwater runoff to stormwater swales in non-launch configuration.

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 SLF system that serves the Shuttle Landing Facility (see Figure 2-3).

2.7.2.5 NPDES Stormwater. In addition to those stormwater management systems permitted by the St. Johns River Water Management District, 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 Shuttle Landing Facility, the Ransom Road Reclamation Yard, the Transportation, Storage and Disposal Facility (TSDF), and the 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).

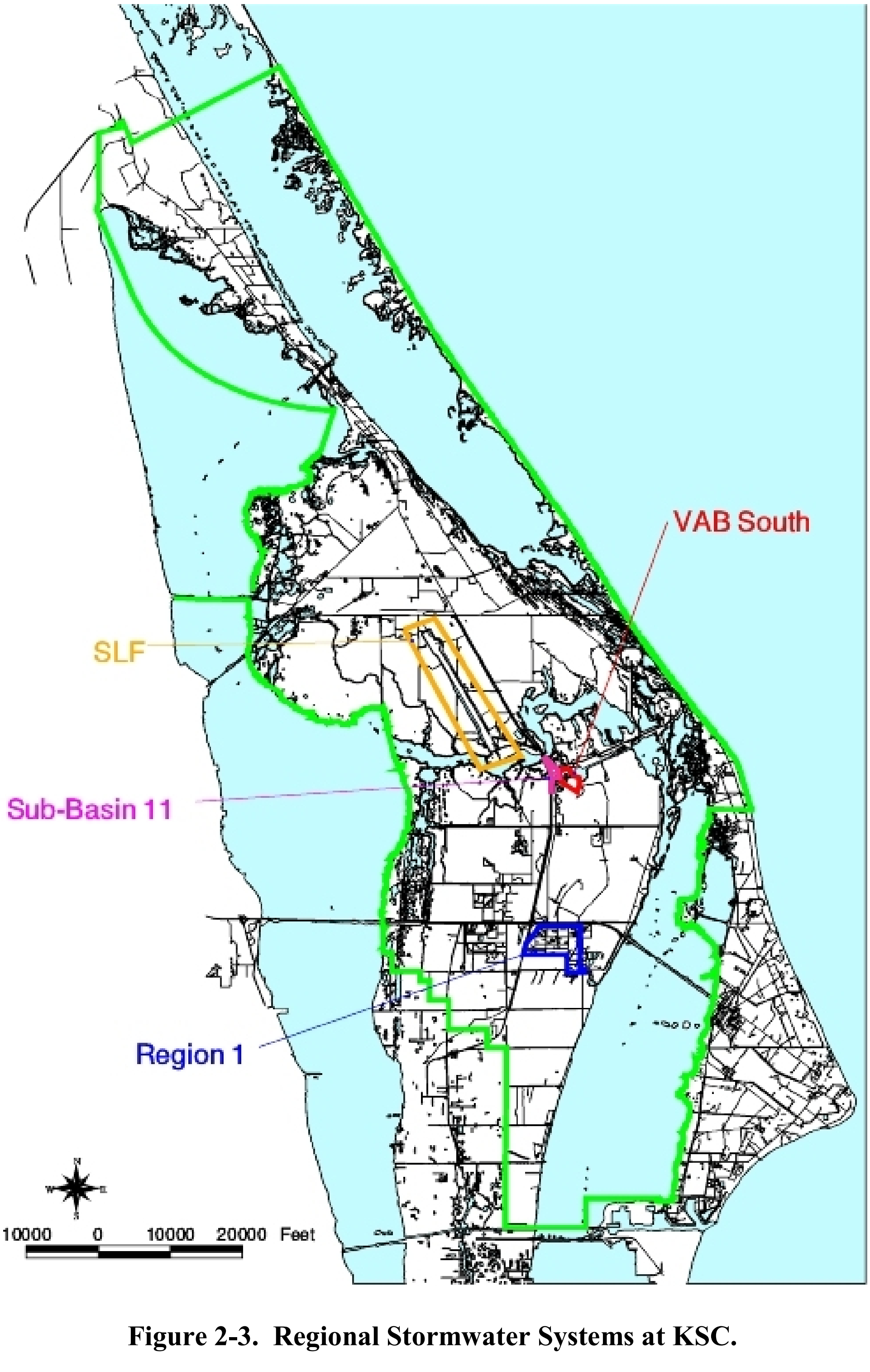


Figure 2-3. Regional Stormwater Systems at KSC.

SECTION III

AIR RESOURCES

3.1 GENERAL

All of KSC's air sources are regulated under a single Title V Operating Permit, 0090051-018-AV.

3.2 AIR QUALITY

3.2.1 REGULATORY OVERVIEW

3.2.1.1 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, as amended) 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. This federal operating permit replaces all previous state air pollution operating permits at KSC. In addition, this program establishes a reporting program and fee program based on emission levels. The program is delegated to the State of Florida and is administrated by the Florida Department of Environmental Protection (FDEP).

Title VI initiates the federal program related to the 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. Additionally, this classification triggers the requirements of the PSD program versus themuch more stringent requirements of the NSR program.

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 ($10\ mg/m^3$)**	8-hour [1]	None		**9 ppm ($10\ mg/m^3$)**
	35 ppm ($40\ mg/m^3$)	1-hour [1]			**35 ppm ($40\ mg/m^3$)**
Lead	**$0.15\ \mu g/m^3$** [2]	Rolling 3-Month Average	Same as Primary		**$0.15\ \mu g/m^3$** [2]
	$1.5\ \mu g/m^3$	Quarterly Average	Same as Primary		**$1.5\ \mu g/m^3$**
Nitrogen Dioxide	**0.053 ppm ($100\ \mu g/m^3$)**	Annual (Arithmetic Mean)	Same as Primary		**0.053 ppm ($100\ \mu g/m^3$)**
Particulate Matter (PM_{10})	**$150\ \mu g/m^3$**	24-hour [3]	Same as Primary		**$150\ \mu g/m^3$**
Particulate Matter ($PM_{2.5}$)	**$15.0\ \mu g/m^3$**	Annual [4] (Arithmetic Mean)	Same as Primary		**$15.0\ \mu g/m^3$**
	$35\ \mu g/m^3$	24-hour [5]	Same as Primary		**$35\ \mu g/m^3$**
Ozone	**0.075 ppm (2008 std)**	8-hour [6]	Same as Primary		**0.075 ppm (2008 std)**
	0.08 ppm (1997 std)	8-hour [7]	Same as Primary		**0.08 ppm (1997 std)**
	0.12 ppm	1-hour [8] (Applies only in limited areas)	Same as Primary		**0.12 ppm**
Sulfur Dioxide	**0.03 ppm**	Annual (Arithmetic Mean)	**0.5 ppm (1300 $\mu g/m^3$)**	**3-hour** [1]	**Annual (Arthrimetic Mean) 0.02 ppm**
	0.14 ppm	24-hour [1]			**24-hour 0.1ppm** **3-hour 0.5 ppm (1300 $\mu g/m^3$)**

(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 15.0 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) 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 0.08 ppm.
(b) The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as EPA undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard.
(8) (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 each state to develop and submit a State Implementation Plan (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 CAA requires the EPA 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 amendments also require the EPA to 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.

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 CAA requires the EPA to develop and implement a federal operating permit program or Title V permit program for all major stationary air pollution sources. The CAA also authorizes the collection of fees on an annual basis based on emission levels to pay for the program cost. 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.

3.2.1.2 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", (Environmental Control, Chapter 403, Florida Statutes). These laws established the FDEP and authorized the development and enforcement of air pollution regulations.

Florida regulations pertaining to air pollution are specified in the Florida Administrative Code (F.A.C.). The applicable chapters include: 62-2, 62-4, 62-200, 62-202, 62-204, 62-209, 62-210, 62-212, 62-213, 62-214, 62-242, 62-243, 62-244, 62-252, 62-256, 62-257, 62-272, 62-273, 62-275, 62-281, 62-296, and 62-297, F.A.C. The regulations applicable to KSC are summarized as follows:

Permits (Chapters 62-4, 62-210, 62-212, 62-213, F.A.C.) 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), F.A.C., 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), F.A.C., 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, F.A.C. Within Florida, the NAAQS are incorporated as well as the more stringent Florida Ambient Air Quality Standards (FAAQS). The FAAQS are listed along with the NAAQS 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, F.A.C. 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, F.A.C. The FDEP and the Florida Department of Forestry are the primary agencies regulating open burning at KSC and the Merritt Island National Wildlife Refuge.

3.2.2 KSC TITLE V OPERATING PERMIT

On December 2, 2008, the FDEP Central District issued KSC a final Title V operating permit (Permit No. 0090051-018-AV). The Title V operating permit 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 carbon monoxide (CO) and oxides of nitrogen (NOx) exceed the 100 tons per year (tpy) Title V major source threshold. KSC is considered a minor source for volatile organic compounds (VOC) emissions as the VOC PTE is less than the 100 tpy Title V major source threshold. KSC is considered a minor source for 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). KSC is considered a minor source of Hazardous Air Pollutants (HAP). KSC was previously considered a major source of HAP; however, pollution prevention initiatives taken by the facility have allowed the facility to reduce HAP emission 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. The usage rate limitations are discussed later. The permit also contains facility-wide conditions that must be complied with for the operations permit to be valid. These include, but are not limited to: 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	001	Not Applicable
Permitted – Subsection B		
Surface Coating Operations	091	HAP/VOC
Permitted – Subsection C		
Compression Ignition Stationary Internal Combustion Engines (Diesel)	086	Not Applicable
Spark Ignition Stationary Internal Combustion Engines (Gasoline)	087	Not Applicable
Launch Complex-39 Emergency Power Plant (K6-1091)	088	Not Applicable
Permitted – Subsection D		
Hypergol Servicing Operations & Activities	089	Not Applicable
Unregulated		
Fog Fluid (Special Effects) at KSC Visitors Center Complex	090	Not Applicable
Insignificant Units and/or Activities		
Auto Services	I-1	Not Applicable
Battery Stations	I-2	Not Applicable
Abrasive Blasting Operations	I-3	Not Applicable
Can Puncturing Devices	I-4	Not Applicable
Cleaning Operations	I-5	Not Applicable
Mixing/Coating Operations	I-6	Not Applicable
Flare Stacks	I-7	Not Applicable
Local Exhaust Ventilations	I-8	Not Applicable
Facility Support Systems	I-9	Not Applicable
Ovens/Dryers	I-10	Not Applicable
Sewage/Wastewater Treatment	I-11	Not Applicable
Storage Tanks	I-12	Not Applicable
Vacuum Systems	I-13	Not Applicable
Remediation Activities	I-14	Not Applicable

EU Description	EU Identification Number	Limited Pollutant
Architectural and Industrial Maintenance Coatings	I-15	Not Applicable
Home and Comfort Heating	I-16	Not Applicable
Storm Cleaning Equipment	I-17	Not Applicable
Sanders (Belt or drum having a total sanding surface of five square feet or less and other equipment used exclusively on wood or plastics or their products having a density of 20 pounds per cubic feet or more)	I-18	Not Applicable
Space Heating Equipment (excluding boilers)	I-19	Not Applicable
Laboratory Equipment (used exclusively for chemical and physical analyses)	I-20	Not Applicable
Brazing, soldering, or welding equipment	I-21	Not Applicable
Fire and Safety Equipment	I-22	Not Applicable
Surface Coating Operations (using only coatings containing less than 5.0% VOC or HAP by volume)	I-23	Not Applicable
Petroleum Lubrication System	I-24	Not Applicable
Application of Fungicide, Herbicide, or Pesticide	I-25	Not Applicable
Non-halogenated solvent cleaning operations containing less than 5% HAP	I-26	Not Applicable
Vehicle Fueling Operations and Associated Fuel Storage	I-27	Not Applicable
Restaurants	I-28	Not Applicable
Relocatable Screening-only Operations	I-29	Not Applicable
Fugitive Emissions	I-30	Not Applicable
Distillation Equipment with PTE < 5 tpy (e.g. vertrell still)	I-31	Not Applicable
Controlled Burning	I-32	Not Applicable
Boilers (with heat input rating of less than 10 MMBtu/hr fired by natural gas, liquefied propane (LP) gas, Number 2 fuel oil, bio-diesel, or synthetically derived fuels)	I-33	Not Applicable
Landscaping Equipment	I-34	Not Applicable
Construction Activities	I-35	Not Applicable
Asbestos Renovation and Demolition Activities	I-36	Not Applicable
Natural Gas Fired Compressor (for compressed natural gas (CNG) fueling operations)	I-37	Not Applicable

EU Description	EU Identification Number	Limited Pollutant
Parachute Dryer	I-38	Not Applicable
Cable Fabrication Operations	I-39	Not Applicable
Photographic Processing Labs (including x-ray processing)	I-40	Not Applicable
Wastewater Treatment Operations	I-41	Not Applicable
Application of Identification Numbers	I-42	Not Applicable

All administrative, insignificant or minor modifications to the permit that occur before the renewal application are submitted must be proposed in a written letter with supporting information or calculations to the FDEP for consideration. If FDEP concurs with the letter, the modification is automatic. If the desired modification or new source is major, then 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 six. 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. 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. 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.

3.2.2.2 Surface Coating Operations. The Surface Coating Operations EUs are found in Subsection B of the KSC Title V operating permit. There are a total of twelve (12) 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 spray booth at Base Support Building M6-0486, a top coat application cell at the SRB-ARF, Thermal Protection System (TPS) 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, Hangar N Paint Booth at CCAFS, 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. SRB assembly and refurbishment operations are responsible for producing the majority of total VOC emissions at KSC. SRB assembly and refurbishment operations involve cleaning, surface preparation, painting, and thermal coating applications. This includes the surface preparation activities performed in Hangar AF on CCAFS. Although the SRB-ARF is permitted to process 24 SRB motors per year, no more than 20 SRB motors have actually been processed in any year.

3.2.2.3 Emission Units 86, 87, 88. EUs 86, 87 and 88 are found in Subsection C of the KSC Title V operating permit. EU 086 includes Compression Ignition Stationary Internal Combustion Engines (diesel), EU 087 includes Spark Ignition Stationary Internal Combustion Engines (gasoline), and EU 088 is the Launch Complex 39 (LC 39) Compression Ignition Backup Power Plant. Fuel usage records are maintained for all of the units included in EU 086 and EU 087 by totaling the diesel (EU 086) and gasoline (EU 087) 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 (5) 2-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. In addition to the fuel limitations set on EU 088, there is 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 for EU 086; 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.

3.2.2.4 Emission Unit 089. EU 089 is found in Subsection D of the KSC Title V operating permit. EU 089 is comprised of hypergol servicing operations and activities. These operations include fueling operations, purging, fume hoods and scrubbers. 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. EU 089 includes the following:

3.2.2.5 Unregulated Emission Units. Unregulated EUs are defined in Appendix U-1 of the KSC Title V operating permit. Unregulated EUs are over the threshold for insignificant units or activities, but emit no "emissions-limited pollutant" and which is subject to no unit-specific work practice standard. The EUs may still be subject to regulations applies on a facility-wide basis, such as unconfined emissions, odor, or general opacity regulations, or to regulations that require only that it be able 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.

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
TM-101	LC - 39 A	Fuel/Oxidizer Servicing Operations
TM-010	LC - 39 B	Fuel/Oxidizer Servicing Operations
TM-40	OPF3	Oxidizer Purging System
TM-41	OPF3	Fuel Purging System
TM-55	OPF 1 & 2	Oxidizer Purging System
TM-56	OPF 1 & 2	Fuel Purging System
TM-88	HMF (South)	East/West Cell Fuel ASP
TM-89	HMF (South)	East/West Cell Oxidizer ASP
TM-94	HMF (North)	East/West Cell Fuel ASP
TM-95	HMF (North)	East/West Cell Oxidizer ASP
TM-96	HMF (North)	Fuel Fume Hood
TM-97	HMF (North)	Oxidizer Fume Hood

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 F.A.C. 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 as follows: auto services, battery stations, abrasive blasting operations, can puncturing devices, cleaning operations, mixing/coating operations, flare stacks, local exhaust ventilations, facility support systems, hypergol servicing operations, ovens/dryers, sewage/wastewater treatment, storage tanks, vacuum systems, remediation activities, architectural and industrial maintenance coatings, home and comfort heating, steam cleaning equipment, sanders, space heating equipment (excluding boilers), laboratory equipment used exclusively for chemical or physical analyses, brazing, soldering or welding equipment, fire and safety equipment, surface coating operations using only coatings containing less than 5.0% VOC or HAP by volume, petroleum lubrication systems, application of herbicide, fungicide or pesticide, non-halogenated solvent cleaning operations using solvents containing less than 5% HAP, vehicle fueling operations and associated fuel storage, restaurants, relocatable screening-only operations, fugitive emissions, distillation equipment with PTE < 5 tpy, controlled burning, boilers with heat input rating of less than 10 MMBtu/hr fired by natural gas, liquefied propane gas, number 2 fuel oil, diesel fuel, biodiesel, or synthetically derived fuels, landscaping equipment, construction activities, asbestos renovation and demolition activities, natural gas fired compressor for CNG fueling operations, parachute dryer, cable fabrication operations, photographic processing labs, waste water treatment operations, application of identification numbers. 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.

3.2.3 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, Executive Order 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, Executive Order 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.

Executive Order 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.

Halons have a special use at KSC with the shuttle program. Halon is the only effective fire suppressant for the fuels used in the orbiter and has received the EPA's approval for an exemption. Because of this, the NASA has set up a "Halon Bank" at KSC. In order to stockpile and prolong the procurement of halon KSC has been designated as the collection center for all of the unused halon from all of the NASA centers.

3.2.4 RISK MANAGEMENT PROGRAM

The Clean Air Act, Section 112(r), places a general duty on the owners and operators of stationary sources producing, processing, handling, or storing any extremely hazardous substance, or any substance listed pursuant to Section 112(r) to:

- Identify hazards that may result from accidental releases;
- Design and maintain a safe facility; and
- Minimize the consequences of releases.

NASA-KSC is led by the guiding principle: "Safety and Health First". The OSHA Process Safety Management (PSM) program has been developed throughout KSC to minimize the potential for fires, explosions, and accidental releases of highly hazardous, toxic, flammable, reactive, or explosive chemicals. The program achieves this goal by taking a comprehensive approach, which involves integrating technologies, procedures, and management practices. All processes at KSC that include hazardous chemicals, regardless of the quantity or applicability to the Risk Management Program (RMP) List Rule, are subject to the general duty clause of the RMP rule. The EPA delegated authority to the State of Florida Department of Community Affairs to administer the RMP regulations.

RMP refers to 40 Code of Federal Regulations (CFR) 68, "Chemical Accident Prevention Provisions".
This section states that companies that manufacture, process, store, or handle regulated substances in amounts greater than threshold quantities are required to comply with these regulations by June 21, 1999. All decisions relating to this activity are based on the EPA List of Regulated Flammable Substances and List of Regulated Toxic Substances and their corresponding threshold quantities. In addition facilities must be aware of the General Duty Clause of the CAA, which addresses all hazardous substances, regardless of the threshold amount.

The original NASA-KSC RMP was submitted June 7, 1999. Since the original submittal of the RMP, the EPA sent a letter titled "Important Notice: Users and Retailers of Flammable Fuels", dated March 15, 2000, which revised the regulation to omit flammable fuels used or sold as fuel. This affects the status of the NASA–KSC submitted RMP and a revision of the RMP was submitted on June 21, 2000. The reporting status development is based on two recent events: the Chemical Safety Information, Site Security and Fuels Regulatory Relief Act (Public Law 106-40) signed on August 5, 1999, and the lifting of the court-ordered stay for propane on January 5, 2000. The revised RMP is similar to the originally submitted RMP with the exception of liquid hydrogen (LH2) and propane as listed substances and left only monomethyl hydrazine (MMH) as a listed substance at KSC. The latest version of the RMP, submitted April 2008 contained no changes or modifications.

3.2.5 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 Part 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 F.A.C. 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.

3.3 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, and wildfires and controlled burning operations. Air quality at KSC is also influenced by emissions from two regional power plants, which are 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 3-3. 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. PAMS A is located approximately 0.4 km (0.25 mi) southeast of the 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), carbon monoxide (CO), ozone (O_3), total inhalable (10-micron) particulates and a meteorological tower with instrumentation for wind speed, wind direction, high (30 m) temperature, and relative humidity (Ref. 1).

A summary of air quality parameters collected from the PAMS A facility from January, 2008 through December, 2008 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 62.3 ppb and it occurred on May 6, 2008. The maximum hourly average value for O_3 was 95.2 ppb and it occurred on March 24, 2008. The maximum 24-hour average value for SO_2 was 11.3 ppb, which occurred on April 6, 2008. The maximum hourly average value for NO_2 was 17.2 ppb, which occurred on February 26, 2008. The maximum hourly average value for CO was 2.2 ppm, which occurred on March 29, 2008. PM-10 or PM-2.5 particulates were not monitored within the last year.

The maximum hourly value for the last twelve months was 75 ppb in April 2002. 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).

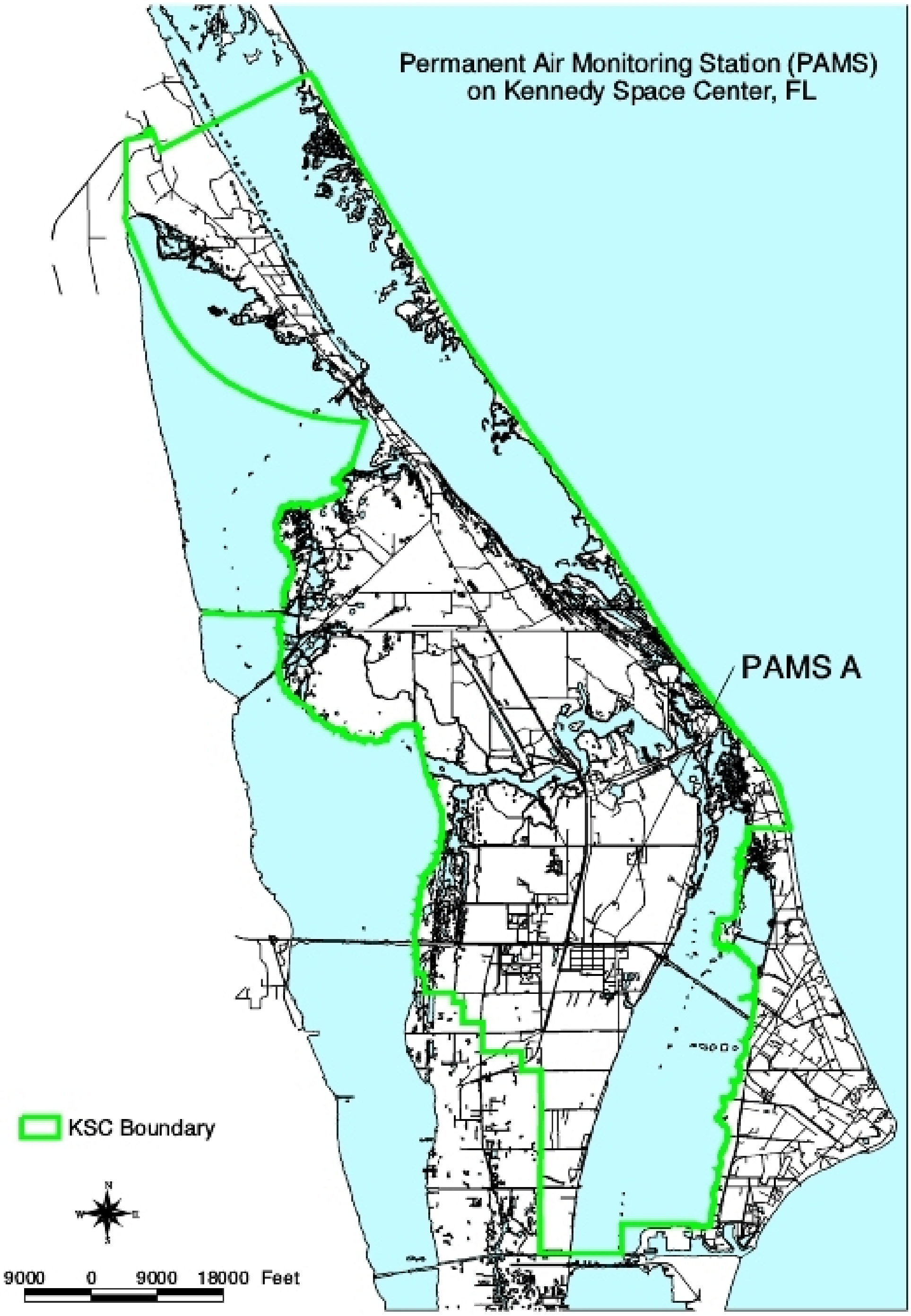


Figure 3-1. Permanent Air Monitoring Station Location.

Table 3-4. KSC Air Quality Data Summary PAMS A, 2008.

Parameter	Federal [4] and State Standard	Jan	Feb	Mar	Apr	May	June
Ozone (ppb)	Primary 75 (8-HR) [1]** Secondary 75 (8-HR-AVG)	44.5 46.1 (24.2%)	52.5 58.6 (100.0%)	57.3 95.2 (94.9%)	60.1 62.8 (99.9%)	62.3 65.3 (100.0%)	46.2 50.5 (100.0%)
Sulfur Dioxide (ppb)	Primary 140 (24-HR) [2,4] Secondary 500 (3-HR) [3]	0.0 0.0 (0.0%)	0.0 0.0 (0.0%)	0.0 0.0 (0.0%)	11.3 13.9 (92.5%)	4.5 6.0 (99.9%)	3.5 3.3 (100.0%)
Nitrogen Dioxide (ppb)	(1 HR-AVG) 50 (ANNUAL-AVG) [3]	7.6 0.469 (24.2%)	17.2 0.480 (100.0%)	9.1 0.453 (94.9%)	10.0 0.469 (99.9%)	6.3 0.446 (92.1%)	1.6 0.413 (62.2%)
Carbon Monoxide (ppm)	35 (HR-AVG) [1] 9 (8-HR) [2]	0.3 0.300 (94.1%)	0.5 0.363 (100.0%)	2.2 0.788 (94.9%)	0.3 0.150 (99.9%)	0.3 0.163 (100.0%)	0.6 0.200 (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]	31.2 36.5 (80.6%)	46.8 54.2 (100.0%)	37.7 41.5 (97.5%)	42.3 49.8 (100.0%)	34.6 39.5 (99.2%)	33.8 35.2 (76.3%)
Sulfur Dioxide (ppb)	Primary 140 (24-HR) [2, 4] Secondary 500 (3-HR) [3]	4.9 3.9 (80.6%)	2.6 3.7 (100.0%)	2.9 1.9 (99.7%)	5.1 5.0 (100.0%)	4.2 6.0 (100.0%)	2.7 2.6 (76.3%)
Nitrogen Dioxide (ppb)	(1 HR-AVG) 50 (ANNUAL-AVG) [3]	7.5 0.460 (54.3%)	10.4 0.676 (100.0%)	5.3 0.869 (99.6%)	5.2 0.523 (100.0%)	10.1 0.778 (100.0%)	6.9 0.808 (76.3%)
Carbon Monoxide	35 (HR-AVG) [1] 9 (8-HR) [2]	0.9 0.371 (77.0%)	0.1 0.100 (99.9%)	0.1 0.100 (99.7%)	0.2 0.200 (100.0%)	0.8 0.600 (100.0%)	0.6 0.242 (76.3%)

[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 SO_2; State Primary (24-hour) is 100 ppb.
NOTE:
** The ozone 8-hour standard and the PM 2.5 standards are included for information only. A 1999 federal court ruling blocked implementation of these standards, which EPA proposed in 1997. EPA has asked the U.S. Supreme Court to reconsider that decision.
Twenty-one days are required to yield a valid month.
(%) = Percentage of validation the month.

SOURCES: References 2, 3, 4, and 5.

3.3.1 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 2008 to December 2008 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 July & November 2008. The maximum 8-Hour Average with a value of 62.3 ppb (0.0623 ppm), which was 83.1 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 July, September, November, and December 2008. This is consistent with the “typical” bi-annual peaks found with ozone. The 95.2 ppb (0.0952 ppm) in March 2008 was 79.3 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). The maximum 8-hour mean for March 24 was 49.8, which was only 66.4 % of the 75 ppb standard.

3.3.2 SULFUR DIOXIDE

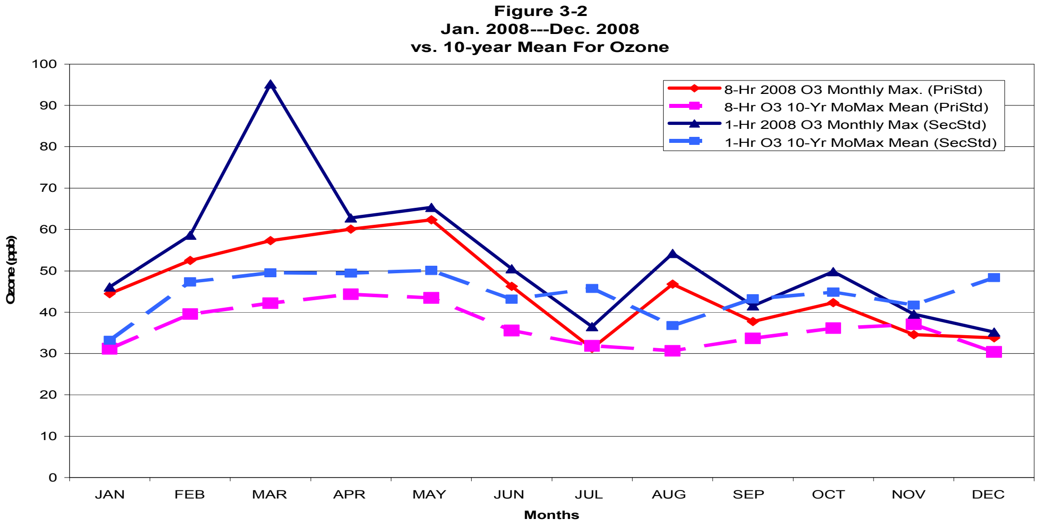
Figure 3-3 displays a plot of the maximum monthly 24-hr and 3-hr mean SO_2 values from January 2008 to December 2008 and the last 10-year means for comparison. The 24-hr data was above the associated 10-year mean for 2 months of the year, and below the remaining 10 months. The months being higher than the 10-year mean were April and July, 2008. The highest 24-hr average was 11.3 ppb on April 6, 2008, 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: April and May, 2008. The highest 3-hr average was 13.9 ppb in April 2008, which was 2.8 percent of the primary standard of 500 ppb.

3.3.3 NITROGEN DIOXIDE

Figure 3-4 displays a plot of the maximum monthly annual average and the 1-hr NO_2 values from January 2008 to December 2008 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 0.869 ppb for September, 2008, which was 1.7 percentage of the standard of 50 ppb (100 ug/m3). The 1-hr data was at or above the associated 10-year mean for 4 months of the year, February, March, April, and August 2008. The highest 1-hr NO_2 value was 17.2 ppb on February 26, 2008.

3.3.4 CARBON MONOXIDE

Figure 3-5 displays a plot of the maximum monthly 1-hr and 8-hr CO values from January 2008 to December 2008 and the last 10-year means for comparison. The 1-hr data was below the



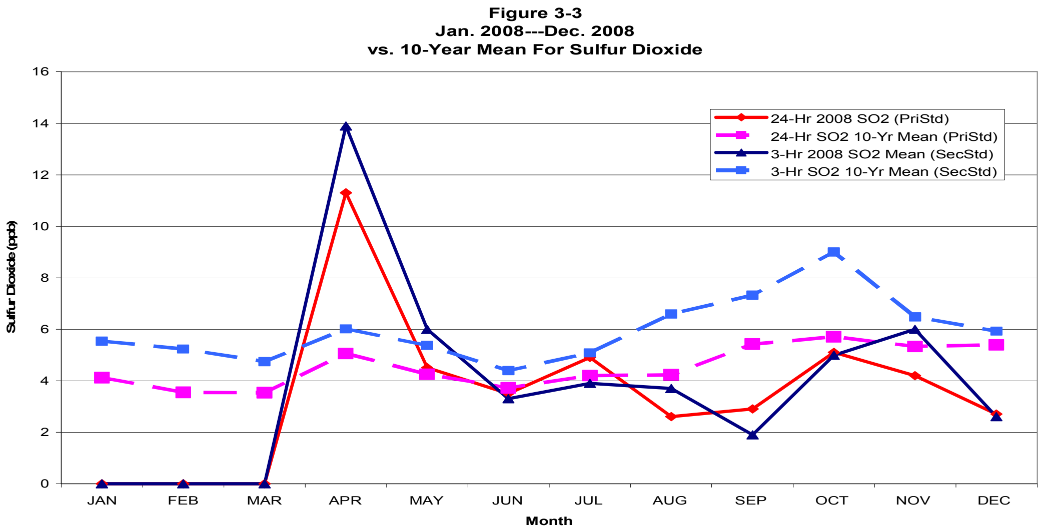
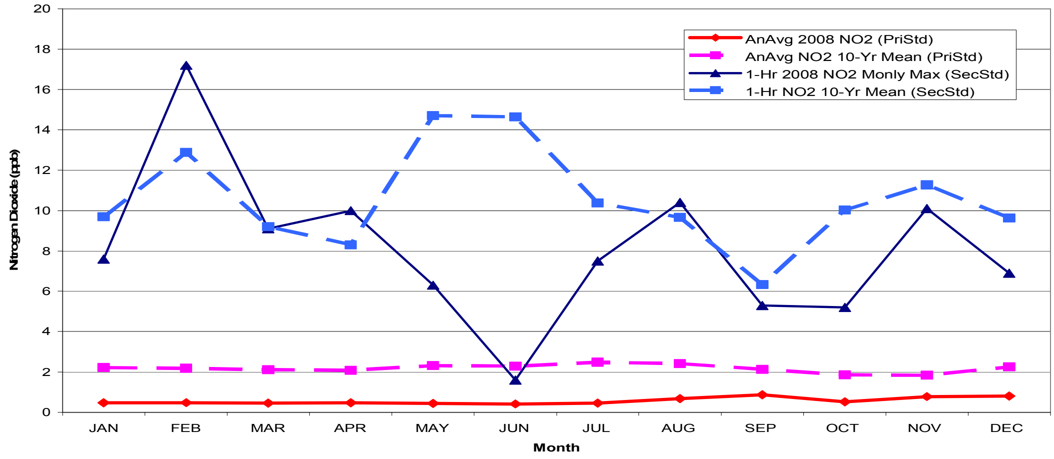
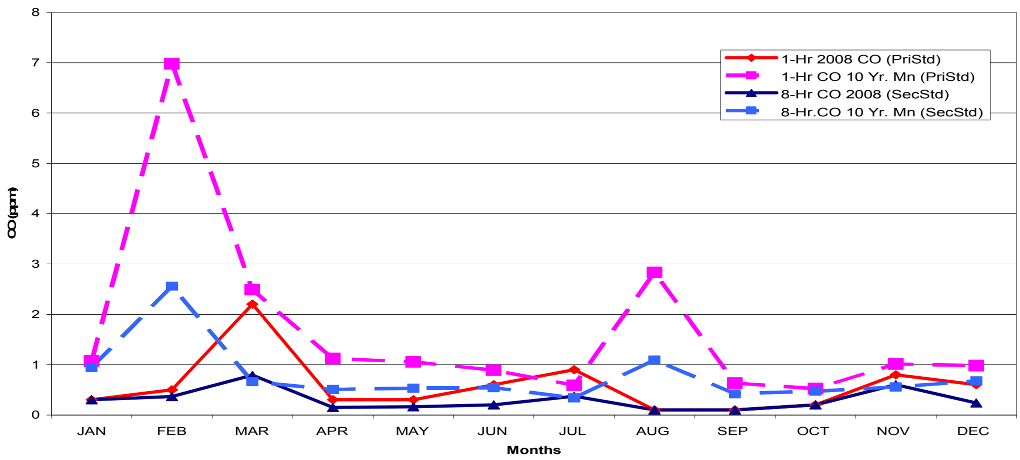


Figure 3-4
Jan. 2008---Dec. 2008
vs. 10-Year Mean For Nitrogen Dioxide



associated 10-year mean for most of the year with the exception of July 2008. The highest 1-hr average of 2.2 ppm on March 2008 was 6.3 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 0.788 ppm, occurred in March 2002 and was 8.8 percent of the proposed 8-hr standard of 9.0 ppm.

Figure 3-5
Jan. 2008---Dec. 2008
vs. 10-Year Mean For Carbon Monoxide



3.4 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. 7). 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. 8).

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 seabreeze 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. 8).

3.4.1 RAINFALL

Rainfall data are gathered from several collecting stations in the KSC area (Ref. 9). These stations (see Figure 3-6 for location) 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 (see Table 3-5 and Figure 3-7).

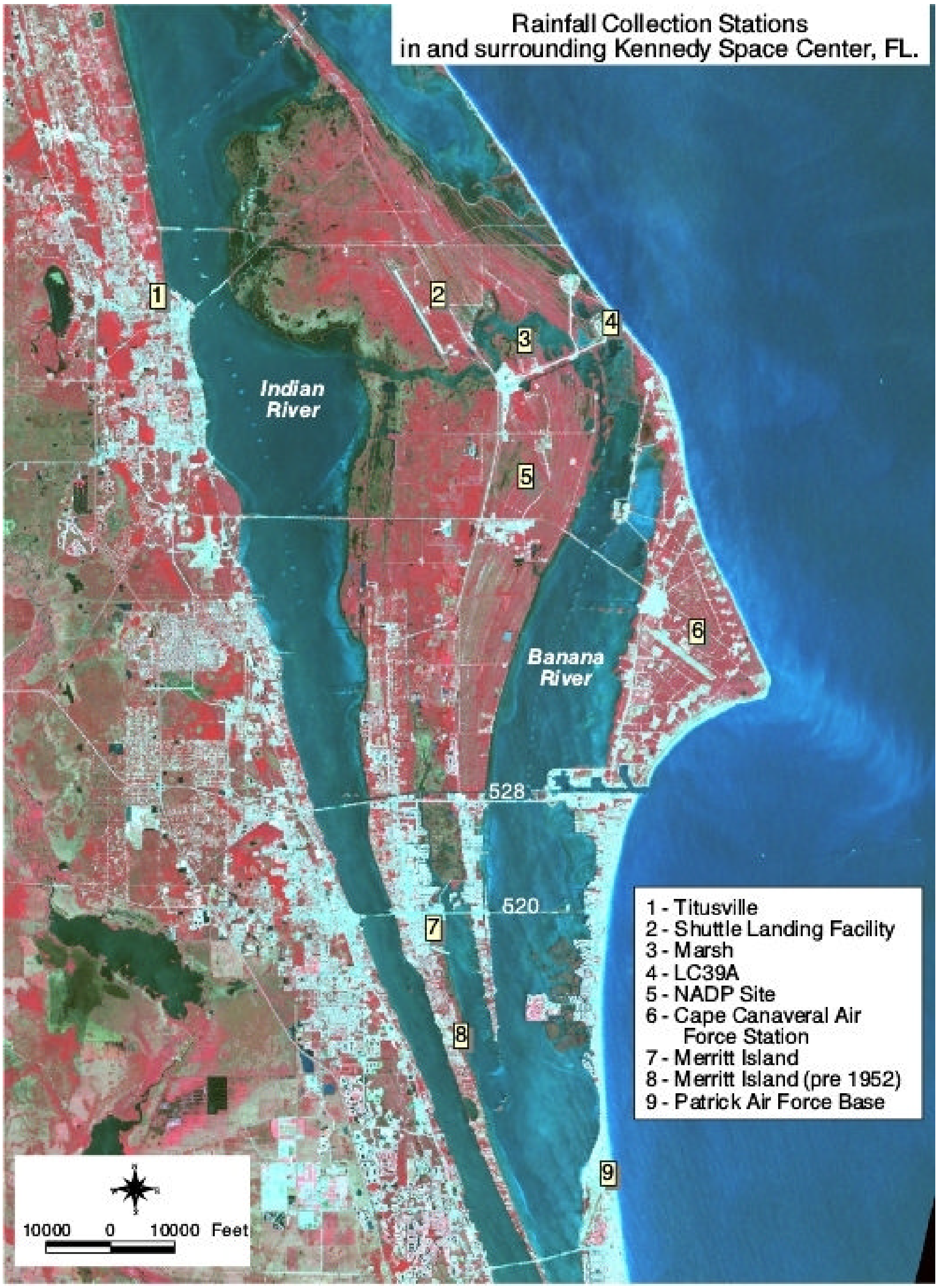


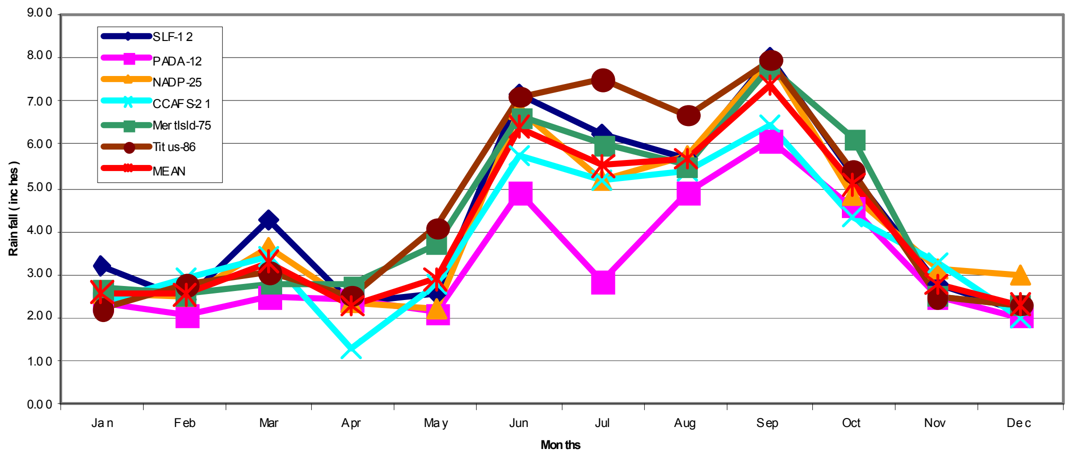
Figure 3-6. Rainfall Collection Stations In and Around KSC.

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

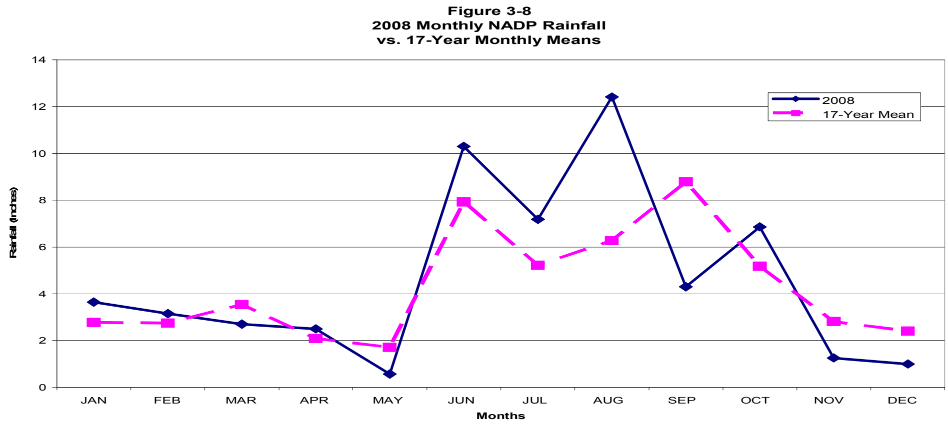
Station	Titusville *	Merritt Island*	CCAFS *	NADP Site	LC-39A	Shuttle 1	Patrick *
Length of Records (yrs)	86	75	21	25	12	12	2
January	2.22	2.68	2.39	2.60	2.39	3.21	2.72
February	2.80	2.56	2.91	2.49	2.10	2.43	1.98
March	3.06	2.79	3.41	3.66	2.49	4.28	6.12
April	2.53	2.77	1.30	2.33	2.41	2.38	0.74
May	4.09	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 3-7). Year to year variability in precipitation is high with drought conditions (high temperatures and low groundwater table) being somewhat common. These occurances 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.

Figure 3-7
Mean Monthly Rainfall At KSC Area Sites



A comparison of the NADP rainfall for 2008 vs. the last 17-year mean shows the rainfall at the NADP site was drier than normal during the spring and fall and wetter than normal during the summer of 2008, except for the month of September (Figure 3-8).



There is a spatial component to rainfall at KSC and CCAFS as can be seen in a 17-year composite figure of data from the Tropical Rainfall Mesoscale Monitoring (TRMM) network (Figure 3-9). 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, and 28. As previously mentioned, there is some degree of year-to-year variability, which is somewhat driven by the El Nino Southern Oscillation (ENSO).

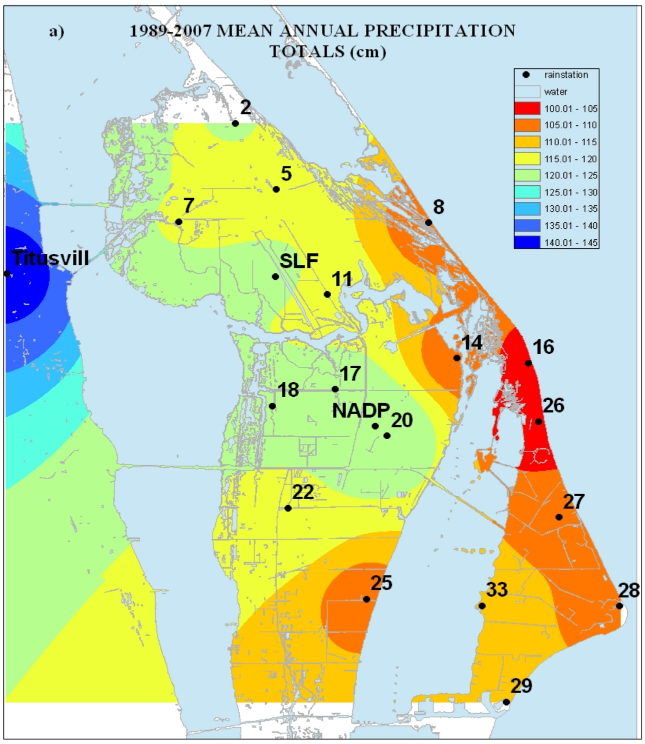
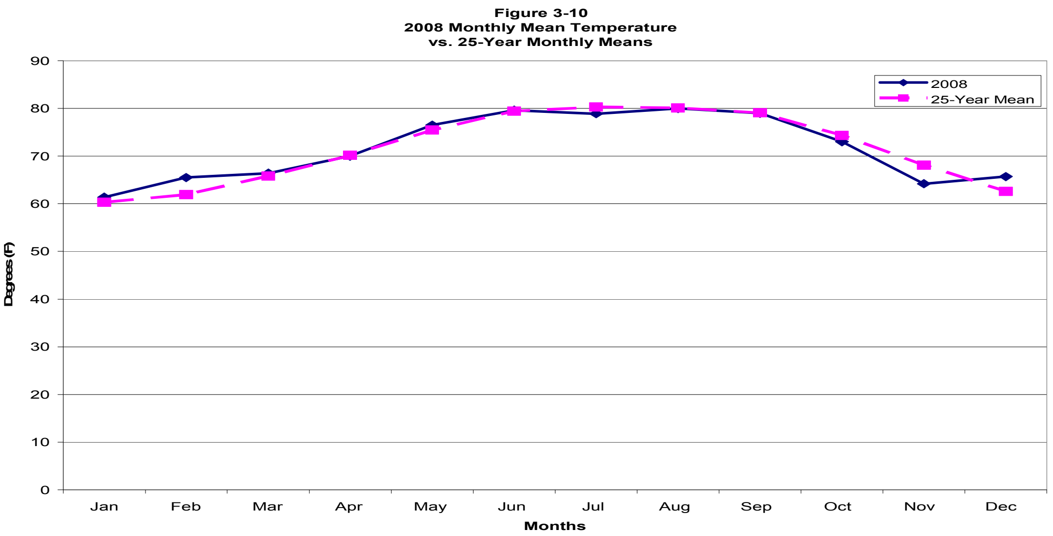


Figure 3-9. 17-Year Mean Rainfall at KSC.

3.4.2. TEMPERATURE

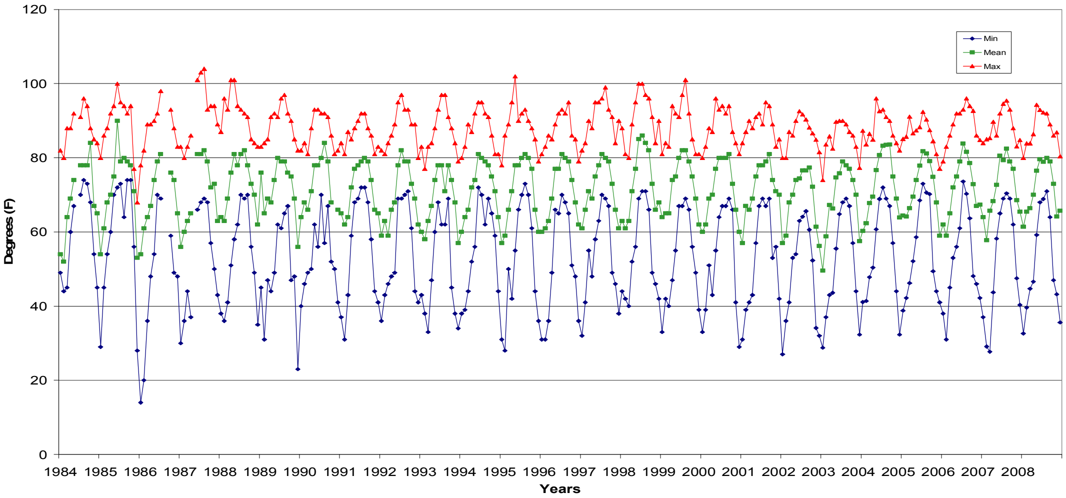
Monthly temperature variations for 2008 at PAMS A and the 26-year mean are shown in Figure 3-10. August was the warmest month of 2008 with an average temperature of 26.7 °C (80.0 °F), while May had the highest maximum temperature of 34.6°C (94.3°F). January is the coldest month, on average, with a mean temperature of 16.3°C (61.4°F) for 2008 and a 26-year mean temperature of 15.7°C (60.3°F).



A plot of monthly minimum, mean, and maximum temperatures from 1984 through 2008 at PAMS A shows that there has been little change over this period (Figure 3-11).

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 maximum temperature during a freeze event being below freezing.

Figure 3-11
Ambient Minimum, Mean, and MaximumTemperatures (1984-2008)



3.4.3 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 the Shuttle Landing Facility from 1978 through 2000 (Figures 3-12 through 3-15). 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. An annual wind rose shows predominate winds for the entire year is from the N, E, and the SE-S (Figure 3-16). There are a three percent of calm winds for the entire year. The annual wind rose tends to ‘smooth out’ the seasonal patterns as shown above.

3.4.4 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 Shuttle Landing Facility 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 fogs occurs from November to March and are light, usually burning off by mid-morning. Figure 3-17 shows that the monthly mean humidity levels for 2002 were elevated for most of the year compared to the 18-year monthly means.

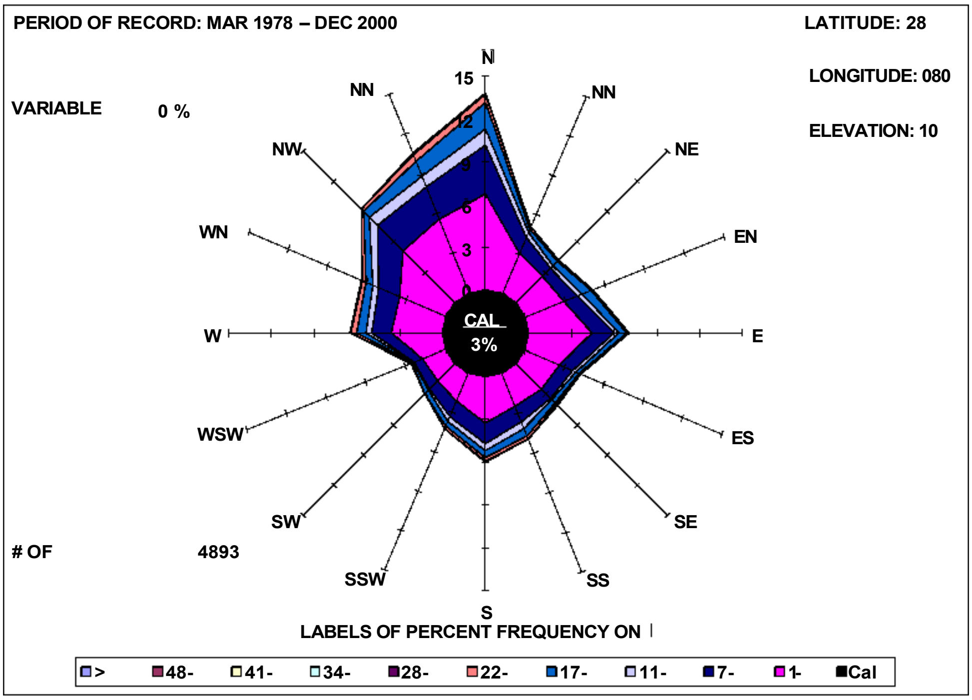


Figure 3-12. Seasonal Wind Rose (Winter).

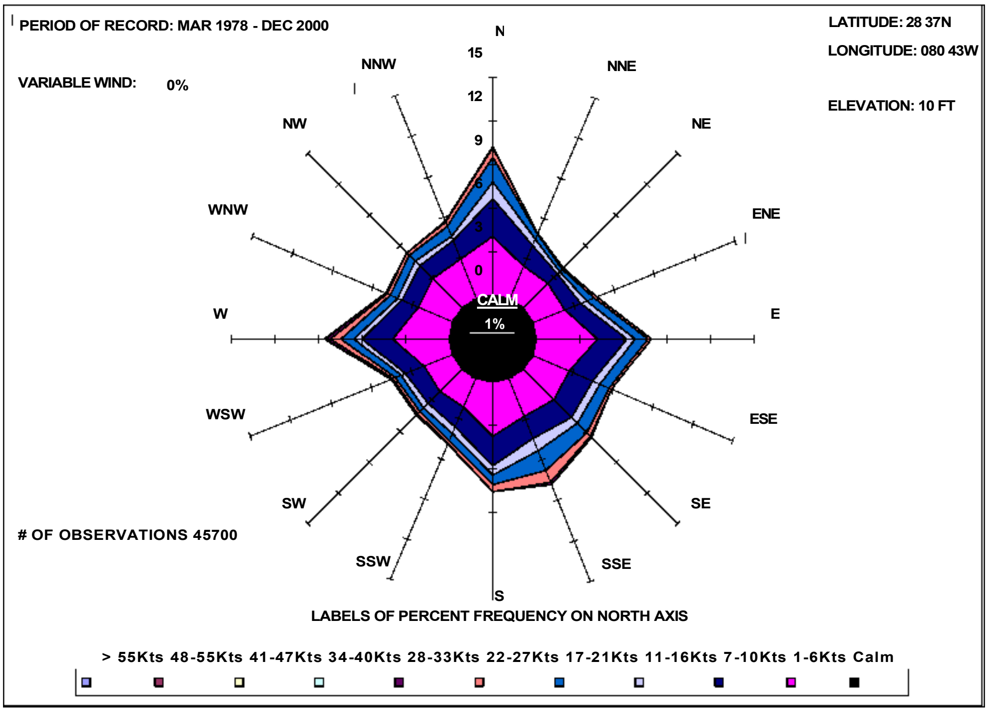


Figure 3-13. Seasonal Wind Rose (Spring).

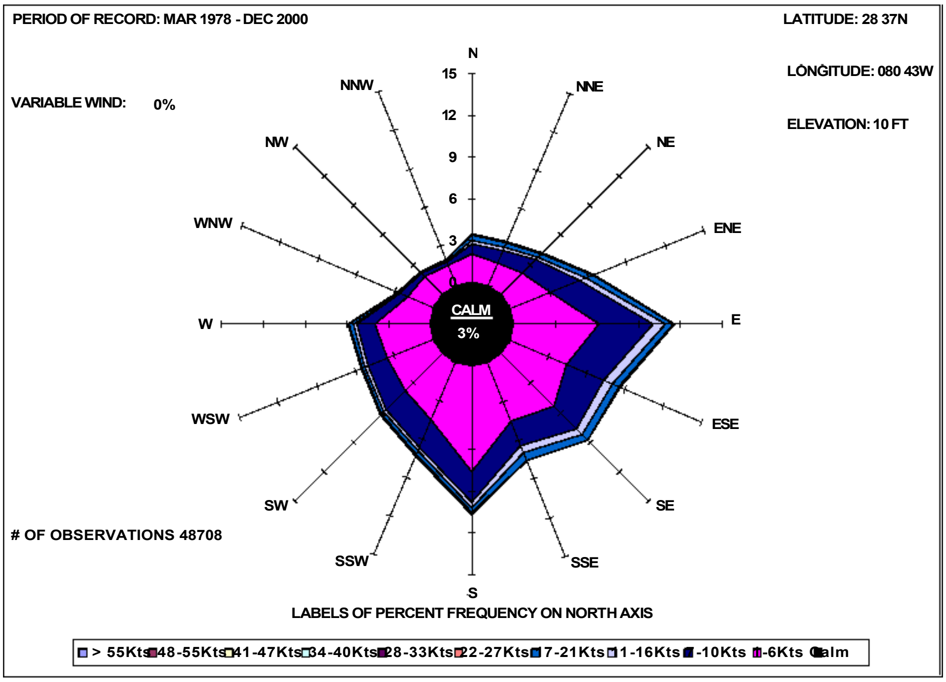


Figure 3-14. Seasonal Wind Rose (Summer).

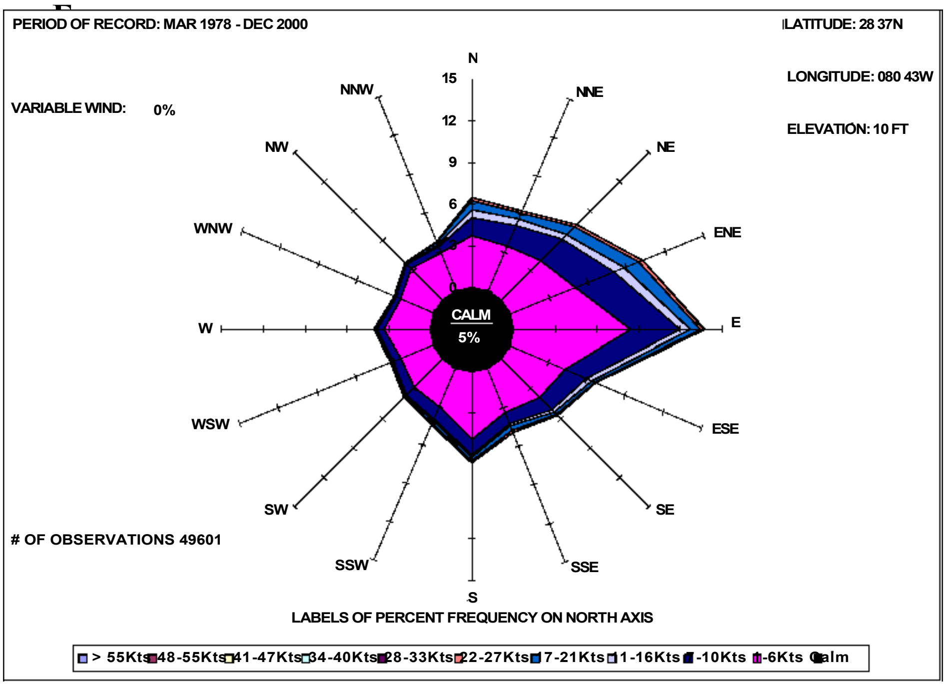


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Figure 3-15. Wind Rose (Fall).

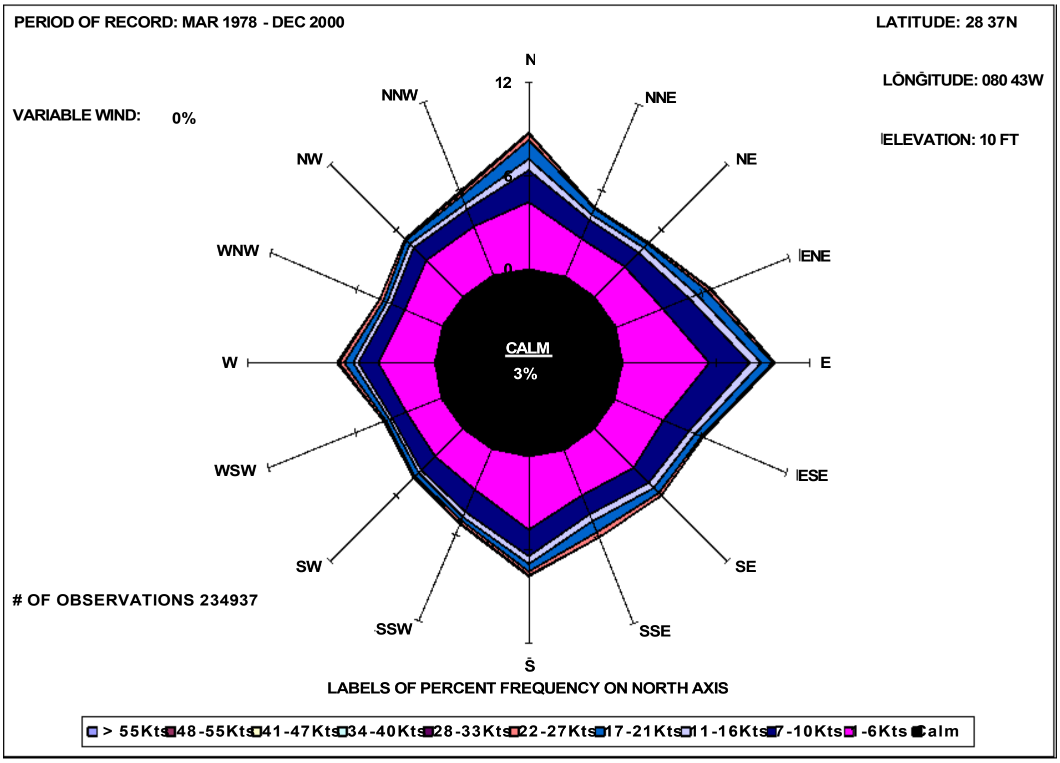


Figure 3-16. Annual Wind Rose.

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				

3.4.5 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.

Figue 3-17
2008 Monthly Mean Relative Humidity vs. 17-Year Means

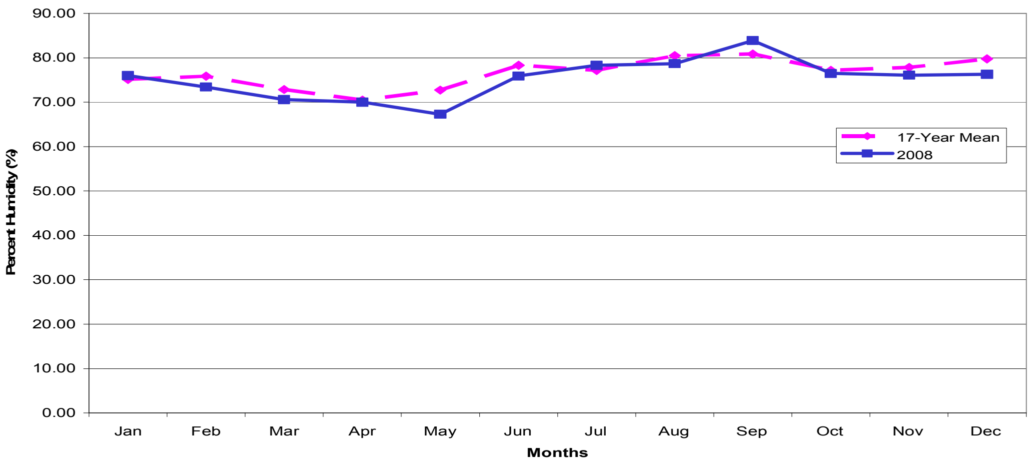


Table 3-7. Mean Daily Solar Radiation, January 1977 through December 1990.

	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/SQ FT
JAN	3960.2	375	1256.2	5691.0	133	1805.5	3285.9	331	1042.3	4833.0	392	1533.1
FEB	4144.9	367	1314.8	6675.1	118	2117.7	3964.8	371	1257.7	5071.6	367	1608.8
MAR	4760.0	389	1509.9	7290.2	135	2312.9	5237.8	392	1661.5	5738.6	394	1820.3
APR	5809.3	348	1842.8	8830.3	131	2801.5	6274.5	350	1990.3	6206.6	381	1968.8
MAY	5612.9	336	1780.5	8898.0	129	2823.0	6627.3	330	212.2	6396.8	358	2029.1
JUN	5209.3	330	1652.5	8430.5	128	2674.6	6439.0	329	2042.5	6282.4	331	1992.8
JUL	5357.6	330	1699.5	8514.6	133	2701.3	6377.9	341	2023.1	6308.7	332	2001.2
AUG	4892.9	372	1552.1	8048.5	137	2553.3	5954.9	372	1888.9	5915.9	372	1876.6
SEP	4288.2	361	1360.3	7225.3	133	2292.2	5168.9	368	1639.6	5469.3	365	1734.9
OCT	4097.2	355	1299.7	6552.9	142	2079.0	4431.5	351	1405.7	5382.2	358	1707.3
NOV	4139.3	350	1313.0	6249.3	138	1982.6	3496.4	332	1109.1	5095.0	350	1616.2
DEC	3541.9	366	1123.5	5381.9	136	1707.5	308.7	341	954.4	4691.2	374	1488.1
ANNUAL MEAN DAILY SOLAR RADIATION												
	4645.1	4279	1473.5	7315.6	1593	2320.9	5043.0	4208	1599.7	5600.0	4374	1776.4

Source: Ref. 10

3.4.6 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 were there 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. 10). 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. 9, Figure I-15).

3.4.7 WEATHER HAZARDS

3.4.7.1 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. 7). Fog is defined as visibility less than 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.

3.4.7.2 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. 7).

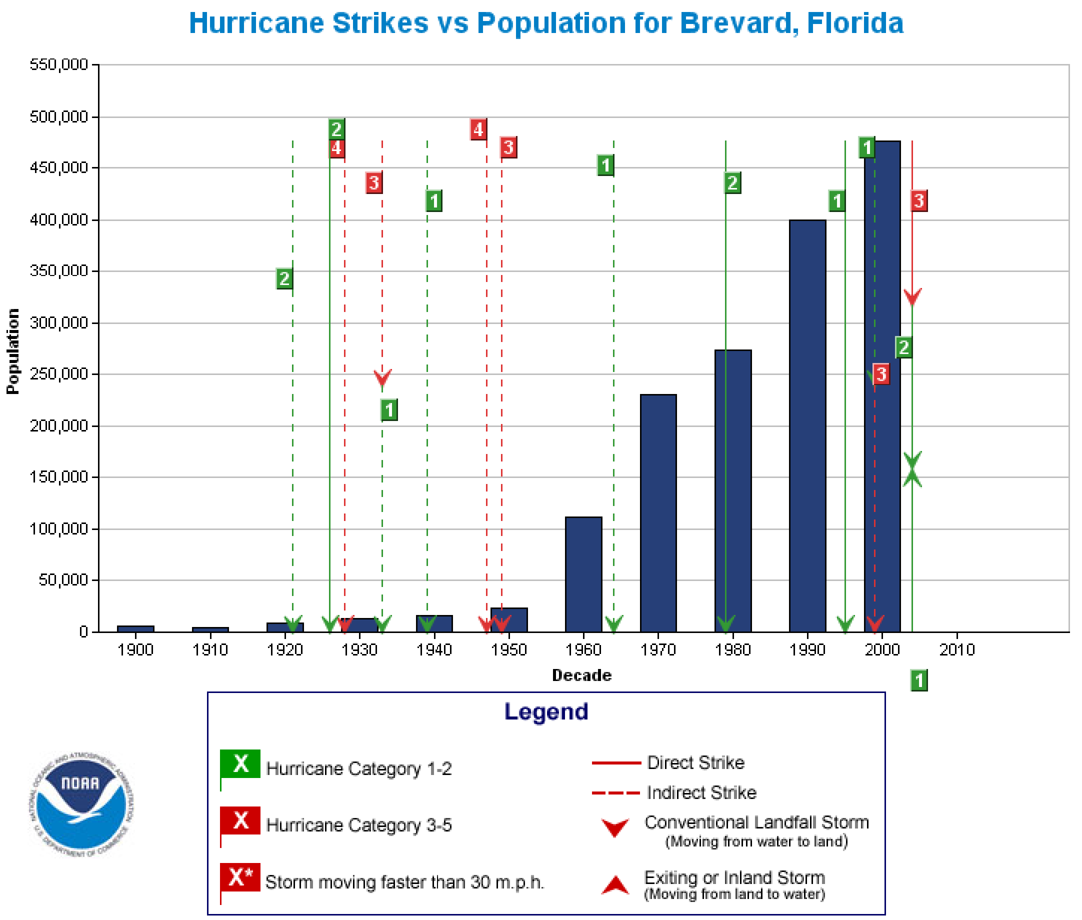
3.4.7.3 Thunderstorms. Eighty percent of the storms at KSC occur in the months of May through September, with an average maximum of 16 thunderstorm days in July (Ref. 9). Thunderstorms most often occur from 2:00 to 6:00 p.m., with a peak occurrence at 4:00 p.m. The storm duration usually is brief; however, cloudbursts sometimes cause adverse driving conditions (Ref. 7). Frequency of regional thunderstorms range 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. 7).

3.4.7.4 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. 7). Estimates of the monthly area density of all discharges during the summers of 1974 through 1980, range from 2 to 10 discharges per square mi. per month. The main area density of CG flashes alone is estimated to be 1 flash per square mi. per month (Ref. 7).

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

3.4.7.6 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. 7).

3.4.7.7 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 74 mi/hr or greater, while tropical storm winds are slower, ranging from 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), 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 (29), 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 3-18 shows the occurrence of Hurricane landfalls in Brevard County, Florida, from 1900 through 2008. The most activity was in the 1920's through the 1940's and from 2000 to present (http://hurricane.csc.noaa.gov/hurricanes/index.htm (select Coastal Population)).



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 3-18. Occurrence of Hurricanes in Brevard County, Florida, from 1900 through 2008.

3.5 REFERENCES

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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 eastern 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 Intercoastal 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 and evaporation.

Within KSC property is Banana Creek, which drains the area adjacent to the Space Shuttle 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 affect 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 Carolian 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, 7, 8, 9, 10). Refer to Section 5 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 for activities in OFW 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 Bananna 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 St. Johns River Water Management District (SJRWMD) in accordance with the rule criteria set forth in Chapter 40C-2, F.A.C. 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, F.A.C. 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.

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 wetlands resource permitting 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 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 wetland resource permit process (Chapter 62-312 F.A.C.). 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 wetland resource permitting authority is supported by the Florida Fish and Wildlife Conservation Commission (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 wetland resource permitting 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 wetland resource permit applications when an activity also requires a stormwater discharge permit, with the following exceptions:

- All wetland resource permits 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 permitting 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 Parts 122, 123, and 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) F.A.C.).

FDEP has stormwater permit authority for discharges to surface water as defined in Chapter 40C-42 F.A.C. (as administered by SJRWMD) and groundwater as defined in 62-4 F.A.C. 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 six 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. See Table 4-1 and Figures 4-1 and 4-2.

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 12 ft.

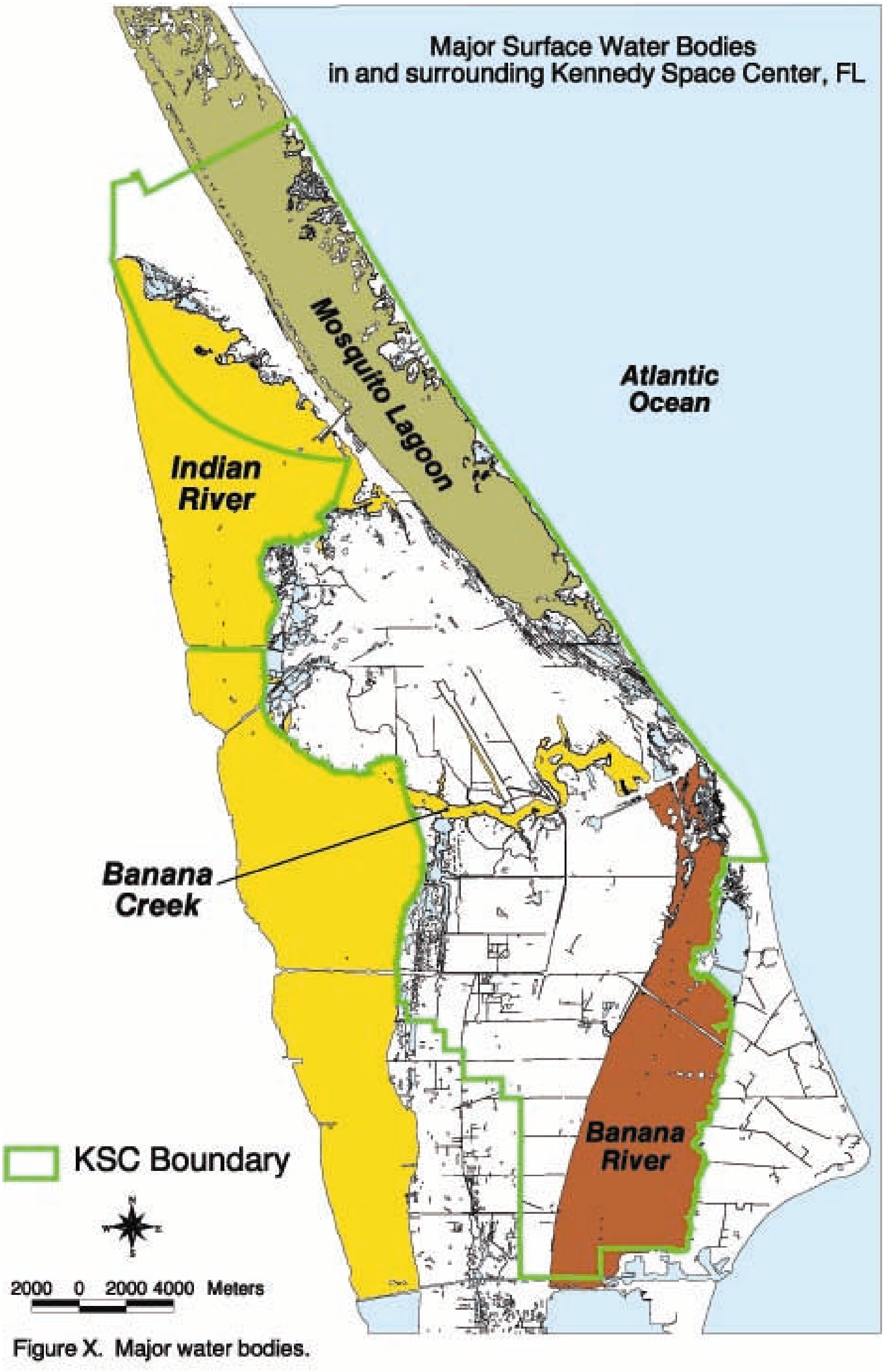

Figure 4-1. Major Water Bodies Around KSC.

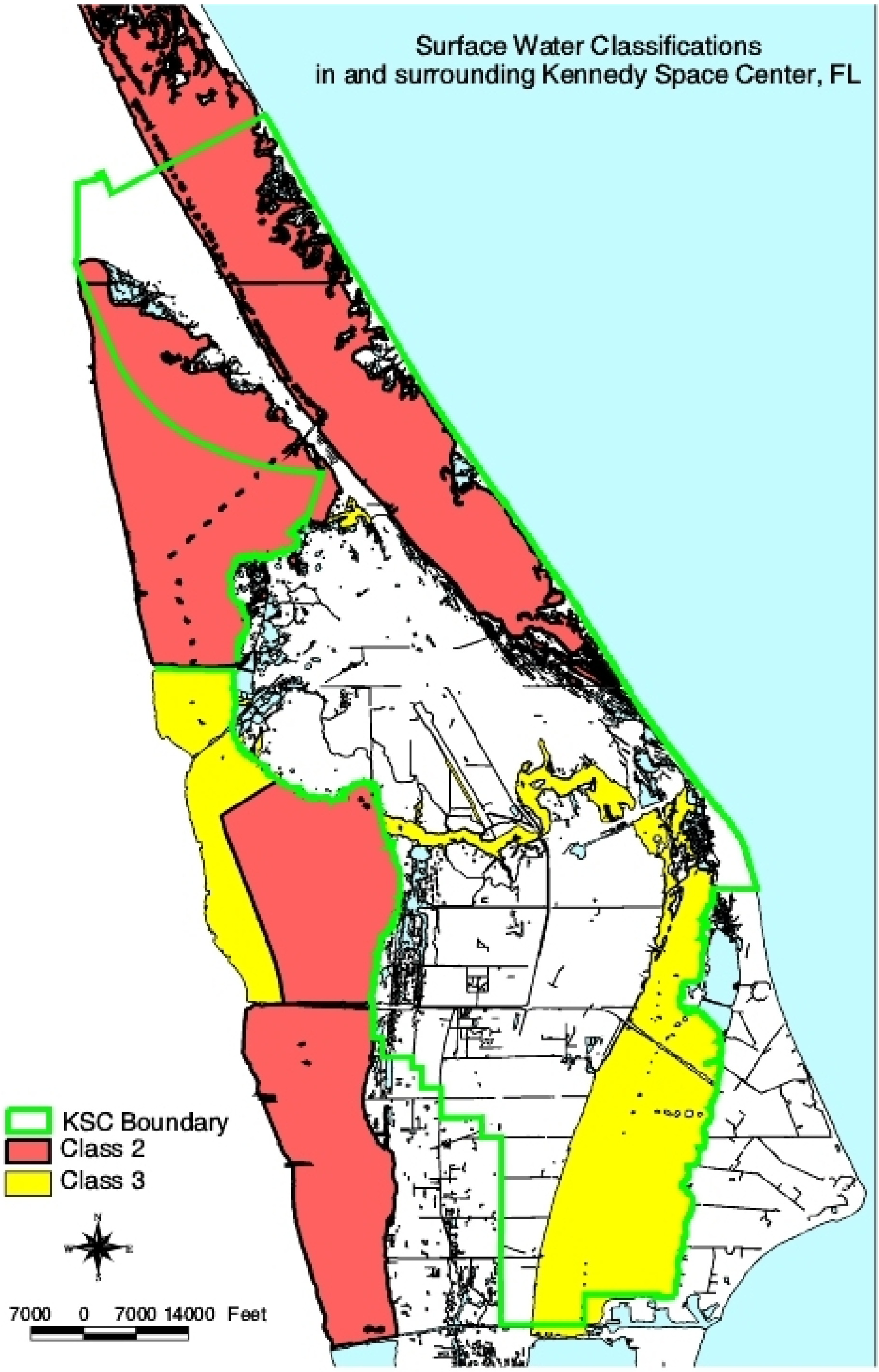

Figure 4-2. Classification of Water Bodies Around KSC.

The Turning Basin access channel extends from Port Canaveral north through the Banana River to the VAB area. A channel spur to Hangar AF provides navigable access for two vessels used in the retrieval of SRBs. Public navigational access is prohibited north of the NASA Parkway East.

The Banana River, south to KARS Park, has been closed to powered vessels with the designation of the area as a Manatee sanctuary (see Section 6.7.6).

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 have been designated as OFW (see Figure 2-2). 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. The best areas of water quality are adjacent to undeveloped areas of the lagoon, such as the north Banana River, Mosquito Lagoon, and the northernmost portion of the Indian River (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 maintain water quality monitoring stations around and within KSC boundaries. The SJRWMD lagoon wide network maintains two surface water quality monitoring stations within KSC (Figure 4-3). Surface water quality data is collected by KSC and is submitted to the SJRWMD for incorporation into a region-wide data management system. 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. Since 1984, eleven sites within the boundary of KSC have been monitored quarterly until 2000 and bi annually to present (Figure 4-3). The purpose of this monitoring program is to maintain a baseline ecological database of basic surface water quality parameters. Most of the monitoring sites are located away from major facilities and operational areas as background stations to characterize ambient conditions which can be compared to several sites that are 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. Most of the basic surface water parameters such as salinity, dissolved oxygen (DO), pH, temperature and conductivity follow seasonal and diurnal patterns typical of the IRL.

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 ongoing, 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).

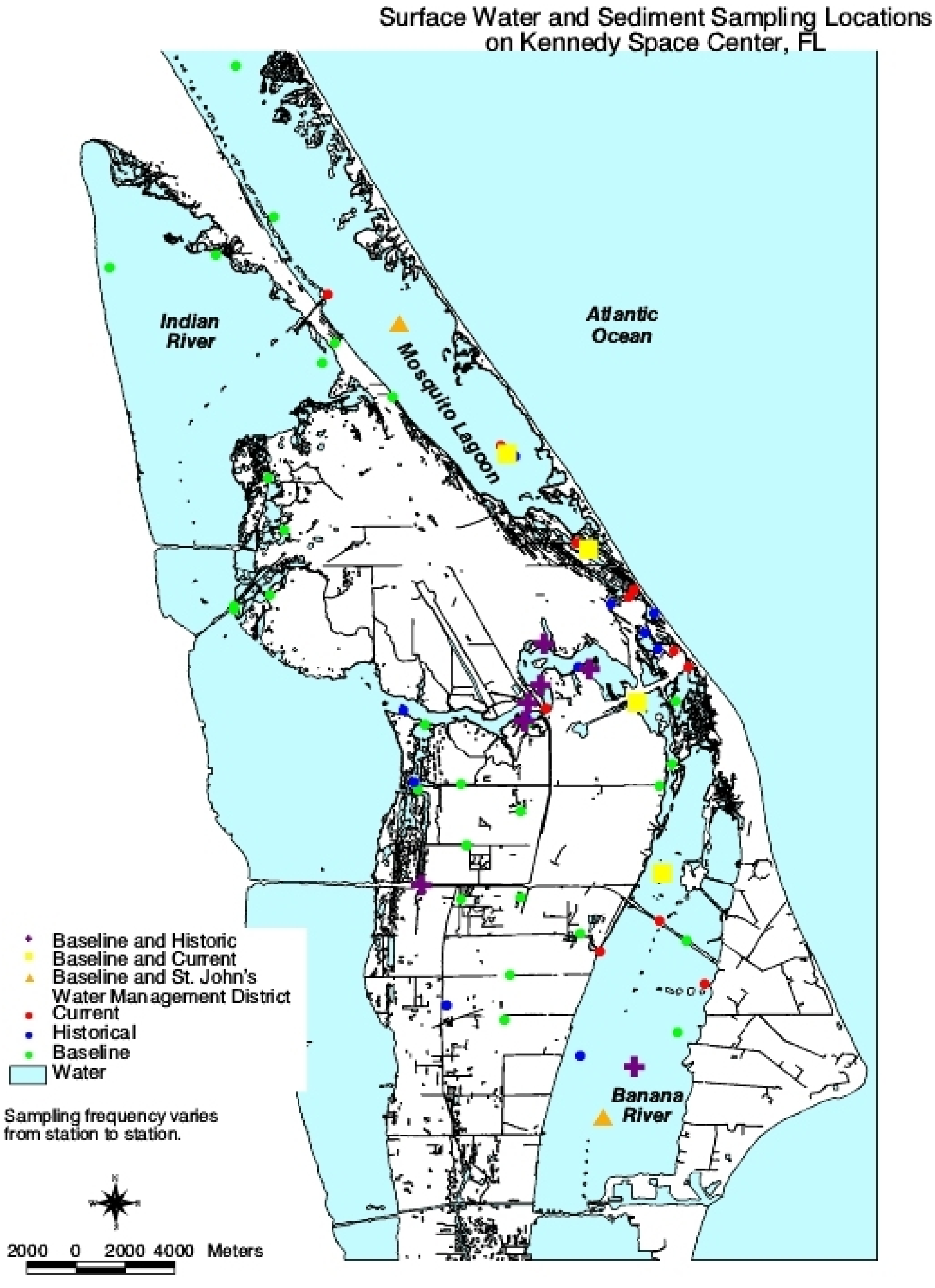

Figure 4-3. Water Quality and Sediment Sampling Stations on KSC.

Surface water was analyzed for organochlorine pesticides, aroclors, chlorinated herbicides, 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 (Ba, Cd, Cr, Co, Hg, Ni, Vn, and Zn) were always below detection. Nine metals (Sb, As, Be, Cu, Pb, Mn, Se, Ag, and Tl) were above detection in too few samples to test for differences among watershed basins. Seven metals commonly above detection limits (Al, Ca, Cl, Mg, Fe, K, and Na) differed among basins (ANOVA, $p<0.05$). Patterns of differences varied among metals. For Al, Banana Creek was higher than the other basins. Fe 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. K was highest in Mosquito Lagoon, intermediate in Banana Creek, Indian River Lagoon, Banana River, and saline ditches, and lowest in freshwater ditches. Na 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 list 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 Containment 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
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

Table 4.2. (cont.).		
4 (2, 4 – Dichlorophenoxy) butyric acid (2, 4 – DB)	8151	0.5 µg/L
Chlorinated Herbicides (continued)		
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
Dalapon	8151	0.5 µg/L
Dicamba	8151	0.5 µg/L
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
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

Table 4-2. (cont.).		
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
Cooper	200.7/ 7211	0.05 mg/L
Iron	200.7	0.05 mg/L
Lead	200.7	0.005 mg/L
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 4-4, 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 4-5). 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; 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 4-6).

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 4-7). 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 4-7). 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).

Recharge to the Intermediate aquifer system is dependent on leakage through the surrounding beds of lower permeability (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 4-4, 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).

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).

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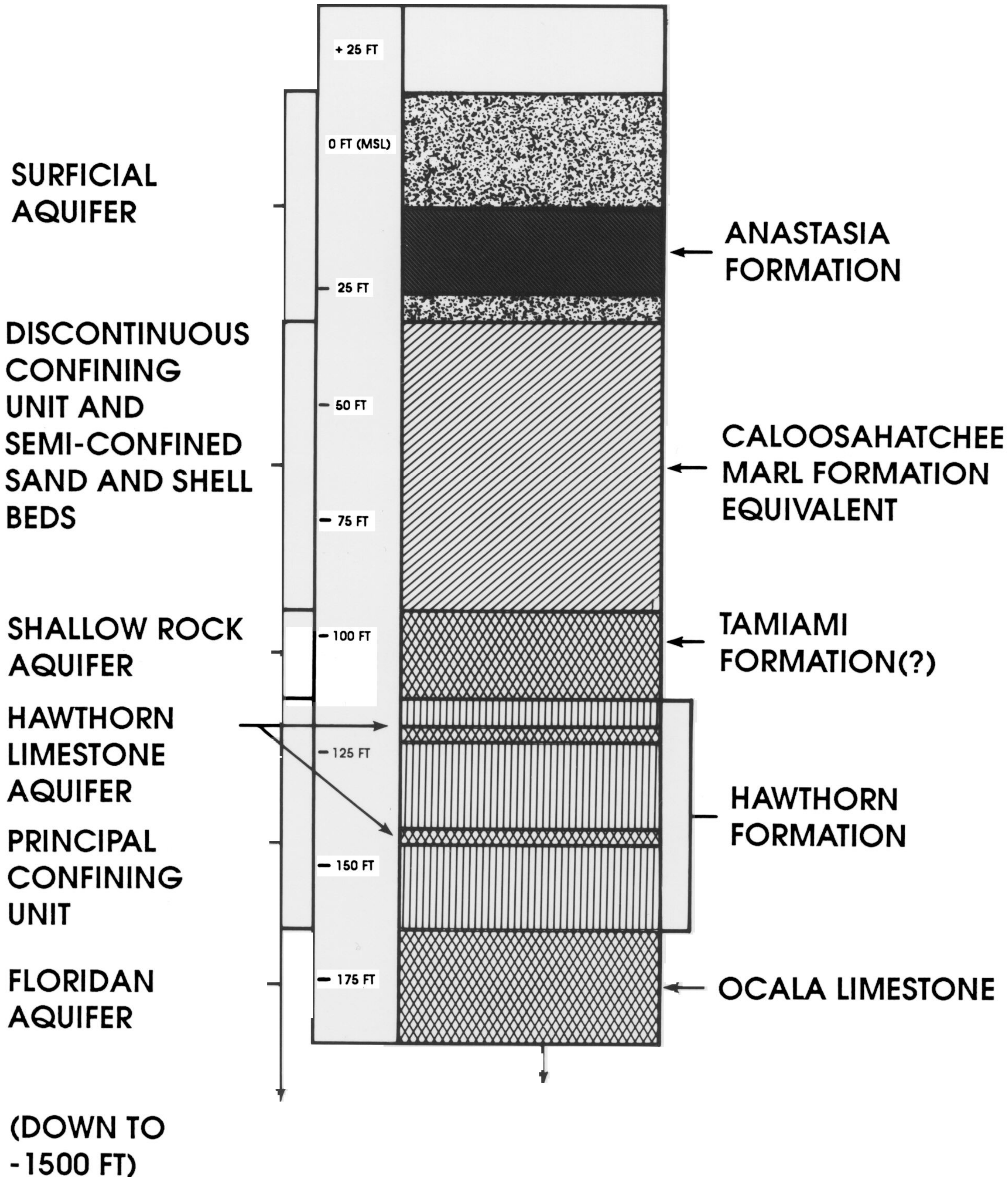

Figure 4-4. Geohydrological Units on Kennedy Space Center (redrafted from Ref. 15).

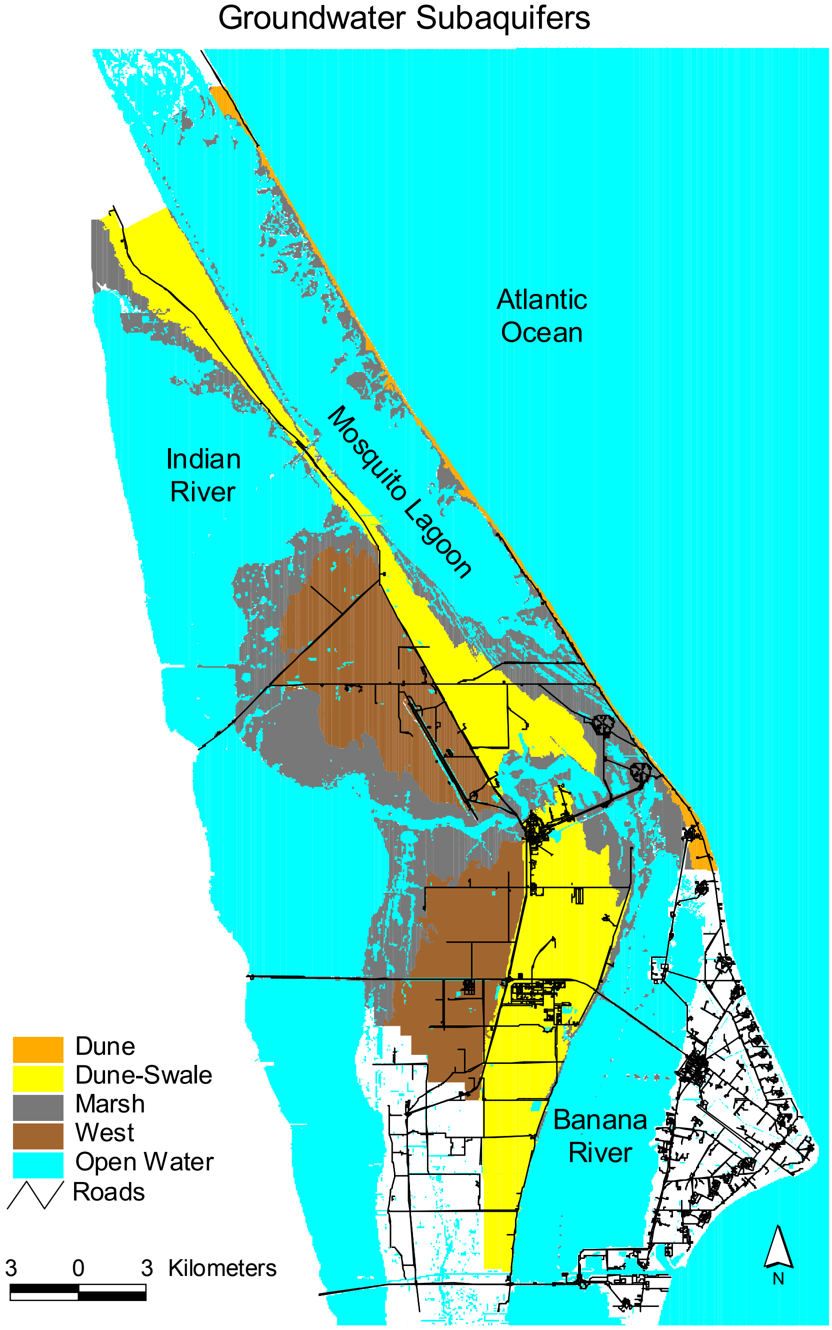

Figure 4-5. Subaquifers of the Surficial Aquifer on Kennedy Space Center (Ref. 3, modified from Ref. 15)

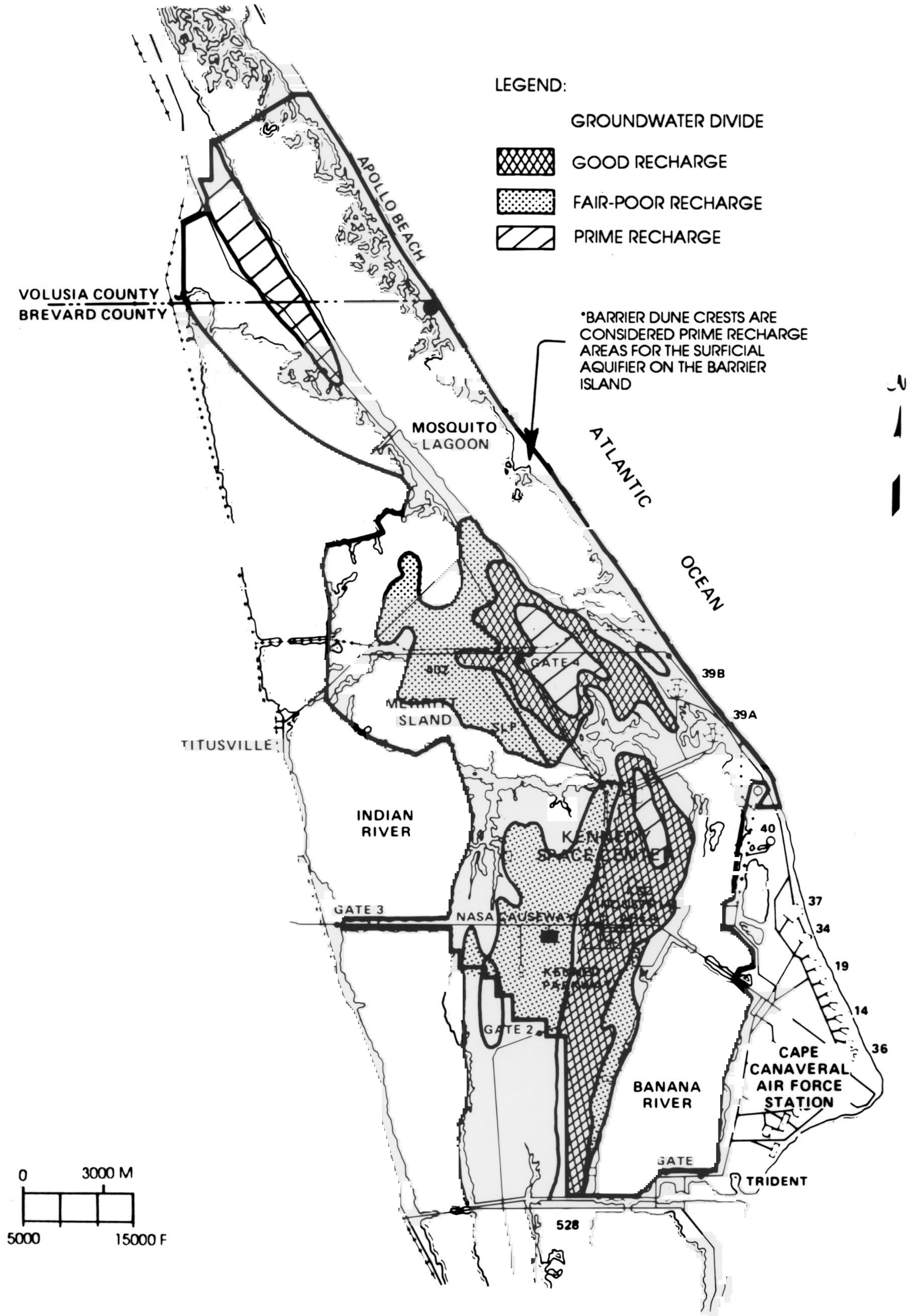

Figure 4-6. Potential for Recharge of the Surficial Aquifer (redrafted from Ref. 15).

Table 4-3. General Characteristics of the Aquifers on Kennedy Space Center.[1]

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

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

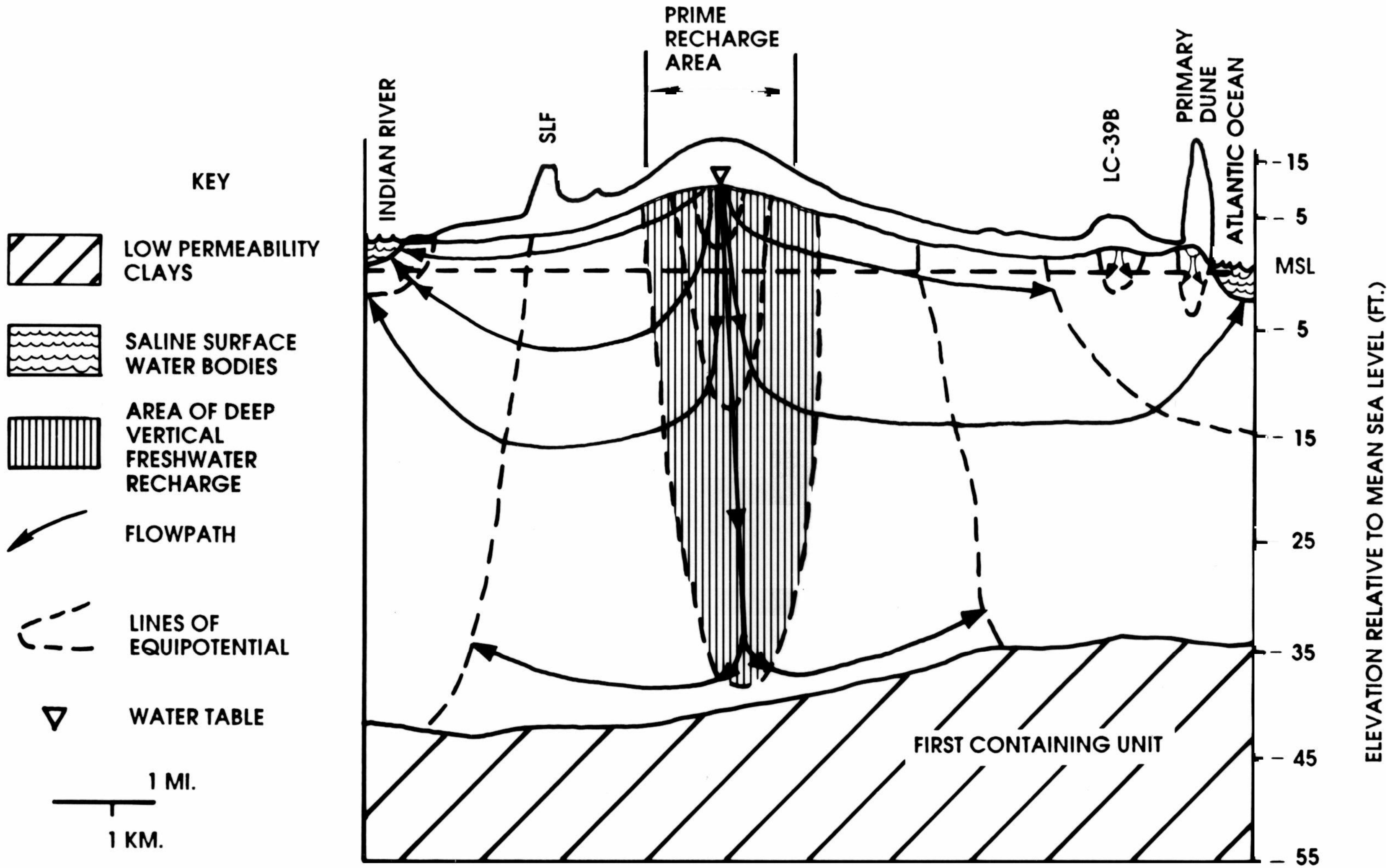

Figure 4-7. Groundwater Circulation in the Surficial Aquifer (redrafted from Ref. 15).

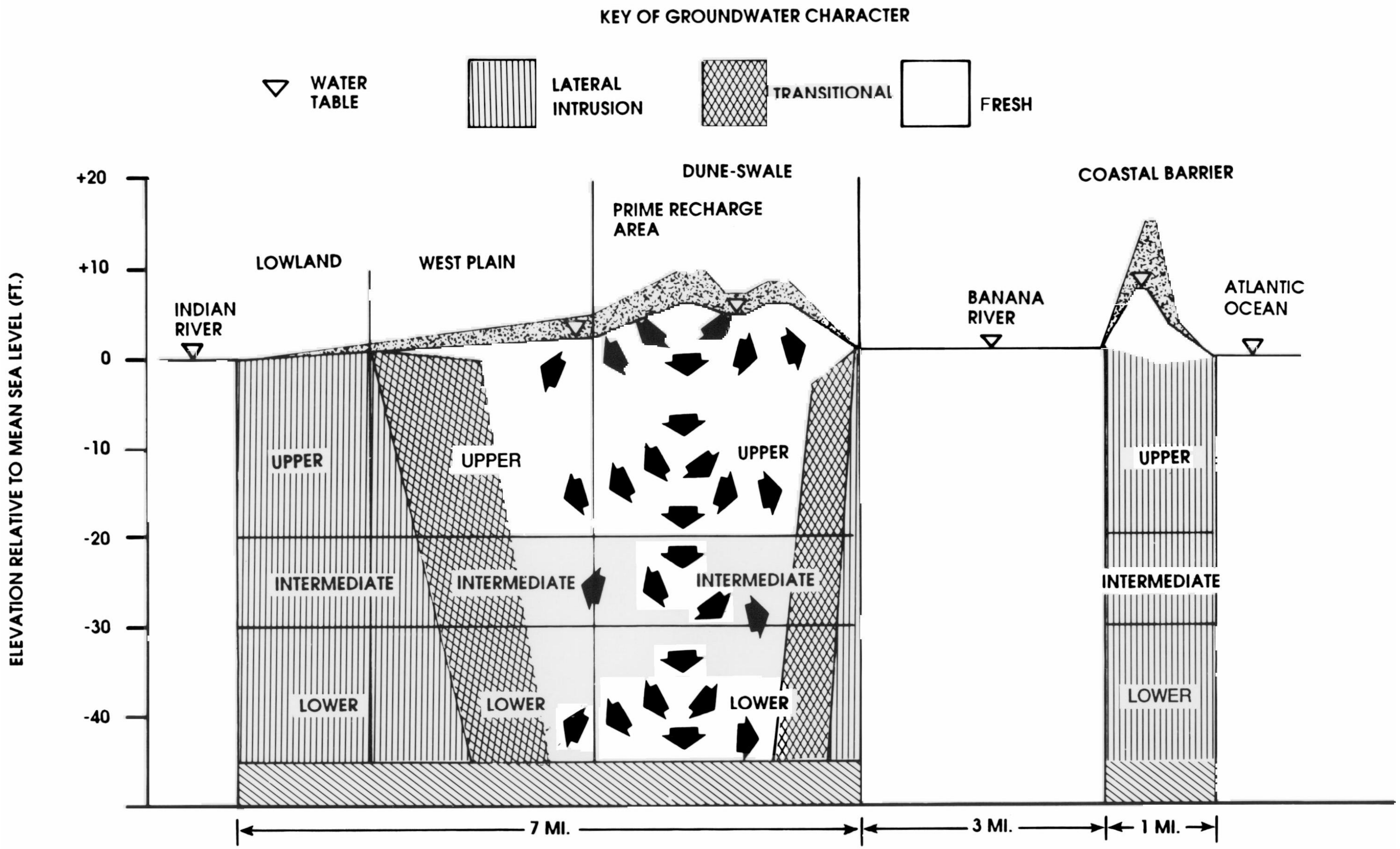

Figure 4-8. Chemical Evolution of Groundwater in the Surficial Aquifer (redrafted from Ref. 15).

Table 4-4. 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 4-4. (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	0.16	0.083	0.105	0.05	0.298	0.117	0.049	0.143	0.057	0.033	0.44	0.15	0.066
(mg/L)	(0.27)	(0.098)	(0.025)	(0.04)	(0.481)	(0.136)	(0.041)	(0.175)	(0.054)	(0.014)	(0.50)	(0.08)	(0.020)
Antimony	0.003	0.003	0.007	0.0025	0.0025	0.0025	0.0053	0.0025	0.0025	0.0025	0.0038	0.0045	0.0025
(mg/L)	(0.002)	nd	(0.004)	nd	nd	nd	(0.0049)	nd	nd	nd	(0.0025)	nd	nd
Arsenic (as	0.011	0.015	0.028	0.021	0.005	0.005	0.005	0.006	0.008	0.005	0.025	0.005	0.005
carcinogen) (mg/L)	(0.016)	(0.02)	(0.039)	(0.014)	nd	nd	nd	(0.002)	(0.007)	nd	(0.029)	nd	nd
Barium	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.11	0.06	0.05
(mg/L)	(0.05)	nd	nd	nd	nd	nd	nd	nd	nd	nd	(0.13)	(0.03)	nd
Beryllium	0.0005	0.0005	0.001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
(mg/L)	(0.0003)	nd	(0.001)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Cadmium	0.0007	0.0008	0.002	0.0007	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
(mg/L)	(0.0011)	(0.0006)	(0.004)	(0.0003)	(0.0002)	nd	nd	nd	nd	nd	nd	nd	nd
Calcium	242.4	148.8	322.4	336.7	56.1	97.6	254.0	144.3	192.0	246.7	262.7	594.0	620.0
(mg/L)	(201.2)	(75.5)	(189.2)	(200.3)	(43.6)	(74.4)	(265.7)	(51.3)	(47.6)	(73.7)	(238.9)	(98.4)	(70.7)
Chloride	4545	2995	12340	7433	27	102	3707	404	1099	1127	4251	14860	14800
(mg/L)	(7272)	(4114)	(8322)	(7420)	(33)	(139)	(6316)	(669)	(618)	(1016)	(3293)	(11870)	(15839)
Chromium (total)	0.006	0.005	0.006	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.009	0.005	0.005
(mg/L)	(0.003)	nd	(0.002)	nd	nd	nd	nd	nd	nd	nd	(0.007)	nd	nd
Copper	0.031	0.025	0.04	0.025	0.025	0.025	0.025	0.025	0.025	0.110	0.022	0.028	0.025
(mg/L)	(0.035)	nd	(0.03)	nd	nd	nd	nd	nd	nd	(0.147)	(0.006)	(0.006)	nd
Iron	1.12	0.058	0.77	2.06	0.36	1.28	1.21	0.81	1.60	2.00	1.60	2.31	1.21
(mg/L)	(1.76)	(0.08)	(0.99)	(3.24)	(0.59)	(0.53)	(1.50)	(0.94)	(0.20)	(0.97)	(3.71)	(2.38)	(1.68)

Table 4-4. (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	0.004	0.0025	0.009	0.004	0.0025	0.0025	0.0025	0.0025	0.0025	0.011	0.003	0.006	0.0025
(mg/L)	(0.005)	nd	(0.10)	(0.003)	nd	nd	nd	nd	nd	(0.015)	(0.001)	(0.005)	nd
Magnesium	307.4	201.1	847.6	1036.7	2.2	10.0	244.9	32.6	73.0	98.7	248.6	796.8	782.5
(mg/L)	(493.8)	(267.6)	(571.1)	(845.6)	(2.6)	(13.5)	(420.1)	(31.7)	(19.4)	(28.7)	(211.6)	(734.0)	(1014.7)
Manganese	0.068	0.02	0.075	0.114	0.015	0.022	0.057	0.024	0.046	0.070	0.062	0.284	0.141
(mg/L)	(0.098)	(0.023)	(0.072)	(0.162)	(0.026)	(0.02)	(0.08)	(0.095)	(0.019)	(0.007)	(0.079)	(0.146)	(0.112)
Nickel	0.006	0.005	0.006	0.007	0.005	0.005	0.005	0.005	0.005	0.015	0.005	0.005	0.005
(mg/L)	(0.004)	nd	(0.003)	(0.003)	nd	nd	nd	nd	nd	(0.014)	nd	nd	nd
Potassium	89.2	66.0	274.2	316.7	1.1	1.2	31.5	8.1	17.0	13.3	74.8	215.6	239.4
(mg/L)	(150.6)	(91.3)	(177.6)	(211.3)	(0.6)	(1.7)	(54.1)	(8.1)	(13.2)	(0.6)	(63.7)	(241.7)	(326.2)
Selenium	0.006	0.005	0.01	0.02	0.007	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
(mg/L)	(0.007)	nd	(0.01)	nd	(0.003)	nd	nd	nd	nd	nd	nd	nd	nd
Silver	0.005	0.005	0.005	0.007	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
(mg/L)	(0.007)	nd	nd	(0.003)	nd	nd	nd	nd	nd	nd	nd	nd	nd
Sodium	2670	1510	6720	8167	13.1	53.6	1875	240	560	883	3121	7360	6650
(mg/L)	(4011)	(2011)	(4342)	(6526)	(11.9)	(59.5)	(3226)	(318)	(399)	(196)	(3030)	(5280)	(7566)
Thallium	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002
(mg/L)	(0.0005)	nd	nd	nd	nd	nd	(0.0006)	nd	(0.0005)	nd	(0.0008)	(0.002)	(0.001)
Vanadium	0.005	0.005	0.007	0.005	0.005	0.005	0.005	0.006	0.005	0.005	0.007	0.005	0.005
(mg/L)	(0.002)	nd	(0.004)	nd	nd	nd	nd	(0.002)	nd	nd	(0.003)	nd	nd
Zinc	0.053	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.11	0.05	0.05	0.05
(mg/L)	(0.024)	nd	nd	nd	nd	nd	nd	nd	nd	(0.10)	nd	nd	nd

Table 4-4. (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-8)	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 F.

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-Eau Gallie-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-Eau Gallie-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). Then Upland soils were 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
	Saline	Coastal, brackish to saline soils – vegetation is saltmarsh or mangroves	Saltwater Wetlands
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 F, Table F-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

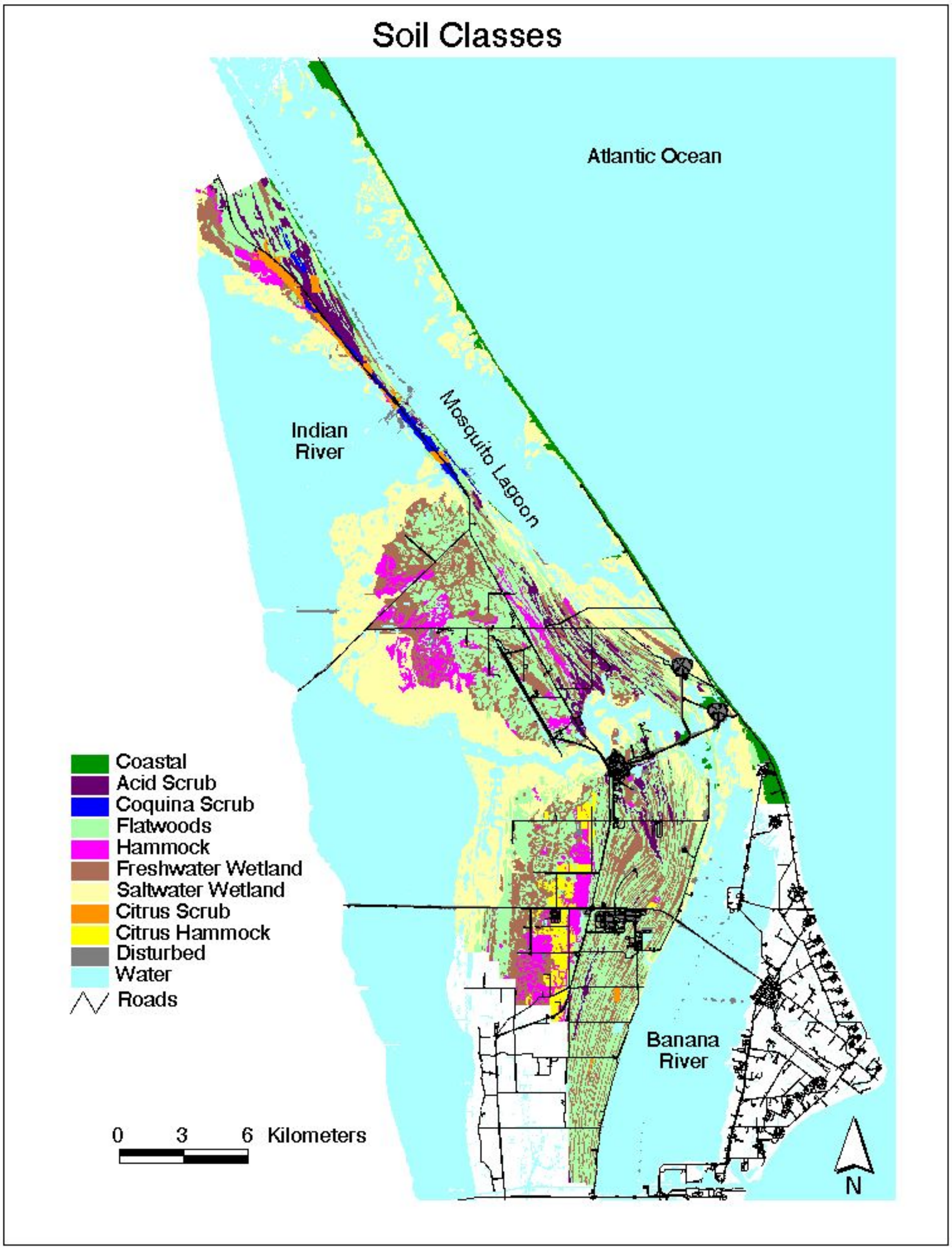

Figure 5-1. Distribution of Soil Classes on Kennedy Space Center (Ref. 7).

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)Cooke 1945). 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 [yr B.P.] to 13,000 yr B.P.), repeated glaciation of the northern hemisphere produced fluctuations in sea level (Ref. 16)Bowen 1978). 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)Mehta and Brooks 1973). Some areas of the barrier island south of Cape Canaveral have a history of overwash, while others have been more stable (Ref. 26)Bader and Parkinson 1990).

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			Highly variable and undifferentiated deposits.
Pleistocene	Anastasia Formation	Surficial Aquifer System	Sand, shell, clay, coquina, and mixtures. Yields moderate amounts of water, depending on permeability of deposits.
Pliocene	Tamiami Formation		Interbedded limestone, coquina, sand and clay (eastern). Shell, sand, clay and cemented zones (western).
Miocene	Hawthorn Formation	Intermediate Confining Unit	Sand clay, green and brown clays, and some limestones. Generally impermeable; poor water yield except for some thin shell and limestone beds.
Oligocene	Suwanee Limestone	Floridan Aquifer System	Gray to cream colored, clayey, granular limestone. Poor water yields.
Eocene	Ocala Limestone		Gray to cream colored, porous massive limestone, generally yields good quantity of water.
	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.

1Ref. 29

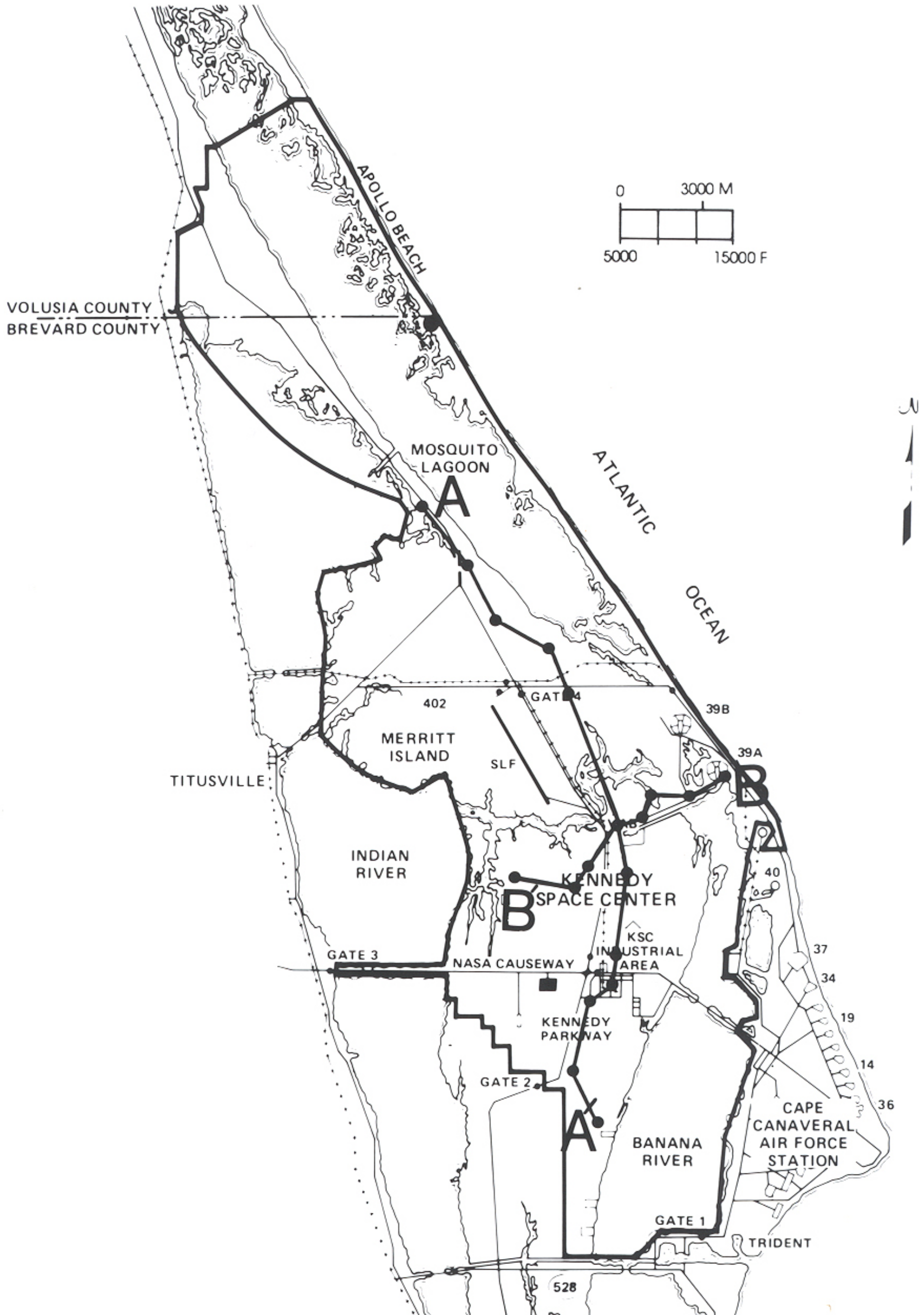

Figure 5-2. Location of North-South and East-West Geologic Cross Sections on Kennedy Space Center (redrafted from Ref 28).

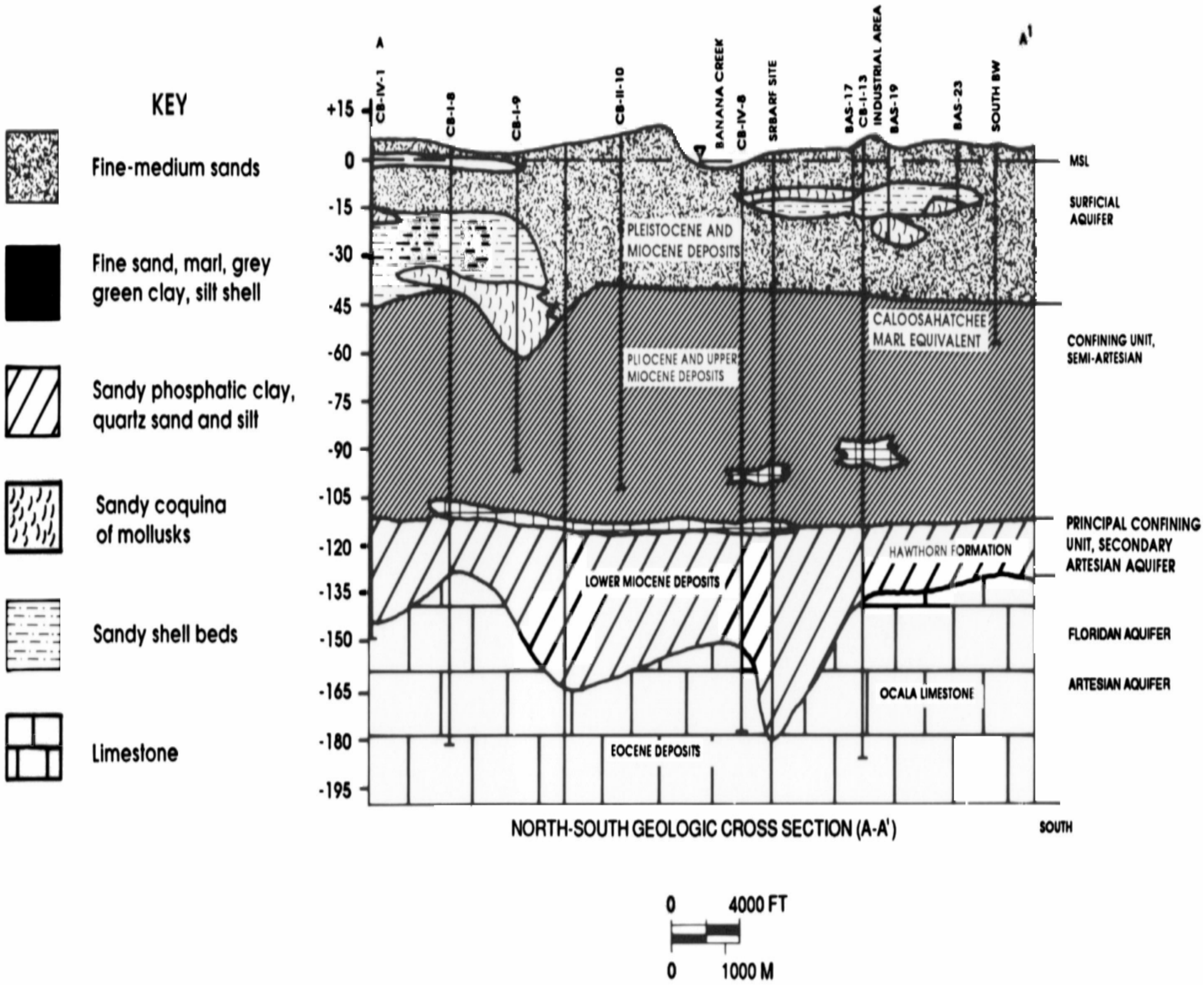

Figure 5-3. North-South Geologic Cross Section for Kennedy Space Center (redrafted from Ref. 28). Vertical scale is elevation in feet relative to mean sea level.

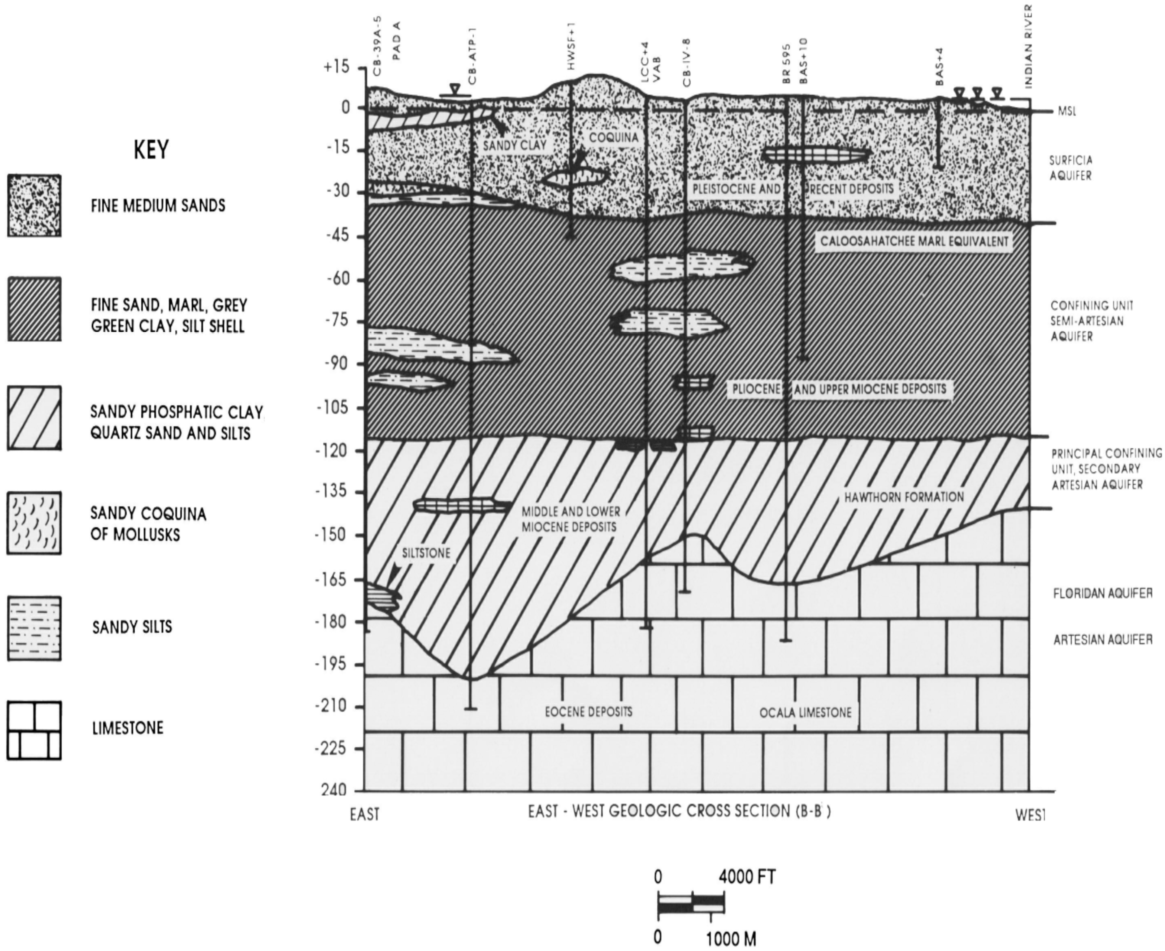

Figure 5-4. East-West Geologic Cross Section for Kennedy Space Center (redrafted from Ref. 28). Vertical scale is elevation in feet relative to mean sea level.

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 long shore 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).

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.

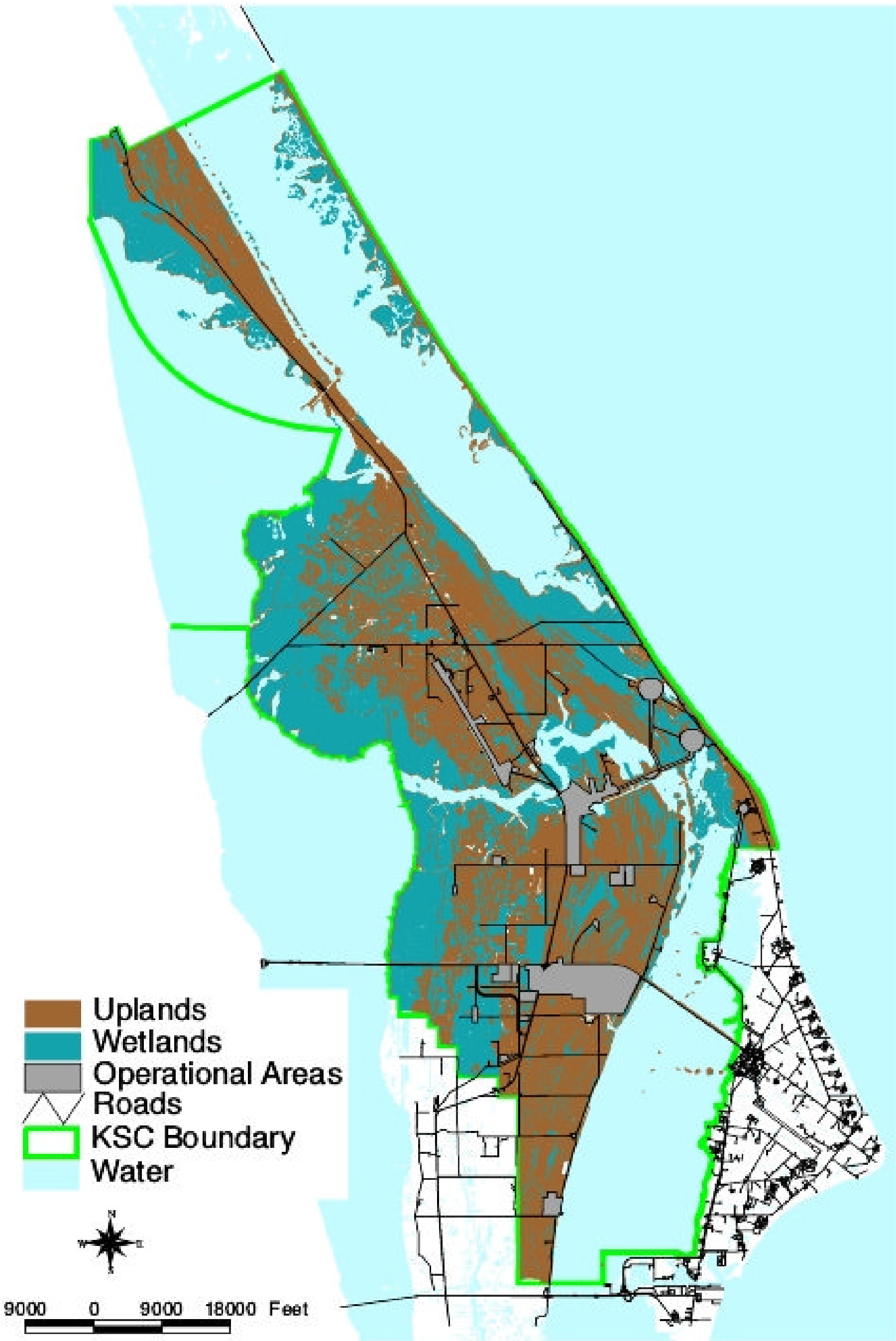

Figure 5-5. General Land Cover on Kennedy Space Center.

5.3.1 UPLAND VEGETATION

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. The types of habitats found in these areas include: scrub, flatwoods and hardwoods and mixed forests.

5.3.2 WETLAND VEGETATION

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. The types of habitats that are found in these areas include: freshwater marshes, hardwood and mixed swamps, wetlands shrub, saltwater marshes, and mangrove swamps.

More detailed described of these habitats can be found in Section VI, Natural Resources. Also in Section VI is a more detailed map of these areas.

5.4 LAND USE, MANAGEMENT, AND PLANNING

NASA exercises control over the 56,510 ha (139,640 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.

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 (see 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 Shuttle Landing Facility, the Industrial Area and the VAB Area (see 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 eleven land use categories to describe the regions within which various types of operational or support activities are conducted.

5.4.2.1 LA – Launch. The Launch land use classification includes all facilities directly related to vehicle launch operations and is subdivided into horizontal launch and vertical launch subcategories. Vertical launch includes the launch pad and immediately adjacent terminal countdown facilities required to be operational at the time of a launch. Horizontal launch includes areas required for the paved runway surface, guideway or similar facility, together with land reserved for safety zones, parallel with and at each end of the launch facility, consistent with the most restrictive FAA clearance requirements for commercial runways. Quantity Distance arcs, transitional surfaces and other related safety setback and exposure limits are considered restrictions on the use of land adjacent to the space launch complexes. Land within those setbacks and limits is not designated part of the Launch and use.

5.4.2.2 LS - Launch Support. The Launch Support land use classification includes all facilities and operations not classified as launch that are essential to processing and launching a vehicle from the Spaceport, recovering and processing a vehicle returning to the Spaceport, and supporting a mission during flight. Launch support also includes all facilities (regardless of function) not classified as Launch that are directly related to a specific program at the Spaceport. An example would be management or research and development facilities dedicated to the Space Shuttle program.

5.4.2.3 AO – Airfield Operations. The Airfield Operations land use classification includes runways and helipads. It also includes adjacent open areas and related support facilities used for takeoff and landing of conventional aircraft in support of Spaceport or program-related operations or for commercial purposes. Facilities in this land use classification would include the Skid Strip (if not designated a horizontal launch/recovery test facility) and various heliports located throughout the Spaceport. Imaginary surfaces related to airfield operational clearances and QD arcs and other related safety setback and exposure limits are considered restrictions on

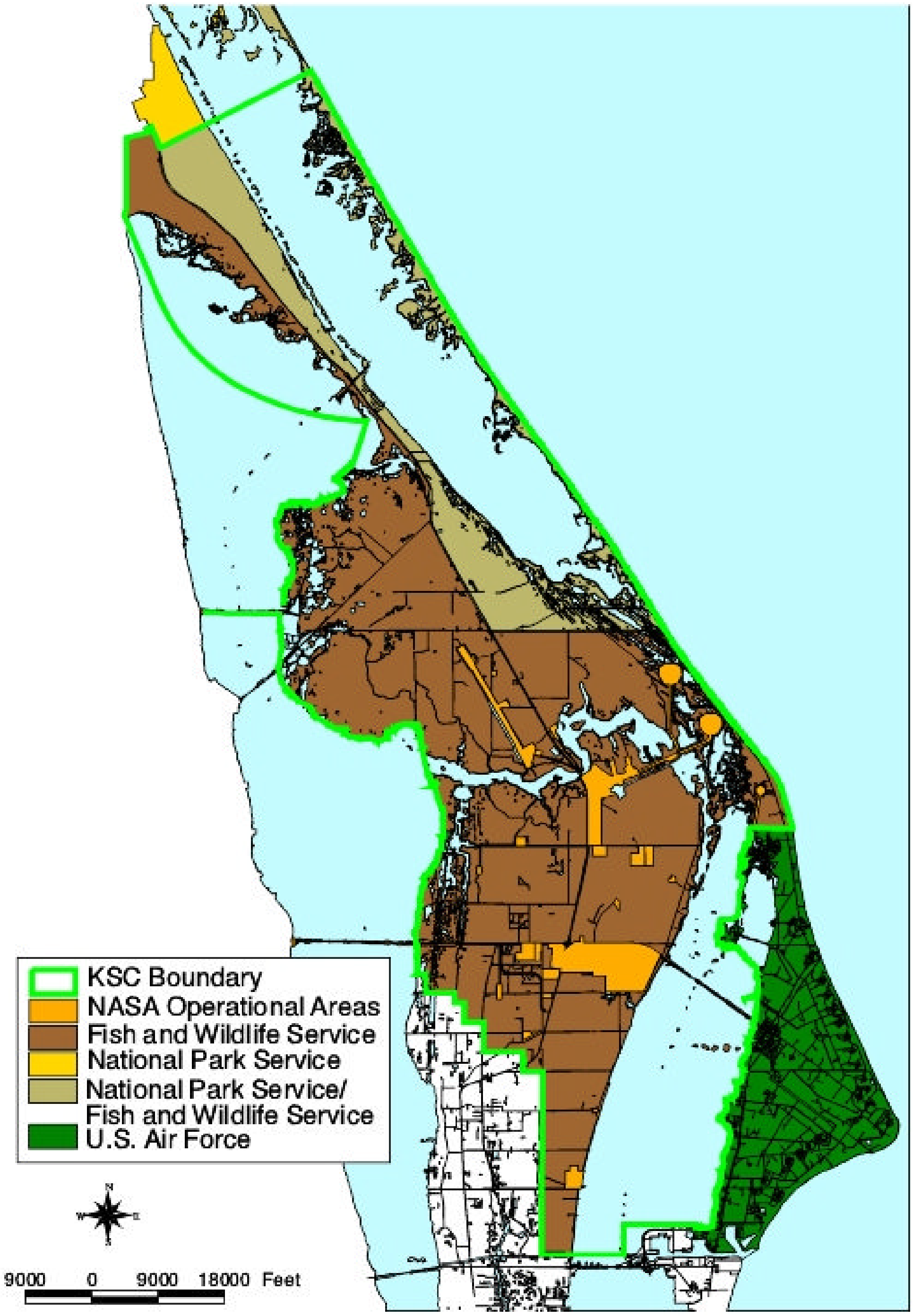

Figure 5-6. KSC Administrative Areas.

the use of land adjacent to Airfield Operations areas. Land within those surface areas, setbacks and limits are not designated as part of the Airfield Operations land use.

5.4.2.4 SM - Spaceport Management. The Spaceport Management land use classification includes all administrative functions that provide for management and oversight of Spaceport operations, plus the services administered by those managing entities for the benefit of the overall Spaceport complex, including operations and maintenance, service and utilities, and infrastructure. Examples of administrative land uses include KSC and CCAFS administrative headquarters, child development and care, training and conference, dispensary, data processing, environmental and occupational health, food service and photo operations facilities. Examples of operations and maintenance land uses include base operations, base support, base electric shop, corrosion control, central supply, facilities maintenance, motor pool, service station, NASA Railroad, reclamation areas, roads and grounds maintenance, and sanitary landfill facilities. Examples of service land uses include entry gates and access control, fire stations, fire and rescue training, security, and security training facilities. Examples of utilities and infrastructure land uses include areas designated as primary transportation corridors for arterial roadways, land required for utility service complexes, such as electrical substations and co-generation plants or sewage and water treatment facilities (but not utility easements or right-of-ways), and engineered water storage areas constructed as part of the stormwater management system.

5.4.2.5 RD – Research and Development. The Research and Development land use classification includes laboratories and related facilities that perform testing and experimentation for the purpose of developing new programs and technologies at the Spaceport. R&D may also include educational institutions offering advanced degrees in disciplines supporting Spaceport research and development activities. Examples of Research and Development land uses include: chemical, physical standards and laser testing laboratories; missile research and testing facilities; centers for experimentation; innovative science and technology; and life sciences. Laboratory, testing, and other related functions that support the operations of a specific established program at the Spaceport are classified as Launch Support land uses related to that specific program.

5.4.2.6 PO - Public Outreach. The Public Outreach land use classification designates facilities that provide an informational or educational connection between the Spaceport and the community. Examples of Public Outreach land uses would include welcome centers, public reception, education and display areas, hotels/motels and conference centers, museums, memorials, media centers, tour facilities and launch viewing areas.

5.4.2.7 SE – Seaport. The Seaport land use classification includes wharves used for the docking of vessels and facilities that directly support wharf operations. Examples of wharf operations include the Vehicle Assembling Building basin at KSC and the Hangar AF wharf at CCAFS, which support NASA programs. Military wharf facilities at Port Canaveral support Air Force program and cargo/supply operations, commercial EELV programs and the Navy Poseidon and Trident wharves. Also included in the Seaport classification are Naval Ordnance Test Unit

(NOTU) facilities located throughout the south gate area, which operate in support of the Poseidon and Trident wharves.

5.4.2.8 RE – Recreation. The Recreation land use classification includes parks, outdoor fitness areas, athletic fields, recreation buildings, centers and clubs within the Spaceport complex. Examples of Recreation land uses and facilities include the KARS Park and KARS Park II complexes, fitness circuits, recreation centers and gymnasiums, athletic fields and recreation or leisure clubs. Coastal beaches and supporting facilities are part of the Canaveral National Seashore and are classified as conservation areas. Camping, fishing, picnic and related outdoor activity areas associated with the Merritt Island National Wildlife Refuge are also classified as conservation areas.

5.4.2.9 CO – Conservation. The Conservation land use classification includes all natural areas and all undeveloped land not assigned to another land use classification. The Conservation classification is divided into two subclassifications—wildlife refuge, which includes all natural and undeveloped land and impoundment areas, and bodies of water, which includes all defined water bodies within Spaceport property. Land within the Canaveral National Seashore and the Merritt Island National Wildlife Refuge is included in the Conservation land use classification. Facilities that support the administration, maintenance and enjoyment of conservation areas are classified as part of the conservation area in which they are located.

5.4.2.10 AG – Agriculture. The Agriculture land use classification includes land areas used for the cultivation of crops or plant material for commercial purposes or for Spaceport facility landscape maintenance. Examples of existing agricultural land uses within the Spaceport include active and abandoned citrus groves and plant nurseries.

5.4.2.11 OS - Open Space. The Open Space land use classification includes undeveloped open land within developed activity centers identified as likely for future development. The criteria for open space includes existing land that is primarily cleared of natural vegetation, level, and located in or immediately adjacent to developed activity centers where future expansion of existing facilities may be anticipated.

For a map of KSC's current land use categories, link to the GIS KSC Map Viewer at http://gis.ksc.nasa.gov. The Launch Impact Zone extends from the shuttle launch pads to the Launch Impact Limit Line and into the Atlantic Ocean. High sound-pressure levels occur within this zone and personnel are excluded from this zone during launch events. Launch Complexes 39A and 39B, direct launch support structures, remote controlled optical and electronic instrumentation facilities, and launch support facilities are sited within this zone. Areas have been reserved for future expansion (Ref. 109).

Various degrees of launch hazards are generated at KSC during preparation, launch, and flight of a space vehicle. The governing clearance is the maximum of all clearances for any one time. Hazard clearances to be considered are for the loss of a vehicle on the pad, hazards associated with a normal launch, and loss of a vehicle after launch.

Flight termination systems are installed on unmanned launch vehicles to minimize the ground area impacted by the loss of a vehicle after launch. An analysis of impact limit lines is prepared for each individual launch.

This analysis considers flight azimuth; vehicle stages, modules, and engines of a space vehicle; wind conditions; turning rates; and trajectory. Such an analysis may dictate impact lines exceeding any other required clearances. These impact limit lines are used in determining approval for building sites.

This zone extends beyond the Launch Impact Limit Line to the General Support Zone. Only those structures required in direct support of launches are located within this area. Structures in this zone may require special design to provide protection from toxic propellants and other hazards. Generally, they are located at prescribed safety distances consistent with inhabitants, materials, and equipment involved. Structures normally located within this zone include:

- Buildings for inspection, assembly, storage and checkout of rockets and related equipment
- Buildings for inspection, checkout, and preparation of Space Shuttles
- Structures related directly to support of launch activities
- Ordinance storage and checkout buildings
- Liquid propellant manufacturing and storage facilities
- Solid propellant manufacturing, inspection, checkout and storage facilities

This zone extends from the Launch Support Zone to the KSC boundaries. Structures located within this area may be manned and are relatively safe from explosions on the pads, acoustic vibrations, and toxic propellant hazards.

This zone contains administrative, logistical, and industrial support facilities. It provides a relatively safe area for large concentrations of people and includes facilities not needed near the launch areas.

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, shuttle overpressure limit, and property overpressure limit.

5.4.4.3 Laser Beams. The Microwave Scanning Beam Landing System (MSBLS) is calibrated by using a laser device located approximately at the midpoint of the SLF (on the east side). When the MSBLS is being calibrated, personnel access is strictly controlled to prevent exposure to the laser beam.

5.4.4.4 SRB Recovery Area. The SRB Recovery Area is a fan-shaped area offshore from the launch site. Two NASA retrieval vessels maintain surveillance of this zone during the launch-through-splashdown period to warn other vessels in the area.

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 Quality/Distance Radii. Quality/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 U.S. Air Force (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 Shuttle and 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, COE 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 Corps of Engineers has a permit for a spoil area located on the north bank of the Barge Canal at the southern boundary of KSC. 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.

Enhanced Use Leasing allows 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 agencies, industries, and universities. NASA-KSC and Florida Power and Light (FPL) have entered into an Enhanced Use Lease (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 of a 10

MW facility. A second phase would be a lease option for 19 additional ha (48 ac) contingent upon an FPL proposal being accepted by NASA-KSC.

The possibility of leasing land to commercial entities to develop and operate a Commercial Vertical Launch Complex (CVLC) on KSC property is under consideration. KSC has also committed to allow Zero Gravity Corporation (Zero G) to use the SLF for a commercially operated parabolic flight program. In addition, Space Florida plans to develop Exploration Park on KSC property for space-related business, transportation and educational activities.

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.

A significant program, relative to NASA operations, is the fire management program administered by the USFWS. 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

KSC is not subject to the provisions of the Coastal Zone Management Act of 1977 (CZMA). However, in rules promulgated to implement the CZMA, federal agencies are to review their activities with regard to direct effects to the coastal zone. 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 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 State, Intergovernmental Coordination and Review Process. The Governor’s Office (GO) functions as the single point-of- contact for the Intergovernmental Coordination and Review Process and coordinates state agency review and response to consistency determination.

Because any action at KSC, which directly affects the coastal zone would also be subject to NEPA documentation, consistency review is typically addressed in the NEPA documentation which is submitted to the GO for review via the Intergovernmental Coordination and Review Process.

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, which significantly impacts floodplains or wetlands is subject to NEPA documentation requirements. The requirement to prepare an Environmental Assessment (EA) insures 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. FIRM indicate the 100-year and 500-year floodplain, and serve as the baseline for floodplain delineation at KSC.

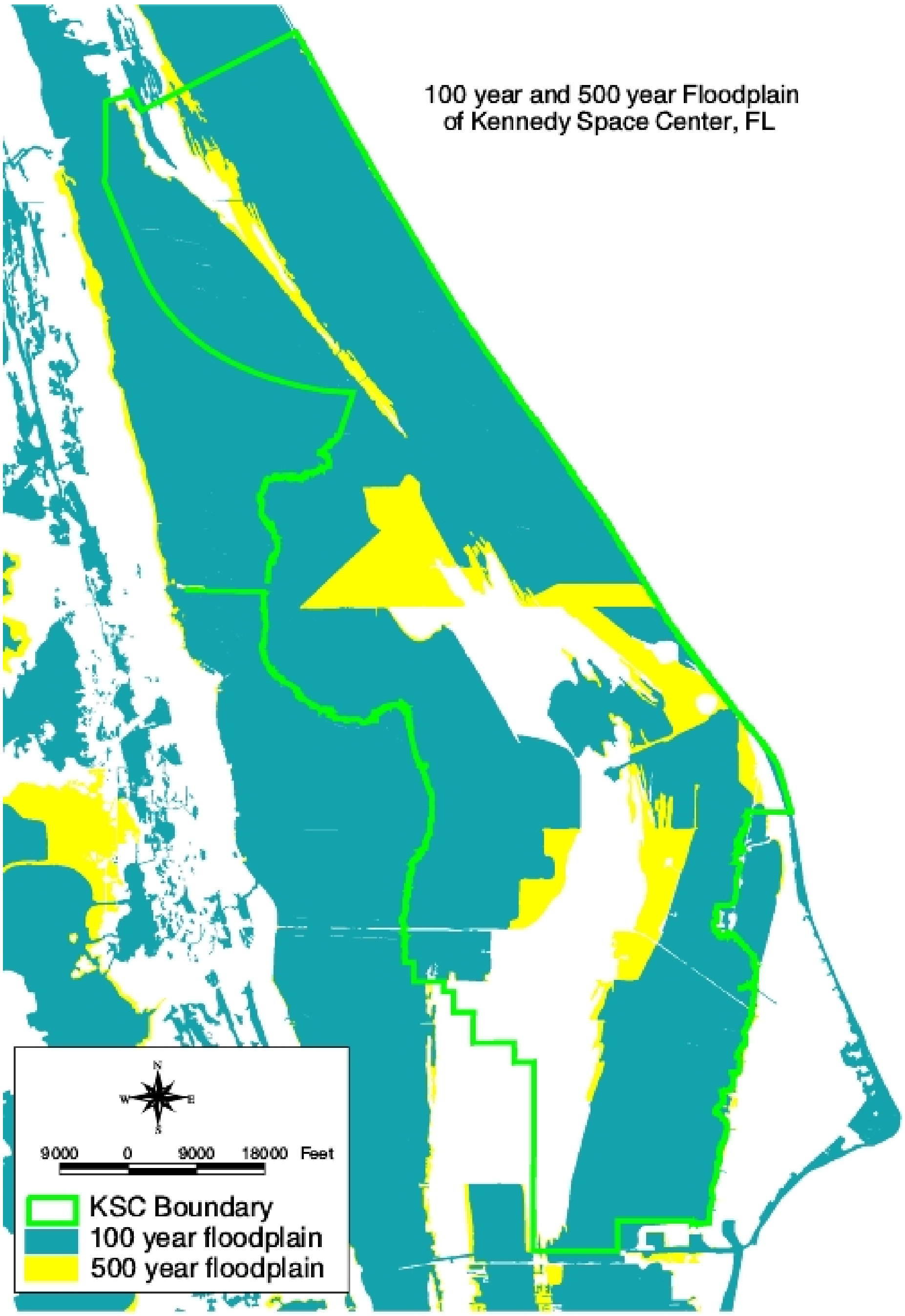

Figure 5-7. 100-Year and 500-Year Floodplain on Kennedy Space Center.

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 acres (6880 ha) 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 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, fuels 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 16,731 acres (6770.8 ha). 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 man made 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

(*Aphelcoma 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 jay 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, personal communication, May 27, 2009).

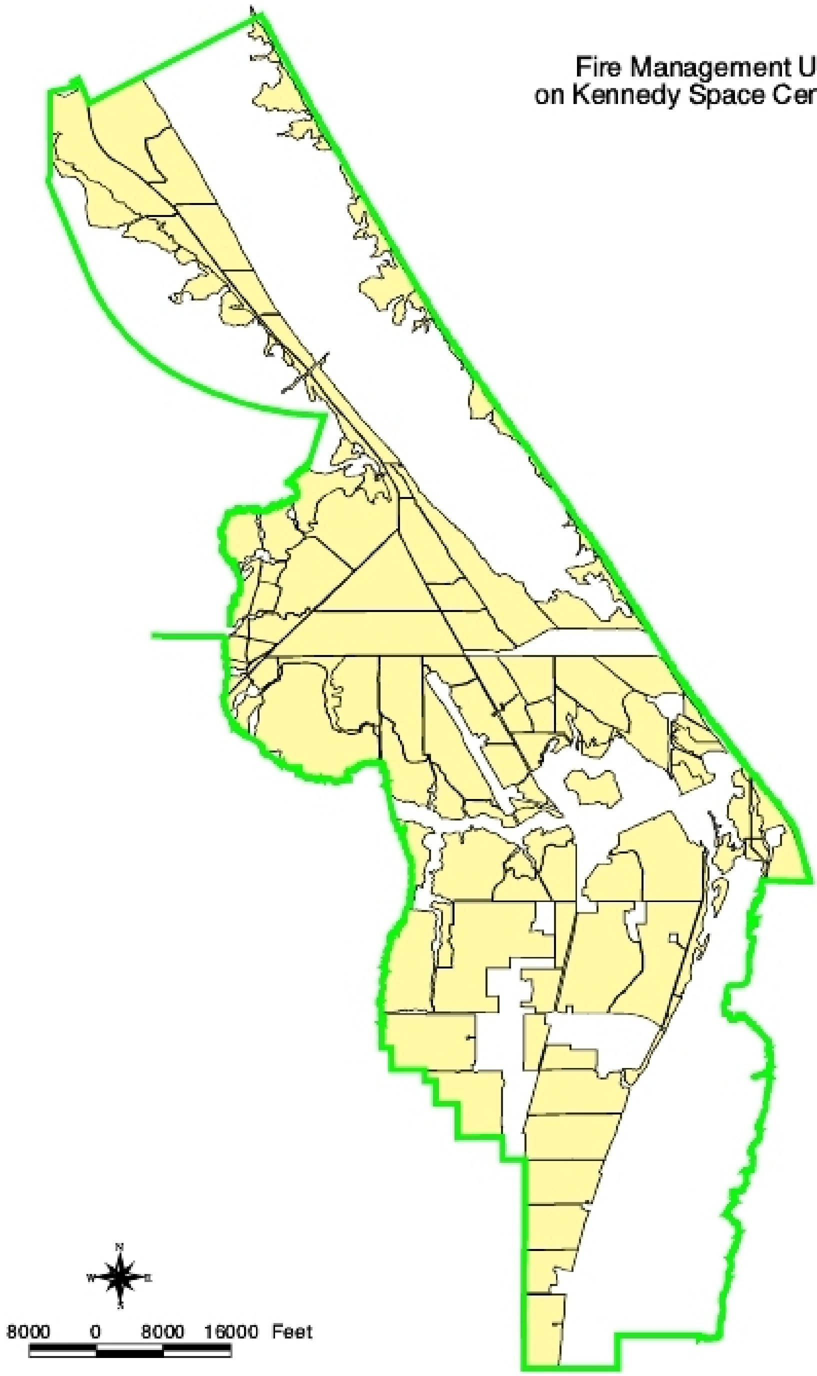

Figure 5-8. Fire Burn Units on MINWR.

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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.

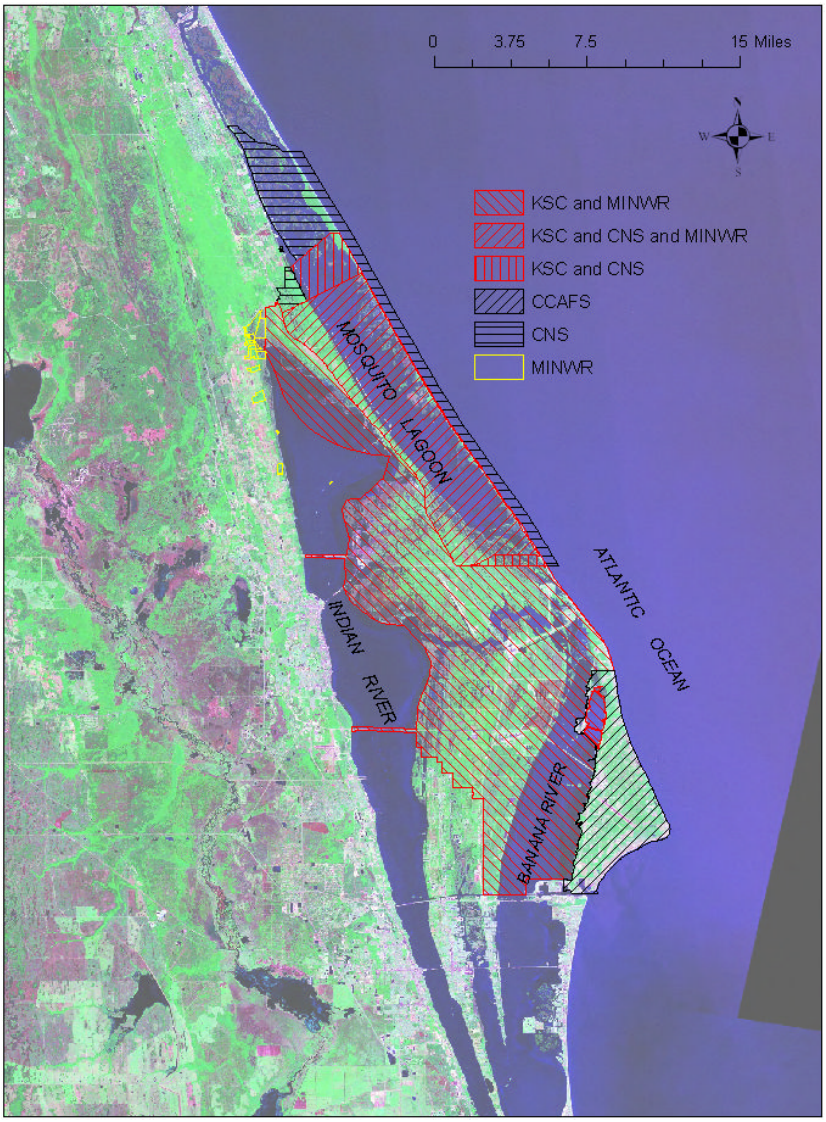

Figure 6-1. KSC and Neighboring Federal Administrations.

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).

All KSC facilities are located on Merritt Island and Cape Canaveral. 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., 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.

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. 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 U.S. Army Corps of Engineers (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. The USACE has issued nationwide permits which cover discharges of dredged or fill material into isolated wetlands or wetlands above the headwaters subject to certain conditions, size limitations and reporting requirements (Ref. 6).

The Florida Department of Environmental Protection (FDEP) and USACE have developed a joint application form for dredge and fill (wetland resource) permits. Copies of applications submitted to FDEP are automatically forwarded to COE. See Section 4 for further information on wetland resource permitting.

The FDEP and Water Management Districts have developed a streamlined permit, which was adopted on July 1, 1994. This permit, the Environmental Resource Permit (ERP), 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.

The USFWS has been delegated the responsibility of protecting wetlands and wildlife habitat. The USFWS actually seeks to preserve or create natural habitat and, under some circumstances has supported wetlands wastewater discharges to achieve these goals (Ref. 6).

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).

Executive Order (EO) 11990 was issued in May 1977 to emphasize the need for wetlands protection. Federal agencies were 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. Executive Order 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 Environmental Protection Agency (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

The St. Johns River Water Management District (SJRWMD) maintains a regulatory and planning program, which focuses on water quantity as well as water quality. The SJRWMD considers wetlands as hydrologically sensitive areas and exerts regulatory jurisdiction over dredge and fill activities within wetlands as well as surface waters.

Briefly, the SJRWMD uses three indices to identify wetlands; 1) reliable hydrologic records, 2) vegetative index, and 3) soils index. The reliable hydrologic records, if available, must indicate that the area is inundated or saturated for 30 or more consecutive days per average year. If such hydrologic records, which are the best indicator of inundation, are not available, the areas dominated by the vegetation listed in SJRWMD Management and Storage of Surface Waters Applicant's Handbook or the presence of the identified soils for Brevard County will be used to identify wetland areas. In situations where two wetland indicators are in conflict, a SJRWMD representative will make the final determination.

6.2.5 STATE REGULATION OF WETLANDS

The State Of Florida enacted a unified Wetland Delineation Rule, Chapter 62-340 of the Florida Administrative Code (F.A.C.) on July 1, 1994 which replaced the previous rule under Chapter 17-340, F.A.C. The rule establishes 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 December 2003 with additional source data including land cover from the SJRWMD, planimetrics from KSC Master Planning, and light detection and ranging data (LIDAR) for 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). A schema relates the 2003 land cover classes to FLUCCS, the USGS classification codes (Ref. 9), and the National Vegetation Classification System (NVCS) (Ref. 10). The land cover map may not identify features (e.g., wetlands) at a scale suitable for jurisdictional delineation or mitigation assessments. 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 2003 land cover map identifies 31 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.

Natural uplands devoid of vegetation include:
3. Beach = Zone of sparse or no vegetation between the ocean and coastal dune.

Disturbed areas with exotic/invasive vegetation include:
4. Ruderal - herbaceous = Herbaceous areas with sparse and/or widely scattered woody vegetation and/or bare soil that is often the result of disturbance. Includes abandoned groves.
5. Citrus = Includes maintained orange and grapefruit groves.
6. 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 dikes (classified as ruderal - woody).
7. 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 5 m tall, with interlocking canopy.

Upland scrub and pine flatwoods includes:
8. Coastal strand = Includes saw palmetto, sea grape and other species.
9. 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 5 m tall, with interlocking canopy but may also contain small areas with little or no vegetation.
10. 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 5 m tall, with interlocking canopy but may also contain small areas with little or no vegetation.
11. Pine flatwoods = Scattered pines, primarily slash pine, with non-interlocking canopy, generally greater than 5 m tall, with a sub-canopy of palmetto or scrubby species.

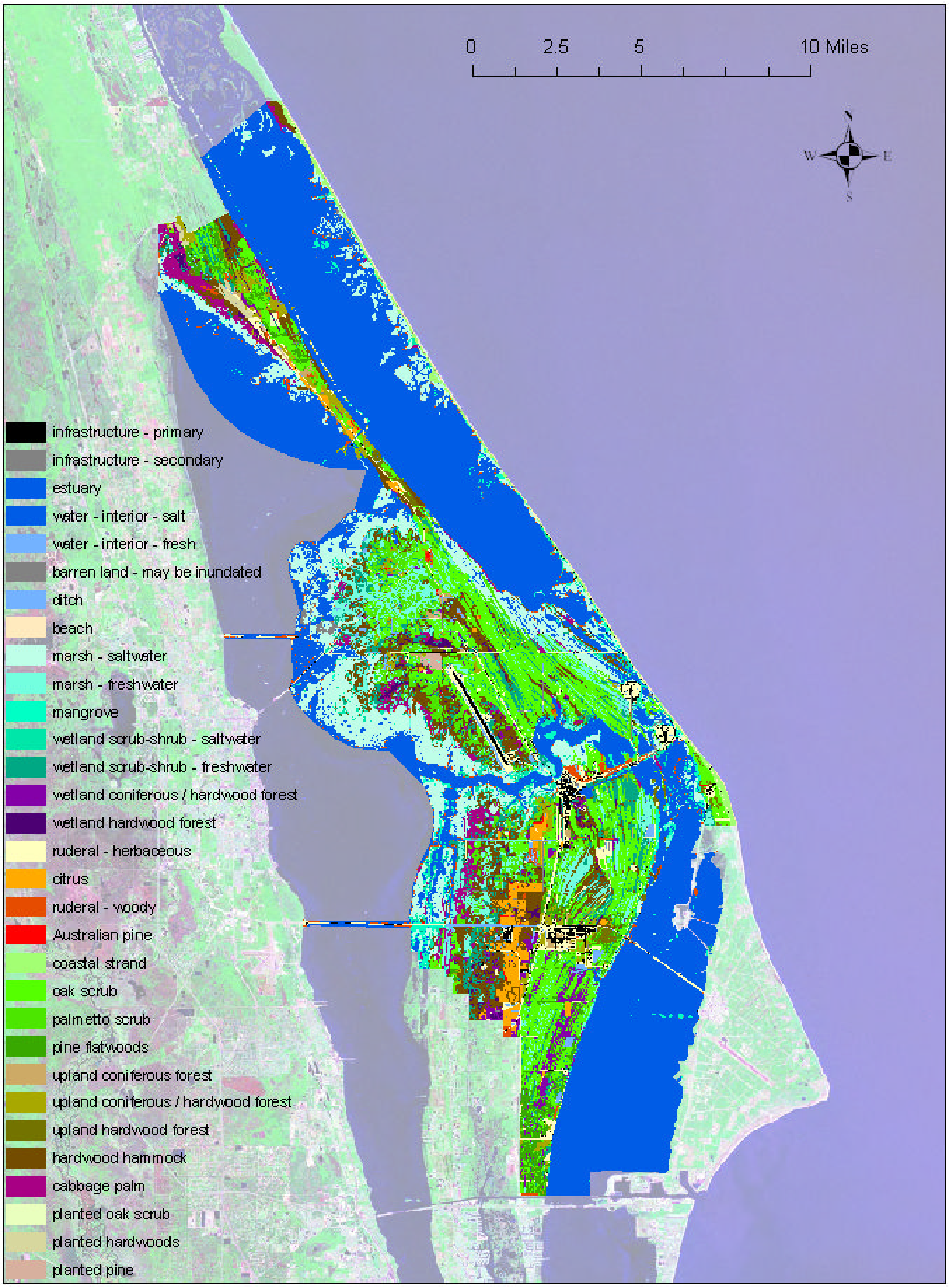

Figure 6-2. Land Cover Types Within KSC.

Table 6-1. Land Cover Types Within KSC.

Community	Land Cover Class	Hectares	Acres
upland	infrastructure - primary	564	1394
upland	infrastructure - secondary	255	630
	infrastructure	819	2024
upland	beach	122	301
	natural uplands devoid of vegetation	122	301
upland	ruderal - herbaceous	1498	3702
upland	citrus	748	1848
upland	ruderal - woody	598	1478
upland	Australian pine	45	111
	disturbed areas with exotic/invasive vegetation	2889	7139
upland	coastal strand	414	1023
upland	oak scrub	6105	15086
upland	palmetto scrub	1294	3198
upland	planted oak scrub	10	25
upland	pine flatwoods	1188	2936
	upland scrub and pine flatwoods	9011	22268
upland	upland coniferous forest	109	269
upland	upland coniferous / hardwood forest	848	2095
upland	upland hardwood forest	236	583
upland	cabbage palm	1093	2701
upland	hardwood hammock	3648	9014
upland	planted hardwoods	113	279
upland	planted pine	81	200
	upland forest	6128	15140
wetland	estuary	22399	55349
wetland	water - interior - salt	3103	7668
wetland	water - interior - fresh	381	941
wetland	barren land - may be inundated	103	255
wetland	ditch	151	373
wetland	marsh - saltwater	5260	12998
wetland	marsh - freshwater	2381	5884
wetland	mangrove	677	1673
wetland	wetland scrub-shrub - saltwater	735	1816
wetland	wetland scrub-shrub - freshwater	2158	5333
wetland	wetland coniferous / hardwood forest	632	1562
wetland	wetland hardwood forest	462	1142
	wetlands - estuary, marsh, shrub, forest	38442	94994
	TOTAL	57411	141866

Upland forest includes:
12. 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.
13. 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.
14. 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.
15. 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.
16. 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.
17. Planted oak scrub = Planted oak scrub - oak scrub above.
18. Planted hardwood = Planted hardwoods - see upland hardwood forest above.
19. 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:
20. 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.
21. Water - interior - salt = Waters surrounded by dikes that may be connected to estuarine waters via underground culverts and other more isolated waters that are salt or brackish.
22. Water - interior - fresh = Isolated waters and drainage areas that may be inundated for only brief periods.
23. Barren land - may be inundated = Lowland areas devoid of vegetation that may be periodically inundated.
24. Ditch = Areas excavated for drainage - only ditches in uplands are coded as 'ditch - ditches in wetlands are coded as the adjacent wetland category (e.g., water).
25. Marsh - saltwater = Herbaceous wetlands that includes impounded and unimpounded systems. Species composition includes sand cordgrass, black rush, salt-tolerant grasses (including saltgrass, seashore paspalum, and seashore dropseed), and other species.
26. Marsh - freshwater = Herbaceous wetlands that include beardgrass, sand cordgrass, sawgrass, cattail, and other species.
27. Mangrove = Includes white mangrove, black mangrove, red mangrove, and buttonwood. Woody vegetation along dikes (classified as ruderal - woody) may contain mangroves along the inundated edge mixed with Brazilian pepper.
28. Wetland scrub - shrub - saltwater = Vegetation composition consists of low height, generally less than 5 m, woody species including saltwort, glasswort, and other species.
29. Wetland scrub - shrub - freshwater = Vegetation composition consists of low height, generally less than 5 m, woody species including Carolina willow intermixed with other species.
30. 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 5 m tall, with interlocking canopy.
31. Wetland hardwood forest = Hardwood trees including red maple, American elm, laurel oak, live oak, cabbage palm, and bay, generally greater than 5 m tall, with interlocking canopy.

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).

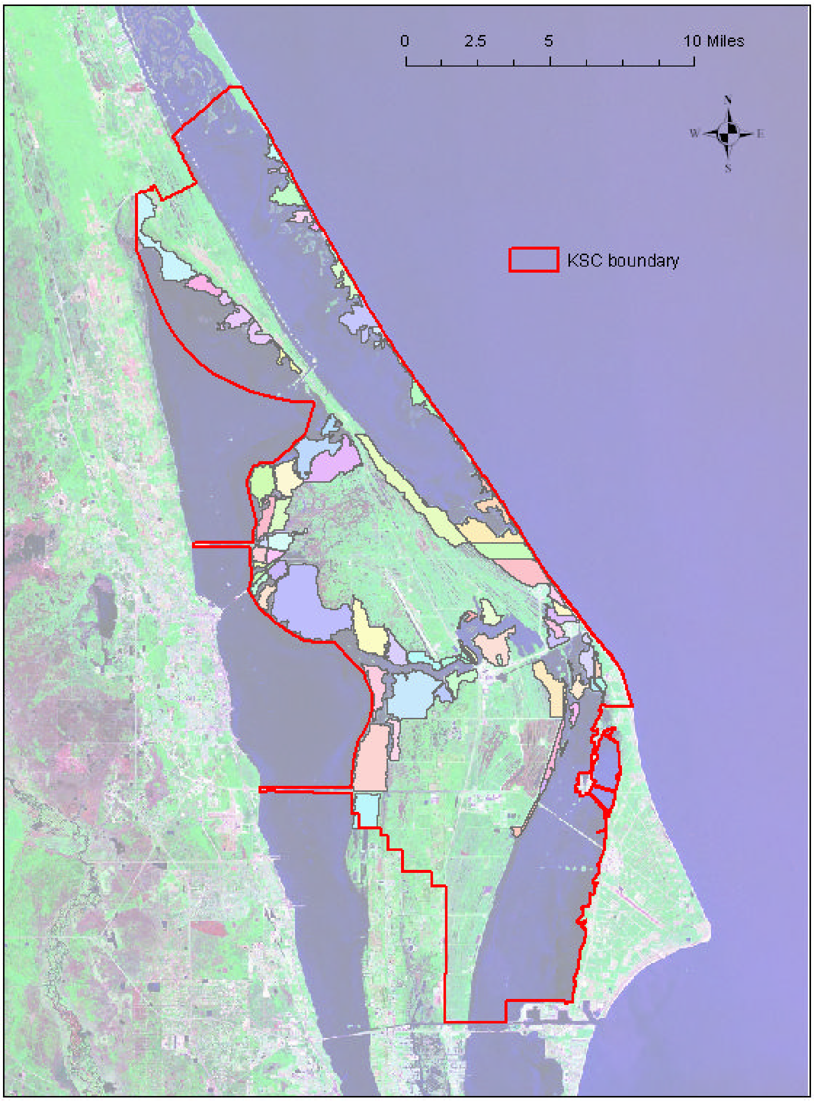

Figure 6-3. Impounded Wetlands Within KSC.

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 and 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, 12, 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, 15, 16, 17, 18, 19).

Beginning in the early 1980's 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 eradicated saltmarsh vegetation, freshwater input altered the saltmarsh habitat into a freshwater marsh type. 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 flapgates 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 was expected. And it helped restore a more natural water quality condition in the marsh. However, this limited the access to the marsh to the culvert locations only.

Follow-on restoration efforts involved complete removal of the dikes that were constructed. 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 decade, NASA and the USFWS have reconnected over 1072 acres of impoundments and restored over 564 acres 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 found offshore spawn and grow in shallow seagrass beds. Seagrasses and submerged aquatic vegetation (SAV) are currently considered the ecological foundation of the Indian River Lagoon system (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). There are seven 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 where *Halodule wrightii*, *Syringodium filiforme*, *Ruppia maritima*, and *Halophila engelmannii* do occur. Primary production and habitat/species interactions research has been predominantly conducted in the southern part of the lagoon (Ref. 24, 25, 26).

The seagrass beds in Mosquito Lagoon provide direct forage for marine turtles (*Chelonia mydas*) and manatees (*Trichechus manatus*). The Banana River portion of the study area supports fewer marine turtles but provides habitat for large numbers of manatees (Ref. 27, 28). Several studies have begun to explore the relationships between this large herbivore and its seagrass forage (Ref. 29, 30, 31, 32, 33).

KSC began supporting baseline ecological studies in the 1970s in preparation for the space transportation system EIS and operations. In 1983, Brevard County and the Space Center began a cooperative project to set up transects in various seagrass beds that would provide ground truth sites to coordinate with aerial photography. The objective was to create a baseline dataset from each transect to provide descriptive information regarding species composition, percent cover, and frequency of occurrence. Collected over a long term, these data provide time series information for assessment of trends in seagrasses in northern IRL.

Assessments of long-term trends of seagrass beds in waters of KSC, using aerial photography from the 1940's through 2005 suggest little or no change in bed distributions. Analyses of field data from collected between 1983 and 1996 were conducted to asses local trends in more detail. This analyses included 8,150 samples collected along 37 shallow water transects. Species composition and percent cover were determined at 5-m intervals along each transects using a canopy-coverage technique originally developed for terrestrial systems (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. Temporal trends in percent cover for *H. wrightii* indicates a significant long-term decline. Variation in overall species composition and coverage appears to be linked to salinity trends. These data provide a benchmark that will be useful to researchers and managers in comparing trends observed elsewhere in the lagoon and determining if these are site specific or regional trends (Ref. 35).

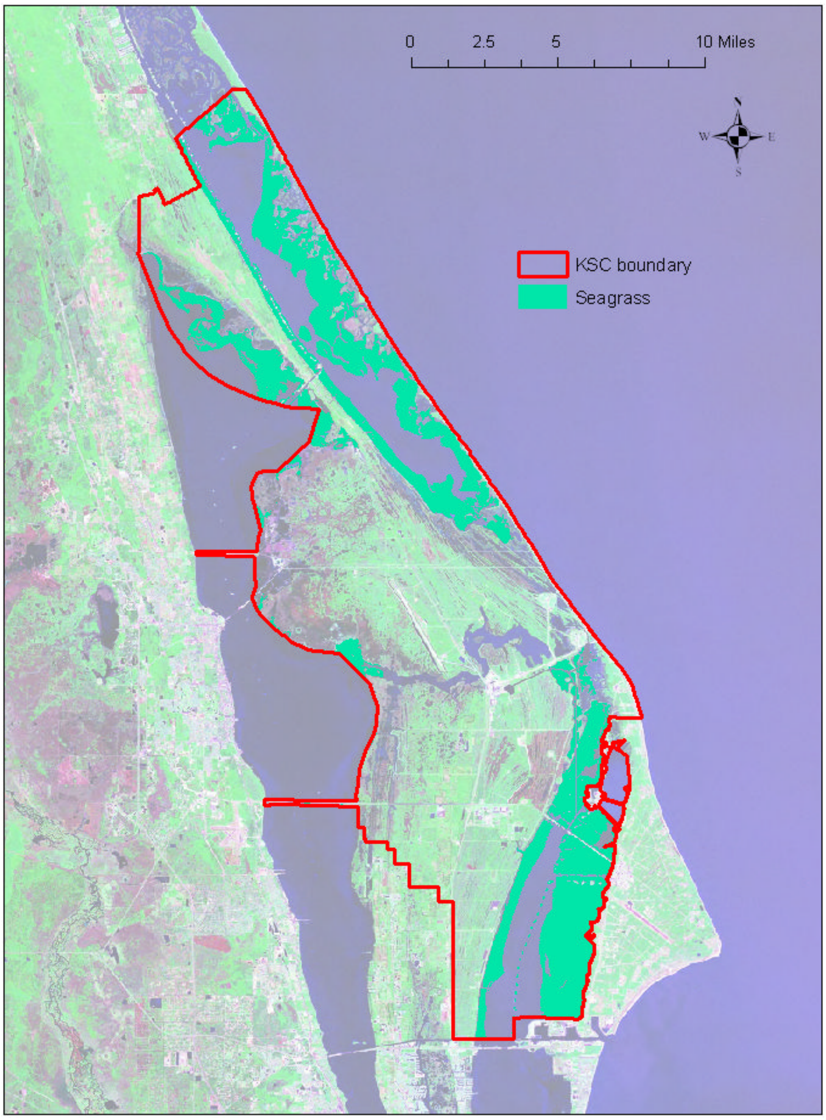

Figure 6-4. Seagrass Beds Within KSC

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. Shoal formations are conspicuous primarily off of False Cape and Cape Canaveral.

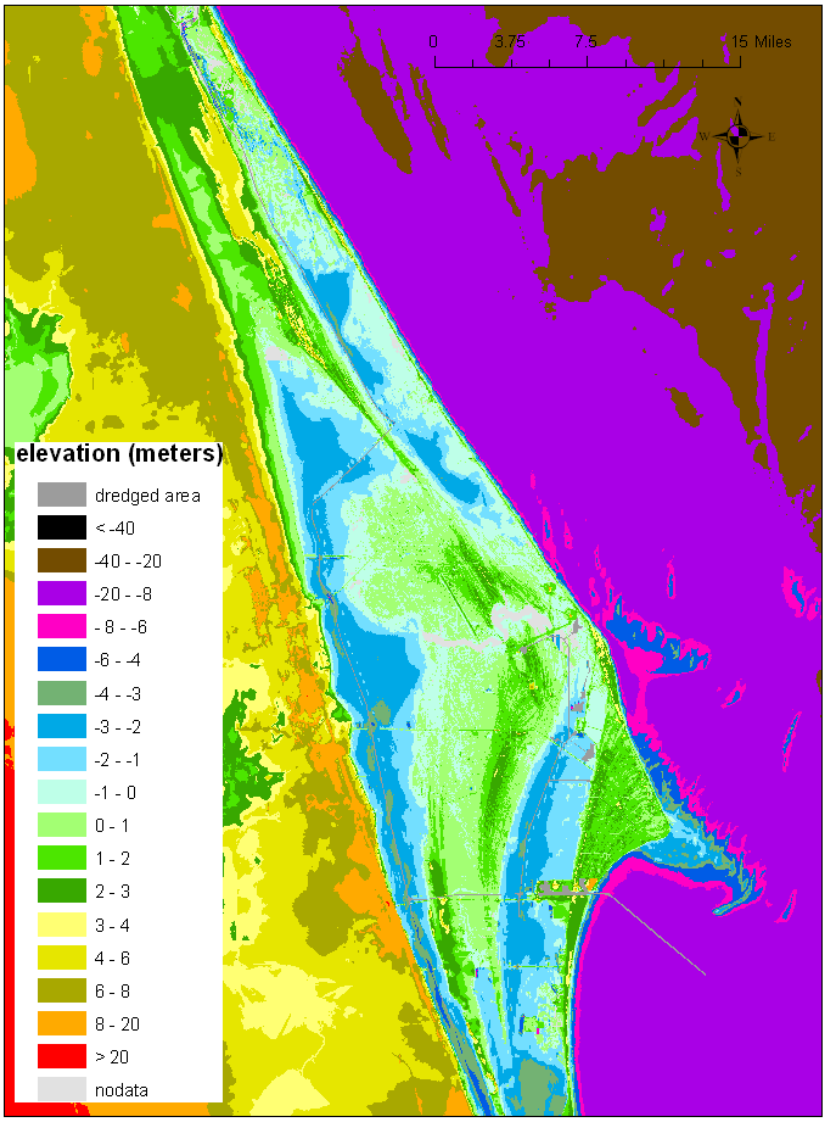

Figure 6-5. Elevations of the KSC Region.

6.7 FLORA

The vascular flora of the KSC area was first studied in the 1970's (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, 43, 44, 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, 49, 50, 51) have been conducted in recent years. There have been additional changes in taxonomy and nomenclature (Ref. 52 – 61). This has required another revision of the floristic list for Kennedy Space Center-Merritt Island National Wildlife Refuge and adjoining federal properties (Canaveral National Seashore, Cape Canaveral Air Force Station).

The revised list (Appendix D, Table D-1) includes 1,105 taxa of which 874 are native and 231 are introduced. This appears to be a substantial proportion of the regional flora. Fifty-seven taxa (Appendix D, Table D-2) are endemic or nearly endemic to Florida (Ref. 52, 62), a level of endemism that appears high for the east coast of central Florida. Of the 231 introduced plants, 33 are Category I invasive exotics and 26 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 WILDLIFE

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, rich in habitats and species, with the highest species diversity of any estuary in North America (Ref. 76). Nearly 150 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 high near inlets and toward the south end of the lagoon system. It is lower near cities, where turbidity is high and where large areas of mangroves and seagrasses have been destroyed. For biological communities and fisheries, seagrass and mangrove habitats are extremely important (Ref. 76). Much of the habitat loss has occurred 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). 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 north IRL system (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). Many of the freshwater fish species collected from Merritt Island were introduced by man (Ref. 77).

On KSC there are up to 25 species of fish found in the wetlands and impounded wetlands (Ref. 18, 19, 68, 76, 78). In the impounded wetlands, the fish fauna is numerically dominated by resident fish. Residents spend their entire life cycle within the wetland or impounded wetland area. These species are usually well adapted physiologically to handle the wide variation in environmental conditions such as extremes in 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*).

Transient fish are species that utilize the marsh habitat during a portion of their life cycle, usually the early stages. 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 transient fish include striped mullet (*Mugil cephalus*), ladyfish (*Elops saurus*), and common snook (*Centropomus undecimalis*).

A summary of fish species, their general habitat requirements, and relative abundance is provided in Appendix B. The coastline from Daytona Beach south to Melbourne and extending seaward to a depth of 100 fathoms was determined to be one of the most productive marine fishery areas along the southern Atlantic coast. The inshore waters are known for their seatrout and red drum sport fishing; however, the fisheries for both these species are subject to regulation.

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

Sixty-nine species of amphibians and reptiles (not including marine turtles), 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 and 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 are 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.

Several discoveries that have come to light since the long-term monitoring program began in 1992. Fourteen 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. Three species are introduced exotics (see discussion below). It is not clear why the remaining four 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 of road cruising the same exact route during both sampling periods found a significant difference in the numbers of cottonmouths between the 1970s and the current studies. One hypothesis as to the reason behind 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).

The ocean beaches at KSC are important nesting areas for loggerhead, green and leatherback sea turtles (Ref. 81, 82). All of these sea turtles are federally protected. Additional information on these turtles is available in Section 7.3 and Appendix C. Surveys conducted in 2008 along the 10 kilometers of KSC and MINWR beach reported 1 leatherback (*Dermochelys coriacea*), 104 green (*Chelonia mydas*) and 1072 loggerhead (*Caretta caretta*) sea turtle nests. Nest predation has been lowered in recent years due to screening of nests after egg deposition and raccoon trapping by MINWR personnel. Hatchling disorientation continues to be a problem particularly near LC39 Complexes, Beach House and CCAFS launch pads 40 and 41.

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 lacertian*	very common, but rarely seen
Frogs		
oak toad	*Bufo quercicus*	occasionally seen, commonly heard
southern toad	*Bufo terrestris*	commonly seen and heard
cricket frog	*Acris gryllus*	rarely seen, commonly heard
green tree frog	*Hyla cinerea*	commonly seen and heard
pinewoods tree frog	*Hyla femoralis*	occasionally heard at night, rarely
barking tree frog	*Hyla gratiosa*	occasionally heard at night, rarely
squirrel tree frog	*Hyla squirella*	commonly seen and heard
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	*Rana capito*	rarely seen or heard
pig frog	*Rana grylio*	rarely seen, commonly heard
southern leopard frog	*Rana utricularia*	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
box turtle	*Terrapene carolina*	occasionally seen
striped mud turtle	*Kinosternon baurii*	occasionally seen
common mud turtle	*Kinosternon subrubrum*	occasionally seen
common musk turtle	*Sternotherus odoratus*	occasionally seen
gopher tortoise	*Gopherus polyphemus*	commonly seen
Florida softshell turtle	*Apalone ferox*	commonly seen
Lizards		

Table 6-2. (cont.).		
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
Mediterranean gecko (E)	*Hemidactylus turcicus*	rarely seen
green anole	*Anolis carolinensis*	commonly seen
brown anole (E)	*Anolis 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
indigo snake	*Drymarchon corais*	occasionally seen
corn snake	*Elaphe guttata*	occasionally seen
yellow rat snake	*Elaphe obsolete*	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	*Masticop his flagellum*	occasionally seen
Atlantic saltmarsh snake	*Nerodia clarkia*	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 picivorus*	rarely seen
diamondback rattlesnake (V)	*Crotalus adamanteus*	occasionally seen
pygmy rattlesnake (V)	*Sistrurus miliarius*	rarely seen
	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*	occasionally 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*	occasionally seen
marsh rice rat	*Oryzomys palustris*	rarely seen
Florida mouse	*Podomys floridanus*	rarely seen
southeastern beach mouse	*Peromyscus polionotus*	rarely seen
cotton mouse	*Peromyscus gossypinus*	rarely seen

Table 6-2. (cont.).		
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*	rarely 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*	rarely seen

E=exotic
V=venomous

6.8.4 BIRDS

Two hundred sixty-seven 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. Ninety species nest at KSC, 111 species are regular winter visitors, and 66 species are considered to be transients (Ref. 84).

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 Whie Ibis, Great Egret, Snowy Egret, and Tricolored Heron. For example, species and numbers of nests of wading birds were monitored yearly from 1987 through 2000, 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 Spoonbills 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 Wigeon, 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.

6.8.5 MAMMALS

Thirty species of mammals have been documented on KSC (Table 6-2); this number includes five introduced species (see non-native wildlife discussion below), and does not include the numerous species of dolphins and whales that occur offshore and occasionally wash up dead on KSC beaches.

A large bat colony exists in the SR 405 bridge crossing over SR 3. Two species, the Brazilian free-tailed bat (*Tadarida brasiliensis*) and the southeastern bat (*Myotis austroriparius*), have been identified using the bridge as a roosting site. The bridge is also used as 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. Six bat houses have been installed; one near a pavillion at KARS Park I and five near the Logistics Facility.

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.

6.8.6 MANATEES

In 1977, KSC supported inventory actions to determine the abundance and distribution of the endangered manatee throughout Florida including the KSC property. The conclusion of those surveys indicated that a large number of manatees were utilizing the same body of water that NASA intended to use for Space operations. As much as 15 percent of the total manatee population of the U.S. is located within the waters immediately surrounding KSC property (Ref. 92). Monitoring the distribution and abundance manatees at KSC has been primarily performed through aerial surveys that have been funded by KSC intermittently from 1977- 1983 and almost continuously since 1984 (Ref. 83). Since 1991, KSC aerial surveys have been conducted during cold periods in conjunction with the FFWCC's population census referred to as the Statewide Synoptic Survey.

The data collected are immediately shared with the FFWCC. The data have been shared with various agencies and universities, presented at scientific meetings and published in peer-reviewed journals. The raw 1977-1990 aerial survey data were made available to the public on a CD-ROM in a joint venture with the Florida Fish and Wildlife Conservation Commission through the Manatee GIS Working Group. (KSC has maintained a position on the Manatee GIS Working Group since its inception.) Data sets have been shared with FFWCC on many occasions over the years and more recent data were submitted (with restricted use) to FFWCC for their evaluation of speed zone regulations which were being developed. Data have also been shared with the public through invited presentations to environmental and educational audiences, marine industry groups, the Brevard County Commission, Marine Mammal Commission, and the USACE.

In 1990, to further protect this endangered species, the USFWS created a sanctuary for manatees covering the majority of the KSC section of the Banana River. 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 6-6. KSC biologists also participate in the manatee-stranding network, for which dead and live standings are reported to FFWCC and USFWS agencies. Those agencies collect the animals, rehabilitate or file necropsy reports. Those data are maintained and archived by FFWCC.

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 our most common frogs.

Three species of lizards, the Cuban anole (*Anolis sagrei*), Indo-Pacific gecko (*Hemidactylus garnoti*), and Mediterranean gekko (*Hemidactylus turcicus*) were never reported in herpetological surveys done in the 1970s. All three 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 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

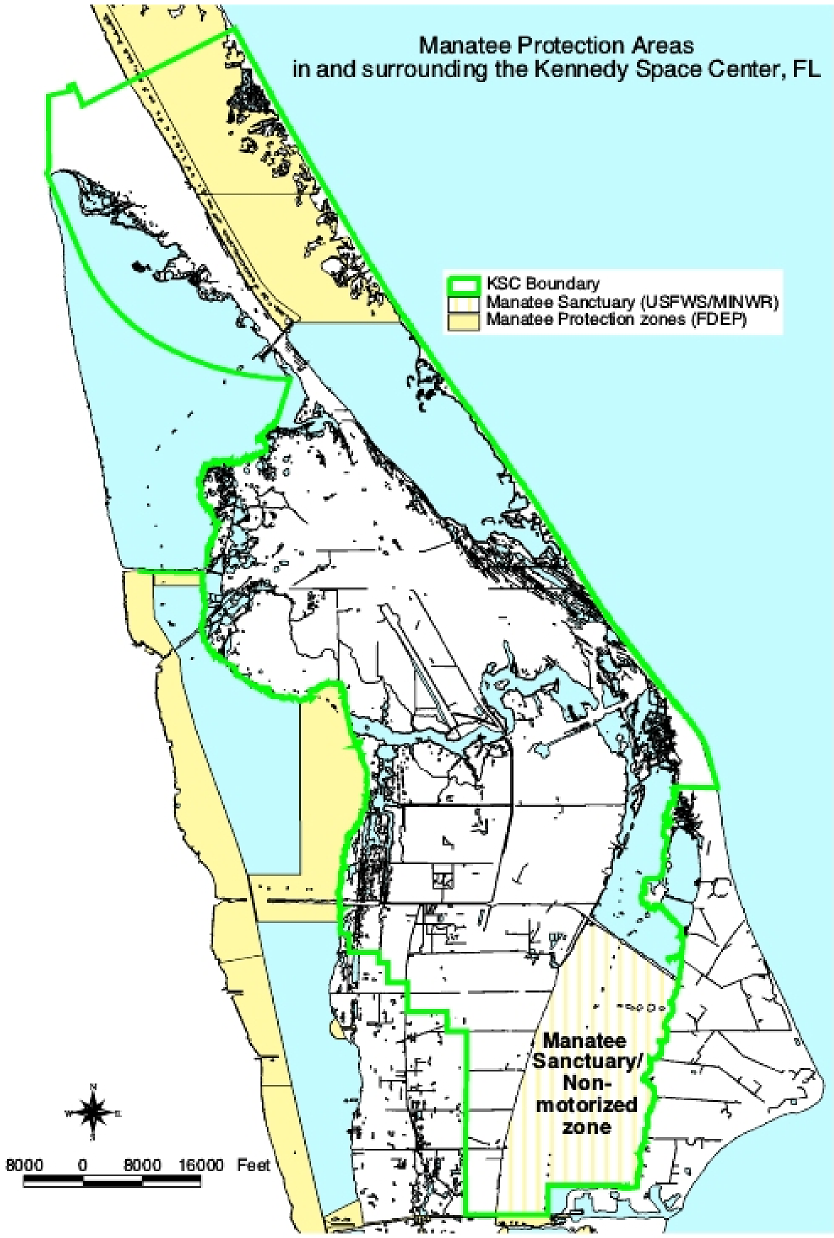

Figure 6-6. Manatee Protection Zones at Kennedy Space Center.

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 – 1998 on the dunes near the Space Shuttle launch pads, nine black rats were captured in traps. 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 Space Station Processing Facility.

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 cats 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 that had 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 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 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 on KSC roads each year, causing property damage and injury to the KSC workforce. (Ref. 93).

6.10 SHUTTLE LAUNCH IMPACTS

Natural resources at KSC, MINWR, and the adjacent Cape Canaveral Air Force Station are recognized as critical to maintenance of regional biodiversity, representing home to many protected and special concern species (see Sections VII). The major industrial activity in this ecosystem is processing and launching of manned and unmanned space vehicles. Launching unmanned vehicles such as the Titan, Atlas, and Delta have been found to have no or minimal direct impacts to protected wildlife (Ref. 94). These unmanned vehicles do not utilize large quantities of sound suppression water and produce a dry launch cloud when compared to the Shuttle, with approximately 1,000,000 l of sound suppression water. Effects of Shuttle launch activities are documented in (Ref. 102, 106, 107, 108, 112). Historic operational activities have lead to instances of groundwater, surface water and soil contamination with metals and solvents resulting in the development of significant remediation projects (see Section X).

6.10.1 NOISE

The highest acoustic noise levels generated by the Space Transportation System (STS) are recorded within the first two minutes of launch. In the launch pad vicinity (within ca. 400 m), noise levels can exceed 160 dBA. Noise levels recorded at the Launch Impact Line (VAB Area, 7.5 km) do 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 have been set at distances where the 115 dBA sound level is not exceeded.

Sonic Booms. Three sonic booms are generated during the launch of the STS. The first sonic boom is generated by the shuttle system upon ascent. This is the largest sonic boom of the mission with a maximum overpressure of 3.66 psf (25.2 kPa) (Ref. 95). The sonic boom focal zone is typically located approximately 64 km (40 miles) offshore of the launch site, in the Atlantic Ocean (Ref. 95).

Following separation of the Solid Rocket Boosters (SRBs) from the orbiter and external tank, the SRBs re-enter the atmosphere. This re-entry generates a sonic boom with a focal zone approximately 242-320 km (150-200 mi) down range of the launch site and a projected maximum overpressure of 2 to 3 psf (13.8-20.7 kPa) (Ref. 96).

The third sonic boom is generated by the reentry of the jettisoned external tank. The sonic boom focal zone is located over the Indian Ocean with a maximum overpressure of 2 to 4 psf (13.8-27.6 kPa) (Ref. 96).

All STS launches from KSC generate sonic booms with focal zones over uninhabited ocean waters. Clearance zones established by the launch trajectory and SRB retrieval areas essentially preclude significant adverse impacts to human populations.

Landing/Florida Sonic Booms. Orbiter reentry through the atmosphere results in a sonic boom of varying intensities distributed along the groundtrack during the final descent and landing phase of a Space Shuttle mission. The intensity and shape of the sonic boom pressure signature is a function of the vehicle shape, weight and volume, combined with the flight path and the prevailing atmospheric conditions (Ref. 97). Sonic boom measurements from early landings at Edwards Air Force Base, California ranged from 0.7-2.4 psf (4.8-16.5 kPa) at different locations (Ref. 95). Beginning with STS-38, the majority of Space Shuttle missions have landed at KSC. Sonic boom measurements were recorded at various points in Florida along the descent and landing trajectory of these flights (Ref. 97, 98, 99). A maximum measured overpressure of 2.2 psf (15.2 kPa) was recorded in Titusville during the landing of the STS-51D flight. All sonic boom measurements recorded in Florida during Orbiter landings have been accurately predicted by computer model analyses.

6.10.2 LAUNCH CLOUD

During the launch of the STS, three main rocket engines, fueled by liquid hydrogen and liquid oxygen, and two SRB engines are ignited. The main engine cloud, primarily water vapor, is directed to the south of the pad by the split flame trench. The shuttle solid rocket boosters (SRBs) are the largest solid rocket motors ever built and flown. Each contains 498,950 kg of propellant. The propellant consists of an aluminum powder fuel (16%), ammonium perchlorate as an oxidizer (69.9%), a catalyst of iron oxidizer powder (0.07%), a rubber-based binder of polybutadiene acrylic acid acrylonitrile (12.04%) and an epoxy curing agent (1.96%) (Ref. 100). Each SRB produces approximately 1,202,020 kg of thrust at sea level. The exhaust from the SRBs is directed northward from the launch pads by the split flame trench.

The SRB exhaust emissions are dominated by carbon dioxide (CO_2), water (H_2O), aluminum oxide (Al_2O_3), and hydrogen chloride (HCl) (Ref. 81). These exhaust gases mix with up to 2.04 x 10^6 liters (5.4 x 10^5 gal.) of sound suppression water to produce a ground cloud. The ground cloud is initially forced to the north of the launch pad by the force of the launch blast and by the configuration of the launch pad structure.

During the first 10-12 seconds of a launch, a ground cloud forms that is approximately 1.4x10^6 m^3 in volume (Ref. 101). This cloud is composed of the complex mixture of gases, 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. As horizontal velocities in the cloud decrease, the cloud cools, rises, and begins to move away from the launch site with prevailing winds. Launches produce acid deposition. Anderson and Keller (Ref. 101) described the mechanisms producing acidic deposition as follows: 1) acidic deposition results from the atomization of deluge water by the turbulence of the vehicle exhausts; 2) large liquid drops produced by this atomization become the core of the deposition; 3) these drops rapidly coagulate with aluminum oxide particles and condensed water in the cloud and scavenge hydrogen chloride gas. Since the mechanism producing acid deposition depends on the interaction of the rocket exhausts with the deluge water and not specific meteorological conditions, it can be expected with each launch.

Near-field Deposition. Near-field deposition is that occurring from the ground cloud sweeping turbulently across the ground, vegetation, and lagoon waters. There are two aspects to quantifying near-field deposition: geographic location and amount of deposition. For each launch, the area impacted by near-field deposition has been mapped based on the visible effects on vegetation and structures. Cumulative maps have been prepared (Ref. 102, 103, 104, 105). Near-field deposition is concentrated north of each launch complex (Figure 6-34, Figure 6-35). After 124 launches the area of cumulative near-field impacts at LC39A is 89.2 ha (220.4 ac), and the area of cumulative near-field impacts at LC39B area is 62.2 ha (153.7 ac). After the first 49 launches the near-field LC39A area was 87.0 ha and the LC39B area was 52.9 ha (Ref. 104). There have been minor increases in area at LC39A, and the LC39B area has increased by about 9 ha (22 ac). Only minor increases in area have occurred since 2002 (Ref. 105).

Deposition of chlorides in the near field recorded for launches from LC39A has ranged from about 0.0-125.0 g/m^2 when winds are from the south; particulate deposition has ranged from 0.0->200 g/m^2 (Ref. 106, 107). With northerly winds, the pattern of deposition is shifted. Total chloride deposition in the near field is estimated at 3.4 x 10^3 kg and particulate deposition at 7.1 x 10^3 kg for normal launches. Particulate deposition collected in the near field ranges in size from submicron particulates to debris several centimeters in diameter. Materials identified include Al_2O_3, sand, shell, paint, vegetation, firebrick, and other debris dislodged by the SRB ignition blast.

Far-field Deposition. Far-field deposition outside of the near-field plume zone occurs from Space Shuttle launches as a result of movement of the launch cloud with prevailing meteorological conditions. Spots of acid or dry deposition on leaves of plants or on structures indicate that the area received far-field deposition. The ground track of deposition from every launch has been mapped. Cumulative maps have been prepared (Ref. 102, 103, 104 105). The geographic distribution of far-field deposition is far more variable than that of near-field deposition (Figure 6-36), and much of KSC has received deposition from at least one launch. After 124 launches, 23,124.7 ha (57,142.2 ac) had received far-field deposition at least once, but 14,065 ha (34,755.2 ac) were impacted no more than two times. The area of cumulative far-field deposition increased from 19,396 ha (47,928 ac) after the first 49 launches (Ref 104) to 23,124.7 ha after 124 launches. Chloride deposition was measured for several launches and ranged from 25-5300 mg/m^2 (Ref. 108).

Rocket Exhaust Effluent Diffusion Model. Direction and amount of deposition are predicted by the Rocket Exhaust Effluent Diffusion Model (REEDM). Predictions are made based on inputs of meteorological data from rawinsonde readings of vertical profiles of wind direction, wind speed, air temperature, atmospheric pressure, and relative humidity from the surface to 3048 m (10000 ft). Early versions of this model (Ref. 109) predicted gaseous HCl (hydrogen chloride) concentrations and aluminum oxide (Al_2O_3) deposition. The model was modified to predict gravitational HCl (hydrochloric acid) deposition (Ref. 110). Comparisons of predictions of the revised REEDM and mapped patterns of deposition for the first 49 launches (Ref. 109) indicated that the model correctly predicted direction but over-predicted the total area that received deposition and the maximum distance that deposition occurred away from the launch pad.

Table 6-3 gives the relationship between launch facilities and primary areas of concern.

6.10.3 DELUGE WATER

Each STS generates approximately 3.26 x 10^6 liters (863,000 gal.) of deluge and washdown wastewater. Upon ignition of the main engines and SRBs 1.9 x 10^6 liters (510,000 gal.) of deluge waters are discharged to the flame trench for sound (pressure wave) attenuation. As the launch proceeds, an additional 102,195 liters (27,000 gal.) of water are discharged to the fixed service structure and moveable launch platform to dissipate launch heat energy. Within 10 min. of a launch, pad facilities are washed down with up to 1.2 x 10^6 liters (326,000 gal.) of water. Washdown waters are collected in two concrete tanks connected by flumes to the flame trench. The high concentrations of HCl gas produced by ignition of the SRBs significantly lower the pH of the collected wash water.

Average pH levels in the tanks immediately following launch range between 1.6 and 2.2 (Ref. 111). Impervious surface coatings have been applied to the tanks at LC39B and LC39A. Operational procedures require that the contained launch waters be neutralized with 50 percent sodium hydroxide (NaOH) to a pH of 8.5 +/- 0.5 within 72 hours following launch. Previously, after neutralization these waters were landspread over the adjacent pad area. Current practices follow the Industrial Wastewater Permit.

6.10.4 SURFACE WATER

Background pH in the estuarine system generally ranges between 7.8 and 8.6 units. At launch, the surface layer of the lagoon receives up to 1700 kg of HCl from deposition (Ref. 106, 107). This acid mixes downward into the water column through advection and diffusion eventually impacting approximately the upper 1.5 m. The rate of mixing is driven primarily by wind speed and direction across the lagoon. Levels of impact are highly variable spatially and temporally depending on meteorological conditions at the time of launch. Maximum pH reductions (about 6 to 7 units) are found at the surface and in the area adjacent to the stormwater 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 are observed around the edges of the near-field ground cloud footprint and at depth where buffering and dilution minimize chemical impacts (Ref. 112).

Surface and ground waters in the region around the launch pads are highly buffered, as a result of local soils and geological conditions, with total alkalinity values typically ranging between 120 and 200 mg/l as $CaCO_3$. This aquatic buffering system reacts readily with the exhausted HCl to produce $CaCl_2$, CO_2, and H_2O (Ref. 118). Advective and diffusive mixing during the 48 to 72 hours post-launch have been found to return pH readings and alkalinity measurements in the lagoon to pre-launch levels (Ref. 112).

6.10.5 GROUNDWATER

Initial groundwater studies at LC39A and LC39B indicated minor groundwater contamination by Al, Cd, Cr, Fe, and Pb with trace and periodic detection of volatile organic compounds (Ref. 113). However, further study concluded that the groundwater data do not show any clear evidence of accumulation of metals in the Surficial Aquifer, nor do they show a cause and effect relationship between STS launches and detectable concentrations of metals in the groundwater (Ref. 114). Periodic trace concentrations of volatile organic compounds were attributed to non-point sources.

During the RCRA Facility Investigation (RFI) performed in 2003 at LC39A, pentachlorophenol (PCP) was identified above the FDEP Surface Water Cleanup Target Levels (SWCTL) in groundwater samples collected from monitoring wells in the Hypergol Oxidizer Facility area, and trichloroethene (TCE), cis-1,2-dichloroethene (cDCE), and vinyl chloride (VC) were identified above their respective FDEP Groundwater Cleanup Target Level (GCTL) in groundwater samples collected from monitoring wells in the vicinity of the LOX discharge pipes. Additional investigations in the LOX area identified a TCE source area in the ditch beneath the LOX pipes that was removed during an interim measure (IM) performed in March 2009 (Ref. 119). Quarterly groundwater monitoring of the remaining dissolved phase TCE, cDCE, and VC is being implemented to obtain additional information to assist in recommending a path forward.

During the RFI and subsequent investigations performed at LC39B, TCE, cDCE, VC, aluminum and iron were identified above their respective FDEP SWCTL in site groundwater (Ref. 119, 120). Aluminum and iron were detected in groundwater samples collected from monitoring wells within the LC39B fence line where groundwater has been designated as GIII (non-potable). TCE, cDCE and VC have been detected in groundwater samples collected from monitoring wells inside the LC39B fence line and in groundwater samples collected from monitoring wells located downgradient of the liquid oxygen (LOX) tank discharge pipes. The clean up strategy selected in the Corrective Measures Study (CMS) was enhanced bioremediation for impacted groundwater in the LOX area and monitored natural attenuation (MNA) for the impacted groundwater inside the LC39B fence line (Ref. 121). Enhanced bioremediation was implemented in the LOX area in December 2005. Enhanced bioremediation is reducing TCE, cDCE and VC concentrations in the LOX area groundwater. Currently, further investigations into the TCE, cDCE and VC impacts to groundwater within the LC39B fence line are being performed.

6.10.6 SOILS

Soil studies completed previous to STS-1 indicated that strong solutions of hydrochloric acid would leach cations (Na, Ca, Mg) and certain metals (Al, Fe, Mn, Ni, Zn, Co) from KSC soils (Ref. 115).

Soil microcosm studies were conducted at LC39A between January 1984 and November 1985 (Ref. 112). The pH of leachate from microcosms exposed to near-field deposition decreased immediately post-launch. During any one event, leachate pH recovered to pre-launch values within seven days. Over the course of the study, a cumulative decline of 0.35 pH units in the background soil pH was noted in the highly exposed soils. With each loading of HCl by the Shuttle exhaust cloud, metal concentrations (e.g., Al, Cu, Fe, Zn) increased in soil leachates due to increased metal solubility at lower pH. Between launches, as leachate pH recovered to near background levels, metal concentrations in the leachate declined, probably due to the formation of less soluble metal oxides and hydroxides, at circumneutral pH. Cation concentrations, particularly Ca^{2+} and Mg^{2+}, were elevated immediately post-launch and between launches probably due in part to dissolution of shell fragments prevalent in these coastal soils.

Soils in the most frequently impacted area north of LC39A were sampled after 9 launches and again after 24 launches from the same sites (Ref. 112). 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 9 launches and after 24 launches differed. In the non-saline soils, there were increases in conductivity, Ca, K, Na, and Zn and decreases in P, NO_3-N, and 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 (Ref. 112). Increases in conductivity, Ca, K, and Na between 9 and 24 launches may be due to leaching of soil material including shell fragments; increases in zinc 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. Since pH was still high, the aluminum deposited by the exhaust cloud was not exchangeable. After 24 launches, monitoring of soil and sediment at LC39A and LC39B became part of the RFI process.

<u>LC39A Soil and Sediment</u>. During the RFI, zinc and copper were identified above their respective FDEP Residential Soil Cleanup Levels (R-SCTLs) (Ref. 122). Copper was identified in sediment samples collected in the Environmental Control System (ECS) area and zinc was identified in the swales and ditches within the LC39A fence line. It appears the source of the copper was cooling water discharge prior to 1995. Zinc is used to coat the launch structures and mobile launch platform for cathodic protection. Due to ongoing shuttle operations and limited ecological impacts identified at LC39A, no additional investigations were warranted.

<u>LC39B Soil and Sediment</u>. During the RFI performed at LC39B, benzo(a)pyrene, arsenic, nickel, and zinc were identified above the FDEP R-SCTLs in site soils (Ref. 120). The benzo(a)pyrene and arsenic impacts were identified in the Heating, Ventilation and Air Conditioning (HVAC) area, the nickel impacts were identified in the Compressed Air Building area, and the zinc impacts were identified in the swale and ditches within the LC39B fence line. Due to ongoing shuttle operations and limited ecological impacts identified at LC39B, no additional investigations were

warranted. A Land Use Control Implementation Plan (LUCIP) was developed to prohibit residential exposure to soil and swale soil (Ref. 123). In addition to the LUCIP, sediment blocks were installed in the ditches and swales with outfalls outside the LC39B perimeter fence to prevent off-site migration of swale soils containing elevated metal (primarily zinc) concentrations (Ref. 119).

6.10.7 BIOLOGICAL

Biological impacts of shuttle launches have been documented since the beginning of the program (Ref. 102, 111, 112, 121, 122). Impacts are concentrated in the near-field impact zones north of each launch complex (Figure 6-34 and 6-35). Acute impacts of the acid ground cloud on the environment near the launch pads include: alteration of the vegetation community structure and species composition, changes in soil chemical characteristics, short-term depression of surface water pH, short-term alteration of water chemistry, and kills of small fish in shallow water areas north of the launch pads (Ref. 102, 106, 107, 112, 121).

Vegetation. Cumulative impacts in the most frequently exposed area north of LC39A through STS-9 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 (Ref. 102). 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. These changes continued until the cessation of launches in 1986 with an increasing amount of bare ground in the most severely impacted area. Considerable regrowth occurred in the period without launches. Resumption of launches in September 1988 initiated another retrogressive sequence. Similar changes have occurred at LC39B (Ref. 112).

Some launches result in damage to the coastal dune community when the near-field zone extends across the dunes (Ref. 102, 112) (see Figures 6-34 and 6-35). Thin leafed herbaceous species and shrubs with succulent leaves, are more sensitive to launch cloud deposits than are typical dune grasses (Ref. 102). Dune community species exhibiting sensitivity to launch cloud effects include camphorweed (*Heterotheca subaxillaris*), inkberry (*Scaevola plumieri*), beach sunflower (*Helianthus debilis*), and marsh elder (*Iva imbricata*). Dune species exhibiting resistance to launch cloud effects include sea oats (*Uniola paniculata*), beach grass (*Panicum amarum*), and slender cordgrass (*Spartina patens*), and sea grape (*Coccoloba unifera*). Within six months vegetation recovery is nearly complete (Ref. 102). Impacts to the dunes are infrequent (Figures 6-34 and 6-35), and cumulative changes in vegetation have not occurred.

Far-field deposition from individual launches can produce damage to foliage of vegetation. Areas receiving 1000 mg/m^2 chlorides experience damage from acid etching of the leaves; sensitive species can be damaged by 100 mg/m^2 chlorides (Ref. 108). Far-field deposition is sufficiently dispersed and variable launch-to- launch that successive launches seldom affect the same areas (Figure 6-36). No changes in plant community composition or structure due to cumulative effects of far-field deposition have been seen (Ref. 112).

Fish. For many launches, a fish kill occurs in the shallow surface waters of the lagoon (Pad 39A) or impoundment (Pad 39B) immediately north of each launch complex in line with the SRB flame trench. This fish kill is the direct result of the surface water acidification that often exceeds 5 pH units. Hawkins et al. (Ref. 116) found that 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 have indicated that this event is generally limited to the shallow shoreline closest to the pad and the stormwater ditches leading away from the north side of the pad surface. At Pad 39A the fish kill appears limited to a band of shallow water approximately 10 m wide (the 0.5 m depth contour). In deeper, open water, fish apparently dive below the area of acidification avoiding the rapid drop in pH. At Pad 39B, the fish kill may cover a larger area and involve a larger number of individuals, because the impoundment water depth is generally less than 0.5 m year round, and the fish are not able to avoid the rapid drop in pH. In every event, the fish kill occurs in direct relation to the spatial pattern of the near-field deposition footprint (Ref. 112).

Species observed after almost every launch include the rainwater killifish (*Lucania parva*), mosquito fish (*Gambusia holbrooki*), sheepshead minnow (*Cyprinodon variegatus*), and sailfin molly (*Poecilia latipinna*). The numbers of individuals observed after each launch are highly variable, depending on such factors as deposition pattern, seasonal water depths, and seasonal reproductive activitiy (presence of large numbers of juveniles). These species are aggressive invaders of open habitats and begin to recolonize the area within several days after each launch. This rapid immigration is possible because only a small portion of the larger contiguous population is actually impacted. Also, these species are tolerant of a wide range of environmental conditions and are extremely prolific, making them ideally suited for life in the shallow brackish waters around the pads. Other taxa that have been observed less frequently have included mullet (*Mugil cephalus*), sheepshead (*Archosargus probatocephalus*), black drum (*Pogonias cromis*), needle fish (*Strongylura* spp.) lady fish (*Elops saurus*) and red drum (*Sciaenops ocellatus*) (Ref. 112).

<u>Wildlife</u>. Acute impacts of Shuttle launches to wildlife populations at KSC appear minimal with the majority of birds being able to flee the pad area in a fright response to the ignition of the shuttle main engines 7 seconds prior to the ignition of the SRBs. On occasion some individuals are caught in the exhaust blast and are killed or injured. Examples of species observed include armadillo, marsh rabbits, snowy egret, killdeer, frogs, and alligators. Because injured animals tend to hide in burrows or dense vegetation, the number may be greater than observed. To date no federally listed threatened or endangered species have been directly identified as being killed as a result of the launch event (Ref. 112).

Two taxa have been given special consideration due to possible impacts that may result from the extreme noise levels near the pads at the time of launch. Low frequency noise levels in the 145-160 dB range have been measured near the launch pads. The Florida Scrub-Jay (*Aphelocoma coerulescens*), a species listed as threatened by the U.S. Fish and Wildlife Service, inhabits scrub vegetation in the vicinity of the two launch pads. After launch, observations were made of the behavior of individuals and their responses to alarm calls. To date no acute effects have been documented. A second species of concern is the Wood Stork *(Mycteria americana*) which nested at the Bluebill Creek Rookery approximately 750-800 m south of Pad 39A. During three nesting seasons, observations of nesting success were conducted at the colony to document possible adverse effects resulting from launch noise or acid deposition. It was speculated that the high noise levels, fright response, or acid deposition on eggs might interfere with some aspect of nesting success. In December 1989, a severe freeze damaged the black mangroves (*Avicennia germinans*) in which the storks nested. These trees deteriorated in subsequent years and became unsuitable for stork nesting. During the period of observation, success of woodstork nesting at the Bluebill Creek site continually declined, with total failure during the 1992 nesting season. Given the loss of mangroves from the freeze, this decline in nesting could not be associated with launch (Ref. 112).

Table 6-3. Distances and Approximate Exhaust Cloud Travel Times Between Spaceport Launch Facilities and Primary Areas of Concern With Four Different Wind Speeds.

Launch Facility	Area of Impact	Approximate Distance		Direction of wind from north	Estimated time (in min) to impact at different wind speeds			
		Miles	Km		2.5 m/s (5.6 mph)	5.0 m/s (11.2 mph)	7.5 m/s (16.8 mph)	10 m/s (22.4 mph)
39A	39B	1.65	2.66	142	17.7	8.8	5.9	4.4
	41	2.15	3.45	322	23.1	11.5	7.7	5.8
	40	3.58	5.75	334	38.3	19.2	12.8	9.6
	37	5.77	9.29	335	61.8	30.9	20.6	15.5
	Bluebill	0.80	1.28	332	8.5	4.3	2.8	2.1
	VAB/ press site	3.28	5.28	62	35.2	17.6	11.7	8.8
	VIP site	3.92	6.32	90	42.1	21.1	14.0	10.5
	SLF (midpoint)	5.47	8.80	96	58.6	29.3	19.6	14.6
	Industrial Area	6.54	10.52	28	70.1	35.0	23.4	17.5
	SMAB	4.57	7.36	350	49.1	24.5	16.4	12.3
	NASA Causeway	6.90	11.11	0	74.1	37.0	24.7	18.5
39B	39A	1.65	2.66	322	17.7	8.8	5.9	4.4
	41	3.80	6.12	322	40.8	20.4	13.6	10.2
	40	5.21	8.38	330	55.8	27.9	18.6	13.9
	37	7.38	11.84	330	78.8	39.4	26.2	19.7
	Bluebill	2.33	3.75	332	25.0	12.5	8.3	6.3
	VAB/ press site	3.44	5.54	34	36.9	18.5	12.3	9.3
	VIP site	3.31	5.33	66	35.5	17.7	11.9	8.8
	SLF (midpoint)	4.58	7.37	80	49.2	24.6	16.5	12.4
	Industrial Area	7.34	11.81	16	78.7	39.4	262	19.6
	SMAB	6.06	9.76	344	65.1	32.5	21.7	16.3
	NASA Causeway	8.26	13.30	354	88.6	44.3	29.6	22.2
41	39A	2.15	3.46	142	23.1	11.5	7.7	5.8
	41	3.80	6.12	142	40.8	20.4	13.6	10.2
	Bluebill	1.58	2.55	130	17.0	8.5	5.6	4.3
	40	1.50	2.42	348	16.1	8.1	5.4	4.0
	37	3.71	5.97	345	39.7	19.8	13.2	9.9
	VAB/press site	4.14	6.66	94	44.4	22.2	14.8	11.1
	VIP site	5.39	8.68	108	57.8	28.9	19.3	14.5
	SLF (midpoint)	7.09	11.41	110	76.1	38.0	25.4	19.0

Table 6-3. (cont.).

Launch Facility	Area of Impact	Approximate Distance		Direction of wind from north	Estimated time (in min) to impact at different wind speeds			
		Miles	Km		2.5 m/s (5.6 mph)	5.0 m/s (11.2 mph)	7.5 m/s (16.8 mph)	10 m/s (22.4 mph)
Industrial Area	5.93	9.54	48	63.6	31.8	21.2	15.9	
SMAB	2.84	4.56	12	30.4	15.2	10.1	7.6	
NASA Causeway	5.34	8.59	14	57.3	28.6	19.1	14.3	
40	39A	3.58	5.75	154	38.3	19.2	12.8	9.6
	39B	5.21	8.38	150	55.8	27.9	18.6	13.9
	Bluebill	2.88	4.63	148	30.8	15.4	10.3	7.7
	41	1.50	2.42	168	16.1	8.1	5.4	4.0
	37	2.21	3.56	350	23.7	11.9	7.9	6.0
	VAB/press site	4.76	7.67	112	51.1	25.6	17.0	12.8
	VIP site	6.26	10.08	120	57.2	33.6	22.0	16.8
	SLF (midpoint)	8.02	12.91	118	86.0	43.0	28.7	21.6
	Industrial Area	5.36	8.62	62	57.5	28.7	19.2	14.4
	SMAB	1.56	2.51	32	16.7	8.4	5.6	4.2
	NASA Causeway	4.06	6.53	26	43.5	21.8	14.5	10.9
37	39A	5.77	9.29	155	61.8	30.9	20.6	15.5
	39B	7.36	11.84	150	78.8	39.4	26.2	19.7
	Bluebill	5.09	8.19	150	54.5	27.3	18.2	13.7
	41	3.71	5.97	165	39.7	19.8	13.2	9.9
	40	2.21	3.56	170	23.7	11.9	7.9	6.0
	VAB/press site	6.41	10.32	305	68.7	34.4	22.9	17.2
	VIP site	8.03	12.92	308	86.0	43.0	28.6	21.5
	SLF (midpoint)	9.35	15.05	310	100.2	50.1	33.6	25.0
	Industrial Area	4.83	7.77	225	51.7	25.9	17.2	13.0
	SMAB	1.74	2.80	195	18.6	9.3	6.2	4.6
	NASA Causeway	2.78	4.47	195	29.8	14.8	9.6	7.4

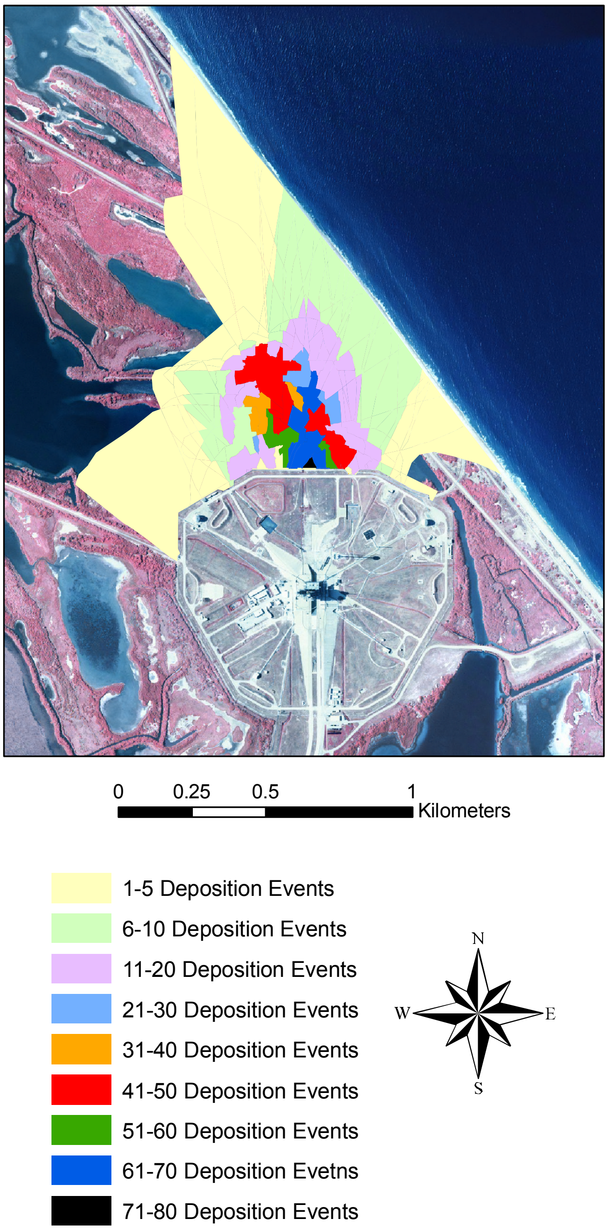

Figure 6-7. Cumulative pattern of near-field deposition at LC39A as of November 2008.

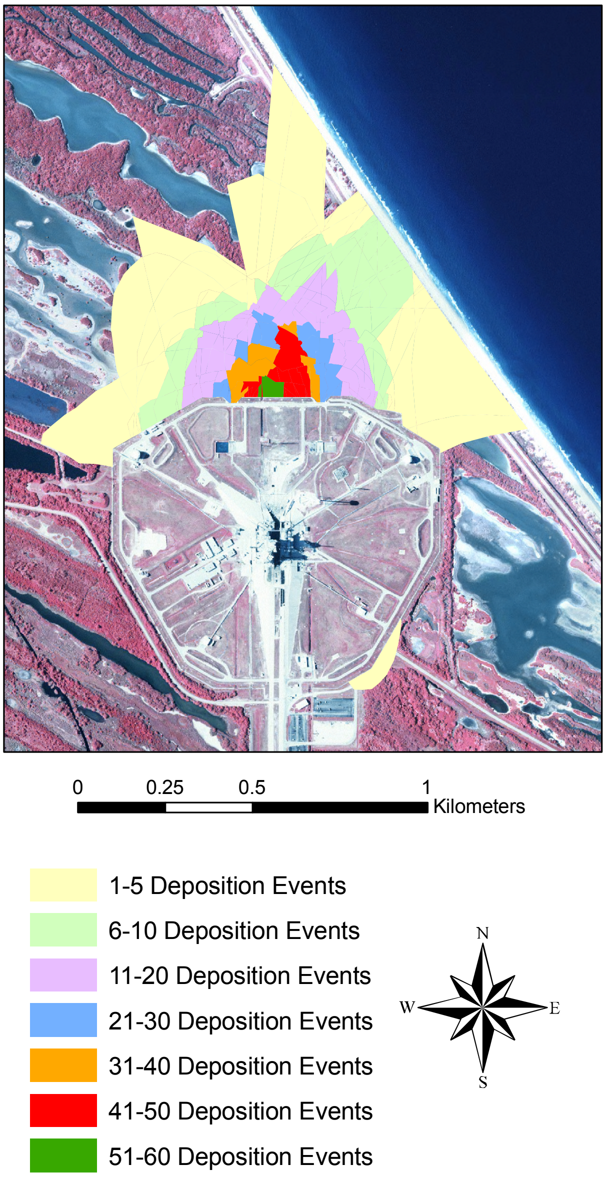

Figure 6-8. Cumulative pattern of near-field deposition at LC39B as of November 2008.

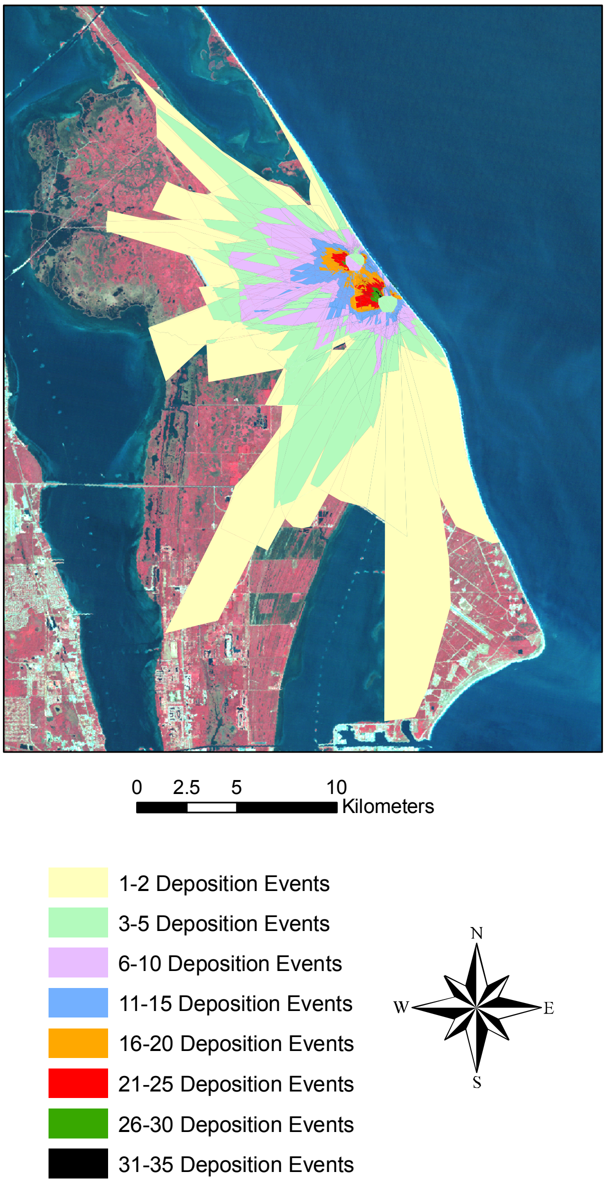

Figure 6-9. Cumulative pattern of far-field deposition after 124 Shuttle launches (November 2008).

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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 33 federally and state-protected animals known to occur 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 Kennedy Space Center that are Protected Federally and/or by the State of Florida.

SCIENTIFIC NAME	COMMON NAME	LEVEL OF PROTECTION	
Amphibians and Reptiles		**STATE**	**FEDERAL**
Rana capito aesopus	Florida gopher frog	SSC	
Alligator mississippiensis	American alligator	SSC	T(S/A)
Caretta caretta	Loggerhead	T	T
Chelonia mydas	Atlantic green turtle	E	E
Dermochelys coriacea	Leatherback sea turtle	E	E
Gopherus polyphemus	Gopher tortoise	SSC	
Drymarchon couperi	Eastern indigo snake	T	T
Pituophis melanoleucus mugitus	Florida pine snake	SSC	
Birds			
Egretta thula	Snowy egret	SSC	
Egretta caerulea	Little blue heron	SSC	
Egretta tricolor	Tricolored heron	SSC	
Egretta rufescens	Reddish egret	SSC	

Table 7-1. (cont.).			
Eudocimus albus	White ibis	SSC	
Ajaia ajaja	Roseate spoonbill	SSC	
Mycteria Americana	Wood stork	E	E
Haliaeetus leucocephalus	Bald eagle	T	T
Falco peregrinus	Peregrine falcon	E	
Falco sparverius paulus	Southeastern American kestrel	T	
Sterna antillarum	Least tern	T	
Rynchops niger	Black skimmer	SSC	
Aphelocoma coerulescens	Florida scrub-jay	T	T
Rostrhamus sociabilis plumbeus	Snail kite	E	
Polyborus plancus audubonii	Crested caracara	T	
Aramus guarauna	Limpkin	SSC	
Grus canadensis pratensis	Florida sandhill crane	T	
Charadrius melodus	Piping plover	T	T
Charadrius alexandrinus	Snowy plover	T	
Haematopus palliatus	American oystercatcher	SSC	
Sterna dougallii	Roseate tern	T	T
Mammals			
Peromyscus polionotus niveiventris	Southeastern beach mouse	T	T
Podomys floridanus	Florida mouse	SSC	
Trichechus manatus	West Indian manatee	E	E
Key: SSC = Species of Special Concern; T(S/A) = threatened because of similarity of appearance to another protected species; T = threatened; E = endangered.			

7.2 PLANTS

Thirty-nine taxa occurring on KSC are listed as threatened, endangered, or of special concern on state lists (Ref. 1, 2, 3) (Table 7-2). *Nemastylis floridana* and *Matelea gonocarpos* have been added due to recent work on Canaveral National Seashore (Ref. 4). *Amyris balsamifera* has been deleted as it does not occur here; *Amyris elemifera* does occur but it is not a listed species.

Several other species previously listed for KSC are no longer included. *Conradina grandiflora* occurs on the mainland of Brevard County (Ref. 5) but years of fieldwork in scrub habitat indicate that it is absent from Merritt Island and Cape Canaveral. *Cereus eriphorus* var. *fragrans* (now *Harrisia fragrans*) was reported from KSC (Ref. 6). *Cereus gracilis* var. *simpsonii* (now *Harrisia simpsonii*) was reported at Turtle Mound (Ref. 7) but was eliminated by freezes (Ref. 8); it 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. The taxonomic status of *Harrisia fragrans* and *H. simpsonii* is unclear. A population of *Harrisia* has been reported recently on

Canaveral National Seashore (John Stiner, personal communication) pending verification of identification, this may be an addition to the current list.

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 7-2). For some of these 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.

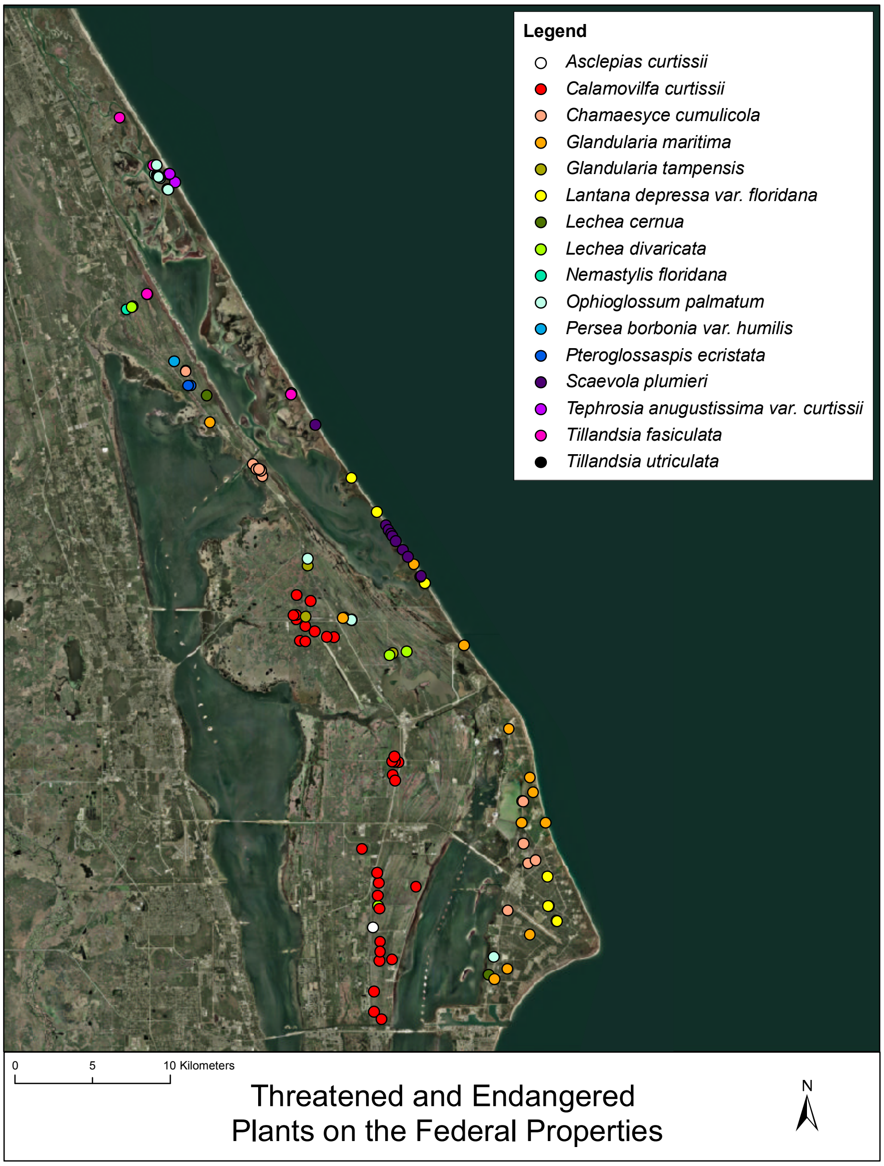

Figure 7-1. Locations of Selected Threatened and Endangered Plants in the Kennedy Space Center Area.

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

Scientific Name	Common Name	USFWS[2]	FDA[1,3]	FCREPA[1,4]	FNAI[5]
Asclepias curtissii[6,8,9,12]	Curtiss milkweed		E		G3, S3
Avicennia germinans[6,7,8,11]	Black mangrove			SP	
Calamovilfa curtissii[6,7]	Curtiss reedgrass	FC2	T		G1G2,S1S2
Calopogon multiflorus	Many-flowered grass pink		E		
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] *(=Verbena maritima)*	Coastal vervain	FC2	E		G2, S2
Glandularia tampensis[6,7] *(=Verbena tampensis)*	Tampa vervain	FC1	E		G1, S1
Harrisella filiformis	Threadroot orchid		T		
Hexalectris spicata	Crested coralroot		E		
Lantana depressa var. *floridana*[7,9,11,12]	East coast lantana	FC2	E		G2T2, S2
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		G4, S3
Matelea gonocarpos[11]	Angle-pod		T		
Myrcianthes fragrans[7,11]	Nakedwood	FC2	T		G4T3, S3
Nemastylis floridana[11]	Fall-flowering ixia		E		G2, S2
Ophioglossum palmatum[6,8,9,11] *(= Cheiroglossa palmata)*	Hand fern		E	E	G5, 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, S2S3
Pecluma plumula *(=Polypodium plumula)*	Plume polypody		E		
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		
Rhizophora mangle[6,7,8,11]	Red mangrove			SP	
Scaevola plumieri[7,10,11]	Scaevola		T		
Sophora tomentosa[11]	Necklace pod				G4, S3
Spiranthes laciniata	Lace-lip ladies'-tresses		T		

Table 7-2. (cont.).

Scientific Name	Common Name	USFWS	FDA	FCREPA	FNAI
Tephrosia angustissima var. *curtissii*[11]	Narrow-leaved hoary pea; coastal hoary pea	FC2	E		G1T1, S1
Tillandsia fasciculata[11]	Common wild pine		E		
Tillandsia utriculata[11]	Giant wild pine		E		
Zamia pumila[6,8,11] (= *Zamia umbrosa*)	East coast coontie		C	T	
	TOTALS	FC1-1 FC2-8 9	E-17 T-12 C-5 34	E-1 T-2 SP-2 5	19
	GRAND TOTAL-39				

[1] Designated Status:
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).

[4] Florida Committee on Rare and Endangered Plants and Animals (Ref. 1).

[5] Florida Natural Areas Inventory (Ref. 2). 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 known from Kennedy Space Center Ecological Program work (1982-2008)

[8] Listed in Final Environmental Impact Statement for Kennedy Space Center (Ref. 11)

[9]Cape Canaveral Air Force Station sites or populations identified by Chafin et al. (Ref. 12)

[10]Cape Canaveral Air Force Station sites or populations identified by Schmalzer and Oddy (Ref. 13)

[11]Canaveral National Seashore sites or populations identified by Schmalzer and Foster (Ref. 4).

[12]Sites or populations identified during rare plant surveys by Schmalzer and Foster (Ref. 10, 14, 15, 16).

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

Scientific Name	Common Name	Habitat	Population Status	Threats to Existence
Asclepias curtissii[1,3,4]	Curtiss milkweed	Oak scrub	Several small populations	Habitat loss, fire exclusion
Avicennia germinans[2,4]	Black mangrove	Mangrove swamps	Common within habitat	Habitat loss, freezes
Calamovilfa curtissii[1,2]	Curtiss reedgrass	Shallow swales in pine flatwoods	Several populations	Habitat loss, fire exclusion
Calopogon multiflorus	Many-flowered grass pink	Pine flatwoods	Unknown	Habitat loss
Chamaesyce cumulicola[3,4]	Sand dune spurge	Coastal dunes, strand and scrub	Several small populations	Habitat loss, fire exclusion
Chrysophyllum oliviforme[1, 3]	Satinleaf	Hammocks	Unknown	Habitat loss
Encyclia tampensis[4]	Butterfly orchid	Hammocks, hardwood swamps - epiphytic	One small population	Habitat loss
Epidendrum canopseum[4]	Greenfly orchid	Hammocks, hardwood swamps - epiphytic	Two small populations	Habitat loss
Glandularia maritima[1,2,3,4] *(=Verbena maritima)*	Coastal vervain	Coastal dunes and strand - openings	Common within habitat	Habitat loss
Glandularia tampensis[1,2] *(=Verbena tampensis)*	Tampa vervain	Edge of hammocks	A few small populations	Habitat loss
Harrisella filiformis	Threadroot orchid	Hardwood swamps - epiphytic	Unknown	Habitat loss
Hexalectris spicata	Crested coralroot	Hammocks	Unknown	Habitat loss
Lantana depressa var. *floridana*[2,3,4]	East coast lantana	Coastal strand and scrub, coquina scrub	Several populations	Habitat loss, hybridization with *L. camara*
Lechea cernua[1,3]	Nodding pinweed	Scrub openings	Not relocated on KSC/MINWR	Habitat loss, fire exclusion
Lechea divaricata[2,4]	Pine pinweed	Scrub openings	Several small populations	Habitat loss, fire exclusion
Lilium catesbaei	Catesby lily	Pine flatwoods	Unknown	Habitat loss
Matelea gonocarpos[4]	Angle-pod	Hammocks	One population	Habitat loss
Myrcianthes fragrans[1,4]	Nakedwood	Hammocks, coastal strand	Common within habitat	Habitat loss
Nemastylis floridana[4]	Fall-flowering ixia	Hammocks, wet flatwoods	One population	Habitat loss
Ophioglossum palmatum[1,3,4] *(= Cheiroglossa palmata)*	Hand fern	Hammocks - epiphytic on cabbage palm	3 extant, 1 historic populations	Habitat loss, freezes
Opuntia stricta[2,4]	Shell mound prickly-pear	Coastal dunes and strand	Common within habitat	Habitat loss, introduced insect
Osmunda cinnamomea[2,4]	Cinnamon fern	Hardwood swamps	Common within habitat	Habitat loss, collection
Osmunda regalis var. *spectabilis*[2,4]	Royal fern	Hardwood swamps	Common within habitat	Habitat loss, collection
Pavonia spinifex[3,4]	Yellow hibiscus	Hammocks	Several populations	Habitat loss
Pecluma plumula *(=Polypodium plumula)*	Plume polypody	Hammocks - epiphytic	Unknown	Habitat loss
Peperomia humilis	Peperomia	Hammocks	Unknown	Habitat loss

Table 7-3. (cont.).

Scientific Name	Common Name	Habitat	Population Status	Threats to Existence
Peperomia obtusifolia	Florida peperomia	Hammocks - epiphytic	Unknown	Habitat loss
Persea borbonia var. *humilis*[1,2,4]	Scrub bay	scrub	A few small populations	Habitat loss, fire exclusion
Pogonia ophioglossoides	Rose pogonia	Marshes and wet pine flatwoods	Unknown	Habitat loss
Pteroglossaspis ecristata[4] (= *Eulophia ecristata*)	False coco	Scrub and dry flatwoods	One population	Habitat loss, fire exclusion
Remirea maritima[2,3] (= *Cyperus pedunculatus)*	Beach-star	Coastal dunes	Occasional within habitat	Habitat loss
Rhizophora mangle[2,4]	Red mangrove	Mangrove swamps	Occasional within habitat	Habitat loss, freezes
Scaevola plumieri[2,4]	Scaevola	Coastal dunes and strand	Occasional within habitat	Habitat loss
Sophora tomentosa[4]	Necklace pod	Coastal strand and hammocks	One population	Habitat loss
Spiranthes laciniata	Lace-lip ladies'-tresses	Marshes	Unknown	Habitat loss
Tephrosia angustissima var. *curtissii*[4]	Narrow-leaved hoary pea; coastal hoary pea	Coastal dunes and strand	Two small populations	Habitat loss, fire exclusion
Tillandsia fasciculata[4]	Common wild pine	Hammocks and hardwood swamps - epiphytic	Five small populations	Exotic insect, habitat loss
Tillandsia utriculata[4]	Giant wild pine; giant air plant	Hammocks and hardwood swamps - epiphytic	Three small populations	Exotic insect, habitat loss
Zamia pumila[1,4] (= *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 (1982-2008) (Ref. 5, 17)
[3] Sites or populations identified by Chafin et al. (Ref. 12)
[4] Sites or populations identified by Schmalzer and Foster (Ref. 4, 10, 14, 15, 16)

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.

KSC is home to three species of marine turtles that nest on the beaches: loggerheads, green turtles, and leatherbacks. Two species loggerheads and green turtles also occurred in the KSC waters of the IRL.

Harvesting of green turtles from the IRL began in about 1878, and early reports (Ref. 17, 18) describe a turtle fishery that took many green turtles. Fishing for turtles was concentrated more in the south end of the system near Sebastian and Ft. Pierce, rather than in the lagoon near KSC. Green turtles were severely affected by commercial harvesting, and by 1895, captures of turtles from the IRL dropped sharply (Ref. 18).

Documented historical evidence for marine turtles' occurrence in Mosquito Lagoon begins with an anecdotal statement that 150 green turtles were exported from Mosquito Lagoon in 1879. Scientific research on marine turtles in Mosquito Lagoon began in 1975 (Ref. 19). Four species were found in the area: green turtles and loggerheads were most common, but during five years of netting, two Kemp's ridleys and one hawksbill were also captured. Mosquito Lagoon is a nursery habitat for green turtles and loggerheads; the size classes present range from post-yearling to sub-adults. Capture rate for Mosquito Lagoon was 0.67 turtles/day; this rate is an order of magnitude lower than the capture rate near Sebastian Inlet (Ref. 20), but greater than the 0.02 turtles/day reported for the northern section of the Indian River (Ref. 19).

Information on marine turtles residing in Mosquito Lagoon were gathered opportunistically during cold-stunning events in 1977, 1978, and 1989. When the water temperatures fall below 8°C, marine turtles become lethargic and float to the surface, and can die if not rescued and rehabilitated (Ref. 20). 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. The relative abundance, distribution and status of the marine turtle population inhabiting Mosquito Lagoon are currently being assessed as part of EMB conservation and stewardship activities. Objectives are to compare the present-day population to baseline data collected in 1976-1979, to determine species ratios, population abundance, and genetic characteristics of marine turtles in the IRL.

Recent data indicate green turtles are more abundant than loggerhead turtles, the inverse of findings observed in the late 1970s. The observed sex ratio is skewed towards females and determined to be 94.4% for greens and 66.6 % for loggerheads. Catch per unit effort (CPUE), a standardized technique to compare sea turtle netting worldwide (Ref. 21). indicate that green turtles are much more abundant today than in the 1970's. Loggerhead captures indicate a slight decline in their numbers since the 1970's. Several turtles originally tagged in Mosquito Lagoon have been recaptured as far away as Cuba. DNA analyses revealed the presence of sea turtles originating from Florida, Mexico, Aves Island, Surinam and Costa Rica. This indicates the Mosquito Lagoon has a significant role in the sea turtle life cycle.

An additional difference observed between the 1970s and current observations is the occurrence of fibropapillomatosis (FP). This debilitating disease is transmitted by a retrovirus that manifests itself as tumors. Tumors may grow to a considerable size, usually attached to soft-tissues such as the eyes and flippers. They may occlude the sea turtle's vision, potentially leading to starvation. Occasionally, recaptured individuals showed regression of FP tumors. FP was not observed in any green turtles in the 1970s in Mosquito Lagoon. Unfortunately, today 57% of the green turtles have FP tumors. FP is extremely rare in loggerhead sea turtles.

Gopher tortoises are a state-protected Species of Special Concern. 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). Monitoring of URTD continues and several sites may potentially have had die-offs that could be contributed to URTD (Ref. 24).

Other than the low-intensity URTD monitoring that continues, most of the work currently occurring 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, roseate tern and Florida scrub-jay are protected under the Endangered Species Act, and 18 additional species are protected by the State of Florida (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).

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 2009, the number of nests was 12, and the average number of known fledglings per year was 12. 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.

The wood stork is federally listed as endangered, and six other species of wading bird 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 show 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. More detailed analysis of habitat preference showed that wading birds feeding in impounded salt marsh on KSC preferred areas within 1 m of the boundary between marsh vegetation and unvegetated open water (Ref. 25).

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. 26), and their numbers have increased steadily since that time. A study of foraging habitat preference by nesting Great and Snowy Egrets showed some evidence for a slight preference for impounded wetlands over other available wetland types on KSC (Ref. 27). Brown pelicans and double-crested cormorants also frequently nest in the wading bird colonies in large numbers.

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 has declined to perhaps half this number because of habitat degradation (Ref. 29, 30, 31). Research on color-banded scrub-jay populations on KSC began in 1987 and showed that territory sizes averaged 10 ha (Ref. 32). Major sources of mortality for adults are hawk predation and road mortality (Ref. 33). 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). Two years of remote recording of egg and nestling predation events found that 13 of 19 were due to yellow rat snakes. Radio-tracking data showed that small mammals, other birds, and snakes readily eat the fledgling scrub-jays before they become efficient fliers.

Florida scrub-jays are restricted to shrublands that have many scrub oaks and few trees (Ref. 28). They 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 tall (Ref. 35, 36, 37). 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). Major Scrub-jay populations are found in four areas on KSC as shown in Figure 7-2.

7.5 MAMMALS

The southeastern beach mouse (*Peromyscus polionotus niveiventris*) is federally protected as threatened while the Florida mouse (*Podomys floridanus*) 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 limited range and rapid loss of habitat outside of the refuge.

Small mammal trapping, primarily done in coastal habitats expected to support southeastern beach mouse populations, has provided data on several 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, Ref. 39). In 1990-1991, a baseline distribution survey (29 transects) at MINWR/KSC was conducted in the coastal dunes, strand, and scrub, which 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 LC39A and one near LC39B) 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

Figure 7-2. Scrub and Major Scrub-jay Populations on KSC.

adults, 28% were juveniles, and 4% were dependent young. No effects of launch could be inferred from the data collected.

Overall, surveys indicated 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. MINWR/KSC is one of the last remaining intact areas to have a viable southeastern beach mouse population but little is known about its habitat occupancy across the KSC landscape. Specimens have been captured as far inland as State Road 3 west of Happy Creek.

Live trapping for Florida mice was conducted four times between July 2001 and July 2002 at Happy Creek. 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.

The manatee (*Trichechus manatus*) is federally listed as endangered (Table 7-1). Monitoring the distribution and abundance of manatees at KSC was conducted through aerial surveys. Surveys were conducted since 1977 (Ref. 41). Since 1991, KSC aerial surveys were also conducted during cold periods in conjunction with the FFWCC's population census referred to as the Statewide Synoptic Survey. A summary of the KSC summer aerial survey data is presented in Figure 7-3. Mean numbers of manatees observed in KSC waters during summer have fluctuated around 160 individuals.

In 1990, to further protect this endangered species, the USFWS created a sanctuary for manatees covering the majority of the KSC section of the Banana River (Ref. 42). 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 shown in Figure 6-6.

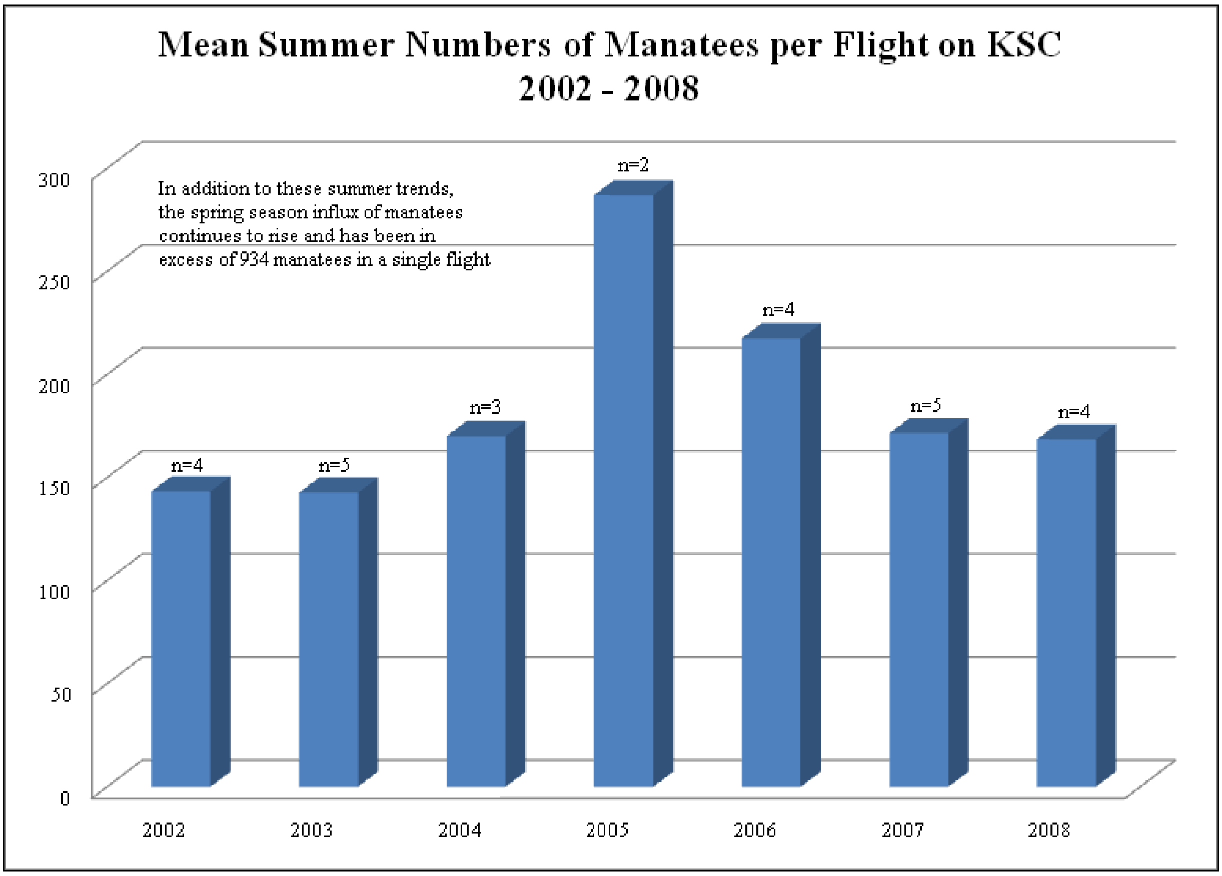

Figure 7-3. Results of Manatee Summer Surveys in KSC Waters for 2002-2008.

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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, the Public Health Service Act of 1962, the Safe Drinking Water Act of 1974, the 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.

Non-ionizing Radiation. FDEP has established requirements to reasonably protect the public health, safety, and welfare from electric and magnetic fields of future electric transmission lines.

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 Resource Conservation and Recovery Act (RCRA), which authorized EPA to regulate current and future waste management and disposal practices. In 1984 the Hazardous and Solid Waste Amendments (HSWA) to the 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 40 CFR Parts 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 Part 261), which is most likely to impact water quality. Required methods for analyzing these pollutants are specified in 40 CFR Part 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, F.A.C. The EPA still retains overview authority and certain permitting functions.

The Hazardous and Solid Waste Amendments (HSWA) to the Resource Conservation and Recovery Act (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 Parts 171-178 which the Florida DOT has adopted and incorporated by reference in Section 316.302, F.S. Similarly, the FDEP has adopted the federal hazardous waste transporter regulations in 40 CFR Part 263 by reference in Chapter 62-730, F.A.C.

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, F.A.C.). 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 (see 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 Treatment Storage and Disposal Facility (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	Facilities, Systems, and Equipment Management Handbook
KNPR 8715.3	KSC Safety Practices Procedural Requirements
KNPR 1840.19	KSC Industrial Hygiene Program
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
KSC-PLN-1912	NASA-KSC Environmental Management System (EMS) Plan

To promote consistency, minimize risk, and ensure compliance with Federal and State regulatory requirements, the NASA Environmental Assurance Branch (EAB) utilizes a center-wide methodology for management of hazardous and controlled waste. This is accomplished by utilizing the KSC Medical and Environmental Support Contract (MESC) for hazardous and controlled waste evaluation, pickup, and disposal services. The hazardous waste management process has been reviewed and approved by the Florida Department of Environmental Protection (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 Executive Order 13423 Strengthening Federal Environmental, Energy, and Transportation Management (EO 13423).

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 Facility (K7-0164 and 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. 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 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. KSC's pollution prevention program is described in Section XV, and Appendix E provides data on the hazardous waste disposal quantities from FY2005 through FY2008. Recent 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 UV 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 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 State on a quarterly basis 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 refuse deposited on a daily basis and 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 in).

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 38 wells, 2 surface water sample points, and 4 additional monitoring wells to be installed during the life cycle of the landfill. 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 16 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 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 closure of the Schwartz Road Landfill occurred in January 1996. Long-term site closure monitoring will continue for 30 years from the date of closure.

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 for UST's as a tank with 10 percent of their volume underground (including connective piping).

9.1.1 UNDERGROUND STORAGE TANKS

In 1984, Congress added Subtitle I to the Resource Conservation and Recovery Act (RCRA), establishing a comprehensive regulatory program for USTs containing regulated substances. EPA regulates this program under Title 40 CFR (Code of Federal Regulations) Part 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 F.A.C. (Florida Administrative Code) 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 & 30A), and for oil and/or petroleum storage tanks, Title 40 CFR Part 112, Spill Prevention, Control and Countermeasure 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 Parts 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.

9.1.4 HAZARDOUS TANK SYSTEMS ON KSC

Table 9-1 lists the existing hazardous tanks systems in operation on KSC:

Table 9-1. Regulated Hazardous Waste Tank Systems for KSC for 2009.

Facility/ Building #	Stored Material	Capacity (gallons)	Construction
Hangar AF/CCAFS 66242	Waste Alcohol (IPA)	225	Stainless Steel
ARF/L6-247	Waste Alcohol (IPA)	225	Stainless Steel
ARF/L6-247	Waste Alcohol (IPA)	225	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 Part 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 Part 264/265 and Part 280. Although both sets of regulations govern tank systems, tanks holding hazardous wastes will be subject to the provisions of RCRA, Title 40 CFR Subtitle C (Parts 264/265).

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 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 three registered USTs remain in service at KSC. They are located at the NASA Gas Station(currently a CITGO station), Facility M6-0596. The three underground tanks (diesel, unleaded, and premium unleaded) have a single-wall fiberglass construction. The single-walled

USTs were to be replaced with double-walled USTs or be replaced with aboveground tanks by the December 31, 2009 regulatory deadline. 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 was to replace the single-walled USTs with new double-walled USTs before the December 31, 2009 deadline.

Table 9-2 lists the registered underground tank systems in operation on KSC:

Table 9-2. Regulated Underground Storage Tank Systems for KSC for 2009.

Facility/ Building #	Stored Material	Capacity (gallons)	Construction	Year Installed
CITGO/M6-0596	Unleaded Regular	10,000	Fiberglass	1990
CITGO/M6-0596	Unleaded Premium	10,000	Fiberglass	1990
CITGO/M6-0596	Diesel	10,000	Fiberglass	1990

9.2.3 KSC ABOVEGROUND STORAGE TANKS

The aboveground (AST) tank regulatory requirements are from F.A.C. 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 F.A.C. 62-762 to the Brevard County Natural Resources Management Office (BCNRMO). The NASA Environmental Assurance Branch or their subcontracted Medical and Environmental Support Contractor (MESC) conduct audits, prepare registrations and coordinate all FDEP compliance inspections.

Table 9-3 lists the registered aboveground tanks systems in operation on KSC:

Table 9-3. Regulated Aboveground Storage Tank Systems for KSC for 2009.

Facility/ Building #	Stored Material	Capacity (gallons)	Construction	Year Installed
VAB/K6-947	Diesel	30,000	DW Steel	2007
VAB/K6-947	Diesel	30,000	DW Steel	2008
VAB/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
S-Band MILA/M5-1444	Diesel	8,000	Concrete Vaulted Steel	2008
HMF Firex/M7-1362	Diesel	1,500	DW Steel	2000

Table 9-3. (cont.).

Facility/Building #	Stored Material	Capacity (gallons)	Construction	Year Installed
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	8,000	DW Steel	2002
FSA #1/CCAFS 77615	JP-8	20,000	SW Steel	1955
FSA #1/CCAFS 77616	JP-8	20,000	SW Steel	1955
Hangar AE/60683	Diesel	675	DW Steel	2003

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 Environmental Assurance Branch (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 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 primary objective of this SPCC Plan is to serve as a guide for installation personnel that are responsible for the prevention, response, control, and reporting of all spills of oil. The KSC SPCC Plan describes both the facility-wide and site-specific approach for preventing and addressing spills.

The KSC SPCC Plan documents the procedures for the prevention, response, control, and reporting of spills of oil at Kennedy Space Center (KSC), Florida. This plan (KSC-PLN-1919) 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 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 gallons (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 located in Appendix B-1 thru B-11 of the SPCC Plan (KSC-PLN-1920) 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 full copy of the SPCC Plan is maintained at the NASA Environmental Assurance Branch (EAB) Office and is available to the Unites States (U.S.) Environmental Protection Agency (EPA) Regional Administrator for on-site review during normal working hours.

SECTION X

REMEDIATION

10.1 RESOURCE CONSERVATION AND RECOVERY ACT OF 1976 (RCRA)

Under the Resource Conservation and Recovery Act of 1976 (RCRA), the United States Environmental Protection Agency (USEPA) 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 Florida Department of Environmental Protection (FDEP), with support from the USEPA. For petroleum, which is also regulated under RCRA, this program is regulated under the FDEP petroleum cleanup regulation, Chapter 62-770 of the Florida Administrative Code (FAC; FDEP 2005a).

10.2 REGULATORY OVERVIEW - STATE

10.2.1 HAZARDOUS WASTE PERMITTING

Hazardous waste permitting has been delegated to the State 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 Chapter 62-730, F.A.C. EPA still retains overview authority and certain permitting functions.

The Hazardous and Solid Waste Amendments (HSWA) to the Resource Conservation and Recovery Act (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 Parts 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 Part 263 by reference in Chapter 62-730, F.A.C. .

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. Table 10-1 lists sites presently on the HSWA permit requiring investigation.

Table 10-1. Solid Waste Management Unit Summary

A.1. List of SWMUs/AOCs/PRLs requiring Confirmatory Sampling:			
SWMU/AOC/ PRL Number	SWMU/AOC/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
SWMU/AOC/ PRL Number	SWMU/AOC/ PRL Name	Comment and Basis for Determination	Dates of Operation
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

A.1. (cont.)			
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
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

A.2. List of SWMUs/AOCs/PRLs requiring a Site Assessment (a/k/a RCRA Facility Investigation [RFI] or a Risk Assessment):

SWMU/AOC/ PRL Number	SWMU/AOC/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
SWMU#89	Convertor/ Compressor Building, K7-468 (formerly PRL # 60)	CS Report/RFI Work approved FDEP July 8, 2005	1965 - present

A.2. (cont.)			
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

A.3. List of SWMUs/AOCs/PRLs requiring a Remedial Action Plan or Natural Attenuation with Monitoring Plan (a/k/a Corrective Measures Study [CMS]):

SWMU/AOC/ PRL Number/Letter	SWMU/AOC/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

A.3. (cont.)			
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

A.4. List of SWMUs/AOCs/PRLs implementing a Remedial Action Plan or Natural Attenuation with Monitoring Plan (a/k/a Corrective Measures Study [CMS]):

SWMU/AOC/ PRL Number/Letter	SWMU/AOC/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)

A.4. (cont.)	
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)
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 #110)
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 #111)
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, certain periodic site inspection, condition certification and agency notification procedures designed to ensure the maintenance by Center personnel 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 that through the Center’s substantial good faith compliance with the procedures called for within each Land Use Control Implementation Plan (LUCIP), reasonable assurances would be provided to EPA and FDEP as to the permanency of those remedies, which included the use of specific LUCs.

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. 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, 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 Environmental Protection Agency (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 Ldn 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-decibel 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 Ldn 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, space vehicle launches and Orbiter landings can be attributed to six general sources: (1) Orbiter reentry sonic booms, (2) launches, (3) aircraft movements, (4) industrial operations, (5) construction, and (6) 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 will be produced by hydraulic pumps operating within the confines of their enclosures. Operators will be 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 will 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; and by aqualaser removal of residual thermal protection materials from recovered SRBs. 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

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.
SOURCE: Ref. 3

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.

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 have 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).

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

Source	Noise Level (Peak)	Distance from Source [a]			
		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
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					

Studies were conducted on wading bird colonies subjected to military overflights (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 that 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
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
½	110
¼ 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.

3. Ardaman and Associates, Inc. 1984. Subsurface Exploration OMRF Building, Kennedy Space Center, Preliminary Engineering Documentation for OMRF Building. Cocoa, Florida.

4. Base Operations Contractor. Memorandum to Mark Mercadante, LBS-6380 dated March 28, 1990. Noise Survey – Complex 40 Titan Launch.

5. Black, B. B., M. W. Collipy, J. F. Percival, A. A. Tiller, and P. G. Bohall. 1984. Effects of Low Level Military Training Flights on Wading Bird Colonies in Florida. Florida Coop. Fish and Wildlife Research Unit, University of Florida. Tech Report No. 7.

6. Environmental Effects of the STS-1 Flight Readiness Firing and Launch. 1981. John F. Kennedy Space Center, Florida.

7. Breininger, D. R., M. J. Kehl. 1990. Report to Clay Gordin/6550 ABG/DEEV on 5 July, 1990.

SECTION XII

CULTURAL RESOURCES

The Kennedy Space Center (KSC) has a stewardship responsibility for managing the cultural resources on the NASA owned lands, as well as the NASA-owned facilities located within the Cape Canaveral Air Force Station (CCAFS). To this end, KSC has developed a Cultural Resource Management Plan (CRMP) (KSC-PLN-1733) that reflects the Agency's commitments to the protection of its significant archaeological sites and historic facilities. The Center has a designated 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, 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 CRMP 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 CRMP is also consistent with KSC's Environmental Policy 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 (EO) and with NASA environmental directives, procedures, and requirements."

12.1 REGULATORY OVERVIEW

The principal federal legislation governing the management of cultural resources or historic properties on federal and tribal lands include the Antiquities Act of 1906, the Historic Sites Act of 1935, the National Historic Preservation Act (NHPA) of 1966, as amended, the National Environmental Policy Act of 1969, Executive Order 13287, Preserve America (2003), Executive Order 11593: Protection and Enhancement of the Cultural Environment (1971), the Archaeological and Historic Preservation Act of 1974, the American Indian Religious Freedom Act of 1978, the Archaeological Resources Protection Act of 1979, and the 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 of the Florida Statutes (F.S.) contains legislation which parallels the federal requirements on the state level.

The following rules in the Code of Federal Regulations (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; and 43 CFR 10, Native American Graves Protection and Repatriation Act Regulations, Final Rule.

Two internal flow charts have been developed to assure compliance of KSC projects with State of Florida guidelines for historic or archaeological sites: Kennedy Documented Procedures (KDP)-P-1733, Historic and Archaeological Site Flowchart and KDP-P-2569, Lease or Exchange of Historic Property. Several NASA policies and directives are also followed: NASA Policy Directive (NPD) 8500.1, NASA Environmental Management; NPD 8580.1, Implementing the National Environmental Policy Act and EO 12114; NPD 4300.1B, NASA Personal Property Disposal Policy; NASA Procedural Requirement (NPR) 4310.1, Identification and Disposition of NASA Artifacts; and KNPR 8500.1, 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.

12.1.1. 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 law. Among the fundamental provisions of the Act is the Section 106 Process, described below. 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 an 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 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 National Historic Landmarks (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."

12.1.2 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. Beginning in September 2005, federal agencies were required to submit triennial progress reports.

12.2 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 Part 800 (as amended in August 5, 2004). Section 106 represents the principal federal review process that looks at how historic properties are affected by projects funded by or under the jurisdiction of federal agencies. 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 Advisory Council on Historic Preservation (ACHP). This is critical to KSC since it is the responsibility of the federal agency involved to discover historic properties and ascertain their potential NRHP eligibility following procedures outlined in the ACHP and NPS regulations, 36 CFR Part 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 in every case, nor does it give the ACHP veto power over a federal agency's action. It does, however, require full consideration of preservation values by federal agencies compared with the projected benefits of the completed undertaking, costs, and other factors. Final action can range from avoidance to unmitigated loss of property, as long as consideration of the effects and available options were carefully evaluated. 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.

12.3 MEMORANDUM OF AGREEMENTS AND PROGRAMMATIC AGREEMENTS

An agreement document is prepared when an undertaking will have an adverse effect on those characteristics of an 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 permits 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. 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 space flight (1998); (3) MOA for the Launch Control Center (LCC) 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 Launch Complex (LC)-34 Environmental Support Building between KSC and the SHPO (2006); (5) a Non-Reimbursable Space Act Agreement 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 has executed a Programmatic Agreement for the Management of Historic Properties. This agreement streamlines the Section 106 process and documentation for "like" multiple assets (such as two (2) launch pads, three (3) mobile launcher platforms, and two (2) crawler transporters). It also allows KSC to do normal maintenance and minor modifications, reuse facilities and property, and ensures that historic, engineering, and architectural values are recognized and considered in the course of ongoing KSC programs.

12.4 INTEGRATING NEPA AND SECTION 106

In accordance with 36 CFR Part 800, Federal agencies are encouraged to coordinate studies and documents prepared under Section 106 with those done under the National Environmental Policy Act (NEPA). Section 800.8(a) of the regulations provides guidance on how NEPA and Section 106 process can be coordinated. NEPA documents (i.e., Environmental Assessment (EA)/Finding of No Significant Impact (FONSI) or an Environmental Impact Statement (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. During preparation of an EA, the results of the Section 106 review should be reported in the FONSI with an explanation of how significant adverse effects will be avoided. During preparation of an EIS, the results of the Section 106 review should be reported in the draft EIS. Consultation to resolve adverse effects should be coordinated with the public on the draft EIS and the results reported in the final EIS. The ROD addresses any MOA developed under Section 106 with final comments from ACHP. Usually, the MOA should be executed before the ROD is issued, and the ROD should provide for implementation of the MOA's terms and/or stipulations (National Preservation Institute 2008). In the case of an action categorically excluded from NEPA review (36 CFR Part 800.8(b)), KSC will determine if it still 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 Part 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.

12.5 HISTORY OF LAND ACQUISITION

KSC became a resident of Cape Canaveral in 1958 when the Army Missile Firing Laboratory (MFL), then working on the Saturn rocket project managed by Kurt Debus, was transferred to KSC. Several Army facilities, various offices, and hangars at CCAFS were given to KSC, including Launch Complexes 5, 6, 26, and 34. MFL was renamed Launch Operations Directorate (LOD) and became a branch office of Marshall Space Flight Center (MSFC). As LOD responsibilities grew, the KSC launch team increased status by making it a field center called the Launch Operations Center (LOC) and separating it from MSFC.

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. Also in 1961, KSC requested from Congress authority to purchase 32,380.0 ha (79,999.7 ac) of property. The land was formally granted in 1962. The U.S. Army Corps of Engineers (ACOE) acted as the agent for purchasing land. KSC 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 State-provided land 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.

An Air Force request in 1962 for space to install new Titan rocket facilities (Launch Complexes 40 and 41) at the south end of KSC's newly purchased land prompted a re-evaluation of the total land buy. 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 ACOE with Air Force money in compensation for 140.4 ha (346.9 ac) taken by CCAFS for the two Titan launching facilities. Total holdings of KSC-owned land increased to 56,970.0 ha (140,735.3 ac). 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.

12.6 PRECONTACT AND HISTORIC CONTEXTS

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" (Milanich 1994:243). 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.

Previously, the KSC area was included in the Indian River area, which begins at the northern headwaters of the coastal Indian River lagoon 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 (1951), 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 (Milanich 1994: pg 250). A chronological sequence of aboriginal cultures for the St. Johns region, as well as the major proto-historic and historic periods, is summarized in Table 2-1, pages 2-6 of the CRMP.

12.7 ARCHAEOLOGICAL SURVEYS AND INVESTIGATIONS

The general KSC area has been the focus of archaeological investigations for over 100 years. The area has been studied by many investigators conducting a number of archaeological surveys. Most of these projects focused upon small parcels of lands proposed for facility development. In addition to proposed developments within KSC property, reconnaissance-level archaeological surveys have been conducted for the CNS, MINWR, and CCAFS. Details of the surveys can be found in the CRMP. The 104 known archaeological sites at KSC contain a total of 120 identified temporal/cultural components of which 92 (76.7%) are precontact and 28 (23.3%) are historic. Archaeological site types are discussed in Chapter 4.3.1 of the CRMP.

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 the 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 Geographic Information System (GIS) database.

In 2007-2008, ACI initiated 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, current as of September 2008. As funds become available, potential historic period archaeological sites will be surveyed, evaluated, and recorded in the FMSF.

12.7.2 CLASSIFICATION AND EVALUATION OF ARCHAEOLOGICAL SITES

All recorded archaeological sites within KSC are classified into one of five evaluation categories:

A. National Register Site - Site is listed in the NRHP.

B. National Register Eligible - Site is considered significant based on existing information, and thus is deemed eligible for listing in the NRHP.

C. Potentially Significant - Site appears potentially significant but additional archaeological data is needed before a final determination can be made.

D. Not Determined - Not enough information currently exists to make an informed assessment of significance.

E. Not Significant/Not Eligible - Site is considered not regionally significant because of limited data, potential or site destruction, and therefore, is not deemed eligible for listing in the NRHP.

The evaluation category for each recorded KSC archaeological site is listed below. In summary, 5% of the sites are presently listed (Category A) in the National Register, 22% are considered eligible for listing (Category B), 11% appear to be potentially eligible (Category C) but require additional information before a final determination can be made, 16% have not been adequately investigated to make a determination (Category D), and 46% have been adjudged non-significant, and thus, not National Register eligible (Category E).

National Register Listed Sites (Category A): Only 4 recorded sites are listed in the NRHP (Table 12-1).

Table 12-1. National Register Listed Sites.

8BR188	Old Haulover Canal
8VO130	Ross Hammock Midden
8VO131	Ross Hammock Indian Mounds
8VO213	Ross Hammock Salt Rendering Plant
Note: Technically, 8VO130, -131, and -213 are components of a single site complex, assigned the FMSF number 8VO2569 (Ross Hammock Archaeological District).	

National Register Eligible Sites (Category B): Twenty-three sites are considered NRHP eligible. Half of these resources are multi-component with a total of 35 components (by type) represented. All are considered to represent the best examples of their type for this vicinity.

Potentially Significant (Category C): Eleven sites appear to be potentially significant, and may be eligible for National Register listing. However, more archaeological information is needed before a final determination can be made.

Not Determined (Category D): Given the absence of available data, the significance of 17 sites has not been determined. These resources could not be sufficiently evaluated because either their locations are recorded as unknown or efforts to relocate them at their recorded coordinates yielded negative results. Many of these sites, visited and examined more than 20 years ago, are recorded primarily on the basis of surface collections. Others, such as those situated along mosquito control dikes around Mosquito Lagoon, were visited recently, but subjected to only limited testing. Further archaeological work will be necessary to determine site limits, contextual integrity, and significance.

Not Significant/Not Eligible (Category E): Forty-eight sites have been evaluated as not eligible for NRHP listing on the basis of existing information. All are considered not significant due to limited data potential and/or loss of contextual integrity.

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 Part 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 of cooperating Federal agency, is the property of KSC. KSC has selected the NPS Southeast Archeological Center, located in Florida, as the repository for permanent curation of its archaeological collections and the facility meets the Federal curation standards contained in 36 CFR Part 79.

12.8 SIGNIFICANT HISTORIC BUILDINGS, STRUCTURES, OBJECTS, AND DISTRICTS

12.8.1 HISTORIC SURVEYS OF NASA-OWNED FACILITIES

In 1973, LC-39 became the first KSC site to be listed in the NRHP. The nomination, which highlighted the national significance of those principal facilities associated with the Apollo Manned Lunar Landing Program, was prepared the previous year by George M. Hawkins, Chief of the Documentation and Data Management Branch of NASA/KSC. 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.

In 1994, the U.S. Army Construction Engineering Research Laboratory recommended that Launch Complexes 1/2, 3/4, 17, 21/22, 25, and 31/32 be considered eligible for the NRHP under Criteria A and/or C. Other properties were not considered eligible for the NRHP at that time. Of these eligible properties, only two, Launch Silo 31-B and Launch Silo 32-B, are in KSC ownership.

In 1996-1997, a site reassessment for LC-39 was conducted by ACI along with an inventory of the Industrial, Vehicle Assembly Building (VAB), and Shuttle Landing Facility (SLF) Areas. The reassessment found the majority of individual facilities within the existing 2,833 ha (7,000 ac) NRHP 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, the boundary of the LC-39 site was removed and 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, (1979); and Apollo-Soyuz Test Project, 1975. The total 322 resources located within the original NRHP site was reduced to eight (8) individually eligible resources and thirty-four (34) facilities considered as contributing to newly identified NRHP historic districts at LC-39 Pads A and B. The VAB, LCC, the Crawlers, the Crawlerway and Launch Pads A and B were retained from the original nomination. The Headquarters Building, Operations & Checkout (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 3 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 Florida SHPO that the new Multiple Property submission be accepted to supersede the original nomination.

In 2006, KSC initiated a historical survey and evaluation of all NASA-owned facilities and properties (real property assets) to determine their eligibility for listing in the NRHP in the context of the U.S. Space Shuttle program (SSP), 1969-2010. KSC developed the set of standard protocols for evaluating the historical significance of SSP-related facilities. The evaluation of KSC facilities focused on 112 properties. As a result, 26 assets were considered to individually meet the criteria of eligibility for listing in the NRHP, including 11 buildings, 14 structures, and 1 object. 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 6 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 Shuttle Landing Facility (SLF) Runway, the Landing Aids Control Building, the Mate-Demate Device, the Orbiter Processing Facility (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, 2 Payload Canisters, 2 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, 4 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 Hypergolic Maintenance and Checkout Area (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 which are not considered individually eligible. Of the 76 significant properties, 36 were previously determined NRHP-eligible and 40 were newly evaluated.

12.8.2 KSC LISTED AND/OR ELIGIBLE HISTORIC RESOURCES

As of November 2008, a total of 89 historic properties have been identified within KSC, including 6 historic districts, 29 individually listed or eligible properties, and fifty-four 54 resources that are contributing to a historic district, but not individually eligible. The individually eligible properties include multiple resources such as 2 Crawler Transporters, 3 Mobile Launcher Platforms, and 2 Payload Canisters. Descriptions and summary statements of the 29 individually eligible properties (including 14 buildings, 14 structures, and 1 object), as well as the 6 historic districts can be found in the CRMP.

Table 12-2 shows Historic Properties listed and/or eligible for listing in the NRHP at KSC.

Table 12-2. KSC Historic Properties Listed and/or Eligible for the NRHP.

Facility No.	Facility	Date	FMSF No.	NRHP Resource Type	NRHP Status	Significant Historic Context(s)	
						Apollo	SSP
M6-342	Central Instrumentation Facility	1965	8BR1692	Building	Listed – Criteria A and C	X	
M6-399	Headquarters Building	1965	8BR1691	Building	Listed– Criteria A and C	X	
M7-355	Operations and Checkout Building	1964	8BR1693	Building	Listed– Criteria A and C	X	
K6-848	Vehicle Assembly Building	1962-66	8BR1684	Building	Listed – Criteria A and C	X	X
K6-900	Launch Control Center	1966	8BR1685	Building	Listed – Criteria A and C	X	X
	Crawler Transporters (2)	1965	8BR1688	Structure	Listed – Criteria A and C	X	X
UK-	Crawlerway	1963-	8BR16	Structure	Listed – Criteria A	X	X

Facility No.	Facility	Date	FMSF No.	NRHP Resource Type	NRHP Status	Significant Historic Context(s)	
						Apollo	SSP
008		65	89		and C		
	Press Site: Clock and Flag Pole	1969	8BR1690	Object	Listed – Criterion A	X	X
	LC 39: Pad A Historic District	1963-85	8BR1686	District	Listed - Criteria A and C	X	X
J8-1708	LC 39: Pad A	1963-65	8BR1995	Structure	Individually eligible and contributing to LC 39: Pad A H.D. - Criteria A and C	X	X
J8-1564	Foam Building	1965		Building	Not individually eligible; contributes to LC-39A H.D.	X	
J8-1565	Pump House	1964		Structure	Not individually eligible; contributes to LC-39A H.D.	X	
J8-1659	Compressed Air Building	1965		Building	Not individually eligible; contributes to LC-39A H.D.	X	
J8-1753	Remote Air Intake Building	1965		Building	Not individually eligible; contributes to LC-39A H.D.	X	
J8-1858	Azimuth Alignment Station	1965		Structure	Not individually eligible; contributes to LC-39A H.D.	X	
J8-1462	High Pressure GH2 Facility	1968	8BR2094	Structure	Not individually eligible; contributes to LC-39A H.D.	X	X
J8-1502	LOX Facility	1966	8BR2095	Structure	Not individually eligible; contributes to LC-39A H.D.	X	X
J8-1503	Operations Support Building A-1	1966	8BR2096	Building	Not individually eligible; contributes to LC-	X	X

Facility No.	Facility	Date	FMSF No.	NRHP Resource Type	NRHP Status	Significant Historic Context(s)	
						Apollo	SSP
					39A H.D.		
J8-1512	Camera Pad A No. 1	1966	8BR2097	Structure	Not individually eligible; contributes to LC-39A H.D	X	X
J8-1513	LH2 Facility	1966	8BR2098	Structure	Not individually eligible; contributes to LC-39A H.D	X	X
J8-1553	Electrical Equipment Building No. 2	1965	8BR2099	Building	Not individually eligible; contributes to LC-39A H.D	X	X
J8-1554	Camera Pad No. 6	1965	8BR2100	Structure	Not individually eligible; contributes to LC-39A H.D	X	X
J8-1563	Electrical Equipment Building No. 1	1965	8BR2101	Building	Not individually eligible; contributes to LC-39A H.D	X	X
J8-1614	Operations Support Building A-2	1966	8BR2102	Building	Not individually eligible; contributes to LC-39A H.D	X	X
J8-1703	Slidewire Termination Facility	1965	8BR2103	Structure	Not individually eligible; contributes to LC-39A H.D	X	X
J8-1707	Water Chiller Building	1968	8BR2104	Building	Not individually eligible; contributes to LC-39A H.D	X	X
J8-1714	Camera Pad A No.2	1965	8BR2105	Structure	Not individually eligible; contributes to LC-39A H.D	X	X
J8-1956	Camera Pad A No. 4	1965	8BR2106	Structure	Not individually eligible; contributes to LC-39A H.D	X	X

Facility No.	Facility	Date	FMSF No.	NRHP Resource Type	NRHP Status	Significant Historic Context(s)	
						Apollo	SSP
J8-1961	Camera Pad A No. 3	1965	8BR2107	Structure	Not individually eligible; contributes to LC-39A H.D.	X	X
J8-1610	Water Tank	1980	8BR2108	Structure	Not individually eligible; contributes to LC-39A H.D.		X
J8-1611	Flare Stack	1985	8BR2109	Structure	Not individually eligible; contributes to LC-39A H.D.		X
J8-1811	Electrical Equipment Building No. 3	1979	8BR2110	Building	Not individually eligible; contributes to LC-39A H.D.		X
J8-1856	Electrical Equipment Building No. 4	1979	8BR2111	Building	Not individually eligible; contributes to LC-39A H.D.		X
J8-1862	Hypergol Oxidizer Facility	1979	8BR2112	Structure	Not individually eligible; contributes to LC-39A H.D.		X
J8-1906	Hypergol Fuel Facility	1979	8BR2113	Structure	Not individually eligible; contributes to LC-39A H.D.		X
	LC 39: Pad B Historic District	1967-85	8BR1687	District	Listed - Criteria A and C	X	X
J7-0337	LC 39: Pad B	1964-68	8BR2010	Structure	Individually eligible and contributing to LC 39: Pad B H.D. - Criteria A and C	X	X
J7-0242	Foam Building	1968		Structure	Not individually eligible; contributes to LC-39B H.D.	X	
J7-0338	Compressed Air Building	1967		Structure	Not individually eligible;	X	

Facility No.	Facility	Date	FMSF No.	NRHP Resource Type	NRHP Status	Significant Historic Context(s)	
						Apollo	SSP
					contributes to LC-39B H.D.		
J7-0432	Remote Air Intake Building	1967		Building	Not individually eligible; contributes to LC-39B H.D.	X	
J7-0537	Azimuth Alignment Station	1967		Structure	Not individually eligible; contributes to LC-39B H.D.	X	
J7-0132	Operations Support Building B-1	1967	8BR2114	Building	Not individually eligible; contributes to LC-39B H.D.	X	X
J7-0140	High Pressure GH2 Facility	1967	8BR2115	Structure	Not individually eligible; contributes to LC-39B H.D	X	X
J7-0182	LOX Facility	1967	8BR2116	Structure	Not individually eligible; contributes to LC-39B H.D		
J7-0183	Camera Pad B No. 6	1968	8BR2117	Structure	Not individually eligible; contributes to LC-39B H.D		
J7-0191	Camera Pad B No. 1	1968	8BR2118	Structure	Not individually eligible; contributes to LC-39B H.D		
J7-0192	LH2 Facility	1967	8BR2119	Structure	Not individually eligible; contributes to LC-39B H.D		
J7-0231	Electrical Equipment Building No. 2	1967	8BR2120	Building	Not individually eligible; contributes to LC-39B H.D	X	X
J7-0241	Electrical Equipment Building No. 1	1967	8BR2121	Building	Not individually eligible; contributes to LC-	X	X

Facility No.	Facility	Date	FMSF No.	NRHP Resource Type	NRHP Status	Significant Historic Context(s)	
						Apollo	SSP
					39B H.D		
J7-0243	Operations Support Building B-2	1967	8BR2122	Building	Not individually eligible; contributes to LC-39B H.D	X	X
J7-0331	Slidewire Termination Facility	1967	8BR2123	Structure	Not individually eligible; contributes to LC-39B H.D	X	X
J7-0342	Camera Pad B No. 2	1967	8BR2124	Structure	Not individually eligible; contributes to LC-39B H.D	X	X
J7-0385	Water Chiller Building	1968	8BR2125	Building	Not individually eligible; contributes to LC-39B H.D	X	X
J7-0584	Camera Pad B No. 4	1968	8BR2126	Structure	Not individually eligible; contributes to LC-39B H.D	X	X
J7-0589	Camera Pad B No. 3	1968	8BR2127	Structure	Not individually eligible; contributes to LC-39B H.D	X	X
J7-0240	Flarestack	1985	8BR2128	Structure	Not individually eligible; contributes to LC-39B H.D.		X
J7-0288	Water Tank	1981	8BR2129	Structure	Not individually eligible; contributes to LC-39B H.D.		X
J7-0490	Hypergol Oxidizer Facility	1981	8BR2130	Structure	Not individually eligible; contributes to LC-39B H.D.		X
J7-0491	Electrical Equipment Building No. 3	1981	8BR2131	Building	Not individually eligible; contributes to LC-39B H.D.		X

Facility No.	Facility	Date	FMSF No.	NRHP Resource Type	NRHP Status	Significant Historic Context(s)	
						Apollo	SSP
J7-0534	Hypergol Fuel Facility	1981	8BR2132	Structure	Not individually eligible; contributes to LC-39B H.D.		X
J7-0535	Electrical Equipment Building No. 4	1981	8BR2133	Building	Not individually eligible; contributes to LC-39B H.D.		X
	Shuttle Landing Facility (SLF) Historic District		8BR1986	District	Eligible – Criteria A and C		X
	Shuttle Landing Facility (Runway)	1976	8BR1987	Structure	Individually eligible and contributing to SLF H.D. - Criteria A and C		X
J6-2313	Landing Aids Control Building	1976	8BR1988	Building	Individually eligible and contributing to SLF H.D. – Criterion A		X
J6-2262	Mate-Demate Device	1977-78	8BR1989	Structure	Individually eligible and contributing to SLF H.D. - Criteria A and C		X
	Orbiter Processing Historic District		8BR1990	District	Eligible – Criteria A and C		X
K6-894	Orbiter Processing Facility (OPF)	1977	8BR1991	Building	Individually eligible and contributing to OPF H.D. - Criteria A and C		X
K6-696	Orbiter Processing Facility High Bay 3 (OPF-3)	1987	8BR1992	Building	Individually eligible and contributing to OPF H.D. - Criteria A and C		X
	Thermal Protection				Individually eligible and		

Facility No.	Facility	Date	FMSF No.	NRHP Resource Type	NRHP Status	Significant Historic Context(s)	
						Apollo	SSP
K6-794	System Facility	1988	8BR1994	Building	contributing to OPF H.D. - Criteria A and C		X
	SRB Disassembly and Refurbishment Complex Historic District		8BR1996	District	Eligible – Criterion A		X
66250	Hangar AF	1962	8BR2001	Building	Not individually eligible; contributes to SRB H.D.		X
66251	High Pressure Gas Facility	1963	8BR2002	Building	Not individually eligible; contributes to SRB H.D.		X
66240	High Pressure Wash Facility	1979	8BR2003	Building	Not individually eligible; contributes to SRB H.D.		X
66242	First Wash Building	1979	8BR2004	Building	Not individually eligible; contributes to SRB H.D.		X
66244	SRB Recovery Slip	1979	8BR2005	Structure	Not individually eligible; contributes to SRB H.D.		X
66310	SRB Paint Building	1984	8BR2006	Building	Not individually eligible; contributes to SRB H.D.		X
66320	Robot Wash Building	1987	8BR2007	Building	Not individually eligible; contributes to SRB H.D.		X
66249	Thrust Vector Control Deservicing Building	1985	8BR2008	Building	Not individually eligible; contributes to SRB H.D.		X
66340	Multi-Media Blast	1992	8BR20	Building	Not individually eligible;		X

Facility No.	Facility	Date	FMSF No.	NRHP Resource Type	NRHP Status	Significant Historic Context(s)	
						Apollo	SSP
	Facility		09		contributes to SRB H.D.		
	Hypergolic Maintenance and Checkout Area (HMCA) Historic District		8BR2015	District	Eligible – Criterion A		X
M7-961	Hypergol Module Processing North	1964	8BR1993	Building	Individually eligible and contributing to HMCA H.D. – Criterion A		X
M7-1061	Hypergol Support Building	1964	8BR2018	Building	Not individually eligible; contributes to HMCA H.D.		X
K6-494	Rotation/Processing Building	1984	8BR1997	Building	Eligible – Criteria A and C		X
L6-247	Manufacturing Building	1986	8BR1998	Building	Eligible – Criterion A		X
M7-657	Parachute Refurbishment Facility	1964	8BR2014	Building	Eligible – Criterion A		X
M7-777	Canister Rotation Facility	1993	8BR2016	Building	Eligible – Criteria A and C		X
	Payload Canisters (2)		8BR2017	Structure	Eligible – Criteria A and C		X
	Retrieval Ship *Liberty Star*	1980-81	8BR2019	Structure	Eligible – Criterion A		X
	Retrieval Ship *Freedom Star*	1980-81	8BR2020	Structure	Eligible – Criterion A		X
	Mobile Launcher Platforms (3)	1963-68	8BR2020	Structure	Eligible – Criteria A and C	X	X

12.8.3 HISTORIC DISTRICTS

KSC has identified 6 eligible historic districts: (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) SRB Disassembly and Refurbishment Complex Historic District, and (6) HMCA Historic

District. Of these, both LC-39 Pads A and B are listed NRHP Historic Districts. Each is significant in the context of both the Apollo program and the Space Shuttle program. As a result of the 2006 NASA-wide survey and evaluation of assets associated with the Space Shuttle program, 4 new historic districts were defined. The historic districts collectively contain 63 contributing resources, of which 9 are also individually listed or eligible and 54 do not independently meet the National Register eligibility criteria (reference Table 12-5).

A contributing resource is a building, structure or object that adds to the historic associations or historic engineering or architectural qualities for which the property is significant because it was present during the period of significance, relates to the documented significance of the property, and possesses historic integrity or is capable of yielding important information about the period; or it independently meets NRHP criteria. A noncontributing resource is a building, structure or object that does not add to the historic engineering or architectural qualities or historic association for which a property is significant because it was not present during the period of significance or does not relate to the documented significance of the property; due to alterations, disturbances, additions, or other changes, it no longer possesses historic integrity or is capable of yielding important information about the period; or it does not independently meet the NRHP criteria.

Table 12-3. Contributing and Non-Contributing Resources at KSC.

District Name	C (IE)	NC	Total
LC-39 Pad A	23 (1)	21	44
LC-39 Pad B	23 (1)	21	44
SLF Area	3 (3)	0	3
Orbiter Processing	3 (3)	0	3
SRB Complex	9 (0)	11	20
HMCA	2 (1)	1	3
Total	**63 (9)**	**54**	**117**

Legend: C=contributing; IE=Individually eligible; NC= non-contributing

12.8.4 NATIONAL HISTORIC LANDMARK

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, included Launch Pads 5, 6, 13, 14, 19, 26, 34, and the original Mission Control Center (MCC). Of these, LC 5/6, 19, 34, and the MCC are NASA-owned properties. At the direction of the Secretary of the Interior's Advisory Board, the boundary of the NHL District included only the area immediately surrounding the seven launch pads and the MCC. The Cape Canaveral Air Force Station Historic District was listed as a NHL on April 16, 1984. The LC-34 Engineering Support Building was demolished in 2007 and the MCC is planned for demolition in 2009.

12.9 REFERENCES

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SECTION XIII

SOCIOECONOMICS

13.1 WORKFORCE

KSC is Brevard County's largest single employer 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 1.93 jobs within this region. 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 have declined since the 1990s and are being phased out as leases expire. 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, and 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 14,181 personnel employed at KSC at the end of September 2008. This population includes contractor, construction, tenant, and permanent civil service employees. Approximately 13 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 historic low in 1976 when a total of 8,441 personnel were employed. Employment levels rose sharply in 1979 when KSC was designated as the launch and operations support center for the STS (see 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.

Approximately 46 percent of the estimated 14,181 personnel at KSC have positions directly related to the STS and payload processing operations. The remaining workforce is employed in ground and base support, unmanned launch programs, crew training, financial and resources management, engineering and technology development, safety, health, and independent assessment, research and development, and administrative positions. The largest concentration of personnel (approximately 49 percent of the KSC workforce) is stationed in the VAB area. The Industrial Area is the next most populated area with approximately 5 percent of the KSC workforce. The remaining personnel are stationed at various outlying facilities at KSC and at the CCAFS.

Table 13-1. History of Workforce at Kennedy Space Center.

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
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

Table 13-1. (cont.).		
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

*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.

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 Turning Basin is provided by 31 km (19.3 mi) of maintained channels. The docking facilities at Hangar AF Wharf are used primarily for the retrieval of the SRB motors following launches. The Turning Basin Wharf is used to unload the external fuel tanks of the STS and other heavy equipment suited to waterway transport. 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 & 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

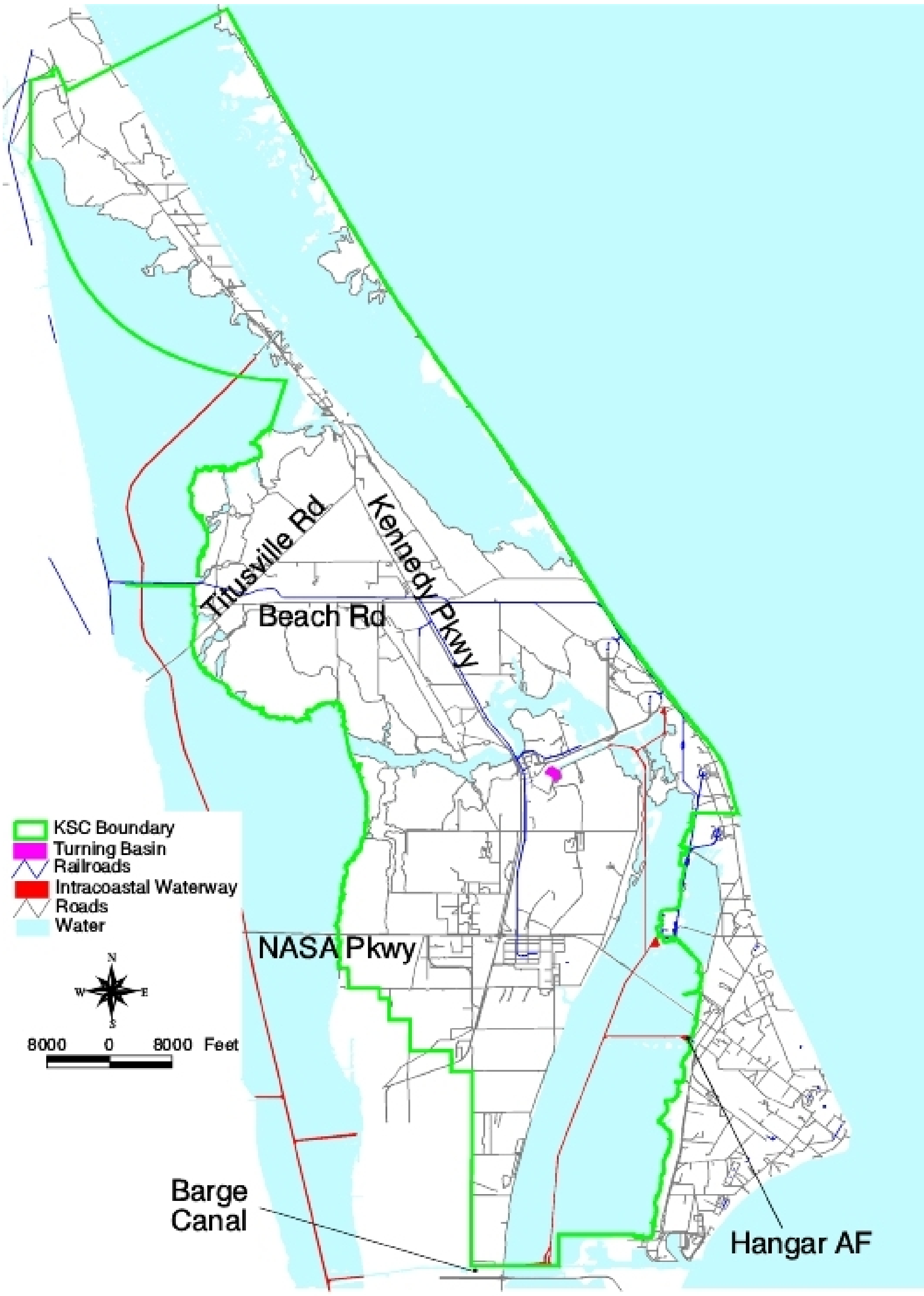

Figure 13-1. Transportation Routes on Kennedy Space Center.

Comptroller. Brevard County is bordered by the Atlantic Ocean and by Volusia, Orange, Osceola, and Indian River counties. The county has 299 square miles of water. Most of Brevard County's population resides along the Indian River and the Atlantic Ocean. In 2000 the most populous incorporated areas were Palm Bay (79,413 persons), followed by Melbourne (71,382 persons), and Titusville (40,670 persons). Cocoa, Rockledge, and Cocoa Beach all had populations in excess of 10,000 in the year 2000. The unincorporated area of Merritt Island, sparsely populated in 1960, had a population of 36,090 in 2000. During the 1980's, Port St. John, 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 2000, 86.8 percent of Brevard County's population was white and 13.2 percent was nonwhite. In 2000, 4.6 percent of the population was Hispanic. Of the population increase between 1980 and 1990, 87.7 percent was due to net migration. The 2000 birth rate for the county was 10.4 live births per 1,000 persons, and the 2000 death rate was 6.8 deaths per 1,000 persons. In 2000 the infant mortality rate was 6.6 per 1,000. The leading causes of death in 2000 were cancer, heart disease, and respiratory disease.

The per capita income for 2000 was $21,484. The median household income in 2000 was $40,099. In 2000, 6.8% of families had incomes below the poverty level. In 1997 there were 470 farms in Brevard County, totaling 111,925 hectares (276,573 acres). Leading agricultural products include cattle and citrus. In 1991, 4,338,679 pounds of fish and 1,539,218 pounds of shellfish were landed in Brevard County. 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 developed by the Environmental Office in 1997 and was updated in 2010. 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.

City of Cape Canaveral. A tiny 4.9 square-kilometer (1.9 square-mile) town sandwiched between the Atlantic Ocean and the Banana River. Cape Canaveral has a population of 8,829. Rich with history, Cape Canaveral is reportedly the oldest named place in the country. 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 hectares (4,160 acres). 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 square meters (500,000 square feet) of warehouse and dry cargo storage, and commercial fishing fleets.

City of Cocoa. Bordered by the Indian River to east, Cocoa extends west to undeveloped hammock areas. 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 16,412 according to the 2000 census data. Cocoa is home to some of Florida's major fruit shippers and the Brevard Community College (BCC) 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 BCC, offers graduate and upper division courses as well. Students can earn bachelor's and master's 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, Clearlake Middle and Cocoa 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 12,482. The city's residential areas house many of the space program's engineers, astronauts and technicians. There are two elementary schools and a junior/senior 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 2000, Rockledge had a population of 20,170. 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 40,670. 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 BCC Titusville campus, Astronaut and Titusville High Schools, plus two middle schools and seven 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 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. North of SR 528 is Kennedy Space Center. Merritt Island recreational areas include the 22-square mile MINWR, Kiwanis Park, Rotary Park, Kelly Park East and West, and Mitchell Ellington Sports Complex. Merritt Island High School, Edgewood Jr./Sr. High and Thomas Jefferson Middle School as well as six 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 2000 was 12,112. 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 Executive Order 12898 and NASA's Environmental Justice Strategy are met. Moreover, KSC will continue to communicate with and

Table 13-2. 2000 Population Census Data of KSC Surrounding Communities.

	2000 Population Census Data					
Place Name	**Total**	**Caucasian**	**African American**	**Native American**	**Asian Pacific Islanders**	**Hispanic**
United States of America	281,421,906	211,460.626	34,658,190	1,959,234	10,641,833	35,305,818
State of Florida	15,982,378	12,465,029	2,335,505	53,541	274,881	2,682,715
Brevard County	476,230	413,411	40,000	1,765	7,457	21,970
Cape Canaveral City	8,829	8,359	126	28	155	307
Cocoa City	16,412	10,252	5,298	104	192	809
Cocoa Beach City	12,482	12,062	78	28	141	314
Merritt Island CDP	36,090	32,560	1,918	149	618	1,381
Mims CDP	9,147	7,919	1,004	58	22	141
Oak Hill City	1,378	1,127	224	9	3	9
Port St. John CDP	12,112	10,985	607	57	132	397
Rockledge City	20,170	16,349	2,952	56	352	662
Titusville City	40,670	34,080	5,142	160	399	1,430
Source: U.S. Census Bureau, American FactFinder, Quick Tables, DP-1, Profile of General Demographic Characteristics: 2000; Data Set: Census 2000 Summary File 1 (SF 1) 100-Percent Data.						

seek the input of local communities 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.

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 participating in:

- Interdisciplinary National Science Project Incorporating Research and Education Experience (INSPIRE) – This program is designed to provide grade-appropriate NASA-related resources and experiences to encourage and reinforce student's aspirations to pursue science, technology, engineering and mathematics.
- KSC Intern Program (KIP) – 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.
- Undergraduate Student Research Program (USRP) – This program offers undergraduates in science, math, and engineering, mentored internship experiences at KSC.
- Exploration Systems Mission Directorate Student Project (ESMD) - This is a higher education student program with the goal to train and develop the highly skilled scientific, engineering, and technical workforce of the future needed to implement the Vision for Space Exploration.
- 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.

SECTION XIV

ENERGY

14.1 REGULATORY OVERVIEW

The following list includes relevant Federal statutes, Executive Orders, NASA directives, and KSC requirements documents:

- 42 U.S.C. 8251, et seq., the National Energy Conservation Policy Act, as amended
- Executive Order (EO) 13423, dated January 26, 2007, Strengthening Federal Environmental, Energy and Transportation Management
- Instructions for Implementing EO 13423, Strengthening Federal Environmental, Energy and Transportation Management
- EO 13221, dated July 31, 2001, Energy Efficient Standby Power Devices
- 10 Code of Federal Regulations (CFR) Part 436, Federal Energy Management and Planning Programs
- NASA Policy Directive (NPD) 8500.1, NASA Environmental Management
- NPR 8570.1, Energy Efficiency and Water Conservation
- Kennedy NASA Policy Directive (KNPD) 8500.1, KSC Environmental Management
- Kennedy NASA Procedural Requirements (KNPR) 8500.1, KSC Environmental Requirements

These directives drive energy conservation and cost reduction requirements. 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 efficiency 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 costs. 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. Tables 14-2 and 14-3 summarize the electric and natural gas utility structures at KSC, respectively.

Table 14-1. FY 2008 Energy Summary.

Source	Consumption	MBtu	%	$M
Electricity	274,929 MWh	938,058	73.8	24.36
Natural Gas	331,010 Dth	331,010	26.0	4.08
#2 Fuel Oil	19,488 gal	2,707	0.2	0.06
	TOTAL	**1,271,775**		**28.50**

Includes about $2.1M 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	74%
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 KiloVolt 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 the CCAFS Industrial Area.
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	26%
Contracts	NASA contracts with 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.
Submetering	No KSC submetering 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. Tables above do not include about 140 MBtu and $1.4M of vehicles and other equipment energy.

14.3 INITIATIVES

The EWG updated the KSC Energy Management Five-Year Plan, and obtained Center Director approval in July 2004. Due to the frequent changes in the Energy Law and the issuance of a new Executive Order (EO), the plan will be undergoing a major revision in 2009. The goal of the EWG is to have the revision finalized by August 2009. The plan divides energy goals among the major programs at KSC, and contains sections where each program identifies how it will meet its share of the goals. KSC tracks progress towards energy efficiency goals using energy metrics for all Goal Subject facilities as defined by the Energy Law. 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 (see example photos). Project funding sources include NASA Construction of Facilities appropriations, 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.

Examples of KSC Renewable Energy Applications

Warning Signs & Alarms

Gate Operation

Lighting

Security Systems

SECTION XV

POLLUTION PREVENTION, GREEN PURCHASING, RECYCLING/WASTE DIVERSION AND ENVIRONMENTAL MANAGEMENT SYSTEM

15.1 REGULATORY OVERVIEW

Section 3002(b) of the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments of 1984, Section 6602(b) of the Pollution Prevention Act and Executive Order 13423: *Strengthening Federal Environmental, Energy, and Transportation Management* 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').

Executive Order 13423 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:

<u>Source Reduction</u>. 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. Several 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 not be prevented or recycled.

15.2.2 KSC POLLUTION PREVENTION 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. The program 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 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
- EPCRA Tier II Data Tracking and Reporting
- EPCRA Toxic Releases Inventory Tracking and Reporting, and
- RCRA 6002 Data Tracking and 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

The Emergency Planning and Community Right-To-Know Act (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
- 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 Toxic Release Inventory (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.

Appendix E provides a summary of KSC EPCRA Tier II and TRI reporting data for FY2008.

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), Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management,* 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. Environmental Protection Agency (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.

Executive Order 13423 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 Environmental Tracking System (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 KSC 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 35% 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 commodities through KSC's Property Disposal Office at KSC's onsite Reutilization, Recycling and Marketing Facility (RRMF),
- Sales contract for mixed paper and cardboard,
- Service contract for plastic, glass and aluminum containers,
- Diversion of wood, land clearing debris and non-hazardous blast media to the KSC onsite Class III C&D landfill for use as landfill cover, 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 the following purposes: 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.

Appendix E provides a summary of Green Purchasing items, waste diversion quantities, and recycling quantities and revenues for KSC for FY2008.

15.4 ENVIRONMENTAL MANAGEMENT SYSTEM

15.4.1 REGULATORY OVERVIEW

Executive Order 13423: *Strengthening Federal Environmental, Energy, and Transportation Management*, NPD 8500.1: *NASA Environmental Management* and NPR 8553.1: *NASA Environmental Management System (EMS)* direct NASA to implement an environmental management system (EMS) at all appropriate organizational levels.

15.4.2 KSC ENVIRONMENTAL MANAGEMENT SYSTEM (EMS)

In response to the requirements, KSC implemented its EMS, which:

- Incorporates organizational elements, procedures, and work practices in a formal structure to ensure that the important environmental impacts of KSC's operations and activities are identified and addressed,
- Promotes continual improvement including periodically evaluating environmental performance,
- Involves all members of the organizations and contracts as appropriate, and
- Involves Senior Management in support of the environmental management program.

KSC's EMS is documented in KSC-PLN-1912*: NASA-Kennedy Space Center Environmental Management System (EMS) Plan.*

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 [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

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. Females 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, due to its similar appearance to the 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 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 shrimp nets. 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 has been exploited commercially as food more than any other sea turtle. Current threats include mortality due to drowning in shrimp nets 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 of 40-60 years. Female tortoises do not reach sexual maturity until 10-20 years of age, and only 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.

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 tunnels 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. The indigo has also been heavily collected for the pet trade in the past, due partially to its handsome appearance and docile demeanor. The biggest threat to eastern indigo snake, however, is habitat loss and fragmentation, increasingly exposing this species to road mortality. The eastern indigo snake is protected as a threatened species by the federal government.

The Atlantic salt marsh snake (*Nerodia clarkii taeniata*) is a small (maximum 61 cm) water snake that is distinguished from other closely related water snakes by its striped face and neck, and dark belly with light spots. It is a unique snake in that it is one of the few North American reptiles that lives in brackish water but has not developed salt glands. It occurs in the northernmost part of KSC in the coastal marshes between the Atlantic Ocean and Mosquito Lagoon. The snake was federally listed for two reasons: 1) the loss and degradation of habitat along the east coast, and 2) the hybridization of Atlantic salt marsh snakes with freshwater species of water snakes. Hybridization is possible because man-made habitat alterations bring species of snakes together where they would not naturally occur, resulting in the loss of a pure Atlantic salt marsh snake gene pool. The Atlantic salt marsh snake is a federally listed threatened species.

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, allowing it to push its way through loose soil and into the burrows of rodents and reptiles, particularly the tunnel systems of pocket gophers and gopher tortoises (Ref. 5). The Florida pine snake is a constrictor, known to feed on ground-dwelling birds and their eggs, mice, and pocket gophers. They have a reputation for being good actors. 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 egret, 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 depreciated during the plume-hunting era. Although the species recovered quite rapidly once granted protection in 1910, the numbers have since begun to decline 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 heron, 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. It appears that the Florida population of this species has never recovered from the impact of plume-hunting almost a century ago. 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 ismostly 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 enormous 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 since the early 1900's due to human development and disturbance to wetland habitats. 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 in more recent times 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. Storks are birds of 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). 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 uniformly 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 peregrine falcon (*Falco peregrinus*) is a medium-sized falcon measuring 38-50 cm (16-20 in) in length with a wingspan of about 1 m (40 in). Adults are slate-gray on the back, with a dark cap on the head and a distinctive sideburn streak extending down through the eye. The breast is white with dark barring, and the feet are bright yellow. The wings are long and pointed. Peregrines feed almost entirely on other birds, which are caught in midair. Peregrines are one of the fastest birds, reaching speeds of 183 km/hr (114 mph). It is a widespread, migratory species that can be seen in Florida in the winter months. Historically, the peregrine falcon suffered a dramatic decline in population numbers due to reproductive failures caused by the use of pesticides that have since been banned in the United States. The peregrine falcon is protected in the state of Florida as an endangered species.

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 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 least tern (*Sterna antillarum*) is a very 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. Least terns will also use spoil islands and various rooftops 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 black skimmer (*Rynchops niger*) is a ternlike 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 mandible 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 and on rooftops 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 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 by the Florida Fish and Wildlife Conservation Commission. Occurrence of limpkin on KSC is not documented, but suitable habitat exists for the species and it occurs on nearby areas of the mainland to the west.

The snowy plover (*Charadrius alexandrinus*) is a small shorebird measuring about 16 cm (6.25 inches) in length. Snowy plovers are distinguished from other plovers by their small size, pale brown upper parts, dark patches on either side of the upper breast, and dark gray to blackish legs. Snowy plovers, which are designated as a species of special concern by the Florida Fish and Wildlife Conservation Commission, breed on the Gulf coast of Florida, but occur along the Atlantic coast during winter when they may rarely occur on the beaches of KSC.

The piping plover (*Charadrius melodus*) is a small shorebird measuring about 18 cm (7 inches) in length. During the breeding season, piping plovers are pale brown above and lighter below, with a black band across the forehead and a white rump. The bill is orange with a black tip, and the legs are orange. Males have a complete or incomplete black band that encircles the body at the breast. Females have a paler head band and an incomplete breast band. In winter, both sexes have a black bill and lack both the breast band and head band. Piping plovers, which are listed as Threatened by the Endangered Species Act, do not breed in Florida, but are uncommon winter visitors on the coasts of Florida and may occur rarely on KSC beaches.

The roseate tern (*Sterna dougallii*) is about 40 cm (15.6 inches) in length, with light-gray wings and back. The top of the head is black, and the first three or four primaries (flight feathers) are black. The rest of the body is white, with a rosy tinge on the chest and belly during the breeding season. The tail is deeply forked, and the outermost streamers extend beyond the folded wings when perched. During the breeding season the basal three-fourths of the otherwise entirely black bill and legs turn orange-red. In winter, it is difficult to tell the roseate tern from the very similar forester's and common terns. Roseate terns breed in the Florida keys, but migrate along the Atlantic coast of Florida when they occasionally occur on KSC near the coast. The roseate tern is listed as Threatened by the Endangered Species Act.

The Florida scrub-jay (*Aphelocoma coerulescens*) is the only species of bird unique to Florida and not worldwide for its cooperative breeding system (Ref. 7). Florida scrub-jays mate for life and live in family groups where young stay with their parents for years helping raise new offspring, defend territory boundaries, spot and mob predators. Florida scrub-jays are 25 to 30 centimeters (12 inches) 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, and 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 only in scrub and scrubby flatwoods of Florida; this unique habitat occurs 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 is sparse, 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 by the Endangered Species Act. Florida scrub-jays are threatened with extinction because of habitat destruction, fragmentation, and habitat degradation (Ref. 8). Scrub-jays use oak scrub and adjacent flatwoods in a specific state since the last fire and reduction in fire regimes imposes high risk to their populations (Ref. 9 and 10). Kennedy Space Center provides for three of the remaining core populations that remain, which are becoming increasingly important because of continued population declines across the range due to habitat fragmentation and reduced fire frequency (Ref. 11). The decline of the Florida scrub-jay has been caused by habitat destruction and degradation, especially due to fire suppression.

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 center. 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 weigh 25-49 grams. 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. Major threats to existing populations include habitat loss and fragmentation, invasion of exotic animals, 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. Newborn calves are 1.0-1.5 m (3.3-5 ft) in length and weigh about 20-30 kg. The maximum weight recorded for a Florida manatee is 1620 kg 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 United States occurs in the state of Florida, where they often congregate in the warm waters of Florida's 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 and the State of Florida.

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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.

- Table D-2. Plants Endemic or Nearly Endemic to Florida Occurring in the Kennedy Space Center Area Flora.

- 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.

- Table D-4. Bryophytes of the Kennedy Space Center Area.

Table D-1. Vascular Flora of the Kennedy Space Center Area Including Adjoining Federal Properties.

CLASS	FAMILY	GENUS	SPECIES	VARIETY	AUTHORITY
p	Aspleniaceae	Asplenium	platyneuron		(L.) BSP.
p	Azollaceae	Azolla	caroliniana		Willd.
p	Blechnaceae	Blechnum	serrulatum		L. C. Rich.
p	Blechnaceae	Woodwardia	areolata		(L.) Moore
p	Blechnaceae	Woodwardia	virginica		(L.) Smith
p	Dennstaedtiaceae	Pteridium	aquilinum (L.) Kuhn	var. pseudocaudatum	(Clute) Clute ex A. Heller
p	Dryopteridaceae	Dryopteris	ludoviciana		(Kunze) Small
p	Lycopodiaceae	Lycopodiella	alopecuroides		(L.) Cranfill
p	Lycopodiaceae	Lycopodiella	appressa		(Chapm.) Cranfill
p	Lycopodiaceae	Lycopodiella	caroliniana		(L.) Pic. Serm.
p	Nephrolepidaceae	Nephrolepis	biserrata		(Sw.) Schott
p	Nephrolepidaceae	Nephrolepis	cordifolia		(L.) Presl
p	Nephrolepidaceae	Nephrolepis	exaltata		(L.) Schott
p	Ophioglossaceae	Ophioglossum	palmatum		L.
p	Ophioglossaceae	Ophioglossum	petiolatum		Hook.
p	Osmundaceae	Osmunda	cinnamomea		L.
p	Osmundaceae	Osmunda	regalis L.	var. spectabilis	(Willd.) A. Gray
p	Polypodiaceae	Campyloneurum	phyllitidis		(L.) Presl
p	Polypodiaceae	Pecluma	plumula		(Humb. & Bonpl. ex Willd.) Price
p	Polypodiaceae	Phlebodium	aureum		(L.) J. Smith
p	Polypodiaceae	Pleopeltis	polypodioides (L.) Andrews & Windham	var. michauxianum	(Weatherby) Andrews & Windham
p	Psilotaceae	Psilotum	nudum		(L.) Beauv.
p	Pteridaceae	Acrostichum	danaeifolium		Langsd. & Fisch.
p	Pteridaceae	Ceratopteris	thalictroides		(L.) Brongn.
p	Salviniaceae	Salvinia	minima		Baker
p	Schizaeaceae	Lygodium	microphyllum		(Cav.) R. Br.
p	Selaginellaceae	Selaginella	arenicola		Underw.
p	Thelypteridaceae	Macrothelypteris	torresiana		(Gaudich.) Ching
p	Thelypteridaceae	Thelypteris	dentata		(Forssk.) E.P. St. John

p	Thelypteridaceae	Thelypteris	hispidula (Decne.) Reed	var. versicolor	(R. St. John) Lellinger
p	Thelypteridaceae	Thelypteris	interrupta		(Willd.) Iwatsuki
p	Thelypteridaceae	Thelypteris	kunthii		(Desv.) Morton
p	Thelypteridaceae	Thelypteris	ovata		R. P. St. John
p	Thelypteridaceae	Thelypteris	palustris Schott	var. pubescens	(G. Lawson) Fern.
p	Vittariaceae	Vittaria	lineata		(L.) J. Smith
g	Cupressaceae	Juniperus	virginiana L.	var. silicicola	(Small) E. Murray
g	Cupressaceae	Taxodium	ascendens		Brongn.
g	Pinaceae	Pinus	clausa		(Chapm. ex Engelm.) Vasey ex Sarg.
g	Pinaceae	Pinus	elliottii Engelm.	var. densa	Little and Dorman
g	Pinaceae	Pinus	palustris		Mill.
g	Pinaceae	Pinus	serotina		Michx.
g	Podocarpaceae	Podocarpus	macrophyllus		(Thunb.) D. Don
g	Podocarpaceae	Podocarpus	nagi		Makino
g	Zamiaceae	Cycas	revoluta		Thunb.
g	Zamiaceae	Zamia	pumila		L.
a	Acanthaceae	Asystasia	gangetica		(L.) T. Anders
a	Acanthaceae	Dicliptera	sexangularis		(L.) Juss.
a	Acanthaceae	Justicia	brandegeana		Wassh. & L.B. Smith
a	Acanthaceae	Odontonema	cuspidatum		(Nees) Kuntz
a	Acanthaceae	Ruellia	caroliniensis		(J. F. Gmel.) Steud.
a	Acanthaceae	Ruellia	tweediana		Griseb.
a	Acanthaceae	Thunbergia	alata		Bojer ex Sims
a	Acanthaceae	Thunbergia	fragrans		Roxb.
a	Adoxaceae	Sambucus	nigra L.	subsp. canadensis	(L.) R. Bolli
a	Adoxaceae	Viburnum	obovatum		Walt.
a	Agavaceae	Agave	decipiens		Baker
a	Agavaceae	Agave	sisalana		Perrine
a	Agavaceae	Yucca	aloifolia		L.
a	Agavaceae	Yucca	filamentosa		L.
a	Agdestidaceae	Agdestis	clematidea		Moc. & Sesse. ex DC.
a	Aizoaceae	Sesuvium	maritimum		(Walt.) BSP.

a	Aizoaceae	Sesuvium	portulacastrum		(L.) L.
a	Aizoaceae	Trianthema	portulacastrum		L.
a	Alismataceae	Sagittaria	filiformis		J.G. Smith
a	Alismataceae	Sagittaria	lancifolia		L.
a	Alismataceae	Sagittaria	subulata		(L.) Buch.
a	Alliaceae	Allium	cuthbertii		Small
a	Altingiaceae	Liquidambar	styraciflua		L.
a	Amaranthaceae	Alternanthera	flavescens		Kunth
a	Amaranthaceae	Alternanthera	philoxeroides		(Mart.) Griesb.
a	Amaranthaceae	Amaranthus	cannabinus		(L.) Sauer
a	Amaranthaceae	Amaranthus	hybridus		L.
a	Amaranthaceae	Amaranthus	spinosus		L.
a	Amaranthaceae	Atriplex	cristata		Humb. & Bonpl. ex Willd.
a	Amaranthaceae	Blutaparon	vermiculare		(L.) Mears
a	Amaranthaceae	Chenopodium	album		L.
a	Amaranthaceae	Chenopodium	ambrosioides		L.
a	Amaranthaceae	Chenopodium	berlandieri		Moq.
a	Amaranthaceae	Froelichia	floridana		(Nutt.) Moq.
a	Amaranthaceae	Gomphrena	serrata		L.
a	Amaranthaceae	Iresine	diffusa		Humb. & Bonpl. ex Willd.
a	Amaranthaceae	Salicornia	bigelovii		Torr.
a	Amaranthaceae	Salsola	kali		L.
a	Amaranthaceae	Sarcocornia	perennis		(Mill.) A.J. Scott
a	Amaranthaceae	Suaeda	linearis		(Ell.) Moq.
a	Amaranthacee	Amaranthus	australis		(A. Gray) J.D. Sauer
a	Amaryllidaceae	Crinum	americanum		L.
a	Amaryllidaceae	Crinum	zeylanicum		(L.) L.
a	Amaryllidaceae	Hymenocallis	crassifolia		Herb.
a	Amaryllidaceae	Hymenocallis	latifolia		(Mill.) Roem.
a	Amaryllidaceae	Hymenocallis	palmeri		S. Watson
a	Anacardiaceae	Mangifera	indica		L.
a	Anacardiaceae	Rhus	copallinum		L.

a	Anacardiaceae	Schinus	terebinthifolius		Raddi
a	Anacardiaceae	Toxicodendron	radicans		(L.) Kuntze
a	Annonaceae	Annona	glabra		L.
a	Annonaceae	Asimina	obovata		(Willd.) Nash
a	Annonaceae	Asimina	parviflora		(Michx.) Dunal
a	Annonaceae	Asimina	pygmaea		(Bartr.) Dunal
a	Annonaceae	Asimina	reticulata		Shuttlew. ex Chapm.
a	Apiaceae	Cicuta	maculata		L.
a	Apiaceae	Cyclospermum	leptophyllum		(Pers.) Sprague ex Britton & Wilson
a	Apiaceae	Eryngium	aromaticum		Baldwin
a	Apiaceae	Eryngium	baldwinii		Spreng.
a	Apiaceae	Eryngium	yuccifolium		Michx.
a	Apiaceae	Oxypolis	filiformis		(Walt.) Britt.
a	Apiaceae	Ptilimnium	capillaceum		(Michx.) Raf.
a	Apiaceae	Sanicula	canadensis		L.
a	Apiaceae	Spermolepis	divaricata		(Walt.) Raf.
a	Apiaceae	Spermolepis	echinata		(Nutt. ex DC.) A. Heller
a	Apocynaceae	Allamanda	cathartica		L.
a	Apocynaceae	Apocynum	cannabinum		L.
a	Apocynaceae	Asclepias	curtissii		A. Gray
a	Apocynaceae	Asclepias	incarnata		L.
a	Apocynaceae	Asclepias	lanceolata		Walt.
a	Apocynaceae	Asclepias	pedicellata		Walt.
a	Apocynaceae	Asclepias	tomentosa		Ell.
a	Apocynaceae	Asclepias	tuberosa		L.
a	Apocynaceae	Carissa	macrocarpa		(Eckl.) A. DC.
a	Apocynaceae	Catharanthus	roseus		(L.) G. Don
a	Apocynaceae	Cynanchum	angustifolium		Pers.
a	Apocynaceae	Cynanchum	scoparium		Nutt.
a	Apocynaceae	Echites	umbellata		Jacq.
a	Apocynaceae	Matelea	gonocarpos		(Walt.) Shinners
a	Apocynaceae	Morrenia	odorata		(Hook. & Arn.) Lindl.

a	Apocynaceae	Nerium	oleander		L.
a	Apocynaceae	Tabernaemontana	divaricata		(L.) R. Br.
a	Apocynaceae	Thevetia	peruviana		(Pers.) Schum.
a	Apocynaceae	Vinca	minor		L.
a	Aquifoliaceae	Ilex	ambigua		(Michx.) Torr.
a	Aquifoliaceae	Ilex	cassine		L.
a	Aquifoliaceae	Ilex	glabra		(L.) A. Gray
a	Aquifoliaceae	Ilex	vomitoria		Aiton
a	Araceae	Arisaema	dracontium		(L.) Schott
a	Araceae	Arisaema	triphyllum		(L.) Schott
a	Araceae	Colocasia	esculenta		(L.) Schott
a	Araceae	Landoltia	punctata		(G. Mey.) Les & D.J. Crawford
a	Araceae	Lemna	aequinoctialis		Welw.
a	Araceae	Lemna	obscura		(Austing) Daubs
a	Araceae	Peltandra	virginica		(L.) Schott & Endl.
a	Araceae	Pistia	stratiotes		L.
a	Araceae	Spirodela	polyrhiza		(L.) Schleiden
a	Araceae	Syngonium	podophyllum		Schott
a	Araceae	Wolffiella	gladiata		(Hegelm.) Hegelm.
a	Araliaceae	Centella	asiatica		(L.) Urban
a	Araliaceae	Hydrocotyle	bonariensis		Comm. ex Lam.
a	Araliaceae	Hydrocotyle	umbellata		L.
a	Araliaceae	Hydrocotyle	verticillata		Thunb.
a	Araliaceae	Tetrapanax	papyriferus		(Hook.) K. Koch
a	Arecaceae	Arecastrum	romanzoffianum		Becc.
a	Arecaceae	Cocos	nucifera		L.
a	Arecaceae	Phoenix	canariensis		Chabaud
a	Arecaceae	Phoenix	dactylifera		L.
a	Arecaceae	Phoenix	reclinata		Jacq.
a	Arecaceae	Phoenix	sylvestris		Roxb.
a	Arecaceae	Sabal	palmetto		(Walt.) Lodd. ex Schultes & Schultes f.
a	Arecaceae	Serenoa	repens		(Bartr.) Small

a	Arecaceae	Washingtonia	robusta		Wendl.
a	Aristolochiaceae	Aristolochia	littoralis		Parodi
a	Asparagaceae	Asparagus	aethiopicus		L.
a	Asparagaceae	Asparagus	setaceus		(Kunth) Jessop
a	Asteraceae	Acmella	oppositifolia (Lam.) R.K. Jansen	var. repens	(Walt.) R. K. Jansen
a	Asteraceae	Ageratina	jucunda		(Greene) Clewell & Wooten
a	Asteraceae	Ambrosia	artemisiifolia		L.
a	Asteraceae	Ambrosia	hispida		Pursh
a	Asteraceae	Arnoglossum	floridanum		(A. Gray) H. Rob.
a	Asteraceae	Arnoglossum	ovatum		(Walt.) H. Rob.
a	Asteraceae	Baccharis	angustifolia		Michx.
a	Asteraceae	Baccharis	glomeruliflora		Pers.
a	Asteraceae	Baccharis	halimifolia		L.
a	Asteraceae	Balduina	angustifolia		(Pursh) B.L. Rob.
a	Asteraceae	Berlandiera	subacaulis		(Nutt.) Nutt.
a	Asteraceae	Bidens	alba (L.) DC.	var. radiata	(Sch.Bip.) R.E. Ballard ex Melchert
a	Asteraceae	Bidens	bipinnata		L.
a	Asteraceae	Borrichia	frutescens		(L.) DC.
a	Asteraceae	Brickellia	eupatorioides		(L.) Shinners
a	Asteraceae	Calyptocarpus	vialis		Lees.
a	Asteraceae	Carphephorus	corymbosus		(Nutt.) T. & G.
a	Asteraceae	Carphephorus	odoratissimus	var. odoratissimus	(J.F. Gmel.) H. Hebert
a	Asteraceae	Carphephorus	odoratissimus (J.F. Gmel.) H. Hebert	var. subtropicanus	(Delaney et al.) Wunderlin & B.F. Hansen
a	Asteraceae	Carphephorus	paniculatus		(J. F. Gmel.) H. Hebert
a	Asteraceae	Chrysopsis	gossypina		(Michx.) Ell.
a	Asteraceae	Chrysopsis	linearifolia Semple	var. dressii	Semple
a	Asteraceae	Chrysopsis	mariana		(L.) Ell.
a	Asteraceae	Chrysopsis	scabrella		T. & G.
a	Asteraceae	Chrysopsis	subulata		Small
a	Asteraceae	Cirsium	horridulum		Michx.
a	Asteraceae	Cirsium	nuttallii		DC.

a	Asteraceae	Conoclinium	coelestinum		(L.) DC.
a	Asteraceae	Conyza	canadensis (L.) Cronq.	var. pusilla	(Nutt.) Cronq.
a	Asteraceae	Coreopsis	floridana		E.B. Sm.
a	Asteraceae	Coreopsis	gladiata		Walt.
a	Asteraceae	Coreopsis	leavenworthii		T. & G.
a	Asteraceae	Eclipta	prostrata		(L.) L.
a	Asteraceae	Elephantopus	elatus		Bertol.
a	Asteraceae	Emilia	fosbergii		Nicholson
a	Asteraceae	Erechtites	hieraciifolius		(L.) Raf. ex DC.
a	Asteraceae	Erigeron	quercifolius		Poir.
a	Asteraceae	Erigeron	strigosus		Muhl. ex Willd.
a	Asteraceae	Erigeron	vernus		(L.) T. & G.
a	Asteraceae	Eupatorium	capillifolium		(Lam.) Small ex Porter & Britton
a	Asteraceae	Eupatorium	compositifolium		Walt.
a	Asteraceae	Eupatorium	leptophyllum		DC.
a	Asteraceae	Eupatorium	leucolepis		(DC.) Torr. & A. Gray
a	Asteraceae	Eupatorium	mikanioides		Chapm.
a	Asteraceae	Eupatorium	mohrii		Greene
a	Asteraceae	Eupatorium	rotundifolium		L.
a	Asteraceae	Eupatorium	serotinum		Michx.
a	Asteraceae	Euthamia	caroliniana		(L.) Green ex Porter & Britton
a	Asteraceae	Euthamia	graminifolia (L.) Nutt.	var. hirtipes	(Fern.) C. E.S. Taylor & R. J. Taylor
a	Asteraceae	Flaveria	linearis		Lag.
a	Asteraceae	Gaillardia	pulchella		Foug.
a	Asteraceae	Gamochaeta	falcata		(Lam.) Cabrera
a	Asteraceae	Gamochaeta	purpurea		(L.) Cabrera
a	Asteraceae	Helenium	amarum		(Raf.) H. Rock
a	Asteraceae	Helianthus	angustifolius		L.
a	Asteraceae	Helianthus	annuus		L.
a	Asteraceae	Helianthus	debilis		Nutt.
a	Asteraceae	Helianthus	floridanus		A. Gray ex Chapm.
a	Asteraceae	Heterotheca	subaxillaris		(Lam.) Brit. & Rusby

a	Asteraceae	Hieracium	gronovii		L.
a	Asteraceae	Hieracium	megacephalon		Nash
a	Asteraceae	Iva	frutescens		L.
a	Asteraceae	Iva	imbricata		Walt.
a	Asteraceae	Iva	microcephala		Nutt.
a	Asteraceae	Krigia	virginica		(L.) Willd.
a	Asteraceae	Lactuca	canadensis		L.
a	Asteraceae	Lactuca	floridana		(L.) Gaertn.
a	Asteraceae	Lactuca	graminifolia		Michx.
a	Asteraceae	Liatris	chapmanii		T. & G.
a	Asteraceae	Liatris	elegans		(Watt.) Michx.
a	Asteraceae	Liatris	gracilis		Pursh
a	Asteraceae	Liatris	graminifolia		(Walt.) Willd.
a	Asteraceae	Liatris	pauciflora		Pursh
a	Asteraceae	Liatris	tenuifolia		Nutt.
a	Asteraceae	Liatris	tenuifolia Nutt.	var. quadrifolia	Chapm.
a	Asteraceae	Lygodesmia	aphylla		(Nutt.) DC.
a	Asteraceae	Melanthera	nivea		(L.) Small
a	Asteraceae	Mikania	cordifolia		(L.f.) Willd.
a	Asteraceae	Mikania	scandens		(L.) Willd.
a	Asteraceae	Oclemena	reticulata		(Pursh) G.L. Nesom
a	Asteraceae	Packera	glabella		(Poir.) C. Jeffrey
a	Asteraceae	Palafoxia	feayi		A. Gray
a	Asteraceae	Palafoxia	integrifolia		(Nutt.) T. & G.
a	Asteraceae	Phoebanthus	grandiflorus		(T. & G.) Blake
a	Asteraceae	Pityopsis	graminifolia		(Michx.) Nutt.
a	Asteraceae	Pluchea	camphorata		(L.) DC.
a	Asteraceae	Pluchea	foetida		(L.) DC.
a	Asteraceae	Pluchea	longifolia		Nash
a	Asteraceae	Pluchea	odorata		(L.) Cass.
a	Asteraceae	Pluchea	rosea		R.K. Godfrey
a	Asteraceae	Pseudognaphalium	obtusifolium		(L.) Hilliard & B.L. Burtt

a	Asteraceae	Pseudogynoxys	chenopodioides		(Kunth) Cabrera
a	Asteraceae	Pterocaulon	pycnostachyum		(Michx.) Ell.
a	Asteraceae	Pyrrhopappus	carolinianus		(Walt.) DC.
a	Asteraceae	Rudbeckia	hirta		L.
a	Asteraceae	Sericocarpus	tortifolius		(Michx.) Nees
a	Asteraceae	Smallanthus	uvedalia		(L.) Mack. ex Small
a	Asteraceae	Solidago	arguta Ait.	var. caroliniana	A. Gray
a	Asteraceae	Solidago	fistulosa		Mill.
a	Asteraceae	Solidago	leavenworthii		T. & G.
a	Asteraceae	Solidago	odora Ait.	var. chapmanii	(A. Gray) Cronq.
a	Asteraceae	Solidago	sempervirens		L.
a	Asteraceae	Solidago	stricta		Aiton
a	Asteraceae	Solidago	tortifolia		Ell.
a	Asteraceae	Sonchus	asper		(L.) Hill
a	Asteraceae	Sonchus	oleraceus		L.
a	Asteraceae	Sphagneticola	trilobata		(L.) Pruski
a	Asteraceae	Symphyotrichum	carolinianum		(Walt.) Wunderlin & B.F. Hansen
a	Asteraceae	Symphyotrichum	dumosum		(L.) G.L. Nesom
a	Asteraceae	Symphyotrichum	elliottii		(T. & G.) G.L. Nesom
a	Asteraceae	Symphyotrichum	simmondsii		(Small) G.L. Nesom
a	Asteraceae	Symphyotrichum	subulatum		(Michx.) G.L. Nesom
a	Asteraceae	Symphyotrichum	tenuifolium		(L.) G.L. Nesom
a	Asteraceae	Tridax	procumbens		L.
a	Asteraceae	Verbesina	virginica		L.
a	Asteraceae	Vernonia	angustifolia		Michx.
a	Asteraceae	Vernonia	gigantea		(Walt.) Trel. ex Branner & Coville
a	Asteraceae	Xanthium	strumarium L.	var. glabratum	(DC.) Cronq.
a	Asteraceae	Youngia	japonica		(L.) DC.
a	Avicenniaceae	Avicennia	germinans		(L.) L.
a	Bataceae	Batis	maritima		L.
a	Betulaceae	Carpinus	caroliniana		Walt.
a	Bignoniaceae	Bignonia	capreolata		L.

a	Bignoniaceae	Campsis	radicans		(L.) Seem.
a	Bignoniaceae	Jacaranda	mimosifolia		D. Don
a	Bignoniaceae	Kigelia	pinnata		DC.
a	Bignoniaceae	Podranea	ricasoliana		(Tanfani) Sprague
a	Bignoniaceae	Pyrostegia	venusta		(Ker-Gawl.) Miers.
a	Bignoniaceae	Spathodea	campanulata		P. Beauv.
a	Bignoniaceae	Tecoma	capensis		(Thunb.) Lindl.
a	Bignoniaceae	Tecoma	stans		(L.) Juss. ex Kunth
a	Boraginaceae	Argusia	gnaphalodes		(L.) Heine
a	Boraginaceae	Heliotropium	angiospermum		Murr.
a	Boraginaceae	Heliotropium	curassavicum		L.
a	Boraginaceae	Heliotropium	polyphyllum		Lehm.
a	Boraginaceae	Tournefortia	volubilis		L.
a	Brassicaceae	Cakile	lanceolata		(Willd.) Schulz
a	Brassicaceae	Capparis	cynophallophora		L.
a	Brassicaceae	Capparis	flexuosa		(L.) L.
a	Brassicaceae	Descurainia	pinnata		(Walt.) Britt.
a	Brassicaceae	Lepidium	virginicum		L.
a	Brassicaceae	Polanisia	tenuifolia		T. & G.
a	Brassicaceae	Raphanus	raphanistrum		L.
a	Brassicaceae	Rorippa	floridana		Al-Shehbaz & Rollins
a	Bromeliaceae	Tillandsia	fasciculata Sw.	var. densispica	Mez
a	Bromeliaceae	Tillandsia	recurvata		(L.) L.
a	Bromeliaceae	Tillandsia	simulata		Small
a	Bromeliaceae	Tillandsia	usneoides		(L.) L.
a	Bromeliaceae	Tillandsia	utriculata		L.
a	Buddlejaceae	Buddleja	madagascariensis		Lam.
a	Burseraceae	Bursera	simaruba		(L.) Sarg.
a	Cabombaceae	Brasenia	schreberi		J.F. Gmel.
a	Cactaceae	Harrisia	simpsonii		Small ex Britton & Rose
a	Cactaceae	Hylocereus	undatus		(Haw.) Britton & Rose
a	Cactaceae	Opuntia	cochenillifera		(L.) Mill.

a	Cactaceae	Opuntia	humifusa		(Raf.) Raf.
a	Cactaceae	Opuntia	stricta		(Haw.) Haw.
a	Cactaceae	Pereskia	aculeata		Mill.
a	Cactaceae	Selenicereus	pteranthus		(Link & Otto) Britton & Rose
a	Campanulaceae	Campanula	floridana		S. Watson ex A. Gray
a	Campanulaceae	Lobelia	feayana		A. Gray
a	Campanulaceae	Lobelia	glandulosa		Walt.
a	Campanulaceae	Lobelia	paludosa		Nutt.
a	Campanulaceae	Lobelia	puberula		Michx.
a	Cannaceae	Canna	flaccida		Salisb.
a	Cannaceae	Canna	x generalis		Bailey
a	Caprifoliaceae	Lonicera	japonica		Thunb.
a	Caricaceae	Carica	papaya		L.
a	Caryophyllaceae	Arenaria	lanuginosa		(Michx.) Rohrb.
a	Caryophyllaceae	Drymaria	cordata		(L.) Willd. ex Schult.
a	Caryophyllaceae	Paronychia	americana		(Nutt.) Fenzl ex Walp.
a	Caryophyllaceae	Stellaria	media		(L.) Vill.
a	Caryophyllaceae	Stipulicida	setacea		Michx.
a	Casuarinaceae	Casuarina	cunninghamiana		Miq.
a	Casuarinaceae	Casuarina	equisetifolia		L.
a	Casuarinaceae	Casuarina	glauca		Sieb. ex Spreng.
a	Celtidaceae	Celtis	laevigata		Willd.
a	Ceratophyllaceae	Ceratophyllum	demersum		L.
a	Ceratophyllaceae	Ceratophyllum	muricatum		Cham.
a	Chrysobalanaceae	Chrysobalanus	icaco		L.
a	Chrysobalanaceae	Licania	michauxii		Prance
a	Cistaceae	Helianthemum	corymbosum		Michx.
a	Cistaceae	Helianthemum	nashii		Britt.
a	Cistaceae	Lechea	cernua		Small
a	Cistaceae	Lechea	deckertii		Small
a	Cistaceae	Lechea	divaricata		Shuttlew. ex Britton
a	Cistaceae	Lechea	minor		L.

a	Cistaceae	Lechea	mucronata		Raf.
a	Cistaceae	Lechea	sessiliflora		Raf.
a	Cistaceae	Lechea	torreyi		Legg. ex Britt.
a	Clusiaceae	Hypericum	brachyphyllum		(Spach) Steud.
a	Clusiaceae	Hypericum	cistifolium		Lam.
a	Clusiaceae	Hypericum	crux-andraea		(L.) Crantz
a	Clusiaceae	Hypericum	galioides		Lam.
a	Clusiaceae	Hypericum	gentianoides		(L.) BSP.
a	Clusiaceae	Hypericum	hypericoides		(L.) Crantz
a	Clusiaceae	Hypericum	mutilum		L.
a	Clusiaceae	Hypericum	reductum		(Svenson) W.P. Adams
a	Clusiaceae	Hypericum	tetrapetalum		Lam.
a	Combretaceae	Conocarpus	erectus		L.
a	Combretaceae	Laguncularia	racemosa		(L.) G.F. Gaertn.
a	Combretaceae	Quisqualis	indica		L.
a	Commelinaceae	Callisia	ornata		(Small) G.C. Tucker
a	Commelinaceae	Commelina	communis		L.
a	Commelinaceae	Commelina	diffusa		Burm.f.
a	Commelinaceae	Commelina	erecta		L.
a	Commelinaceae	Commelina	erecta		L.
a	Commelinaceae	Murdannia	nudiflora		(L.) Brenan
a	Commelinaceae	Tradescantia	ohiensis		Raf.
a	Commelinaceae	Tradescantia	zebrina		Bosse
a	Convolvulaceae	Calystegia	sepium (L.) R. Br.	subsp. limnophila	(Greene) Brummitt
a	Convolvulaceae	Cuscuta	compacta		Juss. ex Choisy
a	Convolvulaceae	Cuscuta	exaltata		Engelm.
a	Convolvulaceae	Cuscuta	indecora		Choisy
a	Convolvulaceae	Dichondra	carolinensis		Michx.
a	Convolvulaceae	Ipomoea	alba		L.
a	Convolvulaceae	Ipomoea	cairica		(L.) Sweet
a	Convolvulaceae	Ipomoea	cordatotriloba		Dennst.
a	Convolvulaceae	Ipomoea	hederacea		Jacq.

a	Convolvulaceae	Ipomoea	hederifolia		L.
a	Convolvulaceae	Ipomoea	imperati		(Vahl) Griseb.
a	Convolvulaceae	Ipomoea	indica (Burm.) Merr.	var. acuminata	(Vahl.) Fosberg
a	Convolvulaceae	Ipomoea	pandurata		(L.) G.F.W. Mey.
a	Convolvulaceae	Ipomoea	pes-caprae (L.) R. Br.	subsp. brasiliensis	(L.) Van Ooststr.
a	Convolvulaceae	Ipomoea	purpurea		(L.) Roth
a	Convolvulaceae	Ipomoea	sagittata		Poir.
a	Convolvulaceae	Ipomoea	violacea		L.
a	Convolvulaceae	Merremia	dissecta		(Jacq.) Hallier. f.
a	Cornaceae	Cornus	foemina		Mill.
a	Crassulaceae	Kalanchoe	daigremontiana		Raym.-Hamet & H. Perrier
a	Crassulaceae	Kalanchoe	delagoensis		Eckl. & Zeyh.
a	Crassulaceae	Kalanchoe	fedtschenkoi		Raym.-Hamet & H. Perrier
a	Crassulaceae	Kalanchoe	pinnata		(Lam.) Pers.
a	Cucurbitaceae	Citrullus	lanatus		(Thunb.) Mats. & Nakai.
a	Cucurbitaceae	Melothria	pendula		L.
a	Cucurbitaceae	Momordica	charantia		L.
a	Cymodoceaceae	Halodule	wrightii		Aschers
a	Cymodoceaceae	Syringodium	filiforme		Kuetz.
a	Cyperaceae	Bulbostylis	barbata		(Rottb.) Clarke
a	Cyperaceae	Bulbostylis	ciliatifolia		(Ell.) Fern.
a	Cyperaceae	Bulbostylis	stenophylla		(Ell.) Clarke
a	Cyperaceae	Bulbostylis	warei		(Torr.) C.B. Clarke
a	Cyperaceae	Carex	alata		Torr.
a	Cyperaceae	Carex	digitalis		Willd.
a	Cyperaceae	Carex	fissa Mack	var. aristata	F.J. Herm.
a	Cyperaceae	Carex	gigantea		Rudge
a	Cyperaceae	Carex	lupulina		Muhl. ex Willd.
a	Cyperaceae	Cladium	jamaicense		Crantz
a	Cyperaceae	Cyperus	articulatus		L.
a	Cyperaceae	Cyperus	compressus		L.
a	Cyperaceae	Cyperus	croceus		Vahl

a	Cyperaceae	Cyperus	distinctus		Steud.
a	Cyperaceae	Cyperus	echinatus		(L.) A. W. Wood
a	Cyperaceae	Cyperus	erythrorhizos		Muhl.
a	Cyperaceae	Cyperus	esculentus		L.
a	Cyperaceae	Cyperus	filiculmis		Vahl
a	Cyperaceae	Cyperus	flavescens		L.
a	Cyperaceae	Cyperus	haspan		L.
a	Cyperaceae	Cyperus	ligularis		L.
a	Cyperaceae	Cyperus	odoratus		L.
a	Cyperaceae	Cyperus	pedunculatus		(R. Br.) J. Kern
a	Cyperaceae	Cyperus	planifolius		L.C. Rich.
a	Cyperaceae	Cyperus	polystachyos		Rottb.
a	Cyperaceae	Cyperus	retrorsus		Chapm.
a	Cyperaceae	Cyperus	strigosus		L.
a	Cyperaceae	Cyperus	surinamensis		Rottb.
a	Cyperaceae	Cyperus	tetragonus		Ell.
a	Cyperaceae	Eleocharis	albida		Torr.
a	Cyperaceae	Eleocharis	atropurpurea		(Retz.) J. Presl & C. Presl
a	Cyperaceae	Eleocharis	baldwinii		(Torr.) Chapm.
a	Cyperaceae	Eleocharis	cellulosa		Torr.
a	Cyperaceae	Eleocharis	geniculata		(L.) Roem. & Schult.
a	Cyperaceae	Eleocharis	montevidensis		Kunth
a	Cyperaceae	Eleocharis	parvula		(Roem. & Schult.) Link ex Bluff et al.
a	Cyperaceae	Fimbristylis	caroliniana		(Lam.) Fern.
a	Cyperaceae	Fimbristylis	cymosa		R. Br.
a	Cyperaceae	Fimbristylis	dichotoma		(L.) Vahl
a	Cyperaceae	Fimbristylis	puberula		(Michx.) Vahl
a	Cyperaceae	Fimbristylis	spadicea		(L.) Vahl
a	Cyperaceae	Fuirena	pumila		(Torr.) Spreng.
a	Cyperaceae	Fuirena	scirpoidea		Michx.
a	Cyperaceae	Fuirena	squarrosa		Michx.
a	Cyperaceae	Kyllinga	brevifolia		Rottb.

a	Cyperaceae	Lipocarpha	micrantha		(Vahl) G.C. Tucker
a	Cyperaceae	Rhynchospora	caduca		Ell.
a	Cyperaceae	Rhynchospora	ciliaris		(Michx.) Mohr
a	Cyperaceae	Rhynchospora	colorata		(L.) Pfeiffer
a	Cyperaceae	Rhynchospora	debilis		Gale
a	Cyperaceae	Rhynchospora	divergens		Chapm. ex M.A. Curtis
a	Cyperaceae	Rhynchospora	fascicularis		(Michx.) Vahl
a	Cyperaceae	Rhynchospora	fernaldii		Gale
a	Cyperaceae	Rhynchospora	filifolia		A. Gray
a	Cyperaceae	Rhynchospora	globularis		(Chapm.) Small
a	Cyperaceae	Rhynchospora	intermedia		(Chapm.) Britt.
a	Cyperaceae	Rhynchospora	inundata		(Oakes) Fern.
a	Cyperaceae	Rhynchospora	latifolia		(Baldw.) Thomas
a	Cyperaceae	Rhynchospora	megalocarpa		A. Gray
a	Cyperaceae	Rhynchospora	microcarpa		Baldw. ex A. Gray
a	Cyperaceae	Rhynchospora	miliacea		(Lam.) A. Gray
a	Cyperaceae	Rhynchospora	odorata		Wright ex Griseb.
a	Cyperaceae	Rhynchospora	plumosa		Ell.
a	Cyperaceae	Rhynchospora	pusilla		Chapm. ex M.A. Curtis
a	Cyperaceae	Rhynchospora	sulcata		Gale
a	Cyperaceae	Rhynchospora	tracyi		Britton
a	Cyperaceae	Rhynchospora	wrightiana		Boeckl.
a	Cyperaceae	Scirpus	americanus		Pers.
a	Cyperaceae	Scirpus	robustus		Pursh
a	Cyperaceae	Scirpus	tabernaemontani		C.C. Gmel.
a	Cyperaceae	Scleria	ciliata	var. ciliata	Michx.
a	Cyperaceae	Scleria	ciliata Michx.	var. pauciflora	(Muhl. ex Willd.) Kuk.
a	Cyperaceae	Scleria	oligantha		Michx.
a	Cyperaceae	Scleria	reticularis		Michx.
a	Cyperaceae	Scleria	triglomerata		Michx.
a	Cyperaceae	Scleria	verticillata		Muhl. ex Willd.
a	Cyperaceae	Websteria	confervoides		(Poir.) S.S. Hooper

a	Cyrillaceae	Cyrilla	racemiflora		L.
a	Dioscoreaceae	Dioscorea	bulbifera		L.
a	Droseraceae	Drosera	brevifolia		Pursh
a	Droseraceae	Drosera	capillaris		Poir.
a	Ebenaceae	Diospyros	kaki		L. f.
a	Ebenaceae	Diospyros	virginiana		L.
a	Ericaceae	Bejaria	racemosa		Vent.
a	Ericaceae	Ceratiola	ericoides		Michx.
a	Ericaceae	Gaylussacia	dumosa		(J. Kenn.) T. & G.
a	Ericaceae	Gaylussacia	frondosa (L.) T. & G.	var. tomentosa	A. Gray
a	Ericaceae	Lyonia	ferruginea		(Walt.) Nutt.
a	Ericaceae	Lyonia	fruticosa		(Michx.) Torr.
a	Ericaceae	Lyonia	lucida		(Lam.) K. Koch
a	Ericaceae	Monotropa	uniflora		L.
a	Ericaceae	Vaccinium	arboreum		Marsh.
a	Ericaceae	Vaccinium	corymbosum		L.
a	Ericaceae	Vaccinium	darrowii		Camp.
a	Ericaceae	Vaccinium	myrsinites		Lam.
a	Ericaceae	Vaccinium	stamineum		L.
a	Eriocaulaceae	Eriocaulon	compressum		Lam.
a	Eriocaulaceae	Lachnocaulon	anceps		(Walt.) Morong
a	Eriocaulaceae	Lachnocaulon	beyrichianum		Sporl. ex Korn.
a	Eriocaulaceae	Lachnocaulon	minus		(Chapm.) Small
a	Eriocaulaceae	Syngonanthus	flavidulus		(Michx.) Ruhl.
a	Euphorbiaceae	Acalypha	gracilens		A. Gray
a	Euphorbiaceae	Acalypha	ostryifolia		Riddell
a	Euphorbiaceae	Chamaesyce	blodgettii		(Engelm. ex Hitchc.) Small
a	Euphorbiaceae	Chamaesyce	bombensis		(Jacq.) Dugand
a	Euphorbiaceae	Chamaesyce	cumulicola		Small
a	Euphorbiaceae	Chamaesyce	hirta		(L.) Millsp.
a	Euphorbiaceae	Chamaesyce	hypericifolia		(L.) Millsp.
a	Euphorbiaceae	Chamaesyce	hyssopifolia		(L.) Small

a	Euphorbiaceae	Chamaesyce	maculata		(L.) Small
a	Euphorbiaceae	Chamaesyce	mesembrianthemifolia		(Jacq.) Dugand
a	Euphorbiaceae	Chamaesyce	ophthalmica		(Pers.) Burch
a	Euphorbiaceae	Chamaesyce	thymifolia		(L.) Millsp.
a	Euphorbiaceae	Cnidoscolus	stimulosus		(Michx.) Englm. & A. Gray
a	Euphorbiaceae	Croton	glandulosus		L.
a	Euphorbiaceae	Croton	punctatus		Jacq.
a	Euphorbiaceae	Drypetes	lateriflora		(Sw.) Krug & Urban
a	Euphorbiaceae	Euphorbia	trichotoma		Kunth
a	Euphorbiaceae	Jatropha	curcas		L.
a	Euphorbiaceae	Pedilanthus	tithymaloides (L.) Poit.	ssp. smallii	(Millsp.) Dressler
a	Euphorbiaceae	Phyllanthus	abnormis		Baill.
a	Euphorbiaceae	Phyllanthus	tenellus		Roxb.
a	Euphorbiaceae	Poinsettia	cyathophora		(Murray) Bartl.
a	Euphorbiaceae	Poinsettia	heterophylla		(L.) Klotzsch & Garke ex Klotzsch
a	Euphorbiaceae	Ricinus	communis		L.
a	Euphorbiaceae	Sapium	sebiferum		(L.) Roxb.
a	Euphorbiaceae	Stillingia	aquatica		Chapm.
a	Euphorbiaceae	Stillingia	sylvatica		L.
a	Euphorbiaceae	Tragia	urens		L.
a	Fabaceae	Abrus	precatorius		L.
a	Fabaceae	Acacia	farnesiana		(L.) Willd.
a	Fabaceae	Aeschynomene	americana		L.
a	Fabaceae	Albizia	julibrissin		Durazz.
a	Fabaceae	Albizia	lebbeck		(L.) Benth.
a	Fabaceae	Alysicarpus	ovalifolius		(Shum. & Thonn.) J. Leonard
a	Fabaceae	Amorpha	fruticosa		L.
a	Fabaceae	Apios	americana		Medik.
a	Fabaceae	Baptisia	lecontii		T. & G.
a	Fabaceae	Bauhinia	variegata		L.
a	Fabaceae	Caesalpinia	bonduc		(L.) Roxb.
a	Fabaceae	Canavalia	rosea		(Sw.) DC.

a	Fabaceae	Centrosema	virginianum		(L.) Benth.
a	Fabaceae	Chamaecrista	fasciculata		(Michx.) Greene
a	Fabaceae	Chamaecrista	nictitans (L.) Moench	var. aspera	(Muhl. ex Ell.) Irwin & Barneby
a	Fabaceae	Clitoria	mariana		L.
a	Fabaceae	Crotalaria	lanceolata		E. Mey.
a	Fabaceae	Crotalaria	pallida Aiton	var. obovata	(G. Don) Polhill
a	Fabaceae	Crotalaria	pumila		Ortega
a	Fabaceae	Crotalaria	retusa		L.
a	Fabaceae	Crotalaria	rotundifolia		J.F. Gmel.
a	Fabaceae	Crotalaria	spectabilis		Roth
a	Fabaceae	Crotolaria	purshii		DC.
a	Fabaceae	Dalbergia	ecastophyllum		(L.) Taub.
a	Fabaceae	Dalea	carnea		(Michx.) Poir.
a	Fabaceae	Dalea	feayi		(Chapm.) Barneby
a	Fabaceae	Dalea	pinnata (J.F. Gmel.) Barneby	var. adenopoda	(Rydb.) Barneby
a	Fabaceae	Desmodium	floridanum		Chapm.
a	Fabaceae	Desmodium	incanum		DC.
a	Fabaceae	Desmodium	paniculatum		(L.) DC.
a	Fabaceae	Desmodium	strictum		(Pursh) DC.
a	Fabaceae	Desmodium	tenuifolium		T. & G.
a	Fabaceae	Desmodium	tortuosum		(Sw.) DC.
a	Fabaceae	Desmodium	triflorum		(L.) DC.
a	Fabaceae	Enterolobium	contortisiliquum		(Vell.) Morong
a	Fabaceae	Erythrina	herbacea		L.
a	Fabaceae	Galactia	elliottii		Nutt.
a	Fabaceae	Galactia	volubilis		(L.) Britt.
a	Fabaceae	Indigofera	caroliniana		Mill.
a	Fabaceae	Indigofera	hirsuta		Harv.
a	Fabaceae	Indigofera	miniata Ortega	var. leptosepala	(Nutt. ex Torr. & A. Gray) B.L. Turner
a	Fabaceae	Indigofera	spicata		Forssk.
a	Fabaceae	Indigofera	suffruticosa		Mill.

a	Fabaceae	Kummerowia	striata		(Thunb.) Schindler
a	Fabaceae	Leucaena	leucocephala		(Lam.) de Wit
a	Fabaceae	Lupinus	diffusus		Nutt.
a	Fabaceae	Macroptilium	lathyroides		(L.) Urban
a	Fabaceae	Medicago	lupulina		L.
a	Fabaceae	Melilotus	albus		Medik.
a	Fabaceae	Melilotus	indicus		(L.) All.
a	Fabaceae	Mimosa	strigillosa		Torr. & A. Gray
a	Fabaceae	Parkinsonia	aculeata		L.
a	Fabaceae	Phaseolus	polystachios		(L.) BSP.
a	Fabaceae	Pueraria	montana (Lour.) Merr.	var. lobata	(Willd.) Maesen & S.M. Almeida
a	Fabaceae	Rhynchosia	cinerea		Nash
a	Fabaceae	Rhynchosia	difformis		(Ell.) DC.
a	Fabaceae	Rhynchosia	minima		(L.) DC.
a	Fabaceae	Senna	alata		(L.) Roxb.
a	Fabaceae	Senna	obtusifolia		(L.) H.S. Irwin & Barneby
a	Fabaceae	Senna	occidentalis		(L.) Link
a	Fabaceae	Senna	pendula (Humb. & Bonpl. ex Willd.) H.S. Irwin & Barneby	var. glabrata	(Vogel) H.S. Irwin & Barneby
a	Fabaceae	Sesbania	herbacea		(Mill.) McVaugh
a	Fabaceae	Sesbania	punicea		(Cav.) Benth.
a	Fabaceae	Sesbania	vesicaria		(Jacq.) Ell.
a	Fabaceae	Sophora	tomentosa L.	var. truncata	Torr. & A. Gray
a	Fabaceae	Strophostyles	umbellata		(Muhl. ex Willd.) Britt.
a	Fabaceae	Stylosanthes	hamata		(L.) Taub
a	Fabaceae	Tephrosia	angustissima Shuttlew. ex Chapm .	var. curtissii	(Small ex Rydb.) Isely
a	Fabaceae	Trifolium	repens		L.
a	Fabaceae	Vicia	acutifolia		Ell.
a	Fabaceae	Vicia	floridana		S. Watson
a	Fabaceae	Vigna	luteola		(Jacq.) Benth.
a	Fabaceae	Wisteria	sinensis		(Sims) Sweet

a	Fagaceae	Quercus	chapmanii		Sarg.
a	Fagaceae	Quercus	ellliottii		Wilbur
a	Fagaceae	Quercus	geminata		Small
a	Fagaceae	Quercus	incana		Bartr.
a	Fagaceae	Quercus	laevis		Walt.
a	Fagaceae	Quercus	laurifolia		Michx.
a	Fagaceae	Quercus	minima		(Sarg.) Small
a	Fagaceae	Quercus	myrtifolia		Willd.
a	Fagaceae	Quercus	nigra		L.
a	Fagaceae	Quercus	virginiana		Mill.
a	Gelsemiaceae	Gelsemium	sempervirens		(L.) J. St. Hil.
a	Gentianaceae	Bartonia	verna		(Michx.) Raf. ex Barton
a	Gentianaceae	Eustoma	exaltatum		(L.) Salisb. ex G. Don
a	Gentianaceae	Sabatia	brevifolia		Raf.
a	Gentianaceae	Sabatia	campanulata		(L.) Torr.
a	Gentianaceae	Sabatia	difformis		(L.) Druse
a	Gentianaceae	Sabatia	grandiflora		(A. Gray) Small
a	Gentianaceae	Sabatia	stellaris		Pursh
a	Geraniaceae	Geranium	carolinianum		L.
a	Geraniaceae	Pelargonium	hortorum		Bailey
a	Goodeniaceae	Scaevola	plumieri		(L.) Vahl
a	Haemodoraceae	Lachnanthes	caroliniana		(Lam.) Dandy
a	Haloragaceae	Proserpinaca	palustris		L.
a	Haloragaceae	Proserpinaca	pectinata		Lam.
a	Hydrocharitaceae	Halophila	engelmannii		Aschers ex Neumayer
a	Hydrocharitaceae	Limnobium	spongia		(Bosc) Rich. ex Steud.
a	Hydrocharitaceae	Najas	guadalupensis		(Spreng.) Magnus
a	Hydrocharitaceae	Najas	marina		L.
a	Hydrocharitaceae	Najas	wrightiana		A. Braun
a	Hydrocharitaceae	Thalassia	testudinum		Banks & Sol. ex J. Koenig
a	Hypoxidaceae	Hypoxis	juncea		J. E. Smith
a	Iridaceae	Gladiolus	x gandavensis		Van Houtte

a	Iridaceae	Iris	hexagona		Walter
a	Iridaceae	Nemastylis	floridana		Small
a	Iridaceae	Sisyrinchium	angustifolium		Mill.
a	Iridaceae	Sisyrinchium	nashii		Bickn.
a	Iridaceae	Sisyrinchium	xerophyllum		Greene
a	Juglandaceae	Carya	aquatica		(Michx. f.) Nutt.
a	Juglandaceae	Carya	floridana		Sarg.
a	Juglandaceae	Carya	glabra		(Mill.) Sweet
a	Juglandaceae	Carya	illinoensis		(Wang.) K. Koch
a	Juncaceae	Juncus	acuminatus		Michx.
a	Juncaceae	Juncus	dichotomus		Ell.
a	Juncaceae	Juncus	effusus		L.
a	Juncaceae	Juncus	marginatus		Rostk.
a	Juncaceae	Juncus	megacephalus		M.A. Curtis
a	Juncaceae	Juncus	polycephalus		Michx.
a	Juncaceae	Juncus	repens		Michx.
a	Juncaceae	Juncus	roemerianus		Scheele
a	Juncaceae	Juncus	scirpoides		Lam.
a	Lamiaceae	Callicarpa	americana		L.
a	Lamiaceae	Clerodendrum	indicum		(L.) Kuntze
a	Lamiaceae	Clerodendrum	speciosissimum		Van Geert ex C. Morren
a	Lamiaceae	Hyptis	alata		(Raf.) Shinners
a	Lamiaceae	Hyptis	mutabilis		(Rich.) Briq.
a	Lamiaceae	Mentha	sp.		
a	Lamiaceae	Monarda	punctata		L.
a	Lamiaceae	Physostegia	purpurea		(Walter) S.F. Blake
a	Lamiaceae	Piloblephis	rigida		W. Bartram ex Benth.) Raf.
a	Lamiaceae	Prunella	vulgaris		L.
a	Lamiaceae	Salvia	coccinea		Buchoz. ex Etling
a	Lamiaceae	Salvia	lyrata		L.
a	Lamiaceae	Scutellaria	integrifolia		L.
a	Lamiaceae	Teucrium	canadense		L.

a	Lamiaceae	Trichostema	dichotomum		L.
a	Lamiaceae	Vitex	trifolia		L.
a	Lauraceae	Cassytha	filiformis		L.
a	Lauraceae	Cinnamomum	camphora		(L.) J. Presl
a	Lauraceae	Ocotea	coriacea		(Sw.) Britton
a	Lauraceae	Persea	americana		Mill.
a	Lauraceae	Persea	borbonia	var. borbonia	(L.) Spreng.
a	Lauraceae	Persea	borbonia (L.) Spreng.	var. humilis	(Nash) Koop
a	Lauraceae	Persea	palustris		(Raf.) Sarg.
a	Lentibulariaceae	Pinguicula	caerulea		Walt.
a	Lentibulariaceae	Pinguicula	lutea		Walt.
a	Lentibulariaceae	Pinguicula	pumila		Michx.
a	Lentibulariaceae	Utricularia	foliosa		L.
a	Lentibulariaceae	Utricularia	gibba		L.
a	Lentibulariaceae	Utricularia	inflata		Walt.
a	Lentibulariaceae	Utricularia	purpurea		Walt.
a	Lentibulariaceae	Utricularia	radiata		Small
a	Lentibulariaceae	Utricularia	subulata		L.
a	Liliaceae	Lilium	catesbaei		Walt.
a	Liliaceae	Lilium	longiflorum		Thunb.
a	Loasaceae	Mentzelia	floridana		Nutt. ex Torr. & A. Gray
a	Loganiaceae	Mitreola	petiolata		(J.F. Gmel.) T. & G.
a	Loganiaceae	Mitreola	sessilifolia		(J.F. Gmel.) G. Don
a	Lythraceae	Ammannia	latifolia		L.
a	Lythraceae	Lagerstroemia	indica		L.
a	Lythraceae	Lythrum	alatum Pursh	var. lanceolatum	(Ell.) T. & G. ex Rothr.
a	Lythraceae	Lythrum	lineare		L.
a	Lythraceae	Rotala	ramosior		(L.) Koehne
a	Magnoliaceae	Magnolia	grandiflora		L.
a	Magnoliaceae	Magnolia	virginiana		L.
a	Malvaceae	Hibiscus	furcellatus		Desr.
a	Malvaceae	Hibiscus	grandiflorus		Michx.

a	Malvaceae	Hibiscus	rosa-sinensis		L.
a	Malvaceae	Hibiscus	rosa-sinensis L.	var. schizopetalus	Dyer
a	Malvaceae	Kosteletzkya	virginica		(L.) Presl ex A. Gray
a	Malvaceae	Malvastrum	corchorifolium		(Desr.) Britt. ex Small
a	Malvaceae	Malvastrum	coromandelianum		(L.) Garcke
a	Malvaceae	Malvaviscus	arboreus Cav.	var. drummondii	Schery.
a	Malvaceae	Pavonia	spinifex		(L.) Cav.
a	Malvaceae	Sida	acuta		Burm. f.
a	Malvaceae	Sida	cordifolia		L.
a	Malvaceae	Sida	rhombifolia		L.
a	Malvaceae	Talipariti	tiliaceum		(L.) Fryxell
a	Malvaceae	Urena	lobata		L.
a	Marantaceae	Thalia	geniculata		L.
a	Melanthiaceae	Schoenocaulon	dubium		(Michx.) Small
a	Melastomataceae	Rhexia	mariana		L.
a	Melastomataceae	Rhexia	nuttallii		C.W. James
a	Melastomataceae	Rhexia	petiolata		Walt.
a	Meliaceae	Melia	azedarach		L.
a	Molluginaceae	Mollugo	verticillata		L.
a	Moraceae	Broussonetia	papyrifera		(L.) Vent.
a	Moraceae	Ficus	aurea		Nutt.
a	Moraceae	Ficus	carica		L.
a	Moraceae	Ficus	elastica		Roxb.
a	Moraceae	Maclura	pomifera		(Raf.) Schneid.
a	Moraceae	Morus	alba		L.
a	Moraceae	Morus	rubra		L.
a	Musaceae	Musa	x paradisiaca		L.
a	Myricaceae	Myrica	cerifera		L.
a	Myrsinaceae	Ardisia	escallonioides		Schiede & Deppe ex Schltdl. & Cham.
a	Myrsinaceae	Rapanea	punctata		(Lam.) Lundell
a	Myrtaceae	Eucalyptus	robusta		Smith
a	Myrtaceae	Eugenia	axillaris		(Sw.) Willd.

a	Myrtaceae	Eugenia	foetida		Pers.
a	Myrtaceae	Eugenia	uniflora		L.
a	Myrtaceae	Melaleuca	quinquenervia		(Cav.) Blake
a	Myrtaceae	Myrcianthes	fragrans		(Sw.) McVaugh
a	Myrtaceae	Psidium	cattleianum		Sabine
a	Myrtaceae	Psidium	guajava		L.
a	Myrtaceae	Syzygium	cumini		(L.) Skeels
a	Myrtaceae	Syzygium	jambos		(L.) Alston
a	Nartheciaceae	Aletris	lutea		Small
a	Nelumbonaceae	Nelumbo	lutea		Willd.
a	Nyctaginaceae	Boerhavia	diffusa		L.
a	Nyctaginaceae	Bougainvillea	glabra		Choisy
a	Nyctaginaceae	Guapira	discolor		(Spreng.) Little
a	Nyctaginaceae	Mirabilis	jalapa		L.
a	Nymphaeaceae	Nuphar	advena		(Aiton) W.T. Aiton
a	Nymphaeaceae	Nymphaea	capensis		Thunb.
a	Nymphaeaceae	Nymphaea	elegans		Hook.
a	Nymphaeaceae	Nymphaea	mexicana		Zucc.
a	Nymphaeaceae	Nymphaea	odorata		Sol.
a	Olacaceae	Schoepfia	chrysophylloides		(A. Rich.) Planch.
a	Olacaceae	Ximenia	americana		L.
a	Oleaceae	Forestiera	segregata		(Jacq.) Krug & Urban
a	Oleaceae	Fraxinus	pennsylvanica		Marshall
a	Oleaceae	Jasminum	sambac		(L.) Aiton
a	Oleaceae	Ligustrum	japonicum		Thunb.
a	Oleaceae	Olea	europeae		L.
a	Oleaceae	Osmanthus	americana		(L.) Benth. & Hook. f. ex A. Gray
a	Onagraceae	Gaura	angustifolia		Michx.
a	Onagraceae	Ludwigia	alata		Ell.
a	Onagraceae	Ludwigia	arcuata		Walt.
a	Onagraceae	Ludwigia	decurrens		Walt.
a	Onagraceae	Ludwigia	erecta		(L.) H. Hara

a	Onagraceae	Ludwigia	hirtella		Raf.
a	Onagraceae	Ludwigia	lanceolata		Elliott
a	Onagraceae	Ludwigia	maritima		R.M. Harper
a	Onagraceae	Ludwigia	microcarpa		Michx.
a	Onagraceae	Ludwigia	octovalvis		(Jacq.) Raven
a	Onagraceae	Ludwigia	palustris		(L.) Ell.
a	Onagraceae	Ludwigia	peruviana		(L.) Hara
a	Onagraceae	Ludwigia	repens		J.R. Forst.
a	Onagraceae	Ludwigia	suffruticosa		Walt.
a	Onagraceae	Oenothera	humifusa		Nutt.
a	Onagraceae	Oenothera	laciniata		Hill
a	Orchidaceae	Calopogon	barbatus		(Walt.) Ames
a	Orchidaceae	Calopogon	multiflorus		Lindl.
a	Orchidaceae	Calopogon	tuberosus		(L.) BSP.
a	Orchidaceae	Encyclia	tampensis		(Lindl.) Small
a	Orchidaceae	Epidendrum	conopseum		R. Br.
a	Orchidaceae	Eulophia	alta		(L.) Fawc. & Rendle
a	Orchidaceae	Habenaria	floribunda		Lindl.
a	Orchidaceae	Habenaria	repens		Nutt.
a	Orchidaceae	Harrisella	porrecta		(Rchb. f.) Fawc. & Rendle
a	Orchidaceae	Hexalectris	spicata		(Walt.) Barnh.
a	Orchidaceae	Malaxis	spicata		Sw.
a	Orchidaceae	Pogonia	ophioglossoides		(L.) Ker-Gawl.
a	Orchidaceae	Ponthieva	racemosa		(Walt.) Mohr
a	Orchidaceae	Pteroglossaspis	ecristata		(Fern.) Rolfe
a	Orchidaceae	Spiranthes	laciniata		(Small) Ames
a	Orchidaceae	Spiranthes	odorata		(Nutt.) Lindl.
a	Orchidaceae	Zeuxine	strateumatica		(L.) Schltr.
a	Orobanchaceae	Agalinis	fasciculata		(Ell.) Raf.
a	Orobanchaceae	Agalinis	filifolia		(Nutt.) Raf.
a	Orobanchaceae	Agalinis	linifolia		(Nutt.) Britt.
a	Orobanchaceae	Agalinis	maritima		(Raf.) Raf.

a	Orobanchaceae	Agalinis	setacea		(J.F. Gmel.) Raf.
a	Orobanchaceae	Buchnera	americana		L.
a	Orobanchaceae	Seymeria	pectinata		Pursh
a	Oxalidaceae	Oxalis	corniculata		L.
a	Oxalidaceae	Oxalis	violacea		L.
a	Papaveraceae	Argemone	mexicana		L.
a	Passifloraceae	Passiflora	incarnata		L.
a	Passifloraceae	Passiflora	lutea		L.
a	Passifloraceae	Passiflora	suberosa		L.
a	Petiveriaceae	Rivina	humilis		L.
a	Phytolaccaceae	Phytolacca	americana		L.
a	Piperaceae	Peperomia	humilis		A. Dietr.
a	Piperaceae	Peperomia	obtusifolia		(L.) A. Dietr.
a	Plantaginaceae	Plantago	lanceolata		L.
a	Plantaginaceae	Plantago	virginica		L.
a	Plumbaginaceae	Limonium	carolinianum		(Walt.) Britt.
a	Plumbaginaceae	Plumbago	auriculata		Lam.
a	Plumbaginaceae	Plumbago	scandens		L.
a	Poaceae	Amphicarpum	muhlenbergianum		(Shult.) Hitchc.
a	Poaceae	Andropogon	brachystachyus		Chapm.
a	Poaceae	Andropogon	floridanus		Scribn.
a	Poaceae	Andropogon	glomeratus		(Walter) Britton et al.
a	Poaceae	Andropogon	glomeratus (Walter) Britton et al.	var. glaucopis	(Ell.) C. Mohr
a	Poaceae	Andropogon	glomeratus (Walter) Britton et al.	var. hirsutior	(Hack.) C. Mohr
a	Poaceae	Andropogon	glomeratus (Walter) Britton et al.	var. pumilus	(Vasey) Vasey ex L.H. Dewey
a	Poaceae	Andropogon	gyrans	var. gyrans	Ashe
a	Poaceae	Andropogon	gyrans Ashe	var. stenophyllus	(Hack.) C.S. Campb.
a	Poaceae	Andropogon	longiberbis		Hack.
a	Poaceae	Andropogon	ternarius		Michx.
a	Poaceae	Andropogon	virginicus	var. virginicus	L.

a	Poaceae	Andropogon	virginicus L.	var decipiens	C.S. Campb.
a	Poaceae	Andropogon	virginicus L.	var. glaucus	Hack.
a	Poaceae	Aristida	patula		Chapm. ex Nash
a	Poaceae	Aristida	purpurascens	var. purpurascens	Poir.
a	Poaceae	Aristida	purpurascens Poir.	var. tenuispica	(Hitchc.) Allred
a	Poaceae	Aristida	purpurascens Poir.	var. virgata	(Trin.) Allred
a	Poaceae	Aristida	spiciformis		Ell.
a	Poaceae	Aristida	stricta Michx.	var. beyrichiana	(Trin. & Rupr.) D.B. Ward
a	Poaceae	Arundinaria	gigantea		(Walt.) Walter ex Muhl.
a	Poaceae	Arundo	donax		L.
a	Poaceae	Axonopus	fissifolius		(Raddi) Kuhlm.
a	Poaceae	Axonopus	furcatus		(Flugge) Hitchc.
a	Poaceae	Bambusa	multiplex		(Lour.) Raeusch. ex Schult. & Schult. f.
a	Poaceae	Bambusa	vulgaris		Schrad. ex J.C. Wendl.
a	Poaceae	Bothriochloa	pertusa		(L.) A. Camus
a	Poaceae	Calamovilfa	curtissii		(Vasey) Scribn.
a	Poaceae	Cenchrus	echinatus		L.
a	Poaceae	Cenchrus	spinifex		Cav.
a	Poaceae	Chasmanthium	laxum (L.) Yates	var. sessiliflorum	(Poir.) Wipff & S.D. Jones
a	Poaceae	Coelorachis	rugosa		(Nutt.) Nash
a	Poaceae	Cynodon	dactylon		(L.) Pers.
a	Poaceae	Dactyloctenium	aegyptium		Willd. ex Asch. & Schweinf.
a	Poaceae	Dichanthelium	aciculare		(Desv. ex Poir.) Gould & C.A. Clark
a	Poaceae	Dichanthelium	acuminatum		(Sw.) Gould & C. A. Clark
a	Poaceae	Dichanthelium	commutatum		(Schult.) Gould
a	Poaceae	Dichanthelium	dichotomum		(L.) Gould
a	Poaceae	Dichanthelium	ensifolium	var. ensifolium	(Baldwin ex Elliott) Gould
a	Poaceae	Dichanthelium	ensifolium (Bald. ex Ell.) Gould	var. breve	(Hitchc. & Chase) B.F.Hansen & Wunderlin
a	Poaceae	Dichanthelium	ensifolium (Bald. ex Ell.) Gould	var. unciphyllum	(Trin) B. F. Hansen & Wunderlin
a	Poaceae	Dichanthelium	laxiflorum		(Lam.) Gould
a	Poaceae	Dichanthelium	leucothrix		(Nash) Freckmann

a	Poaceae	Dichanthelium	oliogsanthes		(Schult.) Gould
a	Poaceae	Dichanthelium	ovale		(Elliott) Gould & C. A. Clark
a	Poaceae	Dichanthelium	portoricense		(Desv. ex Ham.) B.F. Hansen & Wunderlin
a	Poaceae	Dichanthelium	scabriusculum		(Elliott) Gould & C.A. Clark
a	Poaceae	Dichanthelium	sphaerocarpon		(Elliott) Gould
a	Poaceae	Dichanthelium	strigosum (Muhl. ex Ell.) Freckmann	var. glabrescens	(Griseb.) Freckmann
a	Poaceae	Dichanthelium	strigosum (Muhl. ex Ell.) Freckmann	var. leucoblepharis	(Trin.) Freckmann
a	Poaceae	Digitaria	ciliaris		(Retz.) Koeler
a	Poaceae	Digitaria	filiformis		(L.) Koeler
a	Poaceae	Distichlis	spicata		(L.) Greene
a	Poaceae	Echinochloa	colona		(L.) Link
a	Poaceae	Echinochloa	crusgalli		(L.) Beauv.
a	Poaceae	Echinochloa	muricata		(Pursh) A. Heller
a	Poaceae	Echinochloa	walteri		(Pursh) Heller
a	Poaceae	Eleusine	indica		(L.) Gaertn.
a	Poaceae	Eragrostis	ciliaris		(L.) R. Br.
a	Poaceae	Eragrostis	elliottii		S. Watson
a	Poaceae	Eragrostis	hirsuta		(Michx.) Nees
a	Poaceae	Eragrostis	pectinacea	var. pectinacea	(Michx.) Nees ex Jedwabn.
a	Poaceae	Eragrostis	secundiflora J. Presl	subsp. oxylepis	(Torr.) S.D. Koch
a	Poaceae	Eragrostis	spectabilis		(Pursh) Steud.
a	Poaceae	Eragrostis	virginica		(Zucc.) Steud.
a	Poaceae	Eremochloa	ophiuroides		(Munro) Hack.
a	Poaceae	Eriochloa	michauxii	var. michauxii	(Poir.) Hitchc.
a	Poaceae	Eustachys	glauca		Chapm.
a	Poaceae	Eustachys	petraea		(Sw.) Desv.
a	Poaceae	Heteropogon	melanocarpus		(Ell.) Ell. ex Benth.
a	Poaceae	Imperata	cylindrica		(L.) Beauv.
a	Poaceae	Leersia	hexandra		Sw.
a	Poaceae	Leersia	virginica		Willd.
a	Poaceae	Leptochloa	fusca (L.) Kunth	subsp. fascicularis	(Lam.) N. Snow

a	Poaceae	Lolium	arundinaceum		(Schreb.) Darbysh
a	Poaceae	Monanthochloe	littoralis		Engelm.
a	Poaceae	Muhlenbergia	capillaris (Lam.) Trin.	var. filipes	(M.A. Curtis) Chapm. ex Beal
a	Poaceae	Oplismenus	hirtellus		(L.) P. Beauv.
a	Poaceae	Panicum	amarum		Ell.
a	Poaceae	Panicum	anceps		Michx.
a	Poaceae	Panicum	dichotomiflorum		Michx.
a	Poaceae	Panicum	dichotomiflorum Michx.	var. bartowense	(Scribn. & Merr.) Fernald
a	Poaceae	Panicum	hemitomon		Schult.
a	Poaceae	Panicum	hians		Ell.
a	Poaceae	Panicum	maximum		Jacq.
a	Poaceae	Panicum	repens		L.
a	Poaceae	Panicum	rigidulum		Bosc ex Nees
a	Poaceae	Panicum	tenerum		Beyr. ex Trin.
a	Poaceae	Panicum	verrucosum		Muhl.
a	Poaceae	Panicum	virgatum		L.
a	Poaceae	Paspalum	bifidum		(Bertol.) Nash
a	Poaceae	Paspalum	caespitosum		Flugge
a	Poaceae	Paspalum	conjugatum		Berg.
a	Poaceae	Paspalum	floridanum		Michx.
a	Poaceae	Paspalum	laeve		Michx.
a	Poaceae	Paspalum	langei		(Fourn.) Nash
a	Poaceae	Paspalum	notatum Fluegge	var. saurae	Parodi
a	Poaceae	Paspalum	plicatulum		Michx.
a	Poaceae	Paspalum	praecox		Walt.
a	Poaceae	Paspalum	setaceum		Michx.
a	Poaceae	Paspalum	urvillei		Steud.
a	Poaceae	Paspalum	vaginatum		Sw.
a	Poaceae	Pennisetum	purpureum		Schum.
a	Poaceae	Phragmites	australis		(Cav.) Trin. ex Steud.
a	Poaceae	Polypogon	monspeliensis		(L.) Desf.
a	Poaceae	Rhynchelytrum	repens		(Willd.) C.E. Hubb.

a	Poaceae	Saccharum	giganteum		(Walt.) Pers.
a	Poaceae	Sacciolepis	striata		(L.) Nash
a	Poaceae	Schizachyrium	sanguineum		(Retz.) Alston
a	Poaceae	Schizachyrium	scoparium	var. scoparium	(Michx.) Nash
a	Poaceae	Setaria	corrugata		(Ell.) Schult.
a	Poaceae	Setaria	macrosperma		(Scrib. & Merr.) Schum.
a	Poaceae	Setaria	magna		Griseb.
a	Poaceae	Setaria	parviflora		(Poir.) Kerguelen
a	Poaceae	Sorghastrum	elliottii		(Mohr) Nash
a	Poaceae	Sorghastrum	secundum		(Ell.) Nash
a	Poaceae	Sorghum	bicolor		(L.) Moench
a	Poaceae	Sorghum	halepense		(L.) Pers.
a	Poaceae	Spartina	alterniflora		Loisel.
a	Poaceae	Spartina	bakeri		Merr.
a	Poaceae	Spartina	cynosuroides		(L.) Roth
a	Poaceae	Spartina	patens		(Aiton) Muhl.
a	Poaceae	Spartina	spartinae		(Trin.) Merr. ex Hitchc.
a	Poaceae	Sphenopholis	filiformis		(Chapm.) Scribn.
a	Poaceae	Sphenopholis	obtusata		(Michx.) Scribn.
a	Poaceae	Sporobolus	domingensis		(Trin.) Kunth
a	Poaceae	Sporobolus	floridanus		Chapm.
a	Poaceae	Sporobolus	indicus	var. indicus	(L.) R. Br.
a	Poaceae	Sporobolus	virginicus		(L.) Kunth
a	Poaceae	Stenotaphrum	secundatum		(Walt.) Kuntze
a	Poaceae	Tridens	flavus (L.) Hitchc.	var. chapmanii	(Small) Shinners
a	Poaceae	Triplasis	purpurea		(Walt.) Chapm.
a	Poaceae	Tripsacum	dactyloides		(L.) L.
a	Poaceae	Uniola	paniculata		L.
a	Poaceae	Urochloa	distachya		(L.) T.Q. Nguyen

a	Poaceae	Urochloa	fusca (Sw.) B.F. Hansen & Wunderlin	var. reticulata	(Torr.) B.F. Hansen & Wunderlin
a	Poaceae	Urochloa	mutica		(Forssk.) Nguyen
a	Poaceae	Zea	mays		L.
a	Poaceae	Zoysia	tenuifolia		Willd. ex Thiele
a	Polemoniaceae	Ipomopsis	rubra		(L.) Wherry
a	Polemoniaceae	Phlox	drummondii		Hook.
a	Polygalaceae	Polygala	balduinii		Nutt.
a	Polygalaceae	Polygala	cruciata		L.
a	Polygalaceae	Polygala	grandiflora		Walt.
a	Polygalaceae	Polygala	incarnata		L.
a	Polygalaceae	Polygala	lutea		L.
a	Polygalaceae	Polygala	nana		(Michx.) DC.
a	Polygalaceae	Polygala	polygama		Walt.
a	Polygalaceae	Polygala	rugelii		Shuttlew. ex Chapm.
a	Polygalaceae	Polygala	setacea		Michx.
a	Polygonaceae	Antigonon	leptopus		Hook. & Arn.
a	Polygonaceae	Coccoloba	diversifolia		Jacq.
a	Polygonaceae	Coccoloba	uvifera		(L.) L.
a	Polygonaceae	Polygonella	ciliata		Meisn.
a	Polygonaceae	Polygonella	gracilis		Meisn.
a	Polygonaceae	Polygonella	polygama		(Vent.) Engelm. & A. Gray
a	Polygonaceae	Polygonum	hirsutum		Walt.
a	Polygonaceae	Polygonum	hydropiperoides		Michx.
a	Polygonaceae	Polygonum	persicaria		L.
a	Polygonaceae	Polygonum	punctatum		Ell.
a	Polygonaceae	Polygonum	scandens L.	var. cristatum	(Engelm. & A. Gray) Gleason
a	Polygonaceae	Polygonum	setaceum		Baldwin
a	Polygonaceae	Rumex	hastatulus		Baldwin
a	Polygonaceae	Rumex	pulcher		L.
a	Polygonaceae	Rumex	verticillatus		L.

a	Pontederiaceae	Eichhornia	crassipes		(Mart.) Solms
a	Pontederiaceae	Pontederia	cordata		L.
a	Portulacaceae	Portulaca	oleracea		L.
a	Portulacaceae	Portulaca	pilosa		L.
a	Primulaceae	Samolus	ebracteatus		Kunth
a	Primulaceae	Samolus	valerandi L.	subsp. parviflorus	(Raf.) Hulten
a	Proteaceae	Grevillea	robusta		A. Cunn.
a	Ranunculaceae	Clematis	baldwinii		T. & G.
a	Ranunculaceae	Clematis	crispa		L.
a	Rhamnaceae	Berchemia	scandens		(Hill) K. Koch
a	Rhamnaceae	Krugiodendron	ferreum		(Vahl) Urban
a	Rhamnaceae	Sageretia	minutiflora		(Michx.) Mohr
a	Rhizophoraceae	Rhizophora	mangle		L.
a	Rosaceae	Eriobotrya	japonica		(Thunb.) Lindl.
a	Rosaceae	Prunus	angustifolia		Marsh.
a	Rosaceae	Prunus	caroliniana		(Mill.) Aiton
a	Rosaceae	Prunus	persica		(L.) Batsch
a	Rosaceae	Prunus	serotina		Ehrh.
a	Rosaceae	Pyrus	communis		L.
a	Rosaceae	Rubus	argutus		Link
a	Rosaceae	Rubus	cuneifolius		Pursh
a	Rosaceae	Rubus	trivialis		Michx.
a	Rubiaceae	Cephalanthus	occidentalis		L.
a	Rubiaceae	Chiococca	alba		(L.) Hitchc.
a	Rubiaceae	Diodia	teres		Walt.
a	Rubiaceae	Diodia	virginiana		L.
a	Rubiaceae	Ernodea	littoralis		Sw.
a	Rubiaceae	Galium	hispidulum		Michx.
a	Rubiaceae	Galium	pilosum		Aiton
a	Rubiaceae	Galium	tinctorium		L.
a	Rubiaceae	Houstonia	procumbens		(J.F. Gmel.) Standl
a	Rubiaceae	Morinda	royoc		L.

a	Rubiaceae	Oldenlandia	corymbosa		L.
a	Rubiaceae	Oldenlandia	uniflora		L.
a	Rubiaceae	Psychotria	nervosa		Sw.
a	Rubiaceae	Psychotria	sulzneri		Small
a	Rubiaceae	Randia	aculeata		L.
a	Rubiaceae	Richardia	brasiliensis		Gomes
a	Rubiaceae	Richardia	grandiflora		(Cham. & Schltdl.) Schult. & Schult. f.
a	Rubiaceae	Spermacoce	assurgens		Ruiz & Pavon
a	Rubiaceae	Spermacoce	verticillata		L.
a	Ruppiaceae	Ruppia	maritima		L.
a	Ruscaceae	Sansevieria	hyacinthoides		(L.) Druce
a	Rutaceae	Amyris	elemifera		L.
a	Rutaceae	Citrus	X aurantium		L.
a	Rutaceae	Citrus	reticulata		Blanco
a	Rutaceae	Zanthoxylum	clava-herculis		L.
a	Rutaceae	Zanthoxylum	fagara		(L.) Sarg.
a	Salicaceae	Salix	babylonica		L.
a	Salicaceae	Salix	caroliniana		Michx.
a	Sapindaceae	Acer	negundo		L.
a	Sapindaceae	Acer	rubrum		L.
a	Sapindaceae	Cardiospermum	microcarpum		Kunth
a	Sapindaceae	Dodonaea	viscosa		Jacq.
a	Sapindaceae	Exothea	paniculata		(Juss.) Radlk. ex T. Durand
a	Sapindaceae	Koelreuteria	elegans (Seemann) A.C. Sm.	subsp. formosana	(Hayata) F.G. Mey.
a	Sapindaceae	Litchi	chinensis		Sonn.
a	Sapindaceae	Sapindus	saponaria		L.
a	Sapotaceae	Chrysophyllum	oliviforme		L.
a	Sapotaceae	Sideroxylon	foetidissimum		Jacq.
a	Sapotaceae	Sideroxylon	reclinatum		Michx.
a	Sapotaceae	Sideroxylon	tenax		L.
a	Simaroubaceae	Simarouba	glauca		DC.

a	Smilacaceae	Smilax	auriculata		Walt.
a	Smilacaceae	Smilax	bona-nox		L.
a	Smilacaceae	Smilax	glauca		Walt.
a	Smilacaceae	Smilax	laurifolia		L.
a	Smilacaceae	Smilax	tamnoides		L.
a	Solanaceae	Capsicum	annuum L.	var. glabrisculum	(Dunal) Heiser & Pickersgill
a	Solanaceae	Capsicum	frutescens		L.
a	Solanaceae	Cestrum	nocturnum		L.
a	Solanaceae	Lycium	carolinianum		Walt.
a	Solanaceae	Physalis	pubescens		L.
a	Solanaceae	Physalis	walteri		Nutt.
a	Solanaceae	Solanum	americanum		Mill.
a	Solanaceae	Solanum	chenopodioides		Lam.
a	Solanaceae	Solanum	erianthum		D. Don
a	Solanaceae	Solanum	seaforthianum		Jacks.
a	Sterculiaceae	Dombeya	wallichii		D. Jackson
a	Surianaceae	Suriana	maritima		L.
a	Tetrachondraceae	Polypremum	procumbens		L.
a	Turneraceae	Piriqueta	cistoides (L.) Griseb.	subsp. caroliniana	(Walt.) Arbo.
a	Typhaceae	Typha	domingensis		Pers.
a	Typhaceae	Typha	latifolia		L.
a	Ulmaceae	Ulmus	americana		L.
a	Urticaceae	Boehmeria	cylindrica		(L.) Sw.
a	Urticaceae	Parietaria	floridana		Nutt.
a	Urticaceae	Parietaria	praetermissa		Hinton
a	Verbenaceae	Citharexylum	spinosum		L.
a	Verbenaceae	Glandularia	maritima		(Small) Small
a	Verbenaceae	Glandularia	tampensis		(Nash) Small
a	Verbenaceae	Lantana	camara		L.
a	Verbenaceae	Lantana	depressa Small	var. floridana	(Moldenke) R.W. Sanders
a	Verbenaceae	Lantana	involucrata		L.
a	Verbenaceae	Lantana	montevidensis		(Spreng.) Briq.

a	Verbenaceae	Phyla	nodiflora		(L.) Greene
a	Verbenaceae	Verbena	scabra		Vahl
a	Veronicaceae	Bacopa	caroliniana		(Walt.) B.L. Rob.
a	Veronicaceae	Bacopa	monnieri		(L.) Pennell
a	Veronicaceae	Gratiola	hispida		(Benth. ex Lindl.) Pollard
a	Veronicaceae	Gratiola	ramosa		Walt.
a	Veronicaceae	Linaria	canadensis		(L.) Chaz.
a	Veronicaceae	Linaria	floridana		Chapm.
a	Veronicaceae	Mecardonia	acuminata (Walt.) Small	subsp. peninsularis	(Pennell) Rossow
a	Veronicaceae	Micranthemum	glomeratum		(Chapm.) Shinners
a	Veronicaceae	Penstemon	multiflorus		(Benth.) Chapm. ex Small
a	Veronicaceae	Russellia	equisetiformis		Schltdl. & Cham.
a	Veronicaceae	Scoparia	dulcis		L.
a	Violaceae	Viola	lanceolata		L.
a	Violaceae	Viola	primulifolia		L.
a	Violaceae	Viola	sororia		Willd.
a	Viscaceae	Phoradendron	leucarpum		(Raf.) Reveal & M.C. Johnst.
a	Vitaceae	Ampelopsis	arborea		(L.) Koehne
a	Vitaceae	Cissus	trifoliata		(L.) L.
a	Vitaceae	Parthenocissus	quinquefolia		(L.) Planch.
a	Vitaceae	Vitis	aestivalis		Michx.
a	Vitaceae	Vitis	rotundifolia		Michx.
a	Vitaceae	Vitis	shuttleworthii		House
a	Xyridaceae	Xyris	brevifolia		Michx.
a	Xyridaceae	Xyris	caroliniana		Walt.
a	Xyridaceae	Xyris	elliottii		Chapm.
a	Xyridaceae	Xyris	fimbriata		Ell.
a	Xyridaceae	Xyris	flabelliformis		Kral
a	Xyridaceae	Xyris	jupicai		Rich.
a	Xyridaceae	Xyris	platylepis		Chapm.
a	Xyridaceae	Xyris	smalliana		Nash
a	Zingiberaceae	Alpinia	zerumbet		(Pers.) B.L. Burtt & R.M. Sm.

a	Zygophyllaceae	Tribulus	cistoides		L.
a	Zygophyllaceae	Tribulus	terrestris		L.

[1]p = Pteridophyte (ferns and fern allies), g = Gymnosperm, a = Angiosperm

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 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 var. *dressii* Semple
Chrysopsis subulata Small
Coreopsis floridana E.B. Sm.
Coreopsis leavenworthii T. & G.
Eupatorium mikanioides Chapm.
Helianthus debilis Nutt.
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
Rorippa floridana Al-Shehbaz & Rollins

Bromeliaceae
Tillandsia simulata Small

Cactaceae
Harrisa simpsonii Small ex Britton & Rose

Campanulaceae
Campanula floridana S. Wats.
Lobelia feayana A. Gray

Cistaceae
Helianthemum nashii Britt.
Lechea cernua Small
Lechea divaricata Shuttlw. ex Britton

Commelinaceae
Callisia ornata (Small) G.C. Tucker

Cyperaceae
Rhynchospora intermedia (Chapm.) Britt.

Euphobiaceae
Chamaesyce cumulicola Small

Fabaceae
Rhynchosia cinerea Nash
Tephrosia angustissima Shuttlew. ex Chapm. var. *curtissii* (Small ex Rydb.) Isely
Vicia floridana S. Wats.

Juglandaceae
Carya floridana Sarg.

Iridaceae
Nemastylis floridana Small
Sisyrinchium xerophyllum Greene

Lamiaceae
Piloblephis rigida (Batr. ex Benth.) Raf.

Lauraceae
Persea borbonia (L.) Spreng. var. *humilis* (Nash) Koop

Poaceae
Andropogon brachystachyus Chapm.
Andropogon floridanus Scribn.
Andropogon longiberbis Hack.
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.

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

Veronicaceae
Micranthemum glomeratum (Chapm.) Shinners

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.

Schizaeaceae
Lygodium microphyllum (Cav.) R. Br. EPPC-CI

Thelypteridaceae
Macrothelypteris torresiana (Gaudich.) Ching
Thelypteris dentata (Forssk.) E.P. St. John

Gymnosperms

Podocarpaceae
Podocarpus macrophyllus D. Don var. *maki* Endl.
Podocarpus nagi Makino

Zamiaceae
Cycas revoluta Thunb.

Angiosperms

Acanthaceae
Asystasia gangetica (L.) T. Anders EPPC-CII
Justicia brandegeana Wassh. & L.B. Smith
Odontonema cuspidatum (Nees) Kuntz
Ruellia tweediana Griseb. EPPC-CI
Thunbergia alata Bojer ex Sims
Thunbergia fragrans Roxb.

Agavaceae
Agave sisalana Perrine EPPC-CII

Agdestidaceae
Agdestis clematidea Moc. & Sesse.

Amaranthaceae
Alternanthera philoxeroides (Mart.) Griesb. EPPC-CII

Amaranthus hybridus L.
Chenopodium ambrosioides L.
Gomphrena serrata L.
Salsola kali L.

Amaryllidaceae
Crinum zeylanicum (L.) L.

Anacardiaceae
Mangifera indica L.
Schinus terebinthifolius 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.
Thevetia peruviana (Pers.) Schum.
Vinca minor L.

Araceae
Colocasia esculentum (L.) Schott EPPC-CI
Pistia stratiotes L. EPPC-CI
Syngonium podophyllum Schott EPPC-CI

Araliaceae
Tetrapanax papyriferus (Hook.) C. Koch

Arecaceae
Arecastrum ramanzoffianum Becc. EPPC-CII
Cocos nucifera L.
Phoenix canariensis Chabaud
Phoenix dactylifera L.
Phoenix reclinata L. EPPC-CII
Phoenix sylvestris Roxb.
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
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 pinnata DC.
Podranea ricasoliana (Tanfani) Sprague
Pyrostegia venusta (Ker-Gaw.) Miers.
Spathodea campanulata Beauv.
Tecoma capensis (Thunb.) Lindl.
Tecoma stans (L.) Juss.

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
Stellaria media (L.) Cyrillo

Casuarinaceae
Casuarina cunninghamiana Miq. EPPC-CII
Casuarina equisetifolia L. ex J.R. Forst. & G. Forst. EPPC-CI
Casuarina glauca Sieb. ex Spreng. EPPC-CI

Ceratophtllaceae
Ceratophyllum muricatum Cham.

Combretaceae
Quisqualis indica L.

Commelinaceae
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.
Kalonche delagoensis Eckl. & Zeyh.
Kalanchoe fedtschenkoi Ham. & Perr.
Kalanchoe pinnata (Lam.) Pers. EPPC-CII

Cucurbitaceae
Citrullus lanatus (Thunb.) Mats. & Nakai.
Momordica charantia L.

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.
Phyllanthus tenellus Roxb.
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
Crotalaria lanceolata E. Mey.
Crotalaria pallida Aiton var. *obovata* (G. Don) Polhill
Crotalaria retusa L.
Crotalaria spectabilis Roth
Desmodium tortuosum (Sw.) DC.
Desmodium triflorum (L.) DC.
Enterolobium contortisiliquum (Vell.) Morong
Indigofera hirsuta Harv.
Indigofera spicata Forsk.
Indigofera suffruticosa L.
Kummerowia striata (Thunb.) Schindler
Leucaena leucocephala (Lam.) de Wit. EPPC-CII
Macroptilium lathyroides (L.) Urban
Medicago lupulina L.
Melilotus albus Medik.
Melilotus indica (L.) All.
Parkinsonia aculeata L.
Pueraria montana (Lour.) Merr. var. *lobata* (Willd.) Maesen & S.M. Almeida EPPC-CI
Senna alata (L.) Roxb.
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
Trifolium repens L.
Wisteria sinensis (Sims) Sweet EPPC-CII

Geraniaceae
Pelargonium hortorum Bailey

Iridaceae
Gladiolus x gandavensis Van Houtte

Juglandaceae

Carya illinoensis (Wang.) K. Koch

Lamiaceae
Clerodendrum indicum (L.) Kuntze
Clerodendrum speciosum D'Ombrain
Hyptis mutabilis (A. Rich.) Briq.
Mentha sp.
Prunella vulgaris L.
Vitex trifolia L. EPPC-CII

Lauraceae
Cinnamonum camphora (L.) Nees & Eberm. EPPC-CI
Persea americana Mill.

Liliaceae
Lilium longiflorum Thunb.

Lythraceae
Lagerstroemia indica L.

Malvaceae
Hibiscus rosa-sinensis L.
Hibiscus rosa-sinensis L. var. *schizopetalus* Dyer.
Malvastrum coromandelianum (L.) Garcke
Malvaviscus arboreus Cav. var. *drummondii* Schery.
Sida cordifolia L.
Talipariti tiliaceum (L.) Fryxell EPPC-CII
Urena lobata L. EPPC-CII

Meliaceae
Melia azedarach L. EPPC-CII

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 Smith 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.

Oleaceae
Jasminum sambac Ait. EPPC-CII
Ligustrum japonicum Thunb.
Olea europeae L.

Onagraceae
Ludwigia peruviana (L.) Hara EPPC-CI

Orchidaceae
Zeuxine strateumatica (L.) Schltr.

Plantaginaceae
Plantago lanceolata L.

Plumbaginaceae
Plumbago auriculata Lam.

Poaceae
Arundo donax L.
Bambusa multiplex (Lour.) Raeusch
Bambusa vulgaris Schrad. ex J.C. Wendl.
Bothriochloa pertusa (L.) A. Camus
Cynodon dactylon (L.) Pers.
Dactyloctenium aegyptium (L.) Beauv.
Echinochloa colona (L.) Link
Echinochloa crusgalli (L.) Beauv.
Eleusine indica (L.) Gaertn.
Eragrostis ciliaris (L.) R. Br.
Eremochloa ophiuroides (Munro) Hack.
Imperata cylindica (L.) Beauv. EPPC-CI
Panicum maximum Jacq. EPPC-CII
Panicum repens L. EPPC-CI
Paspalum notatum Fluegge var. *saurae* Parodi
Paspalum urvillei Steud.

Pennisetum purpureum Schum. EPPC-CI
Polypogon monspeliensis (L.) Desf.
Rhynchelytrum repens (Willd.) C.E. Hubb. EPPC-CI
Sorghum bicolor (L.) Moench
Sorghum halepense (L.) Pers.
Sporobolus indicus (L.) R. Br.
Urochloa distachya (L.) T.Q. Nguyen var. *reticulata* (Torr.) B.F. Hansen & Wunderlin
Urochloa fusca (Sw.) B.F. Hansen & Wunderlin
Urochloa mutica (Forssk.) R.D. Webster EPPC-CI
Zea mays L.
Zoysia matrella (L.) Merr. var. *tenuifolia* (Willd. ex Thiele) Sasaki

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.

Rosaceae
Eriobotrya japonica Lindl.
Prunus persica (L.) Batsch
Pyrus communis L.

Rubiaceae
Oldenlandia corymbosa L.
Richardia brasiliensis (Moq.) Gomez
Richardia grandiflora (Cham. & Schltdl.) Schult. & Schult. f.
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. EPPC-CII
Litchi chinensis Sonn.

Solanaceae
Cestrum nocturnum L.
Solanum seaforthianum Andr.

Sterculiaceae
Dombeya wallichii D. Jackson

Verbenaceae
Lantana camara L. EPPC-CI
Lantana montevidensis (Spreng.) Briq.

Veronicaceae
Russellia equisetiformis Schlecht. & Cham.

Xyridaceae
Xyris jupicai Rich.

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 (Ref. 1).

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

REFERENCES

1. Whittier, H. O. and H. A. Miller. 1976. Merritt Island ecosystem studies. 2. Bryophytes of Merritt Island. Florida Scientist 39:73-75.

APPENDIX E

Table E-1. Reportable EPCRA Tier II Data

RY 2008 KSC Extremely Hazardous Substances (EHS)	
EHS Chemical	**CAS Number**
1,1-Dimethylhydrazine	57-14-7
Methyl Hydrazine	60-34-4
Hydrazine	302-01-2
Ammonia	7664-41-7
Sulfuric Acid	7664-93-9
Nitric Acid	7697-37-2
Chlorine	7782-50-5
Nitrogen Dioxide	10544-72-6
Epichlorohydrin	106-89-8

RY 2008 KSC Non-Extremely Hazardous Substances (Non-EHS)	
Non- EHS Chemical	**CAS Number**
Ethanol (Ethyl Alcohol)	64-17-5
Isopropanol (Isopropyl Alcohol)	67-63-0
Propane	74-98-6
Freon 21	75-43-4
Halon 1301	75-63-8
Freon 113	76-13-1
Citric Acid	77-92-9
1,2-Dichloroethylene	156-60-5
Iron Oxide – SRM	1309-37-1
Sodium Hydroxide	1310-73-2
Hydrogen	1333-74-0
HCFC 124	2837-89-0
Aluminum Powder- SRM	7429-90-5
Argon	7440-37-1
Helium	7440-59-7
Nitrogen	7727-37-9
Oxygen	7782-44-7
Ammonium Perchlorate - SRM	7790-98-9
Lubricating Oils	8002-05-9
Kerosene	8008-20-6
Petroleum Light Distillates	64742-47-8
Petroleum Mid Distillates	68476-34-5
Petroleum Aromatic Distillates	68476-34-6
Petroleum Distillates	68476-86-8
HCF-43	138495-42-8

Table E-2. Reportable EPCRA Toxic Releases Inventory (TRI) Data

CAS Number	Chemical Name	2007 TRI Activities Data			Comment
		Manufacture Threshold *(25,000 lbs)* ***unless it is PBT Chemical***	Process Threshold *(25,000 lbs)* ***unless it is PBT Chemical***	Otherwise Use Threshold *(10,000 lbs)* ***unless it is PBT Chemical***	
106-89-8	Epichlorohydrin			113,134.00	REPORT - Form A
302-01-2	Hydrazine			11,652.00	REPORT - Form A
60-34-4	Methyl hydrazine			54,384.00	REPORT - Form A
7439-92-1	Lead			2,319.80	REPORT (with Lead Compound)
N420	Lead Compounds			110.95	REPORT
127-18-4	Tetrachloroethylene (Perchloroethylene)			14,023.95	REPORT
N511	Nitrates	11,136.82			Below MFG Threshold

Table E-3. Solid Waste Diversion Data

FY 2008 NASA Agency Solid Waste Diversion			
Site	**Total Quantity Recycled (lbs)**	**Disposed Quantity (lbs)**	**Percent Diverted %**
Ames Research Center	5,170,025	2,491,520	67%
Dryden Flight Research Center	76,366	33,000	70%
Glenn Research Center at Lewis Field	67,379,744	2,625,123	96%
Goddard Space Flight Center	8,663,151	4,668,141	65%
Headquarters RCRA	62,915	0	100%
Jet Propulsion Laboratory	6,199,722	1,775,600	78%
Johnson Space Center	24,347,087	1,841,796	93%
Kennedy Space Center	**38,391,366**	**10,426,460**	**79%**
Langley Research Center	6,248,500	501,056	93%
Michoud Assembly Facility	2,470,626	3,799,320	39%
Marshall Space Flight Center	990,203	2,745,260	27%
Stennis Space Center	470,570	3,761,314	11%
Wallops Flight Facility	21,239,932	1,895,820	92%
White Sands Test Facility	731,025	232,920	76%
NASA Agency Totals	**182,441,229**	**36,797,330**	**83%**

Table E-4. Recycled Materials Data

FY 2008 Kennedy Space Center Recycled Materials			
Recycled Material Name	Unit	Revenue from Sale ($)	Quantity Recycled
Aluminum Cans	lbs	$818.80	806
Aluminum	lbs	$35,577.50	70,990
Antifreeze	gals	$0.00	7,323
Asphalt	lbs	$0.00	533,540
Batteries, All Types	lbs	$6,824.00	44,907
Blast Media	lbs	$0.00	1,517,460
Bubble Wrap	lbs	$0.00	204
C&D projects	lbs	$0.00	149,500
Cardboard	lbs	$733.00	511,420
Cement and Concrete	lbs	$0.00	29,381,580
Chemicals, Misc	lbs	$3,577.00	17,970
Compost	cubic yds	$0.00	10
Cooking Oil/Grease	lbs	$0.00	77,264
Copper	lbs	$484,143.00	257,200
Electronics (scrap property material content only)	lbs	$37,333.00	188,690
Fluorescent Lamps (1.25 lbs. per)	units	$0.00	17,148
Glass	lbs	$0.00	400
Lumber	lbs	$0.00	909,980
Mixed Paper	lbs	$20,121.34	671,102
Mixed Preformed Packaging Materials	lbs	$0.00	4
Oil Filters	lbs	$0.00	6,389
Oily Rags	lbs	$0.00	6,081
Plastic	lbs	$0.00	2,189
Precious Metal Recovery	lbs	$0.00	4
Printer	lbs	$4,766.00	52,426
Scrap Metal	lbs	$119,293.00	2,519,720
Stainless Steel	lbs	$9,145.00	8,750
Styrofoam	lbs	$0.00	137
Tires (25 lbs. per)	units	$0.00	7,875
Toner Cartridges (1.5 lbs per)	units	$0.00	2,397
Used Oil	gals	$0.00	25,965
Yardwaste	cubic yds	$0.00	2,502

Table E-5. Green Purchasing Data

FY 2008 Kennedy Space Center Green Purchasing Items Purchased						
Green Purchasing Items	Unit	Total Quantity Purchased	Total Amount Purchased	Quantity Purchased with Recovered Material	Amount Purchased with Recovered Materials	Number of Waivers
Binders (chipboard and plastic covered, not cloth)	n/a	6,977	$67,207.49	6,727	$47,755.99	3
Biobased Fuels	gals	7,581	$36,684.00	7,581	$36,684.00	0
Building Insulation Products	n/a	0	$40,000.00	0	$0.00	0
Carpet (low and medium wear polyester fiber only)	n/a	3,974	$306,862.78	1,033	$199,849.29	0
Cement	cubic yds	0	$305.00	0	$305.00	0
Commercial Sanitary Tissue Products	each	6,607	$194,041.42	6,607	$194,041.42	0
Concrete	cubic yds	495	$550,643.81	265	$11,173.31	2
Engine Coolants	gals	482	$4,042.07	0	$0.00	4
Engine Lubricating Oil (Re-Refined Oil)	gals	346	$21,893.43	346	$1,998.52	1
Floor Tiles (rubber or plastic only)	n/a	0	$278.00	0	$278.00	0
Industrial Drums	n/a	3,416	$169,981.20	3,416	$169,981.20	0
Landscaping Products	n/a	0	$1,200.00	0	$1,200.00	0
Latex Paints	n/a	141	$5,891.00	0	$0.00	6
Mats	n/a	51	$3,203.00	47	$3,203.00	0
Mobile equip. hydraulic fluid	gals	0	$300.00	0	$300.00	0
Motor Vehicle Tires	units	63	$13,756.40	0	$0.00	3
Office Furniture	each	3,335	$1,457,851.75	1,966	$607,416.48	7
Office R/ W Containers (plastic, paper or steel)	n/a	88	$4,008.40	88	$4,008.40	0
Pallet	each	3,929	$69,378.50	101	$9,847.50	1
Paper and Paper Products	n/a	53,708,741	$1,381,045.35	53,704,731	$1,187,868.73	3
Penetrating lubricants	gals	0	$300.00	0	$0.00	0
Plastic Desktop Accessories	n/a	908	$17,800.10	882	$17,761.62	1
Plastic Trash Bags	n/a	3,883	$119,352.47	3,818	$117,351.02	1
Shower & restroom dividers/partitions	each	0	$15,000.00	0	$0.00	0
Signage	each	1,440	$37,426.48	1,390	$12,176.48	1
Sorbents (Adsorbents and Absorbents)	n/a	3,294	$23,965.98	3,268	$22,685.98	1
Strapping	n/a	0	$9,060.00	0	$9,060.00	0
Structural Fiberboard and Laminated Paperboard	n/a	2,547	$31,438.00	2,547	$31,438.00	0
Toner Cartridges	each	4,432	$347,131.67	3,243	$199,496.67	3
Traffic Barricades	each	16	$941.28	16	$941.28	0
Traffic Cone	each	50	$500.00	0	$0.00	0

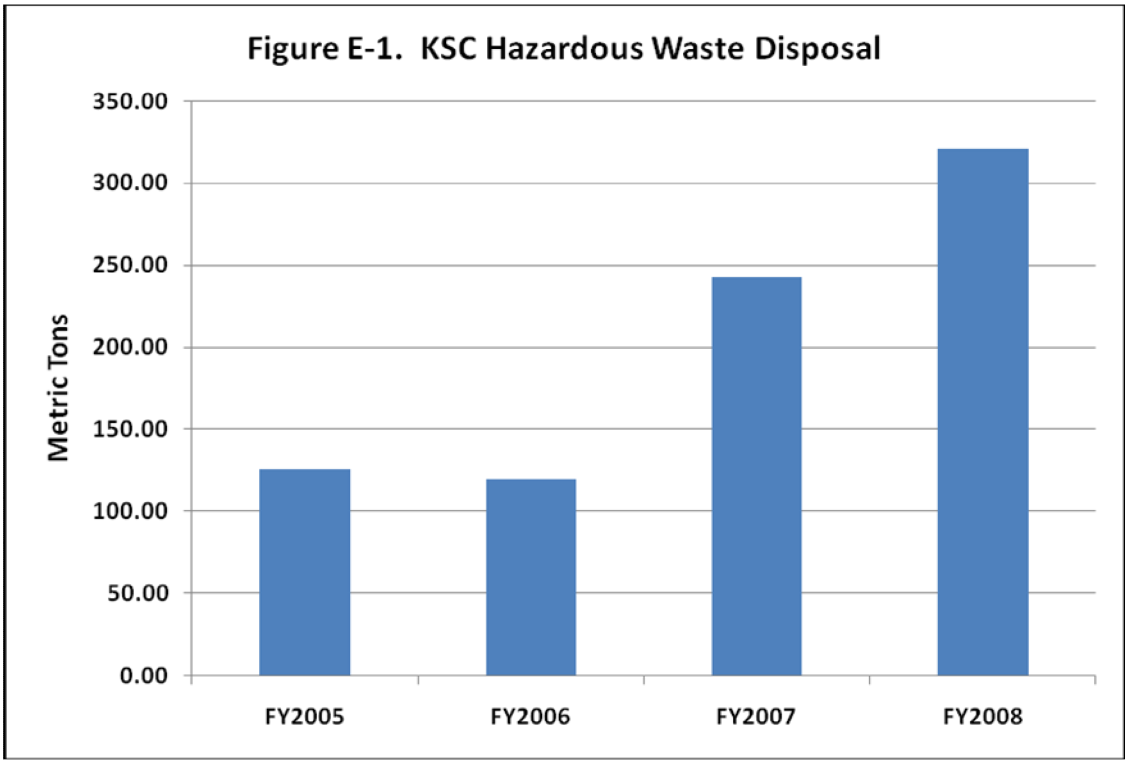
Figure E-1. KSC Hazardous Waste Disposal
Metric Tons
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
FY2005
FY2006
FY2007
FY2008

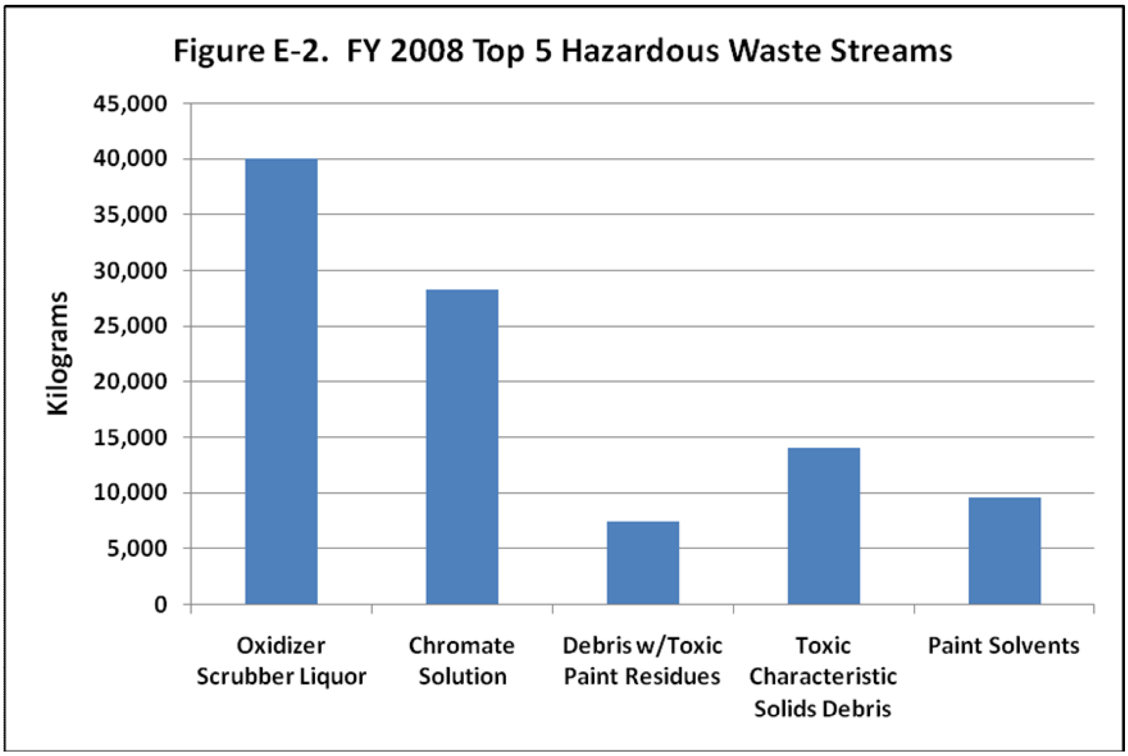
Figure E-2. FY 2008 Top 5 Hazardous Waste Streams
Kilograms
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Oxidizer Scrubber Liquor
Chromate Solution
Debris w/Toxic Paint Residues
Toxic Characteristic Solids Debris
Paint Solvents