Chapter 17. Civil Construction

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17.1. Introduction

This Chapter outlines the conventional facilities required to house and support the proposed 16 GeV, 1 MW rapid cycling Proton Driver. Enclosures to house injection and extraction lines are also required. An enclosure from the existing 400 MeV Linac will be required to inject beam into the Proton Driver. In addition, an enclosure is necessary to carry the 16 GeV extraction line from the Proton Driver to the Main Injector.

The project is separated into two distinct phases. Phase I includes construction of the machine as outlined above. In Phase II the beam power is upgraded to 4 MW as required by the Muon Collider. This report only addresses facilities required in Phase I.

The existing 400 MeV Linac will be reused with technical upgrades at the beginning of the Linac. A future (Phase II) Linac expansion will be required to increase the linac beam energy by 600 MeV and a Pre-Booster to increase the injection energy to 3 GeV.

17.2. Overview of Civil Construction

Civil Construction, for the Proton Driver includes all below-grade beamline enclosures. All above-grade buildings, roads, parking, primary utilities, and primary services to accommodate the equipment for the operation of the Proton Driver on the Fermilab site are also included.

The cost estimate for the civil construction has grouped elements in a logical sequence as well as by facility function or type of construction work involved. While the cost estimate organization presents a reasonable construction scenario, it probably will not be identical with the actual subcontract packages, nor is the final schedule of construction inflexible.

17.2.1. Site Construction

17.2.1.1. Wetland Mitigation - all required compensatory floodplain construction.

17.2.1.2. Site Work and Utilities - Survey monuments, temporary power, construction access roads, tree protection, stream diversion, power and communication duct banks, 13.8kV power feeders, and underground utilities including industrial cold water (ICW), primary cooling ponds, domestic water, sanitary sewer, chilled water supply and return, and final paving of all roads and hardstand areas.

17.2.1.3. Landscaping - includes construction yard removal, signage, site landscaping, and soil erosion control.

17.2.2. Facilities Construction

17.2.2.1. Proton Driver Enclosure - Conventional below grade cast-in-place enclosure constructed to house the Proton Driver.

17.2.2.2. Injection Enclosure - Conventional pre-cast enclosure constructed to house the Injection beamline to the new Proton Driver enclosure. *A portion of this work must be accomplished during Booster beam off conditions.*

17.2.2.3. Extraction Enclosure - Conventional pre-cast enclosure constructed to house the Extraction beamline from the new Proton Driver to the Main Injector enclosure. *A portion of this work must be accomplished during Main Injector beam off conditions.*

17.2.2.4. Proton Driver Service Gallery - An above grade service building used to house support equipment for the Proton Driver Enclosure.

17.2.2.5. Utility Support Building - An above grade utility building used to house equipment for process cooling equipment for the Proton Driver Enclosure.

17.2.3. EDI&A

17.2.3.1. EDI&A - Consists of all Engineering, Design, Inspection, and Administration costs associated with the construction aspects of the project.

17.3. Detailed Facilities Descriptions

Construction of the Proton Driver Enclosure, Extraction Enclosure, Injection Enclosure and above grade service buildings is similar to previously utilized and proven construction methods at Fermilab. Construction of all below-grade enclosures consists of conventional open cut type construction techniques. The architectural style of the new buildings reflects, and is harmonious with, existing adjacent buildings. Currently, the layout has been optimized for the accelerator. Future layouts will consider existing topography, watersheds, vegetation, natural habitat, and wetlands. All these aspects will be thoroughly addressed in the Environmental Assessment for the project.

Safety provisions for radiation, fire protection and conventional safety are included in this report. Energy-efficient construction techniques will be incorporated into all new structures. Quality assurance provisions will be part of all project phases including conceptual, preliminary, and final design, construction, and construction management.

17.3.1. Site Construction

17.3.1.1. Wetlands Mitigation

Detailed and specific definitions of the wetland area, floodplain and storm water management, archaeological concerns and ecological resources will be identified by environmental consultants resulting in the preparation, submittal and approval of a Floodplain/Wetland Assessment Report and an Environmental Assessment. All required permits will be obtained prior the start of construction. See Chapter 18 for environmental considerations.

After the environmental consultants report, modifications may be made on the location of roads, utilities or siting of structures to minimize the impact on the environment while still retaining the ability to construct in a cost effective manner.

17.3.1.2. Site Work and Utilities

Site Drainage will be controlled by ditches and culverts while preserving the existing watershed characteristics both during construction and subsequent operation. Permanent stream relocation of a portion of Indian Creek may be required.

Minor road construction is anticipated for this project. Existing Kautz Road adjacent to the antiproton complex will be out of service for the length of time required to construct the Injection Enclosure. A temporary road will need to be installed to facilitate adequate traffic flow. Parking lots will be required at the Proton Driver Support Buildings.

Power, communications, and chilled water supply and return will tie in to existing systems at the intersection of Main Injector Road and Kautz Road. These utilities will extend up to the Site.

Industrial Cold Water (ICW) will tie into existing utilities at the corner of Kautz and Giese Roads. Primary cooling water will be taken from surrounding existing ponds and one proposed new 20 acre cooling pond.

Sanitary Service (SAN) and Domestic Water (DW) will tie into existing utilities at the intersection of Kautz and Giese Roads.

Natural gas will tie into an existing gas line running along Giese road.

Excess and unsuitable spoil from the construction of the underground enclosures and caverns will be stockpiled on the Fermilab site in an appropriate manner. This material will then be used as nonstructural backfill for future projects.

17.3.1.3. Landscaping

Construction yards will be removed after completion of the construction phase of the project. All disturbed areas will be returned to a natural state or landscaped in a similar manner as found at other Fermilab experimental facilities. Erosion control will be maintained during all phases of construction.

17.3.2. Facilities Construction

17.3.2.1. Proton Driver Enclosure

The Proton Driver Enclosure is a cast in place enclosure 16-ft wide and 9-ft tall with approximately 24.5-ft of equivalent earth radiation shielding (26-ft at all buildings). See attached sketches for location and dimensions.

17.3.2.2. Injection Enclosure

The Injection Enclosure is a conventional below grade 10-ft wide by 8-ft tall precast concrete enclosure with a depth profile as shown in Figure 17.2. This enclosure will house the beamline components necessary to transport the 400 MeV beamline from the existing Linac to the Proton Driver Enclosure.

17.3.2.3. Extraction Enclosure

The Extraction Enclosure is a conventional below grade 10-ft wide by 8-ft tall precast concrete enclosure under approximately 24.5-ft of equivalent earth radiation shielding. This enclosure will house the beamline components necessary to transport the 16 GeV beamline from the Proton Driver to the Main Injector. The existing 8 GeV transport line enclosure will be utilized to continue the 16 GeV beamline to the existing Main Injector.

17.3.2.4. Proton Driver Service Gallery

The proposed Proton Driver Service Gallery will consist of three above grade metal frame and wall panel buildings that house the equipment necessary to supply power, instrument and control the beamline components housed in the Proton Driver enclosure located below and adjacent to the service buildings. The four figures, 17.1 - 4, show building locations and dimensions. Total area of building(s) is approximately 108,000 sq-ft.

17.3.2.5. Utility Support Building

The Utility Support Building will be located in the center of the Proton Driver Service Gallery Campus. The above grade metal frame and wall panel building will house the equipment required for heat rejection and electrical distribution including chillers, pumps, and transformers. Total area of building is approximately 53,000 sq-ft.

17.4. Requirements and Assessments

17.4.1. Safeguards and Security

Security issues related to the design of the facilities will be compatible with the current operating procedures found at other experimental sites and other components of the Fermilab Accelerator complex.

All above grade structures will be accessible to authorized personnel during beam on conditions. The below grade beamline enclosure will not be occupied during beam on conditions and will be interlocked in accordance with Fermilab operating procedures. Access will be allowed in these areas only during beam off conditions either as controlled access or supervised access depending on the beam shutdown conditions.

17.4.2. Energy Conservation

All elements of this project will be reviewed for energy conservation features that can be effectively incorporated into the overall facility design. Energy conservation techniques and high efficiency equipment will be utilized wherever appropriate to minimize the total energy consumption of the buildings.

Design of mechanical and electrical systems, as well as architectural elements, conform to the requirements of the Fermilab Necessary and Sufficient Standards and the Fermilab Environmental, Safety and Health Manual (FESHM).

17.4.3. Health and Safety

17.4.3.1. Life Safety

Exiting for the facilities will be provided in accordance with NFPA 101 Life Safety Code to assure adequate egress in the event of an emergency. The buildings will also be provided with fire detection and suppression systems appropriate for the intended use of the buildings.

17.4.3.2. Safety Analysis Report

An in depth, internal safety analysis review will be conducted for this facility construction project prior to its operation. Based on this analysis, Fermilab will prepare a Preliminary Safety Analysis Document (PSAD), per draft DOE Order 5480.ACC (titled "Safety of Accelerator Facilities"), or a Safety Analysis Report (SAR), per DOE order 4700.1. The facility will not be operated until either a Safety Analysis Document (SAD), or a SAR is prepared and approved.

17.4.4. Environmental Protection

The overall environmental impact of this project is being evaluated and reviewed as required to conform to all applicable portions of the National Environmental Policy Act (NEPA). To initiate this evaluation, an Environmental Notification Form (CH 560) will be written for this project.

17.4.5. Decontamination and Decommissioning

Decontamination and Decommissioning procedures are an important part of Fermilab environment, safety and health policies. These policies are described in Chapter 8070 of the Fermilab Environment, Safety and Health Manual.

17.4.6. Quality Assurance

All aspects of this project will be periodically reviewed with regard to Quality Assurance issues from Conceptual Design through Title III completion. This review process will be completed in accordance with the applicable portions of the Fermilab Institutional Quality Assurance Program (FIQAP). The following elements will be included from the Fermilab Quality Assurance Program for the design and construction effort:

- An identification of staff assigned to this project with clear definition of responsibility levels and limit of authority as well as delineated lines of communication for exchange of information.

- Requirements for control of design criteria and criteria changes and recording of standards and codes used in the development of the criteria.

- Periodic review of the design process, drawings and specifications to insure compliance with accepted design criteria.

- Identification of underground utilities and facility interface points prior to the commencement of any construction in affected areas.

- Conformance to procedures regarding project updating and compliance with the approved construction schedule.

- Conformance to procedures regarding the review and approval of shop drawings, samples test results and other required submittals.

- Conformance to procedures for site inspection by Fermilab personnel to record construction progress and adherence to the approved contract documents.

- Verification of project completion, satisfactory system start-up and final project acceptance.

17.4.7. Telecommunications

The existing Fermilab telephone communications network will be extended to provide normal telecommunication support to the new addition. Operations at this facility will not require enhanced systems.

17.4.8. Handicapped Provisions

The applicable requirements of the 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 buildings. Those areas of the facility that will require accessibility as well as the established routes to those areas will be designed in full compliance to the existing statute.

17.4.9. Emergency Shelter Provisions

Provision for protection of users of the facilities, in the event of a tornado or other extreme weather conditions, will be taken into consideration. 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 select a safe area within each facility, for the protection of the building occupants. These protected areas will be identified by directional signage and will also serve a dual-purpose space with regard to protection during a national emergency in accordance with the direction given in Section 0110-10, DOE 6430.1A.

17.5. Estimated Schedule for Civil Construction

The following schedule is predicated on the assumption that <u>a funding profile to match the construction needs will be established and maintained</u>. This schedule has been developed without consideration to the accelerator operation schedule. Work requiring accelerator beam off conditions is assumed to be accomplished during normal scheduled accelerator shutdowns.

	<u>DURATION</u>
Conceptual Design Complete	TØ - 0.25 yrs
Start Title I	TØ
Complete and submit Environmental Assessment	TØ + 0.25 yrs

Approved Finding of No Significant Impact	TØ + 0.50 yrs
Submit ACOE 404 Permit Application	TØ + 0.50 yrs
Title I Complete, Approval to start Title II	TØ + 1.00 yrs
Obtain ACOE 404 Permit	TØ + 1.50 yrs
Approval to Start Title III (Start Construction)	TØ + 1.75 yrs
Underground Enclosures Complete	TØ + 2.50 yrs
Above Grade Buildings Complete	TØ + 3.25 yrs
Civil Construction Complete	TØ +3.40 yrs
Shielding Assessment Approved - Project Complete	TØ +3.50 yrs

17.6. Cost Estimate Model

A cost estimate for the civil construction part of the project is included in Table A.1. Unit costs are in FY 2000 dollars. Site work and underground enclosures are based on ratios of past projects and buildings are based on square-foot costs. At this stage, the uncertainty in the cost estimate is ±40 percent. At the project definition stage of development, there will be a bottom-up cost estimate with an associated contingency of 25 to 30 percent. Further development of a conceptual design and baseline report will include a contingency of 20 to 25 percent.

17.6.1. Basis For Design

The following information is used in the formulation of this report:

1. Beamline optics program output

2. Design sketches, Figures. 2.1, 2.2 and Figures 17.1-4. It is assumed that all construction will be done using competitive bid fixed priced contracts.

3. Meetings with the Proton Driver Project Group

4. Previous projects and designs

Following are additional comments and explanations for the cost estimate appearing in Appendix A (Table A.1).

Geotechnical investigation, environmental, and material testing costs are estimated for all phases of work. Administration of testing services is included in the EDIA costs.

The cost of the Shielding Assessment Documentation is included in engineering, design, inspection, and administration.

Escalation has not been included in the cost summary and is to be added by the reviewer.

Overhead and Profit by the subcontractor is taken as 20%. This accounts for some upswing in the construction industry over the next several years.

Engineering, Design, Inspection and Administration (EDIA) are consistent with the DOE and Fermilab guidelines. Costs include A/E administration, design data input, project review and project administration.

The total EDIA applied to the project is 21% as shown in Table 17.1.

Table 17.1. Breakdown by the various phases of design

	Fermilab Engineering	Consulting A&E	Percent of total construction
PDR and CDR	3.0%	1.0%	4.0%
Title II	1.0%	10.6%	11.6%
Title III	2.4%	3.0%	5.4%
TOTAL	6.4%	14.6%	21.0%

The cost estimate is based on conventional underground excavation and soil support techniques. The costs have been developed without the completed geotechnical report, which was not available at the time of this estimate.

The cost for utilities, power and process systems for experimental equipment have been restricted to the secondary distribution only with the primary distribution costed elsewhere. Process water (CLCW and LCW) is estimated elsewhere as well. HVAC, utilities and conventional power for building systems have been included in the estimate.

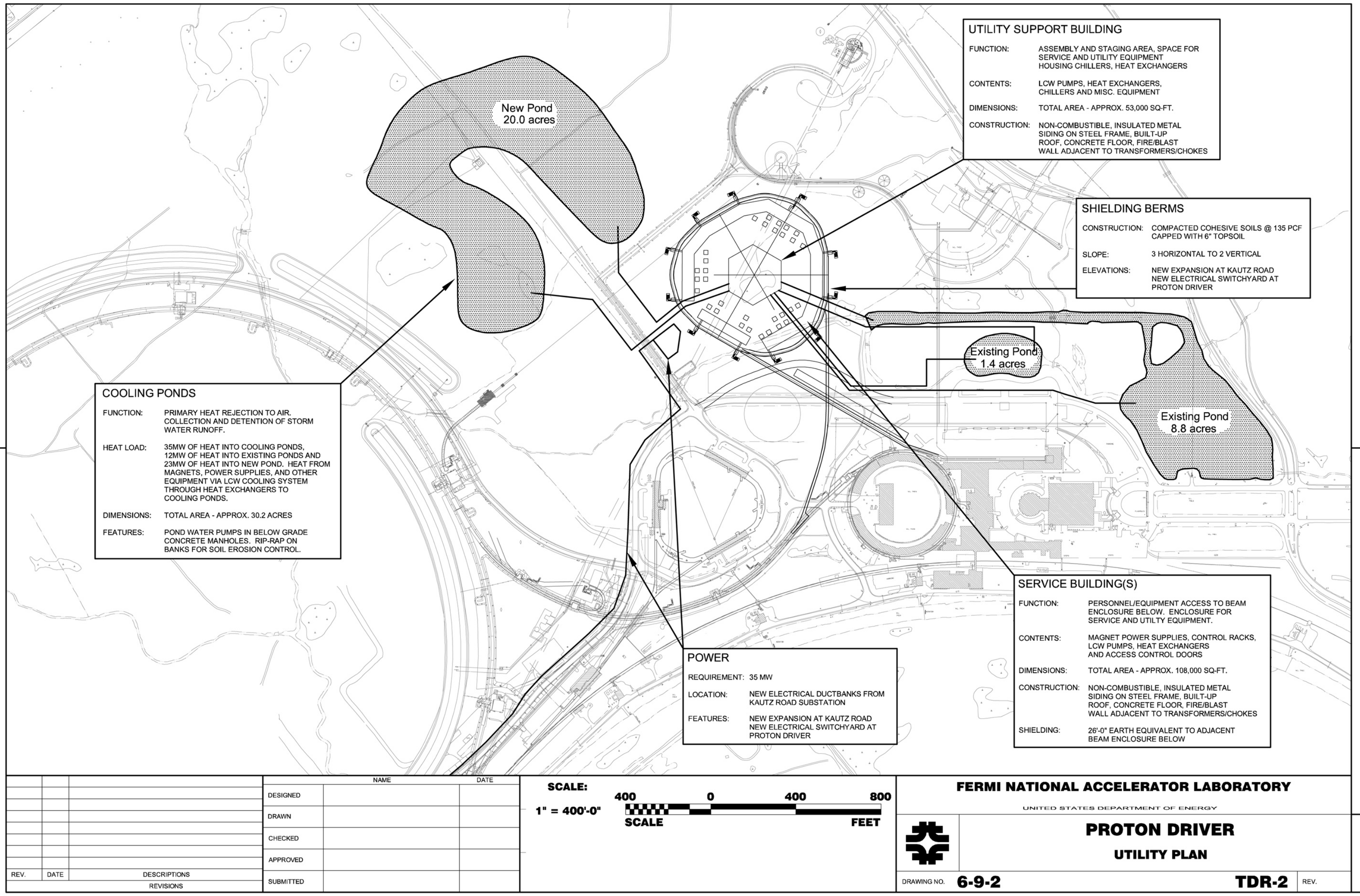

Figure 17.1. Proton Driver Utility

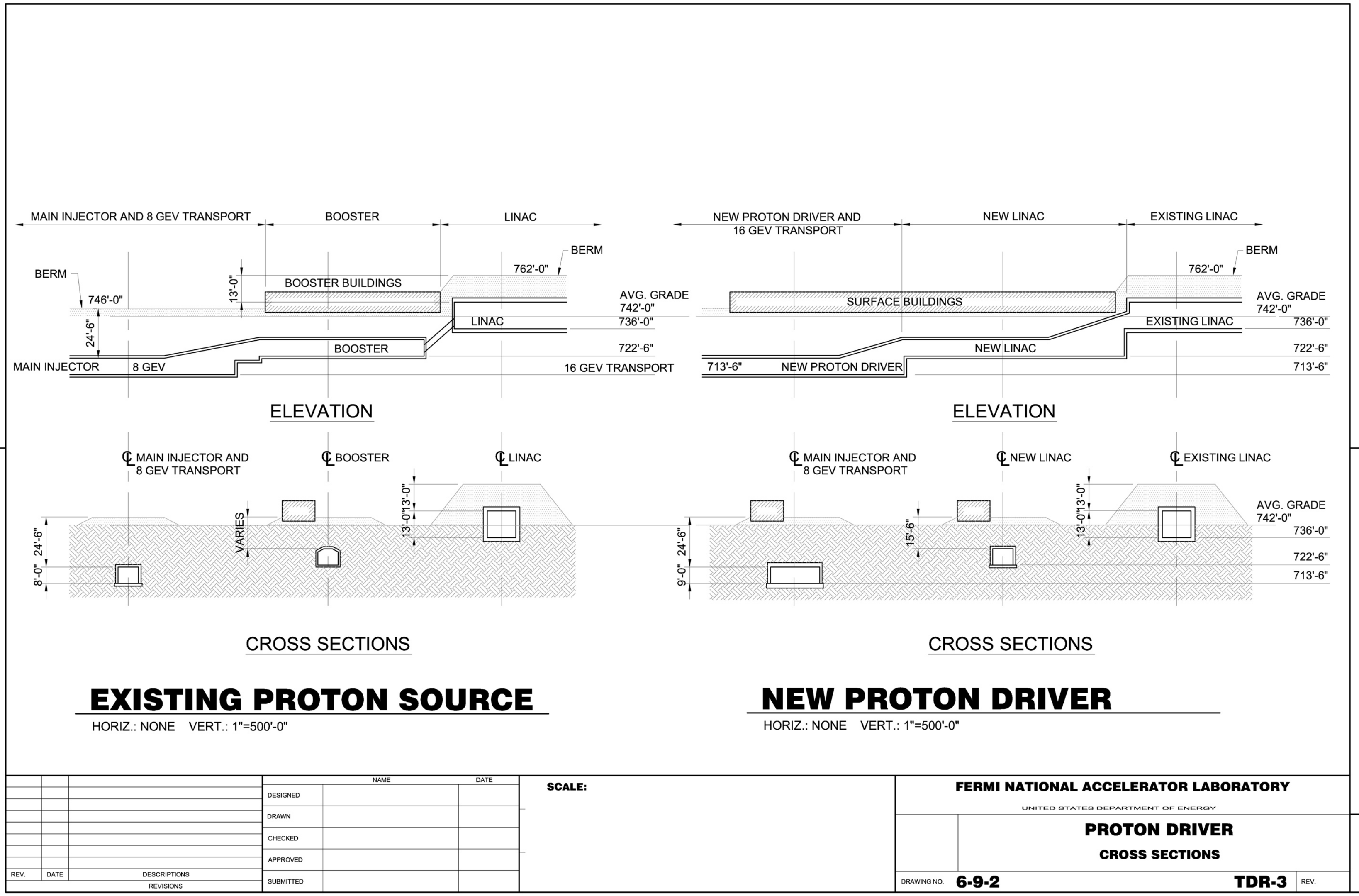

Figure 17.2. Proton Driver Elevation

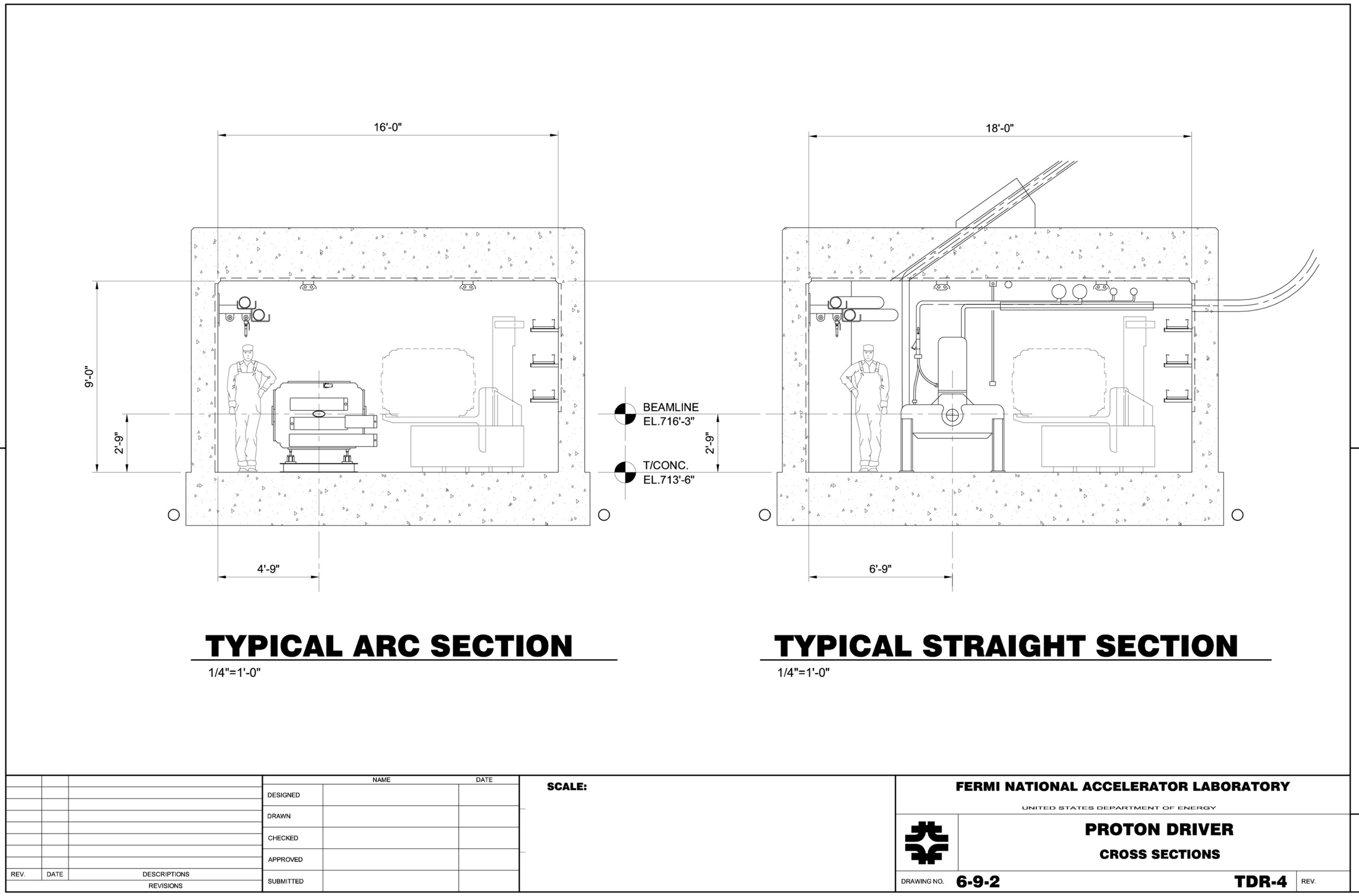

Figure 17.3. Proton Driver Enclosure Cross Sections

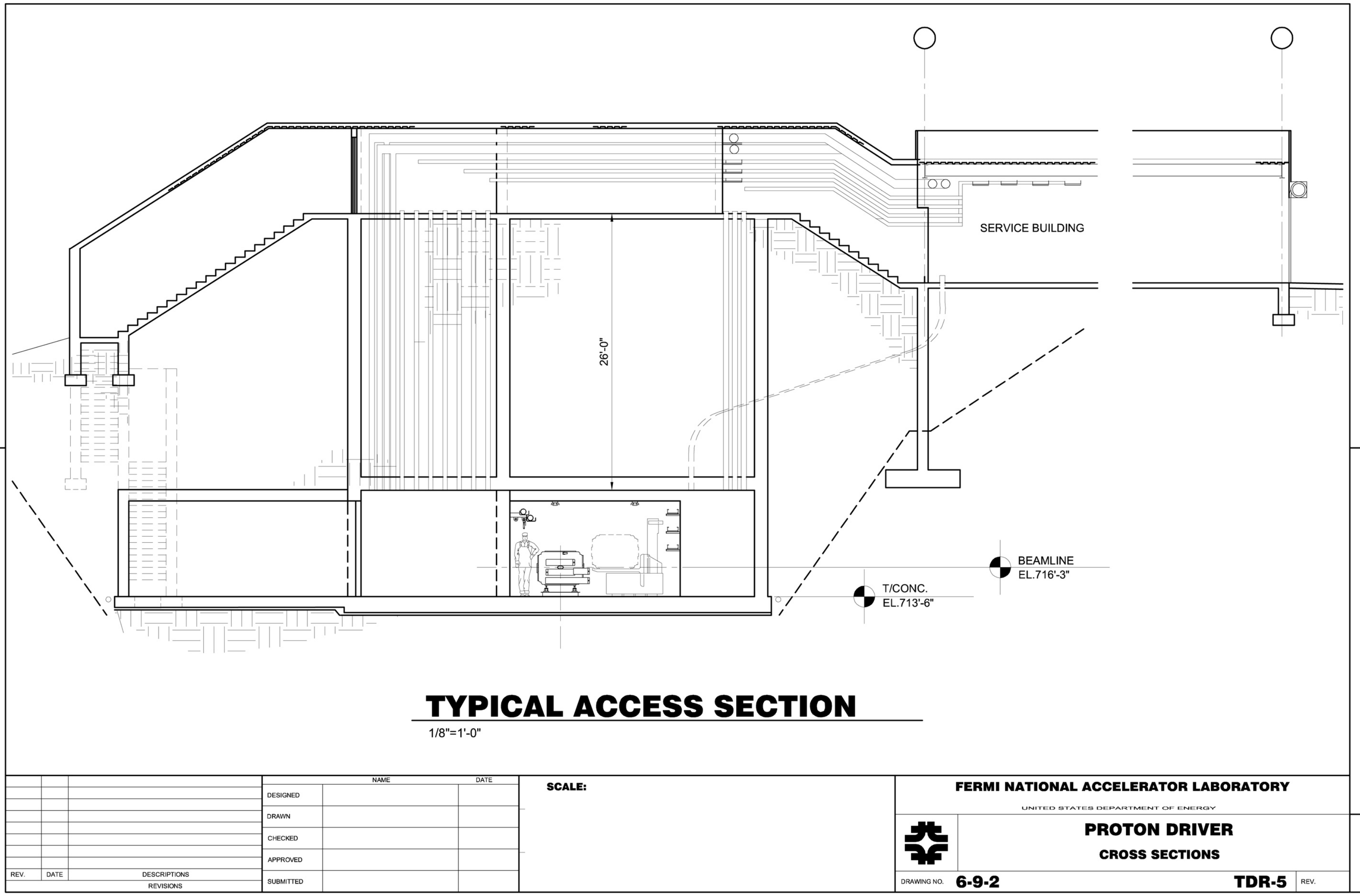

Figure 17.4. Proton Driver Access Section