ENCLOSURE 2

TRISO-X ENVIRONMENTAL REPORT
CHAPTER 3
PART 2 OF 3 (363 MB)

NON-PROPRIETARY

CHAPTER 3

DESCRIPTION OF THE AFFECTED ENVIRONMENT

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
ac.	acre
ACS	American Community Survey
AGL	above ground level
AMO	Atlantic multi-decadal oscillation
ASCE/SEI	American Society of Civil Engineers/Structural Engineering Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
ARAP	Aquatic Resource Alteration Permit
APE	Area of Potential Effects
ASOS	Automated surface (weather) observing station
ATTD	Atmospheric Turbulence and Diffusion Division (managed by the National Oceanic and Atmospheric Administration [NOAA])
bgs	below ground surface
BLM	Bureau of Land Management
BLS	Bureau of Labor Statistics
C	degrees Celsius
CalEPA	California Environmental Protection Agency
CBG	census block groups
CEUS SSC	Central and Eastern U.S. Seismic Source Characterization for Nuclear Facilities
CFR	Code of Federal Regulations
Chi/Q (X/Q)	Relative atmospheric concentration
cm	centimeter
CMA	Cooperative Management Area
cm/sec	centimeters per second
CNS	Consolidated Nuclear Security, LLC
COOP	Cooperative weather observing station

Acronym/Abbreviation	Definition
CROET	Community Reuse Organization of East Tennessee
Cs	Colbert silty clay loam
CSXT	CSX Transportation
CWA	Clean Water Act
dBA	A-weighted decibel
DBT	Dry bulb temperature
Delta-T	Vertical temperature difference
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DVFC	Dandridge-Vonore Fault Corridor
EA	Environmental Assessment
ECHO	Enforcement and Compliance History Online
EF-scale	Enhanced Fujita tornado intensity scale
EFPC	East Fork Poplar Creek
ENSO	El Niño – Southern Oscillation
EPRI	Electric Power Research Institute
ESA	Endangered Species Act
ETTP	East Tennessee Technology Park
ETSZ	East Tennessee Seismic Zone
FAA	Federal Aviation Administration
°F	degrees Fahrenheit
Fc	Fullerton cherty silt loam
Fcl	Fullerton cherty silt loam, hilly phase
FIRM	Flood Insurance Rate Map
F-scale	Fujita tornado intensity scale
FR	Federal Register
ft.	feet
ft/d	feet per day
gpm	Gallons per minute
Gs	Greendale silt loam

Acronym/Abbreviation	Definition
HA	Habitat Area
ha	hectare
HCS	Horizon Center site
HFIR	High Flux Isotope Reactor
HHE	Health Hazard Evaluation
IAEA	International Atomic Energy Agency
IPaC	Information for Planning and Consultation website (USFWS)
HCS	Horizon Center site
in.	inch
IND-2	general industrial district
IND-3	heavy industrial district
I-40	Interstate 40
I-75	Interstate 75
JFD	Joint frequency distribution
kg	kilograms
km	kilometer
KOQT	Station identifier for the ASOS in Oak Ridge, Tennessee
KTYS	Station identifier for the ASOS at the McGhee Tyson airport in Knoxville, Tennessee
L_{dn}	day-night average community noise level
L_{eq}	equivalent noise level
LCD	Local climatological data
lpm	liters per minute
M	Magnitude
m	meter
M_{max}	Magnitude of the largest possible earthquake
M_w	Moment magnitude
MCL	Maximum contaminant level
MCWB	mean coincident wet bulb temperature

Acronym/Abbreviation	Definition
m/d	meters per day
MGD	million gallons per day
mg/L	milligrams per liter
µg/L	micrograms per liter
MHP	Master of Historic Preservation
Mi	Melvin silt loam
mi.	miles
MMI	Modified Mercalli Intensity
mph	miles per hour
mpn/mL	most probable number per milliliter
mrem/yr	millirem per year
m/s	meters per second
m^3/s	cubic meters per second
MSL	Mean sea level
mSv/yr	millisievert per year
MWt	Megawatts thermal
NA	Natural Area
NAAQS	National Ambient Air Quality Standard
NAVD88	North American vertical datum of 1988
NCEI	National Centers for Environmental Information (formerly known as the National Climatic Data Center [NCDC])
NFIP	National Flood Insurance Program
NIOSH	National Institute for Occupational Safety and Health
NLCD	National Landcover Database
NNSA	National Nuclear Security Administration
NOAA	National Oceanic and Atmospheric Administration
NPDWR	National Primary Drinking Water Regulations
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NM	noise monitoring location

Acronym/Abbreviation	Definition
NMSS	Nuclear Material Safety and Safeguards
NWI	National Wetland Inventory
NWS	National Weather Service
ORED	Oak Ridge Electric Department
OREIS	Oak Ridge Environmental Information System
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OSMRE	Office of Surface Mining Reclamation and Enforcement, U.S. Department of the Interior
PCBs	polychlorinated biphenyls
PDO	Pacific decadal oscillation
PH	Potential Habitat
RA	Reference Area
RCP	Reinforced concrete pipes
RCRA	Resource Conservation and Recovery Act
RLME	repeated large magnitude earthquake
RsC	Rolling Stony Land (Colbert and Talbott soil materials)
ROI	region of influence
SODAR	Sound detection and ranging
STP	soil test pit
sq. mi.	Square miles
TCA	Tennessee Code Annotated
TD-3505	A meteorological data archiving format
TDA	Tennessee Department of Agriculture
TDEC	Tennessee Department of Environment and Conservation
TDF	Tennessee Division of Forestry, Tennessee Department of Agriculture
TDOA	Tennessee Division of Archaeology
TDOT	Tennessee Department of Transportation

Acronym/Abbreviation	Definition
THC	Tennessee Historical Commission
THC GIS	Tennessee Historical Commission Geographic Information System
TMDL	Total Maximum Daily Load
TN SHPO	Tennessee State Historic Preservation Office
TOC	Top of casing
TGS	Tennessee Geological Survey
TRISO-X FFF	TRISO-X Fuel Fabrication Facility
Ts	Talbott silty clay loam
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
UF_6	Uranium hexafluoride
USACE	U.S. Army Corps of Engineers
USC	United States Code
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USNRC	U.S. Nuclear Regulatory Commission
VRM	Visual Resource Management
WBNP	Watts Bar Nuclear Plant
WBT	wet bulb temperature
WOTUS	Waters of the United States
Y-12	Y-12 National Security Complex

CHAPTER 3

Description of the Affected Environment

3.1 LAND USE

This section describes the characteristics of the land use of the Horizon Center site (HCS) vicinity and region. This section provides input to various other sections including, but not limited to, Sections 4.1, Land Use Impacts; 4.4, Water Resources Impacts; 4.12, Public and Occupational Health Impacts; and 6, Environmental Measurements and Monitoring Program.

3.1.1 SITE

The HCS (Figure 3.1-1) is located on undeveloped land currently owned TRISO-X, LLC west of Oak Ridge, Tennessee in Roane County. The HCS is an existing City of Oak Ridge industrial park that was formerly part of the U.S. Department of Energy (DOE) reservation but was never developed. DOE transferred the ownership of this site to Horizon Center in 2003 and subsequently Horizon Center transferred it to the Oak Ridge Industrial Board in 2005.

The previously disturbed greenfield site is dedicated for industrial development and consists of four separate development areas. Development Area 6a, has been identified as the preferred site for the proposed TRISO-X Fuel Fabrication Facility (TRISO-X FFF). Figure 3.1-8 shows the current zoning categories for the development areas.

3.1.2 REGION

The region in which the TRISO-X FFF is located is defined as the area within a 5.38-mi. (8.66-km) radius of the center point of the HCS (Figure 3.1-2). Most of the region is located in Roane County, Tennessee. Smaller parts of the region also touch Loudon, Anderson, and Morgan Counties.

Major land uses within the region are depicted in Figure 3.1-3 and are listed in Table 3.1-1. The dominant land uses in the region are forestlands (37,242 ac. [15,071 ha], 64 percent), developed lands (9767 ac. [3953 ha], 17 percent), agriculture (7347 ac. [2973 ha], 13 percent), and waters or wetlands (2674 ac. [1082 ha], 5 percent).

3.1.3 MAJOR POPULATION CENTERS AND INFRASTRUCTURE

The population centers located in and near the HCS region are shown on Figure 3.1-4. The major population center in the region, is the City of Oak Ridge with a population greater than 25,000. Smaller population centers in the region are shown on Figure 3.1-2 and include the town of Oliver Springs and populated places of Union, Clacks Gap, Oak Hill Estates, Scandlyn, and Allingham. Section 3.10 provides a description of the demographic, economic and community characteristics of population centers within the socioeconomic Region of Influence (ROI).

Existing infrastructure located in and near the HCS region are also shown on Figure 3.1-4. Available utilities in City of Oak Ridge and at the HCS include electric service, potable water, gas, sewer, garbage collection, telephone, cable, and internet service (Oak Ridge, 2021).

The major transportation corridors within the region are described in detail in Section 3.2, Transportation. Transportation infrastructure near the site includes the TN 95 — Oak Ridge Turnpike, two interstate highways — Interstate 75 and Interstate 40 — and several Tennessee State highways, and local roads.

CSX Transportation (CSXT) Class I Railroad provides freight rail service in Anderson County. A CSX Operating Agreement extends service into Roane County, along State Route 61, with a mainline extension to the East Tennessee Technology Park (ETTP), adjacent to State Route 327.

The McGhee Tyson Airport is a public/military airport located south of Knoxville. The nearest private airport is the Oliver Springs Airport (Figure 3.1-4).

The Clinch River flows through the HCS Region, downstream of the Melton Hill Dam. The Clinch River is a component of the navigable river channels on the Cumberland and Tennessee Rivers, and is part of the U.S. Inland Waterway System (USACE, 2021).

3.1.4 SPECIAL LAND USES

3.1.4.1 DOE Oak Ridge Reservation

The Oak Ridge Reservation (ORR) is situated in and near to the City of Oak Ridge. ORR covers 52 sq. mi. (134.7 km^2) of land in Anderson and Roane counties. The DOE operates three sites on the reservation: the ETTP, formerly known as the K-25 Site, the Oak Ridge National Laboratory (ORNL), and the Y-12 National Security Complex (DOE-ORR, 2021). The three sites are government-owned, contractor-operated facilities; under DOE guidance, private companies manage the day-to-day operations of the sites according to Federal laws, DOE orders, and State laws and regulations.

Government-sponsored activities in Oak Ridge date back to the Manhattan Project and continue to the current day. Both past and current activities involve hazardous chemicals and radioactive materials. The Manhattan Project National Historical Park protects many structures associated with the Manhattan Project including ones on the ORR as shown in Figure 3.1-5.

The Y-12 National Security Complex (Y-12) is located approximately 5 mi. (8 km) from the HCS. Y-12 is operated by Consolidated Nuclear Security, LLC (CNS) for the National Nuclear Security Administration (NNSA). Primary activities at Y-12 include processing, retrieval, and storage of nuclear materials; dismantling nuclear weapons; providing fuels to the nation’s naval reactors; and performing complementary work for other government and private-sector entities.

3.1.4.2 Other Land Uses

Other special land uses in the vicinity of the HCS include the following facilities:

- U.S. DOE natural areas (Figure 2.1-1)
- Campbell Bend Barrens and Crowder Cemetery State Natural Areas (Figure 3.1-5)
- North Boundary Greenway (Figure 3.1-6)
- McKamey and Carmichael Cemetery (Figure 3.1-6)

3.1.5 AGRICULTURAL RESOURCES AND FACILITIES

According to the U.S. Department of Agriculture (USDA), there are approximately 69,500 farms in Tennessee, comprising approximately 10,800,000 ac. (4,411,100 ha), producing a variety of crops and livestock (USDA/NASS, 2020). Tennessee also produces a variety of forest products (USFS, 2009).

3.1.5.1 Farming

A breakdown of prime farmland data for the HCS Region is provided in Table 3.1-2 and Figure 3.1-7. The USDA Natural Resource Conservation Service (NRCS) soil survey data are not available for Federal land, which comprises over one third of the HCS region. However, a previous DOE Environmental Assessment (EA) did identify soils indicative of prime farmland at the HCS, but did not specify the acreage (DOE, 1996). Based on the distribution of prime farmland in the region, the available soil survey data, and the analysis in the DOE EA, it is estimated that 13 percent of the soils in the HCS region are designated prime farmland.

In Roane County, there are 617 farms, comprising over 47,000 ac. (19,020 ha) with an average size of 77 ac. (31.2 ha). Land in farms consists of cropland (32 percent), pastureland (27 percent), woodland (35 percent), and other (5 percent) (USDA, 2017). Only 37 ac. (14.9 ha) of Roane County farmland is irrigated (USDA, 2017). The major crops include forage (hay/haylage), 10,493 ac. (4246 ha), corn for grain, 128 ac. (51.8 ha), vegetables harvested, 80 ac. (32.4 ha), sweet corn 31 ac. (12.5 ha), and berries, 20 ac. (8.1 ha). The majority of the livestock inventory consists of cattle and layers (i.e., egg-producing poultry). Other livestock includes broilers and other meat-type chickens, goats, hogs, pigs, horses, ponies, pullets, sheep, lambs, and turkeys (USDA, 2017).

3.1.5.2 Forestry

According to the Directory of Tennessee's Forest Industries, which is published by the Tennessee Division of Forestry (TDF) of the Department of Agriculture, in cooperation with the TVA and the USDA Forest Service, wood consuming industries in or near the Region include two secondary mills located in Roane County. The secondary mills process primary materials, such as hardwood lumber or paper, into other products, including furniture from hardwood lumber.

3.1.6 MINERAL RESOURCES

According to the Tennessee Geological Survey (TGS), which is part of the Tennessee Department of Environment and Conservation (TDEC), the State has a history of mining more varieties of mineral resources than any other State east of the Mississippi River, except North Carolina, dating back to the late 18th century (TGS, 2020). Tennessee's non-fuel mineral production includes Portland cement, sand and gravel, stone, zinc, and ball clay (TGS, 2020). Non-fuel mineral products valued at more than $1.5 billion were produced in 2018, creating more than 48,600 jobs and direct and indirect economic impacts of $3.8 billion. (TGS, 2020). Tennessee also has coal, oil, natural gas, oil shale, and radioactive minerals deposits. Only coal, oil, and natural gas are currently being recovered, with a total production value in 2018 of $44.8 million (TGS, 2020).

3.1.6.1 Non-Fuel Mineral Production

The HCS region is an area capable of producing crushed stone, however, there are no producers within the Region. (USGS, 2019).

3.1.6.2 Coal, Oil and Gas

Current coal production includes bituminous coal from 22 counties in the Cumberland Plateau and Cumberland Mountains regions, which includes a slight portion of western Roane County (TGS, 2020; OSMRE, 2019). There is currently no coal, oil, or gas production in the HCS site Region (EIA, 2020).

3.1.7 LAND USE PLANS

Current and future land use plans for the HCS are represented by the Horizon Center Development Plan (HDC, 2001). The Horizon Center is planned to accommodate the development of approximately four million square feet of manufacturing, research and development, distribution, office, and support facilities. Objectives of the Development Plan include the efficient allocation of useable land for buildings, parking, vehicular circulation (auto, truck, and rail), utilities, and employee amenities. Phase One of the plan included the development of on-site and off-site infrastructure for Development Areas 1, 2 and 3 which are designated to provide access to support development throughout the Horizon Center.

Development within the City of Oak Ridge is characterized in the City of Oak Ridge City Blueprint (COR, 2019). The Blueprint is a “living” plan to guide the Oak Ridge City Council and Planning Commission in their efforts to encourage and maintain quality community growth and development in Oak Ridge. The blueprint identifies various elements for meeting citywide objectives which include economic vitality and sustainable growth, housing and healthy neighborhoods, recreation and natural assets, land use and infrastructure, transportation and mobility and livability and community vibrancy. The Blueprint anticipates new development at the HCS, and projects increased worker and resident population and demand for public services and infrastructure. Additionally, the blueprint identifies the North Boundary Greenway, which borders the HCS to the northwest, with main public access from the west guard house on the TN 95 — Oak Ridge Turnpike as a facility which supports the objective of maintaining recreation and natural assets.

3.1.8 ZONING

As discussed in Chapter 1, the City of Oak Ridge has zoned the HCS (and all other development areas at the Horizon Center industrial park) as a general industrial district, IND-2 (Figure 3.1.8). As defined in the City of Oak Ridge Zoning Ordinance, Article VIII, Section 8.02, the IND-2, general industrial district is established to provide areas in which the principal use of land is for processing, manufacturing, assembling, fabrication, and warehousing. The IND-2 district provides for enterprises in which goods are generally mass-produced from raw materials on a large scale through use of an assembly line or similar process, usually for sale to wholesalers or other industrial or manufacturing uses (COR, 2010). However, the HCS requires rezoning as IND-3 (heavy industrial district). This classification covers manufacturing facilities that have a greater impact on the surrounding area than industries found in the IND-2 (general industrial district), including the involvement of radioactive materials.

Section 3.1.1 states that the development areas at the Horizon Center industrial park are separated by dedicated green belts. These areas are zoned as Greenbelt Districts by the City of Oak Ridge. The stated purpose of the Greenbelt District is to provide for certain publicly held property to be preserved in its natural state as much as possible.

In addition to zoning restrictions and regulations, the Oak Ridge Industrial Development Board executed a Declaration of Covenants, Conditions, and Restrictions for the Horizon Center industrial park. This document expands the definition of natural area to include land within the 100-year flood plain of the East Fork Poplar Creek or a buffer area of 100 feet on either side of the centerline of the East Fork Poplar Creek and its tributaries. In addition, land lying between road rights-of-way or land areas designated for development and the boundary of the 100-year flood plain or the 100-foot buffer areas are also defined as Natural Area. Article V, 5.3.2 also includes protection of Indiana bat habitat through retaining live or dead trees with exfoliating bark whenever possible. Cutting of those trees is not permitted between April 15 and September 15 unless coordinated with the U.S. Fish and Wildlife Service (ORIDB, 2013).

Table 3.1-1
Regional Land Use

NLCD Land Cover Class	Area (ac)	Area (%)
Deciduous Forest	30,827	52.97
Hay/Pasture	7347	12.62
Mixed Forest	5041	8.66
Developed, Open Space	3899	6.70
Developed, Low Intensity	3187	5.48
Developed, Medium Intensity	1769	3.04
Woody Wetlands	1621	2.78
Evergreen Forest	1373	2.36
Open Water	1013	1.74
Developed, High Intensity	913	1.57
Shrub/Scrub	635	1.09
Herbaceous	465	0.80
Barren Land	66	0.11
Emergent Herbaceous Wetlands	40	0.07
Total	**58,196**	**100.00%**

Source: Dewitz and USGS, 2019

Table 3.1-2
Prime Farmland in the Region

Farm Class	Acres	Percent
All areas are prime farmland	7225	12.4
Not prime farmland	50,803	87.3
Prime farmland if drained	21	0.035
Prime farmland if protected from flooding or not frequently flooded during the growing season	147	0.25
Total	**58,196**	**100**

Source: NRCS, 2021

3.2 TRANSPORTATION

3.2.1 ACCESS TRANSPORTATION

This section describes transportation facilities at or near the Horizon Center site (HCS). This section provides input into other sections such as 4.2, “Transportation Impacts” and 4.6, “Air Quality Impacts” and includes information on access to and from the HCS and proposed transportation routes.

3.2.2 TRANSPORTATION ROUTES

The TRISO-X Fuel Fabrication Facility (TRISO-X FFF) is located at the HCS in Roane County in the City of Oak Ridge, Tennessee. Tennessee State Route 95 (TN 95 — Oak Ridge Turnpike) is a multi-lane State highway connecting Oak Ridge to Interstates 40 at an interchange southeast of the HCS (Figure 3.2-1). Interstate 75 is a north-south oriented highway passing through eastern Tennessee. Interstate 40 (I-40) is an east-west oriented highway crossing Tennessee. Interstates 40 and 75 interchange in two locations: in Knoxville, Tennessee, for I-75 northbound into Kentucky, and north of Lenoir City for I-75 southbound toward Chattanooga, approximately 9 mi. (14.4 km) southeast of the HCS. State Route 58 is a north–south state highway that serves as a major route for many communities in Roane, Meigs, and Hamilton counties. SR 58 joins I-40 for part of its route in Roane County, from the Kingston exit (352) east to the Oak Ridge exit (356) west of Oak Ridge.

The closest public airport to Oak Ridge and the HCS is the McGhee Tyson airport located approximately 23.5 mi. (37.9 km) southeast of the HCS. The Oliver Springs Airport is a small private airport 6.2 mi. (10 km) to the northeast of the HCS.

CSX Transportation (CSXT) provides industrial rail services to Oak Ridge via a line from Cincinnati, Ohio to Atlanta, Georgia (CSXT, 2015).

The Clinch River borders the southern portion of the HCS Region, approximately 3 mi. (4.8 km) away at its closest point, on the other side of the East Tennessee Technology Park (ETTP). Portions of the Clinch River are used for industry and recreation around Oak Ridge.

The primary access to the HCS is from the TN 95 — Oak Ridge Turnpike to Novus Drive (Figure 3.2-2). The intersection is located approximately 0.4 mi. (0.6 km) southeast of the proposed entrance to the TRISO-X FFF. A secondary access route to the TRISO-X FFF is from the TN 95 — Oak Ridge Turnpike to Imperium Drive intersection, 0.65 mi. (1 km) northeast of the Novus Drive intersection (Figure 3.2-2).

These access routes are available to move construction materials and workers to and from the HCS. The closest vertical height, width or weight restriction is an axle weight restriction for Interstate 40 in the vicinity of U.S. Route 27, approximately 12.7 mi. (20.4 km) to the west of the HCS. Traffic counts from the most recent available 5-year period along routes to and from the HCS are provided in Table 3.2-1. Annual Average Daily Traffic counts provide traffic volumes based on a 24-hour, two-directional count at a given location. Raw traffic data is mathematically adjusted for vehicle type, determined by an axle correction factor. The data is then statistically corrected by a seasonal variation factor that considers time of year and day of the week. (TDOT, 2022). The locations of the traffic counts are shown in Figure 3.2-3. Additionally, a traffic study is being conducted, as required by the City of Oak Ridge. TRISO-X will abide by the results and any recommendations from the study.

Table 3.2-1
Average Annual Daily Traffic Counts (2016 – 2020)

Location	TNDOT Identifier	2016	2017	2018	2019	2020
Oak Ridge Turnpike (SR 95)	73000059	10,890	10,428	11,486	11,593	13,635
WIPP Road (SR 95)	73000058	5043	5066	5830	6234	7453
Oak Ridge Turnpike (SR 95)	73000060	11,531	11,806	12,641	12,560	14,944
Gallagher Road East of Kingston (SR 58)	73000061	11,231	11,296	10,290	12,270	12,924
Blair Road North of SR 95	73000174	2131	2152	2485	2985	3358

Source: TDOT, Transportation Data Management System, 2021

3.3 GEOLOGY AND SOILS

3.3.1 REGIONAL GEOLOGY AND PHYSIOGRAPHY

The geologic region for the TRISO-X Fuel Fabrication Facility (TRISO-X FFF) is defined as the area within a 100-mi. (161-km) radius of the Horizon Center site (HCS) (Figure 3.3.1-1). The geologic region of the HCS includes the following five physiographic provinces, listed from west to east:

- Interior Low Plateaus Province.
- Appalachian Plateaus Province.
- Valley and Ridge Province, which contains the HCS.
- Blue Ridge Province.
- Piedmont Province.

Each of these physiographic provinces is described below in terms of its physiography and geomorphology. A more detailed discussion is provided for the Valley and Ridge Province, in which the HCS is located.

3.3.1.1 Interior Low Plateaus Province

An eastern part of the Interior Low Plateaus Province is situated within the western portion of the HCS region radius. The Interior Low Plateaus exist at the southeastern extent of the Central Lowlands, the boundary between the Interior Low Plateaus and Central Lowlands provinces occurs where the maximum extent of Pleistocene glaciers reached. The Interior Low Plateaus consist almost completely of horizontal beds of Paleozoic sandstone, shale, and limestone. The entire province is divided northeast-southwest by a fold axis known as the Cincinnati Arch. The area is also home to two structural domes that have been eroded to form basins lined with inward-facing cuestas (NPS, 2021a).

The limestone of the province is marked by well-developed karst topography, including Mammoth Cave National Park. Mapping of Mammoth Cave is ongoing, but currently 480 km (300 mi.) of caverns are mapped, making it the longest cave system on earth. The caves are well decorated, with formations that include remarkable gypsum crystals and travertines and include great rooms and a large underground river (NPS, 2021a).

The Interior Low Plateaus are characterized by widespread but small-scale coal, petroleum, and natural gas mineral resources. In addition, fluorite (used in steel production) and phosphate are mined extensively in the region (NPS, 2021a).

3.3.1.2 Appalachian Plateaus Province

The Appalachian Plateaus physiographic province is bounded on the west by the Interior Low Plateaus and on the east by the Valley and Ridge Province. The Appalachian Plateaus form the northwestern-most province of the Appalachian Mountains, stretching from New York southwest to Alabama. The Appalachian Plateaus are composed of sedimentary rocks deposited during the late Paleozoic, including sandstones, conglomerates, and shales. These rocks exist largely

as horizontal beds that have been cut by streams to form the mountainous terrain that is distinctive today. Mountain ranges in the Appalachian Plateaus include the Catskill, Pocono, Allegheny, and Cumberland Mountains. In addition to these sedimentary rocks, beds of coal are locally significant throughout the Appalachian Plateaus, making this area the heart of the American coal industry. Much of this mining has been done underground in the past, but new technology allows entire areas of surface to be removed, exposing the coal beneath (NPS, 2021b).

The Appalachian Mountains as a whole have a long geologic history. In the early Paleozoic, the North American craton (what would eventually become North America) was located near the equator, and the eastern margin was often submerged beneath a shallow sea depositing carbonate and other sedimentary rocks. In the mid-Paleozoic, the supercontinent Pangea began to assemble as the oceanic plate slid underneath the eastern edge of the thick North American craton pulling with its islands, and eventually the continent Gondwana (Africa), to collide with North America. This collision folded and lifted the sedimentary rocks, creating the beginning of the Appalachian Mountains. As the mountains rose, streams cut through them, eroding and carrying sediments to be deposited in the neighboring lowlands. These sediments became the rocks that make up the Appalachian Plateaus. Throughout the Mesozoic, as the supercontinent Pangea broke up and drifted apart, the Appalachian Mountains (then at a height similar to today's Himalayas) slowly eroded (NPS, 2021b).

3.3.1.3 Blue Ridge Physiographic Province

The Blue Ridge Province is bounded on the northwest by the Valley and Ridge physiographic province and to the southeast by the Piedmont physiographic province. The Blue Ridge Province is a mountainous belt stretching from Pennsylvania southwest to Georgia. The mountains are made of highly deformed metamorphic rocks of largely Precambrian ages. These rocks include schists, gneisses, slates, and quartzites, which are extensively intruded by igneous bodies. To the west, the Blue Ridge Province is structurally divided from the Valley and Ridge Province by thrust faults that overlay in part the younger sedimentary rocks of the Valley and Ridge. In the north, the Blue Ridge is as narrow as 20 km (13 mi.) but increases in width and relief to the south, reaching 113 km (70 mi.) wide with peaks above 1,800 m (6,000 ft.). The Blue Ridge Province includes several mountain ranges, including the following (NPS, 2021c):

- Blue Ridge Range, which is a drainage divide between the Great Valley to the west and the Atlantic Ocean to the east.
- The Great Smoky Mountains along the Tennessee-North Carolina border.
- The Unaka and Cahutta Mountains.
- The Black Mountains, which include the highest peak in the eastern United States: Mt. Mitchell at 2037 m (6684 ft.).

3.3.1.4 Piedmont Province

The Piedmont Province is located southeast of the Blue Ridge Province and within the region that extends east and south of Dalton, Georgia. The Piedmont Province extends 1,600 km (1,000 mi.) from Alabama to southern New York and consists of highly complex metamorphic and igneous rocks that have been thoroughly weathered to produce a surface of minimum relief. The metamorphic rocks are primarily schist and gneiss, and the igneous rocks are granites,

commonly slightly metamorphosed. Structural basins, the result of horst-and-graben faulting, are filled with Mesozoic sediments and are commonly called “Triassic-Jurassic basins.” These land-derived sediments form sandstones and conglomerates and are host to features such as dinosaur prints, rain imprints, ripple marks, and plant and freshwater fish fossils. These Mesozoic rocks are interbedded with dark lavas in many cases (NPS, 2021d).

A few especially hard rocks have resisted erosion and exist as monadnocks throughout the Piedmont. Stone Mountain is a 380-m (750-ft.) dome of slightly metamorphosed intrusive igneous rock. Pine Mountain is a linear monadnock of quartzite in western Georgia, stretching nearly 100 km (60 mi.) and trending northeast-southwest. Graves Mountain is a significant location for mineral collection, including lazulite, gem-quality rutile, and kyanite. Beyond kyanite, the Piedmont is also a source of granite, granite-gneiss, and marble as building materials (NPS, 2021d).

3.3.1.5 Valley and Ridge Province

The HCS is located within the Valley and Ridge Province, a long, narrow belt trending northeast to southwest that is bordered on the west by the Appalachian Plateau and on the east by the Blue Ridge Province. The province is expansive and extends from Vermont to Alabama (NPS, 2021e) (Figure 3.3.1-2). This physiographic province consists of a series of northeast/southwest- trending synclines and anticlines composed of Early Paleozoic sedimentary rocks. Limestones and shales are more susceptible to erosion and make up much of the valleys, whereas more resistant sandstones and conglomerates form the ridges. Many of these folds are plunging, meaning that the axes (fold creases) are not horizontal but are tilted to the northeast or southwest (NPS, 2021e).

The general features that distinguish this province from adjacent areas are:

- Parallel ridges and valleys are commonly aligned from northeast to southwest.
- Topographic relief is caused by erosion of interstratified weak and strong formations that are exposed at the surface by exhumation of a relatively strongly folded and faulted terrain.
- Drainage networks comprise a few major transverse superimposed streams with subsequent streams forming a trellis-like drainage pattern (drainages are mostly dendritic in the headwaters with a trellis pattern downstream).
- Many ridges with accordant summit levels suggest a history of erosion.
- Many water and wind gaps occur through resistant ridges.

The southern section of the Valley and Ridge Province is similar to the northern section but differs from the northern section by exhibiting the following features (Hatcher et al., 1992):

- More exposed thrust faults
- Lower ridges
- More distinct longitudinal river systems

Drainage patterns in the Valley and Ridge Province generally follow the northeast-southwest trend of topography. However, segments of major rivers cut across the regional topographic alignment following deeply entrenched, ancient stream courses. These include the Powell, Clinch, Holston, and French Broad rivers that join to form the Tennessee River after flowing many miles in northeast/southwest-trending valleys (Hatcher et al., 1992).

3.3.1.6 Stratigraphy of Valley and Ridge Province

Stratigraphy of the Valley and Ridge Province is characterized by Hatcher et al. (1992) in conjunction with the Oak Ridge Reservation (ORR) (Figure 3.3.1-3). This stratigraphy formed as part of the early Paleozoic drift (ocean-opening) succession. The carbonate bank developed, then uplift and erosion of the carbonate bank occurred in early Middle Ordovician time (post-Knox unconformity). The carbonate bank was reestablished during the Middle Ordovician, then destroyed again during development of a clastic wedge in the Middle and Late Ordovician. The clastic wedge persisted into the Late Ordovician and Silurian. This was followed by erosion and formation of another unconformity, then by deposition of the Upper Devonian-Early Carboniferous clastic wedge (Hatcher et al., 1992).

The Rome Formation and the Conasauga, Knox, and Chickamauga Groups and associated formations comprise the majority of the underlying bedrock of the Valley and Ridge Province and are characterized below.

3.3.1.6.1 Rome Formation

The Rome Formation is the oldest rock unit exposed in the ORR and underlies Haw Ridge, Pine Ridge, and the valley and some small ridges northwest of Pine Ridge. From a distance, Rome topography is recognized by narrow, steep ridges broken by closely spaced wind and water gaps that give it a cockscomb appearance. The lower stratigraphic contact is not exposed in eastern Tennessee because it commonly is cut off by the basal decollement. The upper contact with the Pumpkin Valley Shale is located at the last thick sandstone bed below a consistent section of shale, thin sandstone, and siltstone of the Pumpkin Valley Formation. A thicker sequence of the Rome Formation is present within the Whiteoak Mountain thrust sheet than within the Copper Creek thrust sheet (Hatcher et al., 1992).

3.3.1.6.2 Conasauga Group

The Conasauga Group crops out throughout the southern Valley and Ridge Province but shows lithofacies transitions from clastics in the west to carbonates in the east. North-to-south changes in the amount of carbonate and clastic facies in the Conasauga Group have also been recognized. As reported in Hatcher, et al. (1992), the Conasauga Group is divided into three phases that occur in parallel, north/south- or northeast/southwest-trending belts. The phases are subparallel and cross-structural strike. The central phase consists of six formations that represent interfingering of carbonate and clastic facies. To the west of the ORR, most of the carbonate formations are absent and only two formations are recognized. To the northeast, in the eastern phase, the clastics are reduced in number and three formations can be identified. The ORR lies near the western margin of the central phase of the Conasauga Group, where the group consists primarily of calcareous shale interbedded with shaly to silty limestone. The average thickness of the Conasauga Group is 567 m (1860 ft.) in Melton Valley and 557 m (827 ft.) in Bear Creek Valley (Hatcher et al., 1992). Contributing formations with increasing depth include the Maynardsville Limestone, Nolichucky Shale, Dismal Gap Formation,

Rogersville Shale, Friendship Formation, and Pumpkin Valley Shale (Hatcher et al., 1992) (Figure 3.3.1-3).

3.3.1.6.3 Knox Group

Faunal evidence indicates that the age of the Knox Group is Late Cambrian and Early Ordovician. The Knox was deposited in a peritidal environment on the extensive Late Cambrian–Early Ordovician continental shelf. It forms the principal strong (competent) unit to support the folding and low-angle thrust faulting that occurs throughout the Valley and Ridge Province and the Cumberland Plateau. The Knox Group underlies Copper Ridge, Chestnut Ridge, Blackoak Ridge, and McKinney Ridge in the ORR. Surface differentiation of the Knox Group in the field is based primarily on the characteristics of weathered materials preserved in the residuum. The Knox Group in eastern Tennessee and adjacent States is divisible into the following five formations, listed from oldest (deepest) to most recent (shallowest) (see Figure 3.3.1-3):

- Cambrian Copper Ridge Dolomite
- Ordovician Chepultepec Dolomite
- Longview Dolomite
- Kingsport Formation
- Mascot Dolomite

Total thickness of the Knox Group ranges from approximately 700 to 1000 m (approximately 2000 to 3000 ft.) in eastern Tennessee with the Copper Ridge Dolomite making up roughly one-third of the total. (Hatcher et al., 1992).

3.3.1.6.4 Chickamauga Group

The Middle and Upper Ordovician Chickamauga Group in the vicinity of the ORR and the HCS represents deposition on the regionally extensive disconformity at the top of the Knox Group. The Chickamauga Group underlies East Fork Valley (Oak Ridge Valley) in the Kingston thrust sheet and Bethel Valley in the Whiteoak Mountain thrust sheet. The East Fork Valley is more relevant to the HCS and is therefore discussed herein.

The Chickamauga Supergroup in the Kingston thrust sheet of East Fork Valley (Oak Ridge Valley) consists almost entirely of limestone-dominated lithologies that include the Pond Spring Formation, Murfreesboro/Pierce Limestone, Cannon Limestone, Hermitage Formation, Carters Limestone, Lebanon Limestone, and Ridley Limestone (Figure 3.3.1-3). Thickness of these formations varies between 6 and 138 m (20 and 453 ft.) (Hatcher et al., 1992).

Formations that overly the Chickamauga Supergroup include the Fort Payne Formation (uppermost), Chattanooga Shale, Rockwood Formation, Sequatchie Formation, and Reedsville Shale (Figure 3.3.1-3).

3.3.2 KARST FEATURES

Karst is a unique hydrogeologic feature in which the surface water and groundwater regimes are highly interconnected and often constitute a single, dynamic flow system. The presence of karst usually is indicated by the occurrence of distinctive physiographic features that develop as a result of the dissolution of soluble bedrock, such as limestone or dolostone. In well-developed karst, these physiographic features may include sinkholes, sinking (or disappearing) streams, caves, and karst springs. The presence of karst is also generally associated with distinctive hydrologic characteristics (Taylor and Green, 2008):

- Internal drainage of surface runoff through sinkholes.
- Underground diversion or partial subsurface piracy of surface streams (that is, sinking streams and losing streams).
- Temporary storage of groundwater within a shallow, perched epikarst zone
- Rapid, turbulent flow through subsurface pipelike or channel-like solutional openings called conduits.
- Discharge of subsurface water from conduits by way of one or more large perennial springs.

According to the U.S. Geological Survey (USGS) (2008), the region containing the HCS may contain carbonate rocks that can become karstified. These folded and faulted carbonate rocks are Paleozoic in age and are subject to dissolution that may produce a range of features that include solution, collapse, cover-collapse sinkholes and caves.

The USGS further refines the definition of karst hydrogeology, explaining the formation and interconnected balance of these five general characteristics noted above. Karst hydrogeology is typified by a network of interconnected fissures, fractures and conduits emplaced in a relatively low-permeability rock matrix. Most of the groundwater flow and transport occurs through the network of openings, while most of the groundwater storage occurs in the matrix. As a result, most karst aquifers are highly heterogeneous and anisotropic (USGS, 2021b).

Karst features previously reported on lands adjacent to the HCS have included springs and sinkholes of various sizes (DOE, 2013). Based on the topography of the HCS, several shallow draws and depressions exist which may reveal karst features beneath the surface. One such feature is represented by a sinking stream within the western portion of the HCS that had been mapped by USGS as an intermittent stream but was not identified to be present in conjunction with the delineation of surface waters on the HCS (see Section 3.4.2). Karst features are caused by dissolution of carbonate rocks and deep weathering along prevailing fractures and strike-oriented bedding, creating conduits and voids (open and/or clay-filled). Voids within the dolomite and limestone bedrock were encountered during the geotechnical drilling program. Voids ranged from as thin as 0.2 ft. (0.1 m) to as much as 4.1 ft. (1.2 m) within all seven of the borings that penetrated and cored rock. A total of 21 voids were encountered. Occurrence of voids were primarily (15 of the 21 voids encountered) limited to the upper 25 ft. (7.6 m) below ground surface. These voids were found within limestone, limestone interbedded with shale, and dolomite. Additional investigation was performed to better characterize subsurface conditions within the TRISO-X FFF building footprints. An additional six borings were advanced. Voids ranged from as thin as 0.3 ft. (0.1 m) to as much as 3.8 ft. (1.2 m) within four of the six

borings. Occurrence of voids were limited to the upper 40 ft. (12.2 m) below ground surface. More details regarding these findings are provided in Section 3.3.3.

3.3.3 PHYSIOGRAPHY AND GEOLOGY IN THE VICINITY OF THE HORIZON CENTER SITE

The area of the HCS is located within the Valley and Ridge physiographic province. Several ridges, oriented northeast to southwest, form the undulating topography associated with the HCS. The site is underlain by bedrock associated with formations within the Knox and Chickamauga Groups. Each of the formations (as mapped) are oriented northeast to southwest and dip 30 degrees to 38 degrees southeast, consistent with the regional structural trends. Of the five dolomitic-dominated formations associated with the Knox Group (discussed in Section 3.3.1.6.3), the Kingsport formation and Mascot dolomite have been mapped across the northwest half of the HCS, with the Mascot most dominant (Figure 3.3.3-1). Of the seven limestone-dominated formations associated with the Chickamauga Group (discussed in Section 3.3.1.6.4), only four have been mapped within the HCS. The Pond Springs formation is the most dominant, with the largest distribution across the site. To a lesser extent, the Murfreesboro/Pierce, Lebanon, and Ridley limestones are also present near the surface (Figure 3.3.3-1), with possible exposure aligned along the southeast side of the HCS.

Formations likely to be present as consolidated bedrock and/or associated residuum soils beneath the HCS are described below and shown on Figure 3.3.3-1, which identifies the formation by its associated symbol. These six formations with increasing depth are the Lebanon, Ridley, Murfreesboro/Pierce, and Pond Springs formations and the Mascot Dolomite and Kingsport formations.

- Lebanon (Olb) Limestone is typically light- to dark-gray, thin to medium-bedded, even-regular; with irregular, cobbly beds, micritic to coarse-grained limestone lenses, thin laminae of calcareous mud, and brachiopods, bryozoans, gastropods, and cephalopods present. Minor thick to massive beds may be present. Fucoidal texture is common, and rare chert may be encountered.

- Ridley (Ord) Limestone is typically dark gray, thick to massively bedded, with a fucoidal texture (tan-brown, irregularly shaped, fine to coarse-grained dolomitic patches) and micritic character. The middle part is shale-rich, yellowish-red, mud cracked, and calcareous. The upper part is thick-bedded, coarse-grained crystalline limestone, gray-black, and fossiliferous, with rare chert.

- Murfreesboro/Pierce (Om) Limestone is typically micritic, fine-grained crystalline, thin-bedded (with rare thick to massive beds), minor argillaceous limestone. The middle part is similar but is typically black and includes bryozoans, chert, and ropy pods. The upper portion exhibits thick to massive bedding and is ropy, gray-black, with nodular chert and silicified fossils.

- Pond Springs (Ops) Limestone is typically maroon, green, gray, argillaceous, thin to medium bedded. These are even-regular beds to bioturbated, uneven beds. Where present, mudstone is typically gray-green, red, with uneven, medium to massive beds, and calcareous. Limestones within the middle are typically dark-gray, thick to massive-bedded, and micritic, with chert pods, and very rare fossils consisting of silicified gastropods. Basal contact is typically calcareous shales and argillaceous limestone.

- Mascot (Oma) Dolomite is typically light gray with pinkish streaks and hues, fine to coarse crystalline, and thick to massive bedded. Limestone, where present, is medium gray, fine-grained, also thick to massive-bedded, with irregular dolomitic patches and black chert jasperoidal and flinty, stromatolitic laminations. Its base is defined by sequences of closely spaced chert matrix sandstone beds.

- The deepest, the Kingsport (Ok) Formation, is similar to the overlying Mascot Dolomite but can be darker in color (light to dark gray), with a similar crystalline structure, and it can be medium to massive bedded. Where present, limestone can be darker as well (light to medium gray). Gastropods are rare, as are oolites and quartz sand grains.

The Mascot Dolomite underlain by the Kingsport Formation dominates the northwest half of the site. The overlying limestones, present in the southeastern half of the site (Figure 3.3.3-1), include the Pond Springs (deepest, overlying unconformably the Mascot as an unconformity), the Murfreesboro/Pierce, Ridley, and Lebanon (progressively shallower) formations (Lemiszki, 2000 and 2015).

3.3.3.1 Physiography

The physiography in the vicinity of the site is illustrated on Figure 3.3.3-1 and Figure 3.3.3-2 and is typical of the Valley and Ridge Province. The HCS is situated on a terrace within the valley of East Fork Poplar Creek and consists of undulating terrain. Several ridges oriented northeast to southwest are present within the vicinity of the HCS. Blackoak Ridge is located immediately to the northwest of the site. The Poplar Creek Valley is the next valley north and parallels Blackoak Ridge. East Fork Ridge is located to the south and east of the HCS and is interrupted by the valley of Bear Creek and Tennessee State Route 95. Pine Ridge is located south and east of East Fork Ridge.

3.3.3.2 Site Geology

The understanding of geologic conditions for the HCS is based upon subsurface investigation activities that included drilling and subsequent installation of groundwater monitoring wells as part of the hydrologic investigation and a separate drilling program consisting of geotechnical borings to support facility design.

The groundwater well installation program and geotechnical characterization program provided information to characterize the geology directly beneath the HCS. Locations of geotechnical borings and the monitoring wells initially installed at the site are illustrated on Figure 3.3.3-3. Figure 3.3.3-4 provides a representative “fence” diagram cross-section view of the underlying lithology.

Drilling logs from the groundwater monitoring wells (GW-1, GW-1R, GW-2, GW-3, and GW-4) depict a heterogeneous residuum beneath the HCS. Wells were drilled using sonic methods to collect continuous core. In general, the upper strata encountered at these well locations comprise a moderately thick to thick residuum ranging from 13.5 ft. (4.1 m) bgs to 50 ft. (15.2 m) bgs. The residuum is composed of slightly silty clays and lean clays with varying amounts (5 percent to 30 percent) of fine to coarse chert and dolomitic fragments from 0 ft. to 36 ft. (0-11.0 m) bgs that typically overlays a silt stratum of varying thickness and at varying depths from 5 ft. (1.5 m) to 25 ft. (7.6 m) bgs. At well locations GW-1, GW-1R, and GW-3, overburden and bedrock encountered appear to be representative of residual soils, weathered to moderately weathered dolomite, associated with the Knox Group, likely the Mascot Dolomite. In contrast,

residual soils encountered at well bore locations GW-2 and GW-4 along the south boundary of the HCS are likely associated with the Chickamauga Group, likely the Pond Springs Formation, but may also include an upper veneer of residual clays associated with Ridley Limestone and possibly Lebanon Limestone.

Geotechnical subsurface exploration included the advancement of 22 geotechnical test borings (B-1 to B-22) (Figure 3.3.3-3) at predetermined locations across the site. Exploration included extending the borings to either refusal, target rock core lengths, or target depths of 30 ft. (9.1 m) or 100 ft. (30.5 m). Seven of the borings (B-01, B-02, B-03, B-05, B-07, B-09, and B-10) were extended through the overburden into the bedrock using diamond core barrel drilling wireline drilling methods. Samples were recovered using Shelby tubes at prescribed intervals within cohesive soils. A field geologist provided oversight and on-site documentation of the exploration and characterization of the soil samples with respect to material type and consistency, and the bedrock core was logged at these seven locations for lithology, weathering, and physical weaknesses. Selected soil samples were retained for analysis by geotechnical laboratories for the following properties in conjunction with facility engineering:

- Grain-size analysis and soil classification
- Natural moisture content
- Organic content
- Unit weight
- Atterberg limits
- Unconfined compression of rock cores
- Unconsolidated undrained triaxial
- Consolidation
- Unconfined compressive strength of soils
- pH
- Sulfate
- Chloride
- Soil resistivity
- Soil thermal conductivity

Based on the geotechnical borings conducted within the proposed footprint of the HCS, overburden consisting of residual soils was encountered in each boring to depths ranging from about 3.6 ft. (1.1 m) to 31.5 ft. (9.6 m) bgs.

As noted previously (Section 3.3.2), voids caused by dissolution of carbonate rocks and deep weathering along prevailing fractures and strike-oriented bedding can form conduits within the

dolomite and limestone. A number of voids were encountered during the geotechnical drilling program. Voids (open and/or clay-filled) ranged from as thin as 0.2 ft. (0.1 m) to as much as 4.1 ft. (1.2 m) within all seven of the borings that penetrated and cored rock (B-01, B-02, B-03, B-05, B-07, B-09, and B-10). Voids primarily (15 of the 21 voids encountered) occur within the upper 25 ft. (7.6 m) bgs. These voids were found within limestone, limestone interbedded with shale, and dolomite. The majority of these voids were filled with stiff clay.

Geotechnical boring B-01 penetrated the most voids (11). Six of these voids were encountered at depths to up to 36 ft. (11.0 m) within the overlying limestone. The remaining five were encountered much deeper, within the underlying dolomite, beginning at approximately 82.2 ft (25 m) bgs with the largest estimated to be 2.6 ft. (0.8 m) vertical opening and the other four much smaller with each void forming 0.2 to 0.5 ft (0.06 to 0.15 m) openings. The largest void at B-01 (82.2) bgs was encountered 25 ft. (7.6 m) below the transition from limestone to dolomite. The largest void, estimated at 4.1 ft. (1.2 m) thick in the vertical, was encountered in the relatively shallow limestone at 9.4 ft. (2.9 m) bgs in boring B-09. This large void was found beneath a shallower void (1.5 ft. [0.5 m], vertical) encountered in the same boring at 6 ft. (1.8 m) bgs.

A surface geophysical investigation conducted at the HCS identified the potential for the presence of voids not encountered in the geotechnical subsurface exploration. Therefore, to further characterize the subsurface conditions an additional six borings were advanced at predetermined locations representing the area where the TRISO-X FFF buildings (including the Process Building) would be located on the HCS. Voids within the limestone bedrock were encountered during the supplemental geotechnical drilling program. Voids ranged from as thin as 0.3 ft. (0.1 m) to as much as 3.8 ft. (1.2 m) within four of the six borings. Occurrence of voids were limited to the upper 40 ft. (12.2 m) below ground surface. These voids were found within limestone and limestone interbedded with shale. No large voids were encountered around the target depths of anomalies reported in the surface geophysical investigation.

3.3.3.3 Faults

Figure 3.3.3-5 provides a representative cross-sectional view of the faults within the vicinity of the HCS. The Whiteoak Mountain Fault is the predominant fault within the project vicinity. This fault is a thrust fault located just to the southeast of the HCS along the north side of Pine Ridge (see Figure 3.3.3-1). The geologic structure of the Valley and Ridge Province is characterized by numerous elongate folds and thrust faults that trend northeast-southwest. In the southern section of the province, the faults, and in most places the bedding, dip southeast. These orientations are the result of folding and fracturing during a mountain building episode 230 to 260 million years ago. However, no evidence exists that any of the thrust faults in the Valley and Ridge Province are considered to be active faults still undergoing movement. Geologic evidence indicates that the final episode of movement occurred during the Pennsylvanian or Permian periods or at least 230 million years ago (TVA, 2009).

3.3.4 SOILS

3.3.4.1 Soils in the Vicinity of the Horizon Center site

The Natural Resources Conservation Service (NRCS) soil survey data base identified 36 soil map units digitally within the 3-mi. (1.8-km) radius of the HCS. However, current digital soils data are not available for approximately 54 percent of the 3-mi. (1.8-km) radius area (USDA NRCS Soil Survey Staff, 2022).

The following soil types comprise greater than 3 percent of the soils mapped within a 3-mi. (1.8-km) radius of the HCS that are digitally available:

- Montevallo channery silt loam, 20-35 percent slopes with approximately 10.4 percent of the area.
- Armuchee silt loam, 12-20 percent slopes with approximately 4.6 percent of the area.
- Armuchee silt loam, 5-12 percent slopes, with approximately 3.9 percent of the area.

Montevallo channery silt loam, 20-35 percent slopes, soils are derived from loamy-skeletal residuum weathered from acid shale and occupy convex backslopes (USDA-NRCS, 2009). These soils are typically shallow, well drained, with low runoff potential. Soils of the Armuchee series are formed from residuum of acid shale on rolling to very steep uplands. The Armuchee silt loam,12-20 percent slope, soil map unit is found on backslopes, and the 5-12 percent slope soil map unit is located on summits. The Armuchee soils are moderately shallow, well drained, and have medium to high runoff potential (USDA-NRCS, 2009).

3.3.4.2 Soils Mapped on the Horizon Center Site

Modern soil survey data produced by the NRCS are not available for the HCS as it is located on land previously designated as Federal property; however, the 1942 Soil Survey for Roane County includes the HCS (Swann et al., 1942). Because the 1942 survey does include a description of properties of soils that remain on the HCS, data from the survey are incorporated into the soil descriptions given below.

Soils data from the 1942 U.S. Department of Agriculture (USDA) Soil Survey for Roane County were used to review the mapped soils in the 151-acre HCS. According to the survey, most of the site is mapped as Fullerton, Colbert, or Talbott soils, which are uplands soils derived from the residuum of either cherty dolomitic or clayey limestone (Swann et al., 1942). The mapped Fullerton cherty silt loam (Fc) occupies upland backslopes of rolling and hilly areas. This unit consists of deep soils with chert fragments throughout. These soils have medium runoff potential and are well drained (Swann et al., 1942; USDA NRCS Soil Survey Staff, 2022a). Fullerton cherty silt loam, hilly phase (Fcl), which is mapped to a lesser extent in the site, has the same characteristics as Fullerton cherty silt loam but is located on steeper slopes (15-30 percent), commonly has a thinner surface soil, and likely has greater runoff potential because of the steeper relief (Swann et al., 1942).

Colbert silty clay loam (Cs) and Talbott silty clay loam (Ts) occur on nearly level to steep uplands of limestone valleys. Colbert soils are deep, moderately well drained, and formed in residuum weathered from argillaceous limestone or shaley limestone. They have rapid to slow run-off potential, and flat limestone fragments are common throughout the soil (Swann et al., 1942; USDA NRCS Soil Survey Staff, 2022b). Talbott soils contain few to no chert fragments, are moderately deep, well drained, and have high runoff potential (Swann et al., 1942; USDA NRCS Soil Survey Staff, 2022c). The Talbott silty clay loam, hilly phase soil has similar characteristics as the Talbott silty clay loam but is located on steeper slopes (15-30 percent) that have greater runoff potential and likely a thinner solum (Swann et al., 1942).

The miscellaneous land type, Rolling Stony Land (Colbert and Talbott soil materials) (RsC), ranges from undulating to hilly, but mostly rolling, with slopes of 5-15 percent. This map unit is commonly referred to as “rock land” as it contains numerous outcroppings and weathered

fragments of limestone bedrock. In most areas of the map unit, the soil material among the outcrops is similar to Talbott or Colbert soils (Swann et al., 1942). This map unit occupies the largest area of the HCS.

Three other smaller soil map units in the HCS are Greendale silt loam (Gs), Melvin silt loam (Mi), and Clarksville cherty silt loam, hilly phase. Greendale silt loam is derived from loamy alluvium of toeslopes and talf. These soils are deep to very deep, well drained, and have very low runoff potential (Swann et al., 1942; USDA NRCS Soil Survey Staff, 2022d).

Melvin silt loam are bottomland soils consisting of silty limestone, shale, sandstone, and loess weathered alluvial materials. They are poorly drained, occupying nearly level areas of upland depressions and floodplains. Runoff is negligible, and most areas are subjected to flooding or ponding (Swann et al., 1942; USDA NRCS Soil Survey Staff, 2022e).

Clarksville cherty silt loam, hilly phase, consists of very deep, somewhat excessively drained soils formed in hillslope sediments and the underlying clayey residuum from cherty dolomite or cherty limestone on steep side slopes and narrow ridgetops. Runoff of these soils is medium to very high (USDA NRCS Soil Survey Staff, 2022f). This phase of the Clarksville soil averages a thinner solum with more chert on slopes ranging from 15 to 30 percent (Swann et al., 1942).

3.3.5 SEISMICITY

The East Tennessee Seismic Zone (ETSZ) is the second most active zone in the eastern United States in terms of small magnitude (M<5) seismicity, second in frequency to the New Madrid seismic zone. Activity in the ETSZ has remained high for several decades, however there were only a few events having magnitudes as large as M 4.6 (Hatcher et al., 2012). Generally, earthquakes in the ETSZ produce minor or no damage: the largest observed earthquakes have produced only minor damage to buildings, typically chimney collapse, cracks in plaster, and broken windows, consistent with intensity VI on the Modified Mercalli Intensity (MMI) scale (Stover and Coffman, 1993). The USGS “Did You Feel It?” website (USGS, 2021a) collects and compiles individual observations of macroseismic effects from earthquakes as reported by citizens in the aftermath of an earthquake. A map of cumulative responses in the United States from 1991 to 2017 shows that in eastern Tennessee the observed intensities ranged from II to V MMI. Figure 3.3.5-1 identifies recent seismic events within the ETSZ between 2000 and 2021.

In 2012, the Central and Eastern U.S. Seismic Source Characterization for Nuclear Facilities (CEUS SSC) Project was published as NUREG-2115. The study was conducted over the period from April 2008 to December 2011 to provide a regional seismic source model for use in probabilistic seismic hazard analyses for nuclear facilities. According to the CEUS SSC report, the ETSZ is a well-defined, northeasterly trending belt of seismicity, 300 km (186 mi.) long by less than 100 km (62 mi.) wide, within the Valley and Ridge and Blue Ridge physiographic provinces of eastern Tennessee and parts of North Carolina, Georgia, and Alabama (NUREG-2115).

Structural models presented in the CEUS SSC report explain the association of seismicity with potential field anomalies in the ETSZ, such as the association of the western margin of the ETSZ with a prominent gradient in the total intensity magnetic field marked by the New York–Alabama lineament. One possible interpretation is that seismogenic faulting is localized along a sharp contrast in crustal strength between the relatively weak Ocoee block and relatively stronger crust to the northwest. Hypocenter locations suggest that possible east/west-trending fault sources lie east of, but adjacent to, the New York–Alabama magnetic lineament. An

alternative interpretation is that intraplate earthquakes occur in crust that may be weakened by the presence of anomalously high fluid pressures. Another interpretation is that the seismicity may be related to a reactivation of a basement fault by the modern stress field and that a marginal correlation may exist between the seismicity and major drainage pattern and general topography of the region, suggesting a possible hydrological element linkage. Stearns et al. (2013), however, did not find a clear link between watershed morphology and active tectonics in the ETSZ. Powell (2014) looks at the potential for the ETSZ to extend into Kentucky and concludes that the zone follows the New York–Alabama lineament, and the southern portion of the zone includes thrust faults reactivated as normal faults. Cameron et al. (2017) conclude that hydroseismicity is an implausible control on seismicity in the ETSZ and that the evidence for a link between crustal loading and seismicity is inconclusive.

Recent geologic and paleoseismologic studies suggest that the ETSZ may have produced large prehistoric earthquakes. Evidence of outcrop-scale faulting and fracturing, and disrupted features in river terrace alluvium, along with minor paleoliquefaction as reported by Vaughn et al. (2010), was considered in the CEUS SSC study. Although this preliminary evidence suggests that the ETSZ may have produced one or more large magnitude earthquakes in the Quaternary, the CEUS SSC study assessed it to be insufficient to qualify the ETSZ as a repeated large-magnitude earthquake (RLME) source. Additional evidence of past large-magnitude earthquakes in the ETSZ has been observed near the Douglas Reservoir by Hatcher et al. (2012). Fractures and displacements in Quaternary alluvium along Douglas Reservoir suggest they resulted from earthquakes with magnitudes greater than 6.0 and 6.5 (TVA, 2019). Significant uncertainties exist regarding the origin and age of the features identified by Hatcher et al. (2012). Warrell et al. (2017) use paleoseismology to conclude that the ETSZ has generated three large-magnitude earthquakes, including at least one earthquake on the moment magnitude (M_W) scale ≥6 in the late Pleistocene. The magnitude of the largest event is assessed to be M_W 6.5±0.2 based on a 1-m (3-ft.) displacement on a thrust fault.

Cox et al. (2022) summarize recent paleoseismic investigations in the ETSZ and re-evaluate the paleoseismic evidence identified by Hatcher et al. (2012) and Warrell et al. (2017) at the Dandridge site (Douglas Reservoir) in light of recalculated optically stimulated luminescence. They also discuss paleoseismic evidence collected at two additional sites (Alcoa and Vonore, Tennessee). Their interpretation of the evidence is that the Dandridge-Vonore Fault Corridor (DVFC) has experienced at least two $M_W \geq 6.5$ earthquakes in the last 40,000 years, but they conclude that further research and field investigations are needed to obtain recurrence intervals of $M_W \geq 6.5$ earthquakes in the DVFC. This conclusion is consistent with the Tennessee Valley Authority (TVA, 2019) evaluation of the paleoseismic evidence reported by Hatcher et al. (2012) and Warrell et al. (2017) that the current recent studies do not quantify parameters (i.e., recurrence interval, magnitude) necessary to demonstrate that the ETSZ produces RLMEs. Therefore, studies conducted by TVA at the Clinch River Nuclear Site (TVA (2019) confirms the interpretation of the CEUS SSC and does not define a RLME source for the ETSZ. The potential for large-magnitude earthquakes in the ETSZ is accommodated in the CEUS SSC model by the maximum magnitude distribution of the distributed seismicity zones in which the ETSZ lies, which ranges from M 6 to M 8. Sensitivity analyses conducted for the TVA Clinch River Nuclear Site (TVA, 2019) confirm that the inclusion of paleoseismic events in the ETSZ would not determine the need to revise magnitude of the largest possible earthquake (M_{max}) for the seismic source zones. A second sensitivity test conducted as part of the Clinch River Nuclear Site Safety Analysis Report (TVA, 2019) further shows that the CEUS SSC seismic hazard model generates moderate- to large-magnitude earthquakes with sufficient frequency in the ETSZ area to explain Hatcher et al.'s (2012) interpretation of field observations.

3.4 WATER RESOURCES

3.4.1 GROUNDWATER

This section describes groundwater conditions associated with the Horizon Center site (HCS), including a description of regional aquifers and aquitards and those present at the HCS. The HCS region generally refers to the Valley and Ridge physiographic province in which the HCS is located. This section also includes a review of groundwater resources within the vicinity, a 3-mi. (4.8-km) radius from the proposed HCS. The geologic units within the Valley and Ridge physiographic province are discussed in Section 3.3, Geology and Soils and comprise the aquifers and aquitards found at the HCS (See Figure 3.3.1-3 in Section 3.3, Geology and Soils).

3.4.1.1 Regional Groundwater

The HCS is situated within the Valley and Ridge province (See Figure 3.3.1-2 in Section 3.3, Geology and Soils). The primary aquifers of the Valley and Ridge province are made up of carbonate Mississippian, Cambrian, Ordovician rocks. The aquifers underlie more than one-half of the Valley and Ridge province in Tennessee and are typically present in valleys and rarely present on broad, dissected ridges. The carbonate-rock aquifers are typically connected to rivers or lakes that serve as sources of recharge. The movement of water from the recharge sources through the carbonate rocks has resulted in solution activity and enlargement of original openings. Rock types other than carbonate in the province can yield large quantities of water if they are fractured, contain solution cavities, and or have direct hydraulic connection to a source of recharge (Lloyd and Lyke,1995).

The primary carbonate aquifers in the Valley and Ridge province are the Chickamauga Group, the Knox Group, and the Conasauga Group. The aquifers are typically overlain by the aquitards of the Fort Payne Formation, Chattanooga Shale, Rockwood Formation, Sequatchie Formation, and Reedsville Shale, and underlain by the aquitards of the Nolichucky Shale, Dismal Gap Formation, Rogersville Shale, Friendship Formation, Pumpkin Valley Shale, and Rome Formation (See Figure 3.3.1-3 in Section 3.3., Geology and Soils). However, due to thrust faulting in the area the aquifers and aquitards can be repeated several times across the fault including the confining Rome Formation (Lloyd and Lyke,1995).

The carbonate aquifers have little primary porosity, and permeability and groundwater movement in the Valley and Ridge aquifers is primarily a function of fractures, bedding planes, and solution openings in the rocks that form as secondary features after the rocks were deposited and lithified (Figure 3.4.1-1). The fractures and bedding planes in the carbonate rocks have been enlarged through dissolution by slightly acidic water, especially in the upper 200 ft. (70.0 m) to 300 ft. (91.4 m) of the zone of saturation. The acidic water dissolves some of the calcite and dolomite mostly along fractures and bedding planes where the largest volumes of acidic groundwater flow. While secondary permeability is the primary mechanism for groundwater movement in the carbonate rocks, primary pore spaces that constitute the alluvium along streams and the residuum of weathered material that overlies most of the rocks in the area provides connectivity for shallow groundwater movement (Lloyd and Lyke, 1995).

The repeating lithology created by thrust faulting and the location and presence of streams within the Valley and Ridge province of eastern Tennessee, in part, results in localized groundwater movement. The major streams within the Valley and Ridge province run parallel to the northeast-trending valleys and ridges, and tributary streams typically run perpendicular to the valleys and ridges. Where older rocks are typically stratigraphically deeper, the older rocks

in eastern Tennessee (primarily the Conasauga Group and the Rome Formation) have been displaced upward over the top of younger rocks (the Chickamauga and the Knox Groups) along thrust fault planes (Figure 3.4.1-1). The thrust faulting has resulted in the repeating sequences of permeable and less permeable hydrogeologic units. The combination of the repeating sequences, coupled with the stream network, divides the area into a series of isolated, shallow groundwater flow systems adjacent to these features. Most of the groundwater movement associated with these local flow systems takes place within 300 ft. (91.4 m) of land surface. Typically, in recharge areas, most of the groundwater flows across the strike of the rocks, and from the ridges where the water levels are high toward lower water levels adjacent to major streams that flow parallel to the valleys where it discharges (Figure 3.4.1-1). However, some of the groundwater moves along the strike of the rocks, following highly permeable fractures, bedding planes, and solution zones where it can travel further and discharge at more distant springs or streams. Additionally, while fracture zones locally are present in the clastic rocks, the highly permeable zones primarily present in the carbonate rocks allow for the movement of groundwater (Lloyd and Lyke, 1995).

Recharge also occurs from the percolation of precipitation through the residuum overlying the aquifer system. The discharge of groundwater occurs at springs, as base flow to streams and rivers, through pumping of wells. However, where enough water is present in the residuum for domestic wells, the domestic wells may go dry when water levels decline during drier periods in late summer to early autumn (Brahana et al., 1986). The groundwater that discharges to springs occurs with up to 10 times more water during periods of abundant precipitation (Lloyd and Lyke, 1995).

3.4.1.1.1 Regional Hydrogeology

Rome Formation

While the Cambrian Rome Formation is one of the oldest rock units in the Valley and Ridge province, due to thrust faulting it is near the surface and underlies Haw Ridge, Pine Ridge, and the valley and some small ridges northwest of Pine Ridge (Figure 3.4.1-1). The Rome Formation lithology is comprised of sandstone, shale and siltstone, and the geologic unit is considered an aquitard and a confining unit (Lloyd and Lyke, 1995).

Conasauga Group

The Cambrian Conasauga Group in the Valley and Ridge province has been displaced upward over the top of younger rocks along thrust fault planes and overlies the Cambrian Rome Formation (Figure 3.4.1-1). The Conasauga Group is considered a principal aquifer of the Valley and Ridge Province and is comprised of the Maynardville Limestone and Honaker Dolomite geologic nuts. The aquifer lithology is comprised of alternating beds of cherty dolomite, limestone, dolomite, and shale with groundwater flow through secondary permeability. The Conasauga Group has the largest reported well yields of the principal Valley and Ridge aquifers. Wells completed in the Honaker Dolomite of the Conasauga Group have reported yields of 2500 gallons per minute (gpm) [9463 liters per minute (lpm)]. Reported median yield for the middle part of the Conasauga Group is 100 gpm (378 lpm). Springs in the Upper Conasauga Group have median discharges of 40 gpm (151 lpm), with spring discharge rates up to 1000 gpm (3785 lpm) for both the Upper and Middle Conasauga Group (Lloyd and Lyke, 1995).

Chickamauga Group

The Ordovician Chickamauga Group in the Valley and Ridge province has been displaced upward over the top of younger rocks along thrust fault planes, overlies the Knox Group, and is overlain by the Cambrian Rome Formation (Figure 3.4.1-1). The lower Chickamauga Group is considered a principal aquifer of the Valley and Ridge province which is comprised of the Holston Formation and Lenoir Limestone geologic units. The lithology of the Chickamauga Group aquifer units is comprised of limestone and shale. Large well yields of up to approximately 500 gpm (1892 lpm) are reported for the Chickamauga Group. Some of the largest springs are found to discharge from the Chickamauga Group with rates up to 5000 gpm (18,927 lpm) (Lloyd and Lyke, 1995).

Knox Group

The Knox Group in the Valley and Ridge province has been displaced upward over the top of younger rocks along thrust fault planes and is overlain by the Ordovician Chickamauga Group (Figure 3.4.1-1). The Knox Group is considered a principal aquifer of the Valley and Ridge province which is comprised of several geologic units comprised of cherty dolomite, dolomite, and limestone lithology. Large well yields of up to approximately 500 gpm (1892 lpm) are reported for the Knox Group. Springs issuing from the Knox Group have reported discharges of up to 4000 gpm (15,141 lpm) with median discharge of 50 gpm (189 lpm) (Lloyd and Lyke, 1995).

3.4.1.1.2 Groundwater Use

The Conasauga, Knox, Chickamauga Groups and Rome Formation are the primary underlying bedrock aquifers of the Valley and Ridge province.

Eastern Tennessee fresh groundwater withdrawals from the Valley and Ridge province aquifers were about 82 million gallons per day (310 million liters per day) during 1985. The Valley and Ridge province aquifers withdrawals accounts for approximately 16 percent of the groundwater used in the State of Tennessee. Approximately 37.8 percent was withdrawn for public supply, 24.4 percent for industrial, mining, and thermoelectric power, 23.2 percent for domestic and commercial and 14.6 percent for agriculture (Lloyd and Lyke, 1995).

The U.S. Environmental Protection Agency (USEPA) Sole Source Aquifer Program interactive map was used to determine that there are no sole source aquifers within the area of interest (USEPA, 2022).

3.4.1.1.3 Groundwater Quality

The water quality within the freshwater parts of the Valley and Ridge aquifers is similar for shallow wells and springs. The groundwater typically has total dissolved solids concentrations of 170 milligrams per liter or less and is hard with a calcium magnesium bicarbonate water type. The concentrations of dissolved constituents are thought to be indicators of depth and the rate of groundwater movement through the carbonate-rock aquifers. Lower concentrations are generally associated with groundwater that is moving rapidly through shallow, short flow paths from areas of recharge to discharge locations. Higher concentrations represent groundwater that is moving more slowly through deep, long flow paths and has had longer contact with aquifer minerals and greater opportunity to dissolve minerals. The Valley and Ridge aquifers are

more susceptible to contamination where the residuum that overlies the carbonate rocks is thin (Lloyd and Lyke, 1995).

The highly anisotropic nature and occurrence of water bearing zones with high permeability and rapid groundwater movement associated with solution cavities in the carbonate aquifers of the Valley and Ridge province results in potential contamination of the Valley and Ridge groundwater (Brahana et al., 1986).

As noted in Section 1.3.1 (Site Location and Layout), the HCS is located approximately 6.6 mi. (10.6 km) southwest of Oak Ridge, Tennessee. Historical site operations at the ORR generated a variety of radioactive, non-radioactive and mixed hazardous waste. These wastes have contaminated surface water and sediment outside of the ORR property boundaries. Down-gradient groundwater monitoring in the vicinity of the Clinch River has shown low-levels of contamination have migrated to the Clinch River and some low levels of contamination have been detected off-site directly across from the Clinch River. The off-site contamination is not consistently detected, and when detected is at very low levels that are not considered to pose a threat to human health or the environment. Further studies of the potential for off-site groundwater contamination are currently being investigated by the USEPA as part of ORR cleanup activities. (USEPA, 2021).

3.4.1.1.3.1 Groundwater Wells Within the Vicinity of the HCS

A comprehensive well screening report was developed from several database sources: the Tennessee Department of Environment & Conservation (TDEC, 2022b); the Oak Ridge Environmental Information System (OREIS) and the National Water Quality Monitoring Council's portal service for public access to Federal agencies (including United States Geologic Survey [USGS]) databases. The search area included the 3-mi (4.8-km) radius from the TRISO-X Fuel Fabrication Facility (TRISO-X FFF) boundary (Figure 3.4.1-2).

Within the search radius a total of 37 groundwater wells were identified in the TDEC Database (TDEC, 2022b). Thirty-four of these wells are residential, one is recorded as farming use, and two are listed as use unknown. None of the wells' recorded in the TDEC water well database is noted as industrial or commercial water supply use. The majority of the wells are located in Roane County (32), two are reportedly in Anderson County (the farm use well and one of the residential wells); and two are listed as Polk County. It should be noted that these coordinates may be incorrect because Polk County is well beyond the 3-mile radius, at nearly 60 to 70 miles south of TRISO-X FFF. While the search data does not include municipal wells, as those are considered confidential under Tennessee Code Annotated § 10-7-504 (a)(21)(A) and Tennessee Compilation Rules and Regulations 0400-01-01-.01(4)(c), it was confirmed by Annabelle Dempsey of TDEC via email communication that no public water supply wells exist within the area of the HCS (TDEC, 2022c). A single public supply wellhead protection area is partially included within the 3-mi. (4.8-km) radius from the TRISO-X FFF center point, however that area is currently classified as inactive.

The closest well to the HCS is a residential well at 1.12 mi. (0.1.80 km) north-northwest (Figure 3.4.1-2). This well is developed within the Poplar Creek Valley which is separated from the HCS by Blackoak Ridge. Another residential well is included in the TDEC database that was reportedly installed at coordinates within 0.08-mi. (128.7-m) southwest of the HCS. Field reconnaissance to confirm the location of this well conducted on March 04, 2022, demonstrated that no wellhead, water service connections, power service, or any evidence of a former well

casing were present. As such, it was concluded that the recorded coordinates for this well are erroneous and no well is present on the adjacent parcel (see Figure 3.4.1-2).

The well search of the OREIS (OREIS, 2022) and USGS databases (USGS, 2022a) identified 952 groundwater monitoring and observation wells within the 3-mi (4.8-km) search radius. These wells are associated with the adjacent DOE facilities Y-12 National Security Complex and East Tennessee Technology Park (ETTP, former K25 Plant) as well as parts of the general area defined as the ORR. Most of these wells are located within the ETTP (484). The ORR has responsibility for 249 of the monitoring wells; the Y-12 Plant, 215; and four wells are listed simply as off-site locations. Of these DOE facility-related wells, eight are also associated with the USGS Tennessee Water Science Center. Six of the eight USGS well co-serve as ETTP (former K-25) monitoring wells and two are also used as ORR monitoring wells. The monitoring wells located south and southwest of the HCS within the 3-mi. (4.8 km) radius are part of the National Priorities List (NPL) site where preexisting groundwater contamination exists. However, these locations are located downstream within the Poplar Creek valley and are therefore, downgradient of the HCS (Figure 3.4.1-2).

3.4.1.2 Groundwater at the HCS

3.4.1.2.1 Site Hydrogeology

As described in Section 3.3.3, the area of the HCS is underlain by bedrock associated with formations within the Knox and Chickamauga Groups. Formations likely to be present as bedrock and/or associated residuum soils beneath the HCS are described below and shown on Figure 3.3.3-1, which identifies the formation by its associated symbol. These six formations with increasing depth are the Lebanon, Ridley, Murfreesboro/Pierce, and Pond Springs formations and the Mascot Dolomite and Kingsport formations.

Groundwater at the HCS was characterized for both water quality and physical properties as well as identifying hydrogeologic properties during drilling and well installation. Drilling and associated consolidated monitoring well installation activities were conducted in summer and fall of 2021. In total, four on-site (on HCS Lot 6) wells (GW-1, GW-2, GW-3, and GW 4) and two wells in an adjacent off-site area (GW-5 and GW-6) were installed. A seventh well (GW-1R) was installed and developed in February 2022 and was added to the network for subsequent sampling and monitoring (See Figure 3.4.1-3). Soils and bedrock lithology were logged during drilling of each bore hole prior to being completed as observation wells. Geotechnical borings presented in Section 3.3 Geology and Soils were used to supplement the interpretation of the HCS hydrogeology from monitoring well drilling and well installation data.

The observation wells are completed within the upper bedrock at depths of up to approximately 75 ft. (22.9 m) from ground surface. The underlying bedrock in which the observation wells are completed is primarily comprised of dolomite and is the first type of bedrock encountered at all well locations. At one location, GW-5, limestone was encountered below the dolomitic bedrock at a depth of 52 ft. (18.8 m) below ground surface, and the well is screened across the dolomite limestone interface between 50 to 60 ft. (15.2 to 18.3 m) below ground surface.

Karst features previously reported on lands adjacent to the HCS have included springs and sinkholes of various sizes. Geologic logging during drilling and installation of monitoring wells and geotechnical drilling resulted in identification of karst features at the site including a number of voids (See Section 3.3.2, Karst Features).

An overview of the groundwater observation well network is presented in Table 3.4.1-1. The two off-site wells, GW-5, and GW-6, were subsequently eliminated from the well network but are used to support the interpretation of HCS hydrogeologic conditions, including the potentiometric surface within the vicinity of the HCS.

3.4.1.2.1.1 Groundwater Levels and Elevations

Groundwater levels were measured at the HCS observation wells monthly starting in September 2021 extending to August 2022 (Table 3.4.1-2, Figure 3.4.1-4). The monthly measured groundwater levels collected between September 2021 and August 2022 vary from 9.58 to 56.68 ft. below the top of casing. Groundwater level elevations posted for the site and contoured indicate groundwater flow varies across the HCS seasonally. Figure 3.4.1-4 is a hydrograph of the groundwater levels represented as potentiometric elevations that represents changes in groundwater elevations on a monthly basis. Varied groundwater level changes were observed for the twelve-month period between September 2021 and August 2022. This period coincides with the end of the active growing season cycle, transitioning into the winter season (when evapotranspiration is at its lowest).

Groundwater hydraulic gradients are based on potentiometric level contours of water levels collected on September 16, 2021 and January 12, 2022, shown on Figure 3.4.1-5 and Figure 3.4.1-6, respectively. These two months were selected for their seasonal influence (summer and winter) on potentiometric levels, as it is apparent that lower evapotranspiration levels during colder shorter days (i.e., decreases naturally as vegetation is dormant, and less need of infiltrating water) influences groundwater availability. During such times, a greater part of seepage occurs through the overburden and into bedrock (fissures, joints, and karst-influenced fracture-conduits, voids) where it adds to groundwater storage and results in a rising potentiometric head. This has the effect of steepening hydraulic gradients within the bedrock as well as shifting potentiometric surface. As is evident in Figure 3.4.1-5, the potentiometric contours during the summer period are arcuate in shape from west to northeast across the HCS. Whereas the winter orientation of this surface shifts and follows a more regular southwest to northeast pattern and is steeper, particularly on the northwest side of the HCS, as shown on Figure 3.4.1-6. These potentiometric levels influence flow; however, remnant structural features within the bedrock may provide influence and control as well. The general directions of flow, based on potentiometric surface, are inferred as red dashed lines normal to the contours. These inferred flowlines represent hydraulic gradients. Southwest of HCS in the adjacent parcel the pattern shifts and steepens. Immediately adjacent to southwest side of the site, contours broaden their spread while creating a concave-arcuate pattern indicating a change in potentiometric head that may be influenced by structural feature(s) within the bedrock that influence its transmissive nature and/or flow toward and discharge to East Fork Poplar Creek (EFPC). This hydraulic gradient shift is broader and less steep in summer versus the winter and may be redirecting some of the groundwater southward because of the steeper gradients.

3.4.1.2.1.2 Hydraulic Parameters

Hydraulic parameters evaluated for the HCS groundwater include hydraulic conductivity and storativity. The analyses of parameters were performed using the AQTESOLV software package (Duffield, 2004). A range of derived values for each of these parameters is provided in Table 3.4.1-3. The results support a low water yield and low to moderate hydraulic conductivity of these bedrock materials across the site.

Hydraulic conductivity values for the bedrock aquifer units beneath the HCS were determined from analyses of aquifer slug tests. Analyses of the test data were performed using four solution methods provided in the AQTESOLV software package (Duffield, 2004), including Cooper, Bredehoeft, Papadopulos (1967) solution and KGS (Hyder et al., 1994) solution, both curve matching methods as well as Bouwer-Rice (1976 solution) and Hvorslev (1951) solution, both straight-line methods. The results support very-low to low hydraulic conductivity values for the northwestern-most observation wells GW-1, GW-3 and well GW2 in the southeast area of the HCS. The geometric mean of conductivity values range for these wells range from 0.0011 ft/d (3.8 E-07 cm/sec) to 0.0037 ft/d (1.3 E-06 cm/sec). Whereas GW-4, located in the southwest area of HCS, was reported to have a moderate hydraulic conductivity with a geometric mean value of 6.3 ft/d (2.2 E-03 cm/sec) for these dolomitic bedrock materials. Results for observation wells GW-5 support a low-moderate hydraulic conductivity of 0.23 ft/d (8.1 E-05 cm/sec) for dolomite and limestone bedrock (Table 3.4.1-3).

Storativity is a term used to describe the volume of water released from an aquifer per unit surface area per unit decline in head. Conversely, a volume of water added—via infiltration and seepage—to an aquifer per unit surface area affects a unit increase in head. Estimates of storativity for the carbonate bedrock materials HCS are provided Table 3.4.1-3 using the two curve matching solutions (CBP and KGS, noted above) analyses for each observation well. Geometric mean values of storativity properties were estimated between 9.6 E-11 (GW-3) to 0.00033 ft^3/ft^3 (GW-2).

3.4.1.2.1.3 Groundwater Velocity

Groundwater average linear velocity (also referred to as seepage velocity) is calculated from the combination of data collected from on-site observation wells, including well elevations, water levels, calculated hydraulic gradients, and hydraulic conductivity described in the preceding paragraphs, and from literature values for effective porosity.

Generally, carbonate rock with original (primary) and secondary porosity is reported to have an effective porosity of 0.10 to 0.20 ft^3/ft^3 (10 – 20 percent, Bouwer, 1978). Based on the hydraulic properties associated with GW-4 (i.e., moderate hydraulic conductivity and storativity values), 0.20 ft^3/ft^3 was selected to calculate average linear velocity for groundwater flow through the southwest area of HCS (area surrounding GW-4). However, the remaining observation wells exhibit aquifer characteristics of tighter, much less permeable carbonates with low storage properties. As reported by others, studies at the Oak Ridge Reservation that included pumping tests, tracer tests and analyses of hydrographs (Solomon, D.K., et al, 1992) provide relevant information for comparable conditions at the HCS. These effective porosities reported to be between 10E-03 to 10E-05 ft^3/ft^3. This same reference also indicates that average specific yield (drainable portion of an aquifer and reasonable estimate of effective porosity) for the Chickamauga Group is 0.0025 ft^3/ft^3. The average linear groundwater velocity is calculated for the site as the product of hydraulic conductivity and the range of gradients, divided by the effective porosity resulting in a value of 0.004 ft/d (0.001 m/d) to 3.12 ft/d (0.95 m/d) (Freeze and Cherry, 1979).

3.4.1.2.1.4 Site Groundwater Quality

Groundwater water quality was determined through quarterly sampling of the HCS observation wells. Groundwater sample collection was attempted quarterly using low flow (low purge) sampling methodology with a submersible bladder pump from the six observation wells (GW-1 through GW-6) for the first sampling event in September 2021 (summer), and from the four

observation wells (GW-1 through GW-4) for the subsequent sampling in November 2021 (fall). The first quarter started in September 2021 and five of the wells yielded sufficient water to collect samples. Only GW-1 did not have enough water to collect a sample.

NUREG-1748 does not provide any specific guidance regarding water quality parameters; therefore, the parameter list contained in NUREG-1555 was used to support the characterization of water quality at the HCS. Water quality analysis included field measurements (temperature, pH, conductivity, oxidation reduction potential, dissolved oxygen, color, odor, salinity, and turbidity) and a range of laboratory analytes. Results of water quality sampling from the summer, fall, winter, and spring sampling periods are provided in Tables 3.4.1-4 through 3.4.1-7.

Overall, the groundwater sample analytical results indicate a water of good quality with low total dissolved solids (110 to 390 mg/L) and relatively low concentrations of trace metals and radioactivity. However, detections of fecal and total coliforms are at relatively elevated levels with reported values up to 178.5 and 2,419.6 mpn/mL, respectively, indicating impaired groundwater with respect to these parameters. None of the reported groundwater analytical results exceeded TDEC or USEPA regulatory values. While the TDEC and USEPA regulatory standards are provided as reference for assessing the quality of the water in general terms they do not constitute any violations if a result is in exceedance of a regulatory value.

3.4.2 SURFACE WATER

Surface water hydrologic features and characteristics, including site drainage, within the HCS and vicinity, are summarized in Section 3.4.2.1. Surface water use and surface water quality are summarized in Sections 3.4.2.2 and 3.4.2.3, respectively.

3.4.2.1 Hydrology

3.4.2.1.1 Regional and Local Hydrology

The HCS is located within the Valley and Ridge physiographic province as described in Section 3.3. The HCS is located within the East Fork Valley, a valley between two parallel ridges, Blackoak Ridge on the north and East Fork Ridge to the south (USGS 2019a) (see Figure 3.4.2-1). East Fork Poplar Creek (EFPC) flows southwesterly through this valley and along the southern side of the HCS. The HCS and the EFPC channel are separated by Renovare Boulevard. The EFPC drainage area at the Novus Drive crossing location near the southwestern end of the HCS is 20.38 sq. mi. (52.8 km^2). The EFPC watershed extends to the northeast and encompasses much of the western portion of the City of Oak Ridge. EFPC is a tributary to Poplar Creek, which flows southwesterly in the valley north of East Fork Valley and Blackoak Ridge. The EFPC confluence with Poplar Creek is located southwest of HCS. Poplar Creek is a tributary to the Clinch River at Clinch River Mile 12.0 above the Tennessee River and Watts Bar Lake (USGS 2019b).

Numerous small tributaries drain to EFPC from the ridges along the East Fork Valley. Named tributaries to EFPC identified on USGS quadrangle maps (USGS 2019a) near the HCS include Gum Hollow Branch and Pinhook Branch upstream of the HCS as well as Bear Creek downstream of the HCS. Bear Creek flows southwesterly in the valley south of the East Fork Valley and cuts through Pine Ridge to flow into EFPC southwest of the HCS.

The EFPC headwaters are located east of the HCS and in the City of Oak Ridge. The upper reaches of the EFPC watershed consist predominantly of developed land such as residential subdivisions and commercial development, particularly near the Oak Ridge center (USGS 2019a). The downstream portion of the watershed is substantially less developed and is mostly wooded.

As noted in Table 3.6-1 (Meteorology, Climatology, and Air Quality), the annual average precipitation near the HCS is approximately 51 in. (129 cm), and average snowfall is approximately 6 in. (15 cm). Evapotranspiration, the amount of water transferred from the land and water surface to the atmosphere by evaporation and plant transpiration, has been estimated for the Oak Ridge area to be approximately 29 to 30 in. (73.7 to 76.2 cm) (Parr and Hughes, 2006). The difference in annual precipitation and evapotranspiration, approximately 21 to 22 in. (53 to 56 cm), is the amount of water in combined surface runoff and the net flow to groundwater. Storm event precipitation data for the HCS vicinity are available from the National Oceanic and Atmospheric Administration (NOAA) and selected durations and return periods are summarized in Table 3.4.2-1.

Numerous USGS streamflow monitoring stations are located near the HCS (USGS, 2022a), including a station on EFPC just upstream of the HCS that is no longer active; however, no streamflow data exist at the HCS for the small surface drainages flowing directly onto the HCS. There are nine locations within 3.0 mi. (4.8 km) of the HCS at which USGS has measured surface flow at least one time (Table 3.4.2-2). The locations of the USGS streamflow stations are shown on Figure 3.4.2-1.

3.4.2.1.2 Site Drainage

As shown on Figure 3.4.4-2, surface water features such as streams with defined banks, lakes, impoundments, and ponds, are absent from the HCS. USGS topographic mapping identifies one intermittent stream within the HCS. USGS defines an intermittent steam as “a stream that flows only when it receives water from rainfall runoff or springs, or from some surface source such as melting snow” (USGS, 2022c). This feature, however, was investigated in the field and found to lack the required characteristics, such as a channel with bed and bank, and thus is not considered a regulated stream under the jurisdiction of the U.S. Army Corps of Engineers (USACE) or TDEC. This USGS intermittent stream, perhaps best referred to as a swale, slopes southwesterly, leaving the HCS at SD #1, and flows to a depression located on Lot 5, the adjacent parcel to the southwest. That depression has been referred to as a sinkhole in prior reports (DOE, 1996; DOE, 2003). The depression, defined by closed topographic contours, extends eastward along the drainage course to within approximately 500 ft. of the HCS boundary. The swale drainage area at the HCS boundary is approximately 138 ac. (55.8 ha). Within the HCS, this broad swale has characteristics similar to a “karst swale” as described by TDEC (2014) *“. . much of the length of the headwater stream network in karst terrain is composed of karst swales which appear as wide, shallow, parabolic swales . . . Karst swales lack defined channels, beds, or banks and may only briefly hold water during extreme storm events”*. A description of karst characteristics near the HCS is provided in Section 3.3.2.

Streams and watersheds near the HCS are shown on Figure 3.4.2-2. The HCS encompasses approximately 110 ac. (44.6 ha) located between Blackoak Ridge to the north and EFPC to the south. There are areas that drain from the southern-facing slopes of Blackoak Ridge onto the HCS. All surface runoff from the HCS flows via small drainages to EFPC with the exception of one drainage which flows to a topographic depression located immediately southwest of the HCS (see surface discharge location #1 [SD #1], Figure 3.4.2-2). This drainage, indicated on

USGS topographic maps as an intermittent stream (Figure 3.4.2-2), terminates at an off-site depression, suggesting karst topography with apparent surface drainage to groundwater. This mapped USGS intermittent stream was investigated in the field and determined to lack the characteristics of a stream or a wet weather conveyance as defined by Clean Water Act (CWA) and TDEC regulations.

The majority of the HCS, including the northern portion, drains to SD #1. Based on topographic mapping of the HCS, seven locations where surface drainage leaves the HCS as concentrated, or potentially concentrated, flow were identified. The largest and primary location is SD #1 with a drainage area of approximately 138 acres (ac.) (55.8 hectares (ha)). A small area at the northwestern corner of the HCS drains via SD #2 to the off-site depression in addition to drainage via SD #1. The southern portion of the HCS drains southerly to EFPC via two 24-in. diameter reinforced concrete pipes (RCPs) identified on Figure 3.4.2-2 as SD #5 and SD #6. Two small drainages, SD #3 and SD #4, located along the eastern end of the HCS drain to an off-site intermittent stream which flows southerly to EFPC, passing under Renovare Boulevard near the eastern boundary of the HCS.

The USGS has used long-term regional streamflow monitoring data to develop regression equations to predict various statistical hydrologic parameters, including peak discharge frequency (Law and Tasker, 2003) as well as low flow frequency, mean daily flow duration, mean annual streamflow, seasonal summer mean flow (Law, Tasker and Ladd, 2009), and geomorphic bankfull flow channel geometry, including width, depth, and cross section area (Bieger et al, 2015). The regression equations for each of these have been implemented in Tennessee by USGS in the web-based tool StreamStats (USGS, 2022b).

Drainage areas to the surface discharge locations at the HCS are small. While the web-based StreamStats tool includes mapped stream threads within the HCS boundary allowing automated calculation of hydrologic parameters using the regional regression equations, the HCS drainage areas are smaller than the lower limit of drainage areas for streams used to develop the regression equations and reliable predictions from the regression equations.

3.4.2.2 Water Use

Surface water is the primary source for water use in the area around the HCS. Water use information has been developed by the USGS (Dieter et al, 2018; Robinson, 2018) and water use data at the State and the county levels through the year 2015 have been made publicly available through the USGS National Water Information System Web Interface (USGS, 2022a). A further breakdown of water use by public water supply organizations and by other basic types of users (e.g., self-supplied industrial) is available for the year 2010 from Robinson (2018) and is included in the summary below.

In the five-county area around the HCS (Roane, Knox, Loudon, Anderson, and Morgan Counties), the public water supply source is primarily derived from surface water (USGS, 2022a). In 2015, the last year with available data, the five-county total public water supply provided by 24 public water providers from surface water sources was 91.99 million gallons per day (MGD) [4.84 cubic meters per second (m^3/s)], which was 97 percent of the total public water supply withdrawal with the remainder coming from groundwater sources. Streams flow generally to the southwest in this five-county area to the Tennessee River and Watts Bar Lake, which flows westerly, and only two of the 24 local public water providers, the Kingston Tennessee River water plant and the Rockwood Water System, use water withdrawn from stream locations hydrologically downstream of the HCS and in Roane County (Robinson, 2018). These two

public water systems combined withdrew 3.25 MGD, or 5.0 cubic feet per second (cfs) (0.142 m^3/s) in 2010 (Robinson 2018). For comparison, the average flow of the Tennessee River at Loudon during the 32-year period from 1923 to 1954 was 18,810 cfs (532.64 m^3/s) (USGS, 2022a). For the current condition, the Tennessee River and Clinch River flows and reservoir storages, including Watts Bar Lake, are managed by the Tennessee Valley Authority dam and reservoir system to meet multipurpose objectives of power generation, navigation, water supply, flood control, recreation, and water quality (TVA, 2020).

Self-supplied industrial surface water use in the five-county region in 2015 was 8.73 MGD (0.46 m^3/s) (USGS, 2022a). The USGS database indicates no self-supplied industrial surface water use in Roane County in 2015.

The largest self-supplied surface water use in Roane County in 2015 by user category defined by the USGS is 348 MGD (18.31 m^3/s) for thermoelectric power once-through cooling water (USGS, 2022a). The USGS estimates that 99 percent of thermoelectric power once-through cooling water is returned to the water source with one percent of the withdrawn water lost to evaporation and other consumptive losses.

3.4.2.3 Water Quality

3.4.2.3.1 Water Quality Characteristics

NUREG-1748 does not provide any specific guidance regarding water quality parameters; therefore, the parameter list contained in NUREG-1555 was used to support the characterization of water quality near the HCS. Surface water features such as streams, lakes, impoundments, and ponds, are absent from the HCS.

Surface water quality samples were obtained from representative waterbodies within the site vicinity including surface water sampling stations on the EFPC as well as sites located along the unnamed tributaries to the EFPC (Figure 3.4.2-3). Seven sampling locations were originally selected to obtain data from the prominent water bodies within representative locations from surface waters located around the site. Two of the sample locations (SW-1 and SW-2) were eliminated after the first sampling event (summer 2021) due to changing project conditions, and SW-6 was dry or near dry with flow too low to sample during three of the four sampling events.. All other locations were sampled seasonally from summer 2021 through spring 2022.

A summary of the data collected during surface water quality monitoring is presented in Tables 3.4.2-3 through 3.4.2-6. Most of the parameters monitored were within the water quality standards for fish and aquatic life established by TDEC (Rule 0400-40-03-03) and USEPA (National Primary Drinking Water Regulations [NPDWR] maximum contaminant level [MCL] for Inorganic Chemicals and Radionuclides), with the exception of elevated fecal coliform and total coliform levels in all four sampling events, which exceeded TDEC numeric criteria (TDEC, 2019). Additionally, alpha radiation particles exceeded the USEPA NPDWR standard of 15 pCi/L in the fall sample from SW-4 at a reported concentration of 22 pCi/L. The alpha radiation result from the sample collected previously in summer and in subsequent winter and spring samples from SW-4 were non-detect for alpha radiation (< 3 pCi/L).

EFPC surface water quality is monitored for metals and inorganic compounds annually as a part of the Oak Ridge Reservation integrated monitoring and surveillance program (TDEC, 2020a). A summary of water quality monitoring data from 2018-2019 monitoring can be found in Table 3.4.2-7. Uranium concentrations were three times the USEPA uranium MCL for drinking

water at one site in EFPC (TDEC, 2020a). Historic contamination of the creek with mercury and monomethylmercury has also been documented, both of which have implications for biotic exposure. Monitoring in 2018-2019 indicated that mercury levels in EFPC exceeded the 0.051 µg/L Tennessee recreation criterion at four locations (TDEC, 2020a). Nitrite and nitrate levels are also of concern on EFPC as these parameters exceeded the criterion of 1.22 mg/L. Similarly, phosphorus concentrations at several of the EFPC sites also exceed the water quality criterion of 0.04 mg/L.

Mean total mercury concentration in fish tissue for redbreast sunfish (*Lepomis auritus*) and rock bass (*Ambloplites rupestris*) in 2019 was 0.52 µg/g (DOE, 2020). Bioaccumulation monitoring for polychlorinated biphenyls (PCBs) in EFPC in 2019 in redbreast sunfish and rock bass showed a mean total PCB concentration of 0.44 µg/g, well above the TDEC water quality criterion that triggers impairment for fish tissue concentration of 0.02 µg/g and the water quality criteria under the Tennessee recreation designated-use classification for PCBs of 0.00064 µg/L (DOE, 2020).

3.4.2.3.2 Impaired Waters and Total Maximum Daily Load

Water quality standards are mandated by the CWA and define the goals for a waterbody by designating its uses, setting criteria to protect those uses, and establishing provisions to protect water quality from pollutants (40 CFR Part 131). The USEPA has passed this mandate to TDEC to establish water quality standards for surface waters in Tennessee. The CWA requires States to identify all waters where required pollution controls are not sufficient to attain or maintain applicable water quality standards and to establish priorities for the development of limits based on the severity of the pollution and the sensitivity of the established uses of those waters. States are required to submit reports to the USEPA. The term “303(d) list” refers to the list of impaired and threatened streams and water bodies identified by the State.

The TDEC 303(d) report lists EFPC as impaired in both Roane County and the upstream segment of the creek in Anderson County. The 303(d) listing is related to elevated nutrients (e.g., phosphorus and nitrates), PCBs, sedimentation, and mercury. Sources for impairment are related to municipal and industrial point source discharges (TDEC, 2020b). Additionally, *E. coli* contamination related to sanitary sewage overflows has been documented in the creek (TDEC, 2020b). Surface water features such as streams, lakes, impoundments, and ponds, are absent from the site thus there are no impaired waterbodies within the HCS.

States are required to develop Total Maximum Daily Loads (TMDLs) for 303(d)-listed waterbodies. The TMDL process establishes the maximum amount of a pollutant that a waterbody can assimilate without exceeding water quality standards and allocates this load among all contributing pollutant sources. The purpose of the TMDL is to establish water quality objectives required to reduce pollution from both point and nonpoint sources and to restore and maintain the quality of water resources. Regionally, four TMDL studies have been completed for the Lower Clinch River watershed: pathogens, siltation and habitat alteration, *E. coli,* and PCBs and chlordane (TDEC, 2022a). Sediment loading levels in EFPC during the TMDL study in 2006 averaged 567 lbs/ac/yr (635.5 kg/ha/yr), well above the target sediment load of 279 lbs/ac/yr (312.7 kg/ha/yr) (TDEC, 2006). Fecal coliform was found in EFPC and a total of 21 miles (33.7 km) were designated as impaired due to high level of pathogens in the 2005 study (TDEC, 2005a). Elevated fecal coli levels within EFPC were determined to be attributable to a collection system failure of the City of Oak Ridge sewage treatment plant. EFPC had a total of 21 miles (33.7 km) that were impaired due to presence of E. Coli in 2008-2013 water quality monitoring (TDEC, 2017).

In 2005, TDEC reported that almost 25 percent of the Lower Clinch River Watershed's stream miles were listed as not supporting or partially supporting designated uses and 100 percent of the lakes in the watershed were not supporting their designated uses (TDEC, 2005b). As part of the State's efforts to accomplish long-term nutrient reduction in the water resources, TDEC developed the Draft Tennessee Nutrient Reduction Framework in 2015 (TDEC, 2015). The framework is intended to guide permitting as well as nutrient reduction strategies for both point and nonpoint sources.

3.4.3 FLOODPLAINS

A floodplain is the land area along a stream or river that is subjected to periodic flooding. The area subject to a one percent chance of flooding in any given year is normally called the 100-year floodplain. The area subject to a 0.2 percent chance of flooding in any given year is normally called the 500-year floodplain. A regulatory floodway is a regulatory tool normally associated with the National Flood Insurance Program (NFIP) that refers to the channel of a river or other watercourse and the adjacent land areas that must be reserved to convey the 100-year flood without cumulatively increasing the water surface elevation more than a designated height.

As shown in Figure 3.4.2-1 (FEMA, 2007), the HCS is located within a valley between two parallel ridges. The EFPC flows southwesterly through the valley and to the south of the HCS. The NFIP Flood Insurance Rate Map (FIRM) depicting floodplain mapping within and in the vicinity of the HCS is presented on Figure 3.4.3-1. The FIRM map indicates that the HCS and the area surrounding the site are Zone X (unshaded), which is defined as "areas determined to be outside of the 0.2 percent annual chance floodplain." Near the vicinity of the site, only the EFPC and Poplar Creek have NFIP-mapped floodplains. An NFIP regulatory floodway is also defined on the EFPC. However, detailed mapping of EFPC on the FIRM ends upstream of the HCS at the Highway 95 crossing of EFPC. The EFPC channel downstream of the detailed study area and adjacent to the HCS is encompassed by the Zone X (unshaded) area. However, the FIRM does not appear to accurately depict the EFPC 100-year or 500-year floodplain through this Zone X (unshaded) area near the HCS (i.e., no floodplain shown along this segment of the EFPC channel).

A floodplain study for EFPC was completed by the Tennessee Valley Authority (TVA) in 1991. The TVA floodplain study demonstrates that the maximum 100-year flood elevation along EFPC in the vicinity of the HCS is 764.9 ft. (233.1 m) mean sea level at Mile 2.94 (KM 4.73) upstream of the HCS, and 759.9 ft. (231.6 m) at Mile 2.14 (KM 3.44) in the vicinity of the TRISO-X FFF structures on the HCS (Figure 3.4.3-2). A tabulation of water surface elevations at hydraulic model cross sections is provided in that report, but no mapping of the floodplain was provided. The USACE subsequently obtained the TVA floodplain information for EFPC and created EFPC floodplain maps and a report (USACE,1992). The TVA study data was also recently used to create a floodplain map for EFPC for another project located near the HCS (Leidos, 2020) (Figure 3.4.3-3). The map shows EFPC backwater flood elevations extending upstream (north) along a tributary to EFPC that is located along the eastern boundary of the HCS. However, the map does not show the EFPC 100-year or 500-year floodplain extending onto the HCS. At the southern corner of the HCS, immediately west of the intersection of Novus Drive and Renovare Boulevard, the lowest ground elevation along the HCS boundary is approximately 760 ft. (231.6 m) and the TVA 100-year flood elevation is approximately 759.4 ft. (231.5 m) mean sea level (Mile 1.92 (KM 3.1) of the hydraulic model) .

3.4.4 WETLANDS

As defined in 33 CFR 328.3, wetlands are those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions. Types of wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands and wetland fringe areas can also be found along the edges of many watercourses and impounded waters (both natural and man-made). Wetland habitat provides valuable public benefits including flood storage, erosion control, water quality improvement, wildlife habitat, and recreation opportunities [33 CFR 328.39(b)].

Wetlands located within the HCS may potentially be regulated under Section 404 and 401 of the CWA (33 USC 1251). The USACE regulates the discharge of dredged or fill material into waters of the U.S. (WOTUS), including wetlands, under the CWA Section 404 Permit program (33 US Code 1344). In Tennessee, physical alterations to properties of waters of the State require an Aquatic Resource Alteration Permit (ARAP) or a Section 401 Water Quality Certification, both of which are administered by TDEC.

The U.S. Fish and Wildlife Service (USFWS), through its online Wetland Mapper tool, produces the National Wetland Inventory (NWI). NWI mapping within the HCS includes a very small amount of freshwater forested wetland and a riverine feature located in the northeast portion of the HCS, north of Renovare Boulevard (Table 3.4.4-1 and Figure 3.4.4-1). Additionally, NWI and USGS mapping indicated a blueline stream entering HCS from the northwest, turning to the southwest and flowing across the central part of the site. NWI features mapped within the 3-mi. (4.8-km) vicinity include lacustrine, riverine, palustrine scrub-shrub, palustrine forested, and open water wetlands as summarized in Table 3.4.4-1 (USFWS, 2022).

As TDEC regulates watercourses based on Tennessee-specific regulations, potential WOTUS were also evaluated based on TDEC guidance. At the State-level, watercourses are classified as either a “stream” or “WWC”. TDEC defines a WWC as “man-made or natural watercourses, including natural watercourses that have been modified by channelization: that flow only in direct response to precipitation runoff in their immediate locality; whose channels are at all times above the ground water table; that are not suitable for drinking water supplies; and in which hydrological and biological analyses indicate that, under normal weather conditions, due to naturally occurring ephemeral or low flow there is not sufficient water to support fish, or multiple populations of obligate lotic aquatic organisms whose life cycle includes an aquatic phase of at least two months [TDEC Rule 0400-40-03-.05(9)].” A stream is simply defined as a “surface water that is not a wet weather conveyance [TDEC Rule 0400-4-3-.04(20)].”

The HCS was reviewed in the field for the presence of potential wetlands, including the area of an NWI-mapped forested wetland; however, wetlands were not identified. This mapped stream feature was reviewed in the field and was determined to be a vegetated swale lacking wetland, stream, or WWC characteristics (Figure 3.4.4-2).

Table 3.4.1-1
Summary of Observation Well Installation Details and Monitoring Program

Well ID	Northing US feet, NAD83	Easting US feet, NAD83	TOC Elevation US feet, NAD83	Total Depth ft. bgs	Screen Length feet	Target Aquifer	Water-Level Monitoring	Chemical Testing	In-situ Hydraulic Conductivity Testing
GW-1	597,860.10	2,451,011.18	841.55	75.2	10	Upper Bedrock	x	x	x
GW-2	596,811.83	2,452,480.08	787.11	42.4	10	Upper Bedrock	x	x	x
GW-1R	597,641.48	2,450,984.06	826.70	80.0	15	Upper Bedrock	x	x	
GW-3	596,131.16	2,449,329.48	802.75	49.0	10	Upper Bedrock	x	x	x
GW-4	595,321.09	2,450,833.61	769.72	39.0	10	Upper Bedrock	x	x	x
GW-5	593,948.01	2,450,147.20	784.23	65.0	10	Upper Bedrock	x		
GW-6	593,281.51	2,449,409.50	768.17	47.0	10	Upper Bedrock	x		

ID - Identification

TOC - top of casing

Ft. bgs – feet below ground surface

Survey vertical datum: North America Vertical Datum 1988 (NAVD88)

Table 3.4.1-2
(Sheet 1 of 3)
Summary of Observation Well Groundwater Levels

Well ID	TOC Elevation (ft. NAVD88)	Date Measured	Depth to Water (ft. btoc)	Ground Water Elevation (ft. NAVD88)
GW-1	841.55	9/16/2021	56.68	748.87
		10/26/2021	47.44	794.11
		11/17/2021	42.89	798.66
		12/16/2021	44.85	796.7
		1/12/2022	34.69	806.86
		2/28/2022	31.25	810.30
		3/25/2022	38.33	803.22
		4/22/2022	36.63	804.92
		5/23/2022	39.21	802.34
		6/16/2022	45.69	795.86
		7/26/2022	44.94	796.61
		8/8/2022	43.01	798.54
GW-1R	826.70	2/28/2022	9.76	816.94
		3/25/2022	28.64	798.06
		4/22/2022	26.91	799.79
		5/24/2022	46.40	780.30
		6/16/2022	51.61	775.09
		7/26/2022	45.84	780.86
		8/8/2022	39.83	786.87
GW-2	787.11	9/15/2021	22.74	764.37
		10/26/2021	23.09	764.02
		11/19/2021	22.6	764.51
		12/16/2021	22.07	765.04
		1/12/2022	21.96	765.15
		2/28/2022	21.61	765.5
		3/25/2022	21.84	765.27
		4/22/2022	21.7	765.41
		5/31/2022	21.72	765.39
		6/16/2022	21.53	765.58
		7/26/2022	21.39	765.72
		8/8/2022	21.43	765.68

Table 3.4.1-2
(Sheet 2 of 3)
Summary of Observation Well Groundwater Levels

Well ID	TOC Elevation (ft. NAVD88)	Date Measured	Depth to Water (ft. btoc)	Ground Water Elevation (ft. NAVD88)
GW-3	802.75	9/14/2021	37.79	764.96
		10/26/2021	38.57	764.18
		11/17/2021	41.36	761.39
		12/16/2021	42.19	760.56
		1/12/2022	18.82	783.93
		2/28/2022	12.64	790.11
		3/25/2022	23.97	778.78
		4/22/2022	25.64	777.11
		5/25/2022	39.40	763.35
		6/16/2022	41.34	761.41
		7/26/2022	43.44	759.31
		8/8/2022	38.26	764.49
GW-4	769.72	9/16/2021	13.26	756.46
		10/26/2021	12.7	757.02
		11/18/2021	13.2	756.52
		12/16/2021	12.26	757.46
		1/12/2022	10.48	759.24
		2/28/2022	9.58	760.14
		3/25/2022	11.81	757.91
		4/22/2022	12.14	757.58
		5/25/2022	12.73	756.99
		6/16/2022	13.32	756.4
		7/26/2022	11.18	758.54
		8/8/2022	12.47	757.25
GW-5	784.23	9/17/2021	24.95	759.28
		10/26/2021	24.27	759.96
		11/19/2021	24.41	759.82
		12/16/2021	24.24	759.99
		1/12/2022	23.90	760.33
		2/28/2022	23.46	760.77
		3/25/2022	24.06	760.17
		4/22/2022	24.11	760.12
		6/16/2022	24.34	759.89
		7/26/2022	24.94	759.29
		8/8/2022	24.07	760.16

Table 3.4.1-2
(Sheet 3 of 3)
Summary of Observation Well Groundwater Levels

Well ID	TOC Elevation (ft. NAVD88)	Date Measured	Depth to Water (ft. btoc)	Ground Water Elevation (ft. NAVD88)
GW-6	768.17	9/20/2021	44.37	723.8
		10/26/2021	39.33	728.84
		11/19/2021	34.69	733.48
		12/16/2021	30.32	737.85
		1/12/2022	27.36	740.81
		2/28/2022	25.34	742.83
		3/25/2022	25.14	743.03
		4/22/2022	25.28	742.89
		6/16/2022	25.98	742.19
		7/26/2022	25.48	742.69
		8/8/2022	26.18	741.99

btoc – below top of casing
ft. – feet
ID – Identification
TOC – Top of Casing
Survey vertical datum: North America Vertical Datum 1988 (NAVD88)

Table 3.4.1-3
Groundwater Parameters Associated with the Horizon Center Site

Well ID	Hydraulic Conductivity Range		Hydraulic Conductivity Geometric Average		Storativity Range		Storativity Geometric Average
	Low (ft/d)	High (ft/d)	(ft/d)	(cm/sec)	Low (ft^3/ft^3)	High (ft^3/ft^3)	(ft^3/ft^3)
GW-1	3.25E-04	2.19E-03	1.1E-03	3.8E-07	8.84E-11	1.00E-08	1.5E-09
GW-2	8.43E-05	7.72E-03	2.2E-03	7.6E-07	5.04E-04	1.00E-01	3.3E-04
GW-3	1.86E-03	6.11E-03	3.7E-03	1.3E-06	9.23E-11	1.00E-10	9.6E-11
GW-4	3.53E+00	1.59E+01	6.27E+00	2.2E-03	3.36E-07	5.81E-03	7.9E-05
GW-5	1.54E-01	4.54E-01	2.3E-01	8.1E-05	8.33E-07	4.66E-04	8.1E-05

All analyses performed using AQTESOLV-provided solutions (Cooper, Bredehoeft, Papadopoulos; KGS; Bouwer-Rice; & Hvorslev solution methods)
ft^2/d = feet squared per day
ft/d = feet per day
cm/sec = centimeters per second
ft^3/ft^3 = cubic feet per cubic feet

Table 3.4.1-4
(Sheet 1 of 6)
Groundwater Quality Summary Data – Summer 2021

		Location ID:			**GW-1**		**GW-2**		**GW-3**		**GW-4**		**GW-5**		**GW-5**	
		Sample Date:			**9/16/2021**		**9/15/2021**		**9/14/2021**		**9/16/2021**		**9/17/2021**		**9/17/2021**	
		Sample Type:			**Sample**		**Sample**		**Sample**		**Sample**		**Sample**		**Duplicate**	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**												
Alkalinity, Total:																
A2320	Alkalinity, Total (as $CaCO_3$)	mg/L			NA		280		190		350		390		370	
A2320	Carbon dioxide	mg/L			NA		7.9		< 5.0	U	13		11		9.4	
Anions:																
E300	Chloride	mg/L			NA		7.6		9.8		1.9		1.9		2	
E300	Fluoride	mg/L		4	NA		0.38		0.53		0.15		0.35		0.33	
E300	Sulfate	mg/L			NA		23		35		7.2		37		37	
Biochemical Oxygen Demand:																
A5210B	Biochemical Oxygen Demand (BOD)	mg/L			NA		8.2		< 2.0	U	2.5		< 2.0	U	< 2.0	U
Chemical Oxygen Demand:																
A5220D	Chemical Oxygen Demand (COD)	mg/L			NA		< 10	U	5.3	JQ	< 10	U	< 10	U	< 10	U
Coliform:																
CD137MPN	Fecal Coliform	mpn/mL			NA		5.2		< 1.0	U	178.5	JL	< 1.0	U	< 1.0	U
CD137MPN	Total Coliforms	mpn/mL			NA		2419.6		2419.6		2419.6		195.6		344.8	J

Table 3.4.1-4
(Sheet 2 of 6)
Groundwater Quality Summary Data – Summer 2021

		Location ID:			GW-1		GW-2		GW-3		GW-4		GW-5		GW-5	
		Sample Date:			9/16/2021		9/15/2021		9/14/2021		9/16/2021		9/17/2021		9/17/2021	
		Sample Type:			Sample		Sample		Sample		Sample		Sample		Duplicate	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**												
Cyanide:																
E1677	Cyanide, Free	mg/L	0.2	0.2	NA		< 0.006	U	< 0.006	U	< 0.006	U	< 0.02	U	< 0.02	U
Field Parameters:																
E360.1	Dissolved Oxygen	mg/L			1.4		1.12		1.02		0.28		0.17		0.17	
A2580A	Oxidation Reduction Potential	mV			122.3		100.5		149.8		1.2		-90		-90	
E150.1	pH	pH units			7.69		7.27		7.6		6.96		7.05		7.05	
E120.1	Specific Conductance	mS/cm			0.377		0.61		0.393		0.65		0.75		0.75	
E170.1	Temperature	deg C			24.5		25.1		21.6		16.5		15.7		15.7	
E180.1	Turbidity	NTU			125		155		6.85		4.04		3.98		3.98	
Hardness:																
A2340	Hardness, Total as $CaCO_3$	mg/L			NA		280		190		370		330		330	
Metals, Total:																
E200.7	Aluminum	ug/L			NA		310		51	JQ	< 200	U	< 200	U	< 200	U
E200.8	Antimony	ug/L	6	6	NA		1.6	JQ	< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U
E200.8	Arsenic	ug/L	10	10	NA		< 3.0	U	< 3.0	U	< 3.0	U	< 3.0	U	< 3.0	U
E200.7	Barium	ug/L	2000	2000	NA		24		32		41		78		75	

Table 3.4.1-4
(Sheet 3 of 6)
Groundwater Quality Summary Data – Summer 2021

		Location ID:			GW-1		GW-2		GW-3		GW-4		GW-5		GW-5	
		Sample Date:			9/16/2021		9/15/2021		9/14/2021		9/16/2021		9/17/2021		9/17/2021	
		Sample Type:			Sample		Sample		Sample		Sample		Sample		Duplicate	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**												
E200.7	Beryllium	ug/L	4	4	NA		< 4.0	U	< 4.0	U	< 4.0	U	< 4.0	U	< 4.0	U
E200.7	Boron	ug/L			NA		120	B	< 100	U	< 100	U	520	B	510	B
E200.8	Cadmium	ug/L	5	5	NA		< 0.5	U	< 0.5	U	< 0.5	U	< 0.5	U	< 0.5	U
E200.7	Calcium	ug/L			NA		82000		40000		110000		57000		56000	
E200.7	Chromium	ug/L		100	NA		< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
E200.7	Cobalt	ug/L			NA		< 10	U	< 10	U	2.5	JQ	< 10	U	< 10	U
E200.7	Copper	ug/L			NA		< 20	U	< 20	U	< 20	U	< 20	U	< 20	U
E200.7	Iron	ug/L			NA		280		44	JQ	110	B	110		130	
E200.8	Lead	ug/L			NA		< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U
E200.7	Magnesium	ug/L			NA		16000		20000		15000		39000		38000	
E200.7	Manganese	ug/L			NA		230		49		1800		22		24	
E245.1	Mercury	ug/L	2	2	NA		< 0.2	U	< 0.2	U	< 0.2	U	< 0.2	U	< 0.2	U
E200.7	Nickel	ug/L	100		NA		3.7	JQ	< 40	U	< 40	U	< 40	U	< 40	U
E200.7	Potassium	ug/L			NA		3900		2300		1200		11000		11000	
E200.8	Selenium	ug/L	50	50	NA		< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U
E200.7	Silver	ug/L			NA		< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
E200.7	Sodium	ug/L			NA		34000		24000		4000		38000		37000	
E200.8	Thallium	ug/L	2	2	NA		< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U

Table 3.4.1-4
(Sheet 4 of 6)
Groundwater Quality Summary Data – Summer 2021

		Location ID:			GW-1		GW-2		GW-3		GW-4		GW-5		GW-5	
		Sample Date:			9/16/2021		9/15/2021		9/14/2021		9/16/2021		9/17/2021		9/17/2021	
		Sample Type:			Sample		Sample		Sample		Sample		Sample		Duplicate	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**												
E200.8	Uranium	ug/L		30	NA		0.00069	JQ	0.0011		0.00057	JQ	< 0.001	U	< 0.001	U
E200.7	Vanadium	ug/L			NA		1.2	JQ	1.2	JQ	1.5	JQ	1.3	JQ	< 10	U
E200.7	Zinc	ug/L			NA		< 20	U	< 20	U	< 20	U	< 20	U	< 20	U
Minerals, Dissolved:																
E200.7	Quartz	ug/L			NA		7800	B	11000	B	8500	B	14000		13000	
E200.7	Silicon	ug/L			NA		3600	B	5000	B	4000	B	6400		6200	
Nitrogen Series:																
SM4500-NH3G	Ammonia	mg/L			NA		0.21	B	< 0.25	U	< 0.25	U	0.9	B	0.95	B

Table 3.4.1-4
(Sheet 5 of 6)
Groundwater Quality Summary Data – Summer 2021

		Location ID:			GW-1			GW-2		GW-3		GW-4		GW-5		GW-5	
		Sample Date:			9/16/2021			9/15/2021		9/14/2021		9/16/2021		9/17/2021		9/17/2021	
		Sample Type:			Sample			Sample		Sample		Sample		Sample		Duplicate	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**													
E300	Nitrogen, Nitrate	mg/L	10	10	NA			< 0.05	U	0.034	JQ	< 0.05	U	< 0.05	U	< 0.05	U
E300	Nitrogen, Nitrite	mg/L	1	1	NA			< 0.05	U	< 0.05	U	< 0.05	U	< 0.05	U	< 0.05	U
CALC	Nitrogen, Organic	mg/L			NA			1.2	B	0.21	B	0.22	B	0.7	B	0.35	B
E351.2	Total Kjeldahl Nitrogen	mg/L			NA			1.4	B	0.21	B	0.22	B	1.6	B	1.3	B
Orthophosphate:																	
SM4500-PF	Phosphate as P, Ortho	mg/L			< 0.05	U		0.02	JQ	< 0.05	U	< 0.05	U	< 0.05	U	< 0.05	U
Phosphorus																	
E365.4	Phosphorus, Total	mg/L			NA			0.044	B	< 0.1	U	< 0.1	U	0.062	B	0.093	B
Radioactivity:																	
E900	Alpha Radiation Particles	pCi/L		15	NA			< 3.0	U	< 3.0	U	< 3.0	UL	< 3.0	U	< 3.0	U
E900	Beta Particles & Photon Emitters	pCi/L		1719[c]	NA			3.72	B	5.03		0.555	B	3.67	J	7.57	J
Residue Series:																	
A2540C	Total Dissolved Solids	mg/L			NA			300		220		340		390		380	
A2540D	Total Suspended Solids	mg/L			NA			180		7.7		< 2.5	U	7.4		7	

Table 3.4.1-4
(Sheet 6 of 6)
Groundwater Quality Summary Data – Summer 2021

		Location ID:			GW-1	GW-2	GW-3	GW-4	GW-5	GW-5
		Sample Date:			9/16/2021	9/15/2021	9/14/2021	9/16/2021	9/17/2021	9/17/2021
		Sample Type:			Sample	Sample	Sample	Sample	Sample	Duplicate
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**						

Notes:
a) Rules of the Tennessee Department of Environment and Conservation, Criteria for Fish and Aquatic Life Water Use, Numeric Criteria of Rule 0400-40-03-.03 subparagraph (3)
b) USEPA National Primary Drinking Water Regulations (NPDWR) Maximum Contaminant Level (MCL) for Inorganic Chemicals and Radionuclides
c) USEPA NPDWR MCL for Beta Particles & Photon Emitters is based on the specific radionuclide(s) concentration(s) in pCi/L units that produce a 4 millirem per year dose. The average concentration for listed radionuclides resulting in a 4 millirem per year dose is 1719 pCi/L and the actual site specific concentration could vary significantly depending on the radionuclide
deg C = degrees Celsius
mg/L = milligrams per liter
mg/m^3 = milligrams per cubic meter
mpn/mL = most probable number per milliliter
mS/cm = millisiemens per centimeter
mV = millivolts
NTU = nephelometric turbidity unit
pCi/L = picocuries per liter
ug/L = micrograms per liter

Data Qualifier Definitions:
B = The analyte was detected, estimated, blank contamination
J = The analyte was detected, estimated due to QC criteria
JH = Estimated, may be biased high
JL = Estimated, may be biased low
JQ = Value listed is estimated, reported between the Method Detection Limit (MDL) and the Reporting Limit (RL)
UJ = The analyte was not detected; however, the result is estimated due to discrepancies in meeting certain analyte-specific quality control criteria
UL = The analyte was not detected; however, the reported value may be biased low
U = Not Detected above the Reporting Limit shown

Table 3.4.1-5
(Sheet 1 of 6)
Groundwater Quality Summary Data – Fall 2021

		Location ID:			GW-1		GW-2		GW-3		GW-4		GW-4	
		Sample Date:			11/17/2021		11/19/2021		11/17/2021		11/18/2021		11/18/2021	
		Sample Date:			Sample		Sample		Sample		Sample		Duplicate	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**										
Alkalinity, Total:														
A2320	Alkalinity, Total (as $CaCO_3$)	mg/L			180		290		210		380		380	
A2320	Carbon dioxide	mg/L			< 5.0	U	8.1		< 5.0	U	22		26	
Anions:														
E300	Chloride	mg/L			7.1		8.0		31		1.7		1.5	
E300	Fluoride	mg/L		4	0.4		0.48		0.4		0.12		0.1	
E300	Sulfate	mg/L			10		21		33		12		5.3	
Biochemical Oxygen Demand:														
A5210B	Biochemical Oxygen Demand (BOD)	mg/L			4.3		53		3.3		< 2.0	U	< 2.0	U
Chemical Oxygen Demand:														
A5220D	Chemical Oxygen Demand (COD)	mg/L			8.6	JQ	20		< 10	U	< 10	U	< 10	U
Coliform:														
CD137MPN	Fecal Coliform	mpn/mL			< 1.0	U	< 1.0	U	< 1.0	U	18.5		6.3	
CD137MPN	Total Coliforms	mpn/mL			178.9		2419.6		613.1		238.2		290.9	

Table 3.4.1-5
(Sheet 2 of 6)
Groundwater Quality Summary Data – Fall 2021

		Location ID:			GW-1		GW-2		GW-3		GW-4		GW-4	
		Sample Date:			11/17/2021		11/19/2021		11/17/2021		11/18/2021		11/18/2021	
		Sample Date:			Sample		Sample		Sample		Sample		Duplicate	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**										
Cyanide:														
E1677	Cyanide, Free	mg/L	0.2	0.2	< 0.006	U	< 0.006	U	< 0.006	U	< 0.006	U	< 0.006	U
Field Parameters:														
E360.1	Dissolved Oxygen	mg/L			2.32		0.36		1.86		0.41		0.41	
A2580A	Oxidation Reduction Potential	mV			89.9		-47.5		27.6		33.8		33.8	
E150.1	pH	pH units			7.56		7.56		7.65		7.0		7.0	
E120.1	Specific Conductance	mS/cm			0.35		0.59		0.52		0.66		0.66	
E170.1	Temperature	deg C			21.3		13.5		22.6		15.9		15.9	
E180.1	Turbidity	NTU			33		30.9		46.5		4.51		4.51	
Hardness:														
A2340	Hardness, Total as $CaCO_3$	mg/L			290		250		370		580		590	
Metals, Total:														
E200.7	Aluminum	ug/L			73	JQ	74	JQ	76	JQ	< 200	U	< 200	U
E200.8	Antimony	ug/L	6	6	1.1	JQ	5.5		< 5.0	U	< 5.0	U	< 5.0	U
E200.8	Arsenic	ug/L	10	10	< 3.0	U	< 3.0	U	< 3.0	U	< 3.0	U	< 3.0	U

Table 3.4.1-5
(Sheet 3 of 6)
Groundwater Quality Summary Data – Fall 2021

		Location ID:			GW-1		GW-2		GW-3		GW-4		GW-4	
		Sample Date:			11/17/2021		11/19/2021		11/17/2021		11/18/2021		11/18/2021	
		Sample Date:			Sample		Sample		Sample		Sample		Duplicate	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**										
E200.7	Barium	ug/L	2000	2000	13		20		40		28		25	
E200.7	Beryllium	ug/L	4	4	0.15	JQ	< 4.0	U	< 4.0	U	< 4.0	U	< 4.0	U
E200.7	Boron	ug/L			140		190		< 100	U	< 100	U	< 100	U
E200.8	Cadmium	ug/L	5	5	< 0.5	U	< 0.5	U	< 0.5	U	< 0.5	U	< 0.5	U
E200.7	Calcium	ug/L			42000		67000		49000		110000		110000	
E200.7	Chromium	ug/L		100	< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
E200.7	Cobalt	ug/L			< 10	U	1.4	JQ	< 10	U	2.2	JQ	2.4	JQ
E200.7	Copper	ug/L			< 20	U	< 20	U	< 20	U	< 20	U	< 20	U
E200.7	Iron	ug/L			120		1100		96		380		350	
E200.8	Lead	ug/L			< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U
E200.7	Magnesium	ug/L			18000		14000		27000		16000		16000	
E200.7	Manganese	ug/L			31		270		160		1200		1200	
E245.1	Mercury	ug/L	2	2	< 0.2	U	< 0.2	U	< 0.2	U	< 0.2	U	< 0.2	U
E200.7	Nickel	ug/L	100		< 40	U	< 40	U	< 40	U	< 40	U	< 40	U
E200.7	Potassium	ug/L			3400		5400		2200		1300		1200	

Table 3.4.1-5
(Sheet 4 of 6)
Groundwater Quality Summary Data – Fall 2021

		Location ID:			GW-1		GW-2		GW-3		GW-4		GW-4	
		Sample Date:			11/17/2021		11/19/2021		11/17/2021		11/18/2021		11/18/2021	
		Sample Date:			Sample		Sample		Sample		Sample		Duplicate	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**										
E200.8	Selenium	ug/L	50	50	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U
E200.7	Silver	ug/L			< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
E200.7	Sodium	ug/L			7600		46000		22000		1700		1600	
E200.8	Thallium	ug/L	2	2	< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U
E200.8	Uranium	ug/L		30	0.0033		0.00079	JQ	0.001		< 0.001	U	< 0.001	U
E200.7	Vanadium	ug/L			< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
E200.7	Zinc	ug/L			< 20	U	< 20	U	< 20	U	< 20	U	< 20	U
Minerals, Dissolved:														
E200.7	Quartz	mg/L			6800		8300		12000		8300		8400	
E200.7	Silicon	mg/L			3200		3900		5500		3900		3900	
Nitrogen Series:														
SM4500-NH3G	Ammonia	mg/L			0.26		0.25	JQ	< 0.25	U	< 0.25	U	< 0.25	U
E300	Nitrogen, Nitrate	mg/L	10	10	< 0.05	U	< 0.05	U	0.07		< 0.05	U	< 0.05	U
E300	Nitrogen, Nitrite	mg/L	1	1	0.029	JQ	< 0.05	U	< 0.05	U	< 0.05	U	< 0.05	U
CALC	Nitrogen, Organic	mg/L			0.3		0.29		< 0.2	U	< 0.2	U	< 0.2	U

Table 3.4.1-5
(Sheet 5 of 6)
Groundwater Quality Summary Data – Fall 2021

		Location ID:			GW-1		GW-2		GW-3		GW-4		GW-4	
		Sample Date:			11/17/2021		11/19/2021		11/17/2021		11/18/2021		11/18/2021	
		Sample Date:			Sample		Sample		Sample		Sample		Duplicate	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**										
E351.2	Total Kjeldahl Nitrogen	mg/L			0.56		0.54		< 0.2	U	< 0.2	U	0.11	J Q
Orthophosphate:														
SM4500-PF	Phosphate as P, Ortho	mg/L			< 0.05	U	< 0.05	U	0.038	J Q	< 0.05	U	< 0.05	U
Phosphorus:														
E365.4	Phosphorus, Total	mg/L			< 0.1	U	< 0.1	U	< 0.1	U	< 0.1	U	< 0.1	U
Radioactivity:														
E900	Alpha radiation particles	pCi/L		15	4.91		< 3.0	U	< 3.0	U	< 3.0	U	9.74	
E900	Beta Particles & Photon Emitters	pCi/L		1719 [(C)]	2.96		4.86		1.63		< 4.0	U	4.55	
Residue Series:														
A2540C	Total Dissolved Solids (TDS)	mg/L			160		330		260		360		350	
A2540D	Total Suspended Solids (TSS)	mg/L			78		21		21		4.4		3.2	

Table 3.4.1-5
(Sheet 6 of 6)
Groundwater Quality Summary Data – Fall 2021

Notes:
a) Rules of the Tennessee Department of Environment and Conservation, Criteria for Fish and Aquatic Life Water Use, Numeric Criteria of Rule 0400-40-03-.03 subparagraph (3)
b) USEPA National Primary Drinking Water Regulations (NPDWR) Maximum Contaminant Level (MCL) for Inorganic Chemicals and Radionuclides
c) USEPA NPDWR MCL for Beta Particles & Photon Emitters is based on the specific radionuclide(s) concentration(s) in pCi/L units that produce a 4 millirem per year dose. The average concentration for listed radionuclides resulting in a 4 millirem per year dose is 1719 pCi/L and the actual site specific concentration could vary significantly depending on the radionuclide
deg C = degrees Celsius
mg/L = milligrams per liter
mg/m^3 = milligrams per cubic meter
mpn/mL = most probable number per milliliter
mS/cm = millisiemens per centimeter
mV = millivolts
NTU = nephelometric turbidity unit
pCi/L = picocuries per liter
ug/L = micrograms per liter

Data Qualifier Definitions:
B = The analyte was detected, estimated, blank contamination
J = The analyte was detected, estimated due to QC criteria
JH = Estimated, may be biased high
JL = Estimated, may be biased low
JQ = Value listed is estimated, reported between the Method Detection Limit (MDL) and the Reporting Limit (RL)
UJ = The analyte was not detected; however, the result is estimated due to discrepancies in meeting certain analyte-specific quality control criteria
UL = The analyte was not detected; however, the reported value may be biased low
U = Not Detected above the Reporting Limit shown

Table 3.4.1-6
(Sheet 1 of 5)
Groundwater Quality Summary Data – Winter 2021/2022

Location ID:					**GW-1**		**GW-1R**		**GW-1R**		**GW-1R**		**GW-2**		**GW-3**		**GW-4**	
Sample Date:					**2/28/2022**		**3/3/2022**		**3/3/2022**		**3/11/2022**		**3/2/2022**		**3/4/2022**		**3/3/2022**	
Sample Type:					**Sample**		**Sample**		**Duplicate**		**Sample**		**Sample**		**Sample**		**Sample**	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**														
Alkalinity, Total:																		
SM2320B	Alkalinity, Total (as $CaCO_3$)	mg/L			160		130		130		NA		320		200		340	
SM2320B	Carbon dioxide	mg/L			< 5.0	U	< 5.0	U	< 5.0	U	NA		11		6.6		16	
Anions:																		
E300.0	Chloride	mg/L			7.9		1.1		1.1		NA		3.4		55		1.4	
E300.0	Fluoride	mg/L		4	0.47		0.088	JQ	0.092	JQ	NA		0.53		0.37		0.15	
E300.0	Sulfate	mg/L			7.6		0.97	JQ	1.0		NA		14		55		5.9	
Biochemical Oxygen Demand:																		
SM5210B	Biochemical Oxygen Demand (BOD)	mg/L			8.2	B	4.6	JB	6.5	JB	3.5	JB	8.8	JB	7.3	B	< 2.0	U
Chemical Oxygen Demand:																		
SM5220D	Chemical Oxygen Demand (COD)	mg/L			8.7	JQ	< 10	U	< 10	U	NA		7.7	JQ	< 10	U	< 10	U
Coliform:																		
CD137MPN	Fecal Coliform	mpn/mL			< 1.0	U	< 1.0	U	< 1.0	U	NA		< 1.0	U	< 1.0	U	< 1.0	U
CD137MPN	Total Coliforms	mpn/mL			25.3		24.1	J	396.1	J	NA		52.1		75.4		13.2	J H
Cyanide:																		
E1677	Cyanide, Free	mg/L	0.2	0.2	< 0.002	U	0.0094	JQ	< 0.02	U	NA		<0.002	U	< 0.002	U	0.0015	J Q
Field Parameters:																		
E360.1	Dissolved Oxygen	mg/L			3.98		4.43		4.43		4.31		1.86		1.03		0.32	

Table 3.4.1-6
(Sheet 2 of 5)
Groundwater Quality Summary Data – Winter 2021/2022

Location ID:					GW-1		GW-1R		GW-1R		GW-1R		GW-2		GW-3		GW-4	
Sample Date:					2/28/2022		3/3/2022		3/3/2022		3/11/2022		3/2/2022		3/4/2022		3/3/2022	
Sample Type:					Sample		Sample		Duplicate		Sample		Sample		Sample		Sample	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**														
SM2580A	Oxidation Reduction Potential	mV			-105		52.9		52.9		92.2		-80.8		-9.6		25.7	
E150.1	pH	pH units			7.6		7.71		7.71		7.67		7.07		7.59		6.79	
E120.1	Specific Conductance	ms/cm			0.332		0.266		0.266		0.242		0.66		0.7		0.65	
E170.1	Temperature	deg C			16.2		22.9		22.9		19		16.3		19.8		16.8	
E180.1	Turbidity	NTU			3.56		31.3		31.3		7.21		66.1		3.23		2.3	
Hardness:																		
SM2340C	Hardness, Total as $CaCO_3$	mg/L			160		140		130		NA		260		260		630	
Metals, Total:																		
E200.7	Aluminum	ug/L			< 200	U	120	JQ	110	JQ	NA		1900		< 200	U	< 200	U
E200.8	Antimony	ug/L	6	6	< 5.0	U	< 5.0	U	< 5.0	U	NA		0.86	JQ	< 5.0	U	< 5.0	U
E200.8	Arsenic	ug/L	10	10	< 3.0	U	0.9	JQ	0.92	JQ	NA		1.3	JQ	< 3.0	U	< 3.0	U
E200.7	Barium	ug/L	2000	2000	19		9.8	JQ	9.4	JQ	NA		32		62		28	
E200.7	Beryllium	ug/L	4	4	< 4.0	U	< 4.0	U	< 4.0	U	NA		< 4.0	U	< 4.0	U	< 4.0	U
E200.7	Boron	ug/L			27	JQ	< 100	U	< 100	U	NA		170		< 100	U	< 100	U
E200.8	Cadmium	ug/L	5	5	< 0.5	U	< 0.5	U	< 0.5	U	NA		< 0.5	U	< 0.5	U	< 0.5	U
E200.7	Calcium	ug/L			34000		30000		31000		NA		81000		59000		120000	
E200.7	Chromium	ug/L		100	< 10	U	1.1	JQ	1.4	JQ	NA		4.1	JQ	< 10	U	< 10	U
E200.7	Cobalt	ug/L			< 10	U	< 10	U	< 10	U	NA		< 10	U	< 10	U	< 10	U
E200.7	Copper	ug/L			< 20	U	< 20	U	< 20	U	NA		< 20	U	< 20	U	< 20	U
E200.7	Iron	ug/L			410		51	JQ	52	JQ	NA		5300		31	JQ	74	JQ

Table 3.4.1-6
(Sheet 3 of 5)
Groundwater Quality Summary Data – Winter 2021/2022

		Location ID:			GW-1		GW-1R		GW-1R		GW-1R		GW-2		GW-3		GW-4	
		Sample Date:			2/28/2022		3/3/2022		3/3/2022		3/11/2022		3/2/2022		3/4/2022		3/3/2022	
		Sample Type:			Sample		Sample		Duplicate		Sample		Sample		Sample		Sample	
E200.8	Lead	ug/L			< 2.5	U	< 2.5	U	< 2.5	U	NA		0.82	B	< 2.5	U	< 2.5	U
E200.7	Magnesium	ug/L			17000		15000		16000		NA		20000		31000		18000	
E200.7	Manganese	ug/L			150		4.0	JQ	1.5	JQ	NA		290		51		680	
E245.1	Mercury	ug/L	2	2	< 0.2	U	< 0.2	U	< 0.2	U	NA		< 0.2	U	< 0.2	U	< 0.2	U
E200.7	Nickel	ug/L	100		< 40	U	< 40	U	< 40	U	NA		< 40	U	< 40	U	< 40	U
E200.7	Potassium	ug/L			2800		730	JQ	1400	B	NA		4600		4800		1400	B
E200.8	Selenium	ug/L	50	50	< 2.5	U	< 2.5	U	< 2.5	U	NA		< 2.5	U	< 2.5	U	< 2.5	U
E200.7	Silver	ug/L			< 10	U	< 10	U	< 10	U	NA		< 10	U	< 10	U	< 10	U
E200.7	Sodium	ug/L			7500		950	JQ	1100	JQ	NA		40000		40000		2200	
E200.8	Thallium	ug/L	2	2	< 1.0	U	< 1.0	U	< 1.0	U	NA		< 1.0	U	< 1.0	U	< 1.0	U
E200.8	Uranium	mg/L		30	0.0031		0.00064	JQ	0.00059	JQ	NA		0.0011		0.0012		<0.001	U
E200.7	Vanadium	ug/L			< 10	U	1.0	JQ	1.2	JQ	NA		2.4	JQ	1.1	JQ	< 10	U
E200.7	Zinc	ug/L			< 20	U	< 20	U	< 20	U	NA		< 20	U	< 20	U	< 20	U
Minerals, Dissolved:																		
E200.7	Quartz	ug/L			6900		7400		7700		NA		9200		11000		8300	
E200.7	Silicon	ug/L			3200		3400		3600		NA		4300		5300		3900	
Nitrogen Series:																		
SM4500-NH3G	Ammonia	mg/L			0.11	JQ	< 0.25	U	0.12	JQ	NA		0.26		< 0.25	U	< 0.25	U
E300.0	Nitrogen, nitrate	mg/L	10	10	< 0.05	U	0.08	J	0.088	J	0.11		< 0.05	U	0.89		< 0.05	U
E300.0	Nitrogen, nitrite	mg/L	1	1	< 0.05	U	< 0.05	UJ	< 0.05	UJ	<0.05	U	< 0.05	U	< 0.05	U	< 0.05	U
CALC	Nitrogen, Organic	mg/L			0.23		< 0.2	U	< 0.2	U	NA		< 0.2	U	0.31		< 0.2	U
E351.2	Total Kjeldahl Nitrogen	mg/L			0.34		0.18	JQ	0.19	JQ	NA		0.32		0.31	B	< 0.2	U

Table 3.4.1-6
(Sheet 4 of 5)
Groundwater Quality Summary Data – Winter 2021/2022

Location ID:					**GW-1**		**GW-1R**		**GW-1R**		**GW-1R**		**GW-2**		**GW-3**		**GW-4**	
Sample Date:					**2/28/2022**		**3/3/2022**		**3/3/2022**		**3/11/2022**		**3/2/2022**		**3/4/2022**		**3/3/2022**	
Sample Type:					**Sample**		**Sample**		**Duplicate**		**Sample**		**Sample**		**Sample**		**Sample**	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**														
Orthophosphate:																		
SM4500-PF	Phosphate as P, Ortho	mg/L			< 0.05	U	< 0.05	UJ	< 0.05	UJ	0.021	JQ	< 0.5	U	< 0.05	U	< 0.05	U
Phosphorus:																		
E365.4	Phosphorus, Total	mg/L			< 0.1	U	0.14		< 0.1	U	NA		0.062	JQ	0.083	B	< 0.1	U
Radioactivity:																		
E900.0	Alpha radiation particles	pCi/L		15	< 3.0	U	3.68	JH	< 3.0	U	NA		< 3.0	U	< 3.0	U	< 3.0	U
E900.0	Beta Particles & Photon Emitters	pCi/L		1,7193	3.03	JQ	0.989	JQ	2.24	JQ	NA		< 4.0	U	4.81		< 4.0	UJ
Residue Series:																		
SM2540C	Total Dissolved Solids (TDS)	mg/L			170		120		110		NA		330		380		320	
SM2540D	Total Suspended Solids (TSS)	mg/L			3.1		86	J	14	J	NA		160		< 2.5	U	3.1	

Notes:
a) Rules of the Tennessee Department of Environment and Conservation, Criteria for Fish and Aquatic Life Water Use, Numeric Criteria of Rule 0400-40-03-.03 subparagraph (3)
b) USEPA National Primary Drinking Water Regulations (NPDWR) Maximum Contaminant Level (MCL) for Inorganic Chemicals and Radionuclides
c) USEPA NPDWR MCL for Beta Particles & Photon Emitters is based on the specific radionuclide(s) concentration(s) in pCi/L units that produce a 4 millirem per year dose. The average concentration for listed radionuclides resulting in a 4 millirem per year dose is 1,719 pCi/L and the actual site specific concentration could vary significantly depending on the radionuclide
deg C = degrees Celsius
mg/L = milligrams per liter
mpn/mL = most probable number per milliliter
ms/cm = millisiemens per centimeter
mV = millivolts
NTU = nephelometric turbidity unit
pCi/L = picocuries per liter
ug/L = micrograms per liter

Table 3.4.1-6
(Sheet 5 of 5)
Groundwater Quality Summary Data – Winter 2021/2022

Data Qualifier Definitions:
B = Blank contamination, detected above the Reporting Limit
J = Detected, estimated due to QC criteria
JB = Estimated due to blank contamination, detected below the Reporting Limit
JH = Estimated, may be biased high
JQ = Estimated, reported between the Method Detection Limit and the Reporting Limit
NA = Not Analyzed
U = Undetected
UJ = Not detected, estimated due to discrepancies in meeting certain analyte-specific quality control criteria
< = Not Detected above the Reporting Limit shown

Table 3.4.1-7
(Sheet 1 of 4)
Groundwater Quality Summary Data – Spring 2022

				Location ID:		GW-1		GW-1R		GW-2		GW-3		GW-4		GW-4	
				Sample Date:		5/24/2022		5/24/2022		5/31/2022		5/25/2022		5/25/2022		5/25/2022	
				Sample Type:		Sample		Sample		Sample		Sample		Sample		Duplicate	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**													
Alkalinity, Total:																	
SM2320B	Alkalinity, Total (as $CaCO_3$)	mg/L				150		130		310		210		340		340	
SM2320B	Carbon dioxide	mg/L				7.2		< 5.0	U	8.1		5.0		41		38	
Anions:																	
E300.0	Chloride	mg/L				7.6		0.75		3.2		5.3		1.5		1.5	
E300.0	Fluoride	mg/L		4		0.46		0.093	JQ	0.59		0.60		0.18		0.17	
E300.0	Sulfate	mg/L				6.0		0.48	JQ	13		27		5.5		5.6	
Biochemical Oxygen Demand:																	
SM5210B	Biochemical Oxygen Demand (BOD)	mg/L				12		2.3		3.6		3.3		< 2.0	U	< 2.0	U
Chemical Oxygen Demand:																	
SM5220D	Chemical Oxygen Demand (COD)	mg/L				8.2	JQ	< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
Coliform:																	
CD137MPN	Fecal Coliform	mpn/mL				< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U	3.1	
CD137MPN	Total Coliforms	mpn/mL				5.1		< 1.0	U	5.2		< 1.0	U	16.1		91	
Cyanide:																	
E1677	Cyanide, Free	mg/L	0.2	0.2		<0.0020	U	<0.0020	U	<0.0020	U	<0.0020	U	0.00079	JQ	<0.0020	U
Field Parameters:																	
E360.1	Dissolved Oxygen	mg/L				0.78		4.96		1.87		4.49		0.14		0.14	
SM2580A	Oxidation Reduction Potential	mV				99.4		111.4		-43.1		116.4		4.5		4.5	
E150.1	pH	pH units				7.81		7.92		7.48		7.63		6.93		6.93	
E120.1	Specific Conductance	mS/cm				0.313		0.221		0.62		0.54		0.67		0.67	
E170.1	Temperature	deg C				19.5		21.2		26.4		22.4		17.3		17.3	
E180.1	Turbidity	NTU				4.41		15.6		28.3		48.2		3.15		3.15	

Table 3.4.1-7
(Sheet 2 of 4)
Groundwater Quality Summary Data – Spring 2022

			Location ID:		**GW-1**		**GW-1R**		**GW-2**		**GW-3**		**GW-4**		**GW-4**	
			Sample Date:		**5/24/2022**		**5/24/2022**		**5/31/2022**		**5/25/2022**		**5/25/2022**		**5/25/2022**	
			Sample Type:		**Sample**		**Sample**		**Sample**		**Sample**		**Sample**		**Duplicate**	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**												
Hardness:																
SM2340C	Hardness, Total as $CaCO_3$	mg/L			170		150		240		220		390		390	
Metals, Total:																
E200.7	Aluminum	ug/L			< 200	U	< 200	U	370		57	JQ	< 200	U	< 200	U
E200.8	Antimony	ug/L	6	6	< 5.0	U	< 5.0	U	0.95	JQ	< 5.0	U	< 5.0	U	< 5.0	U
E200.8	Arsenic	ug/L	10	10	< 3.0	U	1.0	JQ	< 3.0	U	< 3.0	U	< 3.0	U	< 3.0	U
E200.7	Barium	ug/L	2000	2000	20		10		33		39		21		24	
E200.7	Beryllium	ug/L	4	4	< 4.0	U	< 4.0	U	< 4.0	U	< 4.0	U	< 4.0	U	< 4.0	U
E200.7	Boron	ug/L			32	JQ	< 100	U	190		< 100	U	< 100	U	< 100	U
E200.8	Cadmium	ug/L	5	5	< 0.50	U	< 0.50	U	< 0.50	U	< 0.50	U	< 0.50	U	< 0.50	U
E200.7	Calcium	ug/L			32000		28000		65000		39000		110000		110000	
E200.7	Chromium	ug/L		100	< 10	U	< 10	U	1.2	JQ	1.5	JQ	< 10	U	< 10	U
E200.7	Cobalt	ug/L			1.4	JQ	< 10	U	1.5	JQ	< 10	U	1.7	JQ	< 10	U
E200.7	Copper	ug/L			< 20	U	< 20	U	< 20	U	< 20	U	< 20	U	< 20	U
E200.7	Iron	ug/L			130		< 100	U	2000		22	JQ	160		210	
E200.8	Lead	ug/L			< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U
E200.7	Magnesium	ug/L			16000		14000		17000		22000		16000		16000	
E200.7	Manganese	ug/L			48		< 10	U	180		3.0	JQ	640		700	
E245.1	Mercury	ug/L	2	2	< 0.20	U	< 0.20	U	< 0.20	U	< 0.20	U	< 0.20	U	< 0.20	U
E200.7	Nickel	ug/L	100		< 40	U	< 40	U	< 40	U	< 40	U	< 40	U	< 40	U
E200.7	Potassium	ug/L			2600		820	JQ	4900		1800		930	JQ	970	JQ
E200.8	Selenium	ug/L	50	50	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U
E200.7	Silver	ug/L			< 10	U	< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
E200.7	Sodium	ug/L			6500		660	JQ	48000		26000		1800	JQ	1700	JQ

Table 3.4.1-7
(Sheet 3 of 4)
Groundwater Quality Summary Data – Spring 2022

				Location ID:		GW-1		GW-1R		GW-2		GW-3		GW-4		GW-4	
				Sample Date:		5/24/2022		5/24/2022		5/31/2022		5/25/2022		5/25/2022		5/25/2022	
				Sample Type:		Sample		Sample		Sample		Sample		Sample		Duplicate	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**													
E200.8	Thallium	ug/L	2	2	< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U
E200.8	Uranium	mg/L		30	0.0026		0.00067	JQ	0.0013		0.0020		< 0.0010	U	< 0.0010	U
E200.7	Vanadium	ug/L			< 10	U	1.2	JQ	< 10	U	< 10	U	< 10	U	< 10	U
E200.7	Zinc	ug/L			< 20	U	< 20	U	< 20	U	< 20	U	< 20	U	< 20	U
Minerals, Dissolved:																
E200.7	Quartz	ug/L			12000		8800		29000		15000		20000		11000	
E200.7	Silicon	ug/L			5800		4100		13000		7000		9200		5000	
Nitrogen Series:																
SM4500-NH3G	Ammonia	mg/L			0.12	JQ	0.13	JQ	0.22	JQ	< 0.25	U	< 0.25	U	0.14	JQ
E300.0	Nitrogen, nitrate	mg/L	10	10	< 0.050	U	0.12		< 0.050	U	1.2		< 0.050	U	< 0.050	U
E300.0	Nitrogen, nitrite	mg/L	1	1	< 0.050	U	< 0.050	U	< 0.050	U	< 0.050	U	< 0.050	U	< 0.050	U
CALC	Nitrogen, Organic	mg/L			< 0.20	U	< 0.20	U	< 0.20	U	< 0.20	U	< 0.20	U	< 0.20	U
E351.2	Total Kjeldahl Nitrogen	mg/L			< 0.20	U	< 0.20	U	0.21		< 0.20	U	< 0.20	U	< 0.20	U
Orthophosphate:																
SM4500-PF	Phosphate as P, Ortho	mg/L			< 0.050	U	< 0.050	U	< 0.050	U	0.016	JQ	< 0.050	U	< 0.050	U
Phosphorus:																
E365.4	Phosphorus, Total	mg/L			0.051	JQ	< 0.10	U	0.074	JQ	< 0.10	U	< 0.10	U	< 0.10	U
Radioactivity:																
E900.0	Alpha radiation particles	pCi/L		15	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U	< 3.00	U

Table 3.4.1-7
(Sheet 4 of 4)
Groundwater Quality Summary Data – Spring 2022

				Location ID:		GW-1		GW-1R		GW-2		GW-3		GW-4		GW-4	
				Sample Date:		5/24/2022		5/24/2022		5/31/2022		5/25/2022		5/25/2022		5/25/2022	
				Sample Type:		Sample		Sample		Sample		Sample		Sample		Duplicate	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**													
E900.0	Beta Particles & Photon Emitters	pCi/L		1,719[c]		1.78		< 4.00	U	< 4.00	U	1.64		< 4.00	U	< 4.00	U
Residue Series:																	
SM2540C	Total Dissolved Solids (TDS)	mg/L				150		130		320		230		340		340	
SM2540D	Total Suspended Solids (TSS)	mg/L				2.5		5.4		12		17		< 2.5	U	< 2.5	U

Notes:

a) 1 Rules of the Tennessee Department of Environment and Conservation, Criteria for Fish and Aquatic Life Water Use, Numeric Criteria of Rule 0400-40-03-.03 subparagraph (3)

b) 2 USEPA National Primary Drinking Water Regulations (NPDWR) Maximum Contaminant Level (MCL) for Inorganic Chemicals and Radionuclides

c) 3 USEPA NPDWR MCL for Beta Particles & Photon Emitters is based on the specific radionuclide(s) concentration(s) in pCi/L units that produce a 4 millirem per year dose. The average concentration for listed radionuclides resulting in a 4 millirem per year dose is 1,719 pCi/L and the actual site specific concentration could vary significantly depending on the radionuclide

deg C = degrees Celsius
mg/L = milligrams per liter
mpn/mL = most probable number per milliliter
mS/cm = millisiemens per centimeter
mV = millivolts
NTU = nephelometric turbidity unit
pCi/L = picocuries per liter
ug/L = micrograms per liter

Data Qualifier Definitions:
JQ = Estimated, reported between the Method Detection Limit (MDL) and the Reporting Limit (RL)
U = Undetected
< = Not Detected above the Reporting Limit shown

Table 3.4.2-1
Precipitation Depth – Duration – Frequency Data for Oak Ridge, TN

Precipitation Duration	Precipitation (inches) for Given Return Period (years)						
	1	**2**	**5**	**10**	**25**	**50**	**100**
5 min	0.34	0.40	0.47	0.54	0.62	0.69	0.77
15 min	0.68	0.80	0.95	1.08	1.26	1.40	1.54
30 min	0.93	1.11	1.35	1.57	1.86	2.11	2.36
60 min	1.16	1.39	1.74	2.05	2.48	2.85	3.25
3 hr	1.48	1.77	2.18	2.56	3.09	3.55	4.04
6 hr	1.85	2.19	2.66	3.09	3.70	4.22	4.77
12 hr	2.30	2.73	3.30	3.82	4.52	5.12	5.75
24 hr	2.81	3.35	4.09	4.68	5.49	6.16	6.84
2 days	3.43	4.11	5.01	5.72	6.71	7.50	8.31
4 days	3.93	4.70	5.69	6.46	7.47	8.27	9.06
7 days	4.80	5.72	6.87	7.74	8.88	9.74	10.60

Reference: NOAA, 2022

Table 3.4.2-2
USGS Streamflow Stations within 3.0 Miles of Horizon Center Site

USGS Station No.	Name	Coordinates		Drainage Area (sq. mi./ac.)	Period of Record		Map No.[a]
		Longitude	Latitude		Begin	End	
03538225	Poplar Creek near Oak Ridge, TN	-84.33964830	35.99887210	82.5 / 52,800	9/1/1960	9/30/1989	1
03538250	East Fork Poplar Creek near Oak Ridge, TN	-84.35826000	35.96618840	19.5 / 12,480	9/1/1960	6/30/1988	2
035382672	Bear Creek Tributary above Bear Creek Road near Wheat, TN	-84.32409119	35.94479970	0.3 / 192	10/1/1986	9/30/1991	3
035382673	Bear Creek near Wheat, TN	-84.32403560	35.94429970	3.2 / 2048	10/1/1986	9/30/1991	4
035382677	Bear Creek Tributary near Wheat, TN	-84.33186930	35.94118850	0.14 / 90	1/19/1987	4/23/1993	5
03538270	Bear Creek at TN 95 near Oak Ridge, TN	-84.33936969	35.93729950	4.34 / 2778	3/1/1985	11/21/2000	6
03538272	Bear Creek Tributary at TN 95 near Wheat, TN	-84.34214770	35.94063285	0.14 / 90	10/1/1986	9/30/1989	7
03538273	Bear Creek at Pine Ridge, near Wheat, TN	-84.34378670	35.94225507	5.0 / 3200	9/25/1986	9/1/1989	8
03538275	Bear Creek near Oak Ridge, TN	-84.36360450	35.94724100	7.15 / 4576	9/1/1960	9/29/1964	9

a) Gauge station number on Figure 3.4.2-1.
Reference: USGS, 2022b.

Table 3.4.2-3
(Sheet 1 of 5)
Surface Water Quality Summary Data for the Horizon Center Site — Summer 2021

Location ID:					SW-1		SW-2		SW-3		SW-4		SW-5		SW-5		SW-7	
Sample Date:					9/13/2021		9/9/2021		9/9/2021		9/13/2021		9/14/2021		9/14/2021		9/14/2021	
Sample Type:					Sample		Sample		Sample		Sample		Sample		Duplicate		Sample	
Analytical Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**														
Alkalinity, Total:																		
A2320	Alkalinity, Total (as $CaCO_3$)	mg/L			150		150		140		160		150		160		160	
A2320	Carbon dioxide	mg/L			< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U
Anions:																		
E300	Chloride	mg/L			19		15		14		16		14		14		14	
E300	Fluoride	mg/L		4.0	0.28		0.22		0.21		0.26		0.23		0.24		0.23	
E300	Sulfate	mg/L			22		19		19		22		21		21		21	
Biochemical Oxygen Demand (BOD):																		
A5210B	BOD	mg/L			7.1	B	2.5	B	< 2.0	U	6.5	B	< 2.0	U	<2.0	U	< 2.0	U
Chemical Oxygen Demand (COD):																		
A5220D	COD	mg/L			< 10	U	< 10	U	8.5	JQ	5.0	JQ	7.5	JL	<10	U	< 10	U
Chlorophyll																		
SM10200H	Chlorophyll-a	mg/m^3			0.89	B	0.89	B	0.89	B	1.8	B	1.8	B	<0.033	UJ	1.8	B
Coliform:																		
CD137MPN	Fecal Coliform	mpn/mL			240		344.8		344.8		365.4		365.4		461.1		517.2	
CD137MPN	Total Coliforms	mpn/mL	28.8		2419.6		2419.6		2419.6		2419.6		2419.6		2419.6		2419.6	
Cyanide:																		
E1677	Cyanide, Free	mg/L	0.200	0.2	< 0.006	U	< 0.006	U	< 0.006	U	< 0.006	U	< 0.006	UJ	< 0.006	UJ	< 0.006	UJ
Field Parameters:																		
E360.1	Dissolved Oxygen	mg/L	>5.0		6.7		8.08		7.86		8.44		6.54		6.54		7.46	

Table 3.4.2-3
(Sheet 2 of 5)
Surface Water Quality Summary Data for the Horizon Center Site — Summer 2021

		Location ID:			SW-1		SW-2		SW-3		SW-4		SW-5		SW-5		SW-7	
		Sample Date:			9/13/2021		9/9/2021		9/9/2021		9/13/2021		9/14/2021		9/14/2021		9/14/2021	
		Sample Type:			Sample		Sample		Sample		Sample		Sample		Duplicate		Sample	
Analytical Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**														
A2580A	Oxidation–Reduction Potential	mV			242.1		221.4		196.7		248		250.4		250.4		234.8	
E150.1	pH	pH units	6.0-9.0		8.03		8.11		8.02		8.47		8.11		8.11		8.17	
E120.1	Specific Conductance	mS/cm			0.443		0.487		0.438		0.457		0.429		0.429		0.418	
E170.1	Temperature	deg C	<30.5		22.8		22.1		23.7		21.4		21.5		21.5		22.1	
E180.1	Turbidity	NTU			2.36		5.02		3.81		2.88		4.85		4.85		5.98	
Hardness:																		
A2340	Hardness, Total as $CaCO_3$	mg/L			190		180		190		200		190		190		190	
Metals, Total:																		
E200.7	Aluminum	µg/L			32	JQ	39	JQ	42	JQ	43	JQ	68	JQ	71	JQ	90	JQ
E200.8	Antimony	µg/L		6	< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U
E200.8	Arsenic	µg/L	34	10	< 3.0	U	< 3.0	U	< 3.0	U	< 3.0	U	< 3.0	U	<3.0	U	< 3.0	U
E200.7	Barium	µg/L		2000	44		44		42		41		45		46		46	
E200.7	Beryllium	µg/L		4	< 4.0	U	< 4.0	U	< 4.0	U	< 4.0	U	< 4.0	U	<4.0	U	< 4.0	U
E200.7	Boron	µg/L			85	JQ	120		62	JQ	68	JQ	72	JQ	71	JQ	67	JQ
E200.8	Cadmium	µg/L	1.8	5	< 0.5	U	< 0.5	U	< 0.5	U	< 0.5	U	< 0.5	U	<0.5	U	< 0.5	U
E200.7	Calcium	µg/L	570	100	52,000		56,000		54,000		51,000		55,000		55,000		55,000	
E200.7	Chromium	µg/L			< 10	U	< 10	U	< 10	U	< 10	U	< 10	U	<10	U	< 10	U
E200.7	Cobalt	µg/L	13		< 10	U	< 10	U	< 10	U	< 10	U	< 10	U	<10	U	< 10	U

Table 3.4.2-3
(Sheet 3 of 5)
Surface Water Quality Summary Data for the Horizon Center Site — Summer 2021

		Location ID:			**SW-1**		**SW-2**		**SW-3**		**SW-4**		**SW-5**		**SW-5**		**SW-7**	
		Sample Date:			**9/13/2021**		**9/9/2021**		**9/9/2021**		**9/13/2021**		**9/14/2021**		**9/14/2021**		**9/14/2021**	
		Sample Type:			**Sample**		**Sample**		**Sample**		**Sample**		**Sample**		**Duplicate**		**Sample**	
Analytical Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**														
E200.7	Copper	ug/L	13		3.0	JQ	2.4	JQ	1.9	JQ	2.3	JQ	2.4	JQ	2.7	JQ		
E200.7	Iron	ug/L			77				67		79		110		120		130	
E200.8	Lead	ug/L	65		< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U	<2.5	U	< 2.5	U
E200.7	Magnesium	ug/L			12000		11000		10000		11000		12000		12000		12000	
E200.7	Manganese	ug/L			13		14		13		10		30		30		30	
E245.1	Mercury	ug/L	1.4	2	< 0.2	U	< 0.2	U	0.08	JQ	< 0.2	U	< 0.2	U	<0.2	U	< 0.2	U
E200.7	Nickel	ug/L	470		< 40	U	< 40	U	< 40	U	< 40	U	< 40	U	2.2	JQ	2.2	JQ
E200.7	Potassium	ug/L			4100		3700		3400		3400		3400		3400		3400	
E200.8	Selenium	ug/L	20	50	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U	<2.5	U	< 2.5	U
E200.7	Silver	ug/L	3.2		< 10	U	< 10	U	< 10	U	< 10	U	< 10	U	<10	U	< 10	U
E200.7	Sodium	ug/L			15000		12000		11000		13000		12000		12000		12000	
E200.8	Thallium	ug/L		2	< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U	<1.0	U	< 1.0	U
E200.8	Uranium	ug/L		30.0	0.0056		0.0057		0.0058		0.0065		0.0073		0.0077		0.0077	
E200.7	Vanadium	ug/L			1.1	JQ	1.2	JQ	< 10	U	1	JQ	1.4	JQ	1.5	JQ	1.5	JQ
E200.7	Zinc	ug/L	120		13	JQ	8.5	B	< 20	U	8.9	JQ	11	JQ	8.6	JQ	8.6	JQ
Minerals Dissolved:																		
E200.7	Quartz	ug/L			6800		6700		6900		6700		7000		7000		7000	
E200.7	Silicon	ug/L			3200		3100		3200		3100		3300		3300		3300	

Table 3.4.2-3
(Sheet 4 of 5)
Surface Water Quality Summary Data for the Horizon Center Site — Summer 2021

Location ID:					SW-1		SW-2		SW-3		SW-4		SW-5		SW-5		SW-7	
Sample Date:					9/13/2021		9/9/2021		9/9/2021		9/13/2021		9/14/2021		9/14/2021		9/14/2021	
Sample Type:					Sample		Sample		Sample		Sample		Sample		Duplicate		Sample	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**														
Nitrogen Series:																		
SM4500-NH3G	Ammonia	mg/L			< 0.25	U	< 0.25	U	< 0.25	U	< 0.25	U	< 0.25	U	< 0.25	U	< 0.25	U
E300	Nitrogen, Nitrate	mg/L		10	5.4		4.5		4.2		4		3.4		3.4		3.2	
E300	Nitrogen, Nitrite	mg/L		1	< 0.1	U	0.025	JQ	0.024	JQ	< 0.05	U	< 0.05	U	< 0.05	U	0.024	JQ
CALC	Nitrogen, Organic	mg/L			0.28		0.34		0.35		< 0.2	U	< 0.2	U	0.34		0.33	
E351.2	Total Kjeldahl Nitrogen	mg/L			0.28		0.34		0.35		< 0.2	U	< 0.2	U	0.34		0.33	
Orthophosphate:																		
SM4500-PF	Phosphate as P, Ortho	mg/L			1.1	J	0.69		0.67		0.8	J	0.67		0.64		0.72	
Phosphorus:																		
E365.4	Phosphorus, Total	mg/L			1.1		0.68		0.64		0.75		0.64		0.72		0.63	
Radioactivity:																		
E900	Alpha Radiation Particles	pCi/L		15	< 3.0	U	< 3.0	U	< 3.0	U	< 3.0	U	< 3.0	U	< 3.0	U	7.1	
E900	Beta Particles & Photon Emitters	pCi/L		1719[c]	6.66	B	2.42	B	< 4.0	U	5.71	B	< 4.0	U	4.48	B	5.82	B
Residue Series:																		
A2540C	Total Dissolved Solids	mg/L			240		220		230		240		220		240		240	
A2540D	Total Suspended Solids	mg/L			< 2.5	U	2.5		3.6		2.6		3.5		3.9		< 2.5	U

Notes:
a) Rules of the Tennessee Department of Environment and Conservation, Criteria for Fish and Aquatic Life Water Use, Numeric Criteria of Rule 0400-40-03-.03 subparagraph (3)
b) USEPA National Primary Drinking Water Regulations (NPDWR) Maximum Contaminant Level (MCL) for Inorganic Chemicals and Radionuclides
c) USEPA NPDWR MCL for Beta Particles & Photon Emitters is based on the specific radionuclide(s) concentration(s) in pCi/L units that produce a 4 millirem per year dose. The average concentration for listed radionuclides resulting in a 4 millirem per year dose is 1719 pCi/L and the actual site specific concentration could vary significantly depending on the radionuclide

deg C = degrees Celsius
mg/L = milligrams per liter
mg/m^3 = milligrams per cubic meter
mpn/mL = most probable number per milliliter,

Table 3.4.2-3
(Sheet 5 of 5)
Surface Water Quality Summary Data for the Horizon Center Site — Summer 2021

mS/cm = millisiemens per centimeter

mV = millivolts
NTU = nephelometric turbidity unit
pCi/L = picocuries per liter
ug/L = micrograms per liter

Data Qualifier Definitions:
B = The analyte was detected, estimated, blank contamination
J = The analyte was detected, estimated due to QC criteria
JH = Estimated, may be biased high
JL = Estimated, may be biased low
JQ = Value listed is estimated, reported between the Method Detection Limit (MDL) and the Reporting Limit (RL)
UJ = The analyte was not detected; however, the result is estimated due to discrepancies in meeting certain analyte-specific quality control criteria
UL = The analyte was not detected; however, the reported value may be biased low
U = Not Detected above the Reporting Limit shown

Table 3.4.2-4
(Sheet 1 of 5)
Surface Water Quality Summary Data for the Horizon Center Site — Fall 2021

	Location ID:				**SW-3**		**SW-4**		**SW-4**		**SW-5**		**SW-7**	
	Sample Date:				**11/15/2021**		**11/15/2021**		**11/15/2021**		**11/16/2021**		**11/16/2021**	
	Sample Type:				**Sample**		**Sample**		**Duplicate**		**Sample**		**Sample**	
Analytical Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**										
Alkalinity, Total:														
A2320	Alkalinity, Total (as $CaCO_3$)	mg/L			150		160		160		180		140	
A2320	Carbon dioxide	mg/L			< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U
Anions														
E300	Chloride	mg/L			16		13		13		14		9	
E300	Fluoride	mg/L		4.0	0.22		0.21		0.21		0.19		<0.1	U
E300	Sulfate	mg/L			19		18		18		19		2.7	
Biochemical Oxygen Demand (BOD):														
A5210B	BOD	mg/L			<2.0	U	< 2.0	U	3.2		<2.0	U	< 2.0	U
Chemical Oxygen Demand (COD):														
A5220D	COD	mg/L			< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
Chlorophyll:														
SM10200H	Chlorophyll-a	mg/m^3			1.8		<0.033	U	0.89		3.6		<0.033	U
Coliform														
CD137MPN	Fecal Coliform	mpn/mL			240		344.8		344.8		365.4			
CD137MPN	Total Coliforms	mpn/mL	28.8		2419.6		1986.3		1986.3		1986.3		2419.6	
Cyanide:														
E1677	Cyanide, Free	mg/L	0.200	0.2	< 0.006	U	< 0.006	U	< 0.006	U	< 0.006	U	< 0.006	U

Table 3.4.2-4
(Sheet 2 of 5)
Surface Water Quality Summary Data for the Horizon Center Site — Fall 2021

	Location ID:				**SW-3**		**SW-4**		**SW-4**		**SW-5**		**SW-7**	
	Sample Date:				**11/15/2021**		**11/15/2021**		**11/15/2021**		**11/16/2021**		**11/16/2021**	
	Sample Type:				**Sample**		**Sample**		**Duplicate**		**Sample**		**Sample**	
Analytical Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**										
Field Parameters:														
E360.1	Dissolved Oxygen	mg/L	>5.0		13.46	J	9.72		9.72		18.7	R	10.97	
A2580A	Oxidation Reduction Potential	mV			162.3		129.3		129.3		183.3		88.4	
E150.1	pH	pH units	6.0 - 9.0		7.95		7.42		7.42		7.76		7.67	
E120.1	Specific Conductance	mS/cm			0.435		0.403		0.403		0.419		0.3	
E170.1	Temperature	deg C	< 30.5		11.6		10.5		10.5		10.5		12.7	
E180.1	Turbidity	NTU			2.85		2.35		2.35		2.24		2.59	
Hardness														
A2340	Hardness, Total as $CaCO_3$	mg/L			180		190		180		190		150	
Metals Total:														
E200.7	Aluminum	ug/L			<200	U	<200	U	<200	U	38	JQ	43	JQ
E200.8	Antimony	ug/L		6	< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U
E200.8	Arsenic	ug/L	34	10	< 0.3	U	< 0.3	U	< 0.3	U	< 0.3	U	< 0.3	U
E200.7	Barium	ug/L		2000	33		32		32		33	B	20	B
E200.7	Beryllium	ug/L		4	0.18	JQ	0.19	JQ	0.19	JQ	< 4.0	U	< 4.0	U
E200.7	Boron	ug/L			75	JQ	65	JQ	62	JQ	51	JQ	<100	U
E200.8	Cadmium	ug/L	1.8	5	< 0.5	U	< 0.5	U	< 0.5	U	< 0.5	U	< 0.5	U

Table 3.4.2-4
(Sheet 3 of 5)
Surface Water Quality Summary Data for the Horizon Center Site — Fall 2021

Location ID:					SW-3		SW-4		SW-4		SW-5		SW-7	
Sample Date:					**11/15/2021**		**11/15/2021**		**11/15/2021**		**11/16/2021**		**11/16/2021**	
Sample Type:					**Sample**		**Sample**		**Duplicate**		**Sample**		**Sample**	
Analytical Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**										
E200.7	Calcium	ug/L			53000		53000		53000		53000		53000	
E200.7	Chromium	ug/L	570	100	< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
E200.7	Cobalt	ug/L			2.3	JQ	1	JQ	1.7	JQ	< 10	U	< 10	U
E200.7	Copper	ug/L	13		1.8	JQ	2.1	JQ	<20	U	<20	U	<20	U
E200.7	Iron	ug/L			58		58		52		100		140	
E200.8	Lead	ug/L	65		< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U
E200.7	Magnesium	ug/L			11000		11000		11000		11000		12000	
E200.7	Manganese	ug/L			8.3	JQ	7.2	JQ	7.3	JQ	30		46	
E245.1	Mercury	ug/L	1.4	2	< 0.2	U	< 0.2	U	< 0.2	U	< 0.2	U	< 0.2	U
E200.7	Nickel	ug/L	470		4.9	JQ	3.8	JQ	3.5	JQ	3.5	JQ	< 40	U
E200.7	Potassium	ug/L			4200		3700		3700		3700		1000	
E200.8	Selenium	ug/L	20	50	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U
E200.7	Silver	ug/L	3.2		< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
E200.7	Sodium	ug/L			13000		11000		11000		11000		3700	
E200.8	Thallium	ug/L		2	< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U
E200.8	Uranium	ug/L		30	0.0047		0.0051		0.0051		0.0057		<0.001	U
E200.7	Vanadium	ug/L			<10	U	<10	U	< 10	U	<10	U	<10	U
E200.7	Zinc	ug/L	120		9.9	JQ	7	JQ	7	JQ	8.3	JQ	<20	U
Minerals Dissolved:														
E200.7	Quartz	ug/L			6500		6300		6300		6600		8300	
E200.7	Silicon	ug/L			3000		3000		3000		3100		3900	

Table 3.4.2-4
(Sheet 4 of 5)
Surface Water Quality Summary Data for the Horizon Center Site — Fall 2021

Location ID:					**SW-3**		**SW-4**		**SW-4**		**SW-5**		**SW-7**	
Sample Date:					**11/15/2021**		**11/15/2021**		**11/15/2021**		**11/16/2021**		**11/16/2021**	
Sample Type:					**Sample**		**Sample**		**Duplicate**		**Sample**		**Sample**	
Analytical Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**										
Nitrogen Series:														
SM4500-NH3G	Ammonia	mg/L			< 0.25	U	< 0.25	U	< 0.25	U	< 0.25	U	< 0.25	U
E300	Nitrogen, Nitrate	mg/L		10	3.3		3.2		4.3		3.7		0.071	
E300	Nitrogen, Nitrite	mg/L		1	< 0.1	U	<0.1	U	<0.01	U	< 0.1	U	< 0.05	U
CALC	Nitrogen, Organic	mg/L			<0.2	U	2.3		<0.2	U	0.49		< 0.2	U
E351.2	Total Kjeldahl Nitrogen	mg/L			<0.2	U	2.3		<0.2	U	0.49		0.14	JQ
Orthophosphate:														
SM4500-PF	Phosphate as P, Ortho	mg/L			0.28		2.3		2.3		2.2		0.18	JL
Phosphorus:														
E365.4	Phosphorus, Total	mg/L			0.94		0.69		0.77		0.58		<0.1	UL
Radioactivity:														
E900	Alpha Radiation Particles	pCi/L		15	< 3.0	U	**22**		**18.2**		< 3.0	U	< 3.0	U
E900	Beta Particles & Photon Emitters	pCi/L		1719[c]	4.56		13.1		13.4		5.34	B	< 4.0	U
Residue Series:														
A2540C	Total Dissolved Solids	mg/L			220		220		210		210		130	
A2540D	Total Suspended Solids	mg/L			< 2.5	U	<2.5	U	<2.5	U	<2.5	U	<2.5	U

Table 3.4.2-4
(Sheet 5 of 5)
Surface Water Quality Summary Data for the Horizon Center Site — Fall 2021

Location ID:					**SW-3**		**SW-4**		**SW-4**		**SW-5**		**SW-7**	
Sample Date:					**11/15/2021**		**11/15/2021**		**11/15/2021**		**11/16/2021**		**11/16/2021**	
Sample Type:					**Sample**		**Sample**		**Duplicate**		**Sample**		**Sample**	
Analytical Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**										

Notes:
a) Rules of the Tennessee Department of Environment and Conservation, Criteria for Fish and Aquatic Life Water Use, Numeric Criteria of Rule 0400-40-03-.03 subparagraph (3)
b) USEPA National Primary Drinking Water Regulations (NPDWR) Maximum Contaminant Level (MCL) for Inorganic Chemicals and Radionuclides
c) USEPA NPDWR MCL for Beta Particles & Photon Emitters is based on the specific radionuclide(s) concentration(s) in pCi/L units that produce a 4 millirem per year dose. The average concentration for listed radionuclides resulting in a 4 millirem per year dose is 1719 pCi/L and the actual site-specific concentration could vary significantly depending on the radionuclide
Bolded values indicate an exceedance of the above referenced criteria
deg C = degrees Celsius
mg/L = milligrams per liter
mg/m^3 = milligrams per cubic meter
mpn/mL = most probable number per milliliter
mS/cm = millisiemens per centimeter
mV = millivolts
NTU = nephelometric turbidity unit
pCi/L = picocuries per liter
ug/L = micrograms per liter

Data Qualifier Definitions:
B = The analyte was detected, estimated, blank contamination
J = The analyte was detected, estimated due to QC criteria
JH = Estimated, may be biased high
JL = Estimated, may be biased low
JQ = Value listed is estimated, reported between the Method Detection Limit (MDL) and the Reporting Limit (RL)
UJ = The analyte was not detected; however, the result is estimated due to discrepancies in meeting certain analyte-specific quality control criteria
UL = The analyte was not detected; however, the reported value may be biased low
U = Not Detected above the Reporting Limit shown

Table 3.4.2-5
(Sheet 1 of 4)
Surface Water Quality Summary Data for the Horizon Center Site — Winter 2021/2022

	Location ID:				**SW-3**		**SW-4**		**SW-5**		**SW-6**		**SW-7**		**SW-7**	
	Sample Date:				**3/2/2022**		**2/28/2022**		**3/2/2022**		**2/28/2022**		**3/1/2022**		**3/1/2022**	
	Sample Type:				**Sample**		**Sample**		**Sample**		**Sample**		**Sample**		**Duplicate**	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**												
Alkalinity, Total:																
SM2320B	Alkalinity, Total (as $CaCO_3$)	mg/L			120	B	110	B	110	B	74	JB	70	B	70	B
SM2320B	Carbon dioxide	mg/L			< 5.0	U	< 5.0	U	< 5.0	U	5.7	JB	8.4	B	7.4	B
Anions:																
E300.0	Chloride	mg/L			7.8		6.4		6.5		0.67		2.2		2.3	
E300.0	Fluoride	mg/L		4.0	0.10		0.077	JQ	0.083	JQ	< 0.1	U	0.042	JQ	0.042	JQ
E300.0	Sulfate	mg/L			11		9.9		9.6		1.9		2.1		2.1	
Biochemical Oxygen Demand:																
SM5210B	Biochemical Oxygen Demand (BOD)	mg/L			< 2.0	U	2.1	B	15	B	4.9	B	4.3	JB	5.3	JB
Chemical Oxygen Demand:																
SM5220D	Chemical Oxygen Demand (COD)	mg/L			< 10	U	< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
Chlorophyll:																
SM10200H	Chlorophyll-a	mg/m3			3.6		1.8		3.6		0.89		4.5		3.6	
Coliform:																
CD137MPN	Fecal Coliform	mpn/mL			125.9		260.3		45.9	J	58.6		13.4		14.6	
CD137MPN	Total Coliforms	mpn/mL	28.8		1986.3		1011.2		2419.6	J	2419.6		579.4		770.1	
Cyanide:																
E1677	Cyanide, Free	mg/L	0.2	0.2	< 0.002	U	< 0.002	U	< 0.002	U	< 0.002	U	< 0.002	U	< 0.002	U
Field Parameters:																
E360.1	Dissolved Oxygen	mg/L	> 5.0		7.36		9.06		8.23		8.85		8.38		8.38	
SM2580A	Oxidation Reduction Potential	mV			236.1		107.3		120.4		60.5		160.1		160.1	
E150.1	pH	pH units	6.0 - 9.0		6.85		7.92		7.84		7.98		7.63		7.63	

Table 3.4.2-5
(Sheet 2 of 4)
Surface Water Quality Summary Data for the Horizon Center Site — Winter 2021/2022

	Location ID:				**SW-3**		**SW-4**		**SW-5**		**SW-6**		**SW-7**		**SW-7**	
	Sample Date:				**3/2/2022**		**2/28/2022**		**3/2/2022**		**2/28/2022**		**3/1/2022**		**3/1/2022**	
	Sample Type:				**Sample**		**Sample**		**Sample**		**Sample**		**Sample**		**Duplicate**	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**												
E120.1	Specific Conductance	ms/cm			0.304		0.277		0.289		0.164		0.161		0.161	
E170.1	Temperature	deg C	< 30.5		10.9		11.2		13		14.4		14.6		14.6	
E180.1	Turbidity	NTU			5.9		10.2		7.3		10.3		11.2		11.2	
Hardness:																
SM2340C	Hardness, Total as $CaCO_3$	mg/L			130		130		120		81		70		69	
Metals, Total:																
E200.7	Aluminum	ug/L			220		440		340		520		630		670	
E200.8	Antimony	ug/L		6	< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U
E200.8	Arsenic	ug/L	34	10	< 3.0	U	< 3.0	U	< 3.0	U	< 3.0	U	< 3.0	U	< 3.0	U
E200.7	Barium	ug/L		2000	33		29		32		20		18		18	
E200.7	Beryllium	ug/L		4	< 4.0	U	< 4.0	U	< 4.0	U	< 4.0	U	< 4.0	U	< 4.0	U
E200.7	Boron	ug/L			< 100	U	< 100	U	< 100	U	< 100	U	< 100	U	< 100	U
E200.8	Cadmium	ug/L	1.8	5	< 0.5	U	< 0.5	U	< 0.5	U	< 0.5	U	< 0.5	U	< 0.5	U
E200.7	Calcium	ug/L			43000		38000		39000		24000		21000		21000	
E200.7	Chromium	ug/L	570	100	1.1	JQ	< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
E200.7	Cobalt	ug/L			< 10	U	< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
E200.7	Copper	ug/L	13		< 20	U	< 20	U	< 20	U	< 20	U	< 20	U	< 20	U
E200.7	Iron	ug/L			190		290		230		240		340		350	
E200.8	Lead	ug/L	65		0.41	JQ	0.46	JQ	0.46	JQ	< 2.5	U	0.46	JQ	0.75	JQ
E200.7	Magnesium	ug/L			7400		6000		7200		4000		5100		5000	
E200.7	Manganese	ug/L			18		19		20		12		14		14	
E245.1	Mercury	ug/L	1.4	2	< 0.2	U	0.13	JQ	< 0.2	U	< 0.2	U	< 0.2	U	< 0.2	U
E200.7	Nickel	ug/L	470		< 40	U	< 40	U	< 40	U	< 40	U	< 40	U	< 40	U
E200.7	Potassium	ug/L			1700		1500		1400		570	JQ	760	JQ	760	JQ
E200.8	Selenium	ug/L	20	50	< 2.5	U	1.4	B	< 2.5	U	1.7	B	< 2.5	U	< 2.5	U

Table 3.4.2-5
(Sheet 3 of 4)
Surface Water Quality Summary Data for the Horizon Center Site — Winter 2021/2022

	Location ID:				**SW-3**		**SW-4**		**SW-5**		**SW-6**		**SW-7**		**SW-7**	
	Sample Date:				**3/2/2022**		**2/28/2022**		**3/2/2022**		**2/28/2022**		**3/1/2022**		**3/1/2022**	
	Sample Type:				**Sample**		**Sample**		**Sample**		**Sample**		**Sample**		**Duplicate**	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**												
E200.7	Silver	ug/L	3.2		< 10	U	< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
E200.7	Sodium	ug/L			5500		4900		4300		770	JQ	900	JQ	910	JQ
E200.8	Thallium	ug/L		2	< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U
E200.8	Uranium	mg/L		30	0.0061		0.0049		0.0062		< 0.001	U	< 0.001	U	< 0.001	U
E200.7	Vanadium	ug/L			< 10	U	< 10	U	< 10	U	< 10	U	1.4	JQ	1.2	JQ
E200.7	Zinc	ug/L	120		< 20	U	< 20	U	< 20	U	< 20	U	< 20	U	< 20	U
Minerals, Dissolved:																
E200.7	Quartz	ug/L			6000		6000		7000		6600		6600		6700	
E200.7	Silicon	ug/L			2800		2800		3300		3100		3100		3100	
Nitrogen Series:																
SM4500-NH3G	Ammonia	mg/L			< 0.25	U	< 0.25	U	< 0.25	UJ	< 0.25	U	< 0.25	U	< 0.25	U
E300.0	Nitrogen, nitrate	mg/L		10	2.2		1.3		1.6		0.055		0.058		0.059	
E300.0	Nitrogen, nitrite	mg/L		1	< 0.1	U	< 0.05	U	0.046	JQ	< 0.05	U	< 0.05	U	< 0.05	U
CALC	Nitrogen, Organic	mg/L			0.35		0.28		0.25		< 0.2	U	< 0.2	U	< 0.2	U
E351.2	Total Kjeldahl Nitrogen	mg/L			0.35	B	0.28	B	0.25	B	0.13	B	< 0.2	U	0.15	B
Orthophosphate:																
SM4500-PF	Orthophosphate	mg/L			0.20		0.13		0.14		< 0.05	U	< 0.05	U	< 0.05	U
Phosphorus:																
E365.4	Phosphorus, Total	mg/L			0.21		0.15		0.16		< 0.1	U	< 0.1	U	0.041	JQ
Radioactivity:																
E900.0	Alpha radiation particles	pCi/L		15	< 3.0	U	< 3.0	U	3.65	JH	< 3.0	U	< 3.0	U	< 3.0	U
E900.0	Beta Particles & Photon Emitters	pCi/L		1,719[c]	1.73		1.46		3.16		1.82		< 4.0	U	< 4.0	U

Table 3.4.2-5
(Sheet 4 of 4)
Surface Water Quality Summary Data for the Horizon Center Site — Winter 2021/2022

		Location ID:			**SW-3**		**SW-4**		**SW-5**		**SW-6**		**SW-7**		**SW-7**	
		Sample Date:			**3/2/2022**		**2/28/2022**		**3/2/2022**		**2/28/2022**		**3/1/2022**		**3/1/2022**	
		Sample Type:			**Sample**		**Sample**		**Sample**		**Sample**		**Sample**		**Duplicate**	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**												
Residue Series:																
SM2540C	Total Dissolved Solids	mg/L			130		150		140		91		86		84	
SM2540D	Total Suspended Solids	mg/L			3.8	B	6.9	B	4.1	B	6.2	B	< 2.5	U	3.0	B

Notes:

a) 1 Rules of the Tennessee Department of Environment and Conservation, Criteria for Fish and Aquatic Life Water Use, Numeric Criteria of Rule 0400-40-03-.03 subparagraph (3)

b) 2 USEPA National Primary Drinking Water Regulations (NPDWR) Maximum Contaminant Level (MCL) for Inorganic Chemicals and Radionuclides

c) 3 USEPA NPDWR MCL for Beta Particles & Photon Emitters is based on the specific radionuclide(s) concentration(s) in pCi/L units that produce a 4 millirem per year dose. The average concentration for listed radionuclides resulting in a 4 millirem per year dose is 1,719 pCi/L and the actual site specific concentration could vary significantly depending on the radionuclide

deg C = degrees Celsius
mg/L = milligrams per liter
mg/m^3 = milligrams per cubic meter
mpn/mL = most probable number per milliliter
mS/cm = millisiemens per centimeter
mV = millivolts
NTU = nephelometric turbidity unit
pCi/L = picocuries per liter
ug/L = micrograms per liter

Data Qualifier Definitions:
B = Blank contamination, detected above the Reporting Limit
J = Detected, estimated due to QC criteria
JB = Estimated due to blank contamination, detected below the Reporting Limit
JH = Estimated, may be biased high
JQ = Estimated, reported between the Method Detection Limit and the Reporting Limit
U = Undetected
UJ = Not detected, estimated due to discrepancies in meeting certain analyte-specific quality control criteria
< = Not Detected above the Reporting Limit shown

Table 3.4.2-6
(Sheet 1 of 4)
Surface Water Quality Summary Data for the Horizon Center Site — Spring 2022

			Location ID:		**SW-3**		**SW-4**		**SW-5**		**SW-7**		**SW-7**	
			Sample Date:		**5/23/2022**		**5/23/2022**		**5/24/2022**		**5/24/2022**		**5/24/2022**	
			Sample Type:		**Sample**		**Sample**		**Sample**		**Sample**		**Duplicate**	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**										
Alkalinity, Total:														
SM2320B	Alkalinity, Total (as $CaCO_3$)	mg/L			140		140		140		140		140	
SM2320B	Carbon dioxide	mg/L			5.0		< 5.0	U	< 5.0	U	5.0		< 5.0	U
Anions:														
E300.0	Chloride	mg/L			22		20		18		17		18	
E300.0	Fluoride	mg/L		4.0	0.24		0.23		0.22		0.21		0.21	
E300.0	Sulfate	mg/L			20		20		22		22		22	
Biochemical Oxygen Demand:														
SM5210B	Biochemical Oxygen Demand (BOD)	mg/L			< 2.0	U	< 2.0	U	< 2.0	U	< 2.0	U	< 2.0	U
Chemical Oxygen Demand:														
SM5220D	Chemical Oxygen Demand (COD)	mg/L			< 10	U	< 10	U	9.6	B	23	B	23	B
Chlorophyll:														
SM10200H	Chlorophyll-a	mg/m^3			1.8		0.89		1.8	J	0.89		2.7	J
Coliform:														
CD137MPN	Fecal Coliform	mpn/mL			613.1		325.5		613.1		410.6		461.1	
CD137MPN	Total Coliforms	mpn/mL	28.8		2419.6	J	2419.6	J	2419.6	J	2419.6	J	2419.6	J
Cyanide:														
E1677	Cyanide, Free	mg/L	0.2	0.2	< 0.002	U	< 0.002	U	< 0.002	U	0.00091	JQ	< 0.002	U
Field Parameters:														
E360.1	Dissolved Oxygen	mg/L	> 5.0		4.87		5.19		5.7		6.25		6.25	
SM2580A	Oxidation Reduction Potential	mV			201.3		157.3		187.3		175.9		175.9	
E150.1	pH	pH units	6.0 - 9.0		7.88		7.65		7.58		7.59		7.59	
E120.1	Specific Conductance	mS/cm			0.421		0.41		0.407		0.406		0.406	
E170.1	Temperature	deg C	< 30.5		21.4		21.3		20.4		19.5		19.5	

Table 3.4.2-6
(Sheet 2 of 4)
Surface Water Quality Summary Data for the Horizon Center Site — Spring 2022

				Location ID:		SW-3		SW-4		SW-5		SW-7		SW-7	
				Sample Date:		5/23/2022		5/23/2022		5/24/2022		5/24/2022		5/24/2022	
				Sample Type:		Sample		Sample		Sample		Sample		Duplicate	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**											
E180.1	Turbidity	NTU			6.75		4.71		6.84		6.64		6.64	
Hardness:															
SM2340C	Hardness, Total as $CaCO_3$	mg/L			180		180		190		200		180	
Metals, Total:															
E200.7	Aluminum	ug/L			97	JQ	130	JQ	98	JQ	130	JQ	74	JQ
E200.8	Antimony	ug/L		6	< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U	< 5.0	U
E200.8	Arsenic	ug/L	34	10	< 3.0	U	0.87	JQ	< 3.0	U	< 3.0	U	< 3.0	U
E200.7	Barium	ug/L		2000	42		40		44		43		44	
E200.7	Beryllium	ug/L		4	< 4.0	U	< 4.0	U	< 4.0	U	< 4.0	U	< 4.0	U
E200.7	Boron	ug/L			77	JQ	69	JQ	38	JQ	38	JQ	39	JQ
E200.8	Cadmium	ug/L	1.8	5	< 0.5	U	< 0.5	U	< 0.5	U	< 0.5	U	< 0.5	U
E200.7	Calcium	ug/L			48000		46000		48000		48000		50000	
E200.7	Chromium	ug/L	570	100	< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
E200.7	Cobalt	ug/L			< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
E200.7	Copper	ug/L	13		< 20	U	< 20	U	< 20	U	< 20	U	< 20	U
E200.7	Iron	ug/L			120		130		120		120	J	74	JQ
E200.8	Lead	ug/L	65		0.36	JQ	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U
E200.7	Magnesium	ug/L			12000		11000		12000		12000		12000	
E200.7	Manganese	ug/L			25		19		19		33		9.2	JQ
E245.1	Mercury	ug/L	1.4	2	0.11	JQ	< 0.2	U	< 0.2	U	0.098	JQ	< 0.2	U
E200.7	Nickel	ug/L	470		10	B	15	B	6.3	JQ	5.3	JQ	6.1	JQ
E200.7	Potassium	ug/L			4700		4000		3700		3600		3700	
E200.8	Selenium	ug/L	20	50	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U	< 2.5	U
E200.7	Silver	ug/L	3.2		< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
E200.7	Sodium	ug/L			18000		16000		15000		15000		15000	
E200.8	Thallium	ug/L		2	< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U	< 1.0	U

Table 3.4.2-6
(Sheet 3 of 4)
Surface Water Quality Summary Data for the Horizon Center Site — Spring 2022

				Location ID:		SW-3		SW-4		SW-5		SW-7		SW-7	
				Sample Date:		5/23/2022		5/23/2022		5/24/2022		5/24/2022		5/24/2022	
				Sample Type:		Sample		Sample		Sample		Sample		Duplicate	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**											
E200.8	Uranium	mg/L		30	0.0035		0.004		0.0054		0.0048		0.0053	
E200.7	Vanadium	ug/L			< 10	U	< 10	U	1.0	JQ	< 10	U	< 10	U
E200.7	Zinc	ug/L	120		11	JQ	10	JQ	< 20	U	< 20	U	< 20	U
Minerals, Dissolved:														
E200.7	Quartz	ug/L			39000		6800		14000	J	13000	JL	8000	J
E200.7	Silicon	ug/L			18000		3200		6300	J	6000	JL	3800	J
Nitrogen Series:														
SM4500-NH3G	Ammonia	mg/L			0.11	JQ	0.11	JQ	0.19	JQ	< 0.25	U	0.15	JQ
E300.0	Nitrogen, nitrate	mg/L		10	3.6		2.8		2.7		2.4		2.7	
E300.0	Nitrogen, nitrite	mg/L		1	< 0.1	U	< 0.1	U	< 0.1	U	< 0.1	U	0.024	JQ
CALC	Nitrogen, Organic	mg/L			0.21		0.33		0.38		< 0.2	U	0.24	
E351.2	Total Kjeldahl Nitrogen	mg/L			0.32		0.44		0.57		< 0.2	U	0.39	
Orthophosphate:														
SM4500-PF	Orthophosphate	mg/L			1.2		0.95		0.81		0.75		0.8	
Phosphorus:														
E365.4	Phosphorus, Total	mg/L			1.0		0.85		0.85		0.51	JH	0.8	
Radioactivity:														
E900.0	Alpha radiation particles	pCi/L		15	< 3.0	U	< 3.0	U	< 3.0	U	< 3.0	U	< 3.0	U
E900.0	Beta Particles & Photon Emitters	pCi/L		1,719[c]	6.05		4.21		3.09		< 4.0	U	3.73	
Residue Series:														
SM2540C	Total Dissolved Solids	mg/L			220		240		220		210		210	
SM2540D	Total Suspended Solids	mg/L			4.7		3.9		3.8		5.0		3.6	

Table 3.4.2-6
(Sheet 4 of 4)
Surface Water Quality Summary Data for the Horizon Center Site — Spring 2022

				Location ID:		SW-3		SW-4		SW-5		SW-7		SW-7	
				Sample Date:		5/23/2022		5/23/2022		5/24/2022		5/24/2022		5/24/2022	
				Sample Type:		Sample		Sample		Sample		Sample		Duplicate	
Analytic Method	**Constituent**	**Units**	**TN Numeric Criteria[a]**	**USEPA NPDWR MCL[b]**											

Notes:
a) Rules of the Tennessee Department of Environment and Conservation, Criteria for Fish and Aquatic Life Water Use, Numeric Criteria of Rule 0400-40-03-.03 subparagraph (3)
b) USEPA National Primary Drinking Water Regulations (NPDWR) Maximum Contaminant Level (MCL) for Inorganic Chemicals and Radionuclides
c) USEPA NPDWR MCL for Beta Particles & Photon Emitters is based on the specific radionuclide(s) concentration(s) in pCi/L units that produce a 4 millirem per year dose. The average concentration for listed radionuclides resulting in a 4 millirem per year dose is 1,719 pCi/L and the actual site specific concentration could vary significantly depending on the radionuclide

deg C = degrees Celsius
mg/L = milligrams per liter
mg/m^3 = milligrams per cubic meter
mpn/mL = most probable number per milliliter
mS/cm = millisiemens per centimeter
mV = millivolts
NTU = nephelometric turbidity unit
pCi/L = picocuries per liter
ug/L = micrograms per liter

Data Qualifier Definitions:
B = Detected, estimated due to blank contamination
J = Detected, estimated due to QC criteria
JH = Estimated, may be biased high
JL = Estimated, may be biased low
JQ = Estimated, reported between the Method Detection Limit (MDL) and the Reporting Limit (RL)
U = Undetected
< = Not Detected above the Reporting Limit shown

Table 3.4.2-7
Mean Concentrations of Metals and Inorganics in East Fork Poplar Creek from Annual Ambient Surface Water Monitoring: July 2018–June 2019

	Sampling Location within EFPC						
Parameter	**EFPC 25.1[(a)]**	**EFPC 24.4[(b)]**	**EFPC 23.4[(c)]**	**EFPC 3.8[(d)]**	**EFPC 6.3[(e)]**	**Criteria[(f)]**	**Units**
Ammonia (mg/L)	0.795	0.0822	0.0264	U	U		
Arsenic (µg/L)	U	U	U	U	U	10	µg/L
Cadmium (µg/L)	0.46	0.194	U	U	U	2	µg/L
Calcium (mg/L)	52.2	53.8	52.7	50.6	46		
Chloride (mg/L)	16	21.2	18.6	8.05	8.91		
Chromium (µg/L)	U	U	U	U	U	570	µg/L
Copper (µg/L)	9.17	6.09	4.11	1.18	1.08	13	µg/L
Inorganic Nitrogen (mg/L)	**3.79**	**3.54**	**2.9**	1.09	**2.65**	1.22	mg/L
Lead (µg/L)	0.545	U	U	0.171	0.276	65	µg/L
Magnesium (mg/L)	12.4	13.9	13.6	9.06	7.77		
Mercury (µg/L)	**0.411**	**0.286**	**0.171**	0.0484	**0.0518**	0.051	µg/L
Nickel (µg/L)	1.53	1.4	1.37	1.31	1.39	470	µg/L
Phosphorus (mg/L)	**0.333**	**0.271**	**0.184**	**0.0516**	**0.173**	0.04	mg/L
Selenium (µg/L)	U	U	U	U	U	20	µg/L
Sodium (mg/L)	12.5	17.8	13.6	5.95	6.7		
Sulfate (mg/L)	43.5	38.5	31.4	16.3	12.2		
Total Dissolved Solids (mg/L)	271	283	261	205	192		
Total Suspended Solids (mg/L)	3.96	0.62	1.22	2.09	3.23		
Uranium (µg/L)	92.1*	52.9*	52.9*	39.5	11.4		
Zinc (µg/L)	36.7	16.6	9.56	1.48	2.9	120	µg/L

Source: TDEC 2020a.
U = undetected
Bolded values indicate an exceedance from Tennessee Fish and Aquatic or Tennessee Recreation limits (whichever is more stringent). Ecoregion values are used for nitrate and phosphorus.
* Exceeds USEPA MCL for drinking water of 30 ug/l
a) Creek headwaters.
b) Sampling location between sites 25.1 and 23.4.
c) Location between DOE property and Oak Ridge.
d) Upstream of Oak Ridge sewage treatment outfall.
e) Downstream of Oak Ridge.
f) Tennessee Fish and Aquatic or Tennessee Recreation Limit Criteria

Table 3.4.4-1
NWI-Mapped Wetland Habitats within the Horizon Center Site and Vicinity

Wetland Type	HCS (ac.)	3-Mile Vicinity (ac.)
Wetlands		
Emergent		
Forested	0.001	418.62
Scrub shrub		
Open Water		
Lacustrine and Palustrine Habitats		273.28
Riverine Habitats	1.11	351.47

3.5 ECOLOGY

This section describes and characterizes the terrestrial and aquatic ecosystems potentially affected by the construction and operation of the TRISO-X Fuel Fabrication Facility (TRISO-X FFF) at the Horizon Center site (HCS). A topographic map of the HCS is shown on Figure 3.3.3-2 in Section 3.3 Geology and Soils. The ecological vicinity is defined as the area within a 5-mi. (8-km) radius of the HCS bounding limits, as described in Section 1.3.1.2, to capture the context of vegetation communities and habitats, especially forests, that support sensitive plant and animal species in the region. Ecological features that are in proximity (adjacent) to the HCS are defined as within a 0.5-mi. (0.8-km) radius of the HCS. The ecological study area includes the HCS (Lot 6a) and the wooded lot in proximity to and northeast of the HCS (Lot 6b), as shown in Figure 3.5-1. Correspondence with the U.S. Fish and Wildlife Service (USFWS) and the Tennessee Wildlife Resources Agency (TWRA) was initiated in March 2022 to obtain information regarding ecological resources near the HCS. A response was received from the USFWS on April 15, 2022. Correspondence with USFWS and TWRA is included in Chapter 1, Appendix 1A (Regulatory Correspondence).

Listings of Federal- and State-listed threatened or endangered species currently listed or proposed for listing that may occur within the project site were obtained from the USFWS Information for Planning and Consultation (IPaC) website (USFWS, 2021) and the Tennessee Department of Environmental and Conservation (TDEC) natural heritage rare species online database (TDEC, 2021a) in September 2021. Federal- and State-listed threatened and endangered species are discussed in Section 3.5.5.

The consultation process was used in combination with online agency databases to obtain information regarding threatened and endangered species, sensitive habitats, commercial and recreational species, and other ecological characteristics for the site and vicinity. Ecological resources described herein are based on recorded information provided by resource agencies and supplemental field surveys. Field surveys for ecological resources were conducted within the ecological study area in summer 2021 (September 8-10, 2021), fall 2021 (November 16-17, 2021), and spring 2022 (April 26-27, 2022). No seasonal survey was conducted during the winter months because the fall survey was performed in late fall and was considered to also be indicative of faunal use during the winter season. Field surveys are used in part to characterize the assemblage of terrestrial plant species and to aid in the identification of any Federally listed threatened or endangered species or Tennessee-listed threatened, endangered, or special concern species potentially occurring within and in proximity to the HCS.

3.5.1 BIOTIC COMMUNITIES

The HCS is located in a valley of the Southern Limestone/Dolomite Valleys and Low Rolling Hills ecoregion within the Ridge and Valley level III ecoregion of eastern Tennessee. Also known as the Great Valley of East Tennessee, the Ridge and Valley level III ecoregion is a relatively low-lying region between the Blue Ridge Mountains to the east and the Cumberland Plateau to the west. As a result of extreme folding and faulting events, the region’s roughly parallel ridges and valleys come in a variety of widths, heights, and geologic materials, including limestone, dolomite, shale, siltstone, sandstone, chert, mudstone, and marble. Springs and caves are relatively numerous. Present-day forests cover about 50 percent of the region (Griffith et al., 1998). The Southern Limestone/Dolomite Valleys and Low Rolling Hills level IV ecoregion is characterized by low rolling hills and valleys underlain by limestone and dolomite. Prevalent natural communities include white oak forests, bottomland oak forest, and sycamore-ash-elm

riparian forests. Grassland barrens intermixed with pine/cedar glades are also found, to a lesser extent (Griffith et al., 1998).

Several rare plant communities that are representative of the Ridge and Valley ecoregion have been documented on the Oak Ridge Reservation (ORR), which is located in the vicinity of the HCS. These communities include northern white-cedar woodland, oak-hickory-ash limestone woodland, rocky limestone woodland, limestone cliff, limestone sinkhole, limestone barren, calcareous mixed mesophytic forest, floodplain pool, sweetflag pond, boggy forested wetland, streamhead seepage swamp, swamp forest, and wet meadow shrub-herb complex (Baranski, 2009). The ORR is one of the largest remaining areas in the Ridge and Valley ecoregion with relatively intact natural communities (especially those of valley bottoms and lower slopes) (Nature Conservancy, 1995).

As noted in Section 3.1.1 and 3.1.8, the development areas on the HCS are separated by dedicated green belts which are zoned as Greenbelt Districts by the City of Oak Ridge. The green belts were established by the DOE in 1996 as a mitigative measure to reduce impacts of development of the Horizon Center. Development of the green belt areas has effectively protected wildlife habitat, plant communities, threatened, or endangered species threatened and endangered species and maintained habitat connections to reduce the ecological effects of fragmentation . Much of the HCS is previously disturbed and periodically mowed. It does not contain intact, high-quality native plant communities. Rare plant communities such as those that have been documented on portions of the ORR are not present on the HCS

3.5.2 TERRESTRIAL RESOURCES

3.5.2.1 Plant Communities

Qualitative surveys characterizing the presence of terrestrial plant communities and vascular plant species within the ecological study area were performed during seasonal field surveys in 2021 and 2022.

Most of the land cover on the HCS is characterized by herbaceous cover (105.2 ac. [42.6 ha]). Mixed forest comprises the second greatest land cover category (4.8 ac. [1.9 ha]), and the remaining 0.2 ac. (0.1 ha) is evergreen forest (Table 3.5.2-1). As depicted on Figure 3.5.2-1 and in Table 3.5.2-1, the National Landcover Database (NLCD) (Dewitz and U.S. Geological Survey, 2021) indicates that the most prevalent land cover type found within the 5-mi (8-km) radius of the HCS is deciduous forest (30,836 ac. [12,479 ha]), followed by hay/pasture (7,361 ac. [2,979 ha]), mixed forest (5,035 ac. [2,038 ha]), and developed-open space (3,872 ac. [1,567 ha]). The NLCD mapped landcover within the 5-mi. (8-km) radius was ground-verified utilizing drive-by and pedestrian surveys and determined to be accurate.

The study area was categorized by landcover types based on dominant species of vegetation observed during the field surveys (Figure 3.5.2-1). Qualitative descriptions of plant communities encountered are provided below, including dominant (abundant to common relative abundance) species occurring in each stratum (tree, shrub, herb, and woody vine layers). Plant species observed during the pedestrian field surveys are summarized in Table 3.5.2-2.

3.5.2.1.1 Plant Communities within the HCS and Ecological Study Area

Herbaceous vegetation is the predominant landcover on the HCS, occupying approximately 95 percent of the site. The large, periodically mowed and overgrown field located behind the

Philotechnics Building is almost entirely in herbaceous cover, with the exception of small islands and fence rows of shrub-scrub and individual, stand-alone mature trees. Around the perimeter of the field, soils are largely undisturbed, and a fairly diverse, old field vegetation community was observed. The most prevalent species recorded here include woody species like sawtooth blackberry, Japanese honeysuckle, autumn olive, and Chinese lespedeza; and herbaceous species such as soft brome, weeping lovegrass, perennial ryegrass, Kentucky bluegrass, Appalachian ragwort, tall goldenrod, tall fescue, yellow crownbeard, plantains, asters, Virginia strawberry, and lyreleaf sage (Table 3.5.2-2).

In the more stripped soils in the center of the herbaceous field on the HCS, Chinese lespedeza grows in a near monoculture with small amounts of poverty oatgrass. Shrub-scrub islands were observed growing in low spots in the field that could not be mowed and along occasional strips of silt fence. Commonly observed species here include autumn olive, sawtooth blackberry, sweetgum, redbud, and black cherry. A very small number of individual or clustered mature trees were scattered throughout the field, including southern red oak, tulip poplar, and snags of American elm (Table 3.5.2-2).

Mixed forest, the dominant forested landcover type in the study area, is mostly concentrated along low hillslopes and the slopes of draws on Lot 6b, and it also borders the edge of the large old field in the western part of the study area (see Figure 3.5-1). Only 4.8 ac. (1.9 ha) of mixed forest occurs on the HCS, with 16.6 ac. (6.7 ha) on Lot 6b, in proximity to the HCS. Mesophytic mixed forest is the most common mixed forest type observed in the study area. Species typical of deciduous mesophytic forests were observed along with a component of loblolly, white pine, Virginia pine, eastern red cedar, and, less commonly, shortleaf pine in the canopy. Ruderal mesic mixed forest was observed growing along the terraces of the narrow intermittent stream valley that bisects the eastern third of Lot 6b. American elm, tulip poplar, and black walnut are dominant species in the canopy, but small amounts of loblolly pine are also present. A dense thicket overgrown with invasive species, including Chinese privet and Japanese stiltgrass, occupy the shrub and herb layer here. During the spring 2022 field survey, a diversity of rich mesic forest wildflowers was observed outside the HCS in Lot 6b growing on the stream terrace and, most abundantly, on the east facing hillslope just above the stream. Representative wildflowers observed include Jacob’s ladder, perfoliate bellwort, eastern shooting star, bloodroot, yellow wakerobin, and white baneberry.

Coniferous forest patches are scattered in the eastern third of the study area in Lot 6b (see Figure 3.5-1). Only 0.2 ac. (0.1 ha) of evergreen forest occurs on the HCS, with 15.4 ac. (6.2 ha) on Lot 6b (Table 3.5.2-1). Early- to mid-successional loblolly forest is the representative evergreen forest community. Tulip poplar is commonly subdominant in the overstory, and species like sweetgum, red maple, and American beech were also commonly encountered, depending on the moisture level. The midstory is typically sparse in older stands of loblolly pine, where little sunlight penetrates to the understory. A large, young stand of evergreen forest in the northeastern corner of Lot 6b (see Figure 3.5-1) has a more prevalent midstory that includes species such as red maple and flowering dogwood. Common and abundant herb species observed in the evergreen forest areas include Christmas fern, muscadine, Japanese honeysuckle, and seedlings of southern red oak and white ash.

Two large patches of deciduous forest were documented in the study area on Lot 6b, in proximity to the HCS, on mid-slopes and low ridges mostly north of the North Boundary Greenway Trail (see Figure 3.5-1). These forest patches appear to represent the oldest successional community within the study area. Topographic and edaphic variation within the study area contributes to subtle shifts in plant associations observed within the deciduous forest

landcover type. Southern red oak trees are the tallest species in the canopy and contribute to the greatest percent cover; additional dominant canopy species include red maple, sassafras, and black cherry. In the shrub layer, flowering musclewood, and beech are dominant and grow over a sparse herb layer composed mostly of tree and woody vine seedlings, including muscadine, Japanese honeysuckle, sweetgum, and white ash. Southern red oak and sassafras become more common in the tree layer as elevation increases and conditions become drier. In slightly more protected, mesic topographic positions, sweet gum, white oak, and northern red oak were observed to be more prevalent in the overstory.

3.5.2.1.2 Plant Communities in Proximity to the Ecological Study Area

A small forested area located outside the ecological study area to the south was supplementally characterized because of its unique plant assemblage and mature successional age relative to the immediate area. In the canopy, mature beech trees were observed to be codominant with large tulip poplars, along with scattered large oak trees that are approximately 40 in. (100 cm) diameter at breast height. Sugar maple and beech are dominant in the sparse shrub layer; seedlings of white ash, paw paw (*Asimina triloba*), muscadine, and sugar maple are abundant in the scattered herb layer.

3.5.2.2 Wildlife

Because most of the HCS is previously disturbed and maintained as periodically mowed, the wildlife communities associated with the small habitat areas remaining on the site generally consist of common species tolerant of fragmented or altered habitats. Therefore, this area is not likely to support any unique or rare wildlife species. However, the ORR is located in the vicinity of the HCS (see Section 3.5.4 Important Ecological Systems) and is largely undeveloped. The ORR provides adjacent wildlife habitat in the form of forested land, extensive areas of undisturbed wetlands, open waterways, and riparian vegetation, and several hundred acres of grassland communities and fallow fields (DOE, 2021).

Habitat types within the HCS include herbaceous and forest (evergreen and mixed) (Table 3.5.2-1 and Figure 3.5-1). Methods used to document wildlife in the study area and in proximity to the study area included direct observation and indirect observation (skat, signs, and calls). The field surveys for wildlife included surveys for avifauna, mammals, and herpetofauna. Lists of wildlife observed and that have the potential to use the HCS for habitat are provided in Tables 3.5.2-3 through 3.5.2-5. The lists of species likely to occur on the HCS were created based upon species lists from the ORR (ORNL, 2019).

Several species of terrestrial mammals, such as white-tailed deer, bobcat, gray fox, red fox, raccoon, eastern cottontail, groundhog, gray squirrel, striped skunk, eastern chipmunk, Virginia opossum, coyote, eastern mole, several bat species, and many small rodents and shrews are likely to inhabit the study area. A list of mammals occurring or potentially occurring on the HCS is provided in Table 3.5.2-3 (ORNL, 2019). White-tailed deer, gray squirrel, and eastern cottontail are recreationally valuable as game species.

Some reptile and amphibian species expected to occur in the vicinity of the ephemeral and intermittent streams in the study area and the EFPC in proximity to the study area include northern cricket frog, American bullfrog, northern green frog, northern spring peeper, southern leopard frog, gray treefrog, red-spotted newt, northern dusky salamander, painted turtle, snapping turtle, and northern water snake. Herpetofauna expected to occur within the herbaceous and forested upland areas of the study area include eastern box turtle, eastern

American toad, northern fence lizard, common five-lined skink, eastern worm snake, black racer, gray ratsnake, black kingsnake, and eastern garter snake. A list of reptiles and amphibians observed or likely to occur on the HCS is provided in Table 3.5.2-4 (ORNL, 2019).

Abundant and common bird species observed during the summer field survey include American crow, blue jay, mourning dove, white-eyed vireo, Carolina wren, downy woodpecker, and tufted titmouse. Abundant and common species observed during the fall field survey include blue jay, northern cardinal, Carolina chickadee, Eastern phoebe, American goldfinch, and Carolina wren. Abundant and common species observed during the spring field survey include northern cardinal, tufted titmouse, common yellowthroat, yellow-breasted chat, and field sparrow. Based on the methodology and observed species, no protected bird species (State or Federally listed) or colonial nesting sites (e.g., heronries) are documented within the study area. A list of birds occurring or potentially occurring on the HCS during all seasons is provided in Table 3.5.2-5. Wild turkey and mourning dove are the only avian species observed in the study area that are recreationally valuable since they are game species. Wood duck, mallard, and Canada goose are other recreationally valuable bird species likely to occur in the study area (ORNL, 2019; eBird, 2022).

Migratory birds are Federally protected under the Migratory Bird Treaty Act, which prohibits the take of migratory bird species without prior authorization by the USFWS. Review of the USFWS IPaC database identified six migratory birds of conservation concern that have the potential to be impacted by the Proposed Actions: cerulean warbler (*Dendroica cerulea*), Kentucky warbler, prairie warbler, prothonotary warbler (*Protonotaria citrea*), red-headed woodpecker, and wood thrush (USFWS, 2021). Several of these species of migratory birds, including prairie warbler, Kentucky warbler, red-headed woodpecker, and wood thrush, have been recorded on the ORR (ORNL, 2019) and are likely to inhabit or use the forested and herbaceous habitats of the HCS during migration and/or the breeding season.

Information regarding rare, threatened, and endangered species within the HCS is included in Section 3.5.5.

3.5.2.3 Location of Important Travel Corridors for Terrestrial Wildlife

Travel corridors are passageways used by species to access various foraging, nesting, and breeding habitats (USDA NRCS, 2004). Depending upon the species of interest, travel corridor requirements vary widely in size, quality, and biotic community.

3.5.2.3.1 Travel Corridors in the Vicinity of the HCS

The Clinch River/Melton Hill Reservoir is approximately 2.7 mi. (4.4 km) from the HCS. According to the Federal Interagency Stream Restoration Working Group, stream corridors, and other types of naturally vegetated corridors as well, can provide migrating forest and riparian species with their preferred resting and feeding habitats during migration stopovers (FISRWG, 1998). The ORR, much of which is within the vicinity of the HCS, is bordered by the Clinch River and has large expanses of mature hardwood forest and other undeveloped habitats (National Audubon Society, 2022). These habitats make the ORR attractive to a large and diverse number of species that use the reservation as a migratory and/or travel corridor. Forested areas present significant sites for migrating and breeding woodland neotropical migrant birds.

Largely undeveloped, forested mountainous ridges associated with the Valley and Ridge province (see Figure 3.3.3-2 in Section 3.3, Geology and Soils), including Blackoak Ridge, East

Fork Ridge, Pine Ridge, Haw Ridge, and Chestnut Ridge, also may act as migratory and/or travel corridors for wildlife. These ridges are oriented northeast to southwest within the vicinity of the HCS, and Blackoak Ridge is located immediately to the north of the HCS.

The Cumberland Plateau, a dissected plateau within the foothills of the Cumberland Mountain range, is another important travel corridor in eastern Tennessee. The plateau, approximately 5 mi. (8 km) northwest of the site, contains some of the largest stretches of contiguous forest in the eastern United States and provides ample food and cover for migrating and breeding terrestrial wildlife species (Nature Conservancy, 2022).

The Oak Ridge Greenways project is an effort to weave nonmotorized trails through the City of Oak Ridge to community resources such as parks, schools, cultural centers, shopping areas, and areas of employment. These linear, vegetated greenways typically follow natural corridors, such as floodway zones or existing rights-of-way, and many are laid out within the approximately 1500 ac. (607 ha) of forested greenbelts within the city (City of Oak Ridge, 2022). The city's greenways likely act as travel corridors for many wildlife species that are adapted to urban/suburban environments, and they can connect the HCS with other habitat areas within and surrounding the city. The North Boundary Greenway is an Oak Ridge Greenway trail system that connects to and traverses the forested area north of the HCS and connected undeveloped areas (City of Oak Ridge, 2022).

3.5.2.3.2 On-Site Travel Corridors

Mobile animals on the HCS, such as white-tailed deer, coyotes, bobcats, foxes, raccoons, rodents, rabbits, and other terrestrial mammals, collectively create diffuse travel corridors across various biotic communities on the site and to and from adjacent properties, such as the ORR. The longest and most complex travel corridors are typically established by white-tailed deer. Other species may use portions of these regularly traveled trails.

Tracks of common wildlife species, such as white-tailed deer, coyote, and raccoon, were observed across the entire HCS during the 2021 and 2022 field surveys, indicating that travel corridors are highly variable. Use of undeveloped areas within the site by these common species does not appear to be impacted by the current level of human and industrial activities occurring on and in proximity to the study area. The animals likely take advantage of connected forested parcels and human-induced corridors, such as wet weather conveyances and other riparian areas, fence lines, edge habitat, road corridors, and utility corridors (USDA NRCS 2004).

With respect to reptiles and amphibians, no specific travel corridors were identified on the HCS during the field surveys. In general, these species are smaller and have smaller home ranges than mammals, and they may only use travel corridors seasonally, rather than daily, to travel to habitats used for breeding or for hibernation. Amphibians and many reptiles utilize both aquatic or wetland habitat as well as nearby uplands (USDA NRCS, 2006); therefore, travel corridors may be present between breeding and foraging habitat.

Much of the habitat areas on the HCS are previously disturbed, periodically mowed, and not considered high-value ecological systems. However, the HCS does provide habitat for many different bird species, including resident and migratory birds (Table 3.5.2-5). Resident and breeding migratory bird species likely use variable on-site flight corridors, mostly within the undeveloped portions of the site, for obtaining food, traveling to and from nesting sites, and as escape routes from predators.

3.5.3 AQUATIC RESOURCES

3.5.3.1 Characterization of the Aquatic Environment

Aquatic communities in the ecological study area consist of streams within and in proximity to the study area; however, no streams occur within the HCS. Aquatic communities in the vicinity of the HCS include the EFPC, a tributary of Poplar Creek which drains to the nearby Clinch River Arm of the Watts Bar Reservoir.

Aquatic habitats present within Lot 6b of the study area include one ephemeral stream and one intermittent stream (see Figure 3.4.4-2 in Section 3.4.4). The lower portion of the ephemeral stream has characteristics of an intermittent stream prior to merging with the intermittent stream channel. No ponds are located on the HCS. All the streams within or in proximity to the study area drain into the EFPC to the south of the HCS.

The ephemeral stream within Lot 6b of the study area does not support fish. The intermittent stream and streams located in the vicinity of Lot 6b, however, do support fish and other aquatic biota. Five stream habitats in proximity to the study area were evaluated during summer and fall 2021 and spring 2022 field surveys to assess the potential to support aquatic organisms and any observed aquatic biota. Seasonal surveys consisted of sampling at five sites in proximity to the HCS for fish and crustaceans. A full list of species found in these surveys can be found in Table 3.5.3-1. The most common species captured across all seasons of sampling included emerald shiner, striped shiner, and blacknose dace. Crayfish was the only crustacean observed.

EFPC, located in proximity to the study area, flows through the urbanized and suburbanized section of Oak Ridge before its confluence with Poplar Creek (TDEC, 2020a). Benthic macroinvertebrate communities were analyzed for the EFPC in 2018. Tennessee Macroinvertebrate Index scores were determined for each of the six monitoring stations. Tennessee Macroinvertebrate Index scores for East Fork Poplar Creek ranged from 14 (C rating, moderately impaired) to 42 (A rating, non-impaired). Across the six sampling stations within the EFPC, taxa richness, a measure of overall diversity, for benthic macroinvertebrates ranged from 21 to 41 taxa present (TDEC, 2020a). In general, in the EFPC, total taxa richness of benthic macroinvertebrates has increased since historical lows in the 1980s (DOE, 2020). Surveys documented 33 fish species present in the EFPC (Table 3.5.3-2; ORNL, 1997). The fish community in the EFPC was monitored in 2019 at six sites along the creek. In general, species richness, density, biomass, and number of pollution-sensitive species has increased since 1986 within the creek (DOE, 2020). Fish species and aquatic biota present in this creek are typical for low-flow tributary streams.

While some aquatic species characteristic of the Clinch River may be found within lower reaches of the tributaries in proximity to the HCS, such as Poplar Creek (especially during high flow conditions), the aquatic biota of the more permanently flowing portions of these streams are likely to be more characteristic of low-flow tributary streams, such as EFPC. Fish sampling within Clinch River upstream of the confluence with Poplar Creek was conducted by TVA in February, May, July, and October 2011. The survey found an average of 33 species at the downstream sampling location (i.e., those nearest the confluence with Poplar Creek) (TVA, 2013). Common fish species within the Clinch River include bluegill, Mississippi silverside (*Menidia audens*), gizzard shad, spotted sucker, white bass (*Morone chrysops*), yellow bass (*Morone mississippiensis*), yellow perch (*Perca flavescens*), green sunfish, redear sunfish (*Lepomis microlophus*), black redhorse, and sauger (*Sander canadensis*) (TVA 2013). A mollusk survey conducted in 2011 in the Clinch River upstream of the confluence with Poplar

Creek found a total of 74 living native mussels from six different species: pimpleback (*Quadrula pustulosa*), fragile papershell (*Leptodea fragilis*), purple wartyback (*Cyclonaias tuberculata*), pink heelsplitter (*Potomilus alatus*), giant floater (*Pyganodon grandis*), and elephant ear (*Elliptio crassidens*) (Third Rock Consultants, 2011). Zebra mussel (*Dreissena polymorpha*), an invasive species, was also observed to be growing on most of the native mussels (Third Rock Consultants, 2011).

Invasive species present in the Clinch River include clams and mussels, fish, and aquatic plants. In addition to zebra mussels, other nonnative aquatic species present include the Asiatic clam (*Corbicula fluminea*), Eurasian watermilfoil (*Myriophyllum spicatum L.*), hydrilla (*Hydrilla verticillata*), curly-leaved pondweed (*Potamogeton crispus L.*), common carp (*Cyrpinius carpo*), Mississippi silverside, redbreast sunfish, striped bass (*Morone saxatilis*), and yellow perch (USGS, 2019). Some of these species, including striped bass, are stocked for recreational fishing activities.

3.5.3.2 Commercial and Sport Fisheries

The only recreationally important aquatic species found in 2021 aquatic surveys of streams in proximity to the HCS was bluegill. The EFPC has a recreational fishery, with targeted fish species including white bass and white crappie (*Pomoxis annularis*). Due to historical mercury contamination on the ORR, including the EFPC, a roving creel study has been initiated (as of 2020) to assess angling effort and potential consumption of fish harvested downstream from EFPC at the confluence of Poplar Creek and Bear Creek as well as at the confluence of Poplar Creek and the Clinch River, however, results of this study are not yet available (TDEC, 2020b). As a result of mercury accumulation as well as bacteriological contamination in EFPC, the TDEC has posted an advisory against the consumption of all fish from EFPC (TDEC, 2020c).

Recreational fisheries also exist within Clinch River. The main target species within the Watts Bar Reservoir, including the lower Clinch River, include largemouth bass, smallmouth bass (*Micropterus dolomieu*), black crappie (*Pomoxis nigromaculatus*), white crappie, bluegill, blue catfish (*Ictalurus furcatus*), channel catfish (*Ictalurus punctatus*), and striped bass (TWRA 2016). Stocking programs exist for largemouth bass, walleye (*Sander vitreus*), and striped bass within the Watts Bar Reservoir (TWRA, 2016). Upstream in the Clinch River, in the Melton Hill Reservoir, target species for recreational fisheries include muskellunge (*Esox masquinongy*), striped bass, hybrid striped bass (*M. chrysops X M. saxatilis*), white crappie, largemouth bass, and skipjack herring (*Alosa chrysochloris*) (Visit Knoxville, 2020).

Commercial fishing is specifically not allowed in the Watts Bar Reservoir of the Clinch River (Tennessee Fish and Wildlife Commission, 2021).

3.5.3.3 Key Aquatic Indicator Organisms

According to NUREG-1748, key aquatic indicators are expected to gauge changes in the distribution and abundance of species populations that are particularly vulnerable to impacts from the Proposed Action. Historically, benthic macroinvertebrates have been monitored within EFPC to assess impacts of previous activities and remediation, as these communities can serve as indictors of overall system health (TDEC 2020a). Benthic macroinvertebrate monitoring in 2019 indicated that the macroinvertebrate score in EFPC ranged from ‘non-impaired’ to ‘moderately impaired’ along its length (TDEC, 2020a). The macroinvertebrate score is based upon measures of presence, species richness, and community diversity within the stream.

3.5.4 IMPORTANT ECOLOGICAL SYSTEMS

3.5.4.1 Ecological Systems in the Vicinity of the HCS

According to NUREG-1748, important ecological systems are areas that are especially vulnerable to change or that contain important species habitats, such as breeding areas (e.g., nesting areas), nursery areas, feeding areas, resting areas, wintering areas, or other areas of seasonally high concentrations of individuals of important species. Important ecological areas may include national or state forests, wilderness areas, scenic areas, nature preserves, wildlife management areas, Nationwide Rivers Inventory streams, and wild and scenic rivers. This section addresses important ecological systems that are within the vicinity (within a 5-mi. [8-km] radius) of the HCS. Important ecological areas within the vicinity of the HCS are illustrated on Figure 3.5.4-1.

The ORR, a Federally owned site covering over 32,000 ac. (13,000 ha) located in Anderson and Roane counties, is within the vicinity of the HCS. The ORNL Natural Resources Management program maintains a list of special habitats within the ORR that are collectively termed Sensitive Areas. Sensitive Areas are those containing State- or Federal-listed species, ecologically significant habitat, and/or particular management requirements (ORNL, 2015). Sensitive Areas on the ORR and other ecologically important areas in the vicinity of the HCS are shown on Figure 3.5.4-1.

With the support of the TWRA, this reservation has been designated as an Important Bird Area by the National Audubon Society (National Audubon Society, 2022). According to the TWRA, “the Oak Ridge Reservation has large expanses of mature hardwood forest, unbroken by development or farmland; brushy corridors and cutover forest; abandoned pastures; grasslands; cedar glades and barrens; and wetlands. These habitats make the area attractive to a large and diverse number of species” (TWRA, 2021). Several access points on the reservation are open to the public and available for hiking and bird watching. Nearly 200 species of birds have been documented on the reservation, including the following State-threatened and State-designated as “in need of management” species: wood thrush, golden-winged warbler (*Vermivora chrysoptera*), cerulean warbler, Henslow's sparrow (*Ammodramus henslowii*), little blue heron (*Egretta caerulea*), least bittern (*Ixobrychus exilis*), loggerhead shrike (*Lanius ludovicianus*), and black-crowned night-heron (*Nycticorax nycticorax*) (National Audubon Society, 2022).

Forested areas provide important habitat for migrating and breeding woodland neotropical migrant species. During the breeding season, 23 out of 27 species found on the ORR were determined to be of top conservation priority in the Appalachian Mountains Bird Conservation Region by Partners in Flight. Biologically and ecologically significant natural areas and habitats on the reservation, including forests, grasslands, bogs, barrens, bluffs, outcrops, and other areas, represent high-quality examples of natural communities and/or habitats for populations of rare species and species of concern (National Audubon Society, 2022). In April 2005, U.S. Department of Energy (DOE) and the State-designated almost 3,000 acres of ORR land in the vicinity of the HCS (see Figure 3.5.4-1) as the Black Oak Ridge Conservation Easement. This natural area, managed by TWRA in cooperation with TDEC, contains the largest block of unfragmented forest on the ORR. It provides valuable rare forest interior that serves as habitat for uncommon wildlife and nesting and migratory birds. An analysis by the ORNL of natural areas, managed areas, and other designated areas within the ORR identified the following categories and numbers of terrestrial or wetland areas (Baranski, 2009; ORNL, 2015):

- 47 Natural Areas (NA) — Terrestrial or Aquatic NAs are systems classified primarily on the basis of the presence of listed species.

- 18 Reference Areas (RA) — Terrestrial or Aquatic RAs are areas that contain uncommon habitat or ecologically sensitive features, such as wetlands, barrens, caves, or springs, that may also serve as reference or control areas for biological monitoring.

- Five Cooperative Management Areas (CMA) — CMAs are areas being used for nonecological purposes (e.g., mowed areas) that contain sensitive habitat for which close cooperation among programs is required to achieve multiple management objectives.

- Eight Habitat Areas (HA) — HAs are areas designated as such because of the presence of plants listed by the State as rare and/or commercially exploited.

- Eight Potential Habitat Areas (PH) — PH areas are areas with habitat characteristics suitable for habitation by State- or Federal-listed species but that have no recorded presence of those species.

Figure 3.5.4-1 provides a map of the ORR designated ecologically significant areas within approximately 5 mi. (8 km) of the HCS. The following four designated areas on the ORR are in proximity (within 0.5 mi. [0.8 km]) of the site (Baranski, 2009; AFORR 2022):

- Poplar Creek Cliffs (NA20) is a 476-ac. (193-ha) NA within the Black Oak Ridge Conservation Easement with a steep, southwest-facing slope in the water gap that bisects Blackoak Ridge. It is located a short distance upstream from the confluence of EFPC with Poplar Creek. Small limestone cliffs occur near the stream. Many species that are unusual within the ORR occur here, including hemlock (Tsuga canadensis), rhododendron (Rhododendron maximum), fringe tree (Chionanthus virginicus), spider lily (Hymenocallis occidentalis), and mock orange (Philadelphus hirsutus). Pink lady's-slipper (Cypripedium acaule) and spreading false-foxglove (Aureolaria patula) also occur at this site.

- East Fork Limestone Quarry/Blackoak Ridge Limestone Quarry/Blackoak Ridge Forest (NA46) is a 300-ac. (121-ha) NA with mature mixed hardwoods and pines. NA46 is located northwest of Lambert's Quarry within the Black Oak Ridge Conservation Easement. Much of the forest is oak-hickory-tuliptree, but native forests of shortleaf pine and white pine dominate some areas. This large, forested area includes commercially exploited pink lady's-slipper. This area has the only confirmed occurrence of white-topped sedge (Rhynchospora colorata) in Tennessee.

- East Fork (Poplar Creek) Floodplain (NA47). This 609-ac. (246-ha) NA includes floodplain hardwood forest with large sycamores and an abundant understory of giant cane in places. Floodplain forests with canebrakes are rapidly disappearing in the southeastern United States because of development. The site also includes adjacent upland areas with rare plant communities, including cedar barrens and beech-maple forest. Rare species found within NA47 include goldenseal (Hydrastis canadensis), American ginseng (Panax quinquefolius), the southeastern shrew, and pink lady's-slipper. The Tennessee dace (Phoxinus tennesseensis) occurs in small tributaries in the floodplain.

- HA4 is an area of mature mixed hardwoods and pines within the Black Oak Ridge Conservation Easement. This area of forest interior includes habitat for rare species (Parr and Hughes, 2006).

Upland forested and open-land community types on Tennessee Valley Authority (TVA)-owned land parcels surrounding TVA reservoirs and reservations provide a broad range of habitats that can support a wide array of terrestrial wildlife species. Habitat Protection Areas are managed by TVA to protect populations of species identified as threatened or endangered by the USFWS, State-listed species, and any unusual or exemplary biological communities/geological features (TVA, 2021).

The Grassy Creek Habitat Protection Area is located along and south of Grassy Creek in the vicinity of the HCS (see Figure 3.5.4-1). The 265-ac. (107-ha) Grassy Creek Habitat Protection Area provides a buffer for sensitive habitat surrounding and immediately south of Grassy Creek and the Grassy Creek embayment of the Clinch River arm of the Watts Bar Reservoir. A State-threatened plant species, shining ladies'-tresses (*Spiranthes lucida*), is among the species with habitat protected by the Grassy Creek Habitat Protection Area. Two caves that would provide suitable habitat for a variety of bat species have also been identified on or near this area (TVA, 2021).

The Campbell Bend Barrens and Crowder Cemetery Barrens are both registered as State natural areas within the vicinity of the HCS (see Figure 3.5.4-1). Campbell Bend Barrens is a 35-acre (14-ha) natural area that is approximately 1 mile (0.6 km) to the northeast of the 15-acre (6.1-ha) Crowder Cemetery Barrens. These areas were once part of a larger natural area complex on the ORR before the land was sold in the mid-1980s. Barrens natural communities are rare in the Ridge and Valley Physiographic Province of East Tennessee. They occur on thin, cherty soil over dolomitic limestone and are dominated by warm-season grasses, legumes, and composites with eastern red cedar, white pine, and hardwoods scattered throughout. These natural areas support a variety of plants associated with cedar barrens and glades, including spreading false foxglove, naked-stem sunflower (*Helianthus occidentalis*), slender blazing star (*Liatris cylindracea*), and prairie dock (*Silphium terebinthinaceum*) (TDEC, 2022).

The Clinch River is another important ecological resource within the vicinity of the HCS. A section of the Clinch River, from Melton Hill Dam upstream to the Pellissippi Parkway, is designated as a Class III Partially Developed River Area under the Tennessee Scenic Rivers Program (TDEC, 2021b). A partially developed river is defined by TDEC as rivers or sections of rivers that are free flowing, unpolluted and with shorelines and vistas essentially more developed. The Tennessee Scenic Rivers Program is a voluntary community-based partnership intended to preserve and protect the free flowing, unpolluted, and outstanding scenic, recreational, geologic, botanical, fish, wildlife, historical, or cultural values of selected rivers or river segments in the State (TDEC, 2021b).

3.5.4.2 Ecological Systems on the HCS

The potential presence of ecological systems, including potentially suitable bat roosting habitat, was investigated for the ecological study area, as illustrated in Figure 3.5-1. Habitats on the study area include significant portions of previously disturbed and periodically mowed areas that are not considered high-value important ecological systems. However, ecological areas found on the study area include one ephemeral stream, one intermittent stream with a headwater seep, and potentially suitable bat foraging and roosting habitat. For more information on

distribution of Waters of the United States on the HCS, refer to Section 3.4.4 (Wetlands) and Figure 3.4.4-2.

Limited areas throughout the study area provide potential suitable summer roosting habitat for the Indiana bat and northern long-eared bat, as well as potential foraging habitat for these and other species of bats. On the northeastern 1/3 of the study area, deciduous, mixed, and evergreen forest communities were identified with potential suitable summer bat habitat totaling 44.3 ac. (17.9 ha) of forested land. However, only 5.0 ac. (2.0 ha) of this forested land is located on the HCS (see Table 3.5.2-1). These forested areas also provide potential suitable habitat for migrating and breeding neotropical migrant bird species.

Fourteen potentially suitable bat roost trees consisting of six different tree species were identified in the study area due to the presence of cavities, hollows, crevices, and exfoliating bark. Seven of these trees are located with the HCS. More information regarding potentially suitable bat habitat can be found in Section 3.5.5 (Rare, Threatened and Endangered Species).

The following categories of important ecological systems were considered but are not present on the HCS: cave habitats, areas that are designated as wilderness areas, State-designated natural areas, and wild and scenic rivers. No commercially valuable species, species essential to the maintenance and survival of rare or commercially or recreationally valuable species, species critical to the structure and function of local terrestrial ecosystems, or species that could serve as biological indicators of effects on local terrestrial ecosystems were observed during field surveys of the study area.

3.5.4.3 Potential Sources of Ecological Stress

As human populations continue to increase and expand in the Oak Ridge area, available large tracts of contiguous forest are becoming smaller and more fragmented. Forest area is lost to clearing of land for residential development, industry, and agriculture uses, and the remaining forest is further disturbed by associated roads and utility corridors. Fragmentation creates an “edge effect” that alters habitat conditions, such as moisture regime and light penetration, and can result in the introduction and spread of invasive species and predators harmful to forest-dependent species (ORNL, 2019).

Certain nonnative species are considered invasive and pose a significant threat to ecological systems. Executive Order 13112, Invasive Species signed February 3, 1999 (published February 8, 1999, in 64 Federal Register [FR] 6183), directs all Federal agencies to address invasive-species concerns and refrain from actions likely to increase invasive-species problems. This executive order was issued for the following purposes:

- Prevent the introduction of invasive species.
- Provide for their control.
- Minimize the economic, ecological, and human health impacts such species cause.

Nonnative terrestrial animal species observed on the HCS and/or on the ORR include the European starling, Eurasian collared dove, and rock dove. Nonnative aquatic species are discussed in Section 3.5.3 (Aquatic Resources). The ORR has developed integrated pest management programs for invasive insects that pose a threat to forest health, including

southern pine beetle (*Dendroctonus frontalis*), hemlock woolly adelgid (*Adelges tsugae*), and emerald ash borer (*Agrilus planipennis*), and for nonnative invasive plants (ORNL, 2015).

Nonnative, invasive plant species are prevalent on the HCS likely because it was previously disturbed, resulting in the introduction and spread of these species. Common nonnative invasive plant species occurring on the study area include the following:

- Japanese honeysuckle
- Chinese privet
- Multiflora rose
- Autumn olive
- Chinese (sericea) lespedeza
- Japanese stiltgrass

Industrial contamination of the natural environment also can cause stress to ecological systems. The DOE constructed three facilities on the Oak Ridge Reservation in the 1940s: ORNL, Y-12, and K-25 (ETTP). Activities at these facilities have resulted in the release of hazardous substances (e.g., polychlorinated biphenyls and mercury) and radioactive compounds, leading to the contamination of natural resources both at the reservation and in the surrounding environment (Industrial Economics, Inc., 2009).

The effects of climate change may also be a potential source of ecological stress. Projected changes in climate can have adverse consequences for natural landscapes, such as forest ecosystems, including shifts in the distribution of plant and animal species. Ecosystem disturbances associated with extreme weather events may become more common, as might invasive and pest species. Freshwater ecosystems and water quality are likely to be adversely affected by rising stream and lake temperatures that influence suitable habitat for Tennessee's wildlife (Sustainable Tennessee Organization, 2012).

3.5.5 RARE, THREATENED, AND ENDANGERED SPECIES

The Endangered Species Act (ESA) (16 United States Code [USC] §§ 1531-1543) was passed to conserve the ecosystems upon which endangered and threatened species depend, and to conserve and recover those species. An endangered species is defined by the ESA as any species in danger of extinction throughout all or a significant portion of its range. A threatened species is likely to become endangered within the foreseeable future throughout all or a significant part of its range. Critical habitats, essential to the conservation of listed species, also can be designated under the ESA. The ESA establishes programs to conserve and recover endangered and threatened species and makes their conservation a priority for Federal agencies.

Provisions under Section 7 of the ESA, as amended, require that any action likely to adversely affect a species classified as Federally protected be subject to review by the USFWS. Other species may receive additional protection under separate laws. A listing of Federally threatened or endangered species currently classified or proposed for classification that may occur within the site was obtained from the USFWS IPaC website in September 2021 (USFWS, 2021). The

USFWS IPaC identified four endangered species, four threatened species, and one candidate species. According to the IPaC, designated critical habitats do not occur within the HCS.

Under the Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974 (TN Code § 70-8-101-112 [2020]), the State of Tennessee provides protection for species considered threatened, endangered, or deemed in need of management within the State other than those Federally listed under the ESA. The listings are handled by the TDEC; additionally, the Tennessee Natural Heritage Program maintains a database of species that are considered threatened, endangered, special concern, or tracked in Tennessee. A review of the TDEC rare species database in September 2021 resulted in a total of 47 species listed as rare in Tennessee that are known to occur in the areas encompassed by the Bethel-Valley, Tennessee, and/or Elverton, Tennessee, topographic map quadrangles (Table 3.5.5-1) (TDEC, 2021a). No rare, threatened, or endangered species (wildlife or plants) were observed within the HCS as part of the 2021 and 2022 seasonal field surveys.

3.5.5.1 Aquatic Animals

3.5.5.1.1 Fish

No aquatic features are present on the HCS. The only aquatic features in the study area include an ephemeral stream (the lower portion of the channel resembles an intermittent stream) and an intermittent stream, both of which are located within Lot 6b and drain into the EFPC, which is located to the east of the HCS. These streams were evaluated for potential habitat for the listed fish species identified in Table 3.5.5-1, and it was determined that they do not support fish due to lack of permanent flow. These streams are characterized by clay and silt substrates with some rock and gravel, and much of the channel bottoms are full of debris, such as leaves and sticks. Small pools of water were observed during summer and fall 2021 and spring 2022 field surveys, with limited flow likely during or after storm events. No aquatic organisms were observed within the study area streams during the fall 2021 stream delineation survey. These aquatic features within the study area do not provide habitat for the Federally threatened spotfin chub or the State-listed tangerine darter, which require large perennial creeks or medium-sized rivers of moderate gradient (NatureServe, 2022; TDEC, 2021a). Therefore, there is no suitable habitat for these listed fish species on the HCS or within the study area.

The Tennessee dace and flame chub are State-listed fish species in need of management, both with ranks of S3 (vulnerable). Both of these species are found in the Tennessee River watershed. The Tennessee dace is found only in spring-fed, first-order streams and small low-gradient woodland tributaries with gravel, sand, and silt-bottomed pools. The flame chub is found in springs and spring-fed streams with lush aquatic vegetation (NatureServe, 2022; TDEC, 2021a). Since no spring-fed, first-order perennial streams occur within the HCS, these species do not occur on-site. Although habitat for these species may occur in the EFPC in proximity to the site, they were not observed during aquatic surveys conducted in this stream and its tributaries during the summer and fall 2021 and 2022 field surveys.

3.5.5.1.2 Mollusks

According to the summer and fall 2021 and spring 2022 field surveys, suitable habitat is not present within the study area for any of the Federal- and State-listed endangered mussels listed in Table 3.5.5-1. All these mussel species require freshwater perennial riverine systems with flowing water (TDEC, 2021a), which is not present on the HCS or within the study area.

3.5.5.1.3 Snails

The rare (rank S2 — imperiled) spiny riversnail is an aquatic snail that is found in large perennial creeks and rivers with cobble/boulder substrates in the vicinity of riffles (NatureServe, 2022). According to the 2021 and 2022 field surveys, no habitat for the spiny riversnail is present on the HCS or within the study area.

3.5.5.1.4 Crustaceans

The valley flame crayfish is State-listed as endangered and is found in open floodplain areas with high water tables (TDEC, 2021a; NatureServe, 2022). According to the 2021 and 2022 field surveys, no habitat with high water tables is present for the valley flame crayfish on the HCS or within the study area.

3.5.5.1.5 Amphibians

The hellbender is a completely aquatic salamander that is State-listed as endangered and prefers fast-flowing, clear, well-oxygenated streams and rivers with substrate consisting of large flat boulders and logs (NatureServe, 2022). According to the 2021 and 2022 field surveys, no suitable habitat is present for the hellbender because no perennial streams exist on the HCS or within the study area.

3.5.5.2 Terrestrial Animals

3.5.5.2.1 Insects

The monarch butterfly is a Federal candidate species. In general, breeding areas are virtually all patches of milkweed in North America and some other regions. The critical conservation features for North American populations are coastal migratory stopover areas and overwintering habitats, which include high altitude Mexican conifer forests or coastal conifer or eucalyptus groves in California (NatureServe, 2022). A small amount of milkweed plants were observed during 2021 and 2022 field surveys, and the study area contains herbaceous habitats with potential breeding habitat for the monarch butterfly.

3.5.5.2.2 Amphibians

Four-toed salamanders have been observed on the ORR, which is in the vicinity of the HCS. This species occurs in areas of middle and eastern Tennessee in woodland swamps, shallow depressions, and sphagnum moss mats on acidic soils (TDEC, 2021a). However, no swamps or wetlands occur in the study area, and no specimens of the four-toed salamander were observed during 2021 and 2022 field surveys. Therefore, no suitable habitat for the four-toed salamander occurs on the HCS or within the study area.

The rare (rank S3S4 — vulnerable/apparently secure) green salamander inhabits crevices in rock outcrops and cliffs in mature forested landscapes. The green salamander needs moist rock crevices to reproduce and hibernate but is also arboreal, using trees and bark seasonally from May to September (Soto et al., 2021). Rock outcrops and ledges were not observed during the 2021 and 2022 field surveys; therefore, the study area does not provide suitable habitat for the green salamander.

The rare (rank S2 — imperiled) streamside salamander is found in scattered populations in middle Tennessee, particularly in limestone bedrock habitats. This species is most often found in upland forests close to streams (TWRA, 2022). The HCS does not contain streams, and the ephemeral and intermittent streams in Lot 6b in proximity to the HCS do not have suitable habitat for the streamside salamander, as they do not have exposed limestone beds and larger flat rocks required for streamside salamander breeding habitat.

3.5.5.2.3 Reptiles

The northern pinesnake is State-listed as threatened in Tennessee. The northern pinesnake's preferred habitat is characterized by pine or pine-oak dominated woodlands with open understory and well-drained sandy soils for burrowing (TDEC, 2021a). A few small early- to mid-successional loblolly pine-dominated areas occur within the study area; however, these areas do not have open understory with sandy soils, and this species is not expected to occur within the study area.

The eastern slender glass lizard is State-listed as in need of management in Tennessee. It is a secretive species that prefers dry, open grasslands or woodlands, and is typically found in dried grass or burrows (TWRA, 2022). Because the herbaceous and forested habitats on the HCS consist of dense vegetation, habitat for this species is not present on the HCS. In addition, eastern slender glass lizards were not observed during summer and fall 2021 and spring 2022 seasonal field surveys.

3.5.5.2.4 Mammals

3.5.5.2.4.1 Indiana and Northern Long-eared Bats

The Indiana bat, northern long-eared bat, and gray bat are the only Federally listed mammal species within Anderson County identified by the USFWS, and they have been observed at the ORR in the vicinity of the HCS. One Indiana bat was caught in a mist net bordering the Clinch River in June and July 2013 (DOE, 2021). The Indiana bat is found throughout much of the eastern half of the United States and has been listed as a Federally endangered species since March 11, 1967. It is also State-listed in Tennessee as endangered. The 2020 Range-Wide Indiana Bat Summer Survey Guidelines defines suitable habitat for the Indiana bat (USFWS, 2020):

> "Suitable summer habitat for Indiana bats consists of a wide variety of forested/wooded habitats where they roost, forage, and travel and may also include some adjacent and interspersed non-forested habitats such as emergent wetlands and adjacent edges of agricultural fields, old fields and pastures. This includes forests and woodlots containing potential roosts (i.e., live trees and/or snags greater than 5 inches in diameter at breast height that have exfoliating bark, cracks, crevices, and/or hollows."

Other summer habitat may include riparian zones, bottomlands, floodplains, wooded wetlands, and adjacent upland forests (USFWS, 2007a). Individual trees may be considered suitable habitat when they exhibit characteristics of suitable roost trees and are within 1,000 feet of other forested habitat (USFWS, 2020). Tree species that Indiana bats have been known to roost and establish maternity colonies in include hickory (*Carya* spp.), oak (*Quercus* spp.), elm (*Ulmus* spp.), ash (*Fraxinus* spp.), maple (*Acer* spp.), and poplar (*Populus* spp.). Some tree species, primarily hickories and, to a lesser extent, oaks, provide adequate bark characteristics in living trees. Space between exfoliating bark and the trunk of the tree appear to be the primary

characteristic needed for bats to use a particular tree. In winter, Indiana bats hibernate in caves or abandoned mines (USFWS, 2007a).

The northern long-eared bat occurs statewide in Tennessee but is now uncommon in the State after the introduction of the fungus causing the deadly disease known as white-nose syndrome, which has caused dramatic declines in populations of this species. The northern long-eared bat was Federally listed as a threatened species in April 2015 and is also listed as threatened by the State of Tennessee. In summer months, northern long-eared bats roost singly or in colonies within cavities, underneath bark, crevices, or hollows of both live and dead trees that typically have a diameter at breast height greater than or equal to 3 in. (7.6 cm). Northern long-eared bats appear to be opportunistic, selecting trees based on the presence of cavities, crevices, or peeling bark. If suitable roost trees are not available, northern long-eared bats have been known, although rarely, to roost in man-made structures, such as barns, bridges, and sheds (USFWS, 2020). Northern long-eared bats emerge from their roosts at dusk to forage through the understory of forested hillsides and ridges and feed on insects (USFWS, 2015).

Suitable summer habitat for the northern long-eared bat includes a wide variety of forested lands to roost, forage, and travel. These areas include forests containing potential roosts, such as woodlots, fencerows, riparian forests, and other wooded corridors. These wooded areas may be dense or loose aggregates of trees with variable amounts of canopy closure. Individual trees may be considered suitable habitat when they exhibit characteristics of suitable roost trees and are within 1000 ft. (305 m) of other forested habitat. Non-forested foraging habitats may include adjacent emergent wetlands and edges of agricultural fields, old fields, and pastures. Northern long-eared bats typically occupy their summer habitat from mid-May through mid-August (USFWS, 2020). In winter, the northern long-eared bat hibernates underground in caves or other man-made structures, such as mines (USFWS, 2015).

Northern long-eared bats are known to be present on the ORR, in the vicinity of the HCS. Their calls have been identified in various acoustic surveys of the reservation, and in 2013 their presence was confirmed when a number were captured in mist nets (McCracken et al., 2015).

A total of approximately 44.3 ac. (17.9 ha) of forested/wooded areas (deciduous forest, evergreen forest, and mixed forest) were documented within the ecological study area based upon the 2021 and 2022 field surveys (Figure 3.5-1 and Table 3.5.2-1). Within those forested/wooded areas, a total of 14 potentially suitable bat roost trees were identified. However, only 5.0 ac. (2.0 ha) of those forested areas and seven potentially suitable bat roost trees are located on the HCS. The location and a description for each of these potentially suitable bat roost trees are presented on Figure 3.5-1 and in Table 3.5.5-2, respectively. No cave or mine habitats were observed on-site that would serve as suitable hibernacula for bats. Several karst sinkholes were observed just outside the study area; however, none possessed aboveground openings to crevices or caves suitable for hibernating or roosting bats.

The 14 potentially suitable bat roost trees in the study area were identified due to the presence of cavities, hollows, crevices, and exfoliating bark. These trees consisted of six species: four dead southern red oak, two dead and one declining American elm, four dead white ash, one declining black cherry, one dead tulip poplar, and one dead slippery elm. Each of the locations where potentially suitable bat roost trees were identified are also considered suitable foraging habitat due to the presence of relatively open understory or midstory layers that provide accessibility for bats to forage and are in proximity to other open suitable foraging ground and water resources (EFPC).

3.5.5.2.4.2 Gray Bat

The gray bat is listed as Federally endangered by the USFWS. Gray bats roost in caves throughout the year and forage over water, including streams and reservoirs, where they consume night-flying aquatic insects near the water surface. Unlike other bat species, gray bats are restricted year-round to cave and cave-like habitats for both hibernation and roosting. Gray bats have been observed over the Clinch River bordering the ORR in 2003 and over a pond on the reservation in 2004 (DOE, 2021). Three gray bats were mist-netted outside a cave on the ORR in 2006, and several gray bats were caught in mist nets bordering the Clinch River in June and July 2013 (DOE, 2021).

No caves or maternal roost sites were observed within or in proximity to the study area during the 2021 and 2022 field surveys. Because neither hibernacula nor maternal roosting habitat for the gray bat is available in the study area, there is no suitable habitat for gray bats within the study area.

3.5.5.2.4.3 Long-Tailed Shrew

The long-tailed shrew is State-listed as in need of management in Tennessee. This species prefers cool and damp rocky slopes in coniferous and deciduous forests, sometimes areas with moss-covered rocks, in the mountains of eastern Tennessee. Long-tailed shrews spend most of their time in the deep crevices between rocks about 1 ft. (0.3 m) beneath the surface (TWRA, 2022). Because the study area is not located in a mountainous area and rocky, loose talus habitats are not present, the long-tailed shrew is not expected to occur on the HCS.

3.5.5.2.4.4 Southern Bog Lemming

The southern bog lemming is State-listed as in need of management in Tennessee. This species prefers low areas of moist, grassy fields, meadows, or swamps with thick vegetation. It also occurs less frequently in bogs and damp woods. Individuals use runways to make underground tunnels for nesting, feeding, resting, and food storage (TWRA, 2022). No suitable wetland habitat for the southern bog lemming is present on the HCS or within the study area.

3.5.5.2.5 Birds

The Bachman’s sparrow is State-listed as endangered by the State of Tennessee. This species historically inhabited mature pine forest during the summer breeding season in Tennessee near the northern limit of its range. That habitat is now extremely rare in the State, and the Bachman's sparrow is nearly extirpated. This bird requires evergreen habitat with a high volume of grasses and forbs, some scattered trees and shrubs, and an open understory on dry, upland sites. Only occasionally do these conditions exist in clearcuts, abandoned fields, and possibly on newly planted commercial pine plantations. These sites usually remain suitable for only three to five years unless they are regularly thinned and burned to reduce understory vegetation (TWRA, 2022). The pine forest in the study area is early to mid-successional with a dense understory. Although potentially suitable habitat for Bachman’s sparrow may occur on the HCS, this species is not expected to occur on-site because it is nearly extirpated from the State and the pine forest does not have the open understory preferred by this species. In addition, Bachman’s sparrows are not known to occur on the ORR (ORNL, 2019).

Bald eagles are Federally protected under the Bald and Golden Eagle Protection Act, and suitable nesting and foraging habitats may exist along the Clinch River adjacent to the ORR and

TVA reservoir lands within the vicinity of the HCS. The TWRA conducts yearly midwinter bald eagle counts along the Clinch River in accordance with a continuing statewide monitoring program. It is part of a count conducted by the agency to monitor population trends for this species, which is increasing in numbers in eastern Tennessee (ORNL, 2019). The ORR supports one or two nests per year, and these are continually monitored (ORNL, 2019).

Bald eagles generally nest near rivers, large lakes, or streams that support an adequate food supply. They often roost and nest in large, mature, or old-growth trees; snags (dead trees); cliffs; and tall structures, such as power poles and communication towers. In forested areas, bald eagles often select the tallest trees with limbs strong enough to support a nest that can weigh more than 1,000 pounds (USFWS, 2007b). One bald eagle was observed off-site near the Philotechnics Building during the spring 2022 seasonal field survey. However, the study area does not have trees that typically support bald eagle nests or roosting.

The cerulean warbler is State-listed as in need of management in Tennessee. It is a summer resident in Tennessee, arriving in mid-April and departing by the end of August. It prefers large areas of mature forest for nesting and breeds from northernmost Alabama to southern Ontario and west to the Great Plains. Eighty percent of the summer population can be found between the Cumberland Mountains of Tennessee to the mountains of West Virginia. The cerulean warbler breeds in mature deciduous forests with tall trees that have well developed canopies in a variety of forests, including bottomland hardwood forests and steep ridges of upland forests (TWRA, 2022). The study area does not have mature forests that would support cerulean warblers, and no cerulean warblers were observed in the study area during 2021 and 2022 seasonal field surveys.

The Swainson’s warbler is State-listed as in need of management in Tennessee. In western and middle Tennessee, the Swainson's warbler breeds during the summer in wooded swamps with canebrakes or dense vine tangles, specifically the Mississippi River valley and the Hatchie River basin. In the mountains of eastern Tennessee, breeding habitat includes rhododendron thickets along mountain ravines (TWRA, 2022). As the study area is not mountainous, habitat for Swainson’s warbler is not present in the study area, and this species was not observed during 2021 field surveys.

Other migratory bird species of conservation concern with the potential to occur on the HCS are discussed in Section 3.5.2.

3.5.5.3 Plants

Two species of Federally listed plants have the potential to occur at the HCS, and 19 species of plants listed by the TDEC as threatened, endangered, or species in need of management in Tennessee are known to occur within the areas encompassed by the Bethel-Valley, Tennessee, and Elverton, Tennessee, topographic map quadrangles (see Table 3.5.5-3). Preferred habitat for each species and the possibility of suitable habitat within the HCS are addressed in Table 3.5.5-3. Lands associated with the HCS have been disturbed by current and/or previous land use and mowing. According to the summer and fall 2021 and spring 2022 field surveys, neither the HCS nor the study area contain intact, high-quality native plant communities. Based on a review of habitat requirements for each of the species listed in Table 3.5.5-3, potentially suitable habitat is not present within the HCS for Federal- or State-listed species. No rare, threatened, or endangered plants were observed on-site as part of the 2021 and 2022 seasonal field surveys. However, a small population of American ginseng was observed along a floodplain terrace of the EFPC, east of the HCS.

The fen orchid and white fringeless orchid are known to occur along partially shaded seeps of the Ridge and Valley ecoregion, and this habitat occurs at the headwater seep of the intermittent stream that runs under the North Boundary Greenway Trail in the eastern third of the study area, which is in Lot 6b in proximity to the HCS. However, this groundwater-fed seep and stream headwater complex was thoroughly searched during the summer and fall 2021 field surveys, and neither species was observed. Because the forested canopy of the seep is so closed, sufficient light may not reach the herb layer to sustain populations of fen orchid or white fringeless orchid.

Tall larkspur was not observed during field surveys but has the potential to occur in Lot 6b of the study area. Because the HCS is currently maintained by mowing during the growing season, tall larkspur is not able to establish or persist on the HCS. Forested margins on the HCS are too overgrown to support populations of tall larkspur. The mesic forested slopes and forested seep found in the study area, in proximity to the HCS, contain potentially suitable habitat for Schreber's aster; however, no individuals were discovered during 2021 and 2022 field surveys.

Table 3.5.2-1
Land Cover within HCS and Vicinity

Land Cover Class	HCS Study Area		
	HCS (ac.) [(a)]	Lot 6b (ac.) [(a)]	5-Mi. (8-km) Vicinity (ac.) [(b)]
Barren Land			67
Deciduous Forest		7.3	30,836
Developed, High Intensity			917
Developed, Low Intensity		1.1	3,179
Developed, Medium Intensity			1,767
Developed, Open Space			3,872
Emergent Herbaceous Wetlands			40
Evergreen Forest	0.2	15.4	1,380
Hay/Pasture			7,361
Herbaceous	105.2	0.5	464
Mixed Forest	4.8	16.6	5,035
Open Water			1,015
Shrub/Scrub			640
Woody Wetlands			1,615
Total	**110.2**	**40.9**	**58,188**

a) Reference: NLCD data (Dewitz and U.S. Geological Survey, 2021) modified based on site observations.
b) Reference: NLCD data (Dewitz and U.S. Geological Survey, 2021).

Table 3.5.2-2
(Sheet 1 of 7)
Vascular Plant Species Observed on the HCS Study Area, 2021-2022

Scientific Name	Common Name	Tree Layer[(a)]	Shrub Layer[(a)]	Herbaceous Layer[(a)]	Woody Vine[(a)]
Acer negundo	Box elder maple	U	U		
Acer rubrum	Red maple	C	C	C	
Acer saccharum	Sugar maple	U	R		
Actaea pachypoda	White baneberry			U	
Aesculus flava	Yellow buckeye		U		
Agrimonia parviflora	Swamp agrimony			O	
Agrimonia pubescens	Downy agrimony			U	
Allium canadense	Wild garlic			O	
Amelanchier sp.	Serviceberry			U	
Ampelopsis cordata	Heartleaf peppervine				U
Amphicarpae bracteata	Hog peanut			O	
Andropogon gerardii	Big bluestem			U	
Andropogon virginicus	Broomsedge bluestem			C	
Anthoxanthum odoratum	Sweet vernal grass			R	
Aralia spinosa	Devil's walking stick		U		
Arisaema triphyllum	Jack in the pulpit			U	
Arundinaria gigantea	Giant cane			U	
Asclepias sp.	Milkweed			U	
Asplenium platyneuron	Ebony spleenwort			O	
Berberis thunbergii	Japanese barberry		R		
Bignonia capreolata	Crossvine			U	U
Botrypus virginianum	Rattlesnake fern			U	
Brachyelytrum erectum	Bearded shorthusk			U	
Bromus hordeaceous	Soft brome			A	
Bromus sterilis	Barren brome			U	
Buxus sp.	Boxwood		R		
Cardamine concatenata	Cutleaf toothwort			U	
Carduus nutans	Musk thistle			U	
Carex amphibola	Creek sedge			U	
Carex cherokeensis	Cherokee sedge			R	
Carex retroflexa	Reflexed sedge			O	
Carpinus caroliniana	Flowering musclewood		O		
Carya cordiformis	Bitternut hickory			O	
Carya glabra	Pignut	U		U	
Carya tomentosa	Mockernut			U	

Table 3.5.2-2
(Sheet 2 of 7)
Vascular Plant Species Observed on the HCS Study Area, 2021-2022

Scientific Name	Common Name	Tree Layer[(a)]	Shrub Layer[(a)]	Herbaceous Layer[(a)]	Woody Vine[(a)]
Celtis laevigata	Sugarberry	U			
Celtis occidentalis	Hackberry	U			
Centrosema virginianum	Butterfly pea			U	
Cerastium glomeratum	Clammy chickweed			O	
Cercis canadensis	Eastern redbud		O		
Chaerophyllum tainturieri	Hairyfruit chervil			U	
Chimaphila maculata	Spotted wintergreen			O	
Cinna arundinacea	Wood reed grass			O	
Cirsium altissimum	Tall thistle			U	
Cirsium discolor	Field thistle			O	
Cocculus carolinus	Carolina snailseed			R	R
Coleataenia anceps	Beaked panicgrass			O	
Collinsonia canadensis	Richweed			U	
Convolvulus arvensis	Field bindweed			R	
Coreopsis auriculata	Lobed tickseed			R	
Cornus florida	Flowering dogwood		O	O	
Corylus americana	American hazelnut		U		
Crataegus intricata	Entangled hawthorne			R	
Crepis pulchra	Smallflower hawksbeard			U	
Cryptotaenia canadensis	Canadian hornwort			R	
Cynoglossum virginianum	Wild comfrey			U	
Dactylis glomerata	Orchard grass			U	
Danthonia spicata	Poverty oatgrass			O	
Desmodium paniculatum	Panicled ticktrefoil			O	
Dichanthelium boscii	Panic grass			O	
Dichanthelium clandestinum	Deertongue grass			U	
Dichanthelium laxiflorum	Openflower witchgrass			U	
Diphasiastrum digitatum	Ground pine			O	
Dodecatheon meadia	Eastern shooting star			U	
Elaeagnus umbellata	Autumn olive		O	O	
Eleusine indica	Goosegrass			O	
Elymus hystrix	Bottlebrush rye			R	
Epifagus virginiana	Beechdrops			U	
Eragrostis curvula	Weeping lovegrass			O	
Erigeron annuus	Annual fleabane			U	
Erigeron philadelphicus	Philadelphia fleabane			O	

Table 3.5.2-2
(Sheet 3 of 7)
Vascular Plant Species Observed on the HCS Study Area, 2021-2022

Scientific Name	Common Name	Tree Layer[(a)]	Shrub Layer[(a)]	Herbaceous Layer[(a)]	Woody Vine[(a)]
Erigeron strigosus	Daisy fleabane			O	
Euonymus alatus	Burning bush		U		
Euonymus americanus	Strawberry bush			O	
Eupatorium rotundifolium	Roundleaf thoroughwort			U	
Fagus grandifolia	American beech	O	O	O	
Festuca subverticillata	Nodding fescue			O	
Fragaria virginiana	Virginia strawberry			C	
Frangula caroliniana	Carolina buckthorn		O		
Fraxinus americana	White ash		U	C	
Galium aparine	Sticky willy			U	
Galium pedemontanum	Foothill bedstraw			O	
Galium triflorum	Fragrant bedstraw			R	
Geum canadense	White avens			O	
Gleditsia triacanthos	Honey locust	U			
Gonolobus suberosus	Anglepod			U	
Goodyera pubescens	Downy rattlesnake plantain			R	
Hedera helix	English ivy			R	
Helianthus microcephalus	Small woodland sunflower			U	
Heuchera americana	Alumroot			R	
Hexastylis arifolia	Little brown jug			U	
Houstonia caerula	Quaker ladies			R	
Ilex opaca	American holly		U		
Juglans nigra	Black walnut	O			
Juniperus virginiana	Eastern red cedar	U	O		
Kummeriowia stipulacea	Korean lespedeza			O	
Lamium purpureum	Purple deadnettle			U	
Leersia virginica	Whitegrass			O	
Lepidium campestre	Field pepperweed			R	
Lespedeza cuneata	Chinese lespedeza		O	O	
Leucanthemum vulgare	Oxeye daisy			U	
Ligustrum obtusifolium	Border privet		U		
Ligustrum sinense	Chinese privet		O	O	
Ligustrum vulgare	European privet		R		
Lindera benzoin	Spicebush			U	

Table 3.5.2-2
(Sheet 4 of 7)
Vascular Plant Species Observed on the HCS Study Area, 2021-2022

Scientific Name	Common Name	Tree Layer[(a)]	Shrub Layer[(a)]	Herbaceous Layer[(a)]	Woody Vine[(a)]
Liquidambar styraciflua	American sweetgum	C	O	O	
Liriodendron tulipifera	Tulip tree	C			
Lithospermum canescens	Hoary puccoon			U	
Lobelia inflata	Indian tobacco			R	
Lobelia siphilitica	Great blue lobelia			U	
Lolium perenne	Perennial ryegrass			C	
Lonicera japonica	Japanese honeysuckle			C	C
Lonicera maacki	Amur honeysuckle		O		
Lotus corniculatus	Birdsfoot trefoil			U	
Luzula multiflora	Common woodrush			R	
Lyonia ligustrina	Maleberry		R		
Magnolia tripetala	Umbrella magnolia		R		
Mahonia bealei	Leatherleaf mahonia			R	
Maianthemum racemosum	False Solomon's seal			R	
Medicago lupulina	Black medic			O	
Melica mutica	Twoflower melicgrass			R	
Menispermum canadense	Canadian moonseed			R	
Microstegium vimineum	Japanese stiltgrass			O	
Monarda fistulosa	Wild bergamot			U	
Morus rubra	Red mulberry	R	U		
Myosotis macrosperma	Largeseed forgetmenot			O	
Nyssa sylvatica	Black tupelo		R		
Onoclea sensibilis	Sensitive fern			R	
Ophioglossum vulgatum	Southern adder's tongue			U	
Ostrya virginiana	Virginia hop hornbeam		U		
Oxalis dilleniid	Southern woodsorrel			O	
Oxalis violaceae	Violet woodsorrel			O	
Oxydendrum arboreum	Sourwood	U	O	U	
Packera anonyma	Appalachian ragwort			O	
Parthenocisus quinquefolius	Virginia creeper			C	C
Paspalum dilatatum	Dallisgrass			U	

Table 3.5.2-2
(Sheet 5 of 7)
Vascular Plant Species Observed on the HCS Study Area, 2021-2022

Scientific Name	Common Name	Tree Layer[(a)]	Shrub Layer[(a)]	Herbaceous Layer[(a)]	Woody Vine[(a)]
Passiflora incarnata	Passionflower			U	
Penstemon pallidus	Pale beardtongue			R	
Persicaria virginiana	Jumpseed			U	
Pinus echinata	Shortleaf pine	R			
Phlox amoena	Hairy phlox			R	
Phlox divaricatae	Wild blue phlox			U	
Pinus strobus	Eastern white pine	U			
Pinus taeda	Loblolly	C			
Pinus virginiana	Virginia pine	O			
Plantago rugelli	Rugel's plantain			O	
Platanus occidentalis	American sycamore	U			
Pleopeltis polypodiales	Resurrection fern			R	
Poa alsodes	Grove bluegrass			R	
Poa annua	Annual bluegrass			U	
Poa autumnalis	Autumn bluegrass			O	
Poa pratensis	Kentucky bluegrass			C	
Podophyllum peltatum	Mayapple			U	
Polemonium reptans	Jacob's ladder			O	
Polygonatum biflorum	Smooth Solomon's seal			U	
Polystichum acrostichoides	Christmas fern			C	
Populus deltoides	Eastern cottonwood	R			
Potentilla simplex	Common cinquefoil			O	
Prunus americana	American plum		U		
Prunus angustifolia	Chickasaw plum		R		
Prunus serotina	Black cherry	O	U	O	
Pyrus calleryana	Bradford pear		O	R	
Quercus alba	White oak	O	U		
Quercus falcata	Southern red oak	C		O	
Quercus muehlenbergii	Chinquapin	U	O		
Quercus rubra	Northern red oak	O			
Quercus shumardii	Shumard oak	R			
Quercus stellata	Post oak	U	U		
Ranunculus abortivus	Kidneyleaf buttercup			R	
Ranunculus hispidus	Hispid buttercup			U	
Ranunculus recurvatus	Hooked buttercup			U	
Ranunculus sardous	Hairy buttercup			U	

Table 3.5.2-2
(Sheet 6 of 7)
Vascular Plant Species Observed on the HCS Study Area, 2021-2022

Scientific Name	Common Name	Tree Layer[a]	Shrub Layer[a]	Herbaceous Layer[a]	Woody Vine[a]
Rhus copallinum	Winged sumac		O		
Rosa multiflora	Multiflora rose		O		
Rubus allegheniensis	Allegheny blackberry		C		
Rubus argutus	Sawtooth blackberry		C		
Rubus flagellaris	Northern dewberry			U	
Rubus occidentalis	Black raspberry			U	
Rudbeckia hirta	Blackeyed Susan			R	
Rudbeckia triloba	Brown eyed Susan			U	
Sabatia angularis	Rosepink			O	
Salix humilis	Prairie willow		U		
Salix nigra	Black willow		U		
Salvia lyrata	Lyreleaf sage			O	
Sanguinaria canadensis	Bloodroot			U	
Sassafras albidum	Sassafras	O			
Sceptridium dissectum	Cutleaf grapefern			R	
Schedonorus arundinaceus	Tall fescue			C	
Securigera varia	Crown vetch			U	
Sherardia arvensis	Blue fieldmadder			O	
Silphium astericus	Rosinweed			O	
Sisyrynchium albidum	Common blue eyed grass			O	
Smilax glauca	Catbriar			U	
Smilax hispida	Bristly greenbriar				U
Smilax rotundifolia	Roundleaf greenbrier				O
Solidago altissima	Tall goldenrod			C	
Solidago caesia	Wreath goldenrod			U	
Solidago nemoralis	Gray goldenrod			O	
Solidago speciosa	Showy goldenrod			U	
Sonchus sp.	Sow thistle			U	
Spiranthes vernalis	Spring ladies' tresses			R	
Sporobolus vaginiflorus	Sheathed dropseed			U	
Stellaria media	Common chickweed			O	
Symphyotrichum dumosum	Bushy aster			O	
Symphyotrichum lanceolatum	White panicled aster			U	
Symphyotrichum pilosum	Frost aster			O	
Taraxacum officinale	Common dandelion			O	
Thalictrum revolutum	Waxy meadowrue			U	
Thalictrum thalictroides	Rue anemone			U	

Table 3.5.2-2
(Sheet 7 of 7)
Vascular Plant Species Observed on the HCS Study Area, 2021-2022

Scientific Name	Common Name	Tree Layer[a]	Shrub Layer[a]	Herbaceous Layer[a]	Woody Vine[a]
Thelypteris noveboracensis	New York fern			U	
Tipularia discolor	Cranefly orchid			O	
Toxicodendron radicans	Poison ivy			C	C
Tridens flavus	Purpletop tridens			O	
Trifolium campestre	Hop trefoil			O	
Trifolium pratense	Red clover			O	
Trifolium repens	White clover			O	
Trillium luteum	Yellow wakerobin			O	
Ulmus alata	Winged elm		U	U	
Ulmus americana	American elm		U		
Ulmus rubra	Slippery elm	R			
Uvularia perfoliata	Perfoliate bellwort			O	
Vaccinium arboreum	Farkleberry	R	R		
Vaccinium pallidum	Lowbush blueberry		U	U	
Valerianella radiata	Beaked cornsalad			O	
Verbesina alternifolia	Wingstem			O	
Verbesina occidentalis	Yellow crownbeard			C	
Vernonia gigantea	Tall ironweed			O	
Veronica serpyllifolia	Thymeleaved speedwell			O	
Viburnum acerifolium	Mapleleaf viburnum		R		
Viburnum dentatum	Arrowwood viburnum			R	
Viburnum rufidulum	Rusty blackhaw		U		
Vicia sativa	Common vetch			O	
Vinca minor	Periwinkle			O	
Viola sororia	Common blue violet			O	
Vitis rotundifolia	Muscadine			C	C
Youngia japonica	Oriental false hawksbeard			U	

a) Relative on-site abundance categories: A = Abundant; C = Common; O = Occasional; U = Uncommon; R = Rare.

Table 3.5.2-3
Mammal Species Observed or Potentially Occurring on or in Proximity to the HCS

Scientific Name	Common Name
Blarina brevicauda	Northern short-tailed shrew
Canis latrans[b, c]	Coyote
Castor canadensis[c]	Beaver
Cryptotis parva	Least shrew
Didelphis virginiana[a, c]	Virginia opossum
Eptesicus fuscus	Big brown bat
Glaucomys volans	Southern flying squirrel
Lasionycteris noctivagans	Silver-haired bat
Lasiurus borealis	Eastern red bat
Lynx rufus[b]	Bobcat
Marmota monax	Groundhog
Mephitis mephitis	Striped skunk
Microtus pennsylvanicus	Meadow vole
Mus musculus	House mouse
Myotis grisescens	Gray bat
Myotis lucifugus	Little brown bat
Myotis septentrionalis	Northern long-eared bat
Myotis sodalis	Indiana bat
Nycticeius humeralis	Evening bat
Odocoileus virginianus[a, b, c]	White-tailed deer
Ondatra zibethicus	Muskrat
Peromyscus leucopus	White-footed mouse
Peromyscus maniculatus	Deer mouse
Pitymys pinetorum	Woodland vole
Procyon lotor[a, b, c]	Raccoon
Rattus norvegicus	Norway rat
Scalopus aquaticus[c]	Eastern mole
Sciurus carolinensis[a, b, c]	Gray squirrel
Sorex longirostris	Southeastern shrew
Sorex cinereus	Masked shrew
Sylvilagus floridanus[a, c]	Eastern cottontail
Tamias striatus	Eastern chipmunk
Urocyon cinereoargenteus	Gray fox
Vulpes vulpes	Red fox

a) Directly or indirectly observed on-site during summer 2021 field survey.
b) Directly or indirectly observed on-site during fall 2021 field survey.
c) Directly or indirectly observed on-site during spring 2022 field survey.
References: ORNL, 2019

Table 3.5.2-4
Herpetofauna Observed or Potentially Occurring on or in Proximity to the HCS

Scientific Name	Common Name
Acris crepitans	Northern cricket frog
Bufo americanus	Eastern American toad
Carphophis amoenus	Eastern worm snake
Cemophora coccinea	Northern scarletsnake
Chelydra serpentina	Snapping turtle
Chrysemys picta	Painted turtle
Coluber constrictor[(a)]	Black racer
Desmognathus fuscus	Northern dusky salamander
Diadophis punctatus edwardsii	Northern ring-necked snake
Gastrophryne carolinensis	Eastern narrow-mouthed toad
Heterodon platirhinos	Eastern hog-nosed snake
Hyla versicolor	Gray treefrog
Lampropeltis getula nigra	Black kingsnake
Lithobates catesbeianus	American bullfrog
Lithobates palustris	Pickerel frog
Lithobates sphenocephalus[(a)]	Southern leopard frog
Nerodia sipedon	Northern water snake
Notophthalmus viridescens	Red-spotted newt
Opheodrys aestivus	Rough greensnake
Pantherophis guttatus	Corn snake
Pantherophis spiloides[(a)]	Gray ratsnake
Plestiodon fasciatus[(a)]	Common five-lined skink
Pseudacris crucifer crucifer[(a)]	Northern spring peeper
Rana clamitans melanota	Northern green frog
Rana sphenocephala	Southern leopard frog
Sceloporus undulatus hyacinthinus	Northern fence lizard
Storeria dekayi	DeKay's brownsnake
Terrapene carolina carolina[(a)]	Eastern box turtle
Thamnophis sirtalis	Eastern garter snake
Virginia valeriae	Eastern smooth earthsnake

a) Observed on-site during 2021 and 2022 seasonal field surveys.
References: ORNL, 2019

Table 3.5.2-5
(Sheet 1 of 8)
Avifaunal Species Observed or Potentially Occurring on or in Proximity to the HCS

Scientific Name	Common Name	Summer Survey Abundance[a]	Fall Survey Abundance[b]	Spring Survey Abundance[c]	Study Area General Reconnaissance			Off-site General Reconnaissance		
					Summer	Fall	Spring	Summer	Fall	Spring
Accipiter cooperii[d,e]	Cooper's hawk		U			X				
Accipiter striatus[e]	Sharp-shinned hawk									
Agelaius phoeniceus[d]	Red-winged blackbird			U						X
Aix sponsa[d]	Wood duck								X	
Anas platyrhynchos[d]	Mallard								X	
Antrostomus carolinensis[d]	Chuck-will's-widow									
Antrostomus vociferus[d]	Eastern whip-poor-will									
Archilochus colubris[d]	Ruby-throated hummingbird									
Ardea herodias[d]	Great blue heron									X
Baeolophus bicolor[d]	Tufted titmouse	C	O	C	X			X		X
Bombycilla cedrorum[d]	Cedar waxwing	O	R							
Branta canadensis[d]	Canada goose							X		
Buteo jamaicensis[d,e]	Red-tailed hawk	R		R						X
Buteo lineatus[d,e]	Red-shouldered hawk									
Buteo platypterus	Broad-winged hawk									
Butorides virescens[d]	Green heron									
Cardellina canadensis[d]	Canada warbler									
Cardellina pusilla[d]	Wilson's warbler									
Cardinalis cardinalis[d]	Northern cardinal		C	A				X	X	X

Table 3.5.2-5
(Sheet 2 of 8)
Avifaunal Species Observed or Potentially Occurring on or in Proximity to the HCS

Scientific Name	Common Name	Summer Survey Abundance[a]	Fall Survey Abundance[b]	Spring Survey Abundance[c]	Study Area General Reconnaissance			Off-site General Reconnaissance		
					Summer	Fall	Spring	Summer	Fall	Spring
Cathartes aura[d]	Turkey vulture	O								
Catharus fuscescens[d]	Veery									
Catharus guttatus[d,e]	Hermit thrush									X
Certhia americana[e]	Brown creeper									
Chaetura pelagica[d]	Chimney swift			U						
Charadrius vociferus[d]	Killdeer			U						
Chordeiles minor[d]	Common nighthawk									
Circus hudsonius[e]	Northern harrier									
Coccyzus americanus[d]	Yellow-billed cuckoo									
Colaptes auratus[d,e]	Northern flicker	R	O							X
Colinus virginianus	Northern bobwhite									X
Columba livia[d]	Rock dove									
Contopus virens[d]	Eastern wood-pewee							X		
Coragyps atratus[d,e]	Black vulture		U							
Corvus brachyrhynchos[d,e]	American crow	A	O	U	X	X	X	X		X
Cyanocitta cristata[d]	Blue jay	A	A	U	X	X		X		X
Dendroica caerulescens	Black-throated blue warbler									
Dendroica castanea	Bay-breasted warbler									
Dendroica pensylvanica	Chestnut-sided warbler									

Table 3.5.2-5
(Sheet 3 of 8)
Avifaunal Species Observed or Potentially Occurring on or in Proximity to the HCS

Scientific Name	Common Name	Summer Survey Abundance[a]	Fall Survey Abundance[b]	Spring Survey Abundance[c]	Study Area General Reconnaissance			Off-site General Reconnaissance		
					Summer	Fall	Spring	Summer	Fall	Spring
Dendroica virens[d]	Black-throated green warbler									
Dendroica striata[d]	Blackpoll warbler									
Dryobates pubescens[e]	Downy woodpecker	C	O		X			X		X
Dryocopus pileatus[d,e]	Pileated woodpecker		O	R	X	X				X
Dumetella carolinensis[d]	Gray catbird	U	R					X		X
Empidonax virescens[d]	Acadian flycatcher									
Falco sparverius	American kestrel									
Fulica americana	American coot								X	
Geothlypis formosa[d]	Kentucky warbler			R						X
Geothlypis trichas[d]	Common yellowthroat	O		C				X		X
Haemorhous mexicanus[d]	House finch									
Haemorhous purpureus[d,e]	Purple finch									
Haliaeetus leucocephalus	Bald eagle									X
Helmitheros vermivorus[d]	Worm-eating warbler									
Hirundo rustica[d]	Barn swallow			O						

Table 3.5.2-5
(Sheet 4 of 8)
Avifaunal Species Observed or Potentially Occurring on or in Proximity to the HCS

Scientific Name	Common Name	Summer Survey Abundance[a]	Fall Survey Abundance[b]	Spring Survey Abundance[c]	Study Area General Reconnaissance			Off-site General Reconnaissance		
					Summer	Fall	Spring	Summer	Fall	Spring
Hylocichla mustelina[d]	Wood thrush									X
Icteria virens[d]	Yellow-breasted chat	U		A						X
Icterus galbula	Baltimore oriole									
Icterus spurius[d]	Orchard oriole			R						
Junco hyemalis[e]	Dark-eyed junco									
Leiothlypis peregrina[d]	Tennessee warbler			R						
Leuconotopicus villosus[d]	Hairy woodpecker	R								
Limnothlypis swainsonii[d]	Swainson's thrush									
Megaceryle alcyon	Belted kingfisher									
Melanerpes carolinus[d]	Red-bellied woodpecker		U	O				X		X
Melanerpes erythrocephalus[d]	Red-headed woodpecker									
Meleagris gallopavo[e]	Wild turkey				X			X		X
Melospiza melodia[d]	Song sparrow	O								X
Mimus polyglottos[d]	Northern mockingbird	O	R	O		X	X	X		X
Mniotilta varia[d]	Black-and-white warbler									
Molothrus ater[d]	Brown-headed cowbird		U	O						X
Myiarchus crinitus[d]	Great-crested flycatcher									

Table 3.5.2-5
(Sheet 5 of 8)
Avifaunal Species Observed or Potentially Occurring on or in Proximity to the HCS

Scientific Name	Common Name	Summer Survey Abundance[a]	Fall Survey Abundance[b]	Spring Survey Abundance[c]	Study Area General Reconnaissance			Off-site General Reconnaissance		
					Summer	Fall	Spring	Summer	Fall	Spring
Parkesia motacilla[d]	Louisiana waterthrush							X		
Parkesia noveboracensis[d]	Northern waterthrush									
Passer domesticus	House sparrow									
Passerella iliaca[e]	Fox sparrow		R							
Passerina caerulea[d]	Blue grosbeak			R						
Passerina cyanea	Indigo bunting			O						X
Petrochelidon pyrrhonota[d]	Cliff swallow	O		O						
Pheucticus ludovicianus[d]	Rose-breasted grosbeak									
Picoides vollosus	Hairy woodpecker									
Pipilo erythrophthalmus[d]	Eastern towhee		U	O				X		X
Piranga olivacea[d]	Scarlet tanager			R						X
Piranga rubra[d]	Summer tanager	U		R						
Poecile carolinensis[d,e]	Carolina chickadee	O	C	O		X		X		X
Polioptila caerulea[d]	Blue-gray gnatcatcher			O				X		X
Progne subis[d]	Purple martin			U						
Quiscalus quiscula[d]	Common grackle		R							
Regulus calendula[d,e]	Ruby-crowned kinglet									

Table 3.5.2-5
(Sheet 6 of 8)
Avifaunal Species Observed or Potentially Occurring on or in Proximity to the HCS

Scientific Name	Common Name	Summer Survey Abundance[a]	Fall Survey Abundance[b]	Spring Survey Abundance[c]	Study Area General Reconnaissance			Off-site General Reconnaissance		
					Summer	Fall	Spring	Summer	Fall	Spring
Regulus satrapa[d,e]	Golden-crowned kinglet		U							
Sayornis phoebe[d]	Eastern phoebe	R	C	O						X
Scolopax minor[d]	American woodcock							X		
Seiurus aurocapillus	Ovenbird			O			X			
Setophaga americana[d]	Northern parula			U			X	X		X
Setophaga citrina[d]	Hooded warbler									X
Setophaga coronata[d,e]	Yellow-rumped warbler			U						X
Setophaga discolor[d]	Prairie warbler			O						X
Setophaga dominica[d]	Yellow-throated warbler			R						X
Setophaga magnolia	Magnolia warbler									
Setophaga palmarum[d]	Palm warbler			U						
Setophaga petechia[d]	Yellow warbler							X		
Setophaga pinus[d]	Pine warbler			R						X
Setophaga ruticilla	American redstart							X		
Setophaga tigrina[d]	Cape may warbler									
Sialia sialis[d]	Eastern bluebird	O	O	U	X	X		X		X
Sitta carolinensis[d,e]	White-breasted nuthatch	O	R	R	X			X		X
Sitta pusilla[d]	Brown-headed nuthatch									

Table 3.5.2-5
(Sheet 7 of 8)
Avifaunal Species Observed or Potentially Occurring on or in Proximity to the HCS

Scientific Name	Common Name	Summer Survey Abundance[a]	Fall Survey Abundance[b]	Spring Survey Abundance[c]	Study Area General Reconnaissance			Off-site General Reconnaissance		
					Summer	Fall	Spring	Summer	Fall	Spring
Sphyrapicus varius[d,e]	Yellow-bellied sapsucker									
Spinus pinus[e]	Pine siskin									
Spinus tristis[d]	American goldfinch	O	C	U	X	X		X		X
Spizella passerina[d]	Chipping sparrow	R		O						
Spizella pusilla[d]	Field sparrow	R		A						X
Streptopelia decaocto	Eurasian collared dove			R						
Strix varia[d]	Barred owl							X		
Sturnella magna[d]	Eastern meadowlark			U						
Sturnus vulgaris	European starling		O	O						
Stelgidopteryx serripennis[d]	Northern rough-winged swallow									
Tachycineta bicolor[d]	Tree swallow	O								
Thryothorus ludovicianus	Carolina wren	C	C	O	X		X	X	X	X
Toxostoma rufum[d]	Brown thrasher	U	R	U	X	X				X
Troglodytes aedon[d]	House wren									
Troglodytes hiemalis[d,e]	Winter wren									
Turdus migratorius[d]	American robin		O	U		X	X	X		X
Tyrannus tyrannus[d]	Eastern kingbird			R						
Vermivora cyanoptera[d]	Blue-winged warbler									

Table 3.5.2-5
(Sheet 8 of 8)
Avifaunal Species Observed or Potentially Occurring on or in Proximity to the HCS

Scientific Name	Common Name	Summer Survey Abundance[a]	Fall Survey Abundance[b]	Spring Survey Abundance[c]	Study Area General Reconnaissance			Off-site General Reconnaissance		
					Summer	Fall	Spring	Summer	Fall	Spring
Vireo flavifrons[d]	Yellow-throated vireo							X		X
Vireo gilvus[d]	Warbling vireo									
Vireo griseus	White-eyed vireo	C		O				X		X
Vireo olivaceus[d]	Red-eyed vireo			O			X	X		X
Vireo solitarius[d]	Blue-headed vireo									
Zenaida macroura[d]	Mourning dove	C		O	X	X		X		X
Zonotrichia albicollis[d]	White-throated sparrow	U	O	U						X
Zonotrichia leucophrys	White-crowned sparrow									

Relative study area abundance categories: A=abundant; C=common; O=occasional; U=uncommon; R=rare.
X = observed during other 2021-2022 ecology field surveys.

a) Species identified along the bird transect route at designated stopping points during Summer 2021 field survey.
b) Species identified along the bird transect route at designated stopping points during Fall 2021 field survey.
c) Species identified along the bird transect route at designated stopping points during Spring 2022 field survey.
d) eBird spring (March-June) bird observation in proximity to HCS.
e) eBird winter (December-February) bird observation in proximity to HCS.

Reference: ORNL, 2019; eBird, 2022

Table 3.5.3-1
Fish and Crustacean Species from 2021-2022 Aquatic Surveys of Streams in Proximity to the Horizon Center Site

		Summer 2021		Fall 2021		Spring 2022	
Scientific Name	**Common Name**	**Count**	**Percent Total**	**Count**	**Percent Total**	**Count**	**Percent Total**
Fish							
Campostoma anomalum	Central stoneroller	18	16.2	1	0.6	1	0.5
Cottus carolinae	Banded sculpin	2	1.8	14	8.0	16	8.8
Etheostoma rufilineatum	Redline darter	-	-	-	-	1	0.5
Etheostoma simoterum	Tennessee snubnose darter	-	-	6	3.4	9	4.9
Gambusia affinis	Western mosquitofish	-	-	22	12.6	-	-
Hybopsis amblops	Bigeye chub	1	0.9	-	-	4	2.2
Hypentelium nigricans	Northern hogsucker	2	1.8	2	1.1	-	-
Labidesthes sicculus	Brook silverside	1	0.9	10	5.7	-	-
Lepomis macrochirus	Bluegill	1	0.9	-	-	-	-
Luxilus chrysocephalus	Striped shiner	31	27.9	35	20.0	100	54.9
Lythrurus ardens	Rosefin shiner	-	-	-	-	1	0.5
Notropis atherinoides	Emerald shiner	49	44.1	46	26.3	35	19.2
Percina caproides	Logperch darter	-	-	1	0.6	3	1.6
Pimephales notatus	Bluntnose minnow	1	0.9	1	0.6	-	-
Rhinichthys atratulus	Blacknose dace	-	-	37	21.1	10	5.5
Semotilus atromaculatus	Creek chub	5	4.5	-	-	2	1.1
Total		**111**	**100**	**175**	**100.0**	**182**	**100**
Crustaceans							
Orconectes spp.	Crayfish	3	100	3	100	9	100
Total		**3**	**100**	**3**	**100**	**9**	**100**

Table 3.5.3-2
(Sheet 1 of 2)
Fish Species Present in East Fork Poplar Creek, March–May 1997

Scientific Name	Common Name
Catostomidae	
Catostomus commersonii	White sucker
Hypentelium nigricans	Northern hogsucker
Minytrema melanops	Spotted sucker
Moxostoma duquesnei	Black redhorse
Moxostoma erythrurum	Golden redhorse
Centrarchidae	
Ambloplites rupestris	Rock bass
Lepomis auritus	Redbreast sunfish
Lepomis cyanellus	Green sunfish
Lepomis gulosus	Warmouth
Lepomis macrochirus	Bluegill
Lepomis sp.	Hybrid sunfish
Micropterus punctulatus	Spotted bass
Micropterus salmoides	Largemouth bass
Clupidae	
Dorosoma cepedianum	Gizzard shad
Cyprinidae	
Campostoma anomalum	Central stoneroller
C. anomalum x. L. chrysocephalus	Central stoneroller x. striped shiner hybrid
Cyprinella spiloptera	Spotfin shiner
Luxilus chrysocephalus	Striped shiner
Lythrurus ardens	Rosefin shiner
Notropis amblops	Bigeye chub
Pimephales notatus	Bluntnose minnow
Rhinichthys atratulus	Blacknose dace
Semotilus atromaculatus	Creek chub
Ictaluridae	
Ameiurus natalis	Yellow bullhead
Poecilidae	
Gambusia affinis	Western mosquitofish
Cottidae	
Cottus carolinae	Banded sculpin
Percidae	
Etheostoma blennioides	Greenside darter
Etheostoma jessiae	Blueside darter
Etheostoma kennicotti	Stripetail darter

Table 3.5.3-2
(Sheet 2 of 2)
Fish Species Present in East Fork Poplar Creek, March–May 1997

Scientific Name	Common Name
Etheostoma rufilineatum	Redline darter
Etheostoma simoterum	Snubnose darter
Percina caprodes	Logperch
Sciaenidae	
Aplodinotus grunniens	Freshwater drum

Reference: ORNL, 1997

Table 3.5.5-1
(Sheet 1 of 3)
Protected Species Potentially Occurring within or in Proximity to the HCS

Common Name	Scientific Name	Status		Suitable Habitat[d] Present within HCS
		Federal[a]	State[b] (Rank[c])	
Fish				
Flame chub*	*Hemitremia flammea*	--	D (S3)	N
Spotfin chub	*Erimonax monachus*	LT	T (S2)	N
Tangerine darter*	*Percina aurantiaca*	--	D (S3)	N
Tennessee dace*	*Chrosomus tennesseensis*	--	D (S3)	N
Mollusks				N
Alabama lampmussel*	*Lampsilis virescens*	LE	E (S1)	N
Fanshell*	*Cyprogenia stegaria*	LE, EXPN	E (S1)	N
Finerayed pigtoe*	*Fusconaia cuneolus*	LE, EXPN	E (S1)	N
Orangefoot pimpleback (pearlymussel)*	*Plethobasus cooperianus*	LE, EXPN	E (S1)	N
Pink mucket (pearlymussel)*	*Lampsilis abrupta*	LE	E (S2)	N
Pyramid pigtoe*	*Pleurobema rubrum*	--	Rare (S1S2)	N
Ring pink (mussel)*	*Obovaria retusa*	LE, EXPN	E (S1)	N
Rough rabbitsfoot*	*Quadrula cylindrica strigillata*	LE	E (S2)	N
Sheepnose mussel*	*Plethobasus cyphyus*	LE	E (S2S3)	N
Shiny pigtoe*	*Fusconaia cor*	LE, EXPN	E (S1)	N
Spectaclecase (mussel)*	*Cumberlandia monodonta*	LE	E (S2S3)	N
Snails				
Spiny riversnail*	*Lo fluvialis*	--	Rare (S2)	N
Crustacean				
Valley flame crayfish*	*Cambarus deweesae*	--	E (S1)	N
Insect				
Monarch butterfly	*Danaus plexippus*	C	S4	PS
Amphibians				
Four-toed salamander*	*Hemidactylium scutatum*	--	D (S3)	N
Hellbender*	*Cryptobranchus alleganiensis*	--	E (S3)	N
Green salamander*	*Aneides aeneus*	--	Rare (S3S4)	N
Streamside salamander	*Ambystoma barbouri*	--	Rare (S2)	N

Table 3.5.5-1
(Sheet 2 of 3)
Protected Species Potentially Occurring within or in Proximity to the HCS

Common Name	Scientific Name	Status		Suitable Habitat[d] Present within HCS
		Federal[a]	State[b] (Rank[c])	
Reptiles				
Northern pinesnake*	*Pituophis melanoleucus*	--	T (S3)	N
Eastern slender glass lizard*	*Ophisaurus attenuatus longicaudus*	--	D (S3)	N
Mammals				
Gray bat*	*Myotis grisescens*	LE	E (S2)	N
Indiana bat	*Myotis sodalis*	LE	E (S1)	PS
Long-tailed shrew*	*Sorex dispar*	--	D (S2)	N
Northern long-eared bat	*Myotis septentrionalis*	LE	T (S1S2)	PS
Southern bog lemming*	*Synaptomys cooperi*	--	D (S3)	N
Birds				
Bachman's sparrow*	*Peucaea aestivalis*	--	E (S1B)	PS
Bald eagle*	*Haliaeetus leucocephalus*	P	S3	N
Cerulean warbler*	*Setophaga cerulea*	--	D (S3B)	N
Swainson's warbler*	*Limnothlypis swainsonii*	--	D (S3)	N
Flowering Plants				
American ginseng*	*Panax quinquefolius*	--	S-CE (S3S4)	N
Branching Whitlow-grass*	*Draba ramosissima*	--	S (S2)	N
Butternut*	*Juglans cinerea*	--	T (S3)	N
Earleaved false-foxglove*	*Agalinis auriculata*	--	E (S2)	N
Fen orchid*	*Liparis loeselii*	--	T (S1)	N
Heller's catfoot*	*Pseudognaphalium helleri*	--	S (S2)	N
Mountain honeysuckle*	*Lonicera dioica*	--	S (S2)	N
Mountain witch-alder*	*Fothergilla major*	--	T (S2)	N
Naked-stem sunflower*	*Helianthus occidentalis*	--	S (S2)	N
Northern bush-honeysuckle*	*Diervilla lonicera*	--	T (S2)	N
Prairie goldenrod*	*Oligoneuron album*	--	E (S1S2)	N
River bulrush*	*Bolboschoenus fluviatilis*	--	S (S1)	N
Schreber's aster*	*Eurybia schreberi*	--	S (S1)	N
Shining ladies'-tresses*	*Spiranthes lucida*	--	T (S1S2)	N
Slender blazing star*	*Liatris cylindracea*	--	T (S2)	N
Small-headed rush*	*Juncus brachycephalus*	--	S (S2)	N

Table 3.5.5-1
(Sheet 3 of 3)
Protected Species Potentially Occurring within or in Proximity to the HCS

Common Name	Scientific Name	Status		Suitable Habitat[d] Present within HCS
		Federal[a]	State[b] (Rank[c])	
Spreading false-foxglove*	*Aureolaria patula*	--	S (S3)	N
Tall larkspur*	*Delphinium exaltatum*	--	E (S2)	N
Tubercled rein-orchid*	*Platanthera flava var. herbiola*	--	T (S2)	N
Virginia spiraea	*Spiraea virginiana*	LT	E (S2)	N
White fringeless orchid	*Platanthera integrilabia*	LT	E (S2S3)	N

a) Federal Status Codes:
LT = Listed Threatened; LE = Listed Endangered; P = Protected; EXPN = Experimental nonessential population; C = Candidate.

b) State Status Codes:
E = Listed Endangered; S = Species of special concern; T = Listed Threatened; Rare = Rare, but not state listed; D = Deemed in Need of Management; CE = Commercially Exploited.

c) State Rank:
S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Apparently Secure; B = Breeds in Tennessee.
S#S# = Denotes a range of ranks because the exact rarity of the element is uncertain (e.g., S1S2).
Migratory species may have separate ranks for different population segments (e.g., S1B, S2N, S4M);
S#B = rank of breeding population S#N = rank of nonbreeding population.

d) Habitat Codes:
N = No, no records of species within or near HCS and no suitable habitat is present.
PS = Potentially suitable habitat is present, but no records of species at or near HCS.

(*) According to the TDEC Natural Heritage Program, records exist within the Bethel-Valley, Tennessee, and Elverton, Tennessee, topographic quadrangles.
Reference: USFWS, 2021, TDEC, 2021a

Table 3.5.5-2
Potentially Suitable Bat Roost Trees Identified within the Study Area

Label	Common Name	Scientific Name	Diameter at breast height (cm)	Condition
Horizon Center Site (HCS)				
BRT-001	American elm	*Ulmus americana*	67.8	Dead
BRT-002	American elm	*Ulmus americana*	68.0	Dead
BRT-003	Southern red oak	*Quercus falcata*	65.9	Dead
BRT-004	Southern red oak	*Quercus falcata*	58.7	Dead
BRT-005	White ash	*Fraxinus americana*	63.3	Dead
BRT-006	Southern red oak	*Quercus falcata*	49.4	Dead
BRT-007	Southern red oak	*Quercus falcata*	29.4	Dead
Lot 6b				
BRT-008	White ash	*Fraxinus americana*	31.6	Dead
BRT-009	American elm	*Ulmus americana*	60.5	Declining
BRT-010	Black cherry	*Prunus serotina*	32.2	Declining
BRT-011	Tulip poplar	*Liriodendron tulipifera*	47.7	Dead
BRT-012	White ash	*Fraxinus americana*	46.3	Dead
BRT-013	Slippery elm	*Ulmus rubra*	20.4	Dead
BRT-014	White ash	*Fraxinus americana*	62.8	Dead

Table 3.5.5-3
Habitat Requirements for Plant Species of Conservation Concern Listed within the Area Encompassed by the Bethel-Valley, Tennessee, and Elverton, Tennessee, Topographic Map Quadrangles

Common Name	Scientific Name	Habitat Requirements	Potential Habitat within HCS[(a)]
American ginseng	*Panax quinquefolius*	Slopes of shaded, rich woodlands	N
Branching Whitlow-grass	*Draba ramosissima*	Calcareous bluffs	N
Butternut	*Juglans cinerea*	Rich woods and hollows	N
Earleaved false-foxglove	*Agalinis auriculata*	Barrens	N
Fen orchid	*Liparis loeselii*	Calcareous seeps	N
Heller's catfoot	*Pseudognaphalium helleri*	Dry sandy woods	N
Mountain honeysuckle	*Lonicera dioica*	Mountain woods and thickets	N
Mountain witch-alder	*Fothergilla major*	Rocky slopes and river banks	N
Naked-stem sunflower	*Helianthus occidentalis*	Limestone glades and barrens	N
Northern bush-honeysuckle	*Diervilla lonicera*	Rocky woodlands and bluffs	N
Prairie goldenrod	*Oligoneuron album*	Barrens	N
River bulrush	*Bolboschoenus fluviatilis*	Marshes	N
Schreber's aster	*Eurybia schreberi*	Mesic woods and seepage slopes	N
Shining ladies'-tresses	*Spiranthes lucida*	Alluvial woods and moist slopes	N
Slender blazing star	*Liatris cylindracea*	Barrens	N
Small-headed rush	*Juncus brachycephalus*	Seeps and wet bluffs	N
Spreading false-foxglove	*Aureolaria patula*	Oak woods and edges	N
Tall larkspur	*Delphinium exaltatum*	Glades and barrens	N
Tubercled rein-orchid	*Platanthera flava var. herbiola*	Swamps and floodplains	N
Virginia spiraea	*Spiraea virginiana*	Wetlands and high-gradient mountain stream banks	N
White fringeless orchid	*Platanthera integrilabia*	Partially shaded seepage slopes or stream heads	N

a) Habitat Codes: PS = Potentially suitable habitat present within HCS; N = No suitable habitat present within HCS.
Reference: TDEC, 2021a; NatureServe, 2022

3.6 METEOROLOGY, CLIMATOLOGY, AND AIR QUALITY

3.6.1 CLIMATOLOGY AND METEOROLOGY

Climate is a statistical description of weather conditions that occur during a long period of time, usually several decades. Sources of data typically used to analyze the climate at a site include weather maps (depictions of areal weather phenomena at one instant of time), records of weather at specific monitoring stations at single instants of time, and long-term climatic statistics recorded from specific monitoring stations.

3.6.1.1 General Climate

The TRISO-X Fuel Fabrication Facility (TRISO-X FFF) is located at the Horizon Center site (HCS), in northern Roane County, Tennessee southwest of Oak Ridge. Oak Ridge is located in the broad Tennessee River valley between the Cumberland Mountains, which lie to the northwest, and the Great Smoky Mountains, to the southeast. The Cumberland Mountains moderate the local climate by retarding the flow of cold air from the north during winter (NCEI, 2020a).

Both mountain ranges are generally oriented in a northeast-southwest direction. The valley between them is corrugated by broken ridges approximately 300 to 500 ft. (90 to 150 m) high and oriented parallel to the main valley in an approximate northeast-southwest direction. During periods of light winds, daytime winds are usually southwesterly and nighttime winds are northeasterly in the valley. The ridges generally decrease the wind velocities (NCEI, 2020a).

Direct deflection of the winds by terrain is a dominant mechanism that drives the winds in the valley. This mechanism acts approximately 50 – 60 percent of the time, resulting in winds that blow in directions generally along the approximate northeast-southwest axis of the valley. Atmospheric pressure gradients acting on the valley drive winds along the axis of the valley. This occurs approximately 10 percent of the time. Other mechanisms, such as differential heating of sloped surfaces, result in transient winds that blow in directions other than the northeast-southwest axis of the valley (ORR, 2020).

The climate of Oak Ridge is classified as humid subtropical. The term “humid” indicates that the region receives an overall surplus of precipitation compared to the level of evaporation and transpiration normally experienced during the year. The “subtropical” designation indicates that the region experiences a wide range of seasonal temperatures. Such areas are typified by significant temperature differences between summer and winter. More specifically, the coldest month’s average temperature is above 27°F (-3 C), and at least one summer month has an average temperature above 72°F (22 C). Also, the definition of the humid subtropical climate means that at least four months of the year have an average temperature above 50°F (10 C) (ORR, 2020). Temperatures of 100°F (37.7 C) or greater have occurred during less than one-half of the years of the period of record, and temperatures of 0°F (-17.8 C) or below are rare (NCEI, 2020a).

Light snows usually occur in all of the months from November through March, but the total monthly snowfall is often only a trace. Snowfalls sufficiently heavy to interfere with traffic and outdoor activities occur infrequently (NCEI, 2020a).

The types of weather systems that produce precipitation vary during the year. During winter, synoptic-scale mid-latitude frontal systems produce significant precipitation events

approximately every three to five days. Precipitation events are occasionally followed by arctic air outbreaks. Although snow and ice are generally not associated with many of these systems, occasional snowfall results (ORR, 2020).

During summer, occasional frontal systems may produce organized lines of thunderstorms and relatively rare, damaging tornadoes. More frequently, however, summer precipitation results from “air mass” thunderstorms that form from the interaction of daytime heating, rising humid air, and local terrain features (ORR, 2020).

Although precipitation is usually adequate during the fall season, August through October are often the driest months of the year. Precipitation during the fall tends to be less cyclical than other seasons but is occasionally enhanced by weakening tropical cyclones moving north from the Gulf of Mexico. In November, mid-latitude frontal systems again begin to dominate the weather patterns and continue until May (ORR, 2020).

Table 3.6-1 summarizes 30-year climatological normals and means from an automated meteorological station operated by the National Oceanic and Atmospheric Administration (NOAA) located in Oak Ridge, Tennessee (station identifier KOQT; data extracted from NCEI, 2020a). The meteorological station is located approximately 8.7 mi. (14.0 km) northeast of the HCS.

Normal daily dry bulb temperatures range from 37.7°F (3.2 C) in January to 78.5°F (25.8 C) in July. The normal daily maximum temperatures range from 46.6°F (8.1 C) in January to 88.4°F (31.3 C) in July. The normal daily minimum temperatures range from 28.9°F (-1.7 C) in January to 68.6°F (20.3 C) in July.

The mean annual wind speed is 2.8 mph (1.3 m/s), with the lowest average monthly wind speeds (ranging from 1.9 mph [0.85 m/s] to 2.1 mph [0.94 m/s]) occurring in August through October. The distribution of prevailing monthly wind directions is bimodal, with winds from the northeast (50 – 60 degrees), or from the southwest (210 – 220 degrees).

The bimodality of the wind direction distribution is visually illustrated by the annual wind rose from Oak Ridge in Figure 3.6-1 (NCEI, 2020e). Prevailing winds are largely parallel to the mountain ranges, which are oriented along an approximate northeast-southwest axis due to the effects of atmospheric pressure gradients and terrain deflection as described above. Figure 3.6-2 shows the seasonal wind roses from Oak Ridge. The bimodal wind direction distribution is evident during each season.

Table 3.6-1 shows that the normal liquid equivalent annual precipitation in Oak Ridge is 50.91 in. (129.31 cm), with the lowest monthly average precipitation occurring in August (2.76 in. [7.01 cm]), and the highest monthly average precipitation occurring in July (5.27 in. [13.39 cm]).

The average annual snowfall at Oak Ridge is 5.9 in. (15.0 cm). The lowest average measurable monthly snowfall occurs in November (0.1 in. [0.25 cm]) and the highest average measurable monthly snowfall occurs in February (2.1 in. [5.3 cm]) (ORNL, 2020i).

Table 3.6-2 summarizes 30-year climatological normals and means from another automated meteorological station at the McGhee Tyson airport in Knoxville, Tennessee (station identifier KTYS; data extracted from NCEI, 2020b). The station is located approximately 23.9 mi. (38.5 km) southeast of the HCS.

Seasonal trends in normal daily temperatures, liquid equivalent precipitation and snowfall in Knoxville are similar to those observed at Oak Ridge.

Table 3.6-2 shows that the mean annual wind speed at Knoxville (6.0 mph [2.7 m/s]) is higher than the annual mean annual wind speed at Oak Ridge (2.8 mph [1.3 m/s] from Table 3.6-1). The monthly average wind speeds at Knoxville range from 4.8 mph (2.2 m/s) in August and September to 7.3 mph (3.3 m/s) in March. The distribution of prevailing monthly wind directions is bimodal, with winds from the northeast (30 or 50 degrees), or from the southwest (240 degrees).

An annual wind rose from the Knoxville airport is shown in Figure 3.6-3 (NCEI, 2020f). The wind direction distribution is also bimodal and overall looks similar to that at Oak Ridge in Figure 3.6-1, except the wind speeds are generally higher, as described above.

Figure 3.6-4 shows the seasonal wind roses from Knoxville. The bimodal wind direction distribution is evident in each season as it is in the seasonal wind roses from Oak Ridge (Figure 3.6-2.).

3.6.1.2 Climate Variations

Decadal-scale and global-scale climate variations regularly affect eastern Tennessee. Most of these variations appear related to the hemispheric temperature and precipitation effects caused by the frequency and phase of the global-scale El Niño – southern oscillation (ENSO), the Pacific decadal oscillation (PDO), and the Atlantic multi-decadal oscillation (AMO).

The ENSO and PDO patterns, with cycles of three to seven years and approximately 60 years, respectively, affect Pacific Ocean sea surface temperature patterns. The AMO, with a cycle of 40 to 70 years, affects Atlantic sea surface temperature similar to the PDO. These medium- and long-range sea surface temperature patterns collectively modulate decadal-scale and longer regional temperature and precipitation trends in eastern Tennessee (ORR, 2020).

Temperature averages for individual years may vary significantly, as noted by a recent contrast of greater than 1.8°F (1 C) between 2014 (58.6°F [14.8 C] average) and 2015 (60.8°F [16.0 C] average), largely the result of the recent strong El Niño in 2015 - 2016. During the post-El Niño years of 2017 and 2018, the annual average temperature at ORNL returned to approximately the same level as in 2014 (i.e., 58.1°F [14.5 C] in 2018). However, values rose again in 2019 under the influence of weak El Niño conditions to 59.4°F (15.2 C) (ORR, 2020).

Human activity may be producing some effect on local temperatures via interacting influences that include well-mixed greenhouse gases, land cover changes, carbon soot and aerosols. Beyond these possible anthropogenic factors, solar influences on the jet stream, via changes to the stratospheric temperature gradient due to an 11-year solar cycle (and perhaps longer cycles), also play a role in inter-annual climate variability (Ineson et al., 2011; ORR, 2020).

Perhaps partially due to the effects of the AMO and ENSO, the Oak Ridge climate has warmed approximately 2.2°F (1.2 C) from the 1970s to the 1990s but has remained within 0.24°F (0.2 C) of the 1990s observed value through the 2010s. This late-20th-century warming appears to have lengthened the growing season (i.e., the period with temperatures above 32°F [0 C]) by approximately two to three weeks during the last 30 years. This warming has primarily affected minimum temperatures; the effect is possibly related to changes in the interaction of the surface boundary layer with greenhouse gases and/or aerosol concentration changes (ORR, 2020).

3.6.1.3 Meteorological and Air Quality-Related Data Sources

Meteorological and air quality-related data are available from the sources described below.

a. Digital records from cooperative ("COOP") weather monitoring stations (NCEI, 2020c)

   Cooperative weather observing stations record parameters of particular interest to agricultural, industrial, and engineering applications. Depending upon the station, those parameters include daily and monthly high and low dry bulb temperatures, liquid precipitation, and snowfall.

   COOP stations do not generally record humidity related parameters, such as relative humidity, dew point or wet bulb temperatures. Therefore, wet bulb temperatures that are coincident with extreme dry bulb temperatures, which are of interest in regional climate analysis, are generally not available from COOP stations.

b. Digital records and other reports from Automated Surface Observing Stations (ASOS)

   An ASOS may be operated by NOAA, the Federal Aviation Administration (FAA) or other agencies. Hourly meteorological data files are available in TD-3505 format (NCEI, 2011) from NCEI, 2020c.

c. Annual and monthly local climatological data (LCD) summaries from the National Centers for Environmental Information (NCEI) (NCEI, 2020a and NCEI, 2020b)

   LCD annual summaries are typically available for meteorological stations located at major airports and select automated weather stations. Those summaries include climatic normals, averages and extremes. Thirty-year monthly histories are generally provided for the following parameters: mean temperature, total precipitation, total snowfall, and heating/cooling degree days. The summaries also include a narrative description of the local climate.

   Monthly LCDs contain much of the same type of information as annual LCDs but are focused on a particular month of a specific year.

   LCDs are available for the ASOS station in Oak Ridge, Tennessee (station identifier KOQT; NCEI, 2020a) and an ASOS station at the McGhee Tyson airport in Knoxville, Tennessee (station identifier KTYS; NCEI, 2020b).

d. Statistical summaries of climatological data from the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) (ASHRAE, 2017)

   ASHRAE provides climatic information for worldwide locations including many U.S. airports and other locations with hourly surface weather observing stations. Parameters include dry bulb, wet bulb and dew point temperatures. Also included are statistical design values of dry bulb with mean coincident wet bulb temperature; design wet bulb temperature with mean coincident dry bulb temperature; and design dew point with mean coincident dry bulb temperature. ASHRAE also provides a methodology and key inputs for estimating extreme dry bulb and wet bulb temperatures for various return intervals.

e. American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI) structural design standards (ASCE, 2016)

   The ASCE/SEI standards provide minimum load requirements for the design of buildings and other structures that are subject to building code requirements. Particularly useful are maps of 100-year, mean return-interval 3-s wind gusts. ASCE also provides maps of 50-year return interval snowpack and a methodology for converting 50-year values extracted from those maps to other return intervals.

f. 100-year 48-hour duration liquid equivalent precipitation

   The 100-year return interval 48-hour duration liquid equivalent precipitation is available for the HCS from NOAA, 2020a.

g. Tornado and other weather event statistics from NCEI's online storm events database and "Storm Data" publications

   The storm events database (NCEI, 2020d) contains a chronological listing, by State and county, of climate statistics of interest for climate analysis. Those statistics describe tornadoes, thunderstorms, hail, lightning, high winds, snow, temperature extremes, and other weather phenomena. Also included are statistics on personal injuries and property damage estimates.

   The "Storm Data" publications are monthly summaries of severe weather events published by NCEI. These publications provide details about specific severe weather events.

h. Climatological summaries and hourly meteorological data for the Oak Ridge area from the Oak Ridge National Laboratory (ORNL)

   A network of 10 meteorological towers and two sound detection and ranging instruments (SODARs) have been installed around ORNL and the Y-12 National Security Complex (Y-12) as part of the environmental monitoring program supporting the Oak Ridge Reservation (ORR) (ORR, 2020; Chapter 6).

   ORNL provides on-line summaries of climatological parameters that include temperature, humidity, wind, precipitation, adverse and extreme weather conditions. Other data include air dispersion parameters from meteorological instrumentation platforms including instrumented towers and SODARs (ORNL, 2020a and ORNL, 2020b). Real-time meteorological data are also available to the public from ORNL, 2020c. ORNL provides a number of climatological summaries online, including ORNL, 2020d-o.

   Relevant to this study is a 60-m multi-level tower (Tower D [also known as Tower MT2]) located approximately 3.5 mi. (5.6 km) southeast of the HCS at ORNL. Joint wind-atmospheric stability frequency distributions (JFDs) were developed using the most recent five full years of available meteorological data (2016 – 2020) from Tower D. Development of the JFDs is described in Section 0.

i. Air quality summaries and air quality monitor data from the USEPA

The U.S. Environmental Protection Agency (USEPA) provides summaries of the current compliance status of counties with the National Ambient Air Quality Standards (NAAQS) (USEPA, 2021b).

The agency also provides digital summaries of measured concentrations and related parameters from air quality monitors (USEPA, 2021c). Concentrations from the monitors are compared with the NAAQS to assess compliance with the specific NAAQS.

3.6.1.4 Regional Meteorological Data Analysis

Climatological parameters from the sources described above are presented in the following sections. For purposes of identifying a climate region containing meteorological stations relatively close to the HCS and subject to the same general climatic influences, this analysis concentrates on the four counties surrounding the HCS— Anderson, Knox, Roane and Loudon counties.

Table 3.6-3 presents a list of ASOS and COOP stations and supplemental meteorological data sources in the region. The Knoxville airport (Blount county) and a COOP station in Strawberry Plains, Tennessee (Jefferson county) were also included due to their proximity to a county border. Figure 3.6-5 shows the locations of stations and data sources listed in Table 3.6-3.

It should be noted that the ground elevations shown in Table 3.6-3 are listed in meters MSL (above Mean Sea Level) because that is the terminology used by NOAA in describing the ASOS and COOP stations, and by ORR in describing the grade elevations of its meteorological instruments. However, the MSL elevations are functionally equivalent to the NAVD 88 elevations used elsewhere in this analysis.

3.6.1.4.1 Severe Weather

3.6.1.4.1.1 Tornadoes

Tornado intensity is classified according to the enhanced Fujita tornado intensity scale (EF-scale). This scale matches the wind speeds to the degree of observed damage according to 28 indicators. Measuring tornadoes from EF-1 to EF-5, the enhanced Fujita scale uses more specific structural damage indicators than the original Fujita tornado intensity scale (F-scale), which was established in 1971 (SPC, 2020). Table 3.6-4 shows the original F-scale and EF-scale for reference.

Eastern Tennessee experiences tornado outbreaks of varying magnitudes approximately every three to six years. Tornadoes generally occur more frequently in the western and middle portions of Tennessee (ORR, 2020).

Tornado climatology for Anderson, Knox, Loudon and Roane Counties from 1950 to 2020 is summarized in Table 3.6-5 (ORNL, 2020d; ORNL, 2020e; ORNL, 2020f; ORNL, 2020g; and NCEI, 2020d). In the four-county area, the highest intensity tornadoes were rated F3 intensity. All of those storms occurred on February 21, 1993. One of those tornadoes touched down near Oak Ridge, moved northeastward through the Bull Run Steam Plant and into Claxton, Tennessee. This tornado destroyed fifty homes, six mobile homes and two businesses. The

storm also damaged 10 businesses, portions of Y-12 and 12 electric transmission towers (NCEI, 1993; Fricke and Kornegay, 1993).

3.6.1.4.1.2 Extreme Wind

ASCE, 2016 (Minimum Design Loads and Associated Criteria for Buildings and Other Structures, ASCE Standard ASCE/SEI 7-16) provides site-specific 100-year mean return-interval wind gusts. The 100-year, mean return-interval 3-s gust wind speed at 33 ft. (10 m) above ground level (exposure category C) for Oak Ridge, Tennessee is 89 mph (40 m/s) (ASCE, 2016; Figure CC.2-4).

3.6.1.4.1.3 Thunderstorms and Lightning

A climatology of thunderstorm days from ORNL for 2001-2019 is provided in Table 3.6-7 (ORNL, 2020h). Thunderstorms and associated lightning occur in Oak Ridge at an annual average frequency of 48.5 days per year, with a maximum monthly average occurring during July, which has a monthly average between 10 and 11 days. Approximately 41 of these thunderstorm days occur during the 7-month period that extends from April through October, with the remainder spread nearly evenly throughout the late fall and winter. The highest number of thunderstorm days at ORNL (65) was observed during 2012; the lowest (34) was observed during 2007.

Monthly and annual average numbers of thunderstorm days at the Knoxville Airport during the 72-year period from 1948 – 2019 are shown in Table 3.6-8 (NCEI, 2020b). This table shows an annual distribution similar to that of Oak Ridge in Table 3.6-7, with thunderstorms occurring at an average annual frequency of 48.8 days per year.

The mean frequency of lightning strikes to earth is estimated via a method from the Electric Power Research Institute (EPRI), per the U. S. Department of Agriculture Rural Utilities Service (USDA, 1998). The method assumes a relationship between the average number of thunderstorm days per year (T), and the number of lightning strikes to earth per square mile per year (N). The mathematical relationship is as follows:

$$N = [0.31][T] \qquad \text{(Equation 3.6-1)}$$

The number of lightning strikes to earth per square mile per year is computed for Oak Ridge and Knoxville in Table 3.6-9. Based on the average number of thunderstorm days per year at Knoxville (48.8 days from NCEI, 2020b), which is slightly higher than the value of 48.5 days for Oak Ridge ORNL, 2020h) and is therefore used here), the frequency of lightning strikes to earth per square mile per year is 15.1 (5.9 strikes per square km per year) for the HCS and surrounding area. For comparison, based on a 10-year period from 2009 – 2018 (Vaisala, 2018), indicates four to eight flashes per square kilometer per year in the region. The EPRI value therefore is shown to be a reasonable indicator.

3.6.1.4.1.4 Hail

The NCEI Storm Events Database (NCEI, 2020d) was queried to extract statistics on observed hail. Table 3.6-10 summarizes the occurrences of hail in the four-county area around the HCS for 1950-2020. As shown in Table 3.6-10, most hailstorm occurrences (approximately 75 percent, or 243 out of 323 observations) do not produce hailstones larger than 1 in. (2.54 cm) in diameter. During the period from 1950 through 2020, 12 hail events with hailstones larger than 2

in. (5.08 cm) were documented. The largest hailstone recorded during the period (4 in. [10.16 cm]) was observed in Loudon County on April 28, 1959). Hailstones ranging from 2.5 in. (6.35 cm) to 3.5 in. (8.89 cm) in diameter were associated with an F3 tornado that struck Oak Ridge on February 21, 1993.

3.6.1.4.2 Ice and Snowstorms

Oak Ridge winters are characterized by synoptic mid-latitude cyclones that produce significant precipitation events approximately every three to five days. Although snow is not associated with many of these systems, occasional snowfall does result (ORR, 2020).

Table 3.6-11 summarizes monthly and annual average snowfall at Oak Ridge for the period of record of 1985 through 2019 (ORNL, 2020i; NCEI, 2020a; NCEI, 1999). The average annual snowfall at Oak Ridge is 5.9 in. (15.0 cm). The highest average monthly snowfall is 2.1 in. (5.3 cm) which occurs in February. The highest monthly snowfall for the 1985 – 2019 period of record is 12 in. (30.5 cm) which occurred in March 1993 and February 1996.

Additional historical records for Oak Ridge are available from NCEI, 2020a and NCEI, 1999 for a combined period of record of 72 years beginning in 1947. From these additional sources, the record monthly snowfall is 21.0 in. (53.3 cm) which occurred in March 1960. The record 24-hr snowfall for Oak Ridge is 12.0 in. (30.5 cm) which also occurred in March 1960.

Table 3.6-12 summarizes monthly and annual snowfall from Knoxville from 1944 – 2019 (NCEI, 2020b). The normal annual snowfall is 6.5 in. (16.5 cm). The record monthly snowfall (23.3 in. [59.2 cm]) was recorded in February 1960. The record 24-hr. snowfall is 18.2 in. (46.2 cm) which occurred in November 1952.

Freezing rain occurs relatively infrequently at Oak Ridge. Table 3.6-13 summarizes the number of days with freezing rain observed at Oak Ridge during 1999-2019 (ORNL, 2020j). Freezing rain is observed on an average of slightly over 1 day/year.

3.6.1.4.3 Atmospheric Stagnation

Major air pollution episodes are typically a result of persistent surface high pressure weather systems that cause light and variable surface winds and stagnant meteorological conditions for four or more consecutive days. Estimates of the stagnation frequency are provided in NOAA, 1999; Figures 1 and 2. Those estimates indicate that, on average, the HCS experiences approximately 15 days with stagnation per year. When stagnation occurs, stagnation lasts approximately five days. A more recent analysis from ORNL that used the technique described in NOAA, 1999 applied to the 1980-2012 period found stagnation conditions were most prevalent in Oak Ridge during August and September (ORNL, 2020k).

3.6.1.4.4 Fog

Table 3.6-14 summarizes the number of days with heavy fog (defined as fog reducing the horizontal visibility to one-quarter mi. [0.40 km] or less) observed at Oak Ridge during 2000 – 2019 from NCEI, 2020a. Heavy fog was observed an average of 48 days/year and occurred most often during September and October.

Table 3.6-15 summarizes the number of days with heavy fog observed at Knoxville during 1964 – 2019 from NCEI, 2020b. Heavy fog was observed on an average of approximately 28

days/year and most frequently during September and October — similar annual trend to that observed at Oak Ridge.

3.6.1.4.5 Precipitation Extremes

This section examines precipitation extremes from the COOP and ASOS monitoring stations near the HCS. The stations were identified in Section 0.

Table 3.6-16 presents maximum recorded daily (calendar day) liquid equivalent precipitation from the monitoring stations from NCEI, 2020c. The maximum recorded daily liquid-equivalent precipitation is 7.45 in. (18.92 cm) at NOAA Atmospheric Turbulence and Diffusion Division (ATTD) in Oak Ridge. The event occurred from thunderstorms during the afternoon and evening of August 10, 1960. During that event a total of 3.43 in. (8.71 cm) of rain fell in one hour (NCEI, 1960a and NCEI, 1960b). The corresponding 24-hour liquid equivalent precipitation total for the event is 7.48 in. (19.0 cm) (NCEI, 1960b and NCEI, 2020a).

The weather observer in Oak Ridge described the event as follows in the station's monthly log (NCEI, 1960a):

> "7.45 inches of rain on the 10th [August 10] is maximum for Oak Ridge (Townsite) station. 7.34 inches fell in three hours, 3.43 [in.] in one hour. Extensive flooding of creek beds and streets occurred with some minor but no major damage."

Table 3.6-16 presents the maximum daily (calendar day) snowfall recorded at the monitoring stations from NCEI, 2020c. The highest daily snowfall recorded at any of the stations is 17.5 in. (44.5 cm), which was recorded at the Knoxville airport on February 13, 1960 (NCEI, 1960c). This event also set the record for the maximum 24-hour snowfall in February at Knoxville (NCEI, 2020b).

Table 3.6-16 presents the maximum monthly snowfall recorded at the monitoring stations from NCEI, 2020c. The highest monthly snowfall recorded at any of the stations is 23.3 in. (59.2 cm), which was recorded at the Knoxville airport on February 1960 (NCEI, 1960c).

Another noteworthy regional snowfall is the record 24-hour snowfall at Knoxville (18.2 in. [46.2 cm]) from NCEI, 2020b. This record was set on November 21 – 22, 1952. A total of 16.0 in. (40.6 cm) of snow fell during the first calendar day of the event. This was followed by 2.2 in. (5.6 cm) during the second day (NCEI, 1952). The weather observer at the Knoxville airport described the event as follows in the station's monthly log (NCEI, 1952):

> "A heavy wet snow of 18.2 inches which fell within a 24-hour period on November 21 – 22, played havoc with communication and power lines, broke many trees, and brought motor traffic to a near halt. The fall of 18.2 inches is the greatest snowfall in any 24-hour period since these records began in 1884. The snow partially melted as it fell and the greatest depth on the ground at any time was 10 inches."

3.6.1.4.6 Ground Snow Load and 100-Year 48-Hour Duration Liquid Equivalent Precipitation

ASCE, 2016; Figure 7.2-1 provides site-specific estimates of the 50-year ground snow load. For the HCS, the 50-year ground snow load is 10 lb/ft^2.

ASCE, 2016; Section C7.3.3 provides a factor of 1.22 for estimating a 100-year ground snow load from a 50-year ground snow load. The resulting 100-year ground snow load as 12.2 lb/ft^2 (10 lb/ft^2 x 1.22 = 12.2 lb/ft^2) (59.6 kg/m^2).

Point estimates of precipitation return intervals are available from NOAA, 2022a. For the HCS, the 100-year return interval, 48-hour duration liquid equivalent precipitation is 8.31 in. (21.07 cm).

3.6.1.4.7 Dry and Wet Bulb Temperatures

3.6.1.4.7.1 Design Dry and Wet Bulb Temperatures

Design basis dry bulb temperatures (DBTs) and wet bulb temperatures (WBTs) are defined for the HCS. These include the following temperatures:

a. Maximum DBT with annual exceedance probability of 0.4 percent

b. Mean coincident WBT (MCWB) at the 0.4 percent DBT

c. Maximum DBT with annual exceedance probability of 1.0 percent

d. MCWB at the 1.0 percent DBT

e. Maximum DBT with annual exceedance probability of 2.0 percent

f. MCWB at the 2.0 percent DBT

g. Minimum DBT with annual exceedance probability of 1.0 percent

h. Minimum DBT with annual exceedance probability of 0.4 percent

i. 100-year return maximum annual DBT

j. 100-year return maximum annual WBT

Design temperatures for (a) – (h) are readily available from ASHRAE, 2017 for the ASOS stations in Oak Ridge and at the Knoxville airport. Worst-case (bounding) values for (a) – (h) are selected from those two stations. To maintain thermodynamic consistency between DBT and coincident WBT, DBT/ MCWB pairs are retained for a single station. The design temperatures and bounding values are listed in Table 3.6-17.

The 100-year return-interval maximum annual DBTs and WBTs (items [i], [j] above) were estimated used a technique described in ASHRAE, 2017. The technique estimates the n-year return-interval extreme maximum or minimum temperature using the mean and standard deviation of a series of annual maximum and minimum temperatures. This technique uses the following equation:

$$T_n = M + I\ F\ s \qquad \text{(Equation 3.6-2)}$$

Where:

T_n = n-year return period value of the extreme temperature computed, in years

M = mean annual extreme maximum or minimum temperature

I = +1 if the maximum temperature is computed; -1 if the minimum temperature is computed

s = standard deviation of the annual extreme maximum or minimum temperatures

n = return period in years (n =100 for a 100-year return interval).

$$F = -\frac{\sqrt{6}}{\pi}\left\{0.5772 + \ln\left[\ln\left(\frac{n}{n-1}\right)\right]\right\}$$

(Equation 3.6-3)

Where:

F is a function that converts the standard deviation of annual extreme temperature parameters (such as the annual extreme temperature) to a new variable that is linearly related to the n-year return-interval extreme temperature T_n.

ASHRAE, 2017 provides the mean annual extreme maximum and mean annual extreme minimum temperature (M) and the corresponding standard deviations (s) in Equation 3.6-2 for the observing stations in Oak Ridge and at the Knoxville airport.

The inputs and the computed 100-year return interval maximum annual DBTs and WBTs computed for Knoxville and Oak Ridge from Equation 3.6-2 and Equation 3.6-3 are listed in Table 3.6-18 and Table 3.6-19, respectively. Worst-case (bounding) values are selected from those two stations. The bounding values are listed in Table 3.6-20.

3.6.1.4.7.2 Extreme Dry Bulb Temperatures

An additional review of regional extreme DBTs is done using COOP meteorological stations in the area. The locations of those stations are shown in Figure 3.6-5.

The COOP stations do not measure WBT and do not record hourly DBTs. Those stations only record maximum and minimum daily DBTs and daily precipitation totals. Therefore, it is not possible to identify WBTs coincident with the extreme DBTs recorded at those stations.

Table 3.6-21 presents extreme DBTs recorded at the COOP and ASOS stations. Many of the COOP stations did not record the dry bulb temperature or had partial temperature records. The extreme temperatures were extracted for each station using the available dry bulb temperature data. Table 3.6-21 also includes the extreme DBTs recorded at the two ASOS stations (Oak Ridge and the Knoxville airport).

Table 3.6-21 shows that the overall extreme DBTs are a maximum of 108°F (42.2 C) recorded on July 29, 1930 at Loudon, 1E in Loudon County, and a minimum of -24°F (-31.1 C) recorded on January 21, 1985 at the Knoxville (NCEI, 1985).

3.6.1.5 Local Meteorological Data Analysis

3.6.1.5.1 Temperature and Wind Data

Surface wind and temperature data from a location near the HCS were required to develop an input data set for computing relative atmospheric concentration (χ/Q) and radiological dose assessments.

Surface data were available from the ASOS in Oak Ridge (station KOQT). This station is relatively close, 8.5 mi. (13.7 km) northeast of the HCS. However, this ASOS is unusual in the respect that it is not located in a relatively open location affiliated with an airport or runway. Instead it is in an urban area between buildings and parking lots of Roane State Community College and U.S. Department of Energy (DOE) buildings of the Oak Ridge Operations Headquarters (Bellinger, 2011).

Due to urban development around the station, NOAA has raised concerned about the data quality from that station (NOAA, 2020b). Also, a relatively high percentage of calm winds reported by the Oak Ridge ASOS (51.12 percent in Figure 3.6-1) raised concerns during preparation of this report about the utility of the wind data from the Oak Ridge ASOS for inputs into air dispersion modeling. Due to these concerns, this report does not use data from the Oak Ridge ASOS to develop an input data set for computing relative atmospheric concentration (χ/Q) and radiological dose assessments.

Other potential data sources consist of 10 single- and multi-level meteorological towers near the HCS. These towers are part of the environmental monitoring program supporting the ORR (ORR, 2020; Chapter 6).

The vertical temperature difference (delta-T) is the preferred method for determining Pasquill stability classes because it is an effective indicator of worst-case stability conditions (Pasquill class E, F and G) (Regulatory Guide 1.23). Thus, a multi-level tower close to the HCS was preferred. In using the delta-T method, temperature measurements at the 60 m (196.8 ft) level are important in assessing atmospheric stability.

Of the 10 towers, only two Tower D, also known as Tower MT2 — located at ORNL; and Tower W (also known as MT6) — located near the western boundary of Y-12 had measurements at 60 m (196.8 ft).

Tower D is located approximately 3.5 mi. (5.6 km) southeast of the HCS, whereas Tower W is located approximately 5.6 mi. (9.0 km) east-northeast of the HCS. Therefore, Tower D is the closest multi-level tower to the HCS with measurements at the 60 m (196.8 m ft) level (ORR, 2020; Table 6.1).

The grade elevation of Tower D is 261 m (856 ft.) MSL (ORR, 2020; Table 6.1). The base elevation of Tower D is reasonably close to the grade elevation of the HCS is approximately 244 m (800 ft.) MSL.

Tower D is instrumented at 2 m (6.6 ft.); 15 m (49.2 ft.); 35 m (114.8 ft.) and 60 m (196.8 ft.). Tower D measures solar radiation, wind speed/direction, dry bulb temperature and humidity. Wind speed/direction and standard deviation of the wind direction are measured at 15 m (49.2 ft.), 35 m (114.8 ft.) and 60 m (196.8 ft.). Dry bulb temperatures are measured at 2 m (6.6 ft.);

15 m (49.2 ft.) and 60 m (196.8 ft.). Relative humidity and dewpoint are measured at 2 m (6.6 ft.); 15 m (49.2 ft. (ORR, 2020; Table 6.1 and Section 6.1.1).

The University of Tennessee-Battelle manages calibrations of the meteorological instruments. A local environmental firm (Holian Environmental, LLC) conducts independent audits of the tower every six months (ORR, 2020; Chapter 6).

Digital files containing hourly data from Tower D for January 1, 2016 through December 31, 2020 were obtained from ORNL, 2020l. Winds at the 15-m (49.2ft.) level and Pasquill stability class derived from 15 – 60 m (49.2 ft. - 196.8 ft.) delta-T measurements were used to construct JFDs of wind direction and wind speed stratified by Pasquill stability class (Section 0).

Table 3.6-22 shows the annual joint data recovery of 15-m (49.2 ft.) wind speed, wind direction, and the computed Pasquill stability class for 2016 through 2020. Joint data recovery was 100 percent for each year, except for 2018 and 2020 when the data recovery was 99.95 percent. and 99.99 percent, respectively. Table 3.6-23 through Table 3.6-27 presents annual summaries of meteorological parameters from Tower W for each year during 2016 through 2020 for reference. Table 3.6-28 provides a summary of the parameters for 2016 through 2020.

Figure 3.6-6 through Figure 3.6-19 show the annual, monthly and seasonal wind roses from Tower D. The period of record on which those plots are based is the five years from January 1, 2016 through December 31, 2020. That period of record is also used for the JFD input to X/Q and radiological dose assessments presented later in this report.

The annual wind rose from the Oak Ridge ASOS (Figure 3.6-1) provides some context for interpreting the annual wind rose from Tower D (Figure 3.6-6). The annual wind rose from the Oak Ridge ASOS and the annual wind rose from Tower D both show a bimodal distribution with dominant northeasterly and southwesterly wind directions. This is expected given the climate of the area, as explained earlier. However, the percentage of calm winds reported by the Oak Ridge ASOS (51.12 percent in Figure 3.6-1) is much higher than the percentage reported by Tower D (1.01 percent during 2016 through 2020 [based on 444 calm wind readings and valid 43,843 wind measurements] in Figure 3.6-6).

Bellinger, 2011 also observed the higher percentage of calm winds at the Oak Ridge ASOS relative to other stations, including the nearby Tower W. He attributed the higher percentage of calm winds to differences to the definition of a “calm” wind used the Oak Ridge ASOS. Due to wind sensor starting thresholds, rounding and conventions for reporting calm winds, an ASOS reports a calm wind when the measured wind speed during a two-minute period is less than 2.5 knots (1.3 m/s).

Bellinger compared winds from the Oak Ridge ASOS with winds from nearby Tower W during January 2005 – February 2011, accounting for this definition of calm winds employed by the ASOS. He found that Tower W would report calm winds at approximately the same average frequency as the Oak Ridge ASOS (51.0 percent calm winds at Tower W, versus 46.3 percent calm winds at the Oak Ridge ASOS) if Tower W used the same reporting convention of calms winds employed by the Oak Ridge ASOS (Bellinger, 2011; Figure 9). Thus, the relatively high percentage of calm winds reported by the Oak Ridge ASOS results from the convention for reporting calm wind from an ASOS instead of actual average differences in calm wind percentages measured at Tower W and the Oak Ridge ASOS.

The annual wind rose from Tower D (Figure 3.6-6) was compared with the annual wind rose from the Knoxville airport (Figure 3.6-3). The annual wind rose from the Knoxville airport and the annual wind rose from Tower D both show a bimodal distribution with northeasterly and southwesterly wind directions.

Annual variations in the large-scale weather patterns that affect eastern Tennessee provide context for interpreting the seasonal wind roses in from Tower D (Figure 3.6-19), Oak Ridge (Figure 3.6-2) and Knoxville (Figure 3.6-4).

During the spring season the westerly jet stream brings synoptic-scale, mid-latitude frontal systems regularly through eastern Tennessee (NWS, 2020; ORR, 2020). General southerly winds ahead of these systems, and northerly winds behind them, combined with terrain influences, result in an overall pattern of frequent northeasterly and southwesterly winds. This is reflected in the spring season wind roses.

During the summer season, the westerly jet stream recedes northward into Canada (NWS, 2020). As a result, frontal systems are less common in the Tennessee Valley. The subtropical high-pressure system over the Atlantic strengthens over the southeastern United States bringing southwesterly winds to the region. This is reflected in the summer season wind roses in Figure 3.6-2, Figure 3.6-4 and Figure 3.6-19.

The subtropical high-pressure system weakens during late summer and early autumn. The westerly jet stream begins to progress southward into the United States bringing synoptic-scale mid-latitude frontal systems more frequently through eastern Tennessee (NWS, 2020). High pressure systems behind the frontal systems affect the eastern United States, bringing easterly winds to eastern Tennessee (TDEC, 2020). This is reflected in the autumn season wind roses.

As autumn transitions into winter, the westerly jet stream progresses farther southward into the United States, bringing synoptic-scale mid-latitude frontal systems more frequently through eastern Tennessee (NWS, 2020; ORR,2020). General southerly winds ahead of these systems, and northerly winds behind them, combined with terrain influences, result in an overall pattern of frequent northeasterly and southwesterly winds. This is reflected in the winter season wind roses in Figure 3.6-2, Figure 3.6-4 and Figure 3.6-19.

The corresponding monthly wind roses from Tower D are provided for reference in Figure 3.6-7 through Figure 3.6-18. The general bimodal wind pattern is shown in each month of the year with seasonal variations described above. The overall consistency of the wind roses from Tower D, Oak Ridge and Knoxville verifies the representativeness of wind measurements from Tower D.

3.6.1.5.2 Wind Direction Persistence

Table 3.6-29 shows the distribution of 15-m (49.2-ft.) wind direction persistence at Tower D during 2016 through 2020. The longest persistence of each wind direction in Table 3.6-29 is listed in Table 3.6-30. Table 3.6-30 shows that the most persistent winds are from the northeast (28 hours), followed by winds from the southwest (20 hours) and winds from the west-southwest (18 hours). The longest period of persistent wind direction during 2016 through 2020 was 28 hours which occurred with northeast winds in November 2018.

3.6.1.5.3 Atmospheric Stability

The Pasquill stability class is derived from the temperature difference (delta-T) between 15-m (49.2-ft.) and 60 m (196.8 ft.) levels at Tower D, per Regulatory Guide 1.23. Table 3.6-31 presents the annual Pasquill class frequency distributions for the period January 1, 2016 through December 31, 2020 and each individual year in the period.

This table shows that the Pasquill class "D" stability class is the most frequently occurring stability class for each year and for the entire period. Extremely unstable conditions (Pasquill class “A”) and extremely stable conditions (Pasquill class “G”) occur relatively less frequently. All of these results are consistent with generally observed stability class climatology. A similar distribution is also presented, for example, in Stern et al., 1984.

The results in Table 3.6-31 are presented in the form of JFDs of 15-m (49.2-ft.) wind direction and wind speed stratified by Pasquill stability class in Table 3.6-32 through Table 3.6-39. These JFDs are used for χ/Q and radiological dose calculations presented later in this report.

3.6.1.5.4 Mixing Height

SODARs use acoustic waves to estimate wind direction, wind speed and turbulence at vertical levels beyond the vertical reach of meteorological towers (ORR, 2020; Chapter 6.1.1). A SODAR is located adjacent to Tower D at ORNL, or approximately 3.5 mi. (5.6 km) southeast of the HCS. The grade elevation of the SODAR is 261 m MSL (856 ft.) (ORR, 2020; Table 6.1).

Table 3.6-40 shows average monthly and annual mixing heights measured from the ORNL SODAR during 2014 through 2019 (ORNL, 2020m). Average mixing heights are lowest in the winter months (560 m [1837 ft.] above ground level (AGL) in December). Average mixing heights are the highest in summer (1189 m [3900 ft.] AGL in June). The average annual mixing height is 872 m (2860 ft.) AGL.

The grade elevation of the HCS is approximately 244 m (800 ft.) MSL. Accounting for the approximate 17 m (56 ft.) difference in grade elevation between the SODAR and the HCS (261 m - 244 m = 17 m [56 ft.]), the magnitudes of the monthly average mixing heights suggest that there is, on the average, sufficient vertical depth through which an emitted or entrained non-buoyant plume could potentially be mixed, especially during the summer months when the mixing heights are the greatest.

Mixing heights vary during the day, with the lowest mixing heights generally recorded during the morning hours and the highest readings recorded during the afternoon (Holzworth, 1972: Figure 1 and Figure 6). A climatology of hourly mixing heights from the SODAR at ORNL for 2014 through 2019 (ORNL, 2020n) shows that the average mixing heights vary from an average of 376 m (1233 ft.) at 6 am to 1931 m (6334 ft.) at 5 pm local daylight time. Again, accounting for the relatively small (17 m) (56 ft.) difference in grade elevation between the HCS and the SODAR, the magnitudes of the hourly average mixing heights measured at ORNL suggest that there is, on the average, sufficient vertical depth for mixing an emitted or entrained non-buoyant plume.

Another SODAR was installed more recently at Y-12, approximately 7.6 mi. (12.2 km) northeast of the HCS (Figure 3.6-5). The grade elevation of this SODAR is approximately 281 m (922 ft.) MSL. Data are available for 2019 from ORNL, 2020o. Although the data are available for only

one year, they provide context for the longer records from the SODAR at ORNL described above.

Table 3.6-41 shows average monthly and annual mixing heights measured from the Y-12 SODAR during 2019 (ORNL, 2020o). Average mixing heights are lowest in the winter months (440 m [1443 ft.] AGL in January). Average mixing heights are the highest in summer (1170 m [3838 ft.] AGL in June). The average annual mixing height is 813 m (2667 ft.) AGL.

The approximate grade elevation of the HCS is approximately 244 m [800 ft.] MSL. Accounting for the relatively small (37 m [121 ft.]) difference in grade elevation between the HCS and the Y-12 SODAR (281 m - 244 m = 37 m), the magnitudes of the monthly average mixing heights suggest that there is, on the average, sufficient vertical depth through which an emitted or entrained non-buoyant plume could potentially be mixed, especially during the summer months when the mixing heights are the greatest.

A climatology of hourly mixing heights from the SODAR at Y-12 for 2019 (ORNL, 2020o) shows that the average mixing heights vary from an average of 355 m (1164 ft.) at 6 am – 7 am to 1932 m (6337 ft.) at 5 pm local daylight time. Accounting for the relatively small (37 m [121 ft.] difference in grade elevation between the HCS and the SODAR, the magnitudes of the hourly average mixing heights measured at Y-12 suggest that there is, on the average, sufficient vertical depth for mixing an emitted or entrained non-buoyant plume.

3.6.1.6 Description of the Local Topography

A topographic map of the local area around the HCS is shown in Figure 3.6-20. The HCS is located approximately 0.5 mi. (0.8 km) southeast of a northeast-southwest oriented ridge — one of a number of such ridges that punctuates the terrain in the Tennessee River Valley between the Cumberland and Smoky Mountains. The ridge extends southwest of the HCS well into Roane County and northeast of the site into Anderson County, Tennessee. The ridge tops reach approximately 1100 ft. (335 m) MSL within approximately 1.0 mi. (1.6 km) of the HCS. Another northeast-southwest oriented ridge (McKinney Ridge) is located approximately 1.0 mi. (1.6 km) south of the HCS. The ridge tops extend to approximately 1100 ft. (335 m) MSL.

3.6.2 AIR QUALITY

3.6.2.1 Ambient Air Quality Standards

The Clean Air Act requires the USEPA to set NAAQS for pollutants considered harmful to public health and the environment.

The Clean Air Act identifies two types of national ambient air quality standards. Primary NAAQS provide public health protection, including protecting the health of sensitive populations such as asthmatics, children, and the elderly. Secondary NAAQS provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings (USEPA, 2021a).

The USEPA has specified NAAQS for six principal pollutants, which are called criteria pollutants. The criteria pollutants and their respective NAAQS are listed in listed in Table 3.6-42 (USEPA, 2021a).

NAAQS maintenance areas are those geographical areas that have a history of non-attainment with a particular NAAQS but are currently meeting that NAAQS. Anderson, Knox, Loudon and Roane counties were in non-attainment for the 24-hour $PM_{2.5}$ NAAQS in the past. Anderson, Knox and Loudon counties were in non-attainment for a 1997 8-hour ozone (O_3) standard that was revoked and replaced with an 8-hour O_3 standard in 2008 which kept Anderson and Knox counties in non-attainment. Later, Anderson and Knox counties were re-designated as being in maintenance for the 2008 8-hour O_3 NAAQS on August 12, 2015. Anderson, Knox, Loudon and Roane were re-designated as being in maintenance for the 24-hour $PM_{2.5}$ NAAQS on September 27, 2017. The attainment status of Anderson Knox, Loudon and Roane counties with respect to current NAAQS as of December 31, 2021 is listed in Table 3.6-43 (USEPA, 2021b).

3.6.2.2 Regional Air Quality

Roane County, Tennessee is part of the Eastern Tennessee-Southwestern Virginia Interstate Air Quality Control Region (USEPA, 1971). Air quality monitors measure concentrations of criteria pollutants to demonstrate attainment with the respective NAAQS. Table 3.6-44 through Table 3.6-50 show comparisons of measured concentrations from the nearest air quality monitors to the HCS with the respective NAAQS for 2017-2020 (USEPA, 2021c).

All of the air quality monitors are located in Anderson, Knox, Loudon or Roane counties, with exception of the carbon monoxide (CO) and nitrogen dioxide (NO_2) monitors. The nearest CO and NO_2 monitors are located south of the HCS in rural Blount County, Tennessee. In addition, sulfur dioxide (SO_2) data for the year 2020 were not available for Anderson, Knox, Loudon or Roane counties. Table 3.6-44 through Table 3.6-50 show that all of measured concentrations are below (better than) the respective NAAQS.

The nearest county to the HCS that is not in attainment with one or more NAAQS is Sullivan County, Tennessee. A portion of Sullivan County is in non-attainment for the 1-hr SO_2 NAAQS as of December 31, 2021 (USEPA, 2021b). Sullivan County is located approximately 100 mi. (161 km) northeast of the HCS in far northeastern Tennessee along the Virginia border.

Criteria pollutant emissions aggregated at the county level from USEPA, 2017 are provided for reference in Table 3.6-51.

3.6.2.3 Class I Areas

Class I areas are national parks and wilderness areas that are potentially sensitive to visibility impairment. U.S. EPA guidance (USEPA, 1990) states that a Class I visibility impact analysis is necessary for a major source locating within 100 km (62 mi.) of a Class I area.

Table 3.6-52 lists the nearest Mandatory (Federal) or American Indian Class I areas to the HCS (USEPA, 2022 and NPS, 2022). The table shows that the nearest Class I area is the Great Smoky Mountains National Park, Tennessee/North Carolina which is located approximately 54 km (34 mi.) southeast of the HCS.

Table 3.6-1
Climatological Normals (1981 – 2010) and Means — Oak Ridge, TN (KOQT)

Parameter	POR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Normal daily max. temperature (°F)	30	46.6	51.9	61.4	70.6	78.3	85.7	88.4	88.0	81.7	71.1	59.6	49.6	69.4
Normal daily min. temperature (°F)	30	28.9	31.7	39.3	46.9	55.2	64.5	68.6	67.2	59.7	48.0	38.3	31.1	48.3
Normal dry bulb temperature (°F)	30	37.7	41.8	50.4	58.8	66.8	75.1	78.5	77.6	70.7	59.5	48.9	40.3	58.8
Normal humidity (%)		-	-	-	-	-	-	-	-	-	-	-	-	-
Mean wind speed (mph)	20	3.3	3.6	3.9	3.7	2.8	2.6	2.4	2.1	1.9	2.1	2.4	2.8	2.8
Prevailing wind direction (tens of degrees)	21	22	05	05	22	22	21	21	06	06	06	05	22	05
Normal liquid equivalent precipitation (in.)	30	4.54	4.57	5.06	4.18	4.29	4.28	5.27	2.76	3.69	2.92	4.49	4.86	50.91
Average snowfall (in.)[a]	35	1.9	2.1	0.5	0.2	Trace	0.0	0.0	0.0	0.0	Trace	0.1	1.5	5.9

a) Snowfall statistics unavailable from NCEI, 2020a. Average snowfall statistics for 1985-2019 from Oak Ridge extracted from ORNL, 2020i

Table 3.6-2
Climatological Normals (1981 – 2010) and Means — Knoxville, TN (KTYS)

Parameter	POR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Normal daily max. temperature (°F)	30	47.3	52.3	61.4	70.3	78.1	85.4	88.2	87.8	81.8	71.2	60.4	49.8	69.5
Normal daily min. temperature (°F)	30	29.2	32.4	39.2	47.3	56.2	64.7	68.7	67.8	60.4	48.5	39.0	31.7	48.8
Normal dry bulb temperature (°F)	30	38.2	42.4	50.3	58.8	67.2	75.0	78.4	77.8	71.1	59.9	49.7	40.8	59.1
Normal humidity (%)	30	74	70	66	65	73	75	75	76	75	75	74	75	73
Mean wind speed (mph)	36	6.7	7.1	7.3	7.2	6.2	5.6	5.4	4.8	4.8	5.0	5.5	6.1	6.0
Prevailing wind direction (tens of degrees)	46	24	24	24	24	24	24	24	24	05	05	03	24	24
Normal liquid equivalent precipitation (in.)	30	4.32	4.26	4.34	4.01	4.51	3.81	5.08	3.27	3.24	2.51	4.01	4.50	47.86
Normal snowfall (in.)	30	2.7	1.6	0.9	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	6.5

Table 3.6-3
(Sheet 1 of 2)
Locations of ASOS and COOP Weather Observing Stations and Supplemental Data Sources from ORR

Label (Figure 3.6-5)	Station	Type	County	Latitude (deg.)	Long. (deg.)	Elev. (m, MSL)	Period of Record
1	Clinton 2 NW	COOP	Anderson	36.1333	-84.1500	302.1	1961 – 1962
2	Clinton 4.3 SSW	COOP	Anderson	36.0312	-84.1500	274.3	2007 – 2016
3	Clinton 4.9 S	COOP	Anderson	36.0199	-84.1255	249.0	2012 – 2020
4	Clinton	COOP	Anderson	36.1000	-84.1000	259.1	1883 – 1962
5	Concord	COOP	Knox	35.9000	-84.1833	305.1	1949 – 1962
6	Farragut 1.0 WNW	COOP	Knox	35.8819	-84.1971	297.2	2000 – 2019
7	Farragut 2.3 NE	COOP	Knox	35.8969	-84.1511	310.3	2007 – 2020
8	Farragut 2.8 ENE	COOP	Knox	35.8876	-84.1352	324.9	2012 – 2020
9	Fountain City	COOP	Knox	36.0333	-83.9333	296.0	1949 – 1953
10	Greenback 2.1 ENE	COOP	Loudon	35.6672	-84.1423	275.8	2015 – 2020
11	Halls Northern Knox	COOP	Knox	36.1109	-83.9205	368.8	2007 – 2009
12	Harriman	COOP	Roane	35.9333	-84.5500	235.0	1893 – 1962
13	Harriman 4.5 SW	COOP	Roane	35.8843	-84.6149	230.4	2007 – 2020
14	Karns 0.6 SSE	COOP	Knox	35.9678	-84.1124	313.9	2007 – 2011
15	Kingston	COOP	Roane	35.8572	-84.5281	248.1	1884 – 2020
16	Kingston Steam Plant	COOP	Roane	35.9000	-84.5167	232.0	1951 – 1962
17	Knoxville Airport	ASOS	Blount	35.8181	-83.9858	293.2	1910 – 2020
18	Knoxville 0.8 ESE	COOP	Knox	35.9709	-83.9335	285.0	2018 – 2019
19	Knoxville 10.6 WSW	COOP	Knox	35.9400	-84.1306	303.6	2019 – 2020
20	Knoxville 3.1 WNW	COOP	Knox	35.9961	-83.9944	311.5	2015 – 2020
21	Knoxville 3.5 WSW	COOP	Knox	35.9523	-84.0019	337.7	2019 – 2020
22	Knoxville 4.5 NNW	COOP	Knox	36.0344	-83.9793	325.8	2007 – 2016
23	Knoxville 4.6 SW	COOP	Knox	35.9339	-84.0125	285.6	2013 – 2016
24	Knoxville 5.5 W	COOP	Knox	35.9831	-84.0442	398.1	2007 – 2020
25	Knoxville 5.7 NNW	COOP	Knox	36.0512	-83.9862	309.4	2013 – 2020
26	Knoxville 6.2 SSW	COOP	Knox	35.8875	-83.9755	282.2	2007 – 2013
27	Knoxville 8.0 WSW	COOP	Knox	35.9168	-84.0693	310.0	2014 – 2018
28	Knoxville Exp. Station	COOP	Knox	35.8984	-83.9569	253.0	1966 – 2020
29	Knoxville Garage	COOP	Knox	35.9833	-83.9167	281.0	1949 – 1953
30	Knoxville Univ. of TN	COOP	Knox	35.9500	-83.9167	272.8	1943 – 1982
31	Knoxville	COOP	Knox	35.9667	-83.9167	296.0	1948 – 1951
32	Lake City	COOP	Anderson	36.2333	-84.1667	262.1	1949 – 1950
33	Lenoir City 3.1 NE	COOP	Loudon	35.8266	-84.2251	260.9	2007 – 2015
34	Lenoir City TN [a]	COOP	Loudon	35.8400	-84.3308	378.0	2003 – 2020
35	Lenoir City [b]	COOP	Loudon	35.8000	-84.2500	249.9	1948 – 1962
36	Lenoir City [c]	COOP	Loudon	35.7875	-84.2622	239.3	1962 – 2020
37	Loudon 1 E	COOP	Loudon	35.7333	-84.3333	244.1	1885 – 1962
38	Loudon 5.3 E	COOP	Loudon	35.7490	-84.2650	260.9	2015 – 2020
39	Mascot 1.4 NNE	COOP	Knox	36.0865	-83.7559	309.1	2007 – 2020
40	McGhee 2 SE	COOP	Loudon	35.6167	-84.2167	259.1	1927 – 1949
41	McGhee	COOP	Loudon	35.6167	-84.2167	246.9	1904 – 1962
42	Melton Hill Dam	COOP	Loudon	35.8833	-84.3000	238.0	1961 – 1962

a) Cooperative observer station identifier USR0000TWES
b) Cooperative observer station identifier USC00403229
c) Cooperative observer station identifier USC00403158

Table 3.6-3
(Sheet 2 of 2)
Locations of ASOS and COOP Weather Observing Stations and Supplemental Data Sources from ORR

Label (Figure 3.6-5)	Station	Type	County	Latitude (deg.)	Long. (deg.)	Elev. (m, MSL)	Period of Record
43	Norris 0.6 NW	COOP	Anderson	36.1997	-84.0765	353.0	2007 – 2020
44	Norris Dam	COOP	Anderson	36.2167	-84.0833	267.9	1949 – 1970
45	Norris Evap. Station	COOP	Anderson	36.2000	-84.0833	305.1	1948 – 1953
46	Norris	COOP	Anderson	36.2130	-84.0602	338.3	1935 – 2020
47	Oak Ridge	COOP	Roane	35.9333	-84.3167	271.0	1947 – 1964
48	Oak Ridge 3.0 NW	COOP	Roane	35.9966	-84.3291	328.0	2013 – 2016
49	Oak Ridge 3.3 NNW	COOP	Anderson	36.0083	-84.3112	360.0	2007 – 2009
50	Oak Ridge 5.4 NE	COOP	Anderson	36.0182	-84.2280	263.0	2018 – 2020
51	Oak Ridge 5.7 NE [d]	COOP	Anderson	36.0191	-84.2211	270.1	2007 – 2020
52	Oak Ridge 5.7 NE [e]	COOP	Anderson	36.0212	-84.2234	260.3	2009 – 2020
53	Oak Ridge 6.9 NNE	COOP	Anderson	36.0462	-84.2298	327.1	2010 – 2011
54	Oak Ridge 8.1 ENE	COOP	Anderson	36.0246	-84.1742	269.4	2019 – 2020
55	Oak Ridge ASOS	ASOS	Anderson	36.0230	-84.2337	274.3	1998 – 2020
56	Oak Ridge ATDD [f]	Other	Anderson	35.9980	-84.2192	310.6	1948 – 2020
57	Oliver Springs 5.6 SW	COOP	Roane	35.9695	-84.3855	256.0	2008 – 2020
58	Philadelphia 2.5 SE	COOP	Loudon	35.6540	-84.3686	329.8	2008 – 2010
59	Powell 1.3 NNW	COOP	Knox	36.0509	-84.0373	376.1	2007 – 2008
60	Powell	COOP	Knox	36.0333	-84.0333	323.1	1961 – 1962
61	Riddles Store	COOP	Loudon	35.6167	-84.5333	310.9	1949 – 1962
62	Ritta	COOP	Knox	36.0500	-83.8667	313.9	1949 – 1962
63	Rockwood 0.6 WSW	COOP	Roane	35.8702	-84.6839	277.1	2007 – 2008
64	Rockwood 2	COOP	Roane	35.8360	-84.6920	233.8	1962 – 2020
65	Rockwood	COOP	Roane	35.8667	-84.6833	278.0	1884 – 1962
66	Strawberry Plains	COOP	Jefferson	36.0667	-83.6833	264.9	1885 – 1962
67	U S Cotton Field Station	COOP	Knox	35.8833	-83.9333	271.0	1949 – 1962
68	Univ. of TN Farm	COOP	Knox	35.9500	-83.9500	244.1	1949 – 1956
69	Univ. of TN Lysimeter	COOP	Knox	35.9500	-83.9500	259.1	1949 – 1962
70	Whittle Springs	COOP	Knox	36.0167	-83.9167	326.1	1949 – 1953
	Supplemental Data Sources from ORR						
71	SODAR / Tower D / MT2 - ORNL	-	Roane	35.9256	-84.3238	261	-
72	SODAR - Y-12	-	Anderson	35.9930	-84.2407	281	-
73	Tower W / MT6 - Y-12	-	Anderson	35.9806	-84.2736	326	-

d) Cooperative observer station identifier US1TNAN0003
e) Cooperative observer station identifier US1TNAN0009
f) "ATDD" is the NOAA Atmospheric Turbulence and Diffusion Division.

Table 3.6-4
Fujita Scale and Enhanced Fujita Scales to Determine Tornado Intensity

F number	Fastest 1/4-mi (mi/hr)	3-s gust (mi/hr)	EF number	3-s gust (mi/hr)
0	40 - 72	45 - 78	0	65 - 85
1	73 - 112	79 - 117	1	86 - 110
2	113 -157	118 - 161	2	111 - 135
3	158 - 207	162 - 209	3	136- 165
4	208 - 260	210 - 261	4	166 - 200
5	261 - 318	262 - 317	5	over 200

Table 3.6-5
Documented Tornadoes in Anderson, Knox, Loudon and Roane Counties, TN (1950 – 2020)

	Tornado Intensity					
County	**F0/EF0**	**F1/EF1**	**F2/EF2**	**F3/EF3**	**F4/EF4**	**F5/EF5**
Anderson	1	1	2	1	0	0
Knox	7	5	3	1	0	0
Loudon	2	3	3	1	0	0
Roane	3	1	0	1	0	0
Total	13	10	8	4	0	0

Table 3.6-6

Not Used

Table 3.6-7
Monthly and Annual Thunderstorm Days Oak Ridge National Laboratory (2001 – 2019)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average	0.9	1.3	2.9	4.8	6.1	8.6	10.7	6.3	3.0	1.7	1.2	1.0	48.5
Maximum	5	4	10	10	10	13	16	10	5	4	4	3	65
Minimum	0	0	1	2	1	4	5	2	0	0	0	0	34

Table 3.6-8
Monthly and Annual Thunderstorm Days Knoxville Airport (1948 – 2019)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average	0.9	1.4	3.3	4.6	6.8	8.6	10.1	6.9	3.1	1.3	1.0	0.8	48.8

Table 3.6-9
Computed Lightning Strike Density at Oak Ridge and Knoxville, Tennessee

Station	Thunderstorm Days	Period of Record	Computed Number of Lightning Strikes per sq. mi.
Knoxville Airport (KTYS)	48.8	1948-2019	15.1
Oak Ridge (ORNL)	48.5	2001-2019	15.0

Table 3.6-10
Summary of Observed Hail in Anderson, Knox, Loudon and Roane Counties, Tennessee (1950 – 2020)

Hail Diameter (in.)	Number of Events
≤ 1.0 in.	243
1 ≤ 2.0 in.	68
2 ≤ 3.0 in.	10
> 3 in.	2
Total	323

Table 3.6-11
Average and Monthly Maximum Snowfall Oak Ridge, TN (1947 – 2019)

Month [a,b,c]	POR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average (in.)	35	1.9	2.1	0.5	0.2	Trace	0.0	0.0	0.0	0.0	Trace	0.1	1.5	5.9
Maximum Monthly (in.)	72	9.6	17.2	21.0	5.9	Trace	Trace	Trace	Trace	0.0	Trace	6.5	14.8	21.0
Year		1966	1979	1960	1987	1993	1998	1993	1990		1993	1950	1963	1960
Maximum 24-hr. Snowfall (in.)	72	8.3	11.3	12.0	5.4	Trace	Trace	Trace	Trace	0.0	Trace	6.5	10.8	12.0
Year		1962	1996	1960	1987	1993	1998	1993	1990		1993	1950	1963	1960

a) Monthly and annual average snowfall statistics for 1985-2019 (35 years) extracted from ORNL, 2020i.
b) Monthly maximum and maximum 24-hr. snowfall statistics from NCEI, 2020a and NCEI, 1999. The combined period of record covered by NCEI, 2020a and NCEI, 1999 is 1947-2019 (72 years).
c) Snowfall data comprise all forms of frozen precipitation, including hail. Thus, a trace of “snow” can be recorded during the warm season.

Table 3.6-12
Normal and Monthly Snowfall Knoxville Airport (1944 – 2019)

Month [a,b]	POR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Normal (in.)	30	2.7	1.6	0.9	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.8	6.5
Maximum Monthly (in.)	75	15.1	23.3	20.2	10.7	Trace	Trace	Trace	Trace	Trace	Trace	18.2	12.2	23.3
Year		1962	1960	1960	1987	2017	2015	2016	1995	2006	2017	1952	1963	1960
Maximum 24-hr. Snowfall (in.)	75	12.0	17.5	14.1	10.7	Trace	Trace	Trace	Trace	Trace	Trace	18.2	8.9	18.2
Year		1962	1960	1993	1987	2017	2015	2016	1995	2006	2017	1952	1969	1952

a) Snowfall statistics from NCEI, 2020b. Period of record (POR) reported in NCEI, 2020b is 30 years for the normal snowfall and 75 years for the monthly maximum snowfall and the maximum 24-hr. snowfall.
b) Snowfall data comprise all forms of frozen precipitation, including hail. Thus, a trace of “snow” can be recorded during the warm season.

Table 3.6-13
Freezing Rain Days at Oak Ridge
(1999 – 2019)

Year	Number of days	Year	Number of days	Year	Number of days
1999	0	2009	0	2019	0
2000	2	2010	5		
2001	0	2011	1		
2002	3	2012	0		
2003	0	2013	3		
2004	0	2014	1		
2005	5	2015	3		
2006	0	2016	2		
2007	0	2017	0		
2008	1	2018	2		

Average: 1.3

Table 3.6-14
Number of Days with Heavy Fog at Oak Ridge (KOQT), Tennessee (2000 – 2019)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average	2.0	1.6	1.3	2.1	4.4	4.0	5.1	4.8	6.9	7.4	4.9	3.5	48.0

Table 3.6-15
Number of Days with Heavy Fog at Knoxville Airport (1964 – 2019)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average	2.4	1.7	1.5	1.2	2.1	1.7	1.9	3.0	3.4	3.8	2.6	2.3	27.6

Table 3.6-16
(Sheet 1 of 2)
Maximum Daily Liquid Equivalent Precipitation and Snowfall from ASOS and COOP Stations

Observing Station [a]	Max. Daily Liquid Equiv. Precip. (in.)	Max. Daily Snowfall (in.)	Max. Monthly Snowfall (in.)
Clinton 2 NW [b]	2.74	N/A	N/A
Clinton 4.3 SSW [b]	2.04	0.1	0.1
Clinton 4.9 S [b]	2.75	0.0	0.0
Clinton	6.00	8.5	22.0
Concord	3.24	6.0	6.0
Farragut 1.0 WNW [b]	4.82	2.2	N/A
Farragut 2.3 NE [b]	6.05	7.0	N/A
Farragut 2.8 ENE [b]	5.99	5.6	N/A
Fountain City	3.33	6.5	6.5
Greenback 2.1 ENE [b]	4.94	0.1	N/A
Halls Northern Knox [b]	2.15	0.0	0.0
Harriman [c]	4.50	7.0	11.0
Harriman 4.5 SW	6.30	6.0	11.0
Karns 0.6 SSE [b]	5.02	0.0	0.0
Kingston	7.03	10.5	19.0
Kingston Steam Plant	3.70	N/A	N/A
Knoxville Airport [d]	6.14	**17.5**	**23.3**
Knoxville 0.8 ESE [b]	2.56	N/A	N/A
Knoxville 10.6 WSW [b]	4.44	1.0	N/A
Knoxville 3.1 WNW [b]	4.70	1.0	N/A
Knoxville 3.5 WSW [b]	3.02	1.3	N/A
Knoxville 4.5 NNW [b]	6.25	2.0	N/A
Knoxville 4.6 SW [b]	2.80	6.0	N/A
Knoxville 5.5 W	6.56	6.6	12.6
Knoxville 5.7 NNW	4.45	5.5	7.8
Knoxville 6.2 SSW	6.04	2.9	5.6
Knoxville 8.0 WSW	3.39	4.4	N/A
Knoxville Exp. Station	6.66	7.4	10.8
Knoxville Garage	3.73	5.8	5.8
Knoxville Univ. of TN	6.09	9.2	16.4
Knoxville [b]	4.60	0.0	0.0
Lake City	2.99	2.0	2.0
Lenoir City 3.1 NE [b]	5.22	1.5	N/A
Lenoir City TN	N/A	N/A	N/A
Lenoir City	4.15	4.2	5.2
Lenoir City	6.12	10.0	17.2
Loudon 1 E	5.61	9.5	17.8
Loudon 5.3 E [b]	4.39	2.3	N/A

a) Maximum values of the respective parameter are in bold front. “N/A”: Not available.
b) Partial snowfall records available
c) No data from 1/1/1912 - 8/31/1948. No snowfall data available after 1/21/1950.
d) Maximum monthly snowfall also listed in NCEI, 2020b. Maximum daily snowfall occurred in February, 1960 (NCEI, 1960c). This event also set the record for the maximum 24-hour snowfall in February at Knoxville (NCEI, 2020b).

Table 3.6-16
(Sheet 2 of 2)
Maximum Daily Liquid Equivalent Precipitation and Snowfall from ASOS and COOP Stations

Observing Station	Max. Daily Liquid Equiv. Precip. (in.)	Max. Daily Snowfall (in.)	Max. Monthly Snowfall (in.)
Mascot 1.4 NNE	5.88	5.0	6.4
McGhee 2 SE	4.51	10.1	13.8
McGhee	4.78	6.9	12.9
Melton Hill Dam	2.81	N/A	N/A
Norris 0.6 NW [b]	5.18	11.0	N/A
Norris Dam	7.03	5.0	10.5
Norris Evap. Station [b]	3.50	0.0	0.0
Norris	6.70	11.0	14.6
Oak Ridge	4.22	7.5	10.5
Oak Ridge 3.0 NW [b]	3.12	7.4	N/A
Oak Ridge 3.3 NNW [b]	2.48	1.2	N/A
Oak Ridge 5.4 NE [b]	5.10	2.0	N/A
Oak Ridge 5.7 NE [b]	6.35	8.6	N/A
Oak Ridge 5.7 NE [b]	6.44	9.7	N/A
Oak Ridge 6.9 NNE [b]	5.09	0.0	N/A
Oak Ridge 8.1 ENE [b]	4.72	0.7	N/A
Oak Ridge ASOS [b]	6.30	1.0	1.5
Oak Ridge ATDD [e]	**7.45**	12.0	21.1
Oliver Springs 5.6 SW	5.86	6.0	7.2
Philadelphia 2.5 SE	3.27	N/A	N/A
Powell 1.3 NNW [b]	1.44	0.0	N/A
Powell	2.71	0.0	0.0
Riddles store	4.00	6.0	9.0
Ritta	3.33	5.0	5.0
Rockwood 0.6 WSW	2.44	0.0	0.0
Rockwood 2	6.79	14.0	14.0
Rockwood	5.65	8.0	12.0
Strawberry Plains [b]	3.40	6.0	20.0
U S Cotton Field Station[b]	3.91	0.0	N/A
Univ. of TN Farm [b]	3.75	0.0	0.0
Univ. of TN Lysimeter [b]	3.73	0.0	0.0
Whittle Springs	3.40	6.0	6.0

e) The corresponding maximum 24-hour liquid equivalent precipitation reported in NCEI, 2020a is (7.48 in. [19.0 cm]).

Table 3.6-17
Design Dry- and Wet- Bulb Temperatures and Bounding Values

	Dry Bulb Temperature (°F)		Dry Bulb/Mean Coincident Wet Bulb Temperature (°F)		
Station	**99.6%**	**99.0%**	**0.4%**	**1%**	**2%**
Knoxville (KTYS)	17.1	21.6	92.7 / 73.9	90.4 / 73.5	88.3 / 72.9
Oak Ridge (KOQT)	17.1	21.2	92.8 / 73.8	90.7 / 73.5	88.5 / 72.7
Bounding values	17.1	21.2	92.8 / 73.8	90.7 / 73.5	88.5 / 72.7

Table 3.6-18
Computed 100-Year Return Interval Extreme Temperatures at Knoxville, Tennessee

	Means and Standard Deviations of Extreme Annual Temperatures (°F) at Knoxville (KTYS) (from ASHRAE, 2017)				Computed 100-Year Return Interval Extreme Temperatures (°F)	
	Mean (M)		Std. Deviation (s)			
	Min.	Max.	Min.	Max.	Min.	Max
Dry Bulb	10.1	95.2	6.2	3.6	-9.3	106.5
Wet Bulb	8.8	78.6	5.9	1.2	-9.7	82.4

Table 3.6-19
Computed 100-Year Return Interval Extreme Temperatures at Oak Ridge, Tennessee

	Means and Standard Deviations of Extreme Annual Temperatures (°F) at Oak Ridge (KOQT) (from ASHRAE, 2017)				**Computed 100-Year Return Interval Extreme Temperatures (°F)**	
	Mean (M)		Std. Deviation (s)			
	Min.	Max.	Min.	Max.	Min.	Max
Dry Bulb	11.4	95.7	4.7	3.7	-3.3	107.3
Wet Bulb	9.8	78.6	4.4	1.3	-4.0	82.7

Table 3.6-20
Bounding Values for the Computed 100-Year Return Interval Extreme Temperatures

	Min.	Max
Dry Bulb (°F)	-9.3	107.3
Wet Bulb (°F)	-9.7	82.7

Table 3.6-21
(Sheet 1 of 2)
Daily Maximum and Minimum Dry Bulb Temperatures from Local ASOS and COOP Stations

Observing Station [a]	Daily Dry Bulb Temperature (°F) Max.	Min.
Clinton 2 NW	N/A	N/A
Clinton 4.3 SSW	N/A	N/A
Clinton 4.9 S	N/A	N/A
Clinton	N/A	N/A
Concord	N/A	N/A
Farragut 1.0 WNW	N/A	N/A
Farragut 2.3 NE	N/A	N/A
Farragut 2.8 ENE	N/A	N/A
Fountain City	N/A	N/A
Greenback 2.1 ENE	N/A	N/A
Halls Northern Knox	N/A	N/A
Harriman [b]	104	-12
Harriman 4.5 SW	N/A	N/A
Karns 0.6 SSE	N/A	N/A
Kingston [c]	106	0
Kingston Steam Plant	N/A	N/A
Knoxville Airport [d]	105	**-24**
Knoxville 0.8 ESE	N/A	N/A
Knoxville 10.6 WSW	N/A	N/A
Knoxville 3.1 WNW	N/A	N/A
Knoxville 3.5 WSW	N/A	N/A
Knoxville 4.5 NNW	N/A	N/A
Knoxville 4.6 SW	N/A	N/A
Knoxville 5.5 W	N/A	N/A
Knoxville 5.7 NNW	N/A	N/A
Knoxville 6.2 SSW	N/A	N/A
Knoxville 8.0 WSW	N/A	N/A
Knoxville Exp. Station [e]	105	-20
Knoxville Garage	N/A	N/A
Knoxville Univ. of TN	105	-8
Knoxville	N/A	N/A
Lake City	N/A	N/A
Lenoir City 3.1 NE	N/A	N/A
Lenoir City TN	105	-2

a) Regional maximum and minimum values of the respective parameter are in bold front. “N/A”: Not available.
b) Temperature data available for 1893 - 1911. No data from 1/1/1912 - 8/31/1948.
c) Temperature data available for 2000-2020
d) Values also found in NCEI, 2020b
e) Partial temperature records are available.

Table 3.6-21
(Sheet 2 of 2)
Daily Maximum and Minimum Dry Bulb Temperatures from Local ASOS and COOP Stations

Observing Station	Daily Dry Bulb Temperature (°F) Max.	Min.
Lenoir City	N/A	N/A
Lenoir City	106	-14
Loudon 1 E [f]	**108**	-9
Loudon 5.3 E	N/A	N/A
Mascot 1.4 NNE	N/A	N/A
McGhee 2 SE	N/A	N/A
McGhee [e]	90	0
Melton Hill Dam	N/A	N/A
Norris 0.6 NW	N/A	N/A
Norris Dam	N/A	N/A
Norris Evap. Station [e]	103	2
Norris	105	-19
Oak Ridge	103	-8
Oak Ridge 3.0 NW	N/A	N/A
Oak Ridge 3.3 NNW	N/A	N/A
Oak Ridge 5.4 NE	N/A	N/A
Oak Ridge 5.7 NE	N/A	N/A
Oak Ridge 5.7 NE	N/A	N/A
Oak Ridge 6.9 NNE	N/A	N/A
Oak Ridge 8.1 ENE	N/A	N/A
Oak Ridge ASOS	105	1
Oak Ridge ATDD	105	-17
Oliver Springs 5.6 SW	N/A	N/A
Philadelphia 2.5 SE	N/A	N/A
Powell 1.3 NNW	N/A	N/A
Powell	N/A	N/A
Riddles store	N/A	N/A
Ritta	N/A	N/A
Rockwood 0.6 WSW	N/A	N/A
Rockwood 2 [g]	107	-12
Rockwood	N/A	N/A
Strawberry Plains	N/A	N/A
U S Cotton Field Station	N/A	N/A
Univ. of TN Farm	N/A	N/A
Univ. of TN Lysimeter	N/A	N/A
Whittle Springs	N/A	N/A

f) Temperature data available 6/21/1913 – 6/30/1962
g) Temperature data available for 1962 – 2012

Table 3.6-22
Annual Joint Data Recovery of 15-m Wind Speed, Wind Direction and Pasquill Stability Class from Tower D (2016 – 2020)

Year	Data Recovery (%)
2016	100.00
2017	100.00
2018	99.95
2019	100.00
2020	99.99

Table 3.6-23
Annual Summary of Dry Bulb Temperature, Relative Humidity, Wind Speed and Precipitation from Tower D for 2016

	Dry Bulb Temperature (°F)			Dew Point (°F)			Relative Humidity (%)	Wind Speed (mph)		Liquid Equiv. Precip. (in.)	Hours with Measurable Precip.	Max. 1-hour Liquid Equivalent (in.)
Month	Maximum	Minimum	Average	Maximum	Minimum	Average	Average	Maximum	Average	Total		
January	62.8	11.3	35.4	48.6	-7.2	23.7	66.0	12.3	2.8	3.59	67	0.38
February	73.0	19.4	42.2	60.4	-2.9	29.9	66.2	14.8	3.5	6.06	94	0.43
March	80.4	29.5	55.3	61.3	10.6	39.5	61.4	11.4	3.5	2.94	49	0.44
April	83.8	33.1	60.5	64.2	8.2	41.3	55.0	14.8	3.4	3.29	31	0.90
May	86.4	37.8	65.3	68.5	27.9	53.8	71.1	8.5	2.6	2.85	43	0.54
June	91.6	54.9	75.2	73.8	44.8	62.8	70.5	8.5	2.3	4.61	29	1.23
July	92.7	60.1	77.8	74.1	55.0	68.2	76.7	9.6	2.3	3.67	30	0.65
August	92.3	61.9	78.2	74.3	54.7	68.2	76.1	10.3	2.3	2.41	24	0.78
September	92.3	46.6	73.8	69.6	39.9	59.0	65.3	8.5	2.1	1.38	13	0.49
October	86.2	36.1	64.0	63.5	28.4	49.0	62.9	9.4	2.3	0.07	4	0.03
November	82.8	25.0	52.2	65.3	8.4	37.1	61.2	11.4	2.2	4.77	32	1.04
December	69.6	19.0	41.6	62.2	-5.3	31.7	71.5	13.0	2.8	7.35	101	0.40

Table 3.6-24
Annual Summary of Dry Bulb Temperature, Relative Humidity, Wind Speed and Precipitation from Tower D for 2017

	Dry Bulb Temperature (°F)			Dew Point (°F)			Relative Humidity (%)	Wind Speed (mph)		Liquid Equiv. Precip. (in.)	Hours with Measurable Precip.	Max. 1-hour Liquid Equivalent (in.)
Month	Maximum	Minimum	Average	Maximum	Minimum	Average	Average	Maximum	Average	Total		
January	66.9	8.2	46.0	61.5	-2.0	37.2	74.8	11.4	3.2	4.08	94	0.63
February	76.8	23.4	48.4	60.6	0.7	34.0	63.4	12.1	2.8	2.69	40	0.44
March	81.0	20.7	51.7	62.2	2.1	33.3	55.2	11.6	3.5	4.83	53	0.67
April	87.3	36.7	64.2	66.9	17.6	49.6	65.6	11.4	3.4	9.66	79	0.96
May	87.3	41.2	66.2	72.0	31.5	55.4	73.4	13.0	3.0	4.56	60	0.45
June	87.1	53.6	71.7	72.7	44.2	61.9	76.0	10.1	2.4	4.22	53	0.37
July	91.6	61.3	76.3	76.1	52.2	67.9	79.9	7.2	2.1	5.07	42	1.03
August	89.1	58.6	74.0	76.1	49.5	65.8	80.0	6.9	2.1	5.54	49	1.45
September	86.4	47.7	67.7	74.5	40.6	59.8	80.2	10.5	2.4	4.45	39	0.92
October	83.8	29.1	59.8	76.5	26.4	51.8	79.8	9.4	2.2	5.54	54	0.69
November	74.5	27.5	50.1	68.2	16.7	41.0	75.1	11.6	2.2	3.06	24	0.56
December	66.4	17.2	40.4	63.1	-1.5	29.6	69.0	13.0	3.0	3.89	53	0.39

Table 3.6-25
Annual Summary of Dry Bulb Temperature, Relative Humidity, Wind Speed and Precipitation from Tower D for 2018

	Dry Bulb Temperature (°F)			Dew Point (°F)			Relative Humidity (%)	Wind Speed (mph)		Liquid Equiv. Precip. (in.)	Hours with Measurable Precip.	Max. 1-hour Liquid Equivalent (in.)
Month	Maximum	Minimum	Average	Maximum	Minimum	Average	Average	Maximum	Average	Total	Total	
January	66.0	4.1	33.8	56.5	-5.1	21.4	64.6	10.7	2.4	1.91	52	0.13
February	78.3	21.0	49.8	65.7	3.4	42.7	80.5	11.0	3.1	9.57	117	0.42
March	75.2	25.2	48.5	58.5	5.9	33.8	62.7	12.1	3.8	4.46	64	0.42
April	79.2	30.7	54.7	64.0	9.3	39.8	63.8	12.5	3.6	4.95	80	0.48
May	88.0	43.9	71.5	73.0	40.8	61.6	75.9	8.1	2.5	4.07	43	0.65
June	91.2	56.7	74.5	74.8	46.8	65.4	78.0	8.1	2.4	4.62	38	0.55
July	92.1	61.9	76.5	77.2	55.9	67.6	78.2	7.2	2.1	5.19	27	1.55
August	88.7	59.7	74.6	74.7	51.6	67.5	82.5	6.9	2.0	3.78	45	0.70
September	90.0	59.7	74.1	75.6	57.0	67.2	83.4	19.2	4.7	7.63	73	0.85
October	86.5	35.8	60.4	72.5	23.5	53.0	80.5	9.6	2.3	3.55	55	0.70
November	69.3	20.1	44.6	61.7	13.6	37.7	79.6	11.4	2.7	5.91	103	0.58
December	70.5	22.6	43.6	61.2	18.3	36.2	78.0	12.1	2.5	7.59	101	0.48

Table 3.6-26
Annual Summary of Dry Bulb Temperature, Relative Humidity, Wind Speed and Precipitation from Tower D for 2019

	Dry Bulb Temperature (°F)			Dew Point (°F)			Relative Humidity (%)	Wind Speed (mph)		Liquid Equiv. Precip. (in.)	Hours with Measurable Precip.	Max. 1-hour Liquid Equivalent (in.)
Month	Maximum	Minimum	Average	Maximum	Minimum	Average	Average	Maximum	Average	Total	Total	
January	67.1	14.4	39.8	55.2	-9.9	29.8	71.0	11.2	3.2	6.52	83	0.43
February	76.5	28.0	47.5	63.5	9.0	37.8	73.6	13.6	3.1	15.21	155	0.61
March	73.6	19.0	48.2	62.1	4.3	31.1	57.3	12.1	3.0	4.46	64	0.42
April	83.7	31.5	61.3	63.3	12.6	46.7	64.3	15.4	3.3	4.95	80	0.48
May	90.3	42.6	70.5	70.0	39.0	59.5	72.7	11.0	2.8	4.07	43	0.65
June	88.9	49.3	72.1	72.9	40.5	63.3	78.1	8.7	2.5	7.02	66	1.04
July	91.2	56.5	76.3	76.1	46.9	68.4	80.7	7.6	2.0	5.19	27	1.55
August	93.0	58.1	75.5	75.0	52.3	66.7	78.4	6.7	1.9	6.81	36	2.23
September	93.2	55.0	75.1	71.4	46.2	63.7	72.5	5.8	1.6	0.01	1	0.01
October	94.1	36.7	61.7	70.0	26.2	52.7	77.3	9.4	2.2	7.78	73	0.83
November	66.2	20.7	44.8	59.9	12.7	35.3	73.2	10.1	2.3	5.35	50	0.40
December	68.5	26.1	45.4	62.6	18.0	37.3	76.2	15.0	2.9	5.65	81	0.43

Table 3.6-27
Annual Summary of Dry Bulb Temperature, Relative Humidity, Wind Speed and Precipitation from Tower D for 2020

	Dry Bulb Temperature (°F)			Dew Point (°F)			Relative Humidity (%)	Wind Speed (mph)		Liquid Equiv. Precip. (in.)	Hours with Measurable Precip.	Max. 1-hour Liquid Equivalent (in.)
Month	Maximum	Minimum	Average	Maximum	Minimum	Average	Average	Maximum	Average	Total	Total	
January	72.1	20.3	44.1	61.3	0.0	34.4	72.1	12.3	2.8	8.84	94	0.85
February	69.4	23.0	44.1	59.5	9.3	35.5	75.2	10.5	3.2	12.28	132	0.59
March	82.4	25.3	55.7	63.0	19.6	44.6	71.5	12.1	3.3	8.17	110	0.41
April	81.1	31.6	55.8	61.5	9.0	41.5	64.9	11.6	3.1	7.28	70	0.52
May	84.0	33.6	63.5	70.3	21.2	53.3	74.3	10.7	2.7	4.48	46	0.48
June	90.1	55.0	72.3	74.1	43.9	62.9	76.6	8.9	2.7	2.30	32	0.28
July	94.8	64.9	78.1	75.0	52.9	68.3	76.5	6.9	2.1	2.87	25	0.55
August	89.4	62.6	75.2	75.7	55.8	68.2	82.8	9.6	2.1	4.93	49	0.97
September	87.8	45.9	69.2	74.3	40.5	61.7	80.9	8.9	2.5	1.30	10	0.46
October	79.2	36.1	60.6	68.7	27.1	53.7	81.8	11.4	2.0	7.28	63	0.97
November	78.4	30.7	51.5	67.8	11.5	40.1	70.2	12.1	2.3	3.59	41	0.77
December	61.3	12.7	39.6	55.8	7.0	32.5	78.3	10.5	2.4	4.07	58	0.29

Table 3.6-28
Summary of Dry Bulb Temperature, Relative Humidity, Wind Speed and Precipitation from Tower D for 2016 – 2020

	Dry Bulb Temperature (°F)			Dew Point (°F)			Relative Humidity (%)	Wind Speed (mph)		Average Liquid Equiv. Precip. (in.)	Average Number of Hours with Measurable Precip.	Max. 1-hour Liquid Equivalent (in.)
Month	Maximum	Minimum	Average	Maximum	Minimum	Average	Average	Maximum	Average			
January	72.1	4.1	39.8	61.5	-9.9	29.3	69.7	12.3	2.9	4.99	78	0.85
February	78.3	19.4	46.3	65.7	-2.9	36.0	71.8	14.8	3.1	9.16	108	0.61
March	82.4	19.0	51.8	63.0	2.1	36.5	61.6	12.1	3.4	4.97	68	0.67
April	87.3	30.7	59.3	66.9	8.2	43.8	62.7	15.4	3.4	6.03	68	0.96
May	90.3	33.6	67.4	73.0	21.2	56.7	73.5	13.0	2.7	4.00	47	0.65
June	91.6	49.3	73.2	74.8	40.5	63.3	75.9	10.1	2.4	4.56	44	1.23
July	94.8	56.5	77.0	77.2	46.9	68.1	78.4	9.6	2.1	4.40	30	1.55
August	93.0	58.1	75.5	76.1	49.5	67.3	80.0	10.3	2.1	4.70	41	2.23
September	93.2	45.9	72.0	75.6	39.9	62.3	76.5	19.2	2.6	2.96	27	0.92
October	94.1	29.1	61.3	76.5	23.5	52.0	76.4	11.4	2.2	4.84	50	0.97
November	82.8	20.1	48.6	68.2	8.4	38.2	71.8	12.1	2.3	4.53	50	1.04
December	70.5	12.7	42.1	63.1	-5.3	33.5	74.6	15.0	2.7	5.71	79	0.48

Table 3.6-29
(Sheet 1 of 2)
Frequency of 15-m Wind Direction Persistence at Tower D (2016 – 2020)

Persistence (Hours)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	936	1308	1702	1514	863	495	420	371	650	1304	2120	2494	1937	1263	882	805
2	124	225	518	515	202	82	49	40	118	362	722	818	497	239	144	99
3	25	68	246	200	64	14	8	10	22	117	320	323	170	61	26	23
4	13	16	128	85	23	2	1	0	5	54	196	131	76	28	5	4
5	1	7	54	59	15	2	0	0	1	16	95	58	31	7	1	1
6	2	4	43	29	6	0	0	0	1	15	77	37	18	4	0	1
7	0	1	28	16	3	0	0	0	0	3	49	17	19	1	0	1
8	0	3	18	5	1	0	0	0	2	5	25	9	10	0	0	0
9	0	0	8	3	0	0	0	0	0	2	14	5	8	0	0	0
10	0	0	7	6	1	0	0	0	0	2	10	5	3	0	0	0
11	0	0	3	0	0	0	0	0	0	3	10	2	2	0	0	0
12	0	0	5	4	1	0	0	0	0	0	7	1	2	1	0	0
13	0	0	1	3	0	0	0	0	0	0	6	1	1	0	0	0
14	0	1	5	0	0	0	0	0	0	0	4	0	1	0	0	0
15	0	0	2	0	0	0	0	0	0	0	3	1	0	0	0	0
16	0	0	1	0	0	0	0	0	0	1	2	0	0	0	0	0
17	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
18	0	0	2	0	0	0	0	0	0	0	1	1	0	0	0	0
19	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0
20	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3.6-29
(Sheet 2 of 2)
Frequency of 15-m Wind Direction Persistence at Tower D (2016 – 2020)

Persistence (Hours)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3.6-30
Longest Wind Direction Persistence at Tower D (15 m) (2016 – 2020)

Wind Direction	Longest Persistence from Table 3.6-29 (Hours)
N	6
NNE	14
NE	**28**
ENE	17
E	12
ESE	5
SE	4
SSE	3
S	8
SSW	16
SW	20
WSW	18
W	14
WNW	12
NW	5
NNW	7

Table 3.6-31
Pasquill Stability Class Frequency Distributions from Tower D
(2016 – 2020)

Pasquill Stability Class	Frequency of Occurrence (Percent)					
	2016	2017	2018	2019	2020	2016 – 2020
A	0.39	0.47	0.10	0.30	0.27	0.31
B	0.42	0.54	0.32	0.35	0.41	0.41
C	0.91	0.81	0.78	1.08	0.88	0.89
D	35.97	35.27	37.00	35.19	34.89	35.67
E	32.17	35.88	38.82	34.47	36.64	35.60
F	19.69	18.84	17.07	20.14	18.92	18.93
G	10.44	8.20	5.90	8.46	7.99	8.20
Total	100.00	100.00	100.00	100.00	100.00	100.00

Figure 3.6-32
Joint Frequency Distribution of Wind Speed and Wind Direction from Tower D 2016 – 2020 (Pasquill Stability Class A)

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm																	0
0.00<WS< 0.50	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	3
0.50<WS< 1.00	1	0	1	2	0	3	0	1	3	1	5	1	5	2	0	0	25
1.00<WS< 1.50	1	0	0	3	2	0	2	1	0	0	0	1	1	0	0	0	11
1.50<WS< 2.00	0	0	4	0	1	0	0	0	0	0	1	1	1	0	0	0	8
2.00<WS< 2.50	0	1	17	9	1	0	0	0	0	0	2	0	0	0	0	0	30
2.50<WS< 3.00	0	0	8	21	1	0	0	0	0	0	0	1	0	0	0	0	31
3.00<WS< 3.50	0	0	5	14	0	0	0	0	0	0	0	0	0	0	0	0	19
3.50<WS< 4.00	0	0	0	3	2	0	0	0	0	0	0	0	0	0	0	0	5
4.00<WS< 5.00	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
5.00<WS< 6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.00<WS< 8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS > 8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	2	2	35	54	7	3	2	2	3	1	10	4	7	2	0	0	134

Frequency of Occurrence (% of Total Observations)

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.00<WS< 0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
0.50<WS< 1.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.06
1.00<WS< 1.50	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
1.50<WS< 2.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
2.00<WS< 2.50	0.00	0.00	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
2.50<WS< 3.00	0.00	0.00	0.02	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
3.00<WS< 3.50	0.00	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
3.50<WS< 4.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
4.00<WS< 5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00<WS< 6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.00<WS< 8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WS > 8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals	0.00	0.00	0.08	0.12	0.02	0.01	0.00	0.00	0.01	0.00	0.02	0.01	0.02	0.00	0.00	0.00	0.31

Figure 3.6-33
Joint Frequency Distribution of Wind Speed and Wind Direction from Tower D 2016 – 2020 (Pasquill Stability Class B)

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm																	0
0.00<WS< 0.50	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0	0	4
0.50<WS< 1.00	0	0	1	0	0	1	0	1	1	2	1	0	1	0	0	0	8
1.00<WS< 1.50	0	2	4	2	0	0	0	0	1	0	0	1	0	0	0	0	10
1.50<WS< 2.00	0	1	11	11	5	0	0	0	0	0	1	0	0	0	0	0	29
2.00<WS< 2.50	1	1	28	23	1	0	0	0	0	0	0	0	1	0	0	0	55
2.50<WS< 3.00	0	0	14	25	2	0	0	0	0	0	0	0	0	0	0	0	41
3.00<WS< 3.50	0	0	2	18	1	0	0	0	0	0	0	0	0	0	0	0	21
3.50<WS< 4.00	0	0	0	5	4	0	0	0	0	0	0	0	0	0	0	0	9
4.00<WS< 5.00	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5.00<WS< 6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.00<WS< 8.00	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
WS > 8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	1	4	61	86	13	1	1	1	2	2	3	2	2	0	0	0	179

Frequency of Occurrence (% of Total Observations)

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.00<WS< 0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
0.50<WS< 1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
1.00<WS< 1.50	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
1.50<WS< 2.00	0.00	0.00	0.03	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
2.00<WS< 2.50	0.00	0.00	0.06	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
2.50<WS< 3.00	0.00	0.00	0.03	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
3.00<WS< 3.50	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
3.50<WS< 4.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
4.00<WS< 5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00<WS< 6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.00<WS< 8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WS > 8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals	0.00	0.01	0.14	0.20	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.41

Figure 3.6-34
Joint Frequency Distribution of Wind Speed and Wind Direction from Tower D 2016 – 2020 (Pasquill Stability Class C)

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm																	0
0.00<WS< 0.50	1	0	2	0	1	1	1	0	0	0	0	1	0	0	1	1	9
0.50<WS< 1.00	1	6	3	2	5	1	0	1	3	0	3	0	1	0	0	0	26
1.00<WS< 1.50	7	5	15	13	4	0	0	0	4	10	5	2	0	0	0	4	69
1.50<WS< 2.00	1	2	19	29	7	0	0	0	1	5	5	3	0	0	0	2	74
2.00<WS< 2.50	1	3	26	59	8	0	0	0	0	3	2	0	0	0	1	1	104
2.50<WS< 3.00	0	2	13	44	14	0	0	0	0	0	1	0	0	0	0	1	75
3.00<WS< 3.50	0	1	0	8	9	0	0	0	0	0	2	0	0	0	0	0	20
3.50<WS< 4.00	0	0	0	2	1	0	0	0	0	0	0	1	0	0	0	0	4
4.00<WS< 5.00	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	3
5.00<WS< 6.00	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
6.00<WS< 8.00	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	5
WS > 8.00	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Totals	11	19	78	165	50	2	1	1	8	18	18	8	1	0	2	9	391

Frequency of Occurrence (% of Total Observations)

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.00<WS< 0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
0.50<WS< 1.00	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.06
1.00<WS< 1.50	0.02	0.01	0.03	0.03	0.01	0.00	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.16
1.50<WS< 2.00	0.00	0.00	0.04	0.07	0.02	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.17
2.00<WS< 2.50	0.00	0.01	0.06	0.13	0.02	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.24
2.50<WS< 3.00	0.00	0.00	0.03	0.10	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
3.00<WS< 3.50	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
3.50<WS< 4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
4.00<WS< 5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
5.00<WS< 6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.00<WS< 8.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
WS > 8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals	0.03	0.04	0.18	0.38	0.11	0.00	0.00	0.00	0.02	0.04	0.04	0.02	0.00	0.00	0.00	0.02	0.89

Figure 3.6-35
Joint Frequency Distribution of Wind Speed and Wind Direction from Tower D 2016 – 2020 (Pasquill Stability Class D)

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm																	14
0.00<WS< 0.50	44	61	77	74	54	61	84	74	93	101	84	52	49	52	49	48	1057
0.50<WS< 1.00	101	104	248	233	223	209	174	159	192	249	327	199	197	109	85	75	2884
1.00<WS< 1.50	65	80	336	404	265	165	97	75	163	396	596	399	252	140	87	90	3610
1.50<WS< 2.00	38	55	266	353	267	60	19	26	102	307	636	359	278	124	45	50	2985
2.00<WS< 2.50	20	23	149	226	181	22	10	7	41	252	560	293	322	112	17	12	2247
2.50<WS< 3.00	4	4	24	63	74	5	4	3	21	148	398	187	266	48	2	5	1256
3.00<WS< 3.50	2	0	2	12	15	0	0	2	20	96	282	110	155	27	0	2	725
3.50<WS< 4.00	0	0	1	3	6	0	0	0	15	77	174	67	58	4	0	0	405
4.00<WS< 5.00	0	0	2	3	8	0	0	0	18	71	175	47	30	3	0	0	357
5.00<WS< 6.00	0	1	3	1	1	0	0	0	2	16	39	15	0	0	0	0	78
6.00<WS< 8.00	0	0	2	1	0	0	0	0	0	4	9	2	0	0	0	0	18
WS > 8.00	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Totals	274	328	1110	1374	1094	522	388	346	667	1717	3280	1730	1607	619	285	282	15637

Frequency of Occurrence (% of Total Observations)

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.00<WS< 0.50	0.10	0.14	0.18	0.17	0.12	0.14	0.19	0.17	0.21	0.23	0.19	0.12	0.11	0.12	0.11	0.11	2.44
0.50<WS< 1.00	0.23	0.24	0.57	0.53	0.51	0.48	0.40	0.36	0.44	0.57	0.75	0.45	0.45	0.25	0.19	0.17	6.58
1.00<WS< 1.50	0.15	0.18	0.77	0.92	0.60	0.38	0.22	0.17	0.37	0.90	1.36	0.91	0.57	0.32	0.20	0.21	8.23
1.50<WS< 2.00	0.09	0.13	0.61	0.81	0.61	0.14	0.04	0.06	0.23	0.70	1.45	0.82	0.63	0.28	0.10	0.11	6.81
2.00<WS< 2.50	0.05	0.05	0.34	0.52	0.41	0.05	0.02	0.02	0.09	0.57	1.28	0.67	0.73	0.26	0.04	0.03	5.13
2.50<WS< 3.00	0.01	0.01	0.05	0.14	0.17	0.01	0.01	0.01	0.05	0.34	0.91	0.43	0.61	0.11	0.00	0.01	2.86
3.00<WS< 3.50	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.05	0.22	0.64	0.25	0.35	0.06	0.00	0.00	1.65
3.50<WS< 4.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.03	0.18	0.40	0.15	0.13	0.01	0.00	0.00	0.92
4.00<WS< 5.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.04	0.16	0.40	0.11	0.07	0.01	0.00	0.00	0.81
5.00<WS< 6.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.09	0.03	0.00	0.00	0.00	0.00	0.18
6.00<WS< 8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.04
WS > 8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals	0.63	0.75	2.53	3.14	2.50	1.19	0.89	0.79	1.52	3.92	7.48	3.95	3.67	1.41	0.65	0.64	35.67

Figure 3.6-36
Joint Frequency Distribution of Wind Speed and Wind Direction from Tower D 2016 – 2020 (Pasquill Stability Class E)

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm																	51
0.00<WS< 0.50	295	400	493	351	130	66	71	56	105	172	303	401	410	278	206	218	3955
0.50<WS< 1.00	156	424	1030	450	89	43	19	19	60	232	689	804	359	165	108	99	4746
1.00<WS< 1.50	40	165	628	283	35	10	6	5	34	125	672	604	243	107	49	29	3035
1.50<WS< 2.00	6	52	277	137	14	6	2	2	15	132	465	430	175	32	8	10	1763
2.00<WS< 2.50	2	7	78	38	8	3	1	2	11	89	331	263	131	23	2	1	990
2.50<WS< 3.00	0	1	20	8	4	1	0	0	4	55	216	113	66	10	0	0	498
3.00<WS< 3.50	0	0	9	2	1	0	0	0	3	30	108	51	48	2	0	0	254
3.50<WS< 4.00	0	1	8	0	2	0	0	0	0	31	76	33	13	0	1	0	165
4.00<WS< 5.00	0	1	14	0	0	0	0	0	1	16	50	23	9	0	0	0	114
5.00<WS< 6.00	0	0	3	0	0	0	0	0	0	10	10	7	2	0	0	0	32
6.00<WS< 8.00	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	3
WS > 8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	499	1051	2560	1269	283	129	99	84	233	893	2922	2729	1456	617	374	357	15606

Frequency of Occurrence (% of Total Observations)

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.00<WS< 0.50	0.68	0.92	1.14	0.81	0.30	0.15	0.16	0.13	0.24	0.40	0.70	0.93	0.95	0.64	0.48	0.50	9.14
0.50<WS< 1.00	0.36	0.97	2.35	1.03	0.20	0.10	0.04	0.04	0.14	0.53	1.57	1.83	0.82	0.38	0.25	0.23	10.82
1.00<WS< 1.50	0.09	0.38	1.43	0.65	0.08	0.02	0.01	0.01	0.08	0.29	1.53	1.38	0.55	0.24	0.11	0.07	6.92
1.50<WS< 2.00	0.01	0.12	0.63	0.31	0.03	0.01	0.00	0.00	0.03	0.30	1.06	0.98	0.40	0.07	0.02	0.02	4.02
2.00<WS< 2.50	0.00	0.02	0.18	0.09	0.02	0.01	0.00	0.00	0.03	0.20	0.75	0.60	0.30	0.05	0.00	0.00	2.26
2.50<WS< 3.00	0.00	0.00	0.05	0.02	0.01	0.00	0.00	0.00	0.01	0.13	0.49	0.26	0.15	0.02	0.00	0.00	1.14
3.00<WS< 3.50	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.25	0.12	0.11	0.00	0.00	0.00	0.58
3.50<WS< 4.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.17	0.08	0.03	0.00	0.00	0.00	0.38
4.00<WS< 5.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.11	0.05	0.02	0.00	0.00	0.00	0.26
5.00<WS< 6.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.07
6.00<WS< 8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
WS > 8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals	1.15	2.41	5.85	2.90	0.65	0.30	0.23	0.19	0.53	2.04	6.67	6.24	3.33	1.42	0.86	0.82	35.60

Figure 3.6-37
Joint Frequency Distribution of Wind Speed and Wind Direction from Tower D 2016 – 2020 (Pasquill Stability Class F)

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm																	134
0.00<WS< 0.50	415	486	728	538	117	32	36	26	47	116	262	613	792	645	435	344	5632
0.50<WS< 1.00	45	85	308	221	21	3	0	1	3	53	295	577	219	70	64	42	2007
1.00<WS< 1.50	2	7	14	14	1	1	0	1	1	16	137	152	32	7	8	2	395
1.50<WS< 2.00	1	0	1	2	0	0	0	0	0	2	44	42	7	1	1	0	101
2.00<WS< 2.50	0	0	0	0	0	0	0	0	1	0	19	4	0	0	0	0	24
2.50<WS< 3.00	0	0	0	1	0	0	0	0	0	1	5	0	0	0	0	0	7
3.00<WS< 3.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.50<WS< 4.00	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
4.00<WS< 5.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.00<WS< 6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.00<WS< 8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS > 8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	463	578	1051	776	139	36	36	28	52	188	762	1389	1050	723	508	388	8301

Frequency of Occurrence (% of Total Observations)

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.00<WS< 0.50	0.97	1.13	1.70	1.26	0.27	0.07	0.08	0.06	0.11	0.27	0.61	1.43	1.85	1.51	1.02	0.80	13.15
0.50<WS< 1.00	0.10	0.19	0.70	0.50	0.05	0.01	0.00	0.00	0.01	0.12	0.67	1.32	0.50	0.16	0.15	0.10	4.58
1.00<WS< 1.50	0.00	0.02	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.04	0.31	0.35	0.07	0.02	0.02	0.00	0.90
1.50<WS< 2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.02	0.00	0.00	0.00	0.23
2.00<WS< 2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.05
2.50<WS< 3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02
3.00<WS< 3.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.50<WS< 4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.00<WS< 5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00<WS< 6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.00<WS< 8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WS > 8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals	1.08	1.34	2.44	1.80	0.32	0.08	0.08	0.07	0.12	0.44	1.75	3.20	2.44	1.68	1.18	0.90	18.93

Figure 3.6-38
Joint Frequency Distribution of Wind Speed and Wind Direction from Tower D 2016 – 2020 (Pasquill Stability Class G)

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm																	245
0.00<WS< 0.50	75	140	434	497	118	26	18	18	34	91	308	418	225	142	98	67	2709
0.50<WS< 1.00	3	8	43	74	8	0	1	0	0	2	143	173	40	9	6	2	512
1.00<WS< 1.50	0	0	0	1	1	0	0	0	0	1	47	32	8	2	0	1	93
1.50<WS< 2.00	0	0	0	0	0	0	0	0	0	0	16	14	0	0	0	0	30
2.00<WS< 2.50	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	4
2.50<WS< 3.00	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
3.00<WS< 3.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.50<WS< 4.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.00<WS< 5.00	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
5.00<WS< 6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.00<WS< 8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WS > 8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	78	148	477	572	127	26	19	19	34	94	517	639	273	153	104	70	3595

Frequency of Occurrence (% of Total Observations)

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.00<WS< 0.50	0.19	0.35	1.08	1.24	0.29	0.06	0.04	0.04	0.08	0.23	0.77	1.04	0.56	0.35	0.24	0.17	6.74
0.50<WS< 1.00	0.01	0.02	0.10	0.17	0.02	0.00	0.00	0.00	0.00	0.00	0.33	0.39	0.09	0.02	0.01	0.00	1.17
1.00<WS< 1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.07	0.02	0.00	0.00	0.00	0.21
1.50<WS< 2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.03	0.00	0.00	0.00	0.00	0.07
2.00<WS< 2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01
2.50<WS< 3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.00<WS< 3.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.50<WS< 4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.00<WS< 5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00<WS< 6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.00<WS< 8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WS > 8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals	0.19	0.37	1.18	1.41	0.31	0.06	0.05	0.05	0.08	0.23	1.24	1.54	0.67	0.38	0.26	0.17	8.20

Figure 3.6-39
Joint Frequency Distribution of Wind Speed and Wind Direction from Tower D 2016 – 2020 (Stability Classes A – G)

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm																	444
0.00<WS< 0.50	830	1088	1734	1461	420	186	211	174	279	480	960	1486	1476	1117	789	678	13369
0.50<WS< 1.00	307	627	1634	982	346	260	194	182	262	539	1463	1754	822	355	263	218	10208
1.00<WS< 1.50	115	259	997	720	308	176	105	82	203	548	1457	1191	536	256	144	126	7223
1.50<WS< 2.00	46	110	578	532	294	66	21	28	118	446	1168	849	461	157	54	62	4990
2.00<WS< 2.50	24	35	298	355	199	25	11	9	53	344	917	561	454	135	20	14	3454
2.50<WS< 3.00	4	7	79	162	95	6	4	3	25	204	620	302	332	58	2	6	1909
3.00<WS< 3.50	2	1	18	54	26	0	0	2	23	126	392	161	203	29	0	2	1039
3.50<WS< 4.00	0	1	9	13	15	0	0	0	15	108	250	102	71	4	1	0	589
4.00<WS< 5.00	0	1	17	6	9	0	0	1	19	87	225	71	39	3	0	0	478
5.00<WS< 6.00	0	1	6	2	1	0	0	0	2	26	49	22	2	0	0	0	111
6.00<WS< 8.00	0	0	2	7	0	0	0	0	0	5	11	2	0	0	0	0	27
WS > 8.00	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
Totals	1328	2130	5372	4296	1713	719	546	481	999	2913	7512	6501	4396	2114	1273	1106	43843

Frequency of Occurrence (% of Total Observations)

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.00<WS< 0.50	1.96	2.56	4.09	3.44	0.99	0.44	0.50	0.41	0.66	1.13	2.26	3.50	3.48	2.63	1.86	1.60	31.51
0.50<WS< 1.00	0.70	1.43	3.73	2.24	0.79	0.59	0.44	0.42	0.60	1.23	3.34	4.00	1.87	0.81	0.60	0.50	23.28
1.00<WS< 1.50	0.26	0.59	2.27	1.64	0.70	0.40	0.24	0.19	0.46	1.25	3.32	2.72	1.22	0.58	0.33	0.29	16.47
1.50<WS< 2.00	0.10	0.25	1.32	1.21	0.67	0.15	0.05	0.06	0.27	1.02	2.66	1.94	1.05	0.36	0.12	0.14	11.38
2.00<WS< 2.50	0.05	0.08	0.68	0.81	0.45	0.06	0.03	0.02	0.12	0.78	2.09	1.28	1.04	0.31	0.05	0.03	7.88
2.50<WS< 3.00	0.01	0.02	0.18	0.37	0.22	0.01	0.01	0.01	0.06	0.47	1.41	0.69	0.76	0.13	0.00	0.01	4.35
3.00<WS< 3.50	0.00	0.00	0.04	0.12	0.06	0.00	0.00	0.00	0.05	0.29	0.89	0.37	0.46	0.07	0.00	0.00	2.37
3.50<WS< 4.00	0.00	0.00	0.02	0.03	0.03	0.00	0.00	0.00	0.03	0.25	0.57	0.23	0.16	0.01	0.00	0.00	1.34
4.00<WS< 5.00	0.00	0.00	0.04	0.01	0.02	0.00	0.00	0.00	0.04	0.20	0.51	0.16	0.09	0.01	0.00	0.00	1.09
5.00<WS< 6.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.11	0.05	0.00	0.00	0.00	0.00	0.25
6.00<WS< 8.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.06
WS > 8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals	3.09	4.94	12.38	9.91	3.94	1.65	1.26	1.11	2.30	6.68	17.21	14.94	10.14	4.91	2.96	2.57	100.00

Table 3.6-40
Average Monthly and Annual Mixing Heights (m) from SODAR at ORNL / Tower D (2014 – 2019)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2014	687	721	839	1050	1137	1219	1074	1001	932	760	655	548	885
2015	550	604	642	899	1202	1281	967	989	907	626	512	555	811
2016	517	701	771	1048	1090	1263	1256	1209	1187	846	614	530	919
2017	613	690	899	1070	1037	1152	1268	1220	1018	732	576	572	904
2018	598	651	807	871	1169	1234	1197	1100	1041	721	608	566	880
2019	512	611	788	935	1091	988	1134	1086	1058	641	556	592	833
Average	580	663	791	979	1121	1189	1149	1101	1024	721	587	560	872

Table 3.6-41
Average Monthly and Annual Mixing Heights (m) from SODAR at Y-12 (2019)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2019	440	539	756	937	1098	1170	1137	1042	981	660	541	494	813

Table 3.6-42
National Ambient Air Quality Standards (NAAQS)

Pollutant	Primary/ Secondary Standard	Averaging Period	Level ($\mu g/m^3$)	Level (ppm)
CO [g]	Primary	1 hr.	--	35
CO [g]	Primary	8 hr.	--	9
Lead (Pb) [a]	Primary and secondary	Rolling 3-month average	0.15	--
NO_2 [b]	Primary	1 hr.	--	0.1
NO_2	Primary and secondary	Annual	--	0.053
Ozone (O_3) [c]	Primary and secondary	8 hr.	--	0.070
$PM_{2.5}$ [d]	Primary and secondary	24 hr.	35	--
$PM_{2.5}$	Primary	Annual	12.0	--
$PM_{2.5}$	Secondary	Annual	15.0	--
PM_{10} [e]	Primary and secondary	24 hr.	150	--
SO_2 [f]	Primary	1 hr.	--	0.075
SO_2 [g]	Secondary	3 hr.	--	0.5

a) In areas designated non-attainment for the lead (Pb) standards prior to promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have been submitted and approved, the previous standards (1.5 $\mu g/m^3$ calendar quarter average) also remain in effect.
b) 98th percentile of 1-hr. daily maximum concentrations averaged over three years
c) Annual fourth-highest daily maximum 8-hr. concentration averaged over three years
d) 98th percentile averaged over three years
e) Not to be exceeded more than once per year on average over three years
f) 99th percentile of 1-hr. daily maximum concentrations averaged over three years
g) Not to be exceeded more than once per year

Table 3.6-43
Current NAAQS Attainment Status of Anderson, Knox, Loudon and Roane Counties, Tennessee

County	Current NAAQS	Current Attainment Status	Date of Re-designation	Former Non-Attainment Classification	Whole or/Part of County Formerly in Non-Attainment?
Anderson	8-hr. Ozone (2008)	Re-designated to Maintenance	8/12/2015	Marginal	Part
Anderson	24-hr. $PM_{2.5}$ (2006)	Re-designated to Maintenance	9/27/2017	Moderate	Whole
Knox	8-hr. Ozone (2008)	Re-designated to Maintenance	8/12/2015	Marginal	Whole
Knox	24-hr. $PM_{2.5}$ (2006)	Re-designated to Maintenance	9/27/2017	Moderate	Whole
Loudon	24-hr. $PM_{2.5}$ (2006)	Re-designated to Maintenance	9/27/2017	Moderate	Whole
Roane	24-hr. $PM_{2.5}$ (2006)	Re-designated to Maintenance	9/27/2017	Moderate	Part

Table 3.6-44
Measured Carbon Monoxide Concentrations and Comparison with NAAQS

				1-hr. NAAQS			8-hr. NAAQS		
Year	Air Quality Monitor #	Monitor Location	County	Max. 1-hr. Conc. (ppm)	1-hr. NAAQS (ppm)	In Compliance with NAAQS (Y/N)?	Max. 8-hr. Conc. (ppm)	8-hr. NAAQS (ppm)	In Compliance with NAAQS (Y/N)?
2020	470090101	Great Smoky Mountains NP Look Rock, TN	Blount	0.3	35	Y	0.2	9	Y
2019	470090101	Great Smoky Mountains NP Look Rock, TN	Blount	1.3	35	Y	0.9	9	Y
2018	470090101	Great Smoky Mountains NP Look Rock, TN	Blount	0.3	35	Y	0.3	9	Y
2017	470090101	Great Smoky Mountains NP Look Rock, TN	Blount	0.3	35	Y	0.3	9	Y

Table 3.6-45
Measured Lead Concentrations and Comparison with NAAQS

Year	Air Quality Monitor #	Monitor Location	County	Max. Quarterly Ave. (µg/m^3)	NAAQS (µg/m^3)	In Compliance with NAAQS (Y/N)?
2020	470930023	1526 New York Ave., Knoxville	Knox	0.04	0.15	Y
2020	470930027	2522 Burnside St., Knoxville	Knox	0.02	0.15	Y
2019	470930023	1526 New York Ave., Knoxville	Knox	0.03	0.15	Y
2019	470930027	2522 Burnside St., Knoxville	Knox	0.01	0.15	Y
2018	470930023	1526 New York Ave., Knoxville	Knox	0.06	0.15	Y
2018	470930027	2522 Burnside St., Knoxville	Knox	0.02	0.15	Y
2017	470930023	1526 New York Ave, Knoxville	Knox	0.06	0.15	Y
2017	470930027	2522 Burnside St., Knoxville	Knox	0.02	0.15	Y
2017	470931017	1613 Vermont Ave., Knoxville	Knox	0.02	0.15	Y

Table 3.6-46
Measured Nitrogen Dioxide Concentrations and Comparison with NAAQS

Year	Air Quality Monitor #	Monitor Location	County	98th Percentile, Daily Max. 1-hr. Conc. (ppb)	1-hr. NAAQS (ppb)	In Compliance (Y/N)?	Max. Annual Conc. (ppb)	Annual NAAQS (ppb)	In Compliance with NAAQS (Y/N)?
2020	470090101	Great Smoky Mountains NP Look Rock, TN	Blount	5	100	Y	0.7	53	Y
2019	470090101	Great Smoky Mountains NP Look Rock, TN	Blount	5	100	Y	0.59	53	Y
2018	470090101	Great Smoky Mountains NP Look Rock, TN	Blount	5	100	Y	0.62	53	Y
2017	470090101	Great Smoky Mountains NP Look Rock, TN	Blount	5	100	Y	0.55	53	Y

Table 3.6-47
Measured Ozone Concentrations and Comparison with NAAQS

Year	Air Quality Monitor #	Monitor Location	County	4th-High, Daily 8-hr. Max. (ppm)	8-hr. NAAQS (ppm)	In Compliance with NAAQS (Y/N)?
2020	470010101	Freels Bend Study Area Melton Lake ORNL	Anderson	0.056	0.070	Y
2020	470930021	9315 Rutledge Pike, Mascot	Knox	0.053	0.070	Y
2020	470931020	4625 Mildred Drive, Knoxville	Knox	0.052	0.070	Y
2020	471050109	2175 Roberts Rd., Loudon	Loudon	0.059	0.070	Y
2019	470010101	Freels Bend Study Area Melton Lake ORNL	Anderson	0.066	0.070	Y
2019	470930021	9315 Rutledge Pike, Mascot	Knox	0.063	0.070	Y
2019	470931020	4625 Mildred Drive, Knoxville	Knox	0.059	0.070	Y
2019	471050109	2175 Roberts Rd., Loudon	Loudon	0.063	0.070	Y
2018	470010101	Freels Bend Study Area Melton Lake ORNL	Anderson	0.063	0.070	Y
2018	470930021	9315 Rutledge Pike, Mascot	Knox	0.067	0.070	Y
2018	470931020	4625 Mildred Drive, Knoxville	Knox	0.064	0.070	Y
2018	471050109	2175 Roberts Rd., Loudon	Loudon	0.065	0.070	Y
2017	470010101	Freels Bend Study Area Melton Lake ORNL	Anderson	0.063	0.070	Y
2017	470930021	9315 Rutledge Pike, Mascot	Knox	0.061	0.070	Y
2017	470931020	4625 Mildred Drive, Knoxville	Knox	0.067	0.070	Y
2017	471050109	2175 Roberts Rd., Loudon	Loudon	0.063	0.070	Y

Table 3.6-48
Measured Concentrations of Particulate Matter with an Aerodynamic Diameter less than 10 Microns and Comparison with NAAQS

Year	Air Quality Monitor #	Monitor Location	County	Max. 24-hr. Conc. ($\mu g/m^3$)	24-hr. NAAQS ($\mu g/m^3$)	In Compliance with NAAQS (Y/N)?
2020	470931013	939 Stewart St., Knoxville	Knox	87	150	Y
2019	470931013	939 Stewart St., Knoxville	Knox	37	150	Y
2018	470931013	939 Stewart St., Knoxville	Knox	39	150	Y
2017	470931013	939 Stewart St., Knoxville	Knox	40	150	Y

Table 3.6-49
(Sheet 1 of 4)
Measured Concentrations of Particulate Matter with an Aerodynamic Diameter less than 2.5 Microns and Comparison with NAAQS

				24-hr. Primary NAAQS		
Year	Air Quality Monitor #	Monitor Location	County	98th Percentile 24-hr. Conc. (µg/m³)	24-hr. NAAQS (µg/m³)	In Compliance with NAAQS (Y/N)?
2020	470930028	1000 Francis Road, Knoxville	Knox	16.0	35	Y
2020	470931013	939 Stewart St., Knoxville	Knox	15.0	35	Y
2020	470931017	1613 Vermont Ave., Knoxville	Knox	17.0	35	Y
2020	470931020	4625 Mildred Drive, Knoxville	Knox	15.0	35	Y
2020	471050109	2175 Roberts Rd., Loudon	Loudon	14.0	35	Y
2020	471450004	1002 N. Roan St., Harriman	Roane	15.0	35	Y
2019	470930028	1000 Francis Road, Knoxville	Knox	16.0	35	Y
2019	470931013	939 Stewart St., Knoxville	Knox	16.0	35	Y
2019	470931017	1613 Vermont Ave., Knoxville	Knox	17.0	35	Y
2019	470931020	4625 Mildred Drive, Knoxville	Knox	16.0	35	Y
2019	471050109	2175 Roberts Rd., Loudon	Loudon	14.0	35	Y
2019	471450004	1002 N. Roan St., Harriman	Roane	14.0	35	Y
2018	470930028	1000 Francis Road, Knoxville	Knox	18.0	35	Y
2018	470931013	939 Stewart St., Knoxville	Knox	17.0	35	Y
2018	470931017	1613 Vermont Ave., Knoxville	Knox	19.0	35	Y
2018	470931020	4625 Mildred Drive, Knoxville	Knox	15.0	35	Y
2018	471050109	2175 Roberts Rd., Loudon	Loudon	14.0	35	Y
2018	471450004	1002 N. Roan St., Harriman	Roane	15.0	35	Y

Table 3.6-49
(Sheet 2 of 4)
Measured Concentrations of Particulate Matter with an Aerodynamic Diameter less than 2.5 Microns and Comparison with NAAQS

				24-hr. Primary NAAQS		
Year	Air Quality Monitor #	Monitor Location	County	98th Percentile 24-hr. Conc. (µg/m^3)	24-hr. NAAQS (µg/m^3)	In Compliance with NAAQS (Y/N)?
2017	470930028	1000 Francis Road, Knoxville	Knox	17.0	35	Y
2017	470931013	939 Stewart St., Knoxville	Knox	20.0	35	Y
2017	470931017	1613 Vermont Ave., Knoxville	Knox	21.0	35	Y
2017	470931020	4625 Mildred Drive, Knoxville	Knox	17.0	35	Y
2017	471050108	130 Webb Drive, Loudon	Loudon	18.0	35	Y
2017	471050109	2175 Roberts Rd., Loudon	Loudon	11.0	35	Y
2017	471450004	1002 N. Roan St., Harriman	Roane	16.0	35	Y

Table 3.6-49
(Sheet 3 of 4)
Measured Concentrations of Particulate Matter with an Aerodynamic Diameter less than 2.5 Microns and Comparison with NAAQS

				Annual Primary NAAQS			Annual Secondary NAAQS		
Year	Air Quality Monitor #	Monitor Location	County	Annual Ave. Conc. ($\mu g/m^3$)	Annual primary NAAQS ($\mu g/m^3$)	In Compliance with NAAQS (Y/N)?	Annual Ave. Conc. ($\mu g/m^3$)	Annual Secondary NAAQS ($\mu g/m^3$)	In Compliance with NAAQS (Y/N)?
2020	470930028	1000 Francis Road, Knoxville	Knox	7.2	12	Y	7.2	15	Y
2020	470931013	939 Stewart St., Knoxville	Knox	7.4	12	Y	7.4	15	Y
2020	470931017	1613 Vermont Ave., Knoxville	Knox	7.5	12	Y	7.5	15	Y
2020	470931020	4625 Mildred Drive, Knoxville	Knox	6.8	12	Y	6.8	15	Y
2020	471050109	2175 Roberts Rd., Loudon	Loudon	6.3	12	Y	6.3	15	Y
2020	471450004	1002 N. Roan St., Harriman	Roane	6.7	12	Y	6.7	15	Y
2019	470930028	1000 Francis Road, Knoxville	Knox	7.6	12	Y	7.6	15	Y
2019	470931013	939 Stewart St., Knoxville	Knox	7.5	12	Y	7.5	15	Y
2019	470931017	1613 Vermont Ave., Knoxville	Knox	8.1	12	Y	8.1	15	Y
2019	470931020	4625 Mildred Drive, Knoxville	Knox	7.3	12	Y	7.3	15	Y
2019	471050109	2175 Roberts Rd., Loudon	Loudon	7.2	12	Y	7.2	15	Y
2019	471450004	1002 N. Roan St., Harriman	Roane	7.1	12	Y	7.1	15	Y
2018	470930028	1000 Francis Road, Knoxville	Knox	7.7	12	Y	7.7	15	Y
2018	470931013	939 Stewart St., Knoxville	Knox	8.1	12	Y	8.1	15	Y
2018	470931017	1613 Vermont Ave., Knoxville	Knox	8.4	12	Y	8.4	15	Y
2018	470931020	4625 Mildred Drive, Knoxville	Knox	7.4	12	Y	7.4	15	Y
2018	471050109	2175 Roberts Rd., Loudon	Loudon	6.2	12	Y	6.2	15	Y
2018	471450004	1002 N. Roan St., Harriman	Roane	6.8	12	Y	6.8	15	Y

Table 3.6-49
(Sheet 4 of 4)
Measured Concentrations of Particulate Matter with an Aerodynamic Diameter less than 2.5 Microns and Comparison with NAAQS

				Annual Primary NAAQS			Annual Secondary NAAQS		
Year	Air Quality Monitor #	Monitor Location	County	Annual Ave. Conc. ($\mu g/m^3$)	Annual primary NAAQS ($\mu g/m^3$)	In Compliance with NAAQS (Y/N)?	Annual Ave. Conc. ($\mu g/m^3$)	Annual Secondary NAAQS ($\mu g/m^3$)	In Compliance with NAAQS (Y/N)?
2017	470930028	1000 Francis Road, Knoxville	Knox	8.2	12	Y	8.2	15	Y
2017	470931013	939 Stewart St., Knoxville	Knox	8.3	12	Y	8.3	15	Y
2017	470931017	1613 Vermont Ave., Knoxville	Knox	8.9	12	Y	8.9	15	Y
2017	470931020	4625 Mildred Drive, Knoxville	Knox	7.9	12	Y	7.9	15	Y
2017	471050108	130 Webb Drive, Loudon	Loudon	7.6	12	Y	7.6	15	Y
2017	471050109	2175 Roberts Rd., Loudon	Loudon	6.0	12	Y	6.0	15	Y
2017	471450004	1002 N. Roan St., Harriman	Roane	7.6	12	Y	7.6	15	Y

Table 3.6-50
Measured Sulfur Dioxide Concentrations and Comparison with NAAQS

Year	Air Quality Monitor #	Monitor Location	County	99th Percentile, Daily Max. 1-hr. Conc. (ppb)	1-hr. NAAQS (ppb)	In Compliance with NAAQS (Y/N)?
2019	470010101	Freels Bend Study Area Melton Lake ORNL	Anderson	7.0	75	Y
2018	470010101	Freels Bend Study Area Melton Lake ORNL	Anderson	6.0	75	Y
2017	470010101	Freels Bend Study Area Melton Lake ORNL	Anderson	6.0	75	Y

Table 3.6-51
Regional Criteria Pollutant Emissions by County (2017)

County	Carbon Monoxide (TPY)	Lead (lb/yr)	Nitrogen Oxides (TPY)	$PM_{2.5}$ (TPY)	PM_{10} (TPY)	Sulfur Dioxide (TPY)
Anderson	14805	110	3691	874	1582	637
Knox	62958	1550	10715	2152	5382	271
Loudon	10422	8	2111	597	1392	193
Roane	12361	317	3605	920	1449	2025

Table 3.6-52
Nearest Federal Class I Areas to the Horizon Center Site

Class I Area [(a)]	Distance from Horizon Center Site (km)	Direction from Horizon Center Site
Mammoth Cave National Park, KY	197	Northwest
Linville Gorge Wilderness Area, NC	220	East
Great Smoky Mountains National Park, TN/NC	54	Southeast
Shining Rock Wilderness Area, NC	145	Southeast
Joyce Kilmer-Slickrock Wilderness Area, TN/NC	64	South
Cohutta Wilderness Area, TN/GA	106	South-southwest

a) Distances extracted from USEPA, 2022 and NPS, 2022

3.7 NOISE

3.7.1 BASELINE NOISE CONDITIONS

3.7.1.1 Site Acoustical Characteristics

Land use surrounding the Horizon Center site (HCS) is described in Section 3.1, Land Use. The most acoustically sensitive land use is the North Boundary Greenway, a low-density recreational trail used for hiking and biking, which borders the HCS to the west (Outdoor Knoxville, 2022). Other land uses adjacent to the site include industrial and commercial businesses associated with the Horizon Center Industrial Park to the south, as well as undeveloped forested land (Figure 3.7.1-1). Except for the North Boundary Greenway, there are no other recreational facilities, schools, churches, or other sensitive noise receptors adjacent to the HCS that would be vulnerable to noise impacts from the proposed TRISO-X Fuel Fabrication Facility (TRISO-X FFF).

The Horizon Center Industrial Park is partially developed, with businesses closest to the HCS consisting of Philotechnics, an industrial facility specializing in radioactive waste repackaging, and the headquarters office of the Community Reuse Organization of East Tennessee (CROET) (Figure 3.7.1-1). Extensive forested buffers separate the industrial park from surrounding public areas, including the nearest residential development located approximately 0.6 mi. (1.0 km) northwest of the HCS boundary off Poplar Creek Road. From an acoustical perspective, these densely forested areas provide additional attenuation of industrial park noise for receptors in the vicinity (Cook and Van Haverbeke, 1971).

As described in Section 3.3, Geology and Soils, the HCS is situated on a terrace within the valley of East Fork Poplar Creek (EFPC) and consists of undulating terrain, with no dramatic changes in elevation that would significantly affect the propagation of sound across the property. There are several ridges that are oriented northeast to southwest within the vicinity of the HCS. Blackoak Ridge is located immediately to the north of the site. In addition to the dense forest, this ridge provides a natural barrier to sounds from the HCS that could otherwise propagate to the north.

3.7.1.2 Ambient Noise Survey

An ambient noise survey was conducted in January 2022 to characterize the baseline acoustical conditions at the HCS and property boundaries.

3.7.1.2.1 Extent of Survey

The ambient noise survey conducted in January 2022 incorporated environmental sound monitors at four locations (noise monitoring location [NM] 1 through 4) around the HCS, as depicted on Figure 3.7.1-1. Monitoring sites were established to characterize the baseline acoustical conditions at the HCS and at the property boundaries adjacent to the nearest noise receptors.

Based on these noise-monitoring objectives, the following sound monitoring locations were identified for inclusion in the survey and are depicted on Figure 3.7.1-1:

- NM-1 is located near the northern corner of the HCS property boundary and is representative of the baseline noise conditions along the adjacent segment of the North Boundary Greenway trail.

- NM-2 is located near the eastern corner of the HCS property boundary.

- NM-3 is located near the western corner of the HCS property boundary and is representative of the baseline noise conditions along the adjacent segment of the North Boundary Greenway trail.

- NM-4 is located along the southern boundary of the HCS and is representative of the baseline noise conditions at the adjacent Philotechnics industrial facility and CROET offices.

3.7.1.2.2 Methodology

Environmental sound monitors were set up at each of the four monitoring locations. Measurements consisted of ambient noise levels measured continuously over approximately 10-minute intervals. A total of five measurements were recorded at each location between Tuesday, January 11, 2022, and Wednesday, January 12, 2022, with three measurements recorded during the daytime period (7:00 a.m. to 10:00 p.m.) and two measurements recorded during the nighttime period (10:00 p.m. to 7:00 a.m.).

Noise measurements were collected using a Quest SoundPro DL-1-1/3 sound level meter, which complies with the requirements of the American National Standards Institute Methods for Electroacoustics Sound Level Meters. The sound level meter was calibrated within the previous 12 months by a certified laboratory and was field-calibrated prior to the field measurements. At each monitoring location, the meter was placed on a tripod at approximately 5.9 ft. (1.8 m) off the ground, and a windscreen was placed over the microphone to minimize the influence of wind noise on the measurements. Instrument settings used the equivalent noise level (L_{eq}) averaging routine in the A-weighted decibel (dBA) scale.

3.7.1.2.3 Weather Conditions during the Sound Survey

Based on field observations, the weather conditions at the HCS during the two days that ambient noise measurements were collected were mostly clear to partly cloudy, with temperatures ranging between 24°F and 40°F (-4.4°C and 4.4°C). There were calm winds and no measurable precipitation. The ground was dry and free of snow during the survey; however, some frost was noted during the nighttime and early morning measurements.

See Section 3.6, Meteorology, Climatology and Air Quality, for monthly and annual summaries of meteorological data and a description of the regional climate. Ambient noise levels are somewhat variable based on seasonal changes and weather conditions. However, the results of the noise survey are generally representative of typical conditions due to the absence of precipitation or other weather extremes during the sound survey monitoring events.

3.7.1.2.4 Sources of Noise Observed

A number of natural and human-generated noise sources were observed during the ambient noise survey for the HCS. Dominant noise sources included area traffic on nearby TN 95 — Oak Ridge Turnpike and local roadways, as well as some drill rig activity on the HCS. Other occasional sources of noise observed during the survey included recreators on the North Boundary Greenway trail and overhead airplane traffic.

3.7.1.2.5 Monitoring Results

Ambient noise monitoring results for each monitoring location are shown in Table 3.7.1-1. The L_{eq} data indicate relatively consistent sound levels across the four monitoring locations and across day and night events. Sound levels at NM-2 and NM-4 tended to be slightly higher than those at NM-1 and NM-3, likely due to their proximity to noise generated by Renovare Boulevard, the existing Horizon Center Industrial Park businesses, and TN 95 — Oak Ridge Turnpike.

Each L_{eq} measurement was converted to sound energy, adding a 10 dBA penalty to nighttime measurements to reflect the sensitivity of receptors during those hours. The average sound power was then calculated by averaging the sound energy from each of the three daytime measurements (weighting the daytime average sound energy by 15 hours per day) and two nighttime measurements (weighting the nighttime average sound energy by 9 hours per day). The sound energy weighted average was then used to calculate the day-night average community noise level (L_{dn}) for each monitoring location. The L_{dn} for each monitoring location is shown in Table 3.7.1-1. These L_{dn} results are representative of the typical ambient noise level at the HCS and are consistent with the L_{dn} for quiet to normal suburban areas, which typically ranges from 48 to 57 dBA (USEPA, 1974).

3.7.1.3 Previous Noise Studies

A noise study was conducted in 2020 when the Horizon Center Industrial Park was considered for the development of a motorsports park. On-site noise monitoring was not conducted as part of that study; however, ambient noise was characterized using sound monitoring data from a 2015 study related to the proposed development of a nearby airport. A monitoring location near the George Jones Memorial Baptist Church, located approximately 1.5 miles south of the proposed racetrack (much of which would have been located on the HCS), was considered representative of the site. The daytime ambient background sound level at this monitoring location was calculated to be approximately 45 dBA, based on the L_{90} metric. The L_{90} metric indicates the sound level that is exceeded for 90 percent of a given time period and is used to describe the background sound level with minimal influence from noise intrusions, such as dogs barking or traffic noise (Leidos, 2020).

3.7.2 APPLICABLE SOUND LEVEL STANDARDS

3.7.2.1 Municipal Regulations

The City of Oak Ridge has established quantitative noise level limits based on adjacent property uses, as codified in Article XII of the City's Zoning Ordinance. The most stringent guidelines apply to properties with adjacent residential uses; however, these guidelines are not applicable

to the HCS because the nearest residences are approximately 0.6 mi. (1.0 km) to the northwest. For properties with adjacent business uses (e.g., the Philotechnics facility and CROET offices), the zoning ordinance sets a maximum noise limit of 80 dBA during both daytime and nighttime hours. Additionally, the sound level should not exceed 70 dBA for more than 50 percent of the survey period or 75 dBA for more than 10 percent of the survey period. These restrictions are specific to outdoor spaces, at the lot boundary (City of Oak Ridge, 2020).

While maximum sound level data were not collected as part of the ambient noise survey, the L_{dn} and L_{eq} values presented in Table 3.7.1-1 indicate that the typical ambient noise levels associated with current baseline conditions at the HCS are well below noise level limits established by the City of Oak Ridge.

3.7.2.2 State and County Regulations

Neither Roane County nor the State of Tennessee has developed noise regulations that specify acceptable community noise levels.

3.7.2.3 Federal Guidelines

At the Federal level, the U.S. Environmental Protection Agency (USEPA) has a broad-ranging set of guidelines for environmental noise levels. USEPA guidelines recommend that outdoor noise levels do not exceed an L_{dn} of 55 dBA, which is sufficient to protect the public from the effect of broadband environmental noise in typical outdoor and residential areas. This level is not a regulatory standard but is intentionally conservative to protect the most sensitive portion of the American population with an additional margin of safety (USEPA, 1974). Based on the results of the ambient noise survey, the L_{dn} at the HCS property boundary during current conditions ranges from 51.8 to 53.1 dBA (Table 3.7.1-1), below the USEPA L_{dn} guideline of 55 dBA.

Table 3.7.1-1
Ambient Noise Monitoring Results

Monitoring Location Number	Measured Daytime[a] Ambient Noise Level; Event 1 (L_{eq}, dBA)	Measured Daytime[a] Ambient Noise Level; Event 2 (L_{eq}, dBA)	Measured Nighttime[b] Ambient Noise Level; Event 3 (L_{eq}, dBA)	Measured Nighttime[b] Ambient Noise Level; Event 4 (L_{eq}, dBA)	Measured Daytime[a] Ambient Noise Level; Event 5 (L_{eq}, dBA)	Calculated Average Community Noise Level (L_{dn}, dBA)[c]
NM-1	45.3	45.4	45.3	45.4	46.2	**51.8**
NM-2	46.3	46.0	45.3	47.6	49.0	**53.1**
NM-3	45.3	45.3	45.4	45.3	45.3	**51.8**
NM-4	45.3	46.0	45.8	45.5	45.4	**52.1**

Notes:

a) Daytime events occur between 7:00 a.m. and 10:00 p.m.

b) Nighttime events occur between 10:00 p.m. and 7:00 a.m.

c) A 10 dBA penalty was added to the measured nighttime L_{eq} sound levels in calculating the average community noise level to reflect the sensitivity of receptors during those hours.

Abbreviations:

L_{dn} = day-night average community noise level
L_{eq} = equivalent noise level
dBA = A-weighted decibel

3.8 HISTORIC AND CULTURAL RESOURCES

Cultural resources include prehistoric or historic districts, archaeological sites, buildings, structures, or objects considered important to a culture, subculture, or community for scientific, traditional, religious, or any other reason. When cultural resources meet any one of the National Register Criteria for Evaluation (36 CFR 60.4), they may be termed historic properties and be eligible for inclusion in the National Register of Historic Places (NRHP).

A cultural resource survey was conducted to identify the potential occurrence of archaeological and historic resources potentially eligible for the NRHP on and near the Horizon Center site (HCS). The survey included a Phase I archaeological survey and historic architecture viewshed survey. Identified resources were assessed against the criteria for the NRHP in order to determine their potential eligibility.

3.8.1 DEFINING THE AREA OF POTENTIAL EFFECTS

The area of potential effects (APE) is determined based upon the potential for both direct and indirect effects. Direct effects are defined as those that result from activities that could damage or destroy the physical integrity of a cultural resource. Thus, the APE for direct effects to cultural resources consists of the areas where construction activities and ground disturbance are proposed, which for this project is considered to be the HCS that covers approximately 110-ac. (44.5-ha). The archaeological survey areas consist of the HCS and an adjacent parcel, totaling 150-ac. (61-ha) (Figure 3.8.1-1). Results of field investigations from both the archaeological survey area and the APE are reported.

Indirect effects are those that do not directly destroy the physical integrity of a cultural resource but would rather adversely affect contributing elements of the cultural resource. For historic structures, this typically consists of visual effects to the viewshed of the cultural resource that may diminish its overall context. A 0.5-mi. (0.8-km) buffer around the direct-effect APE (i.e., the HCS) is considered the APE for indirect effects to cultural resources.

3.8.2 CULTURAL BACKGROUND AND PREVIOUSLY IDENTIFIED CULTURAL RESOURCES

The cultural background of East Tennessee spans thousands of years. The earliest groups to leave a definitive material record of their presence were early Paleoindians who entered the region during the Late Pleistocene glacial epoch at least 12,000 years ago. Their descendants and the descendants of other Native American groups who migrated to the area later occupied the region for the next 11 millennia. This long prehistoric era lasted until the arrival of European explorers in the 16th and 17th centuries.

While cultural change is a slow and continual process, archaeologists and other researchers divide the human history of a region into distinct cultural periods. Archaeologists and historians recognize four broadly defined prehistoric periods for East Tennessee:

- Paleoindian (approximately 10,000 – 8000 B.C.)
- Archaic (8000 – 1000 B.C.)
- Woodland (1000 B.C. – A.D. 900)

- Mississippian (A.D. 900 – 1540)

The historic period includes the Contact/Protohistoric period (A.D. 1540 – 1672) and coincides with the early exploration of the Southeast by the Spanish and French.

Records on file at the Tennessee Division of Archaeology (TDOA) in Nashville and Tennessee Historical Commission (THC) Geographic Information System (THCGIS) were examined to determine if any cultural resource investigations were previously conducted within the archaeological survey area. Also, to provide a more expansive background and understanding of the cultural context of the area, records of cultural resources investigations previously conducted within a 2-mi. (1.6-km) buffer of the archaeological survey area were also examined. Additionally, historic map research was conducted to determine the probability for historic cultural resources to be present within the archeological survey area.

3.8.2.1 Archaeological Sites

According to the TDOA site file and database research, no archaeological sites or surveys have been recorded within or adjacent to the archaeological survey area prior to this survey. However, 22 archaeological sites and nine surveys are recorded within the 2-mi. (1.6-km) buffer surrounding the APE. Of the 22 sites, seven are prehistoric and 15 are historic.

Review of the prehistoric and historic context of the area, previously recorded sites, and completed surveys in the vicinity of the archaeological survey area suggests a high potential for archaeological sites within the archaeological survey area.

3.8.2.2 Historic-Age Structures

As noted in Section 3.8.2 above, the THCGIS database and THC files were reviewed to determine if any architectural resources were previously documented and/or listed on the NRHP within a 2-mi. (1.6-km) buffer around the survey area to provide a more expansive background and understanding of the cultural context of the area. THC files reviewed included available maps, surveys, reports, and/or other relevant data. The review identified 19 properties, including two NRHP-listed resources, located within the 2-mi. (1.6-km) buffer. Of the 19 resources, 17 were recommended as not eligible. Two resources, the George Jones Memorial Baptist Church (92000408) and the TN 95 — Oak Ridge Turnpike Checking Station (92000412), were listed on the NRHP in 1992.

Historic mapping of the archaeological survey area was also reviewed, with the earliest available map dating to 1895. The U.S. Geological Survey (USGS) 1895 Loudon, Tennessee, topographic quadrangle map depicts an unnamed road along the northern boundary of the archaeological survey area. The USGS 1935 Bethel Valley, Tennessee, topographic quadrangle also depicts the unnamed road along the northern boundary. Additionally, four historic structures are shown along this road: three in the northeastern portion of the archaeological survey area and one in the southwestern corner of the archaeological survey area on the 1935 map. On the USGS 1941 Bethel Valley, Tennessee, map, a total of five structures are shown. One of the structures shown on the 1935 map is no longer present on the 1941 map. However, the 1941 map shows two additional structures that were not on the 1935 map: one adjacent to the unnamed road, and one just north of the road. By 1952, no structures are depicted on the USGS Bethel Valley, Tennessee, topographic quadrangle; however, the unnamed road persists. In total, six historic structure locations are shown within or adjacent to the archaeological survey

area. Based on this historic map review, historic sites dating to at least the early 1900s are likely present within the archaeological survey area.

3.8.3 SURVEY METHODS

After reviewing obtainable information about cultural resources within and surrounding each of the APEs, a cultural resource survey was conducted by qualified professionals to determine if any unidentified cultural resources were present. As shown in Chapter 10*,* John A. Hunter, MA, RPA, served as principal investigator for the project. Mr. Hunter is a Registered Professional Archaeologist with a master's degree in Anthropology and more than 20 years of experience. The architectural survey was completed by Matthew Prybylski. Mr. Prybylski has a Master of Historic Preservation (MHP) and over 20 years of cultural resource experience. The archaeological survey was completed by Tiffany Raymond, Tim Reynolds, Jacob Jepson, Aaron Geary, Andrew May, Stacia Yoakam, Kaylee Blum, Mark Bautista, Sydney Swierenga, and Alejandra May. The architectural survey was completed by Matthew Prybylski and Brittany Sams.

3.8.3.1 Archaeological Methods

Field investigations were conducted according to guidelines established in the Tennessee State Historic Preservation Office (TN SHPO) *Standards and Guidelines for Archaeological Resource Management Studies* (TDOA, 2018). Areas within the cultural resources survey area (Figure 3.8.1-1) that had less than 50 percent surface visibility and less than 20 percent slope were investigated by systematic excavation of soil test pits (STPs). All portions of the archaeological survey area exhibiting greater than 50 percent ground surface visibility and/or greater than 20 percent slope were visually inspected for cultural resources (i.e., artifacts, features, etc.) by a pedestrian survey.

The TN SHPO guidelines for pedestrian surveys call for transects to be spaced no more than 100 ft. (30 m.) apart. The surface of the ground was examined for the entire length of several transects throughout the archaeological survey area. If prehistoric or historic artifacts were encountered, the distance between transects was reduced to 49-ft. (15-m) to determine the presence of any additional cultural resources.

A total of 815 STPs were completed, while areas of slope or disturbance were subjected to a pedestrian survey. Soil from the STPs was screened through 0.25-in. (0.64-cm) steel mesh, and all cultural material identified was collected. The purpose of these excavations was to investigate the underlying stratigraphy and help determine if a site contained, or had the potential to contain, intact cultural deposits.

3.8.3.2 Historic Architecture Survey Methods

The architectural survey area included the APE, as well as a 0.5-mi. buffer (0.8-km) viewshed of the survey area (indirect APE). Buildings over 50 years of age were assessed for NRHP eligibility using NRHP Bulletin #15 (NPS, 2002). Fieldwork entailed inspection and documentation of buildings, cemeteries, or structures over 50 years of age within the architectural survey area. Fieldwork included written and photographic documentation of resources with digital photographs for the purposes of determining the architectural and historic details of each structure or building.

3.8.4 SURVEY FINDINGS

3.8.4.1 Archaeological Findings

A total of five archaeological sites and one historic cemetery were documented during the survey: Sites 40RE637, 40RE638, 40RE639, 40RE640, and 40RE641, and the McKamey and Carmichael Cemetery. Site 40RE637, Site 40RE638, and a portion of the McKamey and Carmichael Cemetery are located within the APE. The remaining sites (40RE639, 40RE640, and 40RE641) are located in the archaeological survey area outside of the APE.

Site 40RE637 is a historic domestic dwelling dating to the mid-19th century that continued to be occupied or was reoccupied in the early 20th century. Due to shallow soils, the loss of site integrity from previous disturbance associated with land-clearing activities, and the low potential for 40RE637 to greatly contribute to the history of the region, it is recommended that 40RE637 is not eligible for the NRHP, and no further archaeological work is necessary.

Site 40RE638 is a historic dwelling dating to the early 19th to early 20th century, with a remnant brick-lined sandstone chimney. Due to the low density of artifacts and the shallow and disturbed nature of the soils, 40RE638 has low potential to further contribute to the history of the region. For these reasons, it is recommended that 40RE638 is not eligible for the NRHP, and no further archaeological work is necessary.

Site 40RE639 (located outside of the APE) is a historic domestic dwelling dating to the early to mid-19th century into the late 20th century. Due to the presence of an artifact concentration at 40RE639 and the likelihood of affiliation between 40RE639 and 40RE640, it is recommended that this site be avoided. If avoidance is not possible, additional archaeological and archival work is recommended to determine site NRHP eligibility.

Site 40RE640 (located outside the APE) is a multicomponent historic domestic dwelling dating to the early 19th century that continued through the early 20th century. Due to the presence of intact features, an artifact concentration, a wide range of artifact classes present, and the extended duration of site occupation, the site has high potential to greatly contribute to the history of the region. For these reasons, Site 40RE640 is recommended for avoidance. If avoidance is not possible, additional archaeological and archival work is recommended to determine site NRHP eligibility.

Site 40RE641 (located outside the APE) is a multicomponent site containing three pieces of prehistoric lithic debitage of unknown temporal affiliation and a historic domestic dwelling dating to the late 19th to early 20th century. Site 40RE641 has a low potential to further contribute to the history of the region. Site 40RE641 is recommended as not eligible for the NRHP, and no further archaeological work is required.

The McKamey and Carmichael Cemetery is a family cemetery dating to the mid-19th to mid-20th century. The cemetery contains 22 grave markers and may represent a minimum of 16 graves. These markers include decorated headstones, erected cut stones without inscriptions, and two cut-stone piles. The earliest readable death date is Mary J. Carmichael, died Dec. 17, 1867, and the latest readable headstone is Sarah Carmichael, born 1885, aged 62 years, corresponding to a death date of approximately 1947. Though no depressions were encountered outside of the cemetery enclosure that indicate other unmarked burials, it is still possible that unmarked graves are present.

According to the National Register Bulletin #41, cemeteries and graves are among those properties that ordinarily are not considered eligible for inclusion in the NRHP unless they meet special requirements. Upon review of these requirements, the McKamey and Carmichael Cemetery is recommended as not eligible for the NRHP. However, all human burials are protected under Tennessee State law and a 100 ft. (30.5 m) buffer has been established around the cemetery to protect this resource. Therefore, avoidance of the 100 -ft. (30.5-m) buffer is recommended. If avoidance is not possible, additional archaeological work that includes the use of near-surface geophysics to identify any unmarked graves within or surrounding the cemetery enclosure and archaeological monitoring of all proposed work within the cemetery or associated buffer.

3.8.4.2 Historic Architecture Survey Findings

One resource, the Silvey Cemetery, was identified within the viewshed buffer (indirect APE). The Silvey Cemetery dates to the early 20th century and contains approximately six graves. Wood staff assessed the Silvey Cemetery according to several overarching themes developed using three NRHP criteria applicable specifically to architecture and defined by research used to develop the historic context. These themes included the development of the area (Criterion A), the association with early settlers in Roane County and nearby areas (Criterion B), and the evaluation of headstone architecture within the region (Criterion C). As a result of this assessment, the Silvey Cemetery is recommended not eligible for listing on the NRHP.

3.8.5 REGULATORY COORDINATION

Formal coordination with the TN SHPO was conducted on April 13, 2022 and included the submittal of results of the cultural resource survey (see Chapter 1, Appendix 1A, Regulatory Correspondence). This coordination initiates regulatory review pursuant to Section 106 of the National Historic Preservation Act. However, the full Section 106 consultation process will be conducted by the U.S. Nuclear Regulatory Commission (NRC) through direct coordination with the TN SHPO.

3.9 VISUAL/SCENIC RESOURCES

3.9.1 VIEWSHED BOUNDARIES

The Horizon Center site (HCS) is located in the partially developed Horizon Center Industrial Park, which consists of several existing industrial and commercial facilities, additional lots available for development, and greenbelt areas to remain undeveloped (City of Oak Ridge, 2018). Lands adjacent to the industrial park are predominantly undeveloped and forested, with the exception of the TN 95 — Oak Ridge Turnpike corridor to the east.

The term “viewshed” refers to the landscape that is visible from a given vantage point. Viewshed boundaries for the TRISO-X Fuel Fabrication Facility (TRISO-X FFF) are defined as the area within 3 miles (mi.) (4.8 km) of the site center point radius, depicted in Figure 3.9.1-1. The viewshed from most of the site vicinity is limited by topography and areas of dense vegetation. However, the site vicinity shown in Figure 3.9.1-1 represents an estimate of the foreground-middleground distance zone, defined as the areas seen from viewing locations which are less than 3 to 5 mi. (4.8 to 8.0 km) away, in accordance with the U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) scenic quality rating assessment described in Section 3.9.10. Due to the relatively small scale of the HCS and the TRISO-X FFF, the viewshed is limited to distances under 3 mi. (4.8 km).

3.9.2 LANDSCAPE CHARACTERISTICS

The HCS is located in northern Roane County in the Valley and Ridge physiographic province. The regional topography near the site is typical of the Valley and Ridge province which is characterized by northeast–southwest trending ridges and intervening valleys (NPS, 2021). The HCS and other developed areas along TN 95 to the northeast and southwest are located on relatively flat or slightly undulating terrain associated with the East Fork Valley, while just northwest of the site, there is a steep incline to the top of Blackoak Ridge (see Figure 3.9.1-1).

The ecological environment of the HCS and its immediate surroundings is characterized by herbaceous cover as well as forest habitat, consisting of communities of evergreen, deciduous, and mixed forests. Section 3.5, Ecological Resources, provides detailed descriptions of the specific ecological features (flora, fauna, and ecosystems) present at the site. In addition, descriptions of the site’s soil types are presented in Section 3.3.4, Soils, while surface water features are described in detail in Section 3.4.2, Surface Waters.

Landscape features in the vicinity of the HCS, including the presence of open spaces and uncultivated land, are detailed in Section 3.1, Land Use. The North Boundary Greenway, a low-density recreational trail used for hiking and biking, borders the HCS boundary to the west (Figure 3.9.3-1). The North Boundary Greenway trail provides 16 mi. (25.7 km) of singletrack and gravel paths that offer views of ridge-top woodlands, bluffs, and creek-side habitats showcasing a variety of wildlife and native plants as well as remnants of pre-Manhattan Project settlements and old cemeteries (Outdoor Knoxville, 2022). There are no other parks, wilderness areas, or other recreational areas located within or immediately adjacent to the HCS that offer architectural or aesthetic features that would attract tourists to the area.

3.9.3 LOCATION OF CONSTRUCTED FEATURES

Apart from previous vegetation clearing that has occurred over the majority of the HCS, the property has been minimally developed. There are no buildings present on site. As shown in

Figure 3.9.3-1 and Figure 3.9.3-2, Photo E, a gravel road travels generally north-south through the center of the site. There are no radar, cell, or transmission towers, or aboveground utility distribution lines within the HCS.

Constructed features immediately adjacent to the HCS include Renovare Boulevard, which borders the site to the southeast, and a warehouse/office building occupied by Philotechnics, located near the southern corner of the property (see Figure 3.9.3-1). Renovare Boulevard is a two-lane divided roadway that provides access to the Horizon Center Industrial Park, and includes a landscaped median, streetlights, and an adjacent sidewalk (see Figure 3.9.3-2, Photo B). The Philotechnics facility, which is bordered by Renovare Boulevard to the southeast and the HCS on the remaining sides, consists of a one-story building with offices and warehouse space as well as paved parking lots. Perimeter fencing separates the Philotechnics facility from the HCS (see Figure 3.9.3-2, Photo F). There are no constructed features on the HCS, the adjacent Philotechnics facility, or the adjacent segment of Renovare Road that are currently visible from TN 95.

3.9.4 SITE PHOTOGRAPHS

The HCS is approximately 110 ac. (44.5 ha) in area, and has been previously cleared of most woody vegetation. Figure 3.9.3-1 provides an aerial view of the HCS and indicates various locations from which site photographs were taken. Site photographs are provided in Figure 3.9.3-2.

3.9.5 RESIDENTS AND VISITORS POTENTIALLY AFFECTED BY VISUAL IMPACTS

3.9.5.1 Residents

The closest residents to the HCS are located in a heavily forested residential development off Poplar Creek Road, approximately 0.6 mi. (1.0 km) northwest of the HCS boundary. However, as these residences are separated from the site by Blackoak Ridge and areas of dense vegetation, they are unlikely to be potentially affected by visual impacts from the HCS. There are also residential neighborhoods located to the east off TN 95, approximately 1.3 mi. (2.1 km) or more from the site. These residents would also have minimal to no view of potential development at the HCS due to distance, intervening topography, and heavily forested buffers.

3.9.5.2 Area Visitation

The City of Oak Ridge is home to a number of museums, parks, and attractions that serve as popular visitor destinations (Explore Oak Ridge, 2022). While the majority of these sites are concentrated near the city center in Anderson County, outside the project vicinity, there are some tourist attractions such as the K-25 History Center, the K-25 Overlook and Visitor Center, the Wheat Community Burial Ground, and the Black Oak Ridge Conservation Easement, that are located in and around the Heritage Center Industrial Park, between 1 and 3 mi. (1.6 and 4.8 km) southwest of the HCS (Roane Tourism, 2022). However, due to factors related to distance, intervening topography and forested areas, views of the HCS are minimal or absent from all of these visitor destinations.

The only recreational area or visitor attraction from which the HCS is readily visible is the North Boundary Greenway trail, described in Section 3.9.2 and shown on Figure 3.9.3-1. There is currently a narrow band of trees and vegetation that separates the majority of the trail from the HCS, somewhat shielding views of the site from trail users. However, as noted in Section 2.3,

the ORED is planning to construct a 69-kV transmission line from the ORED substation on Blair Road to the intersection of Imperium Drive and TN 95 — Oak Ridge Turnpike, in order to provide electricity to the Horizon Center Industrial Park. The 69-kV transmission line would abut the south side of the North Boundary Greenway trail segment that borders the HCS, requiring the removal of the vegetative buffer. Thus, the HCS would be visible to greenway users along this segment of the trail.

3.9.6 VISIBILITY FROM ACCESS ROADS

Renovare Boulevard provides direct access for vehicles traveling to and from the HCS. Renovare Boulevard is accessible from TN 95 — Oak Ridge Turnpike via intersections at Imperium Drive to the northeast of the site, or Novus Drive to the southeast. The HCS is only visible from the roadways within the Horizon Center Industrial Park (Renovare Boulevard, Imperium Drive, and Novus Drive). A heavily forested area obscures views of the HCS from TN 95 and other local roadways in the vicinity.

3.9.7 HIGH-QUALITY VIEW AREAS

Based on site visits and a review of available local information, there are no scenic features or vistas on the HCS that are considered to be regionally or locally important or of high scenic quality. Both the vegetation and topography of the HCS are typical of other land parcels in Oak Ridge and northeastern Roane County.

3.9.8 APPLICABLE REGULATORY INFORMATION

Based on the current zoning map for the City of Oak Ridge, the HCS is zoned IND-2 (General Industrial), as are other properties within the Horizon Center Industrial Park that are either currently developed or available for development. The IND-2 general, or medium, industrial district is established to provide areas in which the principal use of land is for processing, manufacturing, assembling, fabrication and for warehousing. Medium industry produces moderate external effects such as smoke, noise, soot, dirt, vibration, and/or odor (City of Oak Ridge, 2020).

Other zoning designations adjacent to the HCS include G (Greenbelt), consisting of areas within the Horizon Center Industrial Park that are designated for environmental preservation or are otherwise unsuitable for development, and FIR (Federal Industry and Research), consisting of U.S. Department of Energy (DOE) land which borders the HCS to the north and surrounds the industrial park in other directions.

Development within the City of Oak Ridge is subject to certain design standards and requirements, as specified in the City's Zoning Ordinance (City of Oak Ridge, 2020). A number of these requirements regulate aspects of property's visual attributes, including:

- Off Street Parking and Loading Requirements (Article XI) – prescribes minimum number of parking spaces and loading/unloading areas, lot dimensions and layout, and lighting requirements.

- Performance Standards (Article XII) – sets controls for the emission of smoke, dust, and light/glare from industrial or other business activities.

- Landscaping and Design Standards (Article XIII) – details landscaping and streetscape requirements, architectural compatibility, screening and buffer transitions between zoning districts, and outdoor lighting requirements.

- Sign Regulations (Article XIV) – regulates size, location, design, and illumination of signs.

3.9.9 COORDINATION WITH LOCAL PLANNERS

Local zoning designations and the current zoning ordinance were obtained from the City of Oak Ridge Planning Division. In addition, TRISO-X, LLC representatives have been in coordination with local officials, including the City of Oak Ridge Community Development Department, the City of Oak Ridge Industrial Development Board, the Oak Ridge Electric Department, the Oak Ridge City Manager, and the Mayor of Oak Ridge, regarding the proposed development since Summer 2021. No unusual planning, zoning, or building code issues were identified in association with the HCS. Additional coordination and plan review are anticipated to occur as appropriate during the project planning process.

3.9.10 AESTHETIC AND SCENIC QUALITY RATING

The BLM has developed and implemented its Visual Resource Management (VRM) policy to evaluate the aesthetic and scenic quality of public lands in the United States and to manage these public lands in a manner which protects the quality of the scenic values (BLM, 1984). This VRM approach has two primary components: inventory and analysis. The inventory component involves assigning the visual resources of an area to an inventory class based on its visual appeal, public concern, and visibility from travel routes and key observation points. The analysis component of the BLM methodology focuses on manipulating the design characteristics of planned buildings and supporting infrastructure (e.g., utility lines, roads) to minimize the contrast between natural and disturbed areas of the landscape. For the purposes of this evaluation, the aesthetic and scenic quality of the HCS were rated using only the inventory component of the VRM methodology.

3.9.10.1 Scenic Quality

Scenic quality is a measure of the visual appeal of a tract of land. In the BLM's visual resource inventory process, lands are given an A, B, or C rating based on the apparent scenic quality which is determined using seven key factors: landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications. For a given tract of land, a score is assigned for each of the seven key factors using the BLM's scoring criteria presented in Table 3.9.10-1. The total score, obtained by summing the individual scores for the seven key factors, is then used to apply a scenic quality rating for the site using the following BLM rating designations: A = total score of 19 or more; B = total score of 12 to 18; and C = total score of 11 or less (BLM, 1986).

Due to the homogeneity of the landscape features across the HCS (i.e., similar physiographic characteristics, visual patterns, colors, and impacts from man-made modifications such as vegetation clearing) it was not necessary to subdivide the site into multiple scenic quality rating units. Thus, for the purposes of the scenic quality evaluation, the HCS was rated as a single unit. The results of the scenic quality evaluation are presented in Table 3.9.10-1. The HCS was assigned a total scenic quality score of 5 which places it within the lowest BLM scenic quality rating of C.

3.9.10.2 Sensitivity Level

The sensitivity level analysis portion of the BLM methodology considers the measure of public concern for scenic quality. Lands are assigned high, medium, or low sensitivity levels by analyzing various indicators of public concern including the type of users, amount of use, public interest, adjacent land uses, and special areas.

Typical users of the land within the HCS would be on-site employees and contractors. Employees who work at the site or in the surrounding industrial park are expected to be less sensitive to changes in visual quality than the general public. The HCS would, however, be visible to members of the public from the North Boundary Greenway hiking and biking trail which borders the HCS to the west. Thus, the public would have interest in the value of the lands adjacent to the trail as a visual resource. However, development of the site is consistent with the planned use of the industrial park and compatible with current zoning designations. Additionally, the topography and surrounding areas of dense forest would obstruct views of the HCS from the remainder of the trail not directly adjacent to the site. Based on these considerations, the HCS is assigned a medium sensitivity rating overall.

3.9.10.3 Distance Zones

The BLM methodology also subdivides landscapes into three distanced zones based on relative visibility of the area from travel routes and key observation points. The three distance zones are the foreground-middleground, the background, and seldom seen. The foreground-middleground zone typically includes areas visible from highways, rivers, or other viewing locations which are less than 3 to 5 mi. (4.8 to 8.0 km) away; the background zone includes areas visible from 6 to 15 mi. (9.7 to 24.1 km) away; and the seldom-seen zone includes areas not visible from travel routes or other frequently occupied places such residences and public areas.

Figure 3.9.1-1 provides an approximation of the foreground-middleground distance zone, though as previously discussed, visibility from many of these areas is limited by topography and intervening vegetation. Additionally, the majority of undeveloped areas within the site vicinity are rarely occupied and thus the viewshed from these areas would fall under the seldom-seen zone.

Due to the scale of the HCS and the regional topography, the site would not be readily distinguishable from the surrounding landscape at background distances.

3.9.10.4 Determination of Visual Resource Inventory Class

The BLM provides a framework for integrating the results of scenic quality evaluation, sensitivity level analysis, and distance zone delineation. The scenic quality rating of C and the medium sensitivity rating place the HCS within Visual Resource Inventory Class IV for all three distance zones. Of the four visual resource inventory classes, Class IV allows for the greatest degree of landscape modification and is considered the least visual and scenic value. The BLM management objectives for Class IV areas allow for high levels of change, with the understanding that an attempt will be made to minimize the effects of the planned disturbance.

Table 3.9.10-1
(Sheet 1 of 2)
Scenic Quality Inventory Evaluation and Scoring for the Horizon Center Site

Key Factor	BLM Scenic Quality Evaluation Scoring Criteria [(a)]			Evaluation and Assigned Score for the Horizon Center Site
Landform	High vertical relief as expressed in prominent cliffs, spires, or massive rock outcrops, or severe surface variation or highly eroded formations, including major badlands or dune systems; or detail features dominant and exceptionally striking and intriguing, such as glaciers. Score 5	Steep canyons, mesas, buttes, cinder cones, and drumlins; interesting erosional patterns or variety in size and shape of landforms; detail features that are interesting, though not dominant or exceptional. Score 3	Low rolling hills, foothills, or flat valley bottoms; or few or no interesting landscape features. Score 1	• While a ridge rises relatively steeply to the northwest, no notable landform features are present within the HCS. • Site characterized by gently to moderately rolling hills. **Landform Score = 1**
Vegetation	A variety of vegetative types as expressed in interesting forms, textures, and patterns. Score 5	Some variety of vegetation, but only one or two major types. Score 3	Little or no variety or contrast in vegetation. Score 1	• HCS consists primarily of periodically mowed herbaceous cover which grows in near monoculture. • Small islands of scrub-shrub vegetation and stand alone mature trees provide limited variety. **Vegetation Score = 1**
Water	Clear and clean appearing, still, or cascading white water, any of which are a dominant factor in the landscape. Score 5	Either flowing, or still, but not dominant in the landscape. Score 3	Either absent, or present, but not noticeable. Score 0	• Water features not present within the HCS. **Water Score = 0**
Color	Rich color combinations, variety or vivid color; or pleasing contrasts in the soil, rock, vegetation, water or snow fields. Score 5	Some intensity or variety in colors and contrast of the soil, rock, and vegetation, but not a dominant scenic element. Score 3	Subtle color variations, contrast, or interest; generally mute tones. Score 1	• Relatively uniform herbaceous cover and limited areas of woody vegetation provide little color variation or contrast. **Color Score = 1**

Table 3.9.10-1
(Sheet 2 of 2)
Scenic Quality Inventory Evaluation and Scoring for the Horizon Center Site

Key Factor	BLM Scenic Quality Evaluation Scoring Criteria [a]			Evaluation and Assigned Score for the Horizon Center Site
Adjacent Scenery	Adjacent scenery greatly enhances visual quality. Score 5	Adjacent scenery moderately enhances overall visual quality. Score 3	Adjacent scenery has little or no influence on overall visual quality. Score 0	• Areas south adjacent to the HCS are being developed in association with the Horizon Center Industrial Park. • Forested ridges to the north and west, however, moderately enhance the overall visual quality of the site. **Adjacent Scenery Score = 3**
Scarcity	One of a kind; or unusually memorable, or very rare within region. Consistent chance for exceptional wildlife or wildflower viewing. Score 5	Distinctive, though somewhat similar to others within the region. Score 3	Interesting within its setting, but fairly common within the region. Score 1	• Vegetation and scenery within the HCS are common throughout the region and contain non-native species and successional communities typical of areas with significant past disturbance. **Scarcity Score = 1**
Cultural Modifications	Modifications add favorably to visual variety while promoting visual harmony. Score 2	Modifications add little or no visual variety to the area and introduce no discordant elements. Score 0	Modifications add variety but are very discordant and promote strong disharmony. Score -4	• While there are no buildings or structures within the HCS, human modification including previous vegetation clearing introduces notable discord with the surrounding areas of forest and natural elements. **Cultural Modification Score = -2** **Total Key Factor Score = 5**

Reference: BLM, 1986

Note:

a) The BLM Scenic Quality Inventory protocol allows for assigning a score at any integer value within the maximum and minimum score range listed for an individual key factor.

3.10 SOCIOECONOMICS

This section describes the population, economic, and community characteristics of the study area surrounding the Horizon Center site (HCS). For the majority of this section, this study area is defined as the five counties surrounding the HCS that are most likely to incur economic, labor force, and infrastructure effects due to the Proposed Action. This study area is also referred to in this section as the Region of Influence (ROI) and includes Roane, Anderson, Knox, Loudon, and Morgan counties. However, pursuant to NUREG-1748, Environmental Review Guidance for Licensing Actions Associated with Nuclear Material Safety and Safeguards (NMSS) Programs, discussions regarding minority populations and households living below the poverty level focus on the approximately 50 sq. mi. (129.5 km^2) area (corresponding to a 4 mi. [6.4 km] radius) surrounding the HCS center point radius, which includes only portions of Roane, Anderson, and Morgan counties.

The data used in this section are the most current and complete data identified to address each topic. In most cases, those data represent relatively current conditions in the study area (for example, 2015-2019 American Community Survey [ACS] 5-year estimates provided by the U.S. Census Bureau [USCB] and USCB 2020 Decennial Census data), or projected conditions during the expected life of the proposed project. Decennial Census data from 2000 and 2010 are also used to illustrate economic and population trends over time. As these available sources provide sufficient data to address each topic, no additional coordination with local and regional agencies or groups who collect these types of data was necessary.

3.10.1 POPULATION CHARACTERISTICS

3.10.1.1 Population and Projected Growth in the Region of Influence

The Horizon Center site (HCS) is located in Roane County, Tennessee, within the limits of the City of Oak Ridge, which spans portions of both Roane and Anderson counties. Oak Ridge had a population of 31,402 in 2020, while Roane County had a population of 53,404 (USCB, 2020). Figure 3.10.1-1 shows the location of Oak Ridge and the HCS, as well as other cities and towns within the ROI. Knox County, which includes the city of Knoxville and its suburbs, is the most urban and densely developed of the counties that comprise the ROI, with a resident population of 478,971 in 2020. The other four counties are more rural and have smaller resident populations, ranging from 21,035 in Morgan County to 77,123 in Anderson County (Table 3.10.1-1). Together, the counties comprising the ROI accounted for approximately 10 percent of the population of the State of Tennessee in 2020.

In recent years, the ROI has grown at rates very similar to those of the State. Loudon County has experienced the most rapid population growth of the counties in the ROI, growing 24.2 percent between 2000 and 2010, compared to the other ROI counties that experienced growth rates ranging from 4.4 percent in Roane County to 13.1 percent in Knox County over the same time period (Table 3.10.1-1). Together, these growth rates resulted in population growth of 12.0 percent across the ROI, just above Tennessee's growth rate of 11.5 percent. Population data for 2020 reveal that population growth in the ROI has continued to be on track with that of Tennessee as a whole. Between 2010 and 2020, the combined population of the ROI grew by 8.4 percent, whereas the total State population grew by 8.9 percent. Loudon and Knox counties continued to grow at rates higher than the State. However, during this same period, the population of Roane and Morgan counties declined by 1.4 percent and 4.3 percent, respectively, while the population of Anderson County increased by 2.7 percent (Table 3.10.1-1).

Future population projections for the State of Tennessee and each county in the State are produced by the University of Tennessee's Boyd Center for Business and Economic Research. Forecasts are informed by the following data trends from 2000 to 2018 (Boyd Center for Business and Economic Research, 2019):

- Vital statistics data (births and deaths) from the Tennessee Department of Health.
- Predicted net migration patterns.
- Life tables from the Social Security Administration.
- Recent average birth rates by county.
- Race and age of female population.
- Forecasted future U.S. populations.

Based on these projections, the population in the ROI is expected to grow at rates slightly lower than that of the total State population throughout the period of operation of the TRISO-X Fuel Fabrication Facility (TRISO-X FFF) until license renewal or decommissioning, which is anticipated to occur in 2065. The total State population is expected to grow 31.3 percent by 2065 relative to the population in 2020. Over this same time period, the combined population of the ROI is expected to increase by approximately 28.7 percent. This overall growth rate is attributed to the combination of a high growth rate in Knox and Loudon counties (35.2 percent and 43.1 percent, respectively), coupled with lower growth rates in Anderson and Morgan counties (9.6 percent and 7.1 percent, respectively) and a projected decline in population (-7.8 percent) in Roane County (Table 3.10.1-2).

3.10.1.2 Demographic Characteristics

According to Appendix C of NUREG-1748, which describes Environmental Justice Procedures as part of Environmental Reviews for Licensing Actions Affecting NMSS Programs, the U.S. Nuclear Regulatory Commission (NRC) recommends that poverty and minority characteristics be considered for an area within a 0.6 mi. (1.0 km) radius from the center of the site if the facility is located within city limits, or for an area within a 4.0 mi. (6.4 km) radius from the center of the site if the facility is located outside city limits or in a rural area. Although the HCS is located within the Oak Ridge city limits, the predominantly rural setting supports the use of the larger radius in order to characterize an adequate sample of the surrounding population. Therefore, in addition to assessing the demographic characteristics of the five counties comprising the ROI and the State of Tennessee, this section also provides a focused discussion of minority populations and households living below the poverty level in the census block groups (CBGs) partially or entirely within a 4.0 mi. (6.4 km) radius of the proposed HCS center point. This area includes portions of Roane, Anderson, and Morgan counties.

The most recent demographic data available during the preparation of this report includes 2020 USCB Decennial Census data (USCB, 2020) for race and ethnicity and 2015-2019 ACS data (USCB, 2019) for poverty level. Note that some CBG designations and boundaries were revised between the 2019 and 2020 data reporting.

3.10.1.2.1 Minority Population

NUREG-1748 defines minority as individual(s) who are members of the following population groups: American Indian and Alaska Native; Asian; Native Hawaiian and Other Pacific Islander; Black or African American; some other race; two or more races; and Hispanic or Latino (of any race). Table 3.10.1-3 provides 2020 population data for minority groups in each of the 13 CBGs within a 4 mi. (6.4 km) radius of the HCS center point, as well as for minority groups in each of the five counties comprising the ROI and the State of Tennessee. The table also reports the percentage of the total population represented by all minority groups combined. The combined minority population across the five-county ROI accounts for 19.3 percent of the ROI's population. Minorities comprise approximately 29 percent of the population of the State of Tennessee.

Within the portion of the ROI that falls within 4.0 mi. (6.4 km) of the HCS, combined minority populations within individual CBGs range from 2.5 percent to 37.0 percent. Additionally, two CBGs, including the CBG that encompasses the HCS, have no resident population. Minorities represent 16.1 percent of the CBG located adjacent to the HCS to the north (Census Tract 301, CBG 2), with Black or African American residents making up the largest minority group, closely followed by those that identify as two or more races (Table 3.10.1-3). Figure 3.10.1-2 depicts the total minority population percentage by CBG within 4.0 mi.(6.4 km) of the HCS.

As shown in Table 3.10.1-3, one CBG within the 4 mi. (6.4 km) radius surrounding the HCS, Census Tract 201, CBG 2, has a combined minority population share that exceeds that of the county by more than 20 percentage points; 37.0 percent of this CBG's population belongs to one or more minority population groups. Additional detail regarding specific minority groups within this CBG are provided in Table 3.10.1-3. As depicted in Figure 3.10.1-2, Census Tract 201, CBG 2 is located east-northeast of the HCS in Anderson County. Only the westernmost portion of the CBG is located within the 4 mi. (6.4 km) radius of the HCS; residential development in this area is sparse and consists of single-family homes on relatively large lots. The majority of the population resides in the more densely developed eastern portion of the CBG, closer to Oak Ridge's city center, in a mixture of single-family and multifamily units (Anderson County, 2022). No churches, institutions, or businesses were identified within this CBG that predominantly serve minority communities. Although not all the residents of Census Tract 201, CBG 2 are of a minority population group, and not all minority residents in the study area live in this CBG, special attention to this community is warranted in the environmental justice analysis (Section 4.11, Environmental Justice) to determine if disproportionately high and adverse impacts occur to the minority population near the site.

3.10.1.2.2 Population with Income Below Poverty Level

NUREG-1748 defines low-income populations as those being below the poverty level defined by the USCB. Low-income status was determined for populations in each of the CBGs within a 4 mi. (6.4 km) radius of the center of the HCS, as well as for populations within each of the five counties comprising the ROI and the State of Tennessee, based on 2019 income data (USCB, 2019). Low-income statistics for the ROI are reported in Table 3.10.1-4.

The percentage of population living in poverty within the ROI (14.7 percent) in 2019 is slightly lower than for the State of Tennessee (15.2 percent). Persons below the poverty level in the CBGs that fall within 4.0 mi. (6.4 km) of the HCS, excluding the CBGs with no resident population, range from 0 percent to 28.7 percent (Table 3.10.1-4). Figure 3.10.1-3 depicts the percentage of the population below the poverty level, by CBG within 4.0 mi. (6.4 km) of the

HCS. Although the CBG that encompasses the HCS has no resident population, only 1.5 percent of the population in the CBG located adjacent to the HCS to the north (Census Tract 301, CBG 2) had an income below the poverty level. As none of the CBGs within 4.0 mi. (6.4 km) of the HCS have low-income populations that exceed their respective county or State figure by 20 percentage points or more, no minority populations were identified that would require consideration of environmental justice in greater detail in Section 4.11, Environmental Justice.

3.10.1.3 Population Density

Population density for each of the ROI counties is provided in Table 3.10.1-5. Population density varies widely among the five counties that make up the ROI. In 2020, Morgan County had the lowest population density, with 40 people/sq. mi., compared to Knox County, which was much more densely populated at 911 people/sq. mi. Figure 3.10.1-4 depicts the population density by CBG within the ROI in the year 2020. Within the ROI, some CBGs are relatively densely populated, and other areas are sparsely populated. For example, in Knox County, some CBGs have population densities above 5,000 people/sq. mi, whereas the rural areas of all five counties have areas with fewer than 100 people/sq. mi. In 2020, the CBG within which the HCS is located had no resident population, while the CBG located north adjacent to the HCS (Census Tract 301, CBG 2) had a population density of 316 residents/sq. mi.

Population projections presented in Table 3.10.1-5 indicate that the ROI population will grow during the period between 2020 and 2065; consequently, population density will also increase. By 2065, Knox County's population density is projected to approach 1,232 people/sq. mi. Other ROI counties will continue to be much less densely populated but will experience incremental increases in population density, with the exception of Roane County, where the population is projected to decrease slightly resulting in a density of 125 people/sq. mi by 2065 (Table 3.10.1-5).

3.10.2 ECONOMIC CHARACTERISTICS

3.10.2.1 Employment and Occupational Patterns

Labor force and employment characteristics of the ROI are shown in Table 3.10.2-1. In 2019, the unemployment rate for the ROI was 4.7 percent, slightly lower than that of the State (5.3 percent). Unemployment trends in the ROI counties appear to closely reflect those of the State. As shown in Table 3.10.2-1, unemployment rates across all five counties of the ROI were higher in 2010 than in 2019; rates in 2000 were slightly lower but generally consistent with 2019 unemployment levels.

Employment by industry within the ROI is shown in Table 3.10.2-2. The regional distribution of employment by industry in the five counties surrounding the HCS is generally similar to the distribution of employment in the State as a whole but exhibits several key differences. Across all five counties, a smaller portion of workers are employed in manufacturing and transportation and warehousing activities than the rest of Tennessee. Conversely, a greater portion of workers are employed in the professional, scientific, management, and administrative and waste management sector, as well as in educational services, healthcare and social assistance, and retail trade. These industries represent many of the ROI's largest employers listed in Table 3.10.2-3.

3.10.2.2 Income

Table 3.10.2-4 reports 2019 per-capita income and median household income for each county within the ROI and State of Tennessee. Per-capita income in the ROI ranged from a low of $20,204 in Morgan County to a high of $33,229 in Knox County. During that same period, the per-capita income in Tennessee as a whole was $29,859, which was in the general range of incomes in Anderson, Knox, Loudon, and Roane Counties. However, per-capita income in Morgan County was only approximately 68 percent of the State per-capita income. Similar patterns were identified when using the median household income measure (Table 3.10.2-4). In Morgan County, the median household income is approximately 78 percent of the value for Tennessee as a whole ($53,320), whereas median household incomes in Anderson, Knox, Loudon, and Roane Counties are within the general range of the State.

3.10.2.3 Tax Structure

The State and local tax structure for all of Tennessee, unless specifically noted at the city or county level, is found in Title 67 of the Tennessee Code Annotated (TCA) and its revisions. Income taxes, privilege and excise taxes, sales and use taxes, and property taxes contribute to the total funds for the State of Tennessee. The State has no personal income tax on salaries and wages.

Corporate income taxes are levied pursuant to guidelines contained in Title 67 of the TCA. These include franchise taxes, based on the greater of net worth or the book value of real or tangible personal property owned or used in Tennessee, and excise taxes, based on net earnings or income for the tax year. Businesses in Anderson, Knox, Loudon, Morgan, and Roane counties have tax incentives available to them, including capital-investment tax credits.

The appraised value of property is determined by the county assessor and constitutes the base for all property taxes, including those of cities and towns on property located within the municipality. Properties in Tennessee are reappraised on either a 4-year, 5-year, or 6-year cycle. Table 3.10.2-5 shows tax revenue by category for the five counties within the ROI for fiscal year 2021. The percentage of property tax assessments by category for the State of Tennessee are shown in Table 3.10.2-6. Property tax rates vary by county and local municipality. The property tax rates for the City of Oak Ridge and Roane County, where the HCS is located, are shown in Table 3.10.2-7 for tax years 2010 through 2020.

3.10.3 COMMUNITY CHARACTERISTICS

3.10.3.1 Housing

Table 3.10.3-1 shows the total number of housing units (298,372) in the ROI in 2019. Approximately 70 percent of the housing units are located in Knox County. There are 31,317 vacant housing units within the ROI, of which 5,640 units are for rent and 3,257 are for sale. Most of the vacant units in the ROI were classified as “other vacant,” followed by vacant units that were available for rent and those that were for seasonal, recreational, or occasional use.

Table 3.10.3-2 shows estimated housing values for owner-occupied units in the ROI. Median home value by county for the ROI ranged from $102,000 to $222,500. Approximately 21 percent of owner-occupied units within the ROI fall below a value of $100,000, while approximately 37 percent of housing units within the ROI are within the $100,000 and $200,000 range, and

another 21 percent are within the $200,000 to $300,000 range. The remaining 21 percent of owner-occupied housing units within the ROI are valued above $300,000.

3.10.3.2 Education

A total of 210 public and private elementary, middle, and high schools are located in the ROI, the majority of which are located in Knox County. A summary of these school statistics, including student enrollment and student-to-teacher ratios for the 2017-2018 private school year and 2020-2021 public school year, are provided in Table 3.10.3-3. In addition to these primary and secondary schools, several college campuses are located within the ROI, including the University of Tennessee—Knoxville, Roane State Community College, Pellissippi State Community College, Johnson University, Tusculum College, South College, Crown College, Knoxville College, and the Tennessee College of Applied Technology. An estimate of the number of individuals within the ROI enrolled in school, by grade level and post-secondary schooling, is shown in Table 3.10.3-4. As shown in this table, during 2019, schools in the ROI served more than 157,800 students.

None of the schools within the ROI are located within the area surrounding the HCS. The closest school to the HCS is Dyllis Springs Elementary School, located 2.49 miles (4.02 km) west of the site, as depicted on Figure 3.10.3-1.

In general, the population of the ROI has more advanced education than the general population in the State (Table 3.10.3-5). In 2019, approximately 27 percent of individuals 25 years and over living in Tennessee had received a bachelor's or more advanced degree, whereas 32 percent of individuals within the ROI had received similar degrees.

3.10.3.3 Health Care Services

As shown in Table 3.10.3-6, health care in the ROI is provided by 12 hospitals as well as various other licensed health care facilities. One hospital (Methodist Medical Center) is located in Oak Ridge Tennessee. The Methodist Medical Center is a 301-bed regional medical center offering a variety of clinical services, including emergency trauma care; a birthing center; specialized surgery; and cardiac, cancer, and rehabilitation services (Covenant Health, 2022). In addition to hospitals and other medical facilities, the five counties within the ROI have numerous facilities to serve seniors, including nursing homes, homes for the aged, and assisted care living facilities (Table 3.10.3-6).

To further convey a sense of the availability of healthcare resources to residents of the study area, Table 3.10.3-7 provides a summary of the number of residents per healthcare professional in each county. These data were collected by the Tennessee Department of Health (2022b). Knox County has more healthcare personnel relative to its population than do the other counties; medical doctors, registered nurses, and dentists in Knox County all have fewer persons per licensed professional than their counterparts in Anderson, Loudon, Morgan, and Roane counties.

3.10.3.4 Public Safety

The City of Oak Ridge Fire Department provides fire and emergency response services to the HCS. The City of Oak Ridge Fire Department employs 74 firefighters at four fire stations. The closest of these is Station 4, located 2.18 miles (3.50 km) southwest of the HCS, on Enrichment Drive north of Tennessee State Route 58 (Oak Ridge Turnpike) in the East Tennessee

Technology Park (ETTP) (Figure 3.10.3-1). The Oak Ridge Fire Department owns the following equipment (City of Oak Ridge, 2020):

- Eight fire trucks (pumpers and ladder).
- Four radio-equipped rescue vehicles.
- Twelve radio-equipped support/command vehicles.
- A HazMat truck.
- Two ambulances.

The Oak Ridge Police Department is the principal law enforcement agency servicing the HCS. In 2020, the Oak Ridge Police Department employed approximately 85 staff, including 41 patrol officers (City of Oak Ridge, 2020). All five ROI counties also have Sherriff's Departments that could provide additional resources if needed. As of 2019, 618 full-time law enforcement officers were employed in the ROI: 64 in Anderson County, 430 in Knox County, 57 in Loudon County, 25 in Morgan County, and 42 in Roane County (FBI, 2019).

3.10.3.5 Transportation Services

The ROI and the areas encompassing the HCS are served by a transportation network of Federal and State highways, as well as freight rail lines; navigable waterways (the Clinch and Tennessee Rivers); and a reliever airport, Knoxville Downtown Island Airport. For greater detail on transportation services and infrastructure near the HCS, see Section 3.2, Transportation.

3.10.3.6 Water and Wastewater

The HCS would be serviced by the City of Oak Ridge Public Works Department, which manages that city's water and wastewater treatment plants, water distribution system, and wastewater collection system (City of Oak Ridge, 2022a). The City of Oak Ridge Public Works Department obtains its water from the Melton Hill Reservoir, obtaining a maximum capacity of 9.9 million gallons per day (MGD). The average daily consumption is 7.7 MGD with an excess of 2.2 MGD (TVA, 2019). The City of Oak Ridge is planning a new membrane filtration water treatment plant south of Bethel Valley Road on the Clinch River, with a capacity to treat 16 MGD. Construction of the plant is expected to be complete in December of 2022 (Oak Ridge Today, 2021). Wastewater is treated by the City of Oak Ridge which has two wastewater systems. The main system treats 30 MGD and the other treats 0.6 MGD, which serves the Clinch River Industrial Park, East Tennessee Technology Park, Horizon Center and Rarity Ridge (City of Oak Ridge, 2022b).

Table 3.10.1-1
Population in the Region of Influence (2000-2020)

Geography	2000	2010	2020	Percent Change 2000-2010	Percent Change 2010-2020	Percent Change 2000-2020
Roane County	51,910	54,181	53,404	4.4%	-1.4%	2.9%
Anderson County	71,330	75,129	77,123	5.3%	2.7%	8.1%
Knox County	382,032	432,226	478,971	13.1%	10.8%	25.4%
Loudon County	39,086	48,556	54,886	24.2%	13.0%	40.4%
Morgan County	19,757	21,987	21,035	11.3%	-4.3%	6.5%
ROI Total	**564,115**	**632,079**	**685,419**	**12.0%**	**8.4%**	**21.5%**
Tennessee	5,689,283	6,346,105	6,910,840	11.5%	8.9%	21.5%

Reference: USCB, 2000; USCB, 2010; USCB, 2020

Table 3.10.1-2
Population Projections for Region of Influence through 2065

Geography	2020	2025	2045	2065	Percent Change 2020-2045	Percent Change 2045-2065	Percent Change 2020-2065
Roane County	53,404	53,386	51,318	49,249	-3.9%	-4.0%	-7.8%
Anderson County	77,123	78,500	81,560	84,524	5.8%	3.6%	9.6%
Knox County	478,971	494,503	568,606	647,574	18.7%	13.9%	35.2%
Loudon County	54,886	57,606	67,203	78,518	22.4%	16.8%	43.1%
Morgan County	21,035	22,100	22,440	22,521	6.7%	0.4%	7.1%
ROI Total	**685,419**	**706,095**	**791,127**	**882,387**	**15.4%**	**11.5%**	**28.7%**
Tennessee	6,910,840	7,153,758	8,068,601	9,074,458	16.8%	12.5%	31.3%

Reference: USCB, 2020; Boyd Center for Business and Economic Research, 2019

Table 3.10.1-3
(Sheet 1 of 2)
Minority Populations in Region of Influence (2020)

		Not Hispanic or Latino								
Geography	**Total Population**	**White Alone**	**Black or African American Alone**	**American Indian and Alaska Native Alone**	**Asian Alone**	**Native Hawaiian and Other Pacific Islander Alone**	**Some Other Race Alone**	**Two or More Races**	**Hispanic or Latino**	**Combined Minority Population**
Roane County	53,404	90.1%	2.4%	0.3%	0.6%	0.0%	0.3%	4.3%	1.9%	9.9%
Census Tract 301, Block Group 1	1,606	84.7%	2.8%	0.1%	2.1%	0.4%	0.9%	5.6%	3.5%	15.3%
Census Tract 301, Block Group 2 [(a)]	1,781	83.9%	5.7%	0.2%	1.7%	0.1%	0.2%	4.9%	3.3%	16.1%
Census Tract 302.06, Block Group 1	1,313	92.2%	0.2%	0.5%	1.0%	0.0%	0.2%	4.0%	1.8%	7.8%
Census Tract 302.06, Block Group 2	905	89.3%	1.1%	0.8%	0.8%	0.0%	0.8%	5.6%	1.7%	10.7%
Census Tract 302.06, Block Group 3	1,743	90.2%	2.0%	0.2%	1.3%	0.0%	0.2%	4.2%	1.9%	9.8%
Census Tract 309, Block Group 1	1,325	90.7%	3.2%	0.3%	0.2%	0.0%	0.0%	3.8%	1.7%	9.3%
Census Tract 309, Block Group 2	4,413	93.8%	0.7%	0.3%	0.4%	0.0%	0.3%	3.7%	0.8%	6.2%
Census Tract 9801, Block Group 1 [(a)(b)]	0	--	--	--	--	--	--	--	--	--
Morgan County	21,035	90.5%	4.6%	0.3%	0.2%	0.0%	0.3%	2.7%	1.4%	9.5%
Census Tract 1104, Block Group 3	1,021	97.5%	0.0%	0.1%	0.0%	0.0%	0.0%	2.3%	0.2%	2.5%

Table 3.10.1-3
(Sheet 2 of 2)
Minority Populations in Region of Influence (2020)

		Not Hispanic or Latino								
Geography	**Total Population**	**White Alone**	**Black or African American Alone**	**American Indian and Alaska Native Alone**	**Asian Alone**	**Native Hawaiian and Other Pacific Islander Alone**	**Some Other Race Alone**	**Two or More Races**	**Hispanic or Latino**	**Combined Minority Population**
Anderson County	77,123	85.6%	3.7%	0.3%	1.3%	0.1%	0.4%	5.1%	3.7%	14.4%
Census Tract 201, Block Group 2	1,628	63.0%	22.5%	0.6%	2.0%	0.4%	0.4%	5.8%	5.3%	37.0%
Census Tract 206, Block Group 1	1,493	85.0%	3.8%	0.1%	1.9%	0.1%	0.0%	4.3%	4.8%	15.0%
Census Tract 210.02, Block Group 2	1,425	90.8%	2.5%	0.4%	0.2%	0.0%	0.4%	3.9%	1.8%	9.2%
Census Tract 9801, Block Group 1 [(b)]	0	--	--	--	--	--	--	--	--	--
Knox County	478,971	78.0%	8.3%	0.2%	2.5%	0.1%	0.4%	4.5%	6.0%	22.0%
Loudon County	54,886	84.6%	1.1%	0.2%	0.8%	0.0%	0.3%	3.3%	9.8%	15.4%
ROI Total	**685,419**	**80.7%**	**6.6%**	**0.2%**	**2.0%**	**0.1%**	**0.4%**	**4.4%**	**5.6%**	**19.3%**
Tennessee	6,910,840	70.9%	15.7%	0.2%	1.9%	0.1%	0.3%	3.9%	6.9%	29.1%

Reference: USCB, 2020
Notes:
a) Census block groups (CBGs) encompassing and/or immediately adjacent to HCS.
b) CBGs with no resident population.

Table 3.10.1-4
Populations Below Poverty Level in Region of Influence (2019)

Geography	Population for Whom Poverty Status is Determined[a]	Population with Income in 2019 below Poverty Level	Percent of Population with 2019 Income below Poverty Level
Roane County	52,262	7,237	13.8%
Census Tract 301, Block Group 1	1,544	11	0.7%
Census Tract 301, Block Group 2 [b]	1,715	26	1.5%
Census Tract 302.01, Block Group 1	1,431	356	24.9%
Census Tract 302.01, Block Group 4	892	0	0.0%
Census Tract 302.01, Block Group 5	1,192	28	2.3%
Census Tract 309, Block Group 1	2,359	676	28.7%
Census Tract 309, Block Group 2	870	15	1.7%
Census Tract 309, Block Group 3	710	96	13.5%
Census Tract 309, Block Group 4	1,124	160	14.2%
Census Tract 9801, Block Group 1 [b][c]	0	0	-
Morgan County	18,539	4,232	22.8%
Census Tract 1104, Block Group 3	822	73	8.9%
Anderson County	74,552	12,481	16.7%
Census Tract 201, Block Group 2	1,518	181	11.9%
Census Tract 206, Block Group 1	1,453	118	8.1%
Census Tract 210, Block Group 4	1,310	263	20.1%
Census Tract 9801, Block Group 1 [c]	0	0	-
Knox County	450,053	65,448	14.5%
Loudon County	51,857	5,845	11.3%
ROI Total	**647,263**	**95,243**	**14.7%**
Tennessee	6,542,792	996,930	15.2%

Reference: USCB, 2019

Notes:

a) USCB does not determine poverty status for certain populations, such as people living in college dormitories and in institutional or military group quarters. Thus, the population for whom poverty status is determined is slightly smaller than the overall population.
b) CBGs encompassing and/or immediately adjacent to HCS.
c) CBGs with no resident population.

Table 3.10.1-5
Population Density in Region of Influence

Geography	Total 2020 Population	Projected Total 2065 Population	Land Area (sq. mi.)	Population per sq. mi. (2020)	Population per sq. mi. (2065)
Roane County	53,404	49,249	394.9	135.2	124.7
Anderson County	77,123	84,524	344.8	223.7	245.2
Knox County	478,971	647,574	525.9	910.8	1,231.5
Loudon County	54,886	78,518	247.3	221.9	317.5
Morgan County	21,035	22,521	522.4	40.3	43.1
ROI Total	**685,419**	**882,387**	**2,035.3**	**336.8**	**433.5**

Reference: USCB, 2020; Boyd Center for Business and Economic Research, 2019

Table 3.10.2-1
Labor Force and Employment Characteristics of the Region of Influence

	2019					2010	2000
Geography	**Total Labor Force**	**Labor Force in Armed Services**	**Employed Civilian Labor Force**	**Unemployed Labor Force**	**Percent Unemployed Labor Force**	**Percent Unemployed Labor Force**	**Percent Unemployed Labor Force**
Anderson County	34,730	9	32,611	2,110	6.1%	7.5%	5.2%
Knox County	242,927	510	232,086	10,331	4.3%	5.6%	4.4%
Loudon County	22,498	49	21,396	1,053	4.7%	9.2%	3.6%
Morgan County	7,891	3	7,370	518	6.6%	8.3%	7.0%
Roane County	23,646	0	22,195	1,451	6.1%	8.4%	5.1%
ROI Total	**331,692**	**571**	**315,658**	**15,463**	**4.7%**	**6.4%**	**4.6%**
Tennessee	3,301,501	18,830	3,109,872	172,799	5.3%	8.6%	5.0%

Reference: USCB, 2019; USCB, 2010; USCB, 2000

Table 3.10.2-2
Employment by Industry in Region of Influence (2019)

Industry	Anderson County		Knox County		Loudon County		Morgan County		Roane County		ROI		TN	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Agriculture, forestry, fishing and hunting, and mining	130	0.4%	1,198	0.5%	480	2.2%	183	2.5%	160	0.7%	1,488	0.7%	30,413	1.0%
Construction	2,226	6.8%	13,540	5.8%	1,986	9.3%	746	10.1%	1,472	6.6%	17,238	6.3%	201,677	6.5%
Manufacturing	3,806	11.7%	18,097	7.8%	3,775	17.6%	936	12.7%	2,414	10.9%	24,317	9.2%	405,457	13.0%
Wholesale trade	499	1.5%	7,055	3.0%	444	2.1%	54	0.7%	519	2.3%	8,073	2.7%	79,884	2.6%
Retail trade	3,457	10.6%	31,843	13.7%	2,602	12.2%	754	10.2%	2,755	12.4%	38,055	13.1%	365,401	11.7%
Transportation and warehousing, and utilities	1,659	5.1%	11,141	4.8%	1,430	6.7%	381	5.2%	1,382	6.2%	14,182	5.1%	205,141	6.6%
Information	297	0.9%	5,098	2.2%	197	0.9%	41	0.6%	259	1.2%	5,654	1.9%	51,593	1.7%
Finance and insurance, and real estate and rental and leasing	1,536	4.7%	14,334	6.2%	939	4.4%	149	2.0%	1,009	4.5%	16,879	5.7%	180,763	5.8%
Professional, scientific, and management, and administrative and waste management services	5,472	16.8%	30,115	13.0%	2,409	11.3%	830	11.3%	3,424	15.4%	39,011	13.4%	308,484	9.9%
Educational services, and health care and social assistance	7,092	21.7%	58,179	25.1%	3,792	17.7%	1,508	20.5%	4,667	21.0%	69,938	24.8%	698,558	22.5%
Arts, entertainment, and recreation, and accommodation and food services	2,732	8.4%	23,894	10.3%	1,721	8.0%	524	7.1%	1,869	8.4%	28,495	9.7%	304,009	9.8%
Other services, except public administration	1,882	5.8%	9,696	4.2%	1,057	4.9%	408	5.5%	1,039	4.7%	12,617	4.5%	150,297	4.8%
Public administration	1,823	5.6%	7,896	3.4%	564	2.6%	856	11.6%	1,226	5.5%	10,945	3.9%	128,195	4.1%
Total	**32,611**	**100.0%**	**232,086**	**100.0%**	**21,396**	**100.0%**	**7,370**	**100.0%**	**22,195**	**100.0%**	**315,658**	**100.0%**	**3,109,872**	**100.0%**

Reference: USCB, 2019

Table 3.10.2-3
Largest Employers in the Region of Influence (2021)

Company	County	Total Employees	Description
Y-12 National Security Complex	Roane	11,627	Refurbishing nuclear weapon components and storage and recycling of nuclear material
Knox County Schools	Knox	9,515	Public education system
The University of Tennessee—Knoxville	Knox	8,959	State university
Oak Ridge National Laboratory	Roane	5,452	Research and development
University of Tennessee Medical Center (UHS)	Knox	5,137	Health care system
State of Tennessee—Regional Offices	Knox	3,307	State administrative offices
Knox County Government	Knox	2,677	County government
City of Knoxville	Knox	2,210	Municipal government
Roane County Schools	Roane	1,930	Public education system
UCOR	Roane	1,842	Engineering, environmental management, and cleanup
East Tennessee Children's Hospital	Knox	1,819	Area children's hospital
Copper Cellar Corp.	Knox	1,576	Full-service restaurants
CVS Caremark Corp.	Knox	1,534	Drugstores and pharmaceutical distribution
Brothers Management	Knox	1,500	McDonald's franchise
United Parcel Service (UPS)	Knox	1,450	Shipping and delivery operation
Oak Ridge City Schools	Anderson	1,323	Local public education system
Tennessee Valley Authority (TVA)	Knox	1,232	Regional power authority and development agency
Knoxville Utilities Board (KUB)	Knox	1,088	Local utilities provider
U.S. Postal Service	Knox	1,060	Mail service
Anderson County Schools	Anderson	1,050	Public education system
Pellissippi State Technical Community College	Knox	1,043	Two-year technical community college
Discovery Inc.	Knox	1,035	Cable networks—HGTV, Food Network, Do-It-Yourself, Fine Living, and GAC
Oak Ridge Associated Universities	Anderson	1,000	University consortium, partnerships between scientific research, government, and industry

Reference: East Tennessee Economic Development Agency, 2022

Table 3.10.2-4
Income Data for Counties within Region of Influence (2019)

	Anderson County	Knox County	Loudon County	Morgan County	Roane County	Tennessee
Per Capita Income	$ 28,455	$ 33,229	$ 31,478	$ 20,204	$ 30,209	$ 29,859
Percent of State Per Capita Income	95.3%	111.3%	105.4%	67.7%	101.2%	-
Median Household Income	$ 50,392	$ 57,470	$ 58,065	$ 41,333	$ 53,367	$ 53,320
Percent of State Median Household Income	94.5%	107.8%	108.9%	77.5%	100.1%	-

Reference: USCB, 2019

Table 3.10.2-5
County Tax Revenue by Category for Fiscal Year 2021[(a)]

Category of Tax	Anderson County	Knox County	Loudon County	Morgan County	Roane County
Property	$20,545,803	$ 186,269,007	$18,394,113	$6,944,680	$19,193,515
Sales	$3,187,447	$ 20,394,798	$2,055,738	N/A	$ 1,687,395
Lodging	$423,965	$ 7,404,768	$514,708	N/A	N/A
Business	$1,363,386	$ 11,541,602	$767,621	N/A	$ 849,951
Additional Local Taxes	$ 658,056	$ 17,009,078	$2,011,584	$1,906,705	$ 2,394,125
Total	**$ 26,478,657**	**$ 242,619,253**	**$23,743,764**	**$8,851,385**	**$24,115,986**

Reference: Anderson County, 2021; Knox County, 2021; Loudon County, 2021; Morgan County, 2021; Roane County, 2021

Note:

a) Fiscal Year 2021 extends from July 1, 2020, through June 30, 2021.

Abbreviation:

N/A = not available

Table 3.10.2-6
Tennessee Property Tax Classes

Description	Assessment Percent (%)
Residential Property	25
Farm Property	25
Commercial and Industrial Property	40
Public Utility Property	55
Business Personal Property	30

Reference: Tennessee Comptroller of the Treasury, 2022a

Table 3.10.2-7
City of Oak Ridge and Anderson County Property Tax Rates over the Last Ten Tax Years
(in $ per $100 assessed value)

Tax Year	City of Oak Ridge Tax Rate	Roane County Tax Rate	Total
2010	2.39	2.19	4.581
2011	2.39	2.18	4.57
2012	2.39	2.18	4.57
2013	2.39	2.18	4.57
2014	2.39	2.18	4.57
2015	2.52	2.575	5.095
2016	2.52	2.575	5.095
2017	2.52	2.575	5.095
2018	2.54	2.575	5.115
2019	2.56	2.685	5.245
2020	2.314	2.471	4.785
2021	2.314	2.47	4.784

Reference: Tennessee Comptroller of the Treasury, 2022b

Table 3.10.3-1
Housing Characteristics in Region of Influence (2019)

	Anderson County	Knox County	Loudon County	Morgan County	Roane County	ROI
Total Housing Units	**34,971**	**205,620**	**23,083**	**9,041**	**25,657**	**298,372**
Units in Structure						
1-unit, detached	23,961	136,591	18,110	6,249	18,271	203,182
1-unit, attached	893	11,585	934	30	414	13,856
2 units	765	3,524	204	55	613	5,161
3 or 4 units	1,529	6,350	245	32	629	8,785
5 to 9 units	1,207	10,279	500	73	421	12,480
10 to 19 units	1,071	13,655	366	18	169	15,279
20 or more units	1,423	14,687	506	9	596	17,221
Mobile home	4,122	8,809	2,157	2,575	4,512	22,175
Boat, RV, van, etc.	0	140	61	0	32	233
Occupancy						
Percent Occupied	87.3%	91.1%	89.5%	84.3%	81.5%	89.5%
Percent Vacant	12.7%	8.9%	10.5%	15.7%	18.5%	10.5%
Occupied Housing Units	30,541	187,319	20,669	7,625	20,901	267,055
Percent Owner Occupied	67.9%	64.3%	77.8%	81.6%	77.2%	67.2%
Percent Renter Occupied	32.1%	35.7%	22.2%	18.4%	22.8%	32.8%
Vacant Housing Units	4,430	18,301	2,414	1,416	4,756	31,317
For rent	591	4,221	233	116	479	5,640
Rented, not occupied	132	1,116	21	6	134	1,409
For sale only	396	1,973	326	57	505	3,257
Sold, not occupied	172	832	11	31	81	1,127
For seasonal, recreational, or occasional use	429	1,785	610	167	1,062	4,053
For migrant workers	0	48	5	0	77	130
Other vacant	2,710	8,326	1,208	1,039	2,418	15,701

Reference: USCB, 2019

Table 3.10.3-2
Value of All Owner-Occupied Housing Units in Region of Influence (2019)

	Number of Housing Units					
Value	**Anderson County**	**Knox County**	**Loudon County**	**Morgan County**	**Roane County**	**ROI**
Less than $50,000	2,106	5,203	692	1,064	1,596	10,661
$50,000 to $99,999	4,262	14,686	2,257	1,988	3,594	26,787
$100,000 to $149,999	4,296	22,599	2,152	1,194	2,857	33,098
$150,000 to $199,999	3,650	24,905	2,062	788	2,800	34,205
$200,000 to $299,999	3,836	26,583	3,502	779	2,340	37,040
$300,000 to $499,999	1,910	17,994	3,321	297	1,826	25,348
$500,000 to $999,999	632	6,934	1,545	82	917	10,110
$1,000,000 or more	54	1,486	545	31	213	2,329
Total Owner-Occupied Units	20,746	120,390	16,076	6,223	16,143	179,578
			Median Value			
Median value for all Owner-Occupied Housing Units	$146,200	$183,200	$222,500	$102,000	$150,300	--

Reference: USCB, 2019

Table 3.10.3-3
Educational Facilities in the Region of Influence (2017-2018 and 2021-2022 School Years)

Geography	Total Number of Schools	Elementary	Middle	Secondary	Student Enrollment	Teachers (FTEs) [(a)]	Student to Teacher Ratio
Anderson County							
Anderson County School District	18	10	4	4	6,222	509.3	12.2
Oak Ridge School District	9	5	2	1	4,643	351.3	13.2
Clinton City Schools	3	3			690	67	10.3
Private Schools	4				303	18.7	16.2
Knox County							
Knox County School District	91	54	17	20	59,169	3,931.40	15.1
Tennessee School for the Deaf	3	2		1	140	40.7	3.4
Private Schools	38				8,153	669.4	12.2
Loudon County							
Loudon County School District	9	4	3	2	4,683	393.2	11.9
Private Schools	2				131	15	8.7
Morgan County							
Morgan County School District	8	1	2	5	2,795	195.6	14.3
Private Schools	2				19	2.6	7.3
Roane County							
Roane County School District	18	6	6	6	6,341	435.2	14.6
Private Schools	5				663	283.7	2.3
ROI Totals	**210**				**93,952**	**6,913**	**13.6**

Reference: National Center for Education Statistics, 2021
Note:
a) FTE = full-time equivalent employee (part-time workers are reported as a fraction of one full-time worker).

Table 3.10.3-4
Enrollment by Level of School in Region of Influence (2019)

	Anderson County	Knox County	Loudon County	Morgan County	Roane County	ROI
Nursery school, preschool	810	6,928	626	170	443	8,977
Kindergarten	867	5,692	323	146	486	7,514
Grade 1 to grade 4	3,650	21,817	2,326	756	2,093	30,642
Grade 5 to grade 8	3,708	21,349	2,443	1,028	2,463	30,991
Grade 9 to grade 12	3,852	21,494	2,388	1,256	2,549	31,539
College, undergraduate years	2,585	32,555	1,359	469	1,834	38,802
Graduate or professional school	450	8,193	265	52	451	9,411
Total	**15,922**	**118,028**	**9,730**	**3,877**	**10,319**	**157,876**

Reference: USCB, 2019

Table 3.10.3-5
Level of Educational Attainment in Region of Influence for Persons 25 and Older (2019)

	Anderson County		Knox County		Loudon County		Morgan County		Roane County		ROI		Tennessee	
Level of Schooling	**Number**	**% of Total**	**Number**	**% of Total**	**Number**	**% of Total**	**Number**	**% of Total**	**Number**	**% of Total**	**Number**	**% of Total**	**Number**	**% of Total**
High school graduate (includes equivalency)	17,839	32.9%	77,939	25.3%	12,394	32.4%	7,546	48.5%	14,192	36.3%	129,910	28.5%	1,472,003	32.1%
Some college, less than 1 year	3,995	7.4%	18,348	6.0%	2,353	6.1%	1,089	7.0%	3,399	8.7%	29,184	6.4%	293,021	6.4%
Some college, 1 or more years, no degree	8,263	15.2%	44,769	14.5%	5,323	13.9%	1,425	9.2%	5,858	15.0%	65,638	14.4%	658,734	14.4%
Associate's degree	4,470	8.2%	25,676	8.3%	2,805	7.3%	974	6.3%	3,617	9.2%	37,542	8.2%	334,362	7.3%
Bachelor's degree	6,864	12.6%	69,085	22.4%	6,406	16.7%	910	5.8%	4,662	11.9%	87,927	19.3%	789,448	17.2%
Master's degree	3,813	7.0%	31,029	10.1%	2,770	7.2%	480	3.1%	2,381	6.1%	40,473	8.9%	327,379	7.1%
Professional school degree	760	1.4%	8,682	2.8%	436	1.1%	37	0.2%	358	0.9%	10,273	2.3%	79,363	1.7%
Doctorate degree	1,200	2.2%	7,290	2.4%	514	1.3%	35	0.2%	334	0.9%	9,373	2.1%	57,955	1.3%
Total (Persons 25 and Older)	**54,265**	**100%**	**308,366**	**100%**	**38,291**	**100%**	**15,570**	**100%**	**39,144**	**100%**	**455,636**	**100%**	**4,012,265**	**100%**

Reference: USCB, 2019

Table 3.10.3-6
Licensed Health Care Facilities in Region of Influence

	Hospitals		Nursing Homes		Homes for the Aged		Assisted Care Living Facilities	
Geography	**Number of Facilities**	**Total Beds**	**Number of Facilities**	**Total Beds**	**Number of Facilities**	**Total Beds**	**Number of Facilities**	**Total Beds**
Anderson County	1	301	5	580	0	0	7	479
Knox County	9	2,642	16	1,960	3	200	31	2,327
Loudon County	1	50	1	180	1	49	6	357
Morgan County	0	0	1	124	0	0	0	0
Roane County	1	54	2	287	1	25	3	200
ROI Total	12	3,029	25	3,131	5	274	47	3,363

Reference: Tennessee Department of Health, 2022a

Table 3.10.3-7
Number of Residents per Type of Licensed Health Care Professional in the Region of Influence

Geography	Residents per Medical Doctor	Residents per Registered Nurse	Residents per Dentist
Anderson County	795	59	1,928
Knox County	249	45	1,530
Loudon County	930	85	2,033
Morgan County	7,002	134	7,012
Roane County	1,526	52	4,450

Reference: Tennessee Department of Health, 2022b; USCB, 2020

3.11 PUBLIC AND OCCUPATIONAL HEALTH

This section describes levels of background radiation, sources and levels of exposure to radioactive materials, major sources and levels of chemical exposure, occupational injury rates, and health effects studies completed in the region.

3.11.1 BACKGROUND RADIATION EXPOSURE

The major sources and levels of background radiation exposure, both natural and man-made, are discussed in this section.

Based on the information contained in the following sections, there are no abnormal radiation hazards in the vicinity of the TRISO-X Fuel Fabrication Facility (TRISO-X FFF) at the Horizon Center site (HCS). Table 3.11-1 summarizes the background radiation exposure in the vicinity of the TRISO-X FFF. As shown in Table 3.11-1, the background radiation exposure due to both natural and man-made sources is 9.1 millisievert per year (mSv/yr) (910 millirem [roentgen equivalent man] per year [mrem/yr]). Although this annual dose is higher than the national average for background radiation, 6.2 mSv/yr (620 mrem/yr) (NRC, 2021a), this annual dose is not an abnormal radiation hazard since the increase in dose (i.e., above average dose) is due to an above average terrestrial dose contribution that is still below the terrestrial dose contribution in several other States in the U.S. (Section 3.11.1.1.2).

3.11.1.1 Natural Background Sources

The U.S. Nuclear Regulatory Commission (NRC) divides natural sources of radiation into three categories: cosmic, terrestrial, and internal. Cosmic radiation is the result of radiation received from extraterrestrial sources, such as the sun and other stars, that penetrate the Earth's atmosphere. Terrestrial radiation is the result of a dose received from naturally occurring uranium, thorium, and radium found in soil and rock. Also, radon gas seeps through the ground and into the air where it is inhaled. This source represents the majority of the background radiation for an average member of the public. In addition, water contains small amounts of dissolved uranium and thorium, and all organic matter (both plant and animal) contains radioactive carbon and potassium; these materials are ingested with food and water. Lastly, internal radiation is the result of naturally occurring potassium-40 (K-40) and carbon-14 (C-14) in all humans. (NRC, 2021b)

Based on information in the following sections, the public in the TRISO-X FFF vicinity would receive an average natural background dose of 6.0 mSv/yr (598 mrem/yr; Table 3.11-1). Although this annual dose is higher than the United States average natural background dose of 3.1 mSv/yr (310 mrem/yr) (NRC, 2021a), this annual dose is not an abnormal radiation hazard since the increase in dose (i.e., above average dose) is due to an above average terrestrial dose contribution that is still below the terrestrial dose contribution in several other States in the U.S. (Section 3.11.1.1.2).

3.11.1.1.1 Cosmic Radiation

Cosmic radiation exposure depends on the site elevation. The approximate grade elevation of the HCS is 244 m (800 ft.; Section 3.6.1.5.4). This elevation is well within the national elevation average (Almanac, 2021). Therefore, it is appropriate to use the average annual dose due to cosmic radiation, 0.31 mSV/yr (31 mrem/yr) (NRC, 2021a).

3.11.1.1.2 Terrestrial Radiation

The State of Tennessee average annual dose for terrestrial radiation, which includes radon, is 5.36 mSv/yr (536 mrem/yr) and is applicable to the vicinity of the TRISO-X FFF (USEPA, 2005). An annual dose for terrestrial radiation of 5.36 mSv/yr (536 mrem/yr) is higher than the national average of 2.48 mSv/yr (248 mrem/yr) (NRC, 2021a). However, an annual dose of 5.36 mSv/yr (536 mrem/yr) is below the terrestrial dose contribution in several other States in the U.S. and therefore, is not an abnormal radiation hazard.

3.11.1.1.3 Internal Radiation

When comparing to the sources of radioactivity contained in the food and water consumed in major cities throughout the U.S., there are no abnormal sources of radioactivity contained in the food and water consumed in Oak Ridge, Tennessee based on publicly available USEPA data (USEPA, 2009). The average annual dose due to internal radiation, 0.31 mSv/yr (31 mrem/yr), is applicable (NRC, 2021a).

3.11.1.2 Man-Made Background Sources

Man-made sources of radiation consist of medical sources, consumer product sources, nuclear power sources, and occupational sources. Medical sources (e.g., diagnostic X-rays, whole body CT scans, and nuclear medicine procedures) account for a vast majority of the man-made radiation dose received annually. Consumer products (e.g., combustible fuels, televisions, smoke detectors, and tobacco) also contribute to man-made radiation dose. In addition, the nuclear fuel cycle (from uranium mining and milling to disposal of spent fuel), the transportation of radioactive materials, and the fallout from nuclear weapons testing and reactor accidents contribute to man-made radiation dose. Lastly, occupational sources (e.g., industrial radiography and university research laboratories) contribute to man-made radiation dose. (NRC, 2021c)

Based on the information in the following sections, there are no abnormal sources of man-made background radiation located in the vicinity of the TRISO-X FFF; therefore, the public receives an average dose due to man-made radiation sources of 3.1 mSv/yr (310 mrem/yr) (NRC, 2021a).

3.11.1.2.1 Medical Sources

Radiation dose from medical sources fluctuate based on the individual in question; therefore, a best estimate of the average annual dose to an individual due to medical sources, 2.98 mSv/yr (298 mrem/yr), is used (NRC, 2021a).

3.11.1.2.2 Consumer Product Sources

Radiation dose from the use of consumer products fluctuate based on the lifestyle of the individual in question; therefore, a best estimate of the average annual dose to an individual due to consumer products, 0.12 mSv/yr (12 mrem/yr), is used (NRC, 2021a).

3.11.1.2.3 Nuclear Power Sources

/There are no nuclear fuel cycle facilities in the immediate area; however, Highway 95 is less than 1 mi. (<1.6 km) southeast from the TRISO-X FFF, therefore there may be some radiation received from the transportation of radioactive material along that roadway (Google,2022).

In addition, the TRISO-X FFF is located near two nuclear power facilities: Oak Ridge National Laboratory (ORNL) (research facility that performs spent fuel examinations and is the location of a 85 Megawatts thermal [MWt] High Flux Isotope Reactor [HFIR]) and Tennessee Valley Authority's (TVA's) Watts Bar Nuclear Plant (WBNP) (a two-unit pressurized water reactor [PWR] with a total power generation of 6870 MWt) (DOE, 2020; ORNL, 2021; NRC, 2021d; NRC, 2021e). ORNL is located approximately 3.5 mi. (5.6 km) southeast of the TRISO-X FFF and WBNP is located approximately 35 mi. (56 km) southwest of the TRISO-X FFF (Google, 2022). Based on the distance between ORNL/WBNP and the TRISO-X FFF, the dose to the public near the TRISO-X FFF is very low.

The NRC requires its licensees to limit the maximum radiation exposure to individual members of the public to 1 mSv/yr (100 mrem/yr) (NRC, 2021c). The dose to the general public from nuclear fuel cycle facilities, such as fuel-processing plants, nuclear power plants, and transportation routes, has been estimated at less than 0.01 mSv/yr (1 mrem/yr) (ASER, 2019).

3.11.1.2.4 Occupational Sources

As described in Section 3.1.1, the HCS is located on undeveloped land. The current site is dedicated for industrial development.

Philotechnics, LLC, a radiological services and mixed radioactive waste brokerage provider, is located adjacent to the HCS. According to the company website (www.philotechnics.com), Philotechnics performs waste characterizations, consulting, decontamination and decommissioning, license terminations, and disposals for their clients.

Those members of the public who are employed at Philotechnics may receive a higher dose due to occupational sources than that of the average citizen occupation dose, an average total dose of less than 0.01 mSv/yr (1 mrem/yr) (NRC, 2021a), but the workers do not receive a dose in excess of the occupational limit set in 10 CFR 20, 0.05 Sv/yr (5 rem/yr) (NRC, 2021c).

3.11.2 MAJOR SOURCES AND LEVELS OF CHEMICAL EXPOSURE

The U.S. Environmental Protection Agency (USEPA) Envirofacts Multisystem Search Form allows users to search multiple environmental databases for facility information, including toxic chemical releases, water discharge permit compliance, hazardous waste handling processes in compliance with the Resource Conservation and Recovery Act (RCRA), Superfund status, and air emission estimates. USEPA's Enforcement and Compliance History Online (ECHO) tool within Envirofacts allows users to access integrated data from a variety of USEPA data systems. A search within a 1-mi radius of the Horizon Center Site (HCS) was conducted using the Envirofacts and ECHO database systems to identify potential sources of chemicals that may represent a potential for exposure to the public. This review identified seven (7) facilities included within the database. Site information and reporting information were reviewed for each facility; however, none of those facilities indicated data pertaining to chemical storage and no violations or enforcement actions were identified for those facilities (USEPA, 2022a). Also, a Tennessee Department of Environment and Conservation (TDEC) Division of Air Pollution

Control database search using TDEC Dataviewer indicated that one (1) of the seven (7) facilities has a current active operating air permit (US Department of Energy, Office of Science, UT Battelle, LLC) and the facility is in compliance with its permit (TDEC, 2022).

The Toxics Release Inventory was established under the Emergency Planning and Community Right-to-Know Act of 1986. Six (6) facilities located within a 10-mi radius of the TRISO-X FFF reported releases in 2020, and five (5) of those reported releases to air in 2020 (USEPA, 2022b). Airborne releases from these facilities are a potential source of chemical exposure and are indicative of storage, use and/or production of the reported contaminants at the facility. Emissions from these five (5) facilities with reported airborne releases for 2020, as reported in the Toxics Release Inventory database, are summarized on Table 3.11-2.

The Toxics Release Inventory data described herein indicate that reported air emissions in the general vicinity of the planned TRISO-X FFF include airborne inhalation toxicants and respiratory irritants that may contribute to regional health conditions (USEPA, 2022c,d,e,f,g,h,i,j,k,l; CalEPA, 2022a,b,c,d).

A search within a 10-mi radius of the HCS was conducted using the USEPA “Cleanups in My Community” database system to identify nearby National Priority List Superfund Sites. This review identified one (1) such site – the Oak Ridge Reservation. The Oak Ridge Reservation includes the U.S. Department of Energy (DOE) Oak Ridge National Laboratory and the NNSA Y-12 National Security Complex (USEPA, 2022n), the airborne emissions for which were detailed on Table 3.11-2 and described above.

3.11.3 OCCUPATIONAL INJURY RATES AND OCCUPATIONAL FATALITY RATES

Occupational injury and fatality rates for occupations relevant to the construction and operation of the TRISO-X FFF are discussed in this section.

Recent Bureau of Labor Statistics (BLS) data, which list incidence rates of nonfatal occupational injuries and illnesses by industry, were reviewed to estimate relevant occupational injury rates to provide a context for analysis of potential project impacts. The incidence rate is defined as the number of recordable cases per 100 full-time workers. For this estimate, the incidence rate of the total number of recordable cases was used.

Table 3.11-3 summarizes the average incidence rates of non-fatal occupational injuries in 2020 for selected industries. Across all private industries, the national rate of recordable cases was 2.7, whereas those for industries that may reflect operations (professional and business services, manufacturing, service providing) ranged from 1.1 to 3.1. Similarly, the rate of recordable cases was 2.7 for Tennessee, whereas those for industries that may reflect operations (professional and business services, manufacturing, service providing) in Tennessee ranged from 1.3 to 3.4. The 2020 incidence rates for non-fatal occupational injuries to construction workers were 2.5 nationally and 2.8 in Tennessee (BLS, 2022a, b).

Comparable BLS data exist for occupational fatal injury rates and are summarized in Table 3.11-3. Fatal injury rates are defined by the BLS as the number of fatal occupational injuries per 100,000 full-time equivalent workers. The national average fatality rate across all private industry in 2020 was 3.7 per 100,000 full-time equivalent workers and in Tennessee it was 5.1 per 100,000 full-time equivalent workers. Fatality rates for construction workers exceeded the fatality rates across all private industry for both the national and Tennessee average in 2020. The national average and Tennessee average fatality rates for construction workers in 2020

was 10.2 and 18.3 fatalities per 100,000 full time equivalent workers, respectively. The 2020 national average fatality rates for manufacturing operations and service providing operations consisted of 2.3 and 3.8 fatalities per 100,000 full-time equivalent workers, respectively. Rates in Tennessee manufacturing operations and professional and business services consisted of 3.6 and 3.4 fatalities per 100,000 full-time equivalent workers, respectively (BLS, 2022c, d).

3.11.4 SUMMARY OF HEALTH EFFECTS STUDIES RELATED TO CHEMICAL SOURCE EXPOSURES

The National Institute for Occupational Safety and Health (NIOSH), a division of the Centers for Disease Control and Prevention, maintains the Health Hazard Evaluation (HHE) Program to assist stakeholders in learning whether health hazards are present at their workplace and recommends ways to reduce hazards and prevent work-related illness. A search of the NIOSH HHE database identified nine (9) HHE Reports published for facilities in Eastern Tennessee, four (4) are located within a 30-mi. (48 km) of the HCS (NIOSH, 2022). Pertinent findings published in those HHE Reports are summarized, herein.

In 1980, NIOSH initiated an HHE at the Aluminum Company of America facility in Alcoa, Tennessee (NIOSH, 1984). The HHE evaluated possible exposures to asbestos at ingot preheating furnaces, chlorine gas at ingot remelt and casting areas, rolling oil at the hot mill area, rolling oil at the cold mill area, solvent vapors at the coil finish and paint lines, caustic mist at the caustic etch line and lead in the battery repair area. Based on the results of sample analyses, review of medical records and interviews with employees, NIOSH found that elevated concentrations of chlorine gas could be present in the workplace during emergency situations; asbestos present in furnaces and floor areas could become airborne and result in inhalation exposure; formaldehyde present in rolling oil bactericides should be monitored; perchloroethylene releases in the coil finishing area should be controlled and monitored; and solvent exposure during floor cleaning and roller cleaning should be controlled.

In 1989, NIOSH initiated an HHE at the Schlegel Tennessee, Inc. facility in Maryville, Tennessee (NIOSH, 1990). This evaluation focused on potential carbon disulfide exposure in the workplace. NIOSH concluded that many of the chemicals used in the production of weather stripping and their decomposition or reaction products could produce some of the medical issues experience by facility workers, but it was not possible to clearly attribute the medical complaints to workplace exposure to carbon disulfide.

In 1996, NIOSH completed an HHE at the Lockheed Martin Energy Systems, Inc., U.S. Department of Energy Oak Ridge K-25 Site in Oak Ridge, Tennessee (NIOSH, 1996). The HHE evaluated potential sources of cyanide exposure in several operations, installations, substances and areas in the workplace. NIOSH determined that occupational exposure to hydrogen cyanide, cyanide salts, or other compounds that contain the $cyanide^-$ ion was not occurring and that the sampling completed did not support a relationship between the health problems reported by the employees and chronic, occupational cyanide intoxication.

In 1999, NIOSH initiated an HHE at the Boeing Commercial Airplane Group facility in Oak Ridge, Tennessee (NIOSH, 2001). The HHE evaluated exposure to synthetic metal-working fluid and medical complaints including respiratory conditions, skin conditions as well as kidney, bladder and prostate problems. NIOSH determined that respiratory symptoms experienced by machine shop workers could be linked to reported respiratory and skin conditions.

Table 3.11-1
Summary of Background Radiation Exposure (mrem/yr) in Vicinity of TRISO-X Fuel Fabrication Facility

Source	Cosmic	Terrestrial	Internal	Medical	Consumer Product	Nuclear Power	Occupational
Natural	31	536	31	N/A	N/A	N/A	N/A
Man-Made	N/A	N/A	N/A	298	12	< 1	< 1
Subtotal		598				312	
Total			910				

Table 3.11-2
Summary of Facilities within a 10-mi Radius of the Planned TRISO-X Fuel Fabrication Facility
and Reported Toxics Release Inventory Emissions to Air in 2020

TRI-Reporting Facility[a]	Approximate Distance from Planned TRISO-X FFF (mi)	Toxics Released to Air[b]	Quantity Released (total pounds)	Quantity Released (total kg)
DOE Oak Ridge National Laboratory	2.7	Nitric Acid Nitrate Compounds	108	49
NNSA Y-12 National Security Complex Oak Ridge	6.3	Chromium Cobalt Copper Diisocyanates Lead and Lead Compounds Manganese Mercury Compounds Methanol Nickel Nitric Acid	11,370	5,157
Diversified Scientific Services Inc. (DSSI)	6.9	Mercury and Mercury Compounds Polychlorinated Biphenyls	1	0.5
Advanced Measurement Technology	8.3	Methanol Nitric Acid	3,050	1,383
US TVA Kingston Fossil Plant	9.4	Ammonia Barium Compounds Chromium Hydrochloric Acid Hydrogen Fluoride Manganese Methanol Nickel Sulfuric Acid Zinc Compounds	145,212	65,867

Notes:

a) All listed facilities are located in Tennessee.

b) Ammonia, chromium, diisocyanates, hydrochloric acid, manganese, mercury and mercury compounds, methanol and polychlorinated biphenyls are inhalation toxicants with published USEPA inhalation reference concentrations and/or inhalation unit risk toxicity criteria (USEPA, 2022c,d,e,f,g,h,i,j,k,l). Hydrogen fluoride, lead and lead compounds, nickel and sulfuric acid are inhalation toxicants with published CalEPA chronic inhalation reference exposure levels and/or inhalation unit risk toxicity criteria (CalEPA, 2022a,b,c,d). Cobalt is an inhalation toxicant with a published USEPA Provisional Peer-Reviewed Toxicity Value inhalation reference concentration (USEPA, 2022m). Barium is an inhalation toxicant with a chronic inhalation reference concentration published in the USEPA Health Effects Assessment Summary Tables (USEPA, 1997). Copper and nitric acid are inhalation toxicants with OSHA Permissible Exposure Limits (OSHA, 2022). Zinc is not an inhalation toxicant, as USEPA and CalEPA have not published inhalation toxicity criteria for this metal.

Table 3.11-3
Summary of Occupational 2020 Incidence Rates for Selected Industries

Nonfatal Occupational Injuries and Illnesses (Recordable Cases per 100 Full-Time Workers)		
Industry Category	**National Average**	**Tennessee Average**
All Private Industry	2.7	2.7
Construction	2.5	2.8
Manufacturing	3.1	3.4
Nuclear Electric Power Generation	0.3	- -
Service Providing (all)	2.7	2.6
Professional and Business Services	1.1	1.3

Fatal Occupational Injuries (Number of Fatalities per 100,000 Full-Time Equivalent Workers)		
Industry Category	**National Average**	**Tennessee Average**
All Private Industry	3.7	5.1
Construction	10.2	18.3
Manufacturing	2.3	3.6
Nuclear Electric Power Generation	- -	- -
Service Providing (all)	3.8	- -
Professional and Business Services	- -	3.4

Notes:
"- -" Category not reported.
Source: BLS, 2022a,b,c,d

3.12 WASTE MANAGEMENT

This section provides descriptions of nonradioactive, radioactive, mixed, and hazardous waste currently generated at the Horizon Center site (HCS), where the TRISO-X Fuel Fabrication Facility (TRISO-X FFF) is located. Where applicable, the quantities, composition, and frequency of waste generation are described. Types of radioactive liquid, solid, and gaseous waste material currently generated at the HCS are described, along with a description of direct radiation sources collected on-site as solid waste prior to disposal. Disposal plans, waste minimization, and environmental impacts of the TRISO-X FFF are discussed in Section 4.13, Waste Management Impacts.

3.12.1 NONRADIOACTIVE WASTE

Waste generators are regulated by the U.S. Environmental Protection Agency (USEPA), as implemented under the Resource Conservation and Recovery Act (RCRA). Title 40 of the Code of Federal Regulations (CFR), Parts 239 through 259 contain the regulations for non-hazardous solid waste. The regulations governing hazardous waste identification, classification, generation, management and disposal are found in Title 40 CFR Parts 260 through 273. (USEPA, 2021)

Sources of nonradioactive waste material, including hazardous waste, currently generated at the HCS are discussed in this section. Nonradioactive liquid and air effluents are discussed in Section 3.4, Water Resources, and Section 3.6, Meteorology, Climatology, and Air Quality.

3.12.1.1 Solid Waste

As described in Section 3.1.1, the HCS is located on undeveloped land. The current greenfield site is dedicated for industrial development. Currently, no solid wastes are generated on the HCS.

3.12.1.2 Hazardous Waste

The HCS is located on undeveloped land. Currently, no nonradioactive hazardous waste is generated at the HCS.

3.12.1.3 Disposal Activities

Since there is no waste generated at the HCS, there are no disposal activities performed. Planned waste disposal activities for the TRISO-X FFF are discussed in Section 4.13, Waste Management Impacts.

3.12.2 RADIOACTIVE AND MIXED WASTES

Radioactive waste disposal is regulated by the U.S. Nuclear Regulatory Commission (NRC) requirements in 10 CFR Part 20, Subpart K. Currently, there are no sources of radioactive liquid, solid, or gaseous waste material stored at the HCS.

3.12.2.1 Gaseous Effluents

The HCS is located on undeveloped land. There are no gaseous effluent releases at the HCS.

3.12.2.2 Liquid Effluents

The HCS is located on undeveloped land. There are no liquid effluent releases at the HCS.

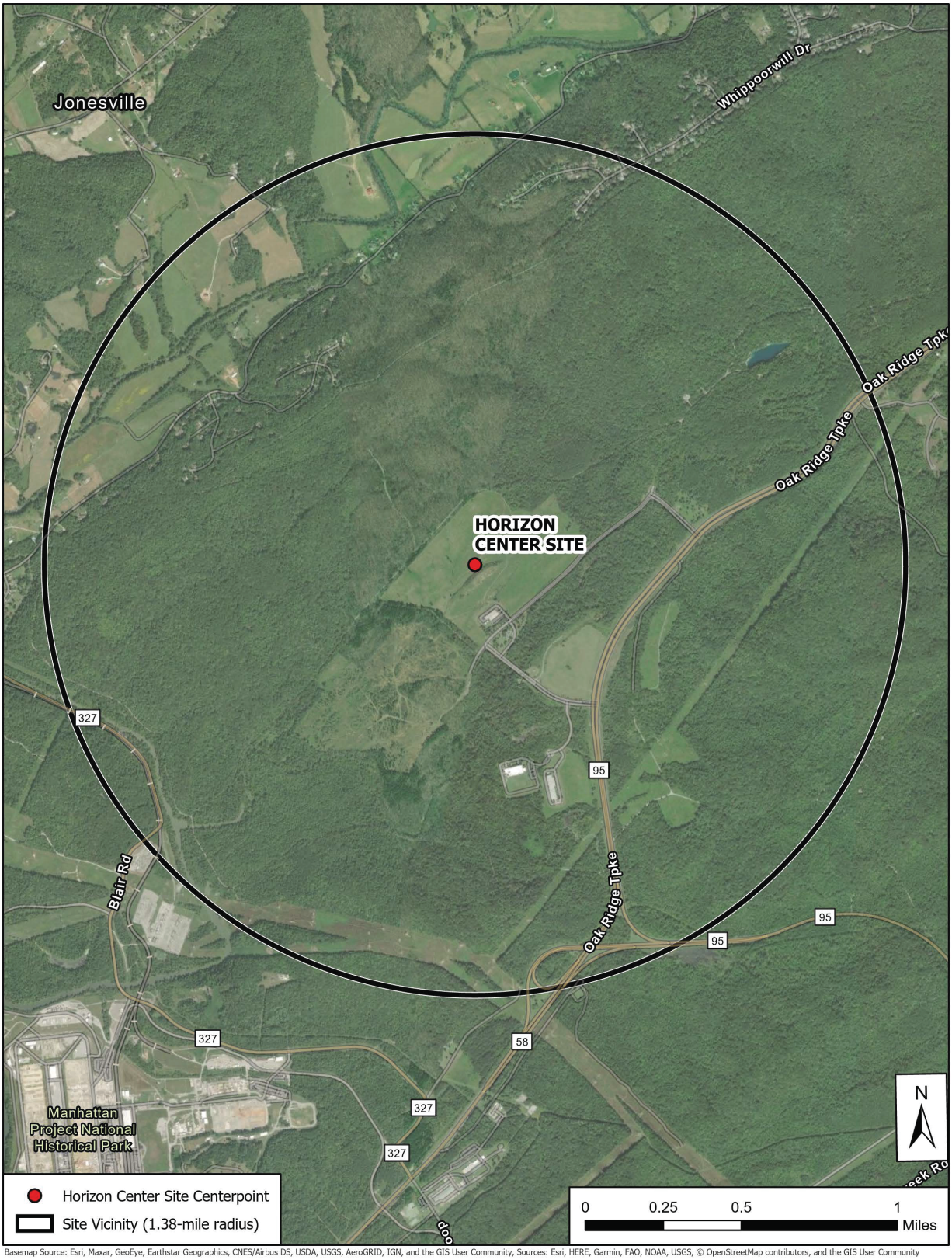
3.12.2.3 Solid Waste

The HCS is located on undeveloped land. There is no solid waste generated or stored at the HCS.

3.12.2.4 Mixed Waste

Mixed waste is waste that contains both radioactive and hazardous waste (40 CFR Part 266, Subpart N, Section 266.210). Mixed waste is not currently generated or stored at the HCS.

Figure 3.1-1
Aerial View of the HCS Vicinity



Basemap Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

Figure 3.1-2
Aerial View of the HCS Region



Figure 3.1-3
Regional Land Uses

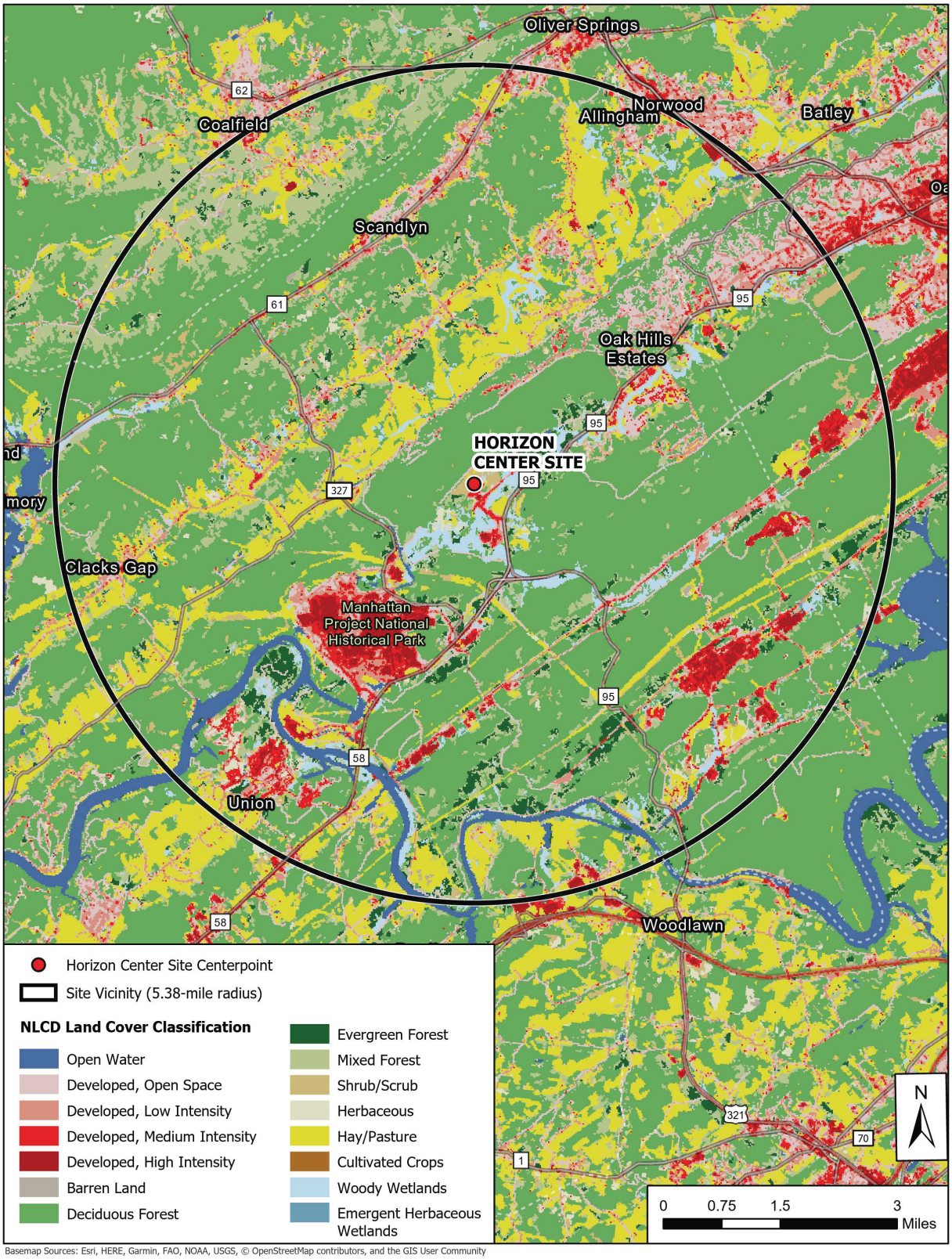


Figure 3.1-4
Major Population Centers near the HCS

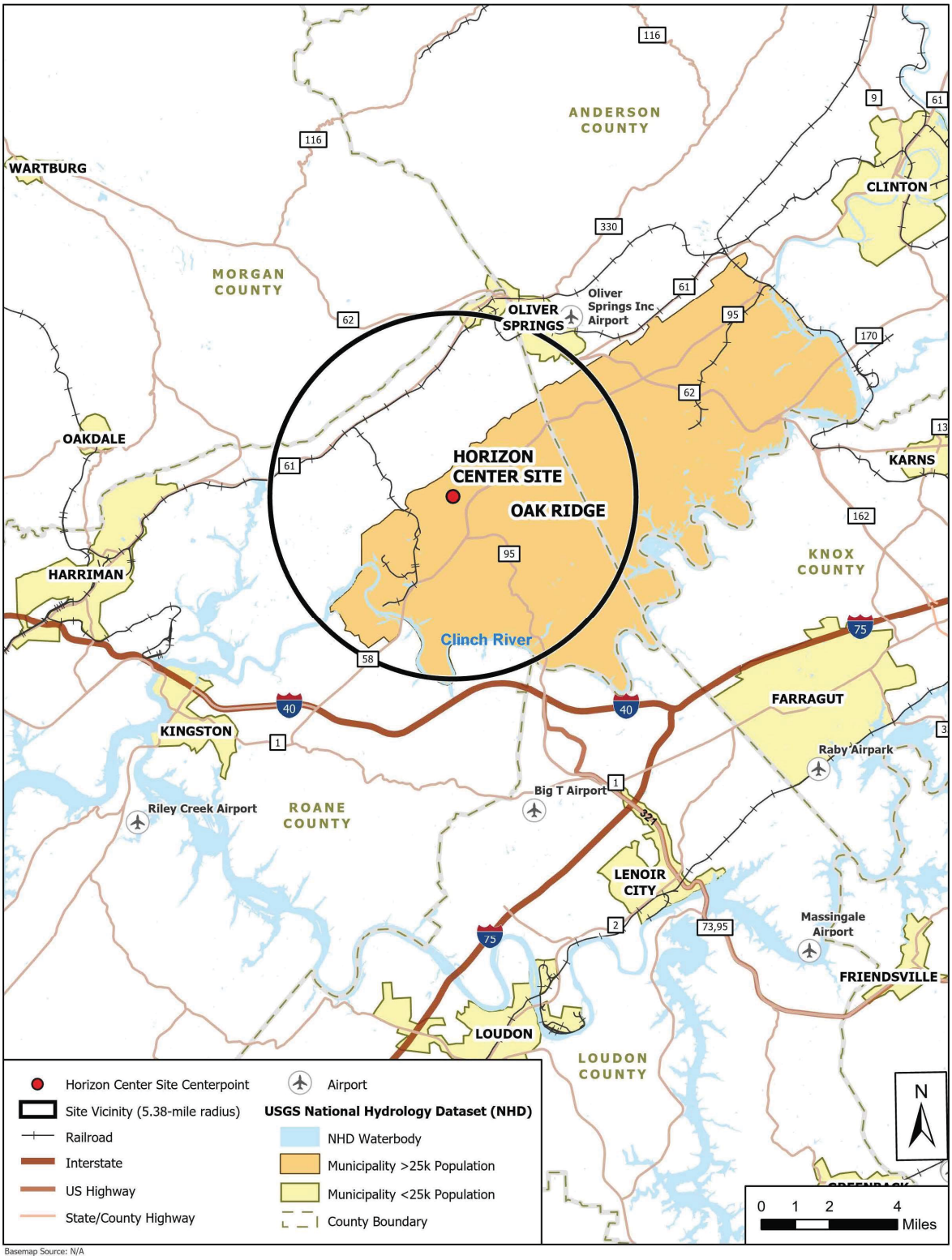


Figure 3.1-5
Major Special Land Uses in the HCS Region

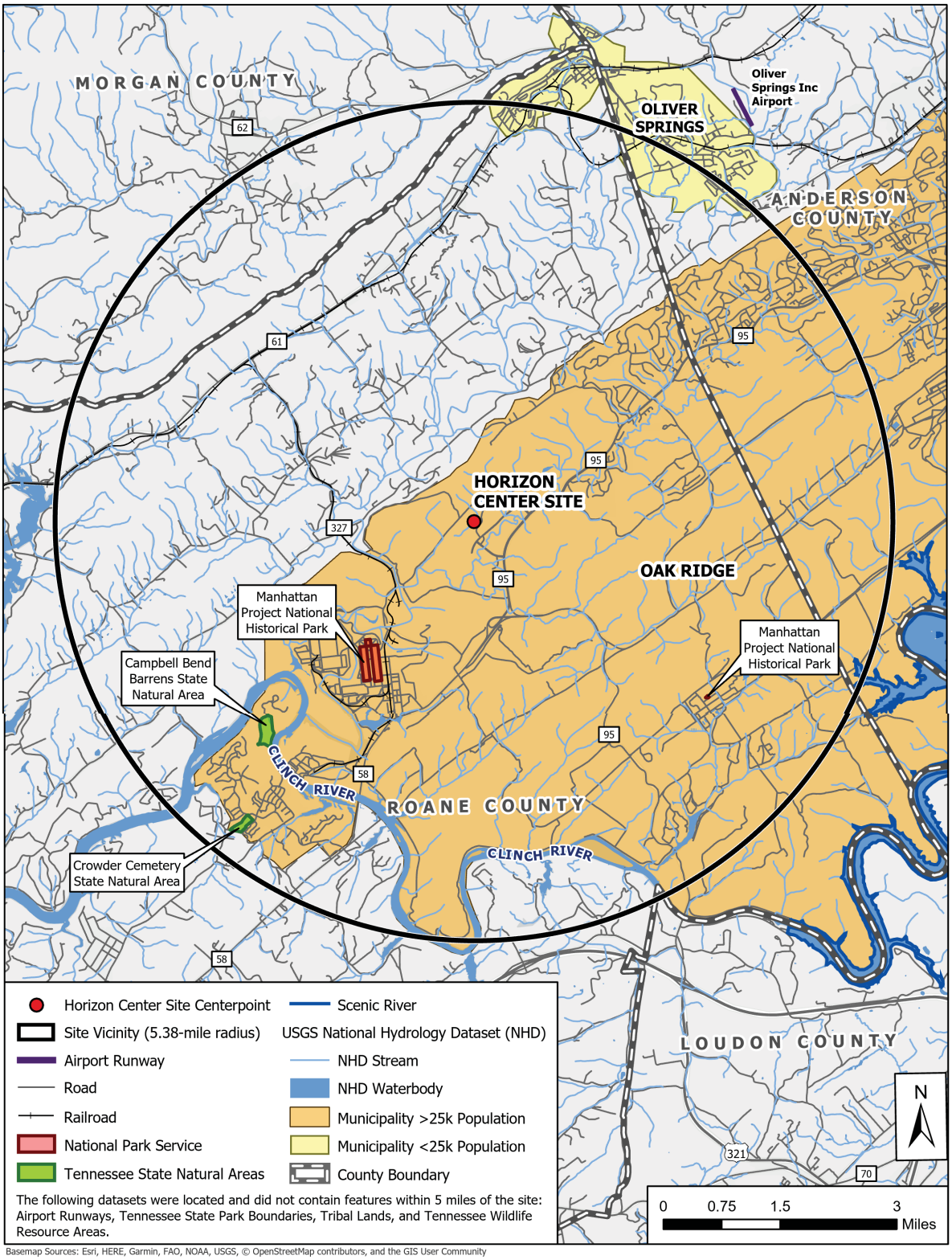


Figure 3.1-6
Other Land Use Features near the HCS

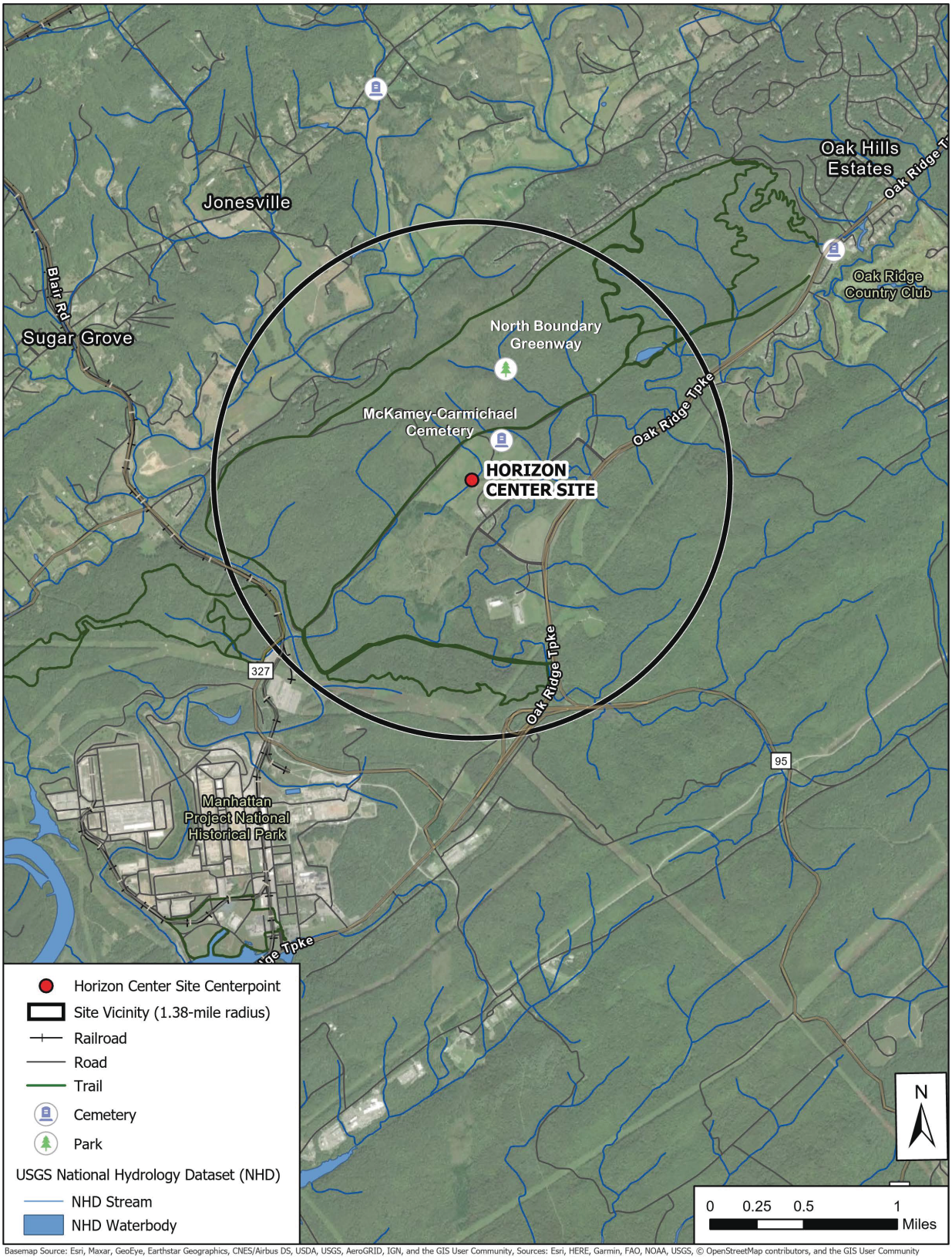


Figure 3.1-7
Prime Farmland in the Region

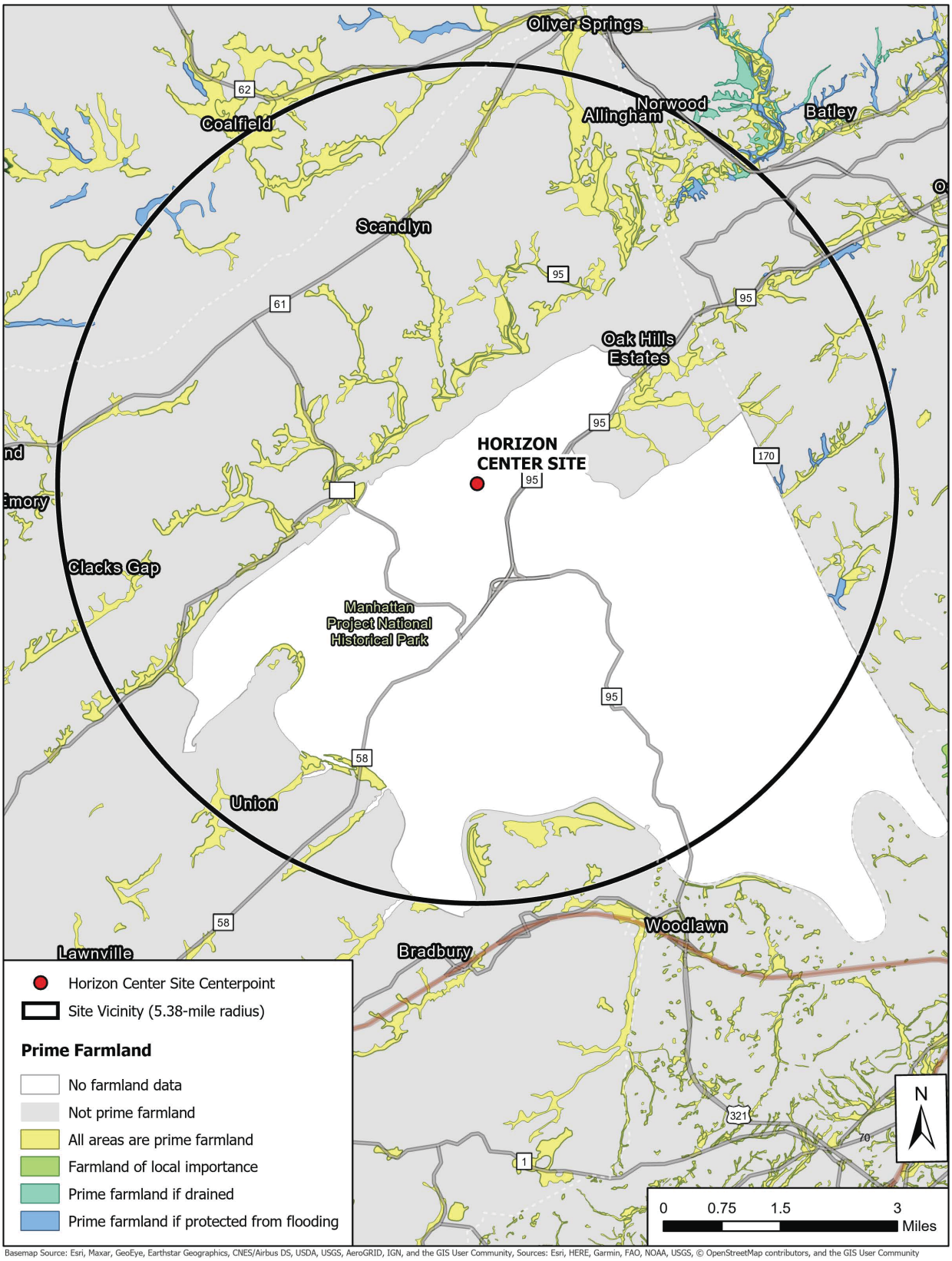


Figure 3.1-8
Map of HCS Vicinity Zoning

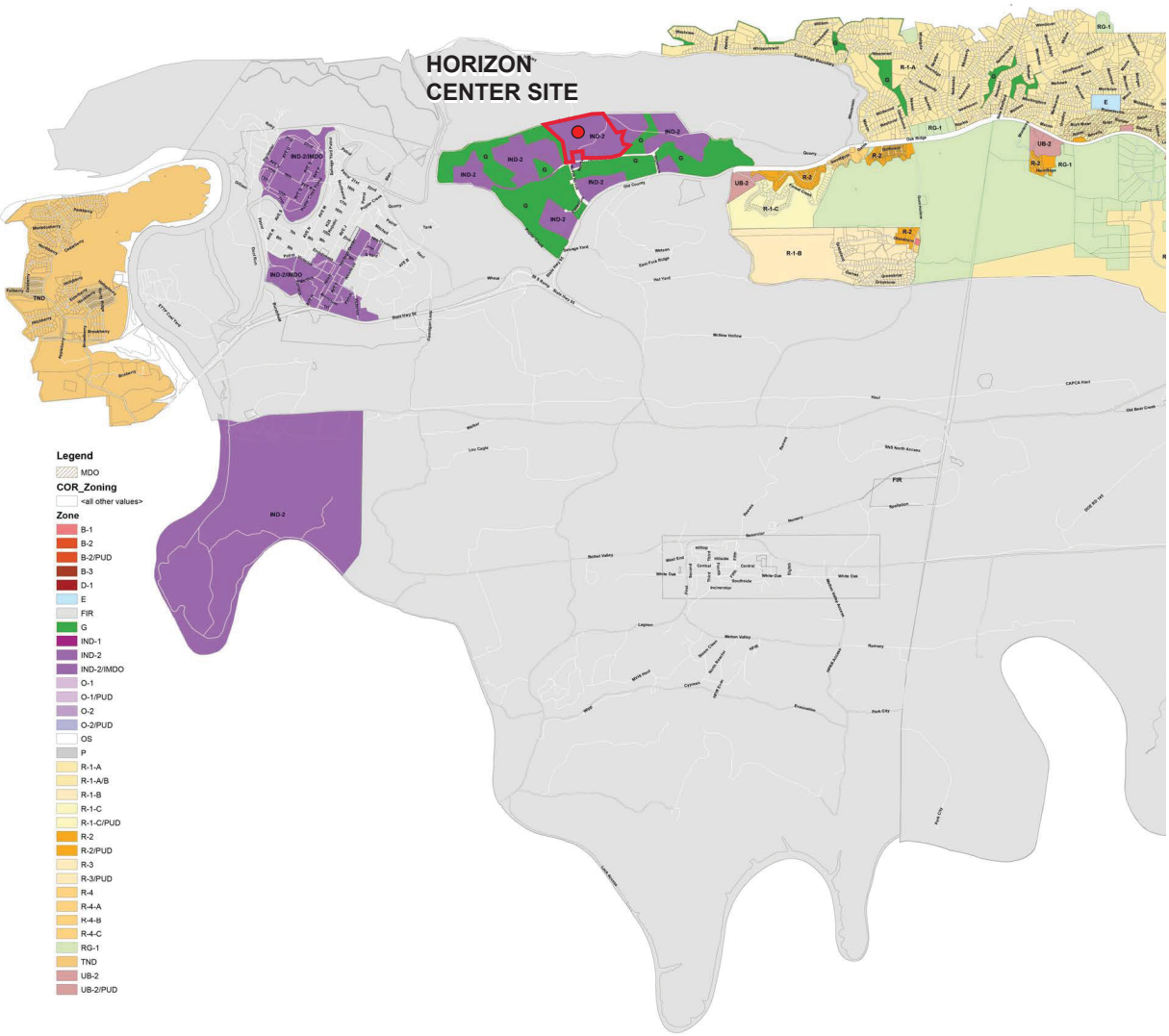


Figure 3.2-1
Regional Highways and Interstates near the HCS

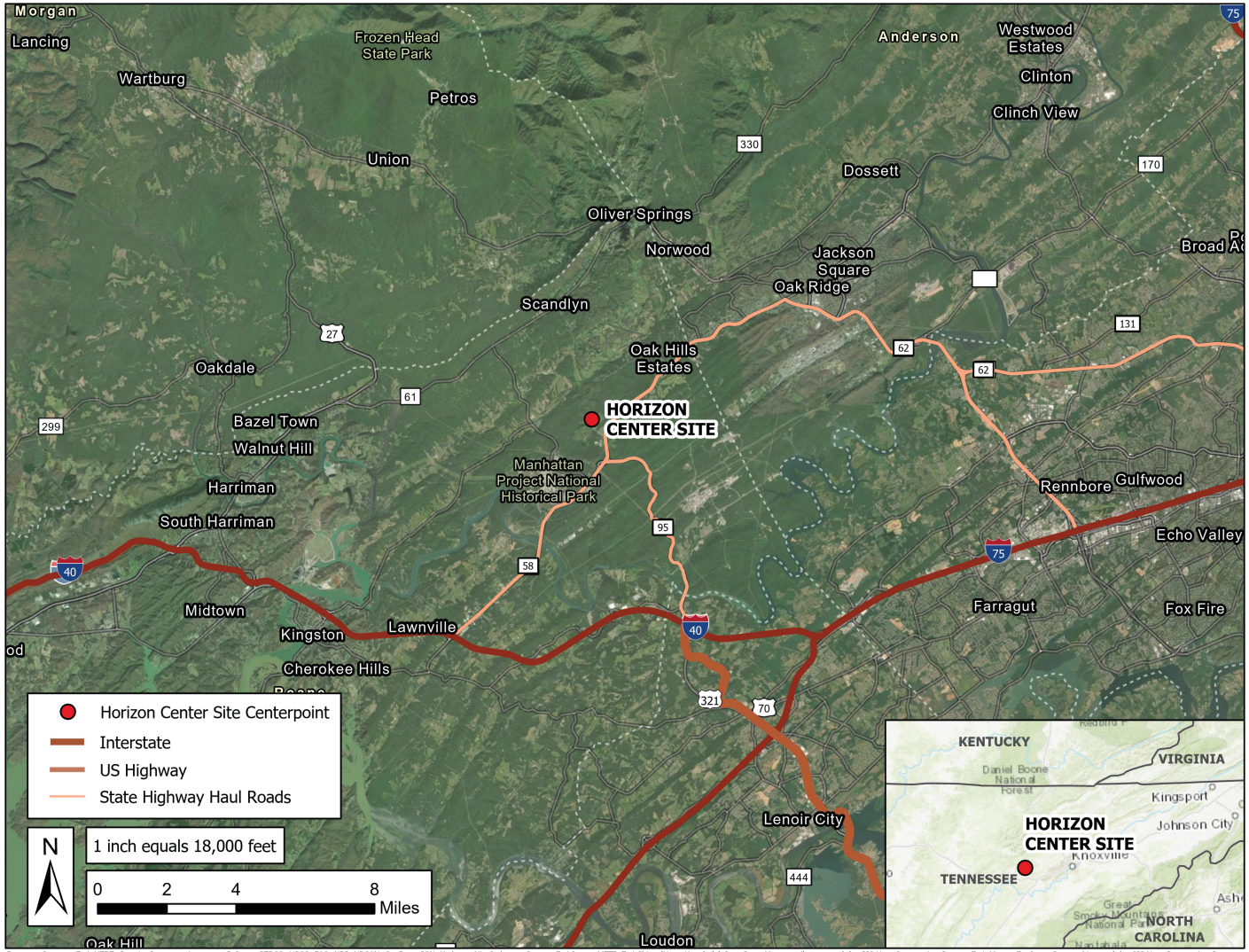
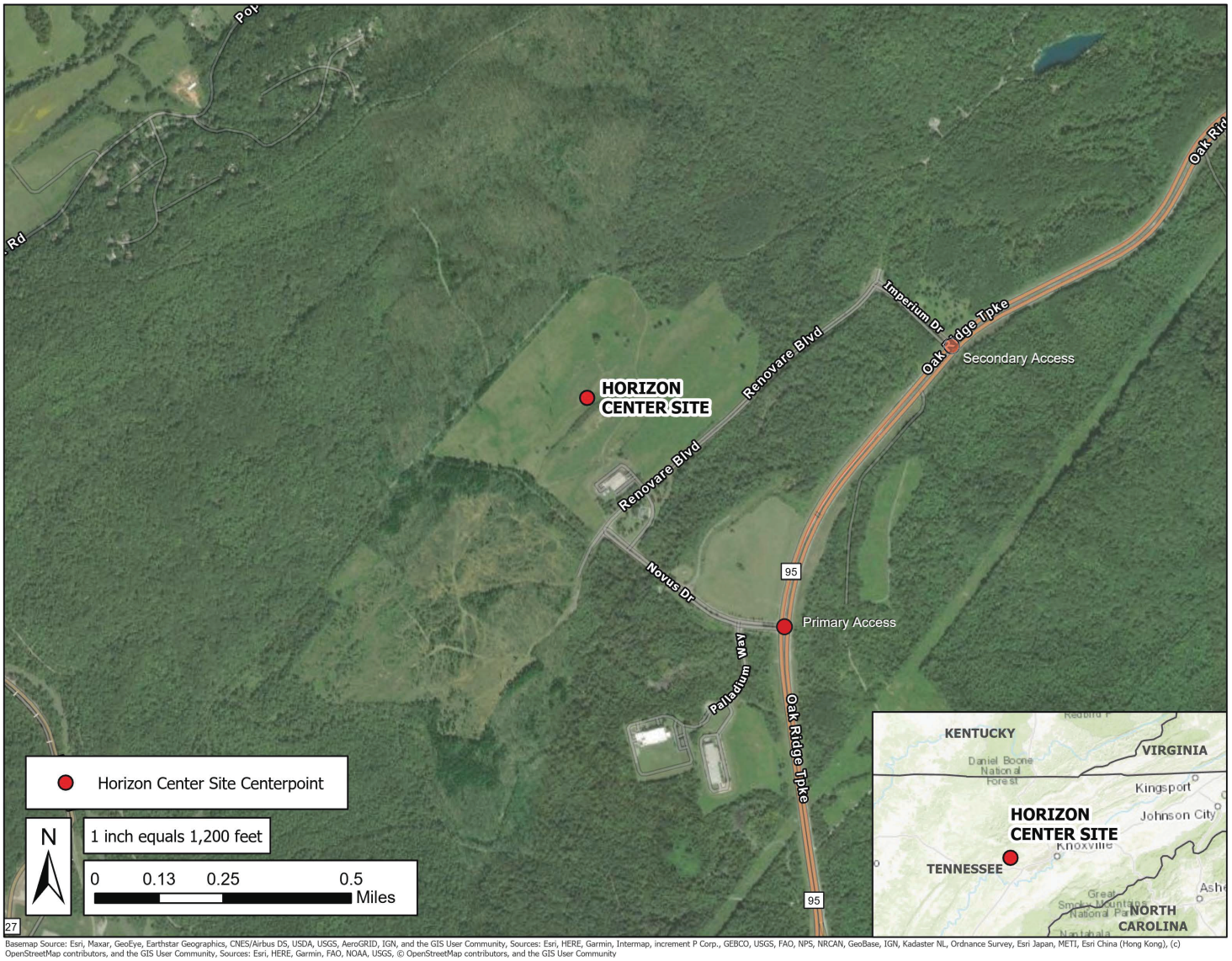


Figure 3.2-2
Roads in the Vicinity of the HCS



Basemap Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community, Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

Figure 3.2-3
Average Annual Daily Traffic Count Locations Along Routes to the HCS

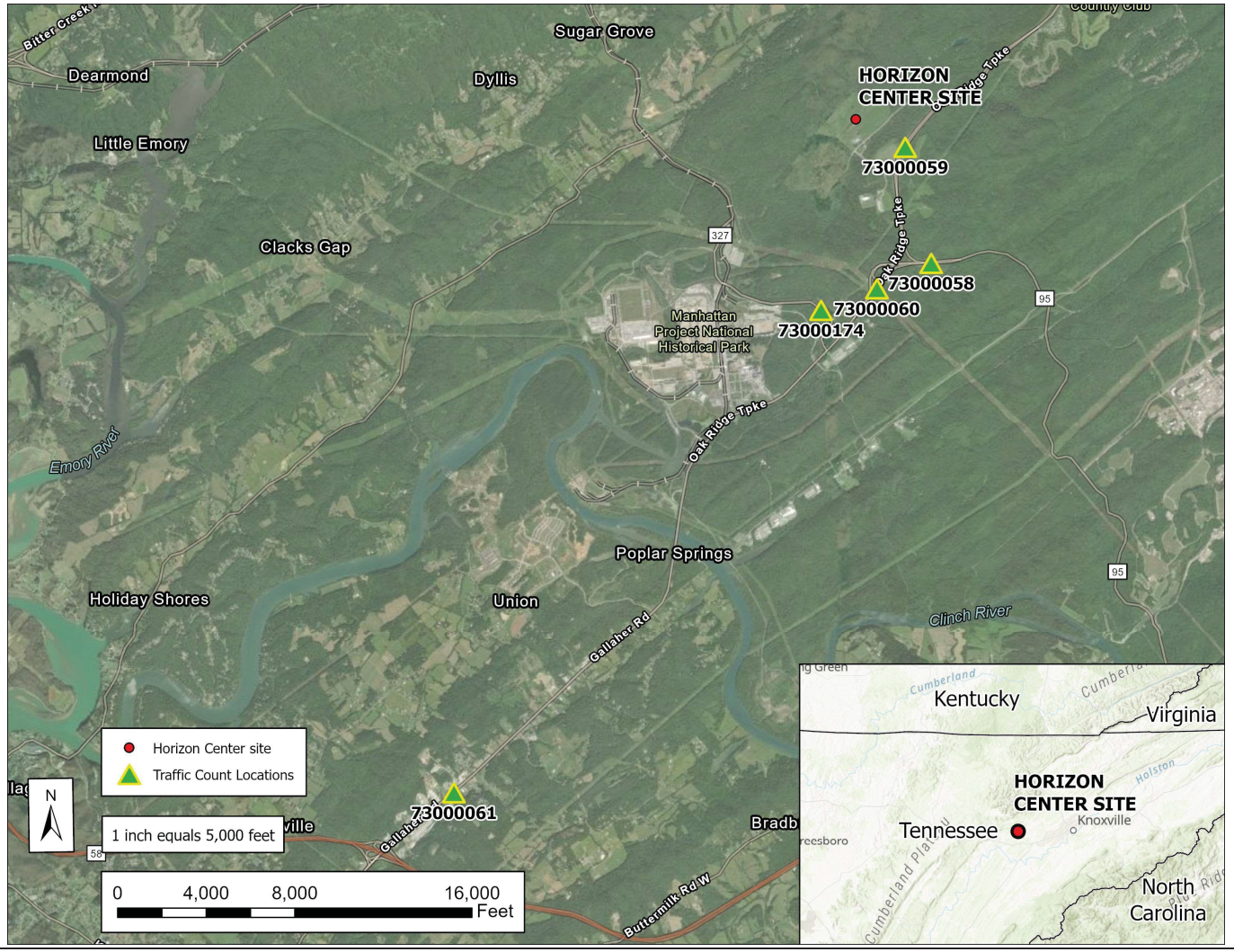


Figure 3.3.1-1

Physiographic Provinces within the Horizon Center Site Region

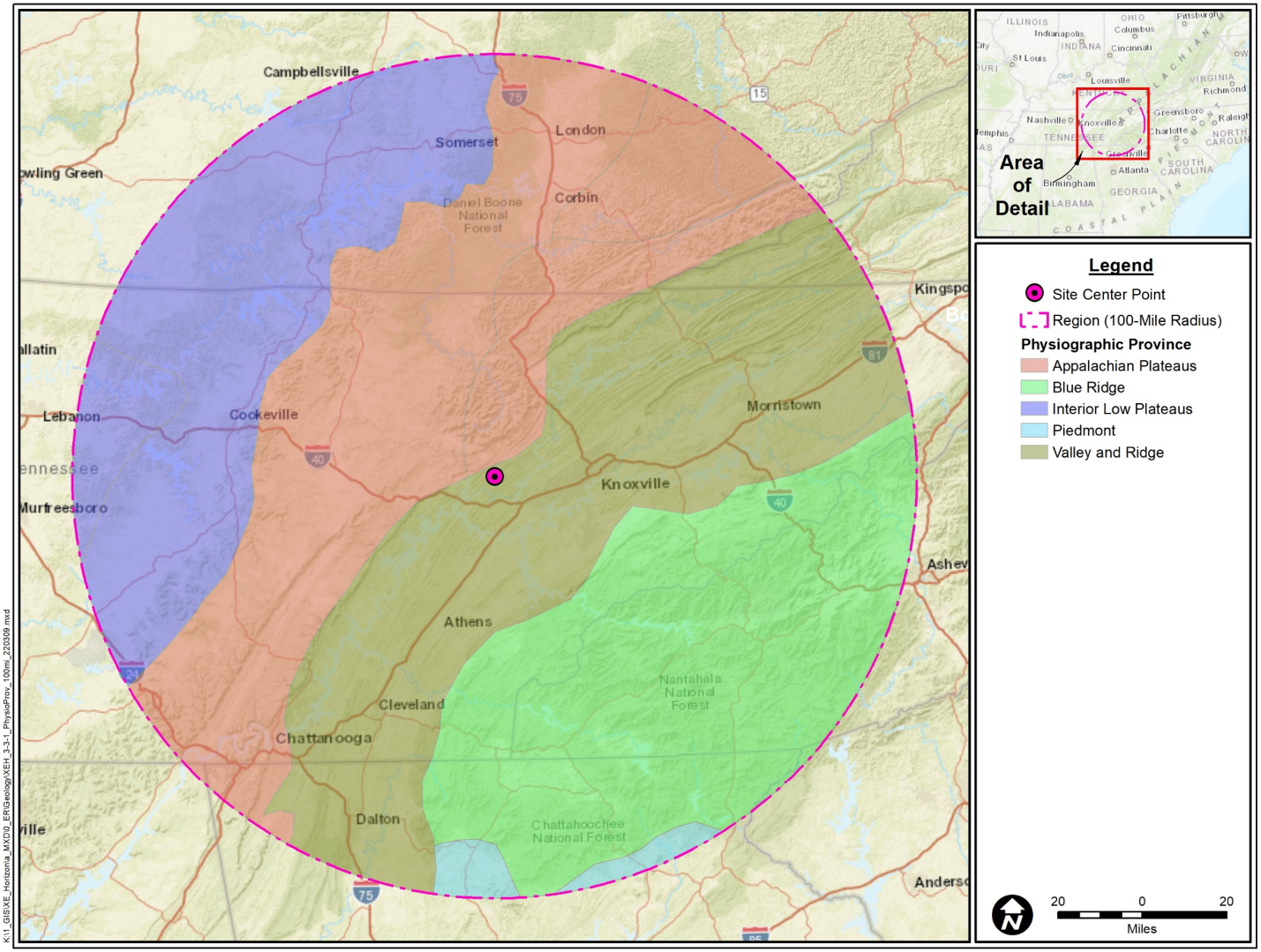


Figure 3.3.1-2

Valley and Ridge Province

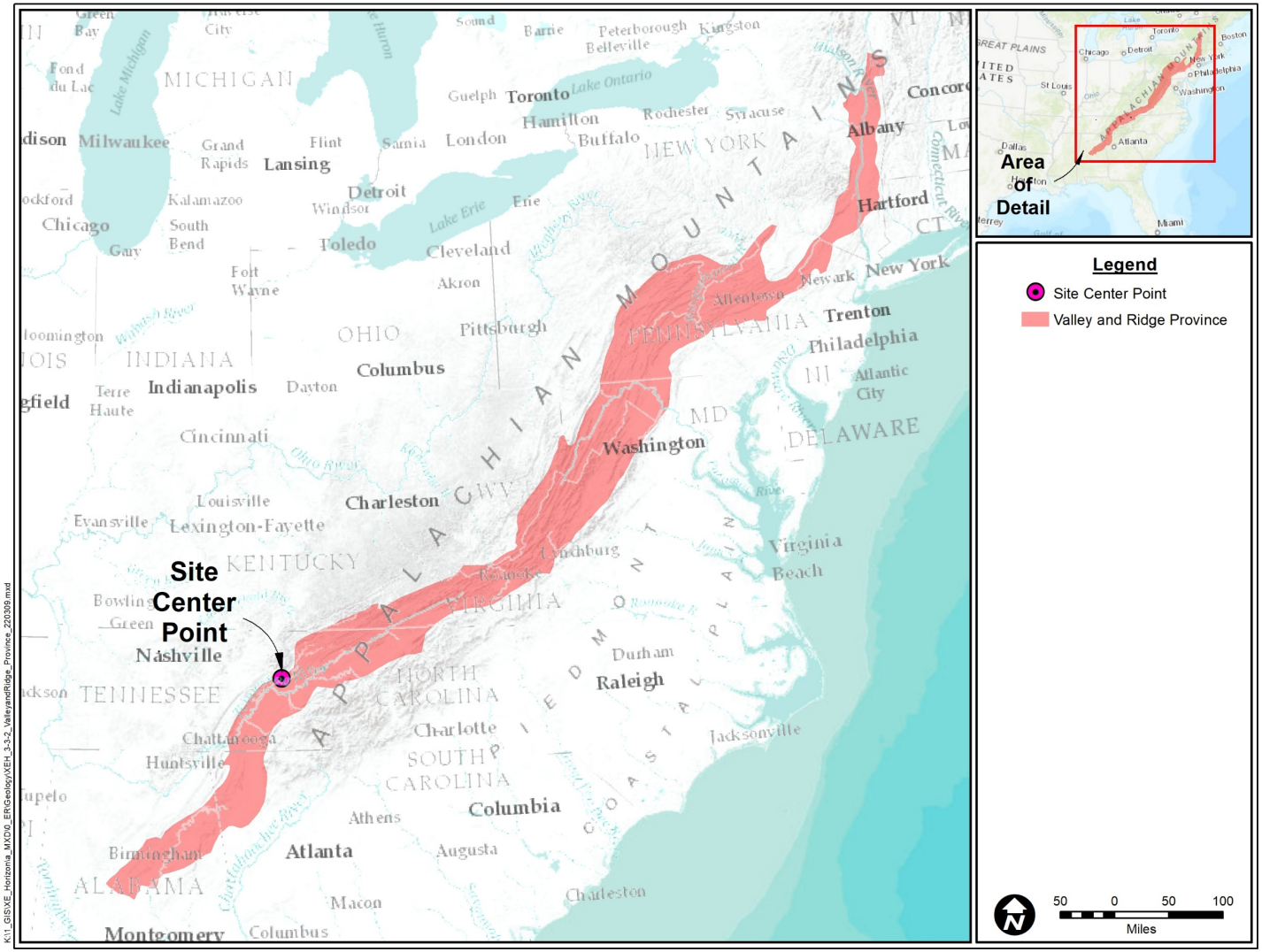
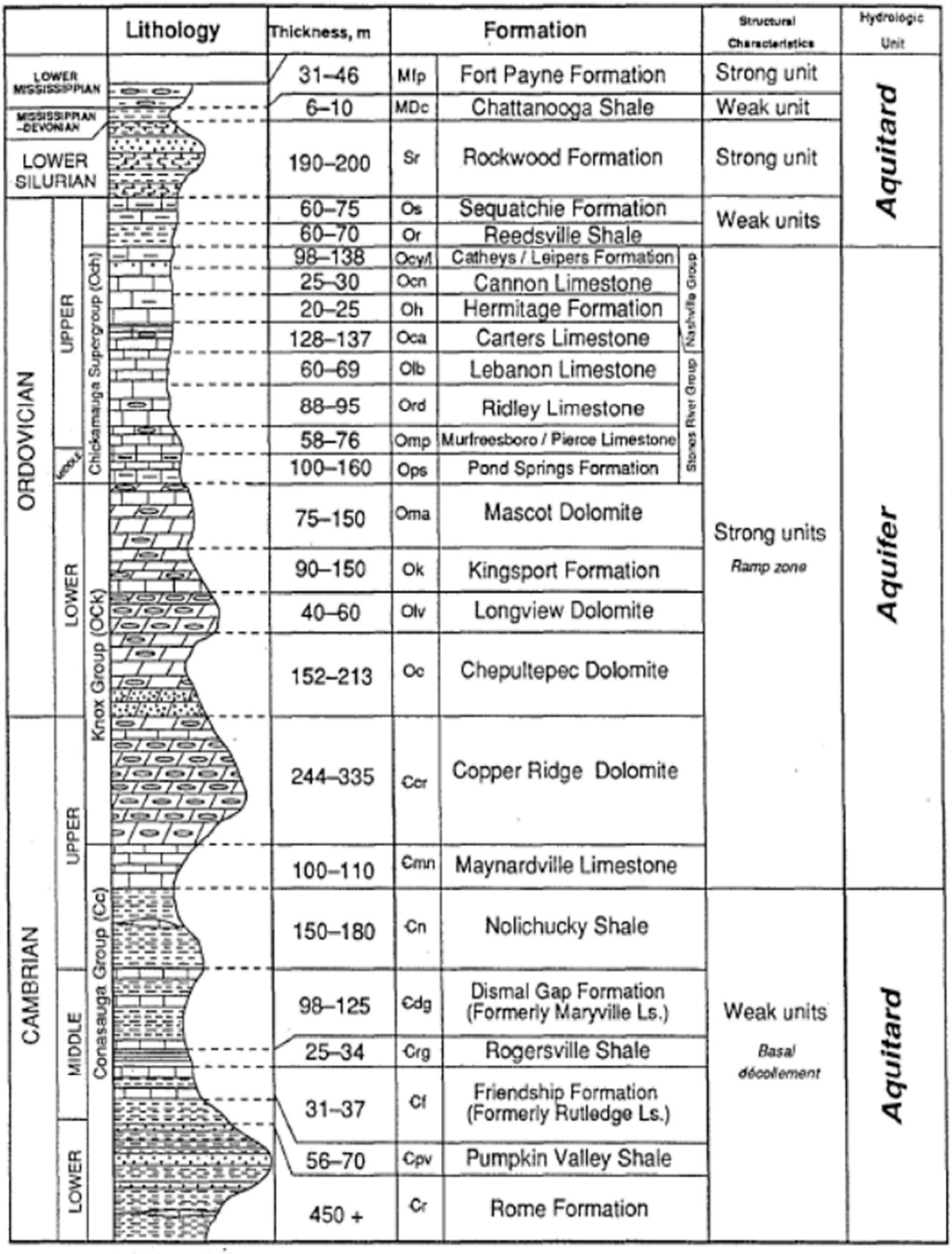


Figure 3.3.1-3
Typical Stratigraphy Within the Valley and Ridge Province Near Oak Ridge Reservation and the Horizon Center Site



Source Hatcher et al., 1992

Figure 3.3.3-1
Geologic Map in Vicinity of the Horizon Center Site

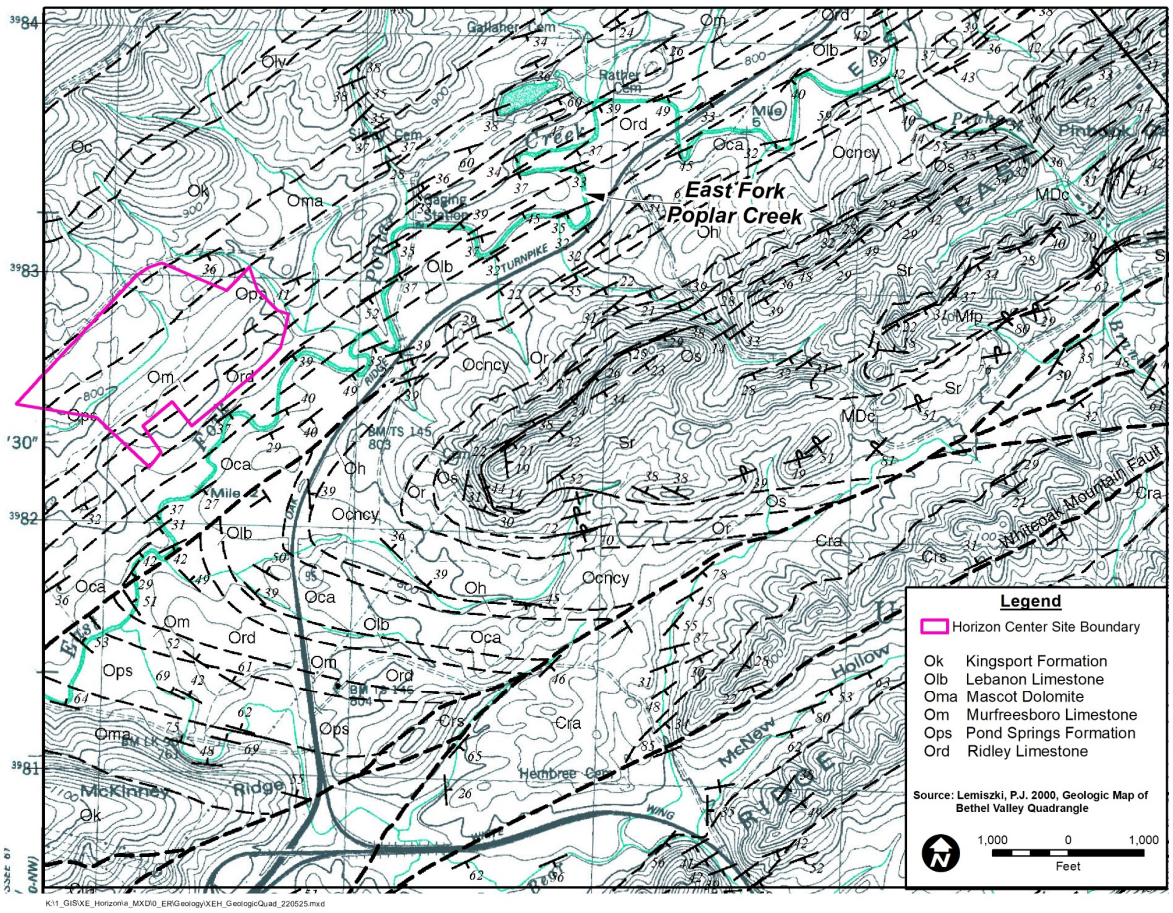


Figure 3.3.3-2

Physiography in the Vicinity of the Horizon Center Site

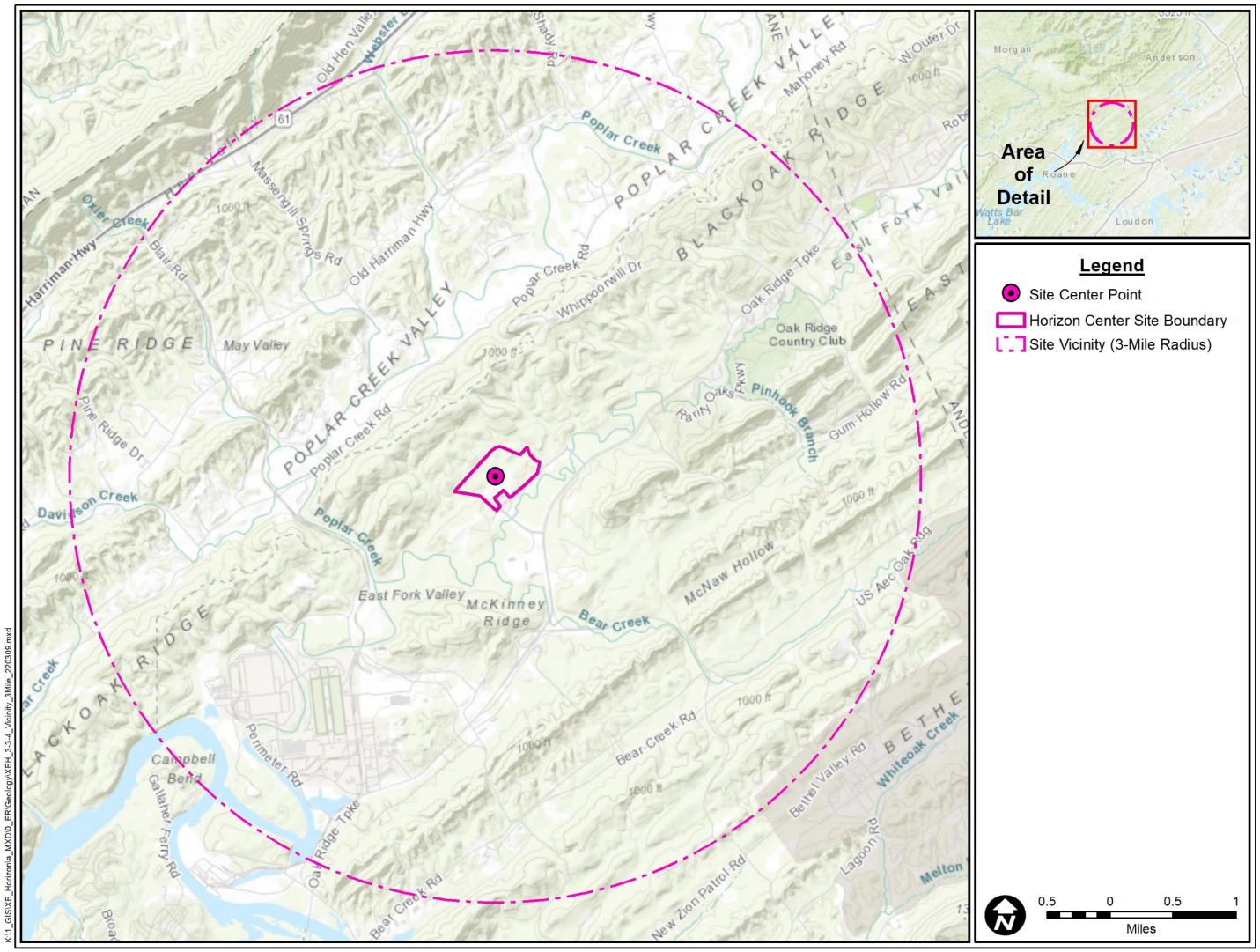


Figure 3.3.3-3

Locations of Selected Geotechnical Borings and Groundwater Wells Used to Characterize Subsurface Conditions at the Horizon Center Site

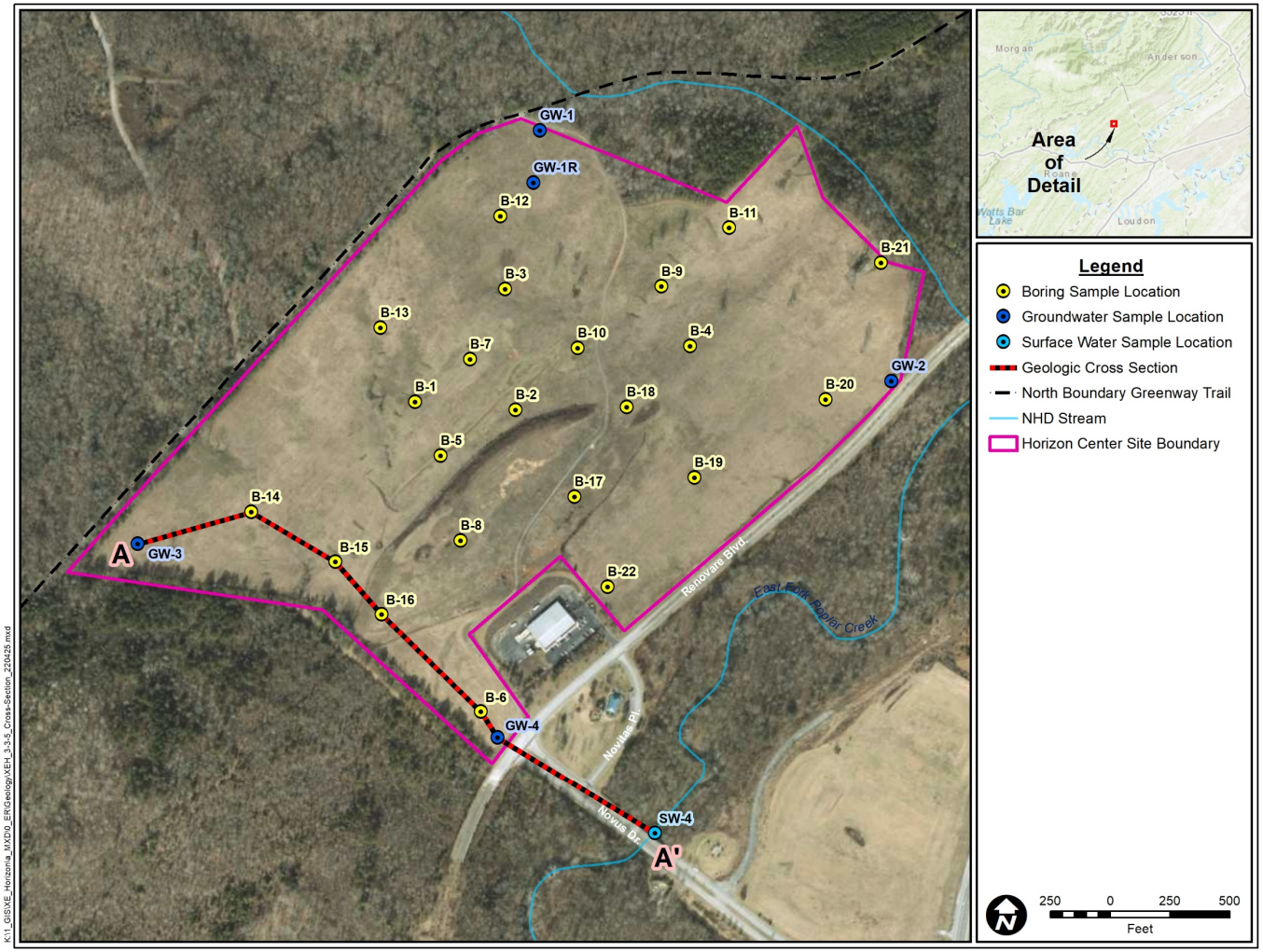


Figure 3.3.3-4

Representative Fence Diagram Illustrating Geologic Cross Section of Horizon Center Site at A-A'

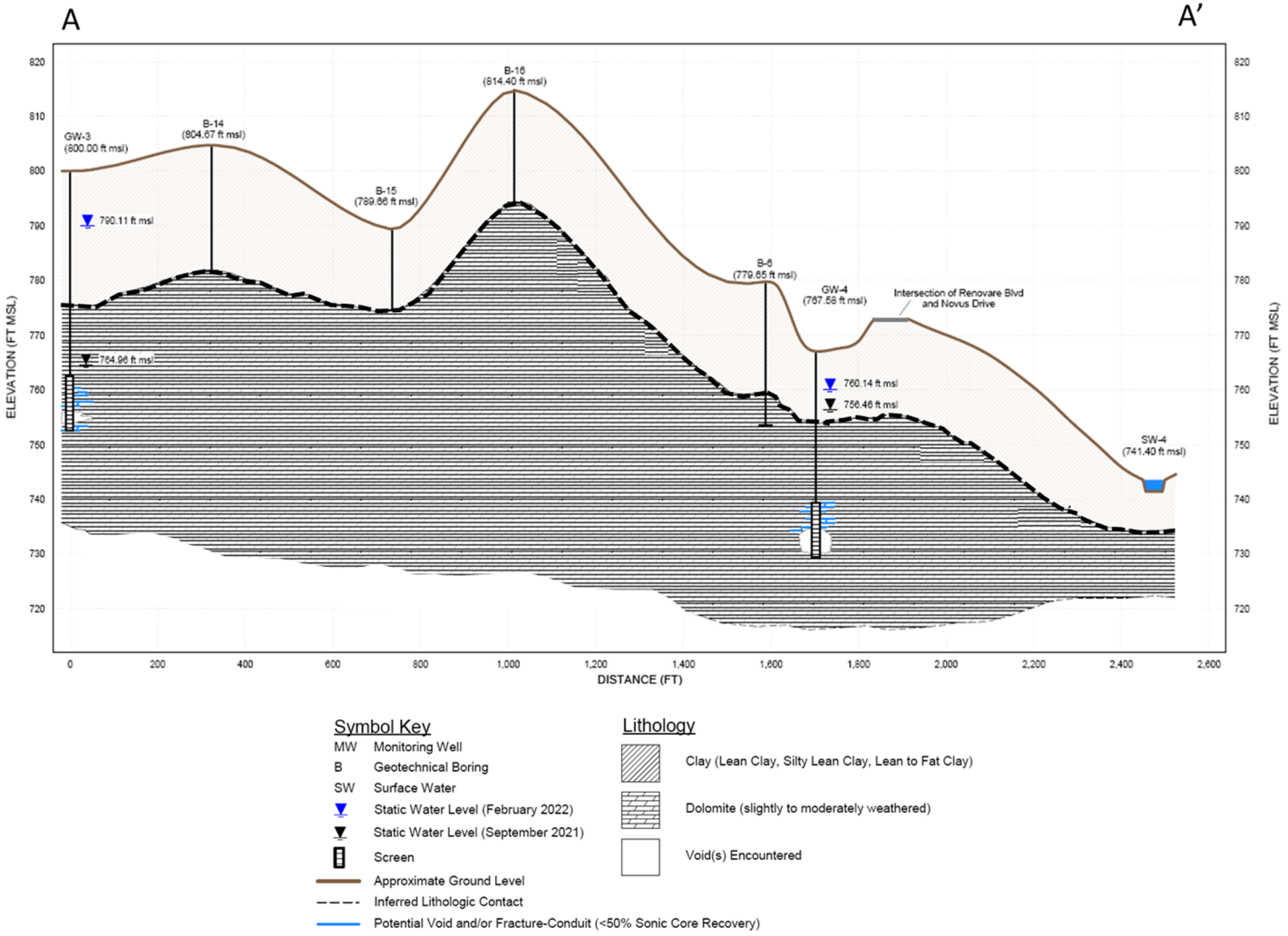
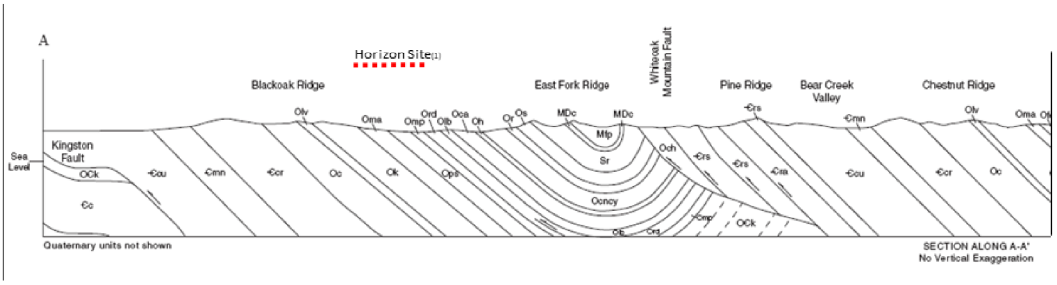


Figure 3.3.3-5
Geologic Cross Section in the Vicinity of the Horizon Center Site



Source: Lemiszki, P.J. 2000. Geologic Map of the Bethel Valley Quadrangle. State of Tennessee, Department of Environment and Conservation, Division of Geology. Draft Open File Map. (1)Section offset approximately one mile from center of HCS)

Figure 3.3.5-1

Seismic Events Recorded by USGS from 2000 to 2021

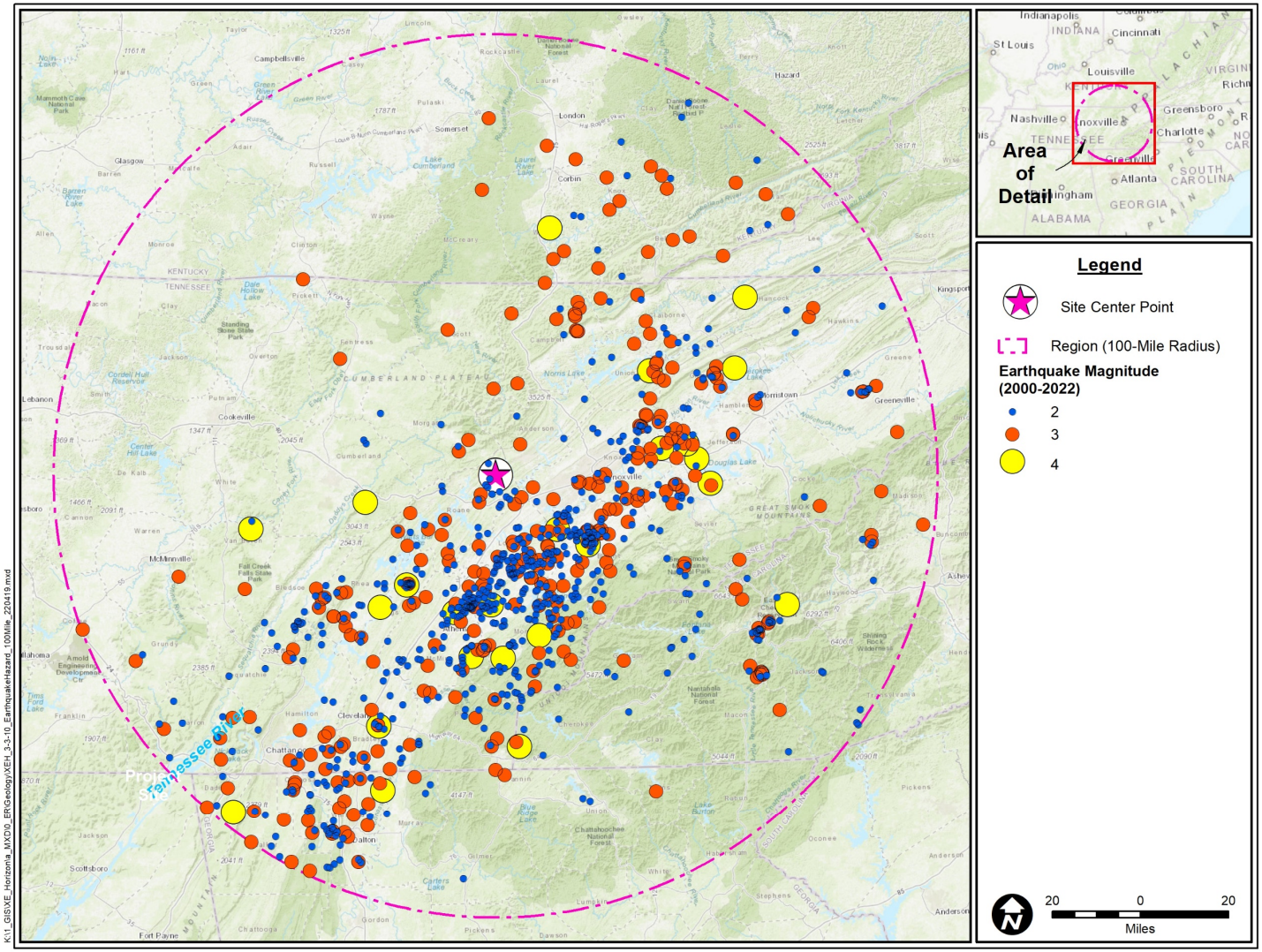
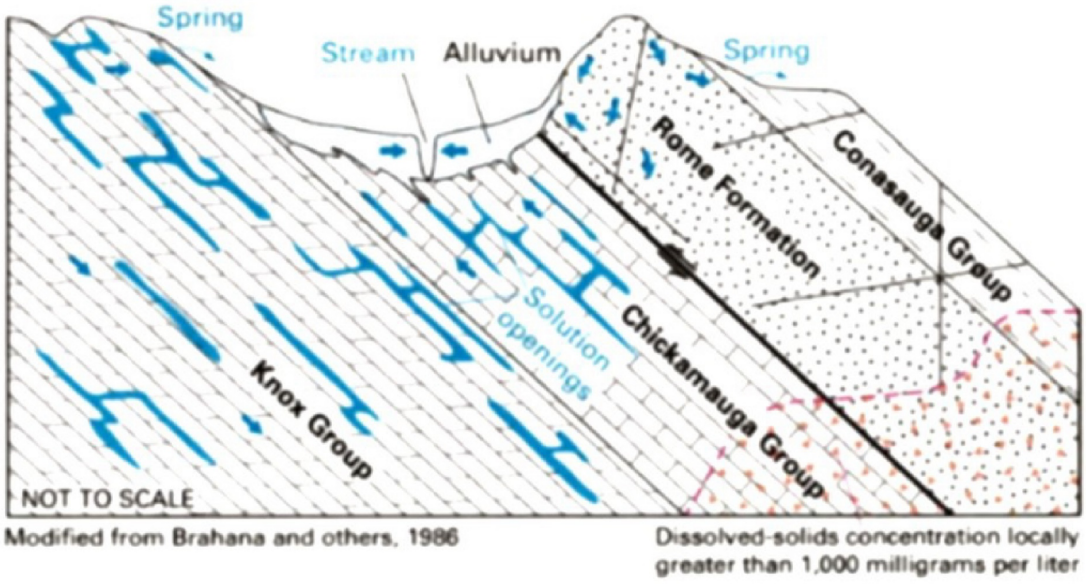
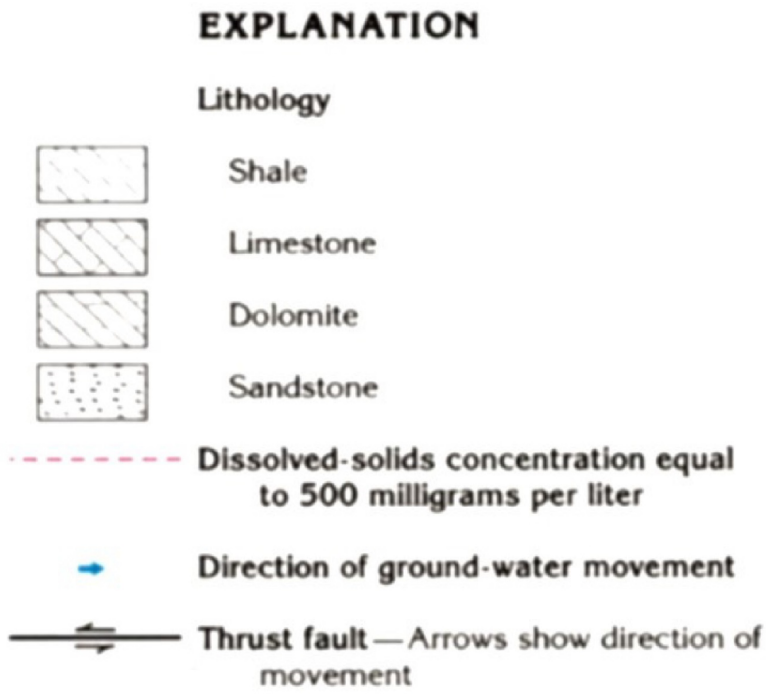


Figure 3.4.1-1

Typical Groundwater Flow Patterns within the Aquifers and Aquitards of the Valley and Ridge Province and at the Horizon Center Site





Source: Lloyd and Lyke, 1995

Figure 3.4.1-2
Groundwater Wells Within a 3-mile Radius of the Horizon Center Site

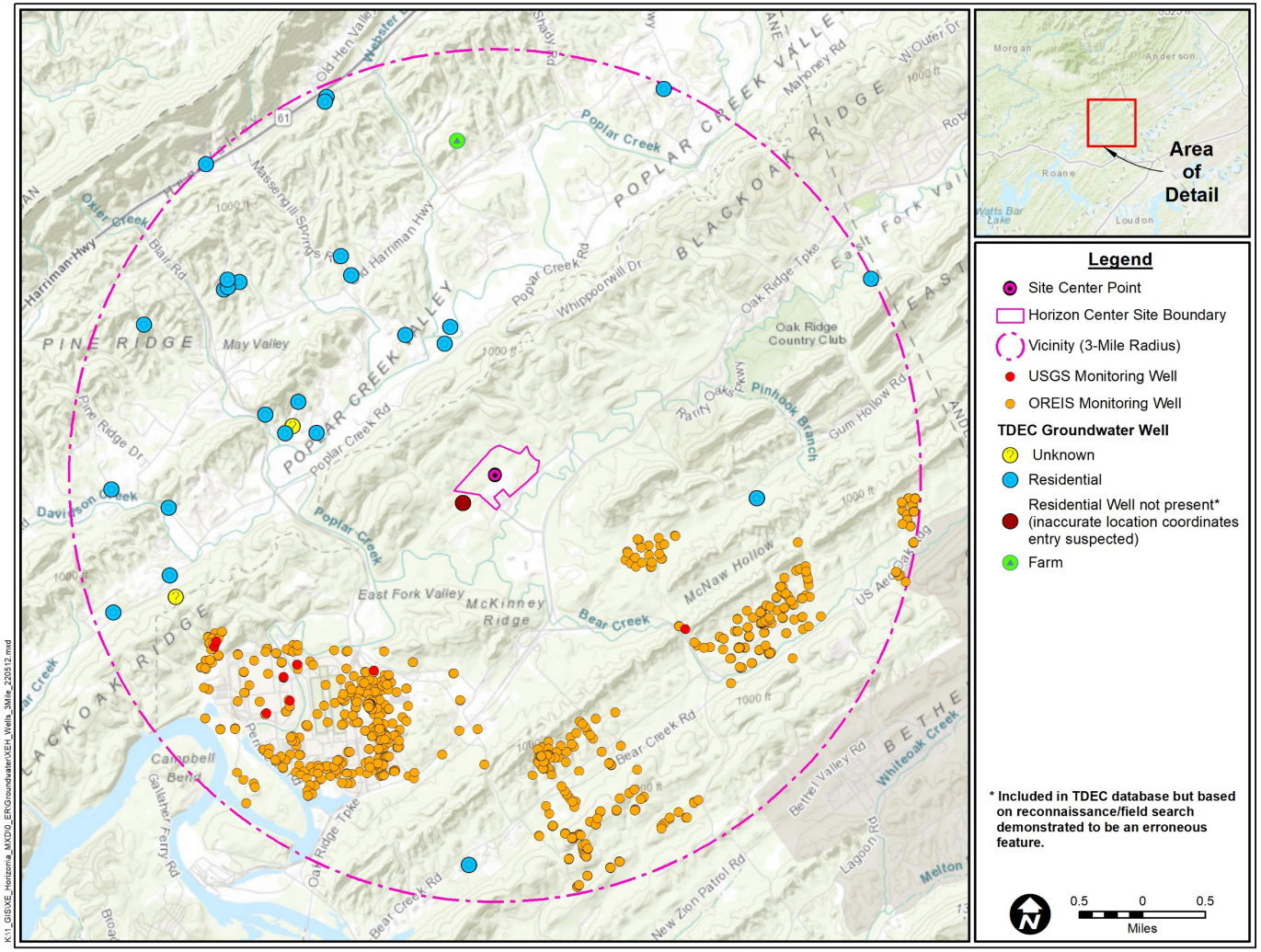


Figure 3.4.1-3

Groundwater Monitoring Wells Within and Adjacent to the Horizon Center Site

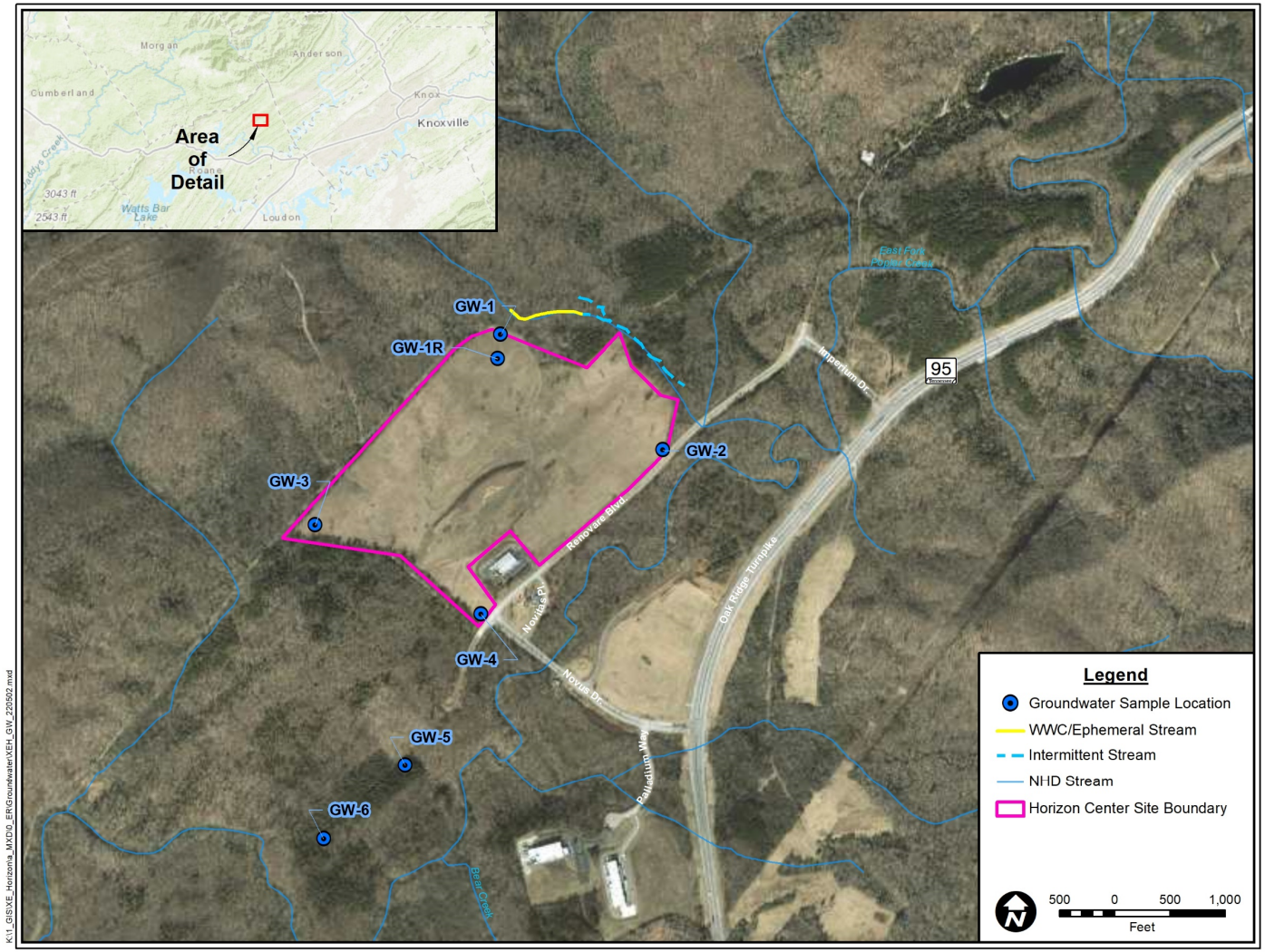


Figure 3.4.1-4

Hydrograph of Groundwater Potentiometric Elevations: September 2021-August 2022

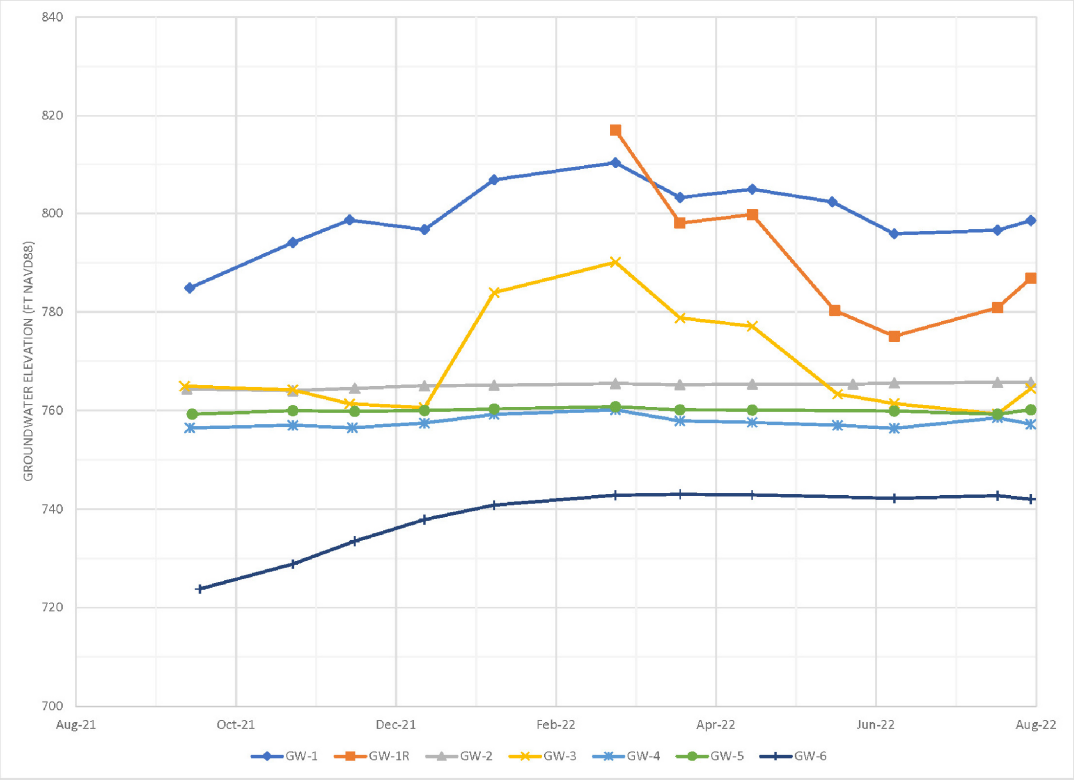


Figure 3.4.1-5

Groundwater Contours – September 2021

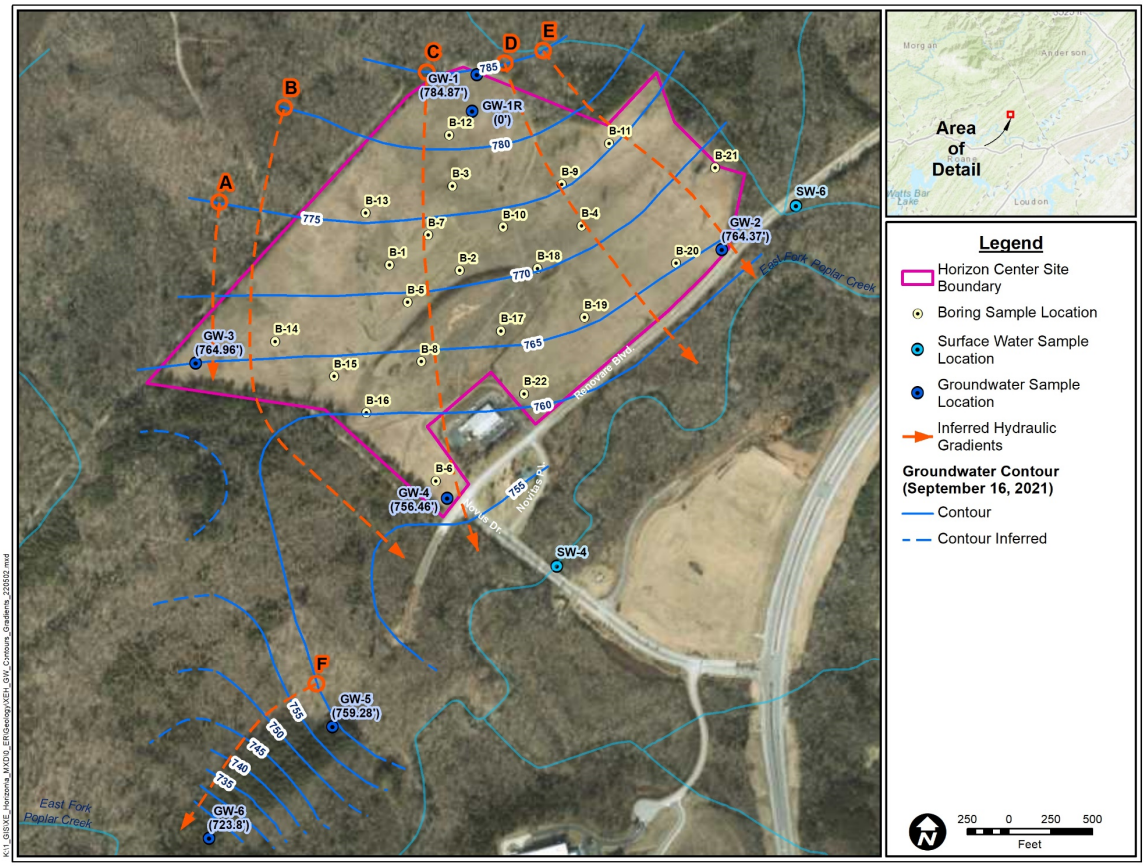


Figure 3.4.1-6

Groundwater Contours – January 2022

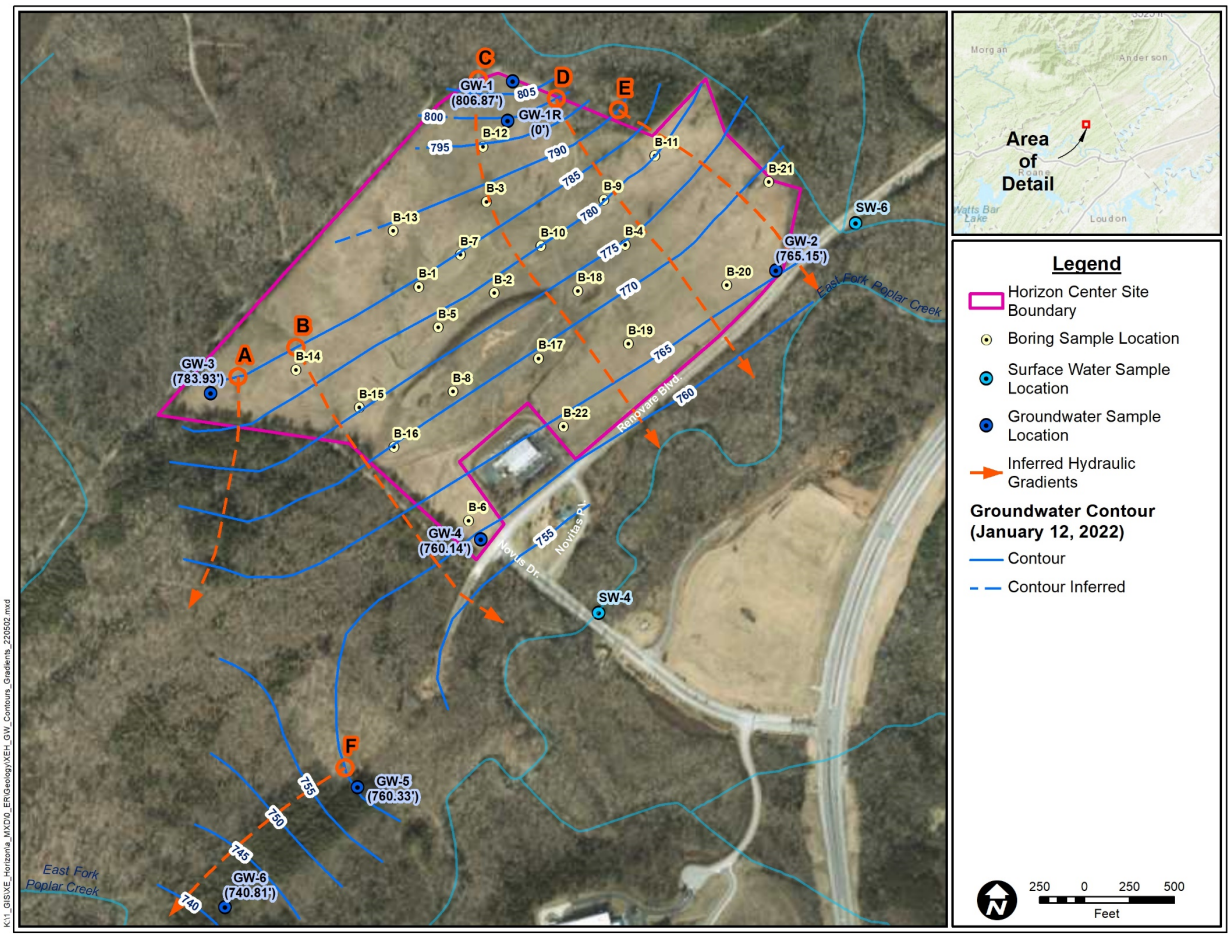


Figure 3.4.2-1

Streams and Topography Within 3-Mile Radius of Horizon Center Site

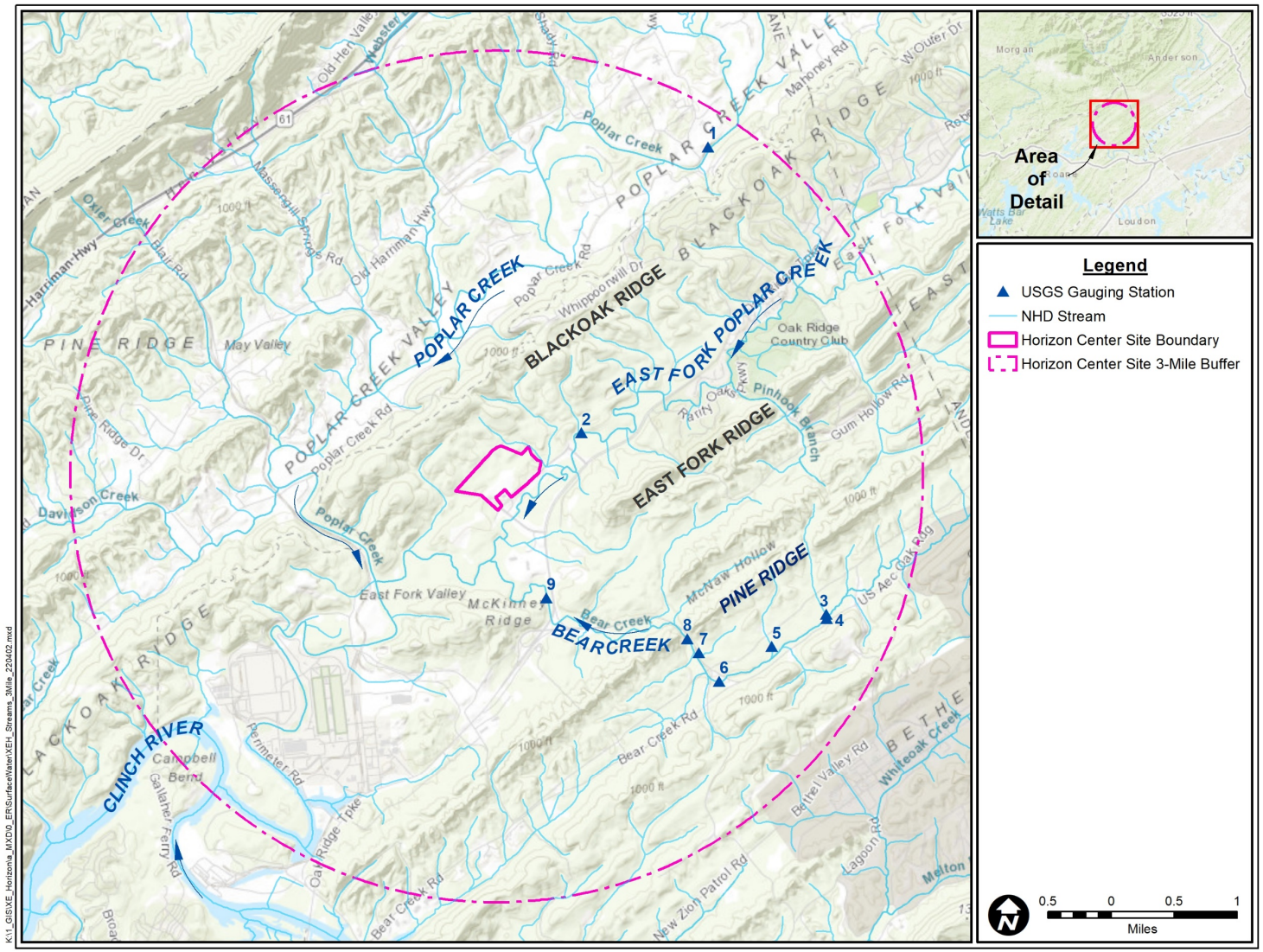


Figure 3.4.2-2

Surface Drainage Near the Horizon Center Site

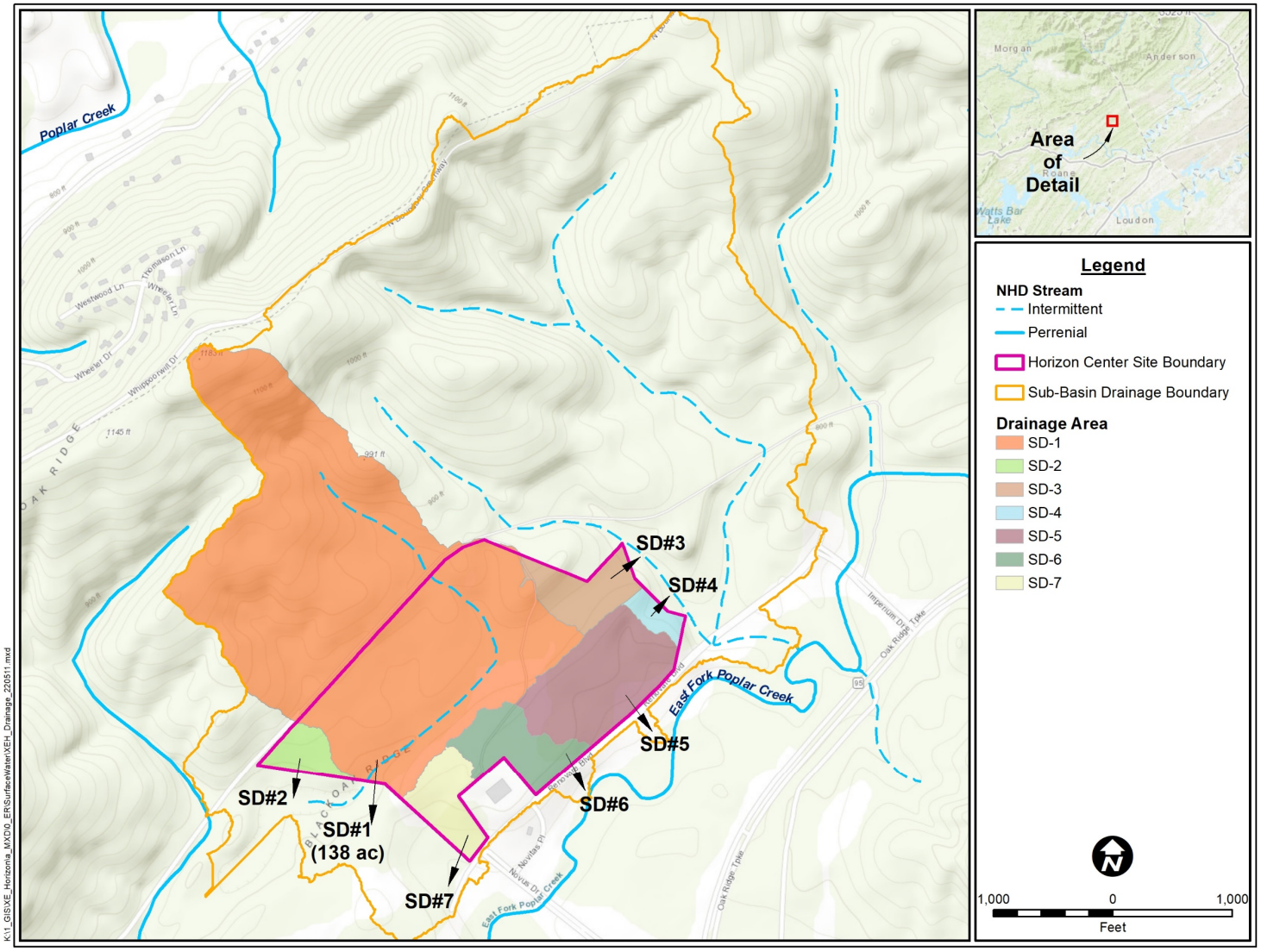


Figure 3.4.2-3

Surface Water Quality Sampling Locations for the Horizon Center Site

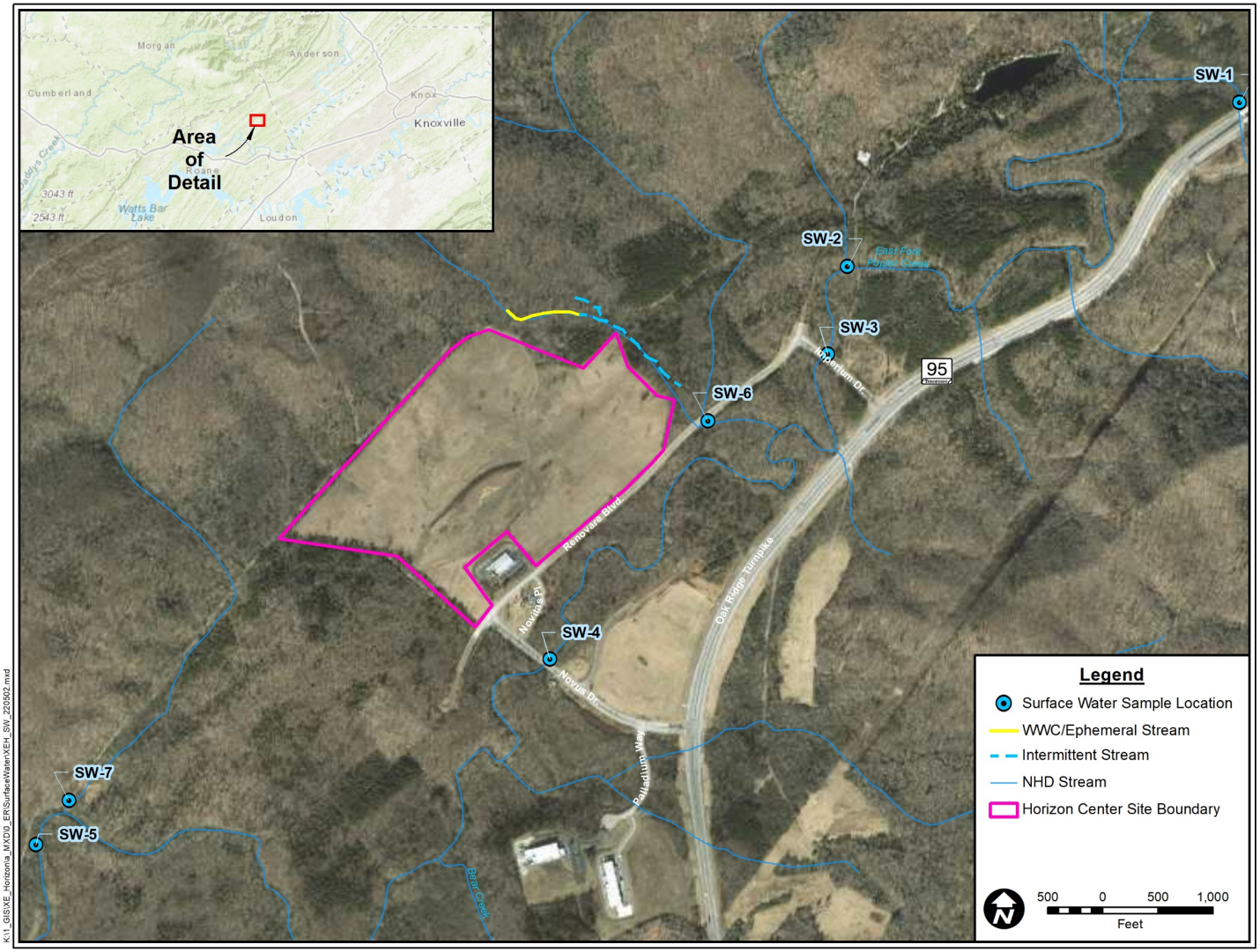
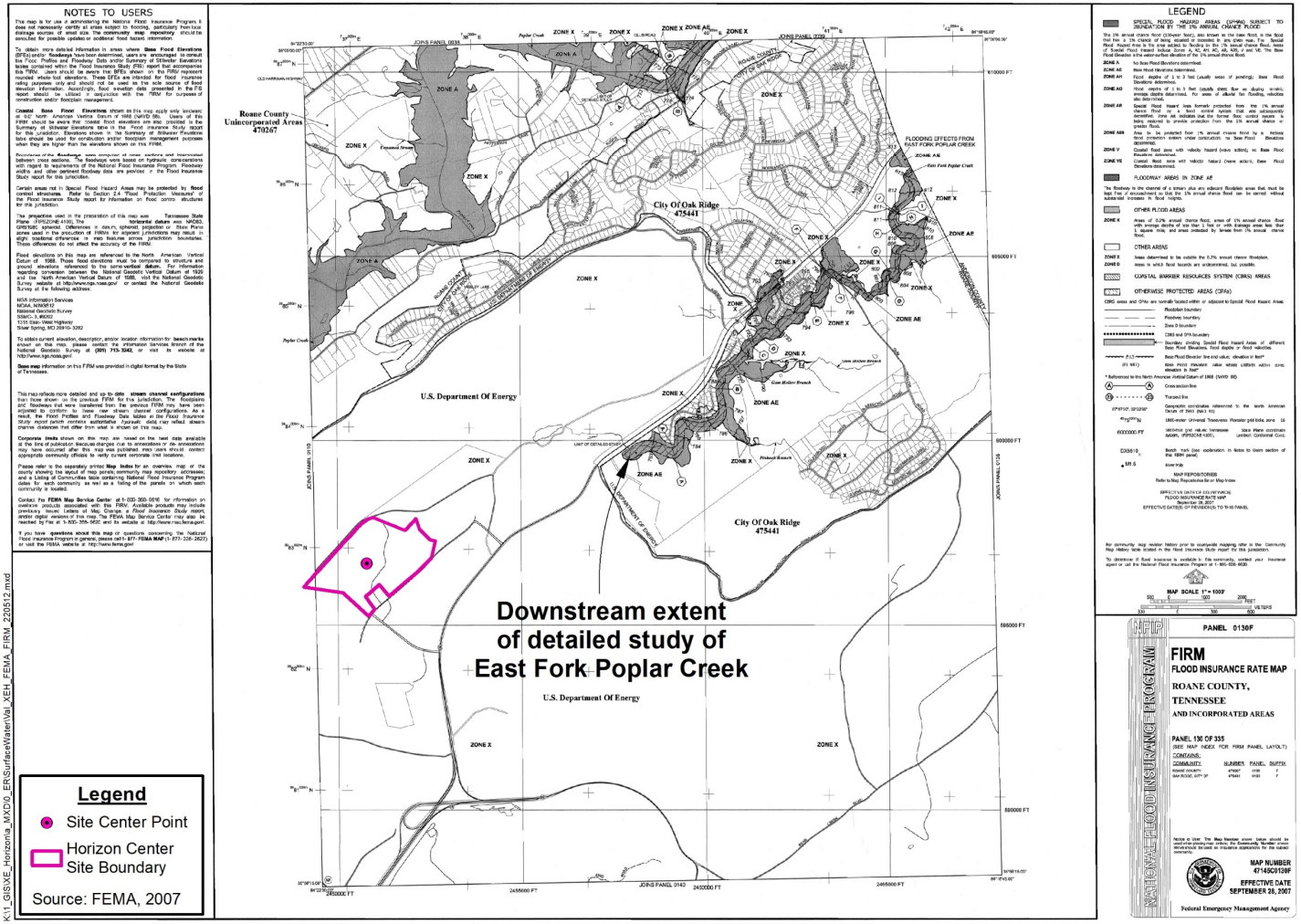


Figure 3.4.3-1

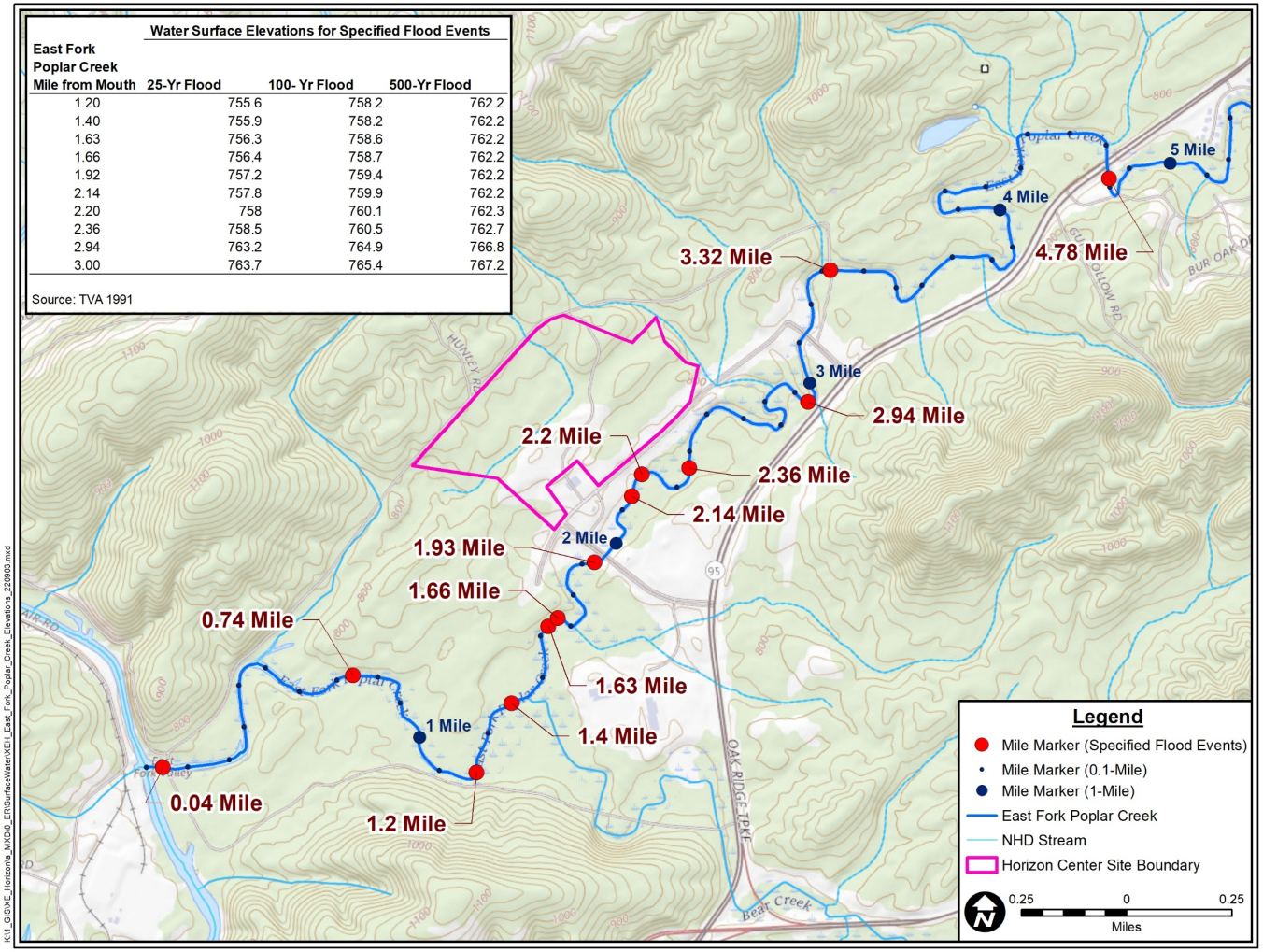
NFIP Flood Insurance Rate Map for the Horizon Center Site



Source: FEMA 2007

Figure 3.4.3-2

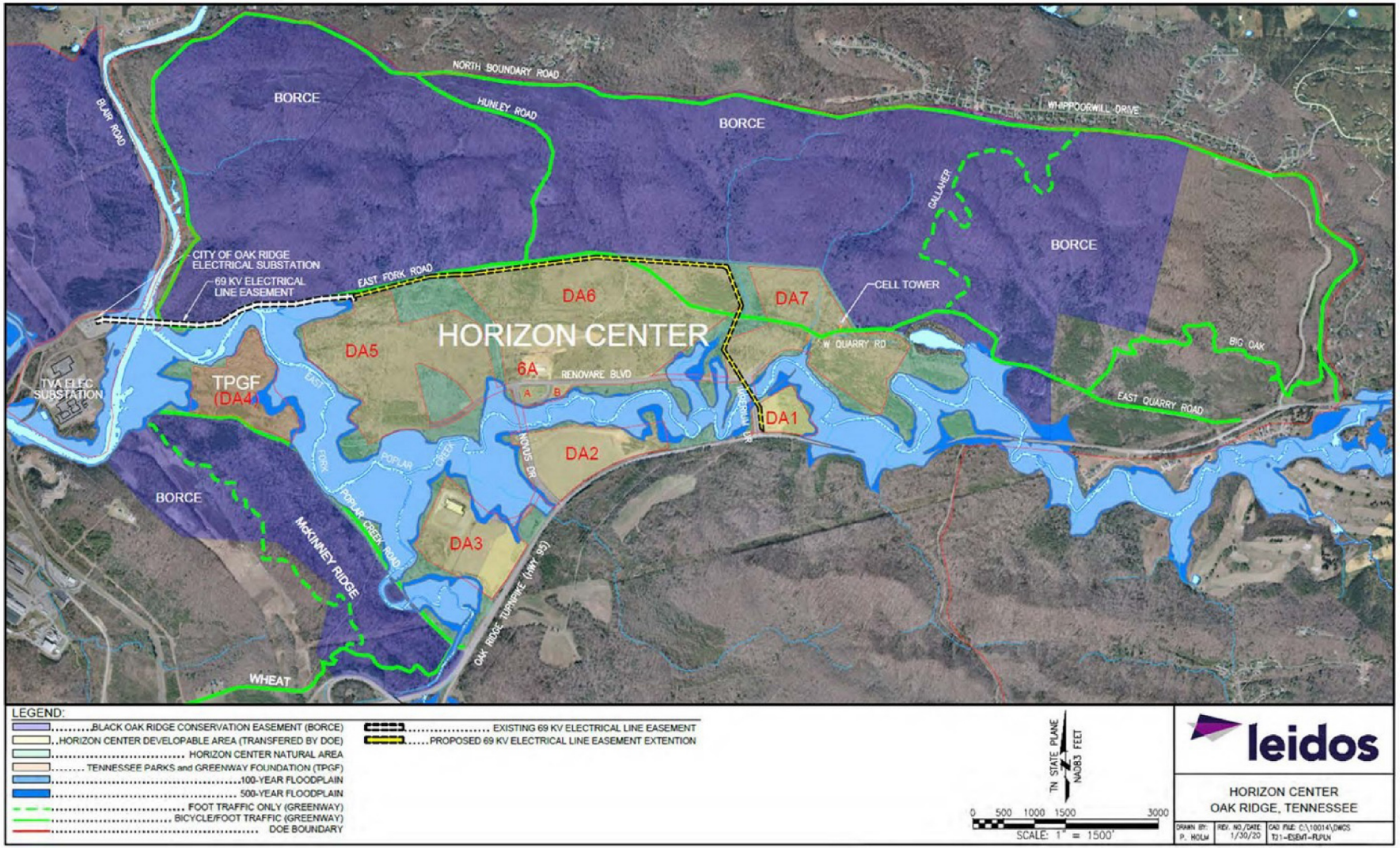
East Fork Poplar Creek Flood Elevations



Source TVA, 1991

Figure 3.4.3-3

East Fork Poplar Creek Floodplain Map



Source: Leidos 2020

Figure 3.4.4-1

NWI-Mapped Wetland Habitats within the Horizon Center Site

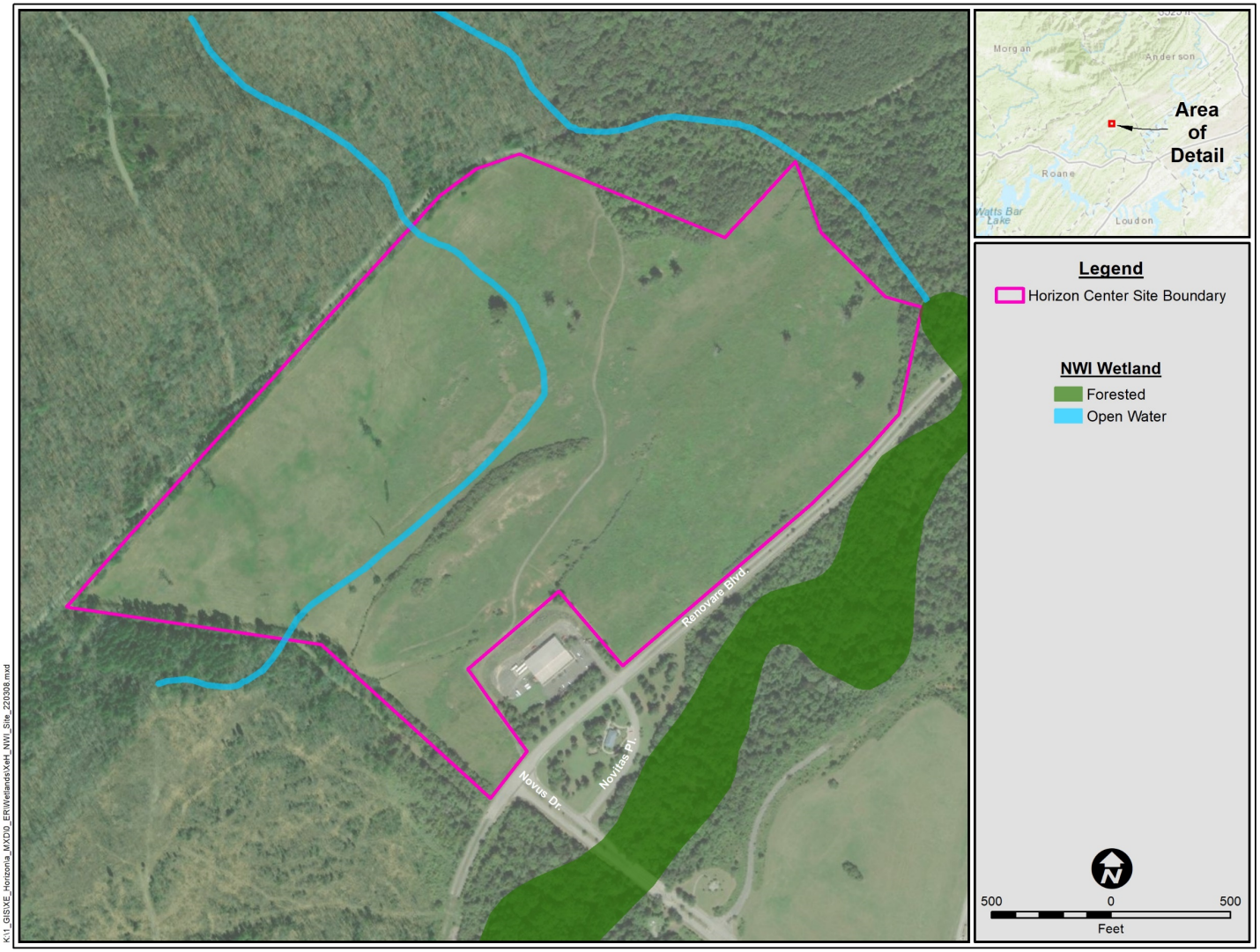


Figure 3.4.4-2

Wetland and Stream Delineation of the Horizon Center Site

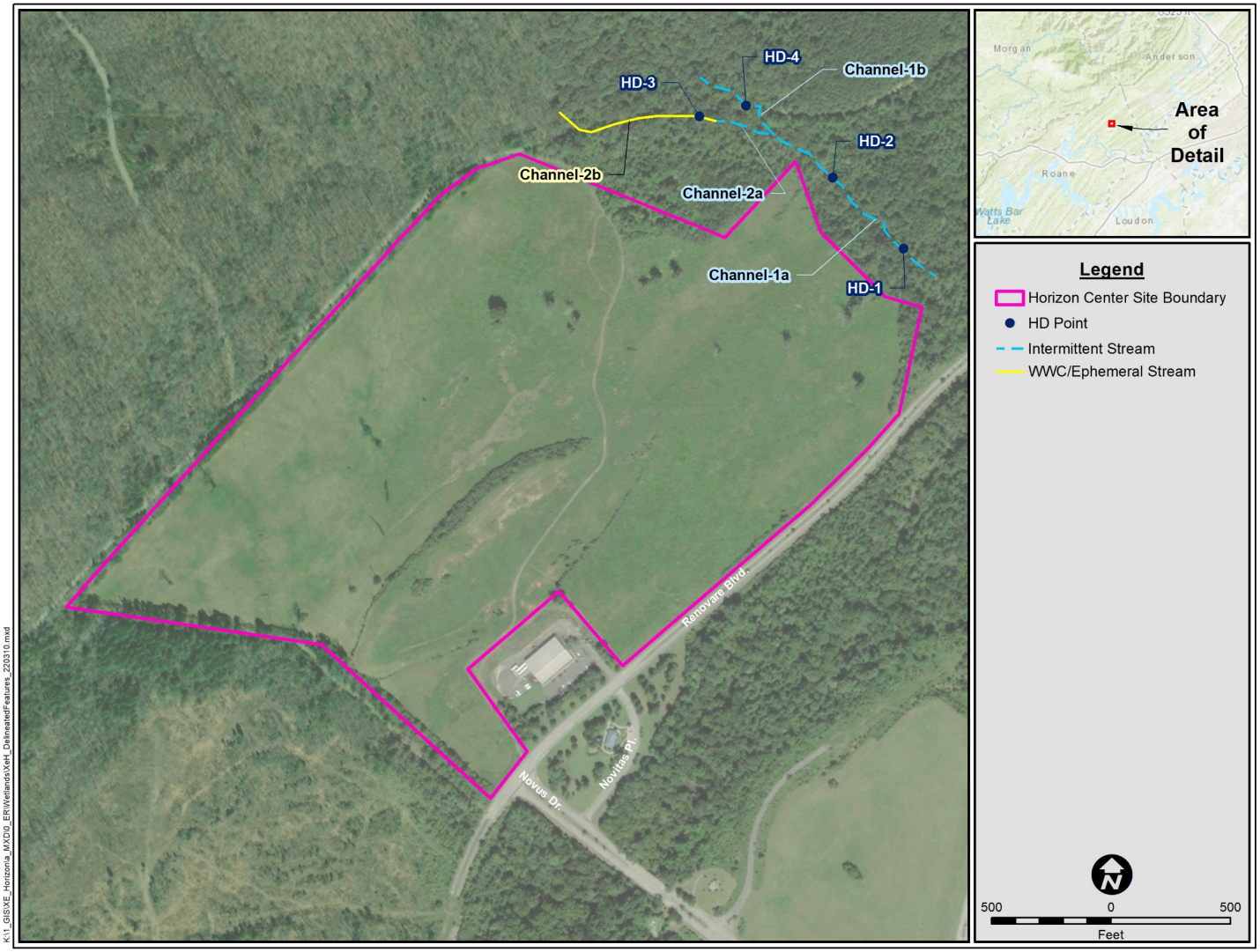


Figure 3.5-1

Land Cover, Vegetation Types, and Bat Habitat in the Study Area

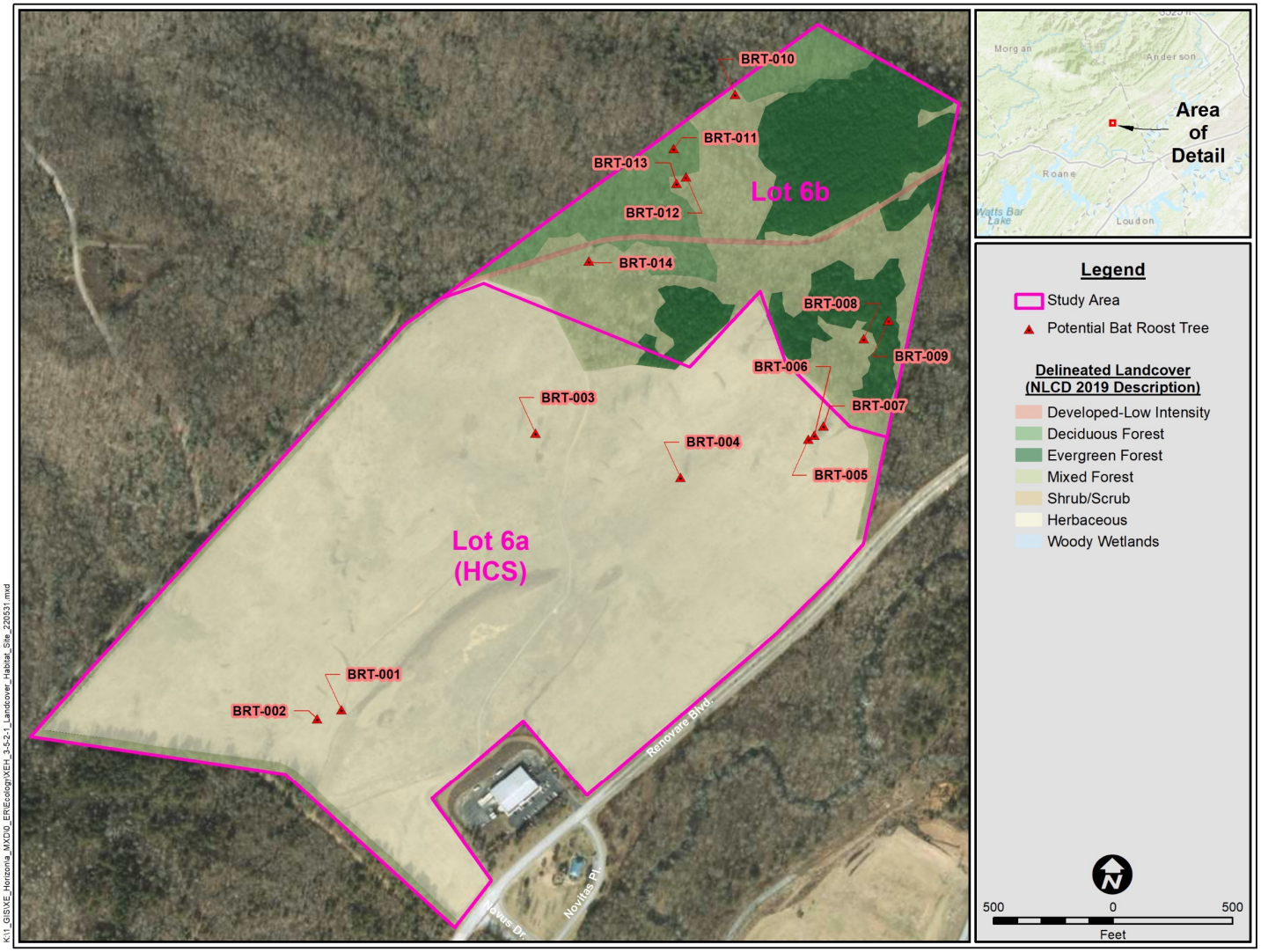


Figure 3.5.2-1

Land Use/Land Cover within 5 Miles of the Horizon Center Site

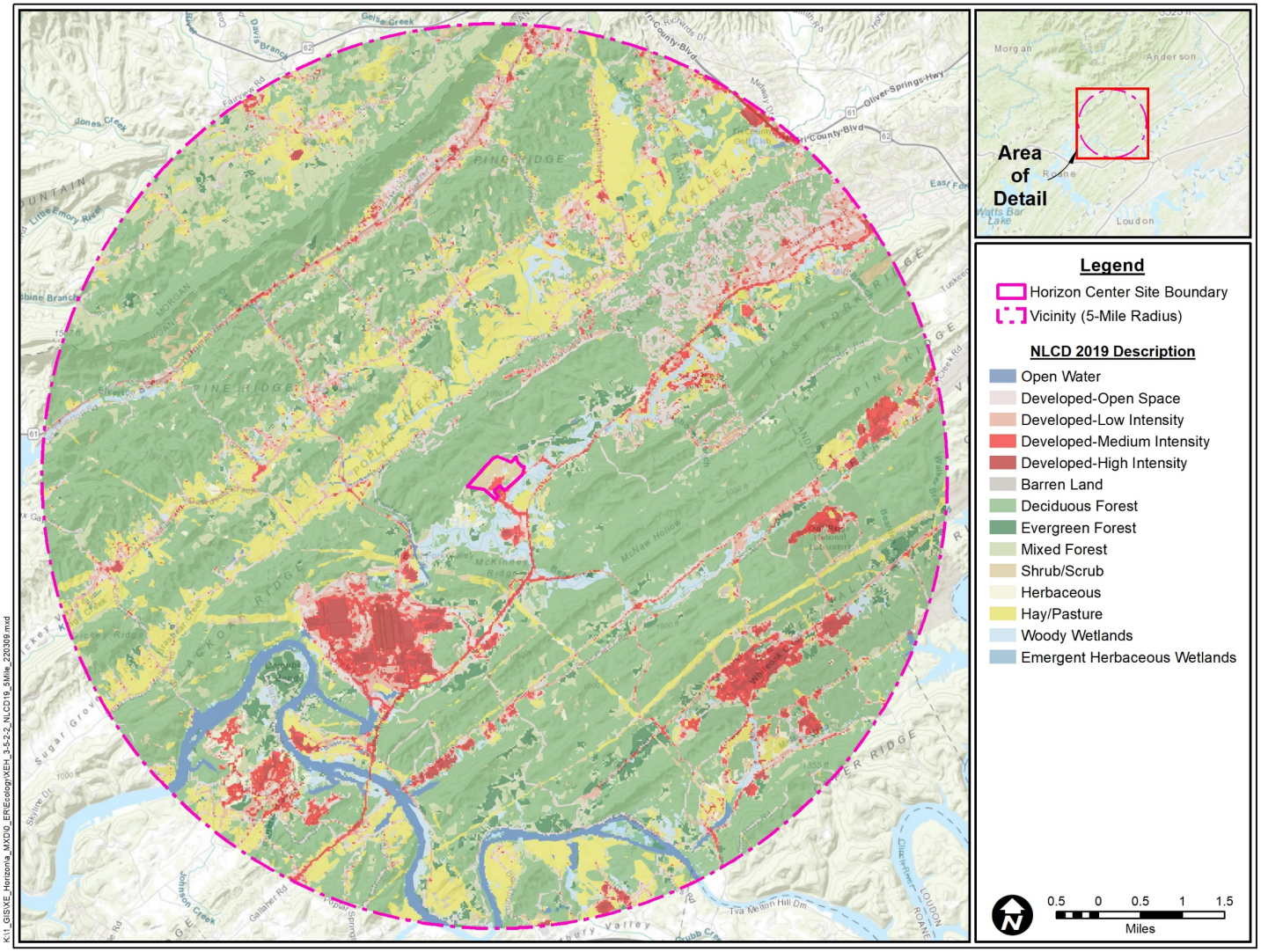


Figure 3.5.4-1

Important Ecological Areas within 5 Miles of the Horizon Center Site

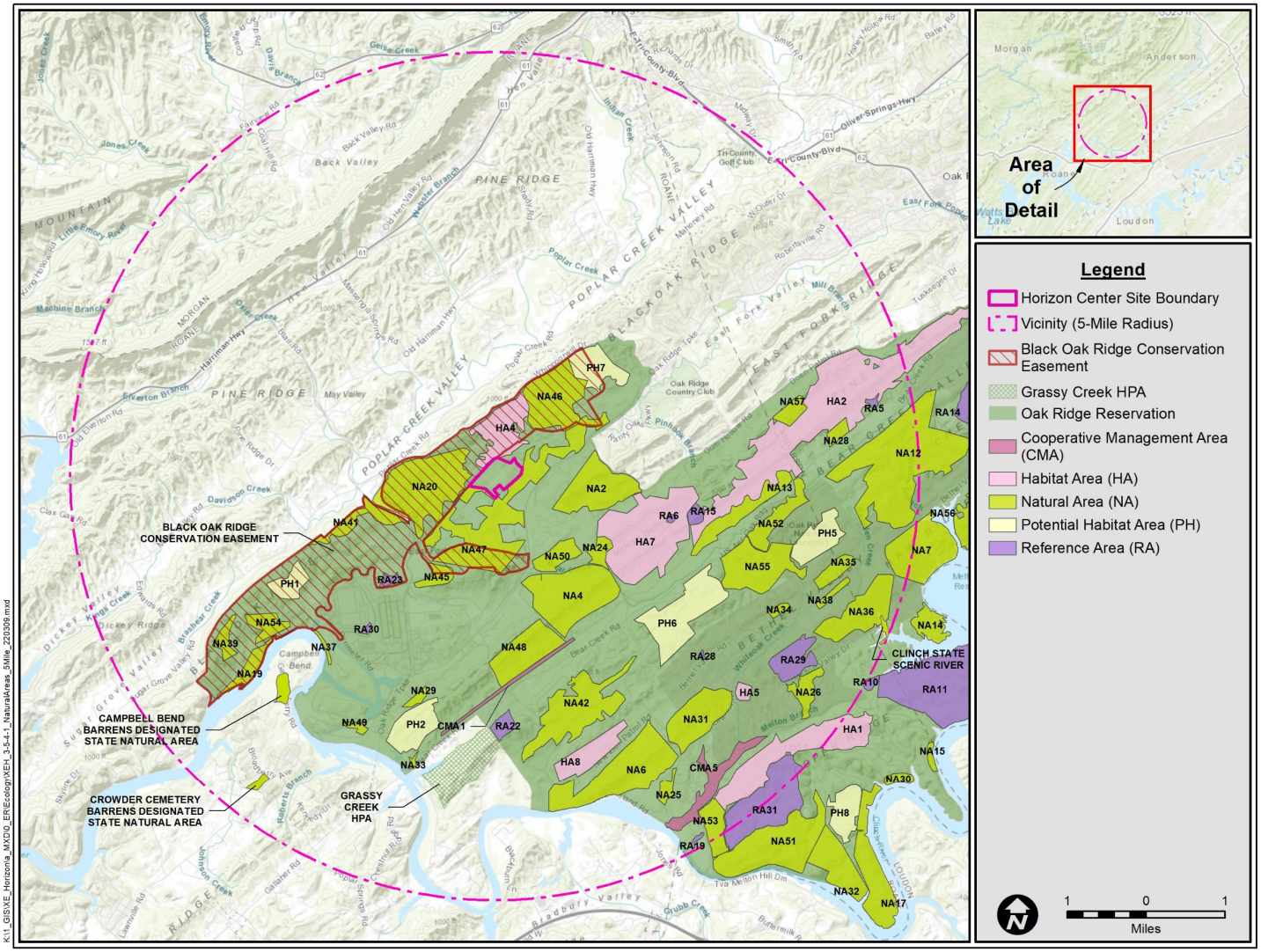


Figure 3.6-1
Annual Wind Rose Oak Ridge, Tennessee (2005 – 2020)

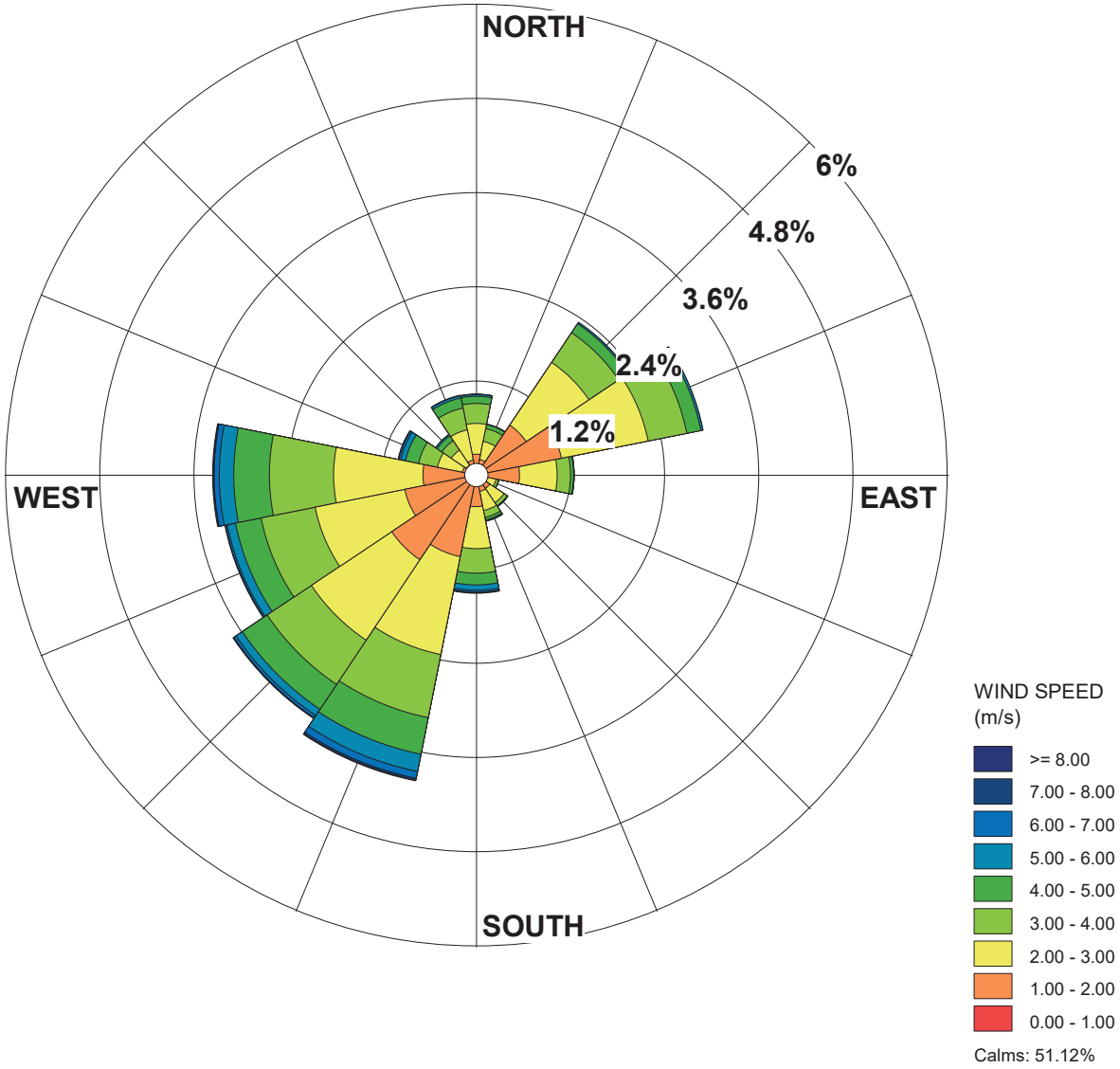


Figure 3.6-2
Seasonal Wind Roses Oak Ridge, Tennessee (2005 – 2020)

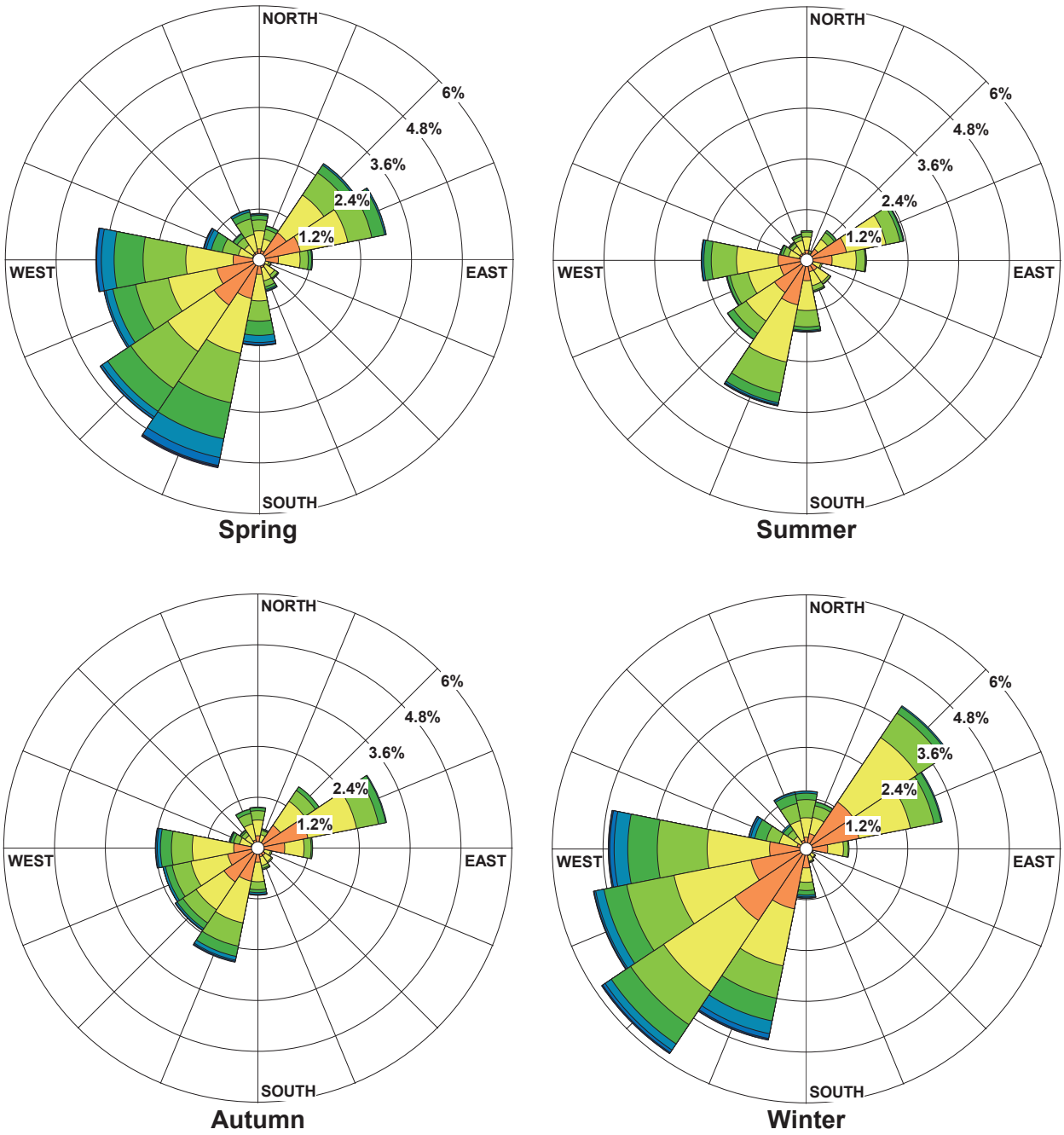


Figure 3.6-3
Annual Wind Rose Knoxville, Tennessee (1990 – 2020)

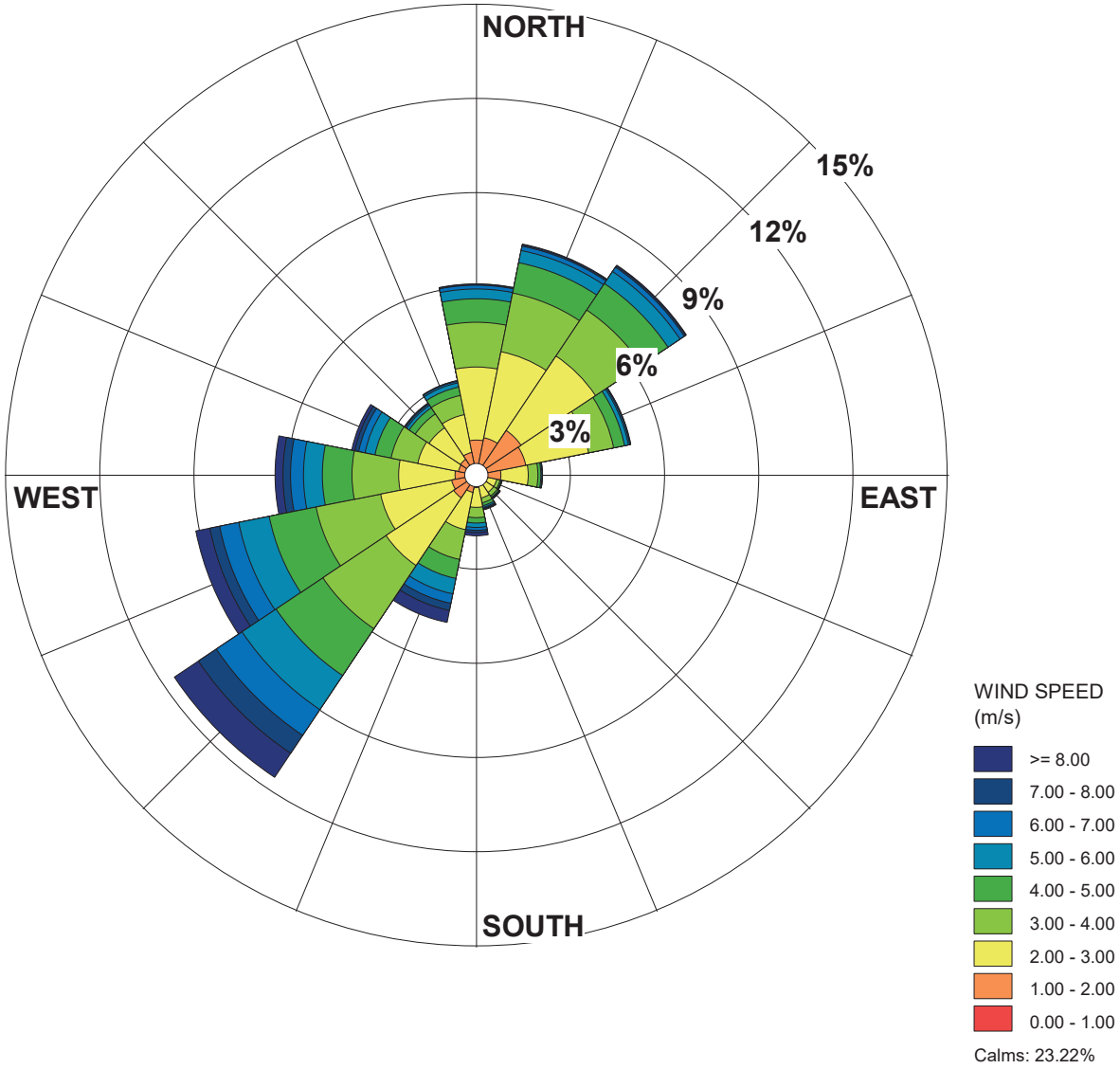


Figure 3.6-4
Seasonal Wind Roses Knoxville, Tennessee (1990 – 2020)

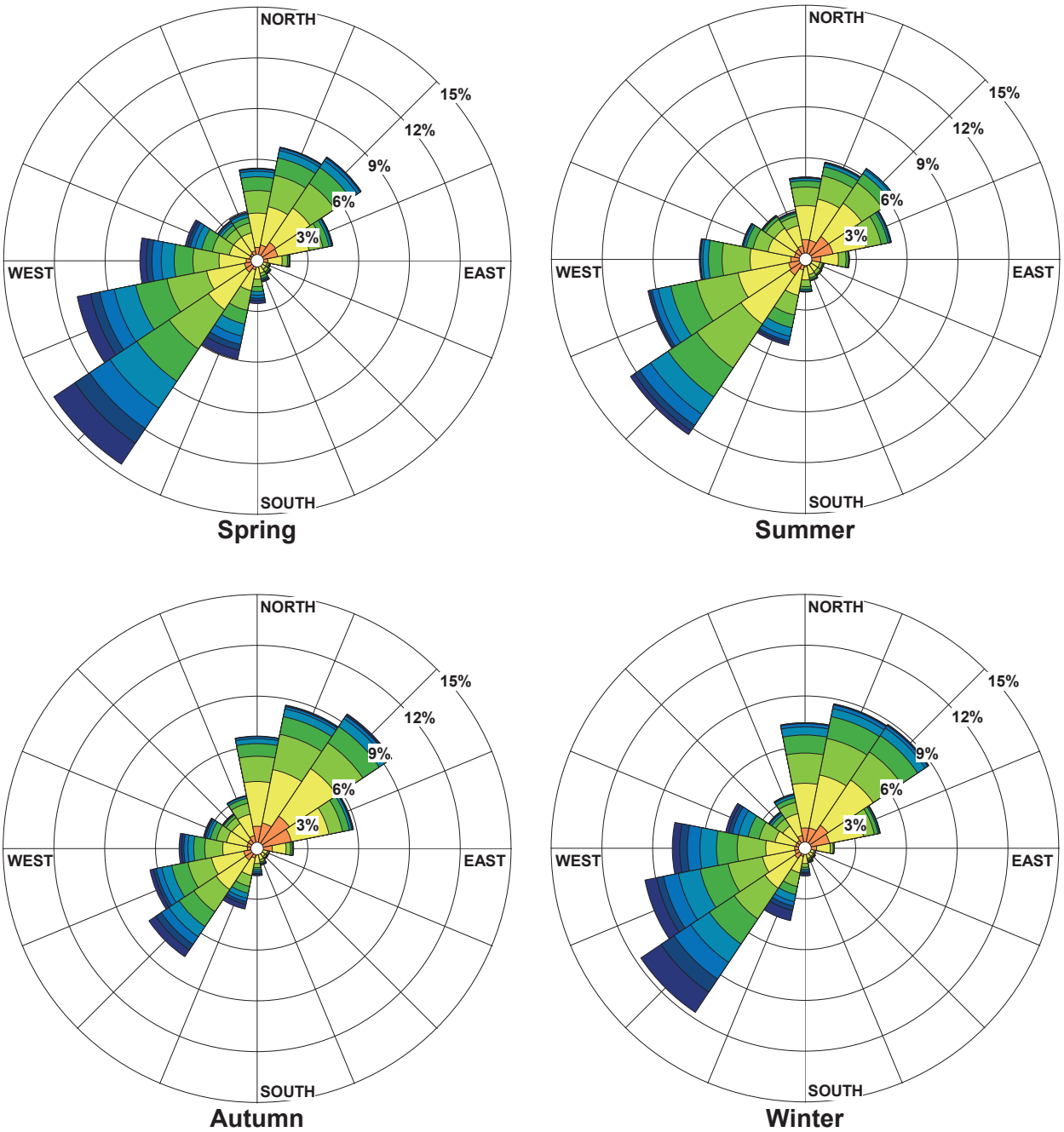


Figure 3.6-5
Locations of ASOS and COOP Meteorological Stations and Supplemental Data Sources

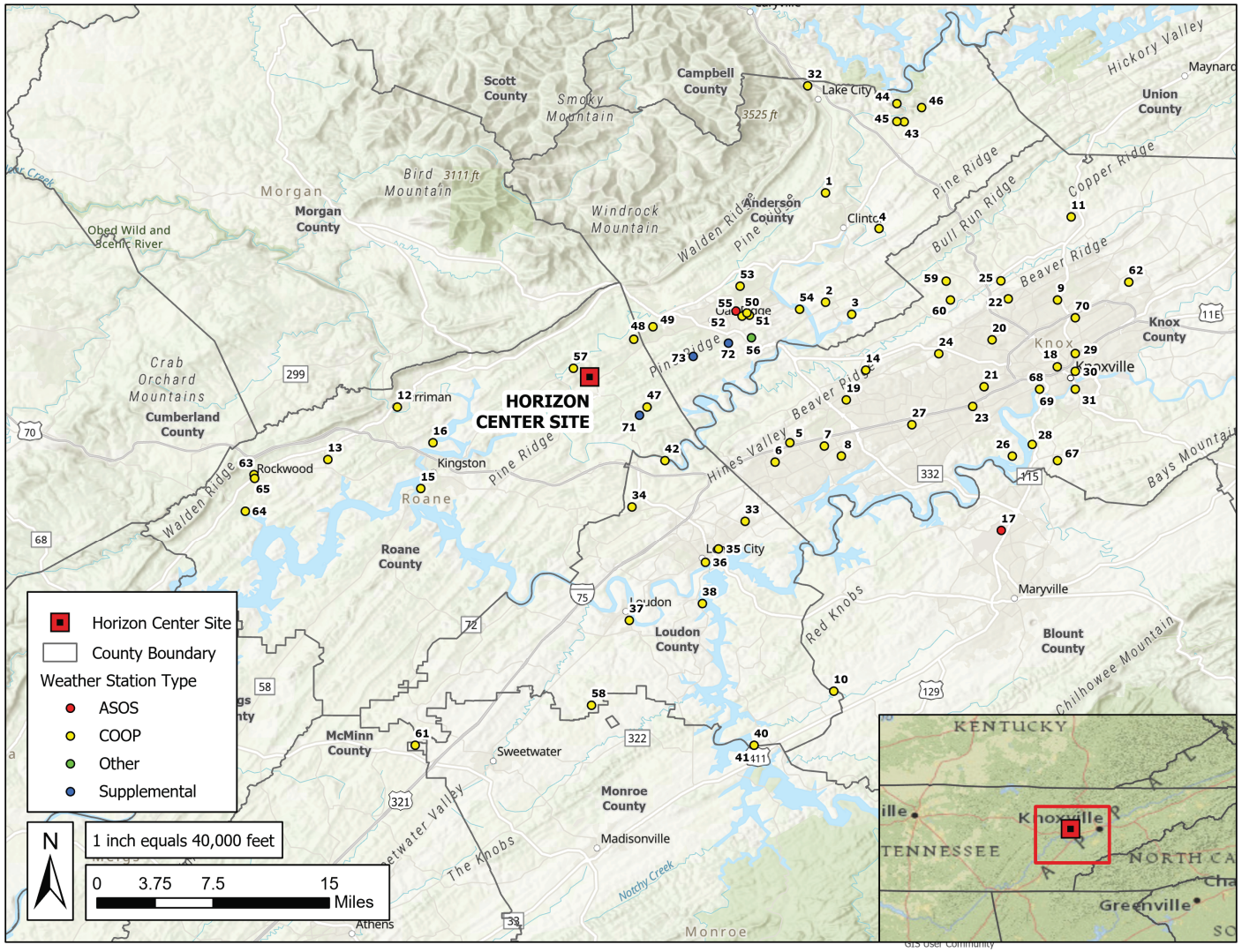


Figure 3.6-6
Annual Wind Rose Tower D (2016 – 2020)

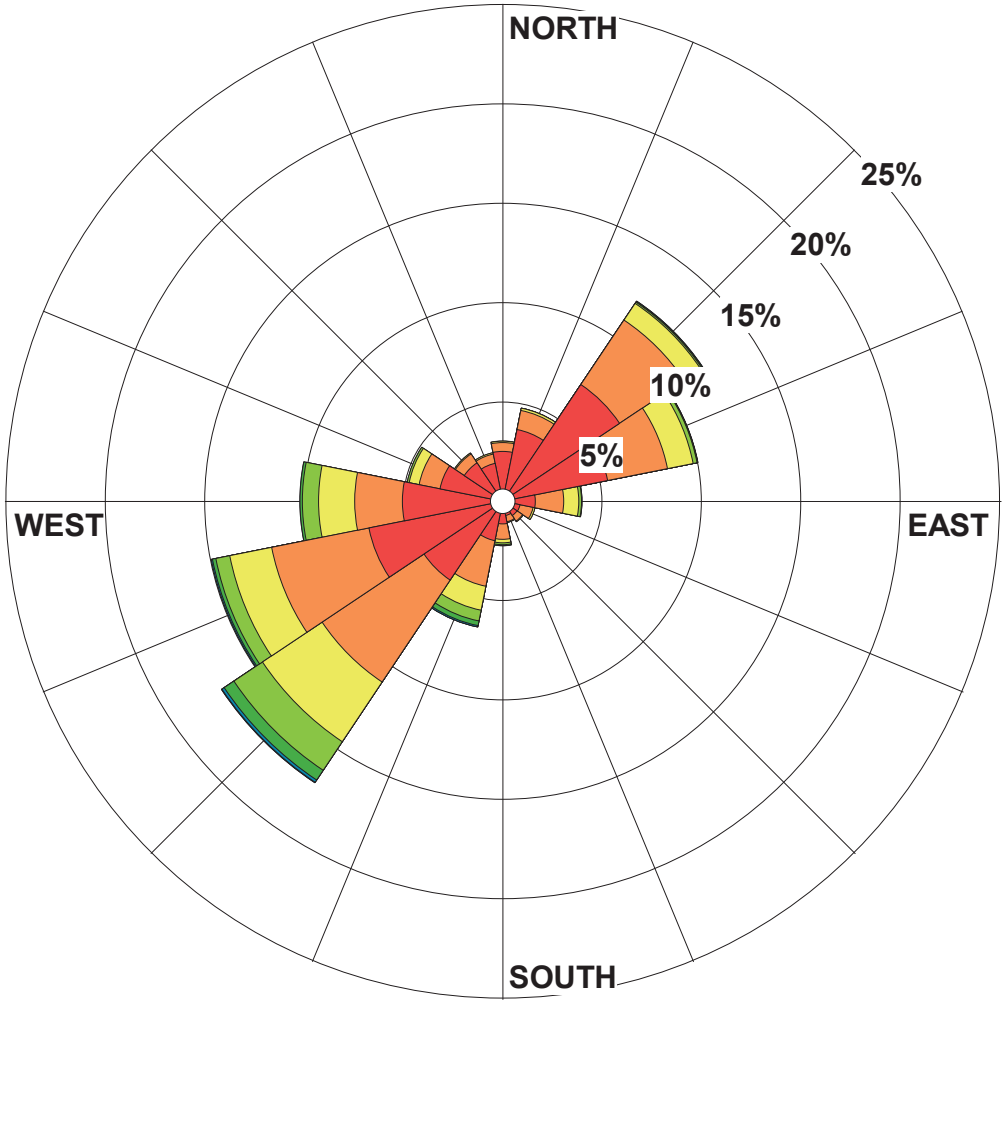


Figure 3.6-7
January Wind Rose Tower D (2016 – 2020)

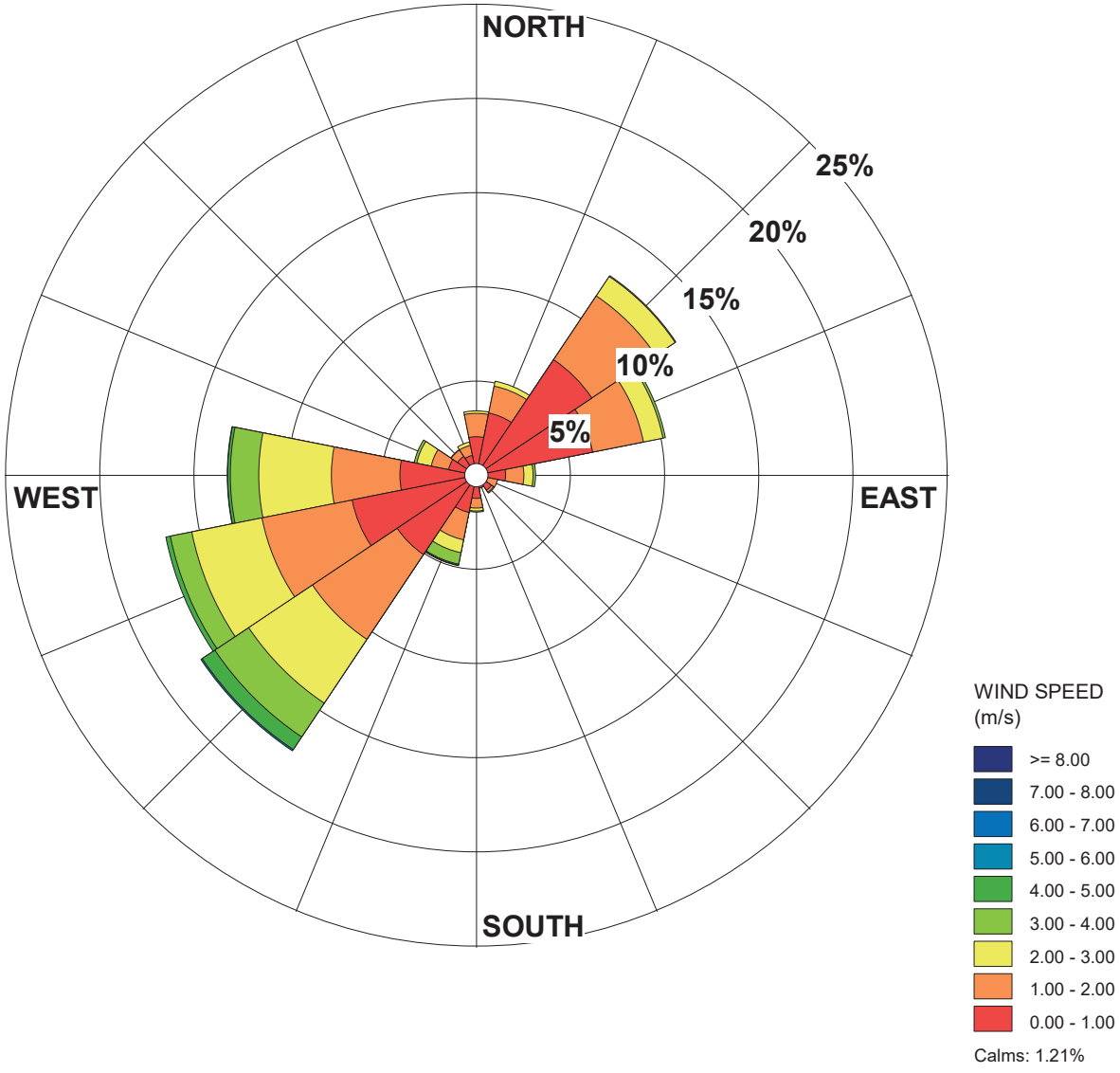


Figure 3.6-8
February Wind Rose Tower D (2016 – 2020)

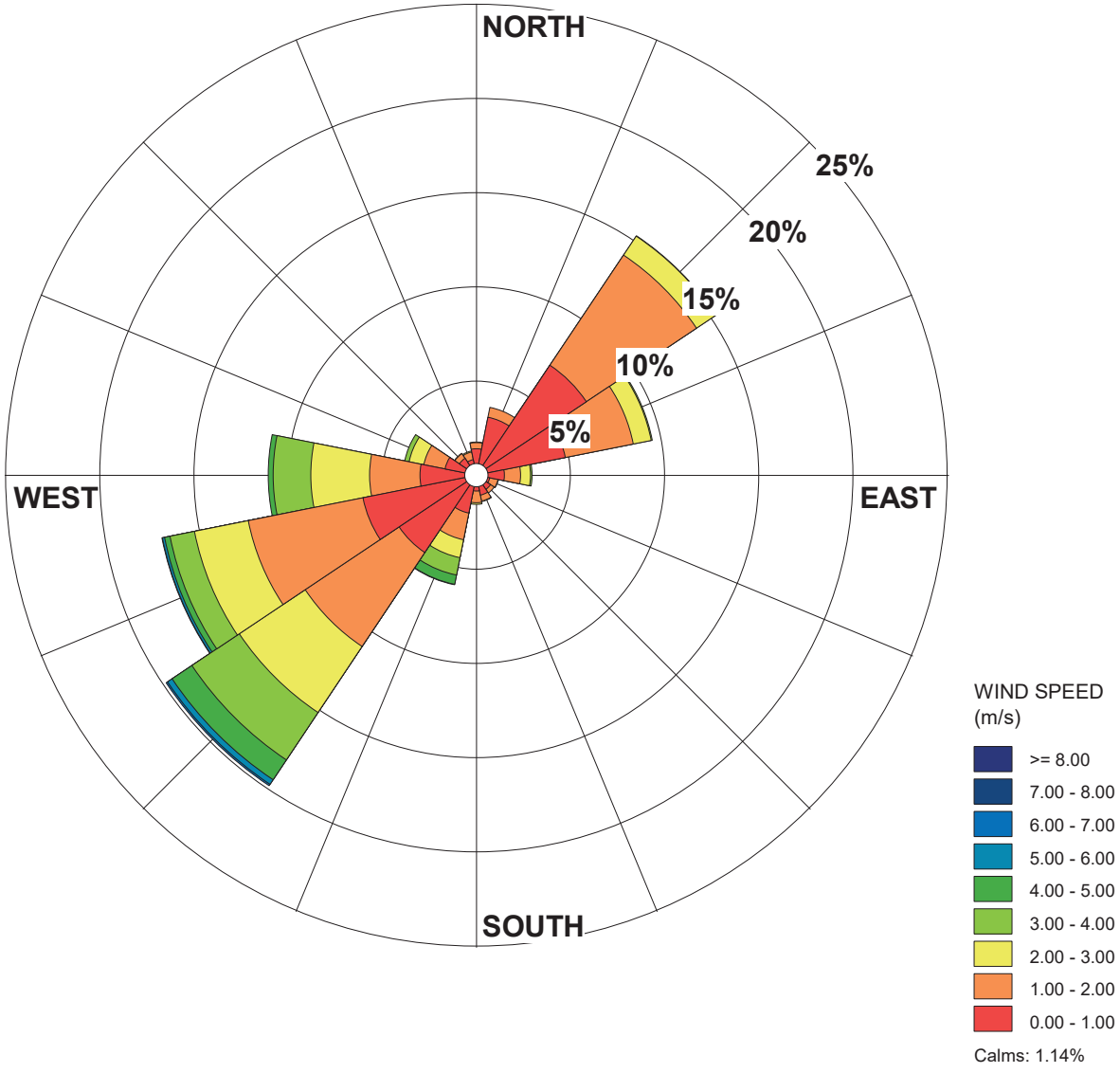


Figure 3.6-9
March Wind Rose Tower D (2016 – 2020)

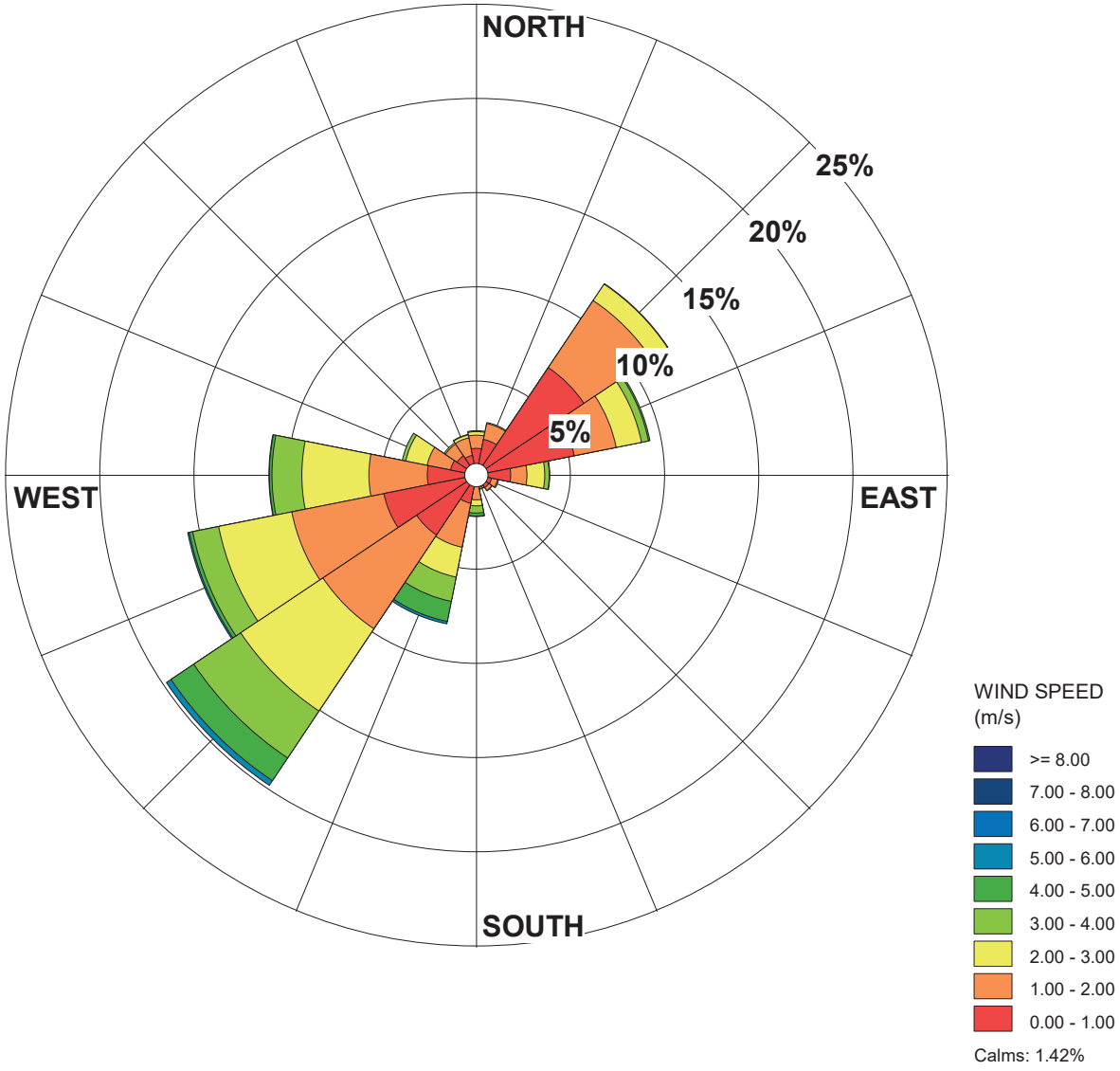


Figure 3.6-10
April Wind Rose Tower D (2016 – 2020)

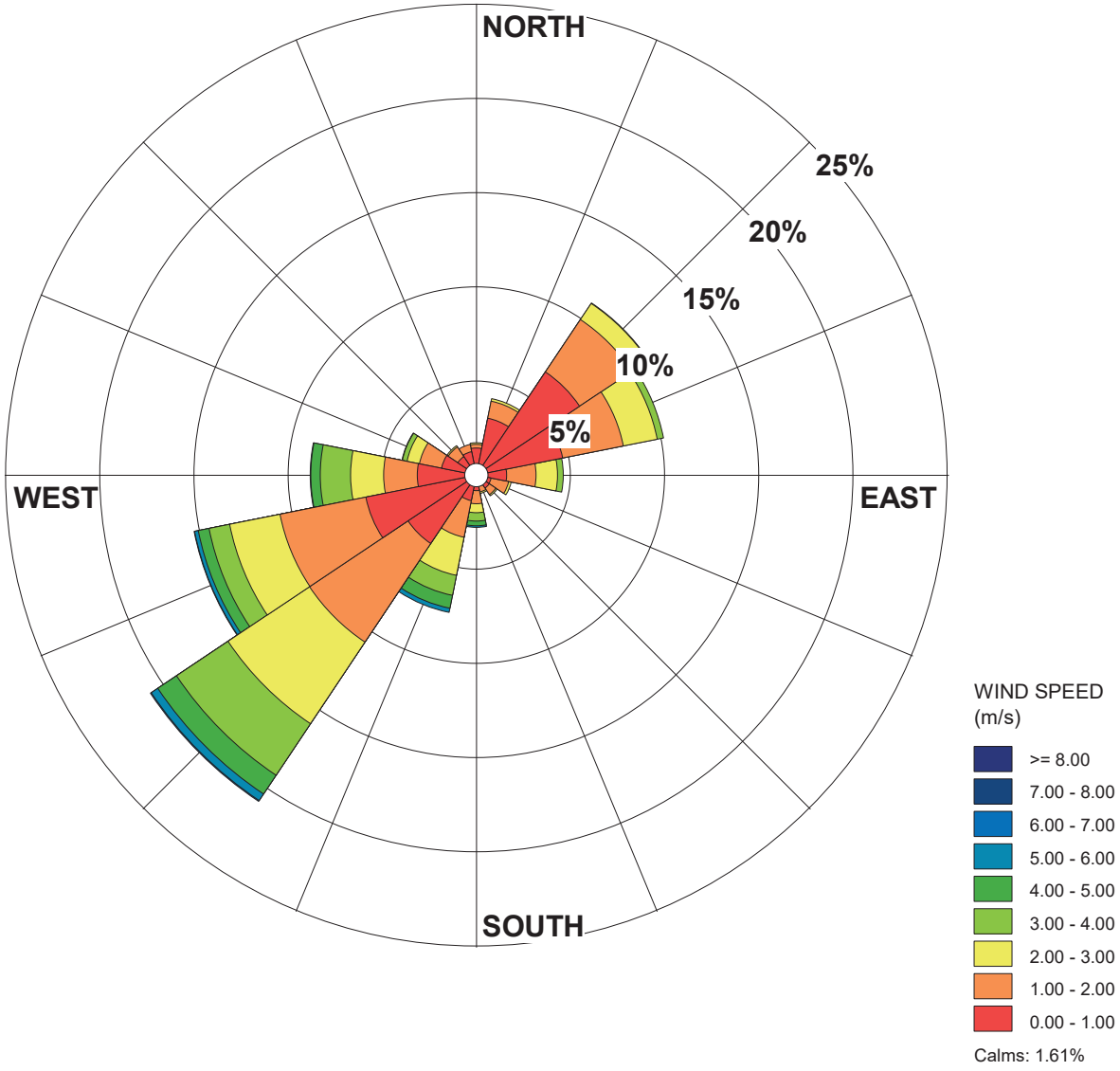


Figure 3.6-11
May Wind Rose Tower D (2016 – 2020)

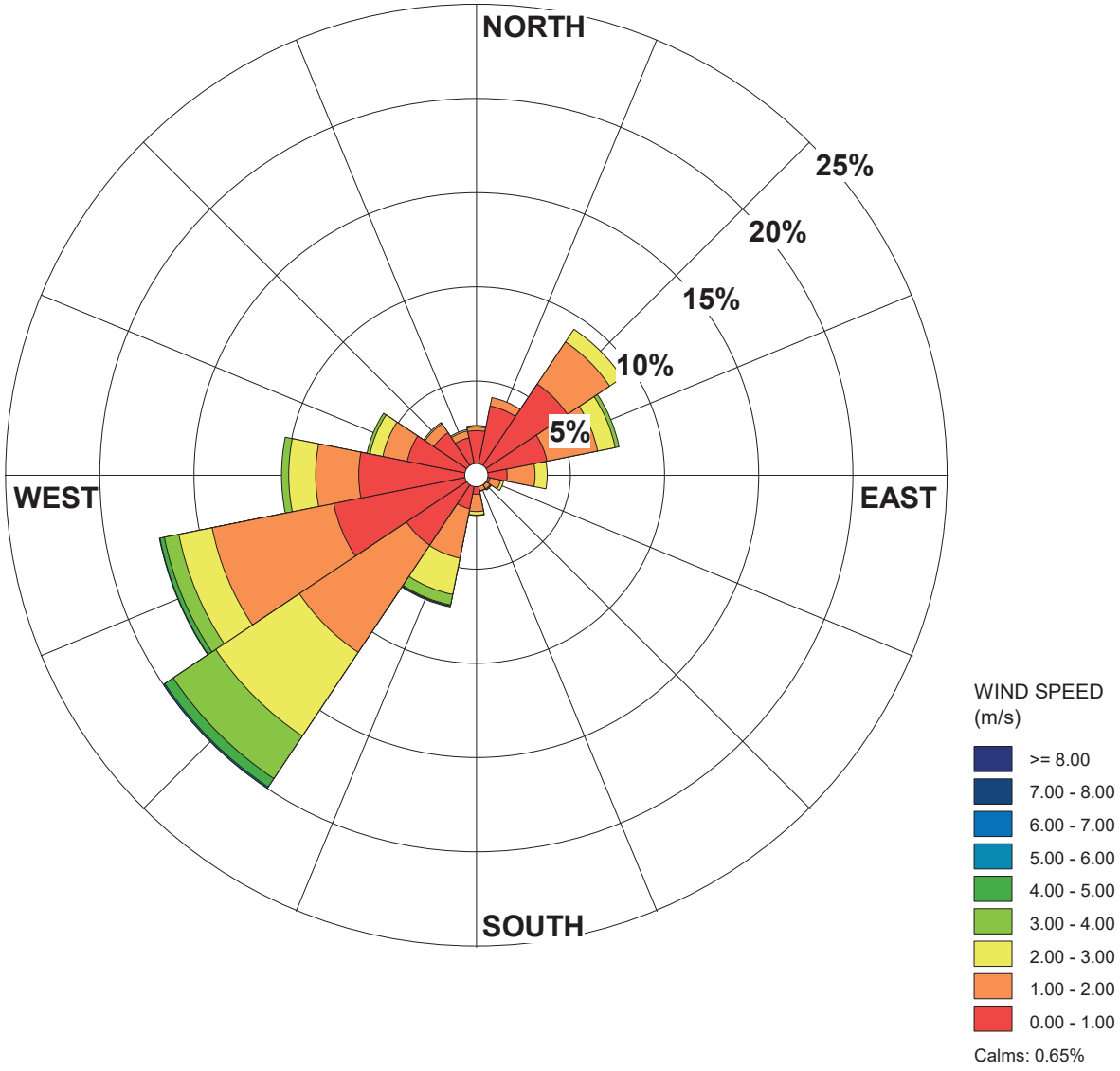


Figure 3.6-12
June Wind Rose Tower D (2016 – 2020)

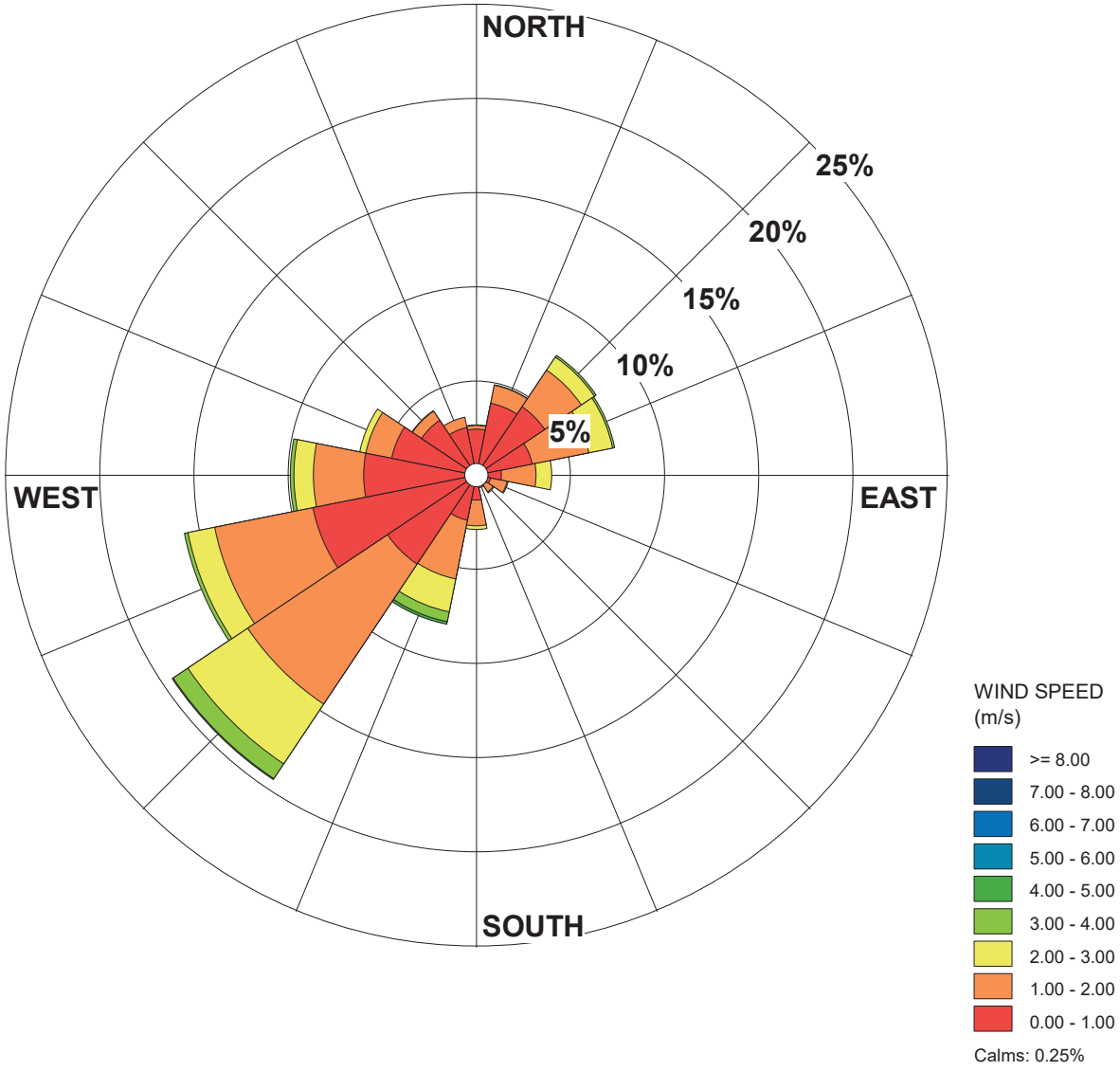


Figure 3.6-13
July Wind Rose Tower D (2016 – 2020)

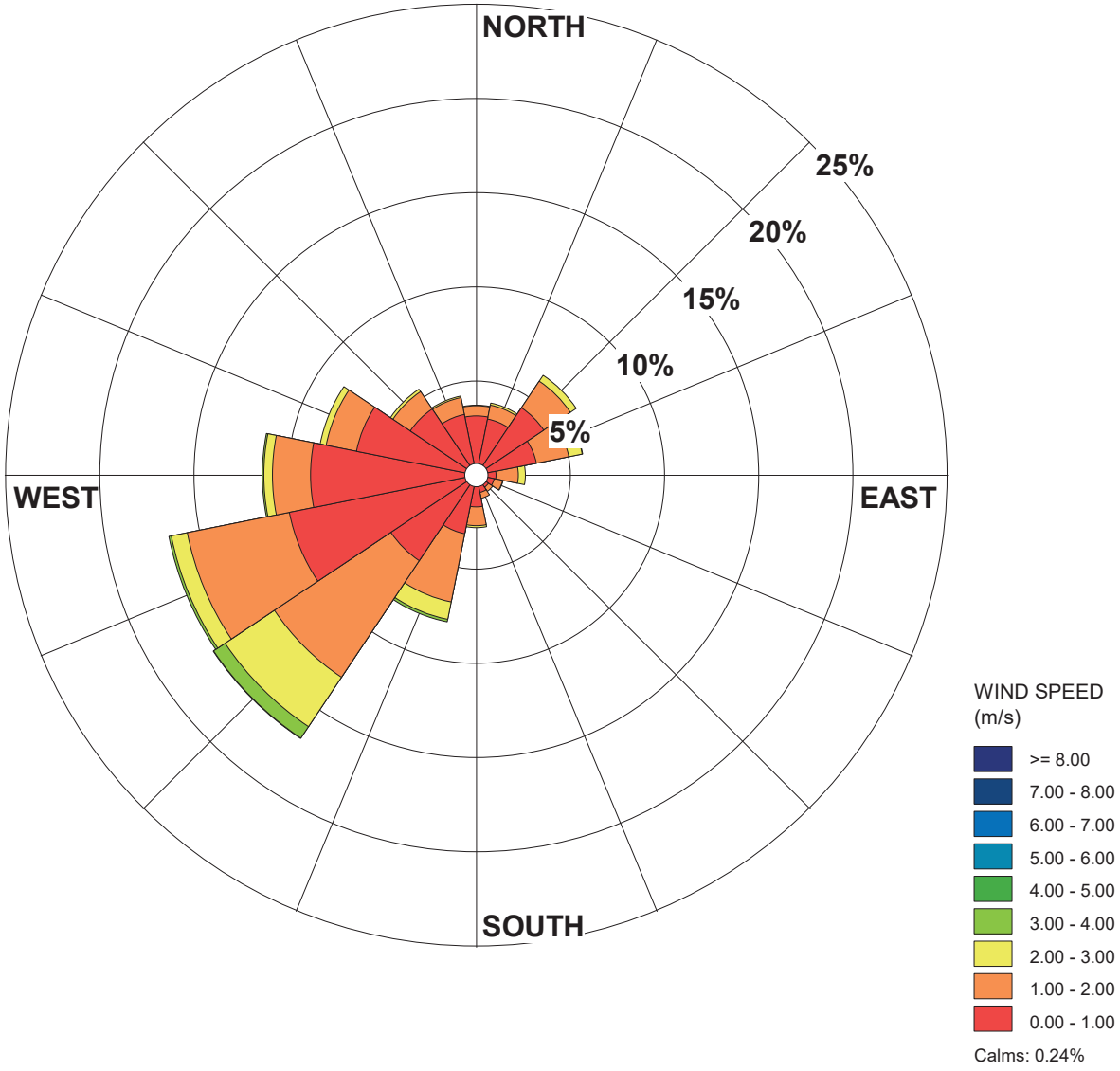


Figure 3.6-14
August Wind Rose Tower D (2016 – 2020)

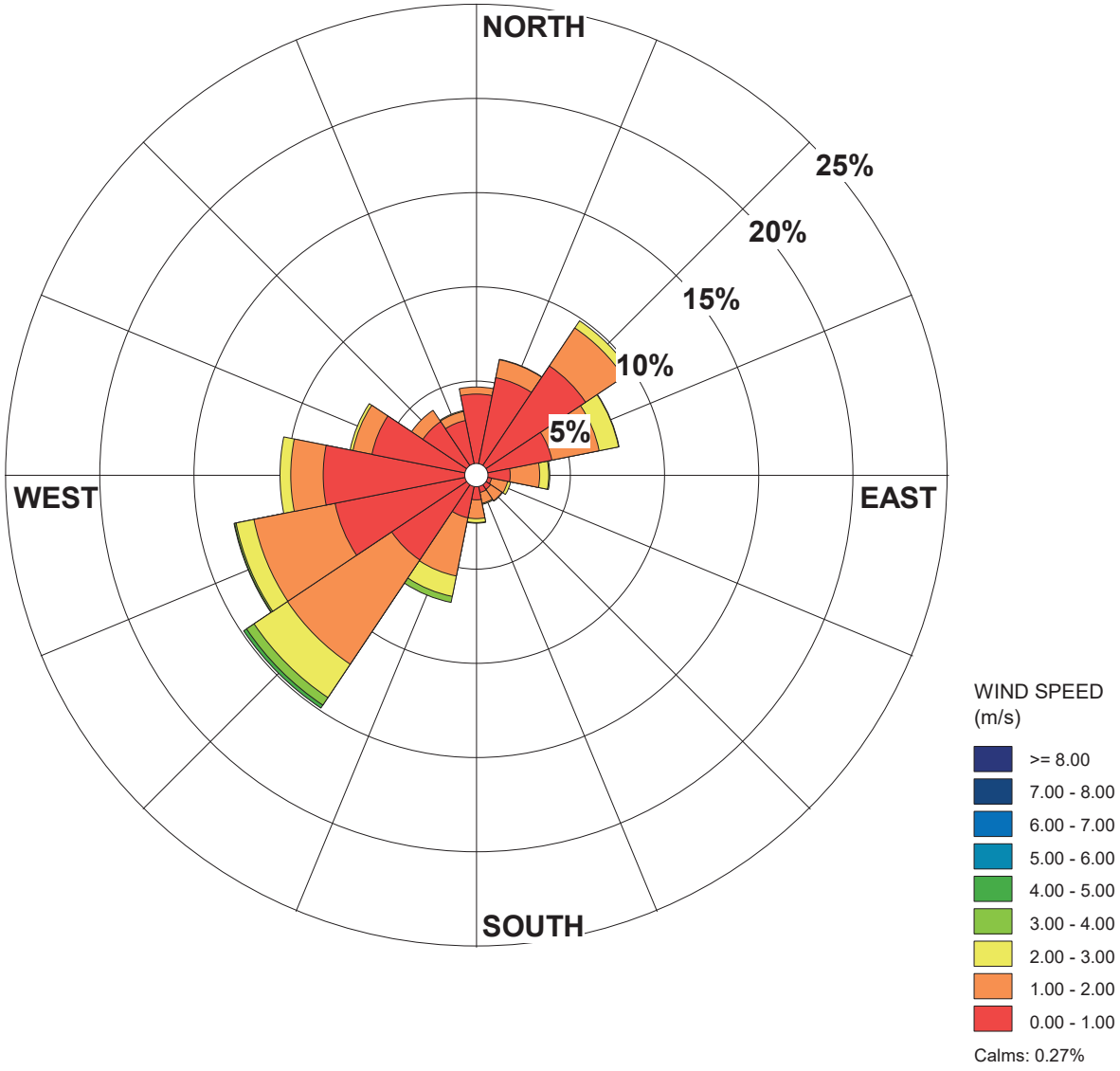


Figure 3.6-15
September Wind Rose Tower D (2016 – 2020)

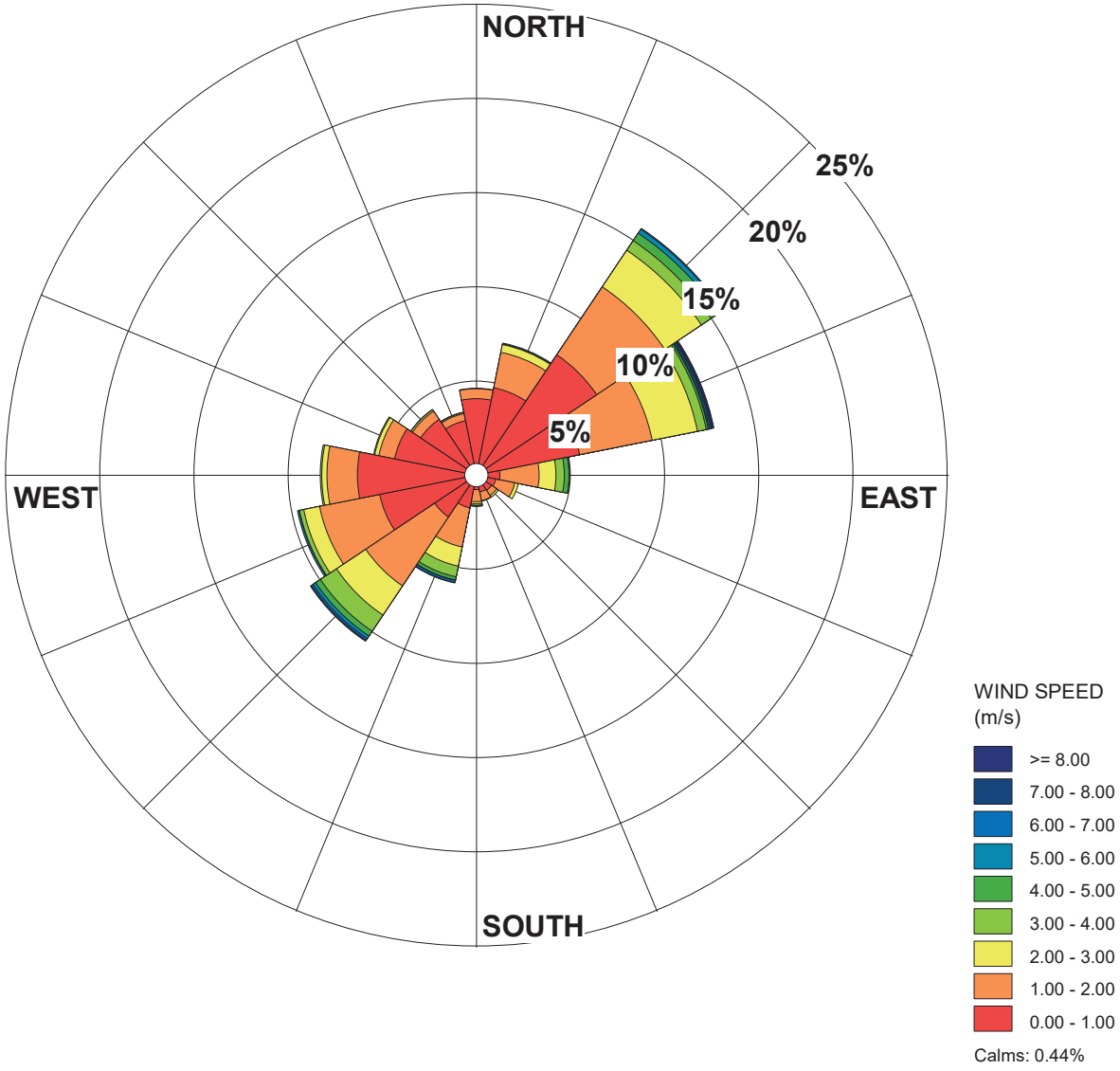


Figure 3.6-16
October Wind Rose Tower D (2016 – 2020)

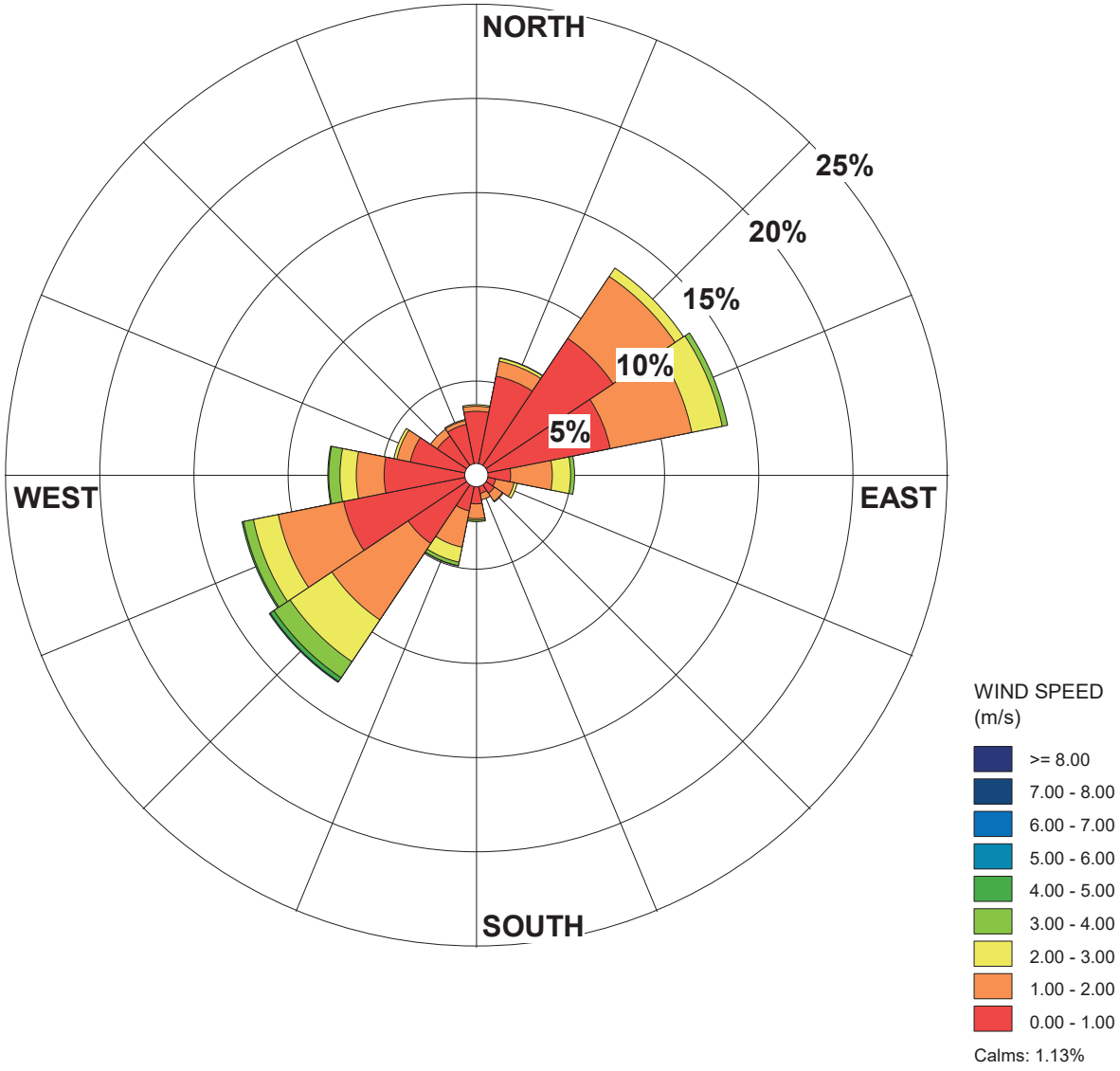


Figure 3.6-17
November Wind Rose Tower D (2016 – 2020)

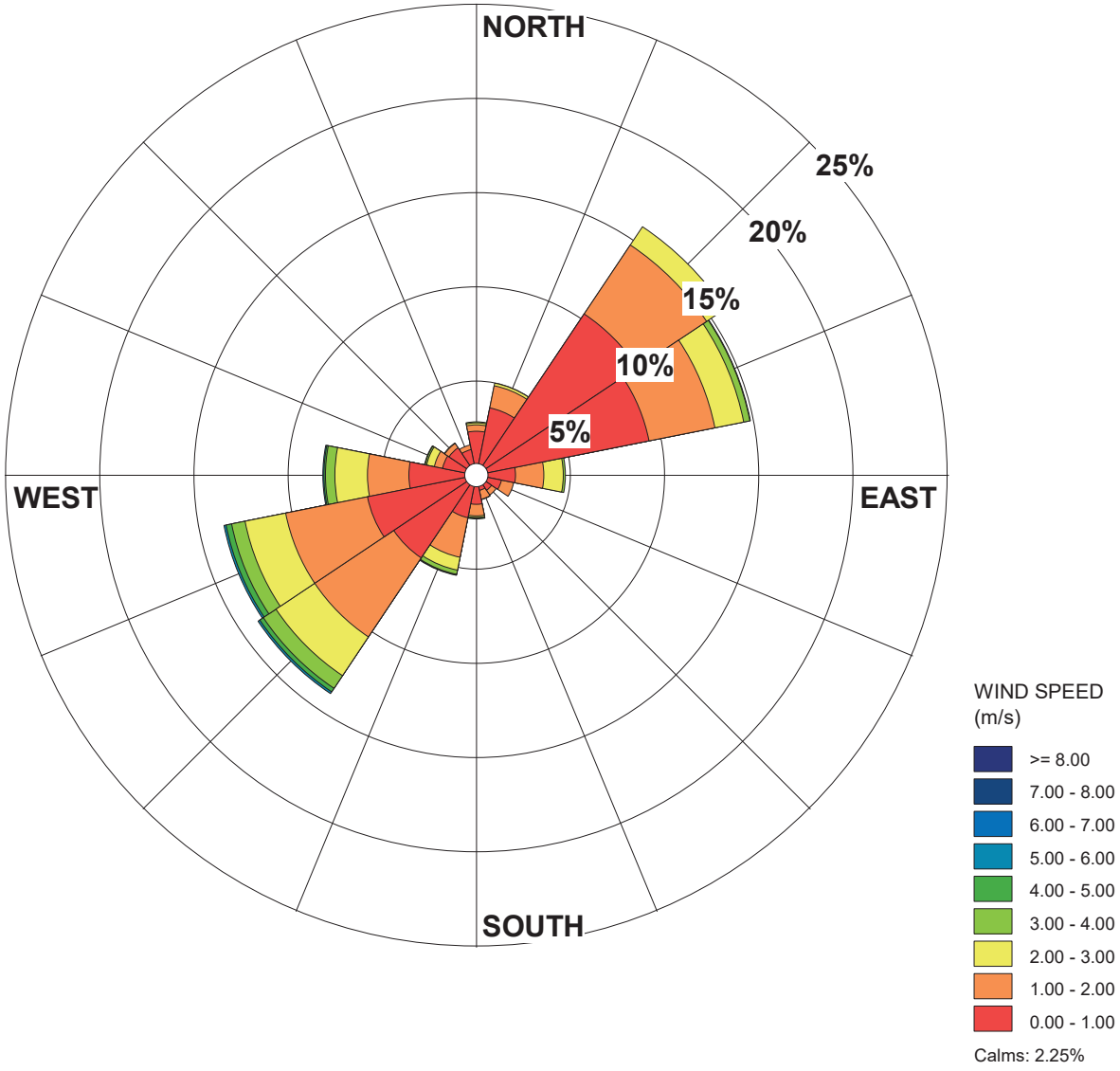


Figure 3.6-18
December Wind Rose Tower D (2016 – 2020)

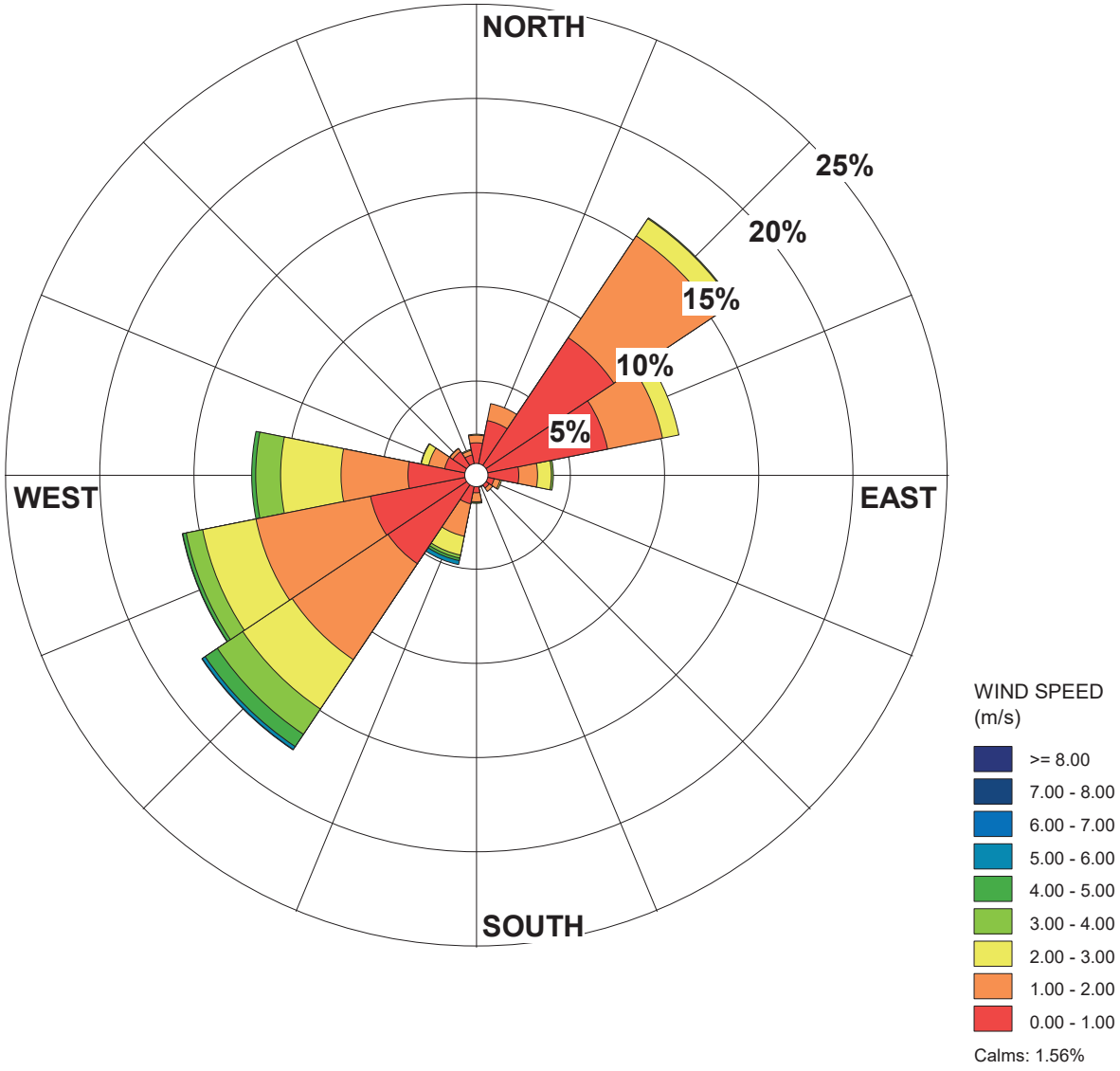


Figure 3.6-19
Seasonal Wind Roses Tower D (2016 – 2020)

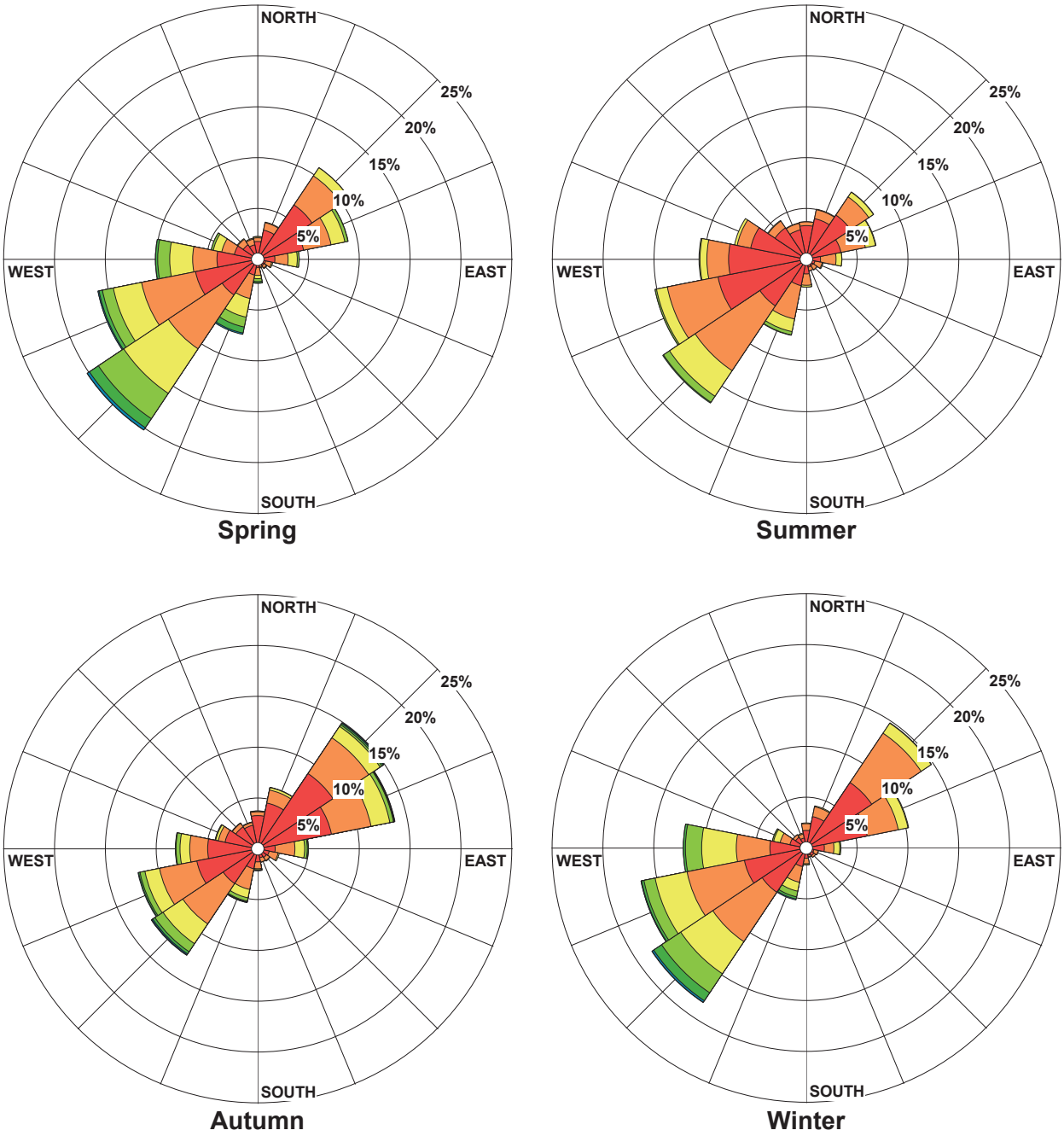


Figure 3.6-20
Terrain Near the Horizon Center Site

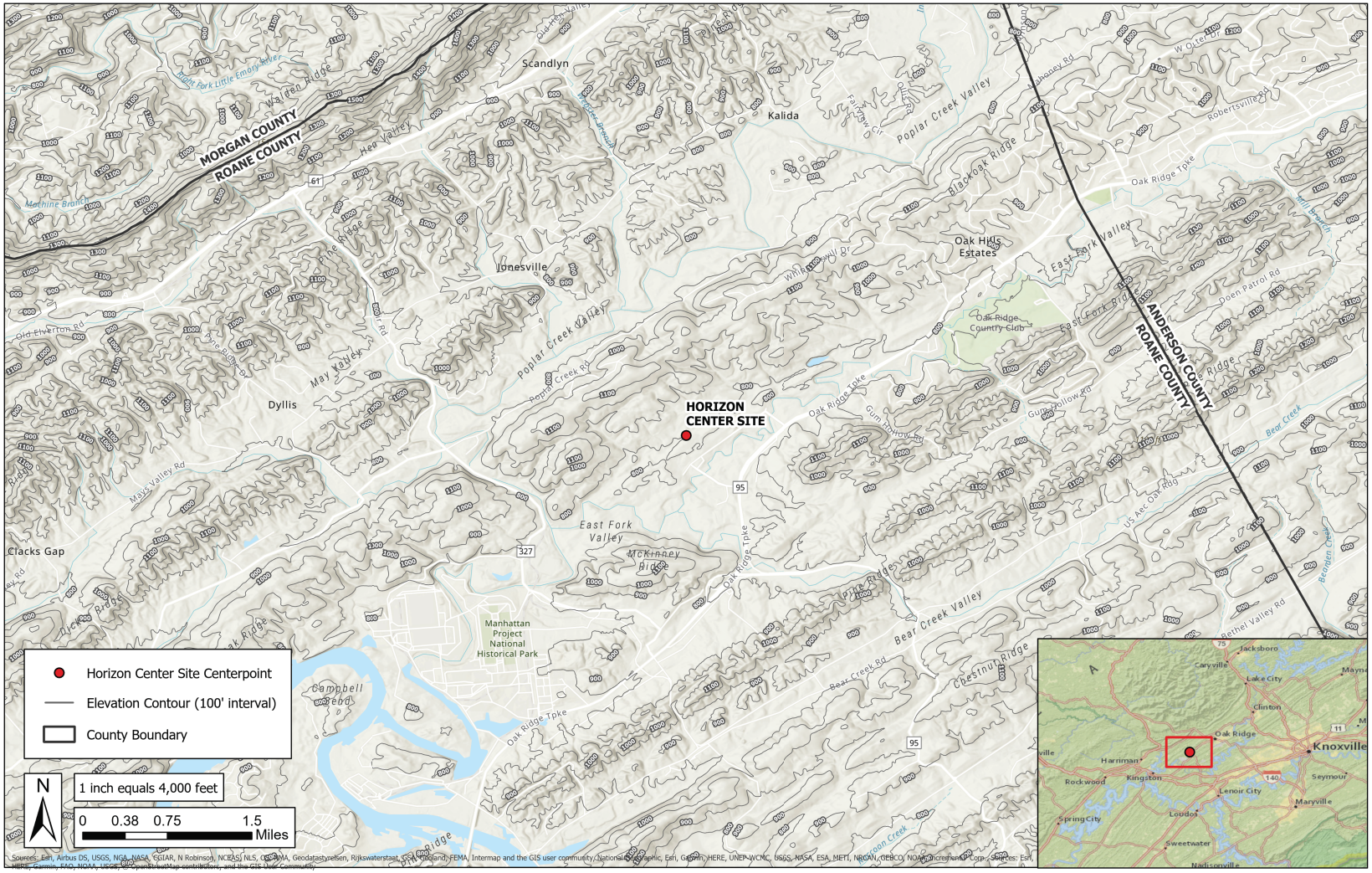


Figure 3.7.1-1
Ambient Noise Survey Monitoring Locations

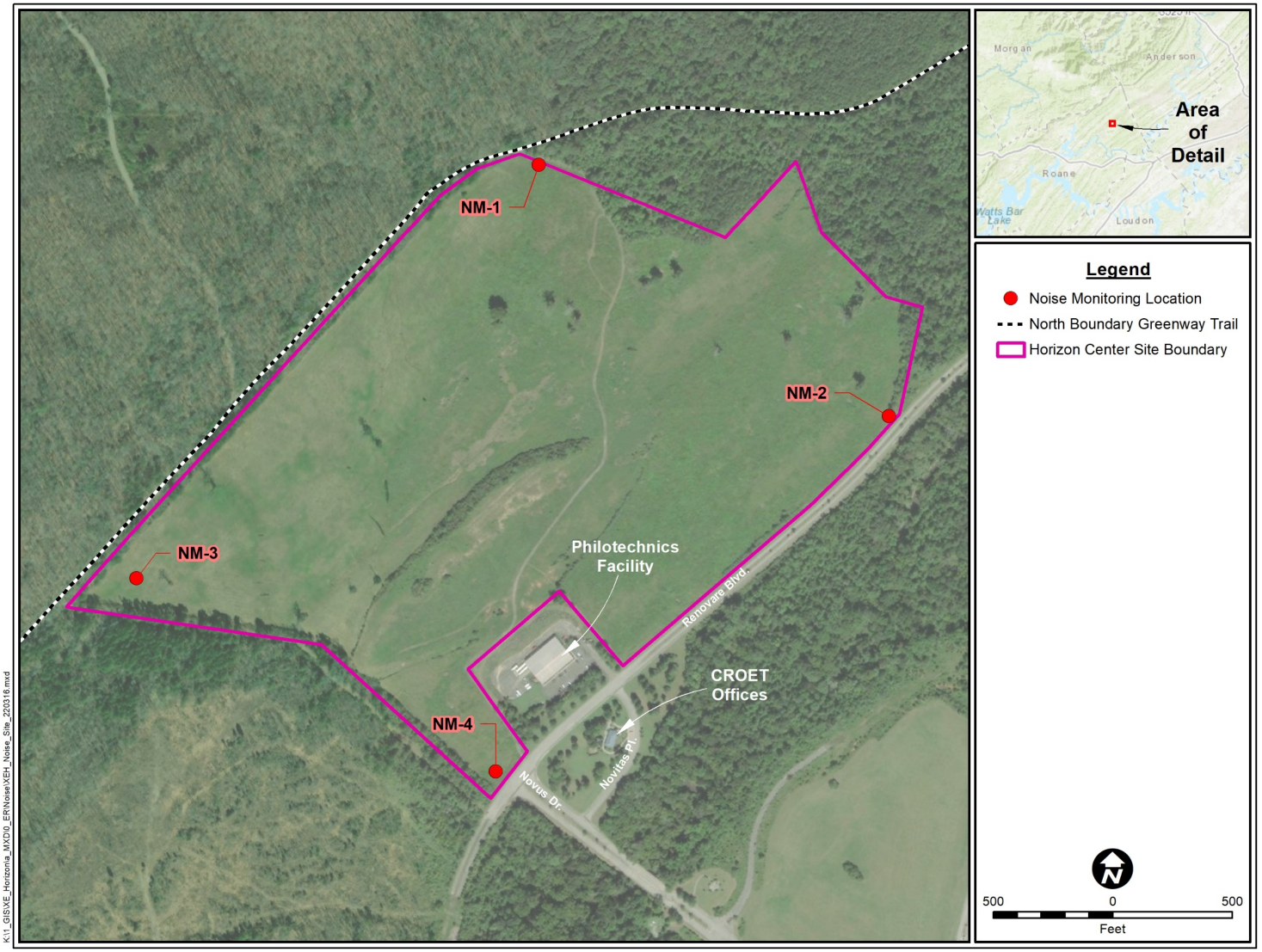


Figure 3.8.1-1
Survey Area for Cultural Resources and Area of Potential Effect

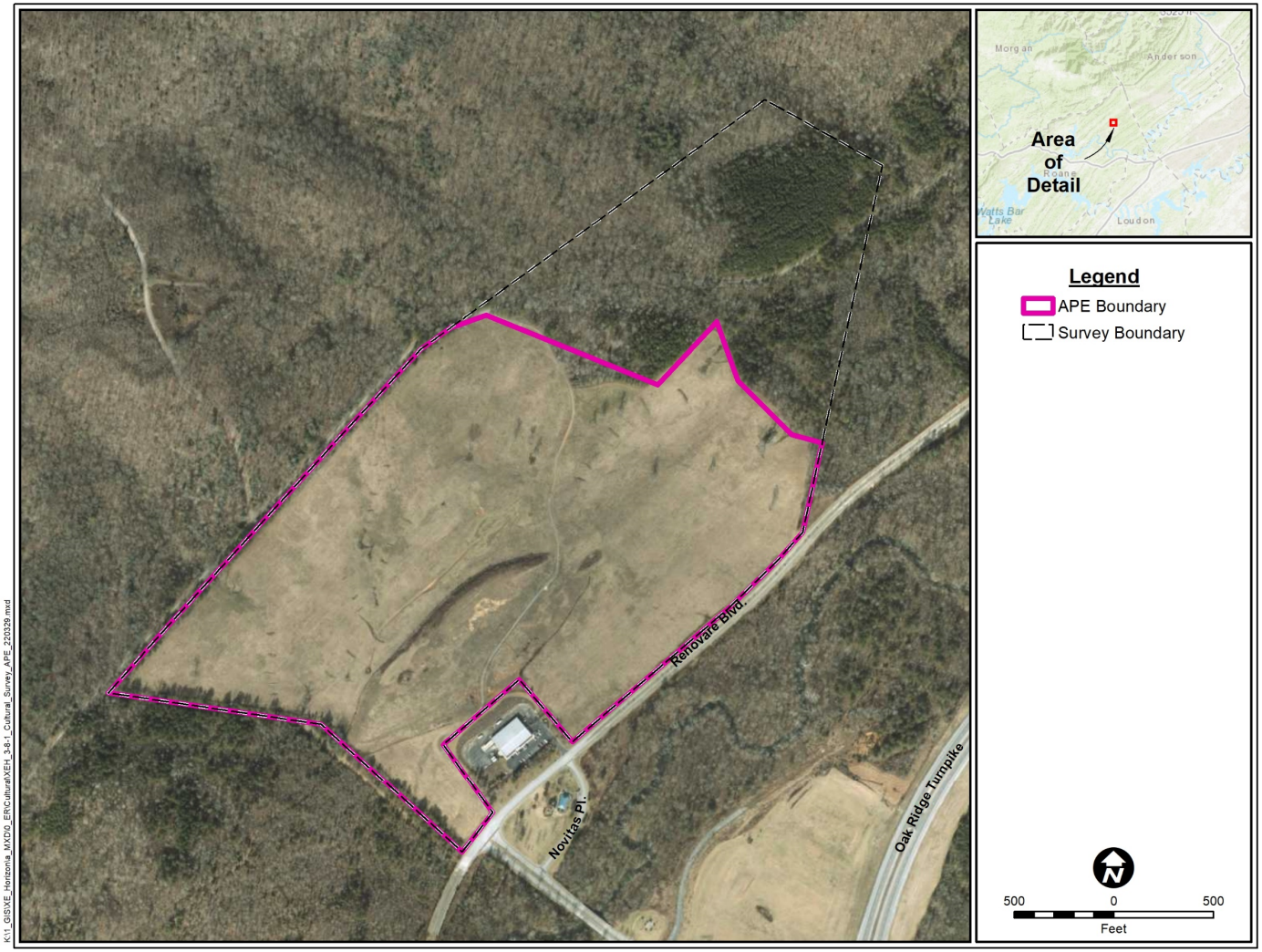


Figure 3.9.1-1
Horizon Center Site Vicinity Map

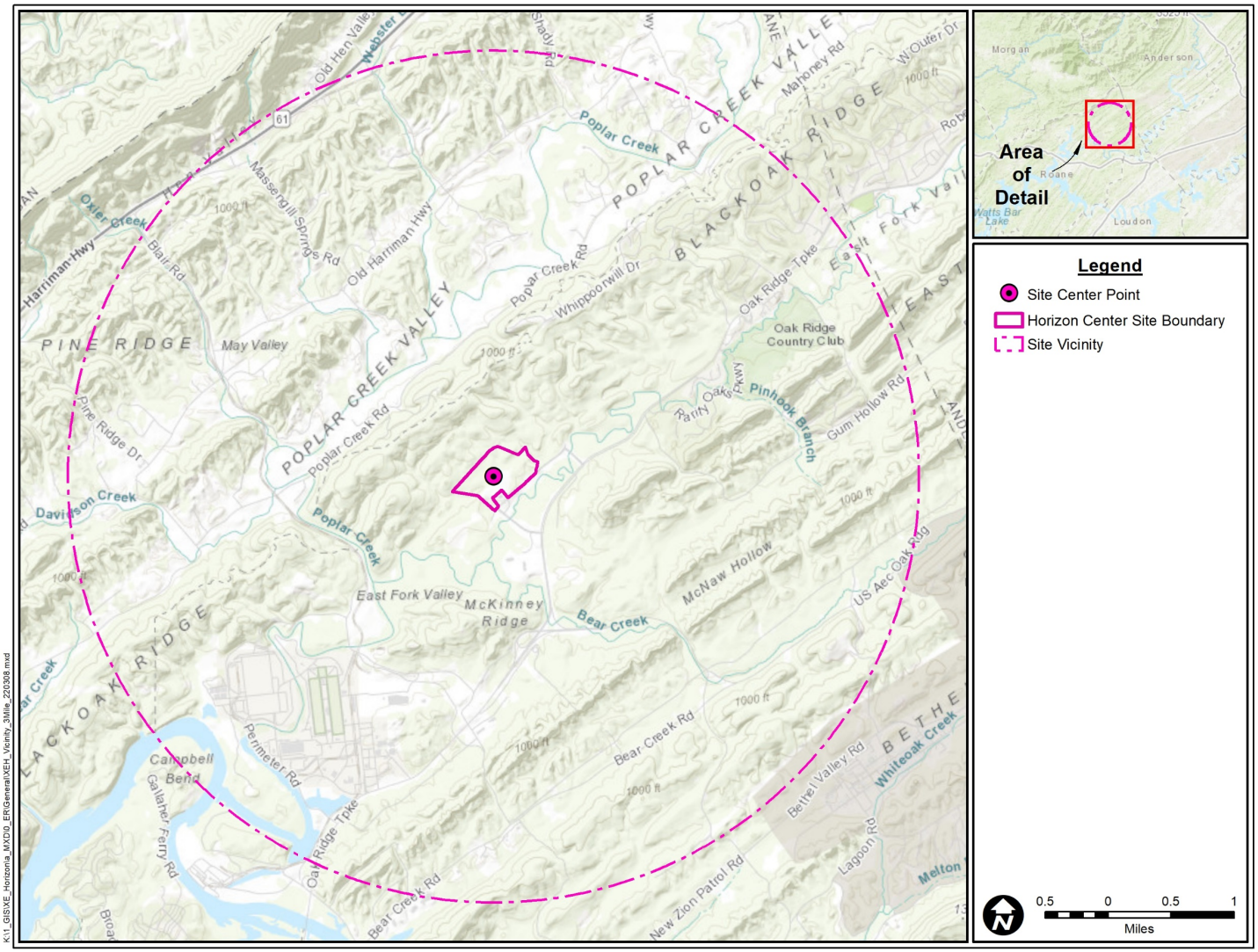


Figure 3.9.3-1
Aerial View of the Horizon Center Site with Photograph Locations

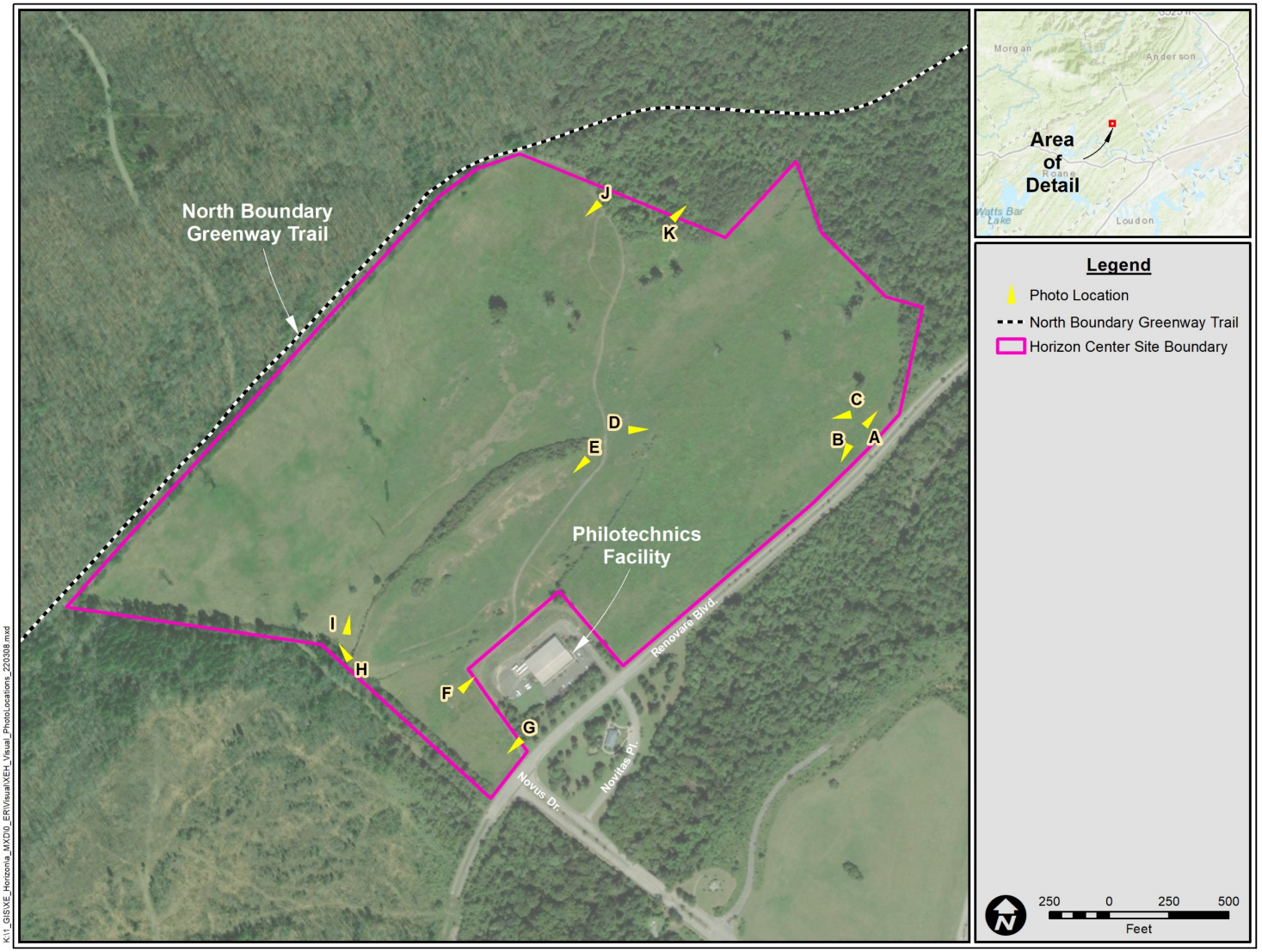


Figure 3.9.3-2
(Sheet 1 of 6)
Horizon Center Site Photographs



Photo A.
Looking northeast from the eastern property boundary, near Renovare Boulevard.

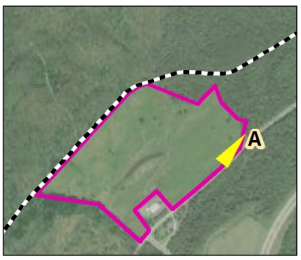
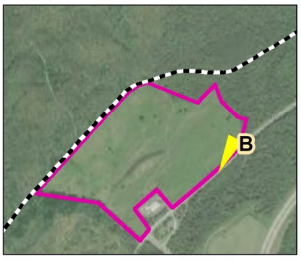




Photo B.
Looking southwest from the eastern property boundary toward Renovare Boulevard.



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Figure 3.9.3-2
(Sheet 2 of 6)
Horizon Center Site Photographs



Photo C.
Looking west across the Horizon Center site from the eastern property boundary, near Renovare Boulevard. The Philotechnics facility is visible in the foreground.

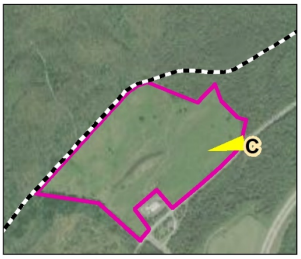
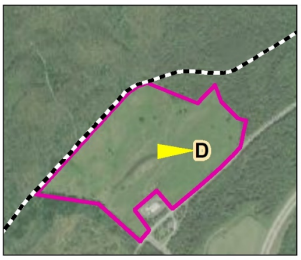




Photo D.
Looking east across the Horizon Center site from the center of the property toward Renovare Boulevard.



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Figure 3.9.3-2
(Sheet 3 of 6)
Horizon Center Site Photographs



Photo E.
Looking southwest across the Horizon Center site from the center of the property.

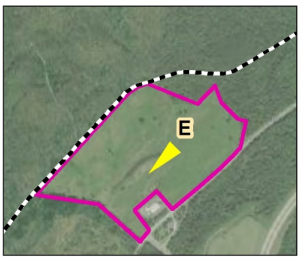
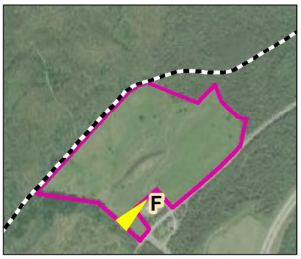




Photo F.
Looking northeast at the Philotechnics facility from the southern corner of the property.



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Figure 3.9.3-2
(Sheet 4 of 6)
Horizon Center Site Photographs



Photo G.
Looking southwest across the southern corner of the property, adjacent to Renovare Boulevard.

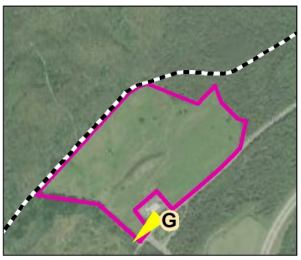
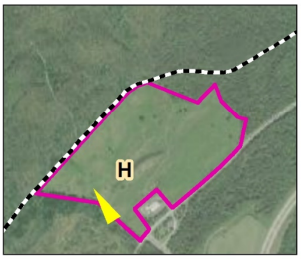




Photo H.
Looking northwest across the Horizon Center site from the southern property boundary.



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Figure 3.9.3-2
(Sheet 5 of 6)
Horizon Center Site Photographs



Photo I.
Looking north-northeast across the Horizon Center site from the southern property boundary.

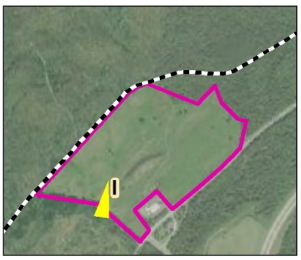
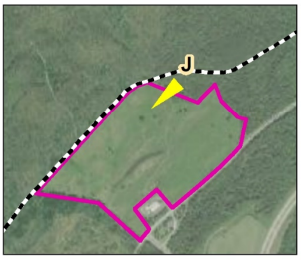




Photo J.
Looking southwest across the Horizon Center site from the northern property boundary.



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Figure 3.9.3-2
(Sheet 6 of 6)
Horizon Center Site Photographs

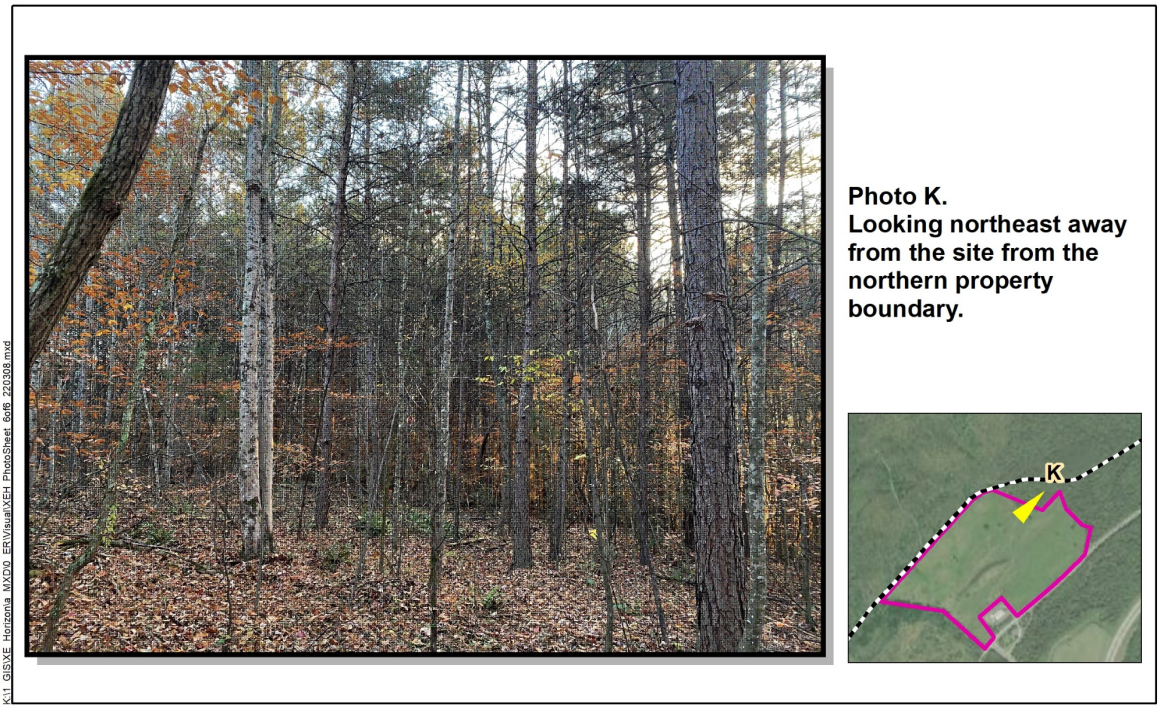


Figure 3.10.1-1

Population Centers within the Region of Influence

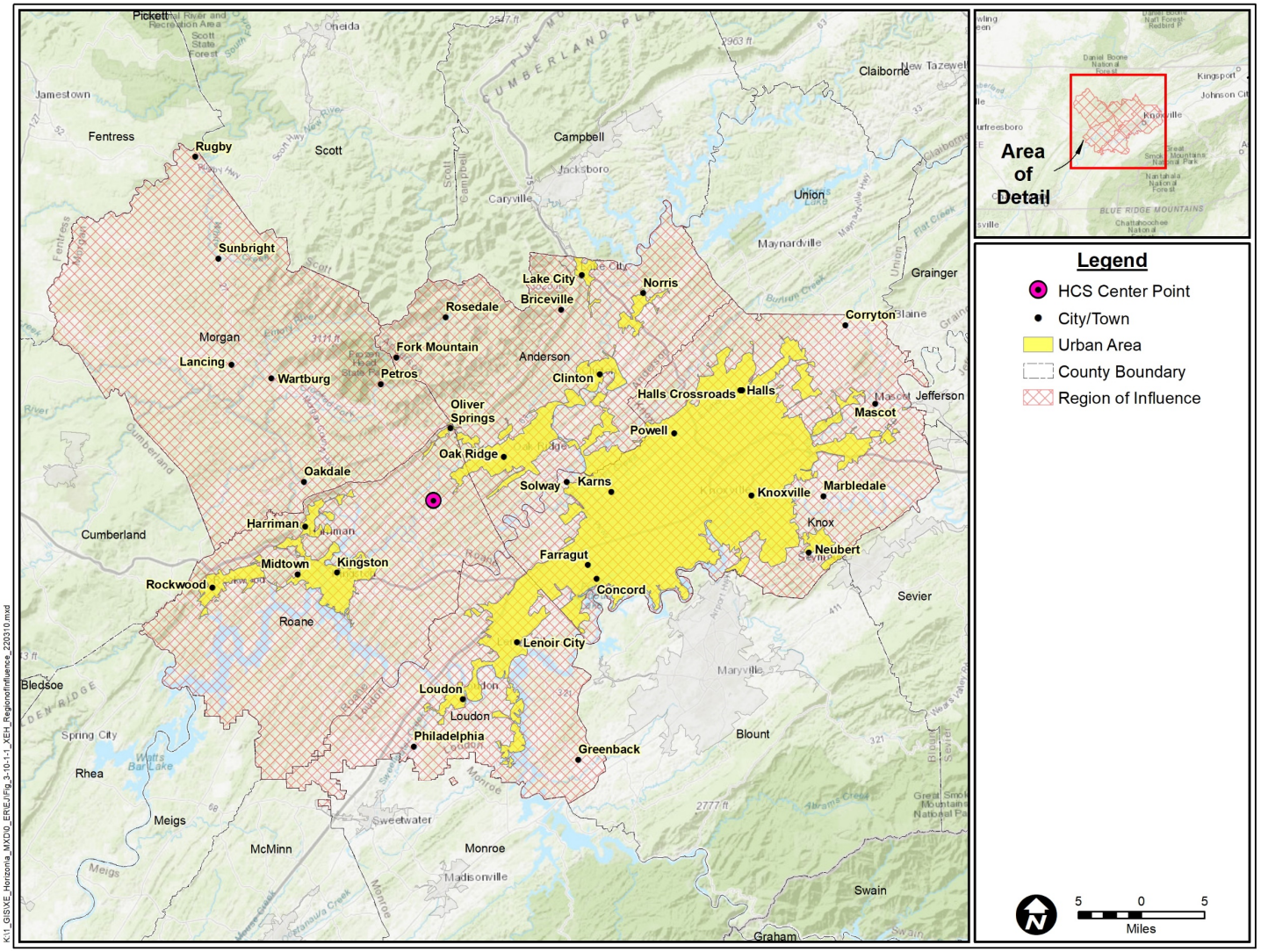


Figure 3.10.1-2

Minority Percentage by Census Block Group within 4.0 MI. (6.4 Km) of the Horizon Center Site

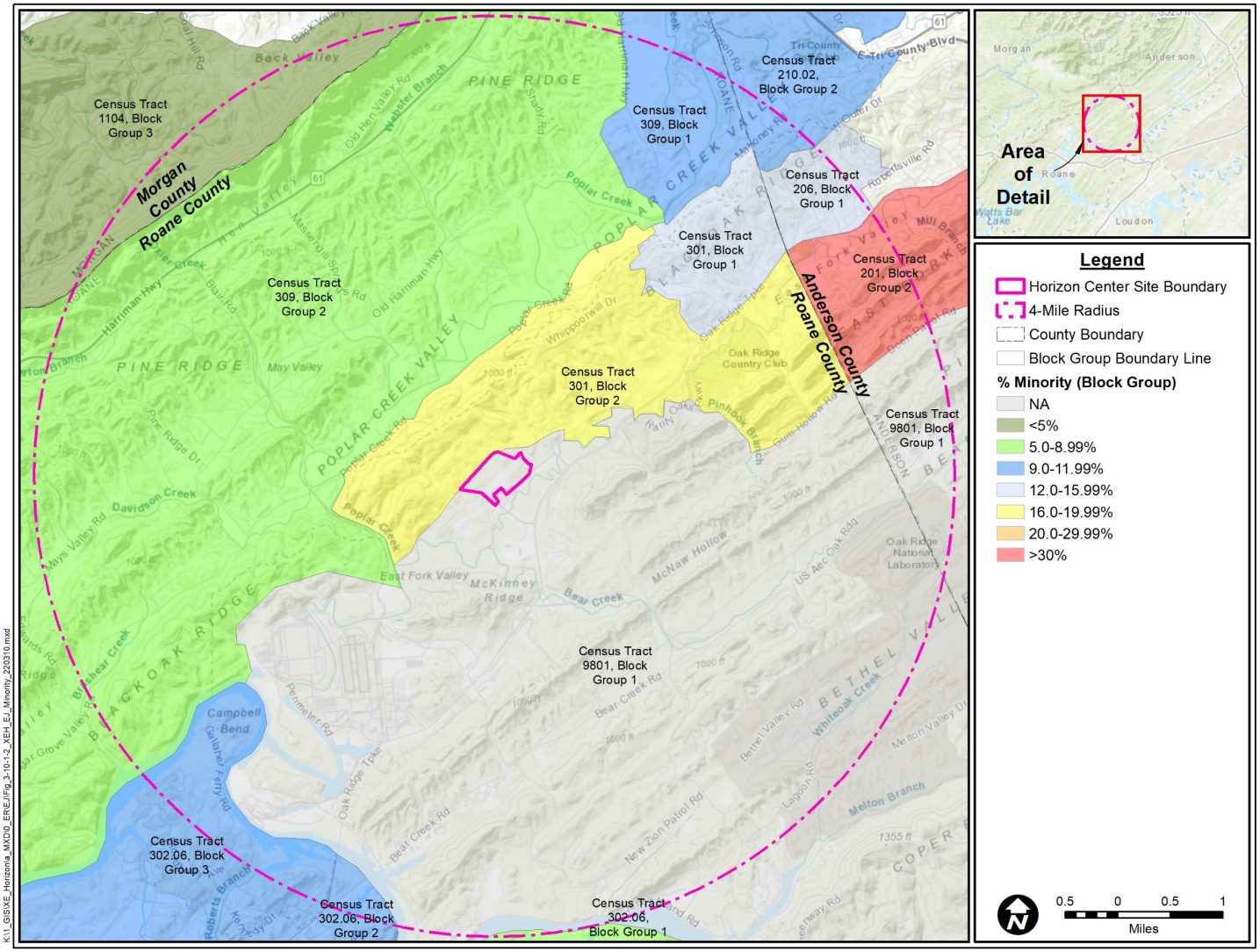


Figure 3.10.1-3

Percentage of Population below Poverty Level by Census Block Group within 4.0 MI. (6.4 Km) of the Horizon Center Site

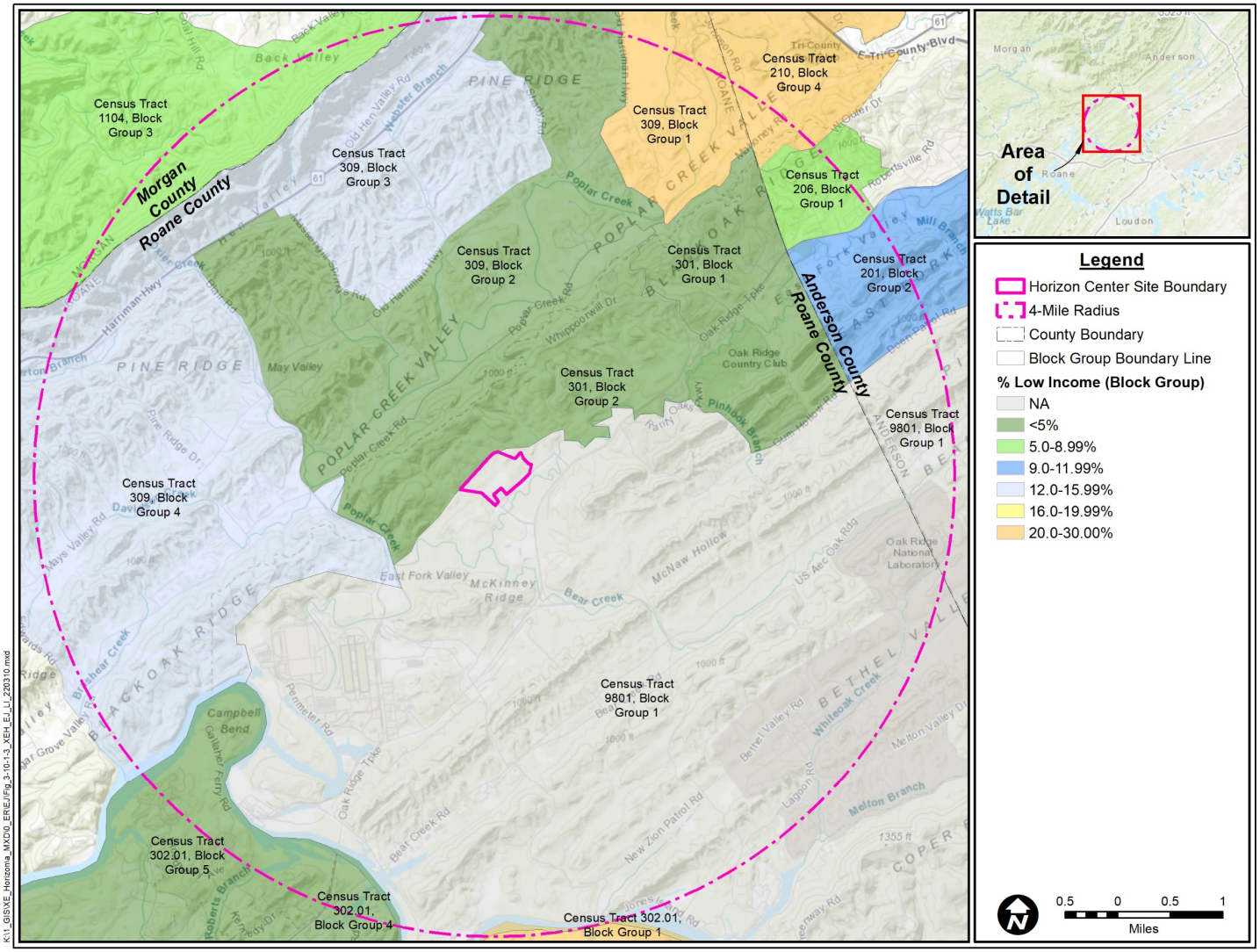


Figure 3.10.1-4

Population Density by Census Block Group within the Region of Influence

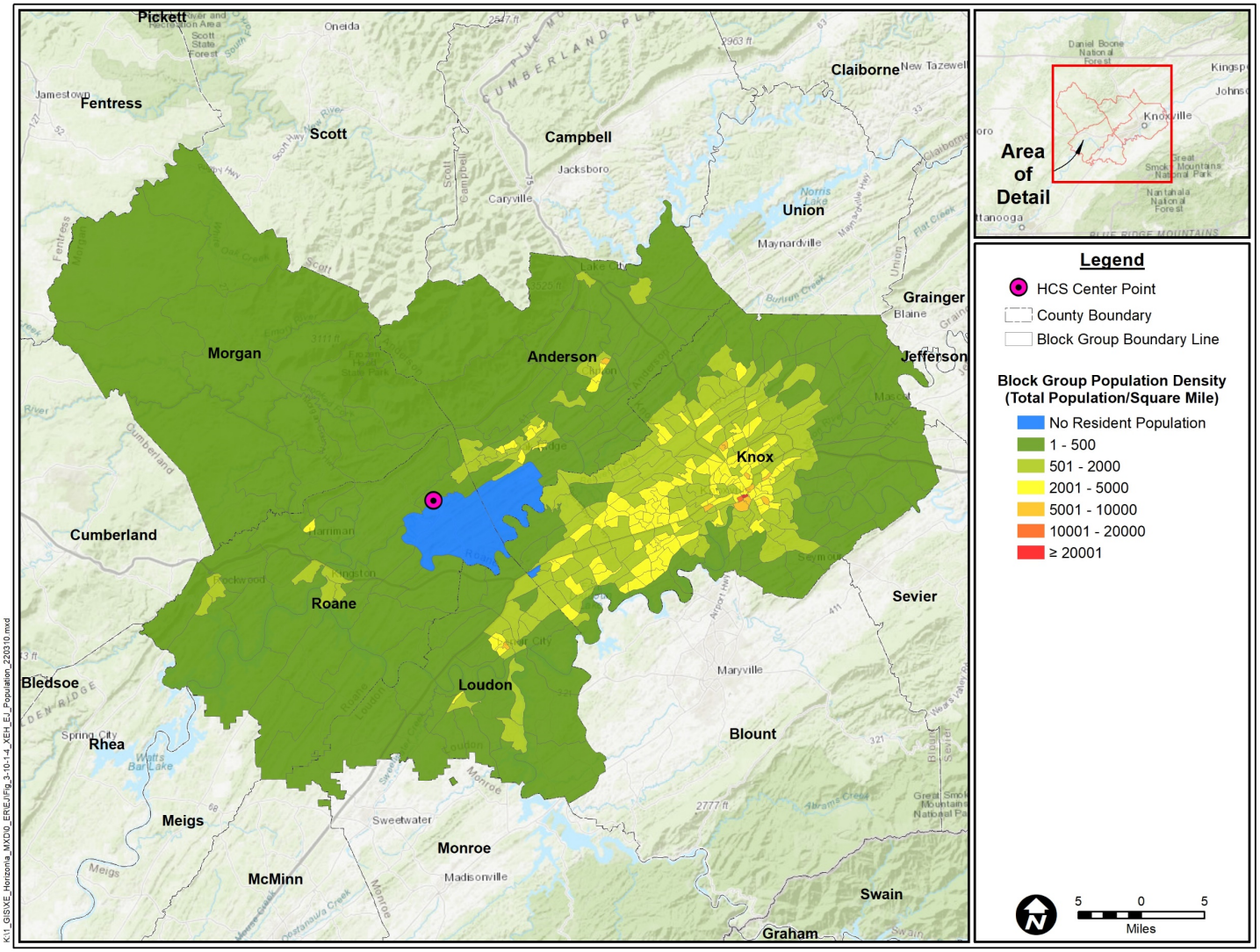


Figure 3.10.3-1

Community Facilities

