3.2 HYDROLOGY

3.2.1 Introduction

The affected environment for hydrology comprises both surface water and groundwater resources. Components of hydrology reviewed in this section include tides and currents, flows, precipitation, and soil characteristics that affect hydrology, land cover, and floodplains. The study area, depicted in Figure 1.6-1, lies on a peninsula of land formed by the Cooper River and Ashley River. The peninsula is crowned generally along the alignment of U.S. Highway 52 (Meeting Street) and U.S. Highway 78 (King Street Extension). A majority of the study area lies within the Cooper River watersheds, while the remainder lies within the Ashley River watersheds.

3.2.2 Tides and Currents

Natural water fluctuations in an aquatic ecosystem consist of daily, seasonal, and annual flood fluctuations in water level. The Charleston Harbor Estuary is a tidally driven system; as such, tides are the dominant mechanism that controls the movement of water between the Charleston Harbor and the Atlantic Ocean. The Charleston—SC Station (ID: 8665530), located on the Cooper River at the Port of Charleston, has a recorded mean tidal range of 5.22 feet and a diurnal range of 5.76 feet. On the Cooper River, tidal influence extends upstream as far as the Pinopolis Dam at Lake Moultrie. Attenuation of tidal influences begins at the confluence of the East and West branches of the Cooper River, approximately 20 river miles upstream from the study area.

The Cooper River has been subjected to extensive anthropogenic changes. Historically, the river was a tidal slough with limited freshwater inflow and extensive tidal marshes. In the eighteenth and nineteenth centuries, the construction of extensive dikes in fields along the banks of the Cooper River for rice cultivation altered the marsh hydrology and salinity. In 1941, the construction of the Santee-Cooper Hydro-Electric Project resulted in a major change to the flow regime of the Cooper River. The upstream construction of Lake Marion and Lake Moultrie, diversion of flow from the Santee River, and discharge of flow from the Pinopolis Dam into the West Branch of the Cooper River for hydro-electric generation altered the system from a tidal slough with a net discharge of approximately 70 cubic feet per second (ft^3/s) to a riverine system with an annual mean discharge of 15,000 ft^3/s. In 1985, extensive shoaling in the Charleston Harbor estuary attributed to the hydroelectric project was addressed via the Cooper River rediversion project, which redirected approximately 70 percent of the Santee River drainage water back into the Santee River, reducing the mean Cooper River flow to 4,500 ft^3/s. The United States Geological Survey (USGS) maintains a gage on the Cooper River at Filbin Creek near North Charleston (Station 021720677). The gage datum is 0 foot above NGVD29. Average gage height at this station is 10.5 feet, with extreme high and low measures of 15.53 feet and 4.51 feet observed over the period of record (1997 to present).

Average ebb currents measured at 9 NOAA buoy stations for the Cooper River from Filbin Creek to Drum Island range from 12.4 to 1.3 feet per second (fps); flood currents are generally slower. Within a river channel, currents are generally faster near the outside of meander bends. As such, current speeds would tend to be greater near the outlets of Filbin Creek, Noisette Creek, and Shipyard Creek, all of which empty into the Cooper River along the outside of meander bends.

3.2.3 Surface Water and Groundwater Flows

3.2.3.1 Stormwater Flows

The majority of stormwater flows east to the Cooper River, with a minor percentage flowing west to the Ashley River. Stormwater flows are further broken down into seven basins, with six of the basins leading to the Cooper River and one basin sloping toward the Ashley River (Figure 3.2-1). The majority of runoff in the vicinity of the study area finds its way to the Cooper River via overland flow and underground storm sewers. A portion of the runoff in the southernmost two stormwater basins is directed into Shipyard Creek, which then makes its way to the Cooper River.

At the northern portion of the study area, the River Center project site straddles two basins. Stormwater from the southern basin makes its way to the Cooper River via overland flow and underground storm sewers, while the northern basin directs its flow to the Cooper River via Noisette Creek.

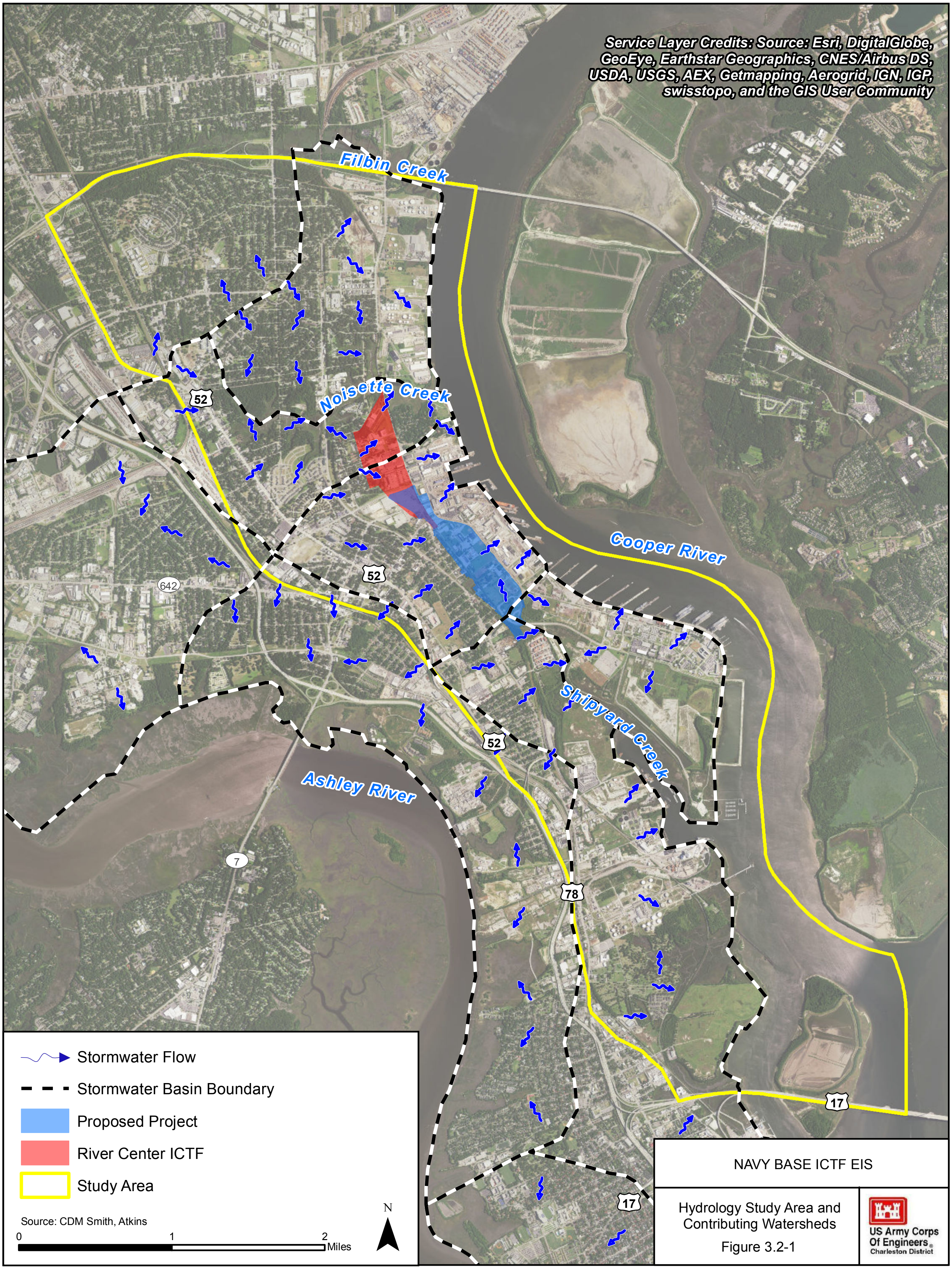
3.2.3.2 Groundwater Flows

Groundwater within the study area occurs in an unconfined aquifer within the Quaternary deposits, with the underlying Ashley Formation acting as a lower bounding unit. The unconfined aquifer varies in total thickness from about 15 to 35 feet. In light of the heterogeneity of the Quaternary deposits, the hydraulic properties of the shallow (surficial) aquifer vary widely, depending on the location. Large variations in hydraulic conductivity result in variable groundwater flow rates and directions. Generally, the shallow groundwater flows toward the Cooper River and, to a lesser extent, toward Shipyard Creek and Noisette Creek (CH2M Hill 2011).

3.2.4 Precipitation

Average rate of precipitation reported by SCDNR for the City of Charleston for the period of record 1948 to 2005 is 45.99 inches annually (SCDNR 2014a). The wettest period of the year is June through September. August has the highest monthly rainfall (6.23 inches). The following Table 3.2-1 provides a monthly breakdown.[51]

[51] As there are no reporting stations within the City of North Charleston, precipitation data was used from stations associated with the City of Charleston.



NAVY BASE ICTF EIS

Hydrology Study Area and Contributing Watersheds

Figure 3.2-1

Table 3.2-1
Average Precipitation Rates

Average Precipi-tation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Total (in.)	2.98	2.79	3.85	2.45	3.09	5.03	6.04	6.23	5.68	3.13	2.07	2.66	45.99
Snowfall (in.)	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Snow Depth (in.)	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: SCDNR 2014a.

3.2.5 Soil Characteristics Affecting Hydrology

According to the NRCS, the soils in the study area are classified as Urban Land (UR) and are comprised of the Yauhannah-Yemassee-Ogeechee association (see Section 3.1 – Geology and Soils). Soils are characterized primarily by loamy marine sediments with slopes ranging from 0 to 6 percent (Table 3.2-2). According to the NRCS, slopes within the limits of the study area are expected to occur on terraces and broad flats of the lower Coastal Plain. Available topography indicates elevations for the Project site range from elevation 15 to elevation 5 and for the River Center project site from elevation 32 to elevation 5 (USGS 2011). Groundwater depths are close to or above the surface at +1.0 to 2.5 feet. Slow runoff rates, poor to moderately well-drained soils, and soils with moderate permeability, are expected within the study area. The hydrologic soil group is B, with moderate infiltration rates (NRCS 2014a).

Soil characteristics affecting hydrology (by soil series) are presented in Table 3.2-2.

Table 3.2-2
Soil Characteristics That Affect Hydrology

Soil Series	Soil Texture	Slopes	Groundwater depth from soil surface (ft)	Permeability
Ogeechee	Loamy, fluvial, and marine sediments	0 to 2%	+1.0 to 1.0	Slow runoff, poorly drained, moderately permeable
Yauhannah	Loamy marine sediments	0 to 6%	1.5 to 2.5	Slow runoff, moderately well drained
Yemassee	Loamy marine sediments	0 to 2%	1.0 to 1.5	Slow runoff, somewhat poorly drained, moderately permeable

Source: NRCS 2014a.

3.2.6 Land Cover

Existing land cover provides a representation of cover type. For purposes of hydrologic analysis, land cover is presented as average percent of impervious cover and is defined by the major land use types considering vegetated, cleared, and impervious surfaces. Measurements were made by visual interpretation of aerial photography. A review of the City of North Charleston's Zoning Map provided the maximum allowable impervious surface for a particular area.

3.2.6.1 Land Cover as Defined by Municipal Zoning

The zoning map for the City of North Charleston defines the zoning districts for the Project site and the River Center project site; however, the zoning guidance did not provide guidelines on percent impervious cover by land use. Utilizing the USDA Urban Hydrology for Small Watersheds, Technical Release 55, June 1986 (TR-55) guidance, the average percent of maximum allowable impervious cover by land use has been identified for each zoning district. Using a composite for the average percent of maximum allowable impervious cover by zoning district, Table 3.2-3 identifies the maximum allowable impervious cover for the Project site and River Center project site.

For the Project site, there is a maximum allowable average percent impervious cover of 73 percent, whereas the River Center project site's maximum allowable impervious cover is 82 percent. The River Center project site's impervious cover is higher, because the Planned Development District (PDD) allows for a broader range of land uses, including commercial and business use, which have higher rates of impervious cover than industrial.

Table 3.2-3
Maximum Allowable Percent Impervious Cover by Zoning District and Site

Site	Zoning district[1]	% of total site	Percent impervious cover by land use (TR-55) [2]	Average percent impervious cover by site
Proposed Project	M-2—Heavy industrial district	89%	72%	73%
	M-1—Light industrial district	2%	72%	
	PDD—Planned Development District	3%	85%	
	R-1-Single Family Residential district	3%	75%	
	R-2-Multifamily Residential district	3%	85%	
River Center	PDD—Planned Development District	80%	85%	82%
	M-2—Heavy industrial district	20%	72%	

Source: City of North Charleston 2014 (1); NRCS 1986 (2).

3.2.6.2 Land Cover as Defined by Aerial Photographic Interpretation

A visual interpretation of aerial photography for each of the project sites was used to estimate the existing average percent of impervious cover. At 40 percent, the Project site is significantly below the 73 percent threshold of maximum allowable percent of impervious cover, while the River Center project site is slightly above the 82 percent threshold with its estimated 85 impervious cover percentage Table 3.2-4).

Table 3.2-4
Average Percent Impervious
Cover by Visual Interpretation

Site	Percent impervious
Proposed Project	40%
River Center	85%

Source: Atkins 2016.

3.2.7 Floodplains

Floodplains are defined as the lowland and relatively flat areas adjoining inland and coastal waters, including flood-prone areas of offshore islands, and at a minimum, those that are subject to a 1 percent or greater chance of flooding in any given year (i.e., the area inundated by a 100-year flood). However, every frequency event has a floodplain and different associated areal extents. Flooding along the floodplains of the Cooper River is primarily from proximity to Charleston Harbor and the Atlantic Ocean. Coastal flooding is caused by extremely high tides and storm surges resulting from hurricanes or intense coastal storms such as nor'easters. The primary factors contributing to coastal flooding within the study area are the openness to Atlantic Ocean storm surges through Charleston Harbor and the wide entrances to the Cooper, Wando, and Ashley Rivers. In addition, the terrain is generally too low to provide an effective barrier to storm surge flooding. Although many segments of the Charleston Harbor are armored to prevent erosion, there are essentially no flood control structures in the low-lying topography surrounding the harbor to defend against major storm surge flooding (Corps 2006).

Riverine flooding in the floodplain of the Cooper River and its tributaries is associated with slow-moving frontal systems, thunderstorms, and tropical storms causing sheetflow, overflow of streams, and ponding. Riverine flooding is prevalent in many areas of Charleston County due to small natural channels, flat stream slopes, wide heavily vegetated floodplains in undeveloped areas, and inland tidal effects. Flooding in urban areas such as the City of Charleston and City of North Charleston typically results from less infiltration, quicker runoff response, and decreased storage (Corps 2006).

The Federal Emergency Management Agency (FEMA) summarizes historical flood events impacting the Charleston area in the current Flood Insurance Study (FIS) for Charleston County (FEMA 2017a). An example of historical hurricane-related flooding is Hurricane Hugo in 1989, which caused flood waters to rise more than 5 feet above normal conditions in Charleston Harbor (FEMA 2017a).

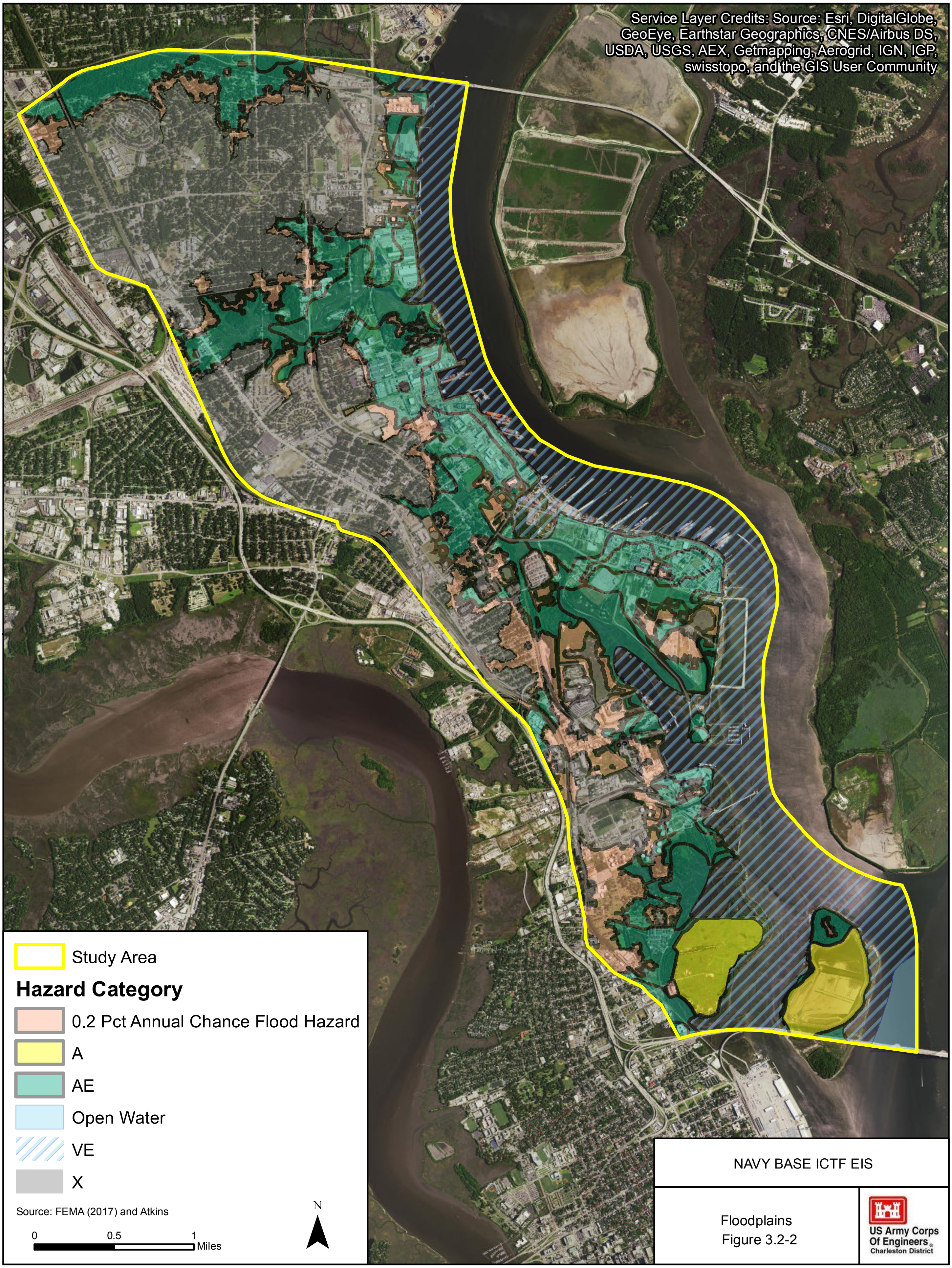
The results of the FIS are presented on a map, referred to as a Flood Insurance Rate Map (FIRM), and presented in the FIS report in a narrative and graphically as flood profiles. The 100-year floodplain is referred to as the Special Flood Hazard Area (SFHA). FEMA determines the SFHA, shown on the FIRMs as A Zones or V Zones, from information obtained through consultation with the community, and from floodplain topographic surveys, detailed hydrologic and hydraulic analyses, and historic records. FEMA uses commonly accepted computer models and engineering methods that estimate hydrologic and hydraulic conditions to determine the 1 percent annual-chance flood, to determine Base Flood Elevations (BFEs), and to designate flood-risk zones. A BFE is the height of the base flood, usually in feet, in relation to the National Geodetic Vertical Datum of 1929 (NGVD29), the North American Vertical Datum of 1988 (NAVD88), other datum referenced in the FIS report, or average depth of the base flood, usually in feet, above the ground surface (FEMA 2017a).

Along rivers, streams, and lakes within the United States, FEMA computes flood elevations using computer models, statistical techniques, or both. These elevations are a function of the amount of water expected to enter a particular system by means of precipitation and runoff. The SFHAs in riverine areas are primarily identified as “A Zones” on the FIRM (FEMA 2017b).

Along the coast, FEMA determines SFHAs by an analysis of storm surge, wind direction and speed, wave heights, and other factors. FEMA designates these areas along the coast as both V Zones and A Zones on the FIRM. V Zones are the more hazardous coastal flood zones because they are subject to high velocity wave action. FEMA applies the V Zone designation to those areas along the coast where water depth and other conditions would support at least a three-foot wave height. FEMA usually designates A Zones in coastal areas landward of the V Zone. Coastal flood hazard areas mapped as A Zones can be subject to storm surge and damaging waves; however, the waves are less than 3 feet in height (FEMA 2017a).

Figure 3.2-2 shows the regional floodplains in the North Charleston area and within the study area. The floodplain boundaries for the 100- and 500-year storm events were obtained from FEMA Q3 Flood Data for Georgia and South Carolina in digital format, and verified with FIRMs for Berkeley County and Charleston County, and the incorporated towns and cities in the two counties, published by FEMA. Definitions for zones shown in Figure 3.2-2 are as follows (FEMA 2017c):

> **Zone A.** Areas subject to inundation by the 1 percent annual-chance flood event generally determined using approximate methodologies. Because detailed hydraulic analyses have not been performed, no BFEs or flood depths are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply.
>
> **Zone AE**. Zone AE is the flood insurance rate zone that corresponds to the 100-year floodplain or areas subject to inundation by the 1 percent annual-chance flood event that is determined in the FIS by detailed methods, which typically involve the use of engineering models. In most instances, BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements and floodplain management standards apply.


Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Study Area
Hazard Category
0.2 Pct Annual Chance Flood Hazard
A
AE
Open Water
VE
X
Source: FEMA (2017) and Atkins
0
0.5
1
Miles
N
NAVY BASE ICTF EIS
Floodplains
Figure 3.2-2
US Army Corps Of Engineers
Charleston District

Zone VE. VE Zones are coastal high-hazard areas where wave action and/or high-velocity water can cause structural damage during the 100-year flood. BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements and floodplain management standards apply.

0.2 Percent Annual Chance Flood Hazard. Also known as the 500-year flood. These areas are not within SFHAs.

Zone X. Zone X is the flood insurance rate zone that corresponds to areas outside the 500-year floodplains. No base flood elevations or depths are shown within this zone.

For the Charleston FIS, water surface elevations for the 100-year flood were computed from numerical models that simulate storm surge coupled with statistical analyses of the probable chance of occurrence. Summaries of the hydraulic analyses conducted for Charleston County are provided in their respective FISs. Final flood zone boundary determinations and delineations are typically rounded to the nearest foot published on the FIRM (FEMA 2017b).

North Charleston has floodplains along the Ashley River, the Cooper River, and the creeks that flow into these rivers. As shown on Figure 3.2-2, the majority of the study area is within the 100-year and 500-year floodplains. Approximately 3.7 percent of the study area is located in zone A, 27.0 percent is located in flood zone AE with a BFE of 13 feet (NGVD29), 23.6 percent is located in zone VE, 0.9 percent is open water and 13.3 percent is located in the 0.2 percent annual chance (500-year) flood hazard. The remaining 31.5 percent is in an X zone with no BFE (i.e., it is outside/above the 500-year floodplain) (Table 3.2-5). At flows associated with the 100-year flood, the water surface elevation of the Cooper River is estimated to be 12 feet (NGVD29) in the study area, with maximum wave crest elevations between 14 and 16 feet (FEMA 2017b).

Table 3.2-5
FEMA Zone Areas Within the Study Area

FEMA Zones	SFHA (Yes or No)	Base Flood Elevation (ft, NAVD88)	Area (acres)	Percent Area
A	Yes	-	296.5	3.7%
AE	Yes	12–14	2,164.7	27.0%
VE	Yes	14–17	1,897.0	23.6%
Open Water	-	-	71.5	0.9%
0.2 Percent Annual Chance (500-year) Flood Hazard	No	-	1,064.4	13.3%
X	No	-	2,531.4	31.5%

Source: FEMA 2017a, b.