ENCLOSURE 2

ATTACHMENT 2

LICENSE APPLICATION
CHAPTER 1

REVISION 2

NON-PROPRIETARY

TRISO-X Fuel Fabrication Facility
Special Nuclear Material
License Application

Revision	**:**	**2**
Status	**:**	**Approved**
Project	**:**	**Fuel**
NRC Docket No.	**:**	**70-7027**

© Copyright 2022 by X Energy, LLC

Release Date: 04-NOV-2022

SPECIAL NUCLEAR MATERIAL LICENSE

CHAPTER INDEX

CHAPTER	TITLE	REVISION	REVISION DATE
1	General Information	2	11/4/2022
2	Organization and Administration	1	4/5/2022
3	Integrated Safety Analysis	1	4/5/2022
4	Radiation Safety	1	4/5/2022
5	Nuclear Criticality Safety	1	4/5/2022
6	Chemical Process Safety	1	4/5/2022
7	Fire Safety	1	4/5/2022
8	Emergency Management	1	4/5/2022
9	Environmental Safety	1	4/5/2022
10	Decommissioning	1	4/5/2022
11	Management Measures	1	4/5/2022
12	Material Control and Accounting of Special Nuclear Material	1	4/5/2022
13	Protection of Special Nuclear Material	1	4/5/2022
Addendum	Sensitive Information	1	4/5/2022

© Copyright 2022 by X Energy, LLC

Release Date: 04-NOV-2022

RECORD OF REVISION

Revision	Date	Section/Page	Description of Change
1	5-Apr-22	ALL	Initial issue.
2	4-Nov-22	N/A	All changes for this revision are based on RSI responses (ML22286A144).
		Section 1.1.1	Added geotechnical discussion of site regarding slope stability, soil liquefaction, differential settlement, bearing capacity, karst features, and site cross sections.
		Section 1.1.2	Added design basis values for seismic, wind, precipitation, hydrological, and geological NPH.
		Section 1.3	Separated special exemptions and special authorizations. Re-numbered subsections.
		Section 1.3.1.1	Added detail for criticality monitoring exemption.
		Figures 1-3 thru 1-8	Added new figures for site geological cross sections.

© Copyright 2022 by X Energy, LLC

ABBREVIATIONS AND ACRONYMS

This list contains the abbreviations and acronyms used in this document.

Abbreviation or Acronym	Definition
ALARA	As Low As Reasonably Achievable
ALI	Annual Limit on Intake
AHJ	Authority Having Jurisdiction
ANS	American Nuclear Society
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
BDC	Baseline Design Criteria
BS/BA	Bachelor of Science / Bachelor of Arts
CAA	Controlled Access Area
CAAS	Criticality Accident Alarm System
CEDE	Cumulative Effective Dose Equivalent
CFR	Code of Federal Regulations
CM	Configuration Management
DAC	Derived Air Concentration
DFP	Decommissioning Funding Plan
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
ETSZ	East Tennessee Seismic Zone
FFF	Fuel Fabrication Facility
FHA	Fire Hazards Analyses
FNMCP	Fundamental Nuclear Material Control Plan
HALEU	High Assay Low Enriched Uranium
HPGe	High Purity Germanium
IAEA	International Atomic Energy Agency
IBC	International Building Code
ICPMS	Inductively Coupled Plasma Mass Spectrometry
ICRP	International Commission on Radiation Protection Publication
ISA	Integrated Safety Analysis
IROFS	Items Relied On For Safety
KPA	Kinetic Phosphorescence Analyzer
LA	License Application
LEU	Low Enriched Uranium
MBA	Material Balance Area

© Copyright 2022 by X Energy, LLC

Abbreviation or Acronym	Definition
MC&A	Material Control and Accountability
MMI	Modified Mercalli Intensity
MOU	Memorandum of Understanding
NCRP	National Commission on Radiation Protection
NCS	Nuclear Criticality Safety
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NMSS	Nuclear Materials Safety and Safeguards
NRC	U.S. Nuclear Regulatory Commission
OCA	Owner Controlled Area
OJT	On-the-Job Training
OSHA	Occupational Safety and Health Administration
PHA	Process Hazard Analyses
PM	Preventive maintenance
PSP	Physical Security Plan
QA	Quality Assurance
RCA	Radiologically Controlled Area
REM	Roentgen Equivalent Man
RPP	Radiation Protection Program
RSO	Radiation Safety Officer
RWP	Radiation Work Permits
SEP	Site Emergency Plan
SME	Subject Matter Expert
SNM	Special Nuclear Material
SRC	Safety Review Committee
TEDE	Total Effective Dose Equivalent
TRISO-X FFF	TRISO-X Fuel Fabrication Facility
U	Uranium
U-235	Uranium-235
U-238	Uranium-238
UL	Underwriters Laboratory
USGS	United States Geological Survey

© Copyright 2022 by X Energy, LLC

NRC SPECIAL NUCLEAR MATERIAL LICENSE

SNM-XXXX

CHAPTER 1

GENERAL INFORMATION

Table of Contents

CHAPTER 1

GENERAL INFORMATION

1.1 Facility and Process Information

The primary purpose of the TRISO-X Fuel Fabrication Facility (FFF) in Oak Ridge, Tennessee, is to manufacture coated particle fuel for the next generation of commercial nuclear reactors. The modular design of the process cells / areas anticipates additional manufacturing capabilities to satisfy the needs of a variety of fuel designs and reactors (e.g., pebble bed high temperature gas-cooled, prismatic gas-cooled, molten salt-cooled, accident tolerant fuel, nuclear thermal propulsion, and others). Nuclear materials enriched to less than 20 weight percent U-235 are utilized in the product manufacturing operations authorized by this license.

1.1.1 Site Description and Location

The TRISO-X site is located in the Horizon Center Industrial Park on property abutting portions of Renovare Boulevard, within the western limits of the City of Oak Ridge and in the northeastern portion of Roane County, Tennessee. The site is situated in an area dedicated and zoned for industrial development, on an approximately 110-acre greenfield site. Of the total acreage, approximately 60 acres are designated for manufacturing and administrative buildings, equipment yards, access roads, parking, and stormwater management. The site is situated at approximately latitude N 35° 57’ 41” and longitude W 84° 22’ 13”.

The site location in northeastern Roane County is 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. The site and other developed areas along State Route 95 (TN 95 – Oak Ridge Turnpike) to the northeast and southwest are located on relatively flat or slightly undulating terrain associated with the East Fork Poplar Creek Valley, while just northwest of the site, there is a steep incline to the top of Black Oak Ridge. Several other ridges oriented northeast to southwest are present within the vicinity of the site. The Poplar Creek Valley is the next valley north and parallels Black Oak Ridge. East Fork Ridge is located to the south and east of the site and is interrupted by the valley of Bear Creek and TN 95. Pine Ridge is located south and east of East Fork Ridge.

1.1.1.1 Population, Nearby Land Uses, and Transportation

A site location map, including the population centers located near the site, is shown in Figure 1-1. The closest major population center is the City of Oak Ridge which had a population of 31,402 as of April 1, 2020, per the United States Census Bureau website. The closest residents to the site are located in a residential development off Poplar Creek Road, approximately 0.6 miles northwest of the site boundary, separated from the site by Black Oak Ridge and areas of dense vegetation. There are also residential neighborhoods located to the east off TN 95, approximately 1.3 miles or more from the site. The North Boundary Greenway, a low-density recreational trail used for hiking and biking, borders the site boundary to the northwest.

The immediate area surrounding the site consists of rural wooded area and light commercial and industrial use buildings. The immediately adjacent one-story warehouse/office building located near the southern corner of the property is the corporate office of Philotechnics Inc., a radiological service and mixed and radioactive waste brokerage provider licensed by the State of Tennessee, does not manage, utilize, or store chemicals (hazardous materials) in quantities that pose hazards to the TRISO-X site. Renovare Boulevard, which borders the site to the southeast, is a two-lane divided roadway that provides access to the site and to other parcels within the Horizon Center Industrial Park.

Lands adjacent to the industrial park are predominantly undeveloped and forested, consisting of large tracts of U.S Department of Energy Oak Ridge Reservation land which border the site to the northwest and surround the industrial park in other directions, with the exception of the TN 95 roadway corridor to the east. The existing land use within one mile of the site consists of primarily industrial development and woodlands. Within a five-mile radius of the site, approximately 83 percent of the land is undeveloped (e.g., forest, pasture, wetland) and the remainder is developed. Other land uses within 5 miles of the site include heavy industrial, light industrial/manufacturing, commercial/office space, agricultural, and residential. The Methodist Medical Center of Oak Ridge is the nearest hospital, located approximately 9 miles from the site. The closest school to the site is Linden Elementary School, located approximately 5 miles from the site.

Transportation infrastructure near the site includes Renovare Boulevard; TN 95; two interstate highways – Interstate 40 and Interstate 75 – several Tennessee state highways; and local roads. The McGhee Tyson Airport, which serves public and military needs, is located 26 miles from Oak Ridge by road.

1.1.1.2 Meteorology

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. Both mountain ranges are generally oriented in a northeast-southwest direction. The valley between them is corrugated by broken ridges approximately 300 to 500 feet high and oriented parallel to the main valley in an approximate northeast-southwest direction.

The climate of Oak Ridge is classified as humid subtropical. 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. The normal liquid equivalent annual precipitation in the Oak Ridge area is 50.91 inches, and the average annual snowfall is 5.9 inches. The normal daily minimum temperature in January is 28.9 degrees Fahrenheit (°F) and the normal daily maximum temperature in July is 88.4°F.

Direct deflection of the winds by terrain is a dominant mechanism that drives the winds in the Tennessee River 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. 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 mean annual wind speed is 2.8 miles per hour.

Severe storm conditions are infrequent in the Oak Ridge area, due to the area being south of most blizzard conditions, and too far inland to be affected by hurricane activity. Tornadoes generally occur more frequently in the western and middle portions of Tennessee; however, Eastern Tennessee experiences tornado outbreaks of varying magnitudes approximately every three to six years. In a four-county area around the site for the period 1950 to 2020, the highest intensity tornadoes were rated F3 as a result of storms on February 21, 1993. Due to the low frequency of tornadoes in this region, no specific design criteria relative to tornadoes are required by the International Building Code. Lightning risk at the site has been addressed through lightning protection systems as specified in the Fire Hazards Analysis as described in Chapter 7.

1.1.1.3 Hydrology

The site is categorized as upland; no water bodies or wetlands were identified within the site. The nearest water body to the site is East Fork Poplar Creek, the closest portions of which run in a southwest direction through the industrial park between TN 95 and Renovare Boulevard at an approximate elevation of less than 770 feet. East Fork Poplar Creek empties into Poplar Creek approximately 1.25 miles southwest of the site, and Poplar Creek empties into the Clinch River approximately 3 miles southwest of the site boundary.

Federal Emergency Management Agency *Flood Insurance Rate Map Number 47145C0130F, Panel 0130F, Roane County, Tennessee, and Incorporated Areas*, Effective Date September 28, 2007, shows the site to be in an area of minimal flood hazard (Zone X). The nearest section of detailed study for East Fork Poplar Creek is approximately 1.5 miles northeast of the site, with a 100-year base flood elevation of 783 feet at the downstream end of mapping. The closest Clinch River location to the site has a 100-year base flood elevation of 747 feet at the Poplar Creek outlet.

The floor in the TRISO-X FFF is located at an elevation of approximately 811 feet, and the elevation of Renovare Boulevard near the primary entrance to the site is approximately 776 feet. Therefore, the facility floor elevation ranges from 28 to 64 feet above the mapped 100-year base flood elevations of the nearest water bodies as described above, and the floor elevation is more than 35 feet above Renovare Boulevard. Renovare Boulevard is situated at a higher elevation than the lower lying unmapped portions of East Fork Poplar Creek closest to the site.

Four groundwater observation wells were installed on the site in fall of 2021 with total depths and screened intervals based on observed first water identified in the upper most bedrock during drilling. No water was identified in the shallow unconsolidated surficial sediments above the

bedrock. Total well depths range from approximately 39 feet to 75 feet below 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 sites.

Depth to groundwater measurements taken at the four observation wells vary from approximately 10 to 57 feet below the top of the well casing. Groundwater elevation measurements and modeling indicate that groundwater generally flows in a southwest direction toward East Fork Poplar Creek. There are no known household, public, or industrial users of groundwater downgradient of the site.

1.1.1.4 Geology

The TRISO-X site 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. This physiographic province consists of a series of northeast/-southwest- trending synclines and anticlines composed of Early Paleozoic sedimentary rocks. 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.

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. The site is underlain by limestones-dolomites of the Knox Group and limestones with interbedded shale, argillaceous limestone, mudstone, and wackestone associated with the Chickamauga Group.

Site Topography

The terrain within the Horizon Center Site (HCS) boundaries is typical of the Oak Ridge region and generally contains mild rolling hills with ridges and valleys. The existing site surface elevations vary from approximately Elevation 780 feet to Elevation 825 feet in most parts of the HCS, except at the north corner where the existing surface elevation rises to approximately 850 feet. More detailed topography descriptions are included in Section 3.3 of the Environmental Report (ER).

The site development for the project will include extensive site grading with cut and fill. Engineered fill will be used for placement and compaction. The final site grade will be relatively level across the site with most boundaries matching the existing surrounding topography. The only significant slope for the site is on the north side of the facility, separated from the primary facility structures and equipment by a perimeter access road. This slope will be designed with a grade of approximately 3:1 (Horizontal:Vertical) after excavation. The design will be verified by a slope stability calculation and designed using standard geotechnical engineering practice. The

toe of the north slope is expected to be at least 150 feet to 200 feet from the edge of the process building (PB).

Site Geotechnical Investigations

Site-specific geotechnical investigations presented in the Environmental Report, Section 3.3.3.2, indicate the overall subsurface profile consists of clay soils underlain by weathered limestone and dolomite to more competent bedrock at greater depths. The clay overburden is classified as CH or CL per USCS (unified soil classification system) and is considered to have negligible potential of liquefaction. The in-situ medium stiff to very stiff or hard clays are not susceptible to strength degradation during seismic events.

Based on the drilling logs from the construction of groundwater monitoring wells (GW-1 to GW-6), the overburden soil thickness varies from 7 feet to 50 feet. The soil thickness of 50 feet was encountered at GW-1 with the surface elevation at 841.55 feet, which was located on the hill at the north corner of the property boundary. However, the groundwater monitoring wells are located away from the main facilities near the property boundaries. Detailed information about groundwater monitoring wells can be found in Section 3.4.1.2 of the Environmental Report.

Based on the soil boring logs within the footprint of the HCS, the overburden consists of residual clay soils encountered at depths ranging from 3.6 feet to 31.5 feet below the existing ground surface at boring locations. The soil overburden becomes deeper at locations closer to the north and northwest boundaries on the hill side.

Potential for Differential Settlement

After site grading cut and fill to establish the final grade, the overburden soil thickness below the final grade is expected to vary generally from less than 5 feet to approximately 25 feet within the footprint of the process building (PB). The majority of the PB area, a low-lying area in the middle of the site, will receive fill. Potential settlement in this area will be mitigated with the following measures.

The entire PB is designed to rest on a large mat foundation to reduce the potential for differential settlement. Furthermore, a geotechnical ground improvement approach using an intermediate foundation system is designed to further minimize the potential for differential settlement from the underlying clay soils. This intermediate foundation type is called a rigid inclusion (RI) system, which primarily consists of cement grout columns being installed down to the top of bedrock across the entire PB area in a grid pattern. The RI elements are similar to a pile foundation, without steel reinforcement. Typically, between the foundation mat and the top of the RI elements there is a layer of compacted granular soil called the load transfer platform (LTP). The LTP, RI elements, and the in-situ soils act as a composite matrix system with overall improved engineering properties to mitigate differential settlements. The large mat foundation supported

by the RI matrix system will minimize the potential long-term differential settlement of the PB and ensure the safe operation of the proposed facility.

Subsurface Bearing Capacity

The subsurface medium stiff to very stiff clay soils discovered by the site-specific geotechnical investigations exhibit adequate bearing capacity for the PB with standard factor of safety against general soil failure based on the preliminary analysis. The primary design concern was the potential for differential settlement produced by the underlying clay soils. As discussed above, the large mat foundation supported by the RI matrix system will minimize the potential for long-term differential settlement of the PB and ensure the safe operation of the proposed facility. With the use of the RI matrix system, the overall foundation bearing capacity will be improved as well. Detailed information about geology and soils can be found in Section 3.3 of the Environmental Report.

Potential for Karst Features

According to the United States Geological Survey (USGS), the region containing the site 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. Karst features previously reported on lands adjacent to the site have included springs and sinkholes of various sizes. Based on the topography of the site, several shallow draws and depressions exist which may reveal karst features beneath the surface. 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 on the site during the geotechnical drilling program to support facility design. Bedrock was encountered during drilling at a minimum depth of 3.6 feet and a maximum depth of 50.0 feet.

In early 2022, a subsurface investigation was performed to support the facility design, which involved 22 geotechnical soil borings and a surface geophysical investigation. There were 6 borings located within the PB footprint with total boring depths ranging from 30 feet to 100 feet below ground surface (b.g.s.) and rock core total lengths ranging from 22 feet to 100 feet. Voids were encountered during rock coring in most borings within the PB footprint with the vertical dimensions from as thin as 0.2 feet to approximately 2.6 feet. The 2.6 feet opening was at 82 feet deep b.g.s. at one corner of the PB, while the majority of voids were filled with stiff clay and encountered within the upper 25 feet b.g.s.

The surface geophysical investigation performed shear wave seismic refraction tomography (SWSRT) and electrical resistivity tomography (ERT) to map the subsurface bedrock conditions, including possible major void (empty or soil-filled) anomalies that may be associated with karst features. The tomography survey lines were over 700 feet long each and spaced at 50 feet to

cover the entire PB area. The geophysical findings indicated the same general subsurface profiles as discovered by soil borings, which contained shallow residual stiff overburden underlain by weathered bedrock with higher weathering at upper rock formation and very hard competent rock at greater depths. The geophysical report also identified some anomalies where the ERT results showed high resistivity at deep zones compared to the surrounding rock data, although the shear wave velocity at those deep zones did not show abnormal results.

Further soil boring investigations were performed in June 2022 to focus on the anomaly locations identified in the geophysical work and included 6 borings in the PB footprint. Rock coring of 60 feet to 80 feet were performed to reach those anomaly zones as identified by geophysical investigation and 20 feet to 30 feet beyond (deeper) the anomaly locations. These additional rock coring samples did not find any significant voids at those anomalies. Detailed information about geology and soils can be found in Section 3.3, and karst is discussed in 3.3.2, of the Environmental Report.

Subsurface Engineering Characteristics

The soil layer over bedrock generally consists of medium stiff to very stiff CH and CL clay at depths ranging from 3.6 feet to 18 feet below the existing ground surface within the PB footprint. At a boring location to the south of the PB, the clay was encountered to a depth of 27 feet b.g.s. Based on the 12 geotechnical borings performed in the PB/AB area, the limestone and dolomite bedrock exhibit higher weathering at shallower depth (generally upper 10 feet to 20 feet) and became more competent at greater depths. The rock core recovery ranges from approximately 24% to 100% while Rock Quality Designation (RQD) ranges from 0 to 100%. The lower recovery and RQD were mostly within the upper rock layers. The unconfined compressive strength values of intact rock cores range from 4,500 psi to 19,500 psi, which indicates hard to very hard strength.

The cross sections of subsurface soil/rock profiles are provided in Figures 1-3 through 1-8.

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 with only a few events having magnitudes as large as M 4.6. 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.

1.1.2 Facility Buildings and Structures

A site plan showing the location and arrangement of buildings is included as Figure 1-2. Security fencing along or near the property boundaries defines the Owner Controlled Area. The site includes 4 buildings for nuclear manufacturing, administrative offices, raw material preparation, and security.

The building code of record for the buildings on the site is the 2018 Edition of the *International Building Code*. The type of construction is classified as non-combustible. All handling, processing, and storage of licensed material occurs in the nuclear manufacturing building, which is sized for two process lines, each including similar process steps as outlined in Section 1.1.3.

Seismic Load: The design of the structures and facilities complies with seismic loadings based on the 2018 Edition of the *International Building Code* and American Society of Civil Engineers (ASCE) 7-16, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, as appropriate for the geographic location of the site.

The ASCE 7 design basis earthquake is set at 2/3 of the site-class adjusted Maximum Considered Earthquake (MCE_R) accelerations in accordance with Section 11.4.5 of ASCE 7-16:

S_{DS} (Design, 5% damped, spectral response acceleration, short periods) = 2/3 * S_{MS} = 0.432
S_{D1} (Design, 5% damped, spectral response acceleration, 1-s periods) = 2/3 * S_{M1} = 0.122

The Seismic Design Category (SDC) is determined in accordance with Section 11.6 of ASCE 7-16 as a function of the structure's Risk Category and the magnitude of the design spectral response acceleration parameters stated above. The SDC for the TRISO-X FFF Process Building is C. The equivalent lateral force (ELF) seismic analysis procedure is used as permitted by Section 12.6 of ASCE 7-16. The ELF procedure detailed in Section 12.8 of ASCE 7-16 takes into consideration the dynamic properties of the structure along with the seismic Importance Factor (1.25 for Risk Category III) structures to determine the seismic response coefficient (C_s) and ultimately the seismic forces on the structure.

Wind Load: The basic (general) wind speed of 112 MPH is based upon a 1,700-yr return period for Risk Category III structures per ASCE 7-16 Commentary Section C26.5.1. For tornado wind loads, the design wind pressures for an EF1 (110 MPH) tornado utilizing the method detailed in ASCE 7-16 Commentary Section 26.14.4 exceed those for the general wind speeds. Conservatively, the higher pressures determined for tornado winds are utilized in the load combinations intended for general wind loads.

Snow Load: The ground snow load of 10 psf is dictated by ASCE 7-16 and used in conjunction with equations in Ch. 7 of ASCE 7-16 to determine the loads on the structure. Per ASCE 7-16 Commentary Section C7.2, the ground snow load maps were developed by the Corp of Engineers, Cold Region Research and Engineering Laboratory (CRREL) to estimate snow loads with a 2% annual probability of being exceeded (50-yr Mean Recurrence Interval or MRI). Further detail is provided in the aforementioned commentary section. Note also that the Snow Importance Factor for a Risk Category III structure is 1.10 which increases the flat room snow load by 10% from what would be calculated for a common Risk Category II structure.

Rain Load: Rain loads are assumed to be bounded by snow or live loads, pending the finalized design of the roof drainage system. This assumption will be evaluated once the roof drainage details are finalized and if the assumption turns out to be invalid, rain loads will be explicitly considered. Chapter 8.3 of ASCE 7-16 requires that each portion of a roof shall be designed to sustain the load of all rainwater that will accumulate on it if the primary drainage system for that portion is blocked plus the uniform load cause by the water that rises above the inlet of the secondary drainage system at its design flow.

Ice Load: The Process Building does not meet the definition of an "ice-sensitive structure" as given in Section 10.2 of ASCE 7-16 which is why atmospheric icing loads and wind-on-ice loads are not explicitly evaluated as a load case.

Hydrological and/or Geological Load: There are no additional hydrological loads that apply to the structure design other than snow, ice, and rain. There are no flooding loads on the structure and the foundations are above the groundwater table.

1.1.3 General Process Description

TRISO-X FFF manufacturing operations consist of receiving high assay low enriched uranium (HALEU) in the form of uranium oxide powder enriched to less than 20 weight percent U-235; converting the oxide into a uranyl nitrate solution, into gel spheres, and then into fuel kernels; and processing the fuel kernels through coating, overcoating, fuel form pressing, and carbonization. Coated particles and/or final fuel forms are removed from the process at the appropriate point and loaded into licensed shipping containers for shipment to other licensed facilities. These operations are supported by shipping and receiving, laboratory, quality control, research and development, uranium and chemical recovery, and waste disposal processes. Detailed facility and process descriptions are provided in the *TRISO-X Fuel Fabrication Facility Integrated Safety Analysis Summary.*

1.1.4 Raw Materials, Products, By-Products and Wastes

1. The feed material for the TRISO-X FFF is uranium oxide powder. The manufacturing, recovery, support, and waste packaging activities are supported by a number of non-radiological chemical materials stored in bulk quantities, as listed in the NRC-required Emergency Plan and ISA Summary.
2. Finished products containing licensed material include coated particles and final fuel forms in various shapes and configurations.
3. There are no byproducts as defined by 10 Code of Federal Regulations (CFR) 30.4 extracted or converted after extraction from the TRISO-X FFF for use in a commercial, medical, or research activity.
4. Uranium is recovered from non-conforming product materials, process solutions, and scrap materials by processing it into a form that is suitable for use as feedstock in the manufacturing process.

5. Process solutions contaminated with uranium that cannot be recovered/recycled are identified as liquid wastes. Liquid wastes are collected and sampled to determine appropriate handling/treatment steps. Treatment typically involves adjustment of pH, filtering, ion exchange, and/or precipitation. Precipitates are de-watered, and the solids are packaged for off-site disposal. If needed, liquid wastes that have been handled/treated can be sampled and discharged through an inline monitor to shipping packages or conveyances for off-site disposal. Used oils may also be sampled and containerized for shipment to a licensed disposal facility.
6. Airborne effluents are discharged to the atmosphere via a number of process stacks. HEPA filtration and dry scrubber systems are used as needed to remove radioactive particulates and chemicals from airborne effluents to assure compliance with 10 CFR 20 and applicable State of Tennessee regulations prior to discharge to the atmosphere.
7. Sanitary wastes are discharged through piping which goes to the City of Oak Ridge publicly owned treatment works. The inputs for the sanitary sewer system from the site include bathrooms and showers.
8. Solid waste materials include, but are not limited to, damaged and/or obsolete equipment, used ventilation filters and personal protective equipment, processing and waste treatment residues, and miscellaneous combustible wastes. Materials could be radiologically contaminated, non-contaminated, hazardous, or mixed (hazardous and radioactive). Solid waste materials are processed, recycled, and/or containerized for shipment to a licensed disposal facility.

1.2 Institutional Information

1.2.1 Corporate Identity

This application is filed by TRISO-X, LLC, a Delaware limited liability company, headquartered at 801 Thompson Avenue, Rockville, Maryland. TRISO-X, LLC is a wholly-owned subsidiary of X Energy, LLC, a Maryland limited liability company. TRISO-X, LLC is a privately held company and is not owned or controlled by a foreign corporation or government. The principal place of business and location of the licensed facility is as follows:

TRISO-X Fuel Fabrication Facility
(specific street address to be assigned by U.S. Post Office/City of Oak Ridge)
Oak Ridge, Tennessee 37830

1.2.2 U.S. Nuclear Regulatory Commission License Information

1. Docket Number: 70-7027
2. License Number: TBD
3. Period of License: 40 years

1.2.3 Financial Qualifications

A summary of financial qualifications that demonstrates the financial capability of TRISO-X, LLC to construct and operate the TRISO-X FFF has been submitted separately for NRC review. The financial arrangements to assure that decommissioning funds will be available are set forth in Chapter 10.

1.2.4 Type, Quantity, and Form of Licensed Material

The following types, maximum quantities, and forms of special nuclear materials (SNM) are authorized under 10 CFR 70, 30 and 40.

1. **[[redacted]]SRI** kilograms of U-235 contained in uranium enriched to less than 20%, in any chemical/physical form. Contaminants may include 10^{-7} grams of transuranic materials per gram of uranium, and 600 Becquerels of fission products per gram of uranium.
2. 350 grams of U-235 in any chemical/physical form and at any enrichment for use in measurement and detection instruments, check sources, and instrument response standards.
3. 350 grams of U-235 in any chemical/physical form and at any enrichment for use in research and development studies.
4. 25 millicuries of plutonium as counting and calibration standards and/or for use in research and development studies.
5. 300 millicuries of Cs-137 as sealed radioactive sources for use in measurement and detection instruments, check sources, instrument response standards, and counting and calibration standards.
6. 2 millicuries of any licensed material between atomic numbers 3 and 83 as sealed and unsealed radioactive sources for use in measurement and detection instruments, check sources, instrument response standards, and counting and calibration standards.
7. 1 microcurie of any licensed material between atomic numbers 84 and 95 as sealed and unsealed radioactive sources for use in measurement and detection instruments, check sources, instrument response standards, and counting and calibration standards.

1.2.5 Authorized Uses and Activities

This license authorizes the use of SNM for operations involving enriched uranium pursuant to 10 CFR Part 70 as listed in this section. This also includes the support activities related to the manufacture of SNM-containing products.

1. Manufacturing Operations
   a. Fuel Manufacturing – Conversion of uranium oxides to uranyl nitrate solutions, and fabrication of coated particles and final fuel forms containing uranium.
   b. Uranium Recovery – recycling/recovery of SNM from process scrap materials.
2. Laboratory Operations
   a. Chemical, instrumental, and physical analyses and testing on material consisting of and/or containing SNM.

   b. Preparation of any required samples or standards.
3. Research and Development Operations – Process, product, and other research and development activities using natural, source, and SNM compounds and mixtures in benchtop, laboratory-scale, and/or full-scale prototype equipment environments related to:
   a. Enriched uranium fuel designs.
   b. Manufacturing and processing technology and equipment.
   c. Recycling/recovery.
4. Waste Operations
   a. Volume reduction, treatment, packaging, and storage of liquid and solid wastes contaminated with or containing non-recoverable uranium.
   b. Treatment, packaging, and storage of hazardous or mixed waste.
   c. Shipment of wastes to licensed facilities for disposal.
5. Support Operations
   a. Receipt, handling, and storage of raw materials.
   b. Storage of licensed material compounds and mixtures in areas with containers arranged specifically for maintenance of radiological and nuclear safety.
   c. Storage of finished fuel products and the preparation of these products for transportation off-site.
   d. Decontamination of equipment and materials.
   e. Maintenance, repair, calibration, and/or testing of SNM processing equipment, instruments, auxiliary systems, contaminated equipment, and facilities.

1.2.6 Site Safeguards

Physical security at the TRISO-X FFF is described in the NRC-approved *TRISO-X Fuel Fabrication Facility Physical Security Plan*, and nuclear material control and accountability (MC&A) is described in the NRC-approved *TRISO-X Fuel Fabrication Facility Fundamental Nuclear Material Control Plan*. Both plans are maintained current in accordance with applicable regulations as outlined in Chapters 12 and 13. These plans detail the measures employed at the facility to detect potential loss of, and mitigate the opportunity for theft of, SNM of Moderate Strategic Significance, in accordance with the applicable requirements of 10 CFR 73 and 10 CFR 74. Safeguards Information is controlled as described in the *TRISO-X Facility Safeguards Information Plan*.

1.2.7 Terminology / Definitions

Definitions for terms specific to a particular safety function may be given in the corresponding chapter on that function. The following definitions apply to terms used in this license:

Term	Definition
U-235 Enrichments	"Low enriched uranium", which is also known as "high assay low enriched uranium (HALEU)," is defined as any compound of uranium in which the enrichment in the isotope of uranium-235 is less than 20 percent by weight.
Nuclear Safety	Nuclear criticality safety
Will, Shall	A requirement.
Should	A recommendation.
May	Permission (optional), neither a requirement nor a recommendation.
Are	An existing practice for which there is a requirement to continue.
Frequencies	When audit, measurement, surveillance, and/or other frequencies are specified in license documents and approved procedures, the following time spans apply: ▪ Monthly – an interval not to exceed 40 days ▪ Quarterly – an interval not to exceed 4 months ▪ Semi-Annually – an interval not to exceed 7 months ▪ Annually – an interval not to exceed 15 months ▪ Biennially – an interval not to exceed 30 months ▪ Triennially – an interval not to exceed 45 months ▪ For time spans not covered above, an extension of 0.25 times the interval will apply.
Criticality Control or Criticality Safety Control	The administrative and technical requirements established to minimize the probability of achieving inadvertent criticality in the environment analyzed.
Work Area Air Samplers	Stationary air samplers demonstrated to be representative of workers breathing air. If stationary air samplers have not been demonstrated to be representative, the results of lapel air samplers will constitute work area air samplers.

Term	Definition
Equivalent Experience	For the purpose of meeting educational requirements described throughout the license, two (2) years experience is considered to be equivalent to one (1) year of post-secondary education. For example, eight (8) years of applicable experience will satisfy the requirement for a B.S. degree (4 years of post-secondary education).
Owner Controlled Area	A site area bounded by a fence designed to provide physical security, and which encompasses the Controlled Access Area. The area contains radioactive material processing, storage, and laboratory areas, as well as support functions.
Restricted Area	A site area in which individuals may be exposed to radiation or radioactive material at levels or concentrations in excess of that allowed for the general public (see definition in 10 CFR 20.1003). This could include any location on the site where the TRISO-X FFF is located, depending upon activities conducted and the exposure potential as evaluated by the safety function.
Radiologically Controlled Area	A site area where uncontained radioactive material is present, such that contamination levels are likely to be encountered in excess of acceptable levels for unrestricted use. This type of area, designated for contamination control purposes, requires various levels of protective clothing and other personnel protective actions. It could include any location within the Restricted Area, either on a permanent or temporary basis. This term is analogous to the 10 CFR 20.1003 defined term “controlled area…an area, outside of a restricted area, but inside the site boundary, access to which can be limited by the licensee for any reason.”
Uncontrolled Area	A site area where radioactive materials may be handled in the form of sealed sources, in packages or closed containers, in small amounts (air samples, bioassay samples, etc.), or not at all. This type of area is designated for contamination control purposes and is not likely to have contamination at levels in excess of those acceptable for unrestricted use.

Term	Definition
Conditions Adverse to Safety	As used in Sections 2.2, 2.5.1, and 11.6, events that could have the potential to impact the safety of licensed activities, including equipment failures, malfunctions, or deficiencies; procedure problems, errors, or omissions; improper installations; non-conformances with regulatory requirements or commitments; quality-related issues; or a significant condition, such that if uncorrected, could have a serious effect on safety.

1.3 Special Exemptions and Special Authorizations

1.3.1 Special Exemptions

1.3.1.1 Criticality Monitoring

10 CFR 70.24(a) requires a licensee authorized to possess SNM in stated amounts to maintain in each area in which such licensed SNM is handled, used or stored to employ a CAAS meeting the stated requirements.

Notwithstanding the requirements of 10 CFR 70.24(a), the licensee is granted an exemption from criticality monitoring requirements for SNM stored in authorized shipping containers complying with the requirements of the Code of Federal Regulations, Title 10, Part 71, and which are in isolated arrays or on a transport vehicle and which are no more reactive than that approved for transport.

The requirements in 10 CFR 71.55, *General Requirements for Fissile Material Packages*, and 10 CFR 71.59, *Standards for Arrays of Fissile Material Packages*, ensure that arrays will remain subcritical under normal conditions and under accident conditions. The exemption does not affect the level of protection for either the health and safety of workers and the public or for the environment; nor does it endanger life or property or the common defense and security.

Under the provisions of 10 CFR 70.17, “Specific Exemptions”, the Commission may, upon application, grant exemptions from the requirements of 10 CFR 70 when the exemption is authorized by law, will not endanger life or property or the common defense and security and are otherwise in the interest of the public.

The exemption is authorized by law because the Atomic Energy Act of 1954, as amended, contains no provisions prohibiting a licensee from being exempted from CAAS monitoring in a given area in which there is negligible risk of criticality. Granting such an exemption will not endanger life, property, or the common defense and security.

Granting this exemption to 10 CFR 70.24(a) is in the public interest because having criticality accident alarms in an area in which there is a negligible risk of criticality may cause unnecessary evacuations and an emergency response based on a potential spurious alarm. Spurious alarms could also cause unnecessary risk to individuals during an evacuation and provide confusing information about the safety of the facility to the public.

1.3.1.2 Posting and Labeling

10 CFR 20.1904(a) requires a licensee to ensure that each container of licensed material bears a durable, clearly visible label bearing the radiation symbol and the words: “CAUTION, RADIOACTIVE MATERIAL” or “DANGER, RADIOACTIVE MATERIAL”. The label must also provide sufficient information (such as the radionuclide(s) present, an estimate of the quantity of radioactivity, the date for which the activity is estimated, radiation levels, kinds of materials, and mass enrichment) to permit individuals handling or using the containers, or working in the vicinity of the containers, to take precautions to avoid or minimize exposure.

Notwithstanding the requirements of 10 CFR 20.1904(a), the licensee is granted an exemption from affixing a label to each container of licensed material when entrances into each building in which radioactive materials are stored, used, or handled are posted with a sign stating "EVERY CONTAINER OR VESSEL WITHIN THIS AREA MAY CONTAIN RADIOACTIVE MATERIALS".

The exemption is authorized by law because there is no statutory prohibition on the proposed posting of a single sign indicating that every container in the posted area has the potential for internal contamination. To reduce unnecessary regulatory burden, the NRC issued a final rule in 2007 that, in part, modified 10 CFR 20.1905, *Exemptions to Labeling Requirements*, thereby exempting certain containers holding licensed material from the labeling requirements of 10 CFR 20.1904 if certain conditions are met. Although the 2007 rulemaking only applied to facilities licensed under 10 CFR 50 and 10 CFR 52, *Licenses, Certifications, and Approvals for Nuclear Power Plants*, the rationale underlying the rule supports the exemption request. Exempting TRISO-X from this requirement reduces licensee administrative and information collection burdens but serve the same health and safety functions as the current labeling requirements. Therefore, the exemption does not affect the level of protection for either the health and safety of workers and the public or for the environment; nor does it endanger life or property or the common defense and security.

1.3.1.3 ICRP-68 DAC and ALI Values

Derived air concentration (DAC) and the annual limit on intake (ALI) values based on the dose coefficients published in the International Commission on Radiation Protection Publication 68 (ICRP-68) may be used in lieu of the DAC and ALI values in Appendix B of 10 CFR 20 in accordance with approved procedures. See Chapter 4 for additional details.

The ICRP-68 guidance was promulgated after the 10 CFR 20, Appendix B criteria were established, and provides an updated and revised internal dosimetry model. Use of the ICRP-68 models provide more accurate dose estimates than the models used in 10 CFR 20 and allows TRISO-X to implement an appropriate level of internal exposure protection. In a Staff Requirements Memorandum dated April 21, 1999 (SECY-99-077), the Commission approved the staff granting exemptions based on the precedent set by the decision to authorize the use of models in ICRP Publication 68.

This exemption is in accordance with the As Low As is Reasonably Achievable (ALARA) principle, international standards on radiation protection, and does not conflict with established NRC dose limits. No new accident precursors are created by this exemption to allow modification to the values used to assess internal dose. There is no significant increase in the risk to workers or members of the public as a result of this exemption. The activities that are authorized by this exemption are in compliance with law and will not endanger life or property or the common defense and security.

1.3.1.4 ICRP-60 Organ Dose Weighting Factors

Tissue weighting factors listed in the International Commission on Radiation Protection Publication 60 (ICRP-60) may be used in lieu of the organ dose weighting factors in 10 CFR 20.1003 for effective dose assessments listed in ICRP-68 methodologies, in accordance with approved procedures.

The ICRP-60 guidance was promulgated in the same year that 10 CFR 20 organ dose weighting factors were established. Use of the ICRP-60 models provide more accurate dose estimates than the models used in 10 CFR 20 and allows TRISO-X to implement an appropriate level of internal exposure protection. In a Staff Requirements Memorandum dated April 21, 1999 (SECY-99-077), the Commission approved the staff granting exemptions based on the precedent set by the decision to authorize the use of models in ICRP Publication 68.

The underlying purpose of 10 CFR Part 20 is to ensure that occupational workers and members of the public are protected from radiation; that their doses, as a result of licensed activities, are within prescribed limits; and that their doses are ALARA.

This exemption is in accordance with the ALARA principle, international standards on radiation protection, and does not conflict with established NRC dose limits. No new accident precursors are created by this exemption to allow modification to the values used to assess internal dose. There is no significant increase in the risk to workers or members of the public as a result of this exemption. The activities that are authorized by this exemption are in compliance with law and will not endanger life or property or the common defense and security.

1.3.1.5 Certain Unplanned Contamination Events

Notwithstanding the requirements of 10 CFR 70.50(b)(1), the licensee is granted an exemption from the requirement to report unplanned contamination events when the following conditions are met:

1. The event occurs in a restricted area in a building which is maintained inaccessible to the public by multiple access controls.
2. The area was controlled for contamination before the event occurred, the release of radioactive material is under control, and no contamination has spread outside the area.
3. Radiation safety personnel trained in contamination control are readily available.
4. Equipment and facilities that may be needed for contamination control are readily available.
5. The otherwise reportable unplanned contamination event is documented in the licensee's Corrective Action Program.

Chapter 4 describes the radiation protection program measures that keep worker exposures ALARA through: (a) approved radiation protection procedures and radiation work permits; (b) the use of ventilation systems, containment systems, and respirators to control exposure to airborne radioactive material; (c) the use of protective clothing to prevent the spread of surface contamination; (d) the use of surveys and monitoring programs to document contamination levels and exposures to workers; and (e) identification of items relied on for safety and management measures to maintain those items available and reliable.

In addition, (f) access to the site is restricted to individuals that have completed site-specific nuclear safety training requirements or individuals that are formally escorted; (g) during normal operations, trained and qualified radiation protection staffing is provided and readily available to support and respond to radiological conditions, and the staff is trained in contamination control procedures and techniques required for responding to a contamination event when needed; (h) appropriate radiation surveys are performed by qualified personnel during or after an unplanned contamination event as necessary to assess radiological conditions and provide the appropriate response, survey results are compared to specified action guides, appropriate actions are taken when contamination levels in excess of action levels are found and the affected area is decontaminated in a safe and timely manner, and survey records for contamination events are documented pursuant to 10 CFR 20.2103 and are available for review.

Based on the limited scope of the exemption, and the access and contamination controls, training, radiation surveys and other ALARA measures described in the application, granting the exemption as stated above does not endanger life or property. The exemption does not alter reporting requirements for unplanned contamination events through other NRC requirements such as 10 CFR 20.2202, *Notification of incidents*, and 10 CFR 20.2203, *Reports of exposures, radiation levels and concentrations of radioactive material exceeding the constraints or limits*. In addition, the exemption does not involve information or activities that could impact the common defense and security.

Granting this exemption request is otherwise in the public interest because it promotes regulatory efficiency. The exemption relieves the licensee from a reporting requirement for unplanned contamination events that do not present a risk to public health and safety given the site-specific conditions and programs described above. Specifically, the exemption relieves the licensee from generating reports of contamination events in controlled areas where the release of radioactive material is under control and no contamination has spread outside the controlled area. Granting the exemption allows the licensee to focus the resources required to fulfill the reporting requirement on other activities. In addition, it relieves the NRC staff from receiving and processing reports which do not present a risk to public health and safety.

Therefore, the exemption does not affect the level of protection for either the health and safety of workers and the public or for the environment; nor does it endanger life or property or the common defense and security.

1.3.2 Special Authorizations

1.3.2.1 Changes to the License Application

Changes may be made to the License Application and/or to supporting documents referenced in the license without prior NRC approval provided that the following conditions are met:

1. The change does not decrease the level of effectiveness of the design basis as described in the License Application.
2. The change does not result in a departure from the methods of evaluation described in the License Application used in establishing the design basis.
3. The change does not result in a degradation of safety.
4. The change does not affect compliance with applicable regulatory requirements.
5. The change does not conflict with an existing license condition.
6. Within 30 days after the end of the calendar year in which the change is implemented, the licensee shall submit the revised chapters of the License Application to the Director, NMSS, using an appropriate method listed in 10 CFR 70.5(a), and a copy to the appropriate NRC Regional Office.

This authorization is consistent with the process for making changes under 10 CFR 70.72, *Facility Changes and Change Process*, and is further supported by Section C5, *Other Changes*, in NRC Regulatory Guide 3.74, *Guidance for Fuel Cycle Facility Change Processes*, January 2012.

1.3.2.2 Release for Unrestricted Use

Limits developed by the NRC as specified in *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material*, U.S. Nuclear Regulatory Commission, April 1993, may be used for decontamination and survey of surfaces or premises and equipment prior to abandonment or release for unrestricted use.

These guidelines are included as a regulatory acceptance criterion in NUREG-1520, *Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility*, as an acceptable method of demonstrating compliance with the radiation survey and monitoring requirements in 10 CFR Part 20. See Chapter 4 for additional details.

Figure 1-1: Site Location

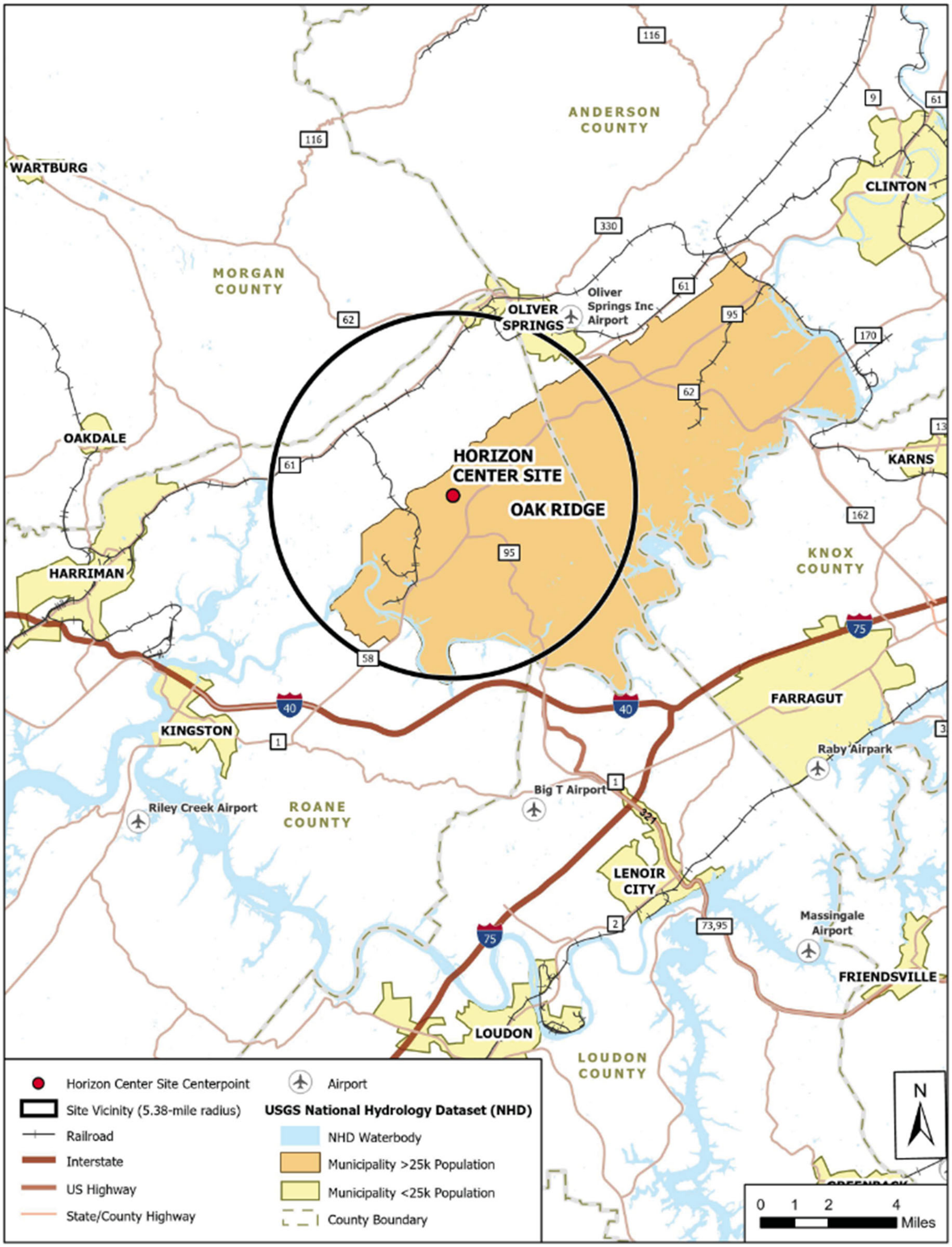
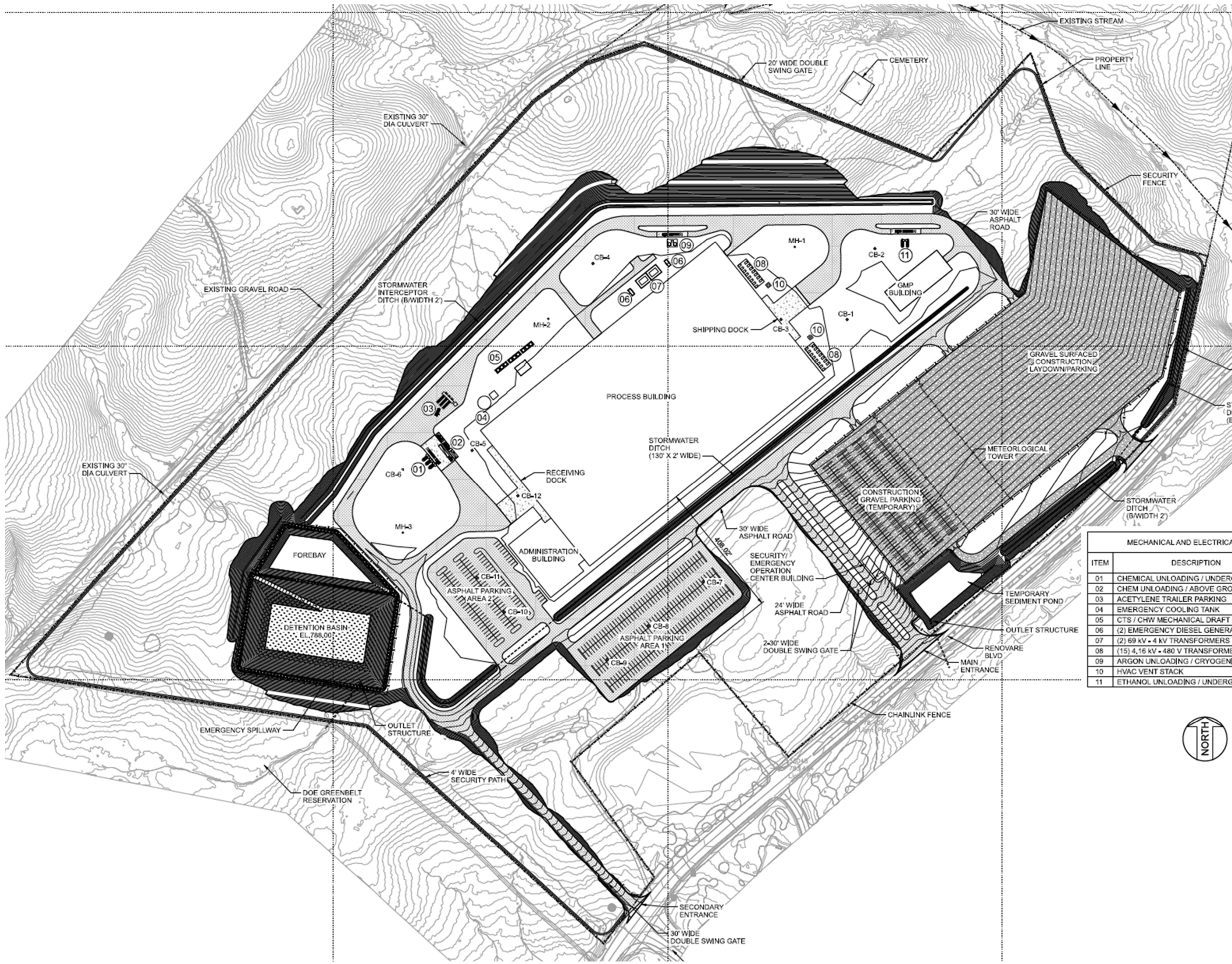


Figure 1-2: Site Plan



MECHANICAL AND ELECTRICAL EQUIPMENT	
ITEM	DESCRIPTION
01	CHEMICAL UNLOADING / UNDERGROUND TANKS
02	CHEM UNLOADING / ABOVE GROUND
03	ACETYLENE TRAILER PARKING
04	EMERGENCY COOLING TANK
05	CTS / CHW MECHANICAL DRAFT COOLING TOWERS
06	(2) EMERGENCY DIESEL GENERATORS
07	(2) 69 kV - 4 kV TRANSFORMERS
08	(15) 4,16 kV - 480 V TRANSFORMERS (PER LINE)
09	ARGON UNLOADING / CRYOGENIC STORAGE
10	HVAC VENT STACK
11	ETHANOL UNLOADING / UNDERGROUND STORAGE

Figure 1-3: Plan View of Geologic Cross Sections

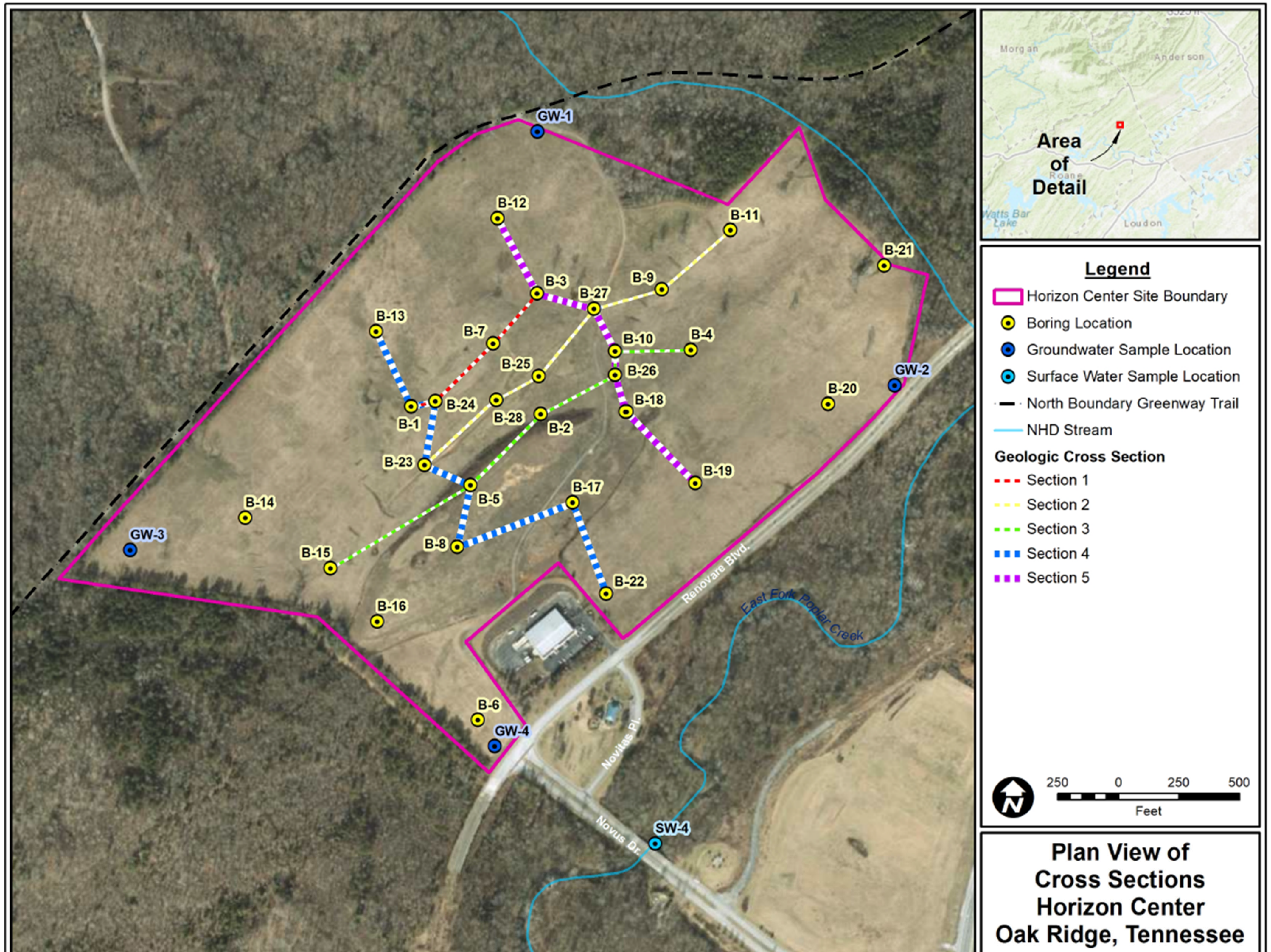
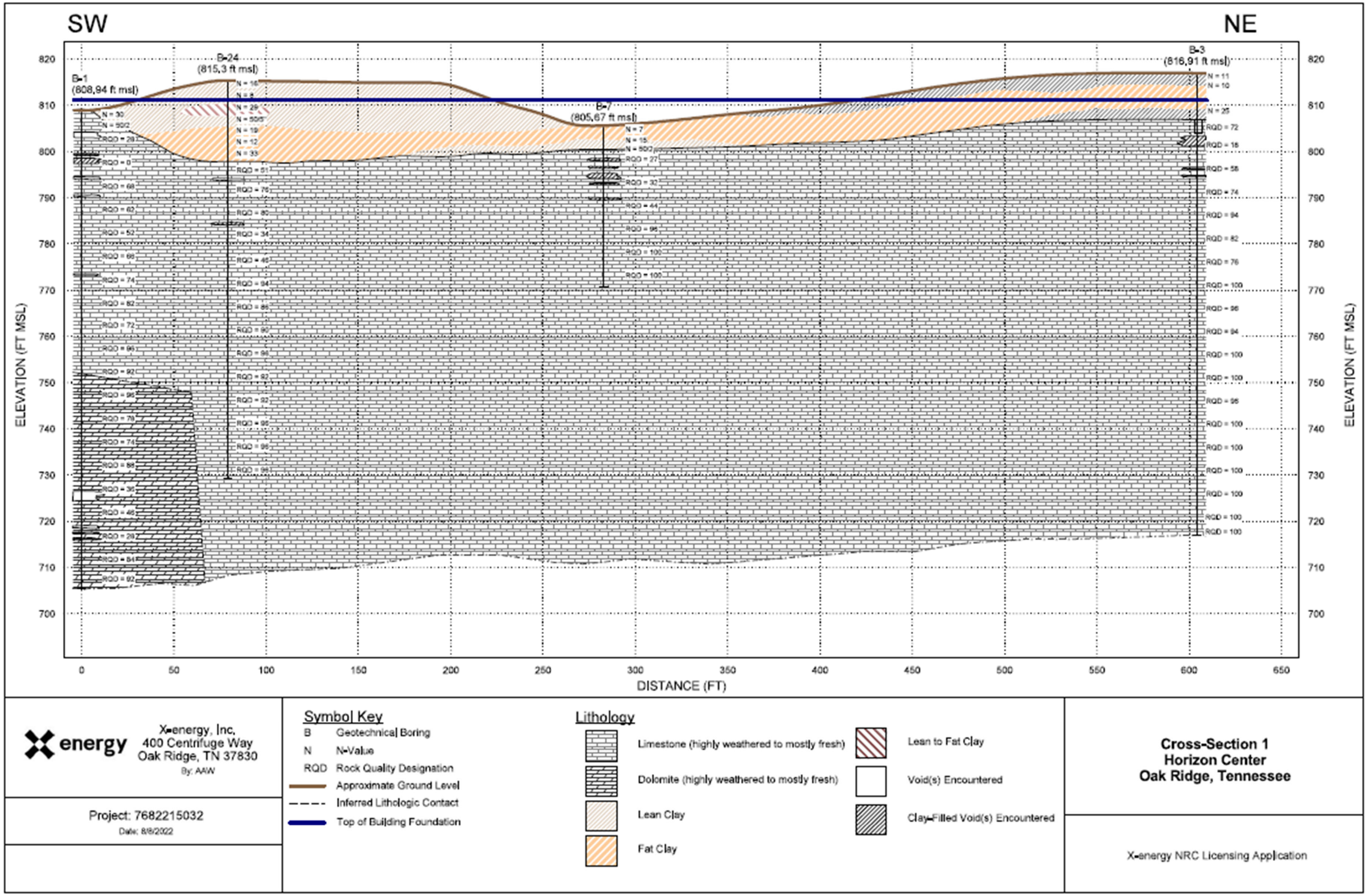
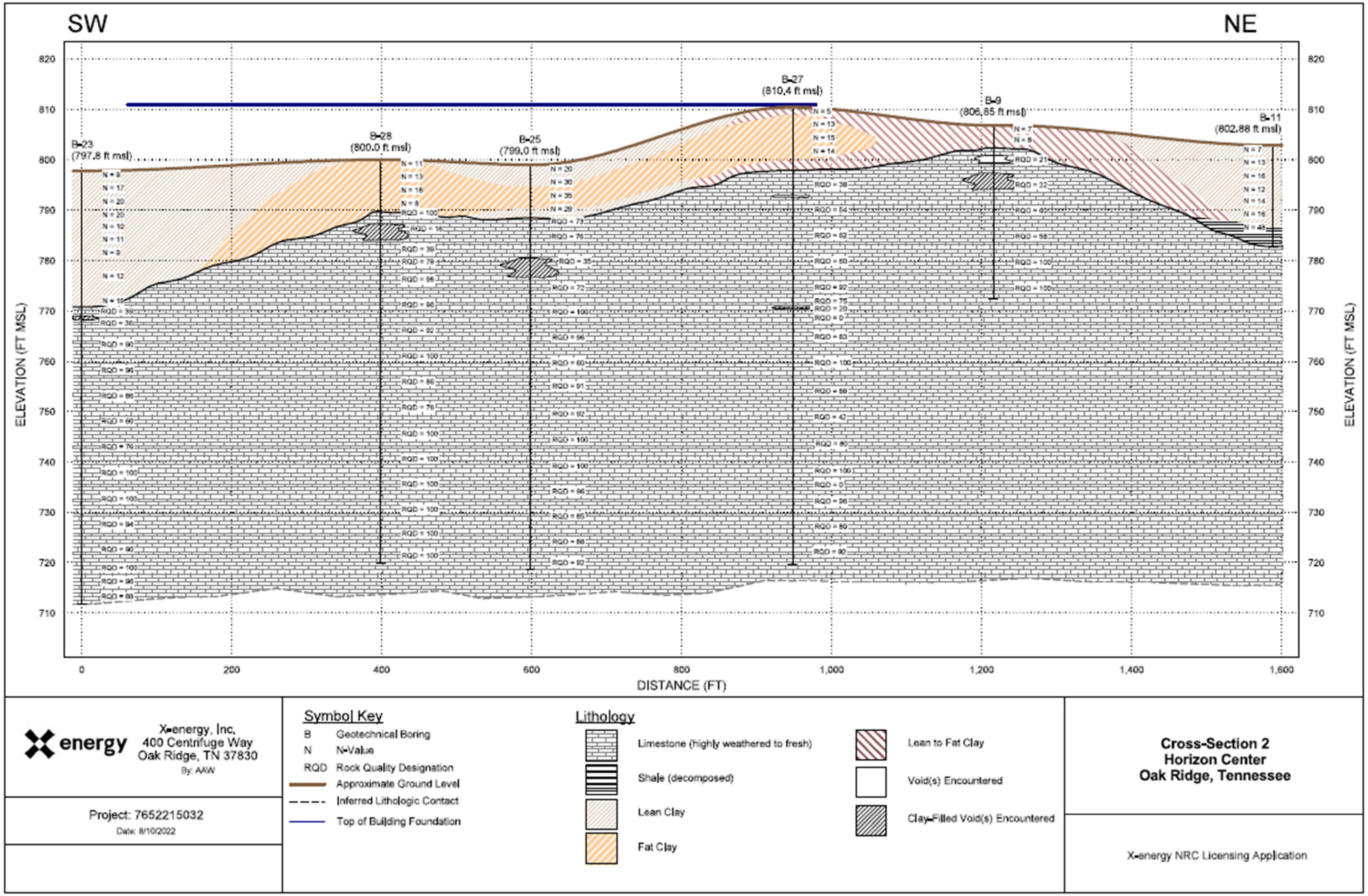


Figure 1-4: Geologic Cross-Section 1



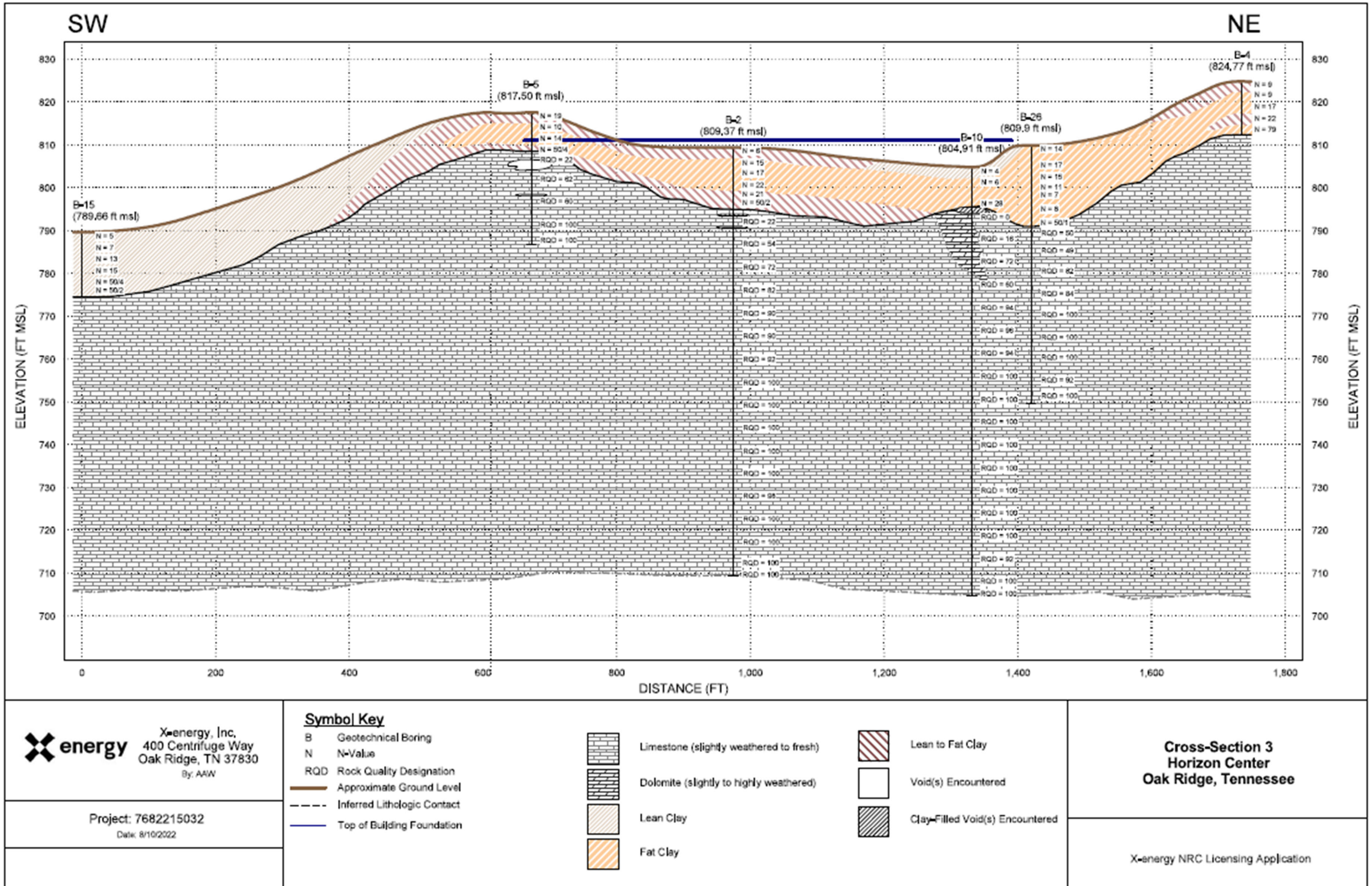
Note: Orientation (angle) of inferred lithologic contact(s) between bedrock (e.g., dolomite and limestone) represents approximate apparent dip (angle, 19 degrees E) calculated from dip observed during drilling operations and adjusted based on actual alignment of cross-section illustrated on the 20:50 vertical-to-horizontal exaggerated-profile scale. N-value and rock quality designation displayed approximately at the mid-point of the run.

Figure 1-5: Geologic Cross-Section 2



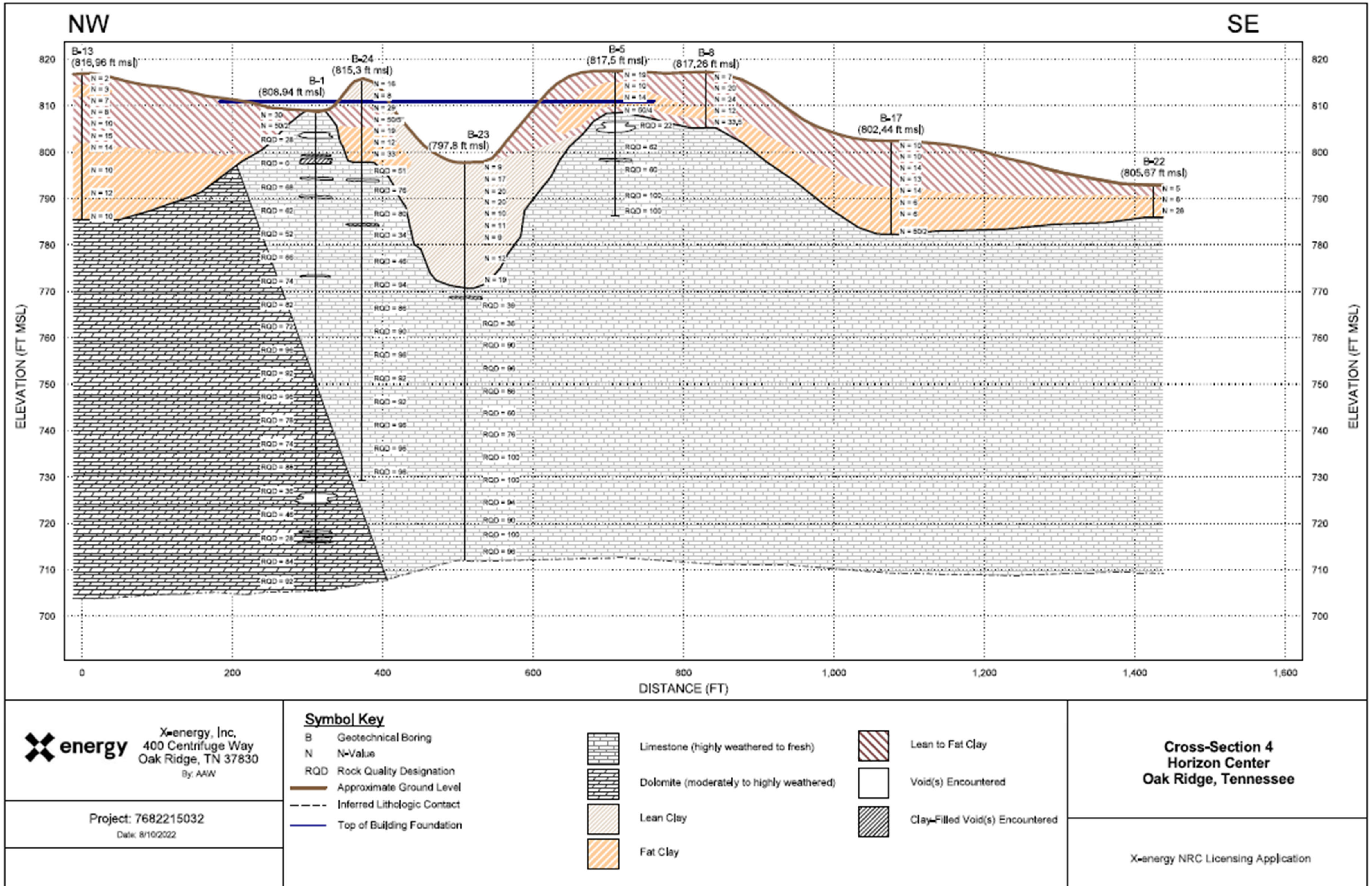
Note: N-value and rock quality designation displayed approximately at the mid-point of the run.

Figure 1-6: Geologic Cross-Section 3



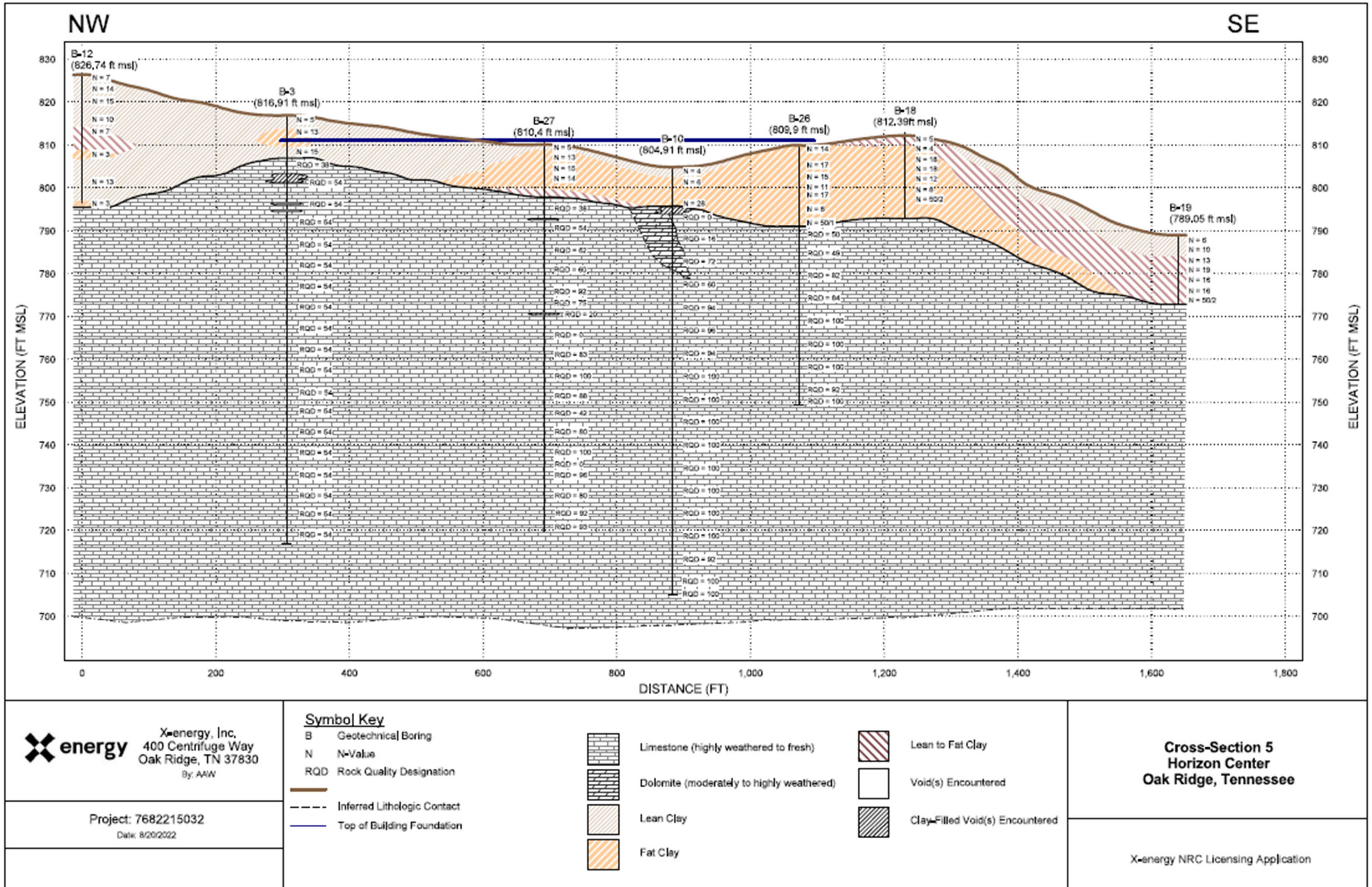
Note: Orientation (angle) of inferred lithologic contact(s) between bedrock (e.g., dolomite and limestone) represents approximate apparent dip (angle, 24 degrees SE) calculated from dip observed during drilling operations and adjusted based on actual alignment of cross-section illustrated on the 30:200 vertical-to-horizontal exaggerated-profile scale. N-value and rock quality designation displayed approximately at the mid-point of the run.

Figure 1-7: Geologic Cross-Section 4



Note: Orientation (angle) of inferred lithologic contact(s) between bedrock (e.g., dolomite and limestone) represents approximate apparent dip (angle, 24 degrees SE) calculated from dip observed during drilling operations and adjusted based on actual alignment of cross-section illustrated on the 34:200 vertical-to-horizontal exaggerated-profile scale. N-value and rock quality designation displayed approximately at the mid-point of the run.

Figure 1-8: Geologic Cross-Section 5



Note: Orientation (angle) of inferred lithologic contact(s) between bedrock (e.g., dolomite and limestone) represents approximate apparent dip (angle, 24 degrees SE) calculated from dip observed during drilling operations and adjusted based on actual alignment of cross-section illustrated on the 40:200 vertical-to-horizontal exaggerated-profile scale. N-value and rock quality designation displayed approximately at the mid-point of the run.