APPENDIX B HEALTH AND SAFETY

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B HEALTH AND SAFETY

This appendix addresses the approach defined by regulatory requirements to evaluating these health and safety impacts associated with the three alternatives identified for this Environmental Impact Statement (EIS): the Proposed Action, the Ocean-Landing Only Alternative, and the No Action Alternative.

FAA assesses the health and safety impacts of launch site and launch through a separate review process. FAA conducts a safety review (14 Code of Federal Regulations [CFR] Part 420) independent of this EIS to determine whether proposed operations can be conducted safely. Additionally, should the launch site be licensed, for each launch from the launch site, FAA would conduct a safety review (14 CFR Part 415). Because the licensee is responsible for public safety, it is important that the applicant demonstrate an understanding of the hazards involved, discuss how all operations would be performed safely, and assess the risks to public health and safety.

B.1 Affected Environment

B.1.1 Definition and Description

Health and safety addresses any hazards and their impacts to individuals associated with any activity, in this case activities associated with the construction or operation of the launch site. Those individuals may be launch site workers or members of the public. Worker (occupational) safety is concerned with the potential impacts to launch site workers associated their normal workplace responsibilities. For a site such as a launch site this could include the handling of hazardous materials or the performance of hazardous tasks. Occupational health and safety can be impacted by normal operation or by accidents. Public health and safety impacts more typically result from accidents as the public is not located onsite and, therefore, not exposed to operational hazards associated with normal operations.

The Commercial Space Launch Act of 1984, as amended and re-codified at 51 United States Code (U.S.C.) §50901–50923 directs FAA to carry out its responsibility to oversee, and regulate commercial launches in a manner consistent with the public health and safety, safety of property, and the national security and foreign policy interests of the United States. One mission of the FAA Office of Commercial Space Transportation is to ensure that this responsibility is met. As part of this process, a Launch Site Operator License is required for any entity to operate a commercial launch facility and a Launch Operator License is required for any entity to undertake launch operations. FAA regulatory requirements for commercial launch activities are contained in 14 CFR Parts 400–460, with site and launch safety specifically being addressed in 14 CFR Part 417.

B.1.2 Regulatory Setting

Federal

The Occupational Health and Safety Administration (OSHA) was created to ensure safe and healthful working conditions by setting and enforcing standards. The General Duty Clause of the Occupational Safety and Health Act of 1970 requires employers to keep their workplace free of serious recognized hazards. OSHA regulations at 29 CFR Part 1910 contain occupational safety and health national consensus or established Federal standards for general industry, which are intended to require

employers to provide a workplace free from serious recognized hazards. (Title 29 CFR Part 1926 contains equivalent regulations for the construction industry.) To increase worker awareness of the hazards associated with their activities, 29 CFR §1910.1200 requires an employer to develop a hazard communication program to communicate information concerning hazards and appropriate protective measures to employees, including development of training programs.

The U.S. Department of Transportation (DOT) Hazardous Materials Transportation Act of 1975 and the Hazardous Material Transportation Uniform Safety Act of 1990 provide provisions for the DOT regulation of safe transport of hazardous materials for truck transportation codified in 49 CFR Parts 171–180. Parts 174 through 177 provide requirements specific to the mode of hazardous material transport. Delivery to the site is expected to be by truck (addressed in 49 CFR Part 177); delivery by vessel (Part 176) is possible. These requirements would be applicable to the transport of hazardous material to the launch site.

FAA regulations for commercial space transportation are contained in 14 CFR Parts 400–460 and sections 413 through 460 address licensing and safety.

State

Georgia is not a "state plan" state. It does not have a federally approved OSHA program; rather, all private employers must meet the requirements of the Federal Occupational Safety and Health Act.

The Georgia Emergency Management and Homeland Security Agency coordinates preparedness, response, and recovery efforts to disasters under the Emergency Management Act of 1981. This agency works with local, State, and Federal governments and the private sector to prevent and respond to natural and man-made emergencies. At the local level, Camden County maintains an emergency management capability with responsibilities that include developing and implementing emergency plans, mitigation, and response activities.

B.1.3 Existing Conditions

The proposed launch site would be constructed in Camden County, Georgia, in the extreme southeastern part of the state, approximately 11.5 miles due east of the town of Woodbine. The proposed launch site would be constructed within an existing 11,800-acre industrial site, consisting of property currently owned by the Union Carbide Corporation and Bayer CropScience. The industrial site is currently not in use and consists of a mix of uplands and marshland. The area surrounding the proposed site is generally rural.

The proposed launch site has several areas within it that have been identified as potentially contaminated sites containing hazardous wastes, including munitions and explosives of concern (MECs). Historically, it has been the site for the production of silicone coatings and sealants and the pesticide TEMIK® (aldicarb). The industrial site has been used in support of Department of Defense activities for the manufacture of orthochlorobenzalmalononitriel (CS) (also known as "tear gas"), including the production of CS-containing munitions, trip flares, illumination cartridges, and M84A1 fuzes. After these manufacturing activities ended, the site was again used for the production of pesticides. Several of the Proposed Action projects overlap contamination sites. The Vertical Launch Facility overlaps two historical contamination sites, the Munitions Response Area (MRA)-2, also known as Solid Waste Management Unit (SWMU) 9, and the Empty Drums Area. The proposed Landing Zone overlaps two historical contamination sites, Loop Road Site and SWMU 6. The Proposed Action also includes improvements to several existing roads. These roads traverse the following historical contamination sites: MRA-1 (SWMU 8), MRA-2 (SWMU 9), Loop Road Site, and SWMU 6. In addition to these sites, 10

additional potentially contaminated sites have been identified. While some may contain munitions-related contaminants, no MECs are located in these areas. They are located in the northwest quadrant of the launch site or located near Union Carbide Road. Section 3.7 of the EIS provides a description of hazardous materials and hazardous and solid wastes that may exist on the site and a detailed discussion of each of these areas.

Launches from the launch site would be generally to the east, resulting in launch closure and hazard areas that could include portions of Cumberland Island and Little Cumberland Island. Both are barrier islands, with a significant portion of the islands being marshland and tidal creeks. The Cumberland Island National Seashore consists of the two islands and a large portion of Cumberland Island has been designated as a Wilderness Area. The number of visitors to the island is restricted to only a few hundred people a day. Little Cumberland Island is privately owned, and the two islands have a small population most of whom generally live on the island part-year.

B.2 Environmental Consequences

B.2.1 Proposed Action

Under the Proposed Action, FAA would issue a Launch Site Operator License to Camden County. The license would allow the County to offer the commercial space launch site, Spaceport Camden, to commercial launch operators to conduct launches of liquid-fueled, up to and including medium-lift class, orbital and suborbital vertical launch vehicles. The proposed launch site would be constructed in an unincorporated area of Woodbine in Camden County, approximately 11.5 miles due east of the town of Woodbine, Georgia, in the extreme southeastern part of the state. Under the Proposed Action, Camden County would construct and operate Spaceport Camden, which would include a Vertical Launch Site, a Landing Zone, a Control Center Complex, and an Alternate Control Complex that would include visitor viewing areas. Spaceport Camden would accommodate up to 12 vertical launches and up to 12 associated launch vehicle first-stage landings per year. In addition, there would be up to 12 static fire engine tests and up to 12 wet dress rehearsals per year.

B.2.1.1 Construction

The facilities identified in the previous section and the site infrastructure necessary to support these facilities would be built over an approximately 15-month construction period. During construction, contractors and their workers would be required to meet the Federal OSHA occupational safety standards 29 CFR Parts 1910 and 1926.

The site would not be open to the public, so the public would not be exposed to any hazards associated with construction of the facility. Therefore, public safety is not a concern during construction.

Several historical areas of contamination are located within Proposed Action areas. These contamination (MEC) sites are primarily associated with historical uses of munitions. Construction in areas such as MRA-1 and MRA-2 could potentially expose workers to MECs.

Direct (handling) or indirect contact with MECs has the potential to result in injury or death. Unlike chemical exposure, for which there may be an exposure limit where no adverse effects will occur, there is no accepted method for establishing the incremental probability for injury or death from an encounter with MECs. If the potential for an encounter with MECs exists, the potential that the encounter will result in death or injury also exists.

To minimize the potential for impacts, prior to any work on MEC sites (e.g., MRA-1 and MRA-2), comprehensive surveys would be conducted by a qualified unexploded ordnance disposal contractor. These surveys usually include establishing transects throughout the entire work area and then performing surface and subsurface scans (visual and electronic) along these transects. To ensure maximum coverage, subsurface scans would employ both magnetometers and electromagnetic metal detectors (magnetometers detect only ferrous metals while electromagnetic metal detectors detect both ferrous and nonferrous metals).

Prior to construction, workers would also be educated on the potential for MECs in these areas, including how to recognize MECs and what procedures to apply in case MECs are encountered. These procedures would include leaving MECs where found, stopping all work around the MECs, and contacting the appropriate response personnel. Any detected MECs (either during the surveys or during construction activities) would be investigated and disposed of by an approved unexploded ordnance disposal contractor. If any explosive MEC is encountered, it would be detonated in place after coordination with local agencies, such as the police and fire departments, and the Georgia Environmental Protection Division.

B.2.1.2 Operation

Operational activities would include all launch related activities (beginning with the delivery of the launch vehicle and payload to the launch site and continuing through recovery of the first stage) and activities between launches. During these operational activities, workers would be exposed to hazards associated with the storage and handling of hazardous materials (propellants and other hazardous chemicals) and those associated with the testing and operation of the launch vehicle. Launch site workers (both Spaceport Camden workers and launch provider workers) would be required to meet the Federal OSHA occupational safety standards, 29 CFR Part 1910. Any hazardous materials would be handled in accordance with Federal, State, and local laws and regulations. In addition, Spaceport Camden would require that a launch provider establish an emergency response team for any hazardous or toxic propellants and materials, and spills would be contained and cleaned up per the procedures identified in a Hazardous Materials Emergency Response Plan (14 CFR Section 417.407[1] and OSHA 29 CFR Section 1910.120). Spaceport Camden would also have its own staff and local first responders trained on emergency response to materials held at the launch site.

Some of the hazardous materials handled during operations fall under the category of explosive material (including the rocket liquid propellant). FAA requires (14 CFR Section 420.63) that the launch operator enact an explosive site plan that is in compliance with the requirements of 14 CFR Sections 420.65–420.69. These requirements address the handling, storage, and use of explosive materials. In addition, any issues associated with explosive siting that are not addressed by those regulations must be handled in a manner that demonstrates a level of safety as required by 14 CFR Part 420.

The potential for impacts during operations from MEC sites would be minimized with the identification and removal of any identified MEC during construction. Additionally, it is anticipated that, short of the complete removal of all MEC from the launch site, the current MEC Institutional Control Plan would be maintained. Therefore, operational workers would also be educated on how to recognize MECs and what procedures to apply in case MECs are encountered.

[1] While 14 CRF Section 417.407 does not specifically require a plan, it does require procedures "…for responding to hazardous material emergencies and protecting the public…"

After construction, signage would be posted along all noncleared MEC areas to inform employees and visitors of potential MEC hazards. Additionally, when nonemployees visit the site, they would be escorted and instructed not to leave the prescribed travel routes. As long as these travel routes are adhered to, the probability of an employee or a visitor being exposed to MECs would be extremely low.

The safety and health risks to the general public during launch site operations result from the potential for launch failures. Launch failures, either at the launch site or during flight, could result in public exposure to debris, toxic fumes, and blast overpressures. To limit the risks associated with accidents, the launch site operator and the launch operator would be required to meet all FAA requirements as contained in 14 CFR Parts 400–460.

FAA flight operations regulations at 14 CFR Parts 417, 420, 431, 433, and 435 (collectively, the risk regulations) prescribe actions to be taken by a launch site operator or launch operator to limit risk and limit the collective risk that a commercial launch or reentry may pose to the public. (Title 14 CFR Parts 433 and 435 are not applicable to Spaceport Camden. These parts of the risk regulations address a reentry site and reentry vehicle. While a launch vehicle first stage could land at the Spaceport Camden site, the first stage does not achieve orbit nor reach outer space. Therefore, it is not a reentry vehicle and Spaceport Camden would not be a reentry site.) The FAA regulations were originally adopted from U.S. Air Force regulations for launches from Federal facilities, but have been modified (most recently in July 2016). These regulations impose limits on risk to the public collectively and to individual members of the public. The risk level to an individual would not exceed a $1x10^{-6}$ probability of a casualty per launch from all hazards (debris, toxicity, and blast overpressure). The collective casualty risk to the public from all hazards cannot exceed $1x10^{-4}$ per launch (excluding persons in water-borne vessels and aircraft).

Spaceport Camden and/or the launch operator must develop and implement agreements and plans with local authorities whose support is needed to ensure public safety during all launch processing and flight, in accordance with 14 CFR Subchapter 3. As an example, Spaceport Camden and the launch operator would jointly develop a Security Plan that defines the process for ensuring that any unauthorized persons or vehicles are not within the FAA-approved hazard area or, if they are, that they conform to criteria in 14 CFR Subchapter 3. (Hazard areas are areas of land, sea, and air identified by the launch operator and approved by FAA that must be controlled or evacuated to control risk (14 CFR Section 417.223). Hazard areas include those areas in which debris from a failed launch would be expected to impact land or water. For any single launch failure, debris would impact only a portion of the hazard area. Exhibits 2.1-14 and 2.1-15 in Chapter 2 show representative hazard areas for the northernmost and southernmost trajectories for a launch from Spaceport Camden.) The Security Plan would include safety and security personnel for each launch operation activity and roadblocks and other security checkpoints. (Additional information about establishing and controlling access to the closure areas is provided in Section 2.1.2.5, *Pre-Launch Activities*, of this EIS.)

The radio communications (between the launch site and the launch vehicle) could have the potential to interfere with other radio communications in the area. In addition to commercial communication systems, both the U.S. Navy and Marine Corps operate communication systems in the area. Launch operations at Spaceport Camden would be controlled by a launch communications plan as required by FAA (14 CFR Section 417.111). The use of radio transmissions for launch operations also requires a Federal Communications Commission (FCC) Experimental Authorization (obtained through the FCC Office of Engineering and Technology). The frequency spectrum allocated for commercial launch operations is often within the spectrum allocated for Federal use. The Experimental Authorization includes a noninterference requirement, meaning that licensed operations can neither cause interference nor claim protection from interference. In granting the authorization for a launch, the FCC

would coordinate with other Federal agencies through the U.S. Department of Commerce's National Telecommunications and Information Administration (NTIA). The NTIA is responsible for managing all Federal agency use of the communications spectrum. Coordination of the assigned frequency for launch operations would ensure that the launch operator's activities would not conflict with the communications of other operators (including Department of Defense operators).

FAA regulations (14 CFR Part 417) identify requirements for post-launch and post-flight-attempt hazard control. Part 417 addresses required actions after a successful flight or a failed flight attempt,[2] and in the event of a launch accident. In the event of a failed flight attempt, the operator would be required by FAA regulations (14 CFR §417.415 part [b]) to maintain the flight termination system in an operable state, ensure the vehicle is in a safe condition, and control entry to the launch complex. Among the requirements in the event of a launch accident, the launch operator would be required by FAA regulations (14 CFR §417.415 part (c)) to establish procedural controls for hazards associated with a launch failure that results in a water or land impact beyond the boundary of the launch site. These procedural controls must address: evacuation of members of the public, extinguishing fires, securing impact areas, and ensuring public safety from hazardous debris.

B.2.2 Ocean-Landing Only Alternative

This alternative includes all of the activities identified for the Proposed Action with two exceptions. Under this alternative, there would be no associated launch vehicle first-stage landings at the launch site. Because there are no landings at the launch site, construction of a landing zone would not be necessary. This alternative does not include any activities other than those identified in the Proposed Action.

The health and safety impacts associated with this alternative would be the same as those described for the Proposed Action.

B.2.3 No Action Alternative

Under the No Action Alternative, FAA would not issue a Launch Site Operator License to the Camden County Board of Commissioners. No activities related to constructing or operating a commercial spaceport would occur at the site. Camden County would not exercise its option to purchase the property and the property would continue to be owned by the private landowner. The property is currently unused, under private ownership, and is not accessible to the public. It is assumed that the property would continue to be unused.

Under the No Action Alternative, no activity is projected for the site. There would be no workforce of any kind associated with spaceport activities, including no launch site or launch service provider workers. There would be no occupational health or safety impacts other than those currently at the site associated with Union Carbide Corporation or Bayer CropScience ongoing or future activities. The site is inaccessible to the general public. With no spaceport activity on site, there would be no public health and safety impacts associated with spaceport development or operation.

[2] A failed flight attempt is the failure of the launch vehicle to take off after commanded to launch.

APPENDIX C NOISE

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Blue Ridge Research and Consulting, LLC

Technical Report

Launch Vehicle Noise Study for Spaceport Camden's Environmental Impact Statement

January 2017 (Final)

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Acronyms and Abbreviations

The following acronyms and abbreviations are used in the report:

AEE	Office of Environment and Energy
AST	Office of Commercial Space Transportation
BRRC	Blue Ridge Research and Consulting, LLC
dB	decibel
dBA	A-weighted decibel level
DI	directivity indices
DNL	Day-Night Average Sound Level
DOD	Department of Defense
DSM-1	Distributed Source Method 1
FAA	Federal Aviation Administration
ft	foot/feet
lbf	pound force
lbm	pound mass
$L_{A,max}$	maximum A-weighted OASPL in decibels
L_{max}	maximum unweighted OASPL in decibels
L_{pk}	peak sound pressure level in decibels
MCLV	Medium class launch vehicle
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NIHL	noise-induced hearing loss
NIOSH	National Institute for Occupational Safety and Health
NPS	National Park Service
OASPL	overall sound pressure level in decibels
OSHA	Occupational Safety and Health Administration
EIS	Environmental Impact Statement
P_k	peak pressure
psf	pounds per square foot
RUMBLE	The Launch Vehicle Acoustic Simulation Model
sec	second
SEL	Sound Exposure Level in decibels
µPa	micropascal

1 Introduction

The Camden County, Georgia Board of Commissioners (the County) is proposing to develop and operate a commercial space launch site called Spaceport Camden. The proposed Spaceport Camden property is located in Camden County, Georgia, as shown in Figure 1. To operate a commercial space launch site, the County must obtain a commercial launch site operator license from the Federal Aviation Administration (FAA) Office of Commercial Space Transportation. The issuance of a launch site operator license is considered a Federal action subject to environmental review under the National Environmental Policy Act (NEPA) of 1969 as amended (42 United States Code [U.S.C.] §4321, et seq.). The noise impact of the proposed future actions is evaluated based on the FAA Order 1050.1F, Environmental Impacts: Policies and Procedures.

The Spaceport Camden launch site would include a vertical launch facility, a landing zone, and operational support facilities. The County plans to offer the site for up to 12 vertical launches and up to 12 landings of associated launch vehicle first-stages per year of liquid-fueled, medium-lift-class, orbital and suborbital vertical launch vehicles. Additionally, the Proposed Action includes 12 pre-launch static fire engine tests per year.

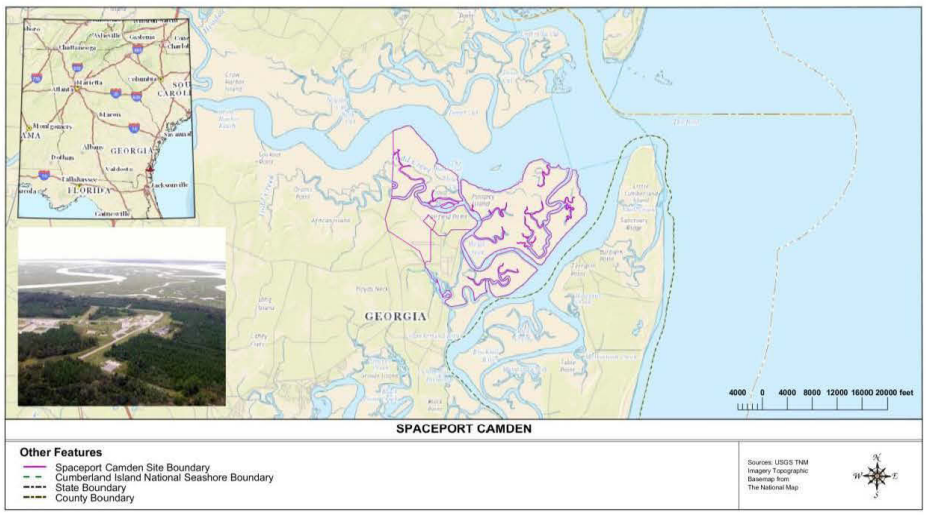

Figure 1. Spaceport Camden site layout

This noise study describes the environmental noise associated with the proposed medium-large class launch vehicle (MCLV) events. Section 2 summarizes the noise metrics discussed throughout this report; Section 3 describes the general methodology of the propulsion noise and sonic boom modeling; Section 4 describes the acoustical modeling input parameters for Spaceport Camden's Launch Site; and Section 5 presents the propulsion noise and sonic boom modeling results. A summary is provided in Section 6 to document the notable findings of this noise study.

2 Noise Metrics and Criteria

2.1 Noise Metrics

Any unwanted sound that interferes with normal activities or the natural environment can be defined as noise. Noise sources can be continuous (constant) or transient (short-duration) and contain a wide range of frequency (pitch) content. Determining the character and level of sound aids in predicting the way it is perceived. Both propulsion noise and sonic booms are classified as transient noise events.

A decibel (dB) is a ratio that compares the sound pressure of a sound source of interest (e.g., the rocket launch) to a reference pressure (the quietest sound humans can hear, 20 µPa [micropascal]). A change in sound level of about 10 dB is usually perceived by the average person as a doubling (or halving) of the sound's loudness. In the community, "it is unlikely that the average listener would be able to correctly identify at a better than chance level the louder of two other-wise similar… events which differed in maximum sound level by < 3 dB" [1]. Standard weighting filters help to shape the levels in reference to how they are perceived. An "A-weighting" filter approximates the frequency response of human hearing, adjusting low and high frequencies to match the sensitivity of human hearing. For this reason, the A-weighted decibel level (dBA) is commonly used to assess community noise. However, if the structural response of a building is of concern in the analysis, a "flat-weighted" (unweighted) level is more appropriate. Sonic boom noise levels are described in units of peak overpressure in pounds per square foot (psf).

Noise metrics are used to describe the noise event and to identify any potential impacts to receptors within the environment. These metrics are based on the nature of the event and who or what is affected by the sound. Individual time-varying noise events have two main characteristics: a sound level that changes throughout the event and a period of time the event is heard. The overall sound pressure level (OASPL) provides a measure of the sound level at any given time and the maximum OASPL (L_{max}) indicates the highest level achieved over the duration of the event. Sound Exposure Level (SEL) represents the cumulative noise exposure of a transient noise event and includes both its magnitude and its duration. However, SEL does not directly represent the sound level heard at any given time. Mathematically, it represents the sound level of a constant sound that would generate the same acoustical energy in one second as the actual time-varying noise event. For sound generated by rocket launches, which last more than one second, the SEL is greater than the L_{max} because an individual launch can last for minutes and the L_{max} occurs over a short duration.

The Day-Night Average Sound Level (DNL) is a cumulative noise metric that accounts for the SEL of all noise events in a 24-hour period. Typically, DNL values are expressed as the level over a 24-hour annual average day. To account for increased human sensitivity to noise at night, a 10 dB penalty is applied to nighttime events (occurring between the hours of 10:00 p.m. and 7:00 a.m.). Therefore, the DNL is dependent on the number of annual daytime and nighttime events. Noise contour maps of these metrics are comprised of lines of equal noise level or exposure, and they serve as visual aids for assessing the impact of noise on the community.

2.2 Noise Criteria

Noise criteria have been developed to protect the public health and welfare of the surrounding communities. The impacts of propulsion noise and sonic booms are evaluated on a cumulative basis in terms of human annoyance per FAA Order 1050.1F. In addition, the propulsion noise and sonic boom impacts are evaluated on a single-event basis in relation to hearing conservation and structural damage criteria. Although FAA Order 1050.1F does not have guidance on hearing conservation or structural damage criteria, it recognizes the use of supplemental noise analysis to describe the noise impact and assist the public's understanding of the potential noise impact.

2.2.1 Human Annoyance

FAA Order 1050.1F, states that a significant noise impact would occur if the "action would increase noise by DNL 1.5 dB[A] or more for a noise sensitive area that is exposed to noise at or above the DNL 65 dB[A] noise exposure level, or that will be exposed at or above this level due to the increase, when compared to the No Action Alternative for the same timeframe". DNL is based on long-term cumulative noise exposure and has been found to correlate well with adverse community impacts for regularly occurring events including aircraft, rail, and road noise [2, 3]. Noise studies used in the development of the DNL metric did not include rocket noise, which are historically irregularly occurring events. Thus, it is acknowledged that the suitability of DNL for infrequent rocket noise and sonic boom events is uncertain. DNL contours are provided in compliance with FAA requirements as the FAA considers DNL the best available metric to estimate the potential long-term annoyance. Additionally, FAA Order 1050.1F notes that the "DNL 65 dB threshold does not adequately address the effects of noise on visitors to areas within a national park or national wildlife refuge where other noise is very low and a quiet setting is a generally recognized purpose and attribute."

2.2.2 Hearing Conservation

Rocket Noise

U.S. government agencies have provided guidelines on permissible noise exposure limits. These documented guidelines are in place to protect human hearing from long-term continuous daily exposures to high noise levels and aid in the prevention of noise-induced hearing loss (NIHL). Three federal agencies have set exposure limits on non-impulsive noise levels including the Occupational Safety and Health Administration (OSHA) [4], Department of Defense (DOD) Occupational Hearing Conservation Program [5], and the National Institute for Occupational Safety and Health (NIOSH) [6]. The most conservative of these upper noise level limits has been set by OSHA at 115 dBA. At 115 dBA the allowable exposure duration is 15 minutes for OSHA and 28 sec for NIOSH and DoD. In addition, the OSHA standard specifies exposure to continuous steady-state noise is limited to a maximum of 115 dBA. Therefore, an $L_{A,max}$ of 115 dBA is used as the best available, conservative threshold to identify potential locations where hearing protection should be considered for a rocket launch.

Sonic Boom

A sonic boom is the sound associated with the shock waves created by a vehicle traveling through the air faster than the speed of sound. Multiple federal government agencies have provided guidelines on permissible noise exposure limits on impulsive noise such as a sonic boom. These documented guidelines are in place to protect one's hearing from exposures to high noise levels and aid in the prevention of NIHL. In terms of upper limits on impulsive or impact noise levels, NIOSH [6] and OSHA [4] have stated that levels should not exceed 140 dB peak sound pressure level, which equates to a sonic boom level of approximately 4 psf.

2.2.3 Structural Damage

Rocket Noise

Typically, the most sensitive components of a structure to propulsion noise are windows, and infrequently, the plastered walls and ceilings. The potential for damage to a structure is unique to the incident sound, the condition of the structure, and the material of each element and its respective boundary conditions. A report from the National Research Council on the "Guidelines for Preparing Environmental Impact Statements on Noise" [7] states that one may conservatively consider all sound lasting more than one second with levels exceeding 130 dB (unweighted) as potentially damaging to structures.

A NASA technical memo found a relationship between structural damage claims and overall sound pressure level, where "the probability of structural damage [was] proportional to the intensity of the low frequency sound" [8]. This relationship estimated that one damage *claim* in 100 households exposed is expected at an average continuous sound level of 120 dB, and one in 1,000 households at 111 dB. The study was based on community responses to the 45 ground tests of the first and second stages of the Saturn V rocket system conducted in Southern Mississippi over a period of five years. The sound levels used to develop the criteria were mean modeled sound levels.

It is important to highlight the difference between the static ground tests in which the rate of structural damage claims is based on and the dynamic events modeled in this noise study. During ground tests, the engine/motor remains in one position which results in longer exposure duration to continuous levels as opposed to the transient noise occurring from the moving vehicle during a launch or landing event. Regardless of this difference, Guest and Slone's (1972) damage claim criteria represents the best available dataset regarding structural damage resulting from rocket noise. Thus, L_{max} values of 120 dB and 111 dB are used in this report as conservative thresholds for potential risk of structural damage claims.

Sonic Boom

Sonic booms are also commonly associated with structural damage. Most damage claims are for brittle objects, such as glass and plaster. Table 1 summarizes the threshold of damage that may be expected at various overpressures [9]. A large degree of variability exists in damage experience, and much of the damage depends on the pre-existing condition of a structure. Breakage data for glass, for example, spans a range of two to three orders of magnitude at a given overpressure. The probability of a window breaking at 1 psf ranges from one in a billion [10] to one in a million [11]. These damage rates are associated with a combination of boom load and glass condition. At 10 psf, the probability of breakage is between one in 100 and one in 1,000. Laboratory tests involving glass [12] have shown that properly installed window glass will not break at overpressures below 10 psf, even when subjected to repeated booms. However, in the real world, glass is not always in pristine condition.

Damage to plaster occurs at similar ranges to glass damage. Plaster has a compounding issue in that it will often crack due to shrinkage while curing or from stresses as a structure settles, even in the absence of outside loads. Sonic boom damage to plaster often occurs when internal stresses are high as a result of these factors. In general, for well-maintained structures, the threshold for damage from sonic booms is 2 psf [9], below which damage is unlikely.

Table 1. Possible damage to structures from sonic booms [9]

Sonic Boom Overpressure Nominal (psf)	Type of Damage	Item Affected
0.5 - 2	Plaster	Fine cracks; extension of existing cracks; more in ceilings; over doorframes; between some plasterboards.
	Glass	Rarely shattered; either partial or extension of existing.
	Roof	Slippage of existing loose tiles/slates; sometimes new cracking of old slates at nail hole.
	Damage to outside walls	Existing cracks in stucco extended.
	Bric-a-brac	Those carefully balanced or on edges can fall; fine glass, such as large goblets, can fall and break.
	Other	Dust falls in chimneys.
2 - 4	Glass, plaster, roofs, ceilings	Failures show that would have been difficult to forecast in terms of their existing localized condition. Nominally in good condition.
4 - 10	Glass	Regular failures within a population of well-installed glass; industrial as well as domestic greenhouses.
	Plaster	Partial ceiling collapse of good plaster; complete collapse of very new, incompletely cured, or very old plaster.
	Roofs	High probability rate of failure in nominally good state, slurry-wash; some chance of failures in tiles on modern roofs; light roofs (bungalow) or large area can move bodily.
	Walls (out)	Old, free standing, in fairly good condition can collapse.
	Walls (in)	Inside ("party") walls known to move at 10 psf.
Greater than 10	Glass	Some good glass will fail regularly to sonic booms from the same direction. Glass with existing faults could shatter and fly. Large window frames move.
	Plaster	Most plaster affected.
	Ceilings	Plasterboards displaced by nail popping.
	Roofs	Most slate/slurry roofs affected, some badly; large roofs having good tile can be affected; some roofs bodily displaced causing gale-end and will-plate cracks; domestic chimneys dislodged if not in good condition.
	Walls	Internal party walls can move even if carrying fittings such as hand basins or taps; secondary damage due to water leakage.
	Bric-a-brac	Some nominally secure items can fall; e.g., large pictures, especially if fixed to party walls.

3 Acoustic Modeling Methodology

Launch vehicle propulsion systems, such as solid rocket motors and liquid-propellant rocket engines, generate high amplitude, broadband noise. The majority of the noise is created by the rocket plume interacting with the atmosphere, and combustion noise of the propellants. Although rocket noise radiates in all directions, it is highly directive, meaning that a significant portion of the source's acoustic power is concentrated in specific directions.

In addition to the rocket noise, a launch vehicle creates sonic booms during supersonic flight. The potential for the boom to intercept the ground depends on the trajectory and speed of the vehicle as well as the atmospheric profile. The sonic boom is shaped by the physical characteristics of the vehicle and the atmospheric conditions through which it propagates. These factors affect the perception of a sonic boom. The noise is perceived as a deep double boom, with most of its energy concentrated in the low frequency range. Although sonic booms generally last less than one second, their potential for impact may be considerable.

3.1 Propulsion Noise Modeling

As the FAA does not currently have an approved model for launch vehicles, the FAA Office of Environment and Energy (AEE), in accordance with FAA Order 1050.1F, must approve all non-standard noise analysis. The Launch Vehicle Acoustic Simulation Model (RUMBLE), developed by Blue Ridge Research and Consulting, LLC (BRRC), is the noise model used to predict the MCLV noise associated with the proposed operations at Spaceport Camden. AEE has reviewed and accepted the RUMBLE noise modeling method for this project as documented in the letter of approval [13]. The core components of the model are visualized in Figure 2 and are described in the following sub sections.

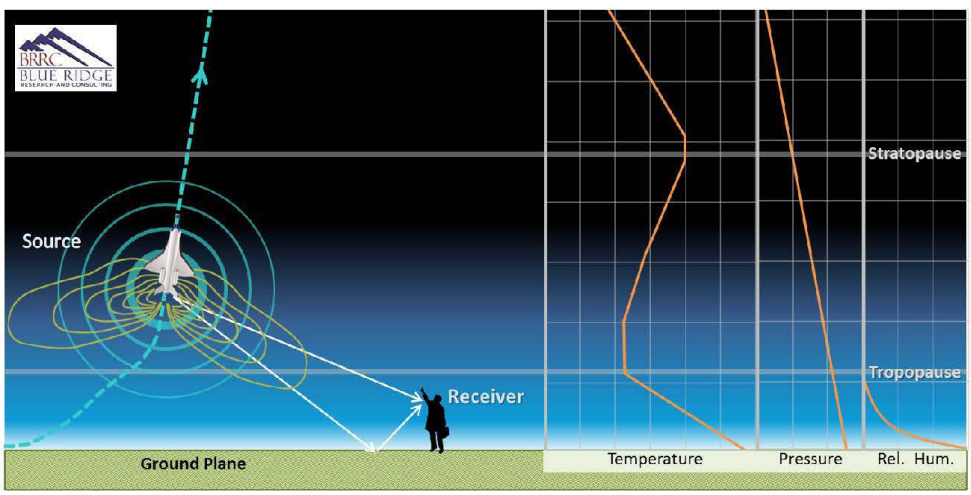

Figure 2. Conceptual overview of rocket noise prediction model methodology.

3.1.1 Source

The rocket noise source definition considers the acoustic power of the rocket, forward flight effects, directivity, and the Doppler effect.

Acoustic Power

Eldred's Distributed Source Method 1 (DSM-1) [14] is utilized for the source characterization. The DSM-1 model determines the launch vehicle's total sound power based on its total thrust, exhaust-velocity and the engine/motor's acoustic efficiency. BRRC's recent validation of the DSM-1 model showed very good agreement between full-scale rocket noise measurements and the empirical source curves [15]. The acoustic efficiency of the rocket engine/motor specifies the percentage of the mechanical power converted into acoustic power. The acoustic efficiency of the rocket engine/motor was modeled using Guest's variable acoustic efficiency [16]. Typical acoustic efficiency values range from 0.2% to 1.0% [14]. In the far-field, distributed sound sources are modeled as a single compact source located at the nozzle exit with an equivalent total sound power. Therefore, launch vehicle propulsion systems with multiple tightly clustered equivalent engines can be modeled as a single engine with an effective exit diameter and total thrust [14]. Additional boosters or cores (that are not considered to be tightly clustered) are handled by summing the noise contribution from each booster/core. The acoustic efficiency and thus power are also affected by the pad impingement and configuration of the flame deflector [17]. When the rocket is close to the pad, the pad impingement reduces the acoustic efficiency and the flame deflector redirects the plume.

Forward Flight Effect

A rocket in forward flight radiates less noise than the same rocket in a static environment. A standard method to quantify this effect reduces overall sound levels as a function of the relative velocity between the jet plume and the outside airflow [18, 19, 20, 21]. This outside airflow travels in the same direction as the rocket exhaust. At the onset of a launch, the rocket exhaust travels at far greater speeds than the ambient airflow. Conversely, for the vertical landing of a launch vehicle, the ambient airflow around the descending rocket body and the jet exhaust are in opposing directions, yielding an increased relative velocity differential from the static condition, and creating increased jet mixing and resultant noise. As the differential between the forward flight velocity and exhaust velocity decreases, jet plume mixing is reduced, which reduces the corresponding noise emission. Notably, the maximum OASPLs are normally generated before the vehicle reaches the speed of sound. Thus, the modeled noise reduction is capped at a forward flight velocity of Mach 1.

Directivity

Rocket noise is highly directive, meaning the acoustic power is concentrated in specific directions and the sound pressure observed will depend on the angle from the source to the receiver. NASA's Constellation Program has made significant improvements in determining launch vehicle directivity of the reusable solid rocket motor (RSRM) [22]. The RSRM directivity indices (DI) incorporate a larger range of frequencies and angles then previously available data. Subsequently, improvements were made to the formulation of the RSRM DI [23] accounting for the spatial extent and downstream origin of the rocket noise source. These updated DI are used for this analysis.

Doppler Effect

The Doppler effect is defined as the change in frequency of a wave for an observer moving relative to its source. The frequency at the receiver is related to the frequency generated by the moving sound source and by the speed of the source relative to the receiver. The received frequency is higher (compared to the emitted frequency) if the source is moving towards the receiver, it is identical at the instant of passing by, and it is lower if the source is moving away from the receiver. During a rocket launch, an observer on the ground will hear a downward shift in the frequency of the sound as the distance from the source to receiver increases. The relative changes in frequency can be explained as follows: when the source of the waves is moving toward the observer, each successive wave crest is emitted from a position closer to the observer than the previous wave. Therefore, each wave takes slightly less time to reach the observer than the previous wave, and the time between the arrivals of successive wave crests at the observer is reduced, causing an increase in the frequency. While they are travelling, the distance between successive wave fronts is reduced such that the waves "bunch together". Conversely, if the source of waves is moving away from the observer, then each wave is emitted from a position farther from the observer than the previous wave; the arrival time between successive waves is increased, reducing the frequency. Likewise, the distance between successive wave fronts increases, so the waves "spread out." Figure 3 illustrates this spreading effect for an observer in a series of images, where a) the source is stationary, b) the source is moving less than the speed of sound, c) the source is moving at the speed of sound, and d) the source is moving faster than the speed of sound. As the frequency is shifted lower, the A-Weighting filtering on the spectrum results in a decreased A-weighted sound level. For unweighted overall sound levels, the Doppler effect does not change the levels since all frequencies are accounted for equally.

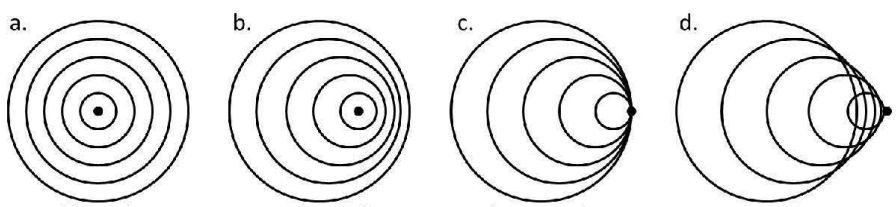

Figure 3. Effect of expanding wavefronts (decrease in frequency) that an observer would notice for higher relative speeds of the rocket relative to the observer for: a) stationary source b) source velocity < speed of sound c) source velocity = speed of sound d) source velocity > speed of sound

3.1.2 Propagation

The sound propagation from the source to receiver considers the ray path, atmospheric absorption, and ground interference.

Ray Path

The model assumes straight line propagation between the source and receiver to determine propagation effects. For straight rays, sound levels decrease as the sound wave propagates away from a source uniformly in all directions. The propulsion noise model components are calculated based on the specific geometry between source (launch vehicle trajectory point) to receiver (grid point). The position of the launch vehicle, described by the trajectory, is provided in latitude and longitude, defined relative to a

reference system (e.g., World Geodetic System 1984 [WGS84]) that approximates the Earth's surface by an ellipsoid. The receiver grid is also described in geodetic latitude and longitude, referenced to the same reference system as the trajectory data, ensuring greater accuracy than traditional flat earth models.

Atmospheric Absorption

Atmospheric absorption is a measure of the sound attenuation from the excitation of vibration modes of air molecules. Atmospheric absorption is a function of temperature, pressure and relative humidity of the air. Figure 2 shows an example atmospheric profile. The atmospheric absorption is calculated using formulas found in ANSI standard S1.26-1995 (R2004). The result is a sound-attenuation coefficient, which is a function of frequency, atmospheric conditions, and distance from the source. The amount of absorption depends on the parameters of the atmospheric layer and the distance that the sound travels through the layer. The total sound attenuation is the sum of the absorption experienced from each atmospheric layer.

Nonlinear propagation effects can result in distortions of high-amplitude sound waves [24] as they travel through the medium. These nonlinear effects are counter to the effect of atmospheric absorption [25, 26]. However, recent research shows that nonlinear propagation effects change the perception of the received sound [27, 28] , but the standard acoustical metrics are not strongly influenced by nonlinear effects [29, 30]. The overall effects of nonlinear propagation on high-amplitude sound signatures and their perception is an on-going area of research.

Ground Interference

The calculated results of the sound propagation using DSM-1 provide a free-field sound level (i.e., no reflecting surface) at the receiver. However, sound propagation near the ground is most accurately modeled as the combination of a direct wave (source to receiver) and a reflected wave (source to ground to receiver) shown in Figure 2. The ground will reflect sound energy back toward the receiver and interfere both constructively and destructively with the direct wave. Additionally, the ground may attenuate the sound energy causing the reflected wave to propagate a smaller portion of energy to the receiver. RUMBLE accounts for the attenuation of sound by the ground [31, 32] when estimating the received noise. The model assumes a five-foot receiver height and a homogeneous grass ground surface. However, it should be noted that noise levels may be 3 dB louder over water surfaces compared to levels over the homogeneous grass ground surfaces assumed in the modeling. To account for the random fluctuations of wind and temperature on the direct and reflected wave, the effect of atmospheric turbulence is also included [31, 33].

3.1.3 Receiver

The received noise is estimated by combining the source and propagation components. The basic received noise is modeled as overall and spectral level time histories. This approach enables a range of noise metrics relevant to environmental noise analysis to be calculated and prepared as output.

3.2 Sonic Boom Modeling

When a vehicle moves through the air, it pushes the air out of its way. At subsonic speeds, the displaced air forms a pressure wave that disperses rapidly. At supersonic speeds, the vehicle is moving too quickly for the wave to disperse, so it remains as a coherent wave. This wave is a sonic boom. When heard at ground level, a sonic boom consists of two shock waves (one associated with the forward part of the vehicle, the other with the rear part) of approximately equal strength and (for fighter aircraft) separated by 100 to 200 milliseconds. For launch vehicles, the separation can be extended because of the volume of the plume. Thus, their waveform durations can be as large as one second. When plotted, this pair of shock waves and the expanding flow between them has the appearance of a capital letter "N," so a sonic boom pressure wave is usually called an "N-wave." An N-wave has a characteristic "bang-bang" sound that can be startling. Figure 4 shows the generation and evolution of a sonic boom N-wave under the vehicle. Figure 5 shows the sonic boom pattern for a vehicle in steady, level supersonic flight. The boom forms a cone that is said to sweep out a "carpet" under the flight track. The boom levels vary along the lateral extent of the "carpet" with the highest levels directly underneath the flight track and decreasing as the lateral distance increases to the cut-off edge of the "carpet." When the vehicle is maneuvering, the sonic boom energy can be focused in highly localized areas on the ground.

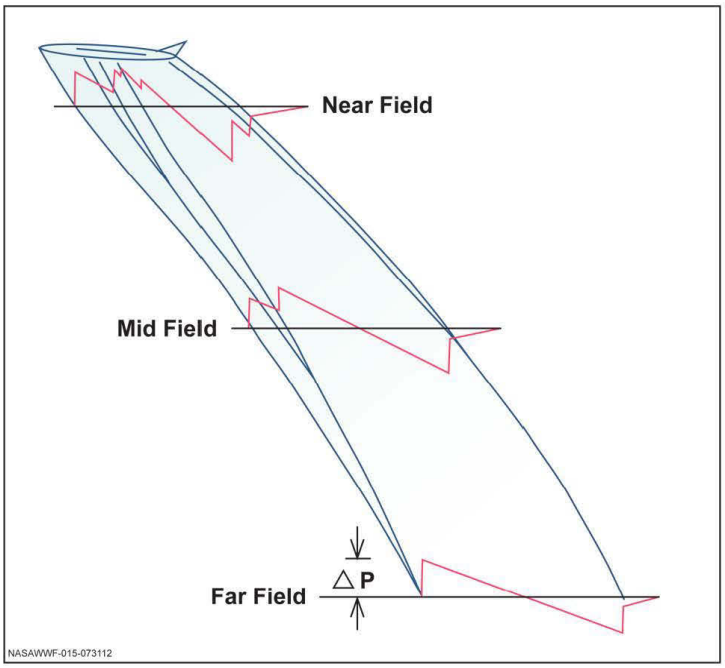

Figure 4. Sonic boom generation and evolution to N-wave [34]

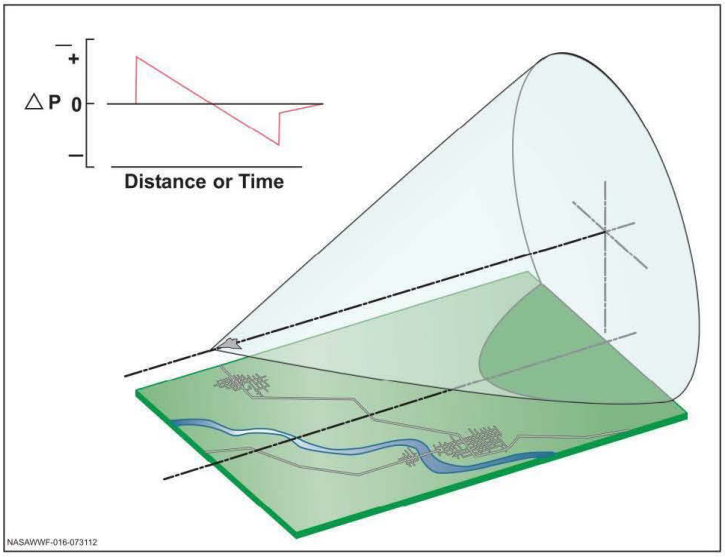

Figure 5. Sonic boom carpet for a vehicle in steady flight [35]

The complete ground pattern of a sonic boom depends on the size, weight, shape, speed, and trajectory of the vehicle. Since aircraft fly supersonically with relatively low horizontal angles, the boom is directed toward the ground. However, for rocket trajectories, the boom is directed laterally until the rocket rotates significantly away from vertical, as shown in Figure 6. This difference causes a sonic boom from a rocket to propagate much further downrange compared to aircraft sonic booms. This extended propagation usually results in relatively lower sonic boom levels from rocket launches. For aircraft, the front and rear shock are generally the same magnitude. However, for a rocket the plume provides a smooth decrease in the vehicle volume, which diminishes the strength of the rear shock.

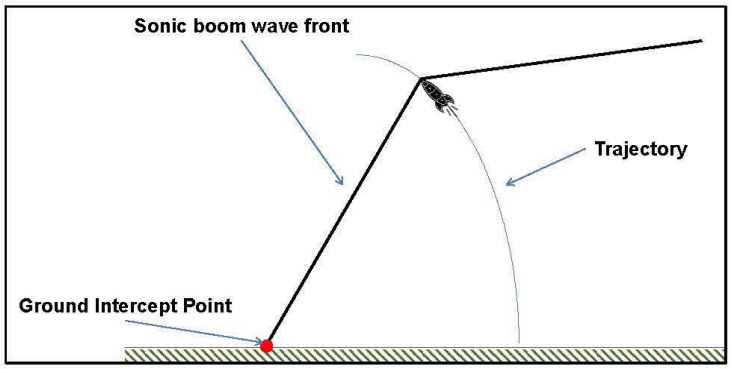

Figure 6. Sonic boom propagation for rocket launch

During reentry of a rocket body, the vehicle can also generate sonic booms on the ground as the body descends back toward the landing site. The sonic booms are somewhat reduced compared to launches as the vehicle is decelerating. For this case, the propagation is directed toward the ground, so the boom is concentrated around the impact site as shown for a sub-orbital rocket in Figure 7.

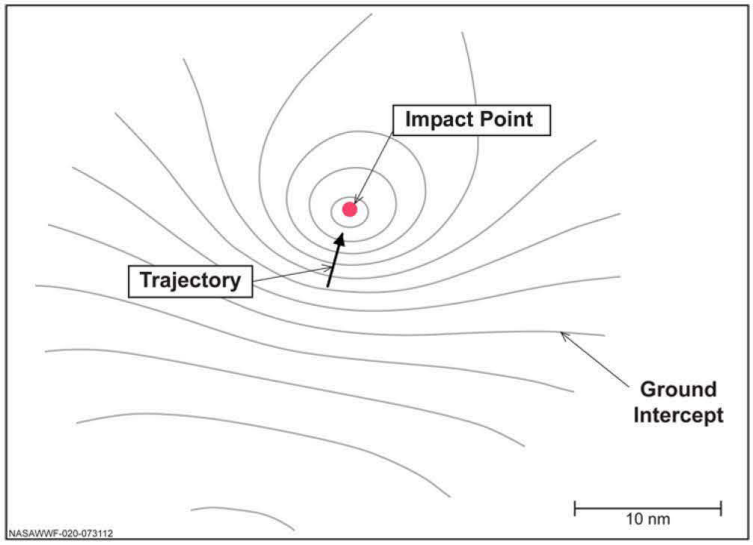

Figure 7. Sonic boom ground intercepts for reentry of a launch vehicle

4 Spaceport Camden Modeling Input

4.1 Launch Site Description

The County has an option to purchase approximately 4,000 acres of an approximately 11,800-acre industrial site on which to construct Spaceport Camden. Spaceport Camden could be expanded to include up to another 7,800 acres of adjoining property in the same industrial site. This land would be used primarily as a buffer. The Spaceport Camden launch site would include a vertical launch facility, a landing zone, and operational support facilities [36].

The locations of the proposed launch and landing sites are shown in Figure 8. Table 2 includes the latitude and longitude coordinates of the sites. The modeled launch pad's flame trench has a heading of 75° measured relative to true north, and an exit angle of 0° measured relative to the horizon. The models utilize an atmospheric profile, which describes the variation of temperature, pressure and relative humidity with respect to the altitude. Standard atmospheric data sources [37, 38, 39] were used to create a composite atmospheric profile for altitudes up to 62 miles.

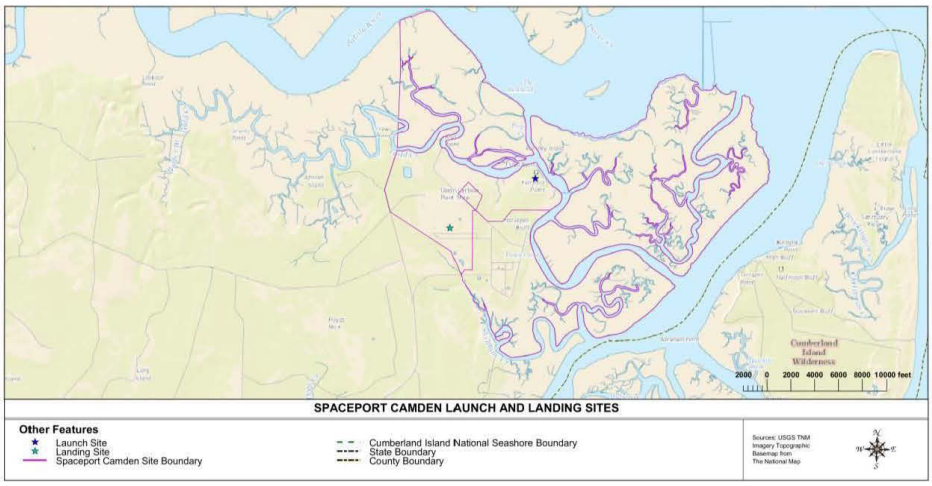

Figure 8. Spaceport Camden proposed launch and landing sites

Table 2. Pad locations at Spaceport Camden

Pad	Latitude degrees	Longitude degrees
Launch Pad/Engine Test Stand	30.947401	-81.506530
Landing Pad	30.936080	-81.529304

4.2 Vehicle and Engine Modeling Parameters

The proposed action involves operations of a liquid-fueled MCLV at Spaceport Camden. The RUMBLE model requires specific vehicle/engine input parameters to determine the noise exposure resulting from the proposed operations of the MCLV. The representative parameters of the MCLV and its engines are presented in Table 3. The combined total thrust of the MCLV's nine engines is modeled using the time varying thrust profile provided in the MCLV nominal trajectory, with a first stage sea level thrust of 1,710,000 lbf.

Table 3. Vehicle and engine parameters used in acoustic modeling

Parameters	Values
Vehicle Description	Medium Class Launch Vehicle
Vehicle Length	229.6 feet
Gross Vehicle Weight	1,207,000 lbs
Number of Engines	9
Net Thrust Per Engine	190,000 lbf
Nozzle Exit Diameter	2.8 feet
Propellant Description	LOX/RP-1

4.3 Flight Trajectory Data

The trajectories of launches departing from the Spaceport Camden launch site and the associated landings are unique to each mission and the environmental conditions. To represent the range of expected missions, three notional trajectory headings have been chosen, 83°, 100°, and 115°, all of which launch over the Atlantic Ocean. The landing trajectories are assumed to return along the same heading as their

associated nominal MCLV launch trajectories. The landing trajectory headings will hereafter be referred to by their associated nominal MCLV launch trajectory heading. As an alternative to the Spaceport Camden landing site, ocean barge landings located off the coast of Georgia will also be considered. Conceptually, MCLV landings include two engine relights. The first engine relight typically happens upon reentering the atmosphere, where the vehicle's altitude is too high to generate significant noise at ground level. The second relight occurs during the final portion of the landing operation. The landing propulsion noise is evaluated for the second relight of the MCLV's landing operation.

4.4 Operational Data

The County plans to offer the site for up to 12 vertical launches and 12 landings of associated launch vehicle first-stages. Additionally, MCLV operations may include up to 12 pre-launch static fire engine tests per year, each test lasting up to seven seconds in duration. This noise study describes the environmental noise associated with the proposed operations of the MCLV, summarized in Table 4.

Table 4. Proposed annual MCLV operations at Spaceport Camden

Operation Type	Trajectory Heading	Annual Operations		
		Acoustic Day 0700 to 2200	Acoustic Night 2200 to 0700	Total
Launch	83°	0	1	1
	100°	8	0	8
	115°	3	0	3
Launch Subtotal		11	1	12
Landing	83°	0	1	1
	100°	8	0	8
	115°	3	0	3
Landing Subtotal		11	1	12
Static		12	0	12
Static Subtotal		12	0	12

5 Results

The following sections present the study results of the environmental noise and sonic boom impacts associated with the proposed 12 vertical launches, 12 landings, and 12 static fire engine tests per year of a MCLV at Spaceport Camden. Single event propulsion noise and sonic boom results are presented in Section 5.1 and cumulative noise results are presented in Section 5.1.2. To provide more detail on potential impacts, supplemental metric results are provided for two specific point of interest locations in Section 5.2. It should be noted that noise levels may be 3 dB louder over water because of the acoustical hardness of the water surface.

5.1 Single Event Results

Propulsion noise and sonic boom impacts are evaluated on a single-event basis in relation to hearing conservation and structural damage criteria. Noise and sonic boom modeling was conducted for on-site launches and landings associated with three notional trajectory headings. As an alternative to on-site landings, Spaceport Camden is considering ocean barge landings. Potential noise and sonic boom impacts from ocean barge landings would be less than those from on-site landings (given the same trajectory heading), therefore, noise and sonic boom modeling for ocean barge landings was not performed. Furthermore, if the ocean barge is located at a sufficient distance off the coast of Georgia, there should

be no sonic boom impacts to land. For example, if the ocean barge platform is located at a distance (measured along the same trajectory path) greater than 20 miles off-shore for the 100° trajectory heading or 30 miles offshore for the 83° and 115° trajectory headings, the sonic boom would not intercept land.

5.1.1 Propulsion Noise

Maximum A-weighted OASPL ($L_{A,max}$)

OSHA has set an upper limit noise level of 115 dBA as a guideline to protect human hearing from long-term continuous daily exposures to high noise levels and to aid in the prevention of noise-induced hearing loss. To assess the potential risk in relation to hearing conservation, the 115 dBA $L_{A,max}$ contours generated by each MCLV event are presented in Figure 10 through Figure 15. $L_{A,max}$ in excess of 115 dBA would be limited to a radius of 0.7 miles from the launch pad for launch events and 0.4 miles from the landing pad for landing events. The static fire engine test $L_{A,max}$ contours are more directive than the launch or landing MCLV events as a result of redirecting the plume in-line with the flame trench heading over the entire duration of the event. During a pre-launch static fire engine test, a receptor located along the peak directivity angle may experience an $L_{A,max}$ of 115 dBA at approximately 0.4 miles from the launch pad. Note, levels produced by static fire engine tests would remain constant over the duration of the event whereas the levels produced by dynamic events would change as the vehicle sound source moves toward or away from the receiver. The area outside of the Spaceport Camden boundary exposed to levels greater than $L_{A,max}$ 115 dBA is limited to waterways that traverse the site's land parcels and 23 acres (0.04 square miles) southwest of the landing pad.

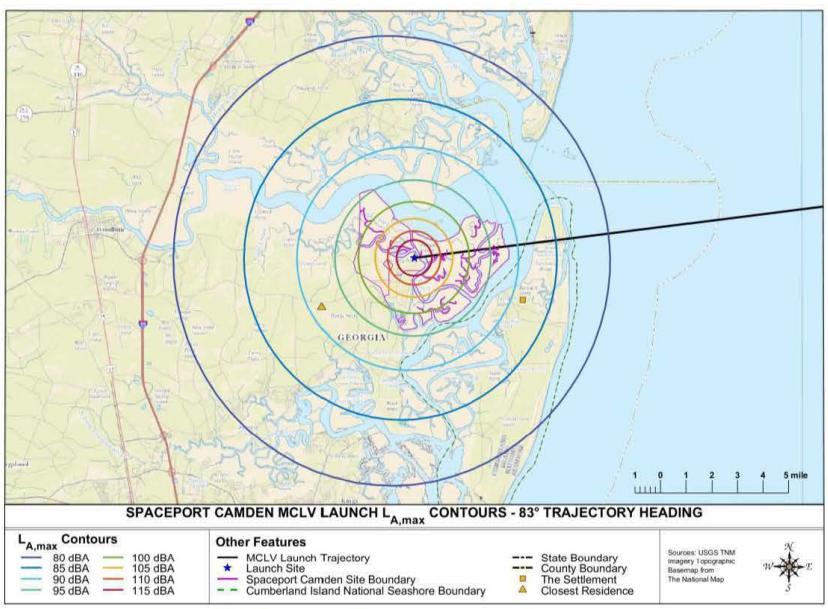

Figure 9. $L_{A,max}$ contours for a MCLV launch - 83° trajectory heading

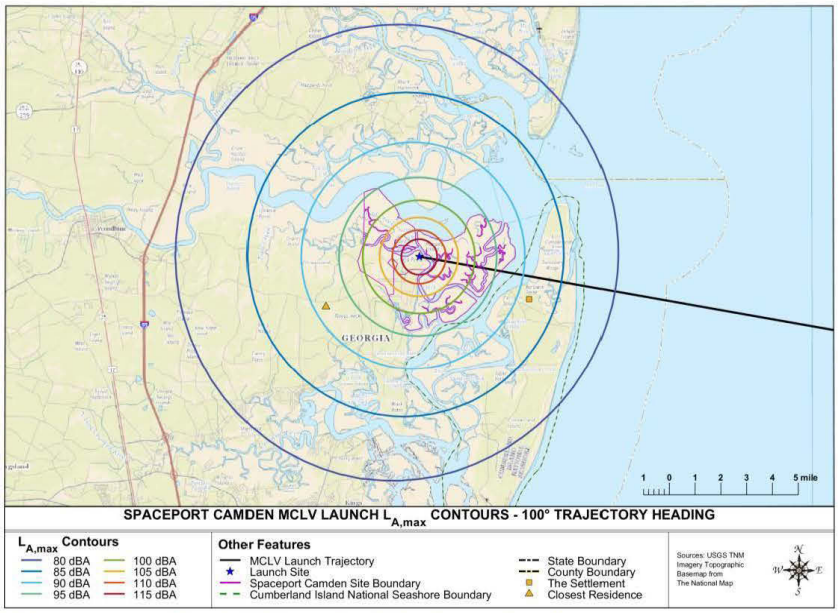

Figure 10. $L_{A,max}$ contours for a MCLV launch - 100° trajectory heading

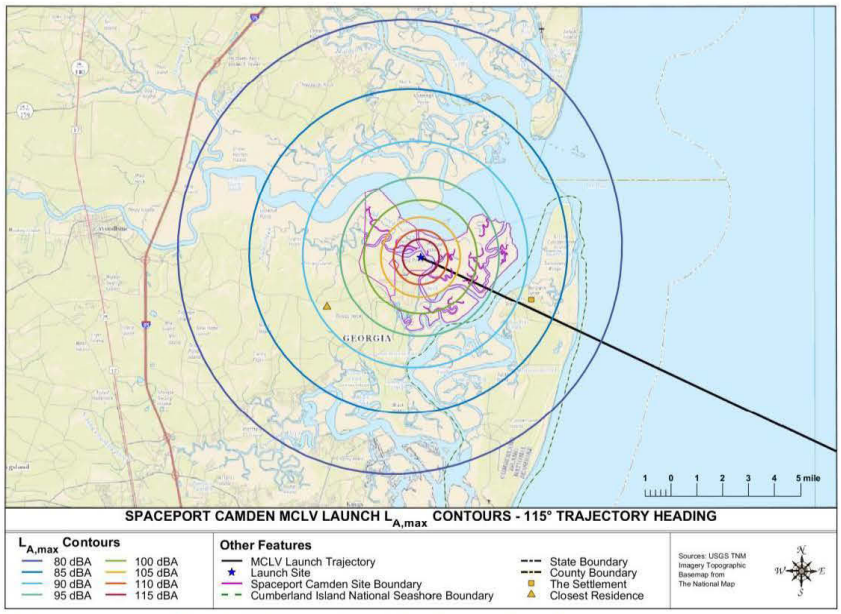

Figure 11. $L_{A,max}$ contours for a MCLV launch - 115° trajectory heading

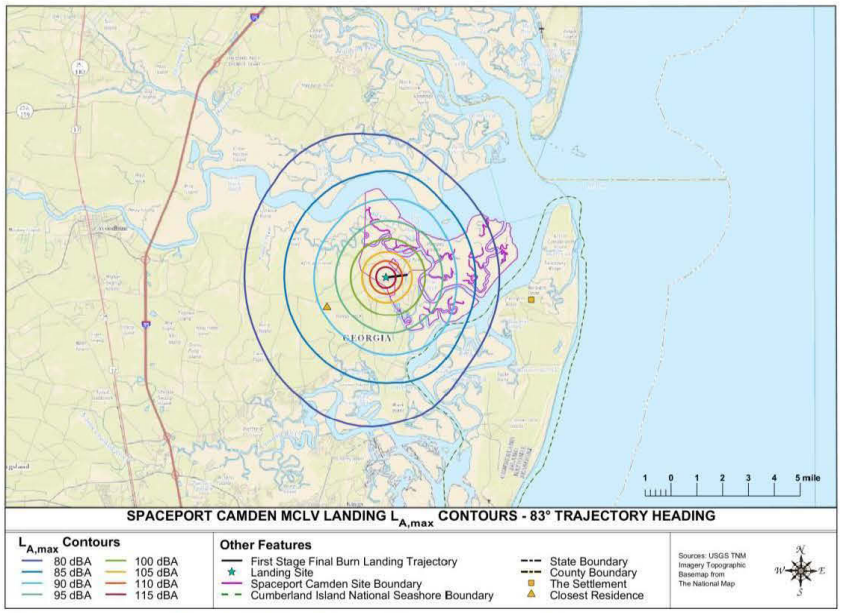

Figure 12. $L_{A,max}$ contours for a MCLV landing - 83° trajectory heading

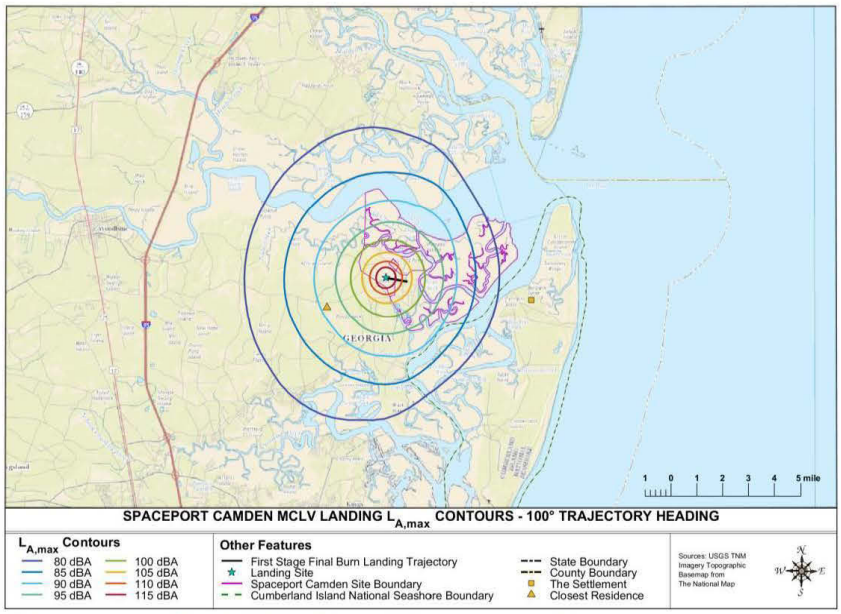

Figure 13. $L_{A,max}$ contours for a MCLV landing - 100° trajectory heading

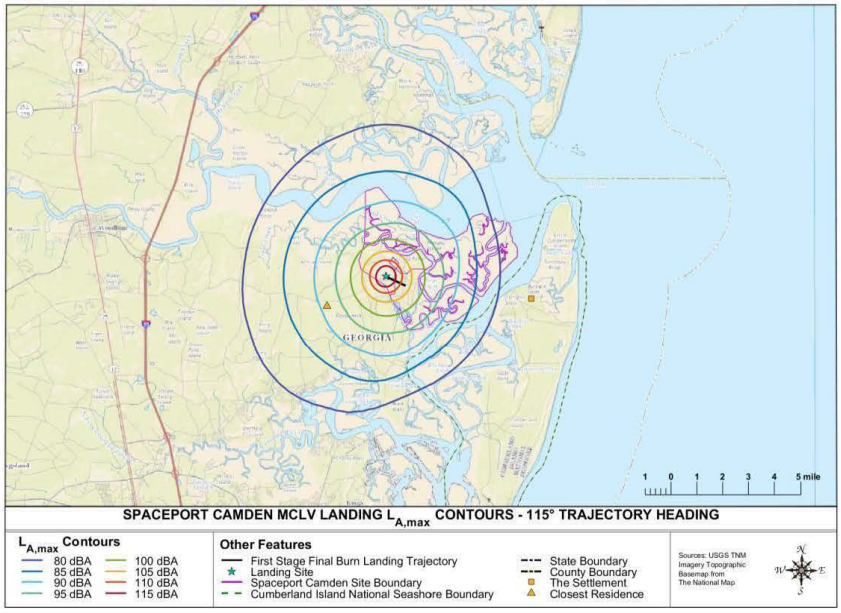

Figure 14. $L_{A,max}$ contours for a MCLV landing - 115° trajectory heading

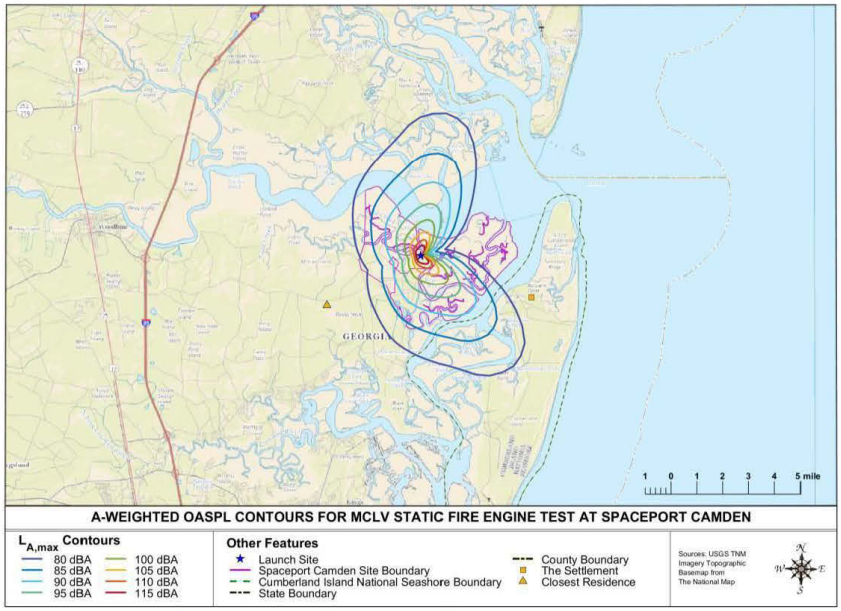

Figure 15. $L_{A,max}$ contours for a MCLV pre-launch static fire engine test

Maximum Unweighted OASPL ($L_{,max}$)

To assess the potential risk to structural damage claims, the 111 dB and 120 dB L_{max} contours generated by each MCLV event are presented in Figure 17 to Figure 22. The potential for structural damage claims is approximately one damage claim per 100 households exposed at 120 dB and one in 1,000 households at 111 dB [8]. L_{max} in excess of 120 dB would be limited to a radius of 2.9 miles from the launch pad for launch events and 0.7 miles from the landing pad for landing events. L_{max} in excess of 111 dB would be limited to a radius of 7.7 miles from the launch pad for launch events and 2.0 miles from the landing pad for landing events. The MCLV pre-launch static fire engine test L_{max} contours, shown in Figure 22, are more directive than the launch or landing MCLV events. A receptor located along the peak directivity angle may experience an L_{max} of 120 dB at 1.8 miles from the launch pad and 111 dB at 4.5 miles from the launch pad. Note, the closest residence, located 4.1 miles from the launch pad, is outside the 120 dB L_{max} contour area.

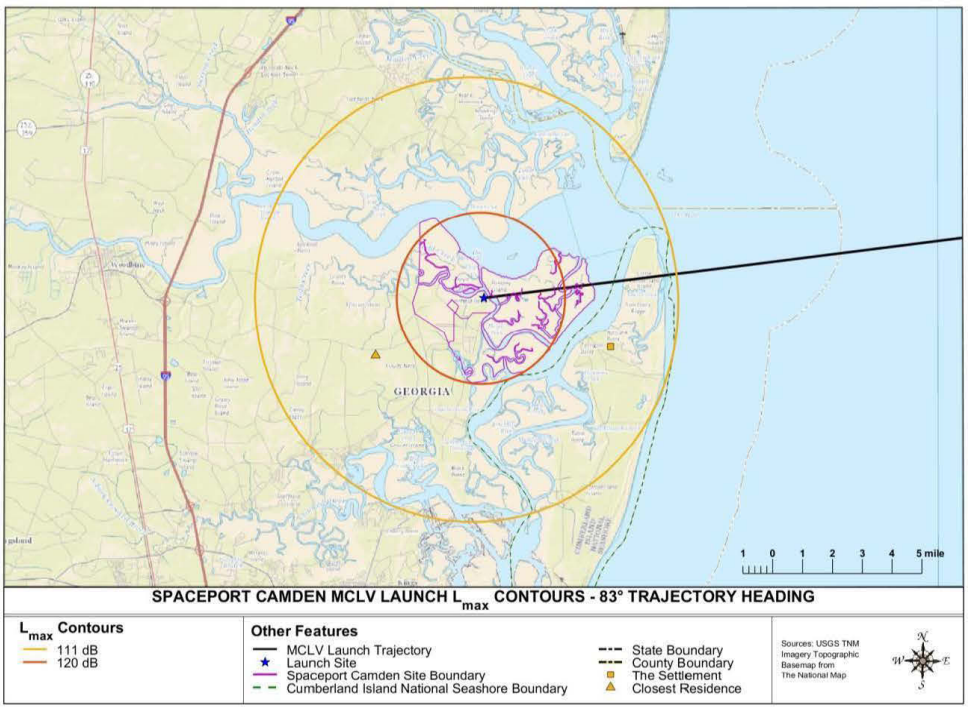

Figure 16. L_{max} contours for a MCLV launch - 83° trajectory heading

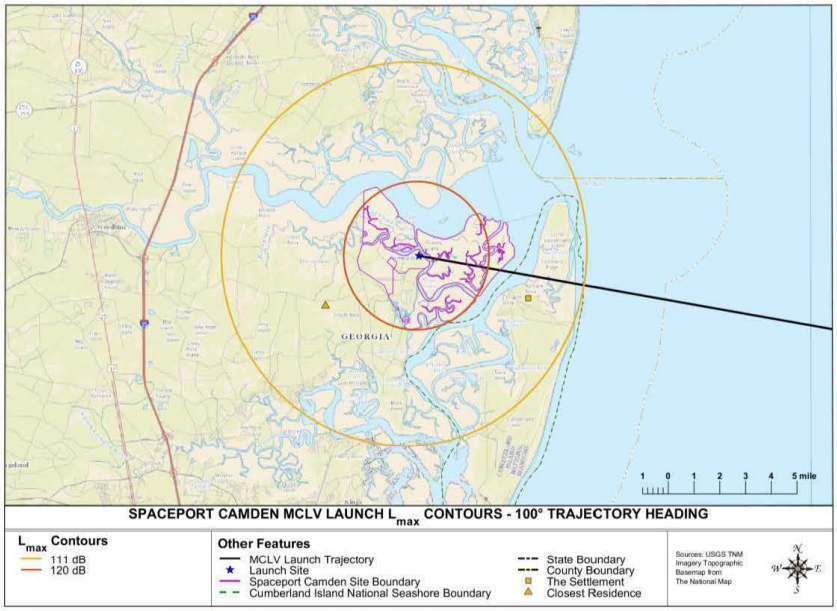

Figure 17. L_{max} contours for a MCLV launch - 100° trajectory heading

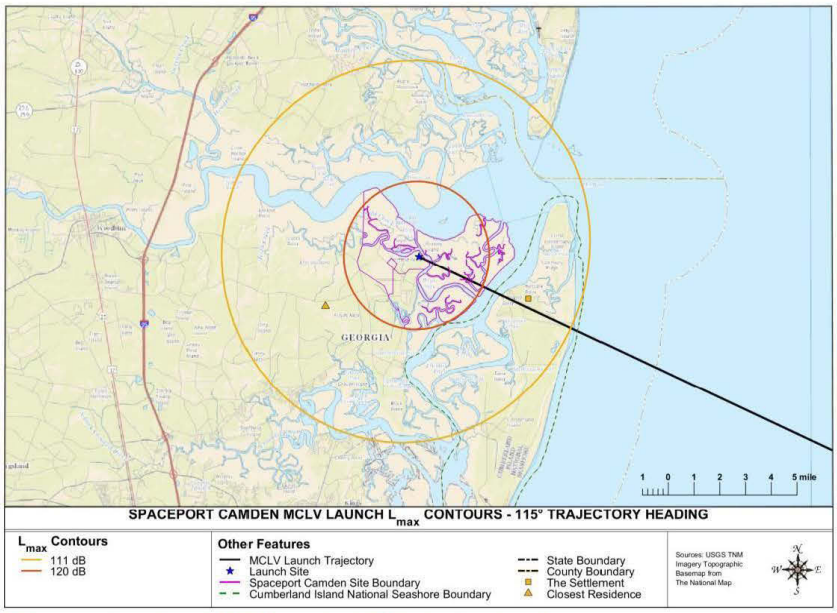

Figure 18. L_{max} contours for a MCLV launch - 115° trajectory heading

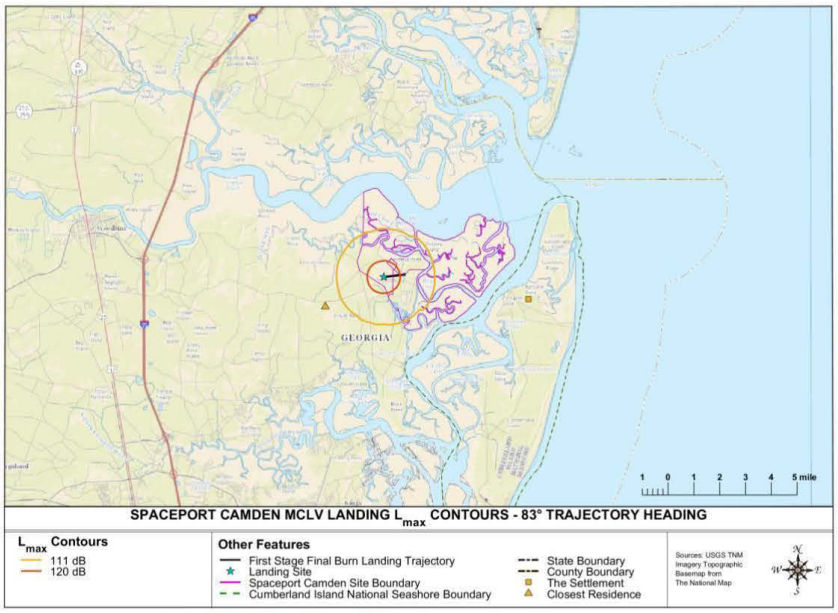

Figure 19. L_{max} contours for a MCLV landing - 83° trajectory heading

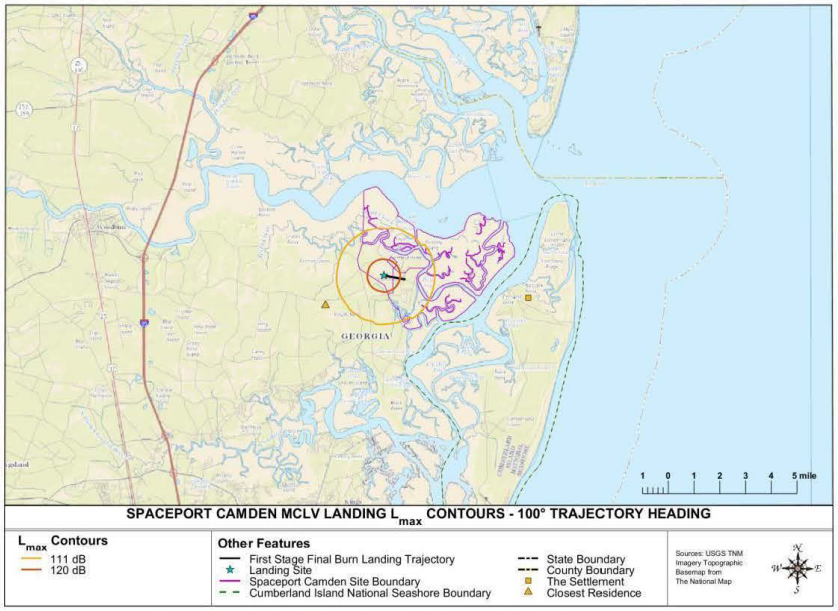

Figure 20. L_{max} contours for a MCLV landing - 100° trajectory heading

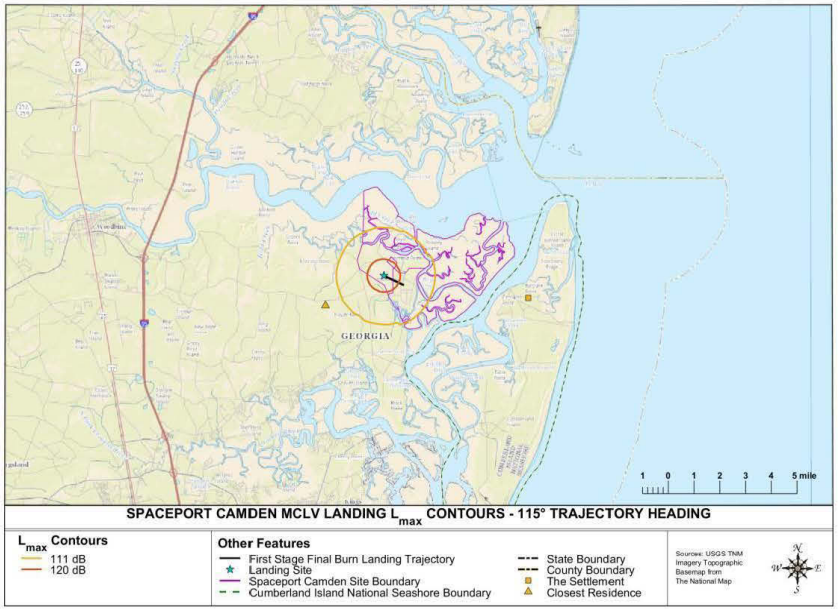

Figure 21. L_{max} contours for a MCLV landing - 115° trajectory heading

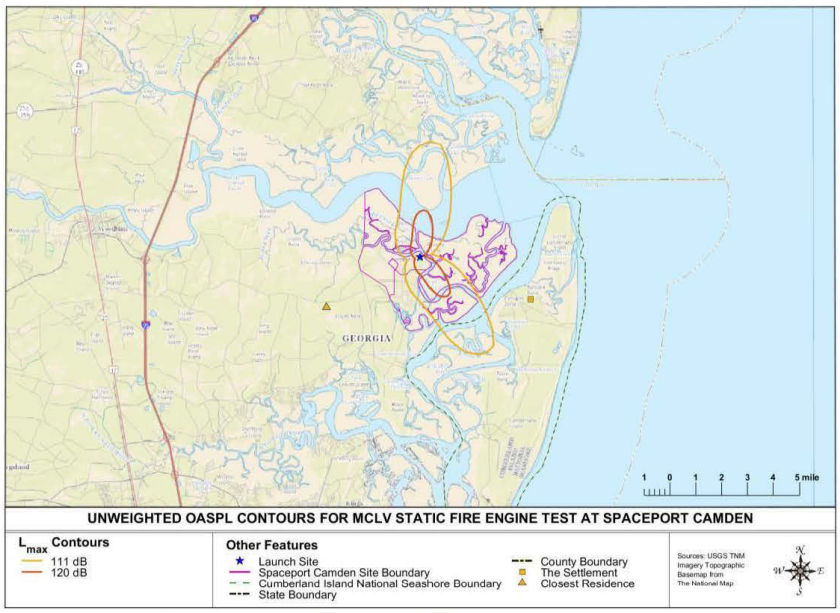

Figure 22. L_{max} contours for a MCLV pre-launch static fire engine test

5.1.2 Sonic Boom

A sonic boom is the sound associated with the shock waves created by a vehicle traveling through the air faster than the speed of sound. The presence and/or location of sonic boom regions is highly dependent on the actual trajectory and atmospheric conditions at the time of flight. The sonic boom contours generated by each MCLV event, represented by peak overpressure in psf, are shown in Figure 24 through Figure 28. In addition to the contours, the figures show the portion of supersonic flight during each event that generate sonic boom footprints that intercept the ground.

For the nominal MCLV launch event, sonic booms intercept the ground during the supersonic portion of the ascent because the flight path angle deviates from vertical with increasing altitude. The modeled overpressure contour values between 0.25 and 5 psf are shown in Figure 24 through Figure 25 for each nominal MCLV launch event. The maximum overpressure is 6.0 psf, is located over water, and covers an area too small to be seen in the figures. The boom footprint falls in the Atlantic Ocean, approximately 47 miles from the launch pad along the launch azimuth. For the nominal launch azimuths, the boom footprint would not intercept land.

For the nominal MCLV first stage landing event, the modeled overpressure contour values between 0.25 and 2 psf are shown in Figure 27 through Figure 28. The boom footprint area largely falls over the Atlantic Ocean. The maximum overpressure is 2.8 psf, located over uninhabited land, just over 2 miles from the landing site in the direction of the landing azimuth, and covers an area too small to be seen in the figure. In inhabited areas, the sonic boom would generate overpressures between 0.25 and 1 psf, with the exception of area adjacent to the landing site and portions of Jekyll Island and Cumberland Island which may experience levels between 1 and 2 psf. For the nominal first stage landings, the boom footprint would intercept land between:

- Savannah, Georgia to the north and Fernandina Beach, Florida to the south for a landing associated with the 83° launch azimuth, and
- Brunswick, Georgia to the north and Fernandina Beach, Florida to the south for a landing associated with the 100° launch azimuth,
- Brunswick, Georgia to the north and St. Augustine, Florida to the south for a landing associated with the 115° launch azimuth.

The maximum modeled overpressure levels over inhabited land are less than 2 psf for sonic booms associated with MCLV first stage landings. The potential for structural damage for levels less than 2 psf is unlikely for well-maintained structures. Damage would be generally limited to bric-a-brac or structural elements that are in ill-repair. The potential for hearing damage (with regards to humans) is negligible, as the modeled sonic boom overpressure levels over land are substantially lower than the ~4 psf impulsive hearing conservation noise criteria.

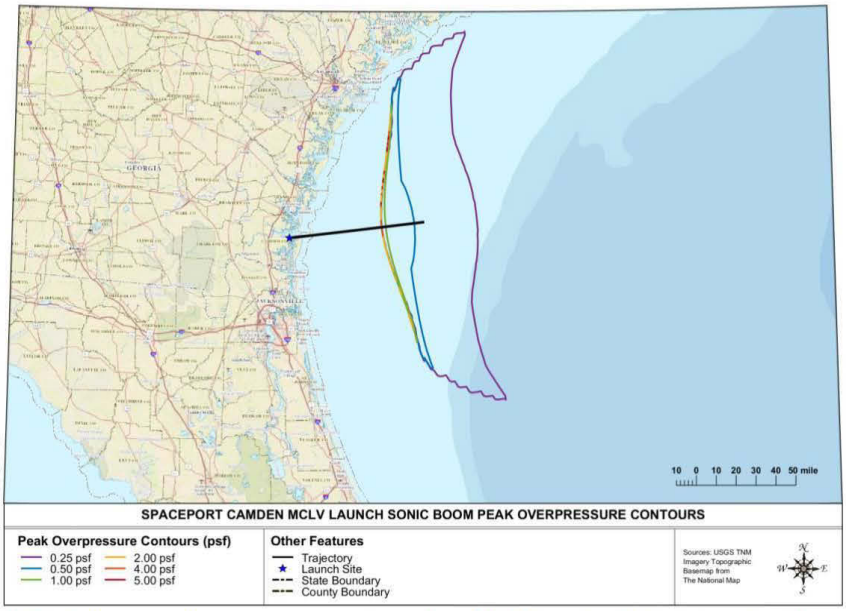

Figure 23. Sonic boom peak overpressure contours for a MCLV launch - 83° trajectory heading

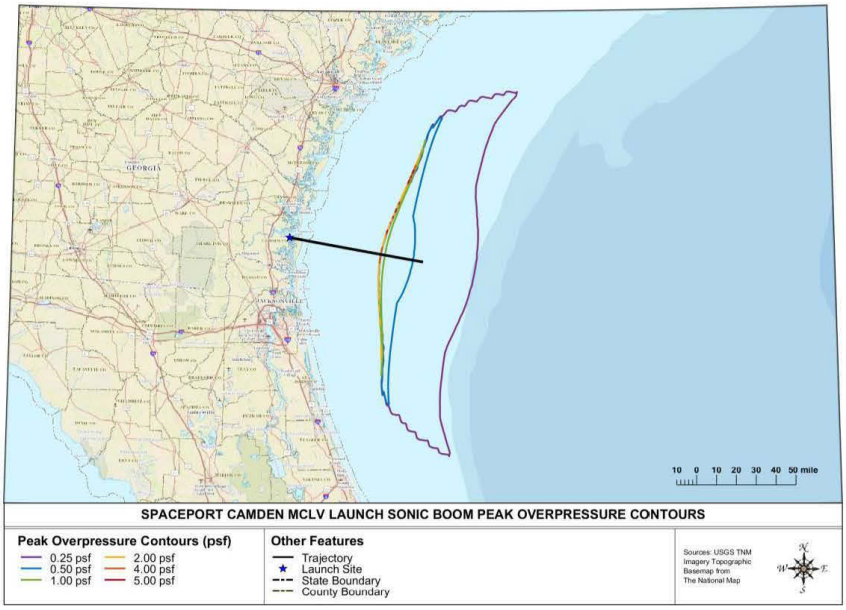

Figure 24. Sonic boom peak overpressure contours for a MCLV launch - 100° trajectory heading

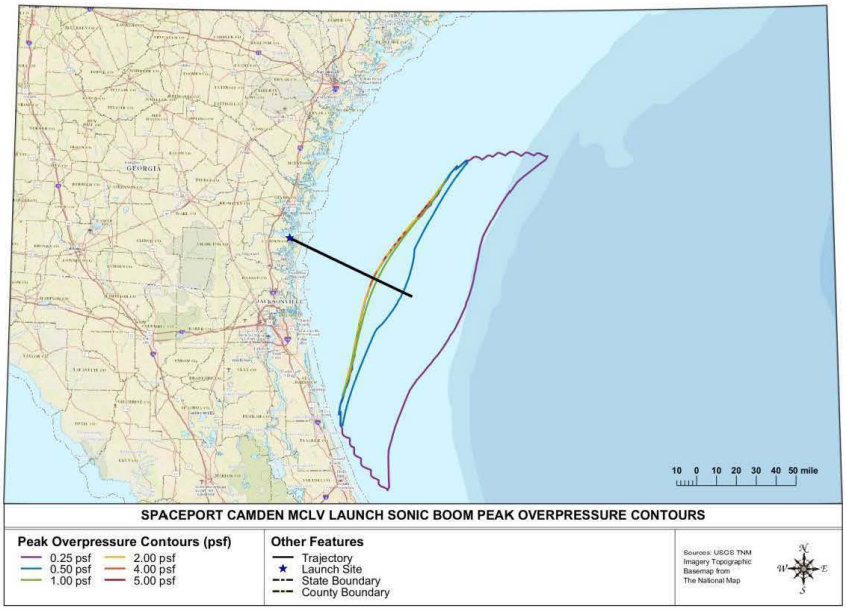

Figure 25. Sonic boom peak overpressure contours for a MCLV launch - 115° trajectory heading

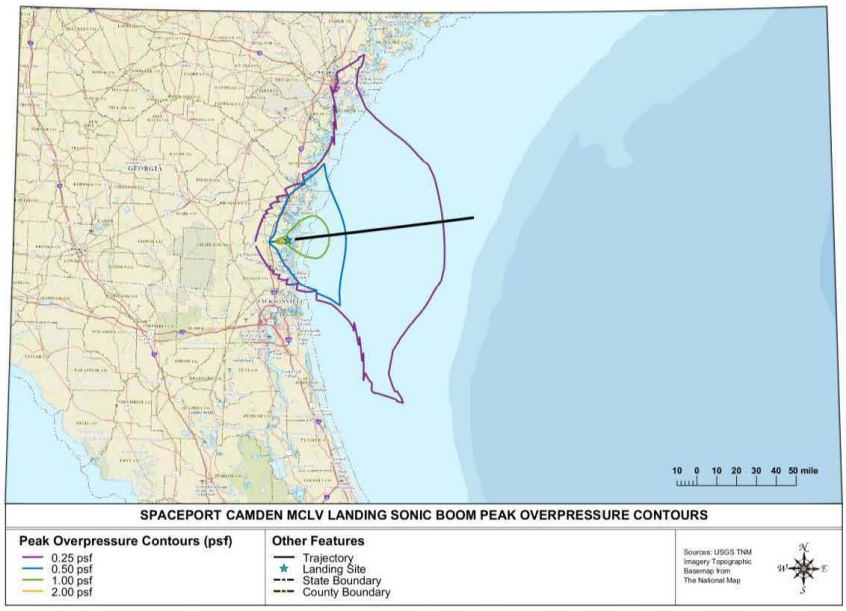

Figure 26. Sonic boom peak overpressure contours for a MCLV landing - 83° trajectory heading

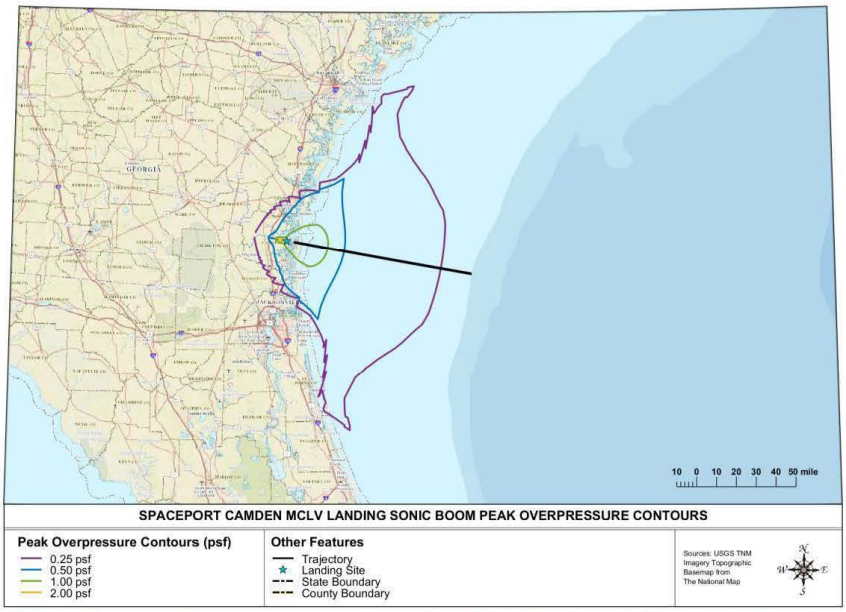

Figure 27. Sonic boom peak overpressure contours for a MCLV landing - 100° trajectory heading

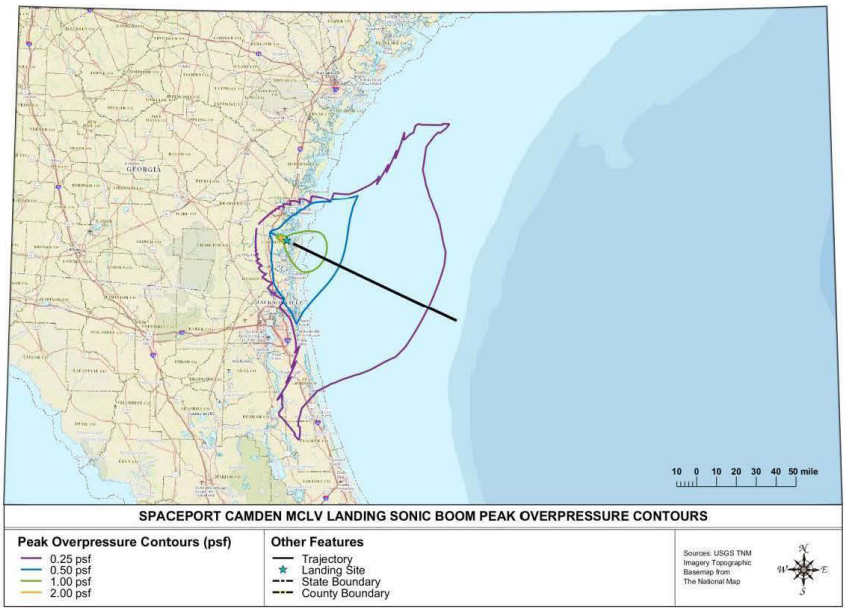

Figure 28. Sonic boom peak overpressure contours for a MCLV landing - 115° trajectory heading

5.2 Cumulative Noise Results

DNL is based on long-term cumulative noise exposure and has been found to correlate well with adverse community impacts. FAA Order 1050.1F, states that a significant noise impact is one in which the "action would increase noise by DNL 1.5 dB[A] or more for a noise sensitive area that is exposed to noise at or above the DNL 65 dB[A] noise exposure level, or that will be exposed at or above this level due to the increase, when compared to the no action alternative for the same timeframe" [40].

Under the no action alternative, the ambient noise conditions in and around the proposed Spaceport Camden site would remain as they are today. A National Park Service (NPS) model reports median sound levels in this area between 36 and 38 dBA [41]. Ambient noise levels for similar environments are typically in the range of 30 to 40 dBA [42].

Under the Proposed Action, the annual MCLV operations would generate levels above the DNL 65 dBA noise exposure threshold, which signifies a large increase in the noise environment compared to the current ambient environment representing the No Action Alternative. The DNL contours from 65 dBA to 85 dBA are presented in Figure 29. The DNL contours near the launch pad exhibit a highly directional pattern as a result of the propulsion noise being re-directed in-line with the flame trench heading at 75°. The contours become more circular further from the launch pad. The DNL contours surrounding the landing pad are approximately circular, with a growth at lower levels in the direction of the landing trajectory. Levels at or above DNL 65 dBA have the potential to affect areas located within 0.8 miles from the launch pad and 0.4 miles from the landing pad. These areas cover approximately 236 acres (0.4 square miles) of land outside of the Spaceport Camden boundary, which is limited to the waterways that traverse the site's land parcels. The area inside the 65 dBA DNL contours is uninhabited.

The sonic boom footprint for nominal launch azimuths does not intercept land and thus would not contribute to the DNL contours. The MCLV first stage landings generate modeled maximum sonic boom overpressure levels of 2 psf over inhabited land, which equates to an equivalent A-weighted DNL of 60 dBA, according to ANSI 12.9 Part 4 Annex B [43]. This 60 dBA contour is well outside the DNL 65 dBA propulsion noise contours and thus would not materially increase the contour area.

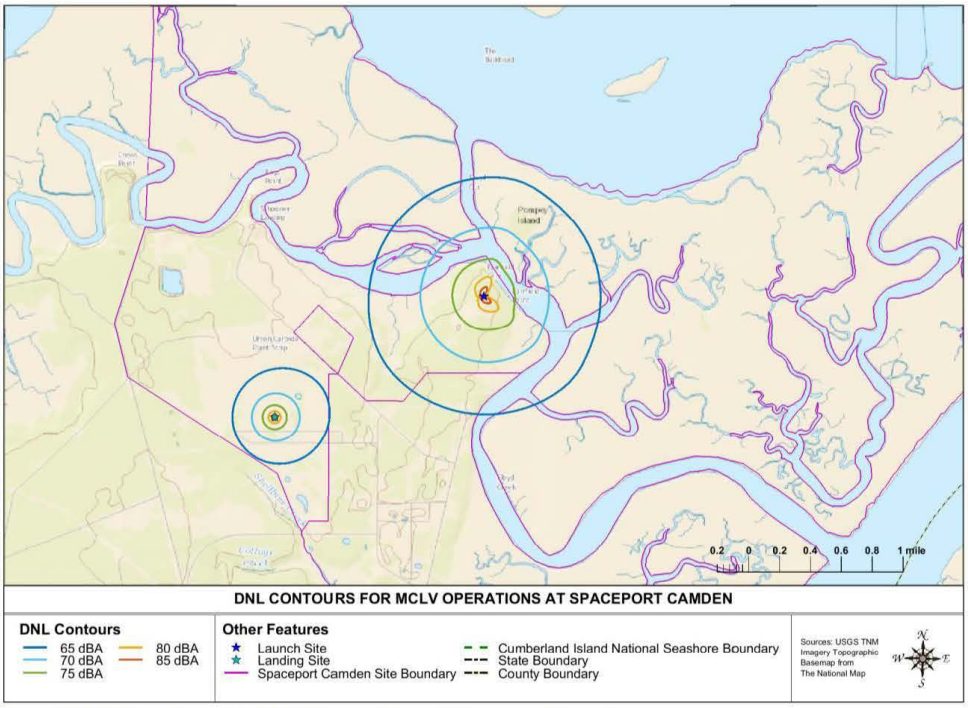

Figure 29. DNL contours for MCLV operations at Spaceport Camden

5.3 Specific Point Analysis

To provide more detail on potential impacts, two specific points of interest were selected (Figure 30):

1. The Settlement (30.923750°N, 81.434717°W), which is located on Cumberland Island (4.6 miles from the launch pad and 5.7 miles from the landing pad) and has been identified as the closest location on the island with standing structures of historic value, and
2. The closest residence (30.919417°N, 81.567733°W), which is located southwest of Spaceport Camden in Camden County (4.1 miles from the launch pad and 2.6 miles from the landing pad).

The results of the specific point analysis are presented in Table 5 and include the $L_{A,max}$, time above 66 dBA, time above 40 dBA, A-weighted SEL, and L_{max} received at The Settlement and the closest residence from the launch, landing, or static fire engine test event that generates the largest impact.

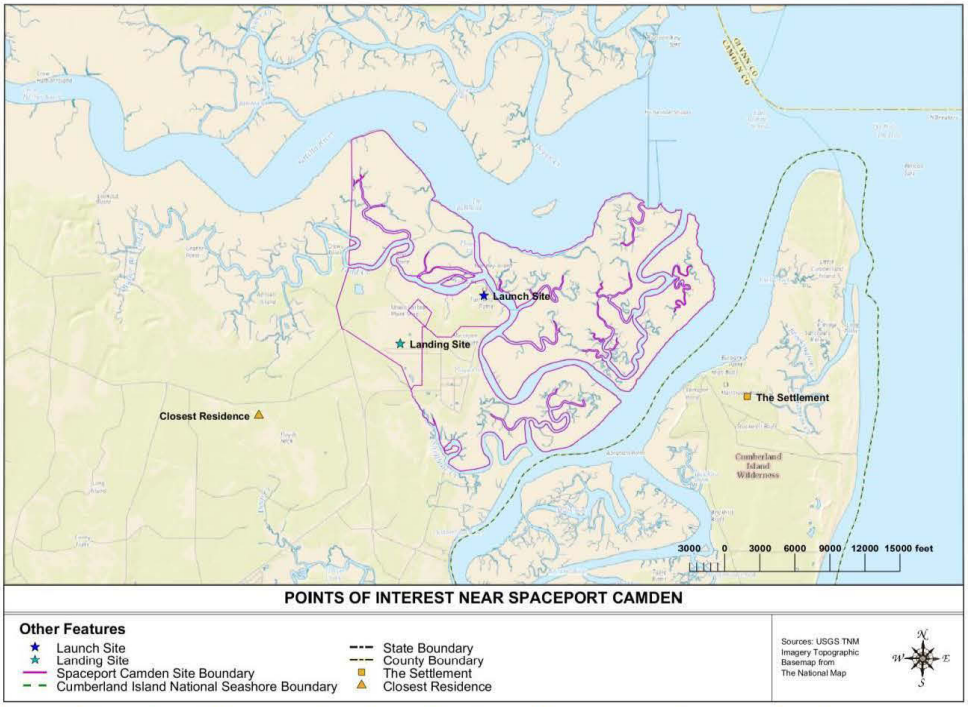

Figure 30. Locations of the two selected specific points of interest near Spaceport Camden

Table 5. Specific point noise analysis results

	The Settlement			Closest Residence		
	Launch	Landing	Static	Launch	Landing	Static
$L_{A,max}$	88 dBA	74 dBA	75 dBA	91 dBA	91 dBA	70 dBA
Time Above 66 dBA	132 sec	28 sec	7 sec	83 sec	23 sec	7 sec
Time Above 40 dBA	266 sec	30 sec	7 sec	240 sec	23 sec	7 sec
SEL	105 dBA	86 dBA	83 dBA	106 dBA	102 dBA	79 dBA
L_{max}	115 dB	93 dB	102 dB	117 dB	108 dB	93 dB

As presented in Table 5, $L_{A,max}$ values received at the points of interest are modeled to be less than the 115 dBA upper limit noise level associated with protecting human hearing. Time above is a supplemental metric associated with speech interference, measured in sentence intelligibility percentage. A sentence intelligibility of 95% usually permits reliable communication because of the redundancy in normal conversation. Levels must remain below 66 dBA to maintain a speech intelligibility of 95% for two people standing outside, approximately 3 ft (1 m) apart [44]. For launches at Spaceport Camden, levels may exceed 66 dBA for a period of up to 83 seconds per launch at the closest residence and 132 seconds per launch at The Settlement as shown by the A-weighted OASPL time history presented in Figure 31.

Although the launch event begins at time zero, it takes approximately 20 seconds for launch noise to propagate over four miles from the launch pad to the points of interest. The time at which the maximum level occurs depends on the thrust profile, peak directivity angle, and distance between the source and the receiver. MCLV first stage landings and static fire engine tests are expected to generate shorter exposure durations above 66 dBA than launch events. The SEL represents the cumulative noise exposure over the noise event and includes both its magnitude and its duration. The MCLV launch event L_{max} values received at the points of interest, presented in Table 5 and shown in Figure 17, are modeled to be between 111 dB and 120 dB, which is predicted to generate structural damage claims at a rate between 1 per 1,000 households and 1 per 100 households.

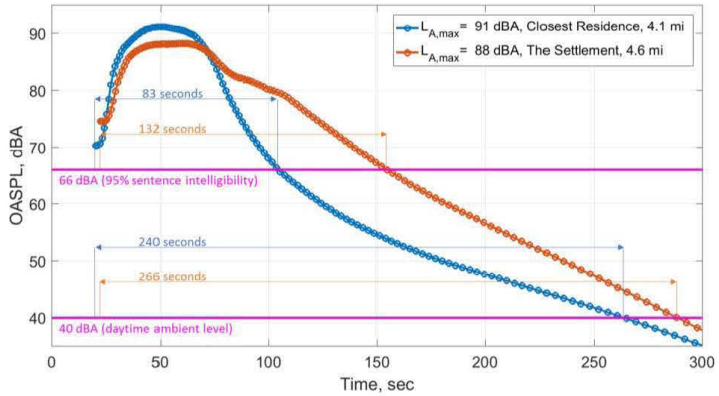

Figure 31. A-weighted OASPL time histories at specific points of interest

The Settlement is located within the Cumberland Island National Seashore and is close to designated wilderness areas, where a quiet setting is a generally recognized purpose and attribute. Thus, additional supplemental metrics are used to better evaluate the effects of noise from Spaceport Camden operations. To better evaluate park visitor response in terms of human annoyance, an adjusted DNL is used to compute the percent highly annoyed. The adjusted DNL for a quiet environment adjusts the basic DNL by adding 10 dBA to account for the greater expectation for and value placed on "peace and quiet" in rural settings. For the Settlement, the adjusted DNL is approximately 53 dBA, which equates to 3% highly annoyed [43]. Additionally, noise levels may exceed daytime ambient levels of 40 dBA for an estimated period of 266 seconds per launch at the Settlement.

The points of interest would experience sonic booms from MCLV first stage landing events but not from MCLV launches as a result of their relative close proximity to the launch site. Sonic boom peak overpressure levels from MCLV first stage landings are modeled to be between 1.4 and 1.5 psf at The Settlement and between 0.9 and 1.1 psf at the closest residence. As the overpressure levels at both points of interest are less than 2 psf, sonic booms associated with the MCLV first stage landings are not anticipated to affect hearing conservation or cause structural damage, assuming the structures at these locations are well-maintained.

6 Summary

The Camden County, Georgia Board of Commissioners is proposing to develop and operate a commercial space launch site called Spaceport Camden. This report documents the noise study associated with Spaceport Camden's proposed 12 vertical launches, 12 landings, and 12 static fire engine tests per year of a MCLV. To represent the range of expected missions, three notional trajectory headings were chosen, 83°, 100°, and 115°, all of which launch over the Atlantic Ocean. The landing trajectories are assumed to return along the same heading as their associated nominal MCLV launch trajectories.

The single event propulsion noise and sonic boom results are discussed in relation to hearing conservation and structural damage claims. The propulsion noise analysis uses OSHA's upper noise level limit of 115 dBA, set as a guideline to protect human hearing from long-term continuous daily exposures. $L_{A,max}$ in excess of 115 dBA would be limited to a radius of 0.7 miles from the launch pad and 0.4 miles from the landing pad. The potential for structural damage claims from propulsion noise is approximately one damage claim per 100 households exposed at 120 dB and one in 1,000 households at 111 dB [8]. L_{max} in excess of 120 dB would be limited to a radius of 2.9 miles from the launch pad and L_{max} in excess of 111 dB would be limited to a radius of 7.7 miles from the launch pad. With regards to the sonic booms resulting from MCLV launches and first stage landings, the potential for structural damage is unlikely for well-maintained structures and the potential for hearing damage (with regards to humans) is negligible as the maximum modeled overpressure levels over inhabited land that are less than 2 psf.

The noise impact of the proposed future actions is evaluated based on the FAA Order 1050.1F, Environmental Impacts: Policies and Procedures. A significant noise impact is one in which the "action would increase noise by DNL 1.5 dB[A] or more for a noise sensitive area that is exposed to noise at or above the DNL 65 dB[A] noise exposure level, or that will be exposed at or above this level due to the increase, when compared to the No Action Alternative for the same timeframe" [40]. DNL in excess of 65 dBA would be limited to a radius of 0.8 miles from the launch pad and 0.4 miles from the landing pad. However, the area within the 65 dBA DNL contour is uninhabited. The sonic boom footprint for nominal launch azimuths does not intercept land and thus would not contribute to the DNL contours. The MCLV first stage landings generate an equivalent A-weighted DNL of 60 dBA, which is well outside the DNL 65 dBA propulsion noise contours, and thus would not materially increase the contour area.

To provide more detail on potential impacts, two specific points of interest were selected: The Settlement on Cumberland Island and the closest residence in Camden county. The modeled $L_{A,max}$ at the points of interest is less than the 115 dBA upper limit noise level associated with protecting human hearing. The modeled L_{max} at the points of interest is between 111 dB and 120 dB, which is predicted to generate structural damage claims at a rate between 1 per 1,000 households and 1 per 100 households. The points of interest would experience sonic booms from MCLV first stage landing events but not from MCLV launches. As the overpressure levels at both points of interest are modeled to be less than 2 psf, sonic booms associated with the MCLV first stage landings are not anticipated to affect hearing conservation or cause structural damage, assuming the structures at these locations are well-maintained.

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APPENDIX D BIOLOGICAL RESOURCES

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D BIOLOGICAL RESOURCES

This appendix provides additional information on biological resources identified in Chapter 3, *Affected Environment*.

D.1 Terrestrial Animals

Eastern Indigo Snake

The federally threatened eastern indigo snake (*Drymarchon corais couperi*) is a wide-ranging snake primarily found in sandhills habitat, but during warmer months it may also be found in stream bottoms, swamps, and flatwoods. The average home range of the indigo snakes varies by season, with an individual using up to 100 hectares for foraging during late summer and fall, and as limited a range as 10 hectares during the winter (NatureServe, 2016). Indigo snakes frequently utilize gopher tortoise burrows as refugia from cold temperatures in winter, for egg laying, and for protection during shedding when they are more vulnerable to predation. Mating occurs from November through March, and eggs are laid in late spring and hatch approximately three months later. Indigo snakes feed on small mammals, snakes, frogs, birds, and other small vertebrates.

The current range from the indigo snake includes southern Georgia and Florida, with rare occurrences in Alabama, Mississippi, and South Carolina. Habitat destruction and fragmentation are the primary threats to this species.

Gopher Tortoise

The gopher tortoise (*Gopherus polyphemus*) is a Federal candidate species in the eastern portion of its range (east of the Mobile and Tombigbee Rivers). The 12-month finding on a petition to list it as threatened within its eastern range stated that the listing of the gopher tortoise is warranted; however, listing is currently precluded by higher priority actions, and a proposed rule to list the gopher tortoise will be developed as priorities allow.

The gopher tortoise is found primarily in longleaf pine and oak sandhills but may also be found in pine flatwoods, dry hammock, scrub, coastal grasslands, and in disturbed habitats, such as roadsides and powerline rights-of-way. Gopher tortoises excavate tunnel-like burrows for shelter from climatic extremes and refuge from predators; these burrows can vary from 9 to 23 feet deep and 3 to 52 feet long but typically are closer to 15 feet long and 6.5 feet deep (USFWS, 2016). The primary features of good tortoise habitat are well-drained sandy soils, open canopy with plenty of sunlight, and abundant food plants (forbs and grasses). Prescribed fire is often employed to maintain these conditions. During warmer months when tortoises are active, they typically will dig and use multiple burrows. Breeding season is April to November, with nest construction from mid-May to mid-June. Eggs are typically laid at the opening to the burrow.

The current range of the gopher tortoise extends from Louisiana to southern South Carolina, primarily in the Coastal Plain. Populations are threatened by habitat destruction, degradation, and fragmentation, incompatible herbicide use, and predation.

Red-Cockaded Woodpecker

The red-cockaded woodpecker (*Picoides borealis*) is federally listed as endangered. This small woodpecker requires large expanses of mature, open pine forest, particularly longleaf, slash, or loblolly

pine. These habitats are typically maintained by fire. Nest and roost cavities are excavated only in old living pines, and the process may take several years to complete. Trees selected for cavities are usually infected with red heart fungus, which softens the heartwood, making excavation easier.

Red-cockaded woodpeckers (RCWs) exist in family groups that typically consist of an adult breeding pair and up to four helpers that are usually male offspring from previous years. The group roosts in a cluster of cavity trees, with an average cluster size of about 10 acres and a typical group territory area of 125 to 200 acres (USFWS, 2016a). Mid-April, the female lays eggs in the tree cavity of the breeding male, and eggs incubate for 10 to 11 days. Both the parents and helpers participate in incubating eggs and brooding and feeding nestlings, which fledge from the nest cavity 24 to 27 days after hatching (USFWS, 2016a). RCWs feed primarily on insects but may also forage on fruits and seeds.

The current range of the RCW includes Alabama, Arkansas, Florida, Georgia, Louisiana, North Carolina, Mississippi, Oklahoma, South Carolina, Virginia, and Texas. Habitat degradation, destruction, and fragmentation are the major threats to RCWs, including conversion to nonforested land uses and fire suppression.

Striped Newt

The striped newt (*Notophthalmus perstriatus*) is a Federal candidate species that is found within longleaf pine-wiregrass communities. Striped newts prefer pine flatwoods and sandhills as adults, while using isolated, ephemeral wetlands for breeding and larval development. These wetlands are typically vegetated with emergent sedges, grasses, and forbs. Striped newts breed in late winter and early spring when ponds fill with rainwater. After larval development and transformation, striped newts are typically exclusively terrestrial for one to three years. Upon reaching sexual maturity, they migrate to ponds to breed and live as aquatic adults until the ponds dry, forcing them back to land. Striped newts feed on crustaceans, insects, and frog eggs (GADNR, 2016).

The range of the striped newt extends from the Georgia side of the Savannah River into northern and peninsular Florida. Where they are found within the Coastal Plain of Georgia, major threats include agricultural and pine plantation conversion, fire suppression, and wetland alteration.

Wood Stork

Wood storks (*Mycteria americana*) are federally threatened birds that nest in large colonies, primarily in cypress or mangrove swamps, where they often nest in the upper branches of large trees. In Georgia, the nesting period begins in late winter or early spring, with fledging in July and August (USFWS, 2016). Preferred foraging habitats for wood storks include narrow tidal creeks, freshwater marshes, and flooded tidal pools, especially depressions where fish become concentrated when water levels fall. Wood stork colonies occur approximately 5 miles north of the Spaceport Camden site at Black Hammock, 10 miles northeast of the site at Jekyll Island and 15 miles to the south near St. Marys (see Exhibit 3.2-2 in the EIS).

Nesting of the threatened southeastern wood stork population is limited to Georgia, Florida, and South Carolina, with storks moving northward after breeding as far as North Carolina, Alabama, and eastern Mississippi. Primary threats to the wood stork include loss of feeding habitat, human manipulation of water levels at nesting sites, predation, and lack of nest tree regeneration. To minimize adverse impacts to wood storks, USFWS has identified management zones for activities in close proximity to rookeries, foraging areas, and roosting sites (USFWS, 1990).

Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) is protected by the Bald and Golden Eagle Protection Act. Eagles are territorial and exhibit a strong affinity for a nest site once a nest has been established. It is common for a breeding pair to rebuild damaged or lost nests in the same tree or in an adjacent tree. Individual pairs return to the same territory year after year, and territories are often inherited by subsequent generations. The nesting period in the southeast United States extends from 1 October to May 15, with most nests being completed by the end of November. The quality and amount of forage resources, mainly fish and carrion, heavily influence fledgling survival.

Piping Plover

The piping plover (*Charadrius melodus*) is federally listed as threatened in the Atlantic coast region. The south Atlantic coast is utilized as winter breeding grounds for the Atlantic coast population, as well as other U.S. populations (USFWS, 2016). Piping plovers forage along intertidal mudflats and beaches and the shorelines of streams, ephemeral ponds, lagoons, and salt marshes. They feed by probing the ground for insects, molluscs, worms, and small crustaceans. Small sand dunes, debris, and sparse vegetation on beach and shoreline habitat provide shelter from wind and extreme temperatures (USFWS, 2016). Wintering birds (July through late October) utilize a variety of habitats, including beaches, mudflats, sandflats, and spoil islands. Critical habitat for the piping plover includes portions of Cumberland Island and Jekyll Island (Exhibit 3.2-3 in the EIS).

Red Knot

The red knot (*Calidris rufa*) is federally listed as threatened. The red knot breeds in central and eastern Russia, Alaska, Canada, and Greenland. Wintering areas occur along the southeast Atlantic Coast, including Georgia. During migration and in the winter, red knots eat bivalves, small snails, and crustaceans. In Georgia, small clams including coquina (*Donax spp.*) and dwarf surf (*Mulinia lateralis*) are an important part of their fall and winter diet; horseshoe crab eggs are consumed heavily during spring staging along the Georgia coast.

D.2 Marine Mammals

Marine mammals are species that rely on ocean environments for all or a significant portion of their life cycles. All marine mammals are protected by the Marine Mammal Protection Act (MMPA). Marine mammals that occur in the Proposed Action area include whales, dolphins, porpoises (under the National Oceanic and Atmospheric Administration [NOAA] jurisdiction) and manatees (under the U.S. Fish and Wildlife Service [USFWS] jurisdiction). Five species of marine mammals may occur in waters of or close to Spaceport Camden: North Atlantic right whale (*Eubalaena glacialis*), humpback whale (*Megaptera novaeangliae*), Atlantic spotted dolphin (*Stenella frontalis*), bottlenose dolphin (*Tursiops truncatus*), and West Indian manatee (*Trichechus manatus*). All marine mammals are protected under the Marine Mammal Protection Act, and two of these species (North Atlantic right whale and West Indian manatee) are also protected under the Endangered Species Act.

North Atlantic Right Whale

The North Atlantic right whale is federally listed as an endangered species under the Endangered Species Act (ESA) (35 *Federal Register* [FR] 18319); this listing was revised in 2008 (73 FR 12024). A five-year review completed in August 2008 recommended maintaining the endangered classification of this species (National Marine Fisheries Service, 2012). The North Atlantic right whale is designated as depleted under the MMPA. North Atlantic right whales are baleen whales that typically feed on dense patches of zooplankton (primarily *Calanus* and *Pseudocalanus*). For much of the year, distribution of this species is strongly correlated with the distribution of its prey (National Oceanic and Atmospheric

Administration, 2016). Right whales generally feed from spring to fall, though feeding may also occur in the winter in some areas. The North Atlantic right whale migrates annually between calving grounds in the coastal waters of the southeastern United States to feeding and nursery grounds in the waters off New England and in the Canadian Bay of Fundy, Scotian Shelf, and Gulf of St. Lawrence.

The primary food sources of the North Atlantic right whale are zooplankton, including copepods, euphausiids, and cyprids. Unlike many other baleen whales, right whales feed by opening their mouths and swimming through large patches of zooplankton. Their baleen filters out tiny prey but allows water to flow through (NOAA Fisheries, 2016). Right whales feed at or just below the surface (Kenney, 2001) or within a few meters of the seafloor on near-bottom aggregations of zooplankton (Baumgartner, 2009; Baumgartner, Ji, & Chen, 2009; Warren, 2009).

NOAA Fisheries has established a series of seasonal management areas along the U.S. east coast at certain times of the year to reduce the threat of ships collisions with the endangered North Atlantic right whales (NOAA Fisheries, 2016). Within these management areas, all vessels 65 feet or longer must travel at 10 knots or less. Regulations to reduce the likelihood of serious injuries and deaths from ship collisions were enacted in 2008 (73 FR 60173) and amended in 2013 (78 FR 73726). The Southeast U.S. Seasonal Management Area restricts ship speed in the calving and nursery grounds from November 15 through April 15. The offshore waters of Spaceport Camden are included in the Southeast U.S. Seasonal Management Area.

Critical habitat for North Atlantic right whales was originally designated in 1994 (59 FR 28793) and included portions of Cape Cod Bay and Stellwagen Bank, the Great South Channel (each off the coast of Massachusetts), and waters adjacent to the coasts of Georgia and the east coast of Florida. These areas were identified as providing critical feeding, nursery, and calving habitat. On January 27, 2016, NMFS issued a final rule (81 FR 4837) to replace the critical habitat for North Atlantic right whales with two new, expanded areas. These expanded areas contain the physical and biological features essential to the conservation of the North Atlantic right whale, providing requirements for successful foraging, calving, and calf survival (National Marine Fisheries Service, 2015). Critical habitat for the protection of essential foraging features is located in the Gulf of Maine and Georges Bank region (Unit 1) and covers a total area of approximately 21,334 square nautical miles (nm^2). Critical habitat for the protection of calving essential features is located off the southeast U. S. coast between North Carolina and Florida (Unit 2) and covers 8,429 nm^2 (Exhibit D-1).

<u>Humpback Whale</u>

NOAA Fisheries revised the ESA listing for humpback whales in September 2016 (81 FR 62259) to divide the globally listed endangered species into 14 distinct population segments (DPSs), remove the current species-level listing and in its place list four DPSs as endangered and one DPS as threatened. The nine remaining DPSs were identified as not warranted for listing. Individuals that occur off Spaceport Camden are considered part of the Gulf of Maine stock (National Oceanic and Atmospheric Administration, 2016). The Gulf of Maine stock is part of the West Indies DPS, which was identified as not warranting listing (81 FR 62259) in the 2016 revision to the ESA listing of humpback whales. Since this DPS is not listed under the ESA, there is no critical habitat. The humpback whale remains designated as depleted under the MMPA.

Humpback whales in the western North Atlantic feed during the spring, summer, and fall over a geographic range that includes the eastern coast of the United States (including the Gulf of Maine), the Gulf of St. Lawrence, Newfoundland/Labrador, and western Greenland (Katona, 1990; National Oceanic and Atmospheric Administration, 2016). During the winter, humpback whales from the North Atlantic will migrate to the West Indies for breeding and calving. Not all whales migrate to the West Indies, with significant numbers of individuals being found in mid- and high-latitude regions at this time (NOAA

Fisheries, 2016b). Calving can occur from December through June and tends to peak from January through March. The gestation period for humpback whales is approximately 11 months, and they tend to prefer shallow waters while feeding and calving. There has been an increase in the number of wintertime humpback whale sightings along the U.S. Atlantic coast from Florida north to Virginia since the early 1990s (Swingle W. B., 1993; Wiley, 1995; Laerm, 1997; Barco, 2002; Swingle W. M., 2007). Considering life history characteristics and historical records of sightings and strandings, humpbacks will be expected to occur in the waters off Spaceport Camden from fall through spring, though the probability of occurrence is low.

The overall North Atlantic population (including the Gulf of Maine), derived from genetic tagging data collected by the YONAH project on the breeding grounds, was estimated to be 4,894 males (95 percent confidence interval [CI] = 3,374 to 7,123) and 2,804 females (95 percent CI = 1,776 to 4,463) (Palsbøll, 1997; National Oceanic and Atmospheric Administration, 2016).The most recent line-transect survey, which did not include the Scotian Shelf portion of the stock, produced an estimate of abundance for Gulf of Maine humpback whales of 331 animals (coefficient of variation [CV] = 0.48), with a resultant minimum population estimate for this stock of 228 animals. The line-transect-based minimum population estimate is unrealistic, because at least 500 uniquely identifiable individual whales from the Gulf of Mexico stock were seen during the calendar year of that survey and the actual population would have been larger because resighting rates of Gulf of Mexico humpbacks have historically been less than one. Using the minimum count from at least two years prior to the year of a stock assessment report allows time to resight whales known to be alive prior to and after the focal year. Thus, the minimum population estimate is set to the 2008 mark-recapture-based count of 823 (National Oceanic and Atmospheric Administration, 2016).

Humpback whales feed on a variety of invertebrates and small schooling fishes and can consume up to 3,000 pounds of food per day (NOAA Fisheries, 2016b). The most common invertebrate prey are krill; the most common fish prey are herring, mackerel, sand lance, sardines, anchovies, and capelin (Clapham, 1999). Feeding occurs both at the surface and in deeper waters, wherever prey is abundant. The humpback whale is the only species of baleen whale that shows strong evidence of cooperation when feeding in large groups (D'Vincent, 1985). Humpbacks have been observed using air bubbles to herd, corral, or disorient fish (Jefferson, 2008). One highly complex variant, called “bubble netting,” is unique to humpbacks (NOAA Fisheries, 2016b). This technique is often performed in groups with defined roles for distracting, scaring, and herding before whales lunge at prey corralled near the surface.

Atlantic Spotted Dolphin

Atlantic spotted dolphins in U.S. waters have been divided into two stocks for management purposes: the Northern Gulf of Mexico Stock and the Western North Atlantic Stock (NOAA Fisheries , 2016c). Individuals that occur off Spaceport Camden belong to the Western North Atlantic Stock.

Atlantic spotted dolphins are distributed in tropical and warm temperate waters of the western North Atlantic, ranging from southern New England, south through the Gulf of Mexico and the Caribbean to Brazil (Leatherwood, 1976; Perrin W. , 2008). Atlantic spotted dolphin sightings have been concentrated in the slope waters north of Cape Hatteras, but in the shelf waters south of Cape Hatteras, sightings extend into the deeper slope and offshore waters of the mid-Atlantic. This species is common in continental shelf waters south of Cape Hatteras and in continental shelf edge and continental slope waters north of Cape Hatteras (National Oceanic and Atmospheric Administration, 2014). Higher numbers of Atlantic spotted dolphins have been reported over the continental shelf west of Florida from November to May than during the rest of the year, suggesting that this species may migrate seasonally (Griffin, 2003). This species occurs in deeper waters of the continental shelf, typically at least 4.9 to 12.4 miles offshore (Perrin W. F., 1994; Davis, 1998; Perrin W. F., 2002).

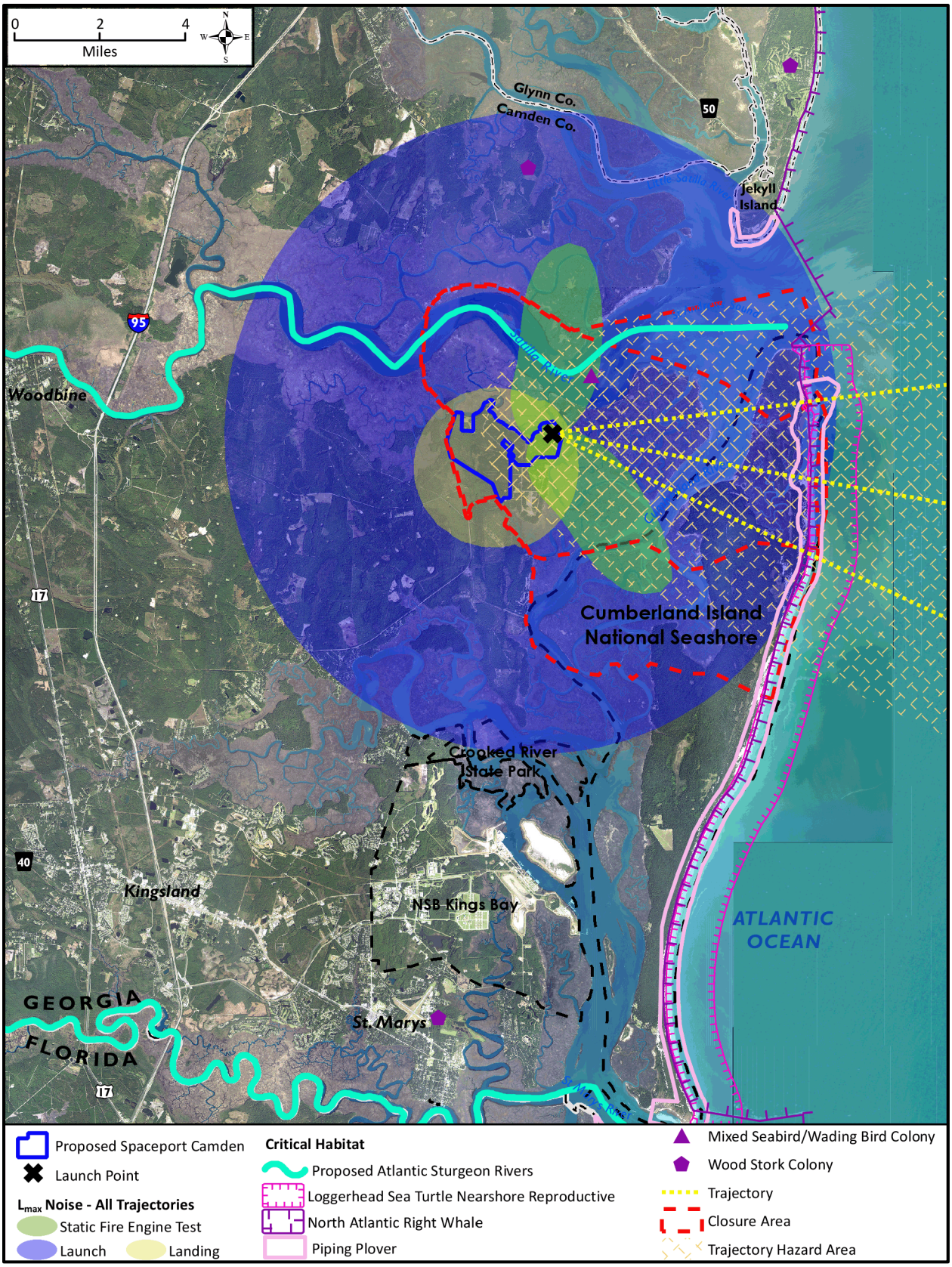

Exhibit D-1. Critical Habitat

The best abundance estimate available for Atlantic spotted dolphins in the western North Atlantic is 44,715 (CV = 0.43). This estimate is from summer 2011 surveys covering waters from central Florida to the lower Bay of Fundy (National Oceanic and Atmospheric Administration, 2014).

The diet of the Atlantic spotted dolphin varies depending on its location (Jefferson, 2008; Perrin W. F., 1994). Atlantic spotted dolphins feed on small cephalopods, fishes, and benthic invertebrates (Perrin W. F., 1994). In the Gulf of Mexico, Atlantic spotted dolphins were observed feeding cooperatively on clupeid fishes and are known to feed in association with shrimp trawlers (Fertl D. &., 1997; Fertl D. &., 1995; MacLeod, Hauser, & Peckham, 2004). In the Bahamas, this species has been observed chasing and catching flying fish (MacLeod, Hauser, & Peckham, 2004).

Bottlenose Dolphin

Bottlenose dolphins in the vicinity of Spaceport Camden may be individuals belonging to any of the following stocks: the Western North Atlantic Offshore Stock, Jacksonville Estuarine System Stock, Western North Atlantic Northern Florida Coastal Stock, and the Western North Atlantic Southern Migratory Coastal Stock.

Bottlenose dolphins occur in tropical and temperate waters of the Atlantic Ocean and can be found in inshore, nearshore, and offshore waters along the U.S. east coast and Gulf of Mexico. They generally do not range north or south of 45° latitude (Jefferson, 2008; Wells, Common bottlenose dolphin Tursiops truncatus, 2008). Bottlenose dolphins can be found in most habitats, ranging from shallow, murky, estuarine waters to also deep, clear offshore waters in oceanic regions (Jefferson, 2008; NOAA Fisheries, 2016d). Bottlenose dolphins commonly observed in groups of 2 to 15 individuals, but offshore herds with several hundred individuals have been reported (Shane, 1986; Kerr, 2005; NOAA Fisheries, 2016d). Based on habitat preferences and incidental sightings in the vicinity of Spaceport Camden (Department of the Navy, 2008), bottlenose dolphins are expected to occur regularly within the region of influence (ROI).

The best available estimate for the Western North Atlantic Offshore Stock of common bottlenose dolphins is 77,532 (CV = 0.40) (National Oceanic and Atmospheric Administration, 2016). The best available estimate for the Western North Atlantic Northern Florida Coastal Stock of common bottlenose dolphins is 1,219 (CV = 0.67). For the Western North Atlantic Southern Migratory Coastal Stock, the best available estimate is 9,173 (CV = 0.46). These estimates are from aerial surveys conducted during the summers of 2010 and 2011, covering waters from Florida to New Jersey. The total number of common bottlenose dolphins residing within the Jacksonville Estuarine System Stock is unknown, because previous estimates are greater than 8 years old and deemed unreliable (National Oceanic and Atmospheric Administration, 2016). A mark-recapture analyses based on photo identification data collected from 1994 to 1997 estimated the population size for the Jacksonville Estuarine System Stock to be 412 residents (CV = 0.06) (Gubbins, 2003).

Bottlenose dolphins are opportunistic feeders, taking a variety of fishes, cephalopods, and crustaceans (Wells, Bottlenose dolphin Tursiops truncatus (Montagu, 1821), 1999)and using a variety of feeding strategies (Shane, 1986). In addition to using echolocation, a process for locating prey by emitting sound waves that reflect back, bottlenose dolphins likely detect and orient to fish prey by listening for the sounds they produce, so-called “passive listening” (Barros N. B., 1987; Barros N. B., 1998). Nearshore bottlenose dolphins prey predominantly on coastal fishes and cephalopods, while offshore individuals prey on open ocean cephalopods and a large variety of near-surface and mid-water fishes (Mead, 1995).

West Indian Manatee

The West Indian manatee is federally listed as an endangered species under the ESA (32 FR 4001) and classified as depleted under the MMPA. On January 8, 2016, the U.S. Fish and Wildlife Service

announced its 12-month finding on a petition to downlist the West Indian manatee and proposed a rule to reclassify this species from endangered to threatened (81 FR 1000). This is due to substantial improvements in the species' overall status since the original listing as endangered under the ESA in 1967. The West Indian manatee is divided into two distinct subspecies, the Florida manatee (*Trichechus manatus latirostris*) and the Antillean manatee (*Trichechus manatus manatus*) (Lefebvre, 2001).

The West Indian manatee occurs in warm coastal and riverine waters of the western North Atlantic Ocean and is found in the southeastern U.S., Central America, northern South America, and in the islands of the Caribbean (Lefebvre, 2001). West Indian manatees are a subtropical species with little tolerance for cold, and they are generally restricted to the inland and coastal waters of peninsular Florida during the winter, when they shelter in or near warm water springs, industrial effluents, and other warm water sites (Hartman, 1979; Lefebvre, 2001; Stith, 2006). In the warmer months, manatees leave these sites and can disperse great distances. Individuals have been sighted as far north as Massachusetts, as far west as Texas, and in all states in between (Fertl D. S.-M., 2005; Rathbun, 1988; Schwartz, 1995; U.S. Fish & Wildlife Service Jacksonville Field Office., 2008). However, warm weather sightings are most common in Florida and coastal Georgia. West Indian manatees have an 11-month gestation period and no defined breeding season; calves are born year-round (O'Shea, 1995). Manatee sightings have been recorded near the Spaceport Camden area since 2011, with 89 percent of the sightings occurring between the months of May and November (Department of the Navy, 2015). West Indian manatees are expected to occur frequently within the ROI.

The best available information suggests a minimum population size for the Florida Stock of the West Indian manatee of 4,834 (79 FR 3856 3859). This estimate is based on 2011 Florida Fish and Wildlife Conservation Commission winter count of manatees at warm water sites throughout peninsular Florida.

West Indian manatees are herbivorous and are known to consume more than 60 species of plants. They typically feed on bottom vegetation, plants in the water column, and shoreline vegetation, such as hyacinths and marine sea grasses (Reynolds, 2009). In some areas, they are known to feed on algae and parts of mangrove trees (Mignucci-Giannoni, 1998; Jefferson, 2008).

Critical habitat for the West Indian manatee was designated in 1976 (41 FR 41914) and reorganized in 1977. It encompasses multiple inland rivers and coastal waterways throughout Florida; however, the designation does not define any primary constituent elements. The St. Johns River and Federal navigation channel to the northwest of the ROI are included in this designation (Exhibit D-1). A petition to revise manatee critical habitat was submitted in 2009, and a 12-month finding on that petition by USFWS stated that revisions should be made, including definition of primary constituent elements (75 FR 1574-1581); however, sufficient funding to make these revisions is not currently available.

D.3 Marine Sea Turtles

There are five species of sea turtles that may occur in proximity to Spaceport Camden: the green sea turtle (*Chelonia mydas*), the hawksbill sea turtle (*Eretmochelys imbricata*), the Kemp's ridley sea turtle (*Lepidochelys kempii*), the loggerhead sea turtle (*Caretta caretta*), and the leatherback sea turtle (*Dermochelys coriacea*). The USFWS and NOAA Fisheries share Federal jurisdiction for sea turtles, with the USFWS having lead responsibility on nesting beaches and NOAA Fisheries in the marine environment. The descriptions below focus on marine habitat usage by sea turtles. All sea turtle species that occur in the area are listed under the ESA as either threatened or endangered. The occurrence of the olive ridley sea turtle (*Lepidochelys olivacea*) in the project area is extralimital (outside the species' normal range). Currently, there are no olive ridley nesting beaches in the eastern United States, and there are no known feeding, breeding, or migration areas within the vicinity of Spaceport Camden.

Green Sea Turtle

Breeding populations of the green sea turtle in Florida and the Pacific coast of Mexico were federally listed as endangered species under the ESA in 1978 (43 FR 32800); throughout the rest of its range, this species was listed as threatened. In April 2016, the range-wide and breeding population listing of the green turtle was removed and replaced with eight threatened and three endangered DPSs (81 FR 20057). Individuals that occur off Spaceport Camden belong to the North Atlantic DPS, which is listed as threatened under the ESA.

The green sea turtle is globally distributed and generally found in tropical and subtropical waters along continental coasts and islands between 30° north and 30° south (NOAA Fisheries, 2016e). Nesting occurs in over 80 countries throughout the year (though not throughout the year at each specific location). Green sea turtles are thought to inhabit coastal areas of more than 140 countries. In the U.S., green sea turtles nest primarily along the central and southeast coast of Florida, where between 200 and 1,100 nesting females have been documented. Between 2011 and 2012, female nesting abundance in Georgia was estimated to be five individuals (National Oceanic and Atmospheric Administration, 2015).

After emerging from the nest, green turtle hatchlings swim to offshore areas where they float passively in major current systems. Post-hatchling green turtles forage and develop in the open ocean associated with floating mats of algae of the genus *Sargassum*. At the juvenile stage (estimated at five to six years) they leave the open-ocean habitat and retreat to protected lagoons and open coastal areas that are rich in seagrass or marine algae (Bresette, 2006), where they will spend most of their lives (Bjorndal K. A., 1988). In the southeastern U.S., green sea turtles nest from June through September, and incubation ranges from 45 to 75 days, depending on incubation temperatures (Department of the Navy, 2015). Green sea turtles have been reported in the Spaceport Camden ROI and turning basin (U.S. Army Corps of Engineers, 2016).

The green sea turtle is the only species of sea turtle that, as an adult, primarily consumes plants and other types of vegetation (Mortimer, 1995). They have a finely serrated jaw that assists with tearing vegetation, and the esophagus is lined with papillae (spiny projections) that trap food before swallowing. While primarily herbivorous, a green sea turtle's diet changes substantially throughout its life. Very young green sea turtles are omnivorous (Bjorndal K. , 1997). Post-hatchling green sea turtles off the coast of southeastern Florida were found to feed near the surface on seagrasses or at shallow depths on comb jellies and unidentified gelatinous eggs (Salmon, 2004). Pelagic juveniles smaller than 8 to 10inches (20.3 to 25.4 centimeters) in length eat worms, young crustaceans, aquatic insects, grasses, and algae (Bjorndal K. , 1997). After settling in coastal juvenile developmental habitat at 8 to 10 inches (20.3 to 25.4 centimeters) in length, they eat mostly mangrove leaves, seagrass, and algae (Balazs, 1994; Nagaoka, 2012).

The loss of eggs to land-based predators such as mammals, snakes, crabs, and ants occurs on some nesting beaches. As with other sea turtles, hatchlings may be preyed on by birds and fish. Sharks are the primary nonhuman predators of juvenile and adult green sea turtles at sea (National Marine Fisheries Service & U.S. Fish and Wildlife Service, 1991).

Critical habitat was designated for the green sea turtle in 1998 (63 FR 46693) but does not occur within the ROI. NOAA Fisheries had indicated that it is in the process of identifying other potential critical habitat, which will be proposed in a future rulemaking (NOAA Fisheries, 2016e).

Hawksbill Sea Turtle

The hawksbill sea turtle was federally listed as an endangered species under the ESA in 1970 (35 FR 8491). In June 2013, NMFS and USFWS released a five-year review, which concluded that the hawksbill

sea turtle remains in danger of extinction throughout all or a significant portion of its range and should not be delisted or reclassified (NMFS and USFWS, 2013).

The hawksbill is the most tropical of the world's sea turtles, rarely occurring above 35° north or below 30° south (The State of the World's Sea Turtles Team, 2008; Witzell, 1983). Hawksbill turtles use different habitats during different stages of their life cycle but are most commonly associated with healthy coral reefs (NOAA Fisheries, 2016f). Hatchlings are believed to occupy open-ocean waters, associating themselves with surface algal mats in the Atlantic Ocean (Witzell, 1983; Parker, Encounter with a juvenile hawksbill turtle offshore Sapelo Island, Georgia, 1995; Witherington, 2006). Juveniles leave the open-ocean habitat after three to four years and settle in coastal foraging areas, typically coral reefs but occasionally seagrass beds, algal beds, mangrove bays, and creeks (Mortimer J. A., 2008). Juveniles and adults share the same foraging areas, including tropical nearshore waters associated with coral reefs, hard bottoms, or estuaries with mangroves (Musick, 1997).

In the continental United States, the hawksbill turtles have been recorded from all Gulf states and along the Atlantic coast as far north as Massachusetts (NOAA Fisheries, 2016f). However, sightings north of Florida are rare, and Texas is the only other state where hawksbills are sighted with any regularity (Keinath J. A., 1991; Lee, 1981; Parker, 1995; Plotkin P. T., 1995). Within the continental U.S., nesting is restricted to the southeast coast of Florida and the Florida Keys, but nesting is rare in these areas (NOAA Fisheries, 2014). Considering that Camden County is located north of the typical nesting range for the hawksbill turtle, and the region lacks suitable juvenile and adult habitat, the likelihood that this species will occur within the study area is low. Critical habitat was designated for the hawksbill sea turtle in 1998 (63 FR 46693) but does not occur in or near the ROI.

The 2013 five-year review (NMFS and USFWS, 2013) determined that the population trends and distribution of the hawksbill sea turtle was largely unchanged from those identified in the previous (2007) five-year review. The hawksbill turtle was once abundant in tropical and subtropical regions throughout the globe. Over the last century, this species has declined in most areas and stands at only a fraction of its historical abundance. Although greatly depleted from historical levels, nesting populations in the Atlantic in general are doing better than in the Indian and Pacific Oceans (NMFS and USFWS, 2013).

Post-hatchling hawksbill turtles feed on floating Sargassum in the open ocean (Plotkin P. A., 1998). During the juvenile stage, hawksbills are considered omnivorous, feeding on sponges, sea squirts, algae, molluscs, crustaceans, jellyfish, and other aquatic invertebrates (Bjorndal K. , 1997). Older juveniles and adult hawksbills are more specialized, feeding primarily on sponges, which compose as much as 95 percent of their diet in some locations (Witzell, 1983; Meylan, 1988). This hawksbill turtle fills a unique ecological niche in marine and coastal ecosystems, feeding on sponges helps to control populations of sponges that may otherwise compete for space with reef-building corals (Hill, 1998; Leon, 2002).

As with other sea turtles, hatchlings may be preyed upon by terrestrial predators after emerging from the next and by birds and fish at sea. Sharks are the primary nonhuman predators of juvenile and adult hawksbills at sea (Witzell, 1983).

Kemp's Ridley Sea Turtle

The Kemp's ridley sea turtle was federally listed as an endangered species under the ESA in 1970 (35 FR 18319). In August 2015, NMFS and USFWS released a five-year review that evaluated the best available information and recommended that the Kemp's ridley remain classified as endangered (NMFS and USFWS, 2015).

Distribution of the Kemp's ridley sea turtle is limited to the Gulf of Mexico and the western North Atlantic Ocean from Florida to the Grand Banks (NMFS and USFWS, 2015; NOAA Fisheries, 2016g). There are also sporadic reports of this species occurring near the Azores, in the waters off Morocco, and within the Mediterranean Sea. Adult female Kemp's ridley sea turtles take part in mass synchronized nesting emergences known as "arribadas" on only a few nesting beaches; a strategy unique to *Lepidochelys* spp. Kemp's ridley turtles may also be solitary nesters, but this is less common and generally occurs outside of the main nesting areas in Mexico (NMFS and USFWS, 2015). In the U.S., nesting occurs primarily in Texas, and occasional nesting occurs in Florida, Alabama, Georgia, South Carolina, and North Carolina (NMFS and USFWS, 2015).

Like other sea turtles, newly emerged hatchlings may forage and develop in floating *Sargassum* habitats of the North Atlantic Ocean. At around two years of age, juveniles migrate to habitats along the U.S. Atlantic continental shelf from Florida to New England (Morreale, 1998; Peña, 2006). Habitats frequently used by adult and juvenile Kemp's ridley sea turtles are muddy or sandy bottoms of warm-temperate to subtropical sounds, bays, estuaries, tidal passes, shipping channels, and beachfront waters, where their preferred food, the blue crab, is abundant (Lutcavage, 1985; Seney, 2005). Kemp's ridley turtles have been recorded in nearby Kings Bay (U.S. Army Corps of Engineers, 2016) and, therefore, may be present in the vicinity of Spaceport Camden. The occurrence of this species in the study area is expected to be seasonal, rare, and correlate with the availability of preferred species of prey.

Since the mid-1980s, the number of nests observed at the main nesting beach of Kemp's ridley sea turtles, Rancho Nuevo, and nearby beaches increased 14 to 16 percent per year and is expected to continue to grow 12 to 16 percent per year, provided that nest protection and other management measures continue (Heppell, 2005). Preliminary data through May 30, 2015, show at total of 11,955 for the three main nesting sites: Rancho Nuevo, Tepehuajes, and Playa Dos (NMFS and USFWS, 2015).

Kemp's ridley sea turtles feed primarily on crabs but are also known to prey on molluscs, shrimp, fish, jellyfish, and plant material (Frick, 1999; Marquez-M., 1994). Blue crabs (*Callinectes sapidus*) and spider crabs (*Libinia emarginata*) are important prey species for the Kemp's ridley (Keinath J. A., 1987; Lutcavage, 1985; Seney, 2005).

In February 2010, NOAA Fisheries and USFWS were jointly petitioned (WildEarth Guardians, 2010) to designate critical habitat for Kemp's ridley sea turtles for nesting beaches along the Texas coast and marine habitats in the Gulf of Mexico and Atlantic Ocean. No further action on this petition has been documented (NOAA Fisheries, 2016g).

Loggerhead Sea Turtle

The loggerhead sea turtle was federally listed as a threatened species throughout its range under the ESA in 1978 (43 FR 32800). In September 2011, the range-wide population listing of the loggerhead turtle was removed and replaced with four threatened and five endangered DPSs (76 FR 58868). The study area is located within the Northwest Atlantic DPS, which is listed as threatened.

Loggerhead sea turtles occur in temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans. In U.S. waters, this species occurs in habitats ranging from coastal estuaries to waters far beyond the continental shelf (Dodd, 1988). Over the course of their life cycle, loggerhead turtles occupy three distinct habitats: terrestrial (beaches), oceanic, and nearshore coastal (NOAA Fisheries, 2016h). Loggerheads nest on ocean beaches, generally preferring high energy, relatively narrow, steeply sloped, coarse-grained beaches (NOAA Fisheries, 2016h). At emergence, hatchlings swim to offshore currents and remain in the open ocean, often associating with floating mats of algae of the genus *Sargassum* (Carr, 1986; Carr, 1987; Witherington, 2006). Migration from oceanic to nearshore habitats occurs when juveniles are between 7 and 12 years old (Bolten, 2003; Mansfield, 2006; NOAA Fisheries, 2016h).

Nearshore, coastal areas also provide crucial foraging, internesting, and migratory habitat for adult loggerheads in the western North Atlantic Ocean (NMFS, 2013).

The nesting season for loggerhead sea turtles in the Northwest Atlantic extends from late April through early September, with the largest nesting aggregations in the U.S. occurring along peninsular Florida (NMFS, 2013). Smaller nesting aggregations also occur along the U.S. East Coast from Georgia through North Carolina and in the Northern Gulf of Mexico. The total estimated loggerhead sea turtle nesting in the U.S. is approximately 68,000 to 90,000 nests per year (NOAA Fisheries, 2016h). Loggerheads have nested on Cumberland Island National Seashore since record keeping began in 1998 (Department of the Navy, 2015).

Juvenile and subadult loggerhead turtles are omnivorous, foraging on crabs, molluscs, jellyfish, and vegetation captured at or near the surface (Dodd, 1988). Adult loggerhead sea turtles are generalized carnivores that forage on nearshore bottom-dwelling invertebrates (molluscs, crustaceans, and anemones) and sometimes fish (Dodd, 1988).

Globally, common predators of eggs and hatchlings on nesting beaches are ghost crabs (*Ocypode* spp.), raccoons (*Procyon lotor*), feral pigs (*Sus scrofa*), foxes (*Vulpes* spp.), coyotes (*Canis latrans*), armadillos (Chlamyphoridae and Dasypodidae), and fire ants (*Solenopsis* spp.) (Dodd, 1988). In the water, hatchlings are susceptible to predation by birds and fish. Sharks are the primary predator of juvenile and adult loggerhead sea turtles (Fergusson, 2000; Simpfendorfer, 2001).

On July 10, 2014, NMFS issued a final rule (79 FR 39856) designating specific areas of critical habitat that included 38 occupied marine areas within the range of the Northwest Atlantic Ocean DPS (Exhibit 3.2-3 in the EIS). These areas contain one or a combination of habitat types: nearshore reproductive habitat, winter area, breeding areas, constricted migratory corridors, and/or *Sargassum* habitat. On the same date, USFWS issued a separate rule (79 FR 39756) designating approximately 685 miles of loggerhead sea turtle nesting beaches as critical habitat in the states of North Carolina, South Carolina, Georgia, Florida, Alabama, and Mississippi. These beaches account for 45 percent of an estimated 1,531 miles of coastal beach shoreline and approximately 84 percent of the documented nesting (numbers of nests) within these six states. Cumberland Island National Seashore is one of the most important loggerhead sea turtle nesting areas in Georgia, accounting for 25 to 30 percent of the statewide nesting total. Since 2014, Cumberland Island has produced over 1,800 nests. (National Park Service, 2017). Given the presence of both nesting and foraging habitat, loggerhead sea turtles are expected to occur regularly in the study area.

Leatherback Sea Turtle

Under the ESA in 1970 (35 FR 8491), the leatherback sea turtle was federally listed as an endangered species throughout its range. In November 2013, NMFS and USFWS released a five-year review that evaluated the best available information and recommended that the leatherback turtle remain classified as endangered (NMFS and USFWS, 2013b). NMFS and USFWS also reported that information exists that indicates an analysis and review of the species should be conducted in the future to determine the application of the DPS policy to the leatherback turtle (NMFS and USFWS, 2013b).

Leatherback turtles have a wide global distribution and can be found in the Atlantic, Pacific, and Indian Oceans (NOAA Fisheries, 2016i). Upwelling areas serve as nursery grounds for post-hatchling and early juvenile leatherback sea turtles, because these areas provide a high biomass of prey (Musick, 1997). Late juvenile and adult leatherback sea turtles are known to range from mid-ocean to the continental shelf and nearshore waters (Grant, 1993; Schroeder, 1987; Shoop, 1992). Juvenile and adult foraging habitats include both coastal and offshore feeding areas (Frazier, 2001).

Nesting typically occurs between March and July in the southeastern U.S. with incubation requiring between 55 and 75 days, depending on incubation temperatures (Department of the Navy, 2015). Leatherback populations in the Caribbean, Atlantic, and Gulf of Mexico are generally increasing. Florida index nesting beach data from 1989 to 2014 indicate that number of nests at core index nesting beach ranged from 27 to 641 in 2014 (NOAA Fisheries, 2016i).

Leatherback sea turtles have pointed, tooth-like cusps and sharp-edged jaws that are adapted for a diet of soft-bodied open-ocean prey such as jellyfish, which is their main food source (Bjorndal K. , 1997; James M. C., 2001; Salmon, 2004). Leatherback sea turtles feed throughout the water column (Davenport, 1988; Eckert, 1989; Eisenberg, 1983; Grant, 1993; James M. C., 2005; Salmon, 2004).

Globally, predators of leatherback sea turtle eggs include feral pigs, dogs, raccoons, ghost crabs, and fire ants. As with other sea turtle species, leatherback hatchlings are preyed on by birds and large fish such as tarpon (*Megalops atlanticus*) and snapper (Lutjanidae). Sharks and killer whales are predators of adult leatherbacks (NMFS and USFWS, 2013b).

Critical habitat was designated for the leatherback sea turtle in the waters adjacent to Sandy Point Beach, St. Croix, and U.S. Virgin Islands in 1979 (44 FR 17710). In January 2012, NMFS revised the critical habitat designation to include waters along the U.S. west coast (77 FR 4170). There is no critical habitat designated for the leatherback turtle along the east coast of the continental U.S. The occurrence of this species in the study area is expected to be seasonal, rare, and correlate with the availability of preferred species of prey. Leatherback turtles may also occur in the in the study area while migrating between nesting habitat south and more productive foraging habitat in the North Atlantic.

D.4 Marine Fish

Table D-1 lists the most abundant fish species and their life stages occurring within the ROI.

Fish occurrence is influenced by physical factors (for example, bottom topography, water temperature, salinity, and depth), as well as biotic factors such as food availability. Fish that occur in the vicinity of Spaceport Camden may be generally categorized as those associated with estuaries (transition zone between fresh and salt water), bottom structure, unstructured seafloor, or the pelagic (open water) environment. A report of the biological resources of the lower St. Johns River (Brody, 1994) identified 170 fish species, many of which are presumably estuarine species. Many additional species inhabit nearshore and offshore areas of the South Atlantic Ocean.

Estuarine fish inhabit areas of varying salinity in the lower portion of the St. Johns River and nearshore areas of the Atlantic Ocean. Some species, such as bay anchovy (*Anchoa mitchilli*) and Atlantic silverside (*Menidia menidia*), typically occur year-round in the estuarine environment but may occur very near the marine shoreline. Other species may move between estuarine and more offshore marine environments.

Striped mullet (*Mugil cephalus*), black drum (*Pogonias cromis*), and sturgeon species are examples of fish that occur in both estuarine and offshore waters, depending on life stage and/or season. Structure-dependent species (typically adults) are associated with areas of topographic relief (e.g., ledges, hard bottom habitat), biotic structures (e.g., reefs, shellfish beds), or artificial structures (e.g., artificial reefs, shipwrecks). Common structure-oriented fish include numerous species of groupers, snappers, drums, amberjack, and triggerfish. Over 300 species of reef fish occur over the continental shelf in the region of Jacksonville (U.S. Navy, 2008). Bottom fish that do not rely significantly on structures are often associated with soft substrates and include species such as flatfish (e.g., flounders) and stingrays. Pelagic species typically occur away from shore (although some species enter estuarine waters at times) and may occupy any level of the water column. Typical pelagic species include mackerels, cobia (*Rachycentron canadum*), and sharks.

Table D-1. Managed Fishery Species Potentially Present in the Action Area

Common Name	Scientific Name	Habitat Associations	Nursery/ Spawning Habitats	Sensitive Life Stage Use of Action Area	Primary Prey	Life Stage in Project Area
Atlantic menhaden	*Brevoortia tyrannus*	Pelagic – water column; migratory	Nursery: estuary Spawn: offshore (mainly north of Carolinas)	Transient	Plankton	P/J/S/A
Bluefish	*Pomatomus saltatrix*	Pelagic – water column; migratory	Nursery: estuary, inshore Spawn: offshore	Nursery (spring-summer) Transient	Opportunistic feeders on fish (e.g., menhaden and herring), squid, lobster	J/S/A
Red drum	*Sciaenops ocellatus*	Tidal creeks, aquatic vegetation, mangrove areas, oyster reefs, unconsolidated sediment, beaches; migratory	Nursery: estuary, inshore Spawn: inshore-offshore	Nursery (summer-fall) Spawn (late summer-fall) Transient	Opportunistic feeders on fish, invertebrates, small crabs, and shrimp	P/J/S/A
Spot	*Leiostomus xanthurus*	Tidal creeks, unconsolidated sediment; migratory	Nursery: estuary Spawn: offshore	Nursery (spring-fall, may overwinter) Transient	Benthic invertebrates such as worms and crustaceans	P/J/S/A
Spotted seatrout	*Cynoscion nebulosus*	Tidal marsh creeks, oyster beds, shallow grass beds, open water; generally nonmigratory	Nursery: estuary Spawn: estuary, inshore	Spawn (spring-summer) Transient	Shrimp and small fish	J/S/A
Weakfish	*Cynoscion regalis*	Sand and sand/seagrass areas; migratory	Nursery: estuary Spawn: estuary, inshore	Spawn (spring-summer) Transient	Shrimp and small schooling fish such as herring and anchovy	J/S/A
Highly Migratory Species—Atlantic Sharks						
Atlantic sharpnose shark	*Rhizoprionodon terraenovae*	Pelagic – water column; migratory	Nursery: estuary, inshore	Nursery (spring-fall) Transient	Opportunistic feeders on fish (e.g., menhaden, eels, silversides, wrasses, jacks), shrimp, crabs, and mollusks	J/S/A
Bonnethead shark	*Sphyrna tiburo*	Pelagic – water column; migratory	Nursery: estuary, inshore	Nursery (warm months) Transient	Opportunistic feeders on crustaceans (e.g., shrimp), mollusks, and fish	J/S/A

Table D-1. Managed Fishery Species Potentially Present in the Action Area

Common Name	Scientific Name	Habitat Associations	Nursery/ Spawning Habitats	Sensitive Life Stage Use of Action Area	Primary Prey	Life Stage in Project Area
Coastal Migratory Pelagics						
Cobia	*Rachycentron canadum*	Pelagic – water column, manmade structures, over reefs, mangroves; migratory	Nursery: inshore Spawn: offshore	Transient	Opportunistic feeders on small fish, crabs, shrimp, and squid	P/J/S/A
Spanish mackerel	*Scomberomorous maculatus*	Pelagic – water column, over rock or seagrass; migratory	Nursery: inshore Spawn: offshore	Nursery (spring-fall) Transient	Pelagic schooling fish such as anchovies	P/J/S/A
Shad and River Herring						
Blueback herring	*Alosa aestivalis*	Eggs – demersal on substrate; juveniles - submerged vegetation; adults - water column; migratory	Nursery: riverestuary Spawn: river	Transient	Plankton	J/S/A
Hickory shad	*Alosa mediocris*	Pelagic – water column; migratory	Nursery: estuary, inshore Spawn: river	Nursery (spring-summer) Transient	Opportunistic feeders on small fish, squid, small crabs, and pelagic crustaceans	P/J/S/A
South Atlantic Snapper—Grouper Complex						
Atlantic spadefish	*Chaetodipterus faber*	Manmade structures, oyster reefs, mangroves, unconsolidated sediment; migratory	Nursery: estuary, inshore Spawn: inshore, offshore	Nursery (spring-summer, may overwinter) Transient	Benthic invertebrates including crustaceans, mollusks, annelids, sponges, and cnidarians; plankton	P/J/S
Bank sea bass	*Centropristis striata*	Hard bottom; unconsolidated sediment	Nursery: inshore Spawn: offshore	Transient	Benthic invertebrates (e.g., crustaceans), squid, and small fish.	P/J/S
Black sea bass	*Centropristis striata*	Manmade structures, oyster reefs, submerged vegetation, unconsolidated sediment; migratory	Nursery: estuary, inshore Spawn: offshore	Nursery (spring-summer) Transient	Benthic invertebrates (crustaceans, mollusks, and worms) and fish	P/J/S

Table D-1. Managed Fishery Species Potentially Present in the Action Area

Common Name	Scientific Name	Habitat Associations	Nursery/ Spawning Habitats	Sensitive Life Stage Use of Action Area	Primary Prey	Life Stage in Project Area
Crevalle jack	*Caranx hippos*	Pelagic – water column, juveniles may occur on seagrass beds; migratory	Nursery: estuary, inshore Spawn: offshore	Nursery (spring-summer) Transient	Opportunistic feeders on fish, shrimp, and invertebrates	P/J/S/A
Gray snapper	*Lutjanus griseus*	Rocky areas, seagrass beds, mangrove areas, reefs, unconsolidated sediment; offshore movement with age	Nursery: estuary, lower reaches of rivers Spawn: offshore	Transient	Opportunistic feeders on small fish, shrimps, crabs, gastropods, and cephalopods	J/S/A
Lane snapper	*Lutjanus synagris*	Mangrove and vegetated flats, reefs, unconsolidated sediment; offshore movement with age	Nursery: mangrove and sea grass beds, bays Spawn: offshore	Transient	Opportunistic feeders on small fish, shrimps, crabs, gastropods, and cephalopods	J/S
Rock sea bass	*Centropristis philadelphica*	Hard bottom, rocks, jetties, unconsolidated sediment; offshore movement with age	Nursery: inshore Spawning: offshore	Nursery (summer-fall) Transient	Opportunistic feeders on small fish, crustaceans, and shellfish	P/J/S
Sheepshead	*Archosargus probatocephalus*	Structure, unconsolidated sediment; limited seasonal movements	Nursery: estuary, inshore Spawn: offshore	Nursery (spring-summer) Transient	Benthic invertebrates, including crabs, crustaceans, and mollusks	P/J/S
Shrimp						
Brown shrimp	*Farfantepenaeus aztecus*	Marsh grass-water interface, mud-sandy substrate; migratory	Nursery: estuary Spawn: offshore	Nursery (spring-summer; may overwinter)	Invertebrates, decaying plant matter, organic debris	P/J/S/A
White shrimp	*Litopenaeus setiferus*	Marsh grass-water interface, mud-sandy substrate; migratory	Nursery: estuary Spawn: offshore	Nursery (spring-summer; may overwinter)	Invertebrates, decaying plant matter, organic debris	P/J/S/A

A = adult; J = juvenile; P = post-larva; S = sub-adult

Atlantic Sturgeon

The Atlantic sturgeon (*Acipenser oxyrinchus*) is federally listed as endangered and is divided into four DPSs. The South Atlantic DPS population corresponds with the location of the action area. Atlantic sturgeon is a long-lived, estuarine-dependent, anadromous fish, meaning adults spawn in freshwater in the spring/summer and migrate into estuarine and marine waters in the fall/winter. Atlantic sturgeon are similar in appearance to shortnose sturgeon (*Acipenser brevirostrum*) but can be distinguished by their larger size, smaller mouth, different snout shape, and scutes. Atlantic sturgeon are benthic feeders and typically forage on benthic invertebrates, including crustaceans, worms, mollusks.

Spawning adults migrate upriver in spring, typically beginning February/March. Following spawning, males may remain in the river or lower estuary until the fall; females typically exit the rivers within four to six weeks. Juveniles move downstream and inhabit brackish waters for a few months, and when they reach a size of about 30 to 36 inches (76 to 92 centimeters), they move into nearshore coastal waters. Tagging data indicate that these immature Atlantic sturgeon travel widely once they emigrate from their natal (birth) rivers. Subadults and adults live in coastal waters and estuaries when not spawning, generally in shallow (10- to 50-meter depth) nearshore areas dominated by gravel and sand substrates. Sturgeon eggs are highly adhesive and are deposited on bottom substrate, usually on hard surfaces (e.g., cobble). It is likely that cold, clean water is important for proper larval development. Once larvae begin migrating downstream, they use benthic structure (especially gravel matrices) as refuges. Juveniles usually reside in estuarine waters for months to years.

Historical threats include overharvest leading to wide-spread declines in Atlantic sturgeon abundance and commercial fishing from the 1950s through the 1990s. Current threats include bycatch of sturgeon in fisheries targeting other species; habitat degradation and loss from various human activities such as dredging; dams, water withdrawals, and other development; habitat impediments including locks and dams; and ship strikes (e.g., Delaware and James Rivers) (NOAA Fisheries, 2016a).

Critical habitat has been proposed for the South Atlantic Sturgeon DPS, specifically in the Satilla River (78 FR 36078, June 3, 2016), which is north of Spaceport Camden.

Shortnose Sturgeon

The shortnose sturgeon (*Acipenser brevirostrum*) is federally listed as endangered. Critical habitat has not been designated for this species. The shortnose sturgeon is the smallest of the three sturgeon species that occur in eastern North America. Similar to Atlantic sturgeon, shortnose sturgeon are anadromous fish living mainly in the slower-moving riverine waters or nearshore marine waters and migrating periodically into faster moving freshwater areas to spawn. Spawning typically occurs in the coastal rivers along the east coast of North America from the St. John River in Canada to the St. Johns River in Florida. Shortnose sturgeon do not appear to make long-distance offshore migrations. They are benthic feeders, eating crustaceans, mollusks, and insects. General threats to shortnose sturgeon include habitat alterations from discharges, dredging or disposal of material into rivers, and related development activities involving estuarine/riverine mudflats and marshes (NOAA, 2016b).

Historically, the shortnose sturgeon had wide occurrence along the eastern seaboard that included rivers in Georgia such as the St. Marys River (NMFS, 1998). Breeding populations are specific to a particular river, and today the southern portion of their range includes the Altamaha, Ogeechee, and Savannah Rivers in Georgia. Their southern range is characterized by distinct populations in two Georgia rivers (the Ogeechee and Altamaha Rivers) and one in Florida. The National Marine Fisheries Shortnose Sturgeon Recovery Plan indicates that collection efforts for sturgeon in the St. Marys and Satilla Rivers in 1994 and 1995 were not successful (NMFS, 1998). Therefore, probability of occurrence within the Spaceport Camden Action Area is low.

D.5 Marine Invertebrates

Animals that live on the sea floor are called benthos. Most of these animals lack a backbone and are called invertebrates. Typical benthic invertebrates include sea anemones, sponges, corals, sea stars, sea urchins, worms, bivalves, crabs, and many more. Invertebrates also occur in the water column. Macroinvertebrates (those large enough to be seen easily with the unaided eye, such as jellyfish) are relatively infrequent in the water column compared to bottom habitats. However, zooplankton may be abundant. Zooplankton includes organisms that drift passively or swim weakly in the water column, such as protozoans, copepods, and the eggs and larvae of many marine species.

Foraminifera, Radiolarians, Ciliates (Kingdom Protozoa)

Foraminifera, radiolarians, and ciliates are miniscule singled-celled organisms, sometimes forming colonies of cells, belonging to kingdom Protozoa. They are found in the water column and seafloor, and most are microscopic. Foraminifera form shells out of calcium carbonate, organic compounds, or sand or other particles cemented together (University of California Berkeley, 2010a). Radiolarians are microscopic zooplankton that form shells made of silica. Ciliates are protozoans with small hair-like extensions that are used for feeding and movement. In general, the distribution of foraminifera, radiolarians, and ciliates is patchy, occurring in regions with favorable growth conditions.

Sponges (Phylum Porifera)

Sponges are bottom-dwelling, multicellular animals that may be best described as an aggregation of cells that perform different functions. Sponges are largely sessile and are common in the Atlantic Ocean at all depths. Sponges are typically found on intermediate to hard bottoms, artificial structures, and biotic reefs. Water flow through the sponge provides food, oxygen, and removes wastes. This filtering process is an important coupler of pelagic and benthic processes (Perea-Bla´zquez, Davy, & Bell, 2012). Many sponges form calcium carbonate or silica spicules or bodies embedded in cells to provide structural support. Sponges provide homes for a variety of animals including shrimp, crabs, barnacles, worms, brittle stars, sea cucumbers, and other sponges (Colin & Arneson, 1995).

Corals, Hydroids, Jellyfish (Phylum Cnidaria)

Cnidarians include corals, sea anemones, sea pens, sea pansies, hydroids, hydromedusae, jellyfish, and sea wasps. Individuals are characterized by a simple digestive cavity with an exterior mouth surrounded by tentacles. Microscopic stinging capsules known as nematocysts are present (especially in the tentacles) and are a defining characteristic of the phylum. The majority of species are carnivores that eat zooplankton, small invertebrates, and fishes. However, many species suspension feed on plankton and dissolved organic matter or contain symbiotic dinoflagellate algae (zooxanthellae) from which they may derive nutrients (Lough & Oppen, 2009). Cnidarians have many diverse body shapes but may generally be categorized as one of two basic forms: polyp and medusa. The polyp form is tubular and sessile and includes examples such as corals and anemones. The medusa form is bell- or umbrella-shaped (e.g., jellyfish), with tentacles typically around the rim. The medusa form generally is pelagic. Many species alternate between these two forms during their life cycle.

A wide variety of cnidarian species occur in nearshore waters of the Atlantic Ocean at all depths and in most habitats. Sessile species typically occur on hard surfaces such as hard bottom habitat or artificial reefs. Some cnidarians form biotic habitats that harbor other animals and influence ecological processes, the primary examples being shallow-water and deep-water corals.

Flatworms (Phylum Platyhelminthes)

Flatworms are the simplest form of marine worm. The largest group of flatworms are parasites commonly found in fishes, seabirds, and marine mammals (University of California Berkeley, 2010b). The remaining groups are nonparasitic carnivores, living without a host. Flatworms are found in various habitats.

Ribbon Worms (Phylum Nemertea)

Ribbon worms, with their distinct gut and mouth parts, are more complex than flatworms. A unique feature of ribbon worms is the extendable proboscis (an elongated, tubular mouth part), which can be ejected to capture prey, to aid in movement, or for defense. Most ribbon worms are active, bottom-dwelling predators of other small invertebrates such as annelid worms and crustaceans (Castro & Huber, 2000). Some are scavengers or symbiotic (parasites or commensals). Some ribbon worms are pelagic, with approximately 100 pelagic species identified from all the oceans (Roe, 1999). Pelagic species generally drift or slowly swim by undulating the body. Ribbon worms occur in most marine environments, although usually in low abundances.

Round Worms (Phylum Nematoda)

Round worms are small and cylindrical, are abundant in sediment habitats such as soft to intermediate shores and soft to intermediate bottoms, and can also be found in host organisms as parasites (Castro & Huber, 2000). Round worms are some of the most widespread marine invertebrates. This group has a variety of food preferences, including algae, small invertebrates, annelid worms, and organic material from sediment.

Segmented Worms (Phylum Annelida)

Segmented worms include approximately 12,000 marine species worldwide in the phylum Annelida, although most marine forms are in the class Polychaeta (World Register of Marine Species Editorial Board, 2015). Polychaetes are the most complex group of marine worms, with a well-developed respiratory and gastrointestinal system (Castro & Huber, 2000). Different species may be highly mobile or burrow in the bottom. Polychaete worms exhibit a variety of lifestyles and feeding strategies and may be predators, scavengers, deposit-feeders, filter-feeders, or suspension feeders (Jumars, Dorgan, & Lindsay, 2014). The variety of feeding strategies and close connection to the bottom make annelids an integral part of the marine food web. Burrowing and agitating the sediment increase the oxygen content of bottom sediments and make important buried nutrients available to other organisms. This allows bacteria and other organisms, which are also an important part of the food web, to flourish on the bottom. Benthic polychaetes also vary in their mobility, including sessile attached or tube-dwelling worms, sediment burrowing worms, and mobile surface or subsurface worms. Some polychaetes are commensal or parasitic. Many polychaetes have planktonic larvae.

The reef-building tube worm (*Phragmatopoma caudata*, synonymous with *P. lapidosa*) constructs shallow-water worm reefs in some areas (Florida Oceanographic Society, 2017). Large pseudocolonies of worms (formed from large numbers of individual larvae that settle in close proximity and undergo fusion to form complex habitats) develop relatively smooth mounds up to 2 meters high (Zale & Merrifield, 1989). The species is particularly common along Florida's east coast, at depths to 2 meters.

Bryozoans (Phylum Bryozoa)

Bryozoans are small box-like, colony-forming animals that make up the "lace corals." Colonies can be encrusting, branching, or free-living. Bryozoans may form habitat similar in complexity to sponges (Buhl-Mortensen, et al., 2010). Bryozoans attach to a variety of surfaces, including intermediate and hard

bottom, artificial structures, and algae, and feed on particles suspended in the water (University of California Berkeley, 2010c). Habitat-forming species are most common on temperate continental shelves with relatively strong currents (Wood, Probert, Rowden, & Smith, 2012).

Squid, Bivalves, Sea Snails, Chitons (Phylum Mollusca)

Molluscs occur throughout the Atlantic Ocean at all depths. Sea snails and slugs (gastropods), clams, and mussels (bivalves), chitons (polyplacophorans), and octopus and squid (cephalopods) are examples of common molluscs. Snails and slugs occur in a variety of soft, intermediate, hard, and biogenic habitats. Chitons are typically found on hard bottom and artificial structures from the intertidal to littoral zone but may also be found in deeper water and on substrates such as aquatic plants. Many molluscs possess a muscular organ called a foot, which is used for mobility. Many molluscs also secrete an external shell, although some molluscs have an internal shell or no shell at all. Sea snails and slugs eat fleshy algae and a variety of invertebrates, including hydroids, sponges, sea urchins, worms, other snails, and small crustaceans, as well as detritus (Castro & Huber, 2000). Clams, mussels, and other bivalves feed are filter feeders, ingesting suspended food particles (e.g., phytoplankton, detritus). Chitons, sea snails, and slugs use rasping tongues, known as radula, to scrape food (e.g., algae) off rocks or other hard surfaces. Squid and octopus are active swimmers at all depths and use a beak to prey on a variety of organisms including fish, shrimp, and other invertebrates. Octopuses mostly prey on fish, shrimp, eels, and crabs.

Shrimp, Crab, Lobster, Barnacles, Copepods (Phylum Arthropoda)

Shrimp, crabs, lobsters, barnacles, and copepods are animals with an exoskeleton, which is a skeleton on the outside of the body and are classified as crustaceans in the phylum Arthropoda. There are over 57,000 marine arthropod species, with most of these belonging to the subphylum Crustacea (World Register of Marine Species Editorial Board, 2015). These organisms occur throughout the Atlantic Ocean at all depths. Crustaceans may be carnivores, omnivores, predators, or scavengers, preying on molluscs (primarily gastropods), other crustaceans, echinoderms, small fishes, algae, and seagrass. Barnacles and copepods are filter feeders, extracting algae and small organisms from the water. As a group, arthropods occur in a wide variety of habitats. Shrimp, crabs, lobsters, and copepods may be associated with soft to hard substrates, artificial structures, and biogenic habitats. Barnacles inhabit hard and artificial substrates.

Sea Stars, Sea Urchins, Sea Cucumbers (Phylum Echinodermata)

Organisms in this phylum include species such as sea stars, sea urchins, and sea cucumbers. Asteroids (e.g., sea stars), echinoids (e.g., sea urchins), holothuroids (e.g., sea cucumbers), ophuiroids (e.g., brittle stars and basket stars), and crinoids (e.g., feather stars and sea lilies) are symmetrical around the center axis of the body (Mah & Blake, 2012). Echinoderms occur at all depth ranges and are almost exclusively benthic, potentially found on all substrates and structures. Many echinoderms are either scavengers or predators on sessile organisms such as algae, stony corals, sponges, clams, and oysters, although some also predate on other species of sea stars. Some species, however, filter food particles from sand, mud, or water.

Habitats present at the alternate mooring sites include the water column and unconsolidated substrate (primarily sand). Therefore, invertebrates that may occur in the area would consist of zooplankton, pelagic macroinvertebrates such as jellyfish and squid, and benthic species living on or within the sand. No structures, such as coral reefs, hard bottom, or artificial reefs, are known to occur in the area. The biological condition of benthic habitats off the southeastern U.S. coast has been rated good overall, based on the number and abundance of species (U.S. Environmental Protection Agency, 2012). A diverse benthic invertebrate assemblage was reported for nearshore environments of the South Atlantic Bight

(the area between Cape Hatteras, North Carolina, and West Palm Beach, Florida). Over 300 invertebrate species were identified in sediment samples collected in this region, with polychaete worms and various crustaceans (particularly amphipods) accounting for about 75 percent of the species.

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APPENDIX E AIR QUALITY

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E AIR QUALITY

This appendix presents an overview of the Clean Air Act (CAA) and Georgia Environmental Protection Division requirements, as well as calculations, including the assumptions used for the air quality analyses presented in the Environmental Impact Statement.

E.1 Air Quality Program Overview

In order to protect public health and welfare, the U.S. Environmental Protection Agency (USEPA) has developed numerical concentration-based standards, or National Ambient Air Quality Standards (NAAQS), for six "criteria" pollutants (based on health-related criteria) under the provisions of the CAA Amendments of 1970. There are two kinds of NAAQS: primary and secondary standards. Primary standards prescribe the maximum permissible concentration in the ambient air to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards prescribe the maximum concentration or level of air quality required to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings (40 Code of Federal Regulations [CFR] 50).

The CAA gives states the authority to establish air quality rules and regulations. These rules and regulations must be equivalent to, or more stringent than, the federal program. The Air Protection Branch of the Georgia Environmental Protection Division is the State agency that regulates air quality emissions sources in Georgia under the authority of the Federal CAA and amendments, Federal regulations, and State laws.

Georgia has adopted the Federal NAAQS as shown in Table E-1. Based on measured ambient air pollutant concentrations, the USEPA designates areas of the United States as having air quality better than the NAAQS (attainment), worse than the NAAQS (nonattainment), and unclassifiable. The areas that cannot be classified (on the basis of available information) as meeting or not meeting the NAAQS for a particular pollutant are "unclassifiable" and are treated as attainment areas until proven otherwise. Attainment areas can be further classified as "maintenance" areas, which are areas previously classified as nonattainment areas but where air pollutant concentrations have been successfully reduced to below the standard. Maintenance areas are subject to special maintenance plans and must operate under some of the nonattainment area plans to ensure compliance with the NAAQS. Camden County is in attainment for all criteria pollutants.

A general conformity analysis is required to be conducted for areas designated as nonattainment or maintenance of the NAAQS if the action's direct and indirect emissions have a potential to emit one or more of the six criteria pollutants at or above concentrations standards shown in Table E-1 or the *de minimis* emission rate thresholds in Table E-2 or Table E-3.

Table E-1. Summary of National Ambient Air Quality Standards

Criteria Pollutant	Averaging Time	Federal Primary NAAQS	Federal Secondary NAAQS
Carbon monoxide (CO)	8-hour	9 ppm	No standard
	1-hour	35 ppm	No standard
Lead (Pb)	Rolling 3-month average	0.15 µg/m^3 [a]	0.15 µg/m³
Nitrogen dioxide (NO_2)	Annual	53 ppb[b]	53 ppb
	1-hour	100 ppb	No standard [c]
Particulate matter ≤10 micrometers (PM_{10})	24-hour	150 µg/m^3	150 µg/m³
Particulate matter <2.5 micrometers ($PM_{2.5}$)	Annual	12 µg/m³	15 µg/m³
	24-hour	35 µg/m³	35 µg/m³
Ozone (O_3)	8-hour	0.070 ppm³[C]	0.070 ppm
Sulfur dioxide (SO_2)	Annual	No standard	No standard
	24-hour[a]	No standard	No standard
	3-hour	No standard	0.50 ppm [c]
	1-hour	75 ppb [d]	No standard

Notes: mg/m³ = milligrams per cubic meter; µg/m³ = micrograms per cubic meter; NAAQS = National Ambient Air Quality Standards; ppb = parts per billion; ppm = parts per million.

(a) In areas designated nonattainment for the Pb standards prior to the promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have not been submitted and approved, the previous standards (1.5 µg/m^3 as a calendar quarter average) also remain in effect.

(b) The level of the annual NO_2 standard is 0.053 ppm. It is shown here in terms of ppb for the purposes of clearer comparison to the 1-hour standard level.

(c) Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) O_3 standards additionally remain in effect in some areas. Revocation of the previous (2008) O_3 standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards.

(d) The previous SO_2 standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (1) any area for which it is not yet 1 year since the effective date of designation under the current (2010) standards, and (2) any area for which an implementation plan providing for attainment of the current (2010) standard has not been submitted and approved and which is designated nonattainment under the previous SO_2 standards or is not meeting the requirements of a State Implementation Plan (SIP) call under the previous SO_2 standards (40 CFR 50.4(3)). An SIP call is a USEPA action requiring a state to resubmit all or part of its State Implementation Plan to demonstrate attainment of the required NAAQS.

Source: USEPA, 2016

Table E-2. Emission Rates for Criteria Pollutants in Nonattainment Areas[1]

Pollutant	Emission Rate (tons/year)
Ozone (VOCs or NO_x)	
Serious nonattainment areas	50
Severe nonattainment areas	25
Extreme nonattainment areas	10
Other ozone nonattainment areas outside an ozone transport region	100
Marginal and moderate nonattainment areas inside an ozone transport region	
VOCs	50
NO_x	100
CO: All nonattainment areas	100
SO_2 or NO_2: All nonattainment areas	100
PM_{10}	
Moderate nonattainment areas	100
Serious nonattainment areas	70
$PM_{2.5}$	
Direct emissions	100
SO_2	100
NO_x (unless determined not to be a significant precursor)	100
VOCs or ammonia (if determined to be significant precursors)	100
Pb: All nonattainment areas	25

Notes: CO = carbon monoxide; NO_2 = nitrogen dioxide; NO_x = nitrogen oxides; VOC = volatile organic compound; Pb = lead; $PM_{2.5}$ = particulate matter with a diameter less than or equal to 2.5 microns; PM_{10} = particulate matter with a diameter less than or equal to 10 microns; SO_2 = sulfur dioxide.
1. *De minimis* threshold levels for conformity applicability analysis.
Source: USEPA, 2016a

Table E-3. Emission Rates for Criteria Pollutants in Attainment (Maintenance) Areas[1]

Pollutant	Emission Rate (tons/year)
Ozone (NO_x, SO_2, or NO_2): All maintenance areas	100
Ozone (VOCs)	
Maintenance areas inside an ozone transport region	50
Maintenance areas outside an ozone transport region	100
CO: All maintenance areas	100
PM_{10}: All maintenance areas	100
$PM_{2.5}$	
Direct emissions	100
SO_2	100
NO_x (unless determined not to be a significant precursor)	100
VOCs or ammonia (if determined to be significant precursors)	100
Pb: All maintenance areas	25

Notes: CO = carbon monoxide; NO_x = nitrogen oxides; VOC = volatile organic compound; Pb = lead; $PM_{2.5}$ = particulate matter with a diameter less than or equal to 2.5 microns; PM_{10} = particulate matter with a diameter less than or equal to 10 microns; SO_2 = sulfur dioxide.
1. *De minimis* threshold levels for conformity applicability analysis.

Each state is required to develop a State Implementation Plan (SIP) that sets forth how CAA provisions will be imposed within the state. The SIP is the primary means for the implementation, maintenance, and enforcement of the measures needed to attain and maintain the NAAQS within each state and includes control measures, emissions limitations, and other provisions required to attain and maintain the ambient air quality standards. The purpose of the SIP is twofold. First, it must provide a control strategy that will result in the attainment and maintenance of the NAAQS. Second, it must demonstrate that progress is being made in attaining the standards in each nonattainment area.

In attainment areas, major new or modified stationary sources of air emissions on and in the area are subject to Prevention of Significant Deterioration (PSD) review to ensure that these sources are constructed without causing significant adverse deterioration of the clean air in the area. A major new source is defined as one that has the potential to emit any pollutant regulated under the CAA in amounts equal to or exceeding specific major source thresholds, that is, 100 or 250 tons/year based on the source's industrial category. A major modification is a physical change or change in the method of operation at an existing major source that causes a significant "net emissions increase" at that source of any regulated pollutant. Table E-4 lists the PSD significant emissions rate thresholds for selected criteria pollutants (USEPA, 1990).

Table E-4. Criteria Pollutant Significant Emissions Rate Increases Under PSD Regulations

Pollutant	Significant Emissions Rate (tons/year)
PM_{10}	15
$PM_{2.5}$	10
Total suspended particulates	25
SO_2	40
NO_x	40
Ozone (VOCs)	40
CO	100

Notes: CO = carbon monoxide; NO_x = nitrogen oxides; VOC = volatile organic compound; Pb = lead; $PM_{2.5}$ = particulate matter with a diameter less than or equal to 2.5 microns; PM_{10} = particulate matter with a diameter less than or equal to 10 microns; PSD = Prevention of Significant Deterioration; SO_2 = sulfur dioxide; VOC = volatile organic compound.
Source: Title 40 CFR Part 51

The goals of the PSD program are to (1) ensure economic growth while preserving existing air quality; (2) protect public health and welfare from adverse effects that might occur even at pollutant levels better than the NAAQS; and (3) preserve, protect, and enhance the air quality in areas of special natural recreational, scenic, or historic value, such as national parks and wilderness areas. Sources subject to PSD review are required by the CAA to obtain a permit before commencing construction. The permit process requires an extensive review of all other major sources within a 50-mile radius and all Class I areas within a 62-mile radius of the facility. Emissions from any new or modified source must be controlled using best available control technology. The air quality, in combination with other PSD sources in the area, must not exceed the maximum allowable incremental increase identified in Table E-5. National parks and wilderness areas are designated as Class I areas, where any appreciable deterioration in air quality is considered significant. Class II areas are those where moderate, well-controlled industrial growth could be permitted. Class III areas allow for greater industrial development.

Table E-5. Federal Allowable Pollutant Concentration Increases Under PSD Regulations

Pollutant	Averaging Time	Maximum Allowable Concentration (μg/m³)		
		Class I	Class II	Class III
PM_{10}	Annual	4	17	34
	24-hour	8	30	60
SO_2	Annual	2	20	40
	24-hour	5	91	182
	3-hour	25	512	700
NO_2	Annual	2.5	25	50

Notes: NO_2 = nitrogen dioxide; PM_{10} = particulate matter with a diameter less than or equal to 10 microns; PSD = Prevention of Significant Deterioration; SO_2 = sulfur dioxide; μg/m³ = micrograms per cubic meter.
Source: Title 40 CFR Part 51

The Ambient Monitoring Program measures levels of air pollutants throughout the state. The data are used to determine compliance with air standards established for five compounds and to evaluate the need for special controls for various other pollutants.

The air quality monitoring network is used to identify areas where the ambient air quality standards are being violated and plans are needed to reduce pollutant concentration levels to be in attainment with the standards. Also included are areas where the ambient standards are being met, but plans are necessary to ensure maintenance of acceptable levels of air quality in the face of anticipated population or industrial growth.

The result of this attainment/maintenance analysis is the development of local and statewide strategies for controlling emissions of criteria air pollutants from stationary and mobile sources. The first step in this process is the annual compilation of the ambient air monitoring results, and the second step is the analysis of the monitoring data for general air quality, exceedances of air quality standards, and pollutant trends.

E.2 Regulatory Comparisons

The CAA Section 176(c), General Conformity, requires federal agencies to demonstrate that their proposed activities would conform to the applicable SIP for attainment of the NAAQS. General conformity applies only to nonattainment and maintenance areas. If the emissions from a federal action proposed in a nonattainment area exceed annual *de minimis* thresholds identified in the rule, a formal conformity determination is required of that action. The thresholds are more restrictive as the severity of the nonattainment status of the region increases. Since the project region is designated as attainment for all criteria pollutants (USEPA, 2016b), the criteria pollutants are compared with the region of influence (ROI) emissions (Camden County and the Jacksonville (FL)-Brunswick (GA) Interstate Air Quality Control Region). Camden County and all counties within the Air Quality Control Region are all in attainment.

For the analysis, in order to evaluate air emissions and their impact on the overall ROI, the emissions associated with the project activities were compared with the total emissions on a pollutant-by-pollutant basis for the ROI's 2014 National Emissions Inventory (NEI) data, which was last updated November 1, 2016. Potential impacts to air quality are evaluated with respect to the extent, context, and intensity of the impact in relation to relevant regulations, guidelines, and scientific documentation.

The Council on Environmental Quality (CEQ) defines significance in terms of context and intensity in 40 CFR 1508.27. This requires that the significance of the action must be analyzed in respect to the setting of the proposed action and based relative to the severity of the impact. The CEQ's National Environmental Policy Act regulations (40 CFR 1508.27(b)) provide 10 key factors to consider in determining an impact's intensity. To provide a more conservative analysis, the county was selected as the ROI instead of the USEPA-designated Air Quality Control Region, which is a much larger area.

E.3 National Emissions Inventory

The NEI is operated under the USEPA's Emission Factor and Inventory Group, which prepares the national database of air emissions information with input from numerous state and local air agencies, tribes, and industries. The database contains information on stationary and mobile sources that emit criteria air pollutants and hazardous air pollutants (HAPs). The database includes estimates of annual emissions, by source, of air pollutants in each area of the country on a yearly basis. The NEI includes emission estimates for all 50 states, the District of Columbia, Puerto Rico, and the Virgin Islands. Emission estimates for individual point or major sources (facilities), as well as county-level estimates for area, mobile, and other sources, are currently available for years 2008 and 2011 for criteria pollutants and HAPs. The 2014 NEI data was last updated December 21, 2016, so those data were used in all analysis.

Criteria air pollutants are those for which the USEPA has set health-based standards. Four of the six criteria pollutants are included in the NEI database:

- Carbon monoxide
- Nitrogen oxides
- Sulfur dioxide
- Particulate matter (with a diameter less than or equal to 10 and 2.5 microns)

The NEI also includes emissions of volatile organic compounds (VOCs), which are ozone precursors, emitted from motor vehicle fuel distribution and chemical manufacturing, as well as other solvent uses. VOCs react with nitrogen oxides in the atmosphere to form ozone. The NEI database defines three classes of criteria air pollutant sources:

Point sources. Stationary sources of emissions, such as an electric power plant, that can be identified by name and location. A "major" source emits a threshold amount (or more) of at least one criteria pollutant and must be inventoried and reported. Many states also inventory and report stationary sources that emit amounts below the thresholds for each pollutant.

Area sources. Small point sources such as a home or office building or a diffuse stationary source such as wildfires or agricultural tilling. These sources do not individually produce sufficient emissions to qualify as point sources. Dry cleaners are one example; for instance, a single dry cleaner within an inventory area typically will not qualify as a point source, but collectively the emissions from all of the dry cleaning facilities in the inventory area may be significant and, therefore, must be included in the inventory.

Mobile sources. Any kind of vehicle or equipment with a gasoline or diesel engine (such as an airplane or ship).

The following are the main sources of criteria pollutant emissions data for the NEI:

For electric generating units—USEPA's Emission Tracking System/Continuous Emissions Monitoring Data and Department of Energy fuel use data.

For other large stationary sources—state data and older inventories where state data were not submitted.

For on-road and nonroad mobile sources—the Federal Highway Administration's estimate of vehicle miles traveled and emission factors from USEPA's MOVES 2014a Model.

USEPA's Clean Air Market program supplies emissions data for electric power plants.

For stationary area sources—state data, USEPA-developed estimates for some sources, and older inventories where state or USEPA data were not submitted.

State and local environmental agencies supply most of the point source data.

E.4 Project Calculations

E.4.1 Construction Emissions

This Construction Emissions section presents the results exported directly from the air quality analysis modeling software, Air Conformity Applicability Model Version 5.0.7, retaining its organizational headings and table formatting. Emission factors for on-road and nonroad vehicles in the software program were derived from the U.S. Environmental Protection Agency's MOVES 2014a.

1. General Information

- Action Location
AQCR: JACKSONVILLE – BRUNSWICK INTERSTATE
County(s): Camden
Regulatory Area(s): NOT IN A REGULATORY AREA

- Action Title: Proposed Action Camden County Commercial Spaceport

- Project Number/s (if applicable):

- Projected Action Start Date: 1 / 2018

- Action Purpose and Need:

The purpose of the County's proposal to construct and operate Spaceport Camden is to allow the County to offer a commercial space launch site to a growing number of small to medium-large lift-class, orbital and suborbital, vertical launch vehicle operators to conduct commercial launches from the east coast of the United States. A commercial space launch site may be able to more effectively respond to the scheduling needs of commercial launch providers than Federal facilities with national security priorities and logistical complexities.

The need for the proposed commercial space launch site is to further the goals of Camden County as established in the County's Strategic Plan 2016, 2021, 2030 to create a strong regional economy with diverse job opportunities based on four major pillars of economic growth and sustainment, one of which is developing a world-class spaceport that would also attract businesses to support its operation.

- Action Description:
Proposed Action
Water Landing Only Alternative
No Action Alternative

- Point of Contact
Name: Brad Boykin
Title: CTR
Organization: Leidos
Email: boykinb@leidos.com
Phone Number: 850-609-3450

- Activity List:

Activity Type		Activity Title
2.	Construction / Demolition	Proposed Action Construction
3.	Construction / Demolition	Vertical Launch Facility
4.	Construction / Demolition	Alternate Control Center and Visitor Center
5.	Construction / Demolition	Landing Zone
6.	Construction / Demolition	Launch Site Roads

2. Construction / Demolition

2.1 General Information & Timeline Assumptions

- Activity Location
County: Camden
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Proposed Action Construction

- Activity Description:
Launch Control Center

- Activity Start Date
Start Month: 1
Start Month: 2018

- Activity End Date
Indefinite: False
End Month: 12
End Month: 2018

- Activity Emissions:

Pollutant	Total Emissions (TONs)
VOC	1.409938
SO_x	0.015811
NO_x	8.265777
CO	7.047960

Pollutant	Total Emissions (TONs)
PM 2.5	0.409445
Pb	0.000000
NH_3	0.003944
CO_2e	1536.3

PM 10	13.749337		

2.1 Site Grading Phase

2.1.1 Site Grading Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration
Number of Month: 12
Number of Days: 0

2.1.2 Site Grading Phase Assumptions

- General Site Grading Information
Area of Site to be Graded (ft^2): 104544
Amount of Material to be Hauled On-Site (yd^3): 24
Amount of Material to be Hauled Off-Site (yd^3): 24

- Site Grading Default Settings
Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Graders Composite	1	6
Other Construction Equipment Composite	1	8
Rubber Tired Dozers Composite	1	6
Tractors/Loaders/Backhoes Composite	1	7

- Vehicle Exhaust
Average Hauling Truck Capacity (yd^3): 20 (default)
Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips
Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

2.1.3 Site Grading Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Graders Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.1049	0.0014	0.7217	0.5812	0.0354	0.0354	0.0094	132.97
Other Construction Equipment Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0633	0.0012	0.4477	0.3542	0.0181	0.0181	0.0057	122.66
Rubber Tired Dozers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2343	0.0024	1.8193	0.8818	0.0737	0.0737	0.0211	239.61
Tractors/Loaders/Backhoes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**Pb**	**NH_3**	**CO_2e**
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

2.1.4 Site Grading Phase Formula(s)

- Fugitive Dust Emissions per Phase

$PM10_{FD}$ = (20 * ACRE * WD) / 2000

$PM10_{FD}$: Fugitive Dust PM 10 Emissions (TONs)
20: Conversion Factor Acre Day to pounds (20 lb / 1 Acre Day)
ACRE: Total acres (acres)
WD: Number of Total Work Days (days)
2000: Conversion Factor pounds to tons

- Construction Exhaust Emissions per Phase

CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

$VMT_{VE} = (HA_{OnSite} + HA_{OffSite}) * (1 / HC) * HT$

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
HA_{OnSite}: Amount of Material to be Hauled On-Site (yd^3)
$HA_{OffSite}$: Amount of Material to be Hauled Off-Site (yd^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

$V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Vehicle Exhaust On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase

$VMT_{WT} = WD * WT * 1.25 * NE$

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

$V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

2.2 Trenching/Excavating Phase

2.2.1 Trenching / Excavating Phase Timeline Assumptions

- Phase Start Date

Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration

Number of Month: 12

Number of Days: 0

2.2.2 Trenching / Excavating Phase Assumptions

- General Trenching/Excavating Information

Area of Site to be Trenched/Excavated (ft^2): 7200
Amount of Material to be Hauled On-Site (yd^3): 0
Amount of Material to be Hauled Off-Site (yd^3): 0

- Trenching Default Settings

Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Excavators Composite	2	8
Other General Industrial Equipment Composite	1	8
Tractors/Loaders/Backhoes Composite	1	8

- Vehicle Exhaust

Average Hauling Truck Capacity (yd^3): 20 (default)
Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips

Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

2.2.3 Trenching / Excavating Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Graders Composite								
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	CH_4	CO_2e
Emission Factors	0.1049	0.0014	0.7217	0.5812	0.0354	0.0354	0.0094	132.97
Other Construction Equipment Composite								
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	CH_4	CO_2e
Emission Factors	0.0633	0.0012	0.4477	0.3542	0.0181	0.0181	0.0057	122.66
Rubber Tired Dozers Composite								
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	CH_4	CO_2e
Emission Factors	0.2343	0.0024	1.8193	0.8818	0.0737	0.0737	0.0211	239.61

Tractors/Loaders/Backhoes Composite								
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	CH_4	CO_2e
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

2.2.4 Trenching / Excavating Phase Formula(s)

- Fugitive Dust Emissions per Phase

$PM10_{FD}$ = (20 * ACRE * WD) / 2000

$PM10_{FD}$: Fugitive Dust PM 10 Emissions (TONs)
20: Conversion Factor Acre Day to pounds (20 lb / 1 Acre Day)
ACRE: Total acres (acres)
WD: Number of Total Work Days (days)
2000: Conversion Factor pounds to tons

- Construction Exhaust Emissions per Phase

CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

VMT_{VE} = (HA_{OnSite} + $HA_{OffSite}$) * (1 / HC) * HT

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
HA_{OnSite}: Amount of Material to be Hauled On-Site (yd^3)
$HA_{OffSite}$: Amount of Material to be Hauled Off-Site (yd^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Vehicle Exhaust On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase
VMT_{WT} = WD * WT * 1.25 * NE

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

2.3 Building Construction Phase

2.3.1 Building Construction Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration
Number of Month: 12
Number of Days: 0

2.3.2 Building Construction Phase Assumptions

- General Building Construction Information
Building Category: Office or Industrial
Area of Building (ft^2): 11700
Height of Building (ft): 45
Number of Units: N/A

- Building Construction Default Settings
Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Cranes Composite	1	4
Forklifts Composite	2	6
Tractors/Loaders/Backhoes Composite	1	8

- Vehicle Exhaust

Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips

Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

- Vendor Trips

Average Vendor Round Trip Commute (mile): 40 (default)

- Vendor Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

2.3.3 Building Construction Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Cranes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.1012	0.0013	0.7908	0.4059	0.0318	0.0318	0.0091	128.85
Forklifts Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0371	0.0006	0.2186	0.2173	0.0101	0.0101	0.0033	54.479
Tractors/Loaders/Backhoes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

2.3.4 Building Construction Phase Formula(s)

- Construction Exhaust Emissions per Phase

CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

VMT_{VE} = BA * BH * (0.42 / 1000) * HT

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
BA: Area of Building (ft^2)
BH: Height of Building (ft)
(0.42 / 1000): Conversion Factor ft^3 to trips (0.42 trip / 1000 ft^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase

VMT_{WT} = WD * WT * 1.25 * NE

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)

0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Vender Trips Emissions per Phase
VMT_{VT} = BA * BH * (0.38 / 1000) * HT

VMT_{VT}: Vender Trips Vehicle Miles Travel (miles)
BA: Area of Building (ft^2)
BH: Height of Building (ft)
(0.38 / 1000): Conversion Factor ft^3 to trips (0.38 trip / 1000 ft^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

V_{POL} = (VMT_{VT} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VT}: Vender Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

2.4 Architectural Coatings Phase

2.4.1 Architectural Coatings Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration
Number of Month: 12
Number of Days: 0

2.4.2 Architectural Coatings Phase Assumptions

- General Architectural Coatings Information
Building Category:
Total Square Footage (ft^2): 11700
Number of Units: N/A

- Architectural Coatings Default Settings
Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Worker Trips

Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

2.4.3 Architectural Coatings Phase Emission Factor(s)

- Worker Trips Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

2.4.4 Architectural Coatings Phase Formula(s)

- Worker Trips Emissions per Phase

$VMT_{WT} = (1 * WT * PA) / 800$

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
1: Conversion Factor man days to trips (1 trip / 1 man * day)
WT: Average Worker Round Trip Commute (mile)
PA: Paint Area (ft^2)
800: Conversion Factor square feet to man days (1 ft^2 / 1 man * day)

$V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Off-Gassing Emissions per Phase

$VOC_{AC} = (AB * 2.0 * 0.0116) / 2000.0$

VOC_{AC}: Architectural Coating VOC Emissions (TONs)
BA: Area of Building (ft^2)
2.0: Conversion Factor total area to coated area (2.0 ft^2 coated area / total area)
0.0116: Emission Factor (lb/ft^2)
2000: Conversion Factor pounds to tons

2.5 Paving Phase

2.5.1 Paving Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration
Number of Month: 12
Number of Days: 0

2.5.2 Paving Phase Assumptions

- General Paving Information
Paving Area (ft^2): 23100

- Paving Default Settings
Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Cement and Mortar Mixers Composite	4	6
Pavers Composite	1	7
Paving Equipment Composite	1	8
Rollers Composite	1	7
Tractors/Loaders/Backhoes Composite	1	7

- Vehicle Exhaust
Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips
Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

2.5.3 Paving Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Graders Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.1049	0.0014	0.7217	0.5812	0.0354	0.0354	0.0094	132.97
Other Construction Equipment Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0633	0.0012	0.4477	0.3542	0.0181	0.0181	0.0057	122.66
Rubber Tired Dozers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2343	0.0024	1.8193	0.8818	0.0737	0.0737	0.0211	239.61
Tractors/Loaders/Backhoes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**Pb**	**NH_3**	**CO_2e**
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

2.5.4 Paving Phase Formula(s)

- Construction Exhaust Emissions per Phase

$CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000$

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

$VMT_{VE} = PA * 0.25 * (1 / 27) * (1 / HC) * HT$

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
PA: Paving Area (ft^2)
0.25: Thickness of Paving Area (ft)
(1 / 27): Conversion Factor cubic feet to cubic yards (1 yd^3 / 27 ft^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)

HT: Average Hauling Truck Round Trip Commute (mile/trip)

V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Vehicle Exhaust On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase
VMT_{WT} = WD * WT * 1.25 * NE

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Off-Gassing Emissions per Phase
VOC_P = (2.62 * PA) / 43560

VOC_P: Paving VOC Emissions (TONs)
2.62: Emission Factor (lb/acre)
PA: Paving Area (ft^2)
43560: Conversion Factor square feet to acre (43560 ft2 / acre)^2 / acre)

3. Construction / Demolition

3.1 General Information & Timeline Assumptions

- Activity Location
County: Camden
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Vertical Launch Facility

- Activity Description:

- Activity Start Date
Start Month: 1
Start Month: 2018

- Activity End Date
Indefinite: False
End Month: 3
End Month: 2019

- Activity Emissions:

Pollutant	Total Emissions (TONs)
VOC	5.542190
SO_x	0.043730
NO_x	23.855715
CO	17.113742
PM 10	219.918687

Pollutant	Total Emissions (TONs)
PM 2.5	1.118789
Pb	0.000000
NH_3	0.019040
CO_2e	4403.7

3.1 Site Grading Phase

3.1.1 Site Grading Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration
Number of Month: 15
Number of Days: 0

3.1.2 Site Grading Phase Assumptions

- General Site Grading Information
Area of Site to be Graded (ft^2): 1263240
Amount of Material to be Hauled On-Site (yd^3): 290
Amount of Material to be Hauled Off-Site (yd^3): 290

- Site Grading Default Settings
Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Excavators Composite	1	8
Graders Composite	1	8
Other Construction Equipment Composite	1	8
Rubber Tired Dozers Composite	1	8

Equipment Name	Number Of Equipment	Hours Per Day
Scrapers Composite	3	8
Tractors/Loaders/Backhoes Composite	3	8

- Vehicle Exhaust

Average Hauling Truck Capacity (yd^3): 20 (default)
Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips

Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

3.1.3 Site Grading Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Excavators Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0848	0.0013	0.5180	0.5159	0.0249	0.0249	0.0076	119.77
Graders Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.1049	0.0014	0.7217	0.5812	0.0354	0.0354	0.0094	132.97
Other Construction Equipment Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0633	0.0012	0.4477	0.3542	0.0181	0.0181	0.0057	122.66
Rubber Tired Dozers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2343	0.0024	1.8193	0.8818	0.0737	0.0737	0.0211	239.61
Scrapers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2135	0.0026	1.6041	0.8417	0.0653	0.0653	0.0192	262.96
Tractors/Loaders/Backhoes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

3.1.4 Site Grading Phase Formula(s)

- Fugitive Dust Emissions per Phase

$PM10_{FD}$ = (20 * ACRE * WD) / 2000

$PM10_{FD}$: Fugitive Dust PM 10 Emissions (TONs)
20: Conversion Factor Acre Day to pounds (20 lb / 1 Acre Day)
ACRE: Total acres (acres)
WD: Number of Total Work Days (days)
2000: Conversion Factor pounds to tons

- Construction Exhaust Emissions per Phase

CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

VMT_{VE} = (HA_{OnSite} + $HA_{OffSite}$) * (1 / HC) * HT

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
HA_{OnSite}: Amount of Material to be Hauled On-Site (yd^3)
$HA_{OffSite}$: Amount of Material to be Hauled Off-Site (yd^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Vehicle Exhaust On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase

VMT_{WT} = WD * WT * 1.25 * NE

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

$V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

3.2 Trenching/Excavating Phase

3.2.1 Trenching / Excavating Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration
Number of Month: 15
Number of Days: 0

3.2.2 Trenching / Excavating Phase Assumptions

- General Trenching/Excavating Information
Area of Site to be Trenched/Excavated (ft^2): 203000
Amount of Material to be Hauled On-Site (yd^3): 0
Amount of Material to be Hauled Off-Site (yd^3): 0

- Trenching Default Settings
Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Excavators Composite	2	8
Other General Industrial Equipment Composite	1	8
Tractors/Loaders/Backhoes Composite	1	8

- Vehicle Exhaust
Average Hauling Truck Capacity (yd^3): 20 (default)

Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips

Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

3.2.3 Trenching / Excavating Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Excavators Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0848	0.0013	0.5180	0.5159	0.0249	0.0249	0.0076	119.77
Graders Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.1049	0.0014	0.7217	0.5812	0.0354	0.0354	0.0094	132.97
Other Construction Equipment Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0633	0.0012	0.4477	0.3542	0.0181	0.0181	0.0057	122.66
Rubber Tired Dozers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2343	0.0024	1.8193	0.8818	0.0737	0.0737	0.0211	239.61
Scrapers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2135	0.0026	1.6041	0.8417	0.0653	0.0653	0.0192	262.96
Tractors/Loaders/Backhoes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

3.2.4 Trenching / Excavating Phase Formula(s)

- Fugitive Dust Emissions per Phase
$PM10_{FD}$ = (20 * ACRE * WD) / 2000

$PM10_{FD}$: Fugitive Dust PM 10 Emissions (TONs)
20: Conversion Factor Acre Day to pounds (20 lb / 1 Acre Day)
ACRE: Total acres (acres)
WD: Number of Total Work Days (days)
2000: Conversion Factor pounds to tons

- Construction Exhaust Emissions per Phase
CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase
VMT_{VE} = (HA_{OnSite} + $HA_{OffSite}$) * (1 / HC) * HT

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
HA_{OnSite}: Amount of Material to be Hauled On-Site (yd^3)
$HA_{OffSite}$: Amount of Material to be Hauled Off-Site (yd^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Vehicle Exhaust On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase
VMT_{WT} = WD * WT * 1.25 * NE

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

3.3 Building Construction Phase

3.3.1 Building Construction Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration
Number of Month: 15
Number of Days: 0

3.3.2 Building Construction Phase Assumptions

- General Building Construction Information
Building Category: Office or Industrial
Area of Building (ft^2): 379400
Height of Building (ft): 65
Number of Units: N/A

- Building Construction Default Settings
Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Cranes Composite	1	7
Forklifts Composite	2	7
Generator Sets Composite	1	8
Tractors/Loaders/Backhoes Composite	1	8
Welders Composite	3	8

- Vehicle Exhaust
Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips

Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

- Vendor Trips

Average Vendor Round Trip Commute (mile): 40 (default)

- Vendor Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

3.3.3 Building Construction Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Cranes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.1012	0.0013	0.7908	0.4059	0.0318	0.0318	0.0091	128.85
Forklifts Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0371	0.0006	0.2186	0.2173	0.0101	0.0101	0.0033	54.479
Generator Sets Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0477	0.0006	0.3758	0.2785	0.0191	0.0191	0.0043	61.100
Tractors/Loaders/Backhoes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912
Welders Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0387	0.0003	0.1940	0.1876	0.0133	0.0133	0.0034	25.690

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

3.3.4 Building Construction Phase Formula(s)

- Construction Exhaust Emissions per Phase

$CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000$

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

$VMT_{VE} = BA * BH * (0.42 / 1000) * HT$

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
BA: Area of Building (ft^2)
BH: Height of Building (ft)
(0.42 / 1000): Conversion Factor ft^3 to trips (0.42 trip / 1000 ft^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

$V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase

$VMT_{WT} = WD * WT * 1.25 * NE$

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

$V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Vender Trips Emissions per Phase

VMT_{VT} = BA * BH * (0.38 / 1000) * HT

VMT_{VT}: Vender Trips Vehicle Miles Travel (miles)
BA: Area of Building (ft^2)
BH: Height of Building (ft)
(0.38 / 1000): Conversion Factor ft^3 to trips (0.38 trip / 1000 ft^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

V_{POL} = (VMT_{VT} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VT}: Vender Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

3.4 Architectural Coatings Phase

3.4.1 Architectural Coatings Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration
Number of Month: 15
Number of Days: 0

3.4.2 Architectural Coatings Phase Assumptions

- General Architectural Coatings Information
Building Category:
Total Square Footage (ft^2): 180100
Number of Units: N/A

- Architectural Coatings Default Settings
Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Worker Trips
Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

3.4.3 Architectural Coatings Phase Emission Factor(s)

- Worker Trips Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

3.4.4 Architectural Coatings Phase Formula(s)

- Worker Trips Emissions per Phase

$VMT_{WT} = (1 * WT * PA) / 800$

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
1: Conversion Factor man days to trips (1 trip / 1 man * day)
WT: Average Worker Round Trip Commute (mile)
PA: Paint Area (ft^2)
800: Conversion Factor square feet to man days (1 ft^2 / 1 man * day)

$V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Off-Gassing Emissions per Phase

$VOC_{AC} = (AB * 2.0 * 0.0116) / 2000.0$

VOC_{AC}: Architectural Coating VOC Emissions (TONs)
BA: Area of Building (ft^2)
2.0: Conversion Factor total area to coated area (2.0 ft^2 coated area / total area)
0.0116: Emission Factor (lb/ft^2)
2000: Conversion Factor pounds to tons

3.5 Paving Phase

3.5.1 Paving Phase Timeline Assumptions

- Phase Start Date

Start Month: 1
Start Quarter: 1

Start Year: 2018

- Phase Duration
Number of Month: 15
Number of Days: 0

3.5.2 Paving Phase Assumptions

- General Paving Information
Paving Area (ft^2): 765700

- Paving Default Settings
Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Pavers Composite	1	8
Paving Equipment Composite	2	8
Rollers Composite	2	6

- Vehicle Exhaust
Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips
Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

3.5.3 Paving Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Excavators Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0848	0.0013	0.5180	0.5159	0.0249	0.0249	0.0076	119.77
Graders Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.1049	0.0014	0.7217	0.5812	0.0354	0.0354	0.0094	132.97
Other Construction Equipment Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**

Emission Factors	0.0633	0.0012	0.4477	0.3542	0.0181	0.0181	0.0057	122.66
Rubber Tired Dozers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2343	0.0024	1.8193	0.8818	0.0737	0.0737	0.0211	239.61
Scrapers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2135	0.0026	1.6041	0.8417	0.0653	0.0653	0.0192	262.96
Tractors/Loaders/Backhoes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

3.5.4 Paving Phase Formula(s)

- Construction Exhaust Emissions per Phase

$CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000$

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

$VMT_{VE} = PA * 0.25 * (1 / 27) * (1 / HC) * HT$

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
PA: Paving Area (ft^2)
0.25: Thickness of Paving Area (ft)
(1 / 27): Conversion Factor cubic feet to cubic yards (1 yd^3 / 27 ft^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

$V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Vehicle Exhaust On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase
VMT_{WT} = WD * WT * 1.25 * NE

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Off-Gassing Emissions per Phase
VOC_P = (2.62 * PA) / 43560

VOC_P: Paving VOC Emissions (TONs)
2.62: Emission Factor (lb/acre)
PA: Paving Area (ft^2)
43560: Conversion Factor square feet to acre (43560 ft2 / acre)^2 / acre)

4. Construction / Demolition

4.1 General Information & Timeline Assumptions

- Activity Location
County: Camden
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Alternate Control Center and Visitor Center

- Activity Description:

- Activity Start Date
Start Month: 1

Start Month: 2018

- Activity End Date
Indefinite: False
End Month: 12
End Month: 2018

- Activity Emissions:

Pollutant	Total Emissions (TONs)
VOC	1.401324
SO_x	0.015803
NO_x	8.262359
CO	7.044910
PM 10	14.663150

Pollutant	Total Emissions (TONs)
PM 2.5	0.409329
Pb	0.000000
NH_3	0.003916
CO_2e	1535.3

4.1 Site Grading Phase

4.1.1 Site Grading Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration
Number of Month: 12
Number of Days: 0

4.1.2 Site Grading Phase Assumptions

- General Site Grading Information
Area of Site to be Graded (ft^2): 105000
Amount of Material to be Hauled On-Site (yd^3): 24
Amount of Material to be Hauled Off-Site (yd^3): 24

- Site Grading Default Settings
Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Graders Composite	1	6
Other Construction Equipment Composite	1	8
Rubber Tired Dozers Composite	1	6
Tractors/Loaders/Backhoes Composite	1	7

- Vehicle Exhaust

Average Hauling Truck Capacity (yd^3): 20 (default)
Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips
Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

4.1.3 Site Grading Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Graders Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.1049	0.0014	0.7217	0.5812	0.0354	0.0354	0.0094	132.97
Other Construction Equipment Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0633	0.0012	0.4477	0.3542	0.0181	0.0181	0.0057	122.66
Rubber Tired Dozers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2343	0.0024	1.8193	0.8818	0.0737	0.0737	0.0211	239.61
Tractors/Loaders/Backhoes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

4.1.4 Site Grading Phase Formula(s)

- Fugitive Dust Emissions per Phase
$PM10_{FD}$ = (20 * ACRE * WD) / 2000

$PM10_{FD}$: Fugitive Dust PM 10 Emissions (TONs)
20: Conversion Factor Acre Day to pounds (20 lb / 1 Acre Day)

ACRE: Total acres (acres)
WD: Number of Total Work Days (days)
2000: Conversion Factor pounds to tons

- Construction Exhaust Emissions per Phase

$CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000$

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

$VMT_{VE} = (HA_{OnSite} + HA_{OffSite}) * (1 / HC) * HT$

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
HA_{OnSite}: Amount of Material to be Hauled On-Site (yd^3)
$HA_{OffSite}$: Amount of Material to be Hauled Off-Site (yd^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

$V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Vehicle Exhaust On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase

$VMT_{WT} = WD * WT * 1.25 * NE$

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

$V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)

VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

4.2 Trenching/Excavating Phase

4.2.1 Trenching / Excavating Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration
Number of Month: 12
Number of Days: 0

4.2.2 Trenching / Excavating Phase Assumptions

- General Trenching/Excavating Information
Area of Site to be Trenched/Excavated (ft^2): 14400
Amount of Material to be Hauled On-Site (yd^3): 0
Amount of Material to be Hauled Off-Site (yd^3): 0

- Trenching Default Settings
Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Excavators Composite	2	8
Other General Industrial Equipment Composite	1	8
Tractors/Loaders/Backhoes Composite	1	8

- Vehicle Exhaust
Average Hauling Truck Capacity (yd^3): 20 (default)
Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips
Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

4.2.3 Trenching / Excavating Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Graders Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.1049	0.0014	0.7217	0.5812	0.0354	0.0354	0.0094	132.97
Other Construction Equipment Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0633	0.0012	0.4477	0.3542	0.0181	0.0181	0.0057	122.66
Rubber Tired Dozers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2343	0.0024	1.8193	0.8818	0.0737	0.0737	0.0211	239.61
Tractors/Loaders/Backhoes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**Pb**	**NH_3**	**CO_2e**
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

4.2.4 Trenching / Excavating Phase Formula(s)

- Fugitive Dust Emissions per Phase

$PM10_{FD}$ = (20 * ACRE * WD) / 2000

$PM10_{FD}$: Fugitive Dust PM 10 Emissions (TONs)
20: Conversion Factor Acre Day to pounds (20 lb / 1 Acre Day)
ACRE: Total acres (acres)
WD: Number of Total Work Days (days)
2000: Conversion Factor pounds to tons

- Construction Exhaust Emissions per Phase

CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

$VMT_{VE} = (HA_{OnSite} + HA_{OffSite}) * (1 / HC) * HT$

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
HA_{OnSite}: Amount of Material to be Hauled On-Site (yd^3)
$HA_{OffSite}$: Amount of Material to be Hauled Off-Site (yd^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

$V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Vehicle Exhaust On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase

$VMT_{WT} = WD * WT * 1.25 * NE$

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

$V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

4.3 Building Construction Phase

4.3.1 Building Construction Phase Timeline Assumptions

- Phase Start Date

Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration

Number of Month: 12

Number of Days: 0

4.3.2 Building Construction Phase Assumptions

- General Building Construction Information

Building Category: Office or Industrial
Area of Building (ft^2): 11000
Height of Building (ft): 45
Number of Units: N/A

- Building Construction Default Settings

Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Cranes Composite	1	4
Forklifts Composite	2	6
Tractors/Loaders/Backhoes Composite	1	8

- Vehicle Exhaust

Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips

Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

- Vendor Trips

Average Vendor Round Trip Commute (mile): 40 (default)

- Vendor Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

4.3.3 Building Construction Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Cranes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.1012	0.0013	0.7908	0.4059	0.0318	0.0318	0.0091	128.85
Forklifts Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0371	0.0006	0.2186	0.2173	0.0101	0.0101	0.0033	54.479
Tractors/Loaders/Backhoes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**Pb**	**NH_3**	**CO_2e**
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

4.3.4 Building Construction Phase Formula(s)

- Construction Exhaust Emissions per Phase

CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

VMT_{VE} = BA * BH * (0.42 / 1000) * HT

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
BA: Area of Building (ft^2)
BH: Height of Building (ft)
(0.42 / 1000): Conversion Factor ft^3 to trips (0.42 trip / 1000 ft^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds

EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase

$VMT_{WT} = WD * WT * 1.25 * NE$

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

$V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Vender Trips Emissions per Phase

$VMT_{VT} = BA * BH * (0.38 / 1000) * HT$

VMT_{VT}: Vender Trips Vehicle Miles Travel (miles)
BA: Area of Building (ft^2)
BH: Height of Building (ft)
(0.38 / 1000): Conversion Factor ft^3 to trips (0.38 trip / 1000 ft^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

$V_{POL} = (VMT_{VT} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{VT}: Vender Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

4.4 Architectural Coatings Phase

4.4.1 Architectural Coatings Phase Timeline Assumptions

- Phase Start Date

Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration
Number of Month: 12
Number of Days: 0

4.4.2 Architectural Coatings Phase Assumptions

- General Architectural Coatings Information
Building Category:
Total Square Footage (ft^2): 11000
Number of Units: N/A

- Architectural Coatings Default Settings
Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Worker Trips
Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

4.4.3 Architectural Coatings Phase Emission Factor(s)

- Worker Trips Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

4.4.4 Architectural Coatings Phase Formula(s)

- Worker Trips Emissions per Phase
$VMT_{WT} = (1 * WT * PA) / 800$

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
1: Conversion Factor man days to trips (1 trip / 1 man * day)
WT: Average Worker Round Trip Commute (mile)
PA: Paint Area (ft^2)
800: Conversion Factor square feet to man days (1 ft^2 / 1 man * day)

$V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Off-Gassing Emissions per Phase
VOC_{AC} = (AB * 2.0 * 0.0116) / 2000.0

VOC_{AC}: Architectural Coating VOC Emissions (TONs)
BA: Area of Building (ft^2)
2.0: Conversion Factor total area to coated area (2.0 ft^2 coated area / total area)
0.0116: Emission Factor (lb/ft^2)
2000: Conversion Factor pounds to tons

4.5 Paving Phase

4.5.1 Paving Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration
Number of Month: 12
Number of Days: 0

4.5.2 Paving Phase Assumptions

- General Paving Information
Paving Area (ft^2): 23100

- Paving Default Settings
Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Cement and Mortar Mixers Composite	4	6
Pavers Composite	1	7
Paving Equipment Composite	1	8
Rollers Composite	1	7
Tractors/Loaders/Backhoes Composite	1	7

- Vehicle Exhaust
Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips

Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

4.5.3 Paving Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Graders Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.1049	0.0014	0.7217	0.5812	0.0354	0.0354	0.0094	132.97
Other Construction Equipment Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0633	0.0012	0.4477	0.3542	0.0181	0.0181	0.0057	122.66
Rubber Tired Dozers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2343	0.0024	1.8193	0.8818	0.0737	0.0737	0.0211	239.61
Tractors/Loaders/Backhoes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

4.5.4 Paving Phase Formula(s)

- Construction Exhaust Emissions per Phase

$CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000$

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)

2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

VMT_{VE} = PA * 0.25 * (1 / 27) * (1 / HC) * HT

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
PA: Paving Area (ft^2)
0.25: Thickness of Paving Area (ft)
(1 / 27): Conversion Factor cubic feet to cubic yards (1 yd^3 / 27 ft^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Vehicle Exhaust On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase

VMT_{WT} = WD * WT * 1.25 * NE

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Off-Gassing Emissions per Phase

VOC_P = (2.62 * PA) / 43560

VOC_P: Paving VOC Emissions (TONs)
2.62: Emission Factor (lb/acre)
PA: Paving Area (ft^2)
43560: Conversion Factor square feet to acre (43560 ft2 / acre)^2 / acre)

5. Construction / Demolition

5.1 General Information & Timeline Assumptions

- Activity Location
County: Camden
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Landing Zone

- Activity Description:

- Activity Start Date
Start Month: 1
Start Month: 2018

- Activity End Date
Indefinite: False
End Month: 10
End Month: 2018

- Activity Emissions:

Pollutant	Total Emissions (TONs)
VOC	1.739717
SO_x	0.020885
NO_x	11.424893
CO	8.872442
PM 10	63.151244

Pollutant	Total Emissions (TONs)
PM 2.5	0.550414
Pb	0.000000
NH_3	0.003492
CO_2e	2048.4

5.1 Site Grading Phase

5.1.1 Site Grading Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration
Number of Month: 10
Number of Days: 0

5.1.2 Site Grading Phase Assumptions

- General Site Grading Information
Area of Site to be Graded (ft^2): 566280
Amount of Material to be Hauled On-Site (yd^3): 130

Amount of Material to be Hauled Off-Site (yd^3): 130

- Site Grading Default Settings
Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Excavators Composite	1	8
Graders Composite	1	8
Other Construction Equipment Composite	1	8
Rubber Tired Dozers Composite	1	8
Scrapers Composite	2	8
Tractors/Loaders/Backhoes Composite	3	8

- Vehicle Exhaust
Average Hauling Truck Capacity (yd^3): 20 (default)
Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips
Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

5.1.3 Site Grading Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Excavators Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0848	0.0013	0.5180	0.5159	0.0249	0.0249	0.0076	119.77
Graders Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.1049	0.0014	0.7217	0.5812	0.0354	0.0354	0.0094	132.97
Other Construction Equipment Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0633	0.0012	0.4477	0.3542	0.0181	0.0181	0.0057	122.66
Rubber Tired Dozers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2343	0.0024	1.8193	0.8818	0.0737	0.0737	0.0211	239.61
Scrapers Composite								

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	CH_4	CO_2e
Emission Factors	0.2135	0.0026	1.6041	0.8417	0.0653	0.0653	0.0192	262.96
Tractors/Loaders/Backhoes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

5.1.4 Site Grading Phase Formula(s)

- Fugitive Dust Emissions per Phase

$PM10_{FD}$ = (20 * ACRE * WD) / 2000

$PM10_{FD}$: Fugitive Dust PM 10 Emissions (TONs)
20: Conversion Factor Acre Day to pounds (20 lb / 1 Acre Day)
ACRE: Total acres (acres)
WD: Number of Total Work Days (days)
2000: Conversion Factor pounds to tons

- Construction Exhaust Emissions per Phase

CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

VMT_{VE} = (HA_{OnSite} + $HA_{OffSite}$) * (1 / HC) * HT

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
HA_{OnSite}: Amount of Material to be Hauled On-Site (yd^3)
$HA_{OffSite}$: Amount of Material to be Hauled Off-Site (yd^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Vehicle Exhaust On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase
VMT_{WT} = WD * WT * 1.25 * NE

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

5.2 Trenching/Excavating Phase

5.2.1 Trenching / Excavating Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration
Number of Month: 10
Number of Days: 0

5.2.2 Trenching / Excavating Phase Assumptions

- General Trenching/Excavating Information
Area of Site to be Trenched/Excavated (ft^2): 63000
Amount of Material to be Hauled On-Site (yd^3): 0
Amount of Material to be Hauled Off-Site (yd^3): 0

- Trenching Default Settings

Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Excavators Composite	2	8
Other General Industrial Equipment Composite	1	8
Tractors/Loaders/Backhoes Composite	1	8

- Vehicle Exhaust
Average Hauling Truck Capacity (yd^3): 20 (default)
Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips
Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

5.2.3 Trenching / Excavating Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Excavators Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0848	0.0013	0.5180	0.5159	0.0249	0.0249	0.0076	119.77
Graders Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.1049	0.0014	0.7217	0.5812	0.0354	0.0354	0.0094	132.97
Other Construction Equipment Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0633	0.0012	0.4477	0.3542	0.0181	0.0181	0.0057	122.66
Rubber Tired Dozers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2343	0.0024	1.8193	0.8818	0.0737	0.0737	0.0211	239.61
Scrapers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2135	0.0026	1.6041	0.8417	0.0653	0.0653	0.0192	262.96
Tractors/Loaders/Backhoes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

5.2.4 Trenching / Excavating Phase Formula(s)

- Fugitive Dust Emissions per Phase

$PM10_{FD}$ = (20 * ACRE * WD) / 2000

$PM10_{FD}$: Fugitive Dust PM 10 Emissions (TONs)
20: Conversion Factor Acre Day to pounds (20 lb / 1 Acre Day)
ACRE: Total acres (acres)
WD: Number of Total Work Days (days)
2000: Conversion Factor pounds to tons

- Construction Exhaust Emissions per Phase

CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

VMT_{VE} = (HA_{OnSite} + $HA_{OffSite}$) * (1 / HC) * HT

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
HA_{OnSite}: Amount of Material to be Hauled On-Site (yd^3)
$HA_{OffSite}$: Amount of Material to be Hauled Off-Site (yd^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Vehicle Exhaust On Road Vehicle Mixture (%)

2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase

VMT_{WT} = WD * WT * 1.25 * NE

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

5.3 Building Construction Phase

5.3.1 Building Construction Phase Timeline Assumptions

- Phase Start Date

Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration

Number of Month: 10
Number of Days: 0

5.3.2 Building Construction Phase Assumptions

- General Building Construction Information

Building Category: Office or Industrial
Area of Building (ft^2): 2500
Height of Building (ft): 15
Number of Units: N/A

- Building Construction Default Settings

Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Cranes Composite	1	4
Forklifts Composite	2	6
Tractors/Loaders/Backhoes Composite	1	8

- Vehicle Exhaust

Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips

Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

- Vendor Trips

Average Vendor Round Trip Commute (mile): 40 (default)

- Vendor Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

5.3.3 Building Construction Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Cranes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.1012	0.0013	0.7908	0.4059	0.0318	0.0318	0.0091	128.85
Forklifts Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0371	0.0006	0.2186	0.2173	0.0101	0.0101	0.0033	54.479
Tractors/Loaders/Backhoes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

5.3.4 Building Construction Phase Formula(s)

- Construction Exhaust Emissions per Phase

CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

VMT_{VE} = BA * BH * (0.42 / 1000) * HT

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
BA: Area of Building (ft^2)
BH: Height of Building (ft)
(0.42 / 1000): Conversion Factor ft^3 to trips (0.42 trip / 1000 ft^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase

VMT_{WT} = WD * WT * 1.25 * NE

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)

0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Vender Trips Emissions per Phase
VMT_{VT} = BA * BH * (0.38 / 1000) * HT

VMT_{VT}: Vender Trips Vehicle Miles Travel (miles)
BA: Area of Building (ft^2)
BH: Height of Building (ft)
(0.38 / 1000): Conversion Factor ft^3 to trips (0.38 trip / 1000 ft^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

V_{POL} = (VMT_{VT} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VT}: Vender Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

5.4 Architectural Coatings Phase

5.4.1 Architectural Coatings Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration
Number of Month: 10
Number of Days: 0

5.4.2 Architectural Coatings Phase Assumptions

- General Architectural Coatings Information
Building Category:
Total Square Footage (ft^2): 2500
Number of Units: N/A

- Architectural Coatings Default Settings
Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Worker Trips

Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

5.4.3 Architectural Coatings Phase Emission Factor(s)

- Worker Trips Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

5.4.4 Architectural Coatings Phase Formula(s)

- Worker Trips Emissions per Phase

$VMT_{WT} = (1 * WT * PA) / 800$

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
1: Conversion Factor man days to trips (1 trip / 1 man * day)
WT: Average Worker Round Trip Commute (mile)
PA: Paint Area (ft^2)
800: Conversion Factor square feet to man days (1 ft^2 / 1 man * day)

$V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Off-Gassing Emissions per Phase

$VOC_{AC} = (AB * 2.0 * 0.0116) / 2000.0$

VOC_{AC}: Architectural Coating VOC Emissions (TONs)
BA: Area of Building (ft^2)
2.0: Conversion Factor total area to coated area (2.0 ft^2 coated area / total area)
0.0116: Emission Factor (lb/ft^2)
2000: Conversion Factor pounds to tons

5.5 Paving Phase

5.5.1 Paving Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration
Number of Month: 10
Number of Days: 0

5.5.2 Paving Phase Assumptions

- General Paving Information
Paving Area (ft^2): 349500

- Paving Default Settings
Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Pavers Composite	1	8
Paving Equipment Composite	2	6
Rollers Composite	2	6

- Vehicle Exhaust
Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips
Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

5.5.3 Paving Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Excavators Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0848	0.0013	0.5180	0.5159	0.0249	0.0249	0.0076	119.77
Graders Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.1049	0.0014	0.7217	0.5812	0.0354	0.0354	0.0094	132.97
Other Construction Equipment Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0633	0.0012	0.4477	0.3542	0.0181	0.0181	0.0057	122.66
Rubber Tired Dozers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2343	0.0024	1.8193	0.8818	0.0737	0.0737	0.0211	239.61
Scrapers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2135	0.0026	1.6041	0.8417	0.0653	0.0653	0.0192	262.96
Tractors/Loaders/Backhoes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**Pb**	**NH_3**	**CO_2e**
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

5.5.4 Paving Phase Formula(s)

- Construction Exhaust Emissions per Phase

CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

VMT_{VE} = PA * 0.25 * (1 / 27) * (1 / HC) * HT

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
PA: Paving Area (ft^2)
0.25: Thickness of Paving Area (ft)
(1 / 27): Conversion Factor cubic feet to cubic yards (1 yd^3 / 27 ft^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

$V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Vehicle Exhaust On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase
$VMT_{WT} = WD * WT * 1.25 * NE$

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

$V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Off-Gassing Emissions per Phase
$VOC_P = (2.62 * PA) / 43560$

VOC_P: Paving VOC Emissions (TONs)
2.62: Emission Factor (lb/acre)
PA: Paving Area (ft^2)
43560: Conversion Factor square feet to acre (43560 ft2 / acre)^2 / acre)

6. Construction / Demolition

6.1 General Information & Timeline Assumptions

- Activity Location

County: Camden
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Launch Site Roads

- Activity Description:

- Activity Start Date
Start Month: 1
Start Month: 2018

- Activity End Date
Indefinite: False
End Month: 7
End Month: 2018

- Activity Emissions:

Pollutant	Total Emissions (TONs)
VOC	1.068993
SO_x	0.012085
NO_x	7.195848
CO	5.063809
PM 10	64.688701

Pollutant	Total Emissions (TONs)
PM 2.5	0.344994
Pb	0.000000
NH_3	0.001886
CO_2e	1205.5

6.1 Site Grading Phase

6.1.1 Site Grading Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration
Number of Month: 7
Number of Days: 0

6.1.2 Site Grading Phase Assumptions

- General Site Grading Information
Area of Site to be Graded (ft^2): 924000
Amount of Material to be Hauled On-Site (yd^3): 212
Amount of Material to be Hauled Off-Site (yd^3): 212

- Site Grading Default Settings
Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Excavators Composite	1	8
Graders Composite	1	8
Other Construction Equipment Composite	1	8
Rubber Tired Dozers Composite	1	8
Scrapers Composite	3	8
Tractors/Loaders/Backhoes Composite	3	8

- Vehicle Exhaust

Average Hauling Truck Capacity (yd^3): 20 (default)
Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips

Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

6.1.3 Site Grading Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Excavators Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0848	0.0013	0.5180	0.5159	0.0249	0.0249	0.0076	119.77
Graders Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.1049	0.0014	0.7217	0.5812	0.0354	0.0354	0.0094	132.97
Other Construction Equipment Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0633	0.0012	0.4477	0.3542	0.0181	0.0181	0.0057	122.66
Rubber Tired Dozers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2343	0.0024	1.8193	0.8818	0.0737	0.0737	0.0211	239.61
Scrapers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2135	0.0026	1.6041	0.8417	0.0653	0.0653	0.0192	262.96
Tractors/Loaders/Backhoes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

6.1.4 Site Grading Phase Formula(s)

- Fugitive Dust Emissions per Phase

$PM10_{FD}$ = (20 * ACRE * WD) / 2000

$PM10_{FD}$: Fugitive Dust PM 10 Emissions (TONs)
20: Conversion Factor Acre Day to pounds (20 lb / 1 Acre Day)
ACRE: Total acres (acres)
WD: Number of Total Work Days (days)
2000: Conversion Factor pounds to tons

- Construction Exhaust Emissions per Phase

CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

VMT_{VE} = (HA_{OnSite} + $HA_{OffSite}$) * (1 / HC) * HT

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
HA_{OnSite}: Amount of Material to be Hauled On-Site (yd^3)
$HA_{OffSite}$: Amount of Material to be Hauled Off-Site (yd^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Vehicle Exhaust On Road Vehicle Mixture (%)

2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase

VMT_{WT} = WD * WT * 1.25 * NE

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

6.2 Paving Phase

6.2.1 Paving Phase Timeline Assumptions

- Phase Start Date

Start Month: 1
Start Quarter: 1
Start Year: 2018

- Phase Duration

Number of Month: 7
Number of Days: 0

6.2.2 Paving Phase Assumptions

- General Paving Information

Paving Area (ft^2): 924000

- Paving Default Settings

Default Settings Used: Yes
Average Day(s) worked per week: 5 (default)

- Construction Exhaust (default)

Equipment Name	Number Of Equipment	Hours Per Day
Pavers Composite	1	8
Paving Equipment Composite	2	8
Rollers Composite	2	6

- Vehicle Exhaust

Average Hauling Truck Round Trip Commute (mile): 20 (default)

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips

Average Worker Round Trip Commute (mile): 20 (default)

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

6.2.3 Paving Phase Emission Factor(s)

- Construction Exhaust Emission Factors (lb/hour) (default)

Excavators Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0848	0.0013	0.5180	0.5159	0.0249	0.0249	0.0076	119.77
Graders Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.1049	0.0014	0.7217	0.5812	0.0354	0.0354	0.0094	132.97
Other Construction Equipment Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0633	0.0012	0.4477	0.3542	0.0181	0.0181	0.0057	122.66
Rubber Tired Dozers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2343	0.0024	1.8193	0.8818	0.0737	0.0737	0.0211	239.61
Scrapers Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.2135	0.0026	1.6041	0.8417	0.0653	0.0653	0.0192	262.96
Tractors/Loaders/Backhoes Composite								
	VOC	**SO_x**	**NO_x**	**CO**	**PM 10**	**PM 2.5**	**CH_4**	**CO_2e**
Emission Factors	0.0512	0.0007	0.3330	0.3646	0.0189	0.0189	0.0046	66.912

- Vehicle Exhaust & Worker Trips Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3	CO_2e
LDGV	000.336	000.002	000.280	003.512	000.008	000.007		000.025	00339.290
LDGT	000.433	000.003	000.488	005.206	000.010	000.008		000.026	00439.098
HDGV	000.867	000.005	001.272	017.093	000.022	000.020		000.045	00771.784
LDDV	000.114	000.003	000.151	002.586	000.004	000.004		000.008	00332.636
LDDT	000.308	000.004	000.487	005.082	000.007	000.007		000.008	00484.402
HDDV	000.584	000.013	005.846	002.028	000.220	000.202		000.029	01527.182
MC	002.616	000.003	000.727	013.442	000.027	000.024		000.053	00395.713

6.2.4 Paving Phase Formula(s)

- Construction Exhaust Emissions per Phase
CEE_{POL} = (NE * WD * H * EF_{POL}) / 2000

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hour)
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase
VMT_{VE} = PA * 0.25 * (1 / 27) * (1 / HC) * HT

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
PA: Paving Area (ft^2)
0.25: Thickness of Paving Area (ft)
(1 / 27): Conversion Factor cubic feet to cubic yards (1 yd^3 / 27 ft^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Vehicle Exhaust On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase
VMT_{WT} = WD * WT * 1.25 * NE

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)

2000: Conversion Factor pounds to tons

- Off-Gassing Emissions per Phase
VOC_P = (2.62 * PA) / 43560

VOC_P: Paving VOC Emissions (TONs)
2.62: Emission Factor (lb/acre)
PA: Paving Area (ft^2)
43560: Conversion Factor square feet to acre (43560 ft2 / acre)^2 / acre)

E.4.2 Operational Emissions

E.4.2.1 Vessel Emissions

Vessel emissions were estimated assuming that one tug boat vessel would be in operation for towing the landing barge out to the site, returning to port, returning to the site to retrieve the barge, and returning the barge to port. Additionally, it was assumed that small vessels with dual outboard motors (assumed dual 250-horsepower [HP] gas outboards) would be used during landing operations to provide support and security clearing the safety area. Operational hours assumed that tugs would travel at an average speed of 8 knots and small vessels averaging 15 knots.

Table E-6. Vessel Emission Factors

Vessel Type	Engines	HP	VOC	SO_x	NO_x	CO	PM_{10}	$PM_{2.5}$	CO_2
Tugboat[1]	2	850	0.6	1.81	17	1.4	0.31	0.28	588.79
HSMST[2]	2	250	0.02	0.00	0.01	0.23	0.00	0.00	646.08

Notes: CO = carbon monoxide; HP = horsepower; HSMST = High Speed Maneuvering Surface Target; NO_x = nitrogen oxides; $PM_{2.5}$ = particulate matter with a diameter less than or equal to 2.5 microns; PM_{10} = particulate matter with a diameter less than or equal to 10 microns; SO_x = sulfur oxides; VOC = volatile organic compounds.
[1] USEPA, 2009
[2] USEPA, 2010

Emissions were calculated using the formula below, and calculated emissions are shown in Table E-7 and Table E-8.

Emissions = HP×HR/YR×EF×ENG×CF

Where:
Emissions = Surface craft Emissions (tons per year)
HP = Horsepower (reflective of a particular load factor/engine power setting)
HR/YR = Hours per year
EF = Emission factor for specific engine type (Lbs. per hour)
ENG = Number of engines
CF = Conversion Factor for pounds to tons

Table E-7. Proposed Action Vessel Emissions

Vessel Type	Engines	HP	Hours	Load Factor	VOC	SO_x	NO_x	CO	PM_{10}	$PM_{2.5}$	CO_2
Tug Boat	2	850	65	1	33.22	100.23	941.37	77.52	17.17	15.50	32,604
Small vessel	2	250	35	1	0.19	0.00	0.05	1.96	0.00	0.00	5615
				TOTAL	33.42	100.23	941.42	79.48	17.17	15.51	38,219

E.4.2.2 Launch, Landing, and Static Test Operations

It was assumed that launches would include a maximum of 10 Falcon 9-type vehicles and 2 Falcon Heavy-type vehicles. Because the vehicles would leave the 3,000-foot above ground level relatively quickly, it was assumed that 20 percent of fuel burn would occur for launches. Similarly, landings were assumed to represent 10 percent of the total and static engine fire tests 5 percent of the total.

Table E-8. Launch, Landing, and Static Test Emissions

Launch Type	Launches	RP-1 gal/launch	RP-1 MMBtu/gal	CO Tons/launch	CO tons	20% emissions	10% emissions	5% emissions
Falcon 9	10	38000	0.135	857.15	8571.5	1714.3	857.15	428.575
Falcon Heavy	2	200000	0.135	2571.45	5142.9	1028.58	514.29	257.145
				Total CO	13714.4	2742.88	1371.44	685.72

Table E-9. Launch, Landing, and Static Test Greenhouse Gas Emissions

Launch Type	Launches	RP-1 gal/ launch	RP-1 MMBtu/ gal	[2]CO_2 kg/MMBtu/ gal	[3]CH_4 kg/MMBtu/ gal	[3]N_2O kg/MMBtu/ gal	CO_2 kg	CH_4 kg	N_2O kg	CO_2e MT/yr
Falcon 9	10	38000	0.135	75.2	0.003	0.0006	3857760	153.9	30.78	3872.473
Falcon Heavy	2	200000	0.135	75.2	0.003	0.0006	4060800	162	32.4	4076.287
				Total CO	0.006	0.0012	7918560	315.9	63.18	7948.76

[2]Emission Factor from Table C-1 to Subpart C of 40 CFR 98, Mandatory GHG Reporting Rule
[3]Emission Factor from Table C-2 to Subpart C of 40 CFR 98, Mandatory GHG Reporting Rule
Launches assumed to be 20% of total emissions as the vehicle would exit the 3000 ft mixing layer within seconds.
Landings assumed to be 10% of total emissions.
Static Engine tests assumed to be 5% of total emissions.

E.4.2 Generator Operations

It was assumed that up to ten 300 kilowatt (kW) diesel generators would be operated 0.5 hours per week for testing and maintenance. Additionally, it was assumed that generators would operate during five 24-hour periods of outages annually. It was also assumed that an additional twelve 48-hour operational periods would occur for launces.

Table E-10. Generator Emission Factors

Pollutant	EFs Diesel Fuel (<447kW or <600hp)
CO	5.50E-03
NO_x	0.024
PM_{10}	0.0007
$PM_{2.5}$	0.0007
SO_2	8.09E-03
VOC	7.05E-04
CO_2	1.16

Source: Emission factors from USEPA, Compilation of Air Pollutant Emission Factors - Vol I (AP-42), Section 3.4, 5th Edition; factors based upon power output.

Table E-11. Generator Annual Emissions

Operational Activity	Proposed Action						
	Emissions						
	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC	CO_2e
Generator Operations	3.99	17.43	0.51	0.51	5.87	0.51	842

E.4.2.3 Staff Commutes

It was assumed that 77 full-time employees would commute to work an average of 250 days per year. It was further assumed that an additional 233 staff personnel would commute to the site for launches an average of 144 days per year. A 50/50 mix of light-duty gas vehicles (cars) and light-duty gas trucks (pickup trucks) was assumed for all personnel.

Table E-12. Commuter Vehicle Emission Factors

	VOC	SO_x	NO_x	CO	PM_{10}	$PM_{2.5}$	NH_3	CO_2
LDGV	0.336	0.002	0.28	3.512	0.008	0.007	0.1017	339.29
LDGT	0.433	0.003	0.488	5.206	0.01	0.008	0.026	439.098

Notes: LDGV = Light-duty gas vehicle; LDGT = Light-duty gas truck.
Source: USEPA MOVES (Motor Vehicle Emission Simulator) 2014a

Table E-13. Commuter Vehicle Annual Emissions

		No. of Vehicles	No. of days	round trip (mi)	Emissions (tons/yr)						
					CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC	CO_2e
Regular Staff	LDGV	38.5	250	50	1.86	0.15	0.00	0.00	0.00	0.18	179.99
	LDGT	38.5	250	50	2.76	0.26	0.01	0.00	0.00	0.23	232.94
Launch Event Staff	LDGV	116.5	144	50	3.25	0.26	0.01	0.01	0.00	0.31	313.71
	LDGT	116.5	144	50	4.81	0.45	0.01	0.01	0.00	0.40	406.00
				TOTAL	12.69	1.12	0.03	0.02	0.01	1.12	1132.64

E.4.2.4 Deliveries

It was assumed that deliveries of fuels and other necessary components would occur over the course of the year totaling an average of 600 annual deliveries.

Table E-14. Delivery Vehicle Emission Factors

	VOC	SO_x	NO_x	CO	PM_{10}	$PM_{2.5}$	NH_3	CO_2
HDDV	0.584	0.013	5.846	2.028	0.22	0.202	0.029	1527.182

Notes: HDDV = Heavy-duty diesel vehicle.
Source: USEPA MOVES (Motor Vehicle Emission Simulator) 2014a

Table E-15. Delivery Vehicle Annual Emissions

	No. of Vehicles	No. of days	round trip (mi)	Emissions (tons/yr)						
				CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC	CO_2e
Shipping Trucks	1	600	200	0.00	0.01	0.00	0.00	0.00	0.00	7.24

E.5 References

Code of Federal Regulations (CFR), Title 40, 1508.27. Protection of Environment Council on Environmental *Quality*. January 1979.

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APPENDIX F CULTURAL RESOURCES

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F CULTURAL RESOURCES

F.1 Historic Context

The material in this appendix is summarized from comprehensive cultural resources studies conducted for the Federal Aviation Administration (Cultural Resources Analysts, Inc., 2017a; Cultural Resources Analysts, Inc., 2017b), which contain complete citations and reference lists.

F.1.1 Prehistory

This section briefly describes the state of knowledge regarding pre-contact occupation of the general project area and the specific archeological area of potential effects (APE). It describes the prehistoric chronology of the region and includes a discussion of broad patterns of human occupation in the project region, as evidenced by known cultural resources, including archeological sites. This information supports conclusions regarding the sensitivity of the APEs for the presence of previously unrecorded archeological resources that could be encountered in the course of construction or operation of the spaceport.

Pre-Paleoindian (before 13,500 B.P.)

The timing and actual entry point of the first humans into North America are still topics for debate. Over the last decade, increasing data have indicated human occupation in North American circa 16,000 to 15,000 B.P.

Several sites in the southeastern United States have been suggested as pre-Clovis candidates. Among these are the Cactus Hill site in southeast Virginia, the Topper site in South Carolina, and the Debra L. Friedkin site in Texas.

Paleoindian Period (11,500–10,000 B.P.)

The earliest known human occupation of Georgia occurred during the Paleoindian period, which coincided with the end of the Wisconsin Glaciation and beginning of the Holocene epoch. Most archeologists divide the Paleoindian period into three subperiods based on changes in projectile point morphology through time. The Early Paleoindian period (11,500 to 10,800 B.P.) is identified by the presence of Clovis points, which are large lanceolate-shaped points with parallel sides and a ground haft with a fluted, slightly concave base. During the Middle Paleoindian period (10,800 to 10,500 B.P.) fluted points decrease in size and unfluted lanceolate points with broad blades and constructed haft elements appear. The Late Paleoindian period (10,500 to 10,000 B.P.) tool kit corresponded with the onset of Holocene environments. The extinction of the megafauna and the establishment of an ecology similar to that of the modern period necessitated new resource procurement strategies. Late Paleoindian points include Dalton, Hardaway, Quad, San Patrice, and Beaver Lake.

The majority of Paleoindian artifacts recovered in Georgia are found in archeologically mixed contexts or as isolated finds. Fieldwork in the vicinity of the project site has produced little information concerning this time period, and no Clovis or Dalton points are known from Camden County. Almost all of the Early Paleoindian sites identified to date were located on the floodplains, with fewer sites on the upland edge. A shift in the choice of habitation sites appears to have occurred during the Middle and Late Paleoindian periods with sites distributed in floodplains, the upland edge, and the uplands.

Archaic Period (10,000–3000 B.P.)

Early Archaic Period (10,000–8000 B.P.)

The transition to the Early Archaic period is marked by the absence of fluted projectile points/knives and the appearance of side-notched hafted bifaces, including Big Sandy, Taylor, and Bolen, along with corner-notched types, such as Palmer and Kirk. The hafted Edgefield scraper is also considered to be diagnostic of this period. In some schemes, the Early Archaic may be divided into four phases. Those phases, from earliest to latest, include Taylor (9900–9500 B.P.), Palmer/Kirk (9500–8300 B.P.), Bifurcate (8900–8000 B.P.), and Kirk Stemmed (8000–7500 B.P.). This scheme may apply to the entire Georgia Coastal Plain.

Research conducted in the Coastal Plain has provided little information about the Early Archaic period. Sites are generally small, consisting of small lithic scatters. Early Archaic groups in this area were likely organized like those noted near the Fall Line in the Lake Oconee basin, where people were living in small seasonal base camps and utilizing smaller camps near extractive resources.

Middle Archaic Period (8000–6000 B.P.)

The Middle Archaic period is marked by a warming climate and an increase in population. The appearance of bannerstones (atlatl weights) signals the innovation of a new projectile technology, while the production of grooved axes signals another technological development. The transition to the Middle Archaic is marked by the appearance of stemmed bifaces, such as the Kirk Stemmed/Serrated, Stanly Stemmed, Morrow Mountain Stemmed, Benton, Guilford, and Brier Creek. The Stanly Stemmed is seldom seen on Coastal Plain sites, and the Benton, Guilford, and Brier Creek are types more typically found in the Piedmont. Sites representing the Middle Archaic are extremely rare on the Coastal Plain.

A Middle Archaic chronology for the Savannah River Valley probably also applies to the study area. Their proposed phases include Stanly (7800–7500 B.P.), Morrow Mountain (7500–6000 B.P.) and Guilford/Brier Creek/MALA (6000–5000 B.P.). Middle Archaic sites appear to be far more common in the Piedmont to the north of the Fall Line than in the Coastal Plain in general, but the highest concentration of known Middle Archaic sites in the Coast Plain is within the Fall Line Hills and the Vidalia Uplands subprovinces. By the latter part of the Middle Archaic, shell middens appear on the St. Johns River in northeastern Florida, along with tapered-stem Newnan bifaces.

Late Archaic Period (6000–3000 B.P.)

The Late Archaic is marked by an increase in the use of riverine environments, an increase in the exploitation of shellfish, more use of ground stone implements, the introduction of soapstone vessels, and emergent ceramic technology. The increased use of soapstone and pottery containers likely indicate a more sedentary population and more extensive trade networks to facilitate the movement of raw materials and ideas. The earliest known house structures in Georgia, found on sites in the Augusta area, date to the Late Archaic. Diagnostic projectile points include the Savannah River, Elora, Kiokee Creek, Ledbetter, and Paris Island. Other artifacts indicative of the Late Archaic include perforated steatite slabs, steatite bowls, winged bannerstones, and grooved axes.

The late Archaic may be divided into four phases. Those phases include, from oldest to youngest, Paris Island (4450–4150 B.P.), Mill Branch 42 (4150–3800 B.P.), Lover's Lane (3800–3300 B.P.), and Dickens (3300–2850 B.P.).

Some of the earliest ceramic technology in the southeast is found near the Georgia coast. The first ceramic vessels were introduced circa 4500 B.P., although it would be about 1,000 years before its use would become widespread. Fiber-tempered pottery is dominated by plain vessels with a fine, consistent paste, more common on the Georgia coast, in contrast to sand-tempered pottery that does not appear in coastal Georgia. Pottery of this period found on the upper Satilla River is semi-fiber tempered with a very sandy paste, and in both plain and simple-stamped styles in the area between the Satilla and Ocmulgee Rivers. The soapstone sources used to make bowls are located north of the Fall Line, so it is expected that soapstone bowls would occur in lower frequency as distance increases south of the Fall Line. It appears that the manufacture of soapstone bowls began after the introduction of pottery in Georgia.

Woodland Period (3000–1000 B.P.)

The Woodland period is marked by changes in settlement and subsistence patterns, technology, and social organization. In the southeastern United States, the Woodland period may be divided into three subperiods: Early (3000–2200 B.P.), Middle 10 (2200–1600 B.P.), and Late (1600–1100 B.P.). The use of stemmed bifaces continued into the Early Woodland and was followed by a transition to a variety of large triangular bifaces, which are reduced in size over time. Use of the bow and arrow became widespread by the Late Woodland period, and extensive trade networks were established as well. The construction of mounds increased and larger villages were settled, as horticulture increased in importance. There is evidence however, that the Woodland period on the Georgia coast was expressed differently than in the interior. With abundant supplies of food from riverine and estuarial sources, small bands continued seasonal rounds from centralized base camps.

Pottery types increase in number and become more varied in both temper and decorative techniques, and recent researchers have begun to discuss the Woodland period in terms of the ceramic traditions that were the hallmark of distinct cultures throughout the period, as changes in lithic technology are less useful in defining cultural differences, especially on the coast.

Mississippian Period (1100–500 B.P.)

The Mississippian period, which is recognized throughout the core southeastern United States, is characterized by major changes in the social structure, subsistence patterns, and settlement patterns of Native Americans. Large permanent settlements arose, led by chiefs and primarily supported by the cultivation of corn. Political and military power emerged in these large centers and appears to have been highly centralized, with each center supported by numerous outlying hamlets and farmsteads. Practices such as the construction of wall-trench houses and changes in pottery technology and style serve as the material correlates for the shared ideology associated with the Mississippian world. Based on firsthand observation by early Spanish explorers in the southeast, Mississippian chiefs maintained armies of professional soldiers who were adept at guerilla warfare.

Across the interior of the southeast, the Mississippian period marked a fundamental change in the settlement patterns that persisted for thousands of years prior. The people of this period were no longer dispersed across the landscape pursuing a hunter-gatherer subsistence system. They were concentrated instead into villages, mainly in floodplain settings with a subsistence base centered on the cultivation of corn, beans, squash, and other cultigens. This change was less drastic, however, for the people that occupied the coast of Georgia. The coastal region lacked the broad, fertile river valleys that were favored by those further inland, so there was much less reliance on maize production and other cultigens and the population remained more dispersed. The inhabitants of the coast were reliant on the

resources provided by the marshes and waters, along with foods gathered and hunted in the uplands, just as they had prior to the Mississippian period. Maize, beans, and squash were eventually cultivated but at a much smaller scale. They did provide a store of foods for periods during the year when wild plant foods were not available.

As with the chronology of the Woodland, the Mississippian period is described based on the prevailing ceramic types as markers of the cultures that occupied the Georgia coast. While the northern and central coastal areas were dominated by Savannah and then Irene types, the southern coastal sequence has been defined as St. Johns II (1250–850 B.P.), followed by St. Marys II (900–550 B.P.), then San Pedro (550–375 B.P.). This sequence has been applied to the area referred to as the St. Marys Region, which extends from the Satilla River in Georgia southward to the St. Johns River in Florida. It was defined to "reflect the transition between cultures of the central and north Georgia coast and the St. Johns culture of northeast Florida."

F.1.2 History

The post-contact history of the general project area dates from the time when written records were kept. It includes ethnohistory of American Indian tribes inhabiting the region and discusses the current status of any tribes with claims to the area. The historical context also describes the non-Native American settlement of the region. Topics of discussion include settlement patterns and historical land use and also include historic themes pertinent to known cultural resources in the project vicinity, including the historic period lighthouse and structures built with tabby construction methods.

Mission Period (A.D. 1526–1683)

The first documented contact between the indigenous people of coastal Georgia and the Spanish occurred in 1521 during a slave raid. Another expedition aimed at locating a favorable location for colonization arrived in 1525, taking on native people to train as interpreters. Based on their linguistic differences, the Spanish identified two groups, the Guale and the Timucua. The Guale were located to the north of the Altamaha River, while the Timucua occupied southeastern Georgia and northeastern Florida from the Altamaha River south to the vicinity of modern day Ocala, Florida, and from the Aucilla River east to the Atlantic. Based on archeological evidence, it appears that the Guale were the descendants of the Irene prehistoric culture, while the Timucua were descended from the St. Johns culture. The Timucua were organized into a series of loose chiefdoms, with one chief presiding over a small number of separate villages. Four groups of Timucua were identified at contact, including the Tacatacuru on Cumberland Island, the Yufera to the south, the Cascange-Icafui to the north, and the Yui to the west.

In 1526, a party of Spanish colonists led by Lucas Vázquez De Ayllón settled at the colony of San Miguel de Gualdape, presumed to be near Sapelo Sound. This first attempt at Spanish colonization ended just six weeks later after disease and starvation claimed many of the colonists, including Ayllón. However, the establishment by the French of Fort Caroline, presumably near the mouth of the St. Johns River in 1564 near present-day Jacksonville, led the Spanish to continue to focus on the southeastern coast of North America. A French settlement in close proximity to the sea lanes used by treasure fleets transporting booty from Mexico to Spain posed a threat. Spain's King Phillip II charged Mendes de Avilles to "dislodge" the French, which led to the establishment of St. Augustine in 1565 and the conquering of Fort Caroline later that year.

Both Fort Caroline (which became San Mateo after changing to Spanish hands) and St. Augustine were established before the Spanish designated Santa Elena as the capital of La Florida in 1566, on Parris Island, South Carolina (on the site of the former Charles Fort established in 1562 by French Admiral Jean Ribault). Santa Elena was the capital of La Florida from 1566 to 1587, after which the capital was moved southward to St. Augustine. A series of forts with small garrisons were constructed along the coast, including a small fort on Cumberland Island, which the Spaniards called San Pedro. The forts, intended to both control the Indians and protect them from English slave raids and attacks on indigenous populations near missions, were widely dispersed, poorly supplied, and difficult to defend against consistent attacks by the French and their Indian allies, so they were abandoned.

Efforts to Christianize the indigenous population began with Jesuits in the 1560s, but permanent missions were not established until the arrival of the Franciscans in the 1580s. The Franciscans constructed a mission, San Pedro de Mocama, on the southern end of San Pedro Island in 1587.

As was the case across the southeast, European diseases took a heavy toll on the Timucua. Those living around San Pedro were especially hard hit, and by 1670, the Timucua mission at San Pedro had been abandoned. It was replaced that year by the mission of San Phelipe, a Guale mission, which also included a number of Yamassee refuges from the north. The scattered mainland missions moved to the barrier islands in an attempt to avoid inland raids by Indians armed by the English from their colony at Charles Town, but the coastal missions fared no better. Raids by French privateers in the 1680s led to the abandonment of the Georgia missions and their consolidation around St. Augustine by 1683.

Camden County (A.D. 1733–Present)

Located on the coast, Camden County is the southernmost county in the state of Georgia. It was created in 1777 by the Georgia constitution as the state's eighth original county. The county features tidal rivers and creeks with plentiful marshlands along the coastal region. Cumberland Island, the largest of the barrier sea islands, is located just off Camden County's coast. The interior portions of the county are flat and sandy. Prior to the county's establishment and European occupation, the land was inhabited by the Mocoma Native Americans, followed by the Creek Native Americans. The first European to land in present-day Camden County was Captain Jean Ribault of France, in search of a suitable place for a Huguenot settlement. Ribault named the rivers he first saw the Seine and Somme; today these are the Satilla and St. Marys Rivers.

In 1565, Spain sent a large force to take the region from the French and subsequently constructed missions in the county but eventually abandoned those, leaving the lands open for English occupation. In 1742, General James Oglethorpe led the English to victory over the Spanish. General Oglethorpe left his mark upon Georgia's landscape as he designed the town of Savannah, constructed a hunting lodge on Cumberland Island named Dungeness (a predecessor to the mansions of the same name built by Greene and Carnegie), founded two forts on Cumberland Island, Fort St. Andrews on the north end and Fort Williams on the south end, and was responsible for naming Amelia Island.

In 1763, Spain ceded Florida to Britain via the Treaty of Paris (also called the Treaty of 1763), which altered Georgia's borders. The state boundaries were extended from the present-day boundary of Glynn County to the St. Marys River, the southern boundary for Camden County. Four parishes were established in 1765: St. Davids, St. Patricks, St. Marys, and St. Thomas.

Camden County was created by combining the colonial parishes of St. Thomas and St. Mary with lands ceded by the Creek Tribe of Native Americans. In 1854, a portion of Camden County was taken to create

Charlton County. The first county seat of Camden County was selected in 1787 and was located at St. Patrick, a town on the south side of the Great Satilla River. In 1792, the county seat was moved to St. Marys. In 1800, it was moved back to the vicinity of St. Patrick to Jefferson, later called Jeffersonton. A courthouse and jail was constructed in 1802. During the antebellum period, large plantations located along the river produced rice, cotton, corn, and other products, but following the Civil War, Jeffersonton was abandoned. In 1872, the county seat was moved back to St. Marys, where it remained until 1923 when it was relocated to Woodbine.

Although slavery was outlawed in Georgia by General Oglethorpe, it was legalized in 1751 by Georgia's government. In Camden County, enslaved African Americans harvested rice, cotton, and timber, the most profitable crops in the county. By 1860, the slave population comprised 76 percent of the 5,420 people living in Camden County.

Two full divisions of men from Camden County fought during the Civil War. The outcome of the war was devastating for plantation owners, many of whom left the area, leaving the land and their name to the formerly enslaved. Land values dropped dramatically, and newly freed slaves were able to purchase large tracts of land. By the turn of the 20th century, approximately half of the land in the county was owned by African Americans.

The arrival of the railroad in 1894 opened up new economic opportunities for Camden County. Bayard Cutting, a New York industrialist, built a 138-mile connector from Savannah to Jacksonville, Florida, creating the Florida Central and Peninsular Railroad (now Seaboard Coast Lines). In 1924, a spur line was completed from Kingsland to St. Marys.

Construction began on the first modern highway in Camden County, the old Dixie Highway, in 1912. The road, which stretched from Quebec to Miami, entered Camden County near Glenco, passed through Woodbine and Kingsland, and extended to the ferry on the St. Marys River before entering Florida. In 1927, the Atlantic Coastal Highway (U.S. 17) was completed through Camden County with a bridge across the St. Marys River. The highway became the main thoroughfare for travelers to Camden County. In the 1960s, construction on I-95 began; it bisects the county from north to south and generally follows the Seaboard rail line.

The current project area is located on land that was once part of the Floyd family's extensive plantation. A veteran of the Revolutionary War, Charles Floyd moved with his wife, Mary, and son, John, from Virginia to his land at Floyd's Neck in Camden County in 1800. In 1804, John Floyd constructed two plantation houses. His home was named Fairfield and was located in the northeastern corner of the current project area. The home that he constructed for his father, Charles, was named Bellevue and was located to the west of Fairfield. While no known description of Fairfield has been located, Bellevue was said to have been a two-story structure that was anchor-shaped in plan to reflect Charles' ship building past. The main floor walls were constructed of tabby, while the second floor was frame construction. The tabby walls of Bellevue are still standing.

After Charles's death in 1820, John moved his family to Bellevue, leaving Fairfield to his son, Charles Rinaldo (C.R.) Floyd. C.R. Floyd became a noted military man during the Seminole Wars after pursuing a group of Indians through the Okefenokee Swamp. He died in 1848 and was buried behind the Fairfield plantation house. A large marble monument was erected over his grave sometime later; it was enclosed by a block wall in the 20th century and is still standing. The Floyd Family Cemetery is located east of Fairfield Plantation and is the final resting place of several members of the Floyd family. Following the Civil War, the property was divided among the family and eventually sold to corporate interests. The

portion where the project area is located is currently owned by Dow Chemical/Union Carbide and Bayer CropScience.

In the 1840s, or possibly earlier, C.R. Floyd founded and ran the Camden Hunt Club, which was one of the first such hunt clubs in the nation. The Camden Hunt Club was located on Floyd's land, but the club likely hunted on adjacent plantation land, including the land associated with the present-day Cabin Bluff area, about 2 miles south of the project area. During the first part of the 20th century, several logging operations bought the land on Floyd's Neck and operated railroad logging facilities while maintaining the hunting preserve. Today, the facility still functions as a recreational hunting resort, and the land also is a managed forest, or tree farm.

The small community of Dover Bluff, approximately 3 miles north of the project area and within the APE, also began as a hunting club sometime in the early 1920, although some of the original community buildings may have been built prior to then. Subsequent development of homes continued into the modern era, with surviving homes dating from as early as 1890 into the 1970s.

A small boost to Camden County's economy occurred in the 1960s when the Thiokol Chemical Company located to the area. In 1964, Thiokol opened a plant on the former Floyd Plantation, including the current project area for a rocket test facility and chemical processing plant. The plant consisted of a complex of 36 buildings located on approximately 7,400 acres. The facility tested and built solid-fuel rockets for the National Aeronautics and Space Administration (NASA) as part of the Saturn I missile program, and the first 3-million-pound-thrust solid propellant rocket motor was manufactured and tested at the site. When NASA changed plans to use liquid fuel instead, Thiokol began manufacturing other products at the plant. In 1966, Thiokol began production of silicone coatings and sealants for General Electric and TEMIK® (aldicarb) for Union Carbide. In 1967, Thiokol began to manufacture orthochlorobenzalmalononitrile (CS) (also known as "tear gas") for Edgewood Arsenal. This work developed into Thiokol's production of several "deterrent containing" munitions including 40-millimeter (mm) CS rounds and the XM-15-CS canister cluster. Later, production included M49 trip flares, 81-mm mortar illumination cartridges, and M84A1 fuzes. In 1969, an Army contract was received to manufacture trip flares for the Vietnam War. Following a devastating explosion in 1971 that killed 29 people and injured 50 people, Thiokol stopped production of trip flares but continued making munitions until 1977. In 1977, the Camden operations were sold to the Union Carbide Corporation, and agricultural chemical production continued. In 1986, Rhone Poulenc (ultimately Bayer CropScience) acquired the manufacturing capabilities, and Union Carbide retained the landfill and the solid waste management units. In 2001, Union Carbide merged with Dow, and Dow continues to operate and maintain the landfill. The facility in Camden County is no longer operational, and most of the associated buildings have been demolished. Photos 1 and 2 show the view of the site from the water in 2009 and 2016, respectively.

Photo 1. Proposed site viewed west to east from the water circa 2009

Photo credit: *Tribune & Georgian* (4 September 2009); provided by Bryan-Lang Historical Archives

Photo 2. Proposed site viewed east to west from the water circa 2016.

Photo credit: Camden County (April 2017)

The Kings Bay Naval Submarine Base, south of the project area, has had the greatest impact on the growth of the county. The naval base was originally constructed as the Kings Bay Army Terminal in 1955. By 2003, Kings Bay employed almost 9,000 people.

Cumberland Island

Sometimes referred to as Great Cumberland Island to distinguish Little Cumberland Island to the north, Cumberland Island is the largest of the barrier islands off Georgia's coast. Since the occupation of the Spanish in the 17th century, the island's population has seldom exceeded 500 people. When the Spanish arrived on Cumberland Island in the 1550s, the island was already inhabited by the Tacatacura tribe of the Timucua Native Americans; they spoke the Mocamo dialect of Timucuan. The Tacatacuru occupied the island sporadically, most likely during the winter months, making seasonal visits to the island for provisions such as fish, shellfish, turtles, and deer. Europeans became interested in Native American medicinal techniques, most notably their use of sassafras. During the late 16th century and into the 17th century, Cumberland Island became a center for sassafras trade, which brought high prices in Europe.

The Spanish established several missions during their occupation, linking the dispersed coastal Spanish garrisons. The Spanish abandoned the missions between 1690 and 1702, when the English, with the help of some Native American allies, moved in from the north and began attacking them. Spain and England spent the first half of the 18th century fighting for control of the land located between the Savannah and St. Marys Rivers. Once General James Oglethorpe established the settlement in Savannah in 1733, Cumberland Island became a strategic coastal defense point. General Oglethorpe arrived on Cumberland Island in 1736, establishing Fort St. Andrews on the north end of the island and a second fort on the southern end of the island in 1740. In 1742, Fort St. Andrews was burned during an attack by the Spanish and never rebuilt. The southern fort, Fort Prince William, remained and functioned as an important outpost until the late 1750s. In addition to the two forts, the English were responsible for naming the island after the Duke of Cumberland, constructing a garrison town of Barrimacke at the

northern end of the island, and building a hunting lodge for General Oglethorpe at the southern end. It may have been General Oglethorpe who was responsible for the first horses on Cumberland Island, bringing them in 1739.

Once the 1763 Treaty of Paris was passed, Cumberland Island was awarded by the British Crown to the Georgia Colony. Permanent settlements began on Cumberland Island in 1765, and advertisements for Cumberland Island land showcased its agricultural and timber qualities. By the American Revolution, the island featured sizeable homesteads and extensive cultivation, with indigo and rice dominating; cotton corn, horses, and cattle were also raised, and live oak and cypress were harvested from existing tree stands.

In 1783, General Nathanael Greene purchased land on Cumberland Island. In 1803, Greene's widow and her second husband, Phineas Miller, built a four-story, tabby mansion called Dungeness on the southern end of Cumberland Island. The Greene-Miller plantation was one of the first places that sea island cotton was cultivated, and the Greene-Millers produced successful cotton raised and processed by the 210 slaves on the plantation. In addition to Dungeness, plantations owned by Greene-Miller descendants include Oakland, Rayfield, and Littlefield; other plantations included Spring Garden, Plum Orchard, High Point, Longwood, and Fairmount. The labor force of the Cumberland Island plantations consisted of a large, enslaved African American population. During the antebellum period, the white population of Cumberland Island likely never reached beyond 60 people; however, the African American population increased from approximately 200 in 1835 to 455 in 1850.

During the Civil War, almost all of the white landholders abandoned the island, with the exception of Robert Stafford at Rayfield Plantation and Rachel Church at High Point. The outcome of the Civil War drastically changed the way of life on the island. Population declined to fewer than 100 people between 1865 and 1880, most of whom were African American. At the start of the war, Phineas Miller Nightingale, owner of Dungeness, had fled his plantation. Upon his return in 1865 or 1866, he found the main house burned, and he sold it to repay. After his death, his nephews inherited his remaining land and eventually sold it to Thomas Carnegie, the younger brother of Pittsburg steel baron Andrew Carnegie. The Carnegies constructed a large, eclectic house on the site of the original Dungeness mansion, completed in 1885. They acquired more land and built gardens and additional structures, including specialty buildings and areas devoted to specific activities, including pool houses, squash courts, beach houses, a golf course, and horse stables. The Carnegies came to own approximately 90 percent of Cumberland Island.

While the Carnegies owned most of the island, the northernmost portion remained in others' hands. Hotels, first constructed in the 1870s, were popular during the latter part of the 19th century and into the 20th century. Travel to the island was made possible due to an increase in steamboat traffic along the Inland Waterway, as well as more accessible rail lines on the mainland to carry passengers to the coast. Around the turn-of-the 20th century, the hotel complex was purchased by a private company and used for a private hunting club and resort. The Candler family, heirs to the Coca Cola fortune, eventually purchased the property and it became a private family estate.

Upon the death of Lucy Carnegie in 1916, 16,000 acres of Cumberland Island passed to her children with the covenant that the land could not be sold while any of them were alive. The buildings on the island fell into a deteriorated state. A good portion of Dungeness was lost to an arsonist's fire in 1959. The Lucy Carnegie Trust ended in 1962, at which point the property was divided and sold. Ten years later, Congress established the Cumberland Island National Seashore. Since 1972, the National Park Service has acquired a majority of the island and its structures, with the exception of reserve life estates and some individually owned properties.

Following the Civil War, former slaves on Cumberland Island settled on the northern end of the island. They eventually were able to purchase the land and constructed a log church/school in 1893 and residences, none of which are extant. The existing buildings associated with the settlement at Half Moon Bluff date to the 1930s and 1940s. The resort at High Point was established in the mid-1880s and was accessed via steamboat at Cumberland Wharf. Guests then traveled by a horse-drawn tramway along High Point Road to the resort. Many residents from the African American settlement found employment at the High Point resort.

Cumberland Island National Seashore was created by Congress in 1972 (Public Law 92-536, codified at 16 United States Code §459i et seq.) "to provide for public outdoor recreation use and enjoyment of certain significant shoreline lands and waters of the United States and to preserve related scenic, scientific, and historical values." High Point-Half Moon Bluff was listed on the National Register of Historic Places (NRHP) in 1978. The United States Congress designated the Cumberland Island Wilderness Area in 1982.

The majority of the historic structures on Cumberland Island today date to the late 1880s and are associated with the Carnegie occupation south of the APE for audible and visual effects. A few resources pre-date this period, such as the tabby house associated with the Greene-Miller occupation, a handful of cemeteries, the slave chimneys associated with the Stafford plantation, and archeological sites.

The historic resources on Cumberland Island are contained within five historic districts, two archeological districts, and two individual sites:

- High Point-Half Moon Bluff Historic District, located at the island's north end, within the APE for audible and visual effects (#78000265, listed on the NRHP 12/22/1978)
- Dungeness Historic District, located on the island's south end, outside the APE for audible and visual effects (#84000920, listed on the NRHP 02/13/1984)
- Greyfield Historic District, located on the south within privately held property, outside the APE for audible and visual effects (#03000675, listed on the NRHP 07/24/2003)
- Stafford Plantation Historic District, located mid-island, outside the APE for audible and visual effects (#84000265, listed on the NRHP 11/23/1984)
- Plum Orchard Historic District, located mid-island, outside the APE for audible and visual effects (#84000258, listed on the NRHP 11/23/1984)
- Table Point Archeological District, located mid-island, outside the APE for audible and visual effects (#84000260, listed on the NRHP 11/23/1984)
- Rayfield Archeological District, located mid-island, outside the APE for audible and visual effects (#84000924, listed on the NRHP 02/13/1984)
- Duck House, outside the APE for audible and visual effects (#84000938, listed on the NRHP02/13/1984)
- Main Road, within the APE for audible and visual effects (#84000941, listed on the NRHP 02/13/1984)

The NRHP-listed High Point-Half Moon Bluff Historic District contains two complexes of buildings: an African-American Settlement at Half Moon Bluff and a former resort at High Point. The African-American Settlement at Half Moon Bluff is located in the current project's APE, as is a portion of the NRHP-listed

Main Road. The remainder of these historic districts and properties are outside the APE for audible and visual effects.

F.2 References

Cultural Resources Analysts, Inc. (2017a). *Phase 1 Archaeological Survey of the Proposed Spaceport Camden, Camden County, Georgia.* Leidos for FAA.

Cultural Resources Analysts, Inc. (2017b). *Historic Resources Survey for the Proposed Camden Spaceport Project in Camden County, Georgia.* Leidos, for Federal Aviation Administration.

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APPENDIX G SOILS AND GEOLOGY

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G SOILS AND GEOLOGY

G.1 Affected Environment

G.1.1 Definition and Description

This section describes the physiographic, geologic, morphologic, and hyspologic features and processes that have and continue to mold the proposed Spaceport Camden landscape configuration and ecological functions, particularly soils. The region of influence (ROI) is defined as the proposed Spaceport Camden and areas in proximity to the proposed Spaceport Camden (see Exhibit 2.1-2, Proposed Spaceport Camden Site Plan, in the EIS). A basic premise of any environmental assessment process is to understand the quantity and quality of natural resources that could be affect by the proposed project. The purpose of this section is to identify landscape features, formulate feature baseline metrics (acres, number, etc.) to assess conditions, and establish a context for comparative and cumulative analysis. The goal is to convey an understanding of the proposed Spaceport Camden and proximity area earth resources and the potential interactions that may accompany proposed disturbances to natural landscape settings.

G.1.2 Regulatory Setting

For this assessment, regulations relating to potential impacts to earth resources are primarily associated with the effects of soil detachment (erosion) and deposition of materials (sedimentation) on aquatic resource water quality and habitats. The State of Georgia has jurisdiction for surface water quality standards for all waters of the state, in accordance with provisions of the Clean Water Act. For more information on Federal and state water quality regulations, refer to Section 3.14, *Water Resources*. Prime farmlands are protected under the Farmland Protection Policy Act and are discussed in Section 3.6, *Farmlands*.

G.1.3 Existing Conditions

This section describes the ROI physiography, surficial geology, surface morphometry, hyposology, soils, paleontological resources, and earthquakes.

G.1.3.1 Physiography

Physiography compartmentalizes landscapes into areas in which all parts are similar in geologic structure and climate, have a unified geomorphic history, and whose landforms differ significantly from adjacent areas. The ROI is located within the Tidewater Major Land Resource Area (MLRA) (153B) of the Atlantic and Gulf Coast Lowland Forest and Crop (T) Land Resource Region. The region includes Atlantic coastal plains, drowned estuaries, tidal marshes, islands, and beaches and Gulf of Mexico river deltas, coastal lowlands, and coastal plains. Generally, it is characterized by level to gently sloping topography and shallow relief. The proposed Spaceport Camden site covers approximately 1,413.2 acres.

The Tidewater MLRA extends along the Atlantic coast from north Florida to Delaware. The majority of the area is within the Sea Island Section of the Atlantic Plain Coastal Province. The nearly level coastal plains are dissected by shallow valleys associated with meandering streams and rivers that discharge

into coastal estuaries. The topography is comparatively smooth and level with gently undulating land; typically, there are no prominent hills or valleys. The Tidewater MLRA is primarily the product of alluvial, fluvial, and marine deposition and erosion (U.S. Department of Agriculture [USDA], 2006).

G.1.3.2 Surficial Geology

Surficial geology defines surface and near-surface consolidated or unconsolidated earth materials, including aggregate materials, and significant landscapes. Frequent advances and retreats of sea level associated with glacial activity during Quaternary Period Pleistocene and Holocene Epochs[1] formed terrace steps that decreased in elevation towards the ocean. Shoreline retreats created sediment deposit complexes that generally parallel the present coast. Area subsurface deposits include cretaceous marine, shale, sandstone, and limestone (USDA, 2006). Local inclusions of kaolin (clay mineral composed of layered silicate minerals) occur in updip areas. The underlying sediment wedge is thickest at the coast and thins in a northwestern direction (Herrick, 1965). Legacy Pleistocene barrier island-salt marsh environments, formed during advancing sea levels, were similar to the current coastal environments (USDA, 1980).

The ROI geomorphology is generally characterized by marine terraces and elongated ridges separated by flatlands that formed from barrier island and back barrier complex formation processes associated with sea-level fluctuations. The proposed Spaceport Camden is within the Pleistocene Age Princess Anne Barrier Island Complex and the tidal flats adjacent to the proposed Spaceport Camden are within the Holocene Age Silver Bluff Back Barrier Complex (CH2MHill, 2015a) (Kellam, 1986).

In addition to unconsolidated coastal marine deposits, there were also periodic inundations and meanders of the area by the Satilla and Cumberland Rivers (north and south of the proposed project area, respectively) that formed deposits along coastal riverbed terraces, floodplains, and deltas (Veatch & Stephenson, 1911). Younger river-laid deposits were composed of clay, silt, sand, and gravel (USDA, 2006). Shoreline advances generally ranged from 20 to 30 miles inland of the current coastline (Veatch & Stephenson, 1911).

A late 19th century report describes steep bluffs along the Satilla River near Brunt Fort (approximately 22 miles east of the proposed Spaceport Camden) from 20 to 30 feet high comprising sands, stratified clays, and occasional clayey-limestone (McCallie, 1896). However, in proximity to the proposed Spaceport Camden, the river is a broad, relatively flat gradient channel with relatively indistinct streambanks that has formed an extensive delta plain[2] of tidal wetlands (see EIS Section 3.14, *Water Resources*).

G.1.3.3 Surface Morphometry

Surface morphometry describes land surface landform and geomorphic component features and geometry such as position, aspect, gradient, complexity, profile, patterns, and shape. Predominate flatplain[3] landforms[4] and geomorphic components[5] that characterize the ROI include tidal marshes, flats,

[1] The Pleistocene Epoch followed the Pliocene Epoch and preceded the Holocene Epoch from approximately 10,000 to 12,000 to 1.6 million years ago. The Holocene Epoch followed the Pleistocene Epoch from the present to about 10,000 to 12,000 years ago. Each epoch includes corresponding temporal-stratigraphic earth materials.

[2] The level or nearly level surface composing the land-ward part of a large delta characterized by repeated channel bifurcation and divergence, multiple distributary channels, and interdistributary flood basins.

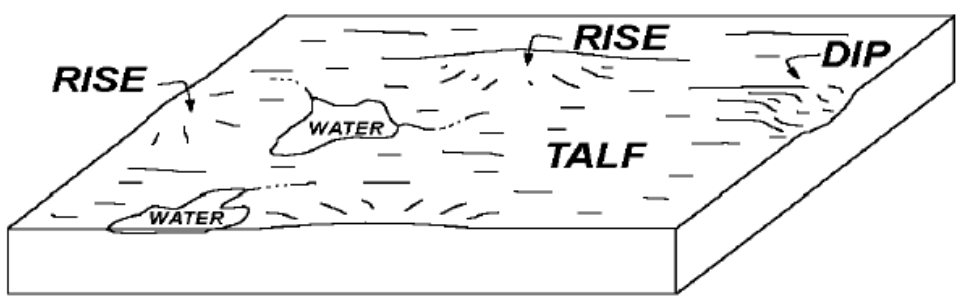
[3] A low, generally broad plain formed by a recently prograded (growth of land further out into the sea) or emerged seafloor with oceanic shore margins and strata that is horizontal or gently slopes toward the water.

[4] Recognizable surface forms that have a characteristic shape and internal composition and were produced by natural processes.

depressions, and drainageways and talfs, dips, and rises, respectively (Table G-1). Over geologic time, these flatplain landforms tend toward dynamic equilibrium, which can be altered by human disturbance activities.

Table G-1. Proposed Spaceport Camden Flatplain Landforms and Geomorphic Components

Feature	Description
Landforms	
Tidal marsh	An extensive, nearly level wetland formed from unconsolidated sediments (e.g., clays, silts, and/or sands and organic materials) bordering a coast (e.g., lagoon, bay, or estuary) that is regularly inundated by high tides.
Flat	An area characterized by a relatively smooth, level (or nearly so), continuous surface that lacks significant slope, elevations, or depressions.
Depression	A shallow and typically closed surface depression that tends to be an area of focused groundwater recharge but not a permanent water body. It is slightly lower and wetter than the adjacent talf and favors the accumulation of fine sediments and organic materials.
Drainageway	A relatively small, roughly linear or arcuate depression that moves concentrated water. Generally, these low-gradient features lack a defined channel (e.g., head slope, swale) or have a small, defined channel (e.g., low-order headwater streams).
Geomorphic Components	
Talf	A relatively flat (e.g., 0 to 1 percent slopes) and broad area dominated by closed depressions and a nonintegrated or poorly integrated drainage system. Stormwater tends to pond, and surface and groundwater lateral transport is slow, which favors the accumulation of soil organic matter and the retention of fine-textured soils. Better-drained soils are frequently adjacent to drainageways and rises.
Dip	A component of plains consisting of a shallow and typically closed depression that tends to be an area of focused groundwater recharge but not a permanent water body and that lies slightly lower and is wetter than the adjacent talf and favors the accumulation of fine sediments and organic materials.
Rise	A slightly elevated but low, broad area with gentle slope gradients (e.g., 1 to 3 percent slopes) and broad, low summits. Typically, this area exists as a microfeature but can be fairly extensive. Generally, rise soils are better drained than those on the surrounding talf.



Source: (USDA, 2012)

Site observations in 2011 documented several depressions and seasonally flooded sites throughout the flatplains area (CH2MHill, 2015a).

[5] A distinct area or geomorphic setting that has unique and prevailing kinetic energy dynamics and sediment transport conditions that result in their characteristic form and patterns of sedimentation and soil development.

G.1.3.4 Hypsology

Hypsology is the study of the relative altitude of places. Generally, changes in topographic relief equate to changes in surface hydrology, geohydrology, and/or soils that affect the biological composition and function of ecosystems. Subtle changes in surface elevations over relatively flat to gently sloping land areas can produce dramatic changes in hydrology (surface and subsurface), soil development, and vegetative communities. Distinguishable differences between landscapes with wet conditions and areas with relatively dry conditions may only reflect changes of a foot or less in elevation. The movement of water across low-gradient landform geomorphic components generally defines the ecology of the ROI landscape. Surface runoff tends to collect and reside at lower elevation dips and depressions and move slowly within natural drainageways or constructed drainage systems.

Elevations and slopes in the proposed Spaceport Camden area generally range from 5 to 29 feet above mean sea level (CH2MHill, 2015a) (Kellam, 1986) and 0 to 2 percent, respectively. Although area hypsometry is generally characterized as relatively flat, there are landform intersects that can create rather abrupt elevation changes. These pronounced increases in surface elevation primarily occur along higher ground flatplain intersects with tidal streams, such as Todd Creek and Floyd Basin to the north and Floyd Creek to the east. Based on a review of photographs and imagery of Todds Creek along the northwestern proposed Spaceport Camden boundary, it is estimated that there are approximately 920 linear feet of streambank along Todd Creek with bare ground conditions indicating active soil erosion. These landform convergence areas may create slope profiles susceptible to natural and accelerated soil erosion.

G.1.3.5 Soils

The ROI soils are a direct result of geologic alluvial, fluvial, and marine deposition and erosion processes. These parent materials[6] generally defined the physical and chemical properties of the eight soils that occur within and in proximity to the proposed Spaceport Camden, including the following:

Bohicket-Capers soil association[7]	Brookman soil series[8]	Cainhoy soil series
Mandarin soil series	Pelham soil series	Pottsburg soil series
Rutlege soil series	Sapelo soil series	

These soils are described in Table G-2 and shown in Exhibit G-1. Soils data were primarily derived from the Natural Resources Conservation Service (NRCS) Official Soil Descriptions and Web Soil Survey websites.

Over most of the southeastern part of Camden County, the primary material exposed is unconsolidated sand (Veatch & Stephenson, 1911). Proposed Spaceport Camden area soils generally fall into two categories: (1) very poorly drained, clayey soils in marshes along tidal streams and (2) dominantly poorly drained sandy soils on higher ground flatplains (see Section G.1.3.3, *Surface Morphometry*). Approximately 62 percent of the proposed Spaceport Camden site soils developed in sandy marine, alluvial, and/or fluvial sediments.

[6] Parent materials are the unconsolidated and chemically weathered mineral or organic matter from which a soil's solum is developed by pedogenic processes.

[7] A soil association is made up of two or more geographically associated soils or miscellaneous areas. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar.

[8] A soil series is a group of soils formed from a particular type of parent material and having soil horizons that are similar in all profile characteristics (e.g., color, texture, structure, reaction, consistence, and mineralogical and chemical composition) and arrangement.

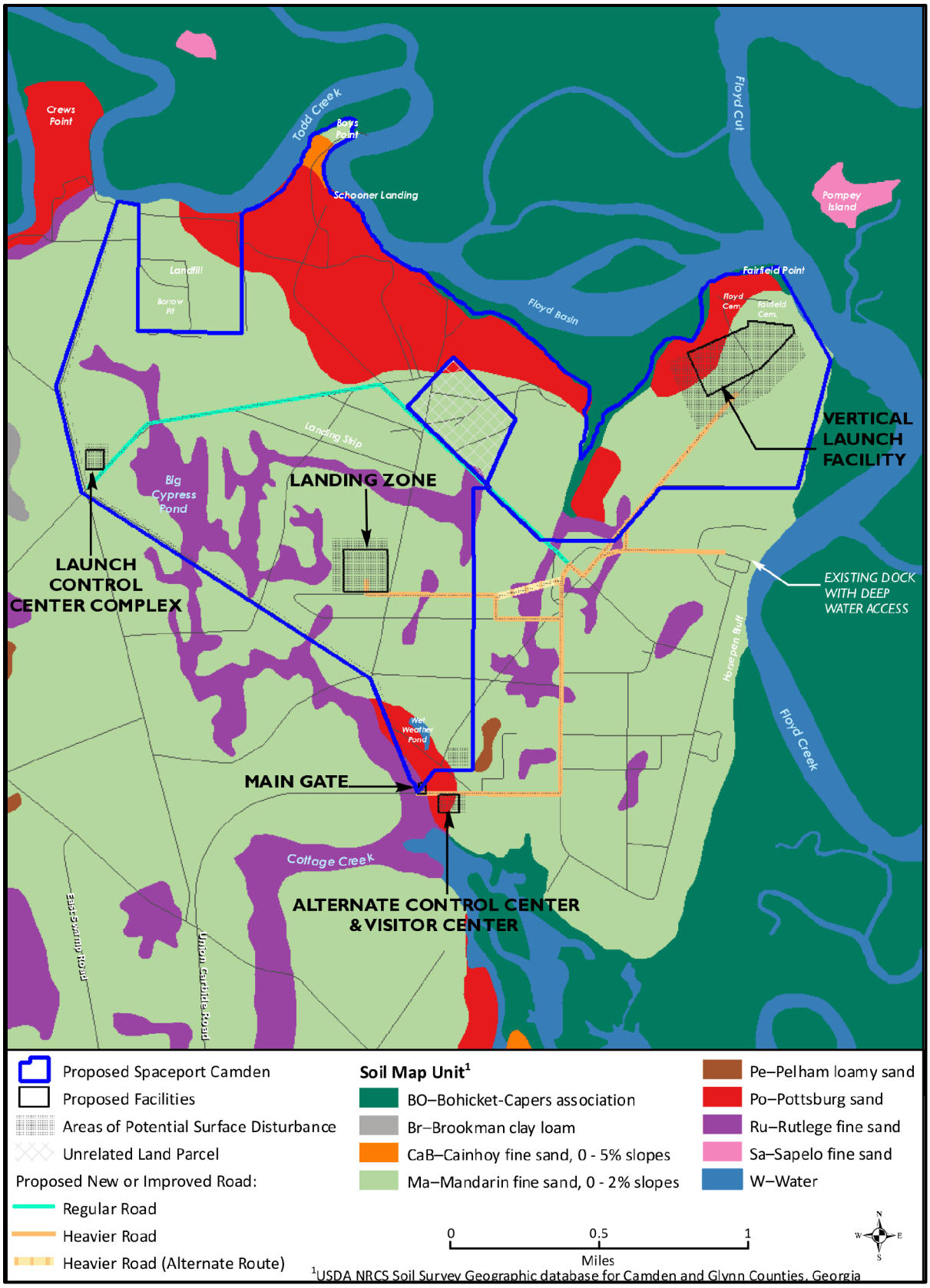


Exhibit G-1. Proposed Spaceport Camden Soil Map

Soil Hydrologic Features

Notable soil hydrologic features include poor to very poor drainage, moderate to rapid permeability, hydric soils, and water tables[9] that are seasonally at or within 2 feet of the surface. For the proposed Spaceport Camden project area, Mandarin, Pelham, Pottsburg, and Rutlege series water table upper limits typically occur during the months of December through April, January through April, November through April, and December through May, respectively. Wet soils exhibit characteristic morphologies that result from repeated periods of saturation, inundation, or both, for more than a few days. For the Cainhoy soil series, the water table upper limit is greater than 6 feet year-round. Flooding is very frequent (the chance of flooding is more than 50 percent in all months of any year) for the Bohicket-Capers association and frequent (the chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year) for the Pelham series.

Table G-2. Soil Series Features and Characteristics

Texture (percent)[a]			Landform (Component)	Water Table (feet)[c]		Hydric Status/Criteria[b]
Sand	Silt	Clay		Upper Limit	Lower Limit	
Bohicket series: These are very poorly drained, very slowly permeable, and continuously saturated tidal flats soils that are flooded twice daily by seawater. The soils were formed in silty and clayey marine sediments. Slopes are less than 2 percent.						
—	—	30 to 60	Tidal marsh (—)	0.0	>6.0	Yes[c]/2
Brookman series: This series consists of clay loam, very deep, very poorly drained, slowly permeable soils that were primarily formed in thick silty and clayey marine sediments. They are saturated in late winter and early in the spring and occasionally in the summer and fall. Slopes are typically less than 2 percent and surface runoff is slow.						
39	43	5 to 30	Depression (—)	0.0 to 1.0	>6.0	Yes/2,4
Cainhoy series: This is a fine sand, very deep, excessively drained, rapidly permeable soil that formed in sandy marine sediments. Runoff is slow, with slopes that range from 0 to 10 percent, and elevations generally range from 10 to 120 feet.						
90	1	2 to 15	Flat (rise)	—	—	No[c]/—
Capers series: These are very deep, very poorly drained, very slowly permeable soils occurring within tidal flats and along the lower margins of larger streams that flow into tidal flats. They are flooded with brackish water at least twice monthly and in some places twice daily. Runoff is very slow, and slopes are generally less than 2 percent.						
8	50	35 to 50	Tidal marsh (—)	0.0	>6.0	Yes/2,3
Mandarin series: This is a fine sand, somewhat poorly drained, moderately permeable soil that formed in sandy alluvial and marine sediments. Slopes range from 0 to 3 percent, and elevations generally range from 0 to 250 feet.						
90 to 99	0 to 10	0 to 10	Flat (talf)	1.5 to 2.5	>6.0	No/—
Pelham series: These are loamy sand, very deep, poorly drained, moderately permeable, sandy soils that formed in unconsolidated alluvial and marine sediments. Runoff is slow, slopes range from 0 to 5 percent, and elevations generally range from 20 to 450 feet. Some areas may be ponded or subject to brief flooding.						
84	9	5 to 10	Flat (talf, dip), depression, drainageway	0.0 to 1.0	>6.0	Yes/2
Pottsburg series: This is a sand, somewhat poorly drained, moderately permeable soil that developed in sandy marine sediments. Runoff is negligible to very low, and some areas are subject to flooding. Slopes are 0 to 2 percent, and elevations generally range from 0 to 300 feet.						
96	2	1 to 4	Flat (talf, rise)	2.0 to 3.5	>6	No/—
Rutlege series: This series consists of fine sand, very poorly drained, rapidly permeable soils that developed in sandy marine and fluvial sediments. Runoff is negligible and ponding is common, slopes are normally 0 to 2 percent, and elevations range from 0 to 300 feet.						
92	2	2 to 10	Flat (talf, dip), depression	0.0 to 0.5	>6.0	Yes/2
Sapelo series: This series consists of fine sand, very deep, somewhat poorly and poorly drained, moderately permeable soils that developed in sandy marine sediments. Runoff is negligible to low, slopes are normally 0 to 2 percent, and elevations range from 14 to 450 feet.						
96	1	2 to 5	Flat (talf, dip)	0.5 to 1.5	>6	No/—

[a] Soil texture values are based on the A horizon depth for a typical soil pedon, which are 0 to 8 inches (Bohicket, Capers, Mandarin), 0 to

[9] *Water table* refers to a saturated zone in the soil. Estimates of the upper and lower limits are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors or mottles (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

Table G-2. Soil Series Features and Characteristics

Texture (percent)[a]			Landform (Component)	Water Table (feet)[c]		Hydric Status/Criteria[b]
Sand	Silt	Clay		Upper Limit	Lower Limit	

10 inches (Pottsburg), 0 to 15 inches (Brookman and Rutlege), 0 to 17 (Sapelo), 0 to 25 inches (Pelham), and 0 to 50 inches (Cainhoy).

[b] **Hydric soil**: A soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (*Federal Register*, 1994). The hydric criteria code is as follows:

1. All Histels except for Folistels, and Histosols except for Folists.
2. Soils in Aquic suborders, great groups, or subgroups, Albolls suborder, Historthels great group, Histoturbels great group, Pachic subgroups, or Cumulic subgroups that:
   A. are somewhat poorly drained and have a water table at the surface (0.0 feet) during the growing season, or
   B. are poorly drained or very poorly drained and have either a water table at:
      1.) the surface (0.0 feet) during the growing season if textures are coarse sand, sand, or fine sand in all layers within a depth of 20 inches, or
      2.) a depth of 0.5 foot or less during the growing season if permeability is equal to or greater than 6.0 inches/hour in all layers within a depth of 20 inches, or
      3.) a depth of 1.0 foot or less during the growing season if permeability is less than 6.0 inches/hour in any layer within a depth of 20 inches.
3. Soils that are frequently ponded for long or very long duration during the growing season.
4. Soils that are frequently flooded for long or very long duration during the growing season.

[c] *Yes* means all map unit components are rated as hydric. *No* means none of the components of a given map unit meet hydric soil criteria.

Pine Plantation Soils

Approximately 900 acres of the proposed Spaceport Camden and adjacent areas have been converted to loblolly and slash pine plantations. Native communities replaced by the pine plantation included oak hammocks, mixed hardwoods, and pine flatwoods (CH2MHill, 2015a). The plantation areas are interspersed with emergent and scrub-shrub wetlands that were too wet to plant.

Plantation site preparations result in intensive surface disturbances to remove competing vegetation and create rows of raised beds for planting pine seedlings. Typically, mechanical site preparation includes timber harvesting; shearing, raking, V-blading, roller drum chopping, and burning; and bedding. Bulldozers and other specialized heavy machinery are used to prepare pine planting sites. Bedding plows are used to create 4- to 6-foot-wide planting beds (Exhibit G-2). Difference in elevations between the crest of the planting bed and bottom of the plow furrow on each side of the bed can range from 1 to 3 feet. A frequent consequence of pine plantation site preparation is the disturbance of natural drainage patterns and soil physical damage from compaction and/or rutting and soil profile mixing (Grace, Skaggs, & Cassel, 2006) (Kelting, 1999) (Miwa, Aust, Burger, Patterson, & Carter, 2004).

Exhibit G-2. Pine Seedling Planting Beds and Bedding Plow

(North Carolina Division of Forest Resources)

Pine plantation soils in the area include the Bohicket-Capers soil association and the Mandarin, Pottsburg, and Rutlege soil series. Recent observations of local plantation sites determined that the Mandarin soils had been disturbed to a depth of 2 feet, and organic surface layers of Rutlege soils were generally absent and mineral soil layers were exposed (CH2MHill, 2015a). Considering the seasonally high water tables and wet nature of sandy soils at the proposed Spaceport Camden site (see Table G-2), it is likely that site preparation activities resulted in localized soil damage (see Section G.2.1.1, *Construction*). Pine plantation soil damage measurements or soil monitoring data were not available.

Soil Erosion

Soil erosion is a three-phase process of detachment, transport, and deposition of surface materials by water overland flow that is difficult to control and easily accelerated by humans. Accelerated erosion caused by humans occurs at rates much greater than under natural erosion conditions. Large quantities of eroded soil sediment delivered to streams can adversely affect channel morphology, degrade aquatic species habitats, and impair water quality by increasing stream water column turbidity, altering water chemistry parameters, and introducing chemical contaminants and other pollutants (see EIS Section 3.14, *Water Resources*).

The primary types of natural soil erosion associated with the proposed Spaceport Camden site include streambank and tidal flats erosion. Typically, streambank instabilities occur as a result of channel entrenchment and scouring of bendway cutbanks. Bank retreat is primarily a result of mass failure of unstable (overheightened and oversteepened) banks. Streambed and bank toe scour increases the bank height and slope angel, decreasing its stability. Noncohesive bank materials such as sandy soils tend to fail from bank slides and sloughing. Site-specific failure mechanisms depend on the topography (height and steepness) and stratigraphy of the bank and the properties of the bank soils.

Generally, the low river delta gradients and water flow and dense vegetative cover minimize the potential for the occurrence of unstable streambanks and their erosion. However, as previously discussed, there are locations at the proposed Spaceport Camden site with abrupt elevation changes between the tidal marshes and higher ground flats that can create streambank conditions susceptible to erosion (see Section G.1.3.4, *Hypsology*). A recent study (CH2MHill, 2015a) identified active erosion on streambanks along Todd Creek that parallels the northern boundary of the proposed Spaceport Camden. It stated that the sites near the landfill are monitored and a streambank stabilization plan would be implemented if bank erosion rates exceed benchmark tolerances (CH2MHill, 2015b). The plan was revised and is under review for final approval by the Georgia Environmental Protection Division.

Typically, tidal flats soil erosion is related to the loss of vegetative cover caused by saltwater intrusion or aggradation, degradation, and migration of intertidal stream and tributary channels. If waters become more saline, vegetation may die, which would allow underlying organic matter, held in place by plant roots, to be washed way. River deltas and estuaries are generally aggrading from riverine and marine sediment deposits. The vegetated mudflats that typically form between tidal creeks and channels tend to capture silty and clayey sediments, whereas the fluvial channels predominantly transport and deposit sandy sediments. As with other natural soil erosion processes, human intervention can accelerate the development of adverse conditions that exceed natural thresholds.

G.1.3.6 Paleontological Resources

Paleontological resources (fossils) are the remains or other indicators (trace fossils) of prehistoric plants and animals. Regional coastal Pleistocene, Holocene, and Miocene[10] marine fossils include pelecypod and gastropod molluscan shells, vertebrate remains (e.g., shark and crocodile teeth and vertebrae), and ostracods. In coastal downdip areas, Pleistocene deposits invertebrate and vertebrate fossils are often found in abundance; Georgia Pleistocene deposits are generally nonfossiliferous except along the coast. Extinct mammal fossil remains have included giant beaver, ground sloth, armadillo, elephant, mastodon, bear, cougar, lynx, saber-tooth tiger, deer, buffalo, and horse. Regional coastal county “bone beds” have been identified near tide levels. Large bones of Pleistocene mammals have been found at

[10] A Tertiary Period epoch (approximately 5.2 to 23 million years ago) that followed the Oligocene and preceded the Pliocene Epoch; also includes the corresponding temporal-stratigraphic earth materials.

Whiteoak (approximately 14 miles northwest of the proposed Spaceport Camden site) in Camden County. Fossils are commonly found at surface outcrops and during soil excavations or well construction (Herrick & Vorhis, Subsurface Geology of the Georgia Coastal Plain, 1963) (Herrick, 1965). No significant paleontological resources are known to occur within the proposed Spaceport Camden site.

G.1.3.7 Earthquakes

The earthquake of 1886 at Charleston, South Carolina (155 miles northeast of the proposed Spaceport Camden site) had an estimated Richter scale magnitude of 6.8 and is the most damaging earthquake known to have occurred in the southeastern United States and one of the largest historical shocks in eastern North America. The magnitude of an earthquake (measure of the energy released during the event) is often measured on the Richter scale, which runs from 0.0 upwards. The Richter scale is logarithmic; a quake of magnitude 5 is 10 times more destructive than a quake of magnitude 4. Earthquakes greater than magnitude 6 can be regarded as significant, with a high likelihood of damage and loss of life.

Earthquake-produced ground motion is expressed in units of percent *g* (force of acceleration relative to that of Earth's gravity). The latest probabilistic peak ground acceleration (PGA) data from the U.S. Geological Survey (USGS) were used to indicate seismic hazard. The PGA values cited are based on a 2 percent probability of exceedance in 50 years. This corresponds to an annual occurrence probability of about 1 in 2,500 (USGS, 2014). Most of the PGA is related to the proximity of the proposed Spaceport Camden site to the Charleston seismic zone and not from locally generated earthquakes. USGS data show that there is less than a 0.3 percent chance of a major earthquake within 31 miles of Camden County (http://www.homefacts.com/earthquakes/Georgia/Camden-County.html). No evidence of liquefaction or paleoliquefaction has been identified for the proposed Spaceport Camden site.

G.2 Environmental Consequences

This section describes potential impacts on earth resources as a result of the Proposed Action and No Action Alternative. Impacts on the existing environmental features and conditions (see Section G.1, *Affected Environment*) will be assessed for both the construction and operational phases of the Proposed Action and No Action Alternative.

The environmental consequences analysis is based on an evaluation of the impacts of the proposed project effectors on soil and landform receptors. The proposed project effectors include ground disturbance activities relating to the construction of proposed Spaceport Camden facilities and infrastructure and operation of rocket launch, landing, and support activities. Effector activity scenarios described in Chapter 2, *Proposed Action and Alternatives*, are used to define the project actions and expenditures.

The analysis focuses on the defined and, as required, estimated interactions between effector actions and receptor vulnerabilities that result in ground disturbance. The determination of earth resource impacts is based on an analysis of the potential for the proposed project activities to damage soil by altering its physical properties or increasing the potential for soil erosion.

The earth resource receptor issues that are the focus of this analysis include (1) soil disturbance, (2) soil erosion, and (3) landform disturbance. Soil disturbance is generally defined as an abrupt change in the physical, chemical, or biological properties of a soil and may be categorized as displacement, exposure of mineral soil, physical damage, mass wasting, nutrient depletion, microclimate changes, and/or hydrologic changes. Soil physical damage includes disturbances to the structural and/or biological

properties of soil or geologic features that compromise their natural condition and function. Examples include compaction,[11] rutting,[12] and soil erosion. Potential impacts of effector soil pollution and contamination on soil chemistry and biology are evaluated in EIS Section 4.7, *Hazardous Materials, Solid Waste, and Pollution Prevention*.

Soil compaction is identified by physical depressions of the soil without soil displacement. In contrast, soil rutting is the churning of a wet soil above its liquid limit to the point that it is broken into its ultimate soil particles and flows outward and upward (soil berming) from applied downward pressure. Compaction may occur in surface as well as subsurface layers of the soil, whereas rutting generally represents the depth and extent of a disturbed soil surface layer or upper seal of a soil column. As soils become saturated, the potential for compaction generally decreases and potential for rutting increases. Under comparable conditions, silt and clay soils generally compact more severely than sandy soils. Structurally damaged soils also increase surface runoff and reduce water-soil infiltration rates, which can increase soil erosion potentials.

The NRCS estimates which soils are highly erodible or potentially highly erodible due to sheet and rill erosion primarily based on the Revised Universal Soil Loss Equation (RUSLE). A highly erodible soil has a maximum potential for erosion that equals or exceeds eight times the tolerable erosion rate.[13] The soils on the proposed Spaceport Camden site have a low soil erodibility rating (little or no natural erosion is likely to occur). The rating is primarily based on horizontal to gentle slope gradients, flatplain surface morphometry, and slow surface runoff. However, erodibility is only one component of the soil erosion process. The disturbance or loss of vegetative cover, localized soil compaction, increases in slope gradients, and stormwater runoff channelization and unprotected discharge at constructed outlets can increase soil erosion potentials.

Landform disturbances would include effector-induced physical alterations in surface gradients, patterns, or shape geometries and/or alterations in surface or geohydrology drainage patterns. Soil disturbance focuses on physical impacts to specific soils whereas, landform disturbance is concerned with mechanical alterations to the overall form and function of landforms (see Section G.1.3.3, *Surface Morphometry*). During construction, site land surfaces are reconfigured to meet design specifications by adding fill materials and/or using heavy equipment to reshape the land. Whether by soil filling or grading, there is the potential for loss of landform integrity[14] during construction preparation, emplacement, and stabilization.

Earth resource receptors must be exposed to an effector for an impact to occur. For this analysis, project-related earth resource environmental impacts are described by their likelihood, intensity, duration, and significance. These impact attributes provide a physical, spatial, temporal, and relational

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[11] *Soil compaction* is the increase in soil density resulting from moving soil particles in response to an applied external force. It significantly increases bulk density, water-filled porosity, heat conductivity and diffusion, and available water and decreases aeration porosity, water infiltration rates, and hydraulic conductivity.

[12] *Soil rutting* is the deformation of the surface that destroys soil structure. It primarily occurs as a result of the operation of heavy vehicles on wet soils. Rutting effects on soils are most severe when the soil is saturated or nearly saturated.

[13] Erosion rates that are lower than the rate of soil development. Soils are assigned a tolerance value primarily based on the thickness of the soil above bedrock or unaltered parent material.

[14] The integrity of landform components helps maintain resistance to damage from threats such as development and land use conversion. Generally, integrity relates to the intactness of the landform structure and provision of applicable ecosystem services (ESs). These services are the benefits of ecosystem features and functions directly consumed, used, or enjoyed to yield human well-being. The structural and functional capabilities of landscapes to provide ESs can differ dramatically and are frequently altered by anthropogenic land uses.

basis for describing the nature and importance of an impact on earth resources. Impact evaluation criteria are presented in Table G-3.

Table G-3. Earth Resources Impact Analysis Evaluation Criteria

Attribute	Description
Likelihood (probability)	
Probable	There is a level certainty that the anticipated impact would occur.
Possible	It is likely that the anticipated impact would occur, however, there are no data to support a level of certainty that the impact would or would not occur.
Unlikely	There is a level of certainty that the anticipated impact is improbable and would not occur.
Unavoidable	Adverse effects would occur regardless of the proposed mitigations or other actions intended to eliminate adverse effects.
Intensity (how much)	
Major	Substantial impact on or change in earth resources receptors that is easily defined, noticeable, and/or calculable but may not be measurable or exceeds a threshold level that may threaten the integrity of one or more resource components.
Moderate	Noticeable change in one or more earth resource receptors occurs, but resource integrity remains intact.
Minor	The impact on earth resource receptors is at the lowest levels of detection (barely measurable and with no perceptible consequences) or would result in only a minor change.
Negligible	Impact is at the lowest level of measurement or is so low as to be immeasurable and has no perceptible consequences.
Duration (how long)	
Long-Term	The impact would likely persist for a period greater than the medium-term impact and would likely extend beyond the life of the project.
Medium-Term	The impact would only occur for specific, relatively brief periods during the project life, interrupted by periods of no impacts.
Short-Term	The impact would extend for short periods much less than the overall project life (for example, during launch operations).
Significance	
Significant	Impacts would be adverse, regional or localized, probable or unavoidable, of major intensity, of any duration, and impact effect is partially reversible or irreversible with mitigation.
Nonsignificant with Mitigation	Appropriate mitigation measures are identified to reverse impact affects to a level below significant criteria.
Nonsignificant	Impacts would occur resulting in a beneficial or neutral changes to the existing environment and do not meet the significant criteria.

Earth resource impacts analysis considered but not carried forward include (1) soil subsidence (2) paleontological resources, and (3) seismic effects. Subsidence of organic soils was excluded from the analysis because the only ROI organic soil of concern is the Bohicket and Capers soil association, which would not be impacted by the proposed effector construction or operation activities. The greatest potential for exposures of fossil-bearing limestone and marl layers beneath the superficial Pleistocene sands and clay to occur is in the margins of Satilla River tributary streams such as Todd Creek (see Section G.1.3.6, *Paleontological Resources*). The fossils that could be encountered during proposed Spaceport Camden construction-related excavations would likely include relatively common marine shells and vertebrate remains that would likely have minimal research or scientific collection value. The type and scale of the proposed construction and operation activities would not expose or disrupt

geologic formations or induce seismic activity; therefore, further analysis of potential consequences to geologic features was excluded.

G.2.1 Proposed Action

To establish a spatial context for analysis, the proposed project facility and infrastructure features are compartmentalized into the proposed Spaceport Camden site and the proximity area. Spatially, the proximity area is the extents of the proposed facility and infrastructure footprints and is not presented in the context of an encompassing polygon area like the approximately 1,413.2-acre proposed Spaceport Camden site.

G.2.1.1 Construction

The construction process is generally divided into three phases: (1) surface preparation, (2) structure emplacement, and (3) stabilization of remaining disturbed areas not covered by the constructed feature. Surface preparations typically include altering the surface by grubbing, clearing, and grading (cuts and fills); topsoil may or may not be removed. Soil excavations may be required to create the appropriate construction feature subgrade and base components.

Disturbance of earth resources includes excavating soil, soil mixing, and soil compaction and rutting and covering with building foundations, parking lots, roadways, and fill materials. Imported crushed stone, aggregates, sand, clay, or gravel are often used as fill during facility and road construction. The physical properties of soil may be dramatically altered during construction. Even when topsoils are stockpiled and replaced, the soil profile will be altered. Depending on pyogenic conditions, recreating a soil profile may take decades or hundreds of years. The subsequent land use changes are essentially permanent. Changes in natural drainageway landforms may also accompany construction activities. Channel alterations may be a direct result of construction activities or an indirect result of natural systems responding to changes in hydrologic features or conditions (see EIS Section 4.14, *Water Resources*). Typically, the primary pollutant generated by the construction process is sediment.

Construction Footprints

The proposed Spaceport Camden construction activities include facility buildings and parking lots, rocket launch and landing pads, a main gate facility, and infrastructure roads and rights-of-way. The proposed project construction footprint soil metrics are presented in Table G-4.

Table G-4. Proposed Spaceport Camden Construction Footprints

Construction Feature	Mandarin Series	Pottsburg Series	Rutlege Series	Total (acres)
Proposed Spaceport Camden[a]				
Vertical Launch Facility	49.6	11.4	0	**61.0**
LCC Complex	3.9	0		**3.9**
Landing Zone	21.4			**21.4**
Main Gate	0		0.1	**0.1**
ACC and Visitor Center	2.5		0	**2.5**
Infrastructure	25.7	0.7	2.2	**28.6**
Subtotal	**103.1**	**12.1**	**2.3**	**117.5**
Proximity Area (outside the Proposed Spaceport Camden)				
ACC and Visitor Center	1.5	1.7	0	**3.2**

Table G-4. Proposed Spaceport Camden Construction Footprints

Construction Feature	Mandarin Series	Pottsburg Series	Rutlege Series	Total (acres)
Main Gate	0	0.1	0.4	**0.5**
Infrastructure	30.5	1.5	4.0	**36.0**
Subtotal	**32.0**	**3.3**	**4.4**	**39.7**
Total	**135.1**	**15.4**	**6.7**	**157.2**

Notes: LCC = Launch Control Center; ACC = Alternate Control Center.
[a] The proposed Spaceport Camden is delineated by the blue line boundary in Exhibit G-1. Proposed Spaceport Camden Soil Map. The proximity area facility and infrastructure construction footprints are located to the immediate south and east of the proposed Spaceport Camden site.

The proposed Spaceport Camden site and proximity area total construction footprint areas are approximately 117.5 acres and 39.7 acres, respectively. Proposed facility and infrastructure construction footprints would impact approximately 8 percent (117.5 acres) of the approximately 1,413.2 acres that compose the proposed Spaceport Camden site.

Exposure to potential geologic hazards and potential for soil erosion and soil limitations were considered when evaluating impacts to earth resources. Generally, impacts can be avoided or minimized if proper construction techniques, erosion-control measures, and structural engineering designs are incorporated into project development.

With the implementation of permit requirements and associated best management practices (BMPs) (see Chapter 6, *Mitigation*, for examples), the Federal Aviation Administration (FAA) has identified no significant adverse impacts under the Proposed Action. Because ground-disturbing activities would exceed 1 acre, a National Pollutant Discharge Elimination System (NPDES) permit would be required. Under the permit, Camden County would be required to implement BMPs as part of the Erosion, Sedimentation, and Pollution Control Plan requirements. These BMPs would serve to mitigate any potential impacts to soils. The base would also have to obtain a Camden County Land Disturbing Permit per the Georgia Erosion and Sedimentation Control Act. With application of BMPs as required and adherence to permit stipulations, potential impacts to soil resources and groundwater recharge areas would not be anticipated.

Much of the activity associated with the Proposed Action would occur on Mandarin and Pottsburg series soils. With flood control and proper drainage measures, there are no major limitations that would preclude this soil type from development. The disturbance footprint would negligibly impact the utility of this soil type, since it is not currently used for, nor are there future plans to utilize the parcel for, any other purposes.

Ground disturbance owing to tree removal, addition of fill, grading, construction, and pavement construction activities could result in soil erosion within the project area. The use of permit-required BMPs would reduce any potential impacts from erosion during these activities. With the implementation of these actions, groundwater resources in the area are likely to be unaffected as well.

Overall, it is probable that impacts associated with soil disturbance and erosion will occur. However, impacts would be of moderate intensity and localized to construction footprints during the short term (i.e., during construction and until soils are stabilized). These impacts would likely be nonsignificant provided that permit-related BMPs and mitigations are implemented.

Mitigation

Soil structural damage can result in impacts to soil and water environments for many years. The natural recovery or amelioration of damaged soils to pre-compaction conditions is extremely slow, if it occurs at all. Recovery of sandy soils is very slow, and compacted subsurface layers take much longer to recover.

Any mitigations associated with construction activities would be covered under the NPDES and Camden County Land Disturbing permits.

G.2.1.2 Operation

An assessment of proposed Spaceport Camden operational launch, landing, and support activities and performance scenarios (see Chapter 2, *Proposed Action and Alternatives*) did not identify activities that would result in impacts to earth resources. The extent of proposed Spaceport Camden operation activity footprints (constructed facility and infrastructure platforms) would be conducted on permanently disturbed sites and would not result in impacts to adjacent natural areas.

Vibrations from rocket launch events were evaluated as a potential source of impacts to unstable streambanks. However, since streambanks potentially sensitive to noise vibrations are over 8,000 feet west of the proposed launch facility, no launch operation impacts are anticipated. Should streambank erosion issues arise, a stabilization plan is in place to prevent further damage (see Section G.1.3.5, *Soils: Soil Erosion*).

In addition, all proposed operational activities would be conducted on constructed building and pad platforms or roadways, which minimize the potential for offsite earth resource impacts. Therefore, analysis of the impacts of proposed operational activities on earth resources is not carried forward.

G.2.2 No Action Alternative

Under the No Action Alternative, FAA would not issue a Launch Site Operator License for operation of Spaceport Camden, and no spaceport facilities would be constructed. The property use would not change, and the proposed construction and operations would not take place. There are no anticipated impacts to earth resources, since there would be no change in the current state.

G.2.3 References

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APPENDIX H WETLANDS DELINEATION

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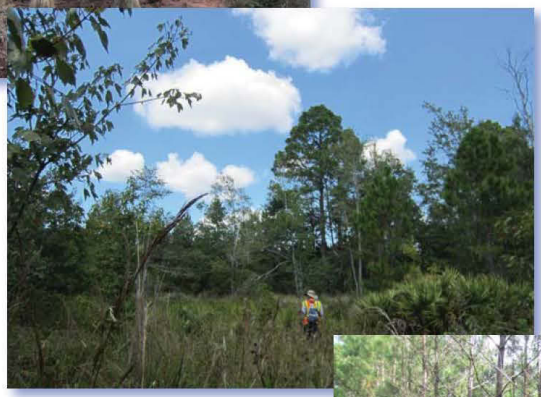
H WETLANDS DELINEATION

Spaceport Camden

Final
Wetlands Delineation Report



Camden County, Georgia

November 2017

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ACRONYMS AND ABBREVIATIONS

ArcGIS	geographical information system mapping program
CFR	*Code of Federal Regulations*
CWA	Clean Water Act
GPS	global positioning system
LIDAR	light detection and ranging
NASA	National Aeronautics and Space Administration
NRCS	Natural Resources Conservation Service
NWI	National Wetland Inventory
PEM	palustrine emergent
PFO	palustrine forested
PSS	palustrine scrub-shrub
PUB	palustrine unconsolidated bottom
SFWMD	South Florida Water Management District
USGS	U.S. Geological Survey
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WRAP	Wetland Rapid Assessment Procedure

1.0 PURPOSE AND BACKGROUND

This report provides the results of the wetland and surface water delineation performed by Leidos, Inc., staff (Brian Tutterow/Sarah Bresnan Rauch) on August 15 through 19, 2016, and a site visit with the USACE on June 22, 2017, at the proposed Spaceport Camden site, Camden County, Georgia (Figure 1).

The site is located in an unincorporated area of Woodbine, Georgia, in Camden County, approximately 11.5 miles east of the town of Woodbine, at the mouth of the Satilla and Cumberland Rivers and just west of Cumberland Island. The site has been in industrial use since the early 1940s and initially was used as a tree farm to supply a local paper mill. During the 1960s, the Thiokol Chemical Company operated a solid rocket motor facility at the site. When the National Aeronautics and Space Administration (NASA) decided to concentrate on liquid-fueled rockets, the site was converted to manufacture military hardware, including mortar ammunition and trip flares. From the mid-1970s to 2012, the property was occupied by a pesticide manufacturing facility operated by various owners.

The purpose of the Camden County Board of Commissioners' (i.e., the County's) proposal to construct and operate Spaceport Camden is to enable the County to offer a commercial space launch site to a growing number of medium and small, orbital and suborbital, vertical launch vehicle operators to conduct commercial launches on the east coast of the United States. A commercial space launch site could more effectively respond to the scheduling needs of commercial launch providers than Federal facilities, which involve national security priorities and logistical complexities.

Under the proposed project, the County would construct and operate Spaceport Camden under a Launch Site Operator License on approximately 4,000 acres of upland at the approximately 11,800-acre industrial site shown on Figure 1. The 11,800-acre site is currently owned by Bayer Crop Science and Union Carbide Corporation (Figure 1). Spaceport Camden would include a Vertical Launch Facility, a Landing Zone, a Launch Control Center Complex, and an Alternate Control Center and Visitor Center. These facilities would be constructed on approximately 100 non-contiguous acres (as shown on Figure 2). In addition to improving existing roads, at least one new road may be constructed. The remainder of the 4,000-acre site, some of which is wetland, would be used as a safety buffer. No additional development has been proposed for the buffer area. The area requested for verification of wetland boundaries is 184.1 acres in size and is shown as the field survey area on Figures 3, 3A, 3B, and 3C.

An existing dock with deep-water access (on the portion of the property not currently under option to Camden County) may be utilized during construction and operation of the proposed Spaceport Camden site. No construction or other changes are proposed for the dock.

Figure 1. Project Location

2.0 REGULATORY FRAMEWORK

2.1 FEDERAL AND STATE ACTS AND REGULATIONS

The U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (USEPA) jointly define wetlands as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (USACE 1987).

Section 404 of the Clean Water Act (CWA) establishes a program to regulate discharges of dredged or fill material in waters of the United States to ensure protection of the biological and chemical quality of the water. Waters of the United States that are subject to jurisdictional review are defined by 33 *Code of Federal Regulations (CFR)* 328 as follows:

- Waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide including the territorial seas;
- All interstate waters including interstate wetlands;
- All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds;
- All impoundments and tributaries of waters defined as waters of the United States; and
- Wetlands adjacent to waters defined as waters of the United States.

As defined previously, jurisdictional waters subject to Section 404 include streams, rivers, and creeks that are navigable waters or tributaries to navigable waters. Certain wetlands are also considered jurisdictional waters of the United States and would also be subject to regulation under Section 404. For a water or wetland to be considered a water of the United States, a jurisdictional determination and/or wetland delineation must be completed and approved by the USACE. If jurisdictional waters or wetlands are found, Section 404 requires a Federal facility to obtain a Section 404 permit from the USACE before dredged or fill material may be discharged into jurisdictional waters of the United States, unless the activity is exempt from Section 404.

The State of Georgia has no state-specific wetland regulations for non-tidal wetlands. Georgia does regulate tidal wetlands under the Georgia's Coastal Marshland Protection Act. No tidal wetlands were identified in the survey areas.

2.2 WETLAND FUNCTIONAL ASSESSMENT

The Wetland Rapid Assessment Procedure (WRAP) is a rating index developed to assist in the regulatory evaluation of wetland sites that have been created, enhanced, preserved, or restored. This standardized rating index can be used in combination with professional judgment to provide an accurate and consistent evaluation of wetland sites (SFWMD 1997).

A WRAP conducted during the wetland delineation documents the functional condition of the wetlands (see Appendix A, Attachment A-1). The WRAP assessed five variables to determine the functional condition of the wetland. These variables are: wildlife utilization; wetland overstory/shrub canopy; wetland vegetative ground cover; adjacent upland support/wetland buffer; field indicators of wetland hydrology; and water quality input and treatment systems

evaluation. These variables are assigned a score from 0 to 3, and then the variables are summed and divided by the maximum potential score for each variable to result in an index score. The index score is shown in the "WRAP Score" section of each data sheet as a number from 0 to 1. A higher WRAP index number represents higher functionality, whereas a lower number represents poor functionality.

3.0 METHODS

Prior to the site visit, the following resources were reviewed:

- Natural Resources Conservation Service (NRCS) soils maps,
- National Wetland Inventory (NWI) maps,
- Camden County elevation models derived from light detection and ranging (LIDAR),
- U.S. Geological Survey (USGS) topographic maps, and
- 2011 Woodbine "Wetland Mitigation Bank–Wetland Delineation" (USACE 2011).

NRCS soil maps were reviewed to identify areas of hydric soils that might support wetlands, and LIDAR and topographic maps were reviewed for evidence of low-lying areas that might support the formation of wetlands.

In November 2010, a wetland delineation was conducted within a portion of the proposed Spaceport Camden site. The delineation was prepared as part of a feasibility study for a wetland mitigation bank. Appendix C, Attachment C-2, contains a figure showing the study area for the mitigation bank and the results of the wetland study.

Areas of the project proposed for construction were selected to avoid known wetland areas (previously delineated wetlands and NWI) and, therefore, few of these areas have wetlands mapped by the NWI. The NWI does map several of the areas that are not proposed for construction as wetlands. These wetlands include emergent and forested/shrub wetlands.

A site visit was conducted from August 15 through August 19, 2016, to identify and delineate waters and surface features in the field survey areas identified on Figure 3. Boundaries and locations of previously delineated wetlands and surface water features were verified in the field, and new wetland features were delineated during the field visit. Any new surface water features observed were mapped using aerial photography and global positioning system (GPS) field points. Only wetlands, streams, and ditches within field survey areas were delineated and mapped.

Wetlands were identified and delineated in accordance with the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region (Version 2.0)* (USACE 2010). Observation points were used to characterize wetlands and to determine the location of the wetland boundary lines. For wetland and surface water features, delineation of the line occurred by walking the line and taking single GPS points and then connecting the points using a geographical information system mapping program (ArcGIS). Each point was taken within visual sight distance of the previous points. Wetland Determination Data Forms were created for observation points used to characterize wetland and upland areas (see Appendix A, Attachment A-2), and photographs were taken at each site (Appendix B). Ditches were mapped using a combination of aerial photography and GPS field mapping.

The primary soil mapped at the proposed Spaceport Camden site is classified as Mandarin fine sand, with 0 to 2 percent slopes (Appendix C, Attachment C-1). This soil has a hydric rating of 6 (i.e., 6 percent of the soil map unit meets the criteria for hydric soil). Other significant soils by acreage include Pottsburg sand (hydric rating 5) and Rutlege fine sand (hydric rating 100). Other soils with hydric components that occur less frequently at the proposed Spaceport Camden site include Bohicket-Capers association and Pelham loamy sand. Cainhoy fine sand, a non-hydric soil, is also present in low percentages (USDA 2016).

3.1 U.S. ARMY CORPS OF ENGINEERS SITE VISIT

A site visit occurred with the USACE, Savannah District, on June 22, 2017, to verify the results of the wetland delineation. After consultation with USACE, the wetland delineation boundaries were revised for Wetlands 6, 10, and 11. A new wetland, Wetland 21, was added alongside an ephemeral stream, and Wetland 5 was re-evaluated and determined to not meet the criteria for a wetland.

4.0 RESULTS

As part of the wetland delineation at the proposed Spaceport Camden site, 184.1 acres were surveyed. This survey resulted in the observation of 3.61 acres of wetlands and 1,043 linear feet of ephemeral streams within the field survey area. Approximately 0.78 acres of wetlands and 0.166 acres of ephemeral streams were observed within the area of project impact (Table 1 and 2). According to the Cowardin Classification System (USFWS 1979), these wetlands are comprised of Palustrine System habitat types including palustrine forested (PFO), palustrine emergent (PEM), palustrine scrub-shrub (PSS), and palustrine unconsolidated bottom (PUB). Table 1 lists the identified wetland areas by habitat type, observation point, wetland type (by Cowardin classification), potential impacted acres, and location (latitude/longitude). The observation point number references the point that was used to characterize that wetland. The habitat type refers to the characteristic vegetation type encountered within the wetland survey area. Table 2 lists stream impacts. A list of habitat types and associated species follows.

- Pine plantation (open canopy) – *Pinus taeda* and/or *P. palustris*
- Pine plantation (closed canopy) – *P. taeda* and/or *P. palustris*
- Cypress/Redbay – *Taxodium ascendens* and *Persea borbonia*
- Unvegetated – no vegetation observed within wetland area
- Grass-sedge meadow – dominated by *Carex* spp. and *Juncus* spp.
- Tupelo – *Nyssa sylvatica*
- Buttonbush scrub/Cattail marsh – *Cephalanthus occidentalis* and *Typha* sp.
- Cypress/Grass-sedge – *T. ascendens* and *Carex* spp. and *Juncus* spp.
- Oak/Sedge – *Quercus nigra, Q. virginiana,* and/or *Q. laurifolia*

Several ditches were field verified and mapped as roadside ditches (Figures 3, 3A, 3B, and 3C). Three ephemeral streams were observed in the survey area. No other surface water features were identified within the survey area.

The following figures and appendices document the results of the field survey.

- Figure 1. Project Location
- Figure 2. Proposed Facilities and Survey Areas
- Figures 3, 3A, 3B, and 3C. Mapped Wetlands, Water Features, and Observation Points
- Figure 4. Photo Points
- Appendix A. Wetland Delineation Data Forms
- Appendix B. Site Photographs
- Appendix C. Natural Resources Conservation Service Soil Survey and Previously Delineated Wetlands Maps
- Appendix D. Global Positioning System Delineation Form
- Appendix E. U.S. Army Corps of Engineers Verification Letter

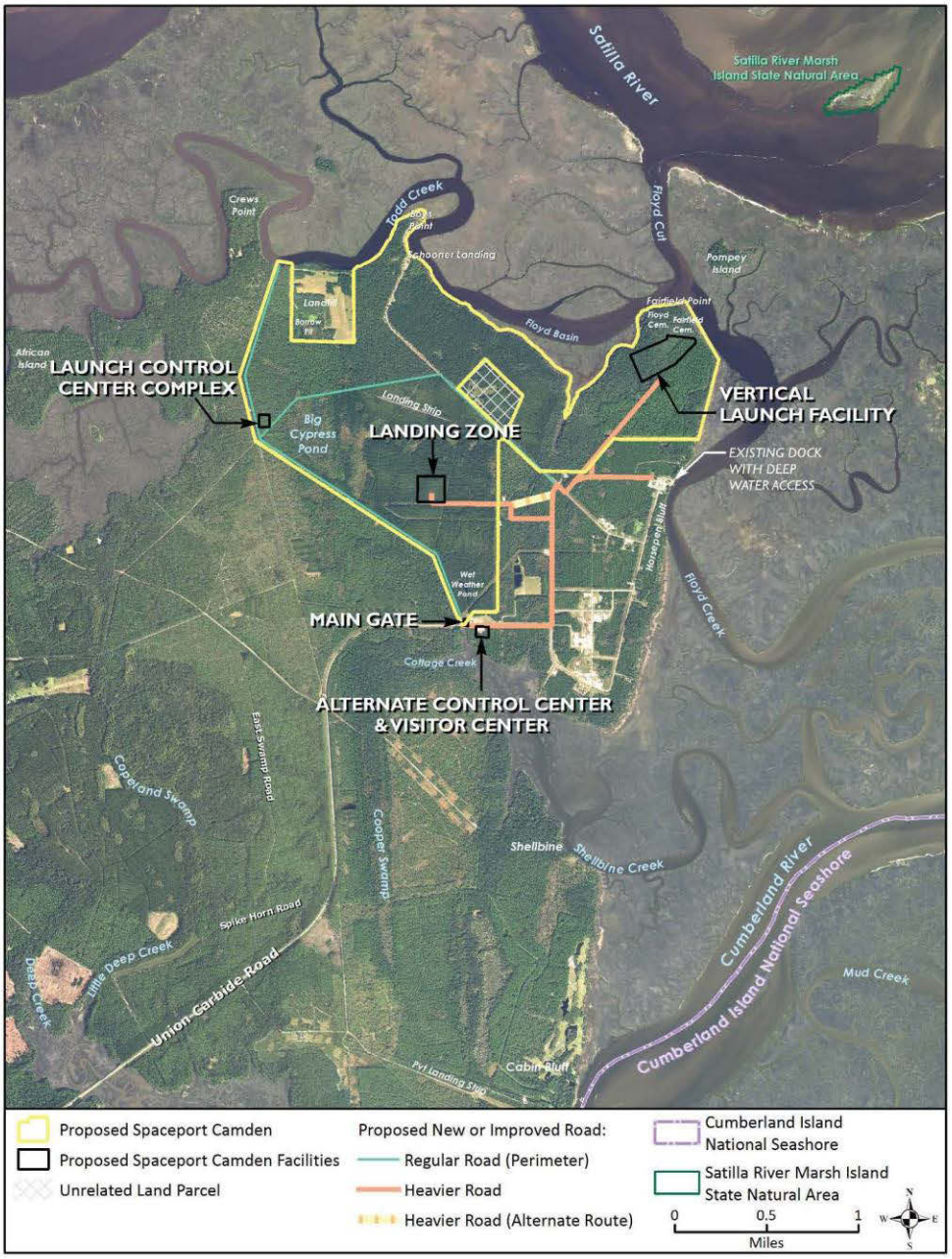

Figure 2. Proposed Spaceport Camden

Table 1. Aquatic Resources within the Field Survey Area at the Proposed Spaceport Camden

Wetland	Acres in the Field Survey Area	Habitat Type	Wetland Type[a]	Estimated Impacted Wetlands (Proposed Project)[b]	Latitude	Longitude
3A	0.184	Cypress/Redbay	PFO	0.043 (Regular Road)	30.94321000	-81.54158000
3B	0.1410	Cypress/Redbay	PFO	0.041 (Regular Road)	30.94363000	-81.53896000
3C	0.4770	Cypress/Redbay	PFO	0.081 (Regular Road)	30.94312000	-81.54120000
3D	0.1720	Cypress/Redbay	PFO	0	30.94342000	-81.53904000
3E	0.3660	Cypress/Redbay	PFO	0.134 (Regular Road)	30.93678000	-81.53945000
6	0.0020	Grassland	PUB	0.002 (Vertical Launch Facility)	30.94697800	-81.50976100
7	0.1960	Unvegetated	PEM	0.073 (Heavier Road)	30.94037400	-81.51296800
9	0.1210	Grass-Sedge Meadow	PEM	0.015 (Heavier Road)	30.94253300	-81.51037800
10	0.6440	Tupelo	PFO	0.267 (Heavier Road [Alternate Route])	30.93529300	-81.51991800
11	0.0820	Grass-Sedge Meadow	PSS/PEM	0.012 (Heavier Road)	30.93688500	-81.51536800
12A	0.0480	Oak/Sedge	PFO	0	30.93181000	-81.51838000
12B	0.0790	Buttonbush Scrub/Cattail Marsh	PFO	0	30.93033000	-81.51839000
14	0.1890	Oak/Sedge	PEM	0.021 (Regular Road)	30.94325800	-81.53758000
15	0.0570	Scrub/Emergent	PEM	0.002 (Regular Road)	30.94369900	-81.53644800
16	0.2760	Grass-Sedge Meadow	PFO/PSS/PEM	0.026 (Regular Road)	30.94452900	-81.53815500
17	0.2100	Grass-Sedge Meadow	PFO/PSS/PEM	0.061 (Regular Road)	30.93489900	-81.53610900
18	0.0920	Cypress/Grass-Sedge	PFO/PSS	0	30.93557000	-81.52572600
19A	0.0780	Cypress/Grass-Sedge	PSS/PFO	0	30.94062000	-81.52322500
19B	0.1610	Cypress/Redbay	PSS/PFO	0	30.93496000	-81.52385000
20	0.0150	Oak/Sedge	PFO	0	30.93700000	-81.51400000
21	0.0170	Cypress/Redbay	PEM	0.004 (Regular Road)	30.93797000	-81.51504000
TOTALS	**3.61**			**0.78**		

[a] PEM = Palustrine Emergent, PFO = Palustrine Forested, PSS = Palustrine Scrub Shrub, PUB = Palustrine Unconsolidated Bottom.
[b] All wetland areas were determined by Leidos, Inc., to be jurisdictional, and any impacts will require Section 404 permits.

Table 2. Potential Ditch and Stream Impacts by Project Area

Ephemeral Stream	Acres in the Field Survey Area	Disturbance	Potentially Impacted Area	
			Linear Feet	Acres
1	0.152	Landing Zone	660	0.1524
2A	0.009	Heavier Road	107	0.0069
2B	0.003	Heavier Road	53.962	0
3A	0.007	Heavier Road	109.492	0.0002
3B	0.015	Heavier Road (Alternate Route)	112.571	0.0062
		TOTALS	**1043.025**	**0.166**

Figure 3. Mapped Wetlands, Water Features, and Observation Points

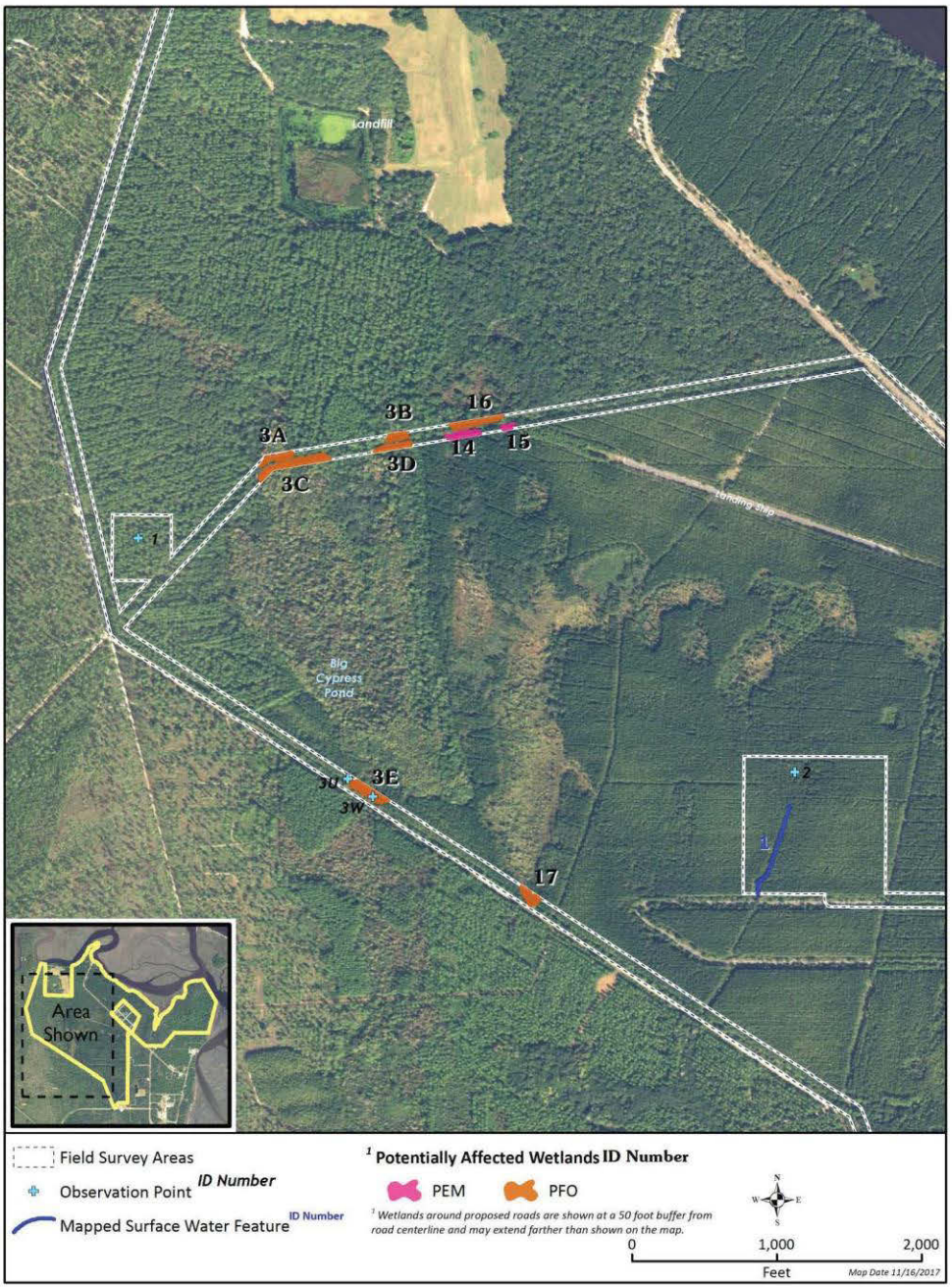

Figure 3A. Mapped Wetlands, Water Features, and Observation Points

Spaceport Camden Wetland Delineation Report

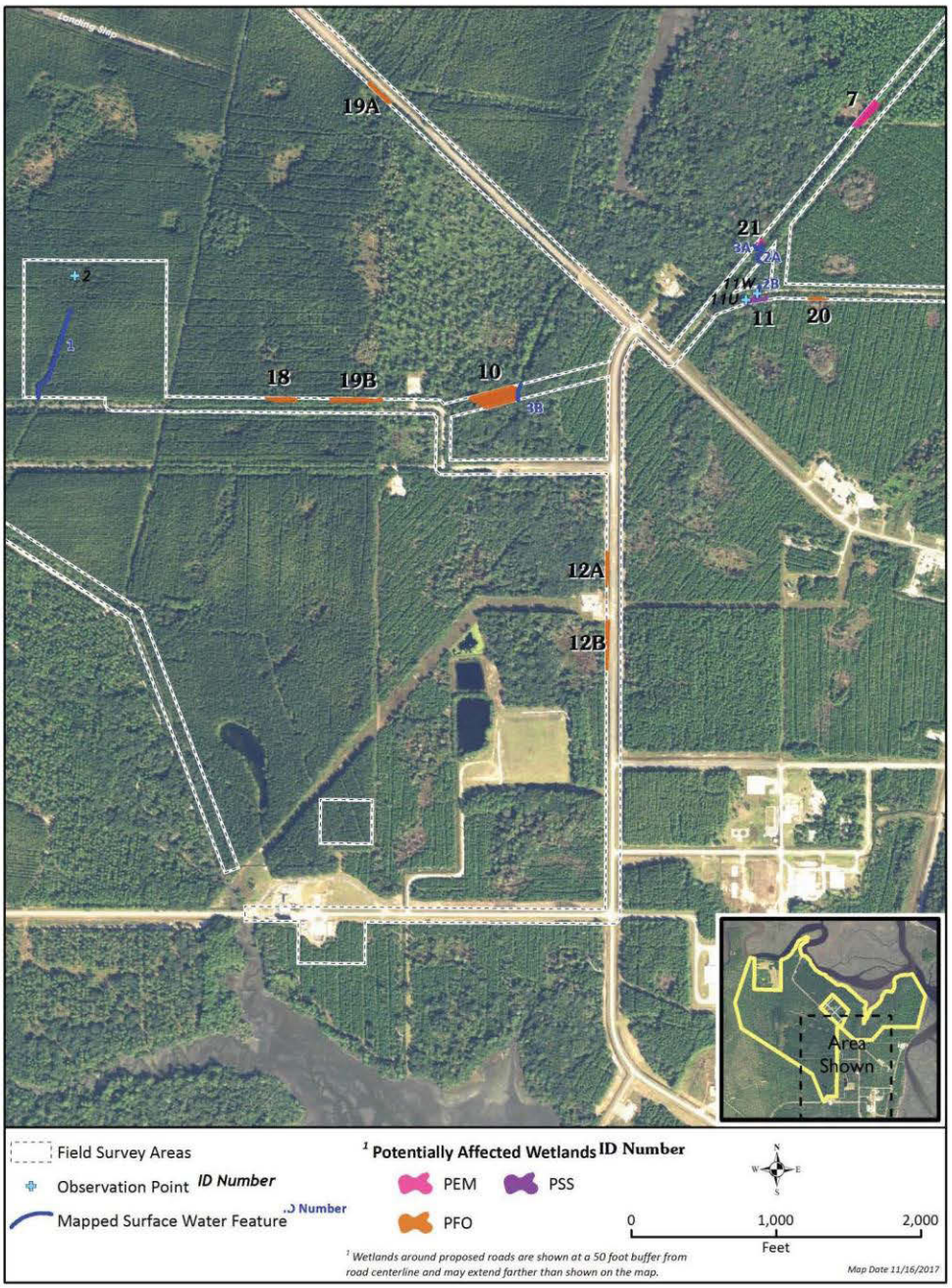

Figure 3B. Mapped Wetlands, Water Features, and Observation Points

Final *12* *November 2017*

Figure 3C. Mapped Wetlands, Water Features, and Observation Points

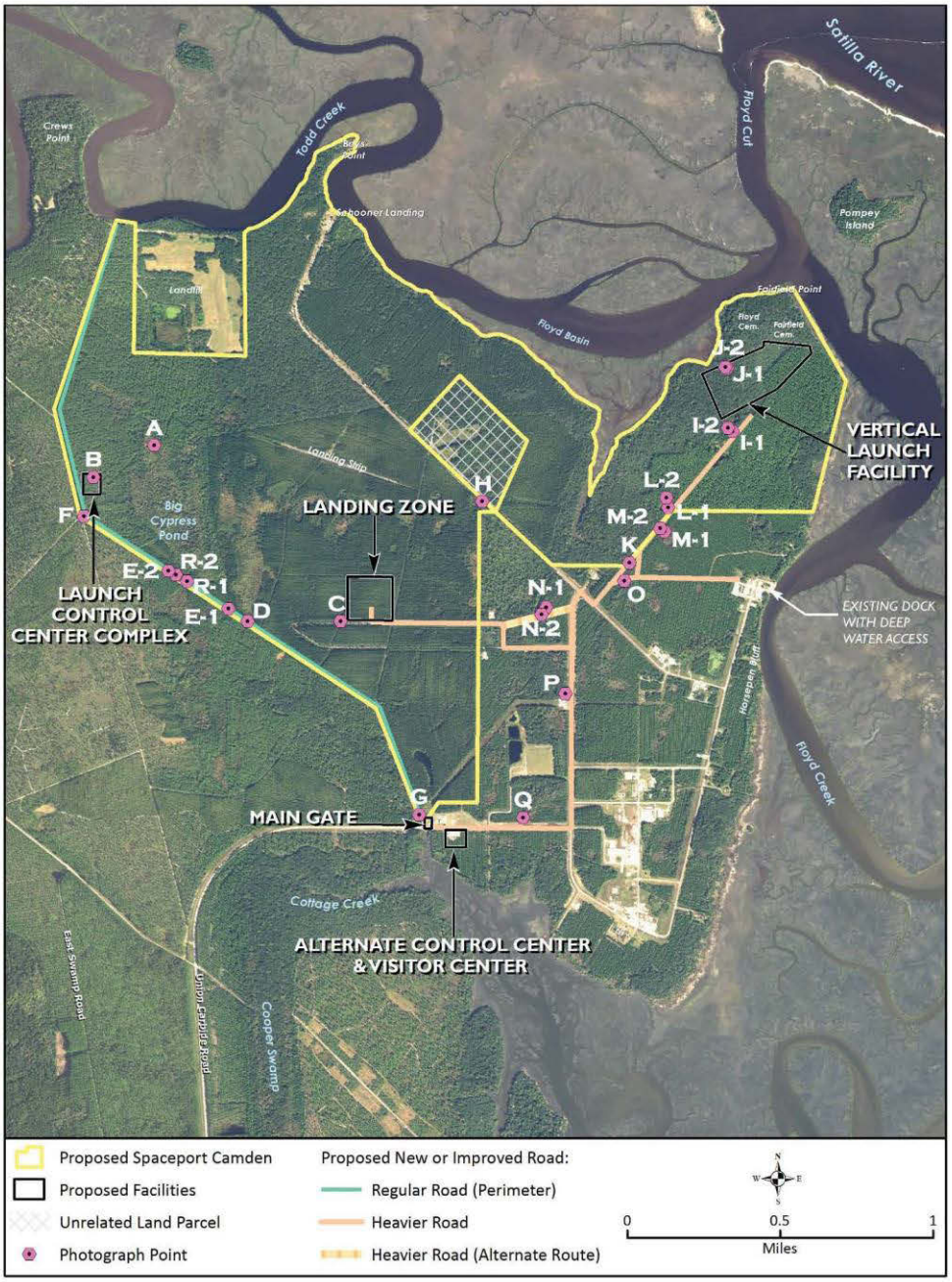

Figure 4. Photo Points

5.0 POTENTIAL IMPACTS

As part of the wetland delineation at the proposed Spaceport Camden site, 184.1 acres were surveyed. Approximately 0.78 acres of wetlands may be impacted as a result of the proposed project. Approximately 886 linear feet of ephemeral streams could be impacted as a result of the proposed project.

A conservative estimate of wetland impacts was made based on the preliminary facility design. To provide the conservative estimate, the survey areas for facilities and any proposed alternatives were used as the extent of potential impacts. Road impacts were assessed based on a 24-foot right-of-way for the perimeter road, a 36-foot right-of-way for internal site regular roads, and a 40-foot right-of-way for internal heavier roads. The footprint for actual impacts is anticipated to be smaller as roads may be shifted to avoid wetlands, alternatives such as the heavy roads may not be used, and the overall wetland impacts are estimated to be less than the 0.78 acres of wetlands described previously. The actual total extent of wetland and ephemeral stream impact will be determined during final permitting and design. A wetland permit will be required from the USACE prior to any work in the wetland or stream areas.

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6.0 REFERENCES

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APPENDIX A

WETLAND DELINEATION DATA FORMS

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Attachment A-1

Wetland Rapid Assessment Procedure (WRAP) Forms

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Wetland 3

Wetland Rapid Assessment Procedure

☑ Check one ☐ Existing Conditions ☐ Proposed Conditions (WRAP)

Application Number	Project Name	Date	Evaluator	Wetland Type
	Spaceport Camden	8-16-16	Brian Tutterow	PFO

Land Use	FLUCCS Code		Wetland Acreage
open space	621	Description: Cypress	58.25

Wildlife Utilization (WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
2.5	2	2

Habitat Support / Buffer

Buffer type	(Score)	X (% of area)	=Sub Totals
Wet	3	80	2.4
Upl	3	15	0.45
Upl	1	5	0.05
		TOTAL	2.9

Field Hydrology (HYD): 2

WQ Input & Treatment (WQ)*: 1.5

* The value of WQ is obtained by adding the TOTAL scores of Land use Category and Pretreatment category then dividing by 2

Land use Category (LU)

Land use Category	(Score)	X (% of area)	=Sub Totals
undevel	3	100	3
		(LU) TOTAL	3

Pretreatment Category (PT)

Pretreatment Category	(Score)	X (% of area)	=Sub Totals
None	0	0	0
		(PT) TOTAL	0

WRAP Score: 0.72

Field Notes:

Wildlife Utilization (WU)

Site is in relatively undeveloped portion of the site. Some disturbance for access roads and pine plantations. Evidence of deer and wild pigs was observed.

Wetland Canopy (O/S)

Open cypress swamp

Wetland Ground Cover (GC)

Graminoid dominated community, no invasives observed, some disturbance related to unimproved roads.

Habitat Support / Buffer

Site is located in undeveloped area with wetlands and historic pine plantations functioning as buffer. Adjacent land owners to the west have created roads which reduce the buffer areas.

Field Hydrology (HYD)

Despite disturbance related to access roads and pine plantation the hydrology is relatively undisturbed.

WQ Input & Treatment (WQ)

This is a small watershed area. Most of the surface water runoff flow directly into the wetland with no treatment.

Wetlands 7,9
Wetlands 14,15

Wetland Rapid Assessment Procedure

☑ Check one
☐ Existing Conditions ☐ Proposed Conditions (WRAP)

Application Number	Project Name	Date	Evaluator	Wetland Type
	Spaceport Camden	8-17-16	Brian Tutterow	PEM

Land Use	FLUCCS Code		Wetland Acreage
open space	640	Description: freshwater non-forest	3.64

Wildlife Utilization (WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
2	2	2

Habitat Support / Buffer

Buffer type	(Score)	X (% of area)	=Sub Totals
Upl	2.5	90	2.25
Upl	0	10	0
		TOTAL	2.25

Field Hydrology (HYD): 2

WQ Input & Treatment (WQ)*: 1.5

* The value of WQ is obtained by adding the TOTAL scores of Land use Category and Pretreatment category then dividing by 2

Land use Category (LU)

Land use Category	(Score)	X (% of area)	=Sub Totals
undevel	3	100	3
		(LU) TOTAL	3

Pretreatment Category (PT)

Pretreatment Category	(Score)	X (% of area)	=Sub Totals
None	0	0	0
		(PT) TOTAL	0

WRAP Score: 0.65

Field Notes:

Wildlife Utilization (WU)
Sites are in relatively undeveloped portions of the site. Some disturbance for access roads and pine plantations. Evidence of wild pigs was observed.

Wetland Canopy (O/S)
Emergent wetland vegetation.

Wetland Ground Cover (GC)
No invasives observed, some disturbance related to roads.

Habitat Support / Buffer
Sites are located in historic pine plantation and coastal oak scrub bordered by access roads.

Field Hydrology (HYD)
Despite disturbance related to access roads and pine plantation the hydrology is relatively undisturbed.

WQ Input & Treatment (WQ)
This is a small watershed area. Most of the surface water runoff flow directly into the wetland with no treatment.

Wetland 6

Wetland Rapid Assessment Procedure

☐ Existing Conditions ☑ Check one ☐ Proposed Conditions (WRAP)

Application Number	Project Name	Date	Evaluator	Wetland Type
	Spaceport Camden	8-17-16	Brian Tutterow	PUB

Land Use	FLUCCS Code	Description:	Wetland Acreage
open space	616	Pond	0.05

Wildlife Utilization (WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
1	0	0

Habitat Support / Buffer

Buffer type	(Score)	X (% of area)	=Sub Totals
UPL	2.5	100	2.5
		TOTAL	2.5

Field Hydrology (HYD)	WQ Input & Treatment (WQ)*
2	3.0

* The value of WQ is obtained by adding the TOTAL scores of Land use Category and Pretreatment category then dividing by 2

Land use Category (LU)

Land use Category	(Score)	X (% of area)	=Sub Totals
natural	3	100	3.0
		(LU) TOTAL	3.0

Pretreatment Category (PT)

Pretreatment Category	(Score)	X (% of area)	=Sub Totals
Natural	3	100	3
		(PT) TOTAL	3

WRAP Score 0.48

Field Notes:

Wildlife Utilization (WU)
Site is located in oak forest area. Small depressional wetland with some evidence of use by pigs.

Wetland Canopy (O/S)
None, wetland was devoid of vegetation

Wetland Ground Cover (GC)
None.

Habitat Support / Buffer
Site is located in oak forest, relatively undisturbed.

Field Hydrology (HYD)
Hydrology appears to be solely based on precipitation.

WQ Input & Treatment (WQ)
Surface water runoff flows directly into the wetland with only natural treatment.

Wetland 10 and 12

Wetland Rapid Assessment Procedure

☑ Check one ☐ Existing Conditions ☐ Proposed Conditions (WRAP)

Application Number	Project Name	Date	Evaluator	Wetland Type
	Spaceport Camden	8-18-16	Brian Tutterow	PFO

Land Use	FLUCCS Code		Wetland Acreage
open space	621	Description: Cypress	13.57

Wildlife Utilization (WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
2.5	2	2

Habitat Support / Buffer

Buffer type	(Score)	X (% of area)	=Sub Totals
Upl	2	70	1.4
Upl	0	30	0
		TOTAL	1.4

Field Hydrology (HYD)	WQ Input & Treatment (WQ)*
2	1.5

* The value of WQ is obtained by adding the TOTAL scores of Land use Category and Pretreatment category then dividing by 2

Land use Category (LU)

Land use Category	(Score)	X (% of area)	=Sub Totals
undevel	3	100	3
		(LU) TOTAL	3

Pretreatment Category (PT)

Pretreatment Category	(Score)	X (% of area)	=Sub Totals
None	0	0	0
		(PT) TOTAL	0

WRAP Score: 0.63

Field Notes:

Wildlife Utilization (WU)
Site is in relatively undeveloped portion of the site. Some disturbance for access roads and pine plantations. Evidence of deer, wild pigs, and alligators were observed.

Wetland Canopy (O/S)
Oak swamp

Wetland Ground Cover (GC)
No invasives observed, some disturbance related to roads.

Habitat Support / Buffer
Site is located in undeveloped area with wetlands and historic pine plantations functioning as buffer. Several roads are located adjacent to the wetland boundaries.

Field Hydrology (HYD)
Despite disturbance related to access roads and pine plantation the hydrology is relatively undisturbed.

WQ Input & Treatment (WQ)
This is a small watershed area. Most of the surface water runoff flow directly into the wetland with no treatment.

Wetland 11

Wetland Rapid Assessment Procedure

☐ Existing Conditions ☑ Proposed Conditions (Check one)

(WRAP)

Application Number	Project Name	Date	Evaluator	Wetland Type
	Spaceport Camden	8-17-16	Brian Tutterow	PFO/PSS/PEM

Land Use	FLUCCS Code		Wetland Acreage
open space	610	Description: hardwoods	5.97

Wildlife Utilization (WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
2.5	2	2

Habitat Support / Buffer

Buffer type	(Score)	X (% of area)	=Sub Totals
Upl	2	100	2
		TOTAL	2

Field Hydrology (HYD)	WQ Input & Treatment (WQ)*
2	1.5

* The value of WQ is obtained by adding the TOTAL scores of Land use Category and Pretreatment category then dividing by 2

Land use Category (LU)

Land use Category	(Score)	X (% of area)	=Sub Totals
undevel	3	90	2.7
devel	1	10	0.1
		(LU) TOTAL	2.8

Pretreatment Category (PT)

Pretreatment Category	(Score)	X (% of area)	=Sub Totals
None	0	0	0
		(PT) TOTAL	0

WRAP Score: 0.67

Field Notes:

Wildlife Utilization (WU)
Site is in slightly more developed portion of the site near an electrical substation and surrounding on three sides by roads.

Wetland Canopy (O/S)
Oak swamp mixed with emergent and scrub wetlands.

Wetland Ground Cover (GC)
No invasives observed, some disturbance related to roads and fill for the electrical substation.

Habitat Support / Buffer
Site is located in more developed area with historic pine plantations and roads surrounding the sites.

Field Hydrology (HYD)
Despite disturbance related to access roads and pine plantation the hydrology is relatively undisturbed.

WQ Input & Treatment (WQ)
This is a small watershed area. Most of the surface water runoff flow directly into the wetland with no treatment.

Wetland 16, 17

Wetland Rapid Assessment Procedure

☑ Check one ☐ Existing Conditions ☐ Proposed Conditions (WRAP)

Application Number	Project Name	Date	Evaluator	Wetland Type
	Spaceport Camden	8-17-16	Brian Tutterow	PFO/PSS/PEM

Land Use	FLUCCS Code		Wetland Acreage
open space	621	Description: Cypress	32.91

Wildlife Utilization (WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
2.5	2	2

Habitat Support / Buffer

Buffer type	(Score)	X (% of area)	=Sub Totals
Wet	3	80	2.4
Upl	3	20	0.6
		TOTAL	3

Field Hydrology (HYD): 2

WQ Input & Treatment (WQ)*: 1.5

* The value of WQ is obtained by adding the TOTAL scores of Land use Category and Pretreatment category then dividing by 2

Land use Category (LU)

Land use Category	(Score)	X (% of area)	=Sub Totals
undevel	3	100	3
		(LU) TOTAL	3

Pretreatment Category (PT)

Pretreatment Category	(Score)	X (% of area)	=Sub Totals
None	0	0	0
		(PT) TOTAL	0

WRAP Score: 0.72

Field Notes:

Wildlife Utilization (WU)

Sites are in relatively undeveloped portion of the site. Some disturbance for access roads and pine plantations. Evidence of deer and wild pigs was observed.

Wetland Canopy (O/S)

Cypress swamp mixed with emergent and scrub wetlands

Wetland Ground Cover (GC)

Graminoid dominated community, no invasives observed, some disturbance related to unimproved roads.

Habitat Support / Buffer

Sites are located in undeveloped area with wetlands and historic pine plantations functioning as buffer. Adjacent roads reduce the buffer areas.

Field Hydrology (HYD)

Despite disturbance related to access roads and pine plantation the hydrology is relatively undisturbed.

WQ Input & Treatment (WQ)

This is a small watershed area. Most of the surface water runoff flow directly into the wetland with no treatment.

Wetland 18,19

Wetland Rapid Assessment Procedure

☑ Check one ☐ Existing Conditions ☐ Proposed Conditions (WRAP)

Application Number	Project Name	Date	Evaluator	Wetland Type
	Spaceport Camden	8-17-16	Brian Tutterow	PFO/PSS

Land Use	FLUCCS Code		Wetland Acreage
open space	621	Description: Cypress	15.57

Wildlife Utilization (WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
2.5	2	2

Habitat Support / Buffer

Buffer type	(Score)	X (% of area)	=Sub Totals
UPL	3	80	2.4
Upl	1	20	0.2
		TOTAL	2.6

Field Hydrology (HYD): 2

WQ Input & Treatment (WQ)*: 1.5

* The value of WQ is obtained by adding the TOTAL scores of Land use Category and Pretreatment category then dividing by 2

Land use Category (LU)

Land use Category	(Score)	X (% of area)	=Sub Totals
undevel	3	100	3
		(LU) TOTAL	3

Pretreatment Category (PT)

Pretreatment Category	(Score)	X (% of area)	=Sub Totals
None	0	0	0
		(PT) TOTAL	0

WRAP Score: 0.7

Field Notes:

Wildlife Utilization (WU)

Wetlands are in relatively undeveloped portion of the site. Some disturbance for access roads and pine plantations. Evidence of deer and wild pigs was observed.

Wetland Canopy (O/S)

Cypress swamp mixed with scrub wetlands

Wetland Ground Cover (GC)

Graminoid dominated community, no invasives observed, some disturbance related to unimproved roads.

Habitat Support / Buffer

Sites are located in undeveloped area with wetlands and historic pine plantations functioning as buffer. A major north/south access road borders wetland 19 to the east and wetland 18 to south

Field Hydrology (HYD)

Despite disturbance related to access roads and pine plantation the hydrology is relatively undisturbed.

WQ Input & Treatment (WQ)

This is a small watershed area. Most of the surface water runoff flow directly into the wetland with no treatment.

Wetland 20

Wetland Rapid Assessment Procedure

☑ Check one ☐ Existing Conditions ☐ Proposed Conditions

(WRAP)

Application Number	Project Name	Date	Evaluator	Wetland Type
	Spaceport Camden	8-17-16	Brian Tutterow	PFO/PSS/PEM

Land Use	FLUCCS Code		Wetland Acreage
open space	613	Description: Gum pond	0.34

Wildlife Utilization (WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
2	2	2

Habitat Support / Buffer

Buffer type	(Score)	X (% of area)	=Sub Totals
Upl	2	90	1.8
		TOTAL	1.8

Field Hydrology (HYD): 2

WQ Input & Treatment (WQ)*: 1.5

* The value of WQ is obtained by adding the TOTAL scores of Land use Category and Pretreatment category then dividing by 2

Land use Category (LU)

Land use Category	(Score)	X (% of area)	=Sub Totals
undevel	3	100	3
		(LU) TOTAL	3

Pretreatment Category (PT)

Pretreatment Category	(Score)	X (% of area)	=Sub Totals
None	0	0	0
		(PT) TOTAL	0

WRAP Score: 0.63

Field Notes:

Wildlife Utilization (WU)

Site is in relatively undeveloped portion of the site. Some disturbance for an access road and pine plantations. Evidence of wild pigs was observed.

Wetland Canopy (O/S)

Tupelo swamp mixed with emergent vegetation.

Wetland Ground Cover (GC)

No invasives observed, some disturbance related to roads.

Habitat Support / Buffer

Site is located in historic pine plantation and bordered by an access road.

Field Hydrology (HYD)

Despite disturbance related to access roads and pine plantation the hydrology is relatively undisturbed.

WQ Input & Treatment (WQ)

This is a small watershed area. Most of the surface water runoff flow directly into the wetland with no treatment.

Wetland 21

Wetland Rapid Assessment Procedure

☐ Existing Conditions ☑ Check one ☐ Proposed Conditions (WRAP)

Application Number	Project Name	Date	Evaluator	Wetland Type
	Spaceport Camden	6-22-17	Brian Tutterow	PEM

Land Use	FLUCCS Code		Wetland Acreage
open space	640	Description: freshwater non-forest	0.017

Wildlife Utilization (WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
2	1	1

Habitat Support / Buffer

Buffer type	(Score)	X (% of area)	=Sub Totals
Upl	2.5	90	2.25
Upl	0	10	0
		TOTAL	2.25

Field Hydrology (HYD)	WQ Input & Treatment (WQ)*
2	1

* The value of WQ is obtained by adding the TOTAL scores of Land use Category and Pretreatment category then dividing by 2

Land use Category (LU)

Land use Category	(Score)	X (% of area)	=Sub Totals
low highw	2	100	2
		(LU) TOTAL	2

Pretreatment Category (PT)

Pretreatment Category	(Score)	X (% of area)	=Sub Totals
None	0	0	0
		(PT) TOTAL	0

WRAP Score
0.47

Field Notes:

Wildlife Utilization (WU)
Site is a small emergent wetland located adjacent to a gravel road Evidence of pigs and some use by amphibians was observed.

Wetland Canopy (O/S)
Vegetation is sparse.

Wetland Ground Cover (GC)
No invasives observed, some disturbance related to roads.

Habitat Support / Buffer
Site is located in historic pine plantation and coastal oak scrub bordered by an access road.

Field Hydrology (HYD)
Despite disturbance related to access roads and pine plantation the hydrology has stabilized and is relatively undisturbed.

WQ Input & Treatment (WQ)
This is a small watershed area. Most of the surface water runoff flow directly into the wetland with no treatment.

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Attachment A-2

Wetland Determination Data Forms

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WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Spaceport Camden City/County: Camden County Sampling Date: 8/15/16
Applicant/Owner: Union Carbide State: GA Sampling Point: 1
Investigator(s): Tutterow, Rauch Section, Township, Range: _____
Landform (hillslope, terrace, etc.): flat Local relief (concave, convex, none): none Slope (%): 0-3%
Subregion (LRR or MLRA): LRR T/MLRA 153A Lat: 30.94167 Long: -81.54464 Datum: NAD 83
Soil Map Unit Name: Ru - Rutledge fine sand NWI classification: none - upland
Are climatic / hydrologic conditions on the site typical for this time of year? Yes ____ No X (If no, explain in Remarks.)
Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes X No ____
Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ____	No X
Hydric Soil Present?	Yes ____	No X
Wetland Hydrology Present?	Yes ____	No X

Is the Sampled Area within a Wetland? Yes ____ No X

Remarks:
Climate - Moderate drought (USDA Drought Monitor 2016).

Plot is located in the location of the proposed Launch Control Command Complex. Area is within a historic pine plantation with thick underbrush.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes ____	No X	Depth (inches): ____
Water Table Present?	Yes ____	No X	Depth (inches): ____
Saturation Present? (includes capillary fringe)	Yes ____	No X	Depth (inches): ____

Wetland Hydrology Present? Yes ____ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
No hydrology indicators observed.

US Army Corps of Engineers Atlantic and Gulf Coastal Plain Region – Version 2.0

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: 1

Tree Stratum (Plot size: 30 ft)	Absolute % Cover	Dominant Species?	Indicator Status
1. Pinus taeda	20	Y	FAC
2. Pinus palustris	3	N	FACU
3. Acer rubrum	2	N	FAC
4.			
5.			
6.			
7.			
8.			
	25 = Total Cover		
50% of total cover: 12.5	20% of total cover: 5		

Sapling/Shrub Stratum (Plot size: 30 ft)			
1. Serenoa repens	30	Y	FACU
2. Morella cerifera	10	N	FAC
3. Ilex opaca	15	Y	FACU
4. Lyonia ligustrina	5	N	FACW
5. Lyonia ferruginea	5	N	FACU
6.			
7.			
8.			
	65 = Total Cover		
50% of total cover: 32.5	20% of total cover: 13		

Herb Stratum (Plot size: 30 ft)			
1. Serenoa repens	8	Y	FACU
2. Morella cerifera	1	N	FAC
3. Lyonia ferruginea	2	N	FACU
4. Lyonia ligustrina	2	N	FACW
5. Ilex opaca	2	N	FACU
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	15 = Total Cover		
50% of total cover: 7.5	20% of total cover: 3		

Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
50% of total cover:	20% of total cover:		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 25% (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species	x 1 =
FACW species	x 2 =
FAC species	x 3 =
FACU species	x 4 =
UPL species	x 5 =
Column Totals: (A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

__ 1 - Rapid Test for Hydrophytic Vegetation
__ 2 - Dominance Test is >50%
__ 3 - Prevalence Index is ≤3.0[1]
__ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? Yes ____ No X

Remarks: (If observed, list morphological adaptations below).

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SOIL Sampling Point: 1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-6	10 YR 4/1	100					sand	
6-24	10 YR 6/1	100					sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes _____ No X

Remarks:
No soil indicators observed.

US Army Corps of Engineers — Atlantic and Gulf Coastal Plain Region – Version 2.0

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Spaceport Camden City/County: Camden County Sampling Date: 8/16/16
Applicant/Owner: Union Carbide State: GA Sampling Point: 2
Investigator(s): Tutterow, Rauch Section, Township, Range: _____
Landform (hillslope, terrace, etc.): flat Local relief (concave, convex, none): none Slope (%): 0-3%
Subregion (LRR or MLRA): LRR T/MLRA 153A Lat: 30.93728 Long: -81.53015 Datum: NAD 83
Soil Map Unit Name: Ma - Mandarin fine sand NWI classification: none - upland
Are climatic / hydrologic conditions on the site typical for this time of year? Yes _____ No X (If no, explain in Remarks.)
Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X No _____
Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No _____	**Is the Sampled Area within a Wetland?** **Yes** _____ **No** X
Hydric Soil Present?	Yes X	No _____	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:
Climate - Moderate drought (USDA Drought Monitor 2016).
Normal circumstances include historic pine plantation, altered topography (furrowed rows), and vegetation.
Plot was taken at location of the proposed Landing Zone. This area is characteristic of the pine plantations of the central region of the proposed spaceport.
In addition to walking transects through this survey area, the the drainage ditch located near the west side of the proposed landing zone was walked. The ditch was dry during the survey but included several sedge and rush species as well as hooded pitcher plants.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☑ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

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VEGETATION (Four Strata) – Use scientific names of plants. Sampling Point: 2

Tree Stratum (Plot size: 30 ft)	Absolute % Cover	Dominant Species?	Indicator Status
1. Pinus taeda	60	Y	FAC
2. Pinus palustris	10	N	FACU
3. Acer rubrum	2	N	FAC
4.			
5.			
6.			
7.			
8.			
	72 = Total Cover		
50% of total cover: 36	20% of total cover: 14.4		

Sapling/Shrub Stratum (Plot size: 30 ft)			
1. Serenoa repens	15	N	FACU
2. Ilex glabra	60	Y	FACW
3.			
4.			
5.			
6.			
7.			
8.			
	85 = Total Cover		
50% of total cover: 42.5	20% of total cover: 17		

Herb Stratum (Plot size: 30 ft)			
1. Panicum hemitomon	1	Y	OBL
2. Panicum dichotomiflorum	1	Y	FACW
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	2 = Total Cover		
50% of total cover: 1	20% of total cover: 0.4		

Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
50% of total cover:	20% of total cover:		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species	x 1 =
FACW species	x 2 =
FAC species	x 3 =
FACU species	x 4 =
UPL species	x 5 =
Column Totals: (A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

__ 1 - Rapid Test for Hydrophytic Vegetation
__ 2 - Dominance Test is >50%
__ 3 - Prevalence Index is ≤3.0[1]
__ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? Yes X No

Remarks: (If observed, list morphological adaptations below).

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SOIL Sampling Point: 2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-24	10 YR 2/1	100					sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☑ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes X No _____

Remarks:

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WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Spaceport Camden City/County: Camden County Sampling Date: 8/16/16
Applicant/Owner: Union Carbonide State: GA Sampling Point: 3U
Investigator(s): Tutterow, Rauch Section, Township, Range: _____
Landform (hillslope, terrace, etc.): flats Local relief (concave, convex, none): none Slope (%): 0-3%
Subregion (LRR or MLRA): LRR T/MLRA 153A Lat: 30.93709 Long: -81.54008 Datum: NAD 83
Soil Map Unit Name: W - Water NWI classification: none - upland
Are climatic / hydrologic conditions on the site typical for this time of year? Yes _____ No X (If no, explain in Remarks.)
Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X No _____
Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No _____	**Is the Sampled Area within a Wetland?** **Yes** _____ **No** X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:
Climate - Moderate drought (USDA Drought Monitor 2016).
Upland plot taken at the edge of the wetland and surrounding pine plantation.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☑ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

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VEGETATION (Four Strata) – Use scientific names of plants. Sampling Point: 3U

Tree Stratum (Plot size: 30 ft)	Absolute % Cover	Dominant Species?	Indicator Status
1. Pinus taeda	40	Y	FAC
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	40 = Total Cover		
50% of total cover: 20	20% of total cover: 8		

Sapling/Shrub Stratum (Plot size: 30 ft)			
1. Serenoa repens	20	Y	FACU
2. Magnolia virginiana	30	Y	FACW
3. Lyonia lucida	60	Y	FACW
4.			
5.			
6.			
7.			
8.			
	110 = Total Cover		
50% of total cover: 55	20% of total cover: 11		

Herb Stratum (Plot size: 30 ft)			
1. Serenoa repens	2	N	FACU
2. Lyonia lucida	10	Y	FACW
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	12 = Total Cover		
50% of total cover: 6	20% of total cover: 2.4		

Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
50% of total cover:	20% of total cover:		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 5 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 80% (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species	x 1 =
FACW species	x 2 =
FAC species	x 3 =
FACU species	x 4 =
UPL species	x 5 =
Column Totals: (A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

__ 1 - Rapid Test for Hydrophytic Vegetation
__ 2 - Dominance Test is >50%
__ 3 - Prevalence Index is ≤3.0[1]
__ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? Yes X No ____

Remarks: (If observed, list morphological adaptations below).

Thick pine leaf litter in herb layer.

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SOIL Sampling Point: 3U

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-14	10 YR 5/1	100					sand	
14-18	10 YR 6/1	100					sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes _____ No X

Remarks:

US Army Corps of Engineers — Atlantic and Gulf Coastal Plain Region – Version 2.0

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Spaceport Camden City/County: Camden County Sampling Date: 8/16/16
Applicant/Owner: Union Carbonide State: GA Sampling Point: 3W
Investigator(s): Tutterow, Rauch Section, Township, Range: _____
Landform (hillslope, terrace, etc.): flats Local relief (concave, convex, none): none Slope (%): 0-3%
Subregion (LRR or MLRA): LRR T/MLRA 153A Lat: 30.93678 Long: -81.53945 Datum: NAD 83
Soil Map Unit Name: W - Water NWI classification: none - upland
Are climatic / hydrologic conditions on the site typical for this time of year? Yes _____ No X (If no, explain in Remarks.)
Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X No _____
Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No _____	**Is the Sampled Area within a Wetland?** **Yes** X **No** _____
Hydric Soil Present?	Yes X	No _____	
Wetland Hydrology Present?	Yes X	No _____	

Remarks:
Climate - Moderate drought (USDA Drought Monitor 2016).
Survey area 3 is part of a large wetland that is located adjacent to the western boundary road and other proposed interior roads. Wetland boundaries in the vicinity of this observation point were expanded slightly from previously delineated boundaries.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☑ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☑ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** X **No** _____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

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VEGETATION (Four Strata) – Use scientific names of plants. Sampling Point: 3W

Tree Stratum (Plot size: 30 ft)	Absolute % Cover	Dominant Species?	Indicator Status
1. Pinus taeda	40	Y	FAC
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	40 = Total Cover		
50% of total cover: 20	20% of total cover: 8		
Sapling/Shrub Stratum (Plot size: 30 ft)			
1. Serenoa repens	15	N	FACU
2. Taxodium distichum	2	N	OBL
3. Lyonia lucida	60	Y	FACW
4. Magnolia virginiana	20	Y	FACW
5.			
6.			
7.			
8.			
	97 = Total Cover		
50% of total cover: 48.5	20% of total cover: 19.4		
Herb Stratum (Plot size: 30 ft)			
1. Carex glaucescens	15	Y	OBL
2. Juncus effusus	15	Y	FACW
3. Rhexia mariana	2	N	FACW
4. Xyris fimbriata	1	N	OBL
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	33 = Total Cover		
50% of total cover: 16.5	20% of total cover: 6.6		
Woody Vine Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 5 (A)

Total Number of Dominant Species Across All Strata: 5 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species _____	x 1 = _____
FACW species _____	x 2 = _____
FAC species _____	x 3 = _____
FACU species _____	x 4 = _____
UPL species _____	x 5 = _____
Column Totals: _____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation
___ 2 - Dominance Test is >50%
___ 3 - Prevalence Index is ≤3.0[1]
___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? Yes X No _____

Remarks: (If observed, list morphological adaptations below).

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SOIL

Sampling Point: 3W

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-12	2.5 YR 2.5/1	70					sand	stripped matrix
	10 YR 5/1	30						
12-14	10 YR 5/1	100					sand	strong sulfur odor

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☑ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☑ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes X No _____

Remarks:

Soil moist but not saturated.

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WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Spaceport Camden City/County: Camden County Sampling Date: 7/22/17
Applicant/Owner: Union Carbide State: GA Sampling Point: 5U
Investigator(s): Tutterow Section, Township, Range: _____
Landform (hillslope, terrace, etc.): depression Local relief (concave, convex, none): concave Slope (%): 0-3%
Subregion (LRR or MLRA): LRR T/MLRA 153A Lat: 30.94415 Long: -81.50970 Datum: NAD 83
Soil Map Unit Name: Ma - Mandarin fine sand NWI classification: PEM1C
Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)
Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X No _____
Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No _____	**Is the Sampled Area within a Wetland?** Yes _____ No X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:
Area 5 is a depressional area located adjacent to an existing site access road.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? Yes _____ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
In addition to the soil profile taken at this observation point, several soil borings were taken throughout the site. No oxidized rhizopheres or other hydrology indicators were observed.

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VEGETATION (Four Strata) – Use scientific names of plants. Sampling Point: 5U

Tree Stratum (Plot size: _____)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Sapling/Shrub Stratum (Plot size: 30 ft)	Absolute % Cover	Dominant Species?	Indicator Status
1. Acer rubrum	5	Y	FAC
2. Quercus virginiana	2	Y	FACU
3.			
4.			
5.			
6.			
7.			
8.			
	7 = Total Cover		
50% of total cover: 3.5	20% of total cover: 1.4		

Herb Stratum (Plot size: 30 ft)	Absolute % Cover	Dominant Species?	Indicator Status
1. Eupatorium capillifollium	10	N	FACU
2. Juncus effusus	80	Y	FACW
3. Rhexia mariana	2	N	FACW
4. Andropogon virginicus	2	N	FAC
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	94 = Total Cover		
50% of total cover: 47	20% of total cover: 18.8		

Woody Vine Stratum (Plot size: _____)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 66 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species _____	x 1 = _____
FACW species _____	x 2 = _____
FAC species _____	x 3 = _____
FACU species _____	x 4 = _____
UPL species _____	x 5 = _____
Column Totals: _____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation
___ 2 - Dominance Test is >50%
___ 3 - Prevalence Index is ≤3.0[1]
___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? Yes X No _____

Remarks: (If observed, list morphological adaptations below).

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SOIL Sampling Point: 5U

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-4	10YR 2/2	100					silt loam	
4-7	10YR 3/1	100					sand	
7-20	10YR 6/1	100					sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes _____ No X

Remarks:

No hydric soil indicators were observed. The soils did not meet criteria for S7 or S9.

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WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Spaceport Camden City/County: Camden County Sampling Date: 8/17/16
Applicant/Owner: Union Carbide State: GA Sampling Point: 6U
Investigator(s): Tutterow, Rauch Section, Township, Range: _____
Landform (hillslope, terrace, etc.): flat Local relief (concave, convex, none): none Slope (%): 0-3%
Subregion (LRR or MLRA): LRR T/MLRA 153A Lat: 30.94702 Long: -81.50986 Datum: NAD 83
Soil Map Unit Name: Po - Pottsburg sand NWI classification: none - upland
Are climatic / hydrologic conditions on the site typical for this time of year? Yes _____ No X (If no, explain in Remarks.)
Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X No _____
Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No _____
Hydric Soil Present?	Yes X	No _____
Wetland Hydrology Present?	Yes _____	No X

Is the Sampled Area within a Wetland? Yes _____ No X

Remarks:
Climate - Moderate drought (USDA Drought Monitor 2016).

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☑ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? Yes _____ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

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VEGETATION (Four Strata) – Use scientific names of plants. Sampling Point: 6U

Tree Stratum (Plot size: 30 ft)	Absolute % Cover	Dominant Species?	Indicator Status
1. Sabal palmetto	20	Y	FAC
2. Quercus virginiana	60	Y	FACU
3.			
4.			
5.			
6.			
7.			
8.			
	80 = Total Cover		
50% of total cover: 40	20% of total cover: 16		
Sapling/Shrub Stratum (Plot size: 30 ft)			
1. Ilex cassine	10	Y	FACW
2. Ilex coriacea	5	Y	FACW
3.			
4.			
5.			
6.			
7.			
8.			
	15 = Total Cover		
50% of total cover: 7.5	20% of total cover: 3		
Herb Stratum (Plot size: 30 ft)			
1. Bulbostylis barbata	60	Y	FAC
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	60 = Total Cover		
50% of total cover: 30	20% of total cover: 12		
Woody Vine Stratum (Plot size: 30 ft)			
1. Campsis radicans	2	Y	FAC
2.			
3.			
4.			
5.			
	2 = Total Cover		
50% of total cover: 1	20% of total cover: 0.4		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 5 (A)

Total Number of Dominant Species Across All Strata: 6 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 83% (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species	x 1 =
FACW species	x 2 =
FAC species	x 3 =
FACU species	x 4 =
UPL species	x 5 =
Column Totals: (A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

__ 1 - Rapid Test for Hydrophytic Vegetation
__ 2 - Dominance Test is >50%
__ 3 - Prevalence Index is ≤3.0[1]
__ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? Yes X No

Remarks: (If observed, list morphological adaptations below).

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SOIL Sampling Point: 6U

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-14	10 YR 2/1	100					sand	
14-20	10 YR 4/1	100					sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☑ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☑ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes X No _____

Remarks:

US Army Corps of Engineers — Atlantic and Gulf Coastal Plain Region – Version 2.0

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Spaceport Camden City/County: Camden County Sampling Date: 8/17/16
Applicant/Owner: Union Carbide State: GA Sampling Point: 6W
Investigator(s): Tutterow, Rauch Section, Township, Range: _____
Landform (hillslope, terrace, etc.): flat Local relief (concave, convex, none): none Slope (%): 0-3%
Subregion (LRR or MLRA): LRR T/MLRA 153A Lat: 30.94698 Long: -81.50976 Datum: NAD 83
Soil Map Unit Name: Po - Pottsburg sand NWI classification: none - upland
Are climatic / hydrologic conditions on the site typical for this time of year? Yes _____ No X (If no, explain in Remarks.)
Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X No _____
Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No _____
Hydric Soil Present?	Yes X	No _____
Wetland Hydrology Present?	Yes X	No _____

Is the Sampled Area within a Wetland? **Yes** X **No** _____

Remarks:
Climate - Moderate drought (USDA Drought Monitor 2016).
Plot was located in the center of a ~65 ft x 40 ft deep depression. Approximately 3-5 ft deep. The plot is located within the boundaries of the proposed Vertical Launch Facility.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☑ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☑ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** X **No** _____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

US Army Corps of Engineers Atlantic and Gulf Coastal Plain Region – Version 2.0

VEGETATION (Four Strata) – Use scientific names of plants. Sampling Point: 6W

Tree Stratum (Plot size: 30 ft)	Absolute % Cover	Dominant Species?	Indicator Status
1. Serenoa repens	1	Y	FAC
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	= Total Cover		
50% of total cover:	20% of total cover:		

Sapling/Shrub Stratum (Plot size:)			
1. none			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	= Total Cover		
50% of total cover:	20% of total cover:		

Herb Stratum (Plot size:)			
1. none			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	= Total Cover		
50% of total cover:	20% of total cover:		

Woody Vine Stratum (Plot size: 30 ft)			
1. Campsis radicans	2	Y	FAC
2.			
3.			
4.			
5.			
	= Total Cover		
50% of total cover:	20% of total cover:		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species	x 1 =
FACW species	x 2 =
FAC species	x 3 =
FACU species	x 4 =
UPL species	x 5 =
Column Totals: (A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

__ 1 - Rapid Test for Hydrophytic Vegetation
__ 2 - Dominance Test is >50%
__ 3 - Prevalence Index is ≤3.0[1]
__ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? Yes X No ____

Remarks: (If observed, list morphological adaptations below).

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SOIL

Sampling Point: 6W

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-7	10 YR 2/2	100					silty sand	
7-14	10 YR 2/1	100					sand	decomposed leaves in soil layer
8-22	10 YR 2/1	100					sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☑ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes X No _____

Remarks:

Soil moist but not saturated.

US Army Corps of Engineers — Atlantic and Gulf Coastal Plain Region – Version 2.0

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Camden Spaceport City/County: Camden County Sampling Date: 8/19/16
Applicant/Owner: Bayer Crop Science State: GA Sampling Point: 11U
Investigator(s): Tutterow, Rauch Section, Township, Range: _____
Landform (hillslope, terrace, etc.): flats Local relief (concave, convex, none): none Slope (%): 0-3%
Subregion (LRR or MLRA): LRR T/MLRA 153A Lat: 30.93689 Long: -81.51537 Datum: NAD 83
Soil Map Unit Name: Ma - Mandarin fine sand NWI classification: none - upland
Are climatic / hydrologic conditions on the site typical for this time of year? Yes _____ No X (If no, explain in Remarks.)
Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X No _____
Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No _____
Hydric Soil Present?	Yes _____	No X
Wetland Hydrology Present?	Yes _____	No X

Is the Sampled Area within a Wetland? Yes _____ No X

Remarks:
Climate - Moderate drought (USDA Drought Monitor 2016).
Plot located near the edge of a wetland within an area with an abrupt terrain change. The plot point is located approximately 2 ft above the wetland terrain.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? Yes _____ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:
No hydrology indicators observed.

US Army Corps of Engineers Atlantic and Gulf Coastal Plain Region – Version 2.0

VEGETATION (Four Strata) – Use scientific names of plants. Sampling Point: 11U

Tree Stratum (Plot size: 30 ft)	Absolute % Cover	Dominant Species?	Indicator Status
1. Quercus nigra	70	Y	FAC
2. Sabal palmetto	20	Y	FAC
3.			
4.			
5.			
6.			
7.			
8.			
	90 = Total Cover		
50% of total cover: 45	20% of total cover: 18		
Sapling/Shrub Stratum (Plot size: 30 ft)			
1. Sabal palmetto	40	Y	FAC
2. Morella cerifera	2	N	FAC
3. Quercus nigra	20	Y	FAC
4. Serenoa repens	20	Y	FACU
5.			
6.			
7.			
8.			
	82 = Total Cover		
50% of total cover: 41	20% of total cover: 16.4		
Herb Stratum (Plot size: 30 ft)			
1. Panicum hemitomon	1	Y	OBL
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	1 = Total Cover		
50% of total cover: 0.5	20% of total cover: 0.2		
Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
50% of total cover:	20% of total cover:		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 6 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 67% (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species	x 1 =
FACW species	x 2 =
FAC species	x 3 =
FACU species	x 4 =
UPL species	x 5 =
Column Totals: (A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

__ 1 - Rapid Test for Hydrophytic Vegetation
__ 2 - Dominance Test is >50%
__ 3 - Prevalence Index is ≤3.0[1]
__ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? Yes X No

Remarks: (If observed, list morphological adaptations below).

US Army Corps of Engineers — Atlantic and Gulf Coastal Plain Region – Version 2.0

SOIL Sampling Point: 11U

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-18	10YR 4/1	100					sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes _____ No X

Remarks:
Dry soil. No indicators observed.

US Army Corps of Engineers — Atlantic and Gulf Coastal Plain Region – Version 2.0

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Camden Spaceport City/County: Camden County Sampling Date: 8/19/16
Applicant/Owner: Bayer Crop Science State: GA Sampling Point: 11W
Investigator(s): Tutterow, Rauch Section, Township, Range: _____
Landform (hillslope, terrace, etc.): flat Local relief (concave, convex, none): concave Slope (%): 0-3%
Subregion (LRR or MLRA): LRR T/MLRA 153A Lat: 30.93701 Long: -81.51512 Datum: NAD 83
Soil Map Unit Name: Ma - Mandarin fine sand NWI classification: none - upland
Are climatic / hydrologic conditions on the site typical for this time of year? Yes _____ No X (If no, explain in Remarks.)
Are Vegetation _____, Soil _____, or Hydrology _____ significantly disturbed? Are "Normal Circumstances" present? Yes X No _____
Are Vegetation _____, Soil _____, or Hydrology _____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No _____	**Is the Sampled Area within a Wetland?** **Yes** X **No** _____
Hydric Soil Present?	Yes X	No _____	
Wetland Hydrology Present?	Yes X	No _____	

Remarks:
Climate - Moderate drought (USDA Drought Monitor 2016).
Plot located near edge of an existing road. A culvert extends to the north of the site into the drainage. A larger unmapped wetland is located to the south, approximately 100 feet from the existing road.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☑ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☑ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☑ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☑ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** X **No** _____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

US Army Corps of Engineers Atlantic and Gulf Coastal Plain Region – Version 2.0

VEGETATION (Four Strata) – Use scientific names of plants. Sampling Point: 11W

Tree Stratum (Plot size:)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	0 = Total Cover		
50% of total cover: 0	20% of total cover: 0		
Sapling/Shrub Stratum (Plot size: 30 ft)			
1. Salix caroliniana	10	Y	OBL
2. Cephalanthus occidentalis	30	Y	OBL
3. Quercus nigra	5	N	FAC
4.			
5.			
6.			
7.			
8.			
	45 = Total Cover		
50% of total cover: 22.5	20% of total cover: 9		
Herb Stratum (Plot size: 30 ft)			
1. Typha latifolia	30	Y	OBL
2. Saururus cernuus	10	N	OBL
3. Panicum hemitomon	20	Y	OBL
4. Echinochloa crus-galli	30	Y	FACW
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	90 = Total Cover		
50% of total cover: 45	20% of total cover: 18		
Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
50% of total cover:	20% of total cover:		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: _____ (A)

Total Number of Dominant Species Across All Strata: _____ (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: _____ (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species	x 1 =
FACW species	x 2 =
FAC species	x 3 =
FACU species	x 4 =
UPL species	x 5 =
Column Totals: (A)	(B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

X 1 - Rapid Test for Hydrophytic Vegetation
__ 2 - Dominance Test is >50%
__ 3 - Prevalence Index is ≤3.0[1]
__ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? Yes X No _____

Remarks: (If observed, list morphological adaptations below).

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SOIL Sampling Point: 11W

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-10	10 YR 2/1	100					silt	
10-12	10 YR 6/1	100					sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☑ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☑ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☑ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes X No _____

Remarks:

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APPENDIX B

SITE PHOTOGRAPS

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Photo Point A, Wetland 3

Photo B-1. View facing north into a portion of Wetland 3 located north of an existing access road.

Photo B-2. View facing east along raised road.

Photo Point B

Photo B-3. View of Area 1 facing north.

Photo B-4. Characteristic soil profile from Area 1.

Photo Point C, Drainage

Photo B-5. View of ephmeral stream 1 in Area 2.

Photo Point D, Wetland 17

Photo B-6. View facing north.

Photo B-7. View facing southwest toward property boundary.

Photo Point E-1

Photo B-8. View northwest along the west perimeter boundary road.

Photo B-9. View facing southeast along the west perimeter boundary road.

Photo Point R, Wetland 3

Photo B-10. View facing northeast into Wetland 3.

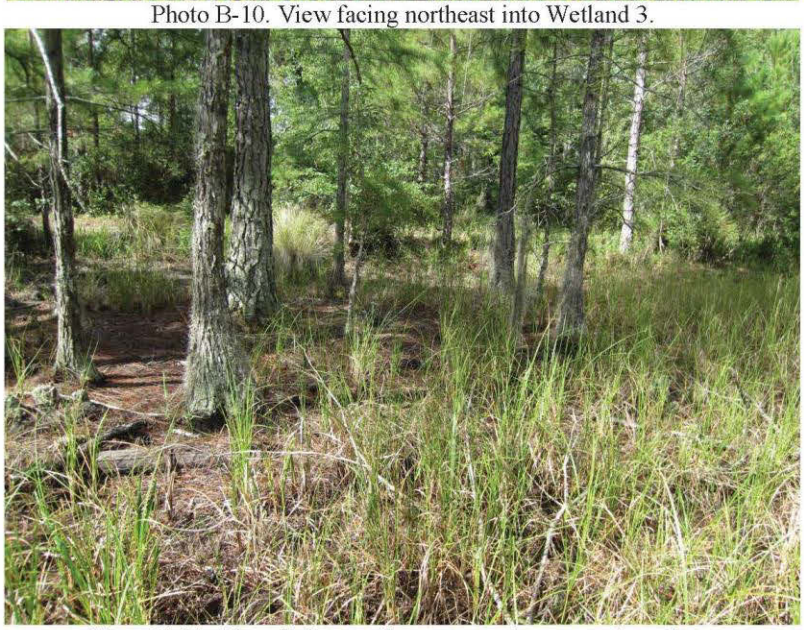

Photo B-11. View facing southwest toward property boundary.

Photo Point R-1, Wetland 3

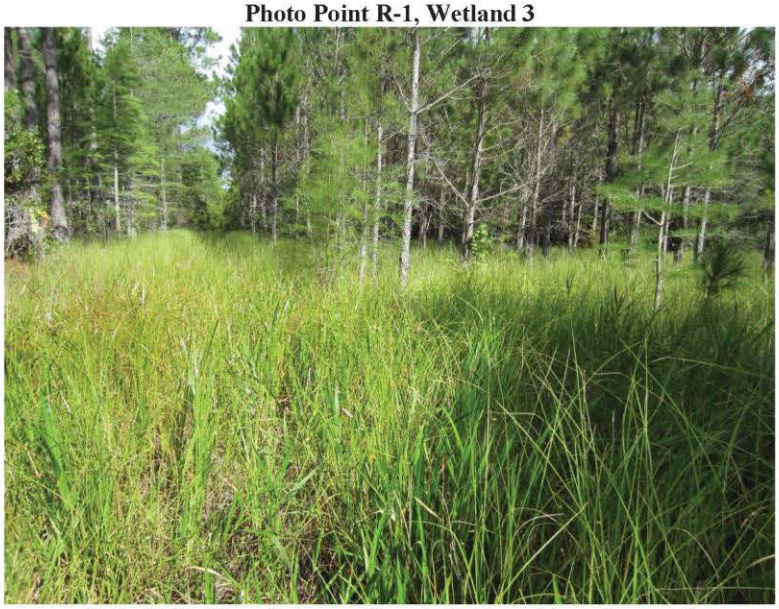

Photo B-12. View facing northwest along west boundary road.

Photo B-13. View facing southeast along western boundary road. The neighboring property road is visible to the right.

Photo Point R-2, Wetland 3 Upland Point

Photo B-14. View facing north at upland point.

Photo B-15. View facing south.

Photo Point E-2 and F

Photo B-16. Western boundary road (Photo Point E-2).

Photo B-17. Access road intersecting the western boundary road (Photo Point F).

Photo Point G, Area 4

Photo B-18. View facing southeast at the power line cut along Shellbine Creek.

Photo B-19. View facing south-southeast along Shellbine Creek. Box culvert under the main site access road is visible in the background. Shellbine Creek is outside the field survey area.

Photo Point H

Photo B-20. View facing south at culvert and Wetland 19.

Photo B-21. View of asphalt roadway near Wetland 19.

Photo Points I-1 and I-2, Area 5

Photo B-22. View of Area 5 facing north. Area extends past the tree line visible to the left.

Photo B-23. View area north of Area 5.

Photo Point J-1 and J-2, Wetland 6

Photo B-24. View of Wetland 6 (Photo Point J-1).

Photo B-25. View of upland observation point near Wetland 6 (Photo Point J-2).

Photo Point K

Photo B-26. View of ephemeral stream 3 north of access road.

Photo B-27. View of access road facing northeast.

Photo Points L-1 and L-2, Wetland 7

Photo B-28. View of Wetland 7, facing north (Photo Point L-1).

Photo B-29. View of upland observation point near Wetland 7, facing north (Photo Point L-2).

Photo Points M-1 and M-2, Wetland 8

Photo B-30. View of Wetland 8, facing south (Photo Point M-1).

Photo B-31. View of upland observation point near Wetland 8 (Photo Point M-2).

Photo Point N-1, Wetland 10

Photo B-32. Wetland 10.

Photo B-33. Soil profile.

Photo Point N-2

Photo B-34. Upland observation point.

Photo B-35. Soil profile.

Photo Point O, Wetland 11

Photo B-36. Wetland 11, view facing south.

Photo B-37. Wetland 11.

Photo Point P, Wetland 12

Photo B-38. View facing north, Wetland 12.

Photo B-39. View facing west.

Photo Point Q, Wetland 13

Photo B-40. View facing north.

Photo B-41. View facing north.

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APPENDIX C

NATURAL RESOURCES CONSERVATION SERVICE SOIL SURVEY MAPS AND PREVIOUSOLY DELINEATED WETLANDS MAPS

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Attachment C-1

National Resources Conservation Soil Survey Maps

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Map Unit Description

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions in this report, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. All the soils of a series have major horizons that are similar in composition, thickness, and arrangement. Soils of a given series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Additional information about the map units described in this report is available in other soil reports, which give properties of the soils and the limitations, capabilities, and potentials for many uses. Also, the narratives that accompany the soil reports define some of the properties included in the map unit descriptions.

Report—Map Unit Description

Camden and Glynn Counties, Georgia

BO—Bohicket-Capers association

Map Unit Setting

National map unit symbol: 46h8
Elevation: 0 to 10 feet
Mean annual precipitation: 44 to 52 inches
Mean annual air temperature: 64 to 70 degrees F
Frost-free period: 230 to 290 days
Farmland classification: Not prime farmland

Map Unit Composition

Bohicket and similar soils: 80 percent
Capers and similar soils: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bohicket

Setting

Landform: Tidal marshes
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Marine deposits

Typical profile

H1 - 0 to 8 inches: stratified silty clay loam
H2 - 8 to 65 inches: silty clay

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Very poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: Very frequent
Frequency of ponding: Frequent
Gypsum, maximum in profile: 1 percent
Salinity, maximum in profile: Moderately saline to strongly saline (8.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 55.0
Available water storage in profile: Very low (about 2.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8w
Hydrologic Soil Group: D

Description of Capers

Setting

Landform: Tidal marshes
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Marine deposits

Typical profile

H1 - 0 to 8 inches: silty clay
H2 - 8 to 60 inches: clay

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Very poorly drained

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: Very frequent
Frequency of ponding: Frequent
Available water storage in profile: Very low (about 1.2 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8w
Hydrologic Soil Group: D

CaB—Cainhoy fine sand, 0 to 5 percent slopes

Map Unit Setting
National map unit symbol: 46hd
Elevation: 10 to 120 feet
Mean annual precipitation: 44 to 52 inches
Mean annual air temperature: 64 to 70 degrees F
Frost-free period: 230 to 290 days
Farmland classification: Not prime farmland

Map Unit Composition
Cainhoy and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cainhoy

Setting
Landform: Rises
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Marine deposits

Typical profile
H1 - 0 to 50 inches: fine sand
H2 - 50 to 99 inches: fine sand

Properties and qualities
Slope: 0 to 5 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.2 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s

Hydrologic Soil Group: A

Ma—Mandarin fine sand, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2sxql
Elevation: 0 to 250 feet
Mean annual precipitation: 39 to 62 inches
Mean annual air temperature: 53 to 81 degrees F
Frost-free period: 209 to 365 days
Farmland classification: Not prime farmland

Map Unit Composition

Mandarin and similar soils: 92 percent
Minor components: 6 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mandarin

Setting

Landform: Rises
Landform position (three-dimensional): Talf, rise
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Parent material: Sandy marine deposits

Typical profile

A - 0 to 7 inches: fine sand
E - 7 to 13 inches: fine sand
Bh - 13 to 18 inches: fine sand
E' - 18 to 62 inches: fine sand
B'h - 62 to 80 inches: fine sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.28 to 19.98 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A

Other vegetative classification: Sandy soils on rises and knolls of mesic uplands (G153AA131FL)

Minor Components

Leon

Percent of map unit: 5 percent
Landform: Flatwoods
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Other vegetative classification: Sandy soils on flats of mesic or hydric lowlands (G153AA141FL)

Rutlege

Percent of map unit: 1 percent
Landform: Depressions, drainageways
Down-slope shape: Concave, linear
Across-slope shape: Concave
Other vegetative classification: Sandy soils on stream terraces, flood plains, or in depressions (G153AA145FL)

Pe—Pelham loamy sand

Map Unit Setting

National map unit symbol: 46hn
Elevation: 20 to 450 feet
Mean annual precipitation: 44 to 52 inches
Mean annual air temperature: 64 to 70 degrees F
Frost-free period: 230 to 290 days
Farmland classification: Not prime farmland

Map Unit Composition

Pelham and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Pelham

Setting

Landform: Flats, depressions, drainageways
Landform position (three-dimensional): Dip
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Parent material: Marine deposits

Typical profile

H1 - 0 to 25 inches: loamy sand
H2 - 25 to 40 inches: sandy clay loam
H3 - 40 to 75 inches: sandy clay loam

Properties and qualities

Slope: 0 to 2 percent

Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.1 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: B/D

Po—Pottsburg sand

Map Unit Setting
National map unit symbol: 46hp
Elevation: 0 to 300 feet
Mean annual precipitation: 44 to 52 inches
Mean annual air temperature: 64 to 70 degrees F
Frost-free period: 230 to 290 days
Farmland classification: Not prime farmland

Map Unit Composition
Pottsburg and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Pottsburg

Setting
Landform: Flats
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Marine deposits

Typical profile
H1 - 0 to 10 inches: sand
H2 - 10 to 63 inches: sand
H3 - 63 to 80 inches: sand

Properties and qualities
Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 24 to 42 inches
Frequency of flooding: None
Frequency of ponding: None

Available water storage in profile: Very low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: A

Minor Components

Rutlege

Percent of map unit: 5 percent
Landform: Drainageways, depressions
Down-slope shape: Linear, concave
Across-slope shape: Concave

Ru—Rutlege fine sand

Map Unit Setting

National map unit symbol: 46hr
Elevation: 0 to 300 feet
Mean annual precipitation: 44 to 52 inches
Mean annual air temperature: 64 to 70 degrees F
Frost-free period: 230 to 290 days
Farmland classification: Not prime farmland

Map Unit Composition

Rutlege and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rutlege

Setting

Landform: Drainageways, depressions
Down-slope shape: Linear, concave
Across-slope shape: Concave
Parent material: Marine deposits

Typical profile

H1 - 0 to 15 inches: sand
H2 - 15 to 70 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Very poorly drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.9 inches)

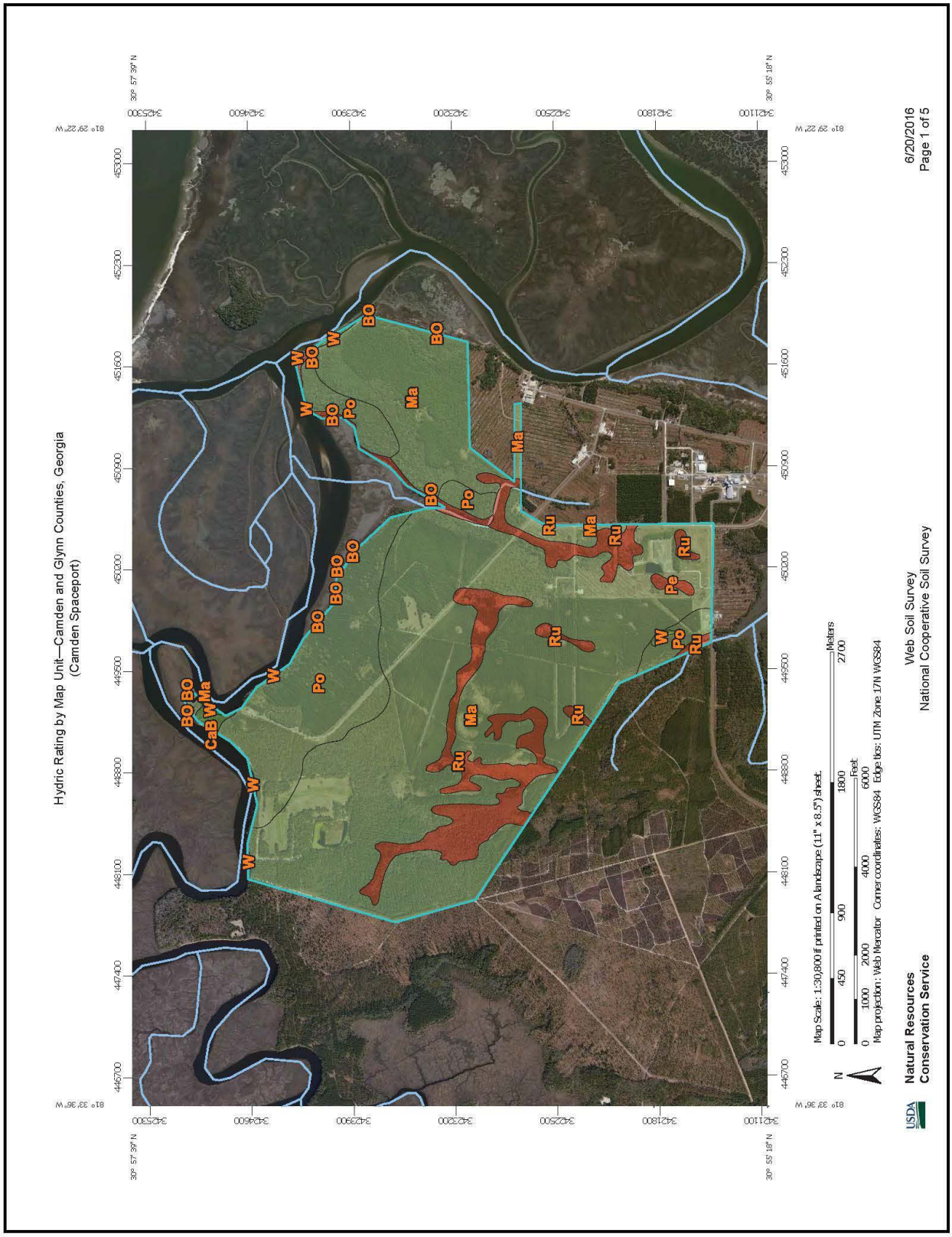
Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A/D

W—Water

Map Unit Composition
Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Data Source Information

Soil Survey Area: Camden and Glynn Counties, Georgia
Survey Area Data: Version 7, Sep 17, 2014


Hydric Rating by Map Unit—Camden and Glynn Counties, Georgia
(Camden Spaceport)
6/20/2016
Page 1 of 5
Natural Resources
Conservation Service
Web Soil Survey
National Cooperative Soil Survey
Map Scale: 1:30,800 if printed on A landscape (11" x 8.5") sheet.
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 17N WGS84

Hydric Rating by Map Unit—Camden and Glynn Counties, Georgia
(Camden Spaceport)

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Hydric (100%)
- Hydric (66 to 99%)
- Hydric (33 to 65%)
- Hydric (1 to 32%)
- Not Hydric (0%)
- Not rated or not available

Soil Rating Lines
- Hydric (100%)
- Hydric (66 to 99%)
- Hydric (33 to 65%)
- Hydric (1 to 32%)
- Not Hydric (0%)
- Not rated or not available

Soil Rating Points
- Hydric (100%)
- Hydric (66 to 99%)
- Hydric (33 to 65%)
- Hydric (1 to 32%)
- Not Hydric (0%)
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Camden and Glynn Counties, Georgia
Survey Area Data: Version 7, Sep 17, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 13, 2011—Mar 15, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydric Rating by Map Unit

Hydric Rating by Map Unit— Summary by Map Unit — Camden and Glynn Counties, Georgia (GA616)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
BO	Bohicket-Capers association	100	17.0	0.9%
CaB	Cainhoy fine sand, 0 to 5 percent slopes	0	5.4	0.3%
Ma	Mandarin fine sand, 0 to 2 percent slopes	6	1,247.9	69.2%
Pe	Pelham loamy sand	100	5.2	0.3%
Po	Pottsburg sand	5	323.8	18.0%
Ru	Rutlege fine sand	100	196.9	10.9%
W	Water	0	7.4	0.4%
Totals for Area of Interest			**1,803.6**	**100.0%**

Description

This rating indicates the percentage of map units that meets the criteria for hydric soils. Map units are composed of one or more map unit components or soil types, each of which is rated as hydric soil or not hydric. Map units that are made up dominantly of hydric soils may have small areas of minor nonhydric components in the higher positions on the landform, and map units that are made up dominantly of nonhydric soils may have small areas of minor hydric components in the lower positions on the landform. Each map unit is rated based on its respective components and the percentage of each component within the map unit.

The thematic map is color coded based on the composition of hydric components. The five color classes are separated as 100 percent hydric components, 66 to 99 percent hydric components, 33 to 65 percent hydric components, 1 to 32 percent hydric components, and less than one percent hydric components.

In Web Soil Survey, the Summary by Map Unit table that is displayed below the map pane contains a column named 'Rating'. In this column the percentage of each map unit that is classified as hydric is displayed.

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). Under natural conditions, these soils are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation.

The NTCHS definition identifies general soil properties that are associated with wetness. In order to determine whether a specific soil is a hydric soil or nonhydric soil, however, more specific information, such as information about the depth and duration of the water table, is needed. Thus, criteria that identify those estimated soil properties unique to hydric soils have been established (Federal Register, 2002). These criteria are used to identify map unit components that normally are associated with wetlands. The criteria used are selected estimated soil properties that are described in "Soil Taxonomy" (Soil Survey Staff, 1999) and "Keys to Soil Taxonomy" (Soil Survey Staff, 2006) and in the "Soil Survey Manual" (Soil Survey Division Staff, 1993).

If soils are wet enough for a long enough period of time to be considered hydric, they should exhibit certain properties that can be easily observed in the field. These visible properties are indicators of hydric soils. The indicators used to make onsite determinations of hydric soils are specified in "Field Indicators of Hydric Soils in the United States" (Hurt and Vasilas, 2006).

References:

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18.

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.

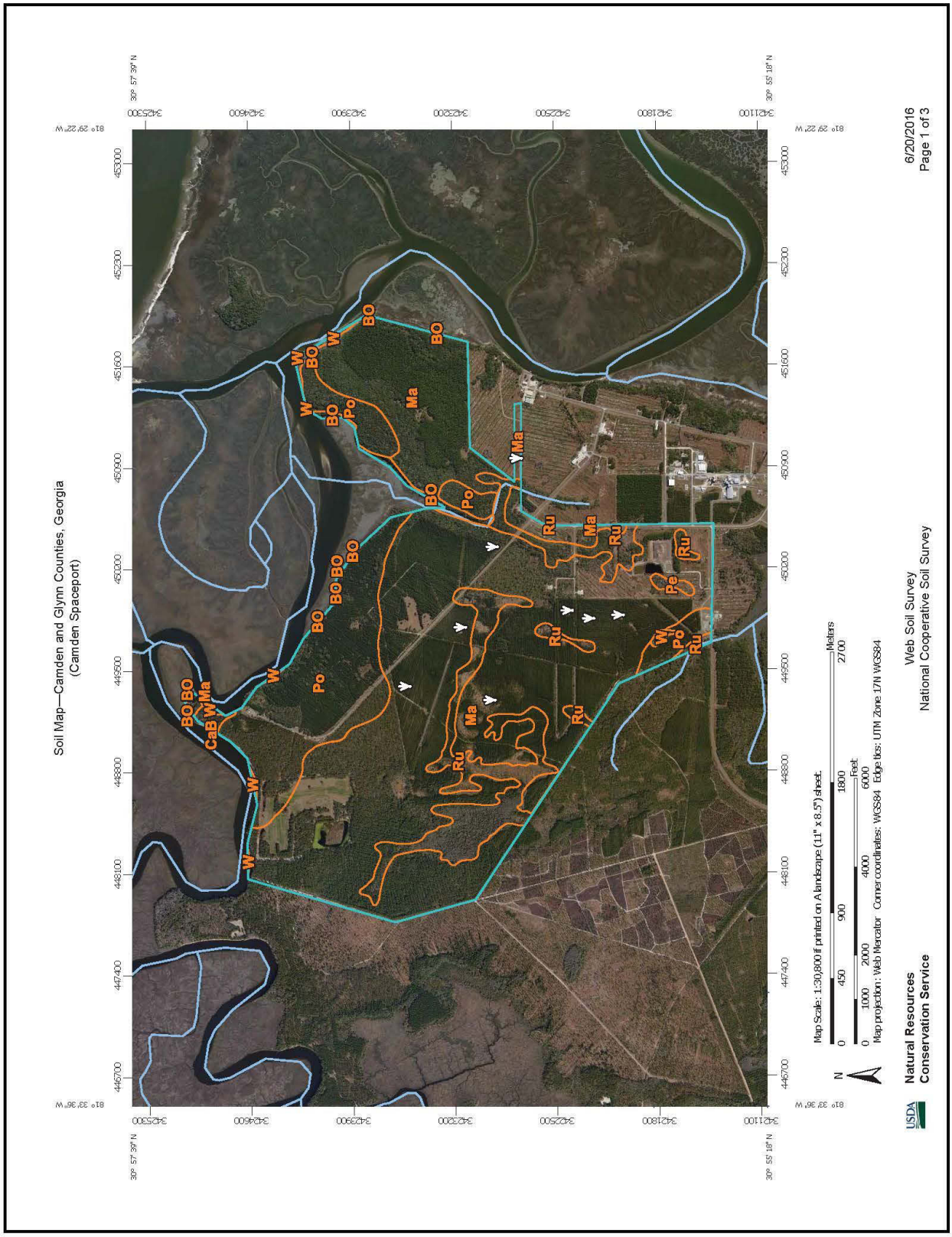
Soil Survey Staff. 2006. Keys to soil taxonomy. 10th edition. U.S. Department of Agriculture, Natural Resources Conservation Service.

Rating Options

Aggregation Method: Percent Present

Component Percent Cutoff: *None Specified*

Tie-break Rule: Lower


Soil Map—Camden and Glynn Counties, Georgia
(Camden Spaceport)
Natural Resources
Conservation Service
Web Soil Survey
National Cooperative Soil Survey
6/20/2016
Page 1 of 3
Map Scale: 1:30,800 if printed on A landscape (11" x 8.5") sheet.
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 17N WGS84

Soil Map—Camden and Glynn Counties, Georgia
(Camden Spaceport)

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Camden and Glynn Counties, Georgia
Survey Area Data: Version 7, Sep 17, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 13, 2011—Mar 15, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Camden and Glynn Counties, Georgia (GA616)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
BO	Bohicket-Capers association	17.0	0.9%
CaB	Cainhoy fine sand, 0 to 5 percent slopes	5.4	0.3%
Ma	Mandarin fine sand, 0 to 2 percent slopes	1,247.9	69.2%
Pe	Pelham loamy sand	5.2	0.3%
Po	Pottsburg sand	323.8	18.0%
Ru	Rutlege fine sand	196.9	10.9%
W	Water	7.4	0.4%
Totals for Area of Interest		**1,803.6**	**100.0%**

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Attachment C-2

Previously Delineated Wetlands Map

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Spaceport Camden Wetland Delineation Report

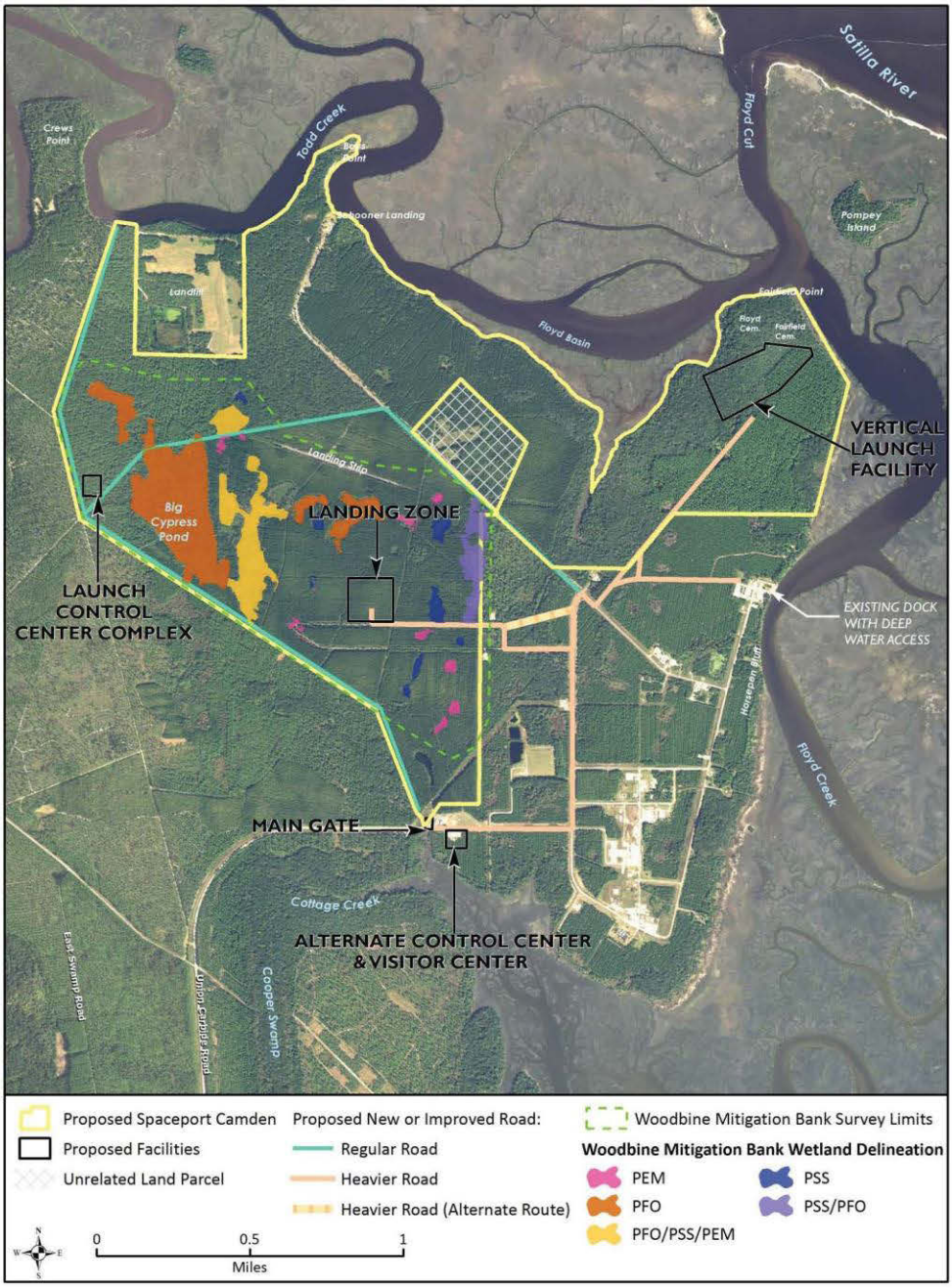

Figure C-1. Previously Delineated Wetlands Map

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APPENDIX D

GLOBAL POSITIONING SYSTEM DELINEATION FORM

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US Army Corps of Engineers
Savannah District, Regulatory Division
Global Positioning Systems (GPS) Datasheet
Delineation of Wetlands, Streams and Other Waters
Within the State of Georgia

USACE File Number_____ Date of Delineation 8/15-8/19 2016

Name of Delineator Present Brian Tutterow

Make and Model of GPS Device Used (must be capable of sub-meter accuracy)
Trimble Geo7X

Geographic Coordinate System Used NAD 83 20111 State Plain Georgia East FIPS 1001 Ft US

Name of Continually Operated Reference Station Used for Post-processing
CORS, TIFTON (GATF), GEORGIA (ITRF00 (1997)-Derived from IGS08 (NEW))

Date Post-processing Performed 8/29/2016

Percent Dilution of Position (PDOP) (6 or less is required) <6 in all cases

Name and Coordinates of Known Property Corner and/or Monument
Control Point 3 851891.436 346449.894; Control Point 5 853592.363 347117.012

GPS Reading of Known Property Corner and/or Monument
Control Point 3 851889.167 346450.98; Control Point 5 853589.589 347117.634

Frequency of Waypoints Taken During Survey Visual site distance

Note: GPS data must be provided, if requested. If GPS data and/or a GPS delineation is determined unacceptable by the Savannah District, a survey sealed by a surveyor licensed in Georgia will be required.

GPS Datasheet 19 Mar 2008

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APPENDIX E

U.S. ARMY CORPS OF ENGINEERS VERIFICATION LETTER

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DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, SAVANNAH DISTRICT
100 W. OGLETHORPE AVENUE
SAVANNAH, GEORGIA 31401-3604

NOVEMBER 0 3 2017

Regulatory Branch
SAS-2015-00823

Mr. Steve Howard
Camden County Administrator
Post Office Box 99
Woodbine, Georgia 31569

Dear Mr. Howard:

I refer to a letter received July 31, 2017, and supplemental information dated July 31, 2017, and September 7, 2017, submitted on your behalf by Mr. Brian Tutterow of Leidos, Inc., requesting a delineation of aquatic resources for a 184.1 acre project site (146.3 acres owned by Union Carbide Corporation and 37.8 acres owned by Bayer CropScience LP). This project site is located at the eastern termination of Union Carbide Road, 11.5 miles east of the town of Woodbine, in Camden County, Georgia (Latitude 30.9042, Longitude -81.5268). This project has been assigned number SAS-2015-00823 and it is important that you refer to this number in all communication concerning this matter.

The enclosed exhibits entitled, "Figure 1., Figure 1A., Figure 1B., Figure 1C., Aquatic Resources at the Proposed Spaceport Camden, and Table 1. Aquatic Resources within the Field Survey Area at the Proposed Spaceport Camden", dated September 7, 2017, identifies the delineation limits of all aquatic resources within the review area. The wetlands were delineated in accordance with criteria contained in the 1987 "Corps of Engineers Wetland Delineation Manual," as amended by the most recent regional supplements to the manual. This delineation will remain valid for a period of 5-years unless new information warrants revision prior to that date.

Please be advised, aquatic resources that are under the jurisdiction of Section 404 of the Clean Water Act (33 United States Code (U.S.C.) § 1344) and/or Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. § 403) may require a permit for the placement of dredged or fill material or mechanized land clearing of those aquatic resources may require prior Department of the Army authorization pursuant to Section 404.

If you intend to sell property that is part of a project that requires Department of the Army Authorization, it may be subject to the Interstate Land Sales Full Disclosure Act. The Property Report required by Housing and Urban Development Regulation must state whether, or not a permit for the development has been applied for, issued or

-2-

denied by the U.S. Army Corps of Engineers (Part 320.3(h) of Title 33 of the Code of Federal Regulations).

This communication does not convey any property rights, either in real estate or material, or any exclusive privileges. It does not authorize any injury to property, invasion of rights, or any infringement of federal, state or local laws, or regulations. It does not obviate your requirement to obtain state or local assent required by law for the development of this property. If the information you have submitted, and on which the U.S. Army Corps of Engineers has based its determination is later found to be in error, this decision may be revoked.

A copy of this letter is being provided to the following parties: Mr. Timothy A. King, Union Carbide Corporation (C/O Dow Chemical), Post Office Box 150, Building 2304, Plaquemine, Louisiana 70765; Mr. David Pittman, Bayer Crop Science, 5954 Union Carbide Road, Woodbine, Georgia 31569; and, Mr. Brian Tutterow, Leidos, Inc., 13397 Lakefront Drive, Suite 100, Earth City, Missouri 63045.

Thank you in advance for completing our on-line Customer Survey Form located at http://corpsmapu.usace.army.mil/cm_apex/f?p=regulatory_survey. We value your comments and appreciate your taking the time to complete a survey each time you have interaction with our office.

If you have any questions, please call me at 912-652-5086.

Sincerely,

Shaun Blocker
Project Manager, Coastal Section

Enclosures

Figure 1. Aquatic Resources at the Proposed Spaceport Camden

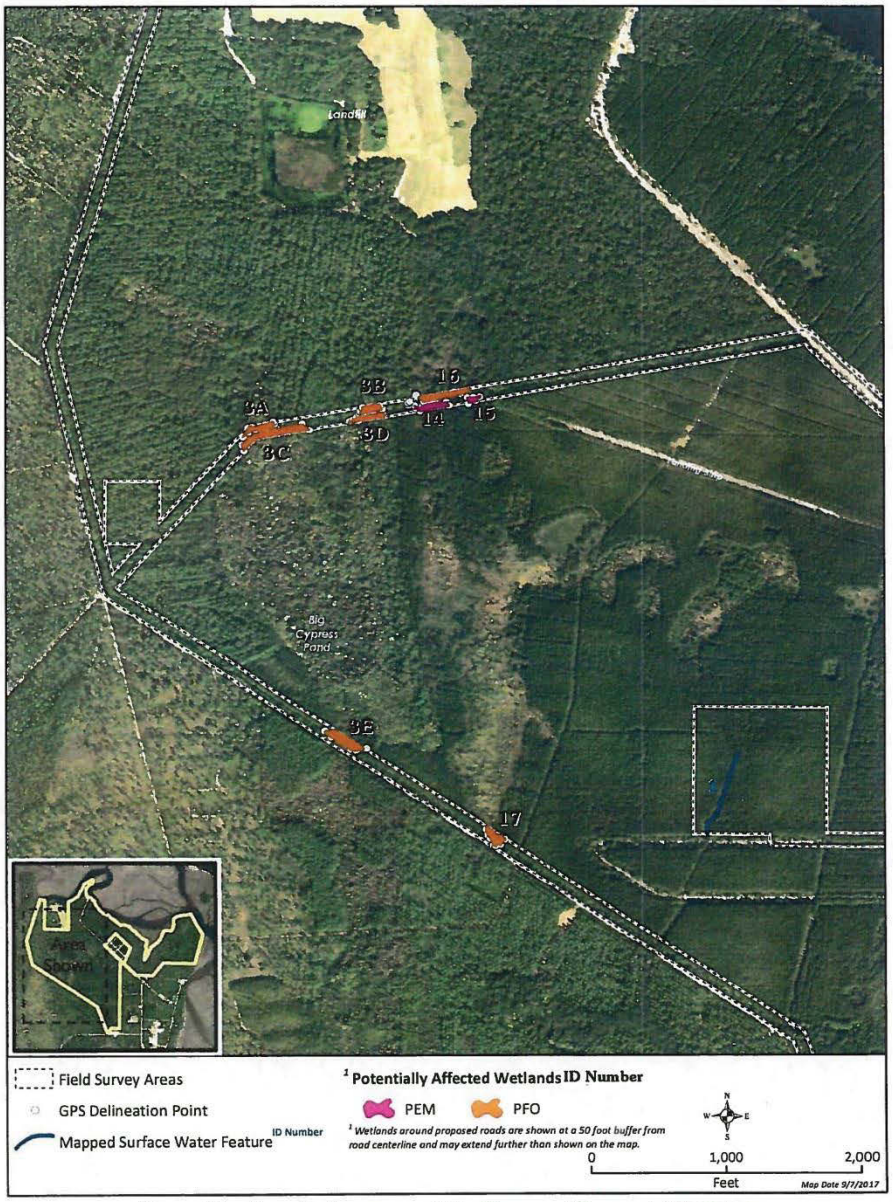

Figure 1A. Aquatic Resources at the Proposed Spaceport Camden

Figure 1B. Aquatic Resources at the Proposed Spaceport Camden

Figure 1C. Aquatic Resources at the Proposed Spaceport Camden

Table 1. Aquatic Resources within the Field Survey Area at the Proposed Spaceport Camden

Wetland	Acres	Latitude	Longitude
3A	0.184	30.94321000	-81.54158000
3B	0.1410	30.94363000	-81.53896000
3C	0.4770	30.94312000	-81.54120000
3D	0.1720	30.94342000	-81.53904000
3E	0.3660	30.93678000	-81.53945000
6	0.0020	30.94697800	-81.50976100
7	0.1960	30.94037400	-81.51296800
9	0.1210	30.94253300	-81.51037800
10	0.6440	30.93529300	-81.51991800
11	0.0820	30.93688500	-81.51536800
12A	0.0480	30.93181000	-81.51838000
12B	0.0790	30.93033000	-81.51839000
14	0.1890	30.94325800	-81.53758000
15	0.0570	30.94369900	-81.53644800
16	0.2760	30.94452900	-81.53815500
17	0.2100	30.93489900	-81.53610900
18	0.0920	30.93557000	-81.52572600
19A	0.0780	30.94062000	-81.52322500
19B	0.1610	30.93496000	-81.52385000
20	0.0150	30.93700000	-81.51400000
21	0.0170	30.93797000	-81.51504000

Stream	Acres	Linear Feet	Latitude	Longitude
1	0.152	660.051	30.93579933	-81.53063736
2A	0.009	122.672	30.93781000	-81.51501000
2B	0.003	53.962	30.93705000	-81.51510000
3A	0.007	109.492	30.93779369	-81.51509391
3B	0.015	112.571	30.93511116	-81.52041196

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APPENDIX I TRANSPORTATION

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I TRANSPORTATION

This appendix addresses the potential direct, indirect, and cumulative environmental impacts of construction and operation of the proposed launch site on the capacity and traffic flow of surface transportation systems serving and in proximity to the proposed project site that would result from the Federal Aviation Administration's (FAA's) Proposed Action to issue a Launch Site Operator License to the County for Spaceport Camden. The region of influence for transportation would include roads that could be used to transport building materials, hazardous and nonhazardous materials, asphalt and concrete, construction equipment to the proposed project site, and removal of construction waste materials from the site. It also includes roads used by contractors travelling to and from the site during construction and by personnel and contractors travelling to and from the proposed spaceport site once it is in operation.

I.1 Affected Environment

I.1.1 Definition and Description

The Federal Highway Administration classifies roadways as principal arterial, minor arterial, collector, or local. Principal arterial roadways (i.e., interstates, freeways, and expressways) serve a large percentage of travel between cities and other activity centers, especially when minimizing travel time and distance is important. Principal arterials are typically roadways with high traffic volumes and are frequently the route of choice for intercity buses and trucks. Minor arterials provide service for trips of moderate length, serve geographic areas that are smaller than principal arterial roadways, and provide intracommunity continuity. Collector roadways (i.e., major collectors and minor collectors) funnel traffic from local roads to principal or minor arterial roadways and generally serve intracounty travel. Local roads provide direct access to abutting land and are not intended for use in long distance travel (Federal Highway Administration, 2013).

The Proposed Action involves truck and worker commuter trips to or from the proposed project site, coming from and going to destinations within the local area and wider region. These trips represent additional traffic volumes over baseline levels that could affect the quality of traffic flow (expressed as a level of service [LOS] rating for each road), based on road, traffic, and control conditions. The level of service rating is a qualitative measure used to relate the quality of traffic service using letter designations A (best) through F (worst) as summarized in Table I-1.

Table I-1. Level of Service Definitions

LOS	Operating Conditions
A	Highest quality of service; free traffic flow, low volumes and densities; little or no restriction on maneuverability or speed
B	Stable traffic flow; speed becoming slightly restricted; low restriction on maneuverability
C	Stable traffic flow but less freedom to select speed, change lanes, or pass; density increasing
D	Approaching unstable flow; speeds tolerable but subject to sudden and considerable variation; less maneuverability and driver comfort
E	Unstable traffic flow with rapidly fluctuating speeds and flow rates; short headways, low maneuverability, and lower driver comfort
F	Forced traffic flow; speed and flow may drop to zero with high densities

Notes: LOS = level of service.
Source: (Transportation Resources Board, 2010).

I.1.2 Regulatory Setting

The Georgia Department of Transportation (GDOT) regulates speed and other vehicle safety parameters using the GDOT Design Policy Manual. The manual is the primary resource for design guidelines and standards adopted by the GDOT for the design of roadways and related infrastructure. The guidelines and standards presented in the manual are based on policies and principles defined by the GDOT, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and various national research organizations (Georgia Department of Transportation, 2017a). Additionally, the U.S. Department of Transportation (DOT) regulates the transport of hazardous materials in 49 Code of Federal Regulations (CFR) Parts 171–179.

I.1.3 Existing Conditions

I.1.3.1 Region of Influence

The proposed Spaceport is located in an unincorporated area of Camden County, approximately 11.5 miles east of the town of Woodbine and approximately 19 miles northeast of the city of Kingsland. Interstate 95 (I-95) traverses north-south approximately 9 miles to the west of the proposed spaceport, and U.S. Route 17 (Ocean Highway) parallels I-95 for 1 to 2 miles to the west for much of Camden County. I-95 traverses north-south, providing local access to the town of Woodbine and the city of Kingsland and regional access to Brunswick to the north and Jacksonville, Florida, to the south (see Exhibit I-1).

Access to Spaceport Camden would be provided by way of Harrietts Bluff Road, which transitions into Union Carbide Road approximately 5.5 miles southwest of the gated entry to the project site. Harrietts Bluff Road is classified as an urban minor arterial road located entirely in Camden County that intersects two urban arterial roads in the area (I-95 [major] and Ocean Highway [minor]). Most traffic to and from the Spaceport Camden site would access Harrietts Bluff Road and Union Carbide Road through one of these two arterial roads. Regional access to the site would be provided by way of Exit 7 (Harrietts Bluff Road/Woodbine) of I-95. Harrietts Bluff Road originates at Ocean Highway and travels approximately 10 miles east until it transitions into Union Carbide Road (classified as a rural collector road) before terminating at the proposed Spaceport Camden project site, which contains a series of unnamed, sporadically maintained roads that were utilized during previous site activities.

As Harrietts Bluff Road, a two-lane road with a speed limit of 35 miles per hour, travels east from Ocean Highway and I-95, it provides access to multiple residential developments and local businesses. As it transitions into Union Carbide Road, population density and the presence of commercial properties diminishes considerably and the road progresses through undeveloped woodland area up to the site access gate. Table I-2 and Table I-3 list the average annual daily traffic (AADT) counts for roadways providing regional and local access to the Spaceport Camden site. Exhibit I-2 illustrates the roadway network in proximity to Spaceport Camden and the locations of GDOT AADT monitoring locations listed in Table I-2. Based on GDOT traffic counts for 2015, 220 vehicles (18 of which were trucks) accessed Union Carbide Road just north of Marys Drive. Since Marys Drive provides access to the last residential area before the proposed spaceport site, it can be assumed that this count represents all traffic to and from the site.

By contrast, in 2015, 3,250 vehicles (206 of which were trucks) accessed Harrietts Bluff Road just south of Pine Drive, which provides access to residential and commercial areas before reaching the transition point of Harrietts Bluff Road and Union Carbide Road (i.e., the access road to the proposed Spaceport site/current Union Carbide/Bayer CropScience property).

Table I-2. Average Daily Traffic for Roadways in the Vicinity of Spaceport Camden

#	Description	Functional Classification	Annual Average Daily Traffic					
			2015	2014	2013	2012	2011	2010
1	I-95 just south of Exit 7 - Harrietts Bluff Road	Urban - interstate	54,900	54,900	No data	50,070	50,070	49,900
2	I-95 Exit 7 - Harrietts Bluff Road (northbound)	Urban - interstate	2,870	2,730	2,520	2,500	2,680	2,990
3	Harrietts Bluff Road east of U.S. 17	Urban - minor arterial[1]	1,310	1,270	940	940	940	960
4	Harrietts Bluff Road just south of Pine Drive	Urban - minor arterial	3,250	3,010	3,010	3,030	3,080	3,410
5	Union Carbide Road just east of Marys Drive	Rural - major collector[2]	220	210	210	330	340	350

Source: (Georgia Department of Transportation, 2017b)

Table I-3. Average Daily Truck Traffic for Access Roadways to Spaceport Camden

Location	Functional Classification	Annual Average Daily Truck Traffic		
		2015	2014	2013
Harrietts Bluff Road just south of Pine Drive	Urban - Minor Arterial	206	191	191
Union Carbide Road just east of Marys Drive	Rural - Major Collector	18	17	17

Source: (Georgia Department of Transportation, 2017b)

A 3.7-mile stretch of the Harrietts Bluff Road and Union Carbide Road, from White Oak Place to just north of the Deep Creek crossing, was milled and resurfaced in 2010 (Georgia Department of Transportation, 2015). Based on AADT counts and road characteristics, the entirety of Harrietts Bluff Road and Union Carbide Road would be categorized as LOS A or B, as indicated in Table I-1. Considering the type, condition, and function of the roadways, coupled with the AADTs listed in Table I-2 and Table I-3, traffic along this corridor is currently well below the capacity of Harrietts Bluff Road.

Because are no bridges or roadways connecting Cumberland Island to the mainland, public access is provided by ferry service operated by the National Park Service. Ferries depart downtown St. Marys twice daily from a dock at the Cumberland Island National Seashore Visitor Center and navigate the St Marys River to the Cumberland Sound before making stops at two docks located on the southern part of the Island (Ice House Museum and Sea Camp Ranger Station) (see Exhibit I-1). To accommodate increased ridership during the spring and summer (March through September), an additional ferry makes a return trip in the afternoon from the Island to St. Marys. During winter (December through February), the ferry does not operate on Tuesday or Wednesday. Guests of a privately-owned, 16-room hotel on Cumberland Island (The Greyfield Inn) access the island by way of a ferry, the Lucy R. Ferguson, which runs from Fernandina Beach, Florida to a dock approximately one mile north of the Sea Camp Ranger Station dock, but as this ferry is open only to guests of the Inn, it is not considered a public access route.

[1] Functional classification for a street or highway serving urban areas and provides the highest level of service at the greatest speed for the longest uninterrupted distance, with some degree of access control (Georgia Department of Transportation, 2017a).

[2] A street or highway that generally serves travel of primarily intracounty rather than statewide importance and constitutes those routes on which (regardless of traffic volume) predominant travel distances are shorter than on arterial routes. On average such roads, more moderate speeds may be typical (Georgia Department of Transportation, 2017a).

Exhibit I-1. Spaceport Camden Regional Transportation Network

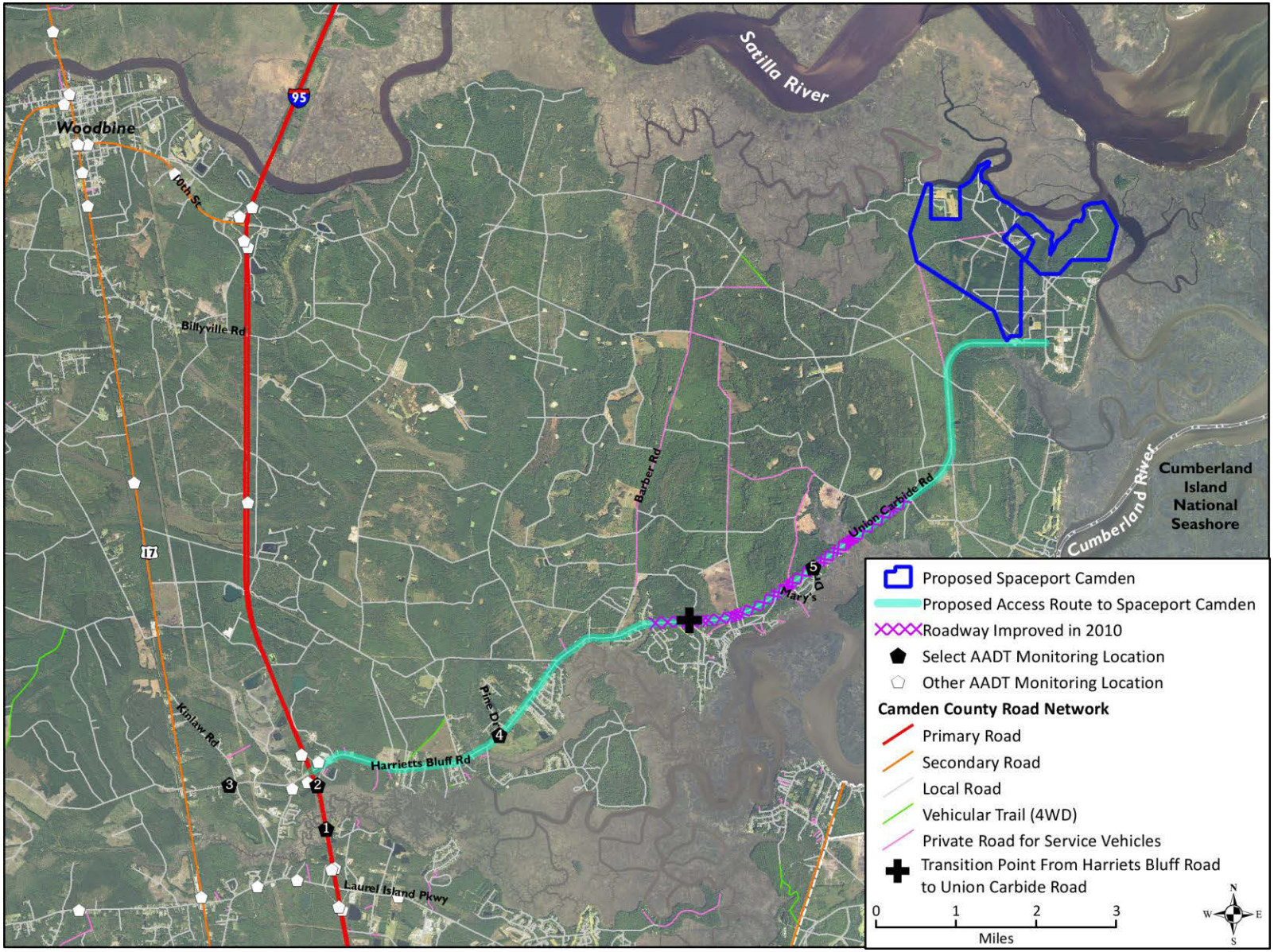

Exhibit I-2. Spaceport Camden Local Transportation Network and AADT Monitoring Locations

Portions of coastal Georgia are included in the Intracoastal Waterway, specifically the Atlantic Intracoastal Waterway, a network of rivers, bays, inlets, and canals that provide navigable routes for commercial boats and recreational water crafts, protected from the open sea. Types of craft using the waterway and waters near Spaceport Camden would typically consist of military craft transiting to and from Kings Bay Naval Submarine Base and commercial shipping vessels and recreational craft (e.g., motorboats and sailboats. Navigable water routes and waterways in proximity to Spaceport Camden include St. Andrew Sound, the Satilla River, Cumberland River, Floyd Creek, and Todd Creek.

I.2 Environmental Consequences

I.2.1 Proposed Action

Implementing the Proposed Action has the potential to impact the local ground traffic and transportation during construction and operation of Spaceport Camden. Based upon the relatively high AADT values identified in Section I.1.3.1 for the area of I-95 closest to the regional access point to the site (54,900 in 2014 and 2015), no significant impacts are expected to major roadways utilized by vehicles associated with the Proposed Action. Because all or most of Harrietts Bluff Road/Union Carbide Road would be used to transport materials and personnel, which have considerably lower AADTs than the major roads that would be utilized by vehicles associated with the construction and operation of Spaceport Camden, this analysis only considers traffic impacts along 15 miles of Harrietts Bluff Road/Union Carbide Road. Proposed improvements to the roadway network on the site are discussed in Section 2.1.1.6 of this EIS, *Infrastructure*. No significant impacts to the local roads connecting to Harrietts Bluff Road/Union Carbide Road are anticipated as a result of the Proposed Action.

Construction

Under the Proposed Action, the County would construct and operate Spaceport Camden, as identified in Section 2.1 of this EIS, *Proposed Action*. Construction of the facilities and infrastructure would occur concurrently and last approximately 15 months, the length of time needed for construction of the Vertical Launch Facility. During the construction period, additional vehicle traffic associated with the Proposed Action would include transportation of construction equipment, delivery of construction materials, removal of construction-related debris, and additional traffic associated with construction workers. Construction activities would occur during daylight hours, six days a week. Because the proposed project site is relatively isolated at the terminus of Union Carbide Road, all material delivery and construction worker traffic is assumed to use Harrietts Bluff Road and Union Carbide Road to access the site. Based on the construction material requirements, delivery of these materials to the site would require an average of 15 trucks per day in each direction (Table I-4).

Table I-4. Construction Truck Trip Requirements – Proposed Action

Construction Material	Total Volume Required (cubic yards)	Delivery Truck Capacity (cubic yards)	Total Number of Trucks
Construction materials	60,600	10	6,060
Backfill [a]	N/A	N/A	N/A
Total number of trucks (over 15 months)			**6,060**
Average number of trucks per day in each direction [b]			**15**

Notes: N/A = not applicable.
[a] It was assumed that all material excavated onsite (estimated at 126,000 cubic yards) would remain onsite to be used as backfill, with any excess suitable material stockpiled onsite. Therefore, no transport of backfill to or from an offsite location would be required during construction of Spaceport Camden facilities.
[b] Construction activities would occur during daylight hours, six days a week.

While the average number of trucks per day is estimated to be 15 in each direction, it is expected that over the duration of construction activities, some days would require more truck trips and some days would require fewer truck trips. For example, as discussed in Section 3.7.3, the construction of Spaceport Camden would generate a total of 435 tons of debris that would be disposed of at the Camden County C&D and Industrial Waste Landfill. In addition, it is anticipated that construction of the launcher track and integration building at the Launch Pad Complex would require large pours of concrete and, therefore, could require more than 15 truck trips per day in each direction. However, the increases are expected to be temporary and not significantly impact the traffic flow of Harrietts Bluff Road and Union Carbide Road. All other facilities would not require large pours of concrete and could be constructed using the average number of daily truck trips presented in Table I-4.

It is anticipated that about 40 to 50 construction workers would be required for the construction of the facilities, and about 20 additional construction workers would be required for the construction of new infrastructure (water, sewer, drainage, and roads). For purposes of analysis, it was assumed that all 70 workers would access the site each day. As shown in Table I-5, traffic along Harrietts Bluff Road/Union Carbide Road would increase from 220 vehicles per day in each direction to 305 vehicles per day in each direction during the Spaceport Camden construction period.

Table I-5. Harrietts Bluff Road/Union Carbide Road Maximum Construction Traffic

Traffic Source	Vehicles per Day in Each Direction
Existing AADT	220
Construction truck traffic	15
Construction worker traffic	70
Total construction traffic during large concrete pours	**305**

Notes: AADT = average annual daily traffic.

Due to Harrietts Bluff Road/Union Carbide Road being the only access point to the proposed project site, it is possible that the increased vehicle traffic from construction activities could cause traffic delays during daily rush hour. To avoid these delays, construction truck access would be scheduled throughout other parts of the day. Although scheduling truck access for off-peak times, there is still the potential for traffic delays along the local roads that connect to Harrietts Bluff Road. However, these delays are expected to be minimal, and there would not be permanent or significant traffic delays. Therefore, the level of service rating for Harrietts Bluff Road is not expected to change as a result of Spaceport Camden construction activities.

As stated in the introduction to this appendix, hazardous materials (i.e., gasoline, diesel, compressed gas, paints, and epoxies) would be transported to the proposed project site during construction activities. Transport of these materials would comply with DOT regulations in 49 CFR Parts 171–179 (i.e., using DOT-approved trucks, containers, and packaging and properly marking the contents for shipment over public roadways). While shipment of hazardous materials is routinely done across the country, there is the potential for a traffic accident. The DOT estimates that the likelihood of an accident involving transport of hazardous materials is 0.32 accidents per million vehicle miles (U.S. Department of Transportation, 2001). However, to be conservative, the nonhazardous material transport accident rate of 0.73 per million vehicle miles traveled was used to calculate potential accidents resulting from construction activities. Assuming that each vehicle travels the entire length of Harrietts Bluff Road and Union Carbide Road (approximately 30 miles round trip), there would be no additional accidents expected (calculated value of 0.13) over the duration of Spaceport Camden construction activities.

Therefore, the transport of hazardous and nonhazardous materials during construction is not anticipated to significantly impact traffic and transportation in the vicinity of the proposed project area.

Operation

Operations at Spaceport Camden would consist of up to 12 launch operations per year, with each operation expected to last four weeks. The level of ground traffic and transportation would fluctuate between normal operational levels and launch operation levels. As stated in Section 2.1.2 of this EIS, *Representative Launch Vehicle and Operational Activities*, there would be approximately 77 full-time employees (27 Spaceport Camden employees and 50 launch operator employees) working onsite during normal operations. However, during launch operations, the number of staff would increase to a maximum of 100 Spaceport Camden employees and a maximum of 200 launch operator employees beginning about two weeks before the launch (see Table I-6). Because construction of housing facilities is not included in the Proposed Action, it is assumed that these workers will commute from offsite locations. If no carpooling of employees takes place and only privately owned vehicles are used, traffic along Harrietts Bluff Road/Union Carbide Road would increase from 220 vehicles per day in each direction to 330 vehicles per day in each direction during normal Spaceport Camden operations and 534 total vehicles per day during launch operation windows.

Launch operations would also include the delivery of rocket vehicle components, propellants and other necessary fluids. A total of approximately six to eight vehicles trucks per month would make deliveries of fluids on an as-needed basis. Ground transportation support for vehicle deliveries would consist of a truck to deliver a crane and four or five delivery trucks for delivery of rocket stages and any miscellaneous items. Average annual daily truck trips in 2015 on Union Carbide Road south of the entry gate was measured by the Georgia Department of Transportation at 18 and 206 on Harrietts Bluff Road just south of Pine Drive.

Table I-6. Additional Traffic on Harrietts Bluff Road/Union Carbide Road Resulting from Spaceport Camden Operation – Proposed Action

Traffic Source	Vehicles per Day in Each Direction	
	Normal Operations	Launch Operations
Existing AADT	220	220
Spaceport Camden employees	77	100
Launch operator employees	27	200
Truck traffic (deliveries and rocket components)	8	14
Total	**330**	**534**

Notes: AADT = average annual daily traffic.

Public access in the vicinity of the Spaceport Camden would be restricted during launches, wet dress rehearsals, and static fire engine tests. Closures could last up to 12 hours on a launch day, with 4 to 6 hours being the typical closure time for a nominal launch. Closure for a wet dress rehearsal or static fire engine test would be typically three hours or less and would include only those areas within a 2-mile radius of the launch pad.

As discussed in Section 2.1.2.5 of this EIS, *Pre-Launch Activities*, as part of the licensing process, Camden County and the launch operator would jointly develop a Spaceport Camden Security Plan that defines the process for ensuring that any unauthorized persons, vessels, trains, aircraft, passenger or recreational vehicles, or other vehicles are not within the FAA-approved hazard area. The plan would describe the procedures for securing a closure area that would limit public access in proximity to the

spaceport on the day of a launch and the development and implementation of the plan would include Camden County, Glenn County and other state law enforcement agencies, the National Park Service, U.S. Navy, FAA, NASA, state parks, the U.S Fish and Wildlife Service, the Georgia Department of Transportation, the U.S. Coast Guard. Although each launch would have an individually-defined closure area, these areas would typically include areas around Spaceport Camden site access points at the end of Harrietts Bluff Road/Union Carbide Road and the waterways surrounding the launch site, in addition to parts of Cumberland Island extending along the trajectory and out to sea.

Closure areas would be developed further in consultation with FAA, the U.S. Fish and Wildlife Service, and the National Park Service in order to ensure that the Cumberland Island National Seashore, the Satilla River, Andrews Sound, and Cumberland River areas are properly secured, while resulting in minimal impacts to access and activities. Closure areas for two representative launch trajectories are displayed in Exhibits 2.1-14 and 2.1-15 in Chapter 2 of this EIS.

Roadway Closures

Under the representative closure areas identified in Section 2.1.2.5, there would be a total of six land checkpoints, two or three of the which would be located at on beachfront points on Cumberland Island where vehicular traffic is not allowed, and two of which would be would be located on old logging roads east of the Spaceport Camden site. The only road closure that would potentially affect the local roadway network is the closure of Union Carbide Road just south of Spaceport Camden site. As indicated in Section I.1.3.1, *Region of Influence*, this section of roadway had an AADT of 220 in 2015 and provides access only to and from the Spaceport Camden site and a network of unnamed logging roads. The Camden County Sheriff's Office would be responsible for, and would coordinate, land closure checkpoints. During closures, only authorized vehicles and personnel would be permitted through these checkpoints and into the closure areas, including approved government and Camden County officials, launch operators, emergency personnel, and other individuals with appropriate credentials. Because this section of roadway is primarily used for access to and from the current Union Carbide/Bayer CropScience properties, impacts to residents on Harrietts Bluff Road and other arterial roads connected to it would not be expected during closures.

Waterway Closures

Waterway closure areas would affect portions of St. Andrews Sound, the Satilla River, and the Cumberland River; access to, and activities on, these waterways would be restricted during for up to 12 hours on a launch day, with 4 to 6 hours representing the nominal time for a normal launch. The Intracoastal Waterway would be temporarily closed north of Crooked River State Park and east to the St. Andrews Sound, as would a section of the Cumberland River from the middle potion of Cumberland Island north to the St. Andrews Sound. Primary users of these sections of waterways would include recreational boaters accessing Crooked River State Park and Cumberland Island National Seashore. Portions of the Atlantic Ocean east of Cumberland Island would be under a hazard area on launch days. Because representative launch trajectories and closure areas would occur well to the north (approximately 10 miles) of dock locations, Cumberland Island Ferry operations would not be impacted by pre-launch and launch activities.

Notifications of closures, which involve securing both land and water areas, could be made as much as a month in advance of the launch, although shorter notifications of two weeks or less are possible, depending upon launch-specific factors or launch delays. Camden County and/or the launch operator would notify the public approximately three to six days prior to a launch operation that would require a closure and would coordinate with the appropriate agencies to undertake the necessary steps for closures. The Camden County Security Plan would outline the process for securing and clearing offshore

areas to ensure public safety, including coordination with the U.S. Coast Guard and the issuance of a Notice to Mariners (NOTMAR).

I.2.2 Ocean-Landing Only Alternative

Construction

Under the Ocean-Landing Only Alternative, the County would construct and would operate Spaceport Camden, as identified in Section 2.2 of this EIS, *Ocean-Landing Only Alternative*. Conditions described for the environmental consequences under this alternative would be the same as described in Section I.2.1, *Proposed Action,* with the exception that, since this alternative does not include the potential for first-stage landings at Spaceport Camden, a Landing Zone facility would not be constructed. Proposed improvements to the roadway network on the site would be the same as those discussed in Section 2.1.1.6 of this EIS, *Infrastructure*, with the exception of a reduction in the total length of heavier road by 11,250 linear feet. Since the Landing Zone facility would not be constructed under this alternative, there would be a reduction in the overall footprint of the project of approximately 30 percent and, consequently, a reduction in the volume of materials that would need to be transported to the site for construction activities, as well as the total number of workers required for the 15-month concurrent build window. Based on the reduced construction material requirements, delivery of these materials to the site would require an average of 11 trucks per day as listed in Table I-7.

Table I-7. Construction Truck Trip Requirements – Ocean-Landing Only Alternative

Construction Material	Total Volume Required (cubic yards)	Delivery Truck Capacity (cubic yards)	Total Number of Trucks
Construction materials	42,450	10	**4,245**
Backfill [a]	N/A	N/A	**N/A**
		Total number of trucks (over 15 months)	**4,245**
		Average number of trucks per day [b]	**11**

Notes: N/A = not applicable.
[a] It was assumed that all material excavated on-site (estimated at 89,000 cubic yards) would remain onsite to be used as backfill with any excess suitable material stockpiled onsite. Therefore, no transport of backfill to or from an offsite location would be required during construction of Spaceport Camden facilities.
[b] Construction activities would occur during daylight hours, six days a week.

Operation

Conditions described for operations under the Ocean-Landing Only Alternative would be the same as those described in Section I.2.1, *Proposed Action*, with the exception of two fewer permanent staff employees at Spaceport Camden (75 instead of 77), resulting in two fewer daily vehicle trips to and from the site. The number of employees required during launch operations would remain the same as described for the Proposed Action.

I.2.3 No Action Alternative

Under the No Action Alternative, FAA would not issue a Launch Site Operator License to the Camden County Board of Commissioners. Camden County would not exercise its option to purchase the property, and the property would continue to be owned by the private landowner in accordance with its current industrial zoning. No activities related to constructing or operating a commercial spaceport would occur at the launch site. As a result, any changes to the local and regional transportation network, traffic volumes, and associated LOS as described in Section I.1.3, *Existing Conditions*, would be the result of ongoing and future transportation planning projects.

APPENDIX J AIRSPACE

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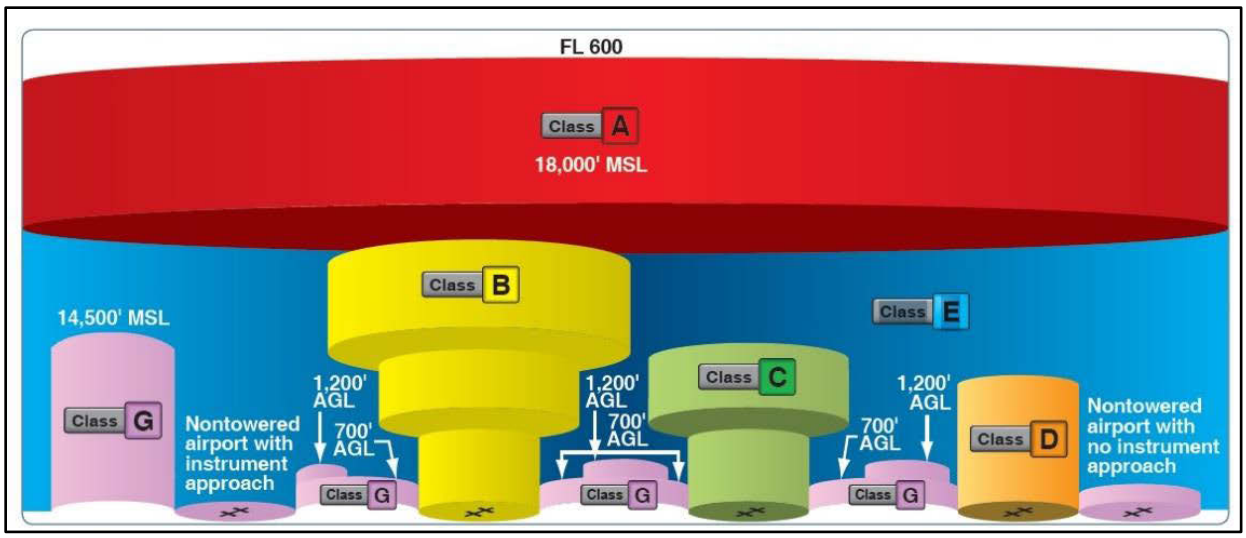
J AIRSPACE

J.1 Definition and Description

The airspace resource area encompasses how airspace is designated, used, and administered to best accommodate the needs of commercial, military, and general aviation. The Federal Aviation Administration (FAA) considers multiple and sometimes competing demands for airspace in relation to airport operations, Federal airways, jet routes, military flight training activities, and other special needs to determine how the National Airspace System can be best structured to address all user requirements. FAA has designated four types of airspace above the United States: controlled airspace, Special Use Airspace (SUA), other airspace, and uncontrolled airspace (FAA, 2016).

- Controlled airspace is categorized into Classes A, B, C, D, and E (see Exhibit J-1). Each class is associated with its own minimum pilot qualifications, rules of flight, and required types of equipment. Class A airspace extends from 18,000 feet above mean sea level (MSL) to 60,000 above MSL throughout the U.S. and above waters within 12 miles of the coast. Class B, C, and D airspace is designated in specific altitude bands at specified horizontal distances from airports. Class E airspace is designated in areas where air traffic control (ATC) services are provided during Instrument Flight Rules (IFR) operations but where the level of control is less than in the other controlled airspace categories. During IFR operations, guidance is provided to aircrews based on radar and other instruments, allowing safe flying operations in low-visibility conditions.
- SUAs designated volumes of airspace within which specific activities must be confined or where limitations are imposed on aircraft not participating in those activities. SUA types, include Prohibited Areas, Restricted Areas, Warning Areas, and Military Operations Areas (MOAs). As described in FAA Order 7400.8V, each SUA type is associated with a specific set of rules regarding access by nonparticipating aircraft. Access to Prohibited Areas and Restricted Areas by nonparticipating aircraft is not permitted while the airspace is active. MOAs are established to separate certain nonhazardous military activities from IFR traffic and to identify for Visual Flight Rules (VFR) traffic where these activities are conducted. VFR operations are permitted only when visibility is good, as they rely on aircrews seeing and avoiding hazards such as other aircraft. Warning Areas, which are only designated over international waters, contain activities that may be hazardous to nonparticipating aircraft. Each SUA has specific times of use that may be established permanently or through the U.S. Notice to Airmen (NOTAM) system.
- Other airspace consists of advisory areas, areas that have specific flight limitations or designated prohibitions, areas designated for parachute jump operations, military training routes, and aerial refueling tracks. This category also includes Air Traffic Control Assigned Airspace and airspace designated for altitude reservations.
- Uncontrolled airspace is designated Class G airspace and has no specific prohibitions associated with its use.



Source: (Federal Aviation Administration, 2016)

Exhibit J-1. Cross Section of Controlled and Uncontrolled Airspace Classes

J.2 Regulatory Setting

FAA regulates all aspects of civil aviation in "navigable airspace'" including, but not limited to, the management of air traffic and the protection of U.S. assets during the launch and reentry of commercial space vehicles. Navigable airspace is airspace above the minimum altitudes of flight prescribed by regulations under United States Code (U.S.C.) Title 49, Subtitle VII, Part A, and includes airspace needed to ensure safety in takeoff and landing of aircraft (49 U.S.C. 40102). This navigable airspace is a limited natural resource that Congress has charged FAA to administer in the public interest as necessary to ensure the safety of aircraft and its efficient use (FAA Order 7400.2K). The system of airspace, navigation facilities, and airports, along with their associated equipment, personnel services, rules, regulations and policies, are collectively known as the National Airspace System. Airspace classes and designations, as discussed in J.1, *Definition and Description*, above, are defined at 14 Code of Federal Regulations (CFR) 71.

Regulations published at 14 CFR 400 require the launch operator to establish agreements with air traffic control facilities with jurisdiction over the airspace to be used. The Letter of Agreement (LOA) must describe the terms and conditions required for safe launch or reentry operations, including procedures for notification and the issuance of NOTAMs (FAA JO 7400.2K). As per 14 CFR 91.143, aircraft may not operate in space operations aircraft hazard areas except when authorized by ATC. A Temporary Flight Restriction (TFR) specifying the dimensions of the area and the time window in which flight restrictions must be published via NOTAM (Advisory Circular 91-63D).

Supersonic flight for civil aircraft is prohibited per 14 CFR 91 unless specific authorization is given by FAA. Authorization may be granted following an application process defined in the CFR.

J.3 Region of Influence

The region of influence for airspace includes the airspace temporarily closed to traffic during launch and landing operations. The dimensions of this area would be determined based on the trajectory of the vehicle itself, any planned debris such as stages, and potential falling debris in the event of an operational failure. Personnel at the Jacksonville Air Route Traffic Control Center (ARTCC), which

controls en route air traffic along the representative launch trajectory, may adjust the boundaries of the initial hazard areas to meet their procedural and operational needs. For example, Warning Areas located offshore could be incorporated into the TFR. Because air traffic is routed by the ARTCC to avoid temporarily-closed airspace, aircraft routings could deviate from normal throughout the region.

J.4 Existing Conditions

Exhibit J-2 shows the airspace associated with the proposed action area. Class E airspace has been designated beginning at 700 feet above ground level (AGL) above portions of Spaceport Camden and continues at this floor altitude to the north. This designation of Class E airspace at 700 AGL (rather than the standard floor altitude of 1,200 feet AGL, which extends across most of the U.S.) facilitates instrument approaches to nearby McKinnon Saint Simons Island airport.

FAA Advisory Circular 91-36C, *Visual Flight Rules Flight Near Noise Sensitive Areas*, states that "All aircraft are requested to maintain a minimum altitude of 2,000 feet above the surface of lands and waters administered by the National Park Service." This guidance applies to Cumberland Island and is reflected in navigational charts (FAA, 2016).

The Brunswick VHF navigational facility-Omnidirectional Course only and UHF navigational facility-Omnidirectional Course and Distance information (VORTAC) is located immediately west of Jekyll Island approximately 8 miles north of Spaceport Camden. The VORTAC is a facility that emits signals intended to be used by aircrews for aerial navigation, and acts as a waypoint for aircraft en route. Several Victor Routes, including V179, V3-37, V441, V3, V37, and V362 as well as the Tango route T204, intersect at this waypoint. These routes extend to 18,000 feet above MSL. Victor 1 and V437 are located off shore from Spaceport Camden. Jet Routes J51-55, J121-174, and J79-103 traverse the area directly above or immediately to the east of Spaceport Camden, facilitating air traffic at altitudes between 18,000 feet above MSL and 45,000 feet above MSL.

Coastal 4 MOA is located approximately 8 miles north of Spaceport Camden. This SUA, which extends from 14,000 feet above mean sea level (MSL) up to but not including 18,000 feet MSL, is controlled by Jacksonville ARTCC, and its using agency is the Air National Guard's Savannah Combat Readiness Training Center. Coastal 4 MOA is used intermittently between 7:00 a.m. and 10:00 p.m. on Monday through Friday and intermittently by NOTAM during the same hours on Saturday and Sunday (FAA Order 7400.8X).

Several Warning Areas are located offshore in the Atlantic Ocean (e.g., W-137, W-138, W-139, and W-140) and extend from the surface to unlimited altitude. These SUAs are controlled by Jacksonville ARTCC, and their using agency is the U.S. Navy's Fleet Area Control and Surveillance Facility. The times of use are continuous for all of the W-137, W-138, W-139, and W-140 subunits. All of the W-138 subunits (i.e., W-138A, B, C, D, E, and L) and all of the W-139 subunits except W-139F (i.e., W-139A, B, C, D, and E) extend from the surface to unlimited altitudes. W-139F and W-140F extend from the surface to 13,000 feet above MSL. The subunits W-140B, C, D, and E extend from the surface to 24,000 feet above MSL, and W-140H extends from 43,000 feet above MSL to unlimited altitude (FAA Order 7400.8X).

Prohibited airspace unit P-50 is located approximately 5 miles south of Spaceport Camden and incorporates altitudes from the surface to 3,000 feet above MSL. The using agency is the FAA, and the airspace is designated for continuous use.

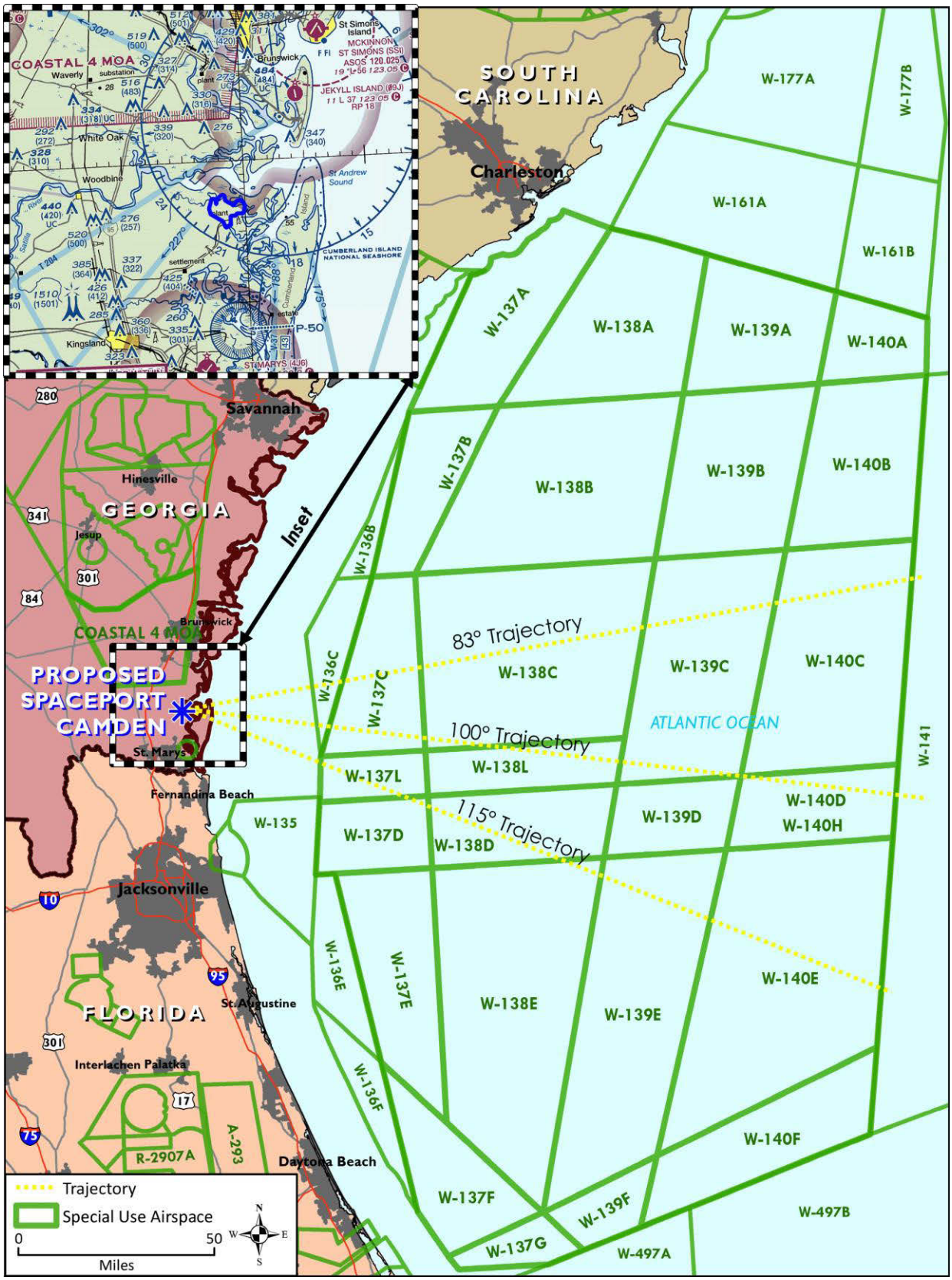


Exhibit J-2. Airspace Associated with the Proposed Action Area

J.5 Proposed Action

Construction

The proposed construction activities would involve use of tall equipment (e.g., crane, impact pile driver) that could obstruct the navigable airspace. Prior to construction, the launch operator would be required to consult 14 CFR 77 and FAA Advisory Circular 7460 to determine whether or not an obstruction evaluation is required. It is possible, although unlikely, that the use of cranes and the construction of the water tower and lighting towers may require an obstruction analysis.

Operation

Under the Proposed Action, the FAA would issue a Launch Site Operator License to the Camden County Board of Commissioners. The license would allow the County to offer the commercial space launch site, Spaceport Camden, to commercial launch operators to conduct launches of liquid-fueled, small to medium-large lift-class, orbital and suborbital vertical launch vehicles. Airspace use would be coordinated by the FAA and the appropriate SUA using agencies (to include Marine Corps Air Station Beaufort), depending on the trajectory and hazard area of the launch vehicles. The launch operator must obtain LOAs from the Jacksonville ARTCC and local airspace using agencies before any launches could commence. Under the Proposed Action, the FAA would not alter the dimensions (shape and altitude) of any existing airspace. However, temporary closures of existing airspace units may be necessary to ensure the safety of the proposed operations. The LOAs would include notification requirements through the NOTAM system in accordance with FAA Order 7930.2Q. The specific airspace units that would need to be closed would depend upon the launch and landing trajectories to be used. Air traffic may need to be rerouted to avoid temporarily closed airspace units, similar to airspace management procedures used in preparation for launches from existing space facilities (e.g., Cape Canaveral, Wallops Island).

Launch trajectories would not traverse airspace above Cumberland Island at altitudes at which flights are discouraged per FAA Advisory Circular 91-36. Aircraft used to confirm that the evacuation area is clear of people prior to launches and landings may operate above Cumberland Island at altitudes below 2,000 feet above ground level. However, as the FAA Advisory Circular was designed to avoid noise impacts rather than airspace management conflicts, no airspace impacts are expected.

Because there would be few launches each year, temporary closures of existing airspace would not impact the performance and capability of the National Airspace System.

J.6 Ocean-Landing Only Alternative

Under the Ocean-Landing Only Alternative, construction would be the same as under the Proposed Action (except that a landing pad would not be built), and impacts to airspace would be the same. Operations would differ in that medium-lift class launch vehicle first-stage landings would not be conducted at Spaceport Camden. Temporary closures of airspace units would still be required to ensure safety during launches. However, landings would occur on a barge in the Atlantic Ocean located more than 300 miles from shore. Airspace over the open ocean is less heavily trafficked and, therefore, temporarily closing the airspace to traffic would be less impactful. Under the Ocean-Landing Only Alternative, airspace along the launch trajectory could, in theory, be reopened to traffic relatively soon after a launch.

J.7 No Action Alternative

Under the No Action Alternative, the FAA would not issue a Launch Site Operator License to Camden County. Under this alternative, the proposed construction would not occur and no additional flight activities would occur in the airspace above Spaceport Camden. As there would be no potential for additional obstructions and airspace use would not change, there would be no impacts to airspace management.