May 2013

FESS/Engineering Project No. 6-10-22

MC Beamline Enclosures

PP

Project Plan for the conventional construction is to construct a beamline enclosure to house the transport beam to the g-2 and the Mu2e experiments.

U.S. DEPARTMENT OF ENERGY
Office of Science

Fermi Research Alliance LLC

Fermilab

Submitted, Accepted, and Approved By:

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Chief Operating Officer
Fermilab Directorate

The Project Plan (PP) describes the management, control systems and procedures used by Fermi National Accelerator Laboratory (Fermilab) to meet the technical, cost, and schedule objectives of this project. The Project Plan is comprised of a Project Charter (PC), Conceptual Design Report (CDR) and Project Execution Plan (PEP). This controlling document establishes the basis for managing the project, throughout the projects life cycle including, initiating, planning, executing, monitoring/controlling and closing.

This project will be managed based on the guidance provided in DOE Manual 413.3b. This manual is not the sole source for all requirements and guidance that apply to the acquisition of capital assets. Other DOE Order and Manuals, especially regarding design, engineering, management reserve and indirect costs have been used to determine the basis for estimating costs and establishing baselines. This identification, implementation and compliance with other relevant Orders, Manuals and requirements are the responsibility of the Integrated Project Team.

This project will be managed by a certified Project Management Professional (PMP) certified by Project Management Institute (PMI) employing FESS/Engineering policies and procedures which adhere to the Project Management Institute's knowledge areas and process groups, tailored to conform to the relevant DOE orders, manuals and requirements.

The Project Plan is to be viewed as a "living document," and as such, will be revised when necessary. The Fermilab Project Manager is authorized to approve non-substantive changes to the Project Plan (e.g. name changes to the positions stated in the Project Plan), but will inform the DOE Federal Project Director via electronic mail of such changes. Baseline changes will require approval by the Department of Energy's (DOE) Fermi Site Office.

Section 1 – Project Charter (PC)
The Project Charter (PC) formally authorizes the project. The Project Charter incorporates the signed U.S. Department of Energy Construction Authorization as part of this document. The Project Charter states the project justification within the framework of the Fermilab's strategic goals. The Project Charter defines the roles and identifies the Fermilab Project Director and the Fermilab Project Manager as well as other key members of the Integrated Project Team.

Section 2 – Conceptual Design Report
The Conceptual Design Report (CDR) is intended to be a self-consistent basis for a project baseline scope, cost estimate and schedule. It is not a Title 1 report and has not answered every technical design question. The current level of contingency is believed to be consistent with the degree of technical confidence in the design at this stage. It is recognized that some basic construction concerns will be reviewed and optimized during the remaining stages of the project.

Section 3 – Project Execution Plan
The Project Execution Plan (PEP) defines the Enterprise Environmental Factors and Fermilab's Organizational Process Assets that provides project management the methodology which defines the process.

Authors of this document:

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Comment and Compliance Review Request
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Project Charter

MC BEAMLINE ENCLOSURE

FESS/Engineering Project No. 6-10-22

1.1 PROJECT JUSTIFICATION **MC Beamline Enclosure**

Fermilab's Strategic Plan outlines a set of key research objectives that Fermilab plans to pursue into the future. One of these objectives, support of High Energy Physics, is a major driving force behind the Muon Campus program and the MC Beamline project that is the subject of this Project Plan.

New facilities at Fermilab, the nation's dedicated particle physics laboratory, would provide thousands of scientists from across the United States and around the world with world-class scientific opportunities. In collaboration with the Department of Energy and the particle physics community, Fermilab is pursuing a strategic plan that addresses fundamental questions about the physical laws that govern matter, energy, space and time. Fermilab is advancing plans for the best facilities in the world for the exploration of neutrinos and rare subatomic processes, far beyond current global capabilities.

Certain particle physics experiments require particle beams with incredibly large numbers of particles: the Intensity Frontier. Beginning in 2013, Fermilab's upgraded accelerator complex will create more intense particle beams for experiments such as MINOS, NOvA and MicroBooNE that will explore neutrino interactions. The updated complex will also enable the planned muon experiments, Muon g-2 and Mu2e, that will explore rare sub-atomic processes and make precision measurements.

To establish a base for these future muon experiments the Muon Campus is being developed to house these future experiments. The MC Beamline Enclosure connects the Delivery Ring (previously known as the PBar Ring) to both the Mu2e Detector Hall and Service Building and the MC1 Building to house the M-4 and M-5 beamlines.

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Project Costs

The Total Estimated Cost (TEC) for this project is estimated to be $9.8M funded in fourth quarter FY15 dollars.

The TEC includes Construction, EDIA (Engineering, Design, Inspection and Administration), Management Reserve and Indirect Costs. The TEC has been escalated to FY15 dollars.

Also included in the TEC are the Indirect Costs associated with this project, which is based on current published laboratory rates as of October 2012. The following dates are based on a project start of June 2013.

Schedule

Project Start	Month 1
Engineering Start	Month 3
Construction Start	Month 21
Construction Complete	Month 42
Engineering Complete	Month 46
Project Complete	Month 50

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1.3.1 DOE MANAGEMENT

The U.S. Department of Energy (DOE) provides funding for this project to Fermilab.

The Site Manager of the FSO has been delegated the authority and responsibility for field oversight of the project. This includes line management authority, responsibility and accountability for overall project implementation and contract administration.

The FSO administers the Management and Operations (M&O) contract with Fermi Research Alliance (FRA) for the operations of Fermilab and exercises oversight of Fermilab. The FSO Manager has been delegated responsibility and authority for execution of the project. The specific responsibilities of the FSO manager are:

- Supervision of DOE Federal Project Director and Fermi Site Office staff;
- Review documents as required by federal regulations or departmental orders or notices;
- Approval of Fermilab subcontract actions, within the authority delegated to FSO;

The DOE-Chicago Integrated Support Center (ISC) can provide support to the FSO in the following areas as requested:

- Quality Assurance
- Implementation of ESH&Q
- Project Management Systems
- Design Review
- Legal

The FSO Manager has delegated authority and responsibility for management and direction of the project to the DOE Federal Project Director, Alan Harris. The specific responsibilities of the DOE Project Director include:

- Measurement of performance against established goals including technical performance, cost levels, and schedule milestones;
- Making any necessary changes or corrective actions within the appropriate thresholds established in this Project Plan;
- Overseeing Fermilab's management of construction activities;
- Monitoring project progress via reports prepared by the Fermilab Project Manager;
- Coordinating the approval of the Project Plan by the FSO Manager.

The DOE has delegated the responsibility for design and construction of this project to Fermilab.

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1.3.2 FERMILAB MANAGEMENT

The project management team structure shown in Figure 1 identifies the organizational structure that will be responsible for design, procurement and construction of the Project.

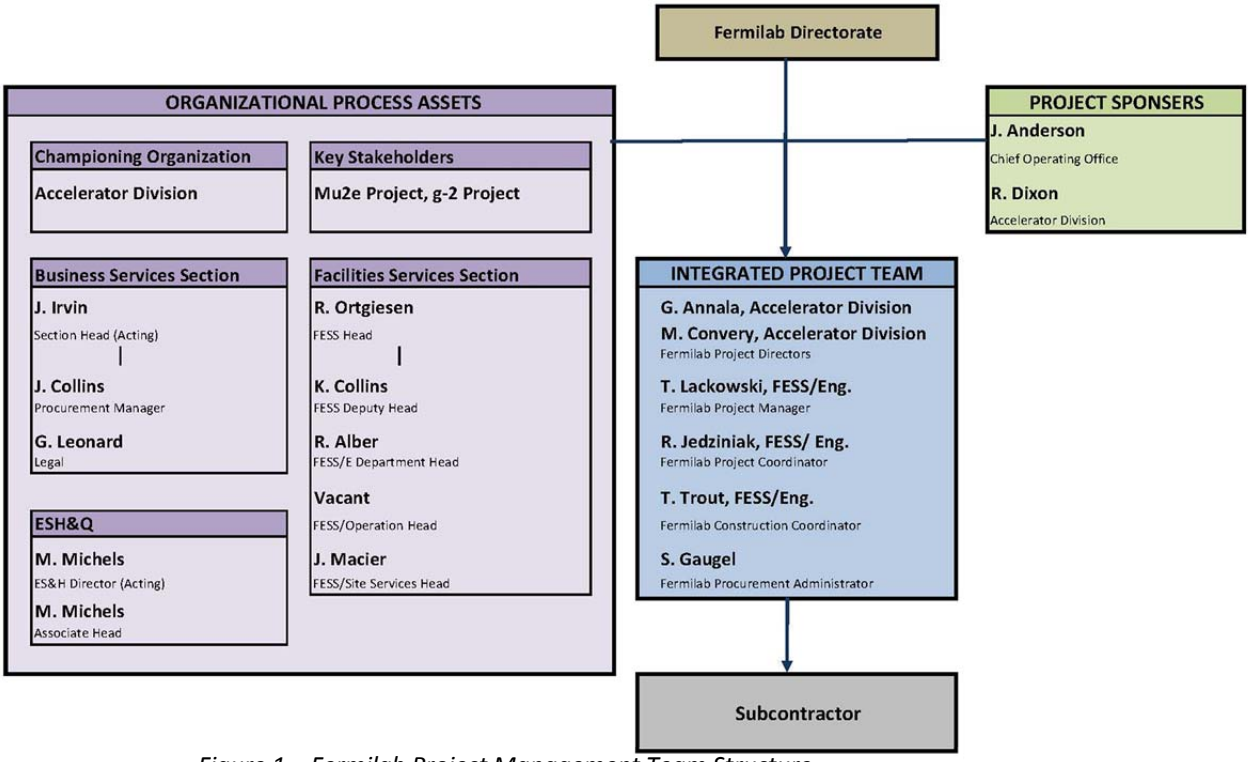

Figure 1 – Fermilab Project Management Team Structure

1.3.2.1 Directorate

As with all activities at Fermilab, the Fermilab Directorate is at the highest level of responsibility.

1.3.2.2 Project Sponsors

The Fermilab Chief Operating Officer (COO), Jack Anderson and Roger Dixon, Division Head of the Accelerator Division are the Project Sponsors championing the project. The Project Sponsors establish and approve the mission need and allocate the funds from the Fermilab budget.

1.3.2.3 Integrated Project Team

The integrated project team is comprised of the Fermilab Project Director, Fermilab Project Manager, Project Engineer, Construction Manager, Fermilab Design

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Coordinator, Fermilab Construction Coordinator and the Fermilab Procurement Administrator.

1.3.2.3.1 Fermilab Project Director

The Project Sponsors have designated Mary Convery and Gerry Annala of Accelerator Division as the Fermilab Project Directors. The Fermilab Project Director is a key stakeholder that has accepted the scope of work as described within this project's Conceptual Design Report as being appropriate and complete. The Fermilab Project Director will initiate all scope changes and shall secure any additional funding authority as defined by the Fermilab Project Manager. A summary of the Fermilab Project Director's functions and responsibilities is provided in the Integrated Project Team Responsibilities Matrix included in Appendix B.

1.3.2.3.2 Fermilab Project Manager

Project Management, design, construction management, cost and schedule for this project are the responsibility of the Facilities Engineering Services Section (FESS). FESS will manage the design and conventional construction activities associated with this project, as well as accept line management responsibility for safety. This effort will be accomplished using the resources of the FESS Engineering Department. The FESS/Engineering Manager shall assure proper attention to the coordination and timely completion of the project.

Fermilab has designated Tom Lackowski of FESS/Eng. as Fermilab Project Manager. The Fermilab Project Manager is certified by the Project Management Institute (PMI) as a Project Management Professional (PMP). The Fermilab Project Manager is committed to manage to a successful completion, the defined project scope for the cost stated within the allotted project schedule.

Based on the size and complexity of this project, the Fermilab Project Manager, will serve as Construction Manager. The Fermilab Project Manager will utilize the resources of the FESS/Engineering Department as appropriate for design, construction phase support, and construction coordination. Portions of the civil design may be subcontracted to an Architectural/Engineering firm. The Fermilab Project Manager/Construction Manager shall be the first line of contact with the Construction Subcontractor's organization. A summary showing the functions and responsibilities of the Fermilab Project Manager/Construction Manager is provided in the Integrated Project Team Responsibility Matrix contained in Appendix B.

1.3.2.3.3 Project Coordinator

Ronald Jedziniak of FESS/Eng. has been assigned as Project Coordinator for this project. The Project Coordinator will handle coordination of design team efforts in the execution of this project. A summary of the Project Coordinator functions and responsibilities is provided in the Integrated Project Team Responsibility Matrix contained in Appendix B.

1.3.2.3.4 Fermilab Construction Coordinator

Job coordination during construction phase activities will be accomplished through the Fermilab Construction Coordinator (FCC), a member of the FESS/Engineering department, who shall be responsible for daily monitoring of all work at the site, including the environment, safety, health and quality (ESH&Q) program. The FCC reports to the Construction Manager for this project.

1.3.2.3.5 Fermilab Procurement Administrator

The Fermilab Procurement Administrator(s) (PA) is a member of the Business Services Section (BSS). Separate PA may be assigned for the procurement of the architectural/engineering services (A&E) and for the construction subcontract. Through the head of the BSS the Fermilab Procurement Administrators will execute all subcontracts. The details of the PA's functions and responsibilities are provided in the Integrated Project Team Responsibility Matrix contained in Appendix B.

1.3.3 ORGANIZATIONAL PROCESS ASSETS

Organizational process assets are those Fermilab processes that can be used to influence the project's success. These assets and organizations are described below.

1.3.3.1 Championing Organization

The championing organization provides support for the project throughout the project process by providing objectives for the eventual operational use of the project. Since the championing organization will be the primary beneficiary of the project, the input of the organization is vital to establishing the goals and objectives for the project.

1.3.3.2 Stakeholders

All project stakeholders are considered to be organizational project assets and are considered invaluable during the planning and execution of the project. The Fermilab Project Director and Fermilab Project Manager will identify those key stakeholders and obtain the relative inputs critical to the project's success.

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Prospective users, landlord ESH&Q personnel and building managers are always key stakeholders that are included in the process.

1.3.3.3 Business Services Section

The Business Services Section (BSS) has the responsibility for subcontract administration, providing budget status and subcontract/requisition information. The details of the Fermilab Procurement Administrator's, a member of the Integrated Project Team, responsibilities have been identified and described in the Integrated Project Team Responsibility Matrix contained in Appendix B.

1.3.3.4 ESH&Q Management

The Environment, Safety and Health (ESH&Q) Section has the responsibility for providing safety coordination support and oversight of safety throughout the project. As with all Fermilab projects, attention to ESH&Q concerns will be part of project management and safety will be incorporated into all processes. Line management for safety on this project will be the responsibility of the Facilities Engineering Services Section.

The ability to perform the construction work in a safe, environmentally acceptable manner will be designed into the project. Construction documents (drawings and specifications) will be reviewed as the documents are developed, by Fermilab engineering, construction, and safety professionals to ensure ESH&Q concerns are addressed. Project specific safety and health requirements for construction will be outlined in the construction documents.

The potential subcontractors will be qualified for bidding by submitting specific information about their safety and health program with the proposals. During construction the subcontractors will utilize Project Hazard Analyzes (PHA) to plan the work and mitigate hazards. The Fermilab Construction Coordinator will audit the subcontractor's compliance with the PHA's and with their overall Safety Plan. The Fermilab ESH&Q Section will augment the FCC with appropriate safety personnel during construction.

1.3.3.5 Facilities Engineering Services Section

The Facilities Engineering Services Section (FESS) has the responsibility of coordinating existing and proposed infrastructure, including sewer and water, power and communication systems, site roads and overall grounds. FESS will provide criteria and project reviews for systems and areas that they will maintain

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and service. The ability to safely maintain and service the project's deliverable will be designed into the project documents. Construction documents (drawings and specifications) will be reviewed as the documents are developed for appropriateness, ESH&Q concerns and life cycle value.

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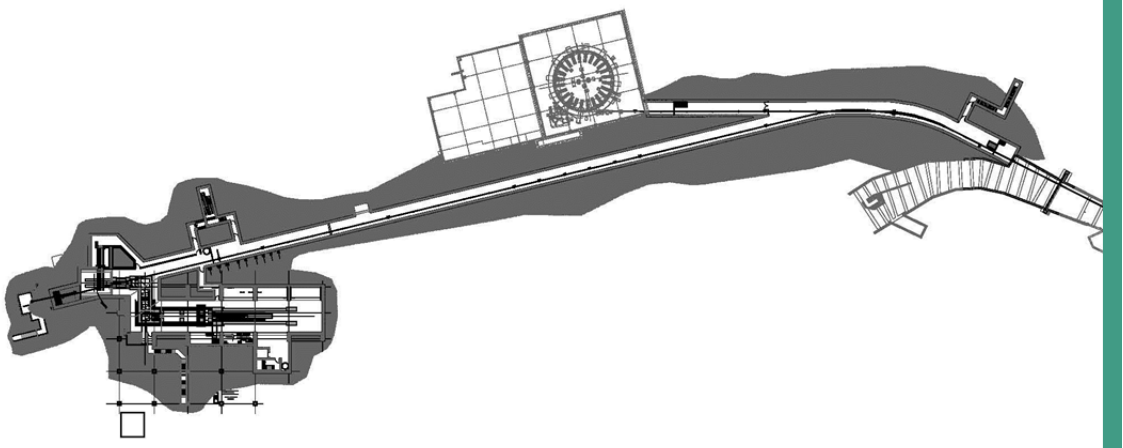
Conceptual Design Report



MC Beamline Enclosure

FESS/Engineering Project No. 6-10-22

2.1 DETAILED DESCRIPTION — MC Beamline Enclosure

The MC Beamline Enclosure scope of work will consist of the activities required for the construction of a below-grade, cast-in-place and/or precast concrete enclosure to house the programmatic beamline components that will be required to transport beam from the existing Delivery Ring into the Mu2e Detector Hall and Service building and the MC-1 Building.

The Beamline Enclosure will be a 10 feet wide by either eight (8'-0) feet, nine feet six inches (9'-6) or twelve feet (12'-0) high concrete enclosure approximately 700 feet long, running from the existing Delivery Ring enclosure to the Mu2e Detector Enclosure interface. The section of enclosure that receives conduits for beamline cabling from the service building will be nine foot six inches high. The section housing the M5 beamline to transport beam from the Delivery Ring enclosure up to the MC-1 Building as is twelve feet (12'-0) high. The beamline enclosure is designed to support 16 feet of earth and concrete shielding to grade as measured from the M4 beamline and 6 feet of shielding measured from the M5 beamline.

The construction of the Beamline Enclosure will utilize traditional "open cut and cover" methods in which earth material is excavated, the concrete beamline enclosure is constructed and the completed enclosure is covered with the excavated material. This method has been used successfully at Fermilab for the construction of the majority of shielded enclosures on-site.

The interior walls and ceiling of the beamline enclosure will be painted and the exterior concrete surface will be moisture proofed to provide a safe, dry semi-conditioned space for personnel and equipment. The enclosure will be flanked with underdrain piping that will negate the hydraulic pressure on the walls and roof of the enclosure. The underdrains will be routed to a duplex sump that will discharge water onto grade and away from the enclosure. The walls and ceiling of the enclosure will be fitted with channel inserts to allow for the support of cable trays, cooling water piping, electrical conduits and fire detection equipment.

Convenience outlets, 120/208VAC, will be provided every sixty feet along the wall on the side of the beamline. Welding outlets, 60 amp / 480V, will be provided at two (2) locations along the enclosure. In addition to required emergency and exit lighting, light fixtures will be provided to supply a minimum of 20 foot-candles. A percentage of these lights will provide emergency lighting during power failures. Lighting will be controlled by the lighting control panel in the Mu2e Building.

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Conditioned air will be introduced into the enclosure as part of the Mu2e project. Approximately 900 CFM of dehumidified air will travel slightly less than 60 minutes to the exhaust near the Delivery Ring. The Delivery Ring, MC-1 building and the Mu2e building require an air barrier to contain the activated air generated at the Mu2e absorber. Fire detection will be via air sampling and line type sensors. The fire detection devices will report to the fire panel in MC-1.

Conceptual Design Report

The performance requirements listed below describe the project specifics that exceed or are not addressed in the applicable building codes and standards requirements contained in Section 2.4, Quality Levels.

2.2.1 GENERAL PROJECT REQUIREMENTS

The enclosure is to provide housing for the beamline elements. The enclosure and earth berm configured to provide sixteen feet of earth equivalent shielding. A list of proposed magnet types along with their weights and dimensions are listed below. The magnets will be supported on stands bearing on the base slab. The beamline elevation is 732'-8" with the base slab located four feet below the beam center. A lift will be provided for the transport of the magnets between the Delivery Ring and the MC enclosure. A monorail 10 ton hoist will be situated at the step in the base slab near the diagnostic abort. A twenty one foot (21'-0) by six foot (6'-0) shielded hatch will be installed for installing magnets that do not fit on the lift or are installed after the g-2 beamline is in place.

The weights and dimensions of a representative sample of the anticipated magnets are listed below. Final design will be based on a mature listing of beamline elements.

The shielding assessment needs to be finalized. Shielding documentation will be prepared and initial approval for construction obtained prior to the start of construction.

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M-5 Magnets and Currents

J. Morgan

April, 2013

Quadrupoles

Magnet	Type	Current (A)	Power Supply	Comments	Integrated Field
gQ1	4Q24	114.3*	Q1	QGVD01	-2.311 T
gQ2	4Q24	78.6*	Q2	QGVF02	1.592 T
gQ3	4Q24	41.4*	Q3	QGVD03	-0.840 T
gQ4	4Q24	28.0*	Q4	VHQ01	0.568 T
gQ5	SQA	170.1*	Q5	VHQ02	3.233 T
gQ6	4Q24	163.1*	Q6	VHQ03	-3.290 T
gQ7	SQA	167.9*	Q7	HBQ01	3.193 T
gQ8	SQC	234.3*	Q8	HBQ02	-6.825 T
gQ9	SQB	233.0*	Q9	HBQ03	6.161 T
gQ10	SQB	233.0*	Q9	HBQ03	6.161 T
gQ11	SQC	234.3*	Q8	HBQ02	-6.825 T
gQ12	SQA	167.9*	Q7	HBQ01	3.193 T
gQ13	4Q24	111.5*	Q10	MATQ01	-2.256 T
gQ14	SQA	169.5*	Q11	MATQ02	3.221 T
gQ15	4Q24	122.3*	Q12	MATQ03	-2.473 T
gQ16	4Q24	94.5*	Q13	MATQ04	1.912 T
gQ17	4Q24	165.2*	Q14	MATQ05	-3.330 T
gQ18	4Q24	126.2*	Q15	FOQ02	2.552 T
gQ19	4Q24	105.9*	Q16	FOQ01	-2.143 T
gQ20	4Q24	126.2*	Q15	FOQ02	2.552 T
gQ21	4Q24	105.9*	Q16	FOQ01	-2.143 T
gQ22	4Q24	126.2*	Q15	FOQ02	2.552 T
gQ23	4Q24	91.5*	Q17	FFQ01	-1.852 T
gQ24	4Q24	110.1*	Q18	FFQ02	-2.227 T
gQ25	SQA	112.7*	Q19	FFQ03	2.280 T
gQ26	SQA	133.0*	Q20	FFQ04	2.686 T
gQ27	4Q24	150.2*	Q21	FFQ05	-2.517 T

Dipoles

Magnet	Type	Current (A)	Power Supply	Comments
VB1	MDC	543#	V1	EXVB01D
HB1	MDC	714#	H1	G_2_HBD1
HB2	MDC	714#	H1	G_2_HBD2
HB3	MDC	714#	H1	G_2_HBD3

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*300 ppm unfiltered regulation
**300 ppm filtered regulation
#100 ppm unfiltered regulation
##100 ppm filtered regulation

Trims

9 BNL 4D16 trims in line

Magnet Dimensions

Magnet Type	Weight (Lb)	Length (in)	Height (in)	Width (in)
4Q24	1,525	35.0	22.5	22.5
SQA	2,930	25.1	30.8	30.5
SQB	4,070	32.3	30.8	30.5
SQC	4,450	34.7	30.8	28.5
MDC	6,100	71.9	14.3	30.2

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M-4 Magnets and Currents

J. Morgan

March, 2013

Quadrupoles

Magnet	Type	Current (A)	Power Supply	Comments	
Q205	8Q32##	1,850 (670)	Q205	D2Q5 (AIP), bused with D:IB?	
EQ1	SQA**	90.6 A	Q1	QDE206	
EQ2	SQC**	195.2 A	Q2	QFE207	
EQ3	SQD**	203.3 A	Q3	QDE208	
EQ4	SQD**	159.4 A	Q4	QFE209	
EQ5	SQD**	46.8 A	Q5	QDE213A	
EQ6	SQD**	195.4 A	Q6	QDE213	
EQ7	SQD**	145.2 A	Q7	QFE214	
EQ8	LQB**	0 A	Q8	MATQ01	Removed from split
EQ9	SQC**	262.4 A	Q9	MATQ01A	
EQ10	SQC**	232.1 A	Q10	MATQ03	
EQ11	SQD**	157.4 A	Q11	MUMQ04A	
EQ12	SQA**	215.0 A	Q12	MUMQ05	
EQ13	SQD**	323.2 A	Q13	MUMQ04	
EQ14	SQD**	284.4 A	Q14	MUMQ03	
EQ15	SQD**	284.4 A	Q14	MUMQ03	
EQ16	SQD**	323.2 A	Q13	MUMQ04	
EQ17	SQA**	215.0 A	Q12	MUMQ05	
EQ18	SQD**	157.4 A	Q11	MUMQ04A	Bused with Q11?
EQ19	SQA**	273.9 A	Q15	MMF01	
EQ20	SQA**	129.5 A	Q16	MMD02	
EQ21	SQA**	231.5 A	Q17	MMF02	
EQ22	SQA**	141.6 A	Q18	MMF03	
EQ23	SQA**	141.8 A	Q19	MUMF04	Bused with Q22?
EQ24	SQA**	197.0 A	Q20	MUMD05	Shown as 8Q16
EQ25	SQA**	14.8 A	Q21	MUMF06	
EQ26	SQB**	252.3 A	Q22	COLQF01	
EQ27	SQA**	300.4 A	Q23	COLQD02	
EQ28	SQA**	291.3 A	Q24	COLQF03	
EQ29	SQB**	222.5 A	Q25	COLQD04	
EQ30	SQB**	222.5 A	Q25	COLQD08	
EQ31	SQA**	291.3 A	Q24	COLQF07	
EQ32	SQA**	300.4 A	Q23	COLQD06	
EQ33	SQB**	252.3 A	Q22	COLQF05	

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EQ34	SQB**	252.3 A	Q22	COLQF09	
EQ35	SQA**	300.4 A	Q23	COLQD10	
EQ36	SQA**	291.3 A	Q24	COLQF11	
EQ37	SQB**	222.5 A	Q25	COLQD12	
EQ38	SQA**	???	Q26?	MDQ0	Not finished
EQ39	SQA**	???	Q27?	MFQ0	Not finished
	Missing 35.6 m matching to final focus/absorber section				6 SQA quads???
EQFF1	LQC**	767.5 A	Q34	FFFQ1	
EQFF2	LQD**	1,351.2 A	Q35	FFDQ2	
EQFF3	LQC**	810.0 A	Q36	FFFQ3	
EQFF4	LQC**	668.6 A	Q37	FFDQ4	
EQFF5	LQC**	810.0 A	Q36	FFFQ3	
EQFF6	LQD**	1,351.2 A	Q35	FFDQ2	
EQFF7	LQC**	767.5 A	Q34	FFFQ1	

Dipoles

Magnet	Type	Current (A)	Power Supply	Comments
VB1	LAM	1,850##	V1	New 1.5 m Lambertson, AIP, estimate
VB2	CMAG	1,200**	V2	New 2.0 m C-Magnet, AIP, estimate
VB3	EDWA	800**	V3	Vertical down bend
VB4	MDC	870**	V4	Dogleg
VB5	MDC	870**	V4	Dogleg
HB1	SDFW	805**	H1	Left Bend
HB2	SDFW	805**	H1	Left Bend
HB3	SDF	805**	H1	Left Bend
HB4	SDF	805**	H1	Left Bend
HB5	SDFW	805**	H1	Left Bend
HB6	SDFW	805**	H1	Left Bend
HB7	MDC	1,070*	H2	Bend to Absorber
VB6	CDA	970**	V5	Down bend to target
VB7	CDA	970**	V5	Down bend to target

*300 ppm unfiltered regulation
**300 ppm filtered regulation
#100 ppm unfiltered regulation
##100 ppm filtered regulation

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Magnet Dimensions

Magnet Type	Weight (Lb)	Length (in)	Height (in)	Width (in)
8Q32	9,600	35.0	22.5	22.5
SQA	2,930	25.1	30.8	30.5
SQB	4,070	32.3	30.8	30.5
SQC	4,450	34.7	30.8	30.5
SQD	5,250	39.7	30.8	30.5
LQC	15,380	44.5	51.5	54.0
LQD	17,440	48.5	51.5	54.0
ELAM	New magnet being designed			
C-Mag	New magnet being designed			
EDWA	9,500	133.0	17.0	26.7
SDF	24,300	138.0	27.8	26.8
SDFW	24,500	138.0	28.8	26.8
CDA	2,500	60.1	17.5	28.0
MDC	6,100	71.9	14.3	30.2

The beamline lattices are listed below for the g-2 or M5 beamline and the M4 beamline. The lattice files are the basis for the location in DUSAF X, Y and Z for each element of these beamlines.

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Conceptual Design Report

MC4 Lattice

1							"MAD"	Version: 8.23/08	Run: 12/02/	3 21.42.58							
Survey.			SURVE	Y		line: L_SURVEY	range	: #S/#E									
			symm:	F	super: 1					page 1							
	ELEMENT		SEQUENCE			POSITIONS		ANGLES									
pos.	element occ.		sum(L)	arc	x	y	z	theta	phi	psi							
no.	name no	.	[m]	[m]	[m]	[m]	[m]	[rad]	[rad]	[rad]			X	Y	Z		
begin	L_SURVEY	1	0	0	30071.51135	222.110343	30447.01575	2.093942	0.053348	0			99891.78105	98659.81129	728.708453		728.7084533
begin	COLSECUP	1	0	0	30071.51135	222.110343	30447.01575	2.093942	0.053348	0			99891.78105	98659.81129	728.708453		728.7084533
begin	HBETAUP	1	0	0	30071.51135	222.110343	30447.01575	2.093942	0.053348	0			99891.78105	98659.81129	728.708453		728.7084533
begin	BEARING	1	0	0	30071.51135	222.110343	30447.01575	2.093942	0.053348	0			99891.78105	98659.81129	728.708453		728.7084533
begin	VERTEXTS	1	0	0	30071.51135	222.110343	30447.01575	2.093942	0.053348	0			99891.78105	98659.81129	728.708453		728.7084533
begin	EXOPTICS	1	0	0	30071.51135	222.110343	30447.01575	2.093942	0.053348	0			99891.78105	98659.81129	728.708453	0	728.7084533
1	CMAG_1	1	2	2.00028	30073.23799	222.274853	30446.01992	2.093942	0.111348	0	-6.5616796	6.56259824	99888.51389	98665.4761	729.248184	-6.5616796	729.2481843
2	DR56_A2	1	2.436465	2.436746	30073.61373	222.323352	30445.80321	2.093942	0.111348	0	-7.99365134	7.99457326	99887.8029	98666.70886	729.407302	-7.993651343	729.4073017
3	DCD	1	2.499965	2.500246	30073.6684	222.330408	30445.77168	2.093942	0.111348	0	-8.20198467	8.20290659	99887.69946	98666.88822	729.430451	-8.201984671	729.4304513
4	TRMDRFT	1	2.961225	2.961506	30074.06549	222.381662	30445.54265	2.093942	0.111348	0	-9.71530484	9.71622675	99886.94807	98668.19101	729.598607	-9.715304837	729.5986075
5	DEX0_1	1	3.244595	3.244876	30074.30944	222.41315	30445.40196	2.093942	0.111348	0	-10.6449964	10.6459183	99886.48647	98668.99137	729.701915	-10.64499641	729.7019146
begin	QDS206	1	3.244595	3.244876	30074.30944	222.41315	30445.40196	2.093942	0.111348	0	-10.6449964	10.6459183	99886.48647	98668.99137	729.701915	-10.64499641	729.7019146
6	MQQ	1	3.244595	3.244876	30074.30944	222.41315	30445.40196	2.093942	0.111348	0	-10.6449964	10.6459183	99886.48647	98668.99137	729.701915	-10.64499641	729.7019146
7	HQD30	1	3.64147	3.641751	30074.65111	222.45725	30445.2049	2.093942	0.111348	0	-11.9470797	11.9480016	99885.83997	98670.11232	729.8466	-11.94707971	729.8465996
8	MQD3	1	3.64147	3.641751	30074.65111	222.45725	30445.2049	2.093942	0.111348	0	-11.9470797	11.9480016	99885.83997	98670.11232	729.8466	-11.94707971	729.8465996
9	MQQ	2	3.64147	3.641751	30074.65111	222.45725	30445.2049	2.093942	0.111348	0	-11.9470797	11.9480016	99885.83997	98670.11232	729.8466	-11.94707971	729.8465996
10	HQD30	2	4.038345	4.038626	30074.99277	222.50135	30445.00785	2.093942	0.111348	0	-13.249163	13.2500849	99885.19347	98671.23327	729.991285	-13.249163	729.9912846
end	QDS206	1	4.038345	4.038626	30074.99277	222.50135	30445.00785	2.093942	0.111348	0	-13.249163	13.2500849	99885.19347	98671.23327	729.991285	-13.249163	729.9912846
11	HTRIM1	1	4.138345	4.138626	30075.07886	222.512462	30444.9582	2.093942	0.111348	0	-13.577247	13.5781689	99885.03057	98671.51571	730.027741	-13.57724698	730.0277413
12	DR67_A	1	4.289175	4.289455	30075.20871	222.529222	30444.88331	2.093942	0.111348	0	-14.072096	14.0730147	99884.78487	98671.94172	730.082728	-14.07209605	730.0827282
13	QDE206	1	4.519805	4.520085	30075.40725	222.554849	30444.7688	2.093942	0.111348	0	-14.8287561	14.8296748	99884.40918	98672.59312	730.166806	-14.82875613	730.1668063
14	QDE206	2	4.750435	4.750715	30075.6058	222.580476	30444.65429	2.093942	0.111348	0	-15.5854162	15.5863349	99884.03349	98673.24451	730.250884	-15.58541622	730.2508844
15	DD1	1	4.866435	4.866715	30075.70566	222.593366	30444.59669	2.093942	0.111348	0	-15.9659936	15.9669123	99883.84452	98673.57215	730.293174	-15.96599363	730.2931744
16	DEX0	1	5.366435	5.366715	30076.13611	222.648925	30444.34844	2.093942	0.111348	0	-17.6064135	17.6073322	99883.03003	98674.98437	730.475455	-17.60641353	730.4754546
17	EXVB01A	1	8.414435	8.416291	30078.77235	222.81852	30442.82799	2.093942	-0.000007	0	-27.6064132	27.6125025	99878.0417	98683.63346	731.031869	-27.60641324	731.0318686
18	DR67_B1	1	8.810408	8.812264	30079.11536	222.818517	30442.63016	2.093942	-0.000007	0	-28.9055372	28.9116265	99877.39264	98684.75884	731.031859	-28.90553722	731.0318588
19	DEX1A	1	8.834519	8.836375	30079.13625	222.818517	30442.61811	2.093942	-0.000007	0	-28.9846415	28.9907308	99877.35312	98684.82736	731.031859	-28.98464155	731.0318588
20	DEX1B	1	8.976971	8.978827	30079.25965	222.818516	30442.54694	2.093942	-0.000007	0	-29.4520037	29.458093	99877.11962	98685.23221	731.031855	-29.45200374	731.0318555
21	DEXH	1	9.119041	9.120896	30079.38272	222.818515	30442.47596	2.093942	-0.000007	0	-29.9181127	29.9241986	99876.88675	98685.63598	731.031852	-29.91811265	731.0318522
22	HTRIM2	1	9.119041	9.120896	30079.38272	222.818515	30442.47596	2.093942	-0.000007	0	-29.9181127	29.9241986	99876.88675	98685.63598	731.031852	-29.91811265	731.0318522
23	VTRIM2	1	9.119041	9.120896	30079.38272	222.818515	30442.47596	2.093942	-0.000007	0	-29.9181127	29.9241986	99876.88675	98685.63598	731.031852	-29.91811265	731.0318522
24	DCOILUP	1	9.474641	9.476496	30079.69076	222.818512	30442.2983	2.093942	-0.000007	0	-31.0847793	31.0908652	99876.30388	98686.64661	731.031842	-31.08477928	731.0318423
25	MBDBUP	1	9.474641	9.476496	30079.69076	222.818512	30442.2983	2.093942	-0.000007	0	-31.0847793	31.0908652	99876.30388	98686.64661	731.031842	-31.08477928	731.0318423
26	BDB0_2	1	9.949303	9.951159	30080.10193	222.818509	30442.06116	2.093942	-0.000007	0	-32.6420693	32.6481585	99875.52584	98687.99561	731.031833	-32.64206926	731.0318325
27	QFE207	1	10.282678	10.284534	30080.39072	222.818506	30441.8946	2.093942	-0.000007	0	-33.7358192	33.7419085	99874.9794	98688.94308	731.031823	-33.73581923	731.0318227
28	QFE207	2	10.616053	10.617909	30080.67951	222.818504	30441.72805	2.093942	-0.000007	0	-34.8295692	34.8356584	99874.43295	98689.89054	731.031816	-34.8295692	731.0318161
29	BDB0_2	2	11.090716	11.092571	30081.09069	222.8185	30441.4909	2.093942	-0.000007	0	-36.3868625	36.3929484	99873.65492	98691.23955	731.031803	-36.38686246	731.031803
30	MBDBDWN	1	11.090716	11.092571	30081.09069	222.8185	30441.4909	2.093942	-0.000007	0	-36.3868625	36.3929484	99873.65492	98691.23955	731.031803	-36.38686246	731.031803
31	DCOILDWN	1	11.395516	11.397371	30081.35472	222.818498	30441.33862	2.093942	-0.000007	0	-37.3868624	37.3929484	99873.15531	98692.1058	731.031796	-37.38686243	731.0317964
32	DEX0	2	11.895516	11.897371	30081.78784	222.818494	30441.08882	2.093942	-0.000007	0	-39.0272823	39.0333683	99872.33574	98693.52681	731.031783	-39.02728233	731.0317833
33	DEX1	1	12.076557	12.078412	30081.94467	222.818493	30440.99837	2.093942	-0.000007	0	-39.6212489	39.6273348	99872.03899	98694.04134	731.03178	-39.62124885	731.03178
34	QDE208	1	12.473432	12.475287	30082.28847	222.81849	30440.80009	2.093942	-0.000007	0	-40.9233321	40.9294181	99871.38846	98695.16927	731.03177	-40.92333215	731.0317702
35	QDE208	2	12.870307	12.872162	30082.63226	222.818487	30440.6018	2.093942	-0.000007	0	-42.2254154	42.2315014	99870.73793	98696.2972	731.03176	-42.22541544	731.0317603
36	DEX0	3	13.370307	13.372162	30083.06539	222.818484	30440.352	2.093942	-0.000007	0	-43.8658353	43.8719213	99869.91837	98697.71822	731.03175	-43.86583534	731.0317505
37	DEX2	1	13.551348	13.553203	30083.22221	222.818482	30440.26155	2.093942	-0.000007	0	-44.4598019	44.4658878	99869.62162	98698.23275	731.031744	-44.45980186	731.0317439
38	DCOILUP	2	13.906948	13.908803	30083.53025	222.81848	30440.08389	2.093942	-0.000007	0	-45.6264685	45.6325545	99869.03874	98699.24337	731.031737	-45.62646849	731.0317374
39	MBDBUP	2	13.906948	13.908803	30083.53025	222.81848	30440.08389	2.093942	-0.000007	0	-45.6264685	45.6325545	99869.03874	98699.24337	731.031737	-45.62646849	731.0317374
40	BDB0_2D	1	14.31811	14.319966	30083.88642	222.818477	30439.87847	2.093942	-0.000007	0	-46.9754251	46.9815144	99868.36479	98700.41191	731.031728	-46.97542515	731.0317275
41	QFE209	1	14.714985	14.716841	30084.23022	222.818474	30439.68019	2.093942	-0.000007	0	-48.2775084	48.2835977	99867.71426	98701.53984	731.031718	-48.27750844	731.0317177
42	MID	1	14.714985	14.716841	30084.23022	222.818474	30439.68019	2.093942	-0.000007	0	-48.2775084	48.2835977	99867.71426	98701.53984	731.031718	-48.27750844	731.0317177
43	QFE209	2	15.11186	15.113716	30084.57401	222.818471	30439.48191	2.093942	-0.000007	0	-49.5799917	49.585681	99867.06373	98702.66777	731.031708	-49.57959174	731.0317078
44	BDB0_2D	2	15.523023	15.524878	30084.93018	222.818468	30439.27649	2.093942	-0.000007	0	-50.9285517	50.9346376	99866.38978	98703.83631	731.031698	-50.92855167	731.031698
45	MBDBDWN	2	15.523023	15.524878	30084.93018	222.818468	30439.27649	2.093942	-0.000007	0	-50.9285517	50.9346376	99866.38978	98703.83631	731.031698	-50.92855167	731.031698
46	DCOILDWN	2	15.827823	15.829678	30085.19421	222.818466	30439.12421	2.093942	-0.000007	0	-51.9285516	51.9346376	99865.89017	98704.70256	731.031691	-51.92855165	731.0316914
47	DEX0	4	16.327823	16.329678	30085.62734	222.818462	30438.8744	2.093942	-0.000007	0	-53.5689715	53.5750575	99865.07061	98706.12358	731.031678	-53.56897155	731.0316783
48	DEX5A	1	18.827711	18.829566	30087.79287	222.818443	30437.62544	2.093942	-0.000007	0	-61.7707036	61.7767895	99860.97296	98713.22835	731.031616	-61.77070359	731.031616
49	DEX0	5	19.327711	19.329566	30088.226	222.81844	30437.37564	2.093942	-0.000007	0	-63.4111235	63.4172094	99860.15339	98714.64936	731.031606	-63.41112349	731.0316061
50	QDE213A	1	19.724586	19.726441	30088.56979	222.818437	30437.17735	2.093942	-0.000007	0	-64.7132068	64.7192927	99859.50286	98715.7773	731.031596	-64.71320679	731.0315963
51	QDE213A	2	20.121461	20.123316	30088.91358	222.818434	30436.97907	2.093942	-0.000007	0	-66.0152901	66.021376	99858.85233	98716.90523	731.031586	-66.01529008	731.0315864
52	DEX0	6	20.621461	20.623316	30089.34671	222.81843	30436.72927	2.093942	-0.000007	0	-67.65571	67.6617959	99858.03276	98718.32624	731.031573	-67.65570998	731.0315733
53	DEX5B	1	21.942414	21.944269	30090.49099	222.818421	30436.06931	2.093942	-0.000007	0	-71.9895452	71.9956311	99855.86755	98722.08043	731.031544	-71.98954516	731.0315438
54	EXVB01B	1	23.466414	23.468542	30091.81045	222.868319	30435.30832	2.093942	0.065502	0	-76.989545	76.9965266	99853.37085	98726.40937	731.195251	-76.98954501	731.1952511
55	DEX0	7	23.966414	23.968542	30092.24265	222.901046	30435.05905	2.093942	0.065502	0	-78.6299649	78.6369465	99852.55304	98727.82734	731.302623	-78.62996491	731.3026232
56	DEX5	1	23.966414	23.968542	30092.24265	222.901046	30435.05905	2.093942	0.065502	0	-78.6299649	78.6369465	99852.55304	98727.82734	731.302623	-78.62996491	731.3026232
57	QDE213	1	24.363289	24.365417	30092.5857	222.927024	30434.86119	2.093942	0.065502	0	-79.9320482	79.9390298	99851.90391	98728.95286	731.387853	-79.93204821	731.3878528
58	QDE213	2	24.760164	24.762292	30092.92876	222.953001	30434.66334	2.093942	0.065502	0	-81.2341315	81.2411131	99851.25477	98730.07837	731.473079	-81.23413151	731.4730792
59	DEX0	8	25.260164	25.262292	30093.36096	222.985729	30434.41407	2.093942	0.065502	0	-82.8745514	82.881533	99850.43696	98731.49634	731.580455	-82.87455141	731.5804545
60	DEX6A	1	26.388059	26.390187	30094.3359	223.059556	30433.85177	2.093942	0.065502	0	-86.5749942	86.5819758	99848.59216	98734.69498	731.822669	-86.57499421	731.8226691
61	QFE214	1	26.784934	26.787062	30094.67896	223.085533	30433.65391	2.093942	0.065502	0	-87.8770775	87.8840591	99847.94302	98735.82049	731.907895	-87.87707751	731.9078955
62	QFE214	2	27.181809	27.183937	30095.02201	223.111511	30433.45606	2.093942	0.065502	0	-89.1791608	89.1861424	99847.29389	98736.94601	731.993125	-89.1791608	731.9931251
63	DEX6	1	27.56868	27.570808	30095.35642	223.136834	30433.26319	2.093942	0.065502	0	-90.4484226	90.4554042	99846.66111	98738.04315	732.076206	-90.44842258	732.0762058
64	DEX0	9	28.06868	28.070808	30095.78862	223.169561	30433.01392	2.093942	0.065502	0	-92.0888425	92.0958241	99845.8433	98739.46112	732.183578	-92.08884248	732.1835779
65	EXVB01C	1	29.59268	29.595081	30097.10808	223.21946	30432.25293	2.093942	-0.000007	0	-97.0888423	97.0967196	99843.34661	98743.79006	732.347289	-97.08884233	732.3472885
66	DEX0	10	30.09268	30.095081	30097.54121	223.219456	30432.00312	2.093942	-0.000007	0	-98.7292622	98.7371395	99842.52704	98745.21107	732.347275	-98.72926223	732.3472754
end	EXOPTICS	1	30.09268	30.095081	30097.54121	223.219456	30432.00312	2.093942	-0.000007	0	-98.7292622	98.7371395	99842.52704	98745.21107	732.347275	-98.72926223	732.3472754
end	VERTEXTS	1	30.09268	30.095081	30097.54121	223.219456	30432.00312	2.093942	-0.000007	0	-98.7292622	98.7371395	99842.52704	98745.21107	732.347275	-98.72926223	732.3472754
begin	MATCH1	1	30.09268	30.095081	30097.54121	223.219456	30432.00312	2.093942	-0.000007	0	-98.7292622	98.7371395	99842.52704	98745.21107	732.347275	-98.72926223	732.3472754
67	MATQ01	1	30.32331	30.325711	30097.74099	223.219454	30431.8879	2.093942	-0.000007	0	-99.4859223	99.4937996	99842.149	98745.86653	732.347269	-99.48592232	732.3472688
68	MATQ01	2	30.55394	30.556341	30097.94077	223.219452	30431.77267	2.093942	-0.000007	0	-100.242582	100.25046	99841.77097	98746.52199	732.347262	-100.2425824	732.3472623
69	DM1	1	31.05394	31.056341	30098.3739	223.219449	30431.52287	2.093942	-0.000007	0	-101.883002	101.89088	99840.95141	98747.94301	732.347252	-101.8830023	732.3472524
70	DMAT2	1	35.803929	35.80633	30102.48859	223.219414	30429.14974	2.093942	-0.000007	0	-117.468955	117.474833	99833.16555	98761.44264	732.347138	-117.4689553	732.3471376
71	MATQ01A	1	36.137304	36.139705	30102.77737	223.219411	30428.98318	2.093942	-0.000007	0	-118.560705	118.568583	99832.6191	98762.3901	732.347128	-118.5607052	732.3471277
72	MATQ01A	2	36.470679	36.47308	30103.06616	223.219409	30428.81663	2.093942	-0.000007	0	-119.654455	119.662332	99832.07265	98763.33756	732.347121	-119.6544552	732.3471212
73	DM1	2	36.970679	36.97308	30103.49929	223.219405	30428.56682	2.093942	-0.000007	0	-121.294875	121.302752	99831.25309	98764.75858	732.347108	-121.2948751	732.3471081
74	DM1	3	37.470679	37.47308	30103.93241	223.219402	30428.31702	2.093942	-0.000007	0	-122.935295	122.943172	99830.43352	98766.17959	732.347098	-122.935295	732.3470982
75	DMAT3	1	40.164293	40.166694	30106.26576	223.219382	30426.97127	2.093942	-0.000007	0	-131.772611	131.780488	99826.01833	98773.83493	732.347033	-131.772611	732.3470326
76	MATQ03	1	40.497668	40.500069	30106.55455	223.219379	30426.80471	2.093942	-0.000007	0	-132.866361	132.874238	99825.47189	98774.7824	732.347023	-132.866361	732.3470228
77	MATQ03	2	40.831043	40.833444	30106.84333	223.219377	30426.63816	2.093942	-0.000007	0	-133.960111	133.967988	99824.92544	98775.72986	732.347016	-133.9601109	732.3470162
78	DM1	4	41.331043	41.333444	30107.27646	223.219373	30426.38835	2.093942	-0.000007	0	-135.600531	135.608408	99824.10588	98777.15088	732.347003	-135.6005308	732.3470031
79	DMAT4	1	41.75067	41.753071	30107.63996	223.21937	30426.1787	2.093942	-0.000007	0	-136.97726	136.985137	99823.41805	98778.34347	732.346993	-136.9772598	732.3469932
80	DM1	5	42.25067	42.253071	30108.07309	223.219366	30425.9289	2.093942	-0.000007	0	-138.61768	138.625557	99822.59848	98779.76449	732.34698	-138.6176797	732.3469801
81	DMAT5	1	42.25067	42.253071	30108.07309	223.219366	30425.9289	2.093942	-0.000007	0	-138.61768	138.625557	99822.59848	98779.76449	732.34698	-138.6176797	732.3469801
end	MATCH1	1	42.25067	42.253071	30108.07309	223.219366	30425.9289	2.093942	-0.000007	0	-138.61768	138.625557	99822.59848	98779.76449	732.34698	-138.6176797	732.3469801
begin	MOMCOL_1	1	42.25067	42.253071	30108.07309	223.219366	30425.9289	2.093942	-0.000007	0	-138.61768	138.625557	99822.59848	98779.76449	732.34698	-138.6176797	732.3469801
begin	MOMCOLNE	1	42.25067	42.253071	30108.07309	223.219366	30425.9289	2.093942	-0.000007	0	-138.61768	138.625557	99822.59848	98779.76449	732.34698	-138.6176797	732.3469801
82	DM1	6	42.75067	42.753071	30108.50621	223.219363	30425.6791	2.093942	-0.000007	0	-140.2581	140.265977	99821.77892	98781.18551	732.34697	-140.2580996	732.3469703
83	DM1	7	43.25067	43.253071	30108.93934	223.219359	30425.42929	2.093942	-0.000007	0	-141.89852	141.906397	99820.95935	98782.60652	732.346957	-141.8985195	732.3469571
84	MUHB01A	1	46.29867	46.302582	30111.49273	223.219337	30423.76482	2.203025	-0.000007	1E-06	-151.898519	151.911354	99815.49847	98790.9838	732.346885	-151.8985192	732.346885
85	DM1	8	46.79867	46.802582	30111.89609	223.219333	30423.46934	2.203025	-0.000007	1E-06	-153.538939	153.551774	99814.52908	98792.30715	732.346872	-153.5389391	732.3468718
86	MUMQ04A	1	47.195545	47.199457	30112.21626	223.21933	30423.23481	2.203025	-0.000007	1E-06	-154.841022	154.853857	99813.75962	98793.35756	732.346862	-154.8410224	732.346862
87	MUMQ04A	2	47.59242	47.596332	30112.53642	223.219327	30423.00028	2.203025	-0.000007	1E-06	-156.143106	156.15594	99812.99016	98794.40796	732.346852	-156.1431057	732.3468522
88	DM1	9	48.09242	48.096332	30112.93978	223.219323	30422.70481	2.203025	-0.000007	1E-06	-157.783526	157.79636	99812.02076	98795.73131	732.346839	-157.7835256	732.346839
89	MUHB01AA	1	51.14042	51.145844	30115.29679	223.219301	30420.77225	2.312108	-0.000007	2E-06	-167.783525	167.801321	99805.68033	98803.46429	732.346767	-167.7835253	732.3467668
90	DM1	10	51.64042	51.645844	30115.66558	223.219298	30420.43462	2.312108	-0.000007	2E-06	-169.423945	169.44174	99804.57263	98804.67423	732.346757	-169.4239452	732.346757
91	MUMQ05	1	51.87105	51.876474	30115.83569	223.219296	30420.27888	2.312108	-0.000007	2E-06	-170.180605	170.198401	99804.06169	98805.23233	732.34675	-170.1806053	732.3467504
92	MUMQ05	2	52.10168	52.107104	30116.0058	223.219294	30420.12315	2.312108	-0.000007	2E-06	-170.937265	170.955061	99803.55075	98805.79043	732.346744	-170.9372654	732.3467439
93	DM1	11	52.60168	52.607104	30116.37459	223.219291	30419.78552	2.312108	-0.000007	2E-06	-172.577685	172.595481	99802.44305	98807.00038	732.346734	-172.5776853	732.346734
94	MUHB01B	1	55.64968	55.657429	30118.47851	223.219269	30417.58012	2.447371	-0.000007	3E-06	-182.577685	182.603108	99795.20747	98813.90301	732.346662	-182.577685	732.3466619
95	DM1	12	56.14968	56.157429	30118.7984	223.219266	30417.19584	2.447371	-0.000007	3E-06	-184.218105	184.243528	99793.94672	98814.95253	732.346652	-184.2181049	732.346652
96	MUMQ04	1	56.546555	56.554304	30119.05232	223.219263	30416.89082	2.447371	-0.000007	3E-06	-185.520188	185.545611	99792.946	98815.78559	732.346642	-185.5201882	732.3466422
97	MUMQ04	2	56.94343	56.951179	30119.30624	223.21926	30416.5858	2.447371	-0.000007	3E-06	-186.822271	186.847695	99791.94528	98816.61864	732.346632	-186.8222715	732.3466323
98	DM1	13	57.44343	57.451179	30119.62613	223.219257	30416.20153	2.447371	-0.000007	3E-06	-188.462691	188.488115	99790.68453	98817.66817	732.346622	-188.4626914	732.3466225
99	MUMQ03	1	57.840305	57.848054	30119.88004	223.219254	30415.89651	2.447371	-0.000007	3E-06	-189.764775	189.790198	99789.68381	98818.50122	732.346613	-189.7647747	732.3466126
100	MUMQ03	2	58.23718	58.244929	30120.13396	223.219251	30415.59149	2.447371	-0.000007	3E-06	-191.066858	191.092281	99788.68309	98819.33428	732.346603	-191.066858	732.3466028
101	DM1	14	58.73718	58.744929	30120.45385	223.219248	30415.20721	2.447371	-0.000007	3E-06	-192.707278	192.732701	99787.42235	98820.3838	732.346593	-192.7072779	732.346593
102	DM1	15	59.23718	59.244929	30120.77375	223.219245	30414.82294	2.447371	-0.000007	3E-06	-194.347698	194.373121	99786.1616	98821.43332	732.346583	-194.3476978	732.3465831
103	COLH	1	59.73718	59.744929	30121.09364	223.219241	30414.43866	2.447371	-0.000007	3E-06	-195.988118	196.013541	99784.90085	98822.48284	732.34657	-195.9881177	732.34657
104	MOM	1	59.73718	59.744929	30121.09364	223.219241	30414.43866	2.447371	-0.000007	3E-06	-195.988118	196.013541	99784.90085	98822.48284	732.34657	-195.9881177	732.34657
end	MOMCOLNE	1	59.73718	59.744929	30121.09364	223.219241	30414.43866	2.447371	-0.000007	3E-06	-195.988118	196.013541	99784.90085	98822.48284	732.34657	-195.9881177	732.34657

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105	MC	1	59.73718	59.744929	30121.09364	223.219241	30414.43866	2.447371	-0.000007	3E-06	-195.988118	196.013541	99784.90085	98822.48284	732.34657	-195.9881177	732.34657
begin	MOMCOLNE	2	59.73718	59.744929	30121.09364	223.219241	30414.43866	2.447371	-0.000007	3E-06	-195.988118	196.013541	99784.90085	98822.48284	732.34657	-195.9881177	732.34657
106	MOM	2	59.73718	59.744929	30121.09364	223.219241	30414.43866	2.447371	-0.000007	3E-06	-195.988118	196.013541	99784.90085	98822.48284	732.34657	-195.9881177	732.34657
107	COLH	2	60.23718	60.244929	30121.41354	223.219238	30414.05438	2.447371	-0.000007	3E-06	-197.628538	197.653961	99783.6401	98823.53236	732.34656	-197.6285376	732.3465602
108	DM1	16	60.73718	60.744929	30121.73343	223.219234	30413.67011	2.447371	-0.000007	3E-06	-199.268957	199.294381	99782.37935	98824.58188	732.346547	-199.2689575	732.346547
109	DM1	17	61.23718	61.244929	30122.05332	223.219231	30413.28583	2.447371	-0.000007	3E-06	-200.909377	200.934801	99781.11861	98825.6314	732.346537	-200.9093774	732.3465372
110	MUMQ03	3	61.634055	61.641804	30122.30724	223.219228	30412.98081	2.447371	-0.000007	3E-06	-202.211461	202.236884	99780.11789	98826.46445	732.346527	-202.2114607	732.3465273
111	MUMQ03	4	62.03093	62.038679	30122.56115	223.219225	30412.67579	2.447371	-0.000007	3E-06	-203.513544	203.538967	99779.11717	98827.29751	732.346518	-203.513544	732.3465175
112	DM1	18	62.53093	62.538679	30122.88105	223.219222	30412.29152	2.447371	-0.000007	3E-06	-205.153964	205.179387	99777.85642	98828.34703	732.346508	-205.1539639	732.3465077
113	MUMQ04	3	62.927805	62.935554	30123.13496	223.219219	30411.9865	2.447371	-0.000007	3E-06	-206.456047	206.48147	99776.8557	98829.18008	732.346498	-206.4560472	732.3464978
114	MUMQ04	4	63.32468	63.332429	30123.38888	223.219216	30411.68148	2.447371	-0.000007	3E-06	-207.75813	207.783554	99775.85498	98830.01314	732.346488	-207.7581305	732.346488
115	DM1	19	63.82468	63.832429	30123.70877	223.219213	30411.2972	2.447371	-0.000007	3E-06	-209.39855	209.423974	99774.59424	98831.06266	732.346478	-209.3985504	732.3464781
116	MUHB01B	2	66.87268	66.882754	30125.49608	223.219192	30408.82823	2.582634	-0.000006	3E-06	-219.39855	219.431601	99766.49892	98836.92652	732.346409	-219.3985501	732.3464092
117	DM1	20	67.37268	67.382754	30125.76123	223.219189	30408.40432	2.582634	-0.000006	3E-06	-221.03897	221.072021	99765.10816	98837.79644	732.346399	-221.03897	732.3463994
118	MUMQ05	3	67.60331	67.613384	30125.88353	223.219188	30408.20879	2.582634	-0.000006	3E-06	-221.79563	221.828681	99764.46165	98838.1977	732.346396	-221.7956301	732.3463961
119	MUMQ05	4	67.83394	67.844014	30126.00584	223.219186	30408.01326	2.582634	-0.000006	3E-06	-222.55229	222.585341	99763.82015	98838.59896	732.34639	-222.5522901	732.3463896
120	DM1	21	68.33394	68.344014	30126.27099	223.219183	30407.58936	2.582634	-0.000006	3E-06	-224.19271	224.225761	99762.42939	98839.46888	732.34638	-224.19271	732.3463797
121	MUHB01AA	2	71.38194	71.393526	30127.74408	223.219164	30404.92097	2.691717	-0.000006	4E-06	-234.19271	234.230722	99753.67483	98844.30185	732.346317	-234.1927098	732.3463174
122	DM1	22	71.88194	71.893526	30127.9615	223.219161	30404.47072	2.691717	-0.000006	4E-06	-235.83313	235.871141	99752.19763	98845.01519	732.346308	-235.8331297	732.3463075
123	MUMQ04A	3	72.278815	72.290401	30128.13409	223.219158	30404.11333	2.691717	-0.000006	4E-06	-237.135213	237.173225	99751.0251	98845.58141	732.346298	-237.1352129	732.3462977
124	MUMQ04A	4	72.67569	72.687276	30128.30667	223.219156	30403.75594	2.691717	-0.000006	4E-06	-238.437296	238.475308	99749.85257	98846.14762	732.346291	-238.4372962	732.3462911
125	DM1	23	73.17569	73.187276	30128.5241	223.219153	30403.30569	2.691717	-0.000006	4E-06	-240.077716	240.115728	99748.37537	98846.86097	732.346281	-240.0777161	732.3462813
126	MUHB01A	2	76.22369	76.236787	30129.69793	223.219135	30400.49279	2.8008	-0.000006	5E-06	-250.077716	250.120685	99739.14669	98850.71213	732.346222	-250.0777159	732.3462222
127	DM1	24	76.72369	76.736787	30129.86505	223.219132	30400.02155	2.8008	-0.000006	5E-06	-251.718136	251.761105	99737.60061	98851.26041	732.346212	-251.7181358	732.3462124
128	DM1	25	77.22369	77.236787	30130.03216	223.219129	30399.5503	2.8008	-0.000006	5E-06	-253.358556	253.401525	99736.05453	98851.8087	732.346203	-253.3585557	732.3462025
end	MOMCOLNE	2	77.22369	77.236787	30130.03216	223.219129	30399.5503	2.8008	-0.000006	5E-06	-253.358556	253.401525	99736.05453	98851.8087	732.346203	-253.3585557	732.3462025
end	MOMCOL_1	1	77.22369	77.236787	30130.03216	223.219129	30399.5503	2.8008	-0.000006	5E-06	-253.358556	253.401525	99736.05453	98851.8087	732.346203	-253.3585557	732.3462025
end	BEARING	1	77.22369	77.236787	30130.03216	223.219129	30399.5503	2.8008	-0.000006	5E-06	-253.358556	253.401525	99736.05453	98851.8087	732.346203	-253.3585557	732.3462025
begin	MOMMATCH	1	77.22369	77.236787	30130.03216	223.219129	30399.5503	2.8008	-0.000006	5E-06	-253.358556	253.401525	99736.05453	98851.8087	732.346203	-253.3585557	732.3462025
129	MMF01	1	77.45432	77.467417	30130.10925	223.219128	30399.33294	2.8008	-0.000006	5E-06	-254.115216	254.158185	99735.34139	98852.0616	732.346199	-254.1152157	732.3461993
130	MMF01	2	77.68495	77.698047	30130.18633	223.219127	30399.11557	2.8008	-0.000006	5E-06	-254.871876	254.914845	99734.62824	98852.3145	732.346196	-254.8718758	732.346196
131	DMOM1	1	79.221958	79.235055	30130.70005	223.219118	30397.66695	2.8008	-0.000006	5E-06	-259.914553	259.957522	99729.87557	98853.99993	732.346166	-259.9145528	732.3461665
132	MMD02	1	79.452588	79.465685	30130.77714	223.219117	30397.44959	2.8008	-0.000006	5E-06	-260.671213	260.714182	99729.16242	98854.25284	732.346163	-260.6712129	732.3461632
133	MMD02	2	79.683218	79.696315	30130.85422	223.219116	30397.23222	2.8008	-0.000006	5E-06	-261.427873	261.470842	99728.44928	98854.50574	732.34616	-261.427873	732.3461599
134	DMOM2	1	94.154108	94.167205	30135.69088	223.219035	30383.59355	2.8008	-0.000006	5E-06	-308.904545	308.947514	99683.70299	98870.37405	732.345894	-308.9045449	732.3458941
135	MMF02	1	94.384738	94.397835	30135.76797	223.219033	30383.37618	2.8008	-0.000006	5E-06	-309.661205	309.704174	99682.98984	98870.62695	732.345888	-309.6612049	732.3458876
136	MMF02	2	94.615368	94.628465	30135.84505	223.219032	30383.15882	2.8008	-0.000006	5E-06	-310.417865	310.460834	99682.2767	98870.87985	732.345884	-310.417865	732.3458843
137	DMOM3	1	99.836455	99.849552	30137.59012	223.219003	30378.23799	2.8008	-0.000006	5E-06	-327.547415	327.590384	99666.13226	98876.60513	732.345789	-327.5474151	732.3457892
138	MMF03	1	100.067085	100.080182	30137.6672	223.219002	30378.02063	2.8008	-0.000006	5E-06	-328.304075	328.347044	99665.41912	98876.85803	732.345786	-328.3040751	732.3457859
139	MMF03	2	100.297715	100.310812	30137.74429	223.219	30377.80326	2.8008	-0.000006	5E-06	-329.060735	329.103704	99664.70598	98877.11093	732.345779	-329.0607352	732.3457793
140	DMT1	1	101.297715	101.310812	30138.07852	223.218995	30376.86077	2.8008	-0.000006	5E-06	-332.341575	332.384544	99661.61382	98878.2075	732.345763	-332.341575	732.3457629
141	AC1	1	104.297715	104.310812	30139.08122	223.218978	30374.0333	2.8008	-0.000006	5E-06	-342.184094	342.227064	99652.33734	98881.49721	732.345707	-342.1840944	732.3457071
end	MOMMATCH	1	104.297715	104.310812	30139.08122	223.218978	30374.0333	2.8008	-0.000006	5E-06	-342.184094	342.227064	99652.33734	98881.49721	732.345707	-342.1840944	732.3457071
end	HBETAUP	1	104.297715	104.310812	30139.08122	223.218978	30374.0333	2.8008	-0.000006	5E-06	-342.184094	342.227064	99652.33734	98881.49721	732.345707	-342.1840944	732.3457071
begin	HBMATCH1	1	104.297715	104.310812	30139.08122	223.218978	30374.0333	2.8008	-0.000006	5E-06	-342.184094	342.227064	99652.33734	98881.49721	732.345707	-342.1840944	732.3457071
begin	ACMATCH1	1	104.297715	104.310812	30139.08122	223.218978	30374.0333	2.8008	-0.000006	5E-06	-342.184094	342.227064	99652.33734	98881.49721	732.345707	-342.1840944	732.3457071
142	MP	1	104.297715	104.310812	30139.08122	223.218978	30374.0333	2.8008	-0.000006	5E-06	-342.184094	342.227064	99652.33734	98881.49721	732.345707	-342.1840944	732.3457071
143	AC1	2	107.297715	107.310812	30140.08392	223.218961	30371.20583	2.8008	-0.000006	5E-06	-352.026614	352.069583	99643.06086	98884.78691	732.345651	-352.0266138	732.3456514
144	DMT1	2	108.297715	108.310812	30140.41816	223.218955	30370.26334	2.8008	-0.000006	5E-06	-355.307454	355.350423	99639.9687	98885.88348	732.345632	-355.3074536	732.3456317
145	MUMF04	1	108.528345	108.541442	30140.49524	223.218954	30370.04597	2.8008	-0.000006	5E-06	-356.064114	356.107083	99639.25556	98886.13638	732.345628	-356.0641137	732.3456284
146	MUMF04	2	108.758975	108.772072	30140.57233	223.218953	30369.82861	2.8008	-0.000006	5E-06	-356.820774	356.863743	99638.54241	98886.38928	732.345625	-356.8207738	732.3456251
147	DMT2	1	114.239202	114.2523	30142.404	223.218922	30364.66355	2.8008	-0.000006	5E-06	-374.800521	374.843493	99621.59668	98892.39872	732.345523	-374.8005206	732.3455234
148	MUMD05	1	114.469832	114.48293	30142.48109	223.218921	30364.44618	2.8008	-0.000006	5E-06	-375.557181	375.600153	99620.88353	98892.65162	732.34552	-375.5571807	732.3455201
149	MUMD05	2	114.700462	114.71356	30142.55817	223.21892	30364.22881	2.8008	-0.000006	5E-06	-376.313841	376.356813	99620.17039	98892.90452	732.345517	-376.3138408	732.3455168
150	DMT3	1	122.854114	122.867211	30145.2834	223.218874	30356.54408	2.8008	-0.000006	5E-06	-403.064667	403.107636	99594.958	98901.84556	732.345366	-403.0646668	732.3453659
151	MUMF06	1	123.084744	123.097841	30145.36048	223.218873	30356.32671	2.8008	-0.000006	5E-06	-403.821327	403.864296	99594.24486	98902.09846	732.345363	-403.8213269	732.3453626
152	MUMF06	2	123.315374	123.328471	30145.43757	223.218871	30356.10934	2.8008	-0.000006	5E-06	-404.577987	404.620956	99593.53171	98902.35136	732.345356	-404.577987	732.3453561
153	MM1	1	123.315374	123.328471	30145.43757	223.218871	30356.10934	2.8008	-0.000006	5E-06	-404.577987	404.620956	99593.53171	98902.35136	732.345356	-404.577987	732.3453561
154	DM1	26	123.815374	123.828471	30145.60469	223.218869	30355.6381	2.8008	-0.000006	5E-06	-406.218407	406.261376	99591.98563	98902.89965	732.34535	-406.2184069	732.3453495
155	DMT4	1	127.905419	127.918516	30146.97172	223.218846	30351.78327	2.8008	-0.000006	5E-06	-419.637189	419.680158	99579.33856	98907.38466	732.345274	-419.6371893	732.3452741
end	ACMATCH1	1	127.905419	127.918516	30146.97172	223.218846	30351.78327	2.8008	-0.000006	5E-06	-419.637189	419.680158	99579.33856	98907.38466	732.345274	-419.6371893	732.3452741
begin	COLSECFU	1	127.905419	127.918516	30146.97172	223.218846	30351.78327	2.8008	-0.000006	5E-06	-419.637189	419.680158	99579.33856	98907.38466	732.345274	-419.6371893	732.3452741
begin	COLSECPA	1	127.905419	127.918516	30146.97172	223.218846	30351.78327	2.8008	-0.000006	5E-06	-419.637189	419.680158	99579.33856	98907.38466	732.345274	-419.6371893	732.3452741
156	DCOL5	1	129.905419	129.918516	30147.64019	223.218835	30349.89829	2.8008	-0.000006	5E-06	-426.198869	426.241838	99573.15424	98909.5778	732.345238	-426.1988689	732.345238
157	COLQF01	1	130.136049	130.149146	30147.71727	223.218833	30349.68093	2.8008	-0.000006	5E-06	-426.955529	426.998498	99572.4411	98909.8307	732.345231	-426.955529	732.3452314
158	COLQF01	2	130.366679	130.379776	30147.79435	223.218832	30349.46356	2.8008	-0.000006	5E-06	-427.712189	427.755158	99571.72795	98910.0836	732.345228	-427.7121891	732.3452281
159	DCOL4	1	130.866679	130.879776	30147.96147	223.218829	30348.99231	2.8008	-0.000006	5E-06	-429.352609	429.395578	99570.18187	98910.63188	732.345218	-429.352609	732.3452183
160	COLQD02	1	131.097309	131.110406	30148.03856	223.218828	30348.77495	2.8008	-0.000006	5E-06	-430.109269	430.152238	99569.46873	98910.88478	732.345215	-430.109269	732.345215
161	COLQD02	2	131.327939	131.341036	30148.11564	223.218827	30348.55758	2.8008	-0.000006	5E-06	-430.865929	430.908898	99568.75558	98911.13768	732.345212	-430.8659291	732.3452117
162	DCOL3	1	136.192894	136.205991	30149.74167	223.218799	30343.97241	2.8008	-0.000006	5E-06	-446.827067	446.870036	99553.71237	98916.47244	732.34512	-446.8270671	732.3451199
163	COLQF03	1	136.423524	136.436621	30149.81876	223.218798	30343.75504	2.8008	-0.000006	5E-06	-447.583727	447.626696	99552.99922	98916.72534	732.345117	-447.5837272	732.3451166
164	COLQF03	2	136.654154	136.667251	30149.89584	223.218797	30343.53768	2.8008	-0.000006	5E-06	-448.340387	448.383356	99552.28608	98916.97824	732.345113	-448.3403873	732.3451133
165	DCOL2	1	137.154154	137.167251	30150.06296	223.218794	30343.06643	2.8008	-0.000006	5E-06	-449.980807	450.023776	99550.74	98917.52653	732.345103	-449.9808072	732.3451035
166	COLQD04	1	137.384784	137.397881	30150.14004	223.218793	30342.84906	2.8008	-0.000006	5E-06	-450.737467	450.780436	99550.02685	98917.77943	732.3451	-450.7374673	732.3451002
167	COLQD04	2	137.615414	137.628511	30150.21713	223.218791	30342.6317	2.8008	-0.000006	5E-06	-451.494127	451.537097	99549.31371	98918.03233	732.345094	-451.4941273	732.3450936
168	DCOL1	1	139.615414	139.628511	30150.8856	223.21878	30340.74672	2.8008	-0.000006	5E-06	-458.055807	458.098776	99543.12939	98920.22547	732.345058	-458.0558069	732.3450575
end	COLSECPA	1	139.615414	139.628511	30150.8856	223.21878	30340.74672	2.8008	-0.000006	5E-06	-458.055807	458.098776	99543.12939	98920.22547	732.345058	-458.0558069	732.3450575
begin	COLSECPA	1	139.615414	139.628511	30150.8856	223.21878	30340.74672	2.8008	-0.000006	5E-06	-458.055807	458.098776	99543.12939	98920.22547	732.345058	-458.0558069	732.3450575
169	DCOL1	2	141.615414	141.628511	30151.55406	223.218769	30338.86174	2.8008	-0.000006	5E-06	-464.617487	464.660456	99536.94507	98922.4186	732.345021	-464.6174865	732.3450214
170	COLQD08	1	141.846044	141.859141	30151.63115	223.218768	30338.64437	2.8008	-0.000006	5E-06	-465.374147	465.417116	99536.23193	98922.6715	732.345018	-465.3741466	732.3450182
171	COLQD08	2	142.076674	142.089771	30151.70823	223.218766	30338.427	2.8008	-0.000006	5E-06	-466.130807	466.173776	99535.51878	98922.9244	732.345012	-466.1308067	732.3450116
172	DCOL2	2	142.576674	142.589771	30151.87535	223.218764	30337.95576	2.8008	-0.000006	5E-06	-467.771227	467.814196	99533.9727	98923.47269	732.345005	-467.7712266	732.345005
173	COLQF07	1	142.807304	142.820401	30151.95243	223.218762	30337.73839	2.8008	-0.000006	5E-06	-468.527887	468.570856	99533.25956	98923.72559	732.344998	-468.5278867	732.3449985
174	COLQF07	2	143.037934	143.051031	30152.02952	223.218761	30337.52103	2.8008	-0.000006	5E-06	-469.284547	469.327516	99532.54642	98923.97849	732.344995	-469.2845468	732.3449952
175	DCOL3	2	147.902889	147.915986	30153.65555	223.218734	30332.93585	2.8008	-0.000006	5E-06	-485.245685	485.288654	99517.5032	98929.31324	732.344907	-485.2456848	732.3449066
176	COLQD06	1	148.133519	148.146616	30153.73263	223.218733	30332.71849	2.8008	-0.000006	5E-06	-486.002345	486.045314	99516.79005	98929.56614	732.344903	-486.0023448	732.3449033
177	COLQD06	2	148.364149	148.377246	30153.80972	223.218731	30332.50112	2.8008	-0.000006	5E-06	-486.759005	486.801974	99516.07691	98929.81905	732.344897	-486.7590049	732.3448968
178	DCOL4	2	148.864149	148.877246	30153.97684	223.218728	30332.02988	2.8008	-0.000006	5E-06	-488.399425	488.442394	99514.53083	98930.36733	732.344887	-488.3994248	732.3448869
179	COLQF05	1	149.094779	149.107876	30154.05392	223.218727	30331.81251	2.8008	-0.000006	5E-06	-489.156085	489.199054	99513.81769	98930.62023	732.344884	-489.1560849	732.3448836
180	COLQF05	2	149.325409	149.338506	30154.13101	223.218726	30331.59514	2.8008	-0.000006	5E-06	-489.912745	489.955714	99513.10454	98930.87314	732.34488	-489.912745	732.3448804
181	DCOL5	2	151.325409	151.338506	30154.79947	223.218715	30329.71016	2.8008	-0.000006	5E-06	-496.474425	496.517394	99506.92022	98933.06627	732.344844	-496.4744246	732.3448443
end	COLSECPA	1	151.325409	151.338506	30154.79947	223.218715	30329.71016	2.8008	-0.000006	5E-06	-496.474425	496.517394	99506.92022	98933.06627	732.344844	-496.4744246	732.3448443
begin	COLSEC1	1	151.325409	151.338506	30154.79947	223.218715	30329.71016	2.8008	-0.000006	5E-06	-496.474425	496.517394	99506.92022	98933.06627	732.344844	-496.4744246	732.3448443
182	DCOL5	3	153.325409	153.338506	30155.46794	223.218703	30327.82518	2.8008	-0.000006	5E-06	-503.036104	503.079073	99500.7359	98935.25941	732.344805	-503.0361042	732.3448049
183	COLQF09	1	153.556039	153.569136	30155.54503	223.218702	30327.60782	2.8008	-0.000006	5E-06	-503.792764	503.835733	99500.02276	98935.51231	732.344802	-503.7927643	732.3448016
184	COLQF09	2	153.786669	153.799766	30155.62211	223.218701	30327.39045	2.8008	-0.000006	5E-06	-504.549424	504.592394	99499.30962	98935.76521	732.344798	-504.5494244	732.3447983
185	DCOL4	3	154.286669	154.299766	30155.78923	223.218698	30326.9192	2.8008	-0.000006	5E-06	-506.189844	506.232813	99497.76354	98936.31349	732.344789	-506.1898443	732.3447885
186	COLQD10	1	154.517299	154.530396	30155.86631	223.218697	30326.70184	2.8008	-0.000006	5E-06	-506.946504	506.989474	99497.05039	98936.56639	732.344785	-506.9465043	732.3447852
187	COLQD10	2	154.747929	154.761026	30155.9434	223.218696	30326.48447	2.8008	-0.000006	5E-06	-507.703164	507.746134	99496.33725	98936.8193	732.344782	-507.7031644	732.3447819
188	DCOL3	3	159.612884	159.625981	30157.56943	223.218668	30321.8993	2.8008	-0.000006	5E-06	-523.664302	523.707272	99481.29403	98942.15405	732.34469	-523.6643024	732.3446901
189	COLQF11	1	159.843514	159.856611	30157.64651	223.218667	30321.68193	2.8008	-0.000006	5E-06	-524.420963	524.463932	99480.58089	98942.40695	732.344687	-524.4209625	732.3446868
190	COLQF11	2	160.074144	160.087241	30157.7236	223.218666	30321.46457	2.8008	-0.000006	5E-06	-525.177623	525.220592	99479.86774	98942.65985	732.344684	-525.1776226	732.3446835
191	DCOL2	3	160.574144	160.587241	30157.89071	223.218663	30320.99332	2.8008	-0.000006	5E-06	-526.818042	526.861012	99478.32166	98943.20814	732.344674	-526.8180425	732.3446737
192	COLQD12	1	160.804774	160.817871	30157.9678	223.218662	30320.77595	2.8008	-0.000006	5E-06	-527.574703	527.617672	99477.60852	98943.46104	732.34467	-527.5747026	732.3446704
193	COLQD12	2	161.035404	161.048501	30158.04488	223.21866	30320.55859	2.8008	-0.000006	5E-06	-528.331363	528.374332	99476.89537	98943.71394	732.344664	-528.3313627	732.3446638
194	DCOL1	3	163.035404	163.048501	30158.71335	223.218649	30318.67361	2.8008	-0.000006	5E-06	-534.893042	534.936011	99470.71105	98945.90708	732.344628	-534.8930423	732.3446277
begin	MATCHH1	1	163.035404	163.048501	30158.71335	223.218649	30318.67361	2.8008	-0.000006	5E-06	-534.893042	534.936011	99470.71105	98945.90708	732.344628	-534.8930423	732.3446277
195	DMATT3	1	165.047523	165.06062	30159.38587	223.218638	30316.77721	2.8008	-0.000006	5E-06	-541.494482	541.537452	99464.48926	98948.1135	732.344592	-541.4944823	732.3445917
196	MDQ0	1	165.278153	165.29125	30159.46295	223.218637	30316.55984	2.8008	-0.000006	5E-06	-542.251142	542.294112	99463.77612	98948.3664	732.344588	-542.2511424	732.3445884
197	MDQ0	2	165.508783	165.52188	30159.54004	223.218635	30316.34247	2.8008	-0.000006	5E-06	-543.007803	543.050772	99463.06297	98948.6193	732.344582	-543.0078025	732.3445818
198	DMATT2	1	166.008783	166.02188	30159.70715	223.218632	30315.87123	2.8008	-0.000006	5E-06	-544.648222	544.691192	99461.51689	98949.16759	732.344572	-544.6482224	732.344572
199	MFQ0	1	166.239413	166.25251	30159.78424	223.218631	30315.65386	2.8008	-0.000006	5E-06	-545.404882	545.447852	99460.80375	98949.42049	732.344569	-545.4048825	732.3445687
200	MFQ0	2	166.470043	166.48314	30159.86132	223.21863	30315.43649	2.8008	-0.000006	5E-06	-546.161543	546.204512	99460.0906	98949.67339	732.344565	-546.1615426	732.3445654
201	DMATT1	1	167.11343	167.126528	30160.07637	223.218626	30314.83011	2.8008	-0.000006	5E-06	-548.272392	548.315365	99458.10115	98950.37891	732.344552	-548.2723923	732.3445523
end	MATCHH1	1	167.11343	167.126528	30160.07637	223.218626	30314.83011	2.8008	-0.000006	5E-06	-548.272392	548.315365	99458.10115	98950.37891	732.344552	-548.2723923	732.3445523
end	COLSEC1	1	167.11343	167.126528	30160.07637	223.218626	30314.83011	2.8008	-0.000006	5E-06	-548.272392	548.315365	99458.10115	98950.37891	732.344552	-548.2723923	732.3445523
end	COLSECFU	1	167.11343	167.126528	30160.07637	223.218626	30314.83011	2.8008	-0.000006	5E-06	-548.272392	548.315365	99458.10115	98950.37891	732.344552	-548.2723923	732.3445523
end	HBMATCH1	1	167.11343	167.126528	30160.07637	223.218626	30314.83011	2.8008	-0.000006	5E-06	-548.272392	548.315365	99458.10115	98950.37891	732.344552	-548.2723923	732.3445523
end	COLSECUP	1	167.11343	167.126528	30160.07637	223.218626	30314.83011	2.8008	-0.000006	5E-06	-548.272392	548.315365	99458.10115	98950.37891	732.344552	-548.2723923	732.3445523
202	DABSORB	1	202.456109	202.469207	30171.88909	223.218429	30281.51998	2.8008	-0.000006	5E-06	-664.22606	664.269033	99348.81596	98989.13456	732.343906	-664.2260602	732.343906
begin	REFLECTF	1	202.456109	202.469207	30171.88909	223.218429	30281.51998	2.8008	-0.000006	5E-06	-664.22606	664.269033	99348.81596	98989.13456	732.343906	-664.2260602	732.343906
begin	REFFFT1	1	202.456109	202.469207	30171.88909	223.218429	30281.51998	2.8008	-0.000006	5E-06	-664.22606	664.269033	99348.81596	98989.13456	732.343906	-664.2260602	732.343906
203	DM1	27	202.956109	202.969207	30172.05621	223.218426	30281.04874	2.8008	-0.000006	5E-06	-665.86648	665.909453	99347.26988	98989.68285	732.343896	-665.8664801	732.3438961
204	FFV13	1	204.175309	204.188436	30172.46367	223.20379	30279.89973	2.8008	-0.024004	5E-06	-669.86648	669.909548	99343.50019	98991.01969	732.295878	-669.8664799	732.2958777
205	DM1	28	204.675309	204.688436	30172.63074	223.191789	30279.42863	2.8008	-0.024004	5E-06	-671.5069	671.549967	99341.95455	98991.56781	732.256504	-671.5068998	732.2565044
206	FFFQ1	1	205.061389	205.074516	30172.75975	223.182523	30279.06485	2.8008	-0.024004	5E-06	-672.773566	672.816634	99340.76108	98991.99105	732.226104	-672.7735665	732.2261041
207	FFFQ1	2	205.447469	205.460596	30172.88875	223.173256	30278.70108	2.8008	-0.024004	5E-06	-674.040233	674.083301	99339.5676	98992.41429	732.195701	-674.0402331	732.1957006
208	DM1	29	205.947469	205.960596	30173.05582	223.161255	30278.22997	2.8008	-0.024004	5E-06	-675.680653	675.723721	99338.02197	98992.96242	732.156327	-675.680653	732.1563272
209	DFF1	1	207.362949	207.376076	30173.52878	223.127282	30276.89628	2.8008	-0.024004	5E-06	-680.324616	680.367684	99333.64634	98994.51414	732.044867	-680.3246161	732.0448673

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210	DM1	30	207.862949	207.876076	30173.69535	223.115281	30276.42517	2.8008	-0.024004	5E-06	-681.965036	682.008104	99332.1007	98995.06226	732.005494	-681.965036	732.0054939
211	FFDQ2	1	208.297949	208.311076	30173.8412	223.10484	30276.01531	2.8008	-0.024004	5E-06	-683.392201	683.435269	99330.756	98995.53913	731.971239	-683.3922013	731.9712386
212	FFDQ2	2	208.732949	208.746076	30173.98655	223.094399	30275.60544	2.8008	-0.024004	5E-06	-684.819367	684.862434	99329.4113	98996.016	731.938983	-684.8193667	731.9369834
213	DM1	31	209.232949	209.246076	30174.15362	223.082399	30275.13433	2.8008	-0.024004	5E-06	-686.459787	686.502854	99327.86566	98996.56413	731.897613	-686.4597866	731.8976133
214	DFF2	1	212.24101	212.254137	30175.15873	223.0302	30272.30008	2.8008	-0.024004	5E-06	-696.328753	696.37182	99318.56694	98999.86172	731.66074	-696.3287528	731.66074
215	DM1	32	212.74101	212.754137	30175.3258	222.9982	30271.82897	2.8008	-0.024004	5E-06	-697.969173	698.01224	99317.02131	99000.40985	731.62137	-697.9693727	731.6213899
216	FFFQ3	1	213.12709	213.140217	30175.4548	222.988933	30271.4652	2.8008	-0.024004	5E-06	-699.235839	699.278907	99315.82783	99000.83309	731.590966	-699.2358393	731.5909663
217	FFFQ3	2	213.51317	213.526297	30175.5838	222.979667	30271.10143	2.8008	-0.024004	5E-06	-700.502506	700.545574	99314.63435	99001.25833	731.560566	-700.502506	731.5605661
218	DM1	33	214.01317	214.026297	30175.75087	222.967666	30270.63032	2.8008	-0.024004	5E-06	-702.342926	702.385993	99313.08872	99001.80446	731.521199	-702.3429259	731.5211927
219	DFF3	1	219.268661	219.281788	30177.50693	222.843526	30265.6785	2.8008	-0.024004	5E-06	-719.33535	719.428437	99296.84258	99007.5658	731.107348	-719.3353499	731.1073476
220	DM1	34	219.768661	219.781788	30177.674	222.829525	30265.20739	2.8008	-0.024004	5E-06	-721.02577	721.068837	99295.29695	99008.11392	731.067974	-721.0257698	731.0679742
221	FFDQ4	1	220.154741	220.167868	30177.803	222.820258	30264.84362	2.8008	-0.024004	5E-06	-722.292436	722.335504	99294.10347	99008.53717	731.087571	-722.2924364	731.0875707
and	REFFFT1	1	220.154741	220.167868	30177.803	222.820258	30264.84362	2.8008	-0.024004	5E-06	-722.292436	722.335504	99294.10347	99008.53717	731.087571	-722.2924364	731.0875707
222	M0	1	220.154741	220.167868	30177.803	222.820258	30264.84362	2.8008	-0.024004	5E-06	-722.292436	722.335504	99294.10347	99008.53717	731.087571	-722.2924364	731.0875707
begin	REFFFT	1	220.154741	220.167868	30177.803	222.820258	30264.84362	2.8008	-0.024004	5E-06	-722.292436	722.335504	99294.10347	99008.53717	731.087571	-722.2924364	731.0875707
223	FFDQ4	2	220.540821	220.553948	30177.93201	222.810992	30264.47984	2.8008	-0.024004	5E-06	-723.559103	723.602171	99292.91	99008.96041	731.00717	-723.5593031	731.0073704
224	DM1	35	221.040821	221.053948	30178.09907	222.798991	30264.00873	2.8008	-0.024004	5E-06	-725.399523	725.242593	99291.18436	99009.50853	730.967797	-725.199523	730.9677971
225	DFF3	2	226.296312	226.309439	30179.35513	222.672851	30259.05491	2.8008	-0.024004	5E-06	-742.441947	742.485015	99275.11828	99015.26987	730.553952	-742.441947	730.5539519
226	DM1	36	226.796312	226.809439	30180.0222	222.66085	30258.5858	2.8008	-0.024004	5E-06	-744.082367	744.125434	99273.57259	99015.818	730.514579	-744.0823669	730.5145786
227	FFFQ3	3	227.182392	227.195519	30180.1512	222.651584	30258.22203	2.8008	-0.024004	5E-06	-745.349034	745.392101	99272.37912	99016.24124	730.484178	-745.3490835	730.4841783
228	FFFQ3	4	227.568472	227.581599	30180.28021	222.642317	30257.85826	2.8008	-0.024004	5E-06	-746.6157	746.658768	99271.18564	99016.66448	730.453775	-746.6157002	730.4537748
229	DM1	37	228.068472	228.081599	30180.44728	222.630816	30257.38715	2.8008	-0.024004	5E-06	-748.25612	748.299188	99269.64001	99017.2126	730.414401	-748.2561201	730.4144014
230	DFF2	2	231.076533	231.08966	30181.45238	222.558118	30254.5529	2.8008	-0.024004	5E-06	-758.125086	758.168154	99260.34128	99020.5102	730.177531	-758.1250863	730.1775313
231	DM1	38	231.576533	231.58966	30181.62945	222.546118	30254.08179	2.8008	-0.024004	5E-06	-759.765506	759.808574	99258.79565	99021.05832	730.138161	-759.7655062	730.1381613
232	FFDQ2	3	232.011533	232.02466	30181.7648	222.535677	30253.67192	2.8008	-0.024004	5E-06	-761.392672	761.235739	99257.45094	99021.53519	730.103906	-761.1926715	730.103906
233	FFDQ2	4	232.446533	232.45966	30181.93015	222.525236	30253.26206	2.8008	-0.024004	5E-06	-762.619837	762.662904	99256.10624	99022.01206	730.069651	-762.6193868	730.0696503
234	DM1	39	232.946533	232.95966	30182.07722	222.513235	30252.79095	2.8008	-0.024004	5E-06	-764.260257	764.303324	99254.56061	99022.56019	730.030277	-764.2602567	730.0302774
235	DFF1	2	234.362013	234.37514	30182.59019	222.479262	30251.45726	2.8008	-0.024004	5E-06	-768.90422	768.947287	99250.18498	99024.11391	729.918817	-768.9042199	729.9188174
236	DM1	40	234.862013	234.87514	30182.73725	222.467261	30250.98615	2.8008	-0.024004	5E-06	-770.54464	770.587707	99248.63935	99024.66004	729.879444	-770.5446398	729.8794441
237	FFFQ1	3	235.248093	235.26122	30182.84626	222.457994	30250.62238	2.8008	-0.024004	5E-06	-771.811306	771.854374	99247.44587	99025.08328	729.849041	-771.8113064	729.8490405
238	FFFQ1	4	235.634173	235.6473	30182.97526	222.448728	30250.25861	2.8008	-0.024004	5E-06	-773.077973	773.121041	99246.25239	99025.50652	729.81864	-773.077973	729.8186403
239	DM1	41	236.134173	236.1473	30183.14233	222.436727	30249.7875	2.8008	-0.024004	5E-06	-774.718398	774.761461	99244.70676	99026.05465	729.779267	-774.7183929	729.7792689
240	FFV13	2	237.353373	237.366529	30183.54956	222.392842	30248.63916	2.800801	-0.048002	5E-06	-778.718398	778.761556	99240.93924	99027.39071	729.635287	-778.7183928	729.6352873
241	DFINAL1	1	240.075008	240.088163	30184.45818	222.262247	30246.077	2.800801	-0.048002	5E-06	-787.647641	787.690801	99232.53321	99030.37173	729.206826	-787.6476412	729.206826
242	DFINAL2	1	244.353373	244.366529	30186.05343	222.032964	30241.57862	2.800801	-0.048002	5E-06	-803.324691	803.367854	99217.77476	99035.60549	728.454585	-803.3246913	728.4545852
end	REFFFT	1	244.353373	244.366529	30186.05343	222.032964	30241.57862	2.800801	-0.048002	5E-06	-803.324691	803.367854	99217.77476	99035.60549	728.454585	-803.3246913	728.4545852
end	REFLECTF	1	244.353373	244.366529	30186.05343	222.032964	30241.57862	2.800801	-0.048002	5E-06	-803.324691	803.367854	99217.77476	99035.60549	728.454585	-803.3246913	728.4545852
end	L_SURVEY	1	244.353373	244.366529	30186.05343	222.032964	30241.57862	2.800801	-0.048002	5E-06	-803.324691	803.367854	99217.77476	99035.60549	728.454585	-803.3246913	728.4545852
----	-------	---	-------	-------	-------	-------	-------	-------	-------	------	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!		
total	length =		244.353373	arc	length =	244.36652	9				803.3246913	#VALUE!	29.5275582	#VALUE!	803.367825		
error	(x) =		0.114542E+	03	erro	r(y) =	-0.77379	3E-01	err	or(z) =	-0.205437E+	3	#VALUE!	#VALUE!	#VALUE!	#VALUE!	-2.53368103	
error	(theta) =		0.706859E+	00	erro	r(phi) =	-0.30335	0E+00	err	or(psi) =	0.478545E-	5	#VALUE!	#VALUE!	#VALUE!	#VALUE!	-0.33251311	
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1 "MAD" Version: 8.23/08 Run: 07/05/13 21.47.55
Survey. SURVEY line: G_2_FULL_2 range: #S/#E
symm: F super: 1 page 1

pos. no.	ELEMENT name	occ. no.	SEQUENCE sum(L) [m]	arc [m]	POSITIONS I x [m]	y [m]	z [m]	ANGLES I theta [rad]	phi [rad]	psi [rad]
begin	G_2_FULL	1	0.000000	0.000000	30071.513158	222.109844	30447.014726	2.093951	0.053348	0.000000
begin	G_LAM_2	1	0.000000	0.000000	30071.513158	222.109844	30447.014726	2.093951	0.053348	0.000000
begin	G_LAM	1	0.000000	0.000000	30071.513158	222.109844	30447.014726	2.093951	0.053348	0.000000
begin	VERTEXTS	1	0.000000	0.000000	30071.513158	222.109844	30447.014726	2.093951	0.053348	0.000000
begin	EXOPTICS	1	0.000000	0.000000	30071.513158	222.109844	30447.014726	2.093951	0.053348	0.000000
1	CMAG_1	1	2.000000	2.000280	30073.239781	222.274354	30446.018882	2.093951	0.111348	0.000000
2	DR56_A2	1	2.436465	2.436746	30073.615527	222.322853	30445.802167	2.093951	0.111348	0.000000
3	DCD	1	2.499965	2.500246	30073.670193	222.329909	30445.770638	2.093951	0.111348	0.000000
4	TRMDRFT	1	2.961225	2.961506	30074.067284	222.381163	30445.541613	2.093951	0.111348	0.000000
5	DEX0_1	1	3.244595	3.244876	30074.311232	222.412651	30445.400914	2.093951	0.111348	0.000000
begin	QDS206	1	3.244595	3.244876	30074.311232	222.412651	30445.400914	2.093951	0.111348	0.000000
6	MQQ	1	3.244595	3.244876	30074.311232	222.412651	30445.400914	2.093951	0.111348	0.000000
7	HQD30	1	3.641470	3.641751	30074.652895	222.456751	30445.203857	2.093951	0.111348	0.000000
8	MQD3	1	3.641470	3.641751	30074.652895	222.456751	30445.203857	2.093951	0.111348	0.000000
9	MQQ	2	3.641470	3.641751	30074.652895	222.456751	30445.203857	2.093951	0.111348	0.000000
10	HQD30	2	4.038345	4.038626	30074.994558	222.500851	30445.006800	2.093951	0.111348	0.000000
end	QDS206	1	4.038345	4.038626	30074.994558	222.500851	30445.006800	2.093951	0.111348	0.000000
11	HTRIM1	1	4.138345	4.138626	30075.080646	222.511963	30444.957148	2.093951	0.111348	0.000000
12	DR67_A	1	4.289175	4.289455	30075.210493	222.528723	30444.882258	2.093951	0.111348	0.000000
13	QDE206	1	4.519805	4.520085	30075.409038	222.554350	30444.767745	2.093951	0.111348	0.000000
14	QDE206	2	4.750435	4.750715	30075.607584	222.579977	30444.653232	2.093951	0.111348	0.000000
15	DD1	1	4.866435	4.866715	30075.707446	222.592867	30444.595636	2.093951	0.111348	0.000000
16	DEX0	1	5.366435	5.366715	30076.137888	222.648426	30444.347375	2.093951	0.111348	0.000000
17	EXVB01A	1	8.414435	8.416291	30078.774119	222.818021	30442.826907	2.093951	-0.000007	0.000000
18	DR67_B1	1	8.810408	8.812264	30079.117130	222.818018	30442.629072	2.093951	-0.000007	0.000000
19	DEX1A	1	8.834519	8.836375	30079.138016	222.818018	30442.617026	2.093951	-0.000007	0.000000
20	DEX1B	1	8.976971	8.978827	30079.261415	222.818017	30442.545855	2.093951	-0.000007	0.000000
21	DEXH	1	9.119041	9.120896	30079.384482	222.818016	30442.474875	2.093951	-0.000007	0.000000
22	HTRIM2	1	9.119041	9.120896	30079.384482	222.818016	30442.474875	2.093951	-0.000007	0.000000
23	VTRIM2	1	9.119041	9.120896	30079.384482	222.818016	30442.474875	2.093951	-0.000007	0.000000
24	DCOILUP	1	9.474641	9.476496	30079.692520	222.818013	30442.297212	2.093951	-0.000007	0.000000
25	MBDBUP	1	9.474641	9.476496	30079.692520	222.818013	30442.297212	2.093951	-0.000007	0.000000
26	BDB0_2	1	9.949303	9.951159	30080.103695	222.818010	30442.060063	2.093951	-0.000007	0.000000
27	QFE207	1	10.282678	10.284534	30080.392480	222.818007	30441.893504	2.093951	-0.000007	0.000000
28	QFE207	2	10.616053	10.617909	30080.681265	222.818005	30441.726944	2.093951	-0.000007	0.000000
29	BDB0_2	2	11.090716	11.092571	30081.092440	222.818001	30441.489796	2.093951	-0.000007	0.000000
30	MBDBDWN	1	11.090716	11.092571	30081.092440	222.818001	30441.489796	2.093951	-0.000007	0.000000
31	DCOILDWN	1	11.395516	11.397371	30081.356473	222.817999	30441.337513	2.093951	-0.000007	0.000000
32	DEX0	2	11.895516	11.897371	30081.789596	222.817995	30441.087705	2.093951	-0.000007	0.000000
33	DEX1	1	12.076557	12.078412	30081.946423	222.817994	30440.997254	2.093951	-0.000007	0.000000
34	QDE208	1	12.473432	12.475287	30082.290215	222.817991	30440.798970	2.093951	-0.000007	0.000000
35	QDE208	2	12.870307	12.872162	30082.634007	222.817988	30440.600685	2.093951	-0.000007	0.000000
36	DEX0	3	13.370307	13.372162	30083.067130	222.817985	30440.350877	2.093951	-0.000007	0.000000
37	DEX2	1	13.551348	13.553203	30083.223956	222.817983	30440.260426	2.093951	-0.000007	0.000000
38	DCOILUP	2	13.906948	13.908803	30083.531994	222.817981	30440.082763	2.093951	-0.000007	0.000000
39	MBDBUP	2	13.906948	13.908803	30083.531994	222.817981	30440.082763	2.093951	-0.000007	0.000000
40	BDB0_2D	1	14.318110	14.319966	30083.888162	222.817978	30439.877340	2.093951	-0.000007	0.000000

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1 "MAD" Version: 8.23/08 Run: 07/05/13 21.47.55
Survey. SURVEY line: G_2_FULL_2 range: #S/#E
symm: F super: 1 page 2

pos. no.	element name	occ. no.	SEQUENCE sum(L) [m]	arc [m]	POSITIONS x [m]	y [m]	z [m]	ANGLES theta [rad]	phi [rad]	psi [rad]
41	QFE209	1	14.714985	14.716841	30084.231954	222.817975	30439.679055	2.093951	-0.000007	0.000000
42	MID	1	14.714985	14.716841	30084.231954	222.817975	30439.679055	2.093951	-0.000007	0.000000
43	QFE209	2	15.111860	15.113716	30084.575746	222.817972	30439.480770	2.093951	-0.000007	0.000000
44	BDB0_2D	2	15.523023	15.524878	30084.931915	222.817969	30439.275347	2.093951	-0.000007	0.000000
45	MBDBDWN	2	15.523023	15.524878	30084.931915	222.817969	30439.275347	2.093951	-0.000007	0.000000
46	DCOILDWN	2	15.827823	15.829678	30085.195947	222.817967	30439.123064	2.093951	-0.000007	0.000000
47	DEX0	4	16.327823	16.329678	30085.629071	222.817963	30438.873257	2.093951	-0.000007	0.000000
48	DEX5A	1	18.827711	18.829566	30087.794592	222.817944	30437.624274	2.093951	-0.000007	0.000000
49	DEX0	5	19.327711	19.329566	30088.227716	222.817941	30437.374467	2.093951	-0.000007	0.000000
50	QDE213A	1	19.724586	19.726441	30088.571508	222.817938	30437.176182	2.093951	-0.000007	0.000000
51	QDE213A	2	20.121461	20.123316	30088.915300	222.817935	30436.977897	2.093951	-0.000007	0.000000
52	DEX0	6	20.621461	20.623316	30089.348423	222.817931	30436.728089	2.093951	-0.000007	0.000000
53	DEX5B	1	21.942414	21.944269	30090.492695	222.817922	30436.068121	2.093951	-0.000007	0.000000
54	EXVB01B	1	23.466414	23.468542	30091.812149	222.867820	30435.307115	2.093951	0.065502	0.000000
55	DEX0	7	23.966414	23.968542	30092.244343	222.900547	30435.057843	2.093951	0.065502	0.000000
56	DEX5	1	23.966414	23.968542	30092.244343	222.900547	30435.057843	2.093951	0.065502	0.000000
57	QDE213	1	24.363289	24.365417	30092.587398	222.926525	30434.859984	2.093951	0.065502	0.000000
58	QDE213	2	24.760164	24.762292	30092.930453	222.952502	30434.662124	2.093951	0.065502	0.000000
59	DEX0	8	25.260164	25.262292	30093.362648	222.985230	30434.412852	2.093951	0.065502	0.000000
60	DEX6A	1	26.388059	26.390187	30094.337588	223.059057	30433.850547	2.093951	0.065502	0.000000
61	QFE214	1	26.784934	26.787062	30094.680643	223.085034	30433.652687	2.093951	0.065502	0.000000
62	QFE214	2	27.181809	27.183937	30095.023698	223.111012	30433.454828	2.093951	0.065502	0.000000
63	DEX6	1	27.568680	27.570808	30095.358105	223.136335	30433.261955	2.093951	0.065502	0.000000
64	DEX0	9	28.068680	28.070808	30095.790300	223.169062	30433.012683	2.093951	0.065502	0.000000
65	EXVB01C	1	29.592680	29.595378	30097.102064	223.340682	30432.256113	2.093951	0.160199	0.000000
66	DEX0	10	30.092680	30.095378	30097.529642	223.420439	30432.009504	2.093951	0.160199	0.000000
end	EXOPTICS	1	30.092680	30.095378	30097.529642	223.420439	30432.009504	2.093951	0.160199	0.000000
end	VERTEXTS	1	30.092680	30.095378	30097.529642	223.420439	30432.009504	2.093951	0.160199	0.000000
67	VMAT01	1	30.416280	30.418978	30097.806370	223.472058	30431.849898	2.093951	0.160199	0.000000
68	VMAT02	1	30.739880	30.742578	30098.083098	223.523676	30431.690293	2.093951	0.160199	0.000000
69	DSPLIT	1	35.353580	35.356278	30102.028530	224.259628	30429.414733	2.093951	0.160199	0.000000
begin	G_END	1	35.353580	35.356278	30102.028530	224.259628	30429.414733	2.093951	0.160199	0.000000
70	DGV1	1	35.353580	35.356278	30102.028530	224.259628	30429.414733	2.093951	0.160199	0.000000
71	QGVD01	1	35.584210	35.586908	30102.225754	224.296416	30429.300982	2.093951	0.160199	0.000000
72	QGVD01	2	35.814840	35.817538	30102.422979	224.333205	30429.187231	2.093951	0.160199	0.000000
73	DM1	1	36.314840	36.317538	30102.850557	224.412962	30428.940622	2.093951	0.160199	0.000000
74	DGV2	1	37.255220	37.257918	30103.654728	224.562966	30428.476809	2.093951	0.160199	0.000000
75	QGVF02	1	37.485850	37.488548	30103.851953	224.599755	30428.363059	2.093951	0.160199	0.000000
76	QGVF02	2	37.716480	37.719178	30104.049177	224.636544	30428.249308	2.093951	0.160199	0.000000
77	DM1	2	38.216480	38.219178	30104.476755	224.716301	30428.002699	2.093951	0.160199	0.000000
78	DGV3	1	39.156860	39.159558	30105.280926	224.866305	30427.538886	2.093951	0.160199	0.000000
79	QGVD03	1	39.387490	39.390188	30105.478151	224.903094	30427.425135	2.093951	0.160199	0.000000
80	QGVD03	2	39.618120	39.620818	30105.675375	224.939883	30427.311384	2.093951	0.160199	0.000000
81	DM1	3	40.118120	40.120818	30106.102953	225.019640	30427.064775	2.093951	0.160199	0.000000
82	DGV4	1	40.145700	40.148398	30106.126538	225.024039	30427.051172	2.093951	0.160199	0.000000
83	EXVB01D	1	41.669700	41.674029	30107.442467	225.145975	30426.292200	2.093951	-0.000007	0.000000
end	G_END	1	41.669700	41.674029	30107.442467	225.145975	30426.292200	2.093951	-0.000007	0.000000

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1 "MAD" Version: 8.23/08 Run: 07/05/13 21.47.55
Survey. SURVEY line: G_2_FULL_2 range: #S/#E
symm: F super: 1 page 3

pos. no.	ELEMENT element name	occ. no.	SEQUENCE sum(L) [m]	arc [m]	I I	POSITIONS x [m]	y [m]	z [m]	I I	ANGLES theta [rad]	phi [rad]	psi [rad]
end	G_LAM	1	41.669700	41.674029		30107.442467	225.145975	30426.292200		2.093951	-0.000007	0.000000
begin	VERTMATC	1	41.669700	41.674029		30107.442467	225.145975	30426.292200		2.093951	-0.000007	0.000000
84	DVH1	1	41.726222	41.730551		30107.491428	225.145974	30426.263961		2.093951	-0.000007	0.000000
85	DM1	4	42.226222	42.230551		30107.924552	225.145970	30426.014153		2.093951	-0.000007	0.000000
86	VHQ01	1	42.456852	42.461181		30108.124335	225.145969	30425.898927		2.093951	-0.000007	0.000000
87	VHQ01	2	42.687482	42.691811		30108.324117	225.145967	30425.783700		2.093951	-0.000007	0.000000
88	DM1	5	43.187482	43.191811		30108.757241	225.145963	30425.533893		2.093951	-0.000007	0.000000
89	DVH2	1	43.893983	43.898312		30109.369246	225.145958	30425.180914		2.093951	-0.000007	0.000000
90	VHQ02	1	44.124613	44.128942		30109.569029	225.145957	30425.065688		2.093951	-0.000007	0.000000
91	VHQ02	2	44.355243	44.359572		30109.768811	225.145955	30424.950461		2.093951	-0.000007	0.000000
92	DM1	6	44.855243	44.859572		30110.201935	225.145951	30424.700654		2.093951	-0.000007	0.000000
93	DVH3	1	44.734182	44.738511		30110.097066	225.145952	30424.761138		2.093951	-0.000007	0.000000
94	VHQ03	1	44.964812	44.969141		30110.296849	225.145950	30424.645911		2.093951	-0.000007	0.000000
95	VHQ03	2	45.195442	45.199771		30110.496631	225.145949	30424.530685		2.093951	-0.000007	0.000000
96	DVH4	1	45.652397	45.656726		30110.892468	225.145945	30424.302383		2.093951	-0.000007	0.000000
97	DM1	7	46.152397	46.156726		30111.325591	225.145942	30424.052576		2.093951	-0.000007	0.000000
98	DM1	8	46.652397	46.656726		30111.758715	225.145938	30423.802768		2.093951	-0.000007	0.000000
99	DVH5	1	46.297348	46.301677		30111.451155	225.145941	30423.980156		2.093951	-0.000007	0.000000
100	DELTABDP	1	53.615748	53.620077		30117.790699	225.145887	30420.323771		2.093951	-0.000007	0.000000
end	VERTMATC	1	53.615748	53.620077		30117.790699	225.145887	30420.323771		2.093951	-0.000007	0.000000
end	G_LAM_2	1	53.615748	53.620077		30117.790699	225.145887	30420.323771		2.093951	-0.000007	0.000000
begin	G_2_FULL	1	53.615748	53.620077		30117.790699	225.145887	30420.323771		2.093951	-0.000007	0.000000
begin	G_2HBEND	1	53.615748	53.620077		30117.790699	225.145887	30420.323771		2.093951	-0.000007	0.000000
begin	G_2HBEND	1	53.615748	53.620077		30117.790699	225.145887	30420.323771		2.093951	-0.000007	0.000000
101	DM1	9	54.115748	54.120077		30118.223823	225.145883	30420.073963		2.093951	-0.000007	0.000000
102	G_2_HBD1	1	55.639748	55.645937		30119.474110	225.145872	30419.202551		2.265020	-0.000007	0.000001
103	DM1	10	56.139748	56.145937		30119.858386	225.145868	30418.882657		2.265020	-0.000007	0.000001
104	HBQ01	1	56.473123	56.479312		30120.114601	225.145866	30418.669367		2.265020	-0.000007	0.000001
105	HBQ01	2	56.806498	56.812687		30120.370817	225.145863	30418.456078		2.265020	-0.000007	0.000001
106	DM1	11	57.306498	57.312687		30120.755092	225.145860	30418.136184		2.265020	-0.000007	0.000001
107	DHB1	1	57.306498	57.312687		30120.755092	225.145860	30418.136184		2.265020	-0.000007	0.000001
108	HBQ02	1	57.639873	57.646062		30121.011308	225.145857	30417.922894		2.265020	-0.000007	0.000001
109	HBQ02	2	57.973248	57.979437		30121.267524	225.145855	30417.709604		2.265020	-0.000007	0.000001
110	DM1	12	58.473248	58.479437		30121.651799	225.145851	30417.389710		2.265020	-0.000007	0.000001
111	HBQ03	1	58.806623	58.812812		30121.908015	225.145849	30417.176420		2.265020	-0.000007	0.000001
112	HBQ03	2	59.139998	59.146187		30122.164230	225.145846	30416.963131		2.265020	-0.000007	0.000001
113	DM1	13	59.639998	59.646187		30122.548506	225.145843	30416.643236		2.265020	-0.000007	0.000001
114	G_2_HBD2	1	60.401998	60.408419		30123.112762	225.145837	30416.131125		2.350554	-0.000007	0.000002
end	G_2HBEND	1	60.401998	60.408419		30123.112762	225.145837	30416.131125		2.350554	-0.000007	0.000002
115	MIDH	1	60.401998	60.408419		30123.112762	225.145837	30416.131125		2.350554	-0.000007	0.000002
begin	G_2HBEND	2	60.401998	60.408419		30123.112762	225.145837	30416.131125		2.350554	-0.000007	0.000002
116	G_2_HBD2	2	61.163998	61.170652		30123.631207	225.145832	30415.572681		2.436088	-0.000007	0.000002
117	DM1	14	61.663998	61.670652		30123.955415	225.145828	30415.192039		2.436088	-0.000007	0.000002
118	HBQ03	3	61.997373	62.004027		30124.171582	225.145826	30414.938245		2.436088	-0.000007	0.000002
119	HBQ03	4	62.330748	62.337402		30124.387748	225.145824	30414.684452		2.436088	-0.000007	0.000002
120	DM1	15	62.830748	62.837402		30124.711957	225.145820	30414.303810		2.436088	-0.000007	0.000002
121	HBQ02	3	63.164123	63.170777		30124.928123	225.145818	30414.050016		2.436088	-0.000007	0.000002

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1 "MAD" Version: 8.23/08 Run: 07/05/13 21.47.55
Survey. SURVEY line: G_2_FULL_2 range: #S/#E
symm: F super: 1 page 4

pos. no.	ELEMENT element name	occ. no.	SEQUENCE sum(L) [m]	arc [m]	I	POSITIONS x [m]	y [m]	z [m]	I	ANGLES theta [rad]	phi [rad]	psi [rad]
122	HBQ02	4	63.497498	63.504152		30125.144289	225.145816	30413.796223		2.436088	-0.000007	0.000002
123	DHB1	2	63.497498	63.504152		30125.144289	225.145816	30413.796223		2.436088	-0.000007	0.000002
124	DM1	16	63.997498	64.004152		30125.468498	225.145812	30413.415581		2.436088	-0.000007	0.000002
125	HBQ01	3	64.330873	64.337527		30125.684665	225.145810	30413.161788		2.436088	-0.000007	0.000002
126	HBQ01	4	64.664248	64.670902		30125.900831	225.145808	30412.907994		2.436088	-0.000007	0.000002
127	DM1	17	65.164248	65.170902		30126.225040	225.145804	30412.527352		2.436088	-0.000007	0.000002
128	G_2_HBD1	2	66.688248	66.696762		30127.110500	225.145794	30411.286975		2.607157	-0.000006	0.000004
129	DM1	18	67.188248	67.196762		30127.365178	225.145791	30410.856696		2.607157	-0.000006	0.000004
end	G_2HBEND	2	67.188248	67.196762		30127.365178	225.145791	30410.856696		2.607157	-0.000006	0.000004
end	G_2HBEND	1	67.188248	67.196762		30127.365178	225.145791	30410.856696		2.607157	-0.000006	0.000004
begin	MATCH1	1	67.188248	67.196762		30127.365178	225.145791	30410.856696		2.607157	-0.000006	0.000004
130	MATQ01	1	67.521623	67.530137		30127.534984	225.145789	30410.569808		2.607157	-0.000006	0.000004
131	MATQ01	2	67.854998	67.863512		30127.704791	225.145787	30410.282920		2.607157	-0.000006	0.000004
132	DMAT1	1	69.905058	69.913572		30128.749000	225.145773	30408.518729		2.607157	-0.000006	0.000004
133	MATQ02	1	70.238433	70.246947		30128.918806	225.145771	30408.231841		2.607157	-0.000006	0.000004
134	MATQ02	2	70.571808	70.580322		30129.088612	225.145769	30407.944953		2.607157	-0.000006	0.000004
135	DMAT2	1	75.044214	75.052728		30131.366656	225.145740	30404.096196		2.607157	-0.000006	0.000004
136	MATQ03	1	75.377589	75.386103		30131.536463	225.145738	30403.809308		2.607157	-0.000006	0.000004
137	MATQ03	2	75.710964	75.719478		30131.706269	225.145736	30403.522420		2.607157	-0.000006	0.000004
138	DMAT3	1	77.352605	77.361119		30132.542448	225.145726	30402.109695		2.607157	-0.000006	0.000004
139	MATQ04	1	77.685980	77.694494		30132.712254	225.145723	30401.822807		2.607157	-0.000006	0.000004
140	MATQ04	2	78.019355	78.027869		30132.882061	225.145721	30401.535919		2.607157	-0.000006	0.000004
141	DMAT4	1	84.853947	84.862461		30136.363297	225.145678	30395.654368		2.607157	-0.000006	0.000004
142	MATQ05	1	85.187322	85.195836		30136.533103	225.145675	30395.367480		2.607157	-0.000006	0.000004
end	MATCH1	1	85.187322	85.195836		30136.533103	225.145675	30395.367480		2.607157	-0.000006	0.000004
begin	G_2_FODO	1	85.187322	85.195836		30136.533103	225.145675	30395.367480		2.607157	-0.000006	0.000004
begin	G_2_FODO	1	85.187322	85.195836		30136.533103	225.145675	30395.367480		2.607157	-0.000006	0.000004
143	FOQ01	1	85.520697	85.529211		30136.702910	225.145673	30395.080593		2.607157	-0.000006	0.000004
144	DF1	1	90.145461	90.153974		30139.058558	225.145644	30391.100723		2.607157	-0.000006	0.000004
145	FOQ02	1	90.478836	90.487349		30139.228364	225.145641	30390.813836		2.607157	-0.000006	0.000004
146	FOQ02	2	90.812211	90.820724		30139.398170	225.145639	30390.526948		2.607157	-0.000006	0.000004
147	DF1	2	95.436974	95.445487		30141.753819	225.145610	30386.547079		2.607157	-0.000006	0.000004
148	FOQ01	2	95.770349	95.778862		30141.923625	225.145608	30386.260191		2.607157	-0.000006	0.000004
end	G_2_FODO	1	95.770349	95.778862		30141.923625	225.145608	30386.260191		2.607157	-0.000006	0.000004
begin	G_2_FODO	2	95.770349	95.778862		30141.923625	225.145608	30386.260191		2.607157	-0.000006	0.000004
149	FOQ01	3	96.103724	96.112237		30142.093431	225.145605	30385.973303		2.607157	-0.000006	0.000004
150	DF1	3	100.728487	100.737001		30144.449079	225.145576	30381.993434		2.607157	-0.000006	0.000004
151	FOQ02	3	101.061862	101.070376		30144.618886	225.145574	30381.706546		2.607157	-0.000006	0.000004
152	FOQ02	4	101.395237	101.403751		30144.788692	225.145571	30381.419658		2.607157	-0.000006	0.000004
153	DF1	4	106.020001	106.028514		30147.144340	225.145542	30377.439789		2.607157	-0.000006	0.000004
154	FOQ01	4	106.353376	106.361889		30147.314147	225.145540	30377.152901		2.607157	-0.000006	0.000004
end	G_2_FODO	2	106.353376	106.361889		30147.314147	225.145540	30377.152901		2.607157	-0.000006	0.000004
begin	G_2_FODO	3	106.353376	106.361889		30147.314147	225.145540	30377.152901		2.607157	-0.000006	0.000004
155	FOQ01	5	106.686751	106.695264		30147.483953	225.145538	30376.866013		2.607157	-0.000006	0.000004
156	DF1	5	111.311514	111.320027		30149.839601	225.145508	30372.886144		2.607157	-0.000006	0.000004
157	FOQ02	5	111.644889	111.653402		30150.009407	225.145506	30372.599256		2.607157	-0.000006	0.000004
158	FOQ02	6	111.978264	111.986777		30150.179214	225.145504	30372.312368		2.607157	-0.000006	0.000004

1 "MAD" Version: 8.23/08 Run: 07/05/13 21.47.55
Survey. SURVEY line: G_2_FULL_2 range: #S/#E
symm: F super: 1 page 5

pos. no.	ELEMENT element name	occ. no.	SEQUENCE sum(L) [m]	arc [m]	I	POSITIONS x [m]	y [m]	z [m]	I	ANGLES theta [rad]	phi [rad]	psi [rad]
159	DF1	6	116.603027	116.611541		30152.534862	225.145474	30368.332499		2.607157	-0.000006	0.000004
160	FOQ01	6	116.936402	116.944916		30152.704668	225.145472	30368.045611		2.607157	-0.000006	0.000004
end	G_2_FODO	3	116.936402	116.944916		30152.704668	225.145472	30368.045611		2.607157	-0.000006	0.000004
end	G_2_FODO	1	116.936402	116.944916		30152.704668	225.145472	30368.045611		2.607157	-0.000006	0.000004
begin	G_2_FF	1	116.936402	116.944916		30152.704668	225.145472	30368.045611		2.607157	-0.000006	0.000004
161	FFQ01	1	117.269777	117.278291		30152.874475	225.145470	30367.758723		2.607157	-0.000006	0.000004
162	DFF1	1	121.263792	121.272306		30154.908848	225.145444	30364.321648		2.607157	-0.000006	0.000004
163	FFQ02	1	121.597167	121.605681		30155.078654	225.145442	30364.034760		2.607157	-0.000006	0.000004
164	FFQ02	2	121.930542	121.939056		30155.248460	225.145440	30363.747872		2.607157	-0.000006	0.000004
165	DFF2	1	122.436108	122.444622		30155.505973	225.145437	30363.312804		2.607157	-0.000006	0.000004
166	FFQ03	1	122.769483	122.777997		30155.675780	225.145434	30363.025916		2.607157	-0.000006	0.000004
167	FFQ03	2	123.102858	123.111372		30155.845586	225.145432	30362.739028		2.607157	-0.000006	0.000004
168	DFF3	1	125.733521	125.742035		30157.185528	225.145415	30360.475195		2.607157	-0.000006	0.000004
169	FFQ04	1	126.066896	126.075410		30157.355335	225.145413	30360.188307		2.607157	-0.000006	0.000004
170	FFQ04	2	126.400271	126.408785		30157.525141	225.145411	30359.901419		2.607157	-0.000006	0.000004
171	DFF4	1	128.399248	128.407762		30158.543331	225.145398	30358.181187		2.607157	-0.000006	0.000004
172	FFQ05	1	128.732623	128.741137		30158.713137	225.145396	30357.894299		2.607157	-0.000006	0.000004
173	FFQ05	2	129.065998	129.074512		30158.882944	225.145394	30357.607411		2.607157	-0.000006	0.000004
174	DIRON	1	130.815998	130.824512		30159.774315	225.145383	30356.101437		2.607157	-0.000006	0.000004
175	INFLECT2	1	131.665998	131.674512		30160.207268	225.145377	30355.369965		2.607157	-0.000006	0.000004
176	MINF	1	131.665998	131.674512		30160.207268	225.145377	30355.369965		2.607157	-0.000006	0.000004
177	INFLECT2	2	132.515998	132.524512		30160.640220	225.145372	30354.638492		2.607157	-0.000006	0.000004
end	G_2_FF	1	132.515998	132.524512		30160.640220	225.145372	30354.638492		2.607157	-0.000006	0.000004
end	G_2_FULL	1	132.515998	132.524512		30160.640220	225.145372	30354.638492		2.607157	-0.000006	0.000004
end	G_2_FULL	1	132.515998	132.524512		30160.640220	225.145372	30354.638492		2.607157	-0.000006	0.000004

total length =	132.515998	arc length =	132.524512		
error(x) =	0.891271E+02	error(y) =	0.303553E+01	error(z) =	-0.923762E+02
error(theta) =	0.513206E+00	error(phi) =	-0.533544E-01	error(psi) =	0.361356E-05

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2.2.2 SITE AND UTILITIES

Open cut excavation techniques are anticipated for the construction of the enclosure. After the concrete enclosure is constructed and damp proofed the enclosures will be backfilled using stone around the enclosure, followed by suitable clays and silts, covered with topsoil and seeded. Berms will be constructed using maintainable 3:H to 1:V slopes.

The storm water culvert installed under the MC-1 Building subcontract will be support during excavation. The Mu2e project will relocate the ICW and DWS piping prior to the beamline excavation. The electrical duct bank from the Giese Road substation will be cut and replaced by the Mu2e Project. The existing 13.8 kv feeder loop encircling the Delivery Ring will be interrupted by the beamline excavation. The feeder will be pulled out, a portion of the duct bank removed, and abandoned. A new routing to maintain the looped feeder will be installed by the Mu2e project. A number of utilities for the Mu2e building will be extended from MC-1 Building. These utilities will be extended under the berm after the enclosure is complete under the Mu2e subcontract.

2.2.3 ELECTRICAL SYSTEMS

Beamline power supplies will be located in the AP-30 building, the MC1 building and the Mu2e Detector Hall and Service Building. Penetrations between the enclosure and the MC1 building will be installed in this project. Penetrations between the Delivery Ring and the AP-10 Service Building are existing. The power supply penetrations at the Mu2e Detector Hall and Service building will be constructed with that project. The twenty 6” schedule 80 PVC ducts between the enclosure and the power supply room in MC1 are part of this project.

A 500 MCM copper ground will be installed along the wall approximately two feet above the base slab adjacent to the magnet. Ground rods will be connected to this cable every sixty feet. Convenience outlets, 120/208VAC, will be provided every sixty feet along the wall on the side of the beamline. Welding outlets, 60 amp / 480V, will be provided at 2 locations along the enclosure. In addition to required emergency and exit lighting, light fixtures will be provided to supply a minimum of 20 foot-candles. A percentage of these lights will be on UPS circuits to provide emergency lighting during power failures.

2.2.4 FIRE PROTECTION SYSTEMS

The beamline will be designed to allow for safe passage of personnel through the enclosure during operations and installation. Egress shall be spaced so that travel distances are no greater than 300 feet where there are two paths of travel to an exit and no more than 50 feet where there is a single path of travel to a vertical exit. The slope up to the MC-1 Building is less than 1 vertical in 12 horizontal which is allowable

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for egress travel to an exit. Doors will be located at the enclosure levels at each exit but since the vertical distance to the exit discharge is less than thirty feet double doors are not required. All exits will lead to an exit discharge without requiring travel through a building.

Sprinklers are not required in the enclosures or vertical exit passageways, based on the Main Injector Life Safety Fire Protection Analysis. Manual pull stations and alarm notifications will be provided in the enclosures. The enclosure will have line type heat detectors running the length of the enclosure. In addition, fire extinguishers will be provided in accordance with FESHM Chapter series 6000. The line type heat detection will be connected to the fire panel in the MC-1 Building.

2.2.5 MECHANICAL SYSTEMS

The enclosure will be used as exhaust path of the once-thru HVAC system from the target/PS area (airflow is limited by decay time =~900cfm). No tunnel Cooling (assume temperature during running to be the average temperature of the LCW) or roughly 95F. No humidity control, but will see the dry air supply from the Target/PS unit. Occupancy ventilation per Ashrae 62.1 will use Target/PS unit for occupancy ventilation. No ODH ventilation requirement. Require tight seal on equipment hatches, doors & penetrations. Requires air barrier to the existing Delivery Ring, Mu2e building and MC-1 building.

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2.3.1 SAFEGUARDS AND SECURITY

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

Access to site areas outside any beam line excavation limits will be allowed during normal business working hours. Access to any radiological areas, areas within 50 feet of existing beam lines, are controlled by the Accelerator Division Radiation Safety and will require coordination of work efforts and beam line operations.

2.3.2 ENERGY CONSERVATION

In accordance with Section 0110-12 "Energy Conservation" of DOE Order 6430.1A - General Design Requirements, all elements of this project will be reviewed for energy conservation features that can be effectively incorporated into the design. Energy conservation techniques and high efficiency equipment will be utilized wherever appropriate to minimize the total energy consumption.

2.3.3 HEALTH AND SAFETY

All aspects of the project will be evaluated to ensure that the adequate health and safety precautions are incorporated in the design and construction of this project.

2.3.4 ENVIRONMENTAL PROTECTION

The overall environmental impact of this project as been evaluated and reviewed as required and the project conforms to all applicable portions of the National Environmental Policy Act (NEPA). A CX was approved by FSO on 6/12/12 and found at the following link and is included in Appendix B.

https://esh-docdb.fnal.gov:440/cgi-bin/RetrieveFile?docid=2112;filename=1%20Muon%20Campus%20NEPA-CX%20Approval%20June%20CY2012.pdf;version=1.

2.3.5 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. Appropriate decontamination and decommissioning procedures will be instituted for this project.

2.3.6 TELECOMMUNICATIONS

Phone service will be extended from the Delivery Ring through the enclosure to both the MC-1 Building and the Mu2e Building.

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2.3.7 COMPUTER EQUIPMENT

No computer equipment will be installed as part of this project.

2.3.8 HANDICAPPED PROVISIONS

The enclosure will not be accessible to handicapped personnel.

2.3.9 EMERGENCY SHELTER PROVISIONS

Site specific emergency shelter provisions will be incorporated into this project.

2.3.10 SPACE MANAGEMENT REQUIREMENTS

In 2009, a space offset request was approved by DOE HQ for this facility.

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The design of this project will be in accordance with recognized engineering practices and design standards and will comply with the applicable portions of the U.S. Department of Energy and the State of Illinois codes, orders and regulations as incorporated into contract No. DE-AC02-07CH11359 between the U.S. Department of Energy and Fermi Research Alliance, LLC. A URL link to the contract is included in Appendix B of this document.

Fermilab has adopted the Necessary and Sufficient Process (NSP) for determining the Work Smart Set (WSS) of Standards which are used to determine the appropriate environment, safety and health standards used to ensure the safe and environmentally responsible operations of the Laboratory. The Work Smart Set in effect for this project is included in Appendix B of this Project Plan. Where no edition or "latest edition" is noted on the Work Smart Set, it is assumed that the edition in effect at the time of the acceptance of this Project Plan will be used.

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The Baseline Project Costs contained in Section 3.2.2 assumes that the improvements will be done as part of the General Plant Project (GPP) program and includes the costs associated with Engineering, Design, Inspection and Administration (EDIA), Contingency and Indirect Costs.

The estimated construction costs are based on cost data taken from Means Cost Estimating Guides, historical data and recent construction history at Fermilab. While the suggested project budget can provide input for the feasibility of the project, further design refinement will affect the final cost of the project.

Engineering Design and Inspection (ED&I) activities are included in the suggested project budgets. ED&I activities include the engineering and design activities in Preliminary and Final Design, the inspection activities associated with Construction Phase Support. The descriptions are based on DOE Directive G413.3-21, Chapter 6. Past historical data and DOE Directive G413.3-21, Section 5.4.3 indicates that 15%-25% of the construction cost is an appropriate range. Non-traditional, first of a kind projects may be higher, while simple construction such as buildings will be lower than this range (on the order of 6%); the more safety and regulatory intervention is involved, the higher the percentage.

Administration activities include those defined by DOE Directive G413.3-21, Section 5.4.3 as Project Management (PM) and Construction Management (CM). Project management costs range from 5%-15% of the other estimated project costs for most DOE projects, depending on the nature of the project and the scope of what is covered under project management.

DOE Directive G413.3-21, Section 6.4.5 was used as guidance in estimating the appropriate Contingency for this project.

Indirect costs are costs incurred by an organization for common or joint objectives and which cannot be identified specifically with a particular activity or project. The multipliers used in this document are based on current Fermilab rates.

The costs contained in the estimates listed above are based on FY2015 dollars. Adjustment to the escalation will need to be applied should this assumption change.

DOE Guide 413.3-21, *Cost Estimating Guide* classifies cost estimates into one (1) of five (5) categories. These classifications are listed below in Figure 2:

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Cost Estimate Classification	Primary Characteristics	
	Level of Definition (% of Complete Definition)	Cost Estimating Description (Techniques)
Class 5, Concept Screening	0% to 2%	Stochastic, most parametric, judgment (parametric, specific analogy, expert opinion, trend analysis)
Class 4, Study or Feasibility	1% to 15%	Various, more parametric (parametric, specific analogy, expert opinion, trend analysis)
Class 3, Preliminary, Budget Authorization	10% to 40%	Various, including combinations (detailed, unit-cost, or activity-based; parametric; specific analogy; expert opinion; trend analysis)
Class 2, Control or Bid/Tender	30% to 70%	Various, more definitive (detailed, unit-cost, or activity-based; expert opinion; learning curve)
Class 1, Check Estimate or Bid/Tender	50% to 100%	Deterministic, most definitive (detailed, unit-cost, or activity-based; expert opinion; learning curve)

Figure 2 - Cost Estimate Classifications

These classifications are based on the Association for the Advanced of Cost Engineering (AACE) Recommended Practice No. 18R-97. These classifications help ensure that the quality of the cost estimate is appropriately considered when applying escalation and contingency.

The level of detail and accuracy of the budget becomes more definitive as the project's scope is refined. In a project's earliest phases, the Initiation, or Pre-Conceptual Phase (before Critical Decision [CD] -0, an Order-of-Magnitude (or Parametric) Estimate is usually required. When a capital asset acquisition project has completed the Conceptual Design Phase, a Preliminary Budget Range is required to establish the Budget Baseline at CD-1. Budget refinements shall be based on a Definitive Estimate for every element in the WBS and is required for CD-2.

The classification for the cost estimates contained in this project definition report is considered a Class 3 (Preliminary) based on the preliminary nature and level of definition of the programmatic requirements.

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FERMILAB FESS COST ESTIMATE						
MC Beamline			Project No.	Status:	Date:	Rev Date
			6-10-22	PP	$41,383	
ITEM NO.	DESCRIPTION OF WORK:		QUANTITY	UNITS	UNIT COST	AMOUNT
Final Design		$495,000				
Management & Administration		$125,000				
	LOE Project Management		1	lot	$125,000	$125,000
Engineering, Design & Inspection		$370,000				
1.2.100	FESS/Eng In House Design		1	lot	$100,000	$140,000
1.2.510	C&C Review		1	lot	$2,000	$2,000
1.2.610	Final Contract Documents Complete		1	lot	$10,000	$10,000
	Geotechnical Borings and Report		1	lot	$9,000	$9,000
1.2.400	Consultants		1	lot	$209,000	$209,000
Construction Phase		$683,000				
Management & Administration		$130,000				
2.3.100	Project Management LOE		1	lot	$130,000	$130,000
Engineering Design & Inspection		$553,000				
1.3.100	Construction Coordinator LOE		1	lot	$355,000	$310,000
1.3.200	Eng. Support LOE		1	lot	$68,000	$68,000
1.3.410	Review Shop Drawing		1	lot	$20,000	$20,000
1.3.510	Respond to RFIs		1	lot	$20,000	$20,000
1.3.500	Consultants		1	lot	$90,000	$90,000
Total Fixed Price Construction Estimated Award						$6,128,000
Escalation at 4%						$250,000
Subtotal						$5,878,000
Overhead and profit						$980,000
Subcontract Base Estimate						$4,898,000
Construction		$4,897,773				
Div 01 General		$0.00				
3.1.010	Release FY 14 GPP Construction Funds	$3,700,000 Funding issued				
3.1.100	NTP					
3.1.150	Partial Benificial Occupancy DR to G-2					
3.1.200	Issue Beneficial Occupancy Beam Enclosure					
3.1.300	Complete Punch List For Beam Enclosure					
3.1.020	Release FY 15 GPP Construction Funds	$5,100,000 Funding Issued				
Div 02 Site Construction		$1,930,511.60				
3.1.2.011010	Install Soil and Erosion Control		1600	LF	$8	$12,800.00
3.1.2.011020	Clear and Grub		2	Acre	$500	$950.00
3.1.2.011030	Sawcut Wall at DR		36	LF	$50	$1,800.00
3.1.2.011040	Remove Concrete wall at DR		4	CY	$200	$720.00
Excavation and Backfill						
3.1.2.1.011010	Excavate Topsoil		1632	CY	$6	$9,792.67
3.1.2.1.011020	Haul and Stockpile Topsoil		2285	CY	$7	$15,994.69
3.1.2.1.011030	Excavate for Enclosure DR to Y/MC 1		5924	CY	$15	$88,860.00
3.1.2.1.011040	Excavate for Stairs		819	CY	$15	$12,277.78
3.1.2.1.011050	Haul Soils up to Y		9440	CY	$7	$66,076.68
3.1.2.1.011100	Excavate for Enclosure Y to Sta +7 near Mu2e		35132	CY	$15	$526,985.56
	Hall soils y to MU2e		49185	CY	$7	$344,297.23
3.1.2.1.011060	Place Stone Backfill Around Enclosure		946	CY	$32	$30,272.00
3.1.2.1.011175	Backfil Enclosure Build Berm Y to Mu2e		7998	CY	$25	$199,950.00
3.1.2.1.011070	Backfill Excavation and Build Berm DR to MC 1		5580	CY	$25	$139,500.00
3.1.2.1.011080	Install 8' Topsoil Haul and Spread		731	CF	$13	$9,503.00
3.1.2.1.011090	Seeding and Landscaping		2	Acre	$23,280	$44,232.00
Utilities						
3.1.2.2.100						
3.1.2.2.110	Install DWS, ICW		200	LF	$60	$12,000.00
	Support Storm Sewer over excavation		1	Lot	$30,000	$30,000.00
3.1.2.2.120	Install Comm/Power Duct Bank for Mu2e Through Berm		300	LF	$450	$135,000.00
	Install Powewr Duct Bank at AP-20		300	LF	$450	$135,000.00
3.1.2.2.130	Continue San S and Storm S		200	LF	$80	$16,000.00
	Rework ICW into enclosure		1	lot	$25,000	$25,000.00
	Remove and Replace LCW S&R @ AP20		200	LF	$80	$16,000.00

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FERMILAB FESS COST ESTIMATE						
	Rework CWS&R around enclosure		1	Lot	$45,000	$45,000.00
	Misc Valves and flanges		5	Ea	$2,500	$12,500.00
Div 03 Concrete		$2,100,689.96				
3.1.3.011010	Mud slab DR to MC1		45	CY	$250	$11,152.50
3.1.3.011020	FBP Base slab DR to MC1		275	CY	$750	$205,937.50
3.1.3.011070	Mud Slab to Mu2e		57	CY	$250	$14,227.78
3.1.3.011080	Temp Barrier / Flood protection Install and remove		5	CY	$1,200	$5,400.00
3.1.3.011050	Base Slab to Mu2e		303	CY	$750	$227,075.33
3.1.3.011030	FBP Walls DR to MC1		214	CY	$850	$182,199.07
3.1.3.011090	FBP Walls to Mu2e		775	CY	$850	$658,844.44
3.1.3.011040	FBP Top Slab DR to MC1		199	CY	$900	$179,073.33
3.1.3.011060	Construct Stair Enclosures At DR		1	EA	$175,000	$175,000.00
3.1.3.011120	Install Abort Concrete		1	CY	$1,200	$1,200.00
3.1.3.011130	Install Abort Core		1	Lot	$10,700	$10,700.00
3.1.3.011100	FBP Top Slab to Mu2e		228	CY	$900	$204,880.00
3.1.3.011110	Construct Stairs/Hatch at Sta 7. near Mu2e		1	Lot	$225,000	$225,000.00
Div 04 Masonry						
Div 05 Metals		$51,000.00				
3.1.5.011010	Install Misc. Metals		1	Lot	$15,000	$15,000.00
3.1.5.011030	Hatch Cover		3	tons	$5,000	$14,500.00
3.1.5.011040	Install Metal Pipes for Fans		4	Tons	$5,000	$21,500.00
Div 06 Wood & Plastics						
Div 07 Thermo & Moisture Protection		$199,928.00				
	Damp Proof Beam Enclosure Y to Mu2e		16192	SF	$8	$129,536.00
	Damp Proof Beam Line Enclosure DR to Y		8799	SF	$8	$70,392.00
Div 08 Doors & Windows		$8,800				
3.1.6.011010	Install Doors and Hardware Interior		5	Ea	$1,200	$6,000.00
3.1.6.011020	Install Door and Hardware Exterior		2	Ea	$1,400	$2,800.00
Div 09 Finishes		$56,038				
3.1.9.011020	Paint Beam Enclosure Y to Mu2e		14560	SF	$3	$36,400.00
3.1.9.011010	Paint Beam Line Enclosure DR to Y		7855	SF	$3	$19,637.50
Div 10 Specialties		$52,000				
3.1.10.010	Install Power Supply Ducts at MC-1		20	Ea	$2,600	$52,000.00
Div 14 Cranes & Elevators		$74,750				
3.1.14.011010	Install Monorail Hoist		1	LOT	$65,000	$65,000.00
3.1.14.011020	Install Magnet Lift		1	LOT	$9,750	$9,750.00
Div 15 Mechanical		$51,868				
HVAC						
3.1.15.020	Install Fans		1	LOT	$13,988	$13,988.00
3.1.15.060	Install Dehumidifiers		0	LOT	$30,000	$0.00
3.1.15.030	Install Controls		1	LOT	$25,000	$25,000.00
Drainage						
3.1.15.1010	Install Under drain		1610	LF	$8	$12,880.00
3.1.15.1020	Install Sumps		0	EA	$28,000	$0.00
3.1.15.1030	Install Sump Above Ground Piping		0	LOT	$16,963	$0.00
3.1.15.1040	Install Sump Controls		0	LOT	$10,000	$0.00
3.1.15.1050	Start Up Sump		0	LOT	$800	$0.00
Fire Protection						
Div 16 Electrical		$372,187.50				
Primary Power						$0.00
	Remove 13.8 feeder AP-30 to MC-1-1		600	LF	$2	$1,200.00
	Install New Manhole near AP-20		0	Lot	$15,000	$0.00
	Install 13.8 Feeder AP-10 to MC-1-1		0	LF	$3	$0.00
	Install new Manhole for Giese Road Relocate		0	lot	$15,000	$0.00
	Install new cable for Giese Road Relocate		0	LF	$35	$0.00
	Splices		0	EA	$800	$0.00
	Remove and replace feeder at AP-20		0	LF	$16	$0.00
Cable Tray						
3.1.16.20	Install 4- 18" Tray Y to Mu2e		275	LF	$74	$20,350.00
3.1.16.10	Install 4 -18" tray DR to Y/MC-1		870	LF	$74	$64,380.00
Electrical Distribution						
3.1.16.1140	Install Ground Grid Wire		1145	LF	$18	$20,037.50
3.1.16..5260	Install ELP - 480Y/277 VAC DR to Y		1	Ea.	$8,125	$8,125.00
3.1.1614060	Install 45 kVA, 480 - 208Y/277 VAC		0	LF	$413	$0.00
3.1.16.1150	Install Ground Rods		19	Ea.	$690	$13,110.00
3.1.16.6150	Connect Other mechanical Equipment		2	Ea.	$5,750	$11,500.00

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FERMILAB FESS COST ESTIMATE							
	3.1.16.5270	Install LP - 480Y/277 VAC DR to Y		1	Ea.	$8,125	$8,125.00
		Install PP 120/208 to Y		1	Ea.	$8,125	$8,125.00
	3.1.16.5230	Install PP 120/208 From Y		1	Ea.	$8,125	$8,125.00
	3.1.16.5280	Install LP - 480Y/277 VAC Y to Mu2e		1	Ea.	$8,125	$8,125.00
	3.1.16.5250	Install 120/208 VAC Receptacles		20	Ea.	$239	$4,780.00
	3.1.16.5240	Install Welding Reciprocals		4	Ea.	$9,281	$37,125.00
	3.1.16.6120	Install Starters		2	Ea.	$400	$800.00
	3.1.16.6130	Install Disconnect Switches		4	Ea.	$955	$3,820.00
	3.1.16.6140	Install Unit Heaters		4	Ea.	$870	$3,480.00
	Lighting						
	3.1.16.1010	Install Incandescent		12951	SF	$10	$129,510.00
	3.1.16.1020	Install Emergency Lighting (UPS)		10	EA	$1,160	$11,600.00
		UPS		1	EA	$3,000	$3,000.00
	Fire Detection						
	3.1.16.11020	Install and test FP Fire Detection DR to Y		475	LF	$6	$2,850.00
	3.1.16..1010	Install and Test Fire Detection Y to Mu2e		670	LF	$6	$4,020.00

Figure 3 – Summary of Engineer's Estimate

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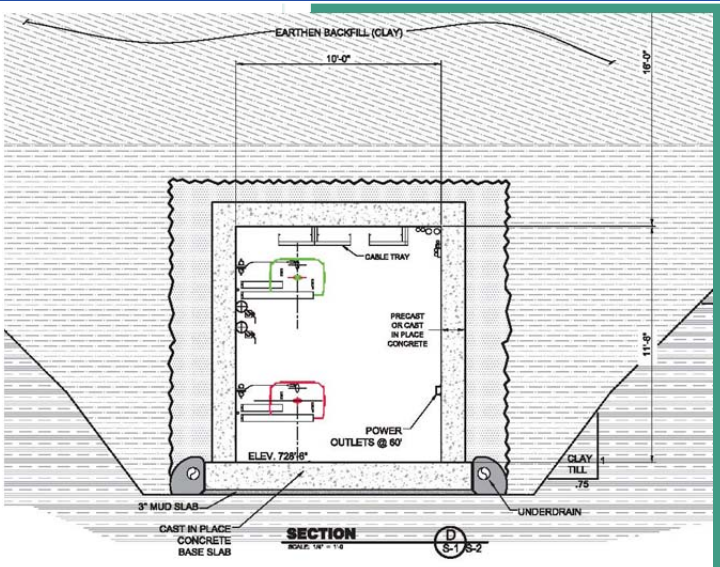
Project Execution Plan



MC Beamline Enclosure

FESS/Engineering Project No. 6-10-22

3.1 RESOURCE REQUIREMENT **MC Beamline Enclosure**

The following resource requirements have been identified for this project.

3.1.1 FUNDING

This project is a General Plant Project (GPP) with a Total Estimated Cost (TEC) of $9.7M.

3.1.2 HUMAN RESOURCES

Divisions/Sections/Research Centers (D/S/C) will be responsible for assigning the responsibilities of individuals within the design and construction organization as indicated in Figure 1 of the Project Charter.

Design reviews will occur at varying levels throughout Final Design. All Divisions/Sections/Research Centers are aware of the design review process and will assign appropriate personnel to complete the reviews for conformance and compliance with D/S/C requirements.

Divisions/Sections/Research Centers will provide required personnel to coordinate construction phase activities that directly affect their operations. For example, the Facilities Engineering Services Section (FESS) will provide personnel to coordinate related activities with the Fermilab Construction Coordinator.

FESS/Engineering will provide licensed professional architects, professional engineers and structural engineers for the design and coordination of the project. Project management will be by certified project manager professionals. Where required, FESS/Engineering will retain the professional services of consulting architects and/or engineers for final design and construction oversight.

If appropriate, the development of construction documents and bid packages may be accomplished by use of an Architectural-Engineering (A/E) firm in conjunction with the Integrated Project Team during Final Design. The selection of the A/E firm will be based on qualifications and past performance on similar FESS/Engineering projects. Existing professional services contract will be used to accomplish this work.

The A/E may be retained during construction phase activities for engineering support of the following:

- Bid Period Information Requests;
- Amendment/Addendum Development;
- Shop Drawing/Submittal Review;

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- Assistance in estimating and negotiating changes to the subcontracted work;
- Responding to subcontractor request for information including developing sketches/revisions to the subcontract documents
- Periodic site visits;
- Punchlist development.

The FESS/Engineering department will provide the construction management for the project, coordinating the subcontractor's construction subcontract. Field inspection, environment, safety and health, and quality control of construction activity will be the responsibility of the subcontractor. FESS/Engineering will provide quality and safety assurance during construction phase activities.

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The Project Baseline identifies the basis for evaluating project performance. The components are the Work Breakdown Structure, which identifies each component of the project, the Baseline Costs, Escalation Rates, and Baseline Schedule and Milestones.

3.2.1 WORK BREAKDOWN STRUCTURE (WBS) DICTIONARY

Listed below is the breakdown of the WBS for this project. Further breakdown of the above listed structure may be applied as required for accounting purposes. Items covered under Other Project Costs are noted as such.

Level 1 – MC Beamline Enclosure

1.0 Engineering, Design and Inspection (ED&I)

ED&I activities include the engineering and design activities in Preliminary Design and Final Design, the inspection activities associated with Construction Management. The descriptions are based on DOE Directive G413.3-21, Chapter 6. In addition, DOE Directive G413.3-21, Section 5.4.3 was used as guidance in estimating the ED&I cost for this project. This DOE Directive can be found at the DOE website. Appendix B of this document contains the URL link to this chapter.

Listed below is a further breakdown of this WBS

1.1 This WBS item will be used for Preliminary Design ED&I
1.2 This WBS item will be used for Final Design ED&I
1.3 This WBS item will be used for Construction Management ED&I

2.0 Administration

Administration activities include those defined by DOE Directive G413.3-21, Section 5.4.3 as Project Management (PM) and Construction Management (CM). This DOE Directive can be found at the DOE website. Appendix B of this document contains the URL link to this chapter.

Listed below is a further breakdown of this WBS

2.1 This WBS item will be used for Preliminary Design Administration
2.2 This WBS item will be used for Final Design Administration
2.3 This WBS item will be used for Construction Management Administration

3.0 Construction

3.1 This is fixed-price construction portion of the project;

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3.2 This is Time and Materials construction orders for this project;
3.3 This WBS item will be used for advanced procured materials.

For accounting purposes, the management reserve of the above listed WBS items will be included in the WBS costs. DOE Directive G413.3-21, Section 6.4 was used as guidance in estimating the appropriate management reserve for this project. This DOE Directive can be found at the DOE website. Appendix B of this document contains the URL link to this chapter.

For accounting purposes, the indirect costs of the above listed WBS items will be included in the WBS items. The multipliers used in this document are based on current Fermilab rates. Appendix B of this document contains the URL link to the Fermilab Indirect Cost rates. While Indirect Costs have been estimated and included in the Total Project Cost, the Finance Section will confirm that the allocated funds are adequate. The Indirect Costs are not considered as part of the managed baseline.

3.2.2 BASELINE PROJECT COSTS

Listed below are the baseline project costs for this project.

		Base Cost	Management Reserve	Indirect Costs	Subtotal
1.1	Title 1 ED&I				$0
1.2	Title 2 ED&I	$495,000	$124,000	$127,000	$746,000
1.3	Title 3 ED&I	$553,000	$139,000	$360,200	$1,138,400
2.1	Title 1 Administration				$0
2.2	Title 2 Administration	$125,000	$29,000	$85,000	$236,800
2.3	Title 3 Administration	$130,000	$33,000	$85,000	$236,800
3.1	Fixed Price Construction	$6,128,000	$1,318,000	$115,000	$7,561,000
3.2	Tim and Materials Const.	$0	$0	$0	$0
3.3	Pre-procurement	$0	$0	$0	$0
	TOTALS	$7,431,000	$1,643,300	$626,000	$9,700,000

3.2.3 SCOPE CONTINGENCY

In order to provide a well-balanced, manageable project, several items of scope contingency have been identified. These items will be identified on the final construction documents as “alternate deducts” during the competitive procurement activities. During the source evaluation process, the project team will review the

alternate deducts and determine which ones should be excluded from the scope of work, if necessary.

3.2.4 ESCALATION

The baseline project and associated cost estimate assumes that the midpoint of construction will be the 4th quarter of fiscal year 2015 (FY15). DOE Directive G413.3-21, Section 6.4.4 was used as guidance in estimating the appropriate escalation for this project. This DOE Directive can be found at the DOE website. Appendix B of this document contains the URL link to this chapter.

3.2.5 BASELINE PROJECT SCHEDULE AND MILESTONES

The baseline schedule listed below sets forth the major activities and milestones essential for the completion of the project. The milestones are defined as:

MILESTONE	DEFINITION	BASELINE
Project Start	Project Request signed	Month 1
Engineering Start	Engineering work for the project starts when a task is entered into the Task Database	Month 3
Construction Start	Notice To Proceed/Purchase Order Issued	Month 21
Construction Complete	Final acceptance of all work	Month 42
Engineering Complete	Completion of Close-out Documents	Month 46
Project Complete	Project Closed	Month 50

3.2.6 FUNDING PROFILE

Listed below are the anticipated total costs by fiscal year for this project as contained in the Fermilab Project Request Form.

	FY13	FY14	FY15	TOTAL
Construction	$0	$2,150,000	$3,878,000	$6,128,000
EDIA	$282,000	$500,000	$521,000	$1,303,000
Management Reserve	$0	$822,000	$822,000	$1,644,000
Subtotal	$282,000	$2,872,000	$5,865,300	$9,075,000
Indirect Costs	$118,000	$228,000	$334,700	$625,000
TOTAL	**$400,000**	**$3,700,000**	**$5,600,000**	**$9,700,000**

The Project Management, Construction Management, design, construction and inspection for this project will be performed in compliance with the applicable DOE Orders and Fermilab Policy and Procedures and in accordance with the Work Breakdown Structure.

3.3.1 DESIGN

If appropriate, the development of construction documents and bid packages may be accomplished by use of an Architectural-Engineering (A/E) firm in conjunction with the FESS/Engineering Project Team during Final Design. The selection of the A/E firm will be based on qualifications and past performance on similar FESS/Engineering projects. Existing professional services contract will be used to accomplish this work.

Architectural and Engineering (A/E) services procurement will conform to the Business Services Section (BSS) A/E selection procedures. Consulting firms will be selected based on the firms strengths of subject area expertise required for the project. Consultants will normally be selected from the firms that have been prequalified and that are under a master contract. Where specific individuals or area of expertise are required for the success of the project and this expertise is not available with the pre-selected firms then sole source justification will be written. A/E's will conform to the current version of the FESS Engineering A&E Handbook in force at the start of the project.

3.3.2 CONSTRUCTION

The majority of the construction work for this project will be accomplished by means of one or more construction packages. The Conventional Construction packages will be a competitively bid, lump sum contract. A Time and Materials (T&M) task may be used for preparatory work that is specialized and difficult to include in the competitive procurement process.

3.3.2.1 Possible Sources for the Conventional Construction Subcontractors

Fermilab has access to several Subcontractors that have sufficient qualifications to execute this Subcontract. Subcontractors are selected in response to a Request for Proposal and must meet specific safety and quality requirements. When applicable, there will be a close-out meeting to formally assess the performance of subcontractors in accordance with FESHM Chapter 7010.

3.3.2.2 Performance Based Incentive Process

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The subcontractor will be paid only for work completed. In addition, retention may be reduced from 10% to as little as 2% during the subcontract if the subcontractor maintains a safe environment and meets subcontract milestones.

3.3.2.3 Methods of Completion

The Request for Proposal (RFP) process will be used to solicit proposals from area Subcontractors with the appropriate safety records and experience to accomplish this work.

3.3.2.4 Source Selection Process

A Source Evaluation Team (SET) will be established which will include the Fermi Project Director, Fermi Project Manager, Fermi Project Coordinator, and Fermi Procurement Officer to evaluate and select a Subcontractor for the Conventional Construction Package. Evaluation criteria will be included in the Request For Proposal (RFP) documents as a basis for the SET evaluation of proposals.

3.3.2.5 Justification for Non-competitive Acquisitions

Anticipated non-competitive acquisitions may include Time and Material (T&M) tasks and advanced-procured items requiring longer than tolerated fabrication or delivery time. These items will be identified during the Final Design phase.

3.3.2.6 Milestones for Acquisition

Construction milestones will be established for inclusion into the subcontract documents.

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3.4.1 COST CONTROL

A separate cost account will be maintained for the following elements listed in the project Work Breakdown Schedule (WBS): Engineering Design and Inspection (ED&I), Administration, and Construction. The baseline budget for each element will be shown on all reports. Costs charged to these accounts will be reported monthly on a report available on the Business Services Section (BSS) website. The Fermilab Project Manager will review the report as needed in order to verify the validity of all cost charges during the reporting period, that commitments are correct, and that projections of costs can be covered by the baseline budget for each work element.

The Fermilab Project Manager has the responsibility for the use and commitment of project funds. Any costs or commitments that are made without his signed approval or that of higher Laboratory management may be rejected. Progress payments to the Architect/Engineer, suppliers, and subcontractors will be made upon receipt and approval of acceptable invoices, nominally on a monthly basis.

The Fermilab Project Manager, within authorized limits, will be responsible for the administration of the project's management reserve funds.

The Funding Profile, depicted in Section 3.2.6, is based on the current DOE funding profile. This plan reflects the best estimate of funding levels and the baseline schedule. The Funding Profile establishes the planned rate of accrued costs for the life of the project. The Fermilab Project Manager is responsible for updating, as needed, the project Estimate at Completion (EAC) for each work element to reflect changes in design and construction, and for overall project fiscal management.

3.4.2 SCHEDULE CONTROL

The Baseline Schedule, shown in Section 3.2.5 of this project plan, depicts the milestones and their expected achievement dates. As the project develops, the schedule may be further refined. The Fermilab Project Manager shall have the responsibility to monitor and control these tasks within the baseline. The baseline may be revised with DOE Fermi Site Office concurrence.

The Integrated Project Team will review work progress with the subcontractor at regular intervals. Any identified difficulties will require the subcontractor to provide a plan for their resolution. Significant schedule slippage will be cause for expediting actions by BSS at the request of the Fermilab Project Manager.

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3.4.3 CHANGE CONTROL PROCEDURES AND AUTHORITIES

Changes to the project's internal baseline can occur to the scope, cost, or schedule aspects of the project. Changes at WBS Level 1 and below will be made with the approval of the Fermilab Project Manager for cost changes up to $75,000 and schedule changes up to 3 months. Cost and schedule changes above these amounts and changes to the scope of the project as outlined in the CDR will require the approvals of the Change Control Board. Any change to the Total Project Cost will require the approval of the Change Control Board and DOE Fermi Area Office. Project change control will be accomplished in accordance with practices listed below.

Change Control Procedures

Change	Approval Required	Change Request Form
Normal Field Changes no added cost or time	Fermilab Project Manager	None
In scope ≤$75k or ≤3 mos. schedule change	Fermilab Project Manager	None
In scope >$75k or >3 mos. schedule change	Control Board	Required
Total Project Cost	Control Board DOE Fermilab Directorate	Required
Non-Emergency Required for ESH&Q regulations	Control Board	Required
Change to Project Scope or Schedule	Control Board DOE Fermilab Sponsors	Required

The Change Control Board (Control Board) will be comprised of the following named individuals or the designees:

DOE Fermi Site Office	A. Harris (non-voting)
Sponsor - Chief Operating Officer	J. Anderson
Sponsor – Accelerator	R. Dixon
Project Director	M. Convery
Project Director	G. Annala
Project Manager	T. Lackowski (Chair)

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The Fermilab Project Manager will act as Chair to the Control Board. The Control Board will consider the change requests promptly and, in cases not requiring additional information or discussion, will respond within two (2) weeks.

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3.5.1 INTEGRATED SAFETY MANAGEMENT (ISM)

Fermilab subscribes to the philosophy of Integrated Safety Management (ISM), in accordance with Department of Energy Order 413.3 "Program and Project Management for the Acquisition of Capital Assets." Appendix B of this document contains a URL link to the DOE order. Fermilab requires its subcontractors and sub-tier subcontractors to do the same. ISM is a system for performing work safely and in an environmentally responsible manner. The term "integrated" is used to indicate that the Environment, Safety & Health (ESH&Q) management systems are normal and natural elements of doing work. The intent is to integrate the management of ESH&Q with the management of the other primary elements of construction: quality, cost, and schedule.

The subcontractor(s) shall submit proof of an effective integrated safety management program. The program must be described in the terms listed below.

- Line Management Responsibility for Safety;
- Clear Roles and Responsibilities;
- Competence Commensurate with Responsibility;
- Balanced Priorities;
- Identification of Safety Standards and Requirements;
- Hazard Controls Tailored to Work Being Performed;
- Operations Authorization.

3.5.2 QUALITY ASSURANCE

All aspects of this project will be periodically reviewed with regard to Quality Assurance issues from Conceptual Design through Close-out. This review process will be completed in accordance with the applicable portions of the Fermilab Director's Policy Manual, Section 10. Appendix B of this document contains a URL link to the Fermilab Director's Policies. The following elements will be included in 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 design process, drawings and specification 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;

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- 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.

3.5.3 HIGH PERFORMANCE BUILDING DESIGN

Refer to Appendix B for High Performance Building Design.

3.5.4 RELIABILITY AND MAINTAINABILITY

Both reliability and future maintenance are considered in the design of all components of Fermilab site. Materials and construction techniques are selected during the design process to provide adequate design life, accessibility, and minimal maintenance.

When completed, the facility resulting from this project will become the formal responsibility of the Fermilab Accelerator Division. The completed project, and the utilities and systems that support it, will be added to the overall laboratory maintenance and building inspection program of the Facilities Engineering Services Section. The Facilities Engineering Services Section and Business Services Section will coordinate the preventative maintenance, normal service and emergency repairs for the building.

The Building Research Board National Research Council states that if a building receives an adequate level of maintenance and repair funding, a steady-state situation should exist wherein the inventory would remain in a service condition that would neither decline nor improve and a maintenance and repair backlog would not develop. Maintenance is defined as the day-to-day work necessary to sustain property in order to realize the originally anticipated useful life of a fixed asset. Maintenance includes periodic inspection, adjustment, lubrication, and cleaning (non-janitorial) of equipment, replacement of parts etc. to assure continuing service and to prevent breakdown. Repair is defined as the work required to restore damaged or worn-out property to a normal operating condition. In general, repairs are curative and maintenance is preventive.

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Operations are the activities related to a building's normal performance of the function for which it is used. The cost of utilities, janitorial services, window cleaning, rodent control and waste management are generally included within the scope of operations and are not maintenance.

The following preliminary maintenance and repair costs forecast is based on information contained in the Whitestone Building and Repair Cost Reference 2011 and indexed for the Chicago, Illinois area. The Building M&R Cost Profile is based on the General Laboratory model. While not an exact match, the functions and basic material selections are considered similar in nature to provide a preliminary forecast of maintenance and repair costs for this project.

Cost (FY2011)	**Annual Cost Per Square Foot**	**Annual Cost as % of Replac. Cost**
PM and Minor Repair	$2.47	0.66%
Unscheduled Maintenance	$2.01	0.49%
Renewal and Replacement	$5.41	1.38%
Total M&R Costs	**$9.89**	**2.53%**

If requested, a detailed maintenance and repair forecast for this project will be developed after the completion of construction. A copy of the referenced Whitestone Building and Repair Cost Reference data is included in the Appendix B of this project plan.

3.5.5 VALUE MANAGEMENT

It is not anticipated that a separate value management exercise will be required for this project. However, internal reviews of designs at various levels of completion will be performed by the most experienced individuals at Fermilab with the goal to identify cost effective design solutions. These internal reviews will focus on understanding the impact of the technical requirements on the overall project including optimization to reduce the life cycle costs.

3.5.6 RISK MANAGEMENT

The majority of the risk management on this project involves the coordinated activities affecting ongoing Fermilab operations. Sufficient schedule float is currently anticipated for the activities related to constructing project to accommodate minor potential disruptions.

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3.5.7 DESIGN REVIEWS

Design reviews are accomplished in accordance with FESS/Engineering Standard Operating Procedure 8.3.5.1, "Document Reviews." Designs are reviewed for conformance to project requirements and for appropriateness of the proposed systems, impacts on existing systems and operations, specific technical requirements to be incorporated into the design and compliance with best and required practices of authority having jurisdiction.

The objective of the reporting and review activity is to provide the assemblage and integration of project related cost data, schedule status and performance progress into reports for the monitoring and management of the project.

Per Fermilab's engineering policy, an Engineering Risk Assessment has been performed and determined that the project is Low Risk therefore the project will follow standard FESS Engineering procedures. See Appendix B for the Engineering Risk Assessment Worksheet.

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3.6.1 REPORTING

Daily – If appropriate, construction logs may be prepared by the Fermilab Construction Coordinator that document the ongoing progress, quality assurance, safety and change issues. When required, the Subcontractor prepares daily quality control reports documenting their efforts on field activities. The Fermilab Project Manager and Fermilab Construction Manager are provided these reports on the following workday.

Weekly – The Subcontractor submits a summary report of quality control activities for the previous week at the weekly construction meeting. These reports will include a "look ahead" schedule that details the expected progress in the coming weeks.

Quarterly - The Fermilab Project Manager will review construction progress, changes, Subcontractor payouts and general project progress in order to prepare a Quarterly General Plant Project (GPP) report.

3.6.2 REVIEWS

Directorate Level Review – If appropriate and requested, the project team will meet with the Directorate to review the project related cost data, schedule status and performance progress.

Multi-Organization Construction Site Safety Walkthrough – These walkthroughs will occur periodically as determined by the Fermilab Project Manager. The walkthroughs will be completed in accordance with Section 7010 of the Fermilab Environment Safety and Health Manual (FESHM). A copy of the procedure is included in Appendix B of this Project Plan.

Conceptual Design Drawings

Fermi National Accelerator Laboratory / Kirk Road and Pine Street / P.O. Box 500 / Batavia, IL 60510 / 630.840.3000 / www.fnal.gov / fermilab@fnal.gov
Office of Science / U.S. Department of Energy / Managed by Fermi Research Alliance, LLC

GIESE ROAD SUBSTATION

GIESE RD.

KAUTZ RD.

Mu2e DETECTOR SERVICE BLDG. PROJECT 6-10-2

KAUTZ ROAD

MC-1 BLDG. PROJECT 6-10-20B

INDIAN CREEK RD.

AP-60

AP-10

• NUMI DECAY TUNNEL

TOE OF BERM @ EL. 745'

ANTIPROTON SOURCE

AP-50

AP-20

KAUTZ ROAD

WELL POND RD.

C.U.B.

BOOSTER RING

AP-30

AP-40

MC-5 BEAM
X = 99823.79
Y = 98777.69
Z = 738.50'

INDIAN CREEK RD.

MI-8 SERVICE BLDG.

8 GEV ENCLOSURE

SCALE: 1" = 40'-0"

SCALE 40 0 40 80 120 160 200 FEET

PROJECT NORTH

MC BEAMLINE ENCLOSURES

AREA SITE - PLAN

CDR

Fermilab

U.S. DEPARTMENT OF ENERGY

DATE

19 APR., 2013

PROJECT NO.

6-10-22

DRAWING NO.

C-1

Apr 19, 2013 - 1:10pm \\blue1\fess\FESS_ENG\Active Projects\6\10\22\2 - Conceptual Design\Drawings\C-01_6-10-22.dwg

BEAMLINE ENCLOSURES

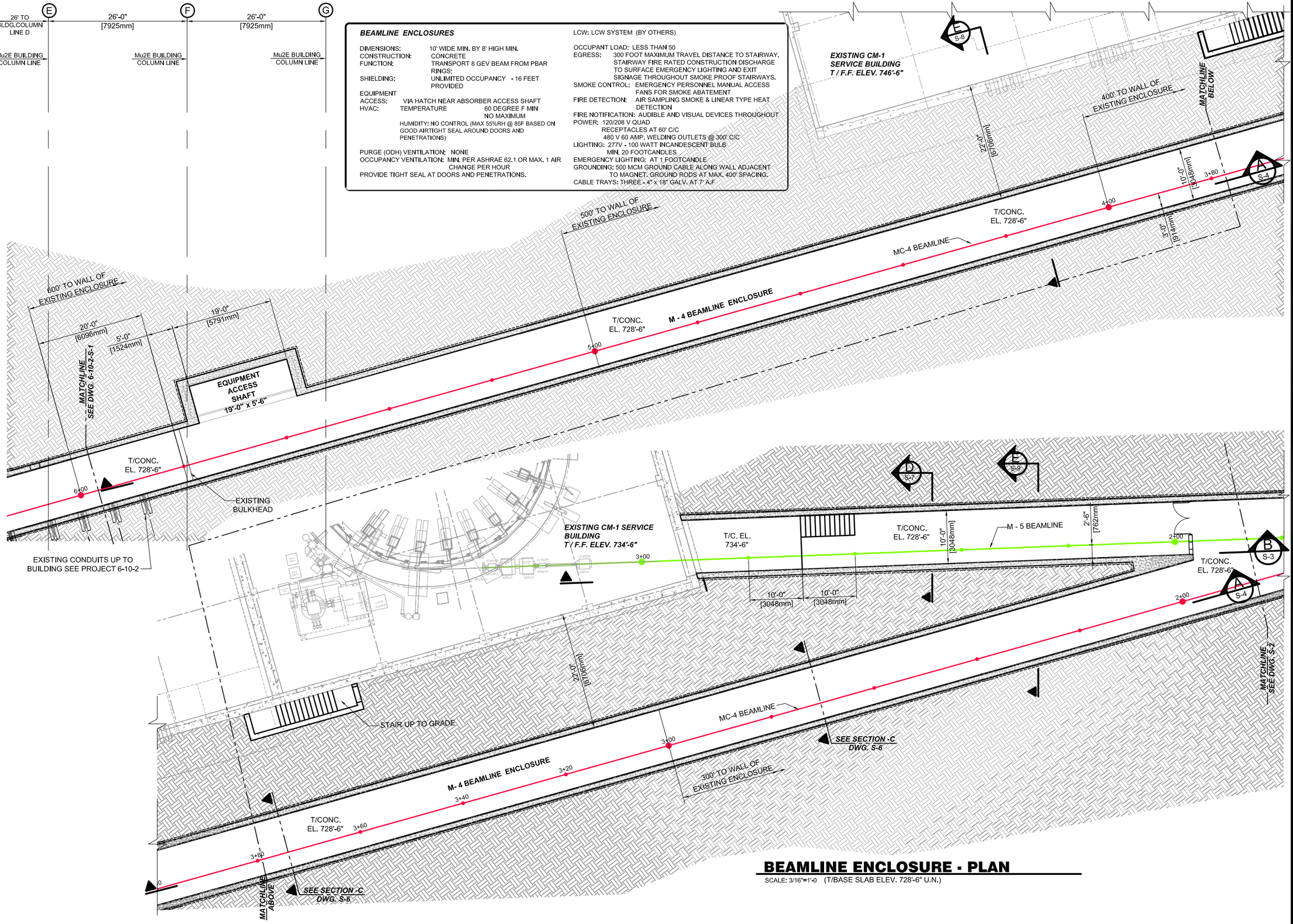
DIMENSIONS: 10' WIDE MIN. BY 8' HIGH MIN.
CONSTRUCTION: CONCRETE
FUNCTION: TRANSPORT 8 GEV BEAM FROM PBAR RINGS;
SHIELDING: UNLIMITED OCCUPANCY - 16 FEET PROVIDED

EQUIPMENT ACCESS: VIA HATCH NEAR ABSORBER ACCESS SHAFT
HVAC: TEMPERATURE 60 DEGREE F MIN
NO MAXIMUM
HUMIDITY: NO CONTROL (MAX 55%RH @ 85F BASED ON GOOD AIRTIGHT SEAL AROUND DOORS AND PENETRATIONS)

PURGE (ODH) VENTILATION: NONE
OCCUPANCY VENTILATION: MIN. PER ASHRAE 62.1 OR MAX. 1 AIR CHANGE PER HOUR
PROVIDE TIGHT SEAL AT DOORS AND PENETRATIONS.

LCW: LCW SYSTEM (BY OTHERS)

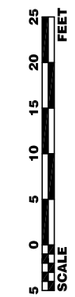
OCCUPANT LOAD: LESS THAN 50
EGRESS: 300 FOOT MAXIMUM TRAVEL DISTANCE TO STAIRWAY. STAIRWAY FIRE RATED CONSTRUCTION DISCHARGE TO SURFACE EMERGENCY LIGHTING AND EXIT SIGNAGE THROUGHOUT SMOKE PROOF STAIRWAYS.
SMOKE CONTROL: EMERGENCY PERSONNEL MANUAL ACCESS FANS FOR SMOKE ABATEMENT
FIRE DETECTION: AIR SAMPLING SMOKE & LINEAR TYPE HEAT DETECTION
FIRE NOTIFICATION: AUDIBLE AND VISUAL DEVICES THROUGHOUT
POWER: 120/208 V QUAD RECEPTACLES AT 60' C/C
480 V 60 AMP. WELDING OUTLETS @ 300' C/C
LIGHTING: 277V - 100 WATT INCANDESCENT BULB MIN. 20 FOOTCANDLES
EMERGENCY LIGHTING: AT 1 FOOTCANDLE
GROUNDING: 500 MCM GROUND CABLE ALONG WALL ADJACENT TO MAGNET. GROUND RODS AT MAX. 400' SPACING.
CABLE TRAYS: THREE - 4" x 18" GALV. AT 7' A.F.

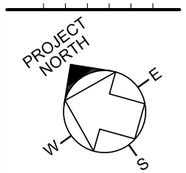


BEAMLINE ENCLOSURE - PLAN

SCALE: 3/16"=1'-0" (T/BASE SLAB ELEV. 728'-6" U.N.)

SCALE: 3/16"=1'-0"





MC BEAMLINE ENCLOSURES

BEAMLINE ENCLOSURES PLAN - SHEET 1

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DATE

19 APR., 2013

PROJECT NO.

6-10-22

DRAWING NO.

S-1

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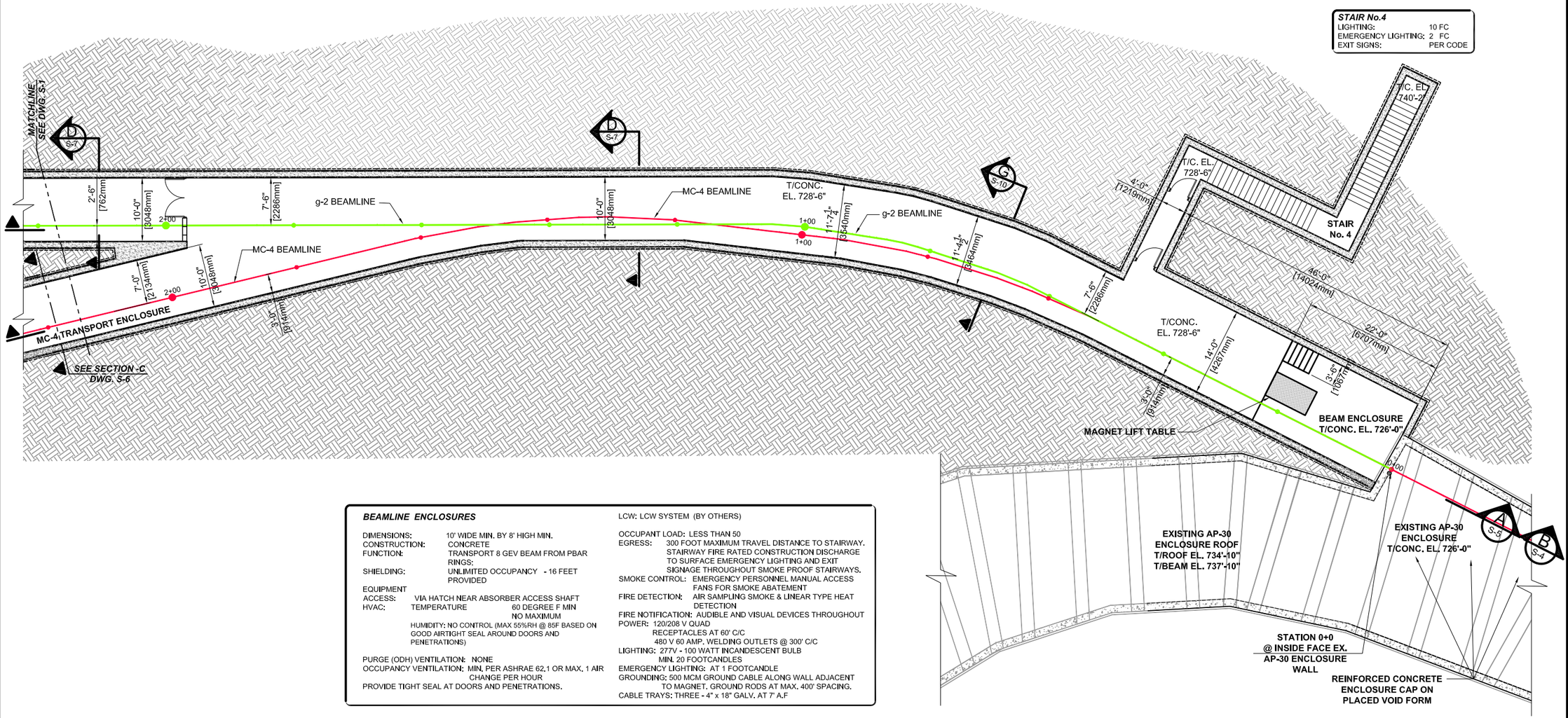

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CABLE TRAYS: THREE - 4" x 18" GALV. AT 7' A.F

BEAMLINE ENCLOSURE - PLAN

SCALE: 3/16"=1'-0 (T/BASE SLAB ELEV. 728'-6")

SCALE: 3/16"=1'-0" — SCALE 5 0 5 10 15 20 25 FEET

PROJECT NORTH

MC BEAMLINE ENCLOSURES

BEAMLINE ENCLOSURES PLAN - SHEET 2

CDR

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DATE

19 APR., 2013

PROJECT NO.

6-10-22

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S-2

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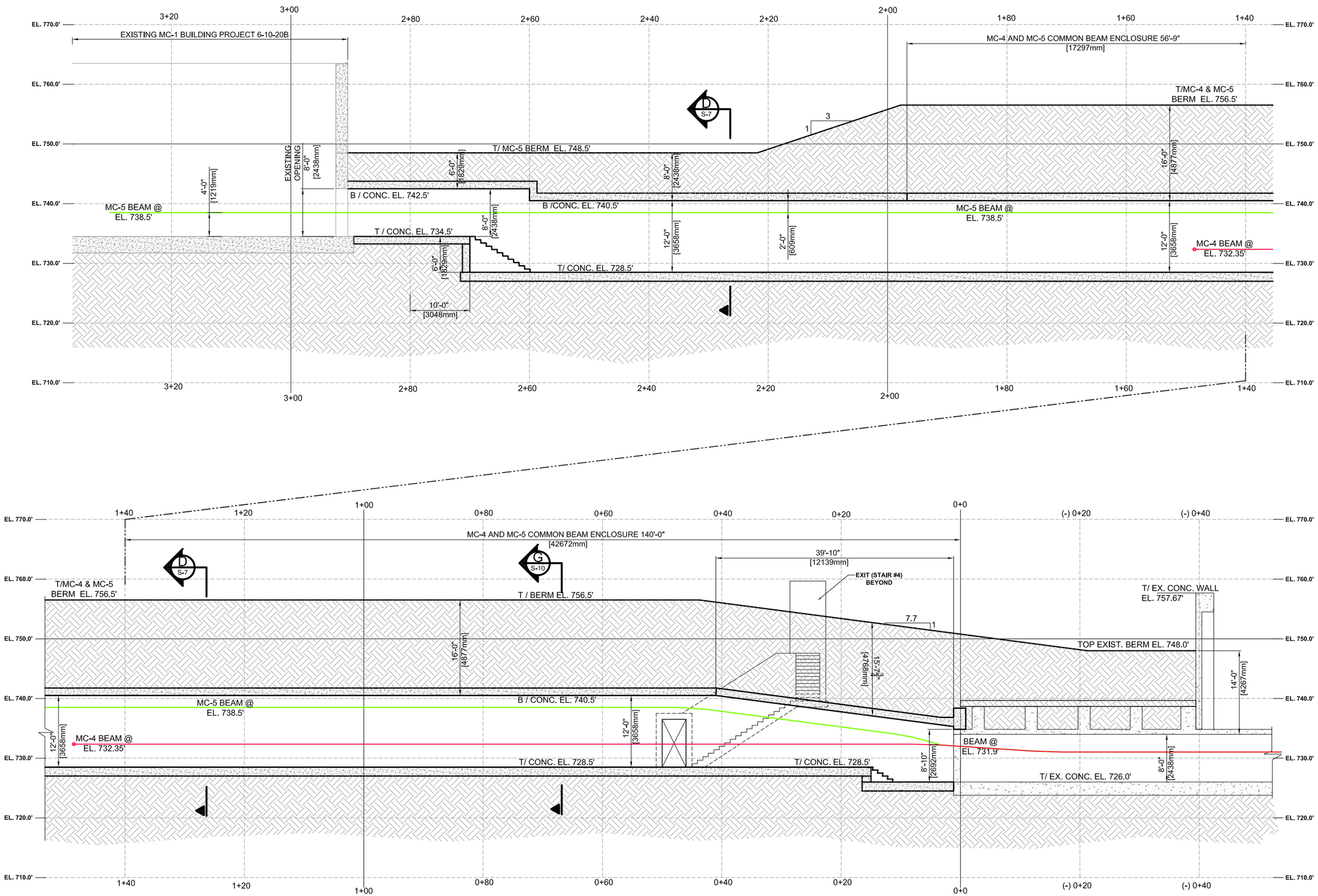

SECTION
SCALE: 1/4" = 1'-0

A
S-1

SCALE:
1/4"=1'-0"
SCALE
4 0 4 8 12 16 20
FEET

MC BEAMLINE ENCLOSURES

MC-5 BEAMLINE ENCLOSURE
LONGITUDINAL SECTION

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DATE
19 APR., 2013

PROJECT NO.
6-10-22

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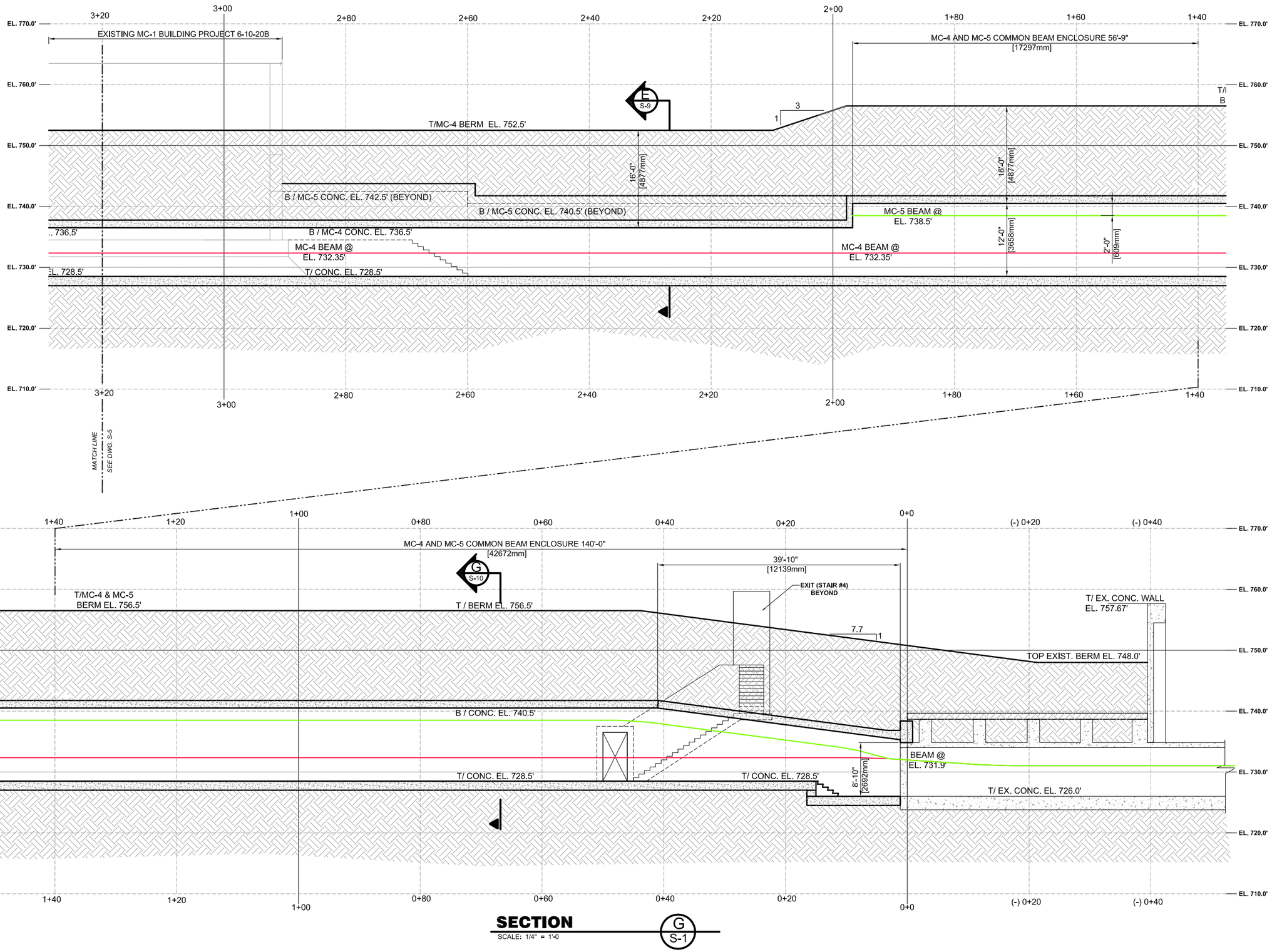

SECTION

SCALE: 1/4" = 1'-0

G S-1

SCALE: 1/4"=1'-0" FEET 4 0 4 8 12 16 20 SCALE

MC BEAMLINE ENCLOSURES

MC-4 BEAMLINE ENCLOSURE
LONGITUDINAL SECTION SHEET-1

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DATE

19 APR., 2013

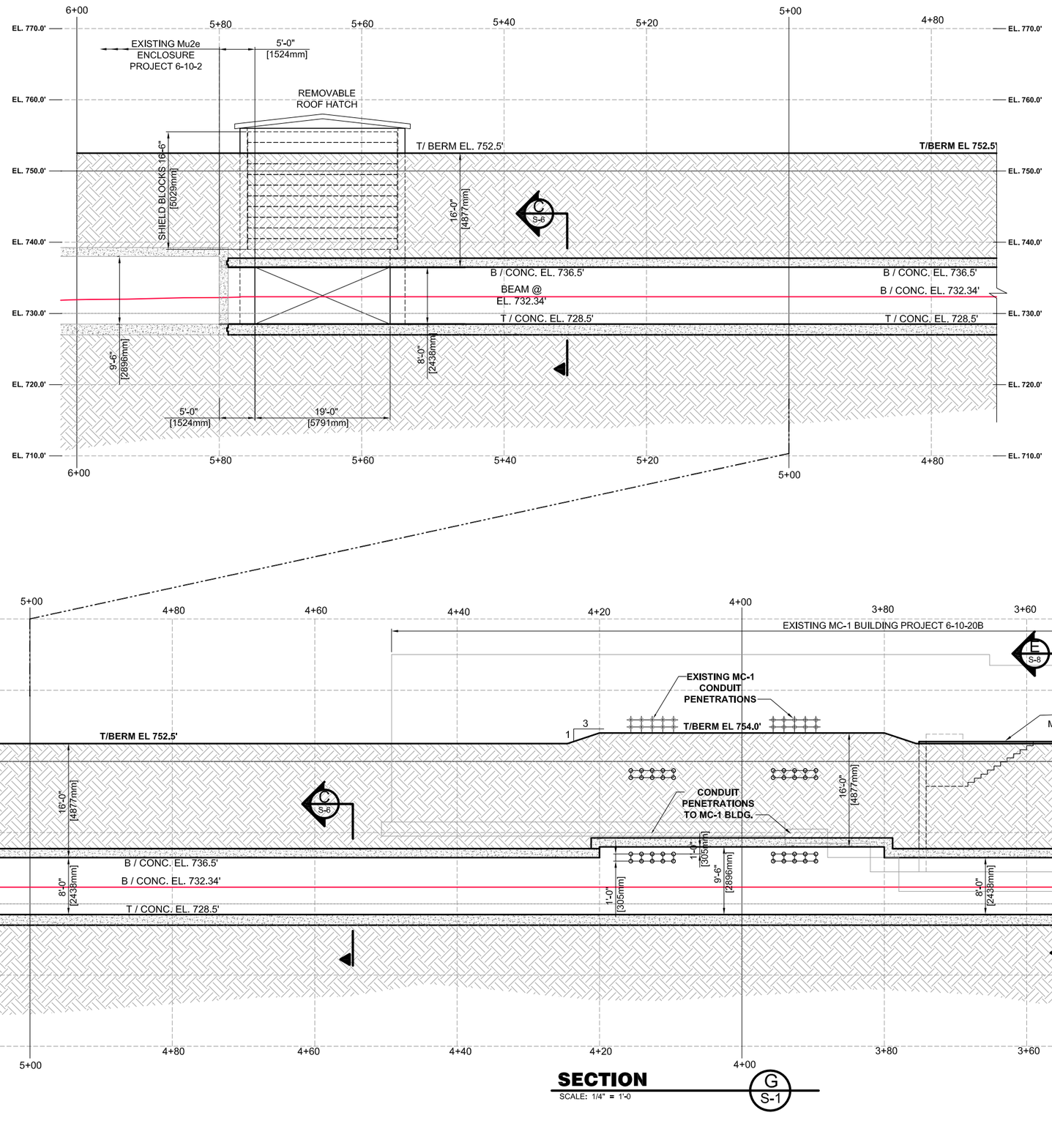
PROJECT NO.

6-10-22

DRAWING NO.

S-4

Apr 19, 2013 - 10:13am \\blue1\fess\FESS_ENG\Active Projects\6\10222 - Conceptual Design\Drawings\S-03 S-04 & S05_6-10-22.dwg



SECTION
SCALE: 1/4" = 1'-0

G S-1

SCALE:
4 0 4 8 12 16 20 FEET
1/4"=1'-0" SCALE

MC BEAMLINE ENCLOSURES

MC-4 BEAMLINE ENCLOSURE
LONGITUDINAL SECTION SHEET-2

CDR

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19 APR., 2013

PROJECT NO.
6-10-22

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S-5

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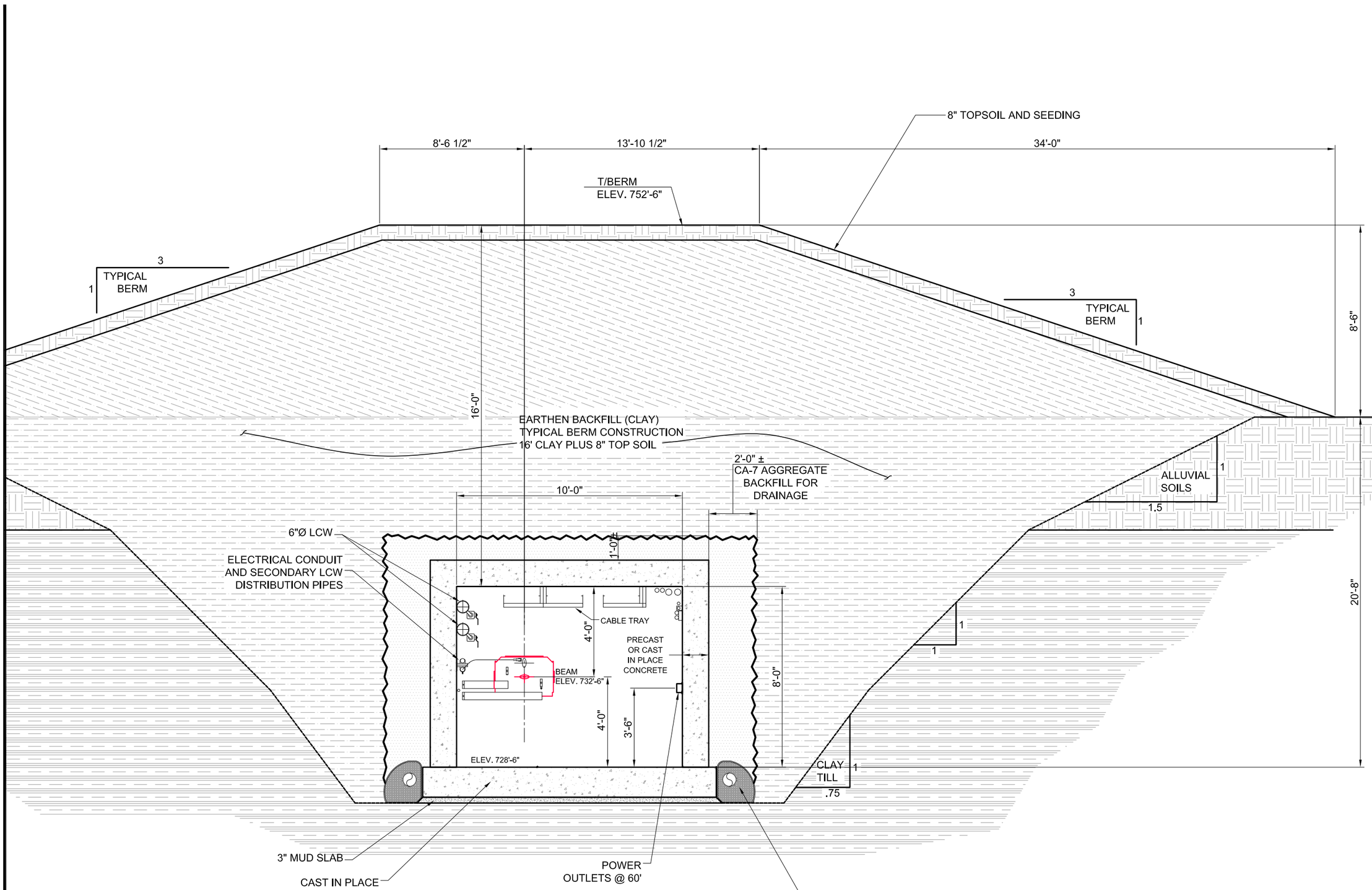

SECTION C S-1 S-2
SCALE: 1/4" = 1'-0

TYPICAL ENCLOSURE SECTION

SCALE: 3/4" = 1'-0

(STA. 2+20 TO STA. 3+80)
(STA. 4+20 TO STA. 5+45.5)

SCALE: 3/4" = 1'-0 SCALE FEET 0 1 2 3 4 5 6 7

MC BEAMLINE ENCLOSURES

BEAMLINE ENCLOSURE SECTION SHEET - 1

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6-10-22

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S-6

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16'-9 13/16"

T/BERM
ELEV. 756'-6"

3
1
TYPICAL
BERM

8" TOPSOIL AND SEEDING

3
1
TYPICAL
BERM

EARTHEN BACKFILL (CLAY)
TYPICAL BERM CONSTRUCTION
16' CLAY PLUS 8" TOP SOIL

10'-0"

16'-0"

ALLUVIAL
SOILS
1
1.5

1
1

2'-0"

CABLE TRAY

PRECAST
OR CAST
IN PLACE
CONCRETE

3'-0"

12'-0"

POWER
OUTLETS @ 60'

ELEV. 728'-6"

CLAY
TILL
.75
1

3" MUD SLAB

UNDERDRAIN

CAST IN PLACE
CONCRETE
BASE SLAB

SECTION
SCALE: 1/4" = 1'-0

D
S-1 S-2

SCALE:
3/4" = 1'-0"
SCALE
FEET
0 1 2 3 4 5 6 7

MC BEAMLINE ENCLOSURES
BEAMLINE ENCLOSURE SECTION SHEET - 2

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DATE
19 APR., 2013

PROJECT NO.
6-10-22

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S-7

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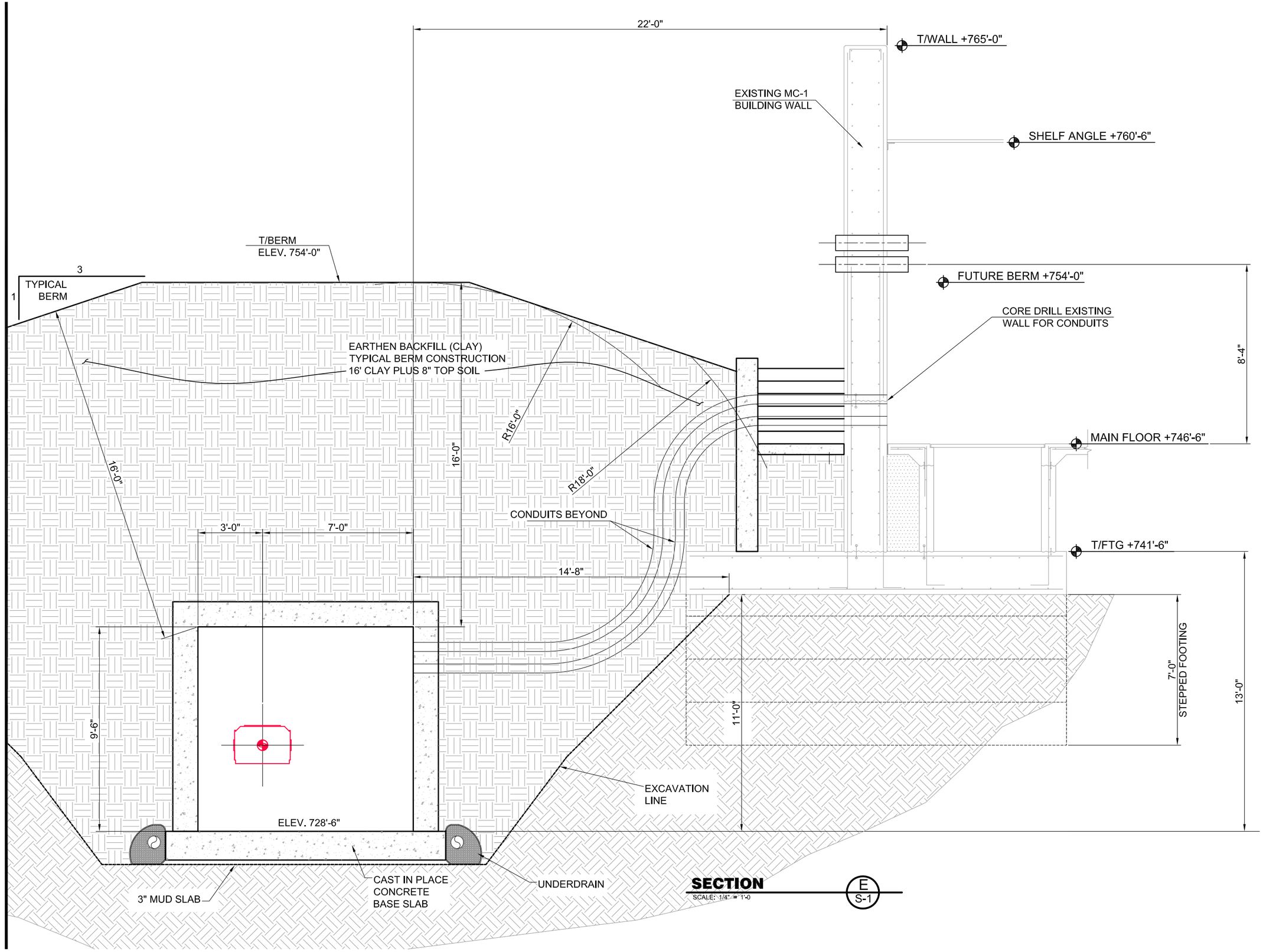

SECTION
SCALE: 1/4" = 1'-0

E
S-1

SCALE:
3/4" = 1'-0"
SCALE
FEET
0 1 2 3 4 5 6 7

MC BEAMLINE ENCLOSURES
BEAMLINE ENCLOSURE SECTION SHEET- 3

CDR

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DATE
19 APR., 2013

PROJECT NO.
6-10-22

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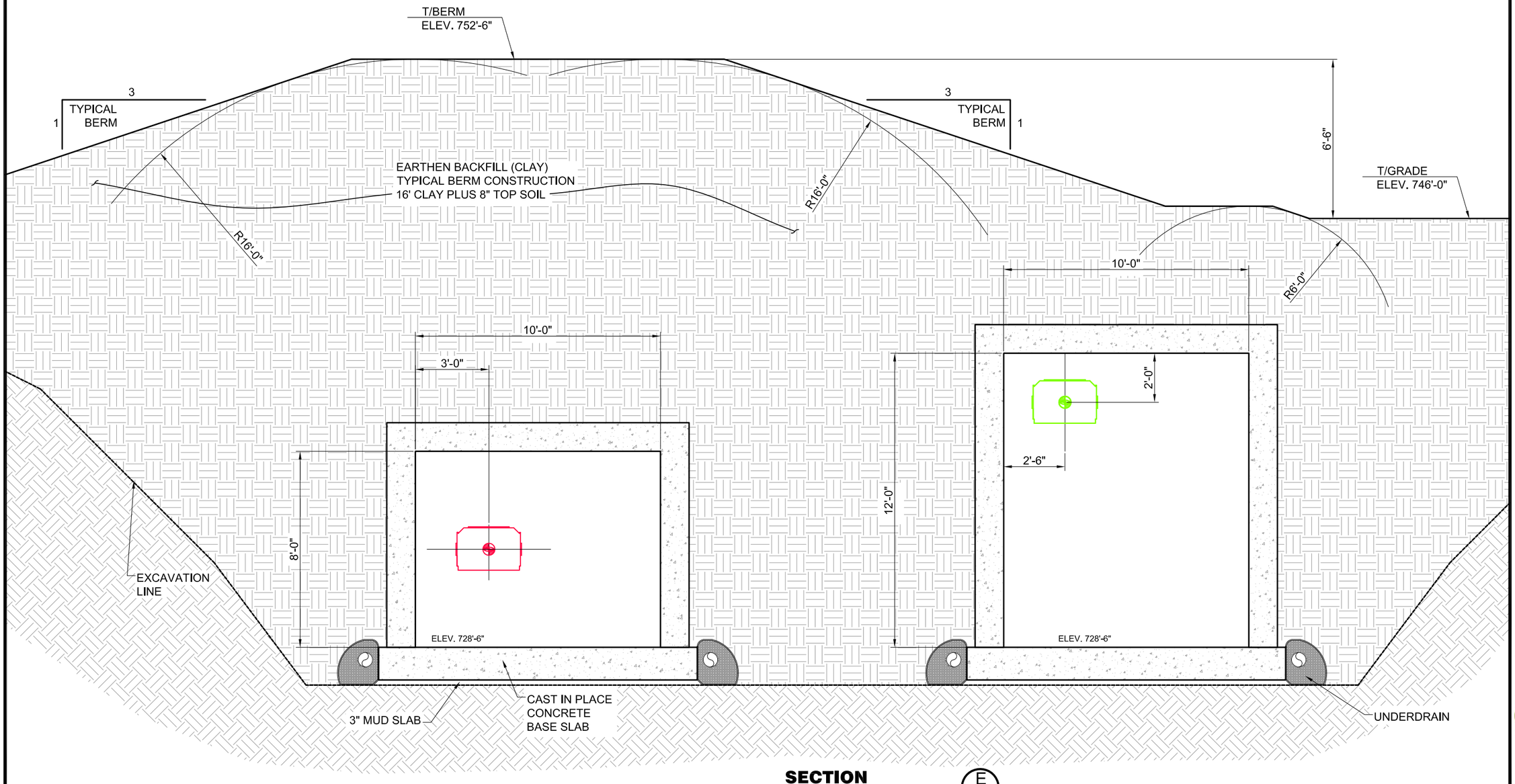

SECTION
SCALE: 1/4" = 1'-0

E
S-1

SCALE:
3/4" = 1'-0"
SCALE
FEET

MC BEAMLINE ENCLOSURES

BEAMLINE ENCLOSURE SECTION SHEET - 4

CDR

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DATE
19 APR., 2013

PROJECT NO.
6-10-22

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S-9

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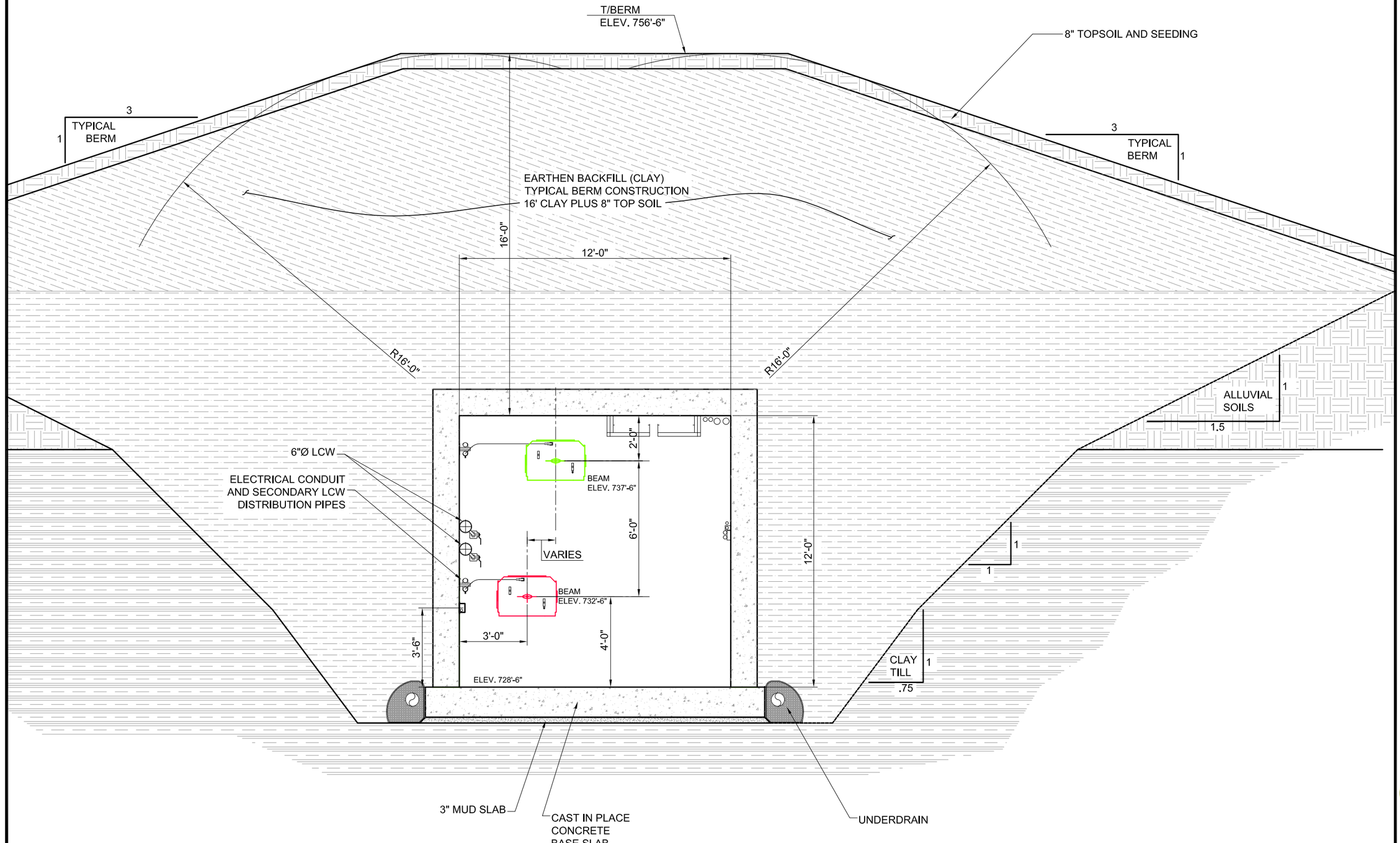

ENCLOSURE SECTION

SCALE: 3/4" = 1'-0

(STA. 0+20 TO STA. 1+20)

SCALE: 3/4" = 1'-0" (0 1 2 3 4 5 6 7 FEET)

MC BEAMLINE ENCLOSURES

BEAMLINE ENCLOSURE SECTION SHEET - 5

CDR

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DATE

19 APR., 2013

PROJECT NO.

6-10-22

DRAWING NO.

S-10

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Attachments Contained In This Appendix

- URL List of referenced DOE Directives and Guides
- URL List of referenced Fermilab Policies, Procedures and Guidance
- Integrated Project Team Responsibility Matrix
- Life Safety Analysis
- NEPA Documentation
- Sustainable Design/High Performance Building Review Memo
- LEED/Guiding Principles Checklist
- Engineering Risk Assessment
- Whitestone Building and Repair Cost Reference Information
- Fermilab Work Smart Set, Chapter 1070 of FESHM
- Multi-Organization Construction Site Safety Walkthrough Procedure
- Stakeholder Input
    - Comment and Compliance Review Request
    - Stakeholder Comments

URL List of referenced DOE Directives and Guides

- DOE Directive 413.3b
  http://www.directives.doe.gov/directives/current-directives/413.3-BOrder-b/view
- DOE Directive G413.3-21
  https://www.directives.doe.gov/directives/current-directives/413.3-EGuide-21/view

URL List of referenced Fermilab Policies, Procedures and Guidance

- DOE/Fermi Research Associates Contract DE-AC02-07CH11359
  http://fra-hq.org/pdfs/FRA_Contract.pdf
- Fermilab Director's Policy Manual
  http://www.fnal.gov/directorate/Policy_Manual.html
- Fermilab Environment Safety and Health Manual (FESHM)
  http://esh.fnal.gov/xms/FESHM
- Fermilab Engineering Manual
  http://www.fnal.gov/directorate/documents/FNAL_Engineering_Manual.pdf
- FESS/Engineering Policy Manual
  http://fess.fnal.gov/engineering/PolicyManual.pdf
- FESS/Engineering Procedure Manual
  http://fess.fnal.gov/engineering/FESSProcedureManual.pdf
- FESS Environmental Review Form Database
  http://fess-fmp/fmi/iwp/cgi?-db=Eng-Review%20Comments&-loadframes
- Fermilab Indirect Burden Rates
  http://finance.fnal.gov/Accounting/index.html

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Office of Science / U.S. Department of Energy / Managed by Fermi Research Alliance, LLC

INTEGRATED PROJECT TEAM RESPONSIBILITY MATRIX

LArTF

	PROJECT SPONSERS		INTEGRATED PROJECT TEAM					ORGANIZATIONAL PROCESS ASSETS									
	Directorate	Championing Organization	D/S/C	FESS/Engineering	FESS/Engineering	FESS/Engineering	Business Services Section	Directorate	Business Services Section	Business Services Section	Facilities Engineering Services Section	Facilities Engineering Services Section	Championing Organization	Championing Organization	Facilities Engineering Services Section	ES&H Section	Business Services Section
	Chief Operating Officer	*Accelerator Div. Head*	*Fermilab Project Directors*	*Fermilab Project Manager*	*Fermilab Design Coordinator*	*Fermilab Construction Coordinator*	*Procurement*	*Finance Section Budget Office*	*Legal*	*Accounting*	*Section Head*	*FESS Engineering Department Head*	*Accelerator Div. Safety Officer*	*Accelerator Div. Budget Officer*	*Environmental*	*Safety and Health*	*Security*
WORK PHASE	**J. Anderson**	**R. Dixon**	**M. Convery/G. Annala**	**T. Lackowski**	**R. Jedziniak**	**T. Trout**	**S. Gaugel**	**D. Keiner**	**Department**	**Department**	**R. Ortgiesen**	**R. Alber**	**J. Anderson**	**A. Nestander**	**R. Walton**	**J. Cassidy**	**B. Flaherty**
Project Justification CD-0																	
establish mission need, identify funding	Approve mission need, place in GPP/AIP queue	Establish mission need; appoint Fermilab Project Director	Prepare/submit mission need									Provide Project Cost Range					
Preliminary Design CD-1																	
Establish FESS/Engineering task		Assess D/S/C resource availability	Define project scope	Establish project and task request for Operating Reserve Funds for devlopment of CDR	Develop design costs for each disciple							Determine Fermilab Project Manager					
				Coordinate engineering resources, selection, tasking													
				Review in-house and A/E human resource requirements													
	Issue Approval to Proceed on Operating Reserve task			Submit task request for Operating Reserve funding							Review engineering task request for Operating Reserve funds	Review, concur and forward task request for Operating Reerve funds to COO					
Human Resource Management				Determine need for in-house and A/E human resource requirements								Review workload assignments					
				Prepare A/E RFP Memo	Review A/E RFP		Issue A/E RFP										
				Review A/E proposal	Review A/E proposal		Forward A/E to FPM		Assist with contracting								
				Initiate requisition for A/E work			Establish tasking purchase order with A/E										
Prepare NEPA documentation				Enter FERF into tracking database	Develop information for FERF						Interface with ES&H Section				Review FERF and detemine if PIF is required.		
				Review PIF											Develop PIF, if needed		
				Submit PIF											Interface with ES&H Section to support PIF process		
Develop Project Plan	Preliminary acceptance of aesthetic concerns	Provide D/S/C Resources as required	Coordinate customer team	Establish project design team	Direct design teams effort						Provide FESS Resources as Required	Monitor, Review and Comment					
			Provide project requirements	Interface with customer	Interface w/ customer												
				Develop Project Plan Documents	Assist in Developing Project Plan Documents												
Lab-wide Comment and Compliance Review	Review and Comment	Review and Comment	Review and Comment	Issues CCR, comment resolution	Coordinate CCR, comment resolution		Review and Comment		Review and Comment		Review and Comment	Review and Comment	Review and Comment	Review and Comment	Review and Comment	Review and Comment	Review and Comment
Fermilab Project Request Form	approve PRF	Approve Fermilab Project Request Form		Draft Fermilab Project Request Form										Review Submittal and Forward to Finance Section			
	Review Directive Request			Submit Fermilab Project Request Form				Create and Submit Directive Request to DOE									
Project Plan Approval			Accepts project scope	Accepts Project Baseline, Cost , Scope and sSchedule													
	Accept and Approve Project Plan	Accept and Approve Project Plan	Accept and Approve Project Plan	Submit Project Plan													
Project Plan Submittal to DOE for Construction Directive Authorization								Submit Construction Directive Authorization									
Project Filing			Monitor Filing	Establish Project File Requirements	Maintain Project Files							Monitor Project Filing					
Final Design CD-2																	
Establish Funding Codes				Request Work Package				Create Work Package						Create PCM for Task Numbers, submit request to Finance			
Human Resource Management				Determine need for in-house and A/E human resource requirements								Review workload assignments					
				Prepare A/E RFP Memo	Review A/E RFP		Issue A/E RFP										
				Review A/E proposal	Review A/E proposal		Forward A/E to FPM		Assist with Contracting								
				Initiate requisition for A/E work			Establish tasking purchase order with A/E										
Design Coordination Meetings			Participate in Meetings	Participate in Meetings	Coordinate and Lead Meetings												
Design Development				Approve change orders	Interface with Customer and Fermilab organizations		issue change orders										
					Lead Development of Construction Documents, Drawings, Exhibits												
Execute Project Plan Exhibit A and Exhibit B				assist in writing Exhibit A	coordinate writing of Exhibit A&B		assist in writing Exhibit A		provide counsel as requested								
Internal Cost Tracking and Control				Monitor Design Progress and Costs						provide timely cost data to PM							
				initiate Design Phase Change Orders (if required)	Review Design Phase Change Orders		Issue Design Phase Change Orders to A/E firms (if required)										
				Review and Approve A/E Invoices	Review and Approve A/E Invoices		Review and Approve A/E Invoices			pay invoices		approve A/E invoices					

LEGEND	
	Indicates Initiator of Action
	Indicates Approval Action Required

LIST OF ACRONYMS	
AP	Acquisition Plan
BO	Beneficial Occupancy
CCB	change control board
A/E	Architectural Engineering Consultant
PIF	Project Information Form (NEPA)
PEP	Project Execution Plan
CDR	Conceptual Design Report
FPM	Fermilab Project Manager
D/S/C	divisions/sections/research centers
PO	Purchase Order
RFP	Request for Proposal
FERF	FESS Environmental Review Form
COO	Chief Operating Officer
SET	Source Evaluation Team

Date Printed: 5/10/2013

INTEGRATED PROJECT TEAM RESPONSIBILITY MATRIX

LArTF

	PROJECT SPONSERS		INTEGRATED PROJECT TEAM					ORGANIZATIONAL PROCESS ASSETS									
	Directorate	Championing Organization	D/S/C	FESS/Engineering	FESS/Engineering	FESS/Engineering	Business Services Section	Directorate	Business Services Section	Business Services Section	Facilities Engineering Services Section	Facilities Engineering Services Section	Championing Organization	Championing Organization	Facilities Engineering Services Section	ES&H Section	Business Services Section
	Chief Operating Officer	*Accelerator Div. Head*	*Fermilab Project Directors*	*Fermilab Project Manager*	*Fermilab Design Coordinator*	*Fermilab Construction Coordinator*	*Procurement*	*Finance Section Budget Office*	*Legal*	*Accounting*	*Section Head*	*FESS Engineering Department Head*	*Accelerator Div. Safety Officer*	*Accelerator Div. Budget Officer*	*Environmental*	*Safety and Health*	*Security*
WORK PHASE	**J. Anderson**	**R. Dixon**	**M. Convery/G. Annala**	**T. Lackowski**	**R. Jedziniak**	**T. Trout**	**S. Gaugel**	**D. Keiner**	**Department**	**Department**	**R. Ortgiesen**	**R. Alber**	**J. Anderson**	**A. Nestander**	**R. Walton**	**J. Cassidy**	**B. Flaherty**
Change Control for Design	Secure Additional Funding	Secure Additional Funding	Initiate Changes to Design Performance Baseline	Establish CCB for Design Phase	Prepare Estimates of Cost and Schedule Impacts												
			Secure Additional Funding For Changes	Provide Cost and Schedule Impact of Proposed Changes to Fermilab Project Director													
Lab-wide Comment and Compliance Review			Review and Comment	Issues CCR, comment resolution	Coordinate CCR, comment resolution		Review and Comment		Review and Comment		Review and Comment	Review and Comment	Review and Comment	Review and Comment	Review and Comment	Review and Comment	Review and Comment
Monitoring and Controlling			Monitor Design Progress	Coordinate Engineering Resources, Selection, Tasking, Invoices													
				Monitor Design Progress													
			Monitor Project Costs	Monitor Project Costs													
				Review and Approve A/E Invoices	Review and Approve A/E Invoices		Review and Approve A/E Invoices			Pay A/E Invoices		Review and Approve A/E Invoices					
Value Management (tailored)			Participate in Value Management	Coordinate and Lead Value Management Exercises	Participate in Value Management	Participate in Value Management											
Develop Design Phase Cost and Schedule Estimate				Lead Development of Design Phase Cost and Schedule Estimate	Assist in Development of Design Phase Cost and Schedule Estimate												
Independent Cost Estimate			Concur with Need for Independent Cost Estimate	Determine need for Independent Cost Estimate	Provide Input for Need for Independent Cost Estimate												
				Prepare A/E RFP Memo	Review A/E RFP		Issue A/E RFP										
				Review A/E proposal	Review A/E proposal		Forward A/E to FPM		Assist with Contracting								
				Initiate requisition for A/E work			Establish tasking purchase order with A/E										
Design Phase Submittals				Prepare Signature Sheet for Release of Design Phase Documents													
			Approve Release of Design Phase Documents	Approve Release of Design Phase Documents	Approve Release of Design Phase Documents						Approve Release of Design Phase Documents	Approve Release of Design Phase Documents					
Request For Proposal			Review Request For Proposal Documents	Review Request For Proposal Documents			Develop Request For Proposal Documents										
Regulatory Permits									Provide Counsel as Requested				Identify Required Permits		Identify Required Permits		
				Provide Permit Information	Provide Permit Information						Approve Permit Submittal				Prepare Permit Application		
			Approval Permit Submittal	Approval Permit Submittal											Submit Application to ES&H Section		
				Monitor Permitting Process													
Update Project Plan			Identify Changes to Project Plan	Identify Changes to Project Plan	Identify Changes to Project Plan						Identify Changes to Project Plan	Identify Changes to Project Plan			Identify Changes to Project Plan		
				Update Project Plan													
			Approve Changes to Project Plan	Approve Changes to Project Plan													
Project Reporting				Monitor Design Progress and Costs				Initiate Request for Quarterly GPP Reports									
				Prepare Quarterly GPP Reports						Provide Timely Cost Data to FPM							
			Review Quarterly GPP Reports									Review Quarterly GPP Reports		Review Quarterly GPP Reports			
	Review Quarterly GPP Reports							Review Quarterly GPP Reports						Forward Quarterly GPP Reports to Finance Section			
								Submit Quarterly GPP Reports to DOE									
Directive Modifications		Review and Approve Directive Modification Request Form	Review Directive Modification Request Form	Prepare Directive Modification Request Form										Review and Approve Directive Modification Request Form			
														Submit Directive Modification Request Form to Finance Section			
								Review Directive Modification Request Form									
	Review and Approve Directive Modification Request Form																
								Forward Directive Modification Form to DOE									
Project Filing			Monitor Filing	Establish Project File Requirements	Maintain Project Files							Monitor Project Filing					
Procurement CD-3																	
Issue Request For Proposal				Initiate Construction Requisition													
	Approve Requsition	Approve Requsition									Approve Requsition	Approve Requsition		Approve Requsition			
							Issue Request For Proposal										
Pre-Proposal Meeting (if required)				Determine Necessity for Pre-Proposal Meeting													
							Coordinate and Chair Pre-Proposal Meeting										

LEGEND	
	Indicates Initiator of Action
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LIST OF ACRONYMS	
AP	Acquisition Plan
BO	Beneficial Occupancy
CCB	change control board
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PEP	Project Execution Plan
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FPM	Fermilab Project Manager
D/S/C	divisions/sections/research centers
PO	Purchase Order
RFP	Request for Proposal
FERF	FESS Environmental Review Form
COO	Chief Operating Officer
SET	Source Evaluation Team

Date Printed: 5/10/2013

INTEGRATED PROJECT TEAM RESPONSIBILITY MATRIX

LArTF

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			Participate in Pre-Proposal Meeting	Participate in Pre-Proposal Meeting	Participate in Pre-Proposal Meeting											Participate in Pre-Proposal Meeting	
Requests For Information					Coordinates RFIs												
			Monitors RFI Process	Concurs with Replies for RFIs	Prepares Replies For RFIs							Monitors RFI Process					
Amendments				Concurs with Need for Amendment to RFP			Determines Need for Amendment to RFP										
			Monitors Amendment Process		Assemble Amendment Documentation							Monitors Amendment Process					
							Issues Amendment to RFP										
Proposal Evaluations				Chair Source Evaluation Team			Source Selection Officer									evaluate safety submittals	
			Participate in Source Evaluation Team	Evaluate Corporate Quality Control Plan	Participate in Source Evaluation Team		Participate in Source Evaluation Team		Provide Counsel as Requested			Monitor Source Evaulation Team Process					
				Evaluate Schedule Submittal			Review Proposals for Business Related Issues										
				Forward Recommendation to Source Selection Officer													
Negotiations				Assist in Negoiations			Conduct Negotiations		Provide Counsel as Requested								
Subcontract Award				Initate Recommendation To Award												Review and Accept Safety Documentation	
			Approve Award	Approve Award			Award Subcontract		Provide Counsel as Requested								
Update Project Plan For Construction Phase			Identify Changes to Project Plan	Identify Changes to Project Plan	Identify Changes to Project Plan						Identify Changes to Project Plan	Identify Changes to Project Plan			Identify Changes to Project Plan		
				Update Project Plan													
			Approve Changes to Project Plan	Approve Changes to Project Plan													
Project Filing			Monitor Filing	Establish Project File Requirements	Maintain Project Files							Monitor Project Filing					
Construction																	
Pre-Construction Meeting				Determine Necessity for Pre-Construction Meeting													
							Coordinate and Chair Pre-Construction Meeting										
			Participate in Pre-Construction Meeting	Participate in Pre-Construction Meeting	Participate in Pre-Construction Meeting	Participate in Pre-Construction Meeting							Participate in Pre-Construction Meeting			Participate in Pre-Construction Meeting	Participate in Pre-Construction Meeting
			Participate in Pre-Construction Meeting	Participate in Pre-Construction Meeting	Participate in Pre-Construction Meeting	Participate in Pre-Construction Meeting							Participate in Pre-Construction Meeting			Participate in Pre-Construction Meeting	Participate in Pre-Construction Meeting
Subcontractor Corporate Safety Plan				Review Submittals		Review Submittals										Review/Approve Safety and Health Submittals	
				Accept Subcontractor Corporate Safety Plan													
Subcontractor Quality Control Plan				Review Subcontractor Plan	Review Subcontractor Plan	Review Subcontractor Plan											
				Accept Subcontractor Quality Control Plan													
Storm Water Erosion Control Plan				Review Plan	Review Plan	Review Plan									Review/Approve Environmental Submittals		
				Accept Storm Water Erosion Control Plan													
Hazard Analysis						Review and Accept Hazard Analysis						Monitor Process				Assist Review as Requested	
Fermilab Permits				Monitor Process	Monitor Process	Obtain and Maintain Currency						Monitor Process			Provide Oversite and Support of Process		
Notice To Proceed				Monitor Process		Assure Predessocors are in Place	Issue Notice To Proceed					Monitor Process					
Cost Loaded Schedule (CLS)				Review CLS	Review CLS	Review and Comment on CLS											
				Accept CLS													
Submittal List				Review Submittal List	Review Submittal List	Review Submittal List											
					Approve Submittal List												
A/E Support For Construction Phase				Determine need for in-house and A/E human resource requirements								Review workload assignments					
				Prepare A/E RFP Memo	Review A/E RFP		Issue A/E RFP										
				Review A/E proposal	Review A/E proposal		Forward A/E to FPM		Assist with Contracting								
				Initiate requisition for A/E work			Establish tasking purchase order with A/E										
Execute Construction Phase				Monitors Process		Fermilab Competent Person											
						First Line Contact with Subcontractor											
						Coordinate Fermilab Interfaces (services, outages, etc.)											
Inspections and Reports				Monitor QA program		QA Inspections for Technical and Safety Plan Compliance					Support as Requested	Support as Requested	Support as Requested			Support as Requested	
				Monitor Progress and Trends		Daily Construction Report to FPM					Monitor Progress and Trends	Monitor Progress and Trends					
Labor Reporting						Obtain Man-hour Reports from Subcontractor	Review Davis-Bacon Payroll Submittals										
Deficiency Log				Monitor Deficiency Log	Monitor Deficiency Log	Maintain Deficiency Log											
Submittals				Monitor Submittal Review Process	Coordinate Submittal Review	Participate in Submittal Review Process											

LEGEND	
	Indicates Initiator of Action
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LIST OF ACRONYMS	
AP	Acquisition Plan
BO	Beneficial Occupancy
CCB	change control board
A/E	Architectural Engineering Consultant
PIF	Project Information Form (NEPA)
PEP	Project Execution Plan
CDR	Conceptual Design Report
FPM	Fermilab Project Manager
D/S/C	divisions/sections/research centers
PO	Purchase Order
RFP	Request for Proposal
FERF	FESS Environmental Review Form
COO	Chief Operating Officer
SET	Source Evaluation Team

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				Issue and Approve Actions													
					Maintain Submittal Log												
Engineering Changes				Initiate Engineering Change Request													
					Develop Documentation for Engineering Changes												
				Concur with Engineering Change Request	Issue Engineering Change Request												
							Issue Engineering Change Request to Subcontractor										
							Forward Engineering Change Request Information from Subcontractor to Project Team				review / approve						
				Review Subcontractor Engineering Change Request Submittal	Review Subcontractor Engineering Change Request Submittal	Review Subcontractor Engineering Change Request Submittal											
				Initiate Requisition													
	Approve Requsition	Approve Requsition									Approve Requsition	Approve Requsition		Approve Requsition			
							Issue Supplemental Agreement										
				Maintain Engineeeing Change Log													
Claim Review and Negotiations				Lead Review and Negotiations	Assist Review	Assist Review	Assist Review and Negotiation		provide counsel as requested		assist review						
				Approve Settlements			Determine Settlements										
Supplemental Agreements				Approve Supplemental Agreements			Issue Supplemental Agreements										
Non-compliance Notifications						Draft Non-compliance Notification	Provide Counsel as Requested		provide counsel as requested								
				Issue Non-compliance Notification			Concur with Non-compliance Notification										
				Monitor Non-compliance Notifications													
Construction Meeting				Participate in Meetings	Patricipate in Meetings	Chair Meeting	Patricipate in Meetings						Attend as Requested		Attend as Requested	Attend as Requested	
Weekly Project Team Meeting			Participate in Meetings	Participate in Meetings	Chair Meeting	Participate in Meetings	Participate in Meetings									Participate in Meetings	
Project Management Group Meeting	Participate in Meetings	Participate in Meetings	Participate in Meetings	Lead Presentation		Participate in Meetings	Participate in Meetings	Participate in Meetings								Participate in Meetings	
Project Reporting				Monitor Design Progress and Costs				Initiate Request for Quarterly GPP Reports									
				Prepare Quarterly GPP Reports						Provide Timely Cost Data to FPM							
			Review Quarterly GPP Reports									Review Quarterly GPP Reports		Review Quarterly GPP Reports			
	Review Quarterly GPP Reports							Review Quarterly GPP Reports						Forward Quarterly GPP Reports to Finance Section			
								Submit Quarterly GPP Reports to DOE									
Cost Tracking and Control				Monitor Construction Progress	Monitor Construction Progress	Monitor Construction Progress	Monitor Construction Progress			Provide Timely Cost Data to FPM		Track A/E invoices and FESS Engineering Costs					
				Monitor EDIA Costs													
				Monitor Project Costs													
Subcontractor Progress Updates				Review and Comment on Subcontractor Update Submittals	Review and Comment on Subcontractor Update Submittals	Conduct Progress Updates with Subcontractor	Review and Comment on Subcontractor Update Submittals										
Invoice Approvals				Review Invoices	Review Invoices	assure invoice checklist is complete											
				Approve Invoices	Approve A/E and Subcontractor Invoices	Approve Subcontractor Invoices	Approve Invoices										
Punch List				Determine Punchlist Start													
			Participate in Walkthroughs	Coordinate Customer Walkthroughs	Coordinate Engineering Portion of Walkthroughs	Coordinate Punch List Walkthroughs	Monitor Punch List Activity										
					Transmit Punch List to Subcontractor	Assemble Lab Punch IList											
						Monitor Completion of Punch List Items											
Beneficial Occupancy			Accept Customer D/S/C Responsibilities	Coordinate Customer D/S/C Responsibilities		Coordinate Walkthroughs											
			Approve Beneficial Occupancy	Approve Beneficial Occupancy	Transmit Beneficial Occupancy to Sucbontractor	Initiate Beneficial Occupancy Form	Approve Beneficial Occupancy				Approve Beneficial Occupancy	Approve Beneficial Occupancy					
Final Acceptance			Approve Final Acceptance	Approve Final Acceptance	Transmit Final Acceptance to Subcontractor	Initiate Final Acceptance Form	Approve Final Acceptance				Approve Final Acceptance	Approve Final Acceptance					
Update Project Plan			Identify Changes to Project Plan	Identify Changes to Project Plan	Identify Changes to Project Plan						Identify Changes to Project Plan	Identify Changes to Project Plan			Identify Changes to Project Plan		
				Update Project Plan													
			Approve Changes to Project Plan	Approve Changes to Project Plan													
Incident Investigations						Initiate Call Tree					Assist as Required	Assist as Required	Assist as Required	Assist as Required	Assist as Required	Assist as Required	Assist as Required
						Obtain Incident Report from Subcontractor										monitor process	monitor process
			Monitor Incident Repsonse	Issue Incident Report, Monitor Response		Prepare Incident Report for FPM					Monitor Incident Repsonse	Monitor Incident Repsonse	Monitor Incident Repsonse	Monitor Incident Repsonse	Monitor Incident Repsonse	Monitor Incident Repsonse	Monitor Incident Repsonse

LEGEND	
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Lessons Learned				Assist as Required	Assist as Required	Assist as Required						Develop Lessons Learned					
Environment, Safety and Heath Compliance	Monitor Compliance	Monitor Compliance	Monitor Compliance	Monitor Compliance		Monitor Compliance	Monitor Compliance				Monitor Compliance	Monitor Compliance	assist on technical issues		Monitor Compliance	Monitor Compliance	
				Interface with Subcontractor	Assist as Requested	Assure Subcontractor Compliance										Assist as Requested	
As-Built Documentation					Assist as Requested	Assure As-builts Kept Current and Accurate											
Directive Modifications		Review and Approve Directive Modification Request Form	Review and Approve Directive Modification Request Form	Prepare Directive Modification Request Form										Review and Approve Directive Modification Request Form			
														Submit Directive Modification Request Form to Finance Section			
								Review Directive Modification Request Form									
	Review and Approve Directive Modification Request Form																
								Forward Directive Modification Form to DOE									
Project Filing			Monitor Filing	Establish Project File Requirements	Maintain Project Files							Monitor Project Filing					
Close-out CD-4																	
Subcontractor Performance Review			Participate in Review	Participate in Review		Participate in Review	Coordinate and Lead Review									Participate in Review	
Final Payment and Renetention Release						Assure Invoice Checklist is Complete											
				Review and Approve Subcontractor Invoices	Review and Approve Subcontractor Invoices	Review and Approve Subcontractor Invoices	Review and Approve Subcontractor Invoices										
				Assist as Required	Assist as Required	Assist as Required	Move Outstanding Issues to Warranty										
Level1 Budget Close	Approve Budget Close	Approve Budget Close		Determine Close Date				Activate Level 1 Budget Close		Assure All Commitments in Place				Request Budget Close			
Notice of Project Closeout	Approve Closeout	Approve Closeout												Submit Project Closeout Request			
Final Budget Close								Activate Final Budget Close						Initiate Final Close			
Directive Modifications		Review and Approve Directive Modification Request Form	Review and Approve Directive Modification Request Form	Prepare Directive Modification Request Form										Review and Approve Directive Modification Request Form			
														Submit Directive Modification Request Form to Finance Section			
								Review Directive Modification Request Form									
	Review and Approve Directive Modification Request Form																
								Forward Directive Modification Form to DOE									
Project Filing			Monitor Filing	Establish Project File Requirements	Maintain Project Files							Monitor Project Filing					

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Mu2e Fire Protection Assessment

Prepared for

Fermi National Accelerator Laboratory

P.O. Box 500
Batavia, IL 60510

Prepared by

Aon Fire Protection Engineering

Aon FPE Project No. 1810171-000

March 8, 2012

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BEAM TRANSPORT ENCLOSURE

A. Occupant Load: The occupant load should be administratively controlled to a maximum of 20 persons.

B. Construction: The facility should be of Type IB construction as defined by Section 602 of the 2012 IBC.

C. Compartmentation: Walls separating the Beamline Transport Enclosure from the Detector Hall should be 2 hr. fire/smoke barrier walls.

D. Smoke Control: No requirements.

Exception: Should the floor level of the Beam Transport Enclosure be located more than 30 feet below grade, the exit stairway enclosures serving the Beam Transport Enclosure should be supplied with outside air to provide a positive pressure of 0.05 in/wg relative to the adjacent space.

E. Means of Egress:

1. At least two separate exits to the surface should be provided. The maximum travel distance to an exit should not exceed 300 feet.

2. Exit stairways should be enclosed by 2 hr. fire rated construction.

3. The common path of travel should not exceed 50 feet.

4. Aisles should be maintained at a minimum clear width of 24 inches. A minimum headroom of 6'-8" should be provided throughout the Beam Transport Enclosure.

   Exception: Should the occupant load for the Beam Transport Enclosure be increased to more than 20 persons, but less than 50 persons, aisles should be maintained at a minimum clear width of 36 inches and a minimum headroom of 7'-6" should be provided.

5. Dead end corridors should not exceed 20 feet in length.

6. Emergency lighting should be provided for all means of egress in accordance with the IBC and NFPA 101.

F. Standpipe System: No requirements.

Exception: Should the floor level of the Beam Transport Enclosure be located more than 30 feet below the level of exit discharge, a Class I standpipe system with 2½" fire department hose valves should be provided at the base of all exit stairways.

G. Fire Detection and Alarm System:

1. An addressable fire detection and alarm system should be provided for the Beam Transport Enclosure. The system should consist of:

    a. Manual pull stations located at the entrances to exit stairways.

    b. Air sampling smoke detection (or spot type smoke detectors) throughout the Beam Transport enclosure.

    c. Combination horn/strobe devices located throughout the facility.

H. Emergency Power and Standby Power Systems:

1. Emergency power should be provided for the following systems such that the transition time from the instant of failure of normal power to an alternate power source does not exceed 10 seconds:

    a. Fire detection and alarm system.
    b. Exit sign illumination.
    c. Lighting throughout the Beam Transport Enclosure.

2. Standby power is not required:

3. The alternate power supply should be capable of providing power for a minimum of 1½ hours for emergency power systems. The fire detection and alarm system should be provided with battery back-up sufficient to power the system for 24 hours in stand-by mode, followed by 15 minutes of alarm mode.

I. Miscellaneous:

1. Use and/or storage of flammable and combustible liquids should be prohibited.

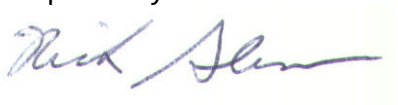
2. All wall and ceiling finishes should be Class A with a flame spread rating not to exceed 25 and a smoke development rating not to exceed 450.

3. Insulated cables and wiring not installed in metal conduits and raceways should meet IEEE Standard 1202 for flame propagation, where possible. All fire alarm system wiring should be installed in metal conduit.

4. On-site self contained breathing apparatus should be provided in the quantities and locations as directed by Fermilab-Environmental, Safety & Health.

5. Portable fire extinguishers should be provided throughout the facility in accordance with NFPA 10, *Standard for Portable Fire Extinguishers, and as directed by the Fermilab Fire Department*.

Prepared By:



Rick Glenn, P.E.
Project Manager

Department of Energy
Fermi Site Office
Post Office Box 2000
Batavia, Illinois 60510

JUN 12 2012

Dr. Bruce L. Chrisman
Chief Operating Officer
Fermilab
P.O. Box 500
Batavia, IL 60510

Dear Dr. Chrisman:

SUBJECT: NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) DETERMINATION AT FERMI NATIONAL ACCELERATOR LABORATORY (FERMILAB) – FERMILAB MUON CAMPUS, INCLUDING THE MUON TO ELECTRON CONVERSION (Mu2e) EXPERIMENT AND THE MC-1 BUILDING

Reference: Letter, from B. Chrisman to M. Weis, dated June 6, 2012, Subject: NEPA Environmental Evaluation Notification Form (EENF) for the Fermilab Muon Campus, including the Mu2e Experiment and the MC-1 Building

I have reviewed the Fermilab EENF for the Fermilab Muon Campus, including the Mu2e Experiment and the MC-1 Building. Based on the information provided in the EENF, I have approved the following categorical exclusion (CX):

Project Name	Approved	CX
Fermilab Muon Campus, including the Mu2e Experiment and the MC-1 Building	6/8/2012	B1.15, B3.10

I am returning a signed copy of the EENF for your records. No further NEPA review is required. This project falls under categorical exclusions provided in Title 10, *Code of Federal Regulations*, Part 1021, as amended in November 2011.

Sincerely,

Michael J. Weis
Site Manager

Enclosure:
As Stated

cc: P. Oddone, w/o encl.
Y.-K. Kim, w/o encl.
N. Grossman, w/encl.
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FERMILAB ENVIRONMENTAL EVALUATION NOTIFICATION FORM (EENF)

for documenting compliance with the National Environmental Policy Act (NEPA), DOE NEPA Implementing Regulations, and the DOE NEPA Compliance Program of DOE Order 451.1

Project/Activity Title: Establishment of a Fermilab Muon Campus (MC) Program, including the Muon to Electron Conversion (Mu2e) Experiment and the MC-1 Building

ES&H Tracking Number: 01090

I hereby verify, via my signature, the accuracy of information in the area of my contribution for this document and that every effort would be made throughout this action to comply with the commitments made in this document and to pursue cost-effective pollution prevention opportunities. Pollution prevention (source reduction and other practices that eliminate or reduce the creation of pollutants) is recognized as a good business practice which would enhance site operations thereby enabling Fermilab to accomplish its mission, achieve environmental compliance, reduce risks to health and the environment, and prevent or minimize future Department of Energy (DOE) legacy wastes.

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I. Description of the Purpose and Need for the Proposed Action; the Proposed Action; and Alternatives to the Proposed Action

Purpose and Need:

The purpose of the proposed action/project is to establish a Fermilab Muon Campus (see Figure 1 and 2 in Appendix A) Program that would be a base for future muon experiments. The Program currently includes the proposed construction and operation of the Muon to Electron Conversion (Mu2e) Experiment and the proposed construction of the Muon Campus (MC)-1 Building, that would be built in anticipation of the future Muon Gyromagnetic Ratio Measurement (g-2, pronounced g minus 2) Experiment. It is expected that the Muon Campus Program would maximize the synergy between the Mu2e Experiment and the g-2 Experiment and minimize the overall cost of developing them individually due to the ability to share utilities, consolidate infrastructure, and mobilize civil construction concurrently.

The purpose of creating the Mu2e Experiment is to enable scientists to make the most sensitive search ever made for the coherent conversion of muons into electrons in the field of a nucleus, which is an example of 'charged lepton flavor violation' (electrons are 1st generation and muons are 2nd generation leptons). The Mu2e Experiment would provide an advance in experimental sensitivity of four orders of magnitude (10,000 times more sensitive) than previous experiments and it is needed to shed light on the mechanism for generating the observed matter-antimatter asymmetry of the universe. Combined with neutrino program results, the Mu2e Experiment could also help point the way to a unification theory of the fundamental forces of nature. This leap in sensitivity could be achieved with a modest evolution of the existing Fermilab accelerator complex, to create the required intense low energy muon beam; a state-of-the art detector capable of precision measurements in the presence of high rates of conversions; and a new detector hall facility to house the experiment. A successful Mu2e Experiment could be the first step in a world-leading muon-decay program that would "advance fundamental knowledge in high energy physics that would result in a deeper understanding of matter, energy, space and time" which is consistent with the Department of Energy Secretarial Strategic Priority of Science, Discovery, and Innovation.

The purpose of the MC-1 Building is to initially house the anticipated g-2 Experiment that is needed to measure the gyromagnetic ratio "g" of the muon; this ratio is particularly sensitive to any new particles or interactions beyond the Standard Model, the current understanding of elementary particle physics. The building would potentially be repurposed for other future muon experiments that would be suited to an intense muon beam and benefit from the reuse of the existing accelerator system, specifically the recycler and antiproton facilities.

Proposed Action:

To fulfill the purpose and need for the Muon Campus Program, which currently includes the Mu2e Experiment and the MC-1 Building, the following activities are proposed.

Mu2e Experiment

To achieve the sensitivity goal described in the 'purpose and need' for the Mu2e Experiment, a high intensity low energy muon beam coupled with a detector capable of efficiently identifying 105 MeV electrons, while minimizing background from conventional processes, is necessary and the muon beam would be created at Fermilab by an 8 GeV pulsed beam of protons striking a production target.

The components necessary to execute the Mu2e Experiment include a Primary Proton Beam which would require modifications to the Fermilab Accelerator Complex that involve Recycler Ring Modifications, Antiproton Debuncher/Delivery Ring Upgrades, a new Muon Campus External Beamline and Beamline Enclosure; Superconducting Solenoids including the Production, Transport, and Detector Solenoids; a Mu2e Detector; Muon Campus Cryogenic Plant; and a Mu2e Facility comprised of an Underground Detector Hall and a Surface Building at grade level. Proposed activities needed to construct and enable operation of the Mu2e Experiment are as follows:

- **Prepare the Muon Campus Site**, which would include relocation of a portion of Kautz Road to the west to accommodate construction of the Mu2e Building. Additionally, a large portion of the Kautz Road stockpile would be relocated to provide for the realignment of the roadway and the existing high-pressure gas line that parallels the existing roadway would be relocated alongside the new roadway alignment. The roadway and gas line would be made functional prior to construction of the new Mu2e Facility.

To accommodate the future electrical loading requirements of the Muon Campus, an additional high-voltage electrical feeder would be extended to the campus footprint. A new extension of Feeder 24 would be constructed from the Master Substation to the F-3 service area and isolating 4-bay air switches would be installed at these locations to provide for configuration changes. The new feeder cables would be pulled through existing ductbank and no new ductbank construction is expected other than at the location of the new switches.

- **Modify the existing Fermilab Accelerator Complex** to facilitate the transfer of 8 GeV protons from the Fermilab Booster to the proposed Mu2e Detector while the 120 GeV neutrino program is operating (see Figure 3 in Appendix A). To accomplish this, the existing Recycler and Antiproton Debuncher/Delivery Ring (the Antiproton Debuncher Ring would be renamed Delivery Ring for the purposes of the Muon Campus so is referred to here as the Antiproton Debuncher/Delivery Ring) would be modified to re-bunch batches of protons from the Booster and then slow extract beam to the Mu2e Detector (see Figures 3 and 4 in Appendix A).

  Primary Proton Beam – The Mu2e Experiment requires a high intensity pulsed proton beam to produce an intense beam of low energy muons with the time structure required by the experiment; Figure 3 illustrates the eventual Fermilab accelerator complex necessary to acquire protons for the Mu2e Experiment. The total number of protons to be delivered on target for the experiment is 1.2×10^{20} per year, corresponding to an average power of about 8 kW. As shown in Figure 4, batches of protons from the existing Booster would be transported to the Recycler Ring for re-bunching via a new Radio Frequency (RF) system and the re-bunched beam would be kicked out of the Recycler into existing transfer lines that would deliver protons to the Antiproton Debuncher/Delivery Ring. A resonant extraction system in the Antiproton Debuncher/Delivery Ring would then slow extract protons to the proposed Mu2e Detector through a new external beamline. The operating scenario and proposed modifications are as follows:

  - **Recycler Ring Modifications** - The transport of protons from the Booster to the Recycler Ring would occur via a connection from the MI-8 line to the Recycler Ring. This connection does not currently exist but it, along with construction and installation of a kicker system to inject Booster batches into the Recycler Ring, are part of the *Neutrinos at the Main Injector (NuMI) Off-Axis Electron Nuetrino Appearance Experiment (NOvA)* project scope that would be completed in advance of the Mu2e Experiment. The scope of this work was included in the *NOvA Environmental Assessment/Finding of No Significant Impact.*

    In addition, the Mu2e Experiment would require the ability to re-bunch beam in the Recycler Ring; therefore, a new 2.5 MHz RF system would be installed to divide batches of protons from the Booster into four smaller bunches that would be transferred one-at-a-time to the existing P1 line. A new connection would be made from the Recycler Ring to the P1 line, which currently connects to the Main Injector. A new extraction kicker is also required.

  - **Transfer Lines and Antiproton Debuncher/Delivery Ring Injection** - Proton bunches formed in the Recycler Ring would be kicked into the P1 line and transported to the Antiproton Debuncher/Delivery Ring through a series of existing transfer lines. For Mu2e running, protons would traverse the P2, AP1 and AP3 lines before being injected into the Antiproton Debuncher/Delivery Ring by a new injection kicker. The proton bunches would be captured in the Antiproton Debuncher/Delivery Ring by a new 2.4 MHz RF system consisting of RF modules that are identical to the RF modules needed for the Recycler Ring. Stochastic cooling tanks and other equipment used for antiproton production would be removed from the Antiproton Debuncher/Delivery Ring to open up the beam aperture as much as possible.

    The Antiproton Debuncher/Delivery Ring upgrade would improve the aperture of the beam transport line to the Antiproton Debuncher/Delivery Ring, as well as the Antiproton Debuncher/Delivery Ring itself to better serve multiple muon experiments. General improvements would be made to support the transport of 8 GeV protons with a large momentum spread and high repetition rate from the Recycler Ring to the AP0 target or to the Antiproton Debuncher/Delivery Ring. The aperture of the beam line would be increased by replacement of limiting magnets as well as modest improvements of

the optics. These changes would minimize beam loss and allow better transmission efficiency. Small changes in the power systems and beamline enclosure would be required for some of these improvements. Instrumentation would be upgraded to allow operation with higher repetition rates and longer bunch structure.

In the Antiproton Debuncher/Delivery Ring, an injection kicker and septum magnet would be added to allow direct injection of 8 GeV protons, or 3.1 GeV muons from the new Muon Campus beamline. Collider equipment that is no longer necessary would be removed to maximize the aperture. An abort system would be installed that would serve as a standard proton abort for Mu2e, as well as provide the ability to remove unwanted protons from the muon beam circling the Antiproton Debuncher/Delivery Ring. Instrumentation would be upgraded to be compatible with the beam structure specified by future muon experiments. Various improvements would be made to allow for the higher radiation environment that would be present with the operation of the muon experiments, including replacement of magnet cooling hoses and tubing with more radiation resistant materials, and magnet shunts would be relocated to service buildings from their present tunnel locations. Within the scope of the Mu2e project, there would be the addition of local shielding and a Total Loss Monitor system which would be implemented to ensure that the radiation dose to the public is below 1 mrem/year while the muon program is in operation. Finally, upgrades to the electrical panels and service buildings would be implemented to better serve the future power supply systems needed for muon operation. There are some power supplies that would be upgraded as a result of their age and difficulty maintaining.

- **Antiproton Debuncher/Delivery Ring Modifications exclusive to Mu2e** - Mu2e requires slow extracted proton beam to be delivered to the Mu2e Detector. A new resonant extraction system is required that delivers narrow microbunches to the detector that are separated by the revolution period of the Debuncher Ring. The resonant extraction system consists of sextupole magnets, quadrupole magnets, an RF knockout device and an electrostatic extraction septum along with the controls and instrumentation necessary to operate and control the resonant extraction process. Internal shielding at loss points in the beamline tunnel and Debuncher Ring are also required for Mu2e operation.

- **Design and construct a new MC External Beamline and Beamline Enclosure from the Antiproton Debuncher/Delivery Ring to the Mu2e Detector** (see Figure 4 in Appendix A). The MC Beamline Enclosure would consist of the activities required for construction of a below-grade, cast-in-place and/or precast concrete enclosure to house the programmatic beamline components that would be required to transport the proton beam from the existing Antiproton Debuncher/Delivery Ring into the Mu2e Detector Enclosure and MC-1 Building. The MC Beamline Enclosure would be a 10 foot wide by 8 foot high concrete enclosure approximately 700 feet long, running from the existing Antiproton Debuncher/Delivery Ring enclosure to the Mu2e Detector Enclosure. A shortened stub up section would be constructed to transport beam from the Antiproton Debuncher/Delivery Ring enclosure to the MC-1 Building as well. The MC Beamline Enclosure would be designed to support 16 feet of earth and concrete shielding to grade.

  The MC Beamline Enclosure would be flanked with underdrain piping that would negate the hydraulic pressure on the walls and roof of the enclosure and the underdrains would be routed to a duplex sump that would discharge water onto grade and away from the enclosure. The walls and ceiling of the enclosure would be fitted with channel inserts to allow for support of cable trays, cooling water, electrical conduits and fire detection equipment. In addition, convenience outlets and welding outlets would be located along the enclosure, in addition to required emergency and exit lighting, as well as normal light fixtures. The enclosure would be ventilated with neutral dehumidified air and fire detection would be via air sampling and line type sensors.

  The majority of the construction of the MC Beamline Enclosure would utilize traditional 'open cut and cover' methods in which material is removed from the beamline location, the beamline is constructed and the completed enclosure is covered with the excavated material. This method has been used successfully at Fermilab for the construction of the majority of shielded enclosures on-site. For those areas located adjacent to existing utility crossings, an earth retention system would be used.

- **Design and construct the proposed Mu2e Superconducting Solenoid System** (see Figure 5 in Appendix A) consisting of a *Production Solenoid* that contains the target for the primary proton beam, an

S-shaped *Transport Solenoid* that serves as a magnetic channel for pions and muons of the correct charge and momentum range and a *Detector Solenoid* that would house the muon stopping target made from a series of thin foils and the detector elements.

Considerable infrastructure is required to support the operation of the solenoids. This includes power, quench protection, cryogens (liquid nitrogen and liquid helium), control and safety systems as well as mechanical supports to resist the substantial magnetic forces on the magnets.

- **Design and construct a proposed Mu2e Detector** (See Figure 5 in Appendix A) consisting of a tracker, a calorimeter, a stopping target monitor, a cosmic ray veto, an extinction monitor and the electronics, trigger and data acquisition required to read out, select and store the data. The tracker would accurately measure the trajectory of charged particles, the calorimeter would provide independent measurements of energy, position and time, the stopping target monitor would measure the characteristic X-ray spectrum from the formation of muonic atoms, the cosmic ray veto would identify cosmic ray muons traversing the detector region that can cause backgrounds and the extinction monitor would detect scattered protons from the stopping target to determine the fraction of out-of-time beam.

- **Design and construct a Muon Campus Cryoplant.** The Mu2e Experiment would require liquid helium to cool superconducting magnets and therefore a cryogenic facility would be constructed. Existing Tevatron compressors would drive compressed Helium from the Tevatron ring to a low bay attached to the proposed MC-1 Building. The low bay would contain 3 recycled Tevatron satellite refrigerators that could handle the dynamic load and cold lines would run from the refrigerators to the proposed Mu2e Detector Hall/Enclosure.

- **Design and construct a proposed facility (Mu2e Facility) to house the Mu2e Detector and the associated infrastructure** (see Figure 6 in Appendix A). This would include an underground enclosure to house the Mu2e Detector (Mu2e Detector Hall/Enclosure) and a surface building to house necessary equipment and infrastructure that can be accessed while beam is being delivered to the detector. Routing of utilities from nearby locations and installation of new transformers to power the facility would be conducted. The Mu2e Facility would be comprised of approximately 25,000 square feet of new construction space.

MC-1 Building

The proposed MC-1 Building (See Figure 7 in Appendix A) would be a general purpose facility for the study of muon detectors and the internal outfitting would be designed and constructed in order to accommodate the future Muon g-2 Experiment. It would be located within the new Muon Campus, northeast of the existing Antiproton Facility (Antiproton Debuncher/Delivery Ring) and the south side of the facility would be constructed to support the berm required to shield the future beamline for the Mu2e Experiment.

The general building would be comprised of a 13,500 gross square feet facility and the experimental area would consist of an 80 feet by 80 feet high-bay facility with overhead bridge crane and one-story basement area designed to support large loads from accelerator equipment. Equipment access would be from a grade-level loading dock. A one and two story Service Building would include areas for the installation of computing facilities; power supplies; control/counting room; storage space and building support equipment. A one-story 40 feet by 40 feet Refrigeration Room would be included to house refrigeration equipment in support of installed experiments as well as toilet and janitorial services and general space for shop equipment.

Utilities would be tapped from nearby feeders and piping in existing utility corridors, including: electrical, communications, natural gas, industrial cooling water, sanitary sewer, domestic water and chilled water. The facility would be constructed in consideration of potential future Muon Campus construction, including beamline enclosures, refrigeration utilities and the future Mu2e Experiment.

Alternatives:

Alternative Sites

The Brookhaven National Laboratory (BNL) Alternating Gradient Synchrotron (AGS), if suitably upgraded, could be used to provide proton beam for a muon conversion experiment. However, the BNL Muon to Electron Conversion (MECO) proposal that was initiated as a National Science Foundation (NSF) project was cancelled due to the cost of the upgrades and therefore this alternative is not viable.

The Los Alamos National Laboratory (LANL) 800 MeV proton line could be used to produce a secondary beam of muons for a muon conversion experiment. The duty factor of the beam, however, is less than 10 percent which would result in substantially higher instantaneous rates that would require more sophisticated, costly and risky detector technologies so this alternative is not viable.

Conversely, the existing Fermilab accelerator complex could be easily and cost effectively adapted to provide a high intensity proton beam necessary for a muon conversion experiment. In fact, Mu2e is ideally suited to the Fermilab complex because the existing antiproton source (Debuncher/Delivery Ring) could be repurposed since the Tevatron collider run has concluded. Furthermore, the Mu2e Experiment requires high intensity pulses of protons that are separated by roughly twice the muon lifetime in aluminum of 864 nanoseconds and the circumference of the antiproton source is 1,694 nanoseconds, which means that as the protons are traversing the antiproton rings they can be appropriately bunched and prepared for slow-extraction to the detector in a straightforward manner. Additionally, the Fermilab scheme that has been developed would result in a high enough duty factor for the delivery of the proton beam, thus reducing instantaneous rates in the detector and minimizing backgrounds to the signal, which makes it superior from a scientific perspective to the above mentioned alternatives.

A short beamline from the antiproton source to the Mu2e Detector and a new Detector Hall/Enclosure would have to be constructed; however, modifications to the existing Fermilab accelerator complex, to accommodate the Mu2e Experiment, would be modest and would capitalize on the existing DOE investment. Additionally, most, if not all, of the magnets required for the new beamline could be recycled from decommissioned transfer lines associated with the Tevatron collider, thereby making efficient use of existing equipment.

In addition, a second anticipated muon experiment, g-2, proposes to use the Fermilab accelerator complex in a similar way to Mu2e and the substantial overlap between the two experiments would allow for a world class Muon Program at Fermilab that would cost considerably less than that of executing the two experiments independently.

In conclusion, Fermilab's scientific and technical expertise, an existing accelerator facility capable of delivering beam that is essential for the desired science, the cost savings realized from the efficient reuse of equipment and infrastructure, and the synergy with the g-2 experiment preclude an alternative site for the Muon Campus and the Mu2e Experiment in particular.

Alternative Locations on the Fermilab Site
The location of the Mu2e facility just north of the Antiproton source near Kautz Road is dictated by the required length of the external beamline and the location of an existing beamline stub that connects to the Antiproton source. No alternate location on the Fermilab site was therefore viable.

The 'No Action' alternative would not meet the above stated purpose and need.

II. Description of the Affected Environment

The proposed location on the Fermilab site of the Muon Campus (see Figure 1 and 2 in Appendix A) was selected due to the needs of the Mu2e Experiment and the anticipated future g-2 Experiment. The Fermilab location for the Mu2e Experiment was dictated by the programmatic requirement for extraction of a proton beam from the existing Antiproton Facility (Antiproton Debuncher/Delivery Ring for Muon Experiments). The proposed Muon Campus area would occur southwest of Wilson Hall/Enclosure and would be bounded by the Antiproton Facility, Giese Road, Indian Creek, and South Booster Road and bisected by Kautz Road, which would need to be rerouted. The area is previously disturbed upland comprised of gravel parking area, upland fields, and woodland. No regulated wetlands would be impacted by the proposed action and the small, degraded wetlands that would be impacted have minimal wetland function and value. Potential indirect impacts to adjacent regulated wetlands from erosion and sedimentation would be mitigated through the development and implementation during construction of a detailed Storm Water Pollution Prevention Plan and an Erosion Control Plan. There would be no construction in the 100-year floodplain.

The Muon Campus proposed MC Beamline Enclosure (also referred to as the Mu2e External Beamline) would be a 10 foot wide by 8 foot high concrete enclosure approximately 700 feet long, running underground from the

existing Antiproton Debuncher/Delivery Ring Enclosure to a proposed Mu2e Detector Enclosure that would be a below grade concrete structure of approximately 15,000 square feet that would be 25 feet deep.

Construction of the Mu2e Detector Hall/Enclosure would involve excavation of previously disturbed land to provide an underground enclosure to house the Mu2e Detector. An estimated 30,000 cubic yards of soil would be excavated for the Mu2e Detector Enclosure and 20,000 cubic yards for the External Beamline. Spoils from excavation would be placed in a temporary pile at the construction site until the construction is complete and then used for backfill, soil shielding, and piled along the length of the underground Mu2e External Beamline enclosure to provide a 16 foot berm for the beamline. Any remaining spoils would be placed on one of the onsite stockpiles or disposed off-site. The placement of the new facilities would necessitate relocation of approximately 1000 feet of the existing Kautz Road to the west by a maximum of approximately 250 feet. Diversion of Kautz Road would involve excavation of approximately 36,000 cubic yards and surface grading in an area of previously disturbed land. A building would also be constructed on the surface directly above the enclosure and utilities would be routed from nearby locations to the new Detector Hall/Enclosure. All construction and debris waste would be disposed of by Fermilab and appropriate material would be sent to a recycling vendor.

Utilities would be run from several locations through previously disturbed soil as follows:

- 13.8 kV power would be run approximately 500 feet to the Mu2e Detector Hall/Enclosure from the MC-1 Building area. Power to the Muon Campus would be extended from the loop that currently circles the Antiproton Area (Debuncher/Delivery Ring).
- Low Conductivity Water (LCW), Chilled Water (CW) and Sanitary Sewer (SS) would be run approximately 600 feet to the Mu2e Detector Hall/Enclosure from the Central Utility Building. Some of the Low Conductivity piping corridor between the Central Utility Building (CUB) and the Antiproton Area would be replaced. LCW to the MC-1 Building and the Mu2e Facility would be through the new beamline enclosure. The existing lift station at the Antiproton Area (Debuncher/Delivery Ring) would be removed and connecting piping to the existing tie-ins would be reconnected to a new sanitary lift station installed at the MC-1 Building. The Mu2e Facility would tie into this new lift station.
- Industrial Cooling Water (ICW), Drinking Water System (DWS), and natural gas (NG) would be run approximately 150 feet each from the existing corridor along relocated Kautz Road. The relocation of Kautz Road would also repositions the ICW, DWS and NG.

Construction of the Mu2e Detector would take place at various locations around Fermilab, at collaborating institutions and in industry in the US and possibly abroad. Final assembly and installation of the detector would take place at Fermilab but would not involve any digging, trenching, demolishing or conventional construction.

The Mu2e beam intensity in the Antiproton Facility (Debuncher/Delivery Ring) would increase from that of the previous Tevatron collider program in which between 4E12 and 5E12 antiprotons passed through the Antiproton complex every day. For Mu2e operations there would be approximately 4E12 protons contained in every Booster batch and approximately 130,000 Booster batches would pass through the Antiproton complex every day, which corresponds to a beam power of about 8 kW. In comparison, the total beam power out of the Booster is 70 kW and the *NuMI* beam power in the *NOvA* era would be 700 kW (see *NovA Environmental Assessment/Finding of No Significant Impact* for more information).

Three service buildings, known as AP-10, AP-30 and AP-50, sit above the Antiproton Facility beamline enclosure (See Figure 2 in Appendix A). The shielding between the top of the beamline enclosure and the floor of the service buildings was sufficient during Tevatron collider operations; however, the shielding in the three service buildings would need to be upgraded for Mu2e operations at a beam power of 8 kW. The deployment of a network of Total Loss Monitors (TLMs) would minimize beam losses and local shielding of known loss points in the beamline enclosure would be implemented. Additionally, the beam current can also be turned down until the losses fall well below the DOE regulatory limits. This is similar to the strategy currently employed in the Fermilab Booster, a more complex machine that runs at substantially higher beam currents.

The 8 GeV proton beam would strike a production target located inside the Production Solenoid. This area would be similar to a target vault for a typical fixed target experiment at Fermilab. The layout in this area is shown in Figure 5 of Appendix A. A map of the residual activation levels in this area that results from the interaction of the proton beam with the production target is shown in Figure 8 of Appendix A. The activation level at the outside surface of the iron yoke surrounding the Production Solenoid is a few mSv/hour. Simulations of Mu2e beamline

operations indicate that ground water activation would be a factor of 10 to 100 times below the regulatory limits and therefore in a range typical to Fermilab experiments. Tritium and other short-lived radionuclides are produced as a normal by-product of beamline operations. The airborne radionuclides produced by the Mu2e beam would be released into the atmosphere through a vent stack to the surface; however, these emissions would be limited by minimizing the ventilation of the area during beam operations. Ventilation would be maximized for personnel access, but only after allowing sufficient time for decay of radionuclides after beam shutdown. The air from the ventilation system would be monitored for radionuclide emissions. The expected dose rate at the site boundary due to Mu2e operations would be an order of magnitude lower than the dose rate due to operation of the NuMI facility for NOvA, which is well below the regulatory limit.

The heat shield that would protect the Production Solenoid from particles produced in the production target would be cooled by a closed loop water system. The water would become radioactive over time. Tritium, 7Be and activated corrosion products are the only radioisotopes that would survive for any substantial duration as the others would decay away on the timescale of a few hours. Most of the 7Be would be trapped in de-ionization bottles. The water would be monitored and replaced at appropriate intervals.

Residual magnetic fields would be present in the detector enclosure when the superconducting solenoids are powered. The magnetic field immediately outside the Transport Solenoid is estimated to be about 5 kG, falling off to about 1 kG at a distance of 100 centimeter. Access would be restricted within a few meters of the solenoids when they are powered and warnings would be posted for people with pacemakers.

Components of the Mu2e Detector would be procured, fabricated and tested at existing facilities at Fermilab, other collaborating institutions and in industry. The main component of the detector is a series of large superconducting solenoids operating at liquid helium temperatures. Particle physics detectors, including drift chambers, scintillating crystals and plastic scintillator would be installed inside and around the outside of one of the solenoids. Liquid helium and liquid nitrogen would be used to maintain the operating temperature of the solenoids. In their natural state, helium and nitrogen are gasses that can displace oxygen and would pose an oxygen deficiency hazard and a freezing hazard in the event of a major leak in the detector hall/enclosure. However, Fermilab has extensive experience with similar systems and appropriate safety measures, based on that experience, would be incorporated into the design and planning of this new experiment.

MC-1 Building
The proposed site has been examined and is not in any wetlands, defined flood plain or other protected area. It would involve excavation that would create temporary spoils to be stored adjacent to the project site; spoils not used as backfill would be disposed on site and erosion control measures would be implemented during construction. All construction waste and debris would be properly managed by Fermilab and appropriate materials would be sent to a recycling vendor.

III. Potential Environmental Effects (Comments/clarification provided for each checked item in Section IV.)

A. Sensitive Resources: Would the proposed action result in changes and/or disturbances to any of the following resources?

- ☐ Threatened or endangered species
- ☐ Other protected species
- ☒ Wetland/Floodplains
- ☐ Archaeological or historical resources
- ☐ Non-attainment areas for Ambient Air Quality Standards

B. Regulated Substances/Activities: Would the proposed action involve any of the following regulated substances or activities?

- ☒ Clearing or Excavation
- ☒ Demolition or decommissioning
- ☐ Asbestos removal
- ☐ PCBs
- ☐ Chemical use or storage

- ☐ Pesticides
- ☒ Air emissions
- ☒ Liquid effluents
- ☐ Underground storage tanks
- ☒ Hazardous or other regulated waste (including radioactive or mixed)
- ☒ Radioactive exposures or radioactive emissions
- ☐ Radioactivation of soil or groundwater

C. Other relevant Disclosures

- ☐ Threatened violation of ES&H permit requirements
- ☐ Siting/construction/major modification of waste recovery or TSD facilities
- ☐ Disturbance of pre-existing contamination
- ☒ New or modified permits
- ☐ Public controversy
- ☐ Action/involvement of another federal agency
- ☐ Public utilities/services
- ☐ Depletion of a non-renewable resource

IV. Comments on checked items in section III.

Wetland/Floodplains
No regulated wetlands would be impacted under the proposed action and the small area of degraded wetlands, which would be impacted, has minimal wetland function or value. Potential indirect impacts to adjacent regulated wetlands from erosion and sedimentation would be mitigated through the implementation during construction activities of a detailed Storm Water Pollution Prevention Plan and an Erosion Control Plan. There would be no construction in the 100-year floodplain.

Planning Resources Inc. performed a delineation of wetlands for the area of the proposed Muon Campus site. The wetland delineation was conducted in accordance with the 'Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Midwest Region (COE 2008)' and the wetland delineation and reporting guidance provided by the Chicago District Corps of Engineers on April 13, 2010. The Corps of Engineers reviewed the results of the wetlands study and determined that these low quality wetlands are exempt from their permit program; therefore, a Department of the Army permit under Section 404 of the Clean Water Act is not required and impacts would not constitute an extraordinary circumstance.

Clearing and Excavation
Clearing and excavation would be necessary for this project. It is anticipated that there would be approximately 36,000 cubic yards excavated for the diversion of Kautz Road; 30,000 cubic yards of soil excavated for the Mu2e Detector Hall/Enclosure; 20,000 cubic yards for the External Beamline; and 9000 cubic yards for the MC-1 Building. About 34,000 cubic yards of the excess soil would be stockpiled on the Fermilab site or disposed off-site and the remainder would be used for backfill and soil shielding for the beamline.

Demolition or Decommissioning
Concrete demolition of the antiproton ring would be required at the interface with the new external beamline; this interface would be approximately 10 feet by 8 feet and the waste would be placed in the soil backfill near the source.

After the useful life of the project has ended, there would be a need for Decommissioning and Dismantling. To the extent possible, components would be reused and materials would be evaluated for reuse and recycle. Resultant waste materials would be managed appropriately and according to all applicable rules and regulations for packaging, transporting, disposal, records management, and reporting.

Air Emissions
During excavation and construction of the Mu2e Detector Hall/Enclosure, the operation of construction equipment and vehicles would be expected to introduce SO_2, NO_x, particulates and other criteria pollutants to the atmosphere, typical of similar sized construction projects. These are mobile sources and therefore do not require a permit, nor would they affect the site wide operating permit. Particulates (dust) generated during earthmoving

activities and vehicle movement over unpaved areas would be minimized by watering or other dust-control measures.

Airborne radionuclides would also be produced by the Mu2e beam during operation of the experiment and would be released into the atmosphere through a vent stack to the surface. Air emissions would be limited by minimizing the ventilation of the area during beam operations. Ventilation would be maximized for personnel access, but only after allowing sufficient time for decay after beam shutdown. Air from the ventilation system would be monitored for radionuclide emissions. The dose rate at the site boundary due to Mu2e operations would be an order of magnitude lower than the dose rate due to operation of the NuMI facility or NOvA, which is well below the regulatory limit. Any necessary modifications to the Fermilab Lifetime Operating Permit (issued by the IEPA Air Bureau) would be obtained prior to beginning work.

Liquid Effluents
Liquid effluents would result from pumping groundwater that seeps into the underground portions of the Mu2e external beamline and experimental hall/enclosure to the surface ponds at Fermilab. The ponds may discharge to streams that flow offsite. The resulting concentration of radionuclides would be a factor of 500-1000 times below the regulatory limits.

Roof and parking lot drains would empty into storm water drainage systems and all other liquid effluents would be discharged to the sanitary sewer system. Work planning, experimental review, and safety inspections are the three methods for ensuring that hazardous effluents do not enter the sanitary waste stream.

Hazardous or other regulated waste (including radioactive or mixed)
Beamline elements and detector components may become activated during operation of the Mu2e experiment. A cool down period would be required before decommissioning could begin. All commonly reused valuable equipment such as magnets would be stored. Small amounts of lead, in the form of thin sheets, may be used as part of the calorimeter system and these sheets may become mildly activated and would have to be disposed of as mixed waste.

Radioactive Exposures or Emissions
Airborne radionuclides would be produced by the Mu2e beam and would be released into the atmosphere through a vent stack to the surface. Emissions would be limited by minimizing the ventilation of the area during beam operations. Ventilation is maximized for personnel access, but only after allowing sufficient time for decay after beam shutdown. Air from the ventilation system would be monitored for radionuclide emissions. The dose rate at the site boundary due to Mu2e operations would be an order of magnitude lower than the dose rate due to operation of the NuMI facility for NOvA, which is well below the regulatory limit. This may require modification of existing permits.

The 8 GeV proton beam would strike a production target located inside one of the superconducting solenoids. This area would be similar to a target vault for a typical fixed target experiment at Fermilab. The layout in this area is shown in Figure 5 of Appendix A. A map of the residual activation levels in this area that results from the interaction of the proton beam with the production target is shown in Figure 8 of Appendix A. The activation level at the outside surface of the concrete shielding surrounding the Production Solenoid is a few mSv/hour. Simulations of Mu2e beamline operations indicate that ground water activation would be a factor of 10 to 100 times below the regulatory limits and therefore in a range typical to Fermilab experiments.

A safety assessment document (SAD) module would be developed that would address radiation exposures to workers and members of the public due to the operation of Mu2e. The SAD would also address the potential radioactive emissions due to the proposed project. Personnel and public exposures would remain well below regulatory limits (Fermilab designs facilities for potential exposures of 10 mrem per year, while the regulatory limit is 100 mrem per year to the public per DOE Orders 458.1) and within guidelines of the Fermilab Radiological Control Manual including the control of occupational radiation exposures during maintenance activities. Radionuclide emissions would be monitored and reported in accordance with existing practices and regulatory requirements. Cumulative air emissions are expected to remain substantially below the National Emission Standards for Hazardous Air Pollutants (NESHAPs) threshold for continuous monitoring and far below the regulatory limit for effective dose to members of the public.

New or Modified Permits

All work activities would be evaluated to determine the necessity of permits and these would be obtained prior to construction. Specifically, expected radionuclide emissions would be evaluated to determine the necessity of a change to the site wide air operating permit.

Additional Information
The proposed Muon Campus is not in the vicinity of any cultural resources previously identified in the Fermilab Cultural Resources Management Plan. If any unexpected potential archaeological/historical/cultural resources are encountered, work would be stopped and the resource would be evaluated as per legal requirement.

The project would incorporate sustainable design principles into all phases of planning, design, and construction and follow Leadership in Energy and Environmental Design (LEED) guiding principles, however, because the facilities would not be occupied on a regular basis, LEED-Gold certification is not appropriate and would not be pursued.

V. NEPA Recommendation

Fermilab staff have reviewed this proposed action and concluded that the appropriate level of NEPA determination is a Categorical Exclusion. The conclusion is based on the proposed action meeting the categorical exclusion descriptions found in DOE's NEPA Implementation Procedures, 10 CFR 1021, Subpart D, Appendix B1.15 and B3.10, and that no extraordinary circumstances are anticipated.

B1.15 states the following: Siting, construction or modification, and operation of support buildings and support structures (including, but not limited to, trailers and prefabricated and modular buildings) within or contiguous to an already developed area (where active utilities and currently used roads are readily accessible). Covered support buildings and structures include, but are not limited to, those for office purposes; parking; cafeteria services; education and training; visitor reception; computer and data processing services; health services or recreation activities; routine maintenance activities; storage of supplies and equipment for administrative services and routine maintenance activities; security (such as security posts); fire protection; small-scale fabrication (such as machine shop activities), assembly, and testing of non-nuclear equipment or components; and similar support purposes, but exclude facilities for nuclear weapons activities and waste storage activities, such as activities covered in B1.10, B1.29, B1.35, B2.6, B6.2, B6.4, B6.5, B6.6, and B6.10 of this appendix.

B3.10 states the following: Siting, construction, modification, operation, and decommissioning of particle accelerators, including electron beam accelerators, with primary beam energy less than approximately 100 million electron volts (MeV) and average beam power less than approximately 250 kilowatts (kW), and associated beamlines, storage rings, colliders, and detectors, for research and medical purposes (such as proton therapy), and isotope production, within or contiguous to a previously disturbed or developed area (where active utilities and currently used roads are readily accessible), or internal modification of any accelerator facility regardless of energy, that does not increase primary beam energy or current. In cases where the beam energy exceeds 100 MeV, the average beam power must be less than 250 kW, so as not to exceed an average current of 2.5 milliamperes (mA).

VI. DOE/CH-FSO NEPA Coordinator Review

Concurrence with the recommendation for determination:

U.S. DOE Fermi Site Office (FSO) Manager: Michael J. Weis

Signature _____

Date 6/12/2012

U.S. DOE FSO NEPA Coordinator Reviewer: Rick Hersemann

Signature Rick Hersemann

Date 6/7/12

APPENDIX A – Figures

Figure 1 The proposed Muon Campus is included in the red circle, superimposed on the Fermilab site.

Figure 2 The Fermilab Muon Campus including the Mu2e Facility, the MC-1 Building, the Muon Campus Beamline berm, and the former Antiproton Facility Buildings (AP-30, AP-10, and AP-50)

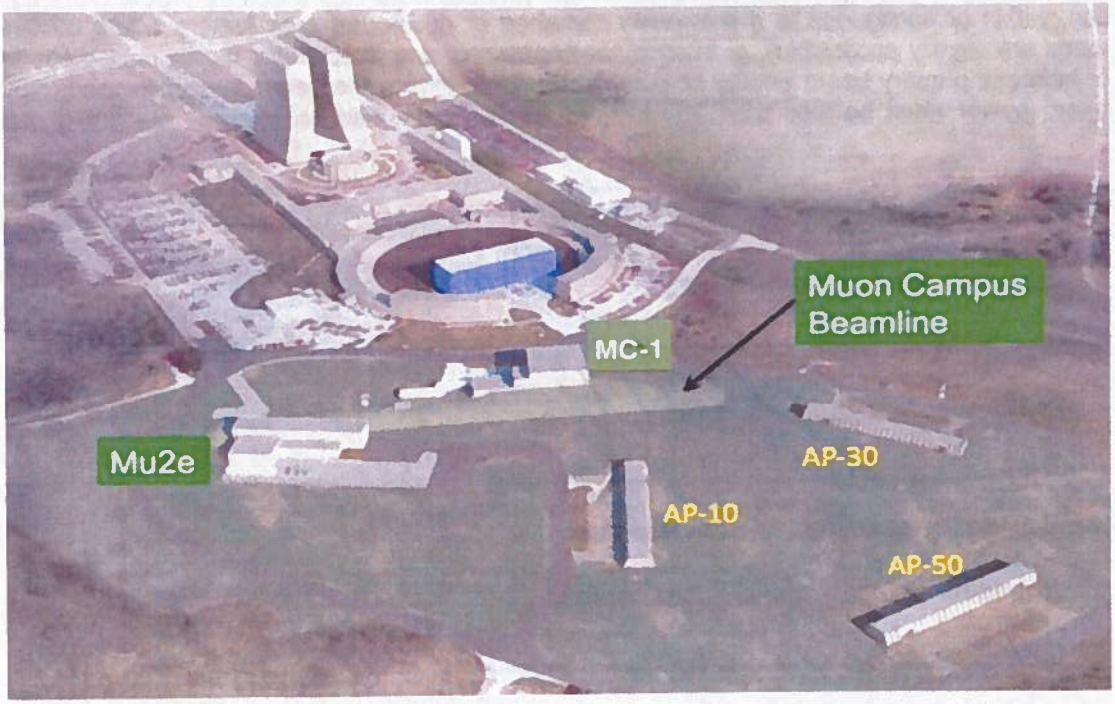


Figure 3 The components of the Fermilab accelerator complex that would be used to acquire protons for the Mu2e experiment. The proton beam path from Booster to Recycler is shown in yellow; the beam path in the Recycler is in red; the beam path from Recycler to Delivery Ring (otherwise called the Antiproton Debuncher Ring) is in blue; and the beam path from Delivery Ring to Mu2e target is in green.

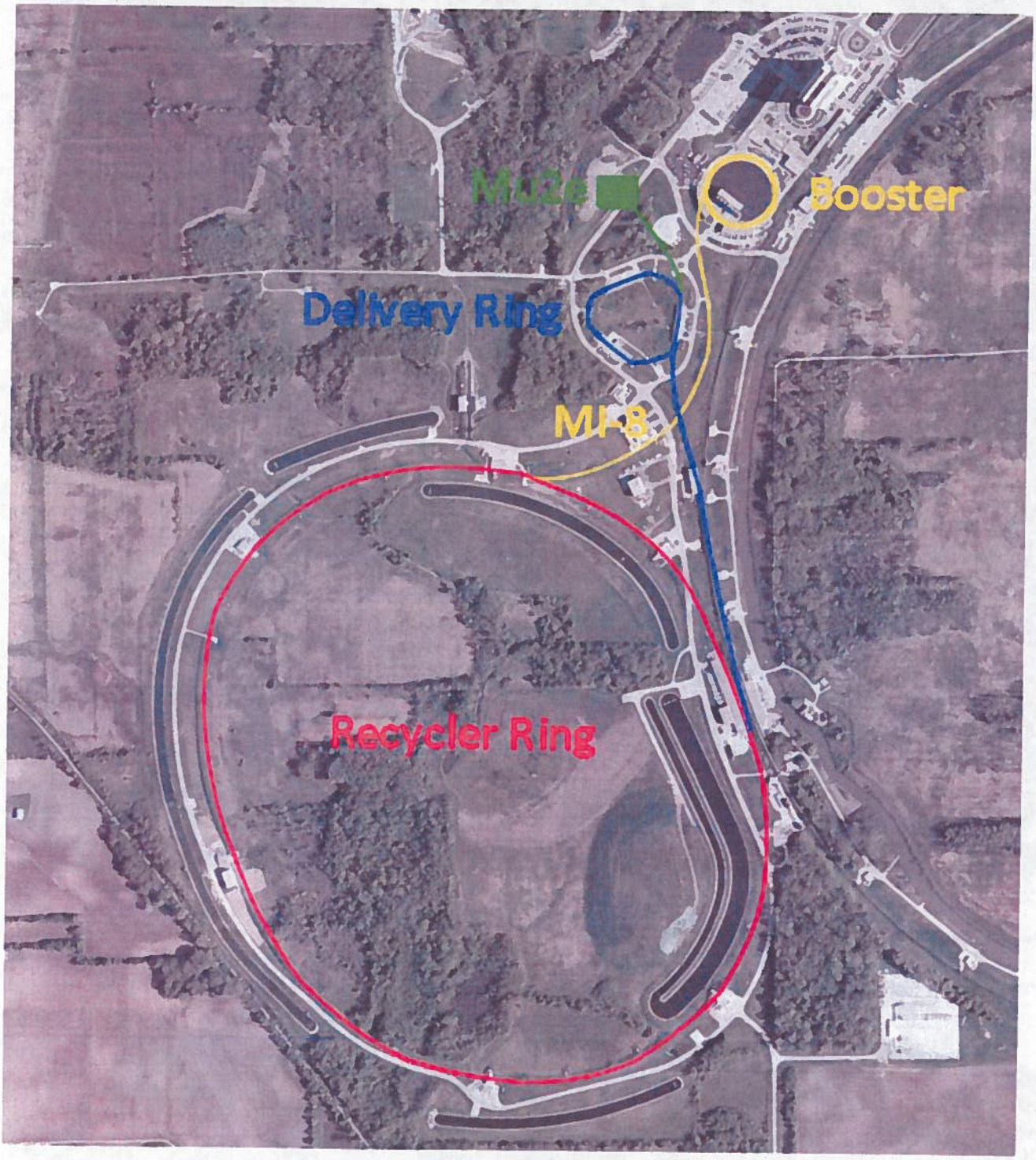


Figure 4 The path of protons from the Fermilab Booster (round figure at the forefront of the photo) to the Mu2e Detector

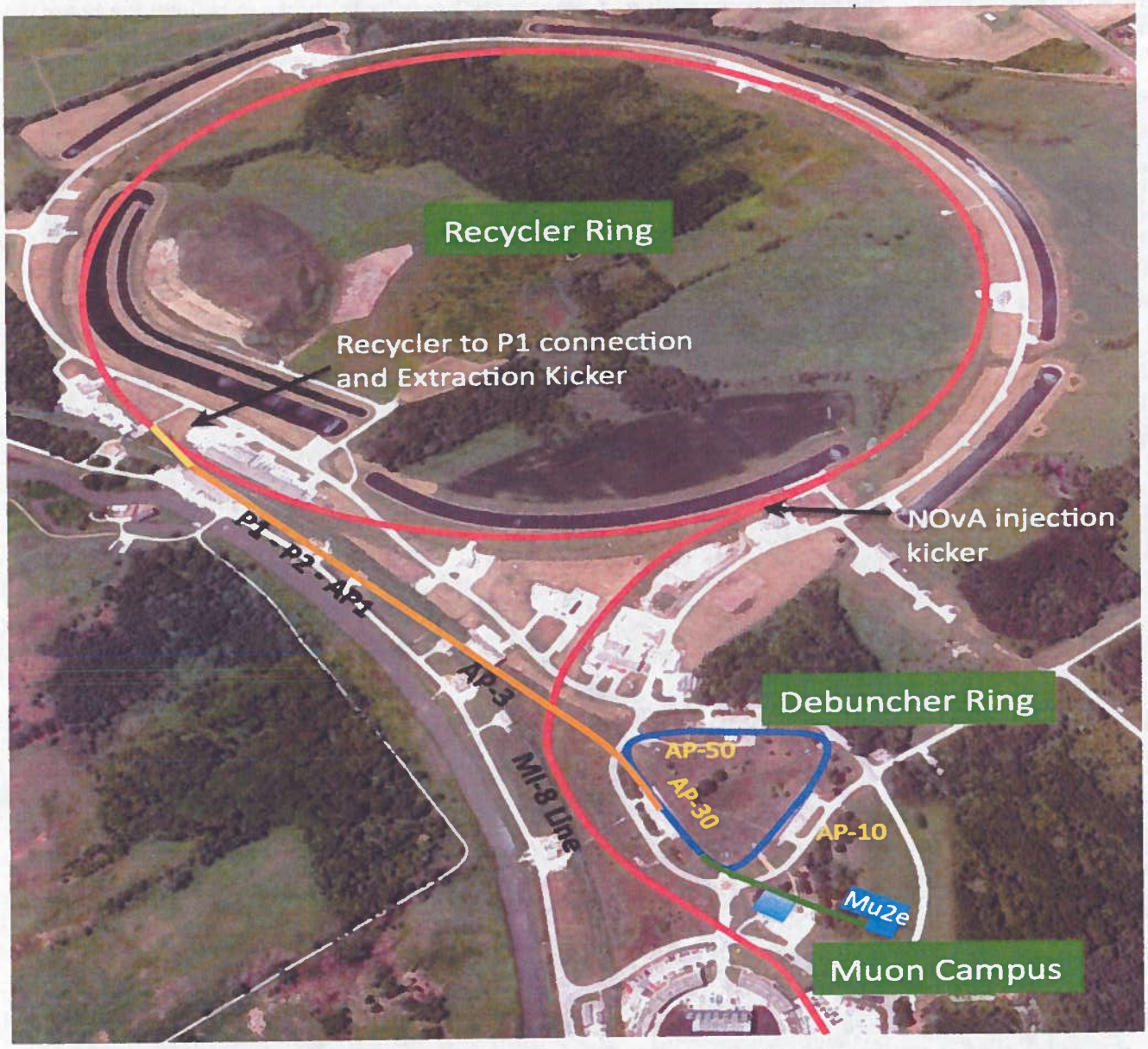


Figure 5 Depiction of the Mu2e Experiment Solenoids

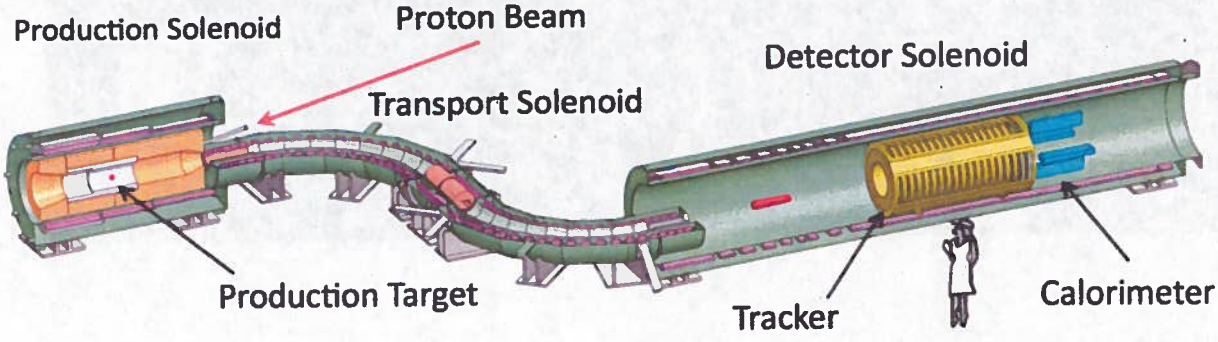


Figure 6 Depiction of the above-grade portion of the Mu2e Facility

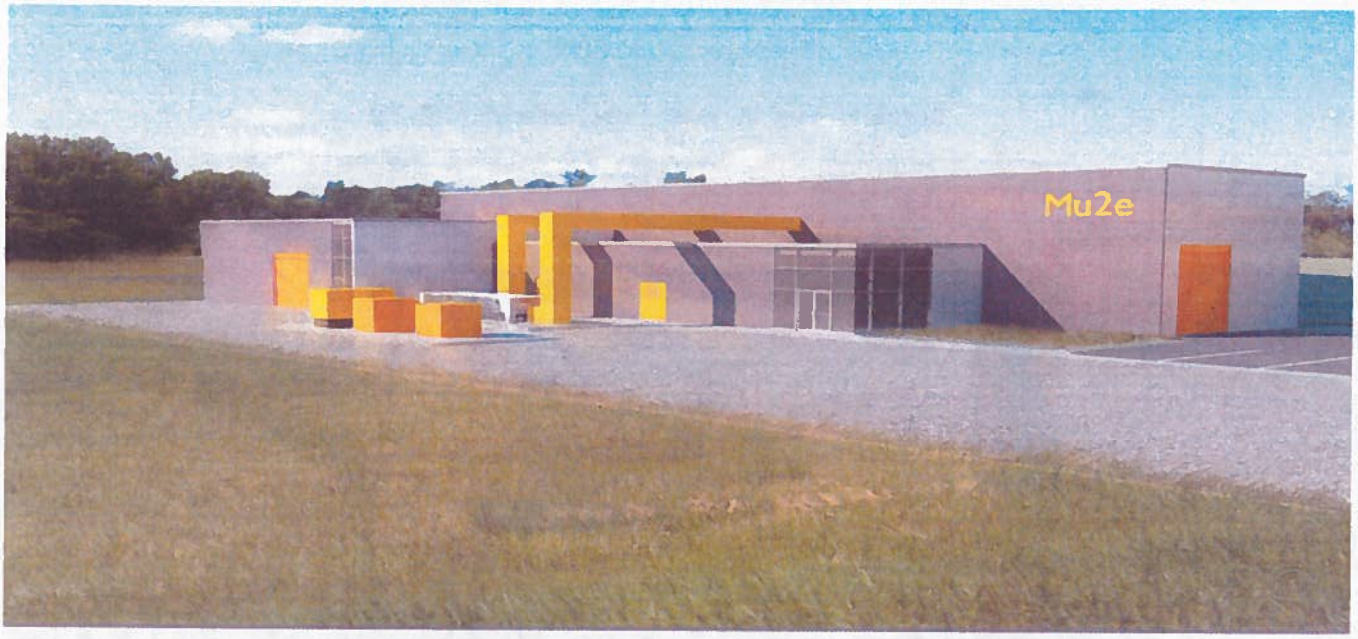
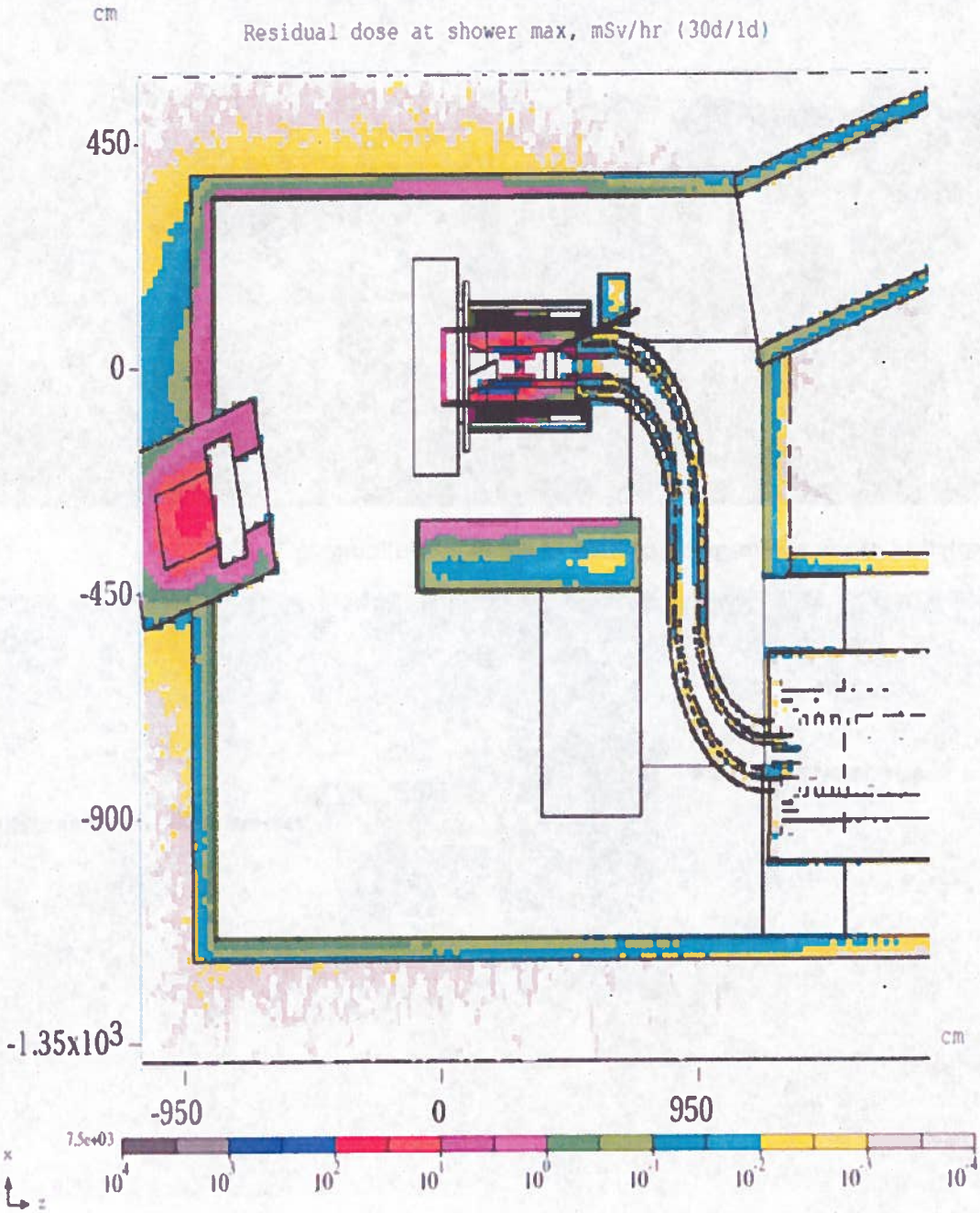


Figure 7 Depiction of the above-grade portion of the MC-1 Building

Figure 8 Residual activation expected in the area around the Mu2e Production Solenoid. At the surface of the surrounding walls and the peak residual activation is a few mSv/hour



High Performance Sustainable Buildings
Compliance Summary Checklist for New Construction

Building Name: MC Beamline Enclosures

Federal Real Property ID: not yet assigned

This field will populate as the Guiding Principles are marked complete and documented. ---------->

% Guiding Principles Complete

61.8%

* For a detailed explanation of each Guiding Principle and required actions please refer to the corresponding Compliance Tab.

Guiding Principle	Action Required	Yes/No	Suggested Compliance Verification Documents	On File?	Notes
1. Employ Integrated Design Principles					
Integrated design	Use a collaborative, integrated planning and design process that:				
	Initiates and maintains an integrated project team as described on the Whole Building Design Guide in all stages of a project's planning and delivery, http://www.wbdg.org/design/engage_process.php		Complete the Building Information Tab or equivalent document, e.g., a team roster. Follow the DOE. O. 430.2B and 450 1A.	☑	Team Roster list to be identified by Project Manager.
	Integrates the use of OMB's A-11, Section 7, Exhibit 300: Capital Asset Plan and Business Case Summary		Provide documentation and use this checklist or equivalent (USGBC LEED) to demonstrate incorporation. The establishment of 413.3A, 430.2B and 450.1A meet the goal setting requirement.	☑	DOE 413.3A
	Establishes performance goals for siting, energy, water, materials and indoor environmental quality along with other comprehensive design goals and ensures incorporation of these goals throughout the design and lifecycle of the building		The establishment of 430.2B and 450.1A meet the goal setting requirement. Use this checklist or equivalent (USGBC LEED) to demonstrate incorporation.	☑	Goals and schedules are set forth in the DOE SSPP and the Fermilab Annual SSP
	Considers all stages of the building's lifecycle, including deconstruction.		The establishment of 430.2B and 450.1A meet the goal setting requirement. Use this checklist or equivalent (USGBC LEED) to demonstrate incorporation.	☑	DOE Order 413.3A

Guiding Principle	Action Required	Yes/No	Suggested Compliance Verification Documents	On File?	Notes
Commissioning	Employ commissioning practices tailored to the size and complexity of the building and its system components in order to verify performance of building components and systems and help ensure that design requirements are met. This should include an experienced commissioning provider, inclusion of commissioning requirements in construction documents, a commissioning plan, verification of the installation and performance of systems to be commissioned, and a commissioning report.		Provide a commissioning plan. In-house experienced personnel or team acceptable. (may provide compliance for GP IV. Enhance Indoor Environmental Quality: Moisture Control.)	☐	This is to be evaluated in the design stage. At a minimum, building-energy-related items (HVAC, lighting control) will be go thru the fundamental commissioning
2. Optimize Energy Performance					
Energy Efficiency	Establish a whole building performance target that takes into account the intended use, occupancy, operations, plug loads, other energy demands, and design to earn the ENERGY STAR® targets for new construction and major renovation where applicable. For new construction, reduce the energy use by 30 percent compared to the baseline building performance rating per the American National Standards Institute (ANSI)/American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., (ASHRAE)/Illuminating Engineering Society of North America (IESNA) Standard 90.1-2007, Energy Standard for Buildings Except Low-Rise Residential. For major renovations, reduce the energy use by 20 percent below pre-renovations 2003 baseline. Laboratory spaces may use the Labs21 Laboratory Modeling Guidelines.		Have a licensed engineer or architect provide documents that identify that the energy use targets were achieved or provide USGBC LEED submittal documentation also stating that the goals were achieved.	☐	At this point, it is unclear whether an Energy model is appropriate for this type of project . This will be explored further before design stage.
	Use ENERGY STAR® and FEMP-designated Energy Efficient Products, where available?		Provide standard purchasing policy/policies, constructions specifications, or retain proof of purchase.	☐	Required by FL-1 and other FL's. The Project manager and the design coordinator will ensure that this language will be incorporated into specifications to get the requirements to those actually doing the work.

Guiding Principle	Action Required	Yes/No	Suggested Compliance Verification Documents	On File?	Notes
On-Site Renewable Energy	Per the Energy Independence and Security Act (EISA) Section 523, meet at least 30% of the hot water demand through the installation of solar hot water heaters, when lifecycle cost effective.		Implement on-site solar hot water heating and retain design specs, statement of work, or photos, etc. If not lifecycle cost effective provide justification.	☑	Based on calculations done for the CMTF project, Solar water heating option is at least twice as expensive on a LCC basis than the gas alternative.
	Per Executive Order 13423, implement renewable energy generation projects on agency property for agency use, when lifecycle cost effective.		Any of the following or equivalent: design specs, statement of work, photos, etc. If not lifecycle cost effective provide justification.	☑	Fermilab has installed several PV generating sources in remote locations where supplying conventional power would be very expensive. A study done in 2008 by NREL suggests that larger PV and/or wind generating projects are not cost effective for Fermilab where conventional power is available due to insufficient available resources (wind, sun) coupled with low electrical energy prices.
Measurement and Verification	Per the Energy Policy Act of 2005 (EPAct) Section 103, install building level electricity meters in new major construction and renovation projects to track and continuously optimize performance.		Retain statement of work, billing records, photos, etc and/or provide ENERGY STAR® label certification if applicable.	☐	Where applicable. electric meter(s) will be installed and connected via Metasys or other tracking means. The project design coordinator will ensure that this will be noted on
	Per EISA Section 434, include equivalent meters for natural gas and steam, where natural gas and steam are used.		Retain statement of work, billing records, photos, etc and/or provide ENERGY STAR® label certification if applicable.	☐	Where applicable, natural gas meter will be installed and connected via Metasys or other tracking means. The design coordinated will coordinate this in the bid/construction documents.
Benchmarking	Compare actual performance data from the first year of operation with the energy design target, preferably by using ENERGY STAR® Portfolio Manager for building and space types covered by ENERGY STAR®. Verify that the building performance meets or exceeds the design target, or that actual energy use is within 10% of the design energy budget for all other building types. For other building and space types, use an equivalent benchmarking tool such as the Labs21 benchmarking tool for laboratory buildings.		Use ENERGY STAR's Portfolio Manager or Labs 21 database to enter annual performance data and print out the Statement of Energy Performance on an annual basis to track performance over time.	☑	After building construction, Fermilab representative (TBD) will enter relevant data into Energy Star Portfolio Manager, including data from all meters.
3. Protect and Conserve Water					

Guiding Principle	Action Required	Yes/No	Suggested Compliance Verification Documents	On File?	Notes
Indoor Water	Employ strategies that in aggregate use a minimum of 20 percent less potable water than the indoor water use baseline calculated for the building, after meeting the EPAct 1992, Uniform Plumbing Codes 2006, and the International Plumbing Codes 2006 fixture performance requirements.		Use Watergy, the LEED® water calculator, or equivalent modeling to establish baseline usage and calculated savings or provide documentation based on metering/bills.	☑	There are no bathroom fixtures in this project so N/A
	The installation of water meters is encouraged to allow for the management of water use during occupancy.		Install water meter(s) and provide documentation.	☑	There are no bathroom fixtures in this project so N/A
	The use of harvested rainwater, treated wastewater, and air conditioner condensate should also be considered and used where feasible for nonpotable use and potable use where allowed.		Document use of harvested rainwater, treated wastewater, and air conditioner condensate as applicable.	☑	ICW water is used for non-potable applications and it is primarily "harvested" rainwater anyway. Documented via FESS Operations Procedure for Surface Water Management 5410.0
Outdoor Water	Use water efficient landscape and irrigation strategies, such as water reuse, recycling, and the use of harvested rainwater, to reduce outdoor potable water consumption by a minimum of 50 percent over that consumed by conventional means (plant species and plant densities).		Retain documentation from design tools, such as the LEED® water calculator or other water tools to provide a statement on how water usage was reduced and calculated, or document minimal use of irrigation water due to nominal or no landscape. Choose irrigation contractors who are certified through a WaterSense labeled program and document outdoor potable water consumption reduction. (May provide compliance for GP III. Protect and Conserve Water: Water-Efficient Products)	☑	Recent memo from FESS Head to Roads and Grounds established the policy of not using any potable water for these uses. Also can cite extensive use of native vegetation to conserve water for landscaping use.
	The installation of water meters for locations with significant outdoor water use is encouraged.		Document Installation and use of outdoor water meters.	☑	Not applicable since we use no potable water.
	Employ design and construction strategies that reduce storm water runoff and discharges of polluted water offsite. Per EISA Section 438, to the maximum extent technically feasible, maintain or restore the predevelopment hydrology of the site with regard to temperature, rate, volume, and duration of flow using site planning, design, construction, and maintenance strategies.		Provide documents that demonstrate strategy implemented to reduce storm water runoff and maintain or restore predevelopment hydrology of the site.	☑	Based on Option 1 in the U.S. EPA Technical Guidance for EISA section 438, we can show that we meet the goal of this element.

Guiding Principle	Action Required	Yes/No	Suggested Compliance Verification Documents	On File?	Notes
Process Water	Per the Energy Policy Act of 2005 Section 109, when potable water is used to improve a building's energy efficiency, deploy lifecycle cost effective water conservation measures.		Document water conservation strategy in process systems. Documentation may be provided by licensed engineer, water utility or through an energy service provider. Guiding principle is met if no potable water is used.	☑	This is not applicable to this project
Water Efficient Products	Specify EPA's WaterSense-labeled products or other water conserving products, where available.		Any of the following or equivalent: purchasing or design specifications, statement of work, receipts, etc.	☑	There are no bathroom fixtures in this project so N/A
	Choose irrigation contractors who are certified through a WaterSense labeled program.			☑	NA
4. Enhance Indoor Environmental Quality					
Ventilation and Thermal Comfort	Meet ASHRAE Standard 55-2004, Thermal Environmental Conditions for Human Occupancy, including continuous humidity control within established ranges per climate zone AND		Document compliance with ASHRAE Standards by licensed architect or engineer or achieve an ENERGY STAR Label Certification	☑	NA since there are no occupants
	ASHRAE Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality.			☑	NA since there are no occupants
Moisture Control	Establish and implement a moisture control strategy for controlling moisture flows and condensation to prevent building damage, minimize mold contamination, and reduce health risks related to moisture.		Document inspection-driven moisture prevention strategy that is part of building commissioning plan that specifies maintenance of the roof drainage and the foundation system, or document that your building does not have a moisture problem.	☐	Project will evaluate this during design (this is one of the item that still is unclear)
Daylighting	Achieve a minimum daylight factor of 2 percent (excluding all direct sunlight penetration) in 75 percent of all space occupied for critical visual tasks.		Document through computer simulation or by light measurement.	☑	NA since there are no occupants
	Provide automatic dimming controls or accessible manual lighting controls, and appropriate glare control.		Document that individual lighting control is available for the occupants by schematic of floor layout, showing locations of manual lighting controls (such as task lighting) or statement based upon visual audit.	☑	NA since there are no occupants

Guiding Principle	Action Required	Yes/No	Suggested Compliance Verification Documents	On File?	Notes
Low-Emitting Materials	Specify materials and products with low pollutant emissions, including composite wood products, adhesives, sealants, interior paints and finishes, carpet systems, and furnishings.		Establish contract(s), design specifications, purchasing specifications or solicitations with specific language for the purchase of low emitting materials, durable goods, consumables and for green cleaning.	☐	The project will evalute this requirement, may need to include this in the specs
Protect Indoor Air Quality during Construction	Follow the recommended approach of the Sheet Metal and Air Conditioning Contractor's National Association Indoor Air Quality Guidelines for Occupied Buildings under Construction, 2007. After occupancy, continue flush-out as necessary to minimize exposure to contaminants from new building materials. After construction and prior to occupancy, conduct a minimum 72-hour flush-out with maximum outdoor air consistent with achieving relative humidity no greater than 60 percent. After occupancy, continue flush-out as necessary to minimize exposure to contaminants from new building materials.		Before major renovations, develop and implement an indoor air quality management plan, specification or guidelines. May use USGBC LEED reference documentation.	☐	Include in the spec as part of Division 1 spec. We will require the contractor to submit their IAQ plan with flushout
Tobacco Smoke Control	Implement a policy indicating that smoking is prohibited within the building and within 25 feet of all building entrances, operable windows, and building ventilation intakes during building occupancy. Post signage indicating that smoking is prohibited within the building and within 25 feet of all building entrances, operable windows, and building ventilation intakes during building occupancy.		Establish environmental tobacco smoke control policy or equivalent. Policy may be for entire site, PSO or for Agency.	☑	Director's policy #25

Guiding Principle	Action Required	Yes/No	Suggested Compliance Verification Documents	On File?	Notes
5. Reduce Environmental Impact of Materials					
Recycled Content	Per Section 6002 of the Resource Conservation and Recovery Act (RCRA), for EPA-designated products, specify products meeting or exceeding EPA's recycled content recommendations. For other products, specify materials with recycled content when practicable. If EPA-designated products meet performance requirements and are available at a reasonable cost, a preference for purchasing them shall be included in all solicitations relevant to construction, operation, maintenance of or use in the building. EPA's recycled content product designations and recycled content recommendations are available on EPA's Comprehensive Procurement Guideline web site at <www.epa.gov/cpg>.		Incorporate the FAR requirements for the purchase of EPA-designated products into contracts, bid solicitations and purchasing specifications and use products meeting or exceeding EPA's recycled content recommendations. Provide construction, purchasing or bid specifications, and/or affirmative procurement report.	☐	We would cite FESHM 5011 on "Sustainable Acquisition", and this language would also be included in Exhibit A in the bid documents. A new FL-300 that would address it as well. It is unclear if this is applicable to this project, the project will evaluate this further during design
Biobased Content	Per Section 6002 of the Resource Conservation and Recovery Act (RCRA), for EPA-designated products, specify products meeting or exceeding EPA's recycled content recommendations. For other products, specify materials with recycled content when practicable. If EPA-designated products meet performance requirements and are available at a reasonable cost, a preference for purchasing them shall be included in all solicitations relevant to construction, operation, maintenance of or use in the building. EPA's recycled content product designations and recycled content recommendations are available on EPA's Comprehensive Procurement Guideline web site at <www.epa.gov/cpg>.		Incorporate the FAR requirements for the purchase of USDA-designated products into contracts and use products meeting or exceeding USDA's biobased content recommendations. In addition, use biobased products made from rapidly renewable resources and certified sustainable wood products. Provide construction, purchasing or bid specifications, and/or affirmative procurement report.	☐	We would cite FESHM 5011 on "Sustainable Acquisition", and this language would also be included in Exhibit A in the bid documents. A new FL-300 that would address it as well. It is unclear if this is applicable to this project, the project will evaluate this further during design

Guiding Principle	Action Required	Yes/No	Suggested Compliance Verification Documents	On File?	Notes
Environmentally Preferable Products	Use products that have a lesser or reduced effect on human health and the environment over their lifecycle when compared with competing products or services that serve the same purpose. A number of standards and ecolabels are available in the marketplace to assist specifiers in making environmentally preferable decisions. For recommendations, consult the Federal Green Construction Guide for Specifiers at <www.wbdg.org/design/greenspec.php>.		Establish purchasing contracts, bids construction documents with specification language for the purchase of environmentally preferable materials, durable goods, cleaning supplies, and consumables. Ensure that language is explicit and clear regarding such considerations as VOC limits and Green Seal requirements.	☐	We would cite FESHM 5011 on "Sustainable Acquisition", and this language would also be included in Exhibit A in the bid documents. A new FL-300 that would address it as well. It is unclear if this is applicable to this project, the project will evaluate this further during design
Waste and Materials Management	Incorporate adequate space, equipment, and transport accommodations for recycling in the building design. During a project's planning stage, identify local recycling and salvage operations that could process site-related construction and demolition materials. During construction, recycle or salvage at least 50 percent of the non-hazardous construction, demolition and land clearing materials, excluding soil, where markets or onsite recycling opportunities exist. Provide salvage, reuse and recycling services for waste generated from major renovations, where markets or onsite recycling opportunities exist.		Documentation may be in the form of receipts, agreements or contracts with local recycling and product reclaiming services. Documentation may include contract specifications with vendors, for example, outlining carpet recycling programs through the manufacturer/distributer or may include photos, or polices that illustrate recycling initiatives for batteries, computers, and beverage containers. Building or site recycling program documentation except able.	☐	The project will include division 1 specification to have the contractor develop, submit & implement their waste management plan to compy with this requirement
Ozone Depleting Compounds	Eliminate the use of ozone depleting compounds during and after construction where alternative environmentally preferable products are available, consistent with either the Montreal Protocol and Title VI of the Clean Air Act Amendments of 1990, or equivalent overall air quality benefits that take into account lifecycle impacts.		Document zero use of CFC-refrigerants (policy, equipment specification, procurement specification or contract) unless a third party audit shows that a replacement or conversion is not economically feasible - in which case show that a phase out plan is in place. Do not use halons in fire suppression. Use all alternatives consistent with EPA's Significant New Alternatives Policy (SNAP) regulatory requirements.	☐	This is already our policy. Or spec items

Engineering Risk Assessment

Project: MC Beamline Enclosure
Lead Engineer: T. Lackowski
Department: FESS/Engineering
Date: April 19, 2013

Technology

Score	
1 - Low Risk	1

This defines the degree of technical complexity the Lead Engineer or engineering team will face in executing the project.

1 The project will use off-the-shelf technology.
3 Engineers will purchase and modify off-the-shelf technology.
5 The project will require the development of new technology.

Environmental Impact

2 - Low to Medium Risk	2

This defines the potential level of environmental impact.

1 There will be no environmental impact.
3 The project may have some environmental impact but will not require an environmental assessment, as determined by FESHM.
5 The project will require an environmental impact statement.

Vendor Issues

2 - Low to Medium Risk	2

This defines the degree of complexity to be expected with vendors. Complicating factors may include long-lead-time items and issues with vendor qualification and reliability.

1 Vendors could cause minor issues.
3 Vendors could cause manageable complications.
5 Vendor issues could result in significant schedule delays or cost overruns or could otherwise jeopardize the successful completion of the project.

Resource Availability

1 - Low Risk	1

This defines the availability of internal and external resources to plan and execute the project.

1 Resources will be readily available.
3 Resources could be somewhat restricted.
5 The difficulty of obtaining resources puts the project schedule at high risk.

Quality Requirements

1 - Low Risk	1

This determines the effort required to achieve the quality level the customer assigns to the final product.

1 The quality requirements can be met easily with existing infrastructure.
3 The quality requirements are challenging but can be met with existing infrastructure.
5 The quality requirements are beyond the capability of existing infrastructure.

Safety

1 - Low Risk	1

This defines the safety issues the project team will encounter while completing the project.

1 The project will require standard safety considerations.

3 The project will require increased diligence due to its location, the configuration of the product or the type of work required. This includes work requiring review according to FESHM.

5 The project will require very restrictive safety considerations. This includes work requiring review and personnel safety systems.

Manufacturing Complexity

1 - Low Risk	1

This defines the degree of complexity to be expected when combining the elements of technology, operations and schedule in product manufacturing.

1 The manufacturing processes will be routine.

3 The project will require an existing technology that the manufacturer has not previously used.

5 The project will require new or complex manufacturing methods.

Schedule

3 - Medium Risk	3

This defines how much time the Lead Engineer or engineering team will have to complete the schedule.

1 Time will be unlimited.

3 The schedule will be somewhat constrained.

5 The subproject will be on the overall project critical path and has no schedule contingency.

Interfaces

2 - Low to Medium Risk	2

This defines the risk associated with the complexity of integrating multiple subprojects.

1 One department at Fermilab will be involved with a standalone project.

3 Project success depends upon contributions from multiple departments at Fermilab.

5 Project success depends upon contributions from multiple institutions.

Experience/Capability

2 - Low to Medium Risk	2

This defines the level of experience and capability project team members will have.

1 Only experts will participate.

3 A blend of experts and inexperienced personnel will participate.

5 Only inexperienced personnel will participate.

Regulatory Requirements

2 - Low to Medium Risk	2

This identifies the degree to which oversight by governmental or other regulatory agencies will impact the project.

1 Regulatory agencies will have minor to no involvement.

3 The Department of Energy, DOE, will have direct regulatory involvement.

5 DOE, as well as state or federal government, will have regulatory involvement.

Project Funding

1 - Low Risk	1

This defines the availability and approval status of project planning and execution funds.

1 A single source within Fermilab will fund the project.
3 A source outside of Fermilab will fund the project.
5 Multiple sources outside of Fermilab will fund the project.

Project Reporting Requirements

3 - Medium Risk	3

This indicates the level of reporting to the senior management the project requires.

1 Reports to senior management about the project will not be required.
3 The project will require quarterly performance reports.
5 The project will be highly visible. Top management or outside agencies will schedule visits and issue monthly performance reports.

Public Impact

1 - Low Risk	1

This indicates how much the project will affect the public or public opinion.

1 The public will not be affected.
3 The public may be somewhat affected and should be informed with news releases.
5 The project may have an impact on the public. The public should be involved through public forums and may participate in advisory councils.

Project Cost

5 - High Risk	5

This defines how much the project is projected to cost.

1 The project will be within the department operating budget.
3 The project will require divisional budget planning.
5 The project will require laboratory or DOE budget tracking and reporting.

Engineering Risk Assessment

Project: MC Beamline Enclosure
Lead Engineer: T. Lackowski
Department: FESS/Engineering
Date: April 19, 2013

Chapter		Engineering Risk Element							High Risk	Subtotal	Assessment
		A	B	C	D	E	F	G			
1	Requirements and Specifications	1	2				1		≥ 10	4	Standard Risk
3	Requirements and Specification Review	1	2		1	1	1		≥ 16	6	Standard Risk
4	System Design	1	2	2		1	1	1	≥ 19	8	Standard Risk
5	Engineering Design Review	1	2	2		1	1	1	≥ 19	8	Standard Risk
6	Procurement and Implementation		2		1	1	1	1	≥ 16	6	Standard Risk
7	Testing and Validation	1				1	1	1	≥ 13	4	Standard Risk
8	Release to Operations						1		≥ 4	1	Standard Risk
9	Final Documentation		2				1		≥ 7	3	Standard Risk

Project Risk Element								High Risk	Subtotal	Assessment
H	I	J	K	L	M	N	O			
3	2	2	2	1	3	1	5	≥ 25	19	High Risk

Engineering Risk Elements	
A	Technology
B	Environmental Impact
C	Vendor Issues
D	Resource Availability
E	Safety
F	Quality Requirements
G	Manufacturing Complexity

Project Risk Elements	
H	Schedule
I	Interfaces
J	Experience / Capability
K	Regulatory Requirements
L	Project Funding
M	Project Reporting Requirements
N	Public Impact
O	Project Cost

2. M&R Cost Profiles

This chapter presents estimates of 50-year maintenance cost profiles for 74 models. Each two-page profile includes a description of the model, a list of major components, and forecasts of maintenance and repair (M&R) costs at various levels of aggregation. The profile estimates were made with the Whitestone MARS Facility Cost Forecast System, calibrated for the Washington, D.C. area. The profiles can be adjusted for other areas using the Local Maintenance Cost Index shown in Chapter 3, and modified to include different components shown in Chapter 5.

Table 2-1
Summary of M&R Cost Profiles

Model	GSFT	PRV	Annual M&R Cost per GSFT*	Annual M&R Cost as % of Repl. Value
Electrical Power, Backup	240	$781,790	$86.52	2.66%
Guard House	100	41,604	69.46	16.70
Central Plant, Boiler	1,100	703,471	40.61	6.35
Electrical Power, Substation	220	320,019	24.25	1.67
Data Center, Tier III	25,000	48,811,977	23.27	1.19
Central Plant, Chilled Water	9,175	7,048,429	20.60	2.68
Pump House	195	124,706	19.07	2.98
Central Plant, Steam	43,500	44,701,494	14.90	1.45
Laboratory, Agricultural	27,000	10,153,418	12.52	3.33
Restaurant, Fast Food	4,000	1,267,243	12.24	3.86
Laboratory, Electronics	30,200	10,237,918	10.71	3.16
Laboratory, Life Science	27,400	10,939,320	10.36	2.59
Car Wash	800	245,033	10.03	3.28
Apartments, 1-3 Story	22,500	4,691,880	9.91	4.75
Garage, Service Station	1,400	379,001	9.54	3.52
Natatorium	10,280	2,375,584	9.06	3.92
Restaurant	10,000	3,121,190	8.52	2.73
Laboratory, General	56,000	18,814,700	8.49	2.53
Apartments, 4-7 Story	60,000	12,121,945	8.34	4.13
Bank, Branch	4,100	1,059,447	8.27	3.20
Public Restroom	500	137,788	7.79	2.83
Motel, 40 Units	18,000	3,673,374	7.38	3.61
Fire Station	6,000	1,535,268	7.36	2.88
Laundry, Self-Service	3,000	655,482	7.25	3.32
Greenhouse, Research	2,100	454,647	7.21	3.33
Motel, 18 Units	8,000	1,747,953	6.97	3.19
Warehouse, HAZMAT	3,680	798,695	6.96	3.21
Clubhouse, Golf	6,000	1,663,465	6.74	2.43
Cafeteria	21,500	7,035,709	6.55	2.00
College Dormitory, 50 Room	25,000	6,547,845	6.33	2.42
Store, Convenience	4,000	826,087	5.73	2.78
Religious Education	10,000	2,726,217	5.67	2.08
Telecom Central Office	5,000	1,436,673	5.60	1.95
Hospital, Research	540,200	176,328,254	5.46	1.67
Hospital, General	125,000	48,607,650	5.45	1.40
College Student Union	25,000	5,387,525	5.38	2.49
Movie Theater	10,000	2,129,316	5.36	2.52
Visitor Center	20,700	4,915,035	5.22	2.20
Medical Clinic	13,000	4,078,007	5.13	1.64
Religious Assembly	17,000	4,327,530	4.99	1.96
Community Center	10,000	2,613,597	4.86	1.86
Store, Retail	8,000	1,652,174	4.79	2.32
Passenger Terminal	12,000	2,633,901	4.77	2.17
Apartments, 24 Story	220,000	44,426,778	4.71	2.33
College Auditorium	24,000	4,286,076	4.70	2.63
Court House	30,000	8,235,749	4.47	1.63
Municipal Building	11,000	2,908,266	4.42	1.67
Health Club w/Gymnasium	40,000	8,655,961	4.40	2.03
Mortuary	10,000	2,384,479	4.34	1.62
Post Office	13,000	1,919,555	4.18	2.83
Club, Social	22,000	5,185,803	4.09	1.74
Skating Rink	30,000	5,174,917	3.87	2.24
Day Care Center	12,000	2,941,441	3.85	1.57
Bowling Center	20,000	4,928,588	3.84	1.56
Manufacturing Plant, Process	50,700	12,091,083	3.82	1.60
Public Library, 3 Story	60,000	13,787,273	3.80	1.66
Jail, County	318,455	64,602,477	3.62	1.78
Maintenance Shop	12,100	2,574,282	3.56	1.67
Outdoor Pool	10,280	2,375,584	3.54	1.53
College Lecture Classrooms	90,000	18,321,957	3.48	1.71
Warehouse, Temperature Controlled	8,200	1,180,707	3.46	2.40
Elementary School	47,000	9,888,099	3.43	1.63
Warehouse, Self-storage	24,000	2,809,848	3.28	2.80
Office Building, 2 Story	83,000	16,561,720	3.16	1.58
Auto Salesroom	21,000	3,331,286	3.00	1.89
Manufacturing Plant, Light	45,000	10,896,218	3.00	1.24
Aircraft Hangar	32,000	9,332,007	2.97	1.02
Supermarket	96,000	16,391,086	2.85	1.67
Office Building, 15 Story	250,000	49,793,402	2.84	1.43
Manufacturing Plant, Machinery	384,000	84,626,798	2.80	1.27
Office Park	65,000	13,023,487	2.80	1.40
Store, Department	94,000	15,400,653	2.71	1.65
Warehouse, Dry	80,000	8,454,513	2.33	2.20
Garage, Parking	110,800	11,658,816	1.06	1.00

*Average costs over 50-year lifetime, Washington, D.C. area

From the cost analyst's perspective, the most useful information in these profiles is the year-by-year total shown under the "Cost per GSFT by System" section. A projection of M&R costs is required in the financial evaluation of virtually all large construction or renovation projects. Often this trend is estimated with a simple approximation (typically two to four percent of replacement value). This simplification obscures the oscillations in M&R requirements, and misstates costs when expressed in terms of present value. In comparison, Whitestone estimates are based on component life-cycles that provide a more realistic and defensible projection of M&R costs.

For the purposes of the facility manager, average values for M&R costs may be more useful than detailed year-to-year estimates. Conversations about facility funding and budgeting usually dwell on average costs per square foot, or average costs as a percentage of replacement value. Among our models, the highest average cost per gross square foot is for the Electrical Power, Backup ($86.52), while the Parking Garage had the lowest average cost ($1.06).

The reader may note the rankings in order of cost are different when expressed in terms of replacement value. The highest average M&R cost from this perspective was for the Guard House —17 percent of replacement value. A complete list of replacement costs is shown in Table A-1 in the Appendix. In general, we are wary of costs expressed in terms of replacement values because of the great variation in new construction costs and the difficulty of determining replacement costs for older assets. Replacement values have been completely revised based on a Whitestone survey of actual federal construction projects.

Profile estimates are sensitive to a variety of factors such as unscheduled maintenance rates, in-house shop rates, and facility utilization. These sensitivities are discussed in Chapter 6, Definitions and Methods.

Laboratory, General

Gross Square Feet:	56,000
Height in Ft:	25
Exterior:	Clay Brick
Floor coverings:	Carpet, Ceramic Tile, Finished Concrete
HVAC:	Chilled Water, Heat Exchanger, Single Zone
Capacity:	N/A
Occupancy:	500
Replacement Cost:	$18,814,700

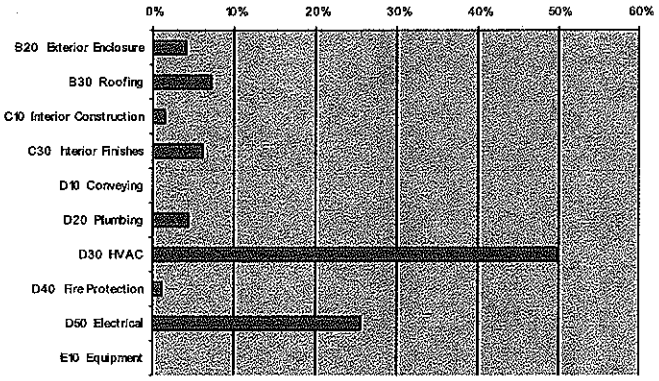
Components

Uniformat / Component	Quantity	Units
B20 Exterior Enclosure		
Aluminum Louver, 1st Floor	5	Each
Clay Brick, Exterior, 1st Floor	11000	Sq Ft
Concrete Block, Exterior, 1st Floor	12800	Sq Ft
Steel Single 12'x12', Painted, Roll-up Door	1	Each
Steel, Painted, Exterior Door	7	Each
B30 Roofing		
Single-Ply Thermoset Roof	56000	Sq Ft
C10 Interior Construction		
Movable Partitions, Office, Fabric, 6'	100	Ln Ft
Toilet Partitions, Painted Metal, Overhead Braced	16	Each
Steel, Painted, Interior Door	114	Each
C30 Interior Finishes		
Ceramic Tile, 4"x4", Interior Wall Finish	2500	Sq Ft
Gypsum Board, Interior Wall Finish	42700	Sq Ft
Carpet, Nylon 20 oz., High Traffic	13800	Sq Ft
Ceramic Tile Flooring	17000	Sq Ft
Concrete, Painted Flooring	25200	Sq Ft
Acoustical Tile, Dropped Ceiling	54400	Sq Ft
Gypsum Board, Finished Ceiling	1600	Sq Ft
D10 Conveying		
Hoist Electric, Overhead, Chain, 3 Ton	1	Each
D20 Plumbing		
Drinking Fountain, Refrigerated	2	Each
Lavatory, Vitreous China	27	Each
Service Sink, Iron, Enamel	2	Each
Sink, Stainless Steel	2	Each
Tankless Water Closet	16	Each
Urinal, Vitreous China	9	Each
Circulator Pump, 1/2 HP, Hot Water	1	Each
Circulator Pump, 1 HP, Cold Water	2	Each
Circulator Pump, 3 HP, Cold Water	3	Each
Pipe & Fittings, 3/4" Copper, Cold Water	1.7	K Ln Ft
Pipe & Fittings, 3/4" Copper, Hot Water	0.88	K Ln Ft
Pipe & Fittings, 2" Copper, Cold Water	0.8	K Ln Ft
Pipe & Fittings, 4" Copper, Cold Water	0.4	K Ln Ft
Pipe & Fittings, 4" Steel	1.5	K Ln Ft
Pipe & Fittings, 12" Steel	1.3	K Ln Ft
Pipe Insulation, Fiberglass, Cold Water	4	K Ln Ft
Pipe Insulation, Fiberglass, Hot Water	1.2	K Ln Ft
Water Heater, Gas/Oil, 275 Gph	1	Each
Backflow Preventer, 4"	2	Each
Floor Drain	4	Each
Pipe & Fittings, 4" Cast Iron	1.6	K Ln Ft
Pipe & Fittings, 6" Cast Iron	1.3	K Ln Ft
Pipe & Fittings, 4" PVC	0.777	K Ln Ft
Roof Drain, 4-6"	16	Each
Sump Pump, 1/2 HP	2	Each
Air Compressor, 25 HP	2	Each
Compressed Air Dryer	2	Each
Gas Compressor, 7 1/2 HP	2	Each
D30 HVAC		
Chemical Feed System	1	Each
Condensate Receiver Station, 10-15 Gal.	1	Each
Expansion Tank, 100 Gal.	2	Each
Expansion Tank, 400 Gal.	1	Each
Heat Exchanger, Steam-to-Water, 40 Gpm	1	Each
Steam Trap, F&T, 2"	6	Each
Valve, Non-Drain, 2"	430	Each
Valve, Non-Drain, 4"	50	Each
Chiller, Reciprocal Water-Cooled Hermetic, 100 Ton	1	Each
Circulation Pump, 5 HP, Chiller & Condenser Water	4	Each
Circulation Pump, 25 HP, Chiller & Condenser Water	2	Each
Cooling Tower, 100 Ton	2	Each
Evaporative Cooler, Indirect, 2,000 Scfm	12	Each
Evaporative Cooler, Indirect, 5,000 Scfm	1	Each
Pipe & Fittings, 2" Copper	0.5	K Ln Ft
Pipe & Fittings, 2" Steel	1.6	K Ln Ft
Pipe & Fittings, 3" Steel	1.8	K Ln Ft
Pipe & Fittings, 6" Steel	1.3	K Ln Ft
Pipe & Fittings, 8" Steel	0.3	K Ln Ft
Air Handler, Single Zone, 6,500 Cfm	2	Each
Air Handler, Single Zone, 10,000 Cfm	25	Each
Duct Insulation, Fiberglass Blanket	18200	Sq Ft
Ductwork	26000	Lbs

50-Year M&R Cost Summary

Task Type	50 Year Total Cost	Annual Cost per GSFT	Annual Cost as % of Replacement
PM & Minor Repair	$6,185,971	$2.21	0.66%
Unscheduled Maintenance	$4,635,141	$1.66	0.49%
Renewal & Replacement	$12,953,025	$4.63	1.38%
Total	**$23,774,137**	**$8.49**	**2.53%**

Distribution of M&R Costs



Thirty Most Costly M&R Tasks

M&R Task	Task Cost*	Pct.**
Replace MV Switchgear, >1,200 Amp.	46.57	13.6%
Replace Air Handler, Single Zone, 10,000 Cfm	29.58	8.7%
Maintain Air Handler, Single Zone, 10,000 Cfm	22.44	6.6%
Lubricate, Repack Gland, Valve, Non Drain, 2"	21.64	6.3%
Replace Membrane, Single-Ply Thermoset Roof	19.28	5.6%
Replace Valve, Non-Drain, 2"	15.84	4.6%
Replace Carpet, Nylon 20 oz., High Traffic	8.54	2.5%
Refinish Gypsum Board, Interior Wall Finish	7.66	2.2%
Replace Ceramic Tile Flooring	6.25	1.8%
Maintain Power Panel Board, 208 Y/120 V, 200 Amp.	6.15	1.8%
Maintain Evaporative Cooler, Indirect, 2,000 Scfm	5.87	1.7%
Replace Power Panel Board, 208 Y/120 V, 200 Amp.	5.81	1.7%
Replace Evaporative Cooler, Indirect, 2,000 Scfm	5.32	1.6%
Maintain Single-Ply Thermoset Roof	5.26	1.5%
Maintain Direct Digital Controls, System Points	5.06	1.5%
Replace Circuit Breaker, Main, MV, 600 V, 1,600 Amp.	4.60	1.3%
Replace Direct Digital Controls, System Points	4.52	1.3%
Replace Transfer Switch, HV, Auto, 600 V	4.02	1.2%
Replace Valve, Non-Drain, 4"	3.54	1.0%
Maintain Chemical Feed System	3.33	1.0%
Clean & Seal Concrete Block, Exterior, 1st Floor	3.14	0.9%
Replace Steel, Painted, Interior Door Locks	3.07	0.9%
Replace Chiller, Reciprocal Water-Cooled Hermetic, 100 Ton	2.97	0.9%
Clean & Reseal Clay Brick, Exterior, 1st Floor	2.71	0.8%
Repair Air Handler, Single Zone, 10,000 Cfm	2.67	0.8%
Lubricate, Repack Gland, Valve, Non Drain, 4"	2.52	0.7%
Maintain Cooling Tower, 100 Ton	2.44	0.7%
Replace Batteries & Check Operation, Smoke Detector	2.17	0.6%
Replace Cooling Tower, 100 Ton	1.99	0.6%
Maintain Chiller, Reciprocal Water-Cooled Hermetic, 100 Ton	1.96	0.6%

**Task cost ($2010) per GSFT over 50 years.*

***Percent of total M&R costs.*

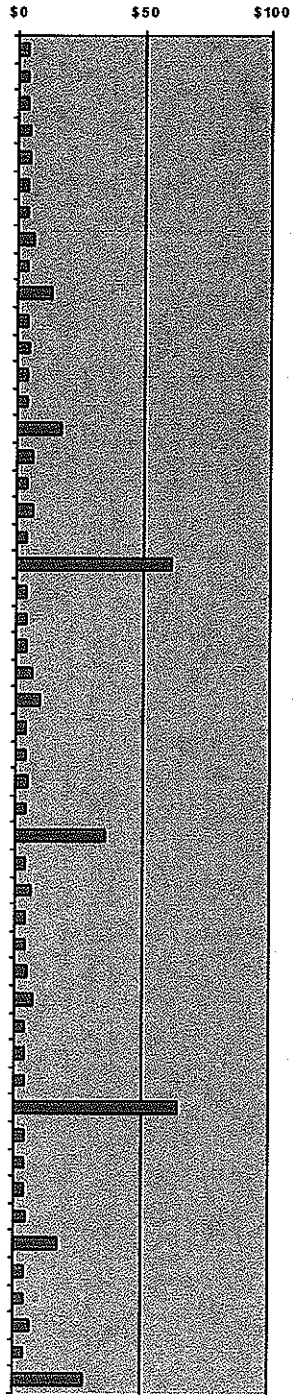
Note: For a complete list of components see Chapter 2.2. For alternative locations use the Local Indexes shown in Chapter 3.

Cost per GSFT by System

Asset Age	Exterior Closure	Roofing	Interior Construction	Stairways	Interior Finishes	Conveying Systems	Plumbing	HVAC Systems	Fire Protection	Electrical	Equipment	Special Construction	Site Improvements	Total per GSFT
1		.20				.00	.15	2.65	.05	.58	.00			3.64
2		.20			.03	.00	.22	2.65	.05	.61	.00			3.77
3		.20				.00	.15	2.70	.05	.58	.00			3.69
4		.20	.05		.70	.00	.28	2.65	.05	.61	.00			4.56
5	.01	.33	.19			.00	.23	2.70	.08	.75	.00			4.31
6		.20			.03	.00	.22	2.70	.05	.61	.00			3.82
7		.20				.00	.19	2.66	.05	.58	.00			3.69
8		.20	.05		2.09	.00	.29	2.65	.05	.61	.00			5.96
9		.20			.06	.00	.15	2.70	.05	.58	.00			3.75
10	2.85	.53	.81		.35	.00	.60	5.71	.25	2.34	.03			13.47
11		.20				.00	.15	2.65	.05	.58	.00			3.64
12		.20	.05		.70	.00	.49	2.69	.15	.61	.00			4.89
13		.20				.00	.15	2.69	.05	.58	.00			3.68
14		.20			.03	.00	.26	2.66	.05	.61	.00			3.82
15	.03	.33	.19		.20	.00	.34	14.48	.11	1.12	.00			16.83
16		.20	.05		2.09	.00	.29	2.69	.05	.61	.00			6.00
17		.20				.00	.16	2.65	.08	.58	.00			3.68
18		.20			.09	.00	.22	2.66	.05	3.17	.00			6.39
19		.20				.00	.15	2.69	.05	.58	.00			3.68
20	2.85	9.64	1.08		1.07	.00	1.30	18.41	.22	26.38	.03			60.99
21		.20				.00	.19	2.67	.05	.58	.00			3.70
22		.20			.03	.00	.23	2.65	.08	.61	.00			3.80
23		.20				.00	.15	2.69	.05	.61	.00			3.71
24		.20	.05		2.09	.00	.49	2.69	.15	.61	.00			6.29
25	1.61	.33	.23		.00	.08	1.95	4.25	.06	.94	.00			9.46
26		.20			.03	.00	.22	2.69	.05	.61	.00			3.81
27		.20			.06	.00	.15	2.66	.05	.58	.00			3.71
28		.20	.05		.70	.00	.26	2.66	.05	.64	.00			4.57
29		.20				.00	.23	2.69	.08	.58	.00			3.79
30	2.88	.53	.81		.55	.00	.74	17.41	.28	11.61	.03			34.83
31		.20				.00	.15	2.65	.05	.58	.00			3.64
32		.20	.05		2.09	.00	.22	2.65	.05	.61	.00			5.89
33		.20				.00	.22	2.70	.05	.61	.00			3.79
34		.20			.03	.00	.23	2.65	.08	.61	.00			3.80
35	.06	.33	.19			.00	.82	2.71	.06	.73	.00			4.91
36		.20	.05		.76	.00	.36	2.73	.15	3.17	.00			7.43
37		.20				.00	.28	2.66	.05	.58	.00			3.78
38		.20			.03	.00	.16	2.65	.05	.61	.00			3.71
39		.20				.00	.21	2.70	.05	.58	.00			3.75
40	2.84	9.64	1.08		2.46	.00	1.22	19.79	.22	26.59	.03			63.88
41		.20				.00	.29	2.65	.08	.61	.00			3.83
42		.20			.03	.00	.20	2.66	.05	.61	.00			3.76
43		.20				.00	.21	2.69	.05	.58	.00			3.75
44		.20	.05		.70	.00	.16	2.66	.05	.61	.00			4.44
45	.05	.33	.19		.26	.00	.60	14.49	.11	1.09	.00			17.14
46		.20			.03	.00	.17	2.69	.08	.64	.00			3.81
47		.20				.00	.21	2.65	.05	.58	.00			3.70
48		.20	.05		2.09	.00	.36	2.69	.15	.61	.00			6.16
49		.20				.00	.32	2.69	.05	.58	.00			3.86
50	4.44	.53	.85		6.61	.08	2.06	4.76	.32	7.91	.03			27.58
Total	**17.62**	**30.39**	**6.15**		**25.98**	**.36**	**19.02**	**211.65**	**4.42**	**108.63**	**.31**			**424.54**

A value of ".00" means a cost of more than $.000 but less than $.005 per GSFT.

50-Year Total M&R Cost Profile per GSFT



Note: For a complete list of components see Chapter 2.2. For alternative locations use the Local Indexes shown in Chapter 3.

3. Local M&R Costs

The statistics in this chapter focus on local maintenance costs for 255 major North American and International areas. Three types of measures are presented:

Section 3.1: Local maintenance cost indexes measure M&R costs across areas.

Section 3.2: In-house shop rates for trades and supervisory positions common to facility staff.

Section 3.3: Contract labor rates for trades common in M&R construction.

The local maintenance cost index is based on the M&R costs of the 2 Story Office Building (shown in Chapter 2) standardized to the Washington, D.C. area. The range of the index is considerable, as Table 3-1 indicates. Costs in New York, NY are an estimated 29% higher than those in Washington, D.C. for the same asset. In the other direction, M&R costs in Beijing, CHN are an estimated 76% lower than the Washington, D.C. value. This index can be used for simple comparisons among areas, and also used to adjust the cost profiles in Chapter 2 for areas other than Washington, D.C. For a listing of international contract labor and in-house shop rates; see tables A-5 and A-6 in Appendix 1.

Table 3-1
Comparison of M&R Costs by Area

Area	Local Maintenance Cost Index*	Area	Local Maintenance Cost Index*	Area	Local Maintenance Cost Index*	Area	Local Maintenance Cost Index*	Area	Local Maintenance Cost Index*
New York, NY	128.5	Albany, NY	97.7	Atlanta, GA	90.4	Little Rock, AR	83.9	**International Cities+**	
Yonkers, NY	128.5	Annapolis, MD	97.5	Manchester, NH	90.3	Boise, ID	83.9		
San Francisco, CA	125.2	Baltimore, MD	97.5	Dover, DE	89.7	Montgomery, AL	83.8	Zurich, CHE	105.5
Philadelphia, PA	121.4	Indianapolis, IN	97.5	Cedar Rapids, IA	89.7	Cheyenne, WY	83.6	Berlin, DEU	87.5
New Brunswick, NJ	121.4	Madison, WI	97.5	Denver, CO	89.7	Tucson, AZ	83.6	Paris, FRA	78.5
Trenton, NJ	121.4	Terre Haute, IN	97.4	Beaumont, TX	89.6	Beaufort, SC	83.5	Sydney, AUS	75.2
Jersey City, NJ	120.7	Worcester, MA	97.4	Altus, OK	89.0	Charleston, SC	83.5	Tokyo, JPN	64.5
Morristown, NJ	120.7	Sacramento, CA	97.4	Louisville, KY	88.9	Dallas, TX	83.4	London, GBR	63.6
Newark, NJ	120.7	Duluth, MN	97.4	Toledo, OH	88.8	Orlando, FL	83.3	Sao Paulo, BRA	55.2
Camden, NJ	120.5	Moline, IL	97.3	Baton Rouge, LA	88.7	Amarillo, TX	83.2	Seoul, KOR	49.4
Chicago, IL	118.1	Akron, OH	97.3	Great Falls, MT	88.6	Huntsville, AL	83.2	Istanbul, TUR	45.8
Oakland, CA	115.3	Salem, OR	97.3	Grand Rapids, MI	88.5	Columbia, SC	83.2	Abu Dhabi, UAE	38.1
San Jose, CA	113.9	Evansville, IN	97.1	Phoenix, AZ	88.5	Las Cruces, NM	83.2	Buenos Aires, ARG	37.7
Springfield, IL	113.0	Springfield, MA	97.0	Utica, NY	88.3	Fort Worth, TX	82.5	Riadh, SAU	36.2
Hilo, HI	112.7	Rochester, MN	96.8	Savannah, GA	88.1	Oklahoma City, OK	82.5	Johannesburg, ZAF	31.9
Honolulu, HI	112.7	Santa Barbara, CA	96.5	Lewiston, ME	87.6	Springfield, MO	82.1	Mexico City, MEX	30.7
Ann Arbor, MI	111.1	Youngstown, OH	96.4	Mobile, AL	87.5	Roanoke, VA	82.0	Moscow, RUS	30.6
Rockford, IL	108.2	San Diego, CA	95.9	Biloxi, MS	87.4	Bowling Green, KY	81.8	St. Petersburg, RUS	30.3
Minneapolis, MN	107.8	Lowell, MA	95.9	Spokane, WA	87.4	Raleigh-Durham, NC	81.8	Cairo, EGY	29.6
St. Paul, MN	107.8	Providence, RI	95.9	Chattanooga, TN	87.4	Knoxville, TN	81.7	Shanghai, CHN	29.4
St. Louis, MO	107.6	Anacortes, WA	95.8	Wichita Falls, TX	87.3	Nashville, TN	81.0	Karachi, PAK	28.5
Kansas City, MO	107.5	Brockton, MA	95.7	St. George, UT	87.2	Fayetteville, AR	80.9	Mumbai, IND	26.3
Las Vegas, NV	107.3	Jefferson City, MO	95.6	Lincoln, NE	87.0	Macon, GA	80.9	Beijing, CHN	24.1
Atlantic City, NJ	106.9	Buffalo, NY	95.4	Sioux City, IA	87.0	Charlotte, NC	80.8		
Peoria, IL	106.6	Riverside, CA	95.4	Shreveport, LA	87.0	Pierre, SD	80.4		
Detroit, MI	105.9	Reno, NV	95.3	Richmond, VA	86.9	Rapid City, SD	80.4		
Boston, MA	105.8	Oxnard, CA	95.2	Houston, TX	86.8	Bismarck, ND	80.2		
Norwalk, CT	105.5	Cincinnati, OH	94.9	Colorado Springs, CO	86.8	Daytona Beach, FL	80.1		
Stamford, CT	105.5	Flint, MI	94.9	Jacksonville, FL	86.7	Columbus, GA	80.0		
New Haven, CT	104.6	Olympia, WA	94.9	Hampton, VA	86.7	Fort Smith, AR	80.0		
Gary, IN	103.7	Davenport, IA	94.7	Newport News, VA	86.7	Greensboro, NC	79.7		
Seattle, WA	103.4	Cumberland, MD	94.5	Norfolk, VA	86.7	Sioux Falls, SD	79.1		
Portland, OR	103.3	Fresno, CA	94.3	Virginia Beach, VA	86.7	Winston-Salem, NC	78.9		
Waterbury, CT	103.2	Harrisburg, PA	94.0	Waco, TX	86.6	Tallahassee, FL	78.8		
Danbury, CT	103.2	Pueblo, CO	94.0	Miami, FL	86.6	Fargo, ND	78.5		
Springfield, OH	103.1	Saginaw, MI	93.3	Wichita, KS	86.5	Lubbock, TX	78.3		
Lansing, MI	103.0	Columbus, OH	93.2	Fort Lauderdale, FL	86.4	Alamogordo, NM	77.7		
Pittsburgh, PA	102.9	Syracuse, NY	93.1	Albuquerque, NM	86.0	El Paso, TX	77.1		
Juneau, AK	101.9	Watertown, NY	93.1	Frankfort, KY	85.8	Hagatna, GU	75.9		
Milwaukee, WI	101.8	Dayton, OH	92.9	Lexington, KY	85.8	San Juan, PR	69.6		
Anchorage, AK	101.3	Rochester, NY	92.8	Sante Fe, NM	85.6				
Kokomo, IN	101.2	South Bend, IN	92.7	Austin, TX	85.5	**Canadian Cities+**			
Hartford, CT	101.1	Stockton, CA	92.6	Pocatello, ID	85.5				
Anaheim, CA	101.0	Green Bay, WI	92.6	Birmingham, AL	85.3	Calgary, AB	97.8		
Los Angeles, CA	101.0	Muncie, IN	92.5	Portland, ME	85.2	Toronto, ON	97.6		
Norwich, CT	100.8	New Orleans, LA	92.3	Jackson, MS	85.1	Ottawa, ON	96.6		
Cleveland, OH	100.3	Concord, NH	92.3	Memphis, TN	85.1	Hamilton, ON	96.4		
Charleston, WV	100.1	Topeka, KS	92.2	Corpus Christi, TX	85.0	London, ON	96.4		
Washington, D.C.	100.0	Erie, PA	92.1	Ogden, UT	84.8	Vancouver, BC	96.3		
Tacoma, WA	99.9	Fall River, MA	92.0	Salt Lake City, UT	84.8	Edmonton, AB	96.2		
Parkersburg, WV	99.6	Medford, OR	92.0	Key West, FL	84.8	Victoria, BC	95.3		
Carson City, NV	99.5	Des Moines, IA	91.8	Tulsa, OK	84.7	Halifax, NS	94.1		
Fairbanks, AK	99.4	Battle Creek, MI	91.6	San Antonio, TX	84.4	Montreal, QC	93.0		
Bakersfield, CA	99.4	Kalamazoo, MI	91.6	Owensboro, KY	84.4	Quebec City, QC	90.5		
Richland, WA	99.2	Lawton, OK	91.3	Tuscaloosa, AL	84.2	St. John's, NL	88.3		
Wilmington, DE	99.0	Omaha, NE	91.0	Augusta, ME	84.1	Regina, SK	85.9		
Marquette, MI	99.0	Helena, MT	90.9	Tampa, FL	84.1	Winnipeg, MB	84.7		
Scranton, PA	98.6	Billings, MT	90.8	Burlington, VT	84.1				
Reading, PA	98.5	Boulder, CO	90.6	Montpelier, VT	84.1				
Eugene, OR	97.9	Eau Claire, WI	90.6	Rutland, VT	84.0				

*Total average cost, Washington D.C.=100
+Adjusted using 5/14/10 exchange rate from Reuters.com

3.1 Local Maintenance Cost Indexes, Selected North American Areas

Area	Cost per GSFT*	Local Index	255 Area Ranking
Charleston, WV			
PM & Minor Repair	$.61	96.4	56
Unscheduled Maintenance	$.46	96.3	50
Renewal & Replacement	$2.08	102.1	44
Total Average Cost	$3.15	100.1	48
Charlotte, NC			
PM & Minor Repair	$.45	70.8	220
Unscheduled Maintenance	$.30	63.6	218
Renewal & Replacement	$1.79	87.9	210
Total Average Cost	$2.54	80.8	218
Chattanooga, TN			
PM & Minor Repair	$.54	84.9	136
Unscheduled Maintenance	$.38	80.0	138
Renewal & Replacement	$1.83	89.9	186
Total Average Cost	$2.75	87.4	152
Cheyenne, WY			
PM & Minor Repair	$.52	81.6	153
Unscheduled Maintenance	$.37	77.3	153
Renewal & Replacement	$1.74	85.8	222
Total Average Cost	$2.63	83.6	198
Chicago, IL			
PM & Minor Repair	$.76	119.6	13
Unscheduled Maintenance	$.58	121.0	13
Renewal & Replacement	$2.38	116.9	3
Total Average Cost	$3.72	118.1	11
Cincinnati, OH			
PM & Minor Repair	$.55	86.9	121
Unscheduled Maintenance	$.40	83.1	122
Renewal & Replacement	$2.04	100.2	59
Total Average Cost	$2.99	94.9	96
Cleveland, OH			
PM & Minor Repair	$.65	101.3	38
Unscheduled Maintenance	$.48	100.9	39
Renewal & Replacement	$2.03	99.8	63
Total Average Cost	$3.16	100.3	47
Colorado Springs, CO			
PM & Minor Repair	$.51	80.3	160
Unscheduled Maintenance	$.36	74.9	161
Renewal & Replacement	$1.86	91.5	169
Total Average Cost	$2.73	86.8	160
Columbia, SC			
PM & Minor Repair	$.46	71.5	216
Unscheduled Maintenance	$.30	63.8	217
Renewal & Replacement	$1.86	91.4	172
Total Average Cost	$2.62	83.2	206
Columbus, GA			
PM & Minor Repair	$.44	68.6	227
Unscheduled Maintenance	$.29	60.2	229
Renewal & Replacement	$1.79	88.2	206
Total Average Cost	$2.52	80.0	223
Columbus, OH			
PM & Minor Repair	$.53	82.5	150
Unscheduled Maintenance	$.38	79.3	143
Renewal & Replacement	$2.03	99.9	62
Total Average Cost	$2.93	93.2	106
Concord, NH			
PM & Minor Repair	$.55	85.7	130
Unscheduled Maintenance	$.38	79.9	140
Renewal & Replacement	$1.98	97.2	94
Total Average Cost	$2.90	92.3	117
Corpus Christi, TX			
PM & Minor Repair	$.47	74.2	199
Unscheduled Maintenance	$.32	68.1	200
Renewal & Replacement	$1.88	92.4	156
Total Average Cost	$2.68	85.0	181
Cumberland, MD			
PM & Minor Repair	$.56	87.4	119
Unscheduled Maintenance	$.41	85.4	111
Renewal & Replacement	$2.01	98.8	74
Total Average Cost	$2.97	94.5	100
Dallas, TX			
PM & Minor Repair	$.49	76.6	183
Unscheduled Maintenance	$.34	70.7	179
Renewal & Replacement	$1.80	88.5	202
Total Average Cost	$2.62	83.4	202
Danbury, CT			
PM & Minor Repair	$.61	95.7	64
Unscheduled Maintenance	$.44	92.1	76
Renewal & Replacement	$2.20	108.1	24
Total Average Cost	$3.25	103.2	35
Davenport, IA			
PM & Minor Repair	$.59	92.0	91
Unscheduled Maintenance	$.43	90.6	86
Renewal & Replacement	$1.96	96.5	104
Total Average Cost	$2.98	94.7	99
Dayton, OH			
PM & Minor Repair	$.53	83.8	143
Unscheduled Maintenance	$.38	79.4	142
Renewal & Replacement	$2.01	99.0	70
Total Average Cost	$2.93	92.9	110

*Annual average costs, over a 50 year service life, of maintaining the 2 Story Office Building shown in Chapter 2.
Note: Local Indexes are standardized (equal 100) for the Washington D.C. area.

Fermilab Work Smart Set

INTRODUCTION

Fermilab has adopted the Necessary and Sufficient (N&S) Process for determining the Work Smart Set of Standards (WSS) to determine the appropriate ES&H standards to ensure the safe and environmentally responsible operations of the laboratory. Fermilab, in conjunction with participation from, the DOE FSO, the Chicago Operations Office (CH) and the Office of Science (SC), conducted the first site-wide application of the Departmental N&S Closure Process. The result was a set of significant hazard aspects and impacts that were used to establish a Work Smart Set of Standards (WSS). The WSS were incorporated into the prime contract with DOE. These standards, if properly implemented, provide adequate assurance that the public, workers, and environment are protected from adverse consequences. Fermilab's work activities, the hazards associated with the work, and the standards are reviewed on an annual basis, and revised as needed. Additionally, new standards promulgated by DOE or national standards-making bodies (e.g. National Fire Protection Association) are evaluated and incorporated into the WSS as appropriate.

RESPONSIBILITIES

The Chief Operating Officer is responsible for assuring that suggested changes to Fermilab's WSS are incorporated into the FRA contract with DOE.

The ESH Section Head is responsible for

- Conducting annual review of WSS and recommending to Fermilab management changes to the set.
- Distributing copies of the revised WSS to the Library.

The Laboratory Services, Information Resources Department Manager is responsible for assuring that all WSS are available through the library system.

PROGRAM DESCRIPTION

The WSS shall be reviewed on an annual basis. The ESH Section Head will transmit to the Chief Operating Officer recommendations of changes to the WSS. Once the set has been accepted by DOE-FSO and incorporated into the contract with FRA, copies shall be distributed to the Library and the FESHM chapter.

Appendix A
Fermilab Work Smart Set of Standards

10 CFR 1021 (DOE NEPA rules)
10 CFR 1022 (Compliance with Floodplain/Wetlands environmental review requirements)
10 CFR 1046 Subpart B, App. A, Chapter X, par. H through I inclusive. (Physical protection of security interests, protective force personnel)
10 CFR 835 (Occupational radiation protection - applicable and enforceable portions)
10 CFR 850 (Chronic Beryllium Disease Prevention Program)
10 CFR 851 (Worker Safety and Health Program)
10 CFR 860 (Trespass to land owned & leased by the U.S. Government)
17 IAC 525 and permit pursuant (Nuisance animal trapping permits)
17 IAC 3702 (Construction and Maintenance of Dams)
18 U.S. Code Sections 841-848 (Use, or threat of use, of explosives; includes civil disorders)
28 CFR 36 (Section 302(b)(2) of the Americans with Disabilities Act and Section 4.1.3(9) of the ADAAG -- accommodations and accessibility)
29 CFR 1903.13 (Imminent danger)
29 CFR 1903.2 (Posting of notice...)
29 CFR 1904 (Recordkeeping and reporting occupational injuries and illnesses)
29 CFR 1910 (OSHA general industry standards - applicable and enforceable portions)
29 CFR 1926 (OSHA construction industry standards - applicable and enforceable portions)
29 CFR 1928 Subpart C (Roll-over protective structures - applicable and enforceable portions)
29 CFR 1928 Subpart D (Safety for agricultural equipment - applicable and enforceable portions)
29 CFR 1977.12 (Exercise of any right afforded by the Act)
29 CFR 1977.4 (Persons prohibited from discriminating)
29 IAC Chapter 1, Subchapter f (Emergency services, disasters, and civil defense /ESDA/ chemical safety)
33 CFR 320-323, 328-330 (Army Corp of Engineers wetlands regs)
35 IAC (State of IL environmental regs - applicable and enforceable portions)
36 CFR 60, 63, 65 (National historic landmark program)
36 CFR 78-79 (NHPA waiver and collection curation regs)
36 CFR 800 (Protection of historic and cultural properties)
40 CFR (Federal environmental regs - applicable and federally-enforceable portions)
41 IAC 100 (Fire prevention and safety)
41 IAC 120 (Boiler and pressure vessels)
41 IAC 140 (Policy and procedures manual for fire protection personnel)
41 IAC 160 (Storage, transportation, sale and use of gasoline and volatile oils: rules relating to general storage)
41 IAC 170 (Storage, transportation, sale and use of petroleum and other regulated substances)
41 IAC 180 (Storage, transportation, sale and use of volatile oils)
43 CFR 7 (Archaeological collections)
49 CFR (Offsite) Parts 100-177 (Applicable Parts) Parts 178-199 (Applicable Parts) Parts 382-399 (Applicable Parts)
49 CFR (Onsite) Parts 382-399 (Applicable Parts) 177.848 (Segregation Table for Hazardous Materials)
50 CFR 17 (Endangered species rules)
71 IAC 400 (Illinois accessibility code, Subparts C-F)

77 IAC 830 (Structural pest control code)
77 IAC 855 (Rules for Asbestos Abatement for Public & Private Schools and Commercial & Public Buildings in Illinois)
77 IAC 890 (Plumbing code)
77 IAC 900 (Drinking water systems requirements)
77 IAC 905 (Private Sewage Disposal Code)
77 IAC 920 (Water well construction code)
77 IAC 925 (Well pump installation)
92 IAC 700 and all permits pursuant (Construction in water course permit application)
92 IAC 704 and all permits pursuant (Regulation of public waters)
92 IAC 708 and all permits pursuant (Floodway construction permit application)
105 ILCS 105 (Asbestos Abatement Act)
225 ILCS 207 (Commercial and Public Building Asbestos Abatement Act)
ACGIH Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, 2005
ANSI A 17.1 (Elevator Construction)
ANSI A 17.3 (Elevator Maintenance)
ANSI A 39 (Window Washing)
ANSI B11 series (Metalworking - applicable portions)
ANSI B15.1 (Power transmission apparatus)
ANSI O1.1 (Woodworking machinery)
ANSI Z88.2 (Respiratory Protection) 1992
ANSI Z136.1 (Lasers), 2000
AWS (American Welding Standard) Z 49.1 (Cutting, Welding and Hot Work Activities) 1999 version
ANSI/ASHRAE 15 (Mechanical refrigeration)
ANSI/ASME B30.10 (Hooks) 2005
ANSI/ASME B30.11 (Monorails and Underhung Cranes) 2004
ANSI/ASME B30.16 (Overhead Hoists (Underhung)) 2003
ANSI/ASME B30.17 (Overhead and Gantry Cranes (Top Running Bridge, Single Girder, Underhung Hoist)) 2003
ANSI/ASME B30.2 (Overhead and gantry cranes) 2005
ANSI/ASME B30.20 (Below the hook lifting devices) 2006
ANSI/ASME B30.21 (Manually Lever Operated Hoists) 2005
ANSI/ASME B30.22 (Articulating Boom Cranes) 2002
ANSI/ASME B30.5 (Mobile and locomotive truck cranes) 2004
ANSI/ASME B30.9 (Slings) 2003
ANSI/ASME B31.1 (Power piping) 2001, B31.1a 2002, Addenda to b 31.1 2001
ANSI/ASME B31.3 (Process Piping) 2004
ANSI/ASME B31.5 (Refrigeration piping) 2001
ANSI/ASME B31.8 (Gas transmission and piping systems) 2003
ANSI/ASME B31.9 (Building Services Piping) 1996
Archaeological and Historic Preservation Act of 1974 (P.L. 93-291)
Archaeological Resources Protection Act of 1979 [amended], 16 USC 470aa et seq.
ASME Pressure Vessel Code - Section VIII
ASME B20.1-1996 (Safety Standard for Conveyors & Related Equipment)
Atomic Energy Act of 1954 [amended], 42 USC 2011 et seq.
ANSI N323A-1997 (Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments)
ANSI N323D-2002 (American National Standard for Installed Radiation Protection Instrumentation)

Batavia Code of Regulations, City Ordinance, Section 8-3-10-3
International Building Code Fire Prevention Code (latest edition)
International Building Code (latest edition)
Boiler & Pressure Vessels of the Illinois Office of the State Fire Marshall - applies to CUB Boilers Only
CERCLA/SARA, 42 USC 9601 et seq.
City Code of Warrenville, IL Title 7, Chapter 4, sewer/sewerage ordinance
Clean Air Act Amendments 1990, 42 USC 7401 et seq., and Illinois State Implementation Plan, 40 CFR 52 Subpart O
Clean Water Act, 33 USC 1251 et seq.
DOE Order 420.1A Fire Protection (Section 4.2)
DOE Order 5400.5 Derived Concentration Guide Table and dose limits to the public (Chapter 2, Section 1; Chapter 3)
DOE Manual 231.1A (Environment, Safety and Health Reporting Manual), as it applies to injury recordkeeping only, September 9, 2004
DuPage County Health Department Private Water Supply Ordinance (Chapter 18, Article 18-4, DuPage County Code)
E.O. 11988 (Floodplain Management)
E.O. 11990 (Protection of Wetlands)
E.O. 12580 (Implementation of superfund)
E.O. 13101 (Greening the Government through Waste Prevention, Recycling, and Federal Acquisition)
E.O. 13058 (Protecting Federal Employees and the Public from Exposure to Tobacco Smoke in the Federal Work Place)
E.O. 13148 (Greening the Government through Leadership in Environmental Management)
E.O. 13149 (Greening the Government through Federal Fleet and Transportation Efficiency)
Endangered Species Act, 16 USC 1531 et seq.
Federal Facility Compliance Act, 42 USC 6961
Fermilab ES&H Section SQIP RPS.8 (Control and accountability of nuclear materials)
FESHM 2010 (Planning and review of accelerator facilities and their operations)
FESHM 3010 (Significant and Reportable Occurrences) (formerly, Occurrence reporting)
FESHM 5031 (Pressure vessels)
FESHM 5031.1 (Pressure piping systems)
FESHM 5032 (Cryogenic system review)
FESHM 5032.1 (Liquid nitrogen dewar installation rules)
FESHM 5032.2 (Guidelines For the Design, Fabrication, Testing, Installation, and Operation of LH2 Targets)
FESHM 5032.3 (Transporting gases in building elevators)
FESHM 5033 (Vacuum vessel safety)
FESHM 5033.1 (Vacuum window safety)
FESHM 5035 (Mechanical refrigeration systems)
FESHM 5040 (Fermilab electrical safety program)
FESHM 5041 (Electrical utilization equipment safety)
FESHM 5042 (AC electrical power distribution safety)
FESHM 5043 (Management and use of cable tray systems)
FESHM 5044 (Protection against exposed electrical bus)
FESHM 5046 (Low voltage, high current power distribution systems)
FESHM 5064 (Oxygen deficiency hazards)
FESHM 5084 (Ergonomics Program)
FESHM 6020.3 (Installation of flammable gas lines in or near cable trays)

FESHM 9030 (Aviation safety)
FIFRA, 7 USC 136 et seq.
FRCM Article 362 (X-Ray Generating Devices & Radiography Sources)
FRCM Article 411 (Radioactive Material Identification, Storage and Control - Definitions)
Handbook for Sampling & Sample Preservation of Water and Wastewater, EPA-600/4-82-029
IEC 61511, Functional Safety, Safety Instrumented Systems for the Process Industry Sector
Illinois Chemical Safety Act, 430 ILCS 45/1 et seq.
Illinois Compiled Statutes (ILCS) Chapter 625 (State vehicle code -- Applicable Portions)
Illinois Department of Public Health, DuPage County Dept. Public Health. CDC December 7,1990
Illinois Endangered Species Protection Act, 520 ILCS 10/1 et seq.
Illinois Ground Water Protection Act, 415 ILCS 55/1 et seq.
Illinois Health and Safety Act, 820 ILCS 225/1 et seq.
Illinois Pesticide Act, 415 ILCS 60/1 et seq.
Illinois Structural Pesticide Act, 225 ILCS 235/1 et seq.
Kane County Health Department Ordinance 04-199/05-141 Water Well Code
National Fire Protection Association Codes and Standards (NFPA Standards - applicable portions)
NFPA (National Electric Code), 2005
NFPA 70E (Standard for Electrical Safety in the Workplace), 2004
National Historic Preservation Act of 1966 [amended], 16 USC 470 et seq.
Native American Graves Protection and Repatriation Act of 1990, 25 USC 3001 et seq.
NEPA, 42 USC 4321 et seq.
OSH Act, 29 USC 654(a)(1) -- General duty clause.
Privacy Act of 1974, 5 USC 552a
RCRA Part B Permit (Illinois Log #131), including Emergency Contingency plan
RCRA, 42 USC 6901 et seq.
Recommended standards for Water Works, Great Lakes Upper Mississippi R. Bd. of State Public Health & Environmental Managers (1992)
Safe Drinking Water Act, 42 USC 300f et seq.
Standard Methods for the Examination of Water and Wastewater, 18th Ed., APHA (1992)
Standards and Specifications for Soil Erosion and Sediment Control, 10/87, IEPA 87-102
TSCA, 15 USC 2601 et seq.
UL Listing
Uniform Federal Accessibility Standards, Chapter 4, Accessible Elements and Spaces: Scope and Technical Requirements
Energy Solutions LLC Bulk Waste Disposal and Treatment Facilities Waste Acceptance Criteria
Rather than attempt a precise analysis of all necessary standard citations to exclude non-applicable parts, inclusive citations were made qualified by the phrase "applicable and enforceable parts thereof." To the extent these standards apply to DOE and not the contractor, the contractor will assist DOE in complying with them. This Set does not change any existing Federal, State or local enforcement authority. For standards not applicable as a matter of law (other than FESHM provisions), the applicable version shall be the revision in effect on July 14, 1995, unless otherwise indicated. For FESHM provisions, the applicable version shall be the most recent version established through the procedures set forth in Appendix I.

Fermilab
ESH Section

Multi-Organization Construction Site Safety Walkthrough

1.0 Background and Purpose

Background: The vast majority of incidents happen when barriers are bypassed, procedures are not followed or there are departures by workers from safe behaviors. Unsafe conditions have historically been a small percentage of the causes of accidents whereas behaviors or unsafe acts are the bulk of the causes. In order to eliminate these incidents from the workplace we must concentrate our efforts to those actions that will have the biggest return on "investment" such as the elimination of unsafe behaviors and the evaluation of work processes and barriers to determine conformance with accepted practices.

Purpose: To establish a process for conducting formal safety program evaluations and field assessments through site safety walkthroughs for construction activities. These walk-throughs should consider management systems, employee behaviors, conformance to the subcontractor safety plan, and performance to Fermilab requirements as expressed in contractual documents, pre-bid and pre-construction meetings.

2.0 Scope

This procedure applies to all active construction activities that require a multi-organizational scrutiny as designated by the Chief Operating Officer.

3.0 Responsibilities

3.1 Construction Manager

3.1.1 Determine the frequency of walkthroughs based upon input received from the Chief Operating Officer and the Project Manager. Frequency should be identified in the Project Execution Plan (PEP).

3.1.2 Identify walk-through team members. The team should be kept to a reasonable size and may include the Construction Manager, Construction Coordinator, Subcontractor Superintendent, a representative from the Fermilab ESH Section, a representative from the Department of Energy Fermi Site Office if requested, and a Project ESH Coordinator, if one is assigned.

3.1.3 Conduct a closeout meeting as described below.

3.2 Construction Coordinator

3.2.1 Assist the Construction Manager in the walkthrough process as requested. Such requests may include:

3.2.1.1 Transmit all concerns to the Sub-Contractor for resolution and provide copies to all team members.

3.2.1.2 Review corrective action responses from the Sub-Contractor and provide feedback to the Construction Manager and the Project ES&H Coordinator.

3.2.1.3 Track responses to action items (in a formal database, daily/weekly logs or construction meeting minutes).

3.2.1.4 Document & distribute closeout-meeting minutes.

3.3 ES&H Section Representative

3.3.1 Provide technical support relative to safety issues.

3.4 Project ES&H Coordinator

3.4.1 Participate in walkthroughs keeping an eye especially toward safety issues that would impact installation and operational activities that will follow construction.

3.4.2 Provide feedback from walkthroughs and closeout meetings directly to the Project Manager.

4.0 Procedure

4.1 The Construction Manager (CM) will identify the time and frequency of the walkthrough.

4.2 The CM will develop an agenda for the walk-through and identify any specific areas to focus on. Appendix A should be used as guidance. Trying to cover a broad spectrum of programs or activities may result in specifics being missed. This is especially true for a larger project, or one covering more than one work site. Interviews with subcontractor employees are encouraged.

Field observations from one visit may give rise to focused assessments at a future date or provide justification for a formal audit.

4.3 CM will complete a closeout meeting with all participating organizations to discuss results of the walkthrough and to discuss suggestions for possible corrective actions.

4.4 Document walkthrough results through meeting minutes that will be distributed to all participating organizations.

4.5 Enter concerns and corrective actions into a database created for the specific project.

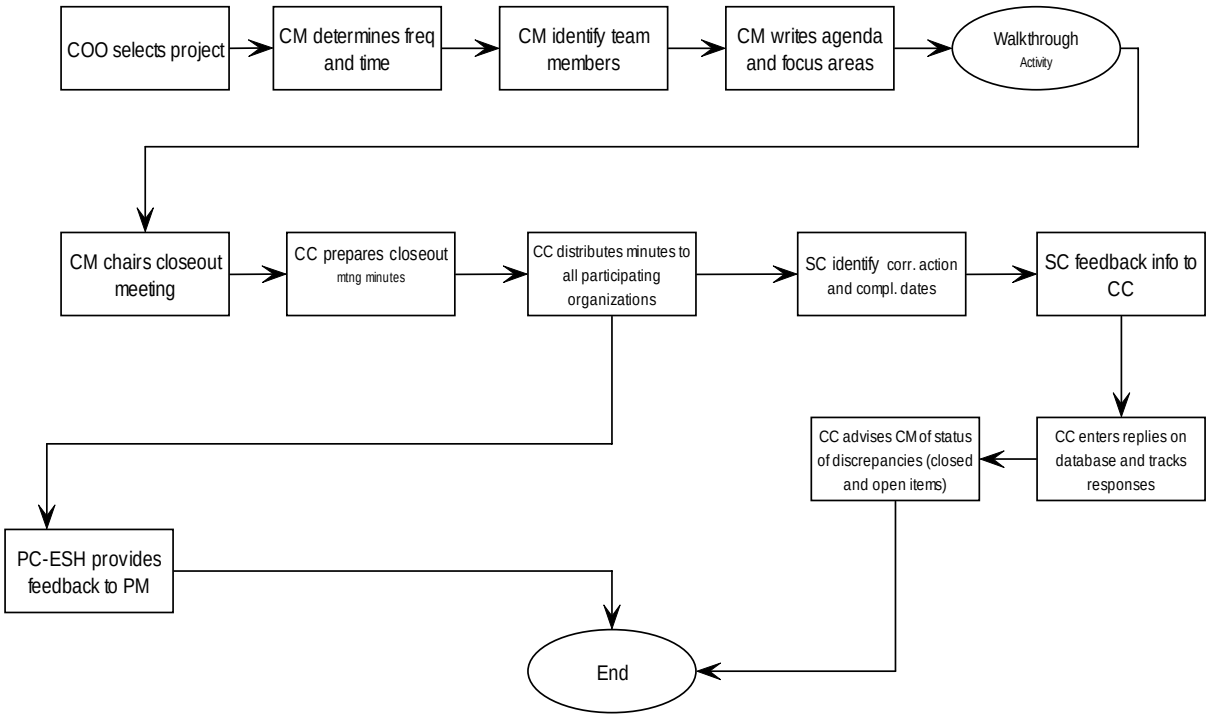
5.0 Corrective Actions

5.1 The walkthrough report shall be provided to the subcontractor for action.

5.2 The subcontractor shall identify corrective actions and completion dates. Corrective actions shall be completed as quickly as possible.

Flow Diagram

Construction Project
Multi-Organizational Safety Walkthrough



Abbreviations:

COO	Chief Operating Officer
CM	Construction Manager
CC	Construction Coordinator
PC-ESH	Project ES&H Coordinator
PM	Project Manager

Appendix

ESH Assessment Guidance- Areas of Inquiry

1. Injuries or Illnesses

2. General
   - Housekeeping
   - Garbage Containers
   - Emergency Phone #s Posted
   - Emergency Communication
   - Fence Condition
   - Gates
   - Signage on Fences and Gates
   - Whip Checks
   - Electrical Cords
   - GFCI's
   - Gas Test Log
   - Machine/Equipment Guards
   - Lighting
   - Ladders
   - Explosive Storage
   - Oxy/Acetylene Storage
   - Scaffolding

2. Traffic Control
   - Barricades
   - Traffic Signs
   - Flag Person
   - Vests
   - Flag

3. Shafts & Tunnels
   - Hand held lights/Miners Lights
   - Lighting
   - Communication
   - Ventilation
   - Self Rescuers Present

- Housekeeping
- Air/Noise Testing
- Signage
- Barricades

4. Emergency Equipment
   - Fire Extinguishers
   - First Aid Kits
   - Oxygen
   - Blankets
   - Eye Wash
   - Infection Control
   - Medical Emergency Teams
   - Rescue Teams

5. Personal Protective Equipment
   - Hard Hats
   - Eye Protection
   - Hearing Protection
   - Foot Protection
   - Respiratory Protection
   - Hand Protection
   - Fall Protection Harness/Lanyard
   - Face Protection
   - Barrier Cream

6. Cranes
   - Inspections
   - Certifications
   - Anti-Two Blocks
   - Hook Latches
   - Perimeter Barricades
   - Glass
   - Horn
   - Fire Extinguisher
   - Rigging Equipment

7. Equipment
   - Daily Inspections
   - Glass

- Back-Up Alarm
- Fire Extinguishers
- Hydraulic Oil Leaks

8. Work Planning
    - H/A for Tasks Performed
    - Dail Huddles
    - Tool Box Meetings
    - Monthly ESH Meetings
    - Records/Log Reviews
    - LOTO

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:

Project Number: **6-10-22**

UIP ECP (If applicable):

Project Phase:

Comment Date: **February 14, 2013**

Print

Duplicate

Main Menu

COMMENT

Drawing Reference:

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

RESPONSE

Project Contact Response:

Comment:

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
Mary Convery

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:
Comment and Compliance

Comment Date:
May 2, 2013

Print | Duplicate | Main Menu

COMMENT

Drawing Reference:

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

1.1 p1 last paragraph: To establish a base for these future muon experiments, the Muon Campus is being developed to house these future experiments. The MC Beamline Enclosure connects the Delivery Ring (previously known as the Pbar Debuncher Ring) to both the Mu2e Detector Hall and Service Building and the MC-1 Building to house the M-4 and M-5 beamlines.

RESPONSE

Project Contact Response:

Agree and will incorporate comments

Comment:

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
Mary Convery

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:
Comment and Compliance

Comment Date:
May 2, 2013

Print | Duplicate | Main Menu

COMMENT

Drawing Reference:

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

1.3 p5: Under Project Director the responsibility to "secure any additional funding" should fall to me (should probably add a heading for me as Program Coordinator)
2.2 p17: typo Gg-2
2.2 p24: "Recovery Ring" -> Delivery Ring
2.5 p29: "2011 dollars" -> 2013?
3.2 p40: typo "2015(FY14)"
3.5 p46: Particle Physics Division -> Accelerator Division

RESPONSE

Project Contact Response:

Agree and will incorporate comments

Comment:

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
Bill Shull

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:
Design Phase

Comment Date:
June 20, 2001

Print Duplicate Main Menu

COMMENT

Drawing Reference:

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

1) Drain trays with drains under heat exchangers provided?

2) Clean - in - place supply and return fittings provided?

RESPONSE

Project Contact Response:

Not Applicable

Comment:

[I believe this comment was entered in error.- JH] This comment Can you give me material and size on the drain tray (ie, is it HX +2", how deep)?

There are no heat exchangers on this project. (TL)

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
Wayne Schmitt

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:

Comment Date:
May 2, 2013

Print | Duplicate | Main Menu

COMMENT

Drawing Reference:

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

I note that the naming convention for the Muon Campus introduces potential confusion with the already-existing Meson Center beamline, which is often abbreviated as "MC". Although I believe the individual beamlines to be M1, M2, etc., collectively referring to them as "MC Beamline Enclosures", as is done on the Comment and Compliance email message, should be avoided when possible.

RESPONSE

Project Contact Response:

Thank You for Reviewing this Project

Comment:

No comment

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
B. Schopp

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:
Comment and Compliance

Comment Date:
May 3, 2013

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COMMENT

Drawing Reference:

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

No comment at this time.

RESPONSE

Project Contact Response:

Thank You for Reviewing this Project

Comment:

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
David Baird

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:
Comment and Compliance

Comment Date:
May 2, 2013

Print Duplicate Main Menu

COMMENT

Drawing Reference:

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

One comment:

Several of the links to the reference documents in Appendix B on page 70 are broken and require updating.

I have signed the ESH&Q Design Review Traveler.

RESPONSE

Project Contact Response:

Agree and will incorporate comments

Comment:

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
Gerald Annala

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:
Comment and Compliance

Comment Date:
May 2, 2013

Print | Duplicate | Main Menu

COMMENT

Drawing Reference:

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

Section 2.2 states that Mu2e will relocate ICW and DWS lines as well as an electrical duct bank from Giesse Rd. substation prior to beam line excavation. I don't believe either of these are true. Mu2e does not expect to have CD3 approval until the middle of FY15.

RESPONSE

Project Contact Response:

Disagree for Reasons Noted Below

Comment:

Mu2e site work planned to start July of FY14.

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
Gerald Annala

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:
Comment and Compliance

Comment Date:
May 2, 2013

Print | Duplicate | Main Menu

COMMENT

Drawing Reference:

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

The Integrated Project Team Responsibility Matrix should contain a column for the Muon Campus Program Manager (Mary Convery). She should be listed under the Integrated Project team. Suggestions for entries in the new column and how they should be shared with the Fermilab Project Director are being sent to the Project Manager.

RESPONSE

Project Contact Response:

Agree and will incorporate comments

Comment:

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
Gerald Annala

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:

Comment Date:
May 2, 2013

Print

Duplicate

Main Menu

COMMENT

Drawing Reference:

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

The M4 line magnet table shows the extraction Lambertson and extraction C-magnet being part of an AIP. These are actually installed by the g-2 project.

RESPONSE

Project Contact Response:

Thank You for Reviewing this Project

Comment:

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
Chris Jensen

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:
Comment and Compliance

Comment Date:
April 22, 2013

Print Duplicate Main Menu

COMMENT

Drawing Reference:

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:
2.2.3 (Page 24)

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

High efficiency lighting does not generally work in beam line enclosures. The radiation destroys electronics. It is expensive to retrofit and old fashioned magnetic ballast light is apparently more expensive than high efficiency lighting these days. The project call for high efficiency would seem to be in conflict with this unless explicitly stated as an exception or a radiation hardness requirement is added.

RESPONSE

Project Contact Response:

Thank You for Reviewing this Project

Comment:

Magnetic ballast are no longer available. The only lights that we can find that are non-electronic and cost effective are standard bulbs incandescent. These bulbs also will be available for a finite amount of time but is the only solution provided by the FESS/Eng. electrical engineer.

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
Amber Kenney

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:
Comment and Compliance

Comment Date:
May 2, 2013

Print | Duplicate | Main Menu

COMMENT

Drawing Reference:

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:
2.3.4

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

Paragraph 2.3.4 infers that the NEPA review is yet to be done. But the NEPA review has been completed for the MC beamline enclosure. It was included as part of the Mu2e and MC1 Building review. A CX was approved by FSO on 6/12/12: https://esh-docdb.fnal.gov:440/cgi-bin/RetrieveFile?docid=2112;filename=1%20Muon%20Campus%20NEPA-CX%20Approval%20June%20CY2012.pdf;version=1.

I also support the other comments about 'Muon Campus beamline' being confusing with

RESPONSE

Project Contact Response:

Agree and will incorporate comments

Comment:

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
Mary Convery

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:
Comment and Compliance

Comment Date:
May 2, 2013

Print | Duplicate | Main Menu

COMMENT

Drawing Reference:

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:
3.2.5

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

I would like to see the milestone for Construction Complete fall within the window necessary in order to not delay Mu2e or g-2. If that date slips, the Muon Campus Program will be in trouble with the DOE regardless of whether the GPP specifically is in trouble with the DOE.

RESPONSE

Project Contact Response:

Disagree for Reasons Noted Below

Comment:

The included milestones include a full range of contingencies

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
T. Leveling

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:
Design Phase

Comment Date:
April 23, 2013

Print Duplicate Main Menu

COMMENT

Drawing Reference:
6-10-22

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

The shielding over the M5 line has not been reviewed to determine if it is adequate. The main question is whether or not losses in the M4 line can penetrate the M5 beam line berm and/or the MC-1 service building through shallow angles relative to the beam direction.

RESPONSE

Project Contact Response:

Agree and will incorporate comments

Comment:

Will add comment that the shielding may change after it has been evaluated.

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
Gary Lauten

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:
Comment and Compliance

Comment Date:
April 23, 2013

Print | Duplicate | Main Menu

COMMENT

Drawing Reference:
C-1, S-1 through S-10

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

I cannot review these drawings without a preliminary shielding assessment. A preliminary shielding assessment would provide me the basis for determining if these plans are sufficient for radiological purposes.

RESPONSE

Project Contact Response:

Agree and will incorporate comments

Comment:

Will add comment that the shielding may change after it has been evaluated.

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
D. Cossairt

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:
Comment and Compliance

Comment Date:
May 2, 2013

Print Duplicate Main Menu

COMMENT

Drawing Reference:
General

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

The drawings included with the package show specific amounts of radiation shielding. This project has not undergone a complete design and a review by the Shielding Assessment Subcommittee. This is required before the design is finalized.

RESPONSE

Project Contact Response:

Agree and will incorporate comments

Comment:

Shielding assessment drawings will be developed and will require approval for construction prior to notice to proceed.

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
D. Cossairt

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:
Comment and Compliance

Comment Date:
May 2, 2013

Print | Duplicate | Main Menu

COMMENT

Drawing Reference:
General

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

This is a comment about nomenclature. Using the abbreviation "MC" to denote a feature of the Muon Campus makes total sense except for the fact that it is also the designation of designation of a Fermilab 120 GeV beamline that is currently active, M-Center.

RESPONSE

Project Contact Response:

Thank You for Reviewing this Project

Comment:

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
James Morgan

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:
Comment and Compliance

Comment Date:
May 2, 2013

Print Duplicate Main Menu

COMMENT

Drawing Reference:
None

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

Beamline magnet lists in section 2.2 that were made by me show magnets that will be outside of the new tunnel enclosures. If that's not what you want, I will be willing to make new lists that show which tunnel enclosure they can be found in.

RESPONSE

Project Contact Response:

Thank You for Reviewing this Project

Comment:

Fermilab

FESS/Engineering

Please ensure that your review included a review of the project for appropriateness of the proposed systems, impacts on existing systems and operations and specific technical requirements to be incorporated into the design

PLEASE ENTER THE FOLLOWING INFORMATION

Reviewer:
James Morgan

Project Number
6-10-22

UIP ECP (If applicable)

Project Phase:
Comment and Compliance

Comment Date:
May 2, 2013

Print | Duplicate | Main Menu

COMMENT

Drawing Reference:
S-6 thru S-10

START WITH PAGE NUMBER FIRST FOLLOWED BY SECTION OR DETAIL REFERENCE. Example: A-1, Detail 4

Specification Reference:

PROVIDE SPECIFICATION SECTION AND PARAGRAPH IF APPLICABLE. Example: 02070 1.5.D.2 (Page 02070-2)

Comment:

Location of tunnel cable trays and utilities, as presently shown on the tunnel sections, will likely lead to conflicts with how the beamline magnets are supported. The monorail system at the downstream end of the M4/Mu2e tunnel also may not work with the proposed tunnel shielding for Mu2e commissioning. I would recommend a small working group of FESS and AD personnel address these issues so that the drawings will more closely represent what will eventually be built.

RESPONSE

Project Contact Response:

Response Incomplete, Additional Information to Follow

Comment:

The current drawing indicate scope for the justification of the cost estimate. During final design the placement of the equipment will be further developed.