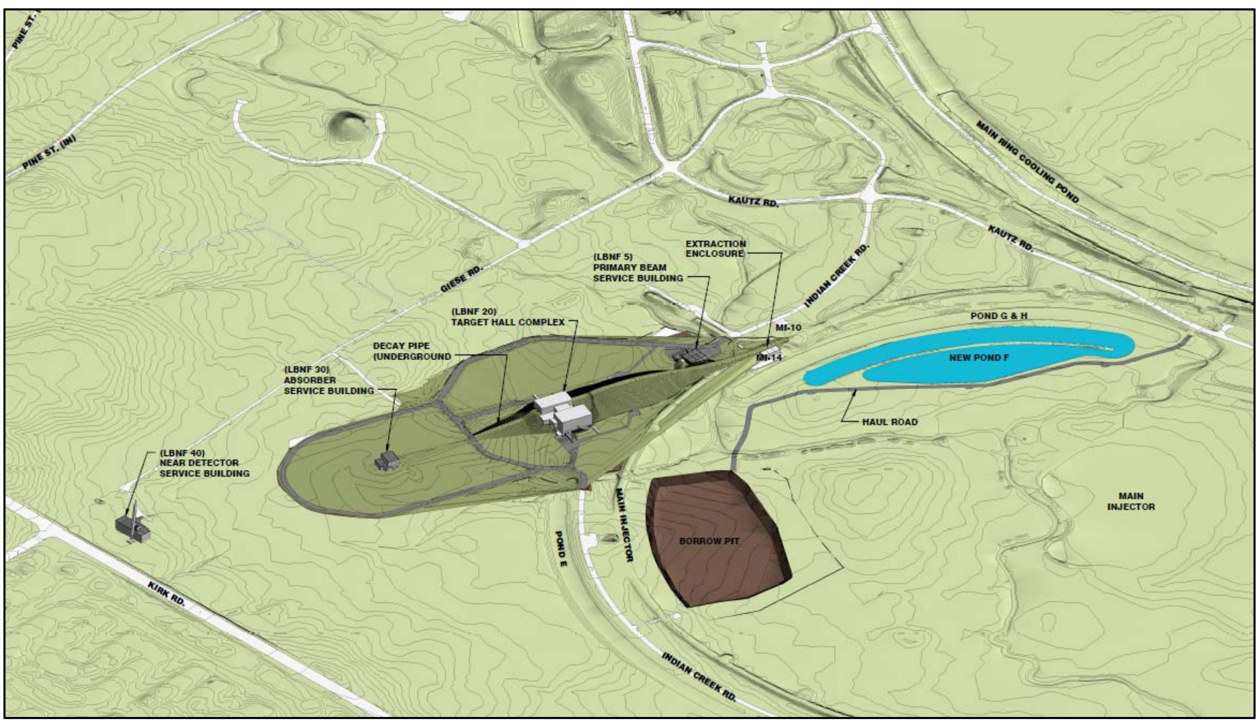
Annex 3B: Conventional Facilities at the Near Site

LBNF/DUNE
Conceptual Design Report

May 2015



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ABBREVIATIONS, ACRONYMS AND DEFINITIONS

Term	Expansion
A	amps
AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
ADAAG	Americans with Disabilities Act Accessibility Guidelines
AHJ	Authority Having Jurisdiction
AHR	Air Handling Room
AHU	Air Handling Unit
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning
CAMs	Control Account Managers
CD	Critical Decision (CD-0, CD-1, etc)
CDR	Conceptual Design Report
CF	Conventional Facilities (Civil design and construction)
cfm	cubic feet per minute
CHW	Chilled Water
DocDB	Document Data Base (LBNE-doc-####)
DOE	Department of Energy
DUSEL	Deep Underground Science and Engineering Laboratory
DWS	Domestic Water Service
EA	Environmental Assessment
EDIA	Engineering, Design, Inspection, Administration
ED&I	Engineering, Design, and Inspection
EENF	Environmental Evaluation Notification Form
ES&H	Environment, Safety, and Health
ft	feet
ft^2	square feet
FEMA	Federal Emergency Management Agency
Fermilab	Fermi National Accelerator Laboratory
FESS	Facilities Engineering Services Section (at Fermilab)
FIRUS	Facilities Information Reporting Utility System
FLS	Fire Life Safety
FNAL	Fermi National Accelerator Laboratory
FONSI	Finding of No Significant Impact
GCL	Geosynthetic clay liner
gpm	gallons per minute
gsf	gross square feet
HEPA	High Efficiency Particle Arrestor
hp	Horse Power
HVAC	heating ventilating and air conditioning
HW	Hot Water
ICW	Industrial Cooling Water
kV	kilo (1000) volts
kVA	kilo volt amps (or kilowatt, electrical power)
kw	kilowatt

KRS	Kautz Road Substation
LEED	Leadership for Energy Efficient Design
LANL	Los Alamos National Laboratory
LAr	Liquid Argon
LBNF	Long-Baseline Neutrino Facility
lf	lineal feet
LCW	Low Conductivity Water
m	meter
MEP	Mechanical, Electrical, and Plumbing
MI	Main Injector
MSL	mean sea level
MSS	Master Substation
MVA	Mega Volt Amps
n+1	The required number of units (n) plus one additional unit
ND	Near Detector
NEC	National Electric Code
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NSSF	Near Surface Storage Facility
NuMI	Neutrinos at Main Injector (Neutrino Beam at Fermilab)
ODH	Oxygen Depletion Hazard
ORNL	Oak Ridge National Laboratory
P5	Particle Physics Project Prioritization Panel
PDR	Preliminary Design Report (DUSEL)
plf	Pounds per Linear Foot
psf	Pounds per Square Foot
RAW	Radioactive Water
RH	Relative Humidity
sf	square feet
SMACNA	Sheet Metal and Air Conditioning Contractors Association
SR3	survey riser 3
STA (Sta.)	Station (100’) (e.g. STA 20+52 = 2052’ from start (STA 0+00))
T	tons
UFAS	Uniform Federal Accessibility Standards
UPS	Uninterruptable Power Supply
WBS	Work Breakdowns Structure
WCD	water Cherenkov detector
Wg	Water Gage
Term	**Definition**
STA 1+00	Denotes 100 feet, from Station 0+00 which is typically used as the starting point.
STA 1+00, STA 1+50	Denotes 150 feet from Station 0+00.
STA -2+38.8	Represents a distance of 238.8 feet before or upstream of Station 0+00

STA 12+47, 35' LT	Represents a distance along the line and an offset from the line, i.e., 1247' from Station 0+00 and 35' left (LT) of the line or alignment while facing down station.
Beam-off	This refers to access to a facility, room, underground space, etc., (area). If the area is called out as beam-off, it means that access to that area is restricted by an interlock system and one can only access when the proton beam is off. In an emergency situation, if access is required into/thru a beam-off area then the interlock door is opened, the beam shuts off and emergency access is allowed/available.
Beam-On	This refers to access to an area that is called out as beam-on is allowed when the proton beam is on.
Site N: Site North = FSCS North	Fermilab employs a laboratory-defined site-wide coordinate system, the Fermilab Site Coordinate System (FSCS). Unless otherwise noted, all coordinates indicated are earth curvature corrected FSCS coordinates. For more information, refer to the Fermilab Facilities Engineering Services Section Engineering Department's CAD Standard Manual.
Plan North	Provides convenient reference directions for plan views that are oriented obliquely with respect to Site North. For site plans where plans are oriented with True North up, Plan North = True North.

1 INTRODUCTION

1.1 Introduction to LBNF Conventional Facilities at the Near Site

The objective of this document [Annex of Volume 3 of the Conceptual Design Report (CDR), doc db 10689] is to document the Conventional Facilities required to house the Beamline and near detector technical facilities at the Fermilab site (also referred to as the Near Site).

Beamline facilities include the primary beam, targetry, horns, absorber, and related systems, the design of and subsequent construction and fit out are the responsibility of the Beamline subproject. Near detector facilities include a small muon alcove area in the Beamline Absorber Hall and a separate near detector Hall that houses the near detector. The design of the technical components for the muon alcove and the Near Detector Hall and their subsequent construction and fit out are the responsibility of the DUNE Project.

The scope discussed in this document represents the full scope, at a Conceptual Design level, for all Near Site Conventional Facilities required to support the Project.

A complete discussion on alternative design configurations and options considered during the Concept Design phase is available the *LBNF Alternatives Analysis* Conceptual Design [1].

This conceptual effort has been completed in support of obtaining DOE approval for CD-1 Refresh and as such, the programmatic requirements described in this volume are developed to a level to support the Conceptual Design milestone of this Project. Further detailed development of all aspects of the design and requirements are required to support future phases of the Project.

The Main Injector (MI) Accelerator is part of the existing Fermilab infrastructure. The numerical addresses (e.g., MI-10, MI-14, MI-60, etc.), around the MI, are used to indicate the points of extraction, or locations of technical components, along the Main Injector. The baseline design for the LBNF Project extracts a proton beam from the MI-10 point of the Main Injector, which in conjunction with the Far Detector location, determines the location of the Near Site Neutrino Detector (ND) and supporting Near Site Conventional Facilities. The Near Site Conventional Facilities not only provide the support buildings for the underground facilities, but also provides the infrastructure to house the Beamline technical systems from the extraction point, through the target and absorber, to the DUNE near detector. The required infrastructure is summarized below and detailed in this volume in the following sections: **3,** *The Facility Layout*, **4**, *New Surface Buildings*, and **5**, *New Underground Structures*.

After the proton beam is extracted from the Main Injector at MI-10 at the starting point (STA 0+00 which is approximately 0.76 ft upstream of the first extraction Lambertson magnet), about 30 ft below grade, the Beamline continues along the Primary Beam Enclosure at an incline into and through an embankment constructed of engineered fill that reaches a height of about 60 ft above existing grade. After reaching the apex of the embankment, the Beamline declines back toward existing grade and through the Target Hall, a 636-ft (194-m) long Decay Pipe, and the Absorber Hall. Downstream of the Absorber Hall, the Beamline passes through 100 feet (30 m) of bulk shielding, then bedrock, allowing muons to range out before the beam of neutrinos enters the near detector Hall on the way to the Far Site. **Figure 1-1** shows a schematic longitudinal section of the entire Near Site with the vertical scale exaggerated to show the entire Project alignment in one illustration. Other options that were considered are discussed in [1]

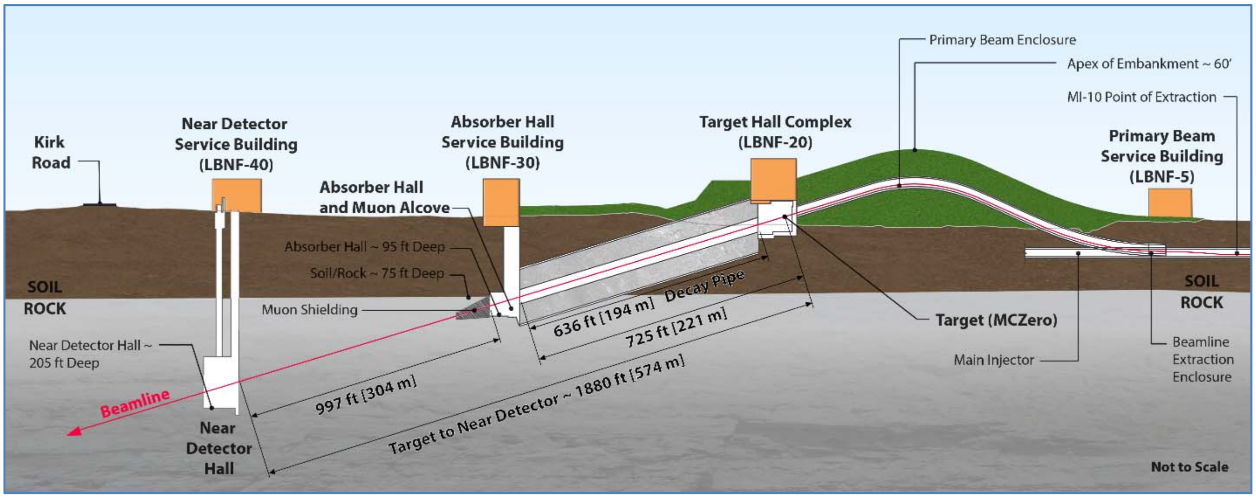

Figure 1-1: LBNF Overall Project Schematic Longitudinal Section View – Vertical Scale Exaggerated

Specifically, the beam will travel approximately 1078 ft (328.7 m) from the extraction point through the proposed Primary Beam Enclosure to the Target Hall where it interacts with a target and a focusing horn system to create an intense neutrino beam that will be directed through a 636-ft (194-m) long decay pipe through a hadron absorber and muon detectors, where the beam will then leave the Absorber Hall and travel 997 ft (304 m) through shielding and bedrock to the near detector, to range out muons. The neutrino beam will then continue through the earth's mantle directed toward a detector located more than 1,300 km (~808 miles) away at the Sanford Underground Research Facility (SURF) located in Lead, South Dakota. SURF is referred to as the Far Site.

The Near Site Conventional Facilities LBNF Project layout at Fermilab, the Near Site, is shown in **Figure 1-2** Following the beam from southeast to northwest, or from right to left in , is the Extraction Enclosure, the Primary Beam Enclosure and its accompanying surface-based Service Building (LBNF-5), Target Complex (LBNF-20) located in the engineered fill embankment, the Decay Pipe, the underground Absorber Hall with Muon Alcove, and its surface-based Service Building (LBNF-30), and the underground near detector Hall and its surface-based Service Building (LBNF-40).

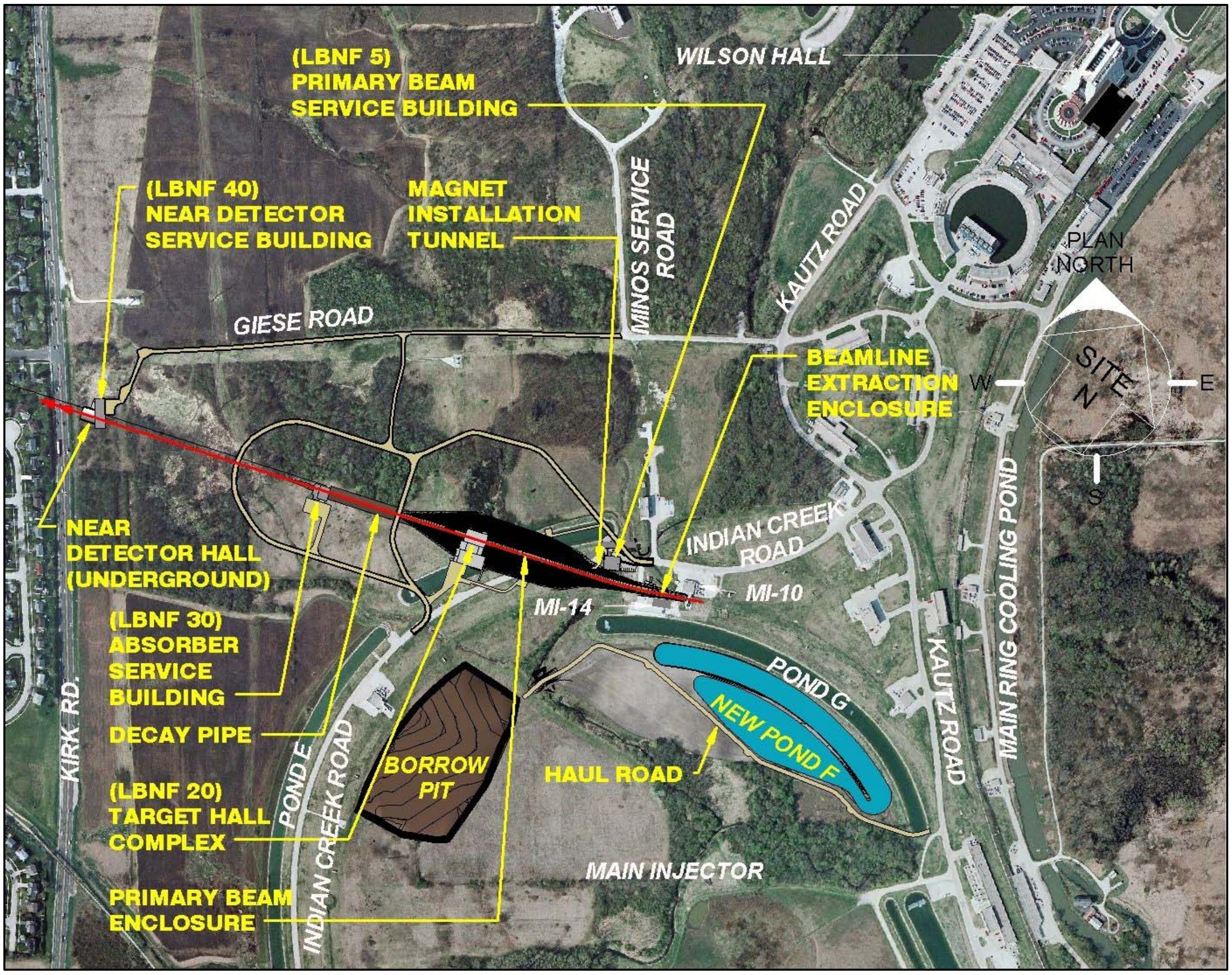

Figure 1-2: LBNF Overall Project Layout at Fermilab

The beamline is designed for initial operation at a proton-beam power of 1.2 MW, with the capability to support an upgrade to 2.4 MW. Those components of the conventional facilities that cannot be upgraded efficiently in a cost effective manner are designed for a proton- beam power of 2.4 MW. Examples of these components include the Decay Pipe and associated shielding **(Section 5.2),** and the cast-in-place concrete and steel shielding in the Target Complex **(Section 4.2),** and Absorber Hall **(Section 5.3).**

1.2 Project Participants

The LBNF Beamline and near detector are planned to be located on the Fermilab site, which is managed by the Fermi Research Alliance, LLC. The design and construction of LBNF Near Site Conventional Facilities will be executed in conjunction with the Facility Engineering Services Section (FESS) staff and Architectural / Engineering consultants.

The LBNF Project Conventional Facilities is managed by staff organized according to the Work Breakdown Structure (WBS) and is led by the Conventional Facilities Project Manager for the Near Site and a deputy that has construction/construction management experience. The supporting team also includes a Conventional Facilities Near Site Deputy Project Manager, who is a part of, and works directly with, the FESS engineering staff. The Near Site Deputy Project Manager is also the LBNF Project liaison with the Beamline Project and the Dune Project to ensure the beamline and detector requirements are addressed and is responsible for all LBNF conventional facilities scope at the Near Site.

The Conventional Facilities Near Site Deputy Project Manager will oversee multiple engineering design and construction consultants. Design consultants have specific areas of expertise in excavation, rock support, geotechnical engineering, geosynthetic barrier systems, fire/life safety, electrical power distribution, cyberinfrastructure, cooling with chilled water, and heating/ventilation systems. Design consultants for LBNF's Conceptual Design were: M+W Group Inc. and AECOM for surface and underground facilities and infrastructure, and W.D. Wightman & Company for rock excavation and support. In addition, Ed Kavazanjian, Ph.D. provided an independent review and assessment of the Geomembrane barrier system of the Decay Region that is discussed in **5.2.1.** Construction at the Near Site will be executed under a Construction Manager/General Contractor (CM/GC) contract where the CM/GC will be, in industry terms, a CM at risk.

Interaction between FESS engineers, LBNF Near Site design teams, and design consultants was completed with weekly conferences, periodic design interface workshops, and electronic mail. The Conventional Facilities Deputy Project Manager - Near Site Manager coordinates all information between design consultants to assure that design efforts remain on track.

Codes and Standards

Conventional Facilities to be constructed at the Near Site shall be design and constructed in conformance with the Fermilab ES&H Manual (FESHM) Chapter 1070, Work Smart Set, revision 8, dated December 2012 (http://esh.fnal.gov/xms/FESHM), but particularly the latest edition of the following codes and standards:

- Applicable Federal Code of Federal Regulations (CFR), Executive Orders, and DOE Requirements
- International Building Code (IBC)
- "Fire Protection/Life Safety Assessment for the Conceptual Design of the Near Site of the Long-Baseline Neutrino Facility (LBNF) MI-10 Shallow – CD-1 Reference Design", dated August 10, 2012, by Aon/Schirmer Engineering
- The Occupational Health and Safety Act of 1970 (OSHA)
- NFPA 101, Life Safety Code
- NFPA 520, Standard on Subterranean Spaces, 2005 Edition
- NFPA 72, National Fire Alarm Code
- American Concrete Institute (ACI) 318
- American Institute of Steel Construction Manual, 14th Edition
- ASHRAE 90.1-2007, Energy Standard for Buildings

- ASHRAE 62, Indoor Air Quality
- 2009 National Electrical Code (NEC)
- American Society of Mechanical Engineers (ASME)
- American Society for Testing and Material (ASTM)
- American National Standards Institute (ANSI)
- National Institute of Standards & Technology (NIST)
- Insulated Cable Engineers Association (ICEA)
- Institute of Electrical and Electronics Engineers (IEEE)
- National Electrical Manufacturers Association (NEMA)
- American Society of Plumbing Engineers (ASPE)
- American Water Works Association (AWWA)
- American Society of Sanitary Engineering (ASSE)
- American Gas Association (AGA)
- National Sanitation Foundation (NSF)
- Illinois Plumbing Code
- Standard Specifications for Water and Sewer Main Construction in Illinois, Sixth Addition 2009, issued by the Illinois Society of Professional Engineers
- Federal American's with Disabilities Act (ADA) along with State of Illinois ADA amendments. These requirements shall only be applied to those facilities which are located at the ground surface and accessible to the public.

2 EXISTING SITE CONDITIONS

The LBNF Project area is located in the western portion of the Fermilab site in Batavia, Illinois. The sections below describe the known and anticipated surface conditions at the site and also include site geology, groundwater conditions, and natural gasses.

2.1 Surface Development, Topographic and Environmental Conditions

The site is partially developed with existing surface and underground structures for the support of ongoing research at the laboratory. Existing underground structures include building foundations, buried utilities, shallow tunnel enclosures constructed by cut-and-cover methods, the associated remnants from previously constructed braced excavation structures, and the existing Neutrinos at Main Injector (NuMI) tunnel which was excavated in the same rock units that LBNF underground enclosures will encounter.

Existing facilities on or adjacent to the Fermilab property that will interface with or constrain the development of the Project are the Main Injector, Kautz Road, Indian Creek Road (also known as the Main Injector Road), the Main Injector Cooling Pond F, and Kirk Road.

The site surface topography is predominantly flat with areas of prairie grass, heavy brush, woodlands, wetlands and developed sites. Surface elevations within the Project area range from about 740 ft to 760 ft above mean sea level (MSL). The topography in the Project area is not an impediment to the development of the construction sites or the use of standard heavy equipment for construction.

2.2 Overview of Site Geology

Subsurface conditions at the Near Site comprises glacial, glaciofluvial and glaciolacustrine deposits, along with flat lying bedrock strata of the middle to lower Silurian period. In descending order, the Silurian rock formations include the Markgraf and Brandon Bridge Members of the Joliet Formation, the Kankakee Formation and the Elwood Formation.

Glacial processes during the Wisconsin glaciation resulted in the deposition of a thick blanket of glacial tills, lacustrine silts and clays, and outwash sands and gravels across the Project area. The total thickness of these overburden sediments in the Project area ranges from about 50 ft to 85 ft. The majority of the sediments are over consolidated glacial till deposits consisting of silt, sand, gravel, cobbles and boulders in a predominantly clay matrix.

The Project area is situated on the eastern flank of a broad structural arch known as the Kankakee Arch, separating the Michigan and Illinois bedrock basins. The rock stratigraphy is composed of a sequence of sedimentary rocks consisting of dolomitic limestone, dolomite, siltstone and shale, generally Silurian in age. The underground structures for this Project will be excavated in formations of these rock types. The bedrock surface is an erosional unconformity where overlying rocks of the Upper Paleozoic Era have been removed by glaciation. The overall dip of the bedrock strata in this region is around 10 ft to 15 ft per mile to the southeast. Bedrock outcrop exposures are rare, except in quarries (North Aurora and Elmhurst) and river bluffs, as the rock strata are overlain by thick glacial deposits.

The Fermilab site is located in a zone of the central mid-continent that is tectonically stable and a region of very low seismic risk. The closest known earthquake source zones capable of producing ground motions of any significance are located several hundred miles to the south. Active faults are not known to exist in the Project area.

Additional descriptions of subsurface materials, geologic profiles and boring logs along the Near Site Project alignment are provided in the LBNE Geotechnical Data Report (LBNE DocDB 8075) prepared by AECOM, dated October 2013, [2] the *LBNE Site Investigation Geotechnical Engineering Services Report* [3] prepared by Groff Testing Corporation, dated February 26, 2010. An additional independent evaluation is documented in the *Geotechnical Investigation, Huer Review* [4].

2.3 Overview of Site Groundwater Conditions

The groundwater regime within the Project area is controlled by the glacial drift aquifer, bedrock aquifers and aquitards. The glacial drift aquifer can be categorized as buried and basal drift aquifers. The buried aquifers occur as isolated lenses or layers of permeable silt, sand and gravel outwash, separated by relatively impermeable clayey and silty tills. The basal aquifers are associated with localized lenses or layers of permeable silt, sand and gravel.

The upper bedrock aquifer consists of the upper weathered and jointed bedrock regardless of stratigraphy or lithology but dominantly the Silurian dolomite formations. The aquifer has a low primary permeability and a much higher secondary permeability consisting of local flow systems mostly associated with discontinuities in the rock mass. The upper bedrock aquifer is a groundwater source for many private and public wells in the Batavia area, including the main water supply for Fermilab. The potentiometric surface of the upper bedrock aquifer is approximately 10 ft below the bedrock surface; however, groundwater elevations may vary.

Underground enclosures of the LBNF Project will be primarily constructed in the drift aquifer and the upper bedrock aquifer. A deeper bedrock aquifer will not be encountered during construction of any of the Project features; however, the Galena-Platteville Formation may be encountered in the near detector Hall excavation.

2.4 Occurrence of Natural Gases

Throughout northern Illinois, isolated pockets and production quantities of methane occur in organic silts and sands associated with interglacial periods, especially the Sangamon soil unit, which represents a long time interval between the Illinois and Wisconsin stages of glaciation. Methane and hydrogen sulfide gases in bedrock formations are uncommon and are usually a result of contaminated groundwater where present.

During geotechnical investigations for the nearby NuMI Project, boreholes and representative soil and rock samples were monitored with flammable gas detection meters in the field for the presence of methane. Methane gas was not detected and is not anticipated to be encountered during the LBNF Project excavations as further described in the *LBNF Site Investigation Geotechnical Engineering Services Report* [3]

3 THE FACILITY LAYOUT

The LBNF Conventional Facilities on the Near Site consist of eight functional areas – three surface buildings, a near-surface, shallow-buried Target Hall Complex located in an embankment constructed of engineered fill, and four underground facility enclosures. Construction will be executed and packaged in a logical sequence based on programmatic and funding driven limitations.

Figure 1-2 shows the Project site aerial view with LBNF facilities highlighted. The Project limits are bounded by Giese Road to the north, Kautz Road to the east, Main Injector Road to the south, and Kirk Road to the west. The Beamline is shown in red in **Figure 1-2**. The four surface and near-surface buildings consist of:

- Primary Beam Service Building (LBNF-5)
- Target Hall Complex (LBNF-20)
- Absorber Hall Service Building (LBNF-30)
- near detector Service Building (LBNF-40)

The four underground facilities consist of:

- Beamline Extraction Enclosure and Primary Beam Enclosure
- Decay Pipe
- Absorber Hall, Muon Alcove and support rooms
- Near Detector Hall and support rooms

Each underground facility has a surface/above-ground service building that functions as a conveyance conduit for conventional and programmatic (for the technical systems) utilities as well as a location for equipment conveyance and personnel access and egress from the underground enclosures. Note that the shallow above and below grade Target Hall is included in the surface based Target Hall Complex at LBNF-20. **Figure 1-1** shows the beamline facilities longitudinal section view and how the surface facilities relate to their corresponding underground facilities.

Based on the Conceptual Design, there will be approximately 250,000 yd^3 of earth excavation, 15,000 yd^3 of rock excavation, 100,000 yd^3 of cast-in-place concrete, 2,000 lf of cut-and-cover excavation, two shafts Near Neutrino Detector equipment handling, components handling and access/egress), and four new surface buildings with a combined floor space area of approximately 70,000 net sf.

The conceptual design drawings, *LBNF Conventional Facilities at Fermilab* [5], depict the general Project layout, transverse and longitudinal cross sections of surface and underground facilities, overall Project and individual surface and underground facilities plan views, single line diagrams of mechanical, electrical, plumbing, and fire protection routing and layout, as well as details and general conceptual specifications of the Conventional Facilities as required by the technical system groups.

The LBNF Conventional Facilities CDR Drawings [5] are the source of most of the figures in this volume. These drawings may be referenced for greater design detail of the Conventional Facilities planned at the Near Site.

The *LBNF Conventional Facilities at Fermilab* drawings are augmented by a set of drawing sheets called *LBNE Advanced Site Prep* (ASP) (See docdb-9760). The ASP was prepared in 2014 and represents the preliminary design of the first anticipated phase of construction of the Conventional Facilities at Fermilab. Refer to Section **3.1.9** for a discussion of the planned construction phasing.

3.1 Project-Wide Considerations

There are several design considerations that apply to many of the facilities that will be constructed for LBNF and are not necessarily specific to any single structure or system. These considerations include the structural and architectural treatment of surface structures, structural and excavation approaches to underground or shallow buried structures, environmental protection, fire protection and life safety systems, safeguards and security, emergency shelter provisions, energy conservation, and DOE space allocation. These Project-wide considerations are addressed in this section.

3.1.1 Structural and Architectural for Surface Structures

The structural building and construction systems for the Near Site Conventional Facilities will be constructed utilizing conventional methods similar to systems established at Fermilab. The architectural features of the Near Site Conventional Facilities will include four surface or near-surface buildings:

- Primary Beam Service Building (LBNF-5)
- Target Hall Complex (LBNF-20)
- Absorber Service Building (LBNF-30)
- Near Detector Service Building (LBNF-40)

The Primary Beam Service Building and the Absorber Service Building will be constructed as a braced-frame, steel and concrete construction with prefinished metal siding. The construction type and style will be consistent with similar adjacent facilities on the Fermilab campus. The Target Complex support service rooms will be constructed of pre-cast and cast-in-place concrete and braced-frame, steel construction with prefinished metal siding as well as natural concrete finish. A Project-specific style of architecture will be developed to unify and mitigate the presence of new buildings upon the surrounding environment.

The near detector Service Building at LBNF-40 is architecturally significant because of its proximity to Kirk Road and visible to Fermilab’s residential neighbors to the west. Therefore the architectural style of the near detector building needs to be complimentary to the surroundings. A landscape embankment or other screening mechanism is being considered between the construction/building site and Kirk Road to shield the neighbors from construction noise and to minimize the visual impact of the building.

The applicable requirements of the Uniform Federal Accessibility Standards (UFAS), Americans with Disabilities Act (ADA) and the Americans with Disabilities Act Accessibility Guidelines (ADAAG) will be incorporated into the design of this project. Compliance with the ADA will be based upon an evaluation of the job descriptions and required tasks for the personnel assigned to work in these surface buildings and underground facilities. Those areas of the buildings and underground facilities that will require accessibility as well as the established routes to those areas will be designed in full compliance with the existing statutes.

3.1.2 Structural and Excavation for Underground Structures

The construction systems for the underground portion of the LBNF Conventional Facilities will be constructed utilizing conventional underground excavation methods.

Most of the below-grade facilities to be built will be constructed using standard open cut methods. This includes much of the Extraction Enclosure, the Primary Beam Enclosure, the Target Complex, the Decay Pipe, and the Absorber Hall. Some of the Primary Beam Enclosure and all of the Target Complex will be constructed in an embankment constructed of engineered fill that reaches a maximum height of about 60 ft above existing grade. The toe of the embankment is shown as a red dashed line in **Figure 3-1.** The extent and height of the embankment will cause consolidation (settlement) of native in situ soils resulting in potential adverse impacts to existing facilities including the Main Injector. **Figure 3-1** also shows the locations, limits, and types of braced excavation, retaining wall systems, and a slurry trench (solid blue line) that are planned to provide protection of the Main Injector and other facilities.

Open cuts for the Decay Pipe and the Absorber Hall will require excavation 70 feet in soil and another 25 feet or so into the bedrock underlying the project site. Rock will be excavated using quarry-type drill-and-blast techniques. The lower half of the downstream one-third of the Decay Pipe and a portion of the Absorber Hall will be excavated in rock.

The Extraction Enclosure and Primary Beam Enclosure will be covered with the required minimum 25 ft of earth-equivalent shielding.

The Near Detector Hall will be constructed using conventional underground rock excavation and tunneling methods. Shaft excavations will employ an earth retention system in the soils. The rock portions of shaft and underground cavities and halls will be excavated using drill-and-blast methods. Rock support of excavations in rock will be provided by rock bolts or rock dowels. Shotcrete will be applied to exposed rock faces.

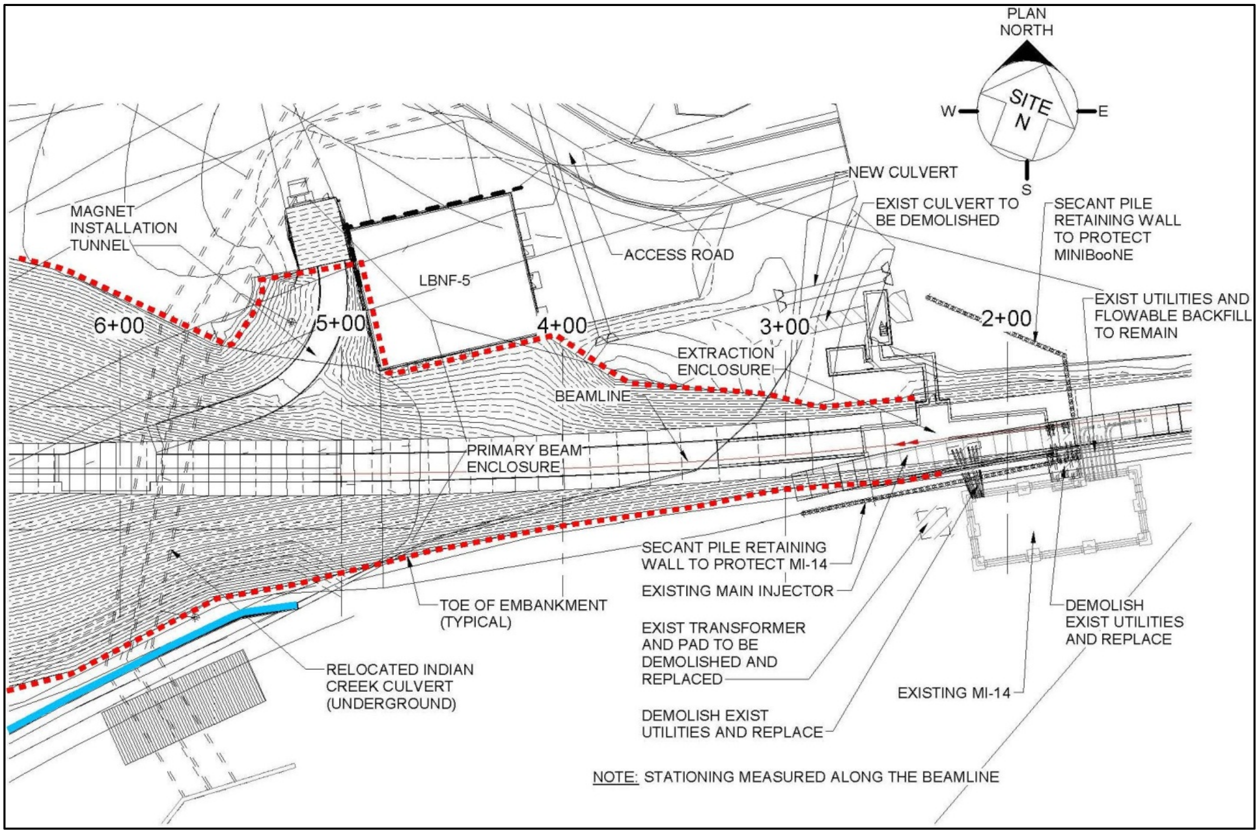

Figure 3-1: Braced Excavation and Retaining Wall Systems with the Toe of the Embankment Shown in Red and the Slurry Trench in Blue

3.1.3 Environmental Protection

The overall environmental impact of this Project will be evaluated and reviewed as required to conform to applicable portions of the National Environmental Policy Act (NEPA). All required permits will be obtained prior to the start of construction. During the ASP Preliminary Design phase of the Project, environmental consultants located and defined the limits of all areas of project impact, including wetland areas, floodplain and storm water management areas, sites of archaeological concern, and any other ecological resource areas. This provided input to the Fermilab NEPA Program Manager and DOE in the preparation of an Environmental Assessment.

A wetland delineation and wetland study were conducted in areas that are anticipated to be disturbed by LBNF construction activities. The *Wetland Report* was prepared by Patrick Engineering, Inc., in August 2010 [6] and supplemented by AECOM in 2014 (docdb 9760). The Wetland Delineation, Floodplain, and Cultural Resources Map, (see **Figure 3-2)** show that limited wetlands, and floodplain, as well as two archaeological sites that may be encountered in the area of LBNF-5, LBNF-20, LBNF-30, LBNF-40, and possibly other areas. Every effort will be made to avoid, minimize, and/or mitigate disturbance to the two archaeological sites. During the NEPA process, the Illinois Historic Preservation Office determined there were no archeological impacts.

In compliance with U.S. Army Corp of Engineers requirements, LBNF must mitigate the disturbance of wetland areas caused by construction activities. LBNF intends to mitigate impacts off site by either funding a wetlands improvement project within Kane County or through the purchase of wetland credits from a wetland bank. The number of credits to be purchased will be based on the area and quality of wetland acres disturbed.

Any volume of the floodplain along the Project alignment that may require filling, notably at and near the LBNF-20 site and along the shielding embankment over the Primary Beam Enclosure, will be delineated and the required compensatory floodplain storage volume will be designed and constructed according to FEMA regulations.

The Near Site Conventional Facilities project will pursue pollution prevention opportunities. Pollution prevention (source reduction) is recognized as a good business practice that also enhances Fermilab site operations. Pursuing pollution prevention enables Fermilab to accomplish its mission of achieving environmental compliance, reducing risks to health and the environment, and preventing/minimizing future DOE legacy environmental issues.

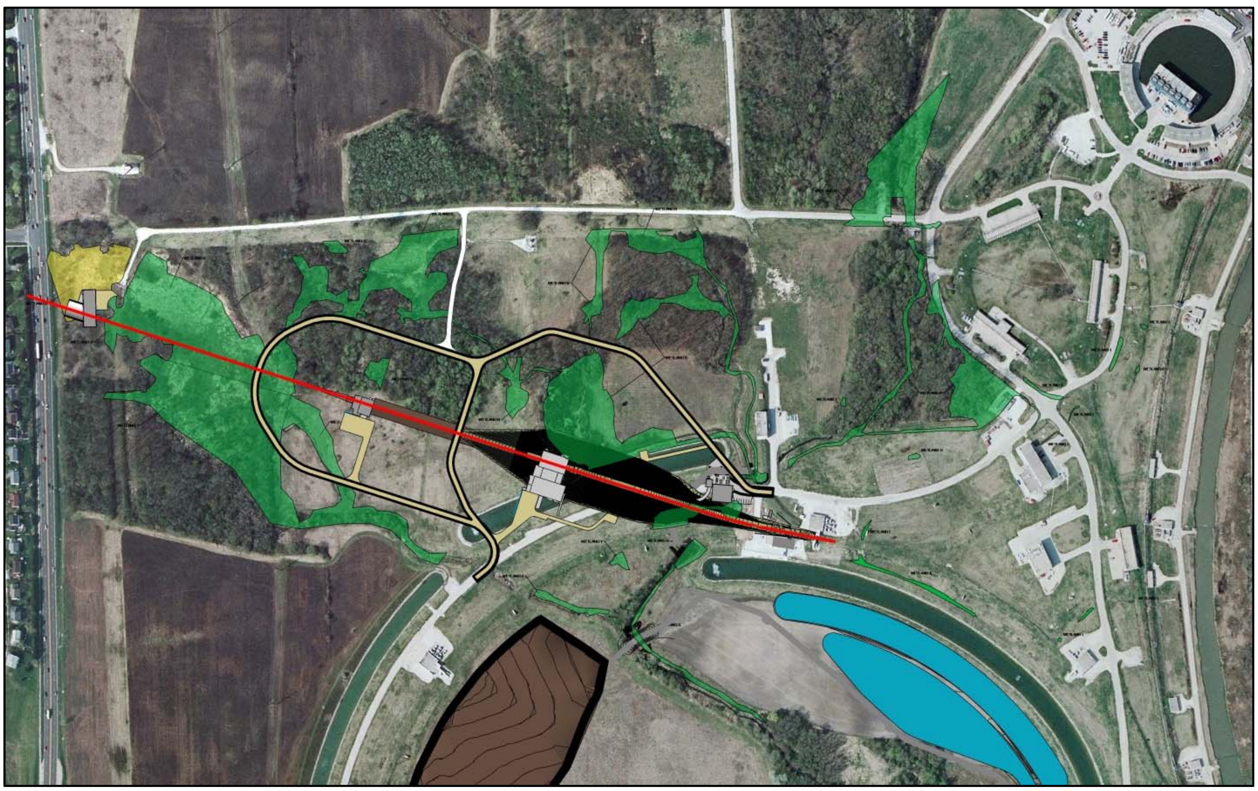

Figure 3-2: Wetland Delineation Map

3.1.4 Fire Protection/Life Safety Systems

A Fire Protection-Life Safety (FLS) Assessment/Report was completed by Aon/Shirmer Fire Protection Engineering Corp. for the LBNF Project [7].

Consistent with the FLS report, facility access and egress will be designed and provided in accordance with all applicable National Fire Protection Association (NFPA) Life Safety Codes and Standards including NFPA 520: *Standard on Subterranean Spaces*, which requires adequate egress in the event of an emergency. Egress paths for surface (service buildings) and underground facilities (tunnels and halls) has been designed to limit the travel paths to egress shafts, stairways, and safe/fire rated corridors to the exterior and surface to a safe gathering location. The specific egress routes are described in Section **5.**

Facility fire detection and suppression systems, as well as personnel occupancy requirements, will be defined in accordance with NFPA 101: Life Safety Code. Fire alarm systems will be designed with a minimum standby power (battery) capacity. These batteries will be capable of maintaining the entire system in a non-alarm condition for 24 hours, and to 15 minutes in full-load alarm condition. Fire alarm/fire suppression systems for the LBNF Conventional Facilities will be designed in accordance with the applicable sections of the Fermilab Engineering Standards Manual which requires that facilities be equipped with a hard-wired, zoned, general evacuation fire alarm system that also includes:

- Manual fire alarm stations at the building exits
- Sprinkler system water flow and valve supervisory devices
- Combination fire alarm horn/strobe located throughout the building
- A 24-V hard-wire extension from the existing control panel
- Connection to the site-wide Facilities Information Reporting Utility System (FIRUS) monitoring system
- Smoke detection and line type heat detection as required.

Automatic sprinkler systems will be designed to a minimum of an Ordinary Hazard Group 1 classification, in accordance with NFPA's latest edition. The NFPA design and construction standards to be used relative to fire alarm systems are referenced in the LBNF Requirements Document [8].

3.1.5 Safeguards and Securities

Direction for security issues related to the design of this Project is taken from the current operating procedures for the Fermilab site.

Service buildings and facilities will be accessible to required Fermilab personnel and contractors during normal work hours. Access to the controlled areas during normal working hours will be controlled internally by the appropriate technical division occupants of each respective building or underground enclosure.

During non-working hours when the buildings and facilities are unoccupied, all exterior roll-up and personnel access doors into the buildings and facilities will be locked. Security card access will be installed in buildings to allow access during non-working hours.

3.1.6 Emergency Shelter Provisions

Required provision for occupant protection in the event of tornadoes or other extreme weather conditions will be incorporated into the design of the service buildings. Guidelines established by the Federal Emergency Management Agency (FEMA) in publications TR-83A and TR-83B and referenced in Section 0111-2.5, DOE 6430.1A, will be used to assess the design of the buildings to insure safe areas within the buildings for the protection of the occupants. These protected areas will also serve as dualpurpose spaces with regard to protection during a national emergency in accordance with the direction given in Section 0110-10, DOE 6430.1A.

FEMA guidelines indicate that protected areas are as follows:

- on the lowest floor of a surface building
- in an interior space, avoiding spaces with glass partitions
- areas with short spans of the floor or roof structure are best; small rooms are usually safe, large rooms are to be avoided.

3.1.7 Energy Conservation

Early 2012, in a position paper titled "Fermilab Strategy for Sustainability," the likelihood of attaining the LEED Gold certification for LBNF facilities was discussed. The context for that analysis was the requirement by DOE that all new buildings and major building modification over $5M must obtain LEED Gold certification from the U.S. Green Building Council (USGBC). That paper was written in part to support a Fermilab request to DOE for an exemption from the LEED Gold requirement for LBNF. The LEED Gold requirement was first articulated in a memo by then-Secretary Samuel Bodman on February 29, 2008, and was subsequently incorporated into DOE's Strategic Sustainability Performance Plans (SSPPs) for 2011 and 2012.

In April, 2012, it was determined by DOE that the "Bodman memo" had, in fact, been rescinded, and DOE removed the LEED Gold requirement for new projects. The 2013 SSPP does not include any LEED requirements, but relies on all new construction meeting the federal Guiding Principles (GP) for High Performance and Sustainable Buildings. The GP were first officially articulated in the 2006 Federal Leadership in High Performance and Sustainable Buildings interdepartmental MOU, which was signed by 20 federal departments. The five GP are as follows:

- Employ Integrated Assessment, Operation, and Management Principles
- Optimize Energy Performance
- Protect and Conserve Water
- Enhance Indoor Environmental Quality
- Reduce Environmental Impact of Materials

These GPs were included explicitly in Executive Orders 13423 and 13514, then in DOE Order 430.2B and its replacement, DOE Order 436.1. Each of the five GP has a set of specifically required goals intended to implement it. There are 34 such specific and mandatory goals. The GP can be found in detail at http://www.wbdg.org/references/fhpsb_new.php. Compliance with the GP appears to be the main formal requirement for demonstrating sustainability in new construction projects. Sustainability is also a prominent goal in DOE Order 413.3B, however, the means of achieving the goal is less prescriptive and formal in DOE Order 413.3B than what is required by the Guiding Principles. DOE Order 413.3B requires only that a Sustainability Plan appropriate to the project be developed and implemented. It does not dictate means and/or methods.

Efforts to apply the GP and develop a Sustainability Plan for the project should complement each other. Both processes will be informed by widely available resources. In making the argument that LEED certification for LBNF is unrealistic, we have committed to the use of LEED concepts and principles to inform decisions about sustainable design, but to avoid confusion, it may be preferable to avoid the term “LEED” altogether and say that we will use USGBC as a resource. There are numerous other resources for sustainable design available to Fermilab, including for example, “Laboratories for the 21st Century” or Labs21, which was developed by DOE and USEPA. The advantage is that it is aimed specifically at buildings that use higher than average amounts of energy. Unlike LEED and USGBC, Labs21 is not in the business of certification. It is mostly a clearinghouse for all sorts of technical guides relating to designing more efficient buildings. Several DOE sites already rely on Labs21 for performance benchmarking.

The LBNF Project has begun evaluating LBNF facilities using the Guiding Principles criteria, and credit has provisionally been taken for 11 of the 34 total required items, based on the near site. The requirements in the Guiding Principles (GP) are more policy/process oriented, whereas the LEED credits are more building/site oriented. For the near site, it is believed that LBNF can eventually meet almost 50% of the GP requirements simply by citing Fermilab-level policies, or overall Lab performance. Of the remaining individual requirements of the Guiding Principles, almost all of them are easily incorporated into the design of the project. Examples are the use of water conserving fixtures, energy efficient lighting, metering, and using materials with recycled and/or bio-based content.

The most difficult of the individual requirements to comply with is to reduce the energy use by 30% relative to the baseline building performance prescribed by the ASHRAE 90.1-2007 standard. This goal originates in the Energy Policy Act (EPAct) of 2005 and the Energy Independence and Security Act (EISA) of 2007. This goal becomes particularly difficult for the types of facilities, i.e., unconventional, high energy using, that Fermilab typically builds.

LBNF confirms the commitment to meet as many of the GP requirements as is reasonably feasible; recognizing that compliance in many of the planned facilities that LBNF is designing may not be straightforward. In these cases, LBNF will take every opportunity to inform our design decisions by taking advantage of resources such as the USGBC, and Labs21.

3.1.8 DOE Space Allocation

The elimination of excess facility capacity is an ongoing effort at all DOE programs. Eliminating excess facilities (buildings) to offset new building construction (on a building square foot basis), frees up future budget resources for maintaining and recapitalizing DOE’s remaining facilities.

The LBNF Near Site Project has obtained a DOE Space Allocation/Space Bank waiver, which assigns elimination of excess facilities capacity elsewhere in DOE labs to offset the new LBNF building square footage. The LBNF Project waiver covers up to 142,000 gross square feet (gsf). The Near Site portion of the Project, as defined by the Conceptual Design, includes a total of approximately 64,000 net sf including underground and surface facilities.

See the LBNF Space Bank Waiver Correspondence [9].

3.1.9 Construction Phasing

Conventional Facilities construction is planned in two phases. The primary objective of the first phase, referred to as the "Advanced Site Preparation" (ASP) phase, is to construct a pre-load embankment to induce settlement in the shallowly-founded Primary Beam and Target Hall Complex regions before the remaining facilities are constructed to minimize beamline settlement after the remaining facilities are constructed. To accomplish this objective, existing facilities in the region must be relocated or replaced, including the relocation of Indian Creek Road, the relocation of the utilities serving the Main Injector, the decommissioning and replacement of Cooling Pond F, new culverts for Indian Creek where it crosses the Main Injector and Indian Creek Road. During this phase, electrical and communications ductbanks, Industrial Cooling Water (ICW), and sewer intended to serve the future LBNF operational spaces will be constructed along the alignment of the relocated Indian Creek Road to avoid disturbing the new alignment later. To provide the needed fill material for the pre-load embankment, a borrow pit will be opened within the Main Injector infield. Excess topsoil will be stockpiled near Butterfield Road on the Fermilab site. The pre-load embankment and underlying soils will be allowed to settle a minimum of twelve months prior to the construction of the Primary Beam and Target Hall Complex facilities. The performance of the pre-load embankment will be monitored throughout the settlement period and compared with the time-rate-of-settlement predictions to allow for refinements in the required settlement period.

The second phase of construction, referred to as the "Beamline and Near Neutrino Detector Conventional Facilities", or "Beamline Conventional Facilities" (BCF) and "near detector Conventional Facilities" (NDCF) (See docdb10831) for short, includes the balance of the work including the Project's underground enclosures and surface-level service buildings, utilities, roads, hardstands, and other conventional facilities features needed for the Project.

3.2 Project Site Infrastructure

The locations of the eight Near Site Conventional Facility functional areas define the LBNF Conventional Facilities at the Near Site. Facility locations were selected based on the programmatic requirement for extracting beam from the existing Main Injector near MI-10 and the planned location of the Far Detector. A significant portion of the Project site infrastructure is provided for the benefit of the entire Project and is not provided in response to a requirement of a specific site address, such as LBNF-20. This section describes Project site infrastructure systems that apply Project-wide.

The scope of the LBNF Conventional Facilities will include the work required to provide road access and the creation of hardstands, parking areas and site restoration. Also included is the extension of the utilities to the Project site.

3.2.1 Roads and Infrastructure

The existing Giese Road will be improved and extended to provide access to the Main Injector Road. This reroute will also allow access to LBNF-20 and LBNF-30 from the north. The new road will be suitable for all-weather and emergency access during construction and beamline operations.

Parking and staging areas will be incorporated into the design of each surface building. Designs will provide for the operation phase, with parking and hardstand requirements for construction and installation designed to be temporary.

As part of the Conventional Facilities work, the existing Main Injector Cooling Pond F and associated infrastructure will be removed/filled-in to create space required for the embankment and the Target Complex (LBNF-20). A new cooling pond will be designed and constructed, along with the additional Project-required cooling capacity, in the infield of the Main Injector. Compensatory floodplain storage volume that is required due to filling in the floodplain, for site grading and drainage, will be mitigated (reconstructed) in the infield of the Main Injector.

3.2.2 Electrical

Fermilab is supplied electrical power through the Northern Illinois Bulk pPower Transmission system that is operated by a local investor-owned utility. The site interconnects with the bulk transmission system at two locations. Service connections, at 345 kV voltage, are made to one of two transmission lines at each location. At the interconnection sites, Fermilab takes power and delivers it along Fermilab owned and operated transmission lines to two separate electrical substations where it is transformed to 13.8 kV for site-wide distribution.

Fermilab maintains two separate types of power systems, pulsed power and conventional power. The technical systems pulsed power loads are large and can cause power quality issues for the conventional facilities if interconnected. Therefore two separate systems are maintained. The electrical systems located throughout the LBNF Project will conform to the National Electric Code (NEC) and applicable sections of the Fermilab Engineering Standards Manual.

The electrical power requirements for the LBNF Project are significant and will require the extension and expansion of the existing 13.8-kV electric distribution facilities. The improvements include electrical substation modifications, the extension of existing 13.8-kV distribution feeders from a nearby feeder for pulsed power and the expansion of Kautz Road substation for the conventional power. The LBNF Project will also require the relocation of the existing electrical power ductbank system around the proposed facilities. Existing ductbanks will be rerouted along the proposed roadways to the LBNF facilities and continue to reconnect to the existing ductbanks to maintain the existing infrastructure.

Figure 3-3 shows the proposed project electrical power routing plan for both pulsed and conventional power for LBNF. **Figure 3-4** shows the location of MI power systems duct bank and feeders, both pulsed and conventional, that will need to be removed and rerouted around the proposed facilities and through the proposed embankment due to LBNF facilities interferences and conflicts.

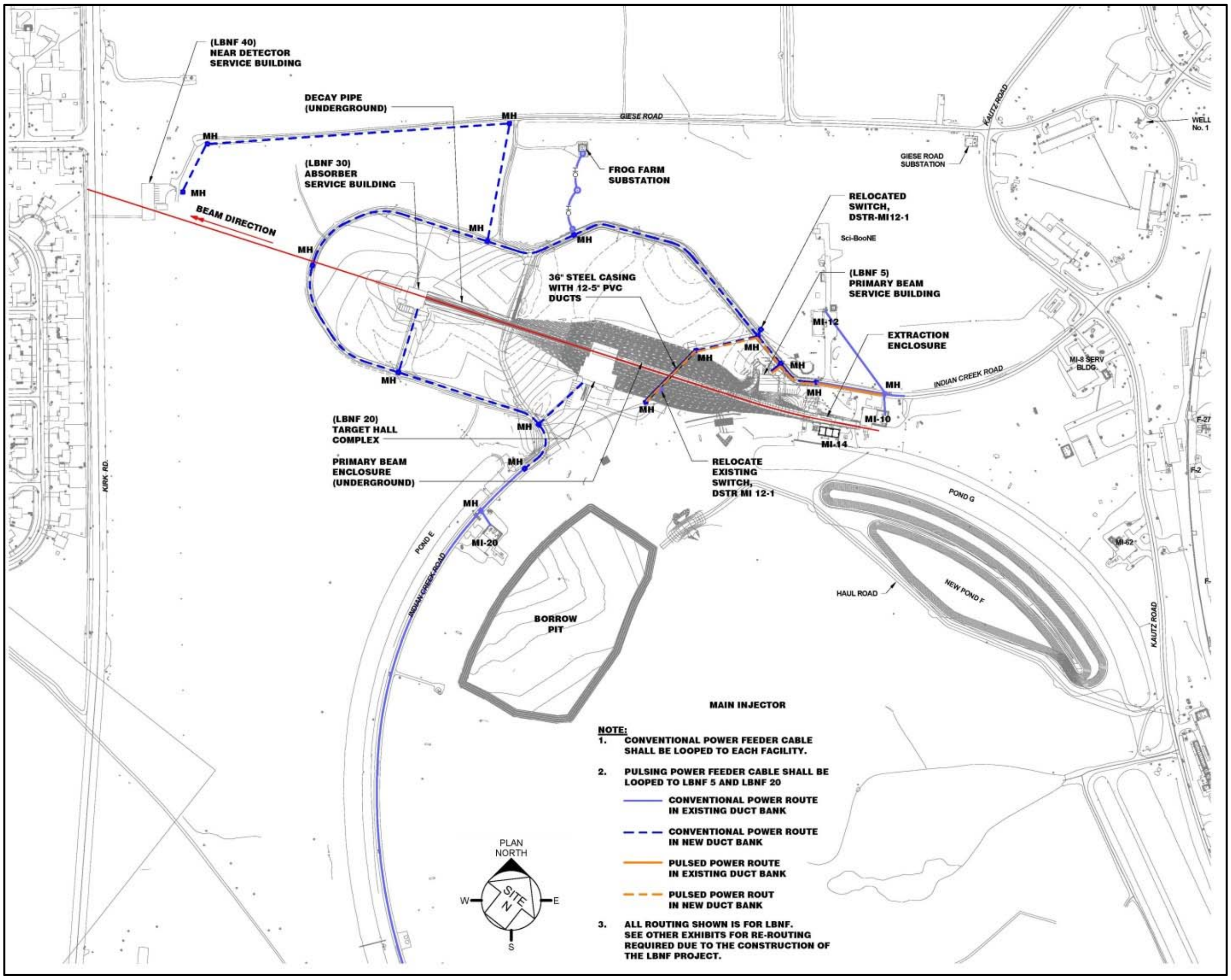

Figure 3-3: Electrical Power Routing Plan

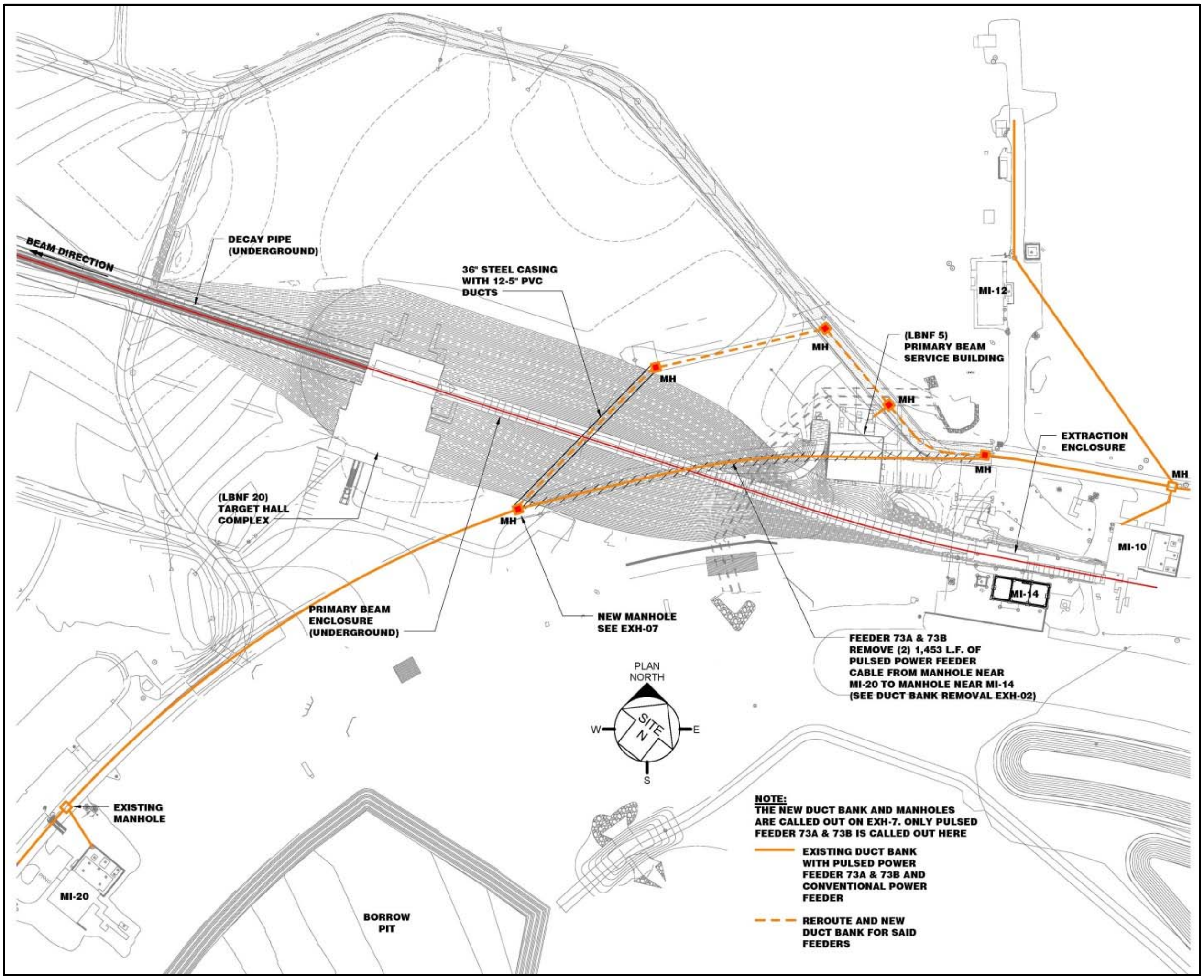

Figure 3-4: Rerouting of Existing Power System Ductbank and Use of Casing Pipe Under the LBNF Embankment

3.2.2.1 Pulsed Power System

Pulsed power service is required at LBNF-5 and will be served from existing Kautz Road Substation, feeder 96/97 at 13.8 kV that is currently serving the Main Injector.

The existing feeder is configured as a loop for operational flexibility. The LBNF-5 pulsed power service will be spliced into the loop, maintaining the looped configuration.

The pulsed power system requires a harmonic filter to maintain power quality. The existing feeder 96/97 is connected to a harmonic filter at the Kautz Road substation.

Sectionalizing switches, 13.8 kV, 600 A, will be installed at various locations along the feeder route. A switch will be installed at each location where pulsed power is required. The switches will serve to provide operational flexibility in load and fault isolation.

Pulsed power service at LBNF-5 will be routed to a 13.8-kV site switch with an interconnection for transformers to the 13.8-kV pulsed power system. The remainder of the electrical equipment for service from the substation into the building will be provided by the Beamline Level 2 Project. The Conventional Facility scope of work will prepare each site by installing concrete pads and conduits for the equipment installation by the Beamline Level 2 Project.

3.2.2.2 Conventional Power System

Conventional power service is required at four sites, LBNF-5, LBNF-20, LBNF-30, and LBNF-40.

The conventional power system for LBNF will be served from Kautz Road substation at 13.8 kV by a new looped feeder. The feeder equipment will include the cable and a new 13.8-kV Kautz Road substation circuit breaker pair. The feeder system from the Kautz Road substation to the LBNF Project will be provided by installing the new underground feeder cables in existing spare ductbank. The feeder will be constructed in a looped configuration to enable cable segment isolation, fault clearing and service restoration without cable repair or replacement and extended service outage.

Sectionalizing switches, 13.8 kV, 600 A, will be installed at various locations along the feeder route. A switch will be installed at each location that conventional power is required. The switches will serve to provide operational flexibility in load and fault isolation.

The 13.8-kV feeder will be routed to each site sectionalizing switch and oil-filled transformers sized to accommodate the design loads. Each site will be provided with fully constructed electrical service to the buildings. Secondary conductors from the transformer will be constructed at each building and will terminate at the main service electrical panelboard.

3.2.2.3 Mechanical and HVAC

The heating, ventilation and air conditioning (HVAC) systems located throughout the LBNF Project will conform to ASHRAE 90.1, ASHRAE 62, applicable NFPA requirements and applicable sections of the Fermilab Engineering Standards Manual. The design parameters for the general HVAC are summarized below:

- Air conditioned facilities will be maintained between 68° to 78°F.
- The relative humidity in air conditioned spaces will be maintained below 50%. There is no minimum requirement.
- Ventilated spaces will be maintained at maximum approximately 10ºF above ambient.
- HVAC for the Target Chase, Target Hall, Decay Pipe, Absorber Hall, and Near Neutrino Detector Hall are specially designed systems that are detailed in other sections of this document.
- All HVAC systems will be design and installed with Metasys automated building controls capable of local and remote monitoring, control and operation optimization. Direct Digital Controls will be further investigated during subsequent phases in accordance with the applicable codes and Federal life cycle costing analysis.

3.2.3 Plumbing and Cooling Systems

The industrial cooling water (ICW), domestic water service (DWS), sanitary sewer, and other related utility services for the Project will be extended from existing services found along the Main Injector Road utility corridor to LBNF-5, LBNF-20, and LBNF-30. The residential subdivision directly west of Kirk Road has City of Batavia domestic water and sanitary sewer capacity to accommodate the near detector facility (LBNF-40) needs. All domestic plumbing work will be installed in accordance with the Illinois Plumbing Code and Standard Specifications for Water and Sewer Main Construction in Illinois, and applicable sections of the Fermilab Engineering Standards Manual.

Details of the anticipated utility work are as follows:

- ICW will be used for fire protection in the sprinkler systems.
- An adequate supply of drinking water is available through an existing DWS supply line in the MI area for LBNF-20 and LBNF-30. Domestic water services from Kirk Road will be provided to LBNF-40 for the restroom, drinking water, and fire protection.
- The connection to the sanitary sewer service will be extended from existing Fermilab system for buildings LBNF-20 and LBNF-30. The sanitary sewer service for LBNF-40 will be connected to the existing sanitary sewer in Kirk Road.
- Adequate cooling capacity for the LCW system required for the beamline magnets and power supplies will be provided at LBNF-5 through heat rejection to the Cooling Pond Water (CPW) system. The design, procurement and installation of the LCW system itself are included in the Beamline Level 2 Project.

3.2.4 Data and Communications

The existing Fermilab data, telephone communications and controls network will be extended from existing sources at the MI-8 service building to the LBNF-5, Target Complex (LBNF-20), Absorber Hall (LBNF-30) and near detector facility (LBNF-40), to provide normal telecommunication and controls communication support to the new LBNF facilities. Connections will be included in the form of new stub-ups for future expansion of the existing fiber network. The existing duct bank network and proposed extensions are shown as green in **Figure 3-5.** The required communications ductwork and manholes will be designed, estimated and constructed as part of the conventional facility portion of the Project. The Conventional Facilities work will also include supplying and installing (pulling and connecting) the required fiber-optic lines.

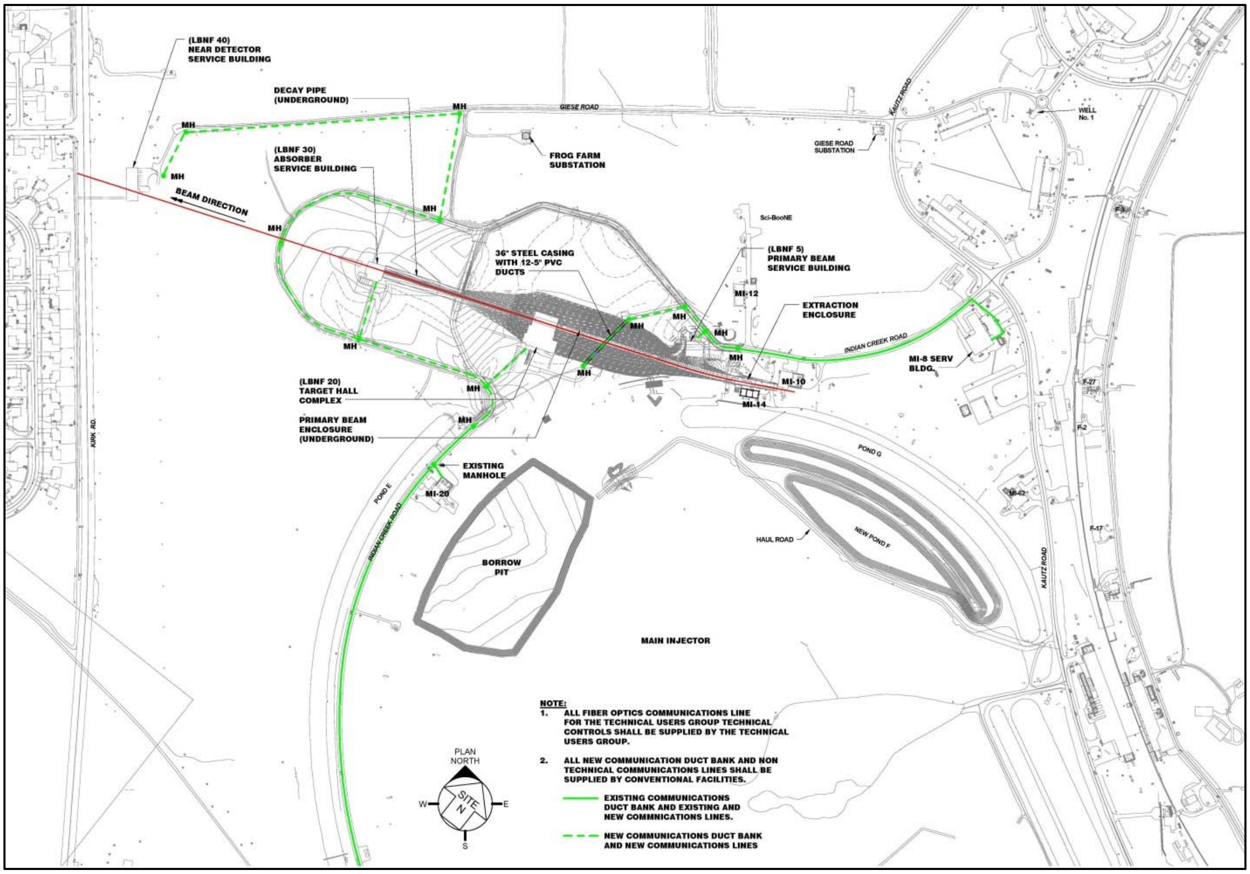

Figure 3-5: LBNF Communications Routing Plan

4 NEW SURFACE BUILDINGS

The LBNF Conventional Facilities on the Near Site will include surface buildings at LBNF-5, LBNF-30, and LBNF-40. A near-surface, shallow-buried structure will be located in an embankment constructed of engineered fill at LBNF-20. This section provides additional details regarding these surface-based structures.

4.1 Primary Beam Service Building (LBNF-5)

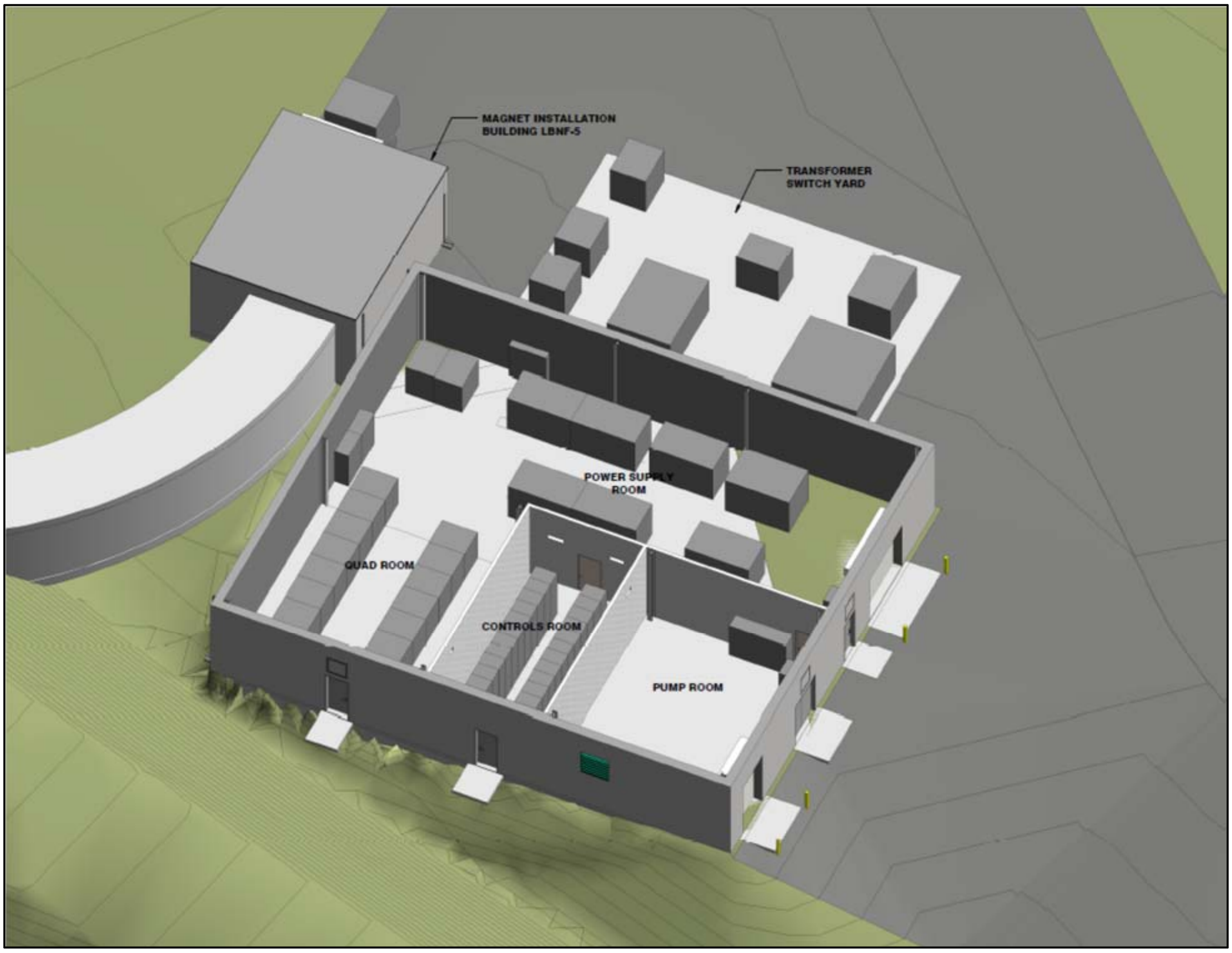

Figure 4-1: Primary Beam Service Building (LBNF-5)

One of four at-grade service buildings is the Primary Beam Service Building (LBNF-5). A facility layout and floor plan of LBNF-5 is shown in **Figure 4-2.** The function of LBNF-5 is to provide housing for primary beam support equipment and utilities, and access for personnel and light equipment to the Primary Beam Enclosure below. This single-story, steel-framed, metal-sided service building will have approximately 4,800 sf of floor space (60 ft by 70 ft main building plus an approximately 500 sf Magnet Installation Tunnel structure), with a minimum 12-ft interior clear height. The building will be positioned north of the beamline and interface with the Magnet Installation Tunnel to provide a path for technical and conventional utilities routing to the Primary Beam Enclosure. The Magnet Access Tunnel structure is a small building constructed similar to the main LBNF-5 building and includes the facilities needed to offload magnets as well as serve as a convenient location to shed foul-weather clothing and to prepare tools and equipment outside the interlocked entry to the Primary Beam Enclosure, as shown in **Figure 4-3.**

Utilities conveyed to the Primary Beam Enclosure will consist of low conductivity water (LCW), technical (pulsed) and conventional power, and communication/control lines. Access to and egress from the Primary Beam Enclosure will be provided thru the Magnet Installation Tunnel.

Space is provided in the Power Supply Room for installation of dipole and quadrupole power supplies within the building as well as water-cooling lines and related equipment. A Pump Room is provided for CPW/LCW heat exchangers, and LCW pumps; and a Controls Room is provided for technical system controls. Electrical switchgear and power transformers will be installed on the transformer pad adjacent to the north face of the building, as shown in **Figure 4-2**.

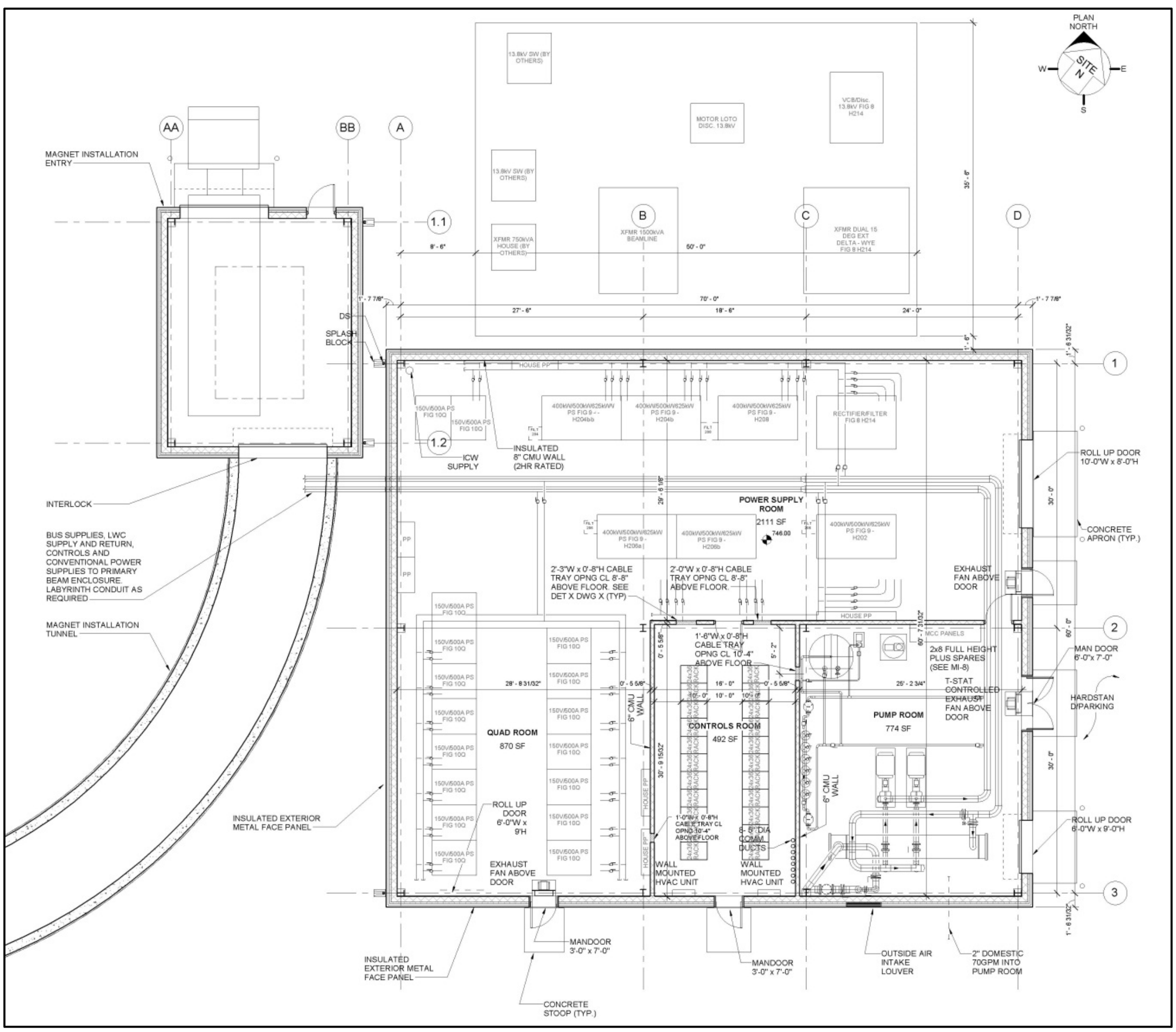

Figure 4-2: Primary Beam Service Building (LBNF-5) Floor Plan

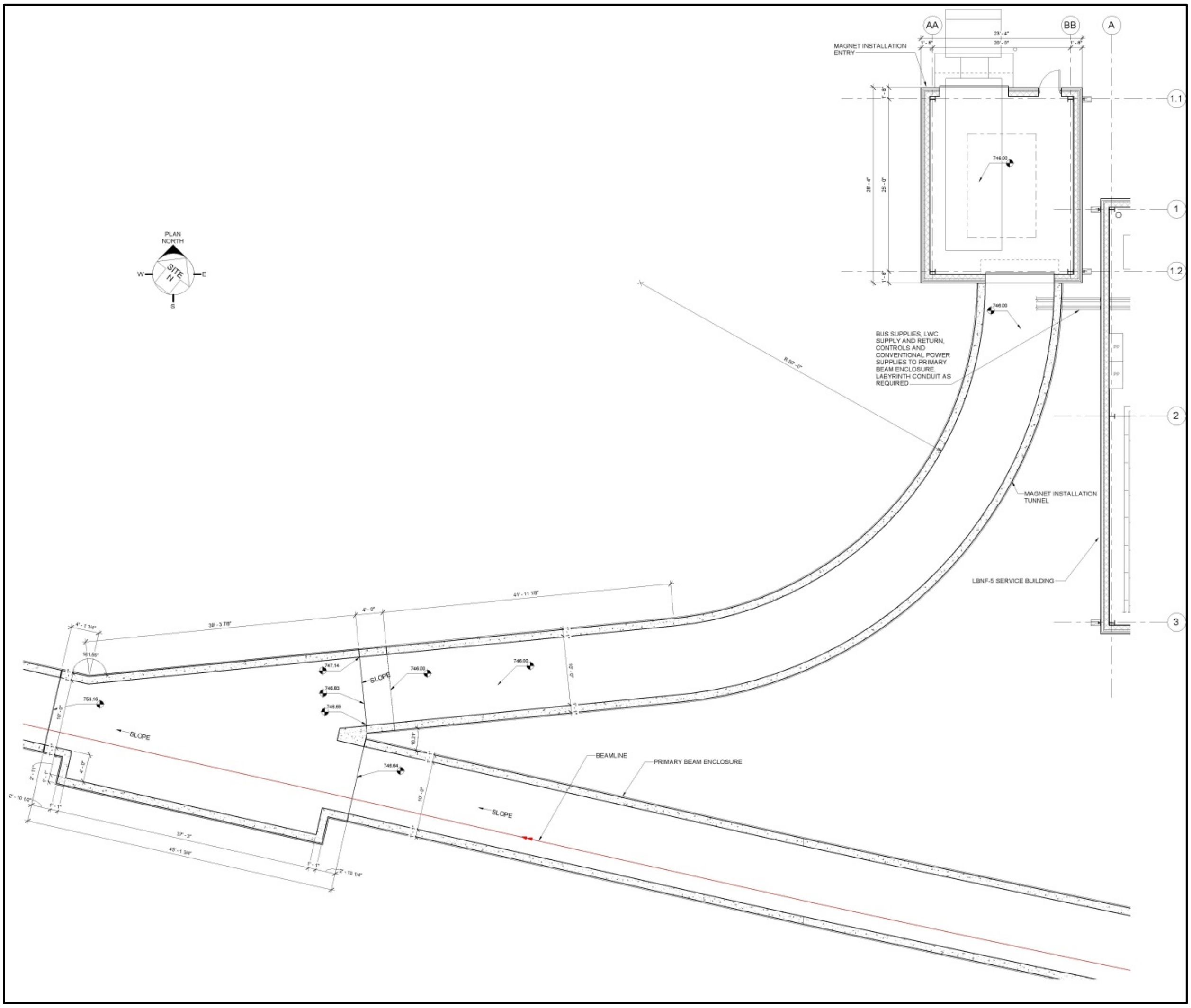

Figure 4-3: Magnet Installation Tunnel and Access Structure

4.1.1 Mechanical

Heat rejection for the LCW system will utilize CPW from the modified Main Injector Cooling Pond network. The building will be heated with electric unit heaters to maintain a minimum winter temperature of 68ºF. The power supply room and the pump room will be ventilated using outside air fans to maintain summer maximum temperatures of about 10ºF above ambient outdoor temperature. The electronics/control room will be cooled by wall mounted cooling units to maintain summer maximum temperatures of 78ºF. There will be no natural gas or sanitary sewer service. Restroom facilities are available in the existing MI-12 Service Building located about 350 ft to the north. One of the building's roof support beams will be sized and configured to serve as a maintenance monorail for equipment removal and replacement.

4.1.2 Electrical

The electrical facilities provided at LBNF-5 supports the requirements of the Beamline in accordance with the Fermilab standards, NEC, and other applicable codes. The building site will have two separate electrical services. A conventional power system will be provided for electrical service to the building systems, lighting, HVAC, crane, miscellaneous loads, and low power technical system components such as electronics racks and computers. A technical system power system space will be provided for electrical service to large technical systems such as beam power supplies. Conventional Facilities will provide 13.8-kV primary electrical power to outdoor switchgear and prepare a space at LBNF-5 for the technical systems transformers and components to be installed by the technical systems. An emergency/standby power system with generator will be installed to serve critical loads for life safety and technical system components.

The building will be outfitted with panelboards, lighting, power receptacles, emergency/standby power systems and HVAC components to support the requirements of the beamline. A main switchboard/panelboard will be installed to distribute power to large dedicated loads and sub-panelboards in local building and underground areas. Emergency/standby power will be provided at a dedicated emergency power panelboard.

The lighting system and the level of lighting provided will be designed according to the lighting level required by the use of the space. All lighting installed in areas that are exposed to radiation will be protected from the radiation or will be resistant to the degrading and contaminating effects of radiation on electronic components. All emergency lighting in the Primary Beam Enclosure shall be powered from a separate remote battery powered uninterruptable power supply (UPS) system that is completely isolated from sources of radiation. This system will remain operable until the standby generator is available to provide power or power is restored.

Power receptacles will be provided in the building and underground areas for use during outfitting and operation. The receptacles will be configured based on site equipment standards. All loads that require emergency/standby power will be served from the dedicated panelboard. The HVAC equipment will be served from the nearest conventional power panelboard.

The LBNF-5 exterior transformer cast in place concrete pad will be sized for one 4,000-kVA TeV-style power supply transformer and switchgear, one 2,000-kVA transformer with a 15-kV motor-driven switch and a 750-kVA house power transformer.

The pad and the programmatic pulsed power duct banks to the pad and from the pad into the building (below the floor) will be designed and constructed under the Conventional Facilities scope. The technical systems transformers and power supplies are designed and constructed by the Beamline Level 2 Project scope of work.

Table **4-1** shows the PBE Service Building (LBNF-5) electrical power loads, both normal power and the standby power generators.

Table 4-1: Primary Beam Service Building (LBNF-5) Electrical Power Loads

Equipment Description	Normal Power (kw)	Standby Power Generators (kw)
Packaged AHU	73	
Electric Heater (2 heaters/room; 3 rooms = 6 total)	210	210
Lighting & Receptacle	42	11
Pump Room Ventilating Fan (3 hp; 5,000 cfm)	3	3
Power Supply Room Ventilating Fan (5 hp; 10,000 cfm)	5	5
Total Connected Load	**333**	**229**

4.1.3 Plumbing

A 2” domestic water service will be extended from Indian Creek Road for LCW make-up water. There is no sanitary sewer or natural gas services provided to this building.

4.1.4 Fire Protection/Life Safety Systems

The Primary Beam Service Building (LBNF-5) will be equipped with a wet pipe sprinkler system served from the site-wide industrial cooling water (ICW) network that is extended to the building from the existing nearby system. Egress paths for surface (service buildings) and underground facilities (tunnels and halls) have been conceptually designed to limit the travel path distances to egress shafts, stairways, and safe/fire rated corridors to the exterior and surface to a safe gathering location. See Section **3.1.4** of this volume for a general overview of fire protection and fire life/safety requirements.

Conventional Facilities is responsible for the design and construction of fire/life safety systems including the mechanical (emergency ventilation), electrical (emergency generator for lighting, ventilation, sump pumping, fire alarms, and communication), and plumbing (fire suppression/sprinkler piping and fixtures, and emergency sump pumping) systems.

Emergency egress routes for the Primary Beam Service Building (LBNF-5) will allow exiting through multiple exterior doors. **Section 5.1.4** describes the egress paths from the Primary Beam Enclosure Building.

4.2 Target Hall Complex (LBNF-20)

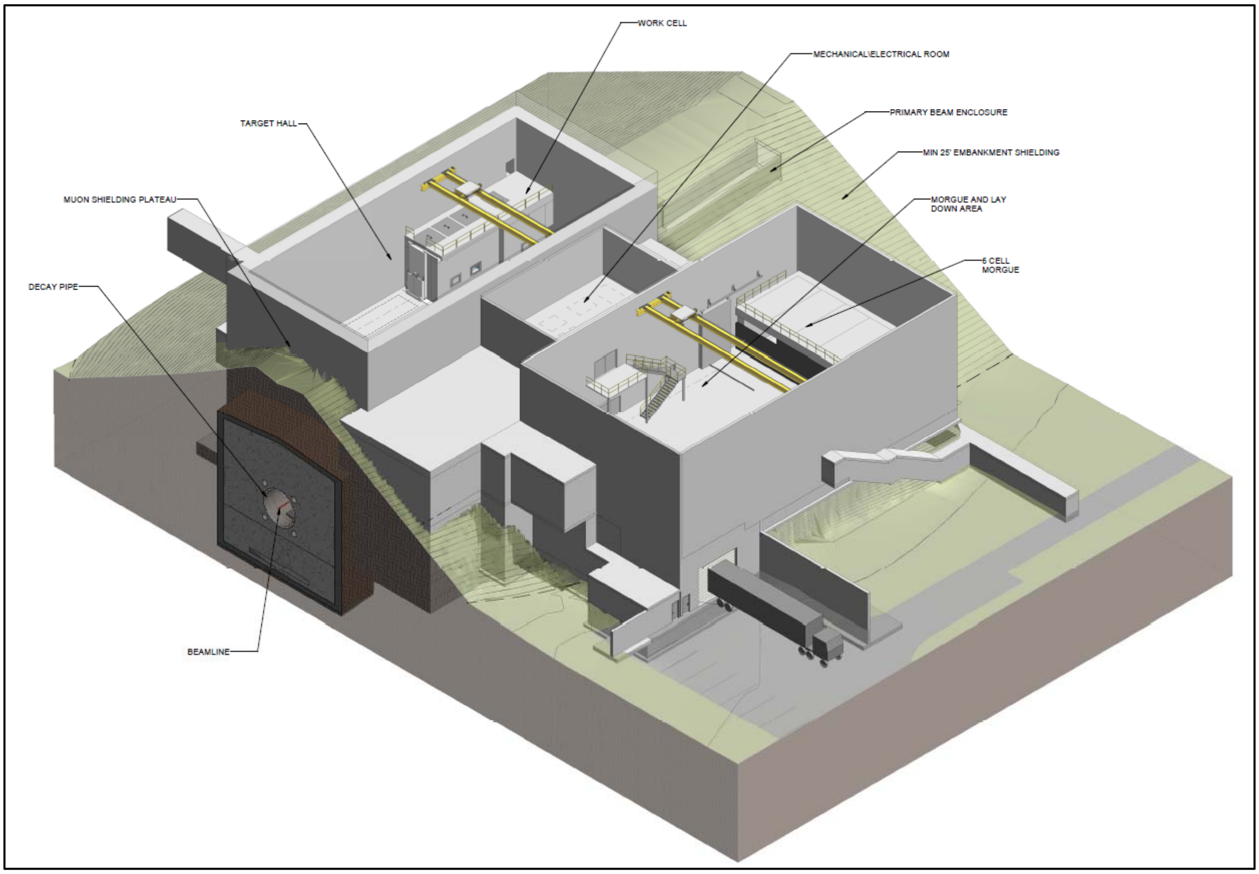

Figure 4-4: Target Hall Complex

The Target Complex (LBNF-20) will be a 31,000 net sf near-surface facility constructed in the engineered fill embankment, that combines the Target Hall, corresponding beam-on and beam-off support rooms (power supply, piping system carrying radioactive water (RAW), and air handling rooms), and the Target Hall service rooms (a truck bay with a lay down/staging area, morgue area, mechanical/utilities rooms, and rest room). Beam-on spaces are accessible by personnel while the beamline components are energized, and access to beam-off spaces is only permitted when the beamline components are not energized. These support and service rooms accommodate the support equipment and utilities and provide access needed to assemble and operate the equipment and conventional and programmatic/technical components for the Target Hall. An overview is shown in **Figure 4-4**

The Target Hall, shown in **Figure 4-5**, is located at the north end of the Target Hall Complex, with beam-on and beam-off service and support rooms adjacent on the beam left side (as one faces downstream), which is also the south side of the Target Hall.

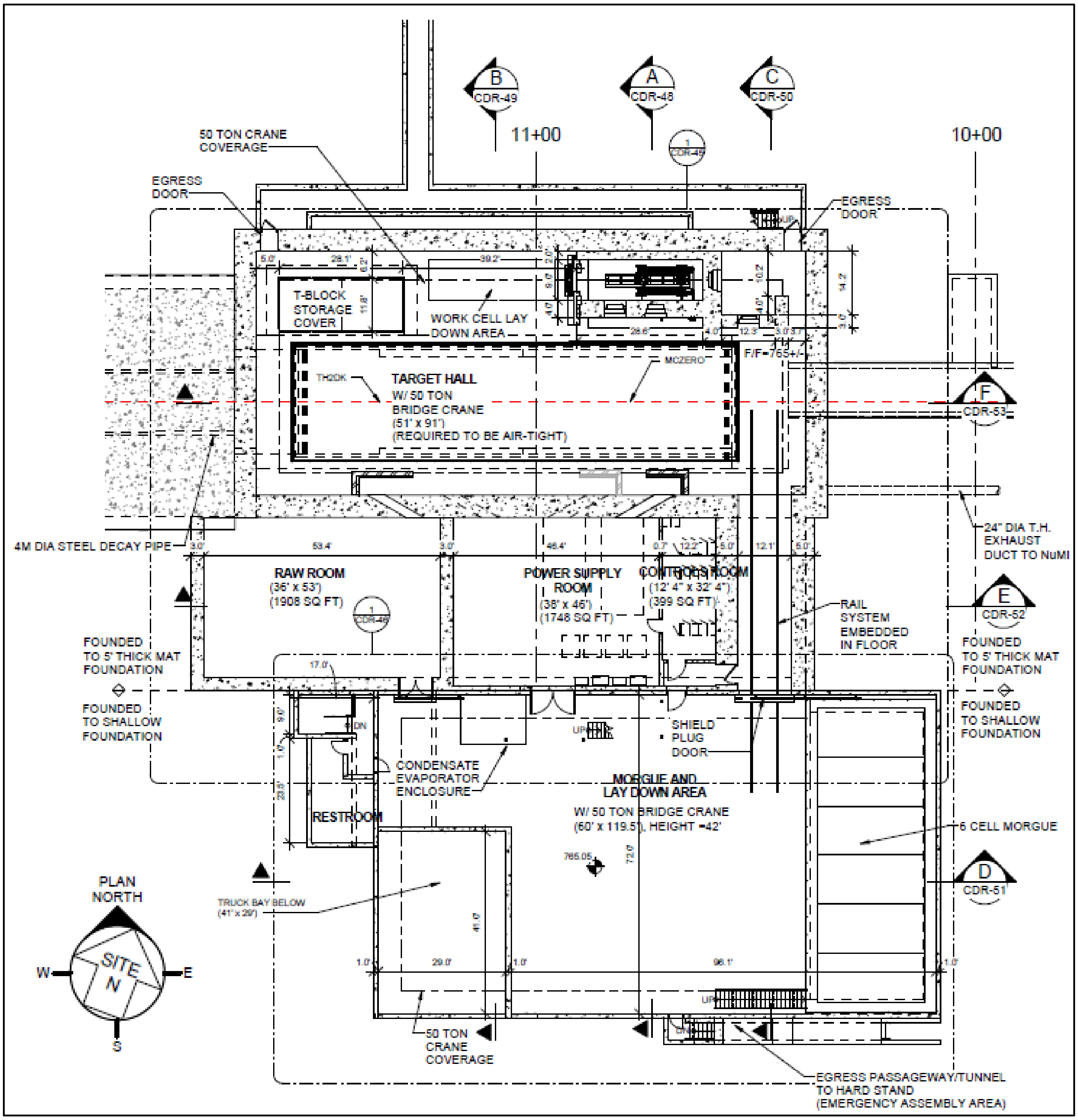

Figure 4-5: Target Complex; Main Level Floor Plan

The Target Hall will house the target and focusing horns in a shielded target chase enclosure below the floor. The required concrete and steel shielding will be provided around these beamline target components. The Target Hall and target chase (section views shown in **Figure 4-6**) consist of steel shielding blocks, and the target and horns, along with the associated power feeds, cooling water channels, and gaps/spaces for air cooling. Target pile bulk shielding steel will be provided by the Beamline Level 2 Project and installed by Conventional Facilities. A portion of the steel shielding blocks at the upstream end of the chase will be permanently cast into concrete. Other shielding blocks will be stacked within the chase.

The target chase is longer and wider than the minima necessary to accommodate the reference design target-horn system. This will provide flexibility to accommodate more advanced designs which have the promise of enhancing the neutrino flux and substantially increasing the capability of the experiment.

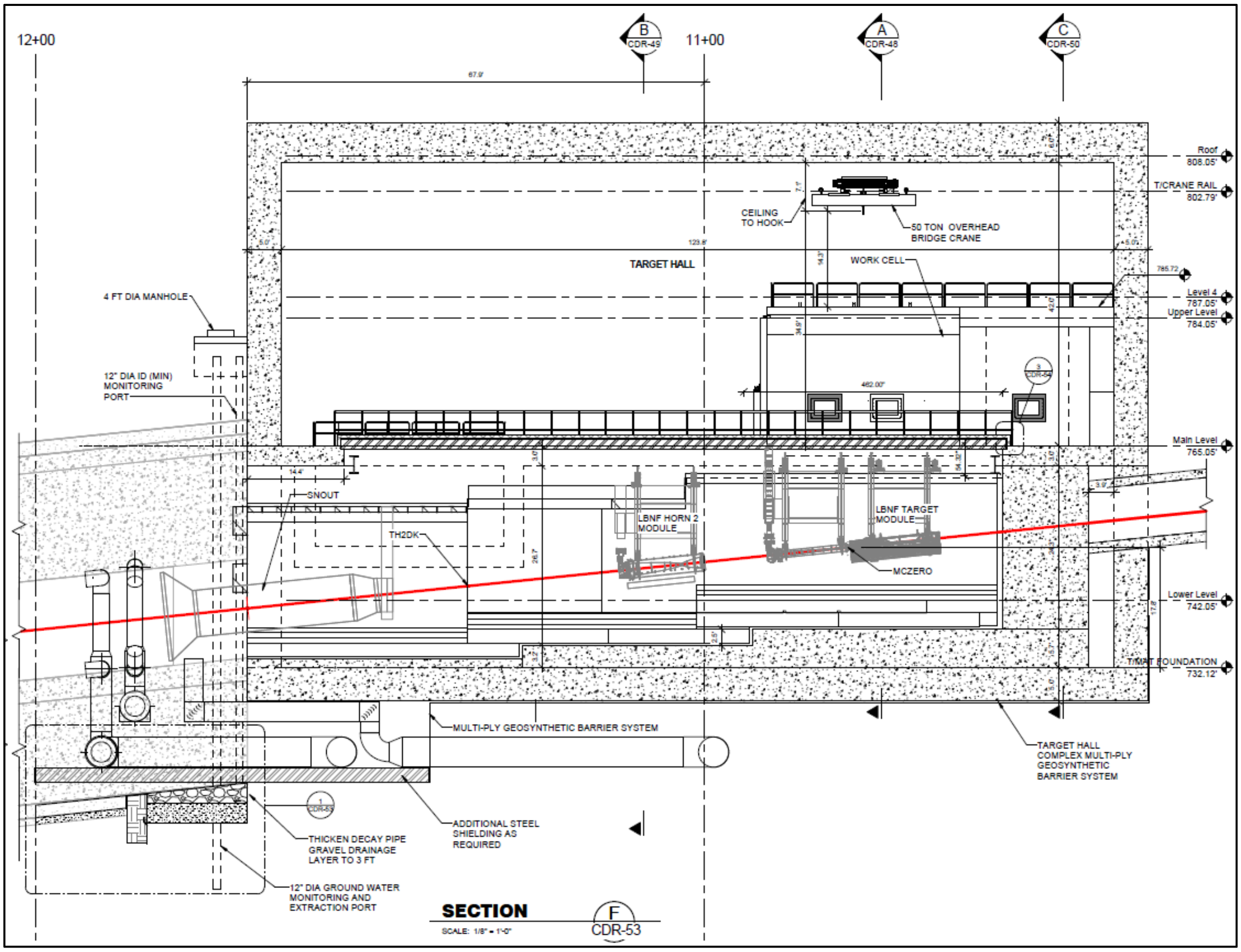

Figure 4-6: Target Hall and Target Chase Longitudinal Section

The Target Hall will have a 50-ton overhead bridge crane running the length of the hall that will be used for installing and removing target modules and horn components in the chase, as well as transporting these components to the work cell. The crane will be equipped with redundant drive systems and removable remote electronics to ensure reliance during remote handling operations. The crane will be equipped with a load cell or similar device to understand weight on crane hook, be capable of a minimum of .75 rpm for hook rotation, and have a programmable 2-axis simultaneous movements which would involve feedbacks on all crane drives. This bridge crane will also be used to install, remove and reset shielding blocks, hatch covers, as well as other equipment and components.

The cast-in-place concrete work cell (see **Figure 4-7**) will be shielded from the rest of the Target Hall for personnel protection and, will be used for both prepping new or refurbished target components.

This Conventional Facilities fit-out work will also include internal concrete masonry unit (CMU) walls, cast-in-place structural concrete walls and abutments (with the thicknesses required for shielding), the cast-in-place work cell, doors, internal stairways, and the 50-ton overhead bridge crane in the Target Hall.

The wall and ceiling thicknesses in LBNF-20 are designed for the required beam shielding. The Target Hall, including the egress labyrinth and rail transport passageway walls will be 5-ft thick cast-in-place (CIP) structural concrete walls with a 6.0-ft thick CIP structural roof for the 1.2MW beam power, upgradable to 7-ft thick for a possible future upgrade to 2.4 MW. The air handing room, RAW room, and truck bay, morgue, will have 3-ft thick CIP structural concrete walls except that any portions of all rooms adjacent to the Target Hall will have 5-ft thick CIP structural concrete walls. All other rooms will have 1-ft thick CIP structural concrete walls or as otherwise determined by structural design. The Target Hall and Air Handling Room, and Decay Pipe/target chase air ducts will be lined, on the exterior, with an air seal geomembrane, as these facilities are required to be air and water tight.

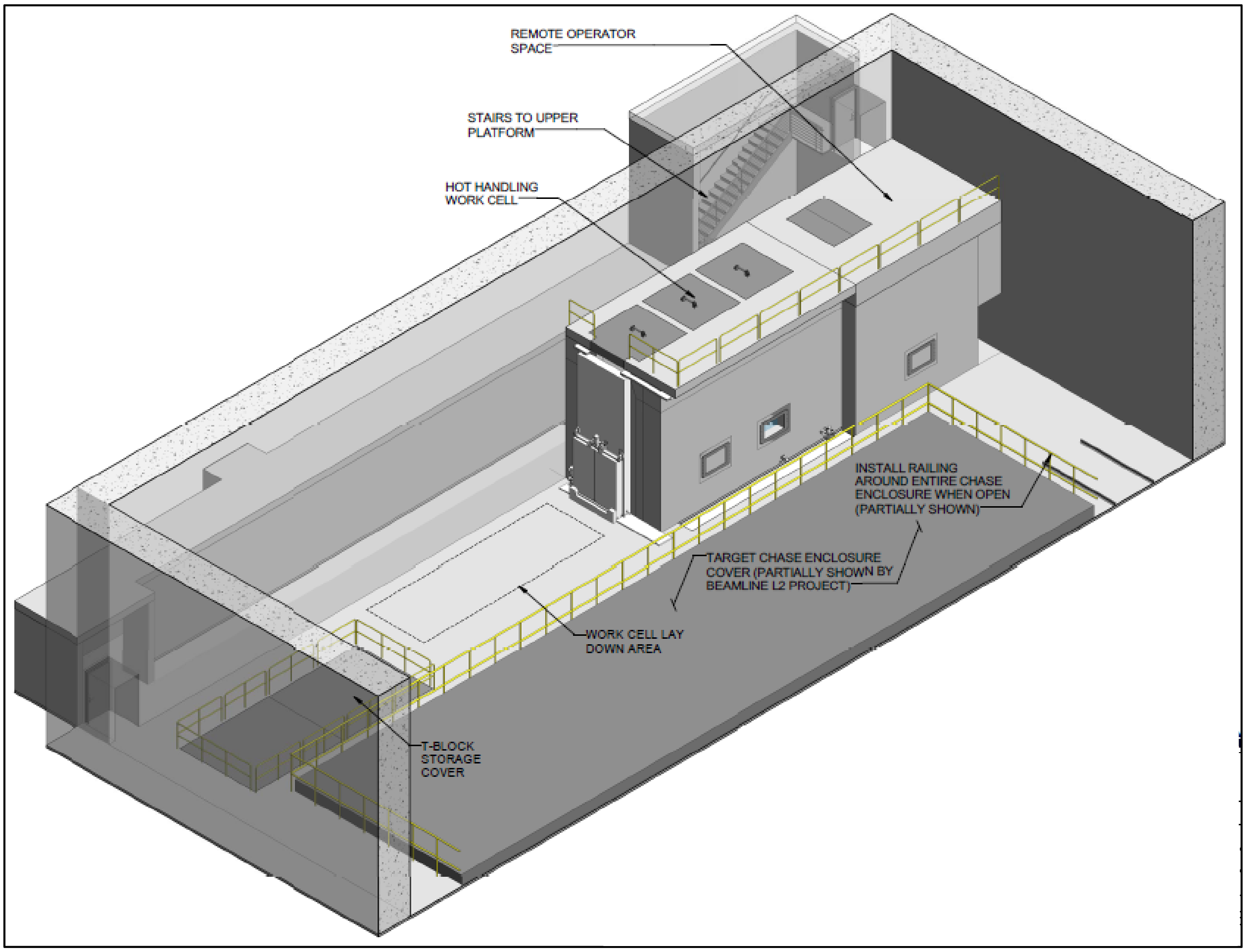

Figure 4-7: Target Hall 3-D View Showing the Hot Handling Work Cell located in the Upstream Beam-right Corner of the Target Hall. The Beamline Direction is from right-to-left in This Figure.

Adjacent to the Target Hall, on beam-left side, to the south of the Target Hall (shown in**),** on the Main Level, is the radioactive water (RAW) room, Power Supply room, Controls/Instrumentation room, and rail system egress corridor. Adjacent to these service/support rooms are the morgue/laydown area/morgue with a 50-ton bridge crane used for unloading Target Hall and target components, shielding blocks and equipment. These target components will be staged in the laydown area for eventual transport into the Target Hall using an in-the-floor rail/track system thru a shield plug door (provided by the Beamline Level 2 Project) opening during beam-off conditions. The 50-ton bridge crane will also be used to move spent or damaged components (target modules, horns, etc.) to the 6-cell side-load morgue. This 60-ft wide by 25-ft long by 13-ft high, concrete shielded, 6-cell morgue will be used for temporary storage of hot/spent/damaged targets, horns and other components before transporting these components to Fermilab's long-termstorage facility, which is not part of the LBNF Project scope, where they will reside until such a time when they can be transported off site for permanent disposal. Devices removed from the Target Hall will be transported during beam-off conditions. The laydown area will also be used to store temporary shielding blocks and related components, and will be used for Target Hall component staging. Additional spaces are provided for fixture and tool storage a shielded frisking area, and a target insert mock-up area. This area will be equipped with proper ventilation, fire protection, lighting and life safety. A restroom and the Fire/Life Safety room are also located on this Main Level.

On the Lower Level (shown in **Figure 4-5**) adjacent to Target Chase Enclosure, and below the RAW room and Power Supply room, is the Air Handling room. Adjacent to the Air Handling Room is the depressed Truck Dock with 50-ton bridge crane coverage.

Located on the Upper Level (shown in **Figure 4-7**) and above the RAW room and Power Supply room, will be the Mechanical/Electrical room, which will house the Target Complex HVAC, boiler and chiller pumps, water treatment/expansion tanks, and electrical panels and transformers.

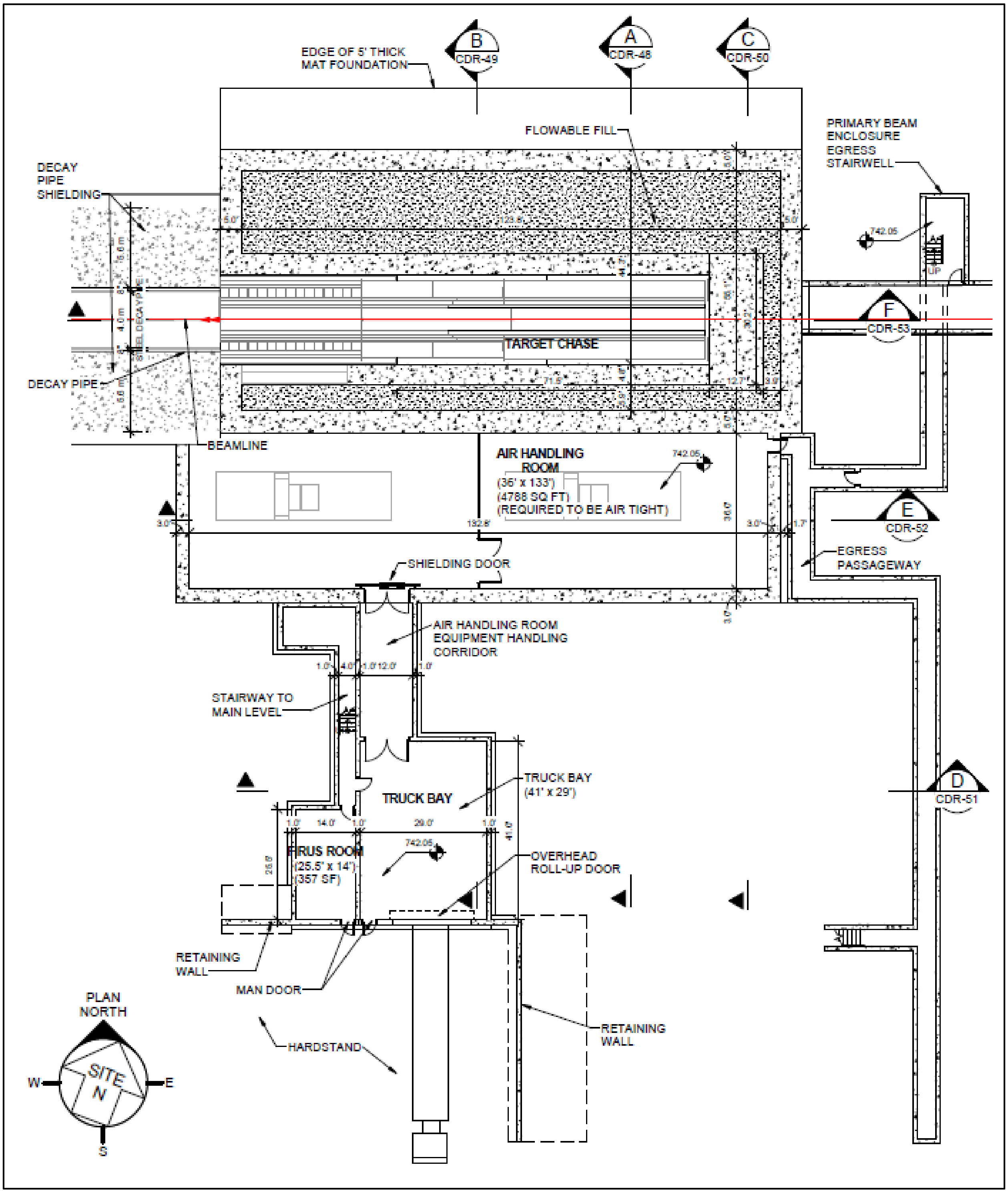

Figure 4-8: Target Complex: Lower Level Air Handling Room

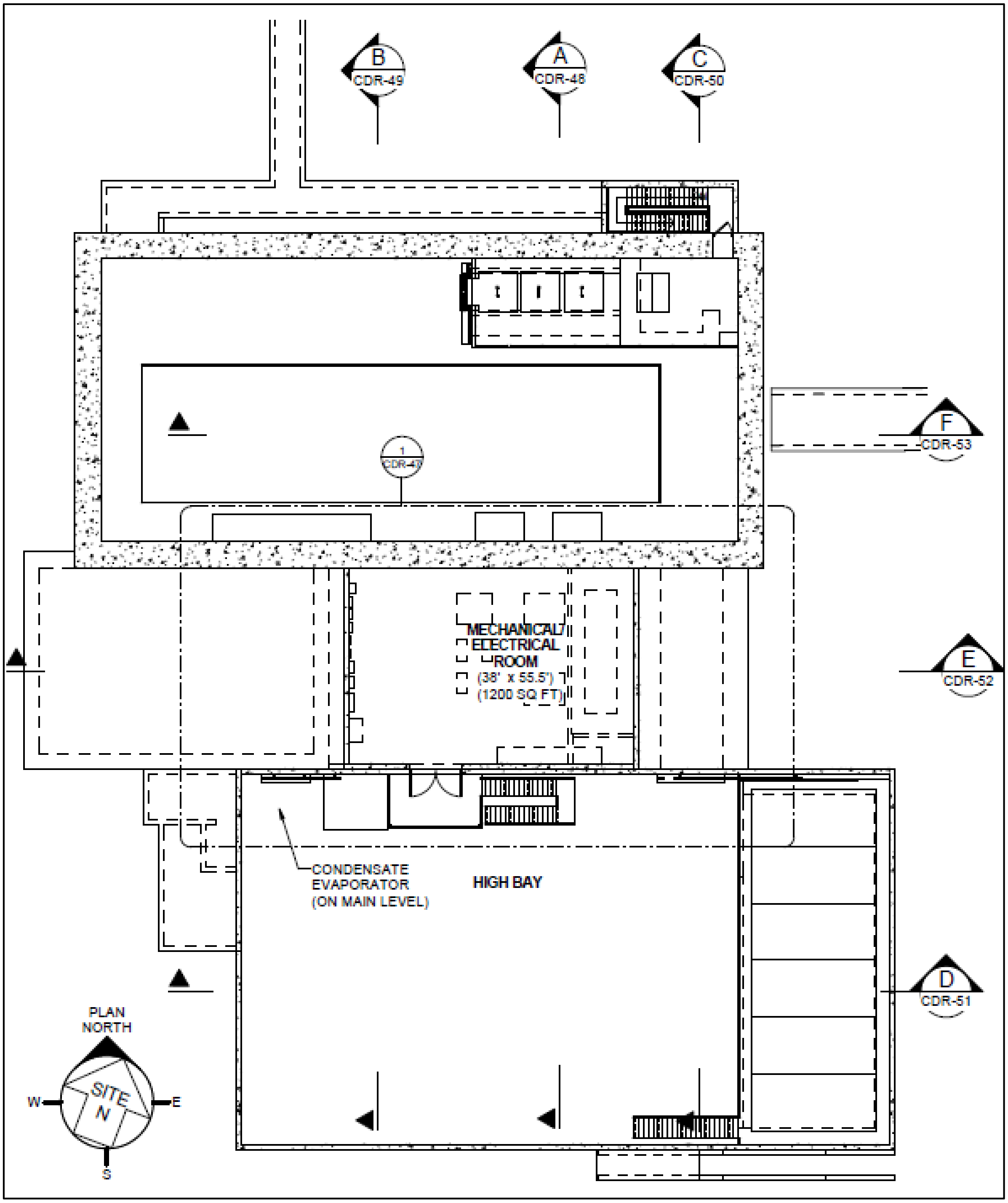

Figure 4-9: Target Complex: Upper Level, Mechanical/Electrical Room

4.2.1 Mechanical

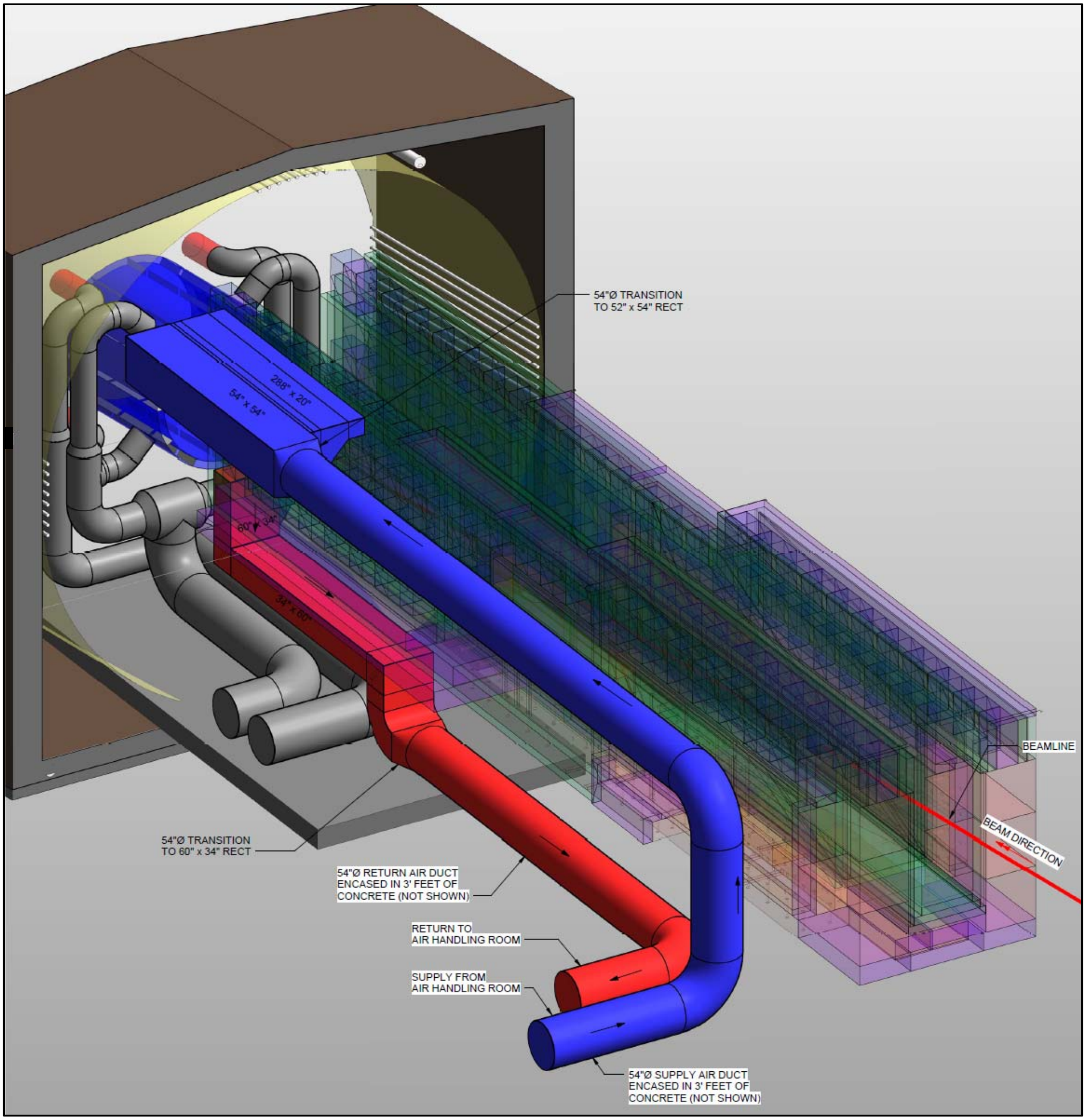

Figure 4-10: Target Chase Cooling Ducts

The entire Target Hall Complex (LBNF-20) shown in **Figure 4-4** will be conditioned to 68°F (winter) or 78°F (summer) using chilled water/hot water (CHW/HW) air handling units (AHUs). Additional HW unit heaters will be strategically located as necessary to insure winter time minimum temperatures. CHW will be provided by packaged air-cooled chillers located on the LBNF-20 hardstand. The chilled water system will contain an appropriate level of propylene glycol to prevent freezing damage to all associated components. HW will be provided by natural gas hot water heaters.

The Target Hall chase and Decay Pipe will each be served by separate 35,000-CFM (cubic feet per minute) custom built air conditioning units capable of removing heat and moisture. The supply air for both regions shall be at a temperature of 59°F+/-2°F and 12 grains +/- 2 grains of moisture per pound of dry air. The return air condition will be in the range of 90°-100°F and 30 grains of moisture per pound of dry air. The units will utilize CHW, HW desiccant wheels for dehumidification, and bag-in/bag-out High Efficiency Particle Arrestor (HEPA) air filter systems. All materials of the unit that come in contact with the airstream or condensate will be resistant to corrosion from the radio-chemically induced nitric acid that is present in the air. The AHUs will be constructed minimizing single points of failure. Ductwork to and from the target chase and to and from the Decay Pipe will be routed through passageways/ducts between the air handling room and the Target Hall and the upper end of the Decay Pipe. Duct materials will be welded steel pipe and welded steel plate constructed to Sheet Metal and Air Conditioning Contractors Association (SMACNA) 10 in water gage (wg) pressure class.

Condensate from the target chase and decay pipe AHUs will contain tritium and nitric acid. The condensate will be captured and routed to a holding tank in the AHU room. The holding tank will have secondary containment and redundant pumps (n+1) for pumping the condensate to the evaporation system in the LBNF-20 Service Building. A secondary pump (manually controlled) will be provided to pump condensate to a location in the accessible common underground area for barreling condensate (barreling provides back-up in case of evaporator system or other failure). All piping will be stainless steel or schedule-80 PVC and any piping outside the AHU room will have secondary containment (double walled).

The Target Hall air conditioning unit will be similarly designed to the Target Chase/Decay Pipe AHUs providing one air change per hour, approximately 4,000 CFM, to the Target Hall. The units will be located in the same room. The air supply and return will be ducted through the pressure equalization duct that connects the hall to the AHU room. The condensate from this unit will be routed to the condensate holding system.

Target Hall negative pressure during beam-on will be provided by an exhaust duct near the upstream end of the Target Hall. This duct exits the hall at the upstream end above the Primary Beam Enclosure. Outside of the building, but within a secured area, a fan will be provided to exhaust 6,000 CFM discharging air vertically at a height of 14 feet during beam-off for Target Hall purge. During beam-on operation the Target Hall will be maintained at a negative pressure relative to the outside air by taking an airflow of 1,077 CFM directed to the NuMI survey riser 3 (SR3) through a below-grade duct. A fan will be provided within a secured areaway at the NuMI SR3 location to direct the airflow down into the NuMI Target Hall.

The 1,200 sf Mechanical/Electrical room will house the conventional and programmatic mechanical equipment including: chilled water pumps, hot water pumps, heat exchangers, evaporators, natural gas boilers, hot water pumps, CHW/HW air handlers, and ventilation/exhaust fans. The air-cooled chillers will be located outside adjacent to the building. Target Hall controls are housed here as well as fire protection systems and plumbing for occupants. The wet pipe sprinkler system for this complex is served from the sitewide ICW network extended to the building from the existing nearby system. Any space where the application of water could constitute a radiation-related risk as determined by LBNF and the AHJ will not have sprinkler systems.

Also located in the Mechanical/Electrical room are systems dedicated to serve the Target Hall Complex. These include the CHW/HW dedicated outside air system (DOAS) AHU that provides conditioned ventilation air to the Target Hall support areas. The condensate evaporation system is located in a separate area within the truck dock. Condensate from the target chase/Decay Pipe AHU system is pumped to an elevated holding tank in the second floor room. The holding tank will have a nitric acid neutralization system to pH balance the condensate before it is evaporated. From this tank the condensate is gravity fed into evaporators. The evaporated discharge is drawn to roof mounted exhaust fans and discharged vertically.

The 3,500-sf air handing room will house the two 35,000-CFM AHUs and desiccant dryers to supply air cooling, dehumidification, and bag-in/bag-out HEPA air filter systems for the target chase and Decay Pipe. The power supply room will house the power supply cabinet and relays, and a penetration supported by a 30-in diameter steel pipe cast into the 5-ft thick concrete Target Hall wall for the power strip line.

Target Hall support areas containing the power supply, RAW skid and utility rooms will be conditioned by a locally placed chilled water/hot water AHU. Ventilation for these areas will be provided by a dedicated outside air system (DOAS) located in the service building mechanical area. The DOAS shall provide adequate personnel ventilation and dehumidified neutral air to the space for humidity control and positive pressurization with respect to the Target Hall. Maximum final space condition shall be 73°F +/- 5°F and 50% RH.

There is a scope increase option being considered to use a gas other than air (e.g., helium or nitrogen) for the target chase environment. The use of nitrogen will require the AHU serving the target hall to be fabricated with additional attention given to sealing and leakage rates. The impact of using helium or other gasses is still being explored.

4.2.2 Electrical

The electrical facilities provided at LBNF-20 Target Hall Complex, will support the requirements of the technical systems in accordance with the Fermilab standards, NEC, and other applicable codes. A conventional 13.8-kV power system will be provided for electricity service to the building systems, lighting, HVAC, crane, misc. loads, and low power technical system components such as racks and computers. The conventional systems group will provide the 13.8-kV primary electrical power to an outdoor switchgear, one for each power system. Conventional Facilities will provide a prepared space at LBNF-20 for the technical system transformers and components to be installed by the Beamline Level 2 Project. Two transformers for Conventional Facilities will be installed at LBNF-20, one to serve the building loads and the other to serve the 4.16-kV chillers. An emergency/standby power system with generator will be installed to serve critical loads for life safety and technical system components as well as the crane systems.

The building will be outfitted with panelboards, lighting, power receptacles, emergency/standby power systems and HVAC components to support the requirements of the technical systems. A main switchboard/panelboard will be installed to distribute power to large dedicated loads and sub-panelboards in local building and underground areas. Emergency/standby power will be provided at a dedicated emergency power panelboard.

The lighting system will be installed according to the lighting level required by the use of the space. All lighting installed in areas that are exposed to radiation must be protected from the radiation or be resistant to the degrading and contaminating effects of radiation on electronic components. All emergency lighting in the Target Complex will be powered from a separate remote battery powered UPS system that is completely isolated from sources of radiation. This system will remain operable until the standby generator is available to provide power or power is restored.

Power receptacles will be provided in the LBNF-20 area for use during outfitting and operation. The receptacles will be configured based on site equipment standards. All loads that require emergency/standby power will be served from the dedicated panelboard. The HVAC equipment will be served from the nearest conventional power panelboard.

Table 4-2 shows the Target Hall Complex (LBNF-20) electrical power loads, for both normal power and the standby power generators.

Table 4-2: Target Hall Complex (LBNF-20) Electrical Power Loads

Equipment Description	Normal Power (kw)	Standby Power Generators (kw)
Chiller (400 ton) (3 ea.)	1123	
Chilled water pumps [total] (2200 gpm, 100 hp) (2 ea., 1 full time)	70	
Condensate pumps (3 total)	3	
Sump pump (3 total)	3	3
Hot water pump	19	
MAU (makeup air): Support, morgue, truck dock/control rooms (3 total)	15	
MAU Desiccant	12	
RCU Desiccant (Target Hall)	203	
RCU Desiccant (other)	24	
RCU: Utility Room, Power Supply Room (2 total)	16	
AHU: service, MEP, Target Hall (3 total)	43	
Dehumidifier	5	
Exhaust fans: morgue, truck dock, Target Hall, Target Chase (4 total)	22	
Lighting & Receptacle & Experimental	233	58
50 ton bridge crane -Target Hall, morgue/laydown (2 total)	98	98
Total Connected Load	**1889**	**159**

4.2.3 Plumbing

Plumbing systems, including a restroom, are included. The wet pipe sprinkler system for this complex is served from the sitewide ICW network that is extended to the building from the existing system. Target Pile and Decay Pipe AHU cooling water is supplied from the air cooled chiller in the LBNF-20 mechanical room which is a closed-loop glycol system. Natural gas is routed to this building from the site-wide network to be used for hot water heating for domestic water and building heat.

Ground water monitoring ports are located just outside and downstream of the Target Hall to allow monitoring of any accumulating ground water beneath the Target Hall and the detection and sampling of any water penetrating the outer geomembrane barrier and into the geosynthetic water barrier system drainage layer. These ports will allow the future installation of pumps if a significant amount of water accumulates.

4.2.4 Fire Protection/Life Safety Systems

Fire protection systems are included. Egress paths for surface (service buildings) and underground facilities (tunnels and halls) have been conceptually designed to limit the travel path distances to egress shafts, stairways, and safe/fire rated corridors to the exterior and surface to a safe gathering location. See **Section 3.1.4** of this volume for a general overview of fire protection and fire life/safety requirements.

Conventional Facilities is responsible for the design, cost/scheduling and construction of these systems including the mechanical (emergency ventilation), electrical (emergency generator for lighting, ventilation, sump pumping, fire alarms, and communication), and plumbing (fire suppression/sprinkler piping and fixtures, and emergency sump pumping). Any space where the application of water could constitute a radiation-related risk as determined by LBNF and the AHJ will not have sprinkler systems.

The three-level Target Complex has several egress routes which are shown in **Figure 4-11**, **Figure 4-12,** and **Figure 4-13.**

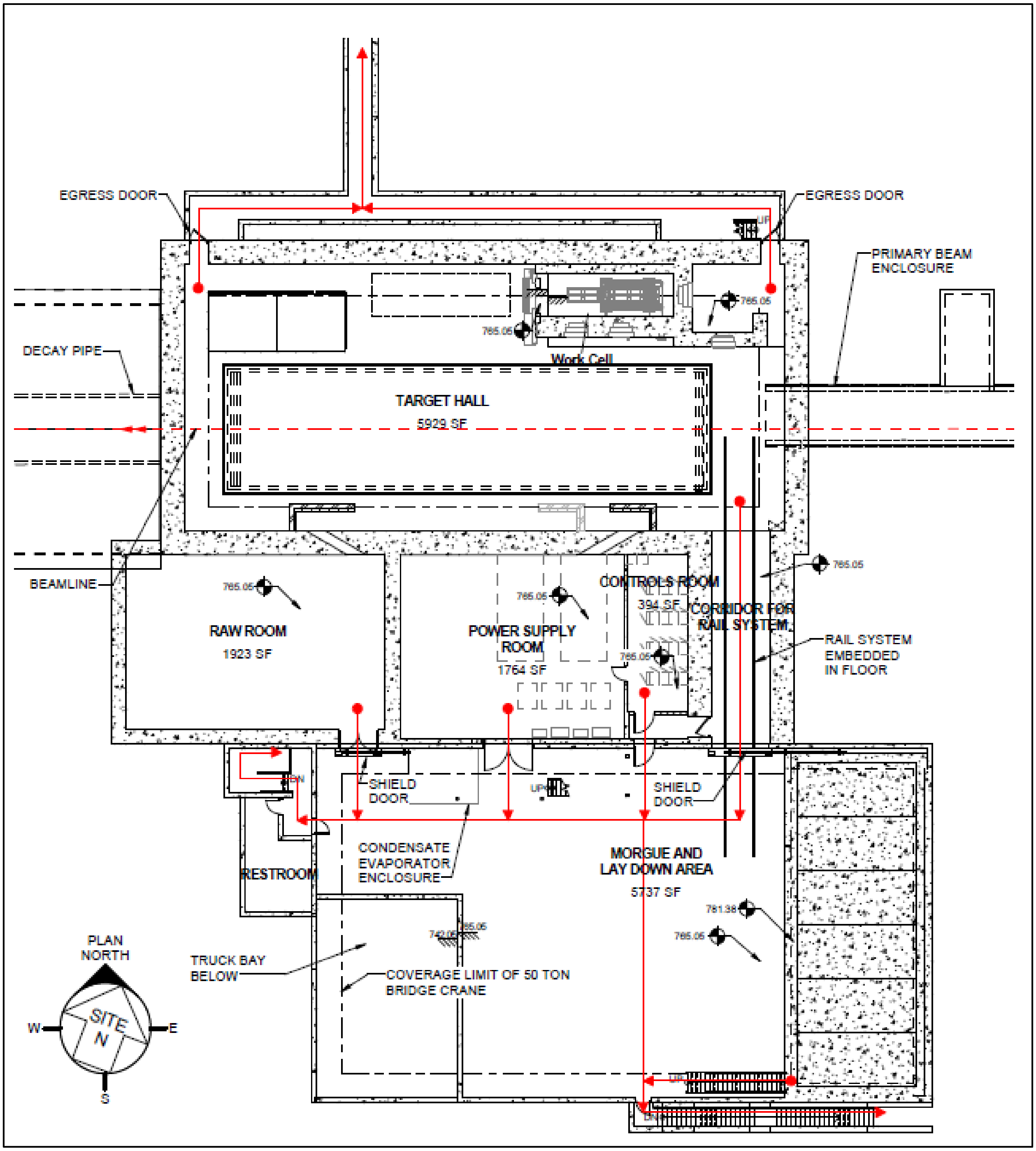

Figure 4-11: Target Complex: Main Level, Egress Routing

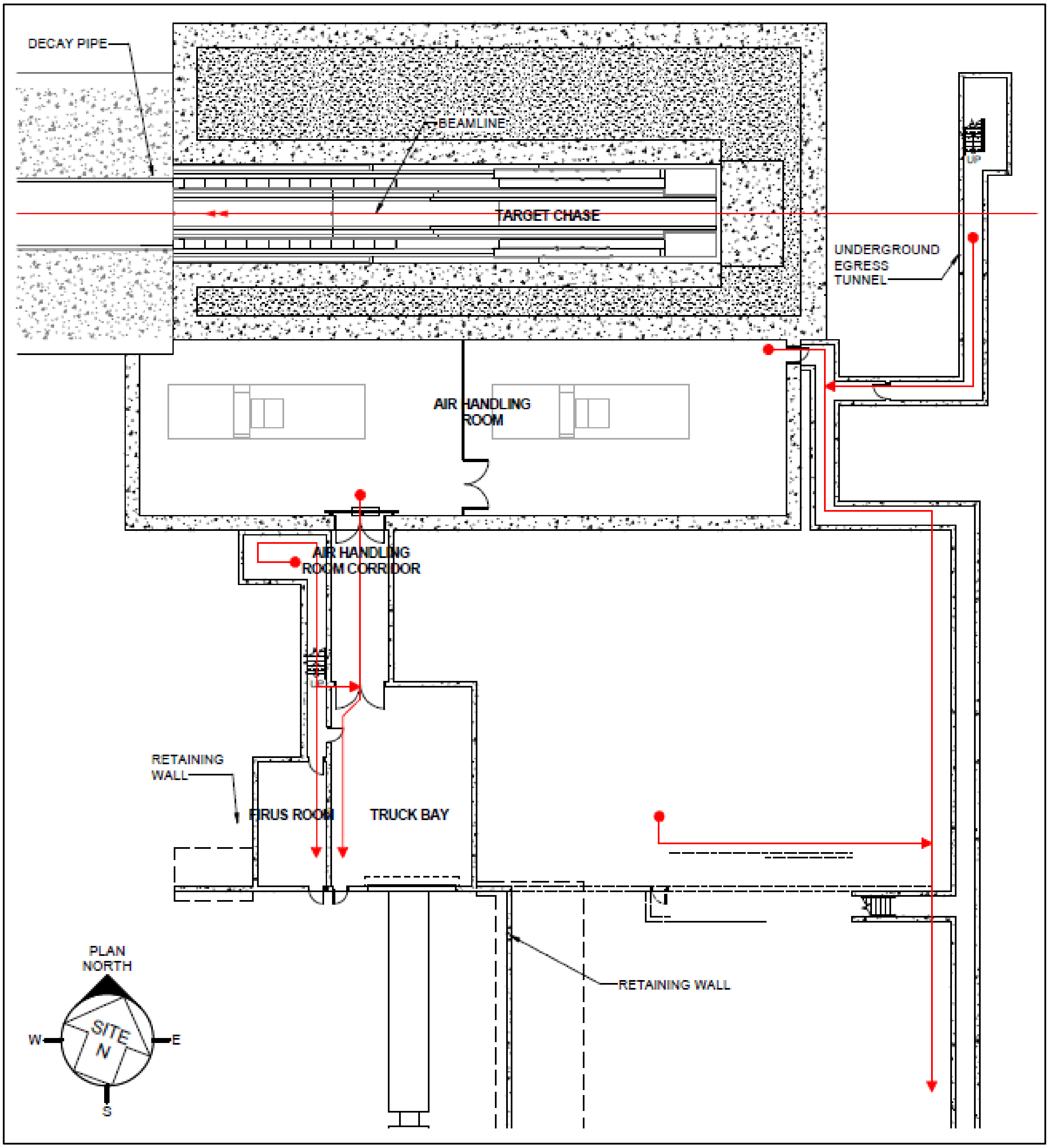

Figure 4-12: Target Complex: Lower Level, Egress Routing

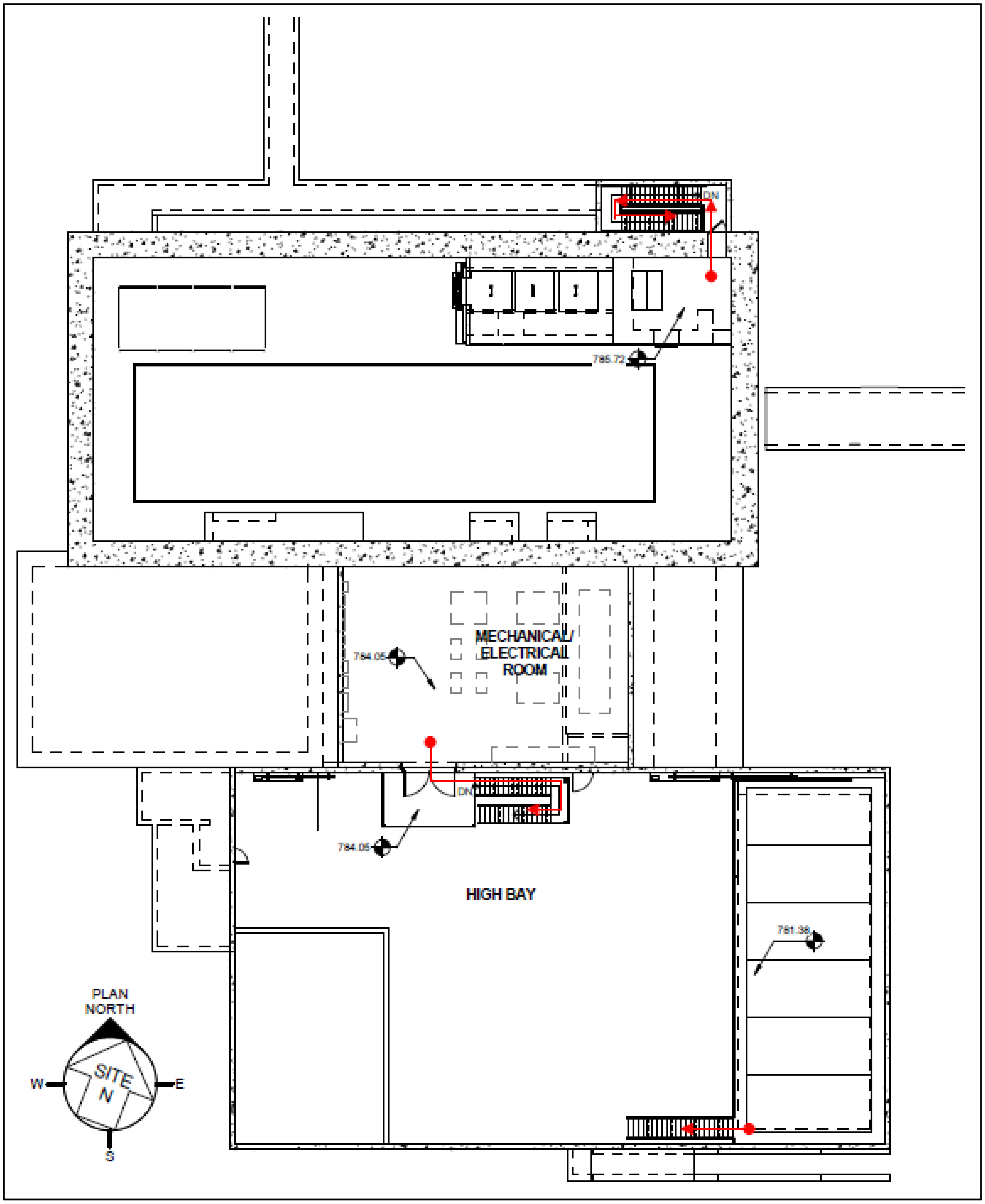

Figure 4-13: Target Complex: Upper level, Egress Routing

4.3 Absorber Service Building (LBNF-30)

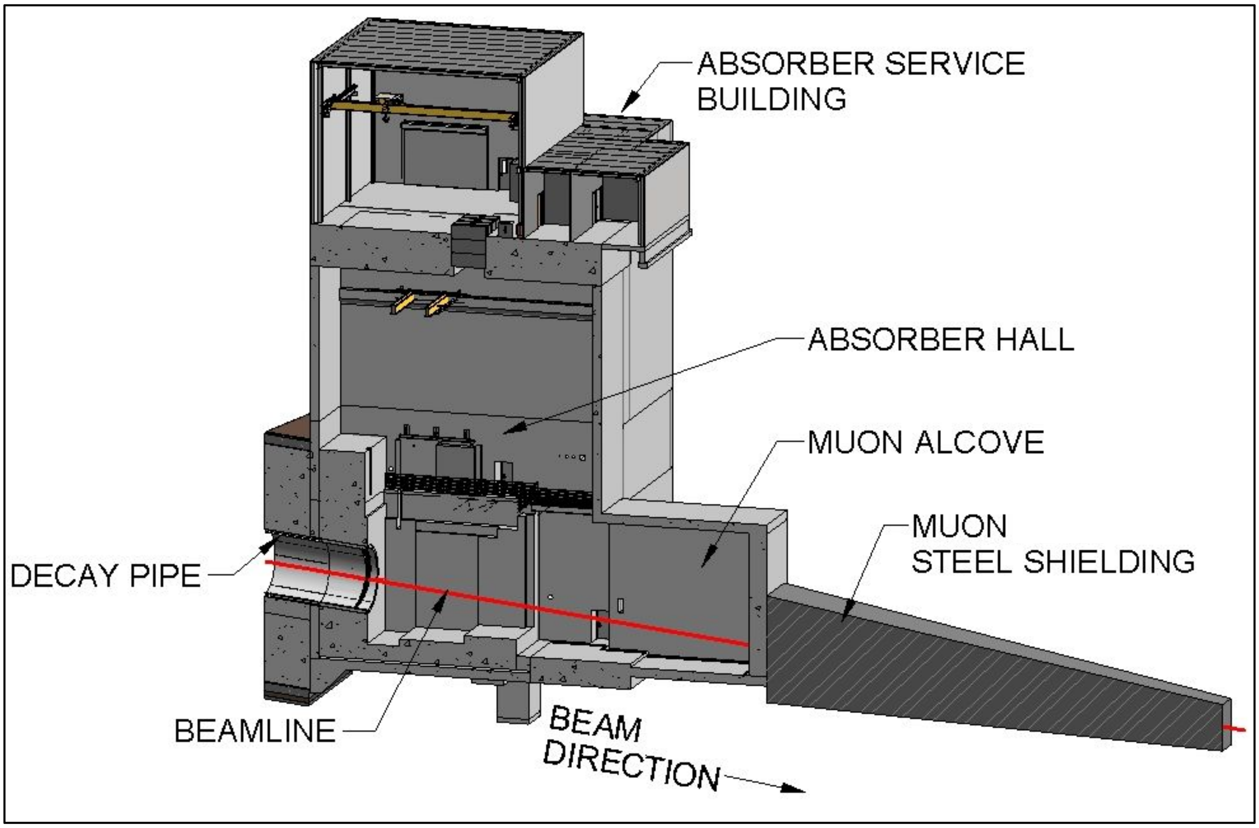

Figure 4-14: Absorber Complex Including the Absorber Service Building (LBNF-30)

The 4,300 sf Absorber Service Building (LBNF-30), shown in **Figure 4-14** consists of a 70-ft wide by 62-ft long above-grade concrete and steel-framed building with metal siding which accommodates the support equipment and provides access needed for the assembly and operation of the equipment and technical components of the Absorber Hall, Muon Alcove, and support rooms located beneath the service building floor. Personnel will access the lower levels using an elevator. Secondary egress is provided by a stairwell.

This building has a 35-ft clear crane height for the truck bay area and will house the open truck bay and laydown area. A portion of the LBNF-30 floor slab is a 9-ft thick cast-in-place concrete slab providing shielding from the Absorber Hall which lies directly underneath. A 6.5-ft wide by 17-ft long opening provides equipment direct access to the Absorber Hall and Muon Alcove 90-ft below using the 30-ton bridge crane. This opening will be filled with shielding blocks and sealed while beam is in operation. Much of the rest of the LBNF-30 floor slab overlies support rooms which are adjacent to the Absorber Hall including the Absorber Air Handling Room, Instrumentation Room, Controls Room, RAW Room.

LBNF-5 includes an instrumentation/controls room, fire/life safety room, and a mechanical equipment and utility room, including: chilled water (CHW) pumps, hot water (HW) pumps, heat exchangers, exterior air cooled chillers, natural gas boilers, hot water pumps, CHW/HW air handlers, ventilation/exhaust fans for the surface building and desiccant dryers (dehumidifiers for the Absorber

Hall, Muon Alcove, and support rooms). Utilities pass from LBNF-5 to the lower levels through a 5-ft x 10-ft equipment shaft.

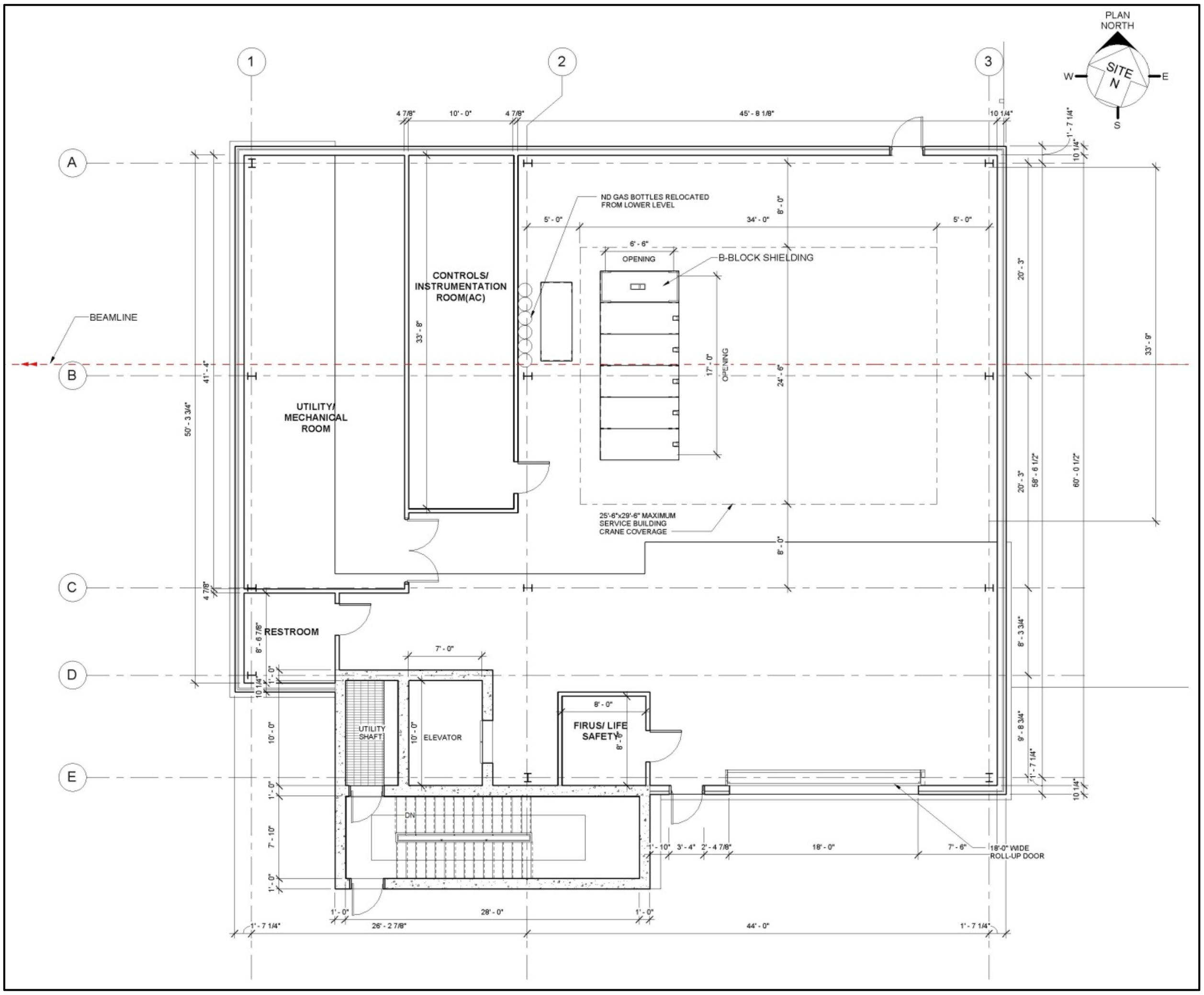

Figure 4-15: Absorber Service Building (LBNF-30) Floor Plan

4.3.1 Mechanical

The air in the Absorber Service Building (LBNF-30) will be conditioned to 68ºF (winter) and 78ºF (summer) using CHW/gas-fired AHUs. Additional gas unit heaters will be located, as necessary to ensure winter time minimum temperatures. CHW will be provided by packaged air cooled chillers located on the LBNF-30 hardstand. The chilled water system shall contain propylene glycol to prevent freeze damage to all associated components. Also located in the mechanical area are CHW/gas-fired dedicated outdoor air AHUs with desiccant dehumidification that provide dry neutral temperature ventilation air to the below grade general areas and exit passageways.

4.3.2 Electrical

The electrical facilities provided at LBNF-30 Absorber Service Building will support the requirements of the Beamline technical systems in accordance with the Fermilab standards, NEC, and other applicable codes. The building site will have one electrical service. A conventional 13.8-kV electrical power service will be provided to the building systems, lighting, HVAC, crane, miscellaneous loads, and low power technical system components such as racks and computers. A beamline technical system (pulsed power), 13.8-kV power system is not required. The Conventional Facilities scope of work will provide the 13.8-kV primary electrical power to an outdoor 600-A switchgear. Two transformers for Conventional Facilities will be installed at LBNF-30, one to serve the building loads and the other to serve the 4.16-kV chillers. An emergency/standby power system with generator will be installed to serve critical loads for life safety and technical system components. A dedicated separate emergency/standby power system will be provided for the three Absorber Hall sump pump systems.

The building will be outfitted with panelboards, lighting, power receptacles, emergency/standby power systems and HVAC components to support the requirements of the technical systems. A main switchboard/panelboard will be installed to distribute power to large dedicated loads and sub-panelboards in local building and underground areas. Emergency/standby power will be provided at a dedicated emergency power panelboard.

The lighting system will be installed according to the lighting level required by the use of the space. All lighting installed in areas that are exposed to radiation must be protected from the radiation or be resistant to the degrading and contaminating effects of radiation on electronic components. All emergency lighting in the Absorber Service Building will be powered from a separate remote battery powered UPS system that is completely isolated from sources of radiation. This system will remain operable until the standby generator is available to provide power or power is restored.

Power receptacles will be provided in the building and underground areas for use during outfitting and operation. Receptacles will be configured based on site equipment standards. All loads that require emergency/standby power will be served from the dedicated panelboard. The HVAC equipment will be served from the nearest conventional power panelboard.

Table 4-3 shows the Absorber Service Building (LBNF-30) electrical power loads, both normal power and standby power generators.

Table 4-3: Absorber Hall and Absorber Service Building (LBNF-30) Electrical Power Loads

Equipment Description	Normal Power (kw)	Standby Power Generators (kw)
Chiller (300 tons) (2 ea.)	562	
Chilled water pump (1,400 gpm, 50 hp) (2 ea., 1 full time)	37	
Condensate pump (3 total)	3	
Hot water pump	5	
Refrigerated Dehumidifier	12	
Sump pump (6 total, 4 running full time)	163	25
Manual Pumps – Decay pipe water (2 total)	31	31
Holding tank pump (2 total, 1 running full)	38	
Fan coil	1	
Elevator	37	37
AHU Surface Building	27	
AHU desiccant	6	
Dehumidifier	5	

Equipment Description	Normal Power (kw)	Standby Power Generators (kw)
Exhaust fan	2	2
Lighting & receptacle & Experimental	85	21
30-ton bridge crane	49	49
Total Connected Load	**1063**	**165**

4.3.3 Plumbing

Fire protection systems and plumbing systems, including restrooms, are included. The wet pipe sprinkler system for this complex is served from the site wide ICW network that is extended to the building from the existing system. Natural gas is routed to this building from the site-wide network to be used for hot water heating for domestic water and building heat.

4.3.4 Fire Protection/Life Safety Systems

Egress paths for surface (service buildings) and underground facilities (tunnels and halls) are designed to limit the travel path distances to egress shafts, stairways, and safe/fire rated corridors to the exterior and surface to a safe gathering location. See **Section 3.1.4** of this volume for a general overview of fire protection and fire life/safety requirements.

Conventional Facilities is responsible for the design and construction of these systems including the mechanical (emergency ventilation), electrical (emergency generator for lighting, ventilation, sump pumping, fire alarms, and communication), and plumbing (fire suppression/sprinkler piping and fixtures, and emergency sump pumping). Any space where the application of water could constitute a radiation-related risk as determined by LBNF and the AHJ will not have sprinkler systems.

4.4 Near Detector Service Building (LBNF-40)

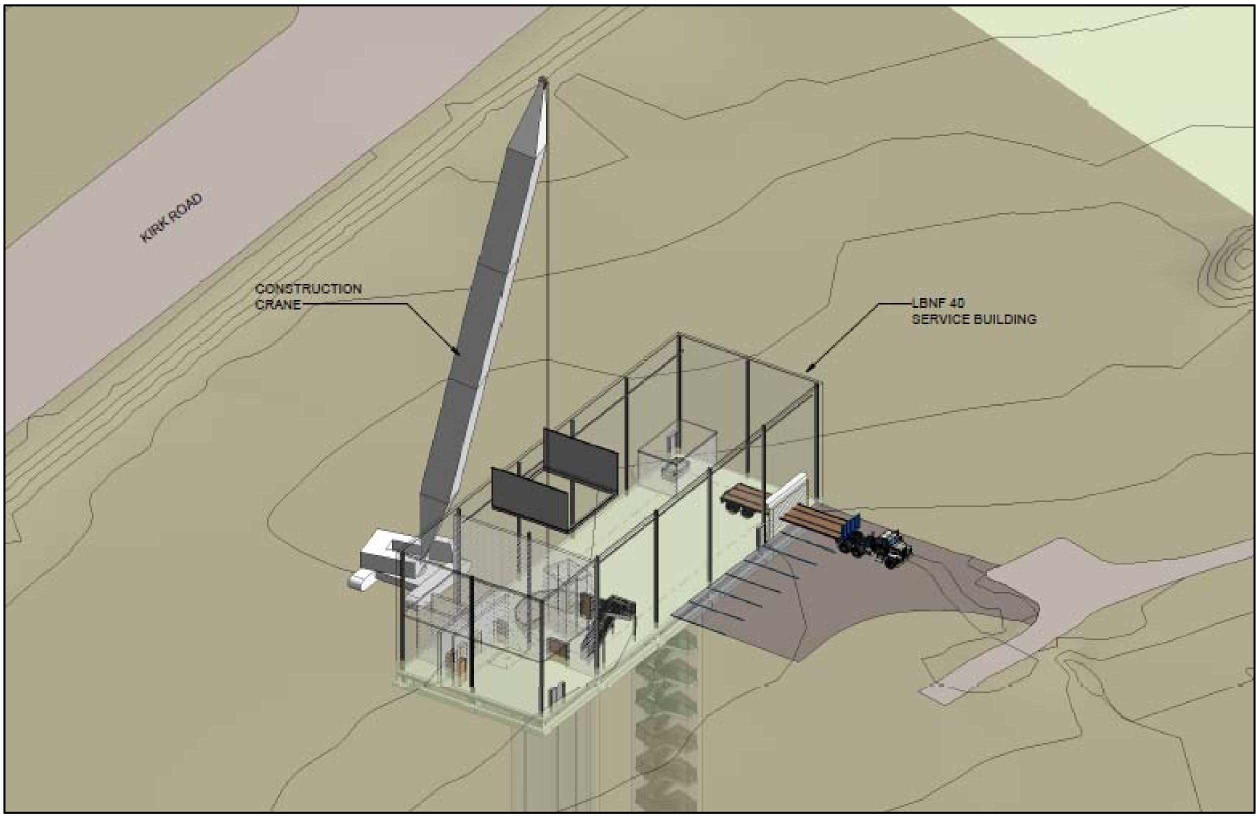

Figure 4-16: Near Detector Service Building (LBNF-40)

The near detector Service Building (LBNF-40), as shown in **Figure 4-17** is a 45-ft wide by 136-ft long by 42-ft high grade-level building. It will be used to house the support equipment and truck bay/lay down area needed for the assembly and operation of the equipment and technical components for the near detector Hall and support rooms. The truck bay/staging area portion of the building has a 35-ft interior clear ceiling height.

Also included in this building are the mechanical/electrical rooms, fire/life safety room, domestic water/meter room, and restroom. The mechanical room will house the shaft mechanicals, chilled water pumps, heat exchangers, exterior air cooled chillers, natural gas boilers, hot water pumps, CHW/HW air handlers, ventilation/exhaust fans for the surface building and desiccant dryers (dehumidifiers) for the near detector Hall and support rooms.

The truck bay is provided for equipment to be unloaded using the 15-ton overhead bridge crane. Equipment and detector components will be lowered down the 22-ft diameter shaft to the near detector Hall approximately 210 ft below grade. This equipment can then be moved, using carts or portable hoists, where required. Because the initial detector installation and possible future removal are isolated events, the building crane capacity is not designed for these infrequent loads. Instead, a removable service building roof hatch cover over the 22-ft diameter shaft will be required for initial installation and future removal or replacement of near detector Hall components by use of a rented 200-ton crawler crane.

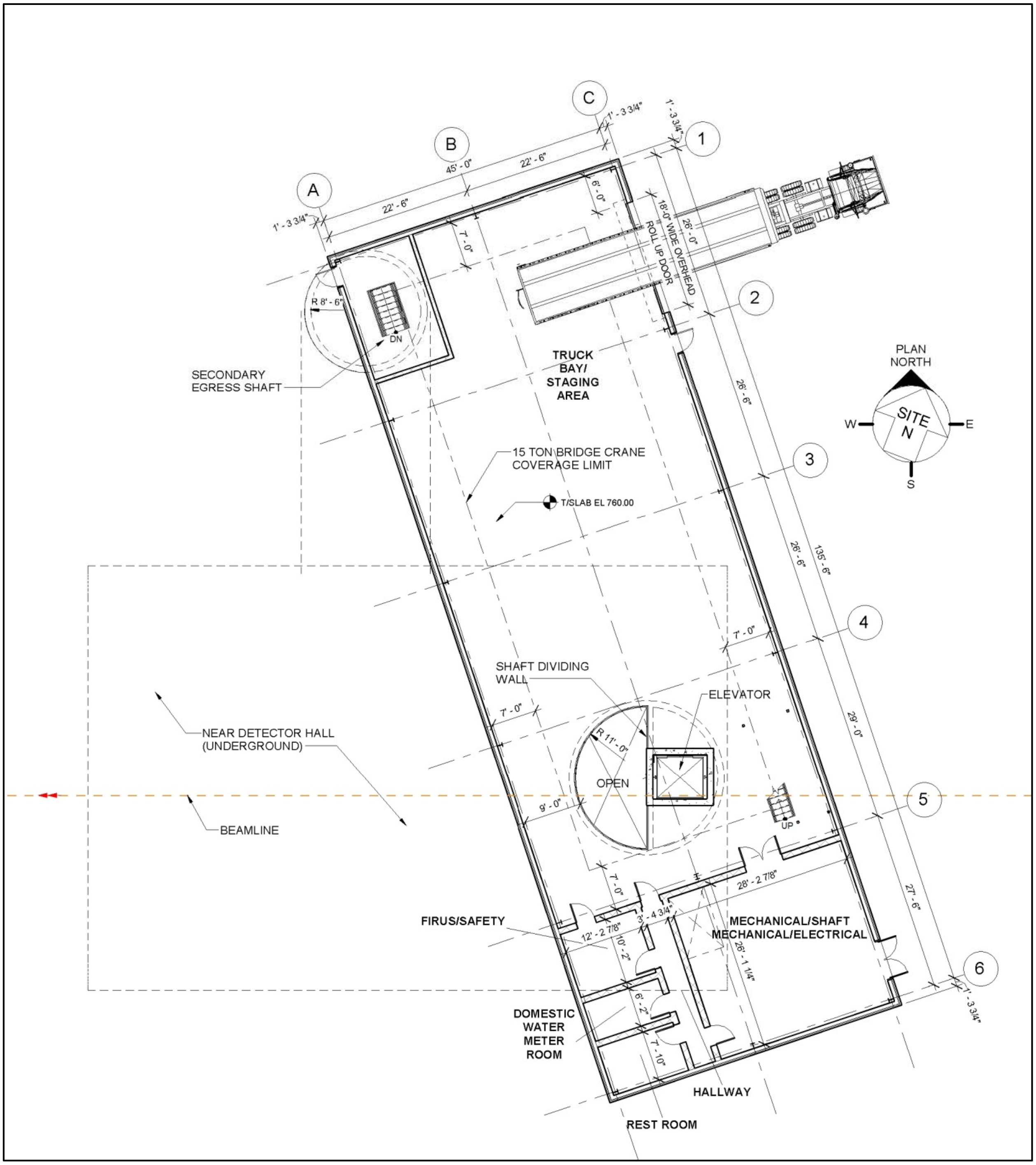

Figure 4-17: Near Detector Service Building (LBNF-40) Floor Plan

Due to its proximity to Kirk Road and the adjacent residential area west of Kirk Road, the LBNF near detector Service Building will be visible and will be architecturally appropriate for the surroundings. The building façade is planned to consist of a steel frame with brick and metal siding on a cast-in-place concrete foundation. A landscape embankment or other screening mechanism is being considered between the construction/building site and Kirk Road to shield the neighbors from construction noise and to minimize the visual impact of the building.

4.4.1 Mechanical

The entire near detector Service Building (LBNF-40) will be conditioned to 68ºF (winter) and 78ºF (summer) using CHW/gas-fired AHUs. Additional gas-fired unit heaters will be located, as necessary to ensure winter time minimum temperatures. CHW will be provided by packaged air cooled chillers located on the LBNF-40 hardstand. The chilled water system will contain propylene glycol to prevent freeze damage to all associated components. Also located in the mechanical area are CHW/gas-fired dedicated outdoor air AHUs with desiccant dehumidification that provide dry neutral temperature ventilation air to the below grade general areas and exit passageways.

4.4.2 Electrical

The electrical facilities provided at LBNF-40 near detector Service Building will support the requirements of the technical systems in accordance with the Fermilab standards, NEC, and other applicable codes. The building site will have one electrical service. A conventional 13.8-kV power system will be provided for electricity service to the building systems, lighting, HVAC, crane, miscellaneous loads, and low power technical system components such as racks and computers. A technical system (pulsed power), 13.8-kV power system is not required and will not be provided. The Conventional Facilities scope of work will provide the 13.8-kV primary electrical power to an outdoor 600-A switchgear. Two transformers for Conventional Facilities will be installed at LBNF-40, one to serve the building loads and the other to serve the 4.16-kV chillers. An emergency/standby power system with generator will be installed to serve critical loads for life safety and detector technical system components.

The building will be outfitted with panelboards, lighting, power receptacles, emergency/standby power systems and HVAC components to support the requirements of the technical systems. A main switchboard/panelboard will be installed to distribute power to large dedicated loads and sub-panelboards in the building and tunnel areas. Emergency/standby power will be provided at a dedicated emergency power panelboard.

The lighting system will be installed according to the lighting level required by the users of the space. All emergency lighting in the underground detector enclosure will be powered from a separate remote battery powered UPS system. This system will remain operable until the standby generator is available to provide power or power is restored.

Power receptacles will be provided in the building and tunnel for use during outfitting and operation. The receptacles will be configured based on site equipment standards. All loads that require emergency/standby power will be served from the dedicated panelboard. The HVAC equipment will be served from the nearest conventional power panelboard.

Table 4-4 shows the near detector Service Building (LBNF-40) and near detector Hall electrical power loads for both Normal Power and the Standby Power Generators.

Table 4-4: Near Detector Hall and Near Detector Service Building (LBNF-40) Electrical Power Loads

Equipment Description	Normal Power (kw)	Standby Power Generators (kw)
Chiller (300 tons) (2 ea.)	243	
Chilled water pump (700 gpm, 25 hp) (2 ea., 1 full time)	19	
Hot water pump	5	
Fan coil (2 total)	4	
AHU desiccants (2 total)	11	
AHU (2 total)	27	
Elevator	37	37
Exhaust fan (2 total)	17	17
Sump pump (2 total)	38	38
Lighting & Receptacle & Experimental	85	21
15-ton bridge crane – near detector Hall, LBNF-40 (2 total)	310	310
Total Connected Load	**795**	**423**

The significant electrical loads in the near detector Hall will be served directly from 480-volt panelboards located in the underground facility. The significant 480-volt loads include the sump pumping system, HVAC systems, 15-ton crane, and the 120/208 panelboards for controls and instrumentation.

The near detector technology is evolving and not well defined at this time. Electrical service size and power distribution for the selected near detector technology and its heat rejection system will be developed during preliminary design. Detector power estimates as high as 3 MW have been discussed but are not shown in **Table 4-4**.

4.4.3 Plumbing

Fire protection systems, plumbing, and a restroom for occupants are included. The wet pipe sprinkler system for this complex is served from the LBNF-40 domestic water system. The domestic water and sanitary sewer services will be supplied from the city of Batavia water and SS mains located on the west side of Kirk Road. Natural gas is routed to this building from the site-wide network to be used for hot water heating for domestic water and building heat. A connection to the ICW system will be provided to allow the capture of water discharged from the Detector Hall sumps.

4.4.4 Fire Protection/Life Safety Systems

Egress paths for surface (service buildings) and underground facilities (tunnels and halls) have been conceptually designed to limit the travel path distances to egress shafts, stairways, and safe/fire rated corridors to the exterior and surface to a safe gathering location.

See **Section 3.1.4** of this volume for a general overview of fire protection and fire life/safety requirements.

Conventional Facilities is responsible for the design and construction of these systems including the mechanical (emergency ventilation), electrical (emergency generator for lighting, ventilation, sump pumping, fire alarms, and communication), and plumbing (fire suppression/sprinkler piping and fixtures, and emergency sump pumping).

Emergency egress routes for the near detector Service Building (LBNF-40) will be provided to allow exiting through a choice of two single exterior doors or an exterior double door.

5 NEW UNDERGROUND STRUCTURES

The LBNF Conventional Facilities at the Near Site will include new underground structures including the Beamline Extraction Enclosure and Primary Beam Enclosure, the Decay Pipe, and the Absorber Hall and Support Rooms, and the near detector Hall and Support Rooms. This section provides additional details regarding these facilities.

5.1 Beamline Extraction Enclosure and Primary Beam Enclosure

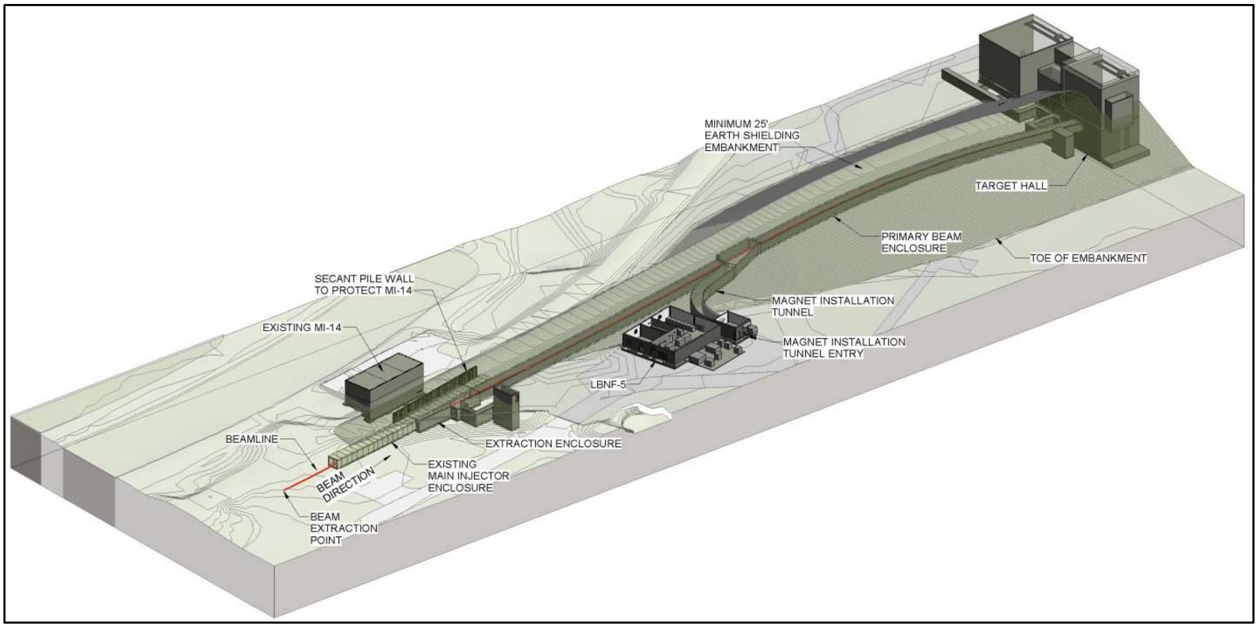

Figure 5-1: Overview of Beamline Extraction Enclosure and Primary Beam Enclosure

The first underground functional area is the Beamline Extraction Enclosure and Primary Beam Enclosure. This area, consisting of the upstream Beamline Extraction Enclosure and the downstream Primary Beam Enclosure allows the beam extraction from the Main Injector and transported 328 m (1078 ft) to the LBNF Target Complex (to the target). An overview of these regions is shown in **Figure 5-1**. The construction of the upstream portion of this area will consist of a cut-and-cover below-grade section. The downstream portion of this area includes a transition from the below-grade section to an above-grade section located within an embankment. Some of these areas will be constructed using cast-in-place concrete sections and other areas will be pre-cast concrete enclosure sections. The Beamline Extraction Enclosure and Primary Beam Enclosure are shown in aerial view in **Figure 5-2.**

The Beamline Extraction Enclosure portion, shown in plan view in **Figure 5-3**, begins at the existing Main Injector near MI-10, and extends approximately 84 ft where it transitions to the typical Primary Beam Enclosure section.

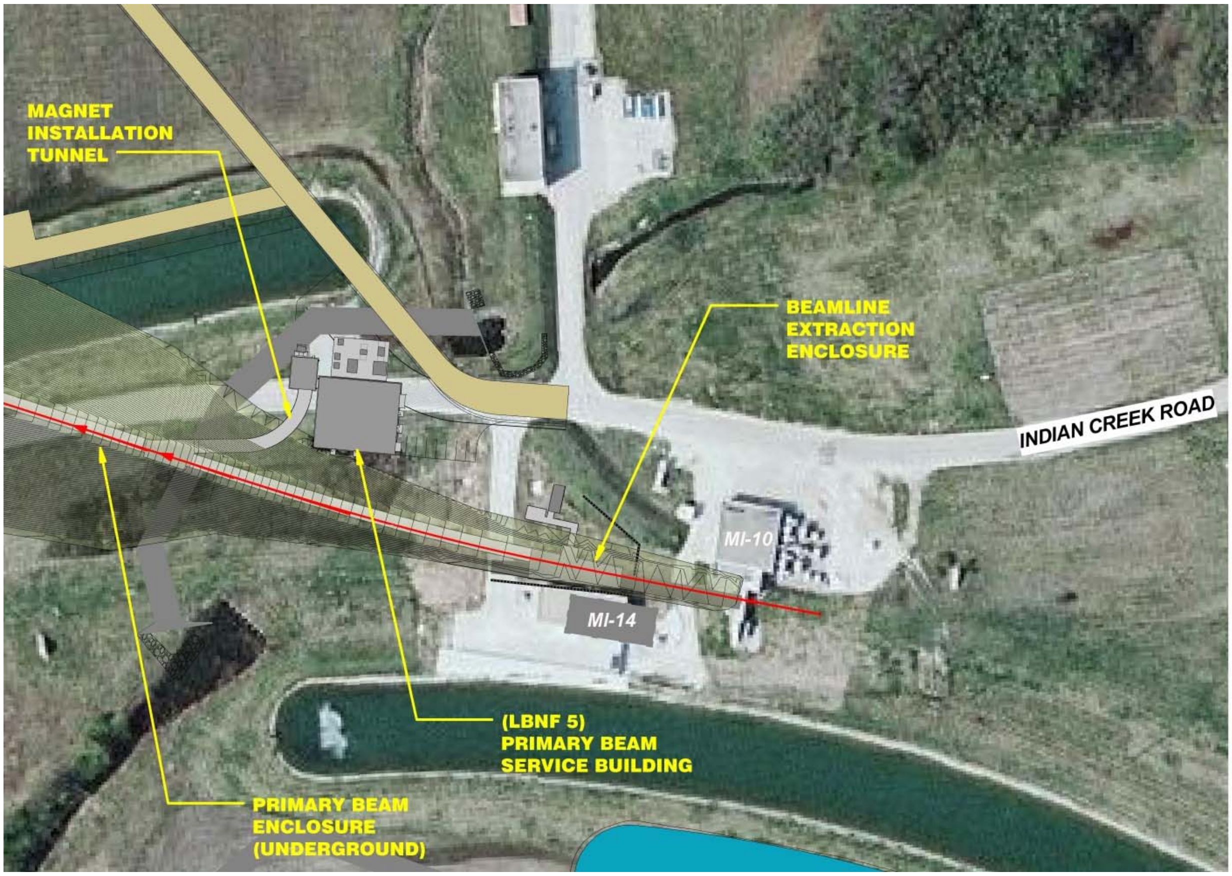

Figure 5-2: Beamline Extraction Enclosure and Primary Beam Enclosure – Aerial View

An open cut braced excavation will expose the MI Enclosure and protect the existing MI-14 building. **Figure 5-4** shows a section through the cast in place (CIP) structural concrete cocoon Extraction Enclosure near Station 2+00. The cocoon will be constructed around the MI Enclosure to protect it from the loading of the additional soil shielding fill required for LBNF and to add structural integrity to the MI Enclosure before the side wall of the MI Enclosure is slotted to permit the beam transport pipe to pass from the MI into the LBNF Primary Beam Enclosure. This opening will allow the installation of 12-in diameter steel beamline transport pipe to divert beam to the Primary Beam Enclosure.

The excavated area will be backfilled with light weight flowable concrete fill. Secant pile braced excavation walls will be constructed to protect the existing MiniBooNE beamline enclosure. A slurry trench will be constructed to protect the Main Injector Enclosure from lateral loading and settlement resulting from the influence of the 60-foot high embankment.

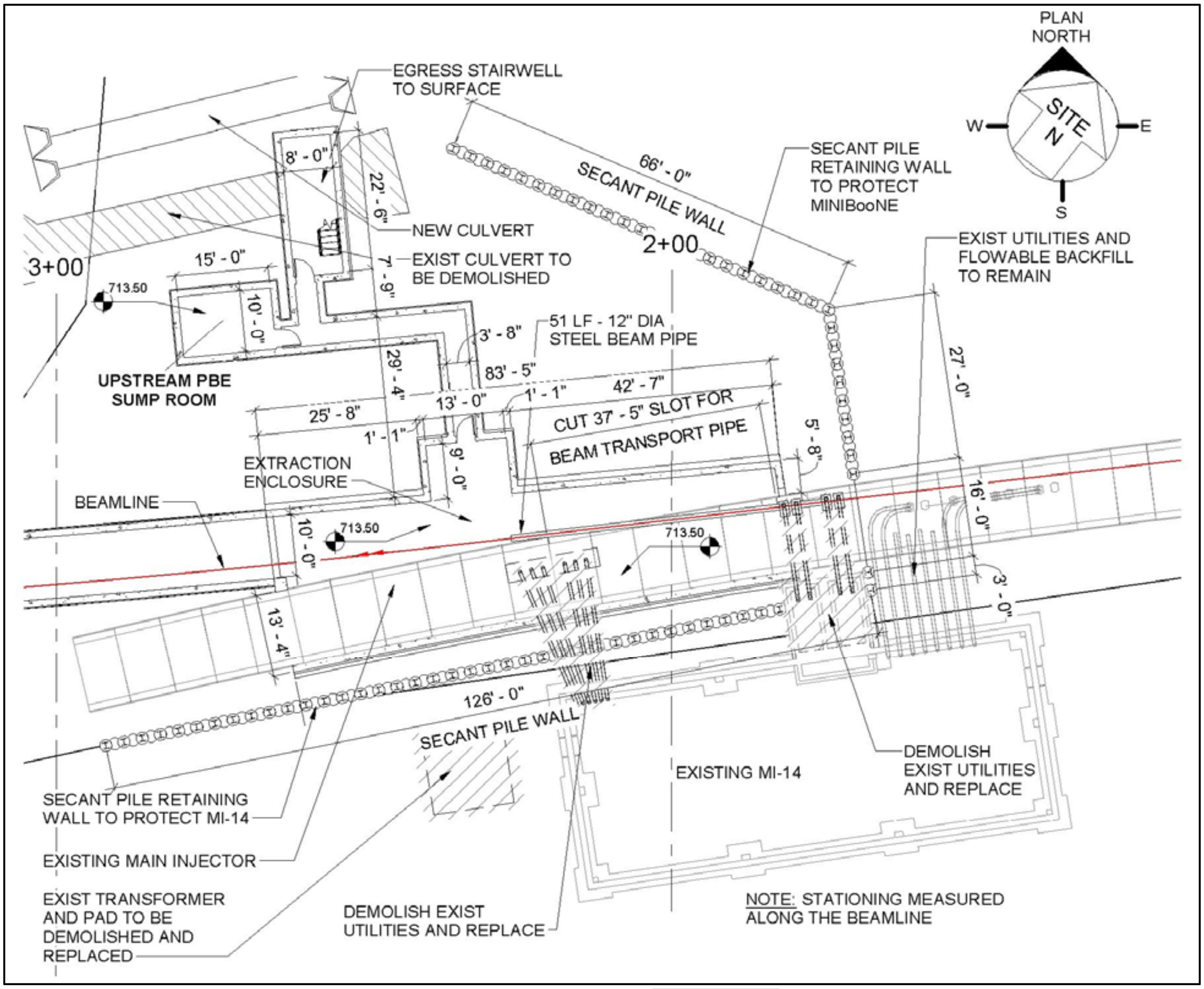

Figure 5-3: Beamline Extraction Enclosure. Refer to Figure 5-4 for a Section Near Station 2+00

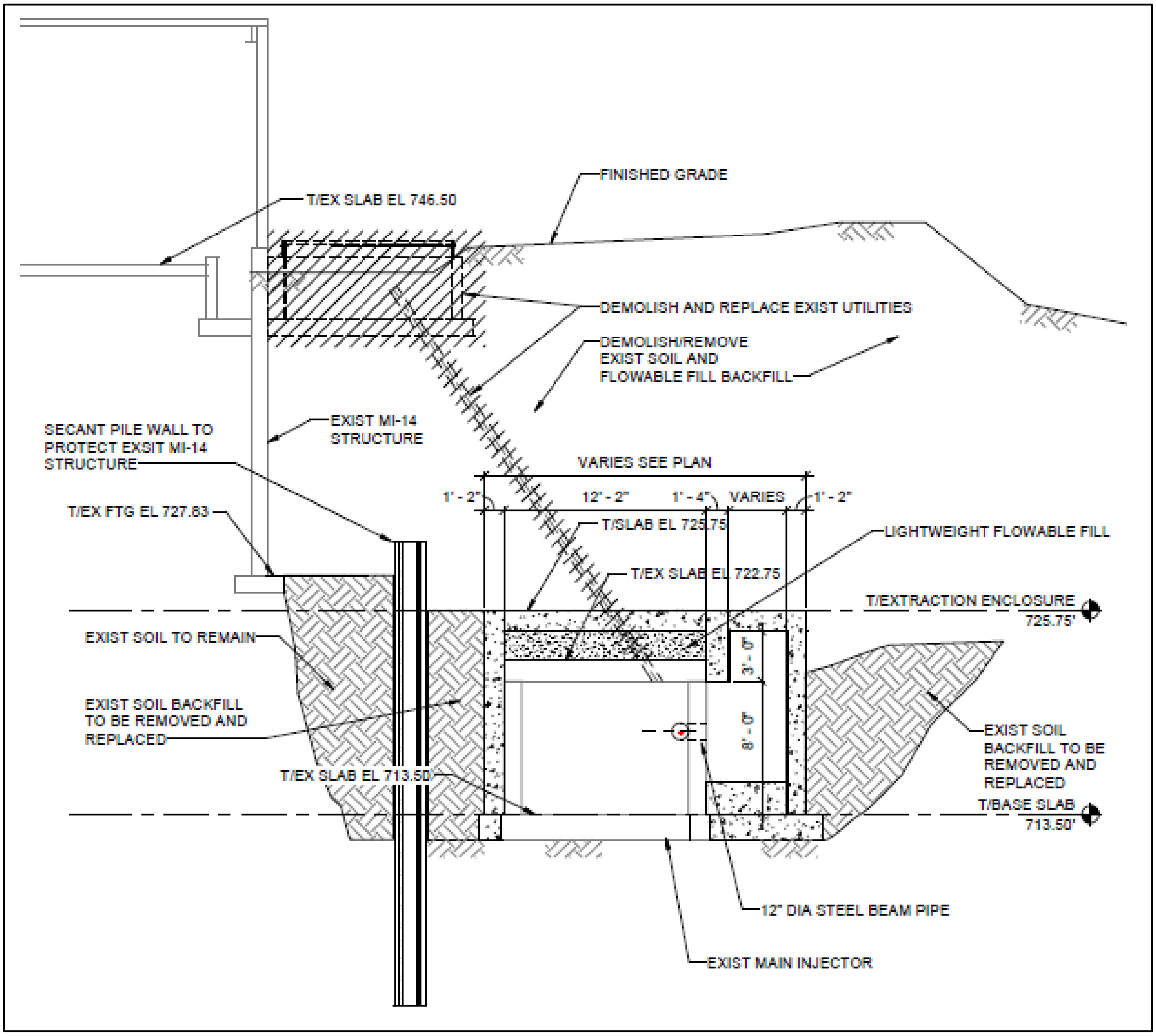

Figure 5-4: Beamline Extraction Enclosure Section View at MI-14 Showing the Structural Concrete Cocoon Around the MI Enclosure

The 778-ft long Primary Beam Enclosure will start at the end of the extraction enclosure and continue along a 15% incline into and through the above-grade embankment, and then at a 10% decline to and through the Target Hall. The depth of the enclosure will be 33 ft from the top of the soil shielding fill to the invert/floor. This will provide a minimum of 25 ft of soil and concrete shielding (measured radially outward from the center of the beamline) for both the 1.2-MW and 2.4-MW beam power levels. The apex of the embankment over the Primary Beam Enclosure will be approximately 60 ft above existing grade. With the required minimum 25 ft of soil shielding, the apex of the beamline will be about 30 ft above existing grade as shown in **Figure 1-1.**

Figure 5-5 shows a cross section in the soil overburden which will be constructed in a cut-and-cover excavation from STA 2+68 to STA 10+43. From about STA 5+00, the Primary Beam Enclosure will be constructed in the embankment with the required 25 ft of soil shielding cover up to STA 10+43. The enclosure will be a combination of cast-in-place concrete where construction constraints require, as well as precast concrete inverted U-shaped sections constructed on a cast-in-place concrete slab. **Figure 5-5** also graphically depicts the required minimum 25 ft of soil shielding.

The Primary Beam Enclosure has interior dimensions measuring 10 ft wide and 8 ft high. These dimensions match that of the existing Main Injector enclosure. **Figure 5-6** shows a typical cross section of the Primary Beam Enclosure that shows the locations of the technical components and technical and conventional utilities.

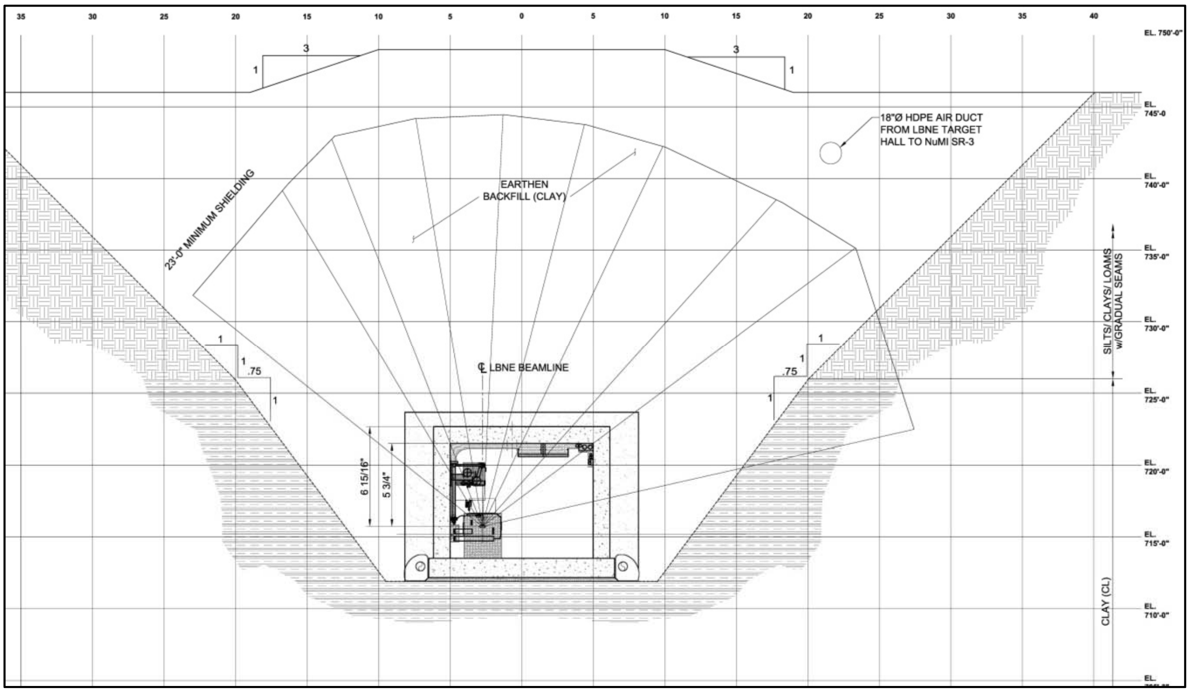

Figure 5-5: Primary Beam Enclosure Section View (Shown as Constructed in Open Cut Trench)

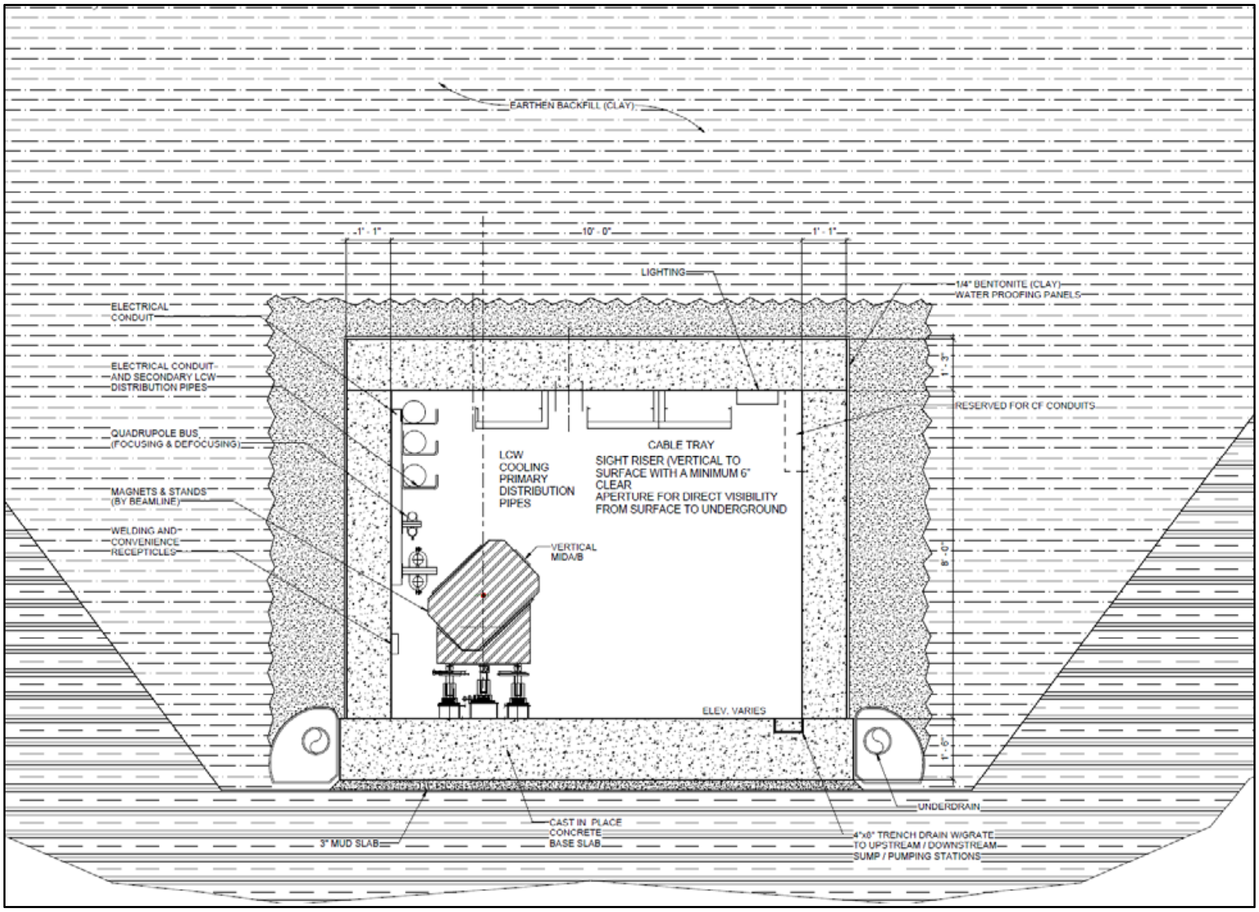

Figure 5-6: Primary Beam Enclosure Showing Technical Components, Typical Enclosure Section

Due to the construction of this facility over the existing Main Injector (MI) Road, Cooling Pond F, and associate existing underground and overhead utilities, rerouting of the road and utilities, plus construction of a new cooling pond will be required.

Site work for the construction of the engineered embankment, the Primary Beam Enclosure, and the Target Complex (LBNF-20) includes the re-routing of Main Injector Road, which is shown in **Figure 5-7**. Existing underground utilities, including electrical power and communications duct banks were identified in this area and must also be re-routed around the embankment. The portion of underground work from the extraction enclosure to STA 4+50 will be completed during a scheduled Main Injector shutdown.

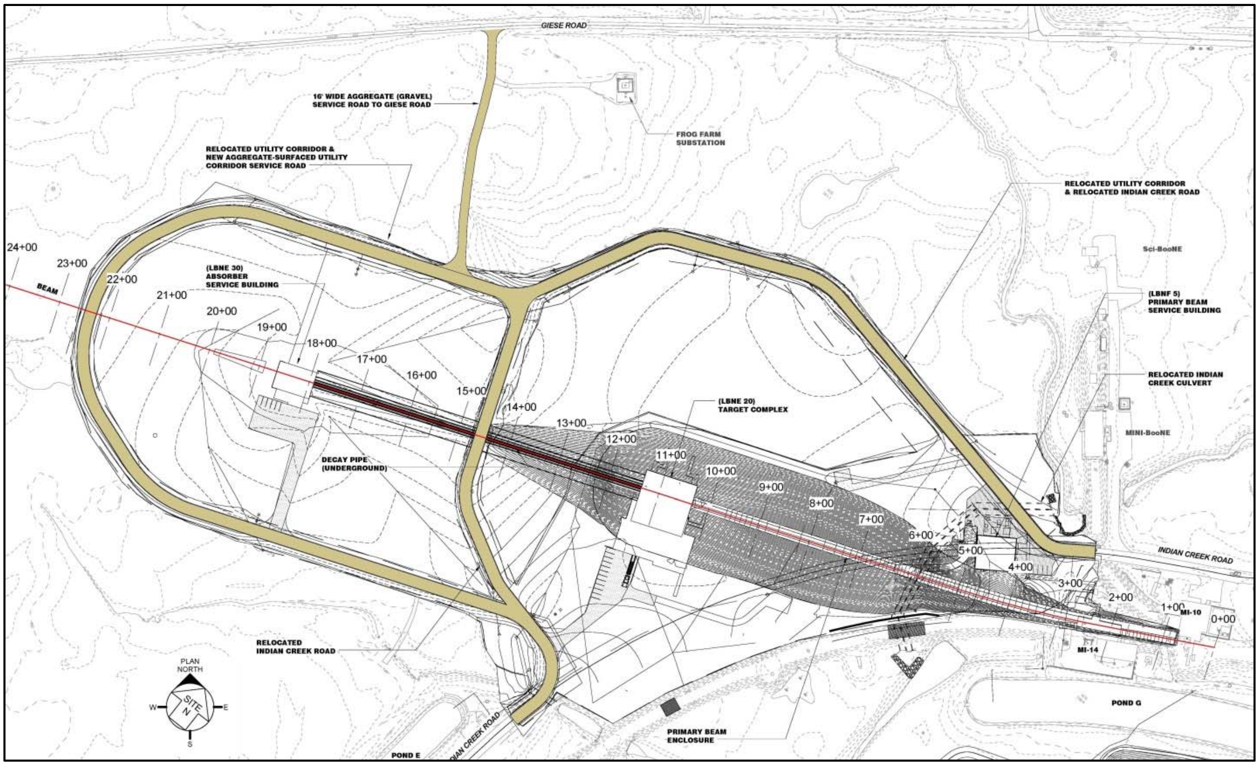

Figure 5-7: Plan View Re-route of MI Road

5.1.1 Mechanical

Ventilation air is drawn from the Target Hall support area and the Extraction Enclosure region then exhausted through a vent shaft at the high mid-point of the enclosure.

5.1.2 Electrical

The Primary Beam Enclosure will be outfitted with electrical facilities to support the small programmatic equipment and periodic maintenance tasks. Conventional Facilities will provide lighting and electrical facilities to support all mechanical systems, small programmatic loads, and power receptacles needed for maintenance. The power will be delivered from the nearest surface building to 480-V panels in the enclosure. Dry type transformers with 208/120-V panelboards will be provided in the enclosure for power devices and receptacles.

Lighting and emergency signage will be incandescent with an alternate power sources. Batteries and electronic ballasts will not be allowed in areas that are subject to radiation due to the degradation of electronics and the possible creation of mixed waste.

5.1.3 Plumbing

The Primary Beam Enclosure is equipped with a floor trench drain and exterior underdrains, a fire department stand pipe and hose connection fire suppression system, as well as LCW cooling lines, and power and control lines for the equipment. Site risers to the surface, will be constructed at the required spacing along the Primary Beam Enclosure, and will provide a minimum 6-in clear aperture for magnet/beam alignment. Enclosure underdrain water collection is provided at both low ends of the enclosure. These duplex sump pumps discharge to grade where they will flow into existing ditches or cooling ponds.

5.1.4 Fire Protection/Life Safety Systems

Conventional Facilities is responsible for the design, cost/scheduling, and construction of the fire protection and life safety systems including the mechanical (emergency ventilation), electrical (emergency generator for lighting, ventilation, and sump pumping, fire alarms, and communication), and plumbing (fire suppression/sprinkler piping and fixtures, and emergency sump pumping). Any space where the application of water could constitute a radiation-related risk as determined by LBNF and the AHJ will not have sprinkler systems.

Egress paths from underground facilities (tunnels and halls) are designed to limit the travel path distances to egress shafts, stairways, and safe/fire rated corridors to the surface. See **Section 3.1.4** of this volume for a general overview of fire protection and fire life/safety requirements. The Primary Beam Enclosure is designed to have three egress routes which are shown in **Figure 5-8.** From the approximate midpoint of the tunnel, the egress route requires traveling approximately 183-ft downstream to the safe rated corridor adjacent to the beam-right Rail System/Egress corridor and morgue which then exits to the exterior and surface to a safe gathering location.

From the same midpoint of the Primary Beam Enclosure, the egress route requires traveling approximately 250-feet upstream to the magnet installation tunnel and access building to the exterior, or upstream of the magnet installation tunnel, to the safe/fire rated egress stair that is approximately 370 feet away near the extraction enclosure, allowing access to the surface and the designated safe gathering area.

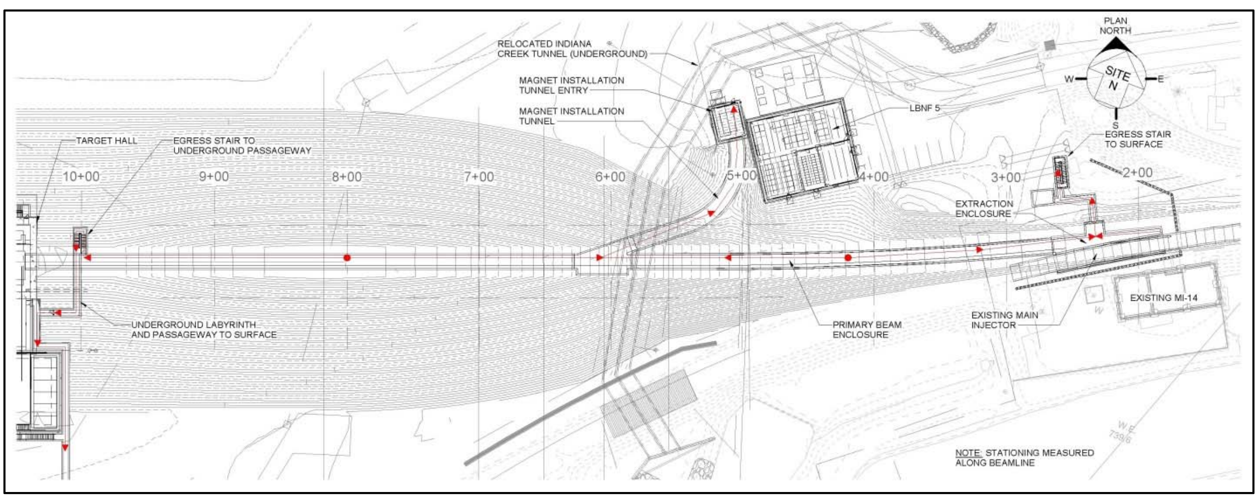

Figure 5-8: Primary Beam Enclosure Egress Routes

5.2 Decay Pipe

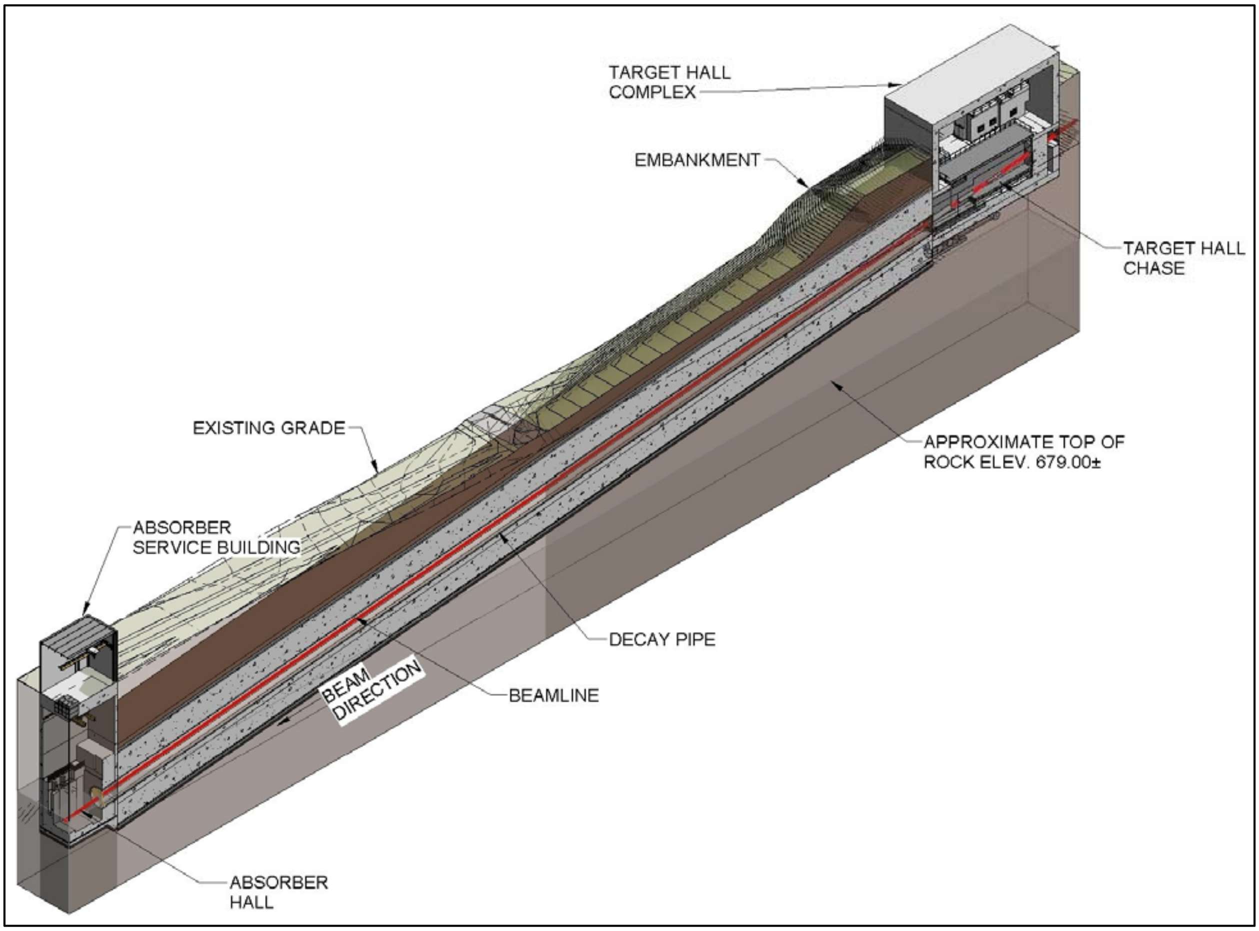

Figure 5-9: Longitudinal Section through the Decay Pipe

The LBNF Decay Pipe (longitudinal section shown in **Figure 5-9**; cross section shown in **Figure 5-11**) begins at the downstream end of the target chase/Target Hall and continues 636 ft (194m) at a decline of approximately 10% to the Absorber Hall, which is approximately 95 ft below grade.

The Decay Pipe consists of two concentric steel pipes; the inner pipe is a 13 ft-2 in (4-m) diameter pipe and the outer pipe is a 14 ft-5 in (4.4-m) diameter pipe. The walls of both pipes are ½-inch thick. The outer pipe is surrounded by 18 ft-4.5 in (5.6-m) of cast-in-place concrete shielding.

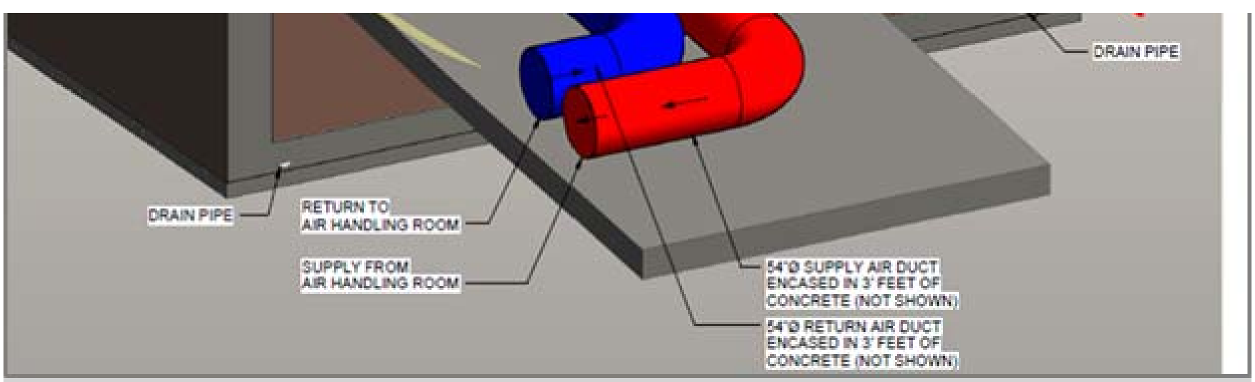

Figure 5-10 is a 12-in diameter gasketed concrete or HDPE pipe (cast into the Decay Pipe concrete shielding backfill) air duct connection from the interior of the Absorber to the Target Hall. This will allow a negative air pressure to be maintained in the Absorber Hall.

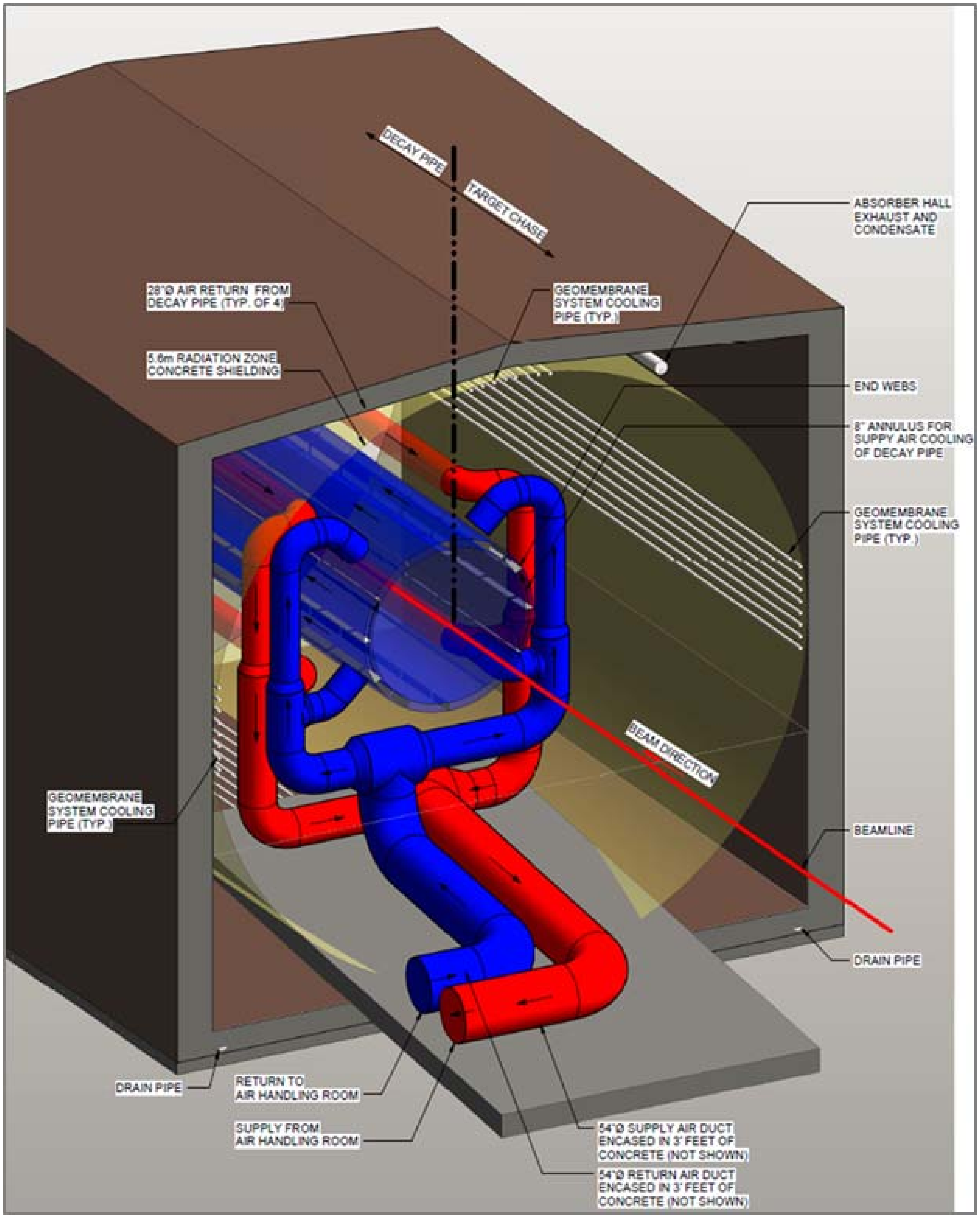

Figure 5-10: Decay Pipe Cooling Ducts

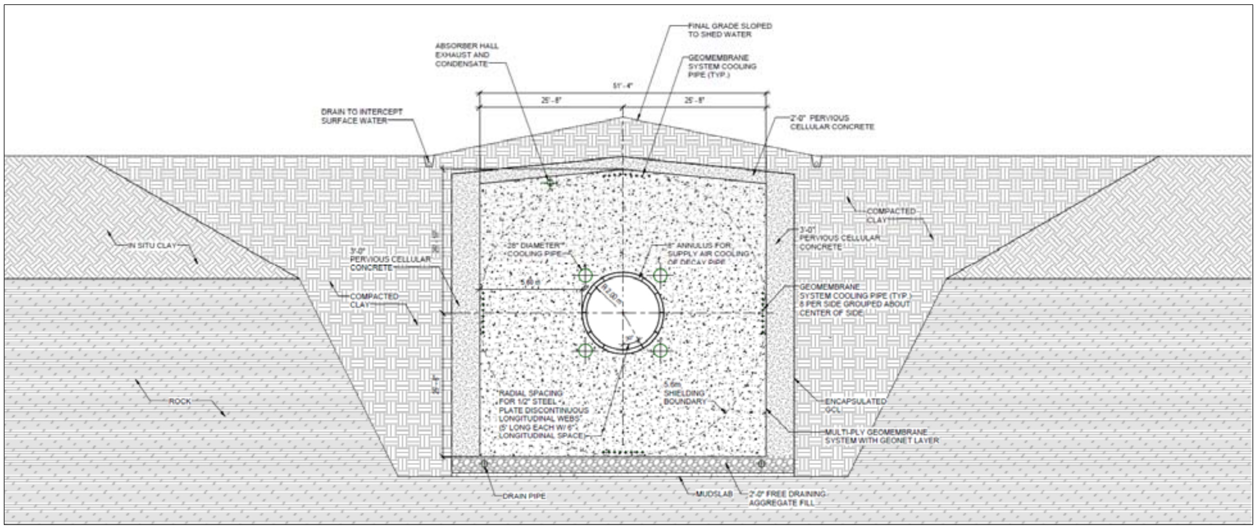

Figure 5-11: Decay Pipe Cross Section

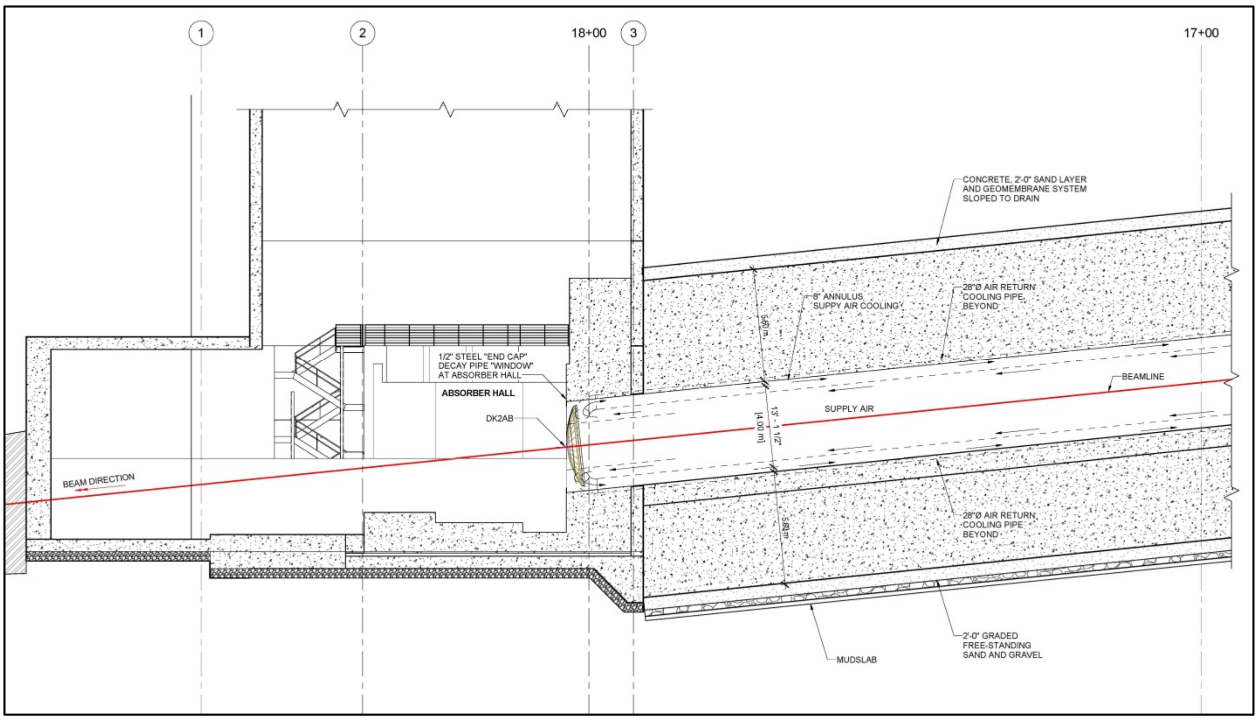

Figure 5-12: Longitudinal Section of the Decay Pipe at Absorber Hall

5.2.1 Decay Region Geosynthetic Barrier System

A multi-ply geosynthetic barrier system, as shown in **Figure 5-13** and **Figure 5-14** will surround the Decay Pipe structure to protect the decay region from potential groundwater infiltration and also to protect the surrounding groundwater from any possible tritiated water being created and escaping from the decay region. The use of the geosynthetic system in the decay region is a unique application of standard and common practices and materials used for decades in the landfill industry. This system will create a three-dimensional barrier system between the decay region and the environment.

The proposed geosynthetic barrier system concept includes an encapsulated geosynthetic clay liner surrounding a several-feet-thick drainage region constructed of free-draining porous cellular concrete that surrounds an inner multi-ply geosynthetic barrier in contact with the decay pipe shielding concrete. The inner multi-ply system will incorporate a minimum of one membrane barrier and a geonet leak detection layer placed on the inside of the membrane barrier.

A secondary cooling pipe system consisting of approximately 32 – 3-in diameter pipes located along the perimeter of the decay pipe shielding concrete can be employed using a one-pass air system to provide additional cooling if the geosynthetic barrier system temperature rises above acceptable levels.

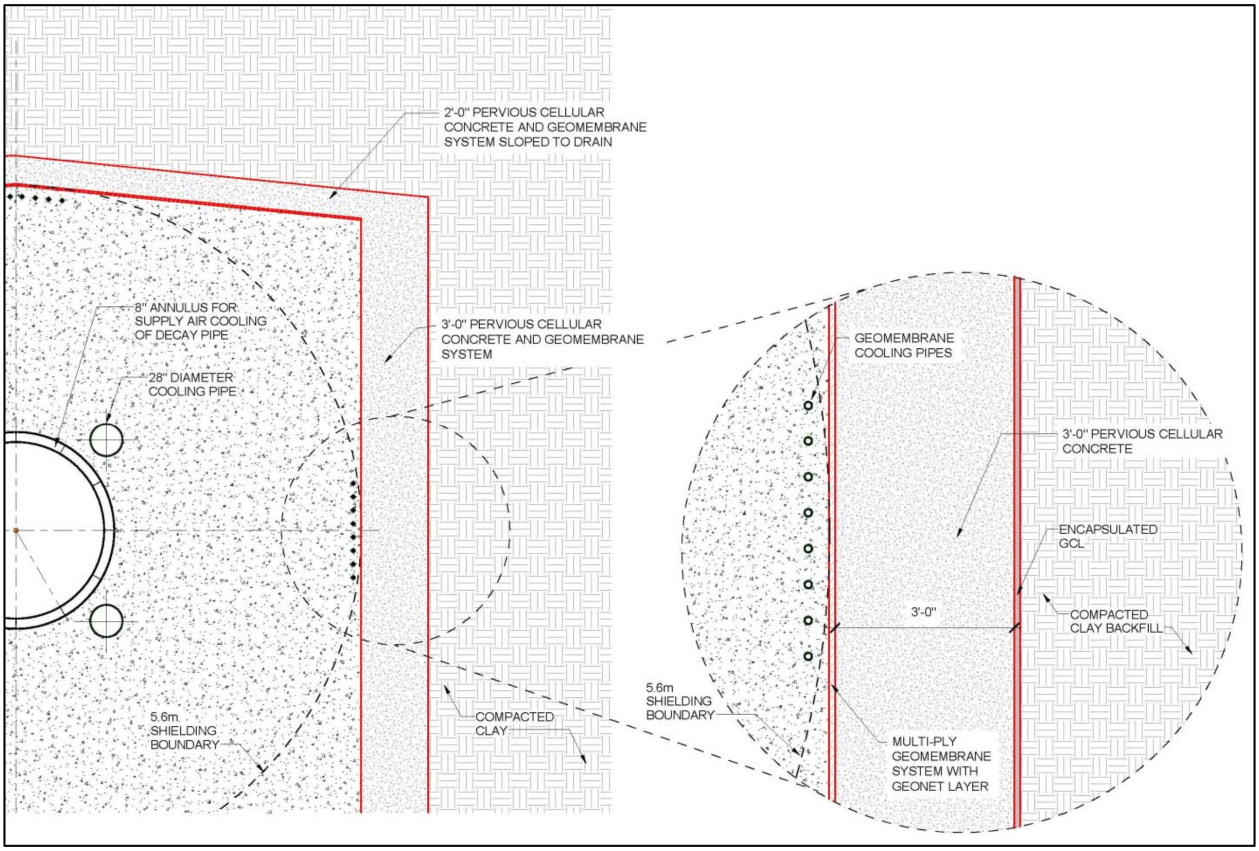

Figure 5-13: Geomembrane System Section View (From Outside Right to Inside Left in the Exploded View)

At the base of the decay region cross section the free-draining granular region consists of 24 inches of open graded (no fines) aggregate/gravel with 12-inch (300-mm) diameter perforated drainage pipes as shown in **Figure 5-12**. This pipe underdrain system will drain down a 10% slope the length of the Decay Pipe to a collection system at the upstream face of the Absorber Hall and into the decay pipe tritium monitoring sump system.

Surface water drainage and infiltration over the top of the concrete shielding is managed by crowning the top surface of the shielding concrete, crowning the outer geosynthetic barrier system, and crowning the ground surface above the top of the decay region to shed surface water off to the side to drainage swales and a drain tile system, as shown in **Figure 5-11**.

An independent study and review was conducted by a leading expert in the geosynthetic industry who generally concurred with the application and details of the geomembrane barrier system. The review provided some comments which will be considered during Preliminary Design [10] [11].

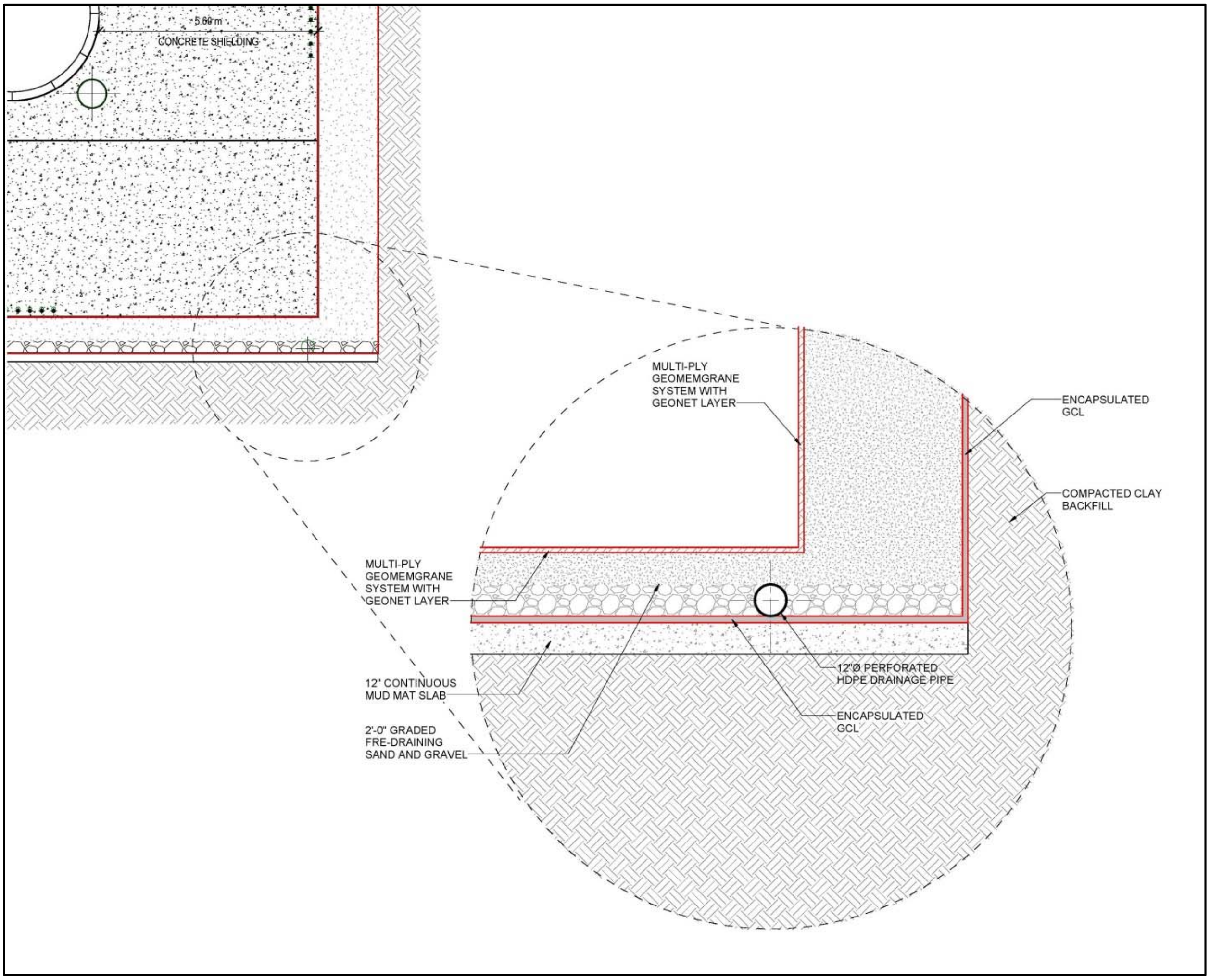

Figure 5-14: Decay Pipe Cross Section Showing the Base of the Decay Pipe Barrier System

5.3 Absorber Hall and Support Rooms

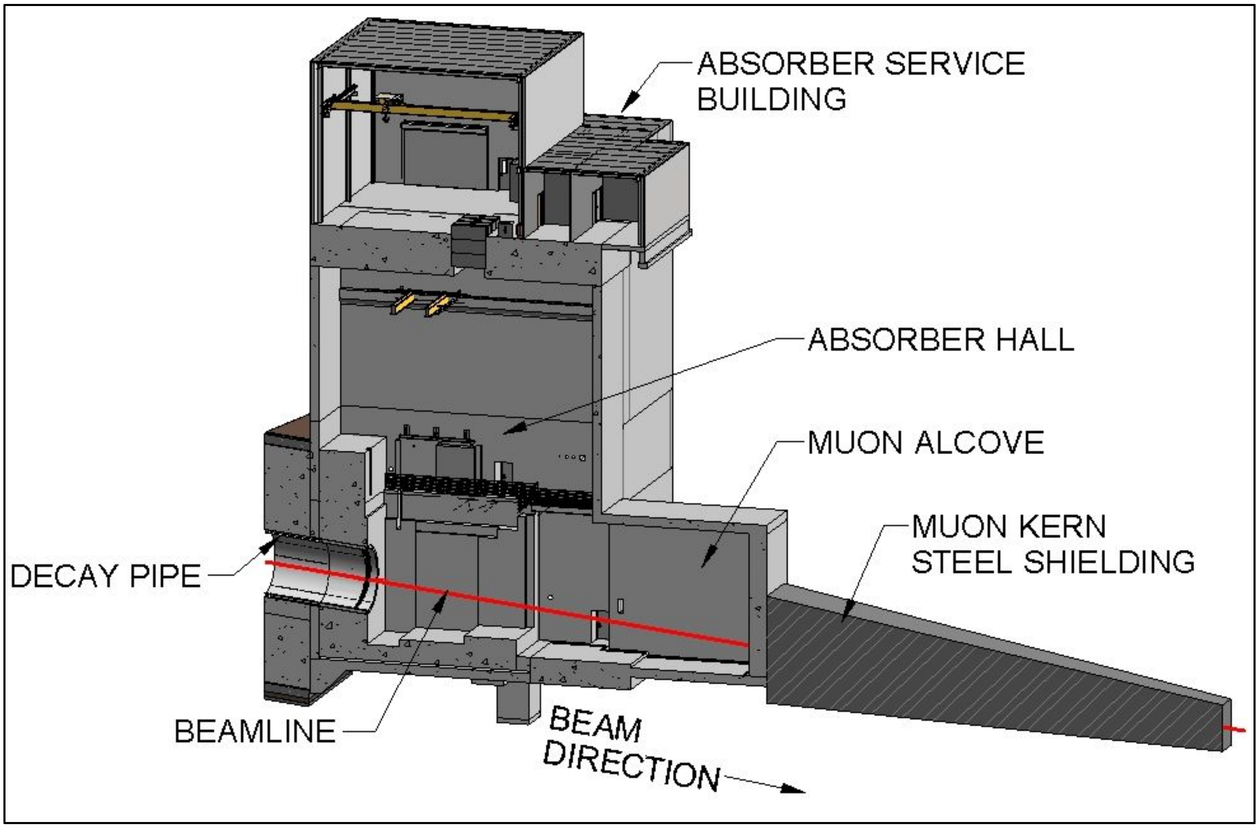

Figure 5-15: Absorber Hall and Support Rooms

An overview of the Absorber Hall and Support Rooms is shown in **Figure 5-15**. The Absorber Hall will be approximately 90 ft below grade as shown in plan view in **Figure 5-16**, **Figure 5-17**, and **Figure 5-18** and in longitudinal cross section in **Figure 5-19**. The Absorber Hall will house the concrete shielded hadron absorber and monitor, the Muon Alcove, and the absorber support rooms, all constructed in an open cut soil excavation to bedrock and then a drill-and-blast rock excavation to the base of the underground facility. Also housed in the Absorber Hall and Muon Alcove is the DUNE Project's beamline – measurement system (BLM) (muon detectors) and a Global Data Acquisition system (GDAQ). A geosynthetic barrier system will be included between the rock/open cut earth excavation and the internal concrete structure to seal the facility from groundwater infiltration. The underground Absorber Hall will be a three-level cast in place concrete structure. The lower level of the Absorber Hall will house the absorber pile/enclosure/hadron monitor, Muon Alcove, and sump and pump systems, and will provide access to the base of the egress shaft. The middle level of this underground facility will house the top of the absorber pile and the RAW Room. The upper level of this underground facility will house the Instrumentation and Air Handling rooms.

The 9-ft thick roof/ceiling of the underground portion of the facility will serve to provide concrete shielding between the Absorber Hall and the above ground Absorber Service Building (LBNF-30). A portion of the concrete foundation walls for the above ground service building serves as the shaft walls to the underground facilities' equipment and utilities access corridor, which is accessed via a 6.5-ft wide by 17-ft long opening in the truck bay floor of the above ground service building which has 30-ton bridge crane coverage. This opening will have a 9-ft thick concrete shield block air sealed hatch cover that will be provided by the Beamline Level 2 Project.

The corridor from the Absorber Hall/Muon Alcove (lower level) to the egress shaft will have an air-seal door provided by Conventional Facilities and a shielding door provided by beamline. An interlock and air seal door system will separate the Absorber Hall/Muon Alcove from the rest of the underground rooms. The Conventional Facilities outfitting includes conventional and technical/programmatic utilities (to the base of the shaft); air handling equipment, emergency systems, a 4,000-lb capacity personnel elevator, and the sump and pump room systems.

The scope of the Conventional Facilities Absorber Hall and support rooms includes the design and construction of the underground facility. This includes the absorber pile cast-in-place concrete shielding enclosure that will house the hadron monitor. Slots/voids will be cast into the beam-right side of the absorber concrete shielding pit to create a morgue for storing spent absorber components. The scope also includes the associated Conventional Facilities outfitting with required utilities.

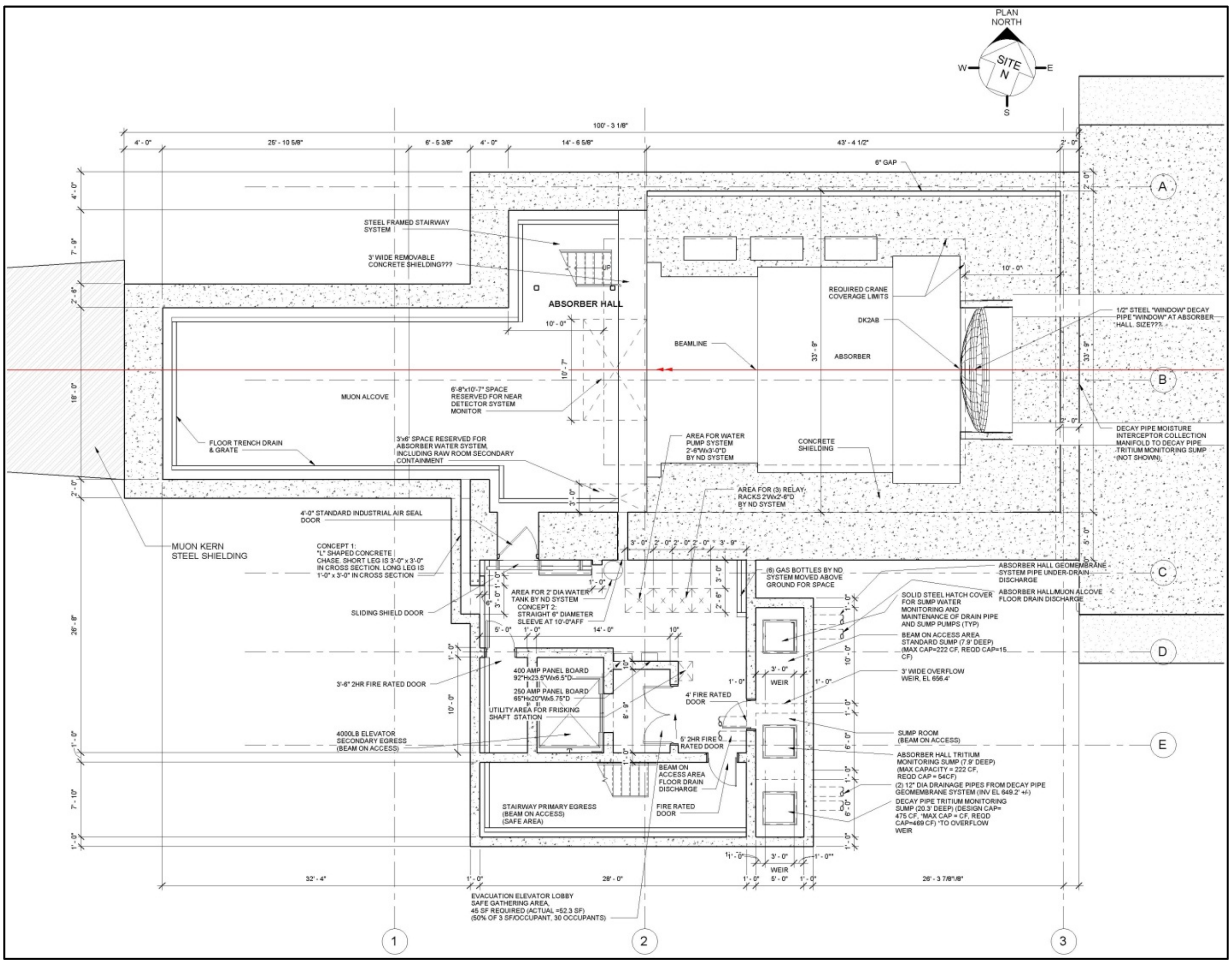

Figure 5-16: Absorber Hall, Muon Alcove: Lower-level Plan View in Bedrock

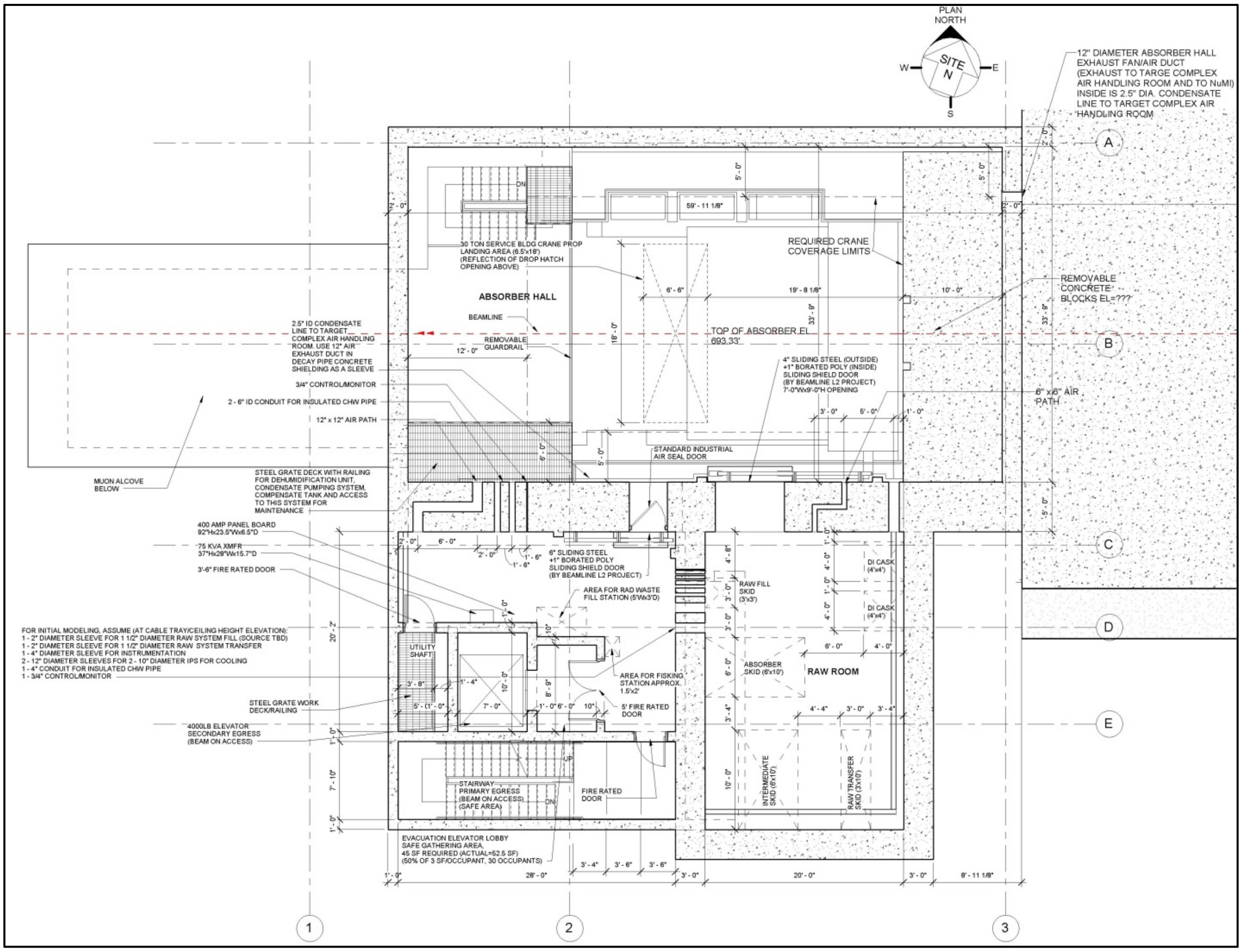

Figure 5-17: Absorber Hall, RAW Room: Middle-Level Plan View in Soil

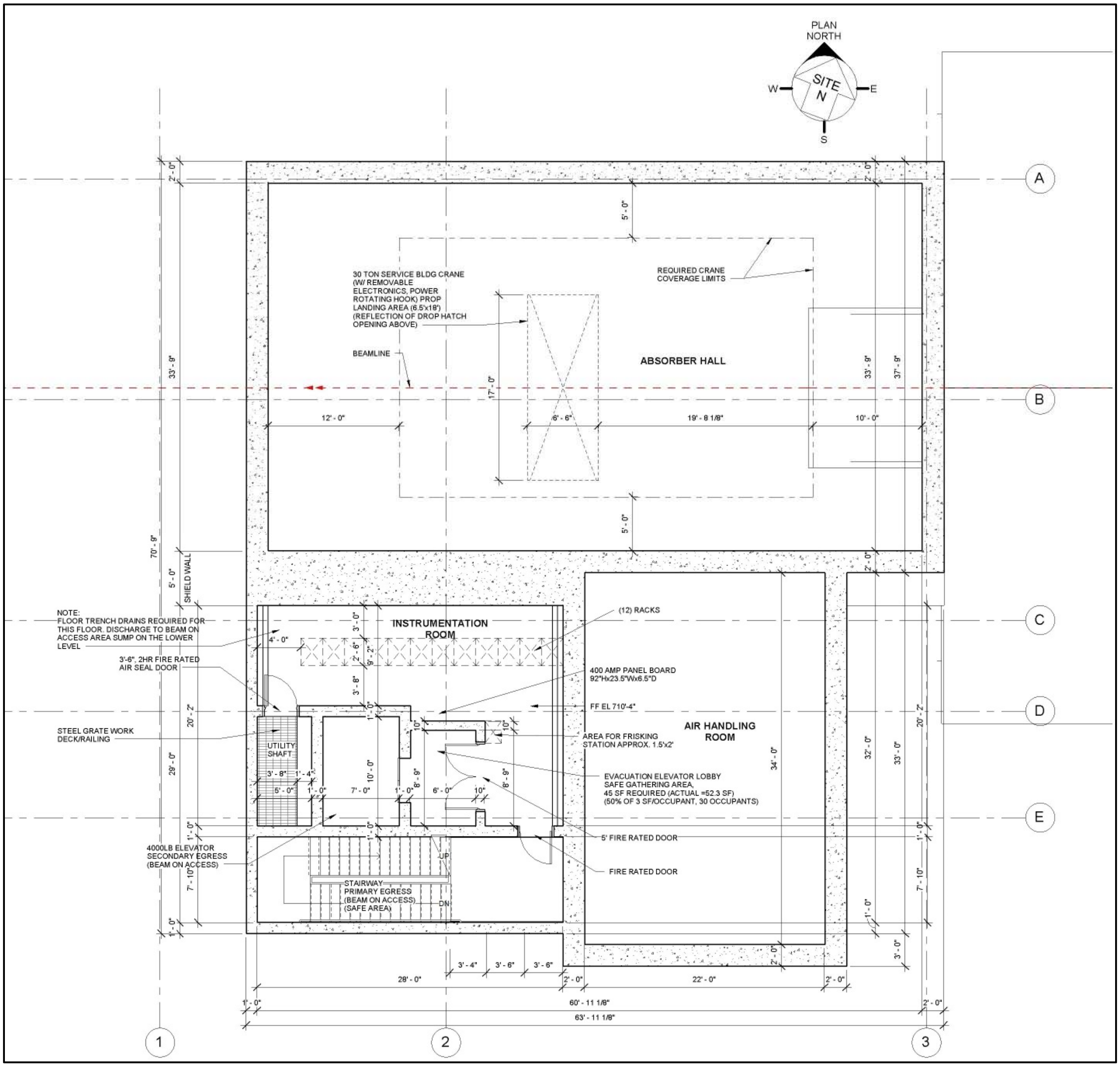

Figure 5-18: Absorber Hall Instrumentation Room; Upper-Level Plan View in Soil

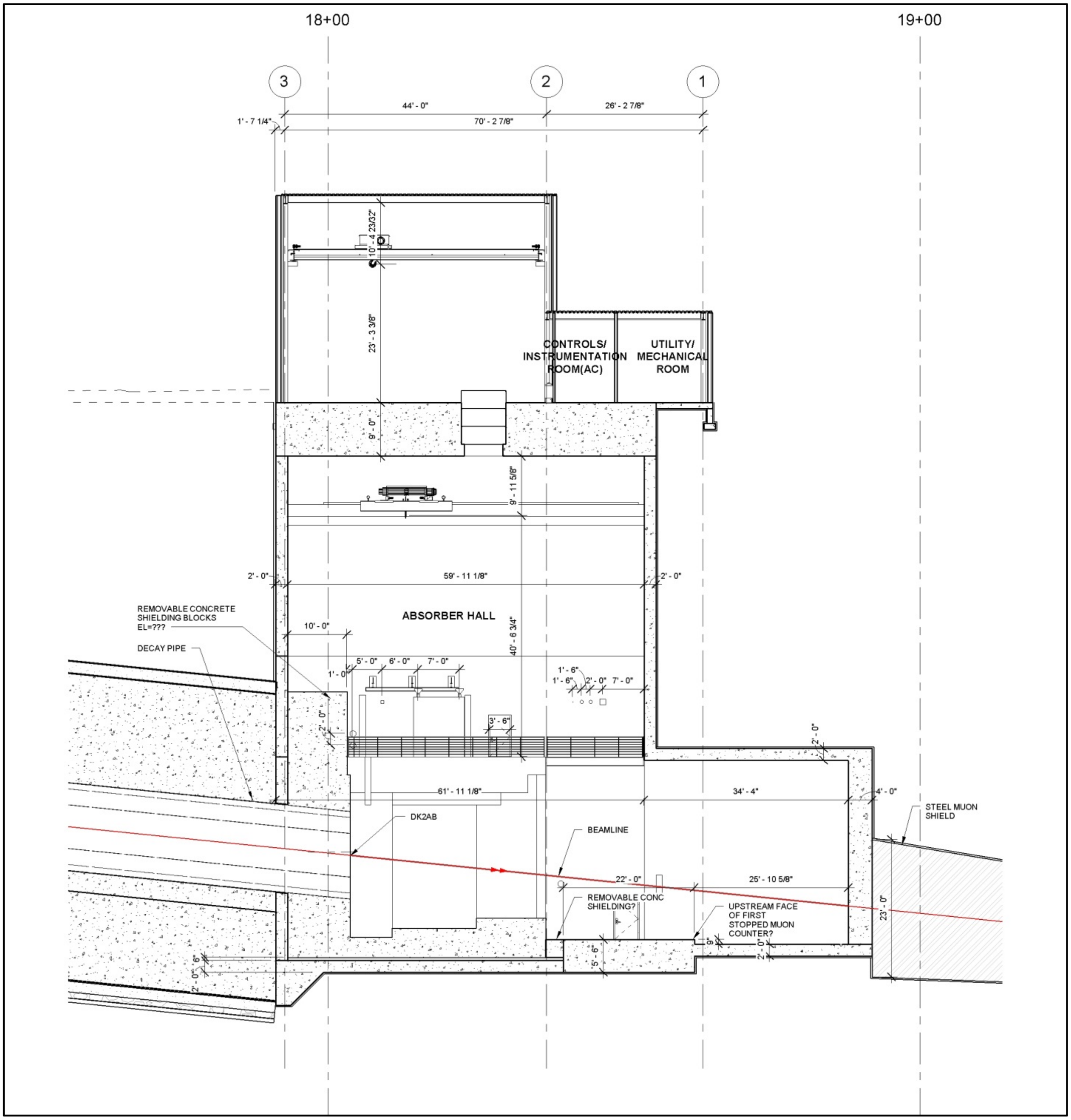

Figure 5-19: Absorber Hall Longitudinal Cross Section Cut Along the Decay Pipe Centerline

5.3.1 Grouting of the Rock Mass in the Decay/Absorber Region

The downstream end of the Decay Region and the base of the Absorber Hall will penetrate the top of rock to a depth of up to about 25 ft. The soil/rock interface and the upper portion of the rock mass is regionally known as a water bearing zone or aquifer. Due to the importance of providing as dry a Decay Region and Absorber Hall as possible, a systematic program to grout the rock mass to seal off fractures and bedding planes is included in the conceptual design. This grouting program will be executed prior to any excavation and will augment the groundwater barrier system installed between the rock face and the internal concrete structure.

As shown in **Figure 5-20** for the Absorber Hall area, a grouting program has been developed that includes a 10-foot by 10-foot grid of primary grout holes that will be drilled and grouted to create an impermeable grouted zone about 20 feet thick around the entire perimeter of the Decay Region and Absorber Hall rock excavations [12]. Secondary and tertiary grout holes will be drilled and grouted on split spacing between the primary grout holes as needed, as dictated by grout takes within holes that are drilled.

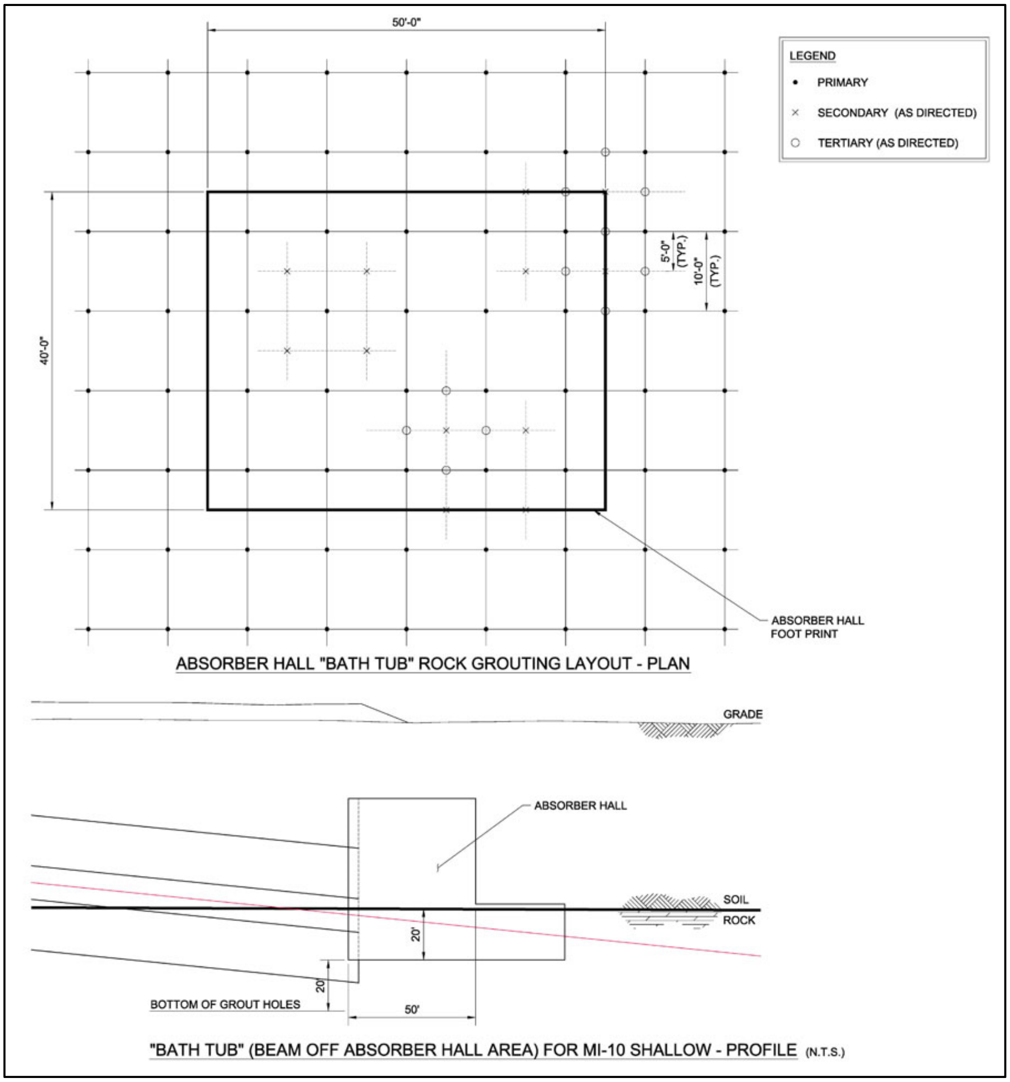

Figure 5-20: Grouting Plan and Section

5.3.2 Mechanical

Ventilation for this area is to be provided by a dedicated outside air system (DOAS) located in the LBNF-30 service building mechanical area. The DOAS shall provide adequate personnel ventilation and dehumidified neutral air to the underground space for humidity control and positive pressurization with respect to the Absorber Hall. Maximum final space humidity shall be 50% RH.

A 2,400-CFM combined refrigeration/desiccant air conditioning unit will be provided that is capable of removing of heat and moisture from the Absorber Hall. The space condition of the Absorber Hall will be kept at 80ºF +/- 5ºF. All materials of the unit that come in contact with the airstream or condensate will be resistant to corrosion from the level of nitric acid that is anticipated to be present in the air. The AHU shall be constructed minimizing single points of failure.

The Absorber pile will be air cooled by a dedicated 25,000-CFM (cubic feet per minute) air conditioning unit capable of removing heat and moisture. The supply air will be at a temperature of 59°F+/-2°F and 12 grains +/- 2 grains of moisture per pound of dry air. The return air condition will be in the range of 90°-100°F and 30 grains of moisture per pound of dry air. The unit will utilize CHW and desiccant wheels for dehumidification, and bag-in/bag-out High Efficiency Particle Arrestor (HEPA) air filter systems. All materials of the unit that come in contact with the airstream or condensate will be resistant to corrosion from the radio-chemically induced nitric acid that is present in the air. The AHU will be constructed minimizing single points of failure. Ductwork to and from the absorber will be routed through passageways/ducts between the air handling room and the Absorber Hall. Duct materials will be welded steel pipe and welded steel plate constructed to Sheet Metal and Air Conditioning Contractors Association (SMACNA) 10 in water gage (wg) pressure class.

Condensate from this system will contain tritium and nitric acid. The condensate will be captured and routed to a holding tank in the Absorber Hall. The holding tank will have a secondary containment and multiple pumps (n+1) for pumping the condensate to the Target Hall condensate holding tank. A secondary pump (manually controlled) will pump condensate to a convenient valved location for barreling during beam-on operations. All piping will be stainless steel or high pressure radiation resistant plastic pipe. All ground water intrusion will be contained and routed outside of this room to the main ground water drainage system.

5.3.3 Electrical

The Absorber Hall will be outfitted with electrical facilities to support the small programmatic equipment and periodic maintenance tasks. Conventional Facilities will provide lighting and electrical facilities to support all mechanical systems, small programmatic loads and power receptacles needed for maintenance. The power will be delivered from the Absorber Hall Service Building main panelboard to 480 V panels in the lower Absorber Hall. Dry type transformers with 208/120 V panelboards will be provided in the hall for small power devices and receptacles.

Lighting and emergency signage will be provided with remote or isolated ballast and alternate power sources. Batteries and electronic ballasts will not be allowed in areas that are subject to radiation due to the degradation of electronics and the possible creation of a mixed waste disposal problem with the batteries.

5.3.4 Plumbing

The underground absorber area sump pump system will consist of three duplex pump systems. The first will receive any drainage from the Decay Pipe enclosure system. This system will be provided a dedicated monitoring sump with switchable automatic/manual controls and a holding tank so that contaminating drainage can be held and monitored. The second system receives drainage from the decay enclosure under drainage and is discharged to the third and main sump pump system. This system will be sized to serve the entire upstream underground facilities with redundant back up pumps and emergency back-up power. The system will be designed to a 0.9999 reliability level. This system shall discharge to a surface holding tank near LBNF-30. Duplex pumps within the holding tank shall discharge to the site-wide ICW system.

5.3.5 Fire Protection/Life Safety Systems

Conventional Facilities is responsible for the design and construction of these systems including the mechanical (emergency ventilation), electrical (emergency generator for lighting, ventilation, sump pumping, fire alarms, and communication), and plumbing (fire suppression/sprinkler piping and fixtures, and emergency sump pumping). Any space where the application of water could constitute a radiation-related risk as determined by LBNF and the AHJ will not have sprinkler systems.

Each of the three levels of the underground Absorber Hall, Muon Alcove and support rooms has a safe/fire rated egress corridor leading to the 19-ft by 22-ft egress shaft that houses a separate primary egress elevator to the service building (LBNF-30) at the surface and also a secondary egress stairway to the surface.

Egress paths for underground facilities (tunnels and halls) have been conceptually designed to limit the travel path distances to egress shafts, stairways, and safe/fire rated corridors to the surface. See Section 3.1.4 of this volume for a general overview of fire protection and fire life/safety requirements.

Figure 5-22, **Figure 5-22,** and **Figure 5-23** shows the egress paths in red from the Absorber Hall to the LBNF-30 Service Building at the surface and to the exterior safe gathering area. Two routes to the surface are provided, one using the Primary Egress elevator, the other using the Secondary Egress Stairway.

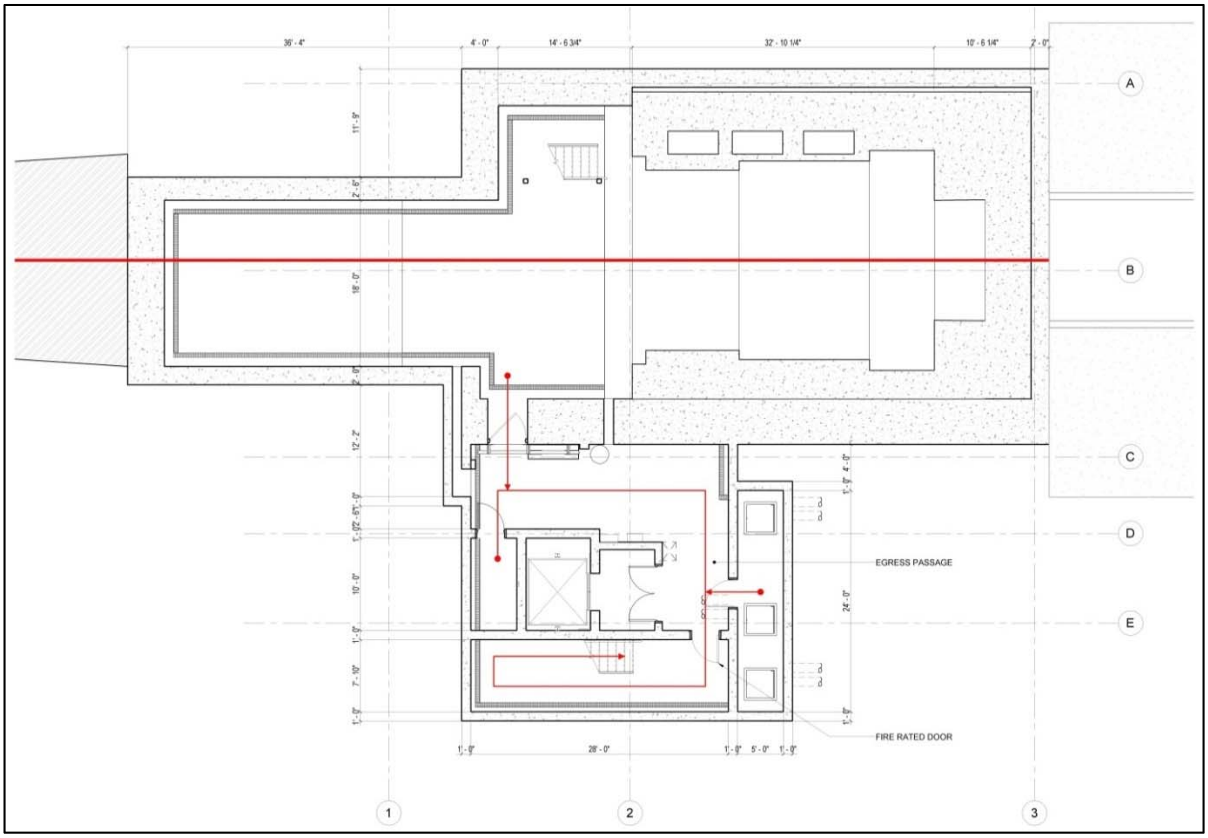

Figure 5-21: Absorber Hall, Muon Alcove, and Support Rooms: Upper-Level Egress Routing

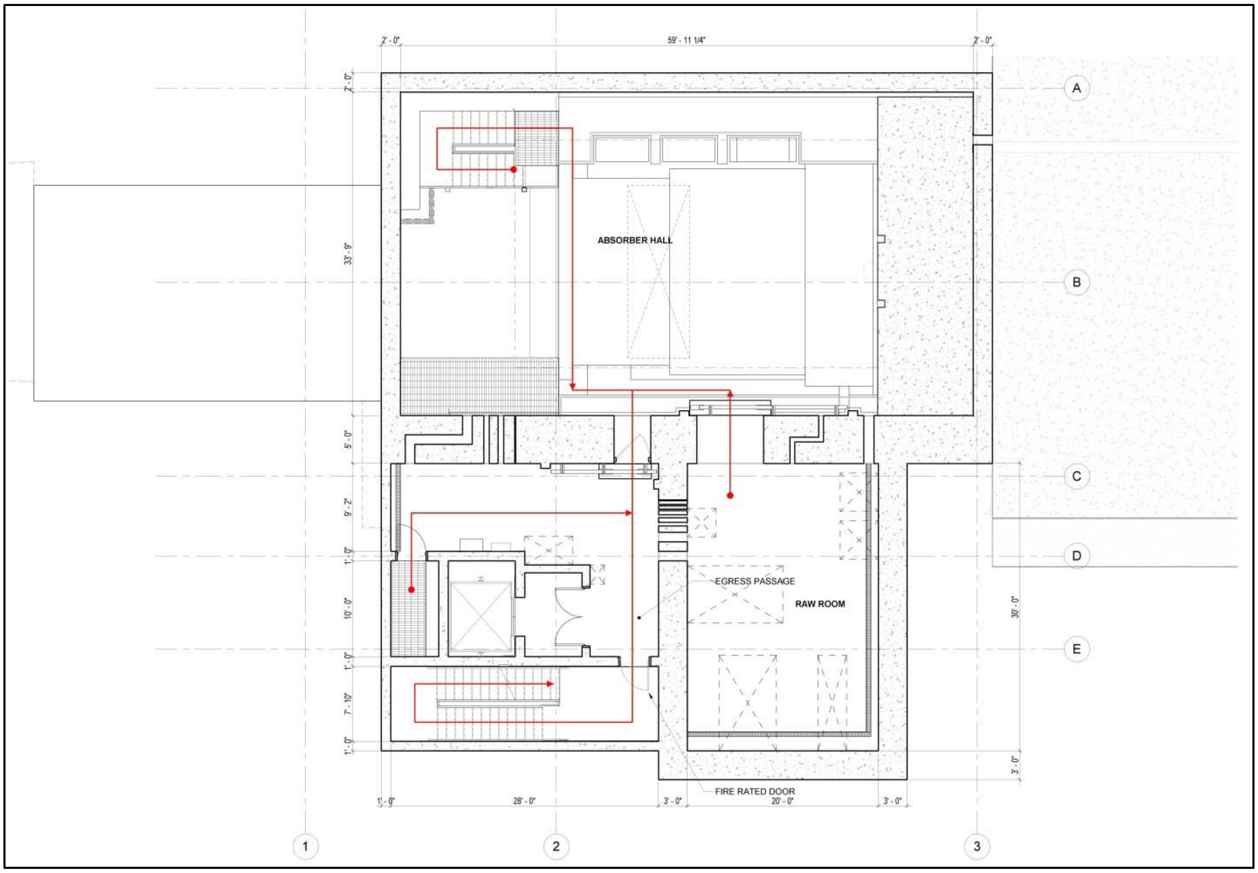

Figure 5-22: Absorber Hall, RAW Room: Middle-Level, Egress Routing

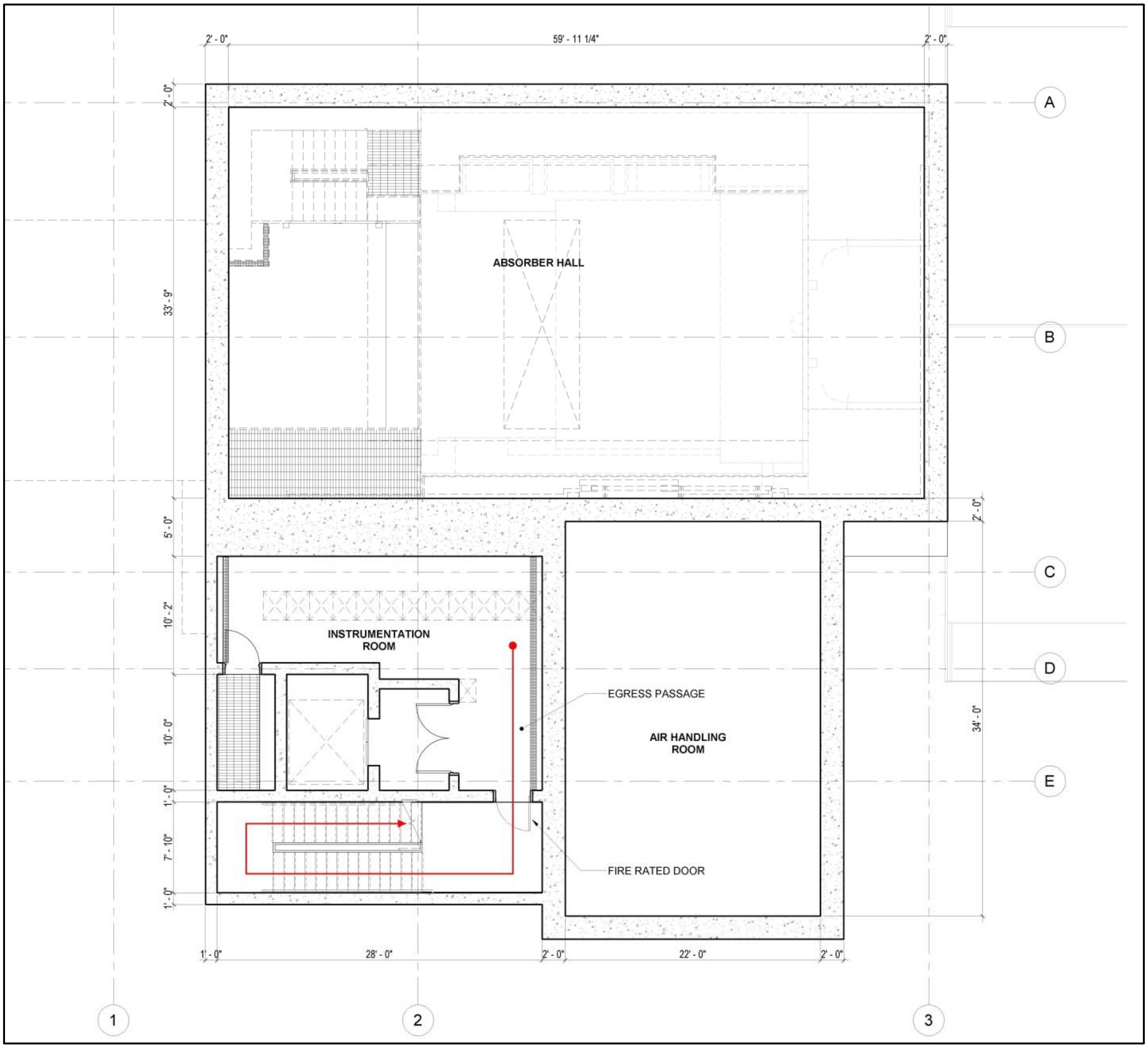

Figure 5-23: Absorber Hall, Instrumentation Room: Upper Level, Egress Routing

5.4 Near Detector Hall and Support Rooms

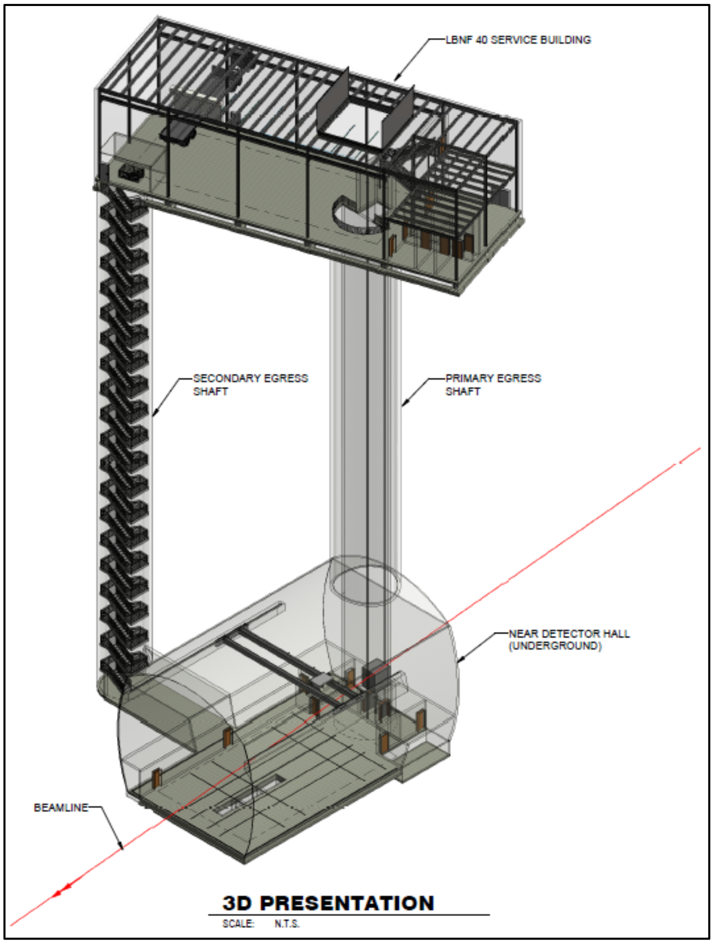

Figure 5-24: Near Detector Complex

The near detector Hall and support rooms (see **Figure 5-24, Figure 5-25**, and **Figure 5-26**) will house the LBNF near detector and related components, and is located a minimum of 689-ft (210-m) downstream of the Absorber Hall approximately 185 ft below grade. The Near Detector Hall has been sized to accommodate either of two detector technologies that were considered during Conceptual Design; a design similar to the MicroBoone liquid argon (LAr) detector, and, alternatively, a Straw Tube Tracker design. At Conceptual Design, the Conventional Facilities design as presented is generic enough to accommodate either detector technology. The LAr detector will require special Oxygen Depletion Hazard (ODH) emergency ventilation, and egress design criteria, which has been included in the reference design.

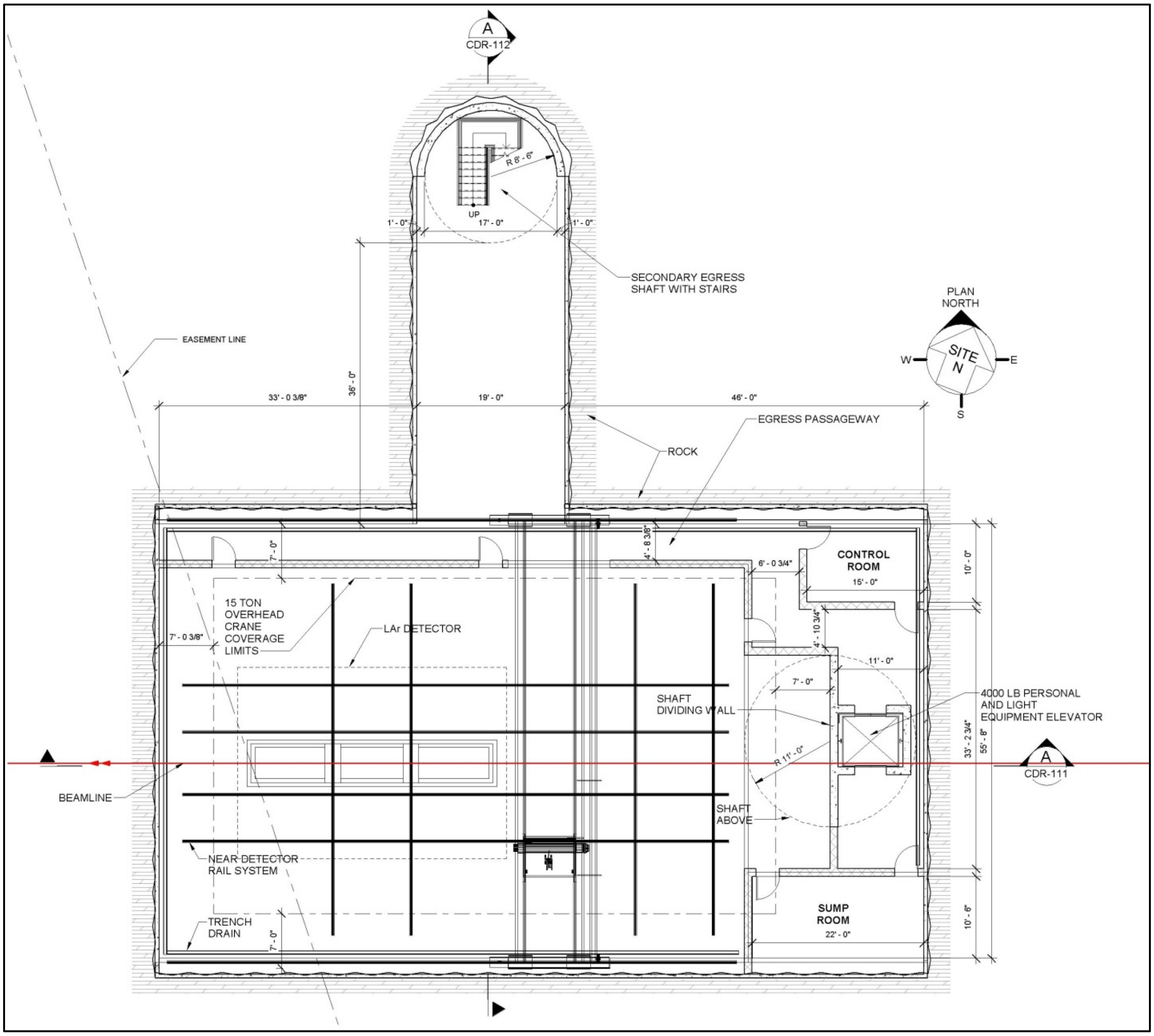

Figure 5-25: Near Detector Plan View

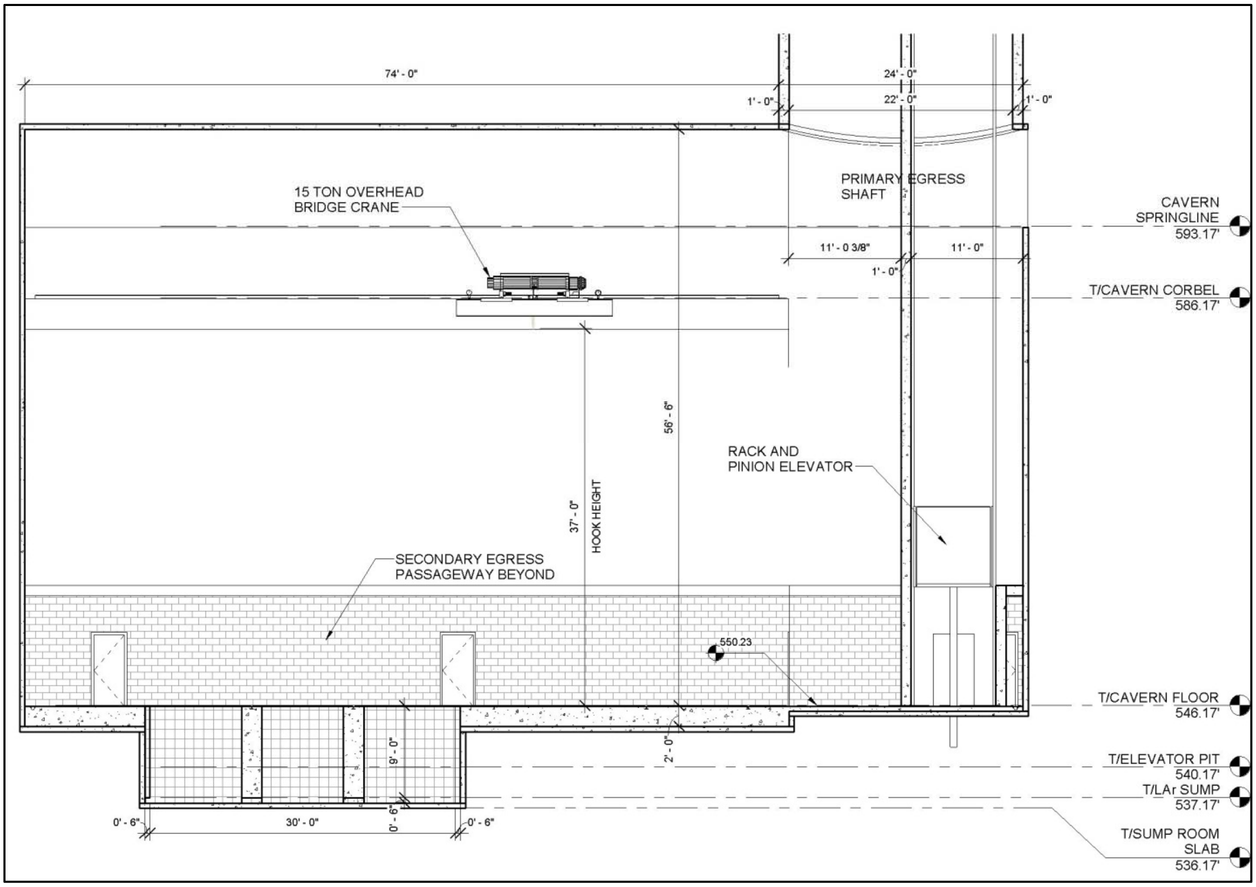

Figure 5-26: Near Detector Hall Longitudinal Section

The 5,510-ft^2 near detector Hall and support rooms will include access to a 22-ft diameter shaft which will be used for equipment handling and primary egress that includes utilities and has a 4,000-lb capacity elevator. This shaft serves as the major equipment access corridor from LBNF-40 above to the near detector Hall and support rooms below grade. The near detector Hall will have a 15-ton bridge crane running the length of the hall that will be used for installing detector components and related equipment lowered down from the surface building to the near detector Hall. A secondary egress shaft which is 17 feet in diameter will allow personnel to egress the hall via a stairway to the surface.

The near detector Hall and support rooms will also be outfitted with air handling equipment, power/control systems, and emergency systems. The 12-ft wide by 21-ft long (252 ft^2) control room is beam-right of the shaft and the Sump and Pump Room is beam-left of the shaft.

To accommodate a possible LAr detector, a recessed sump design below the floor of the hall is included to capture any leak or spill of LAr from the detector above as shown in Figure 5-26. A ventilation system is designed to ventilate the boil-off of the LAr gas.

Rock bolts or rock dowels will be used to provide both short- and long-term rock stability. The rock surface will be treated with shotcrete. The roof/ceiling of the near detector Hall and support rooms will be lined with an internal metal roof drip ceiling system (drip pans) to collect and route groundwater infiltration to protect the hall and support room contents from water and loose material. The groundwater will be channeled to the main sump via trench floor drains.

Grouting is also planned for the rock portion of the shafts serving the near detector Hall.

The Conventional Facilities work includes the bridge crane and its supports, internal CMU walls, fire walls, miscellaneous poured concrete walls and abutments, doors, fire protection, the sump pump system, fire detection, and mechanical, electrical and plumbing (MEP) systems.

A scope increase option is being considered to double the length of the Detector Hall to provide space for additional detectors in the future. There is adequate distance between the Absorber Complex and the Present upstream end of the Detector Hall to accommodate additional length without compromising the 210-m muon range-out distance.

5.4.1 Mechanical

Ventilation for the underground enclosure area is to be provided by a CHW/HW/Desiccant dedicated outside air system (DOAS) located in the near detector Service Building (LBNF-40) mechanical area. The DOAS will provide adequate personnel ventilation and dehumidified neutral air to the underground space for humidity control and positive pressurization with respect to the near detector Hall. Maximum final space humidity shall be 50% RH. The two ventilation systems serving the near detector Hall/Support Rooms and the emergency egress corridor (including stairway and elevator areas also) are provided by separate AHUs that are located in the surface service building. Additional local cooling in the near detector Hall/Support Rooms will be provided by a 6,000-CFM CHW AHU that will be located below grade in the near detector hall. Local cooling for the near detector Hall control room will be provided by small fan coil units. A separate ODH emergency ventilation exhaust system will be required for a LAr detector. This system will draw air from the LAr spill containment and exhaust directly to the outside through a separate dedicated 36-inch exhaust duct.

The near detector technology is evolving and not well defined at this time. The heat rejection system for the selected near detector technology will be developed during preliminary design. Detector power estimates as high as 3 MW have been discussed.

5.4.2 Electrical

The near detector Hall will be outfitted with electrical facilities to support the small programmatic equipment and periodic maintenance tasks. Conventional Facilities will provide lighting and electrical facilities to support all mechanical systems, small programmatic loads and power receptacles needed for maintenance. The power will be delivered from the main panelboard in the near detector Service Building to 480 V panels in the below grade Detector Hall. Dry type transformers with 208/120 V panelboards will be provided for small power devices and receptacles. Lighting and emergency signage will be provided with remote or isolated ballast and alternate power sources.

5.4.3 Plumbing

The near detector area sump pump system will have redundant back up pumps and emergency back-up power. The system shall be designed to a 0.9999 reliability level. This system will discharge to a surface holding tank near LBNF40. Pumps within the holding tank discharge to the site wide ICW system. This underground complex is provided with a wet pipe sprinkler system served from the LBNF-40 domestic water system.

5.4.4 Fire Protection/Life Safety Systems

Conventional Facilities is responsible for the design and construction of these systems including the mechanical (emergency ventilation), electrical (emergency generator for lighting, ventilation, sump pumping, fire alarms, and communication), and plumbing (fire suppression/sprinkler piping and fixtures, and emergency sump pumping).

Egress paths for underground facilities (tunnels and halls) have been conceptually designed to limit the travel path distances to egress shafts, stairways, and safe/fire rated corridors to the exterior and surface to a safe gathering location. See Section **3.1.4** of this volume for a general overview of fire protection and fire life/safety requirements. The near detector Hall has three egress routes; two are along the beam-right side of the Hall to a safe/fire rated egress corridor and one from there to either the primary egress elevator or to the secondary egress stairway. Both the elevator and the stairway lead to the surface and then to an exterior safe gathering area. **Figure 5-27** shows the egress paths in red from the near detector Hall.

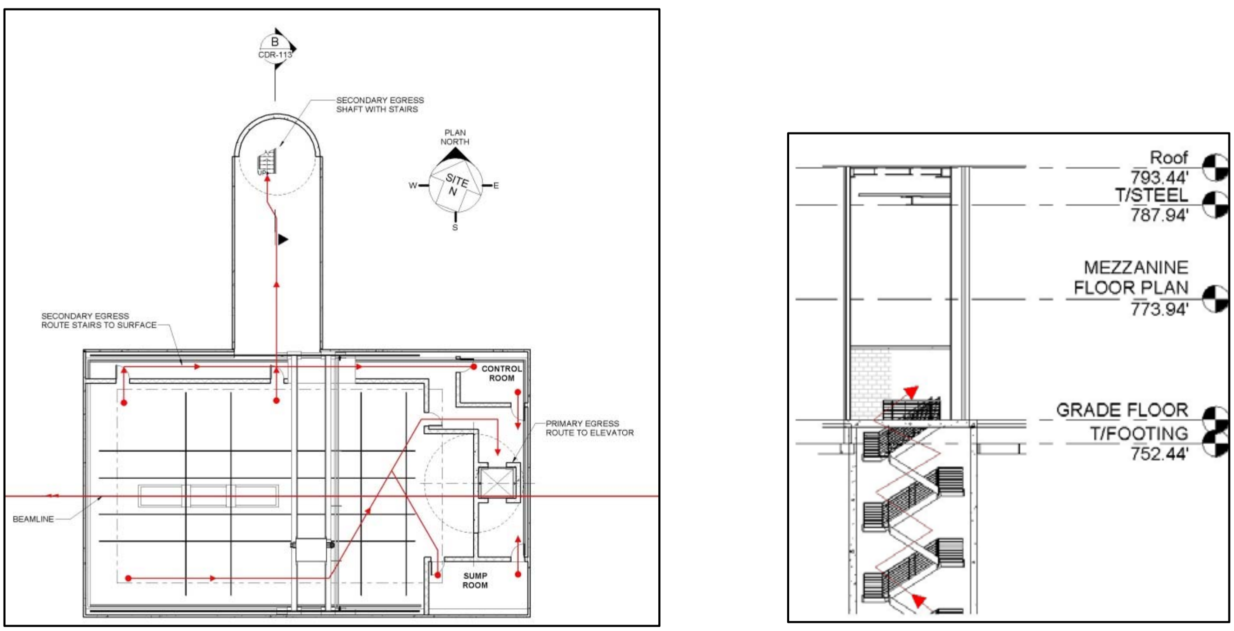

Figure 5-27: Near Detector Hall Egress Routes

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[11] E. Kavazanjian, "Kavazanjian Presentation to LBNE at Fermilab (LBNE-doc-4419)".

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