PennState

EEW Room 113 Cleanroom Study

The Pennsylvania State University

University Park, PA

GANNETT FLEMING

120 Regent Court, Suite 200
State College, PA 16801-7986

PSU Project No.00-08958.00

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EXECUTIVE SUMMARY

Study

The Pennsylvania State University, College of Engineering will be initiating a new Packaging Research Laboratory led by Dr. Madhavan Swaminathan. In preparation for the new laboratory, the University needs to understand the space and utility requirements, available space and utility capacity, and associated renovation and project costs.

Project Summary

Penn State tasked the Gannett Fleming Engineering team to evaluate the conditions of the existing Electrical Engineering West (EEW), Suite 113 Cleanrooms and assess the costs and viability of renovating this space into a new cleanroom. Additionally, the design team was tasked with evaluating a scenario of splitting the cleanroom program elements between EEW 113 and the existing cleanroom in the Millennium Science Complex (MSC). This study identifies program space requirements as well as HVAC and electrical needs to create the requested space conditions for the proposed cleanroom. A cost analysis was performed based on this study to provide appropriate funding guidance to the PSU team members.

The evaluation of the MSC facility was driven by the possibility of taking advantage of existing infrastructure and facilities already in place on campus to minimize the need for potentially costly and time-consuming utility infrastructure installations in EEW. The anticipated lack of utility infrastructure in EEW, including compressed dry air, nitrogen, deionized water, scrubbed exhaust, acid waste treatment, as well as electrical service capacity will require extensive upgrades or additions to meet the requirements of the new cleanroom space. The utility infrastructure in MSC, however, has more than sufficient capacity for the listed utilities and will only require minor modifications or extensions of existing systems to meet the requirements of the cleanroom additions. Additionally, MSC already has a team of cleanroom operators in place to be able to facilitate the additional equipment and processes, and a centrally supported location is highly advantageous to the University to leverage shared equipment across several departments.

Two other facilities were identified as possible locations for housing the new cleanroom. Both are in Innovation Park, but both lacked the required infrastructure and easy access to that infrastructure. Additionally, both would have presented less than ideal leasing arrangements for Penn State since neither location is owned by Penn State. These facilities were ruled out by PSU College of Engineering (CoE) early in the study phase.

Schedule

Penn State Office of Physical Plant (OPP), with input from Gannett Fleming, Inc., identified a likely schedule for the installation of the new cleanroom in each location. Below is a high-level milestone schedule. The construction duration is highly dependent on currently unknown material lead times, potential phasing due to work adjacent to occupied spaces and the ability to relocate of current occupants in a timely manner. The durations listed below are to be considered as minimum required time, with potential for longer durations.

Project Phase	Duration
• Funding Procurement	3 - 5 months
• Design Procurement	3 Months
• Design	6 - 9 Months
• Bid/Procurement	3 Months
• Construction	12 Months

PSU OPP therefore estimates it would be between over two years and almost three years from the date of this report until final project completion. The EEW/MSC hybrid scenario presents phasing possibilities that could potentially provide a small, time savings, however, this study assumes the same duration for both location scenarios.

PROJECT GUIDELINES

Codes & Regulations

The lab will be required to be designed and constructed according to the 2018 International Building Code suite of codes, and other applicable PA UCC requirements, as well as PSU Design Standards.

Assumptions & Qualifications

- The purpose of the conceptual design is to indicate the basis of design scope of work for the design phase and the opinion of budget cost on the proposed solution. These study documents should not be construed to be a final design for the project.
- This study is limited to mechanical and electrical improvements pertaining to the clean room, and the architectural and structural changes needed to support new lab equipment and new MEP systems. No site analysis is included in this study.
- It is assumed that the project will be required to be submitted to the Pennsylvania Department of Labor & Industry for review and for issuance of a construction permit as part of a Level 2 renovation.
- Access to the building and its components was limited. For the purpose of establishing existing conditions, the design team reviewed existing drawings and conducted visual site surveys. No destructive/exploratory surveys were performed as part of this study. Based on what was visible, the drawings made available were deemed to be relatively accurate.

General

This study includes preliminary conceptual layouts that are provided based on review and discussions of equipment requirements and available space within each of the subject buildings as known at the time of this study. A detailed review of equipment needs, space availability, and building utilities will need to be performed once the project moves into design.

Study concept layouts are based on the division of equipment into five categories representing the five processing stages of the packaging process. These five categories include:

- Wet Processing for plating, development, stripping and etching, including surface treatment and surface finish.
- Substrate Processing (Dry Processing)
- Assembly/Inspection, Surface Analysis
- Reliability (Non-Cleanroom)
- Materials Storage and Equipment Core Area

Design Requirements

The following list of design requirements was provided by the research team at the beginning of the study.

- All cleanroom areas are to meet Class Level ISO6 (FED Class 1000 with local containment at Class ISO5/FED100.
- Tight temperature and humidity control is critical, many resist and dielectric materials are hygroscopic.
    - Temperature: 68F+/- 2 Degrees
    - Humidity: 50% +/- 2%
- Lighting: Yellow (Eliminates 500 nm and below light). Required wherever none fully exposed/developed substrates will be processed.

- Building Vibration: Most equipment for research specifications down to 1um would be considered microelectronics manufacturing equipment.
    - IEST Criteria, Class VC-D, 6.25 mm/s (250 min/s) between 1 and 80 Hz.
    - Some Class VC-E, 3.1 mm/s (125 min/s) between 1 and 80 Hz, these require their own Isolation pads.
- Acid/Chemical Exhaust with EPA Mandated Scrubber Required: Volume to be determined.
- General Exhaust Required: Volume to be determined.
- Chemical Storage/Waste Management: 5gal Plating/Develop/Strip/Etch/Surface Treatment/Surface Solutions
- Ultra-Pure Water: Type E1, per ASTM D 5127-13 18.1 Meg Ohm, as minimum. Type E1.1 preferred for less than 1um line and spacing. When installing ability to upgrade should be considered.
- Compressed Dry Air (CDA): Oil-free, filtered to .01um, compressed air dried to a pressure dew point of -100 degrees F.
- Vacuum Pressure: 28 inches Hg.

Due to the nature of the research and the chemicals and chemical sensitivities off certain materials used for certain processes, the wet lab, including wet storage, requires physical separation from the other processes.

PROPOSED ALTERATIONS

Architectural

Project Locations

As indicated above, during the early stages of this study, Penn State determined that two scenarios for project location were to be examined by the study team. These scenarios were developed to allow the University and the researcher to compare the suitability of each to the goals of the project related to budget, schedule and work-flow efficiency.

During the study, several meetings with representatives of the researcher and the College of Engineering were held to establish ideal workflows, equipment adjacencies and infrastructure needs. Based on these discussions, preliminary conceptual plans were developed as proofs of concept and as basis for the opinion of budget for each scenario. Preliminary concepts relating to programming and layout within each given project locations were developed. The concepts developed are highly conceptual and should not be considered as final design.

Refer to the preliminary conceptual plans in Appendix (A) related to each scenario below.

Figure 1: Location Map

Electrical Engineering West (EEW) – Suite 113 Scenario

The first scenario was identified to allow the research to be performed within a single facility, consolidating all the process stages into one laboratory. This involved the evaluation of a new complete cleanroom, including support spaces. The University identified the eastern portion of the north wing of the first floor of Electrical Engineering West (EEW). This included areas renovated in both the 1987 Microelectronics Research renovation project (PA-2-3-01007) and the 1991 DGS renovation project (D.G.S. 800-182S). This area is identified as Cleanroom 113 but excludes Laboratory 113L. Refer to Figure 2 below.

The total area to be renovated in this scenario is approximately 5,100 square feet (sf).

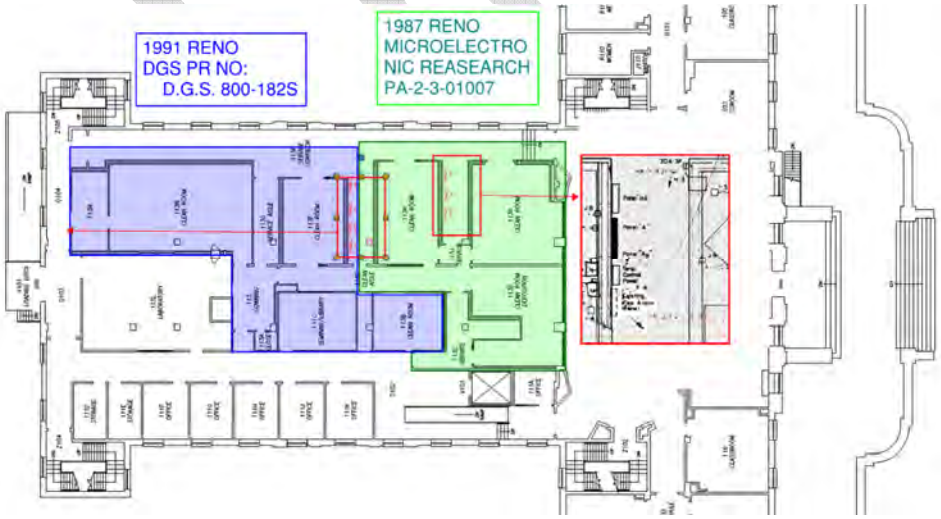

Figure 2: EEW Prior Renovations

Millennium Science Complex – North Wing Clean Room Expansion Hybrid Scenario

The second scenario was identified to potentially expedite the project schedule while taking advantage of existing infrastructure to support certain lab processes, and at the same time minimizing installation costs associated with the project. This included the installation of the lab in two locations. A portion of the clean room would be installed mostly in the area of the 1987 Microelectronics Research lab and the other portion in and adjacent to the existing clean room in the North wing of the Millennium Science Complex (MSC). The MSC currently contains much of the required infrastructure for many processes within the lab, and the lab itself shares several processes with other research already housed in MSC. This scenario supports the idea of interdepartmental collaboration and would create certain efficiencies of use of equipment.

Clean Room 113B, while a part of the 1991 renovation as indicated in Figure 2, will likely be required to be renovated as part of the hybrid scenario.

The total area to be renovated in this scenario is approximately 5,300 square feet (sf). This includes 2,300 sf in EEW and 3,000 sf in MSC.

Cleanroom Construction

With the removal of existing cleanroom structure for the EEW 113 full renovation Gannett Fleming received a quote from a contractor that has several years of experience in constructing clean rooms, including an installation at Penn State. This quote included the construction of the walls, doors, ceiling, installation of all equipment in the ceiling, certification and testing of the space (Alternate #3), and an onsite construction protocol (Alternate #2) during the first 8 weeks of construction on proper construction habits during the install. Static flooring system installation and furnishing cost (Alternate #1) is added into the architectural number. This does not include utility construction such as ductwork, piping, or electrical. This quote can be found in Appendix B.

The information received from the clean room contractor did not include the hybrid EEW 113/MSC option. Pricing for this has been extrapolated based on square foot difference between the two scenarios.

Lab Equipment List

The following equipment was provided by the research team and is considered, at the time of this study, to be required for the new laboratory. Figure 4 shows a preliminary division of equipment between the two project locations in the hybrid scenario. Figures 3a and 3b represent refined equipment locations based on input from cleanroom operators in the MSC building.

SUBSTRATE FABRICATION

PROCESS STEP	ITEM CODE	TOOL(S) / REQUIRED APPROACH	HYBRID LOCATION
SUBSTRATE VIA DRILLING AND CAVITY FORMING	SF1	OPTEC FEMTOSECOND INFRARED OR OTHER LASER MICRO-MACHINING SYSTEM	MSC CR EXPANSION
	SF2	UV PICO SECOND LASER	MSC CR EXPANSION
SUBSTRATE VIA DRILLING	SF3	INDUCTIVELY COUPLED PLASMA ETCH	MSC EXISTING CR
SUBSTRATE CLEANING AND ROUGHENING	SF4	RF PLASMA CLEANER – CF4, OXYGEN, NITROGEN, ARGON	MSC EXISTING CR
	SF5	HEATED ULTRASONIC CLEANER	MSC CR EXPANSION
	SF6	DRYING OVEN – N2 OVEN	MSC CR EXPANSION
ELECTROLESS COPPER DEPOSITION	SF7.1	20-24 TANK, CHEMCUT ELECTROLESS COPPER PLATING DEPOSITION SYSTEM	MSC CR EXPANSION
ELECTROLYTIC COPPER DEPOSITION – VIA, CONFORMAL, FINAL SURFACE	SF7.2	6-10 TANK, CHEMCUT ELECTROLESS COPPER PLATING DEPOSITION SYSTEM	MSC CR EXPANSION
WET FILM APPLY	SF8	LAUREN SPIN COATER WITH AUTO DISPENSE	MSC EXISTING CR*
DIELECTRICS	SF9	SLOT DIE COATER	MSC CR EXPANSION
PHOTO RESISTS	SF10	SLIT COATER	MSC CR EXPANSION
DRY FILM APPLY	SF11	ROLL LAMINATOR	MSC CR EXPANSION
DIELECTRICS	SF12	MEIKI MVLP300/300 VACUUM LAMINATOR	MSC CR EXPANSION
PHOTO RESISTS	SF13	PHI LAMINATION PRESS	MSC CR EXPANSION
EXPOSURE	SF14	SUSSMICROTECH MA8 MASK ALIGNER	MSC EXISTING CR*
	SF15	HEIDELBERG MLA300 DIRECT WRITE	MSC EXISTING CR
DEVELOP	SF16	CHEMCUT SPRAY DEVELOP	MSC CR EXPANSION
STRIP	SF17	CHEMCUT SPRAY STRIP	MSC CR EXPANSION
ETCH	SF18	CHEMCUT SPRAY ETCH	MSC CR EXPANSION
SOLDER/SOLDER MASK APPLY	SF19	ASYS SCREEN PRINTER	EEW 1987
DRYING/BAKING /CURING OVENS (3)	SF20A, SF20B, SF20C	N2 OVEN	MSC CR EXPANSION
PLANARIZATION	SF21	DISCO FLY CUTTER - DAS8930	MSC NON-CLEANROOM
DICING/SEPARATION	SF22	DISCO DICING SAW - DAD3240	MSC NON-CLEANROOM

* DENOTES EQUIPMENT ALREADY EXISTING IN INTENDED LOCATION

ASSEMBLY

PROCESS STEP	ITEM CODE	TOOL(S) / REQUIRED APPROACH	HYBRID LOCATION
SOLDER REFLOW	A1	LPKF PROTOFLOW S N2 REFLOW OVEN	EEW 1987
FLIP CHIP THERMO-COMPRESSION	A2	FINETECH - FINEPPLACER MATRIX -1UM ACCURACY	EEW 1987
BONDER	A3	TORAY ENGINEERING - FC3000S	EEW 1987
	A4	FINETECH LAMDA BONDER 3UM ACCURACY	EEW 1987
WEDGE BONDER	A5	ALUMINUM/GOLD WEDGE BONDER	EEW 1987
RIBBON BONDER (HFREQ)	A6	ALUMINUM/GOLD RIBBON BONDER	EEW 1987
WIRE/STUD BUMP/COINING	A7	GOLD BALL BONDER	EEW 1987
UNDERFILL DISPENSE	A8	GLENMARC PORTION-AIRE® BENCH TOP DISPENSERS	EEW 1987
HERMETIC SEALING	A9	HELIU/INERT CHAMBERED CAP WELDER	EEW 1987
COPPER BUMPING	A10	CU 3D PRINTER	EEW 1987

* DENOTES EQUIPMENT ALREADY EXISTING IN INTENDED LOCATION

RELIABILITY TESTING – NON CLEANROOM

PROCESS STEP	ITEM CODE	TOOL(S) / REQUIRED APPROACH	HYBRID LOCATION
AIR TO AIR THERMAL CYCLING	RT1	ESPEC BTZ-4200 -70 TO 180C	MSC BASEMENT OR OTHER
LIQUID TO LIQUID THERMAL CYCLING	RT2	ESPEC TSA-73EL-A	MSC BASEMENT OR OTHER
TEMP/HUMIDITY/BIAS STORAGE/HALT	RT3	THERMOTRON SE 300	MSC BASEMENT OR OTHER
HAST	RT4	ESPEC EHS-412MD	MSC BASEMENT OR OTHER

* DENOTES EQUIPMENT ALREADY EXISTING IN INTENDED LOCATION

Figure 3a: Equipment List

GENERAL CLEANROOM

PROCESS STEP	ITEM CODE	TOOL(S) / REQUIRED APPROACH	HYBRID LOCATION
COLD STORAGE FOR RESISTS, ETC.	SE1A, SE1B	EXPLOSION PROOF FREEZER -40C	MSC EXPANSION
	SE2A, SE2B	EXPLOSION PROOF REFRIGERATOR – 20F	EEW 1987
FUME HOODS	6 FT FUME HOOD 8 FT FUME HOOD	QTY TBD – 4 MIN	BOTH LOCATIONS
CHEMICAL STORAGE WITH SECONDARY CONTAINMENT	SE4		MSC EXPANSION

* DENOTES EQUIPMENT ALREADY EXISTING IN INTENDED LOCATION

INSPECTION / PROCESS VALIDATION

PROCESS STEP	ITEM CODE	TOOL(S) / REQUIRED APPROACH	HYBRID LOCATION
4PT PROBE STATION	IPV1	STATION TBD + AIR TABLE + LCR ELECTRONICS RACK	EEW 1987
OPTICAL INSPECTION	IPV2	CONFOCAL MICROSCOPE	MSC EXPANSION + EEW 1987
TOPOGRAPHY AND STRESS	IPV3	KEYENCE LASER MICROSCOPE ON AIR TABLE	MSC EXPANSION + EEW 1987
	IPV4	AKROMETRIX THERMOIRÉ AXP 2.0	EEW 1987
	IPV5	SHADOW MOIRE	EEW 1987
DELAMINATION AND VOID	IPV6	SONSCAN C-SAM	EEW 1987
WIRE BOND TESTER	IPV7	XYZTEC CONDOR SIGMA BOND PULL/SHEAR TESTER	EEW 1987
X-RAY INSPECTION	IPV8	DAGE XRAY INSPECTION SYSTEM	EEW 1987
ADHESION MEASUREMENT OF THIN LAYERS	IPV9	LUMIFRAC ADHEASION TESTER	MSC EXPANSION
THERMAL EXPANSION MEASUREMENT	IPV10	TA INSTRUMENTAL TMA Q400	MSC EXPANSION
POLYMER MATRIX AND ADDITIVES STRUCTURE ANALYSIS	IPV11	BRUKER NANOSCALE AFM-IR	EEW 1987
EMBEDDED WAVEGUIDE OPTICAL LOSS MEASUREMENT	IPV14	AUTOMATED SYSTEM TBD	EEW 1987
THERMAL CONDUCTIVITY / DIFFUSIVITY / IMPEDANCE CHARACTERIZATION	IPV12	NETSCH TIM-TESTER	EEW 1987
ELECTICAL CHARACTERIZATION	IPV13	HIGH V METER	EEW 1987
		PICO-AMMETER	EEW 1987
VISCOSITY MEASUREMENT	IPV15	RHEOMETER	MSC EXPANSION

* DENOTES EQUIPMENT ALREADY EXISTING IN INTENDED LOCATION

Figure 3b: Equipment List (cont.)

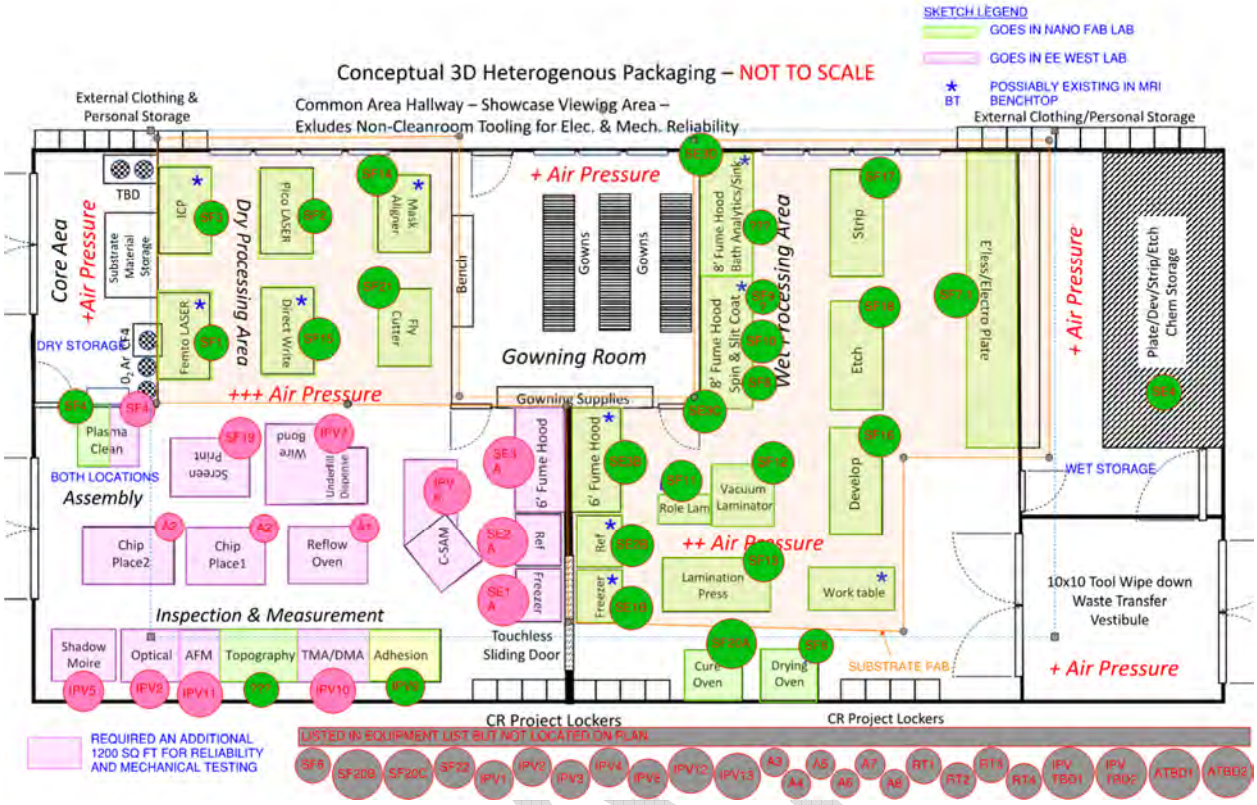

Figure 4: Early Study Partial Equipment Distribution Layout

Mechanical

Existing Conditions

Electrical Engineering West

The existing cleanroom in area 113 of EEW is conditioned by two packaged dx/electric rooftop units with electric reheat coils. These units are split between the cleanroom serving different spaces to a FED Class 1000 classification, which provides 180 air changes per hour (ACH). Supply air is provided from the rooftop unit to several recirculation fans in the space. These fans then supply air to HEPA diffusers laid out in the ceilings. Return air is captured low along the walls and returned to the recirculation fans and unit inside the modular cleanroom walls. Cleanroom exhaust is captured directly by exhaust fans on the roof.

This existing equipment is past its useful life and will be recommended to be replaced in the sections below to service the new cleanroom layout scenarios.

An existing compressed air system provides dry air at -100° F dewpoint to the building.

This building also has an existing DI and RO system below the cleanroom space.

Millennium Science Complex

The existing cleanroom space has all necessary utilities and airflow requirements to meet the expansion of EEW 113 cleanroom into MSC cleanroom space. This includes supply air, exhaust air, recirc air, heap filter diffusers, compressed dry air, nitrogen, DI water, etc.

Full EEW 113 Renovation

The new cleanroom will require a FED Class of 1000 (180 ACH) like the existing one. Temperature and humidity requirements for the cleanroom spaces are 68° F +/- 2 degrees and 50% RH +/- 2% year-round. Tight temperature and humidity control are critical to the operation of the cleanroom spaces.

The existing rooftop units are recommended to be removed and replaced with dedicated outside air units to serve the clean room. This air will be conditioned to maintain the temperature setpoint above using both chilled water and hot water. The rooftop unit will serve the cleanroom spaces through recirculation fan units to meet the air change requirement of each space. HEPA filter diffusers will be provided in the new ceiling layout to meet the filtration requirements of FED Class 1000. Return air will be captured low along the walls of the service corridors and ducted to the recirculation units of each space. Exhaust air will be captured through fume hoods and as general exhaust to maintain the pressurization requirements of the spaces. One exhaust fan will be provided on the roof to replace the existing fans of the clean room space. See below figure for pressurization diagram of the clean room space.

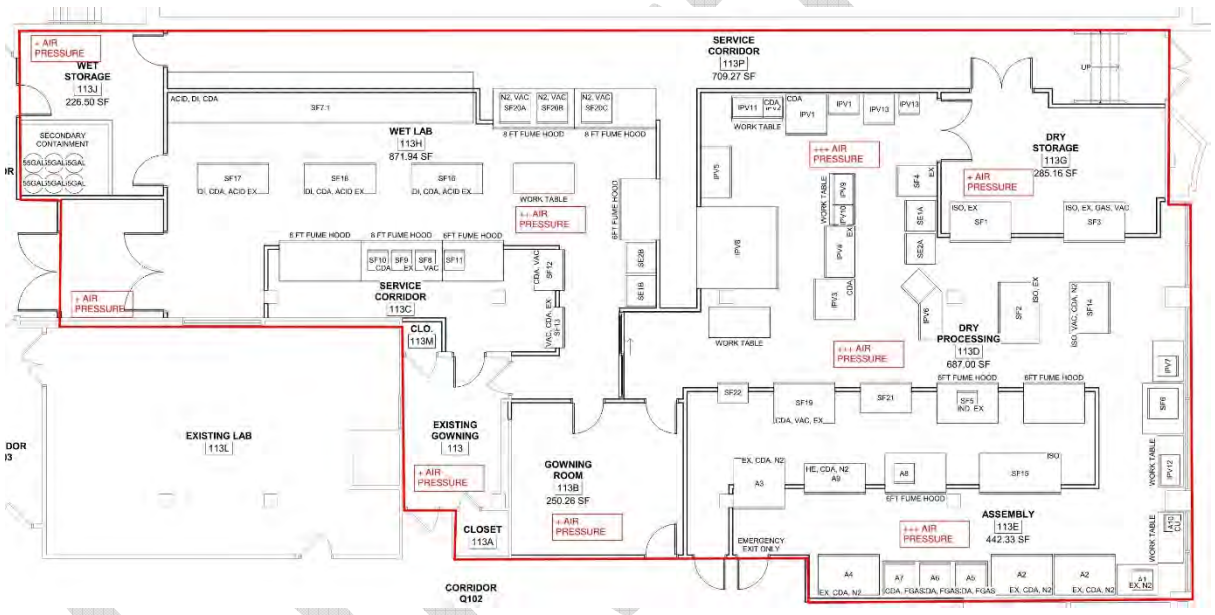

Figure 5: Cleanroom Pressurization Plan

Existing ductwork above the clean room will be removed and replaced as required to meet the new layout and pressurization requirements and locations of the new recirc fan units. Existing vertical ductwork from the roof to the first floor will be reused as appropriate and cleaned for supply and exhaust air.

A new exhaust scrubber will be required for the renovation to the EEW 113 cleanroom space.

Compressed air piping will be extended from the existing system and supplied throughout the new cleanroom layout for all required equipment.

DI water will be extended from the basement below to required locations throughout the cleanroom.

The addition of combination shower eyewashes will be required based on the chemical listing which includes sulfuric acid and hydrochloric acid.

An acid waste treatment system may be required in the upgrades to the EEW 113 cleanroom space.

Partial EEW 113 Renovation with Additional MSC Renovation

The new cleanroom space will occupy a portion of the existing cleanroom space in EEW 113 and MSC cleanroom. The EEW space will occupy the front portion of the cleanroom that is served by one of the existing rooftop units. The MSC cleanroom will be expanded near the entrance and an existing space will be taken near the back.

Electrical Engineering West

Like the full EEW 113 renovation the unit serving the front portion of the space will be removed and replaced with a new dedicated outside air unit. This air will be conditioned to maintain the temperature setpoint in the above section using either chilled water or dx and hot water. The rooftop unit will serve the cleanroom spaces through recirculation fan units to meet the air change requirement of each space. HEPA filter diffusers will be provided in the new ceiling layout to meet the filtration requirements of FED Class 1000. Return air will be captured low along the walls of the service corridors and ducted to the recirculation units of each space. Exhaust air will be captured through fume hoods and as general exhaust to maintain the pressurization requirements of the spaces. One exhaust fan will be provided on the roof to replace the existing fans of the clean room space. See below figure for pressurization diagram of the clean room space.

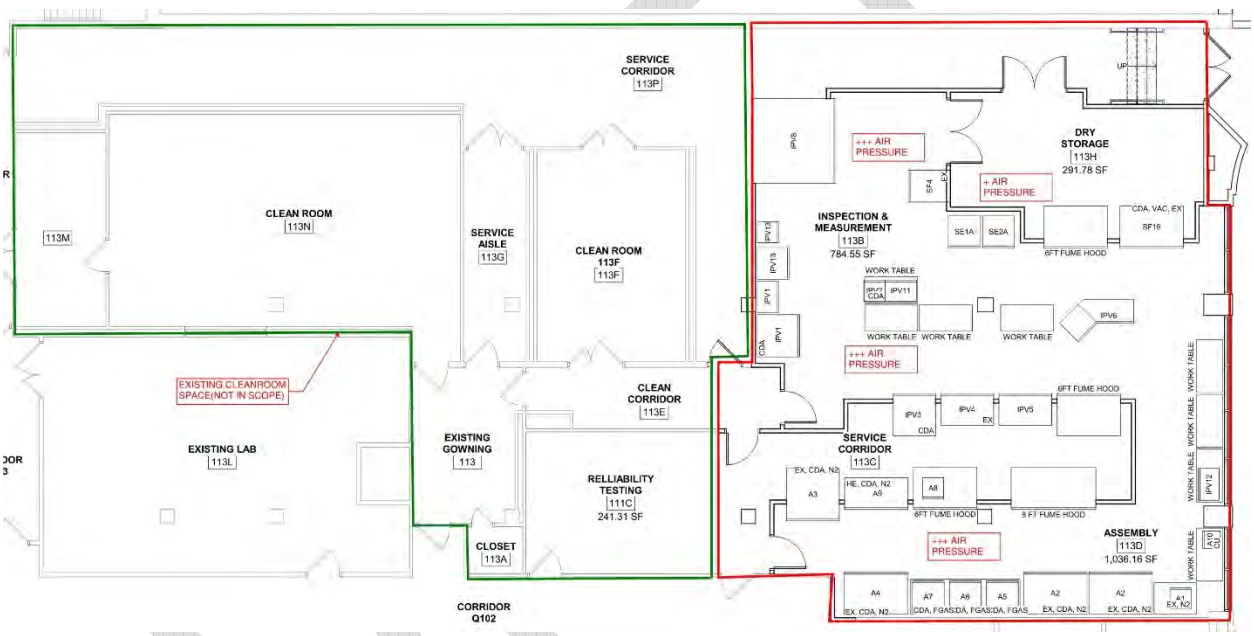

Figure 6: Cleanroom Pressurization Plan -Hybrid EEW

Existing ductwork above the clean room will be removed and replaced as required to meet the new layout and pressurization requirements and locations of the new recirc fan units. Existing vertical ductwork from the roof to the first floor will be reused as appropriate and cleaned for supply and exhaust air.

Compressed air piping will be extended from the existing system and supplied throughout the new cleanroom layout for all required equipment.

DI water will be extended from the basement below to required locations throughout the cleanroom.

The addition of a combination shower eyewash will be required based on the chemical listing which includes sulfuric acid and hydrochloric acid.

Millennium Science Complex

The existing cleanroom mechanical systems in MSC will be modified and extended to serve the new front portion of the hybrid EEW cleanroom. The existing mechanical systems will be modified as well for the

use of a back section of the cleanroom to meet the FED Class 1000 requirements. MSC has an existing exhaust scrubber that can be utilized.

All utilities required will be extended from the existing systems as required for the new equipment and layouts.

The addition of a combination shower eyewash maybe required in the expansion portion based on the chemical listing which includes sulfuric acid and hydrochloric acid.

See below figure for pressurization diagram of the cleanroom spaces in MSC.

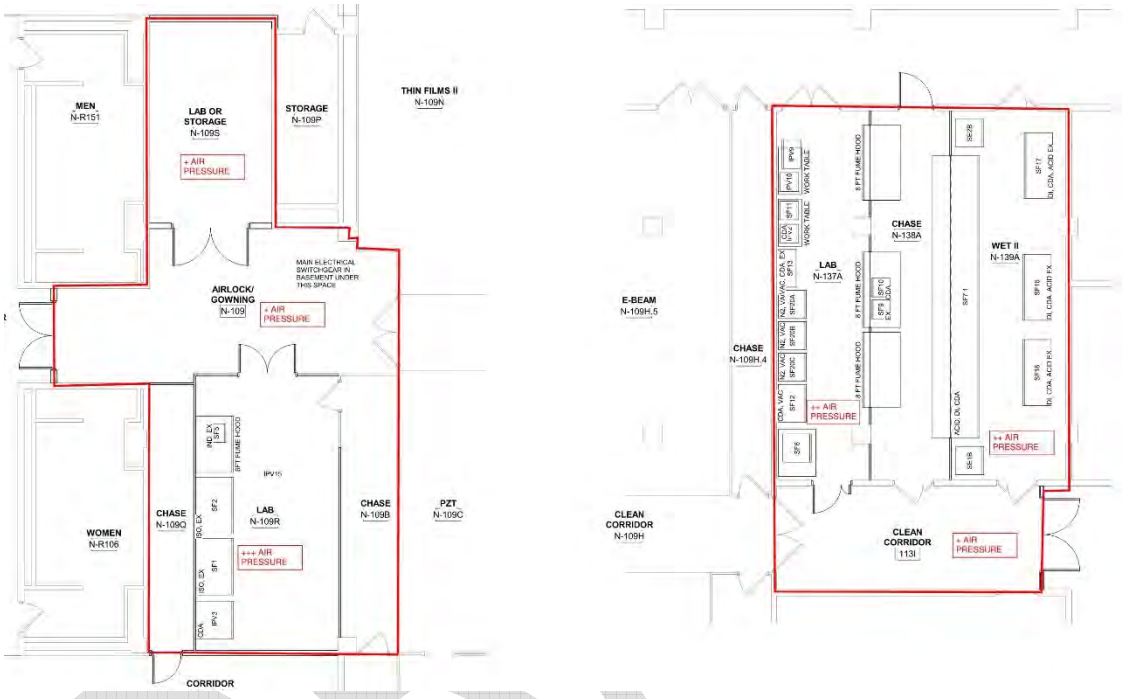

Figure 7: Cleanroom Pressurization Plan -Hybrid MSC

Fire Protection

The Electrical Engineering West building is not sprinklered. No work in this cleanroom space for fire protection will be required.

The Millennium Science Complex building is sprinklered. Modifications to sprinkler head locations and branch piping will be required to serve the additional clean room space added in MSC to the current lobby area on the first floor.

Electrical

Power Distribution

<u>EEW 113 Existing Conditions - Power Distribution</u>

The most current renovations to the Cleanroom 113 area occurred in/around 1987 & 1991 and were performed in separate phases as depicted below. Green representing the 1987 Micro-Electronic Research Renovation and blue representing the 1991 DGS Renovation.

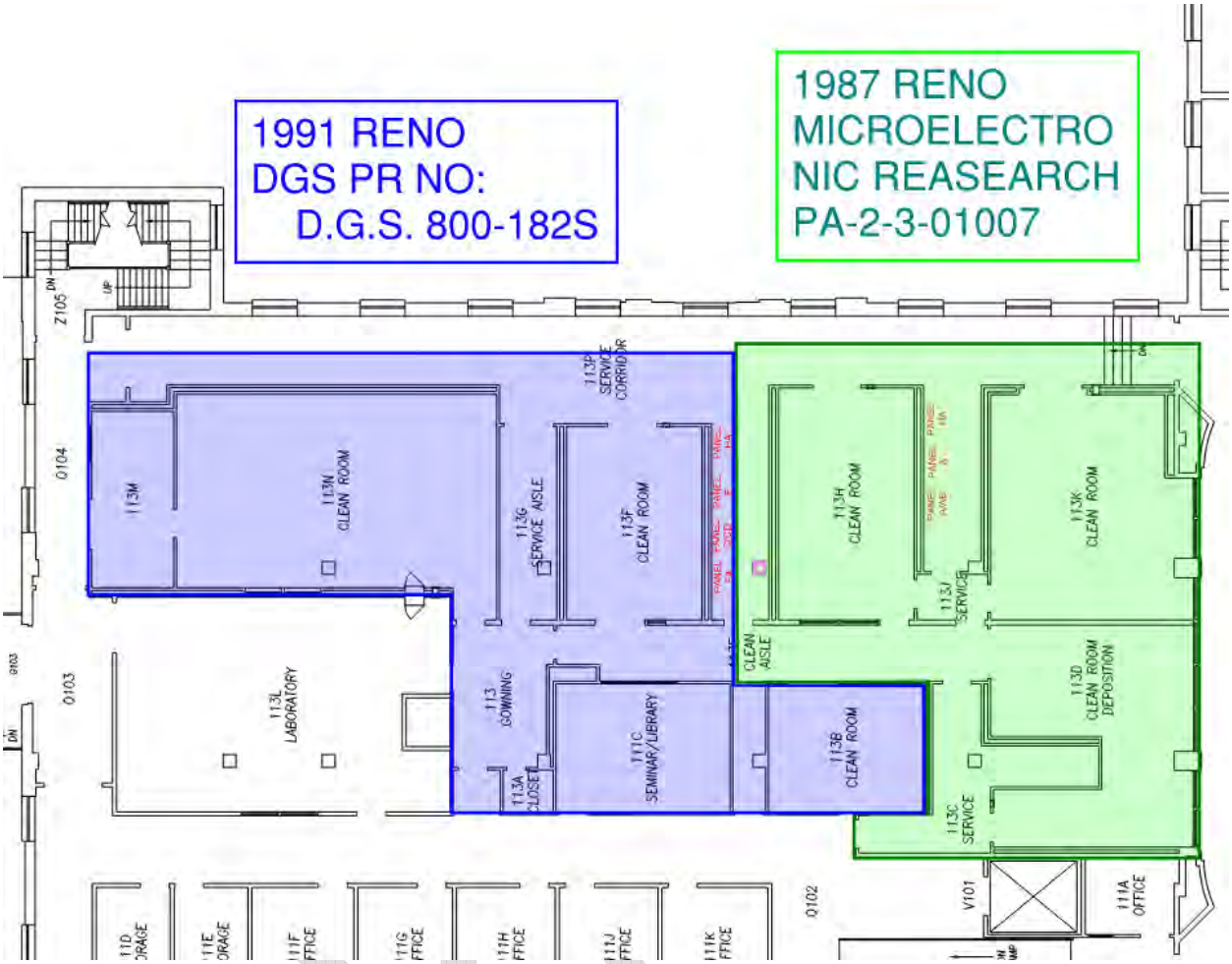

Figure 8: EEW Prior Renovations

In addition to the space renovations, major HVAC and Electrical building renovations were performed for the facility under both renovations. For the purpose of the electrical portion of this study we will refer to these two areas as “87” for the green 1987 renovation area and “91” for the blue 1991 renovation area.

The following electrical distribution equipment was installed and serves the represented areas as shown below. The panelboards for the 87 renovation are Westinghouse PRL1 & 2 series panels and the 91 renovation are Siemens Type S3 series panels. The existing panelboards are in fair condition, but new panels are recommended for the new renovations to ensure new and future breaker requirement availability.

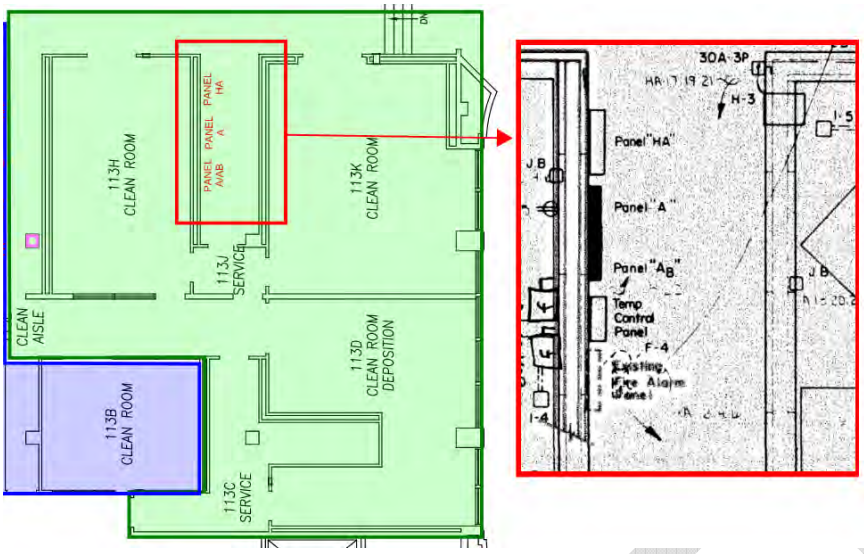

Figure 9: 1987 RENOVATION AREA PANELBOARDS

- HA – 400A, 480/277V, 3 Phase, 1 Section, fed from 4MSWB
- A – 400A, 208/120V, 3 Phase, 2 Section, fed from 2MDP
- A/AB - 400A, 208/120V, 3 Phase, 1 Section fed from 2MDP

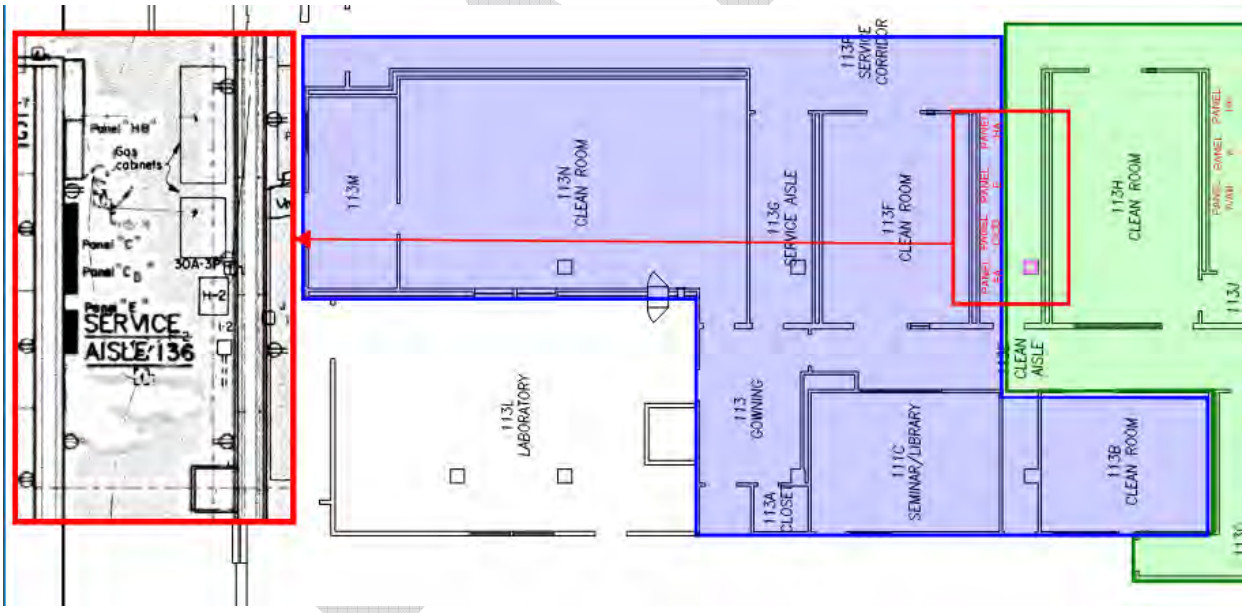

Figure 10: 1991 RENOVATION AREA PANELBOARDS

- HB – 400A, 480/277V, 3 Phase, 1 Section, fed from 4MSWB
- C /CD– 400A, 208/120V, 3 Phase, 2 Section, fed from 2MSWB
- E - 400A, 208/120V, 3 Phase, 1 Section, fed from 2MSWB

PHOTOS OF EXISTING PANELBOARDS ARE AVAILABLE UPON REQUEST

The existing panelboards installed during the renovations are fed from distribution switchboards which are in the main electrical room below the 87-renovation area as shown below. 4MSB and 2MSWB were installed during the 91 renovation and appear to be of a newer generation type switchboard. 2MDP appears to of an older renovation and of a later legacy distribution board. Breakers in 2MDP will require replacement during the renovations.

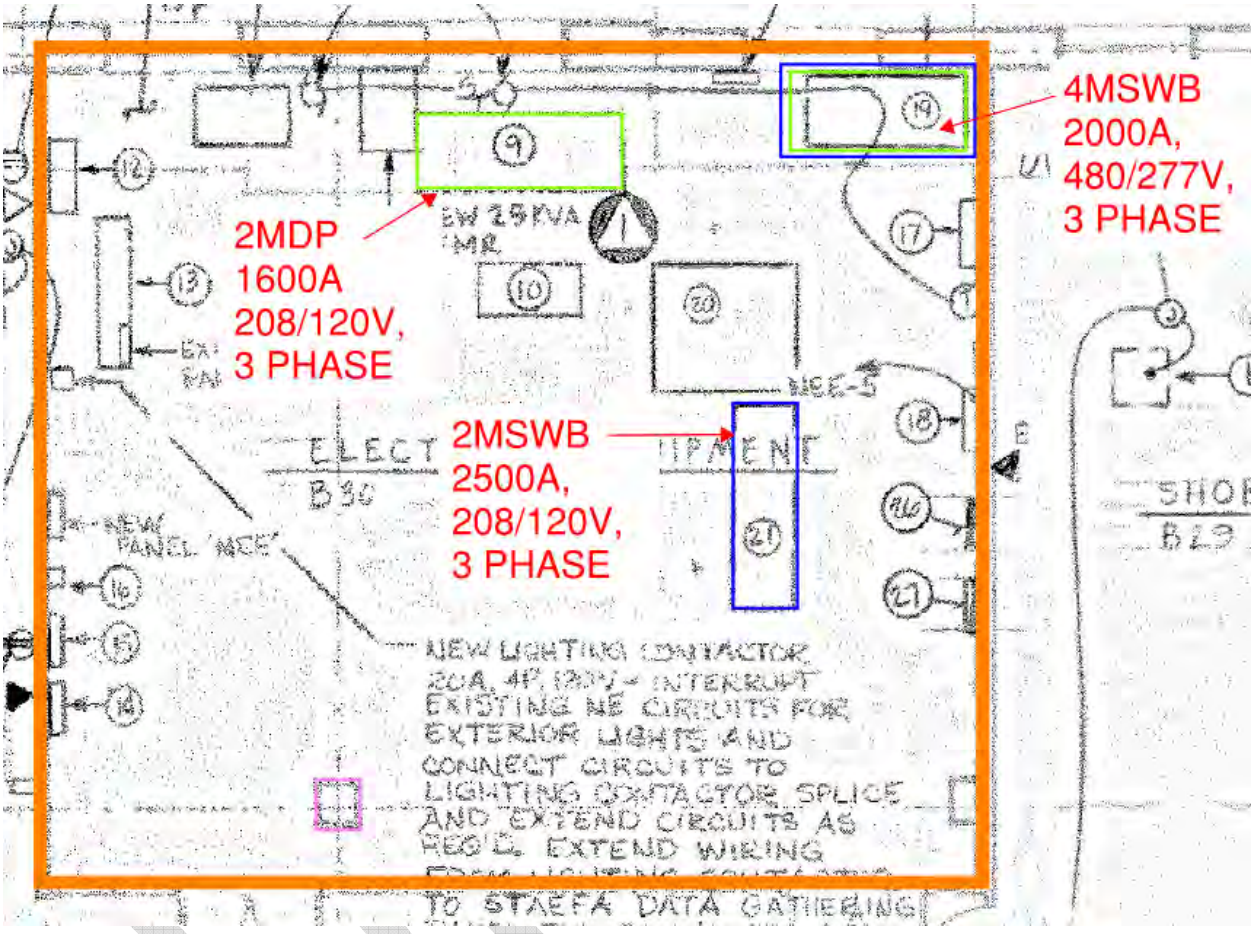

Figure 11: Main Electrical Room Distribution Switchboard Plan

Below are snapshots taken off the existing one-line diagram that shows the panelboard feeds. Breakers in the switchboards were verified during our study walkthroughs and the one-line diagram appears to be accurate for this equipment. A full one-line diagram as well as the equipment floor plan drawing for the facility is provided in Appendix C of this report.

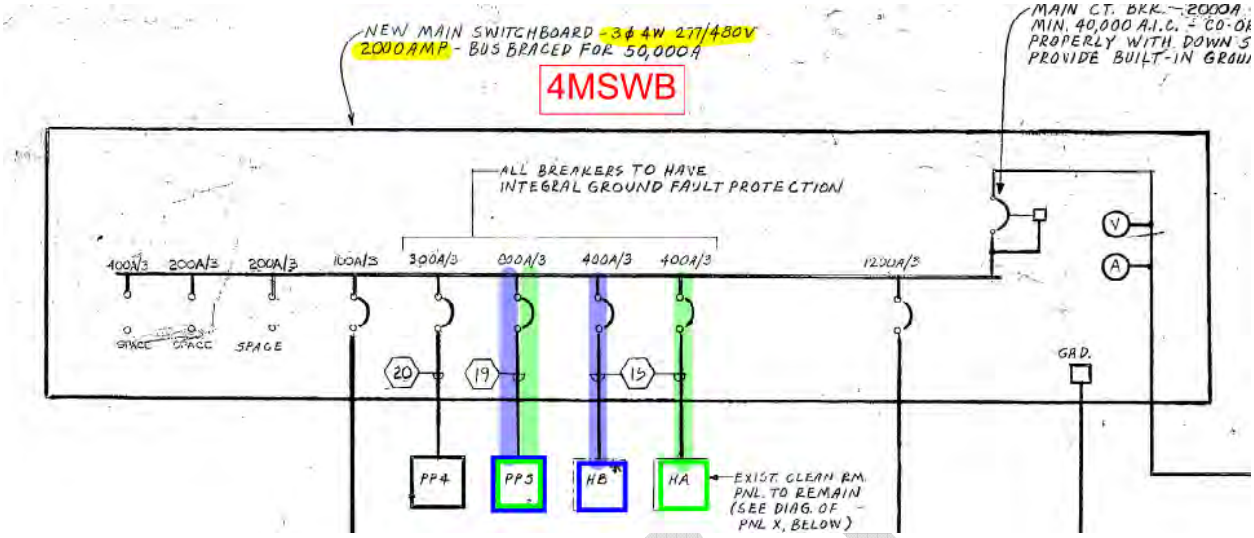

Figure 12a: One-line Diagram of Panelboard Feeds

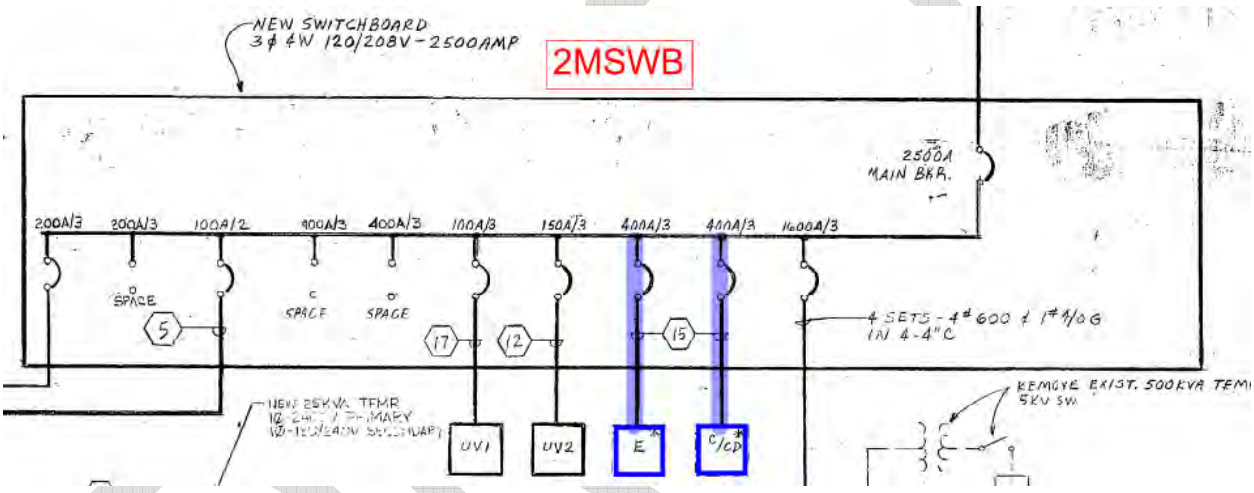

Figure 12b: One-line Diagram of Panelboard Feeds

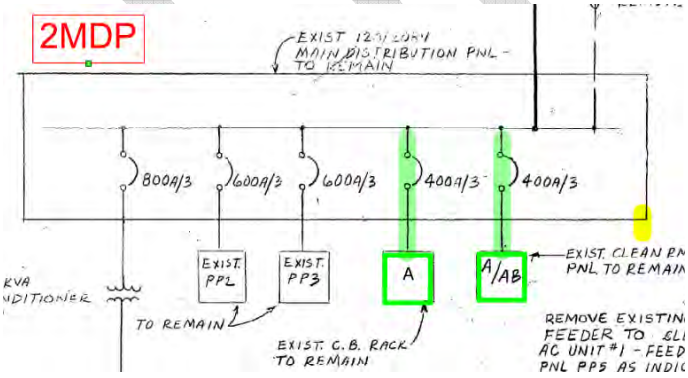

Figure 12c: One-line Diagram of Panelboard Feeds

Each renovation consisted of a new DX Cooling/Electric Heat roof-top mechanical unit as depicted below. Each unit is fed from a 480V, 3 Phase breaker in Panel PP5 in the Mechanical Equipment Penthouse on the roof. AC#1 is utilizing a 400A breaker in PP5 and AC#2 utilizes a 250A breaker in PP5. Panel PP5 is fed from an 800A breaker in 4MSWB in the main electrical room as shown in one-line diagram in the previous section.

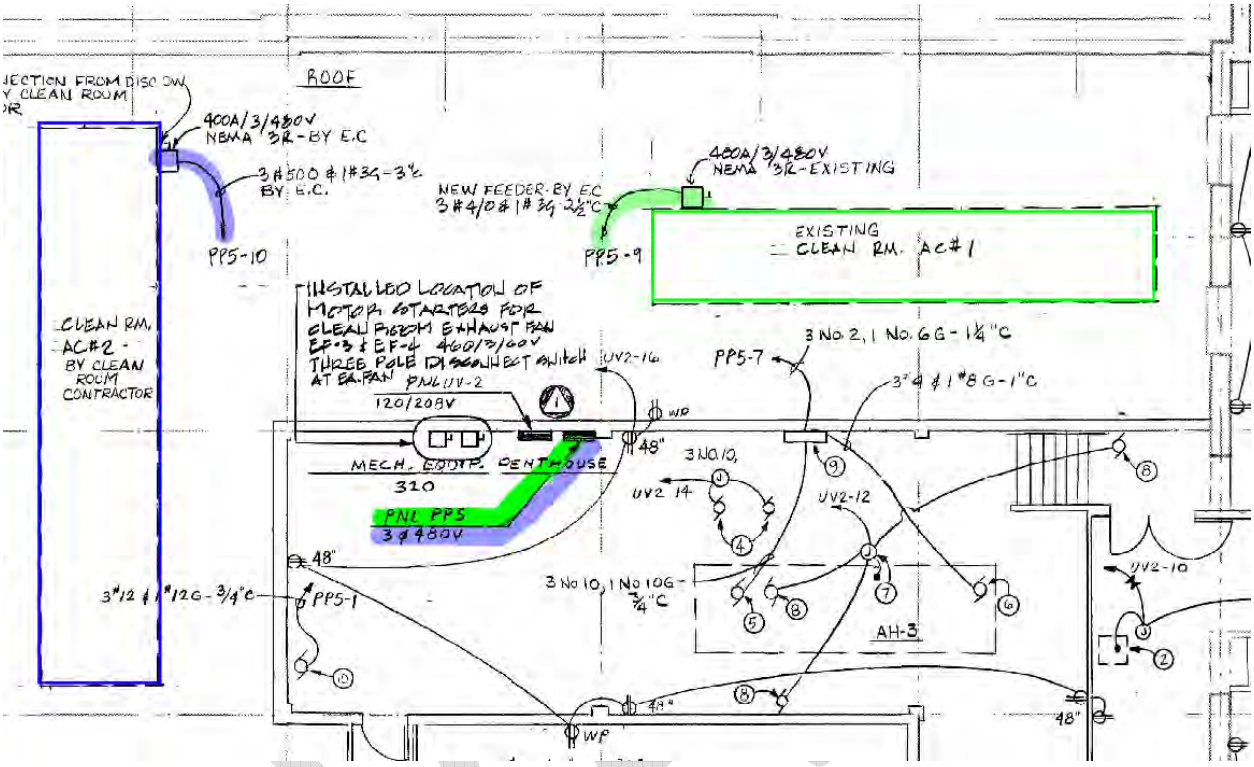

Figure 13: Rooftop HVAC Equipment Power Supply Plan

Full EEW 113 Renovation - New Power Distribution

Under a full renovation of Lab 113 for a new cleanroom space, it is our recommendation that the existing panelboards and associated feeders be demolished back to the distribution breakers in the switchboards within the basement. The existing breakers would then be utilized to feed new branch panelboards within the new space except for breakers within 2MDP. These breakers will need replaced. Based on the existing breakers and a 4,350 sqft renovation, the space would have the following power available:

480/277V, 3 Phase = 800A ~ 530 kVA ~ 120 VA/sqft @ 80% Rating

208/120V, 3 Phase = 1,600A ~ 460 kVA ~ 105 VA/sqft @ 80% Rating

Available Equipment Capacity = 990 kVA ~ 225 VA/sqft @ 80% Rating

Less the two feeds out of PP5 for proposed new mechanical equipment.

New mechanical equipment would utilize the 480/277V capacity that would now be available in panel PP5 after the demolition of the existing AHU's. Feeders for the new AHU's should marginally decrease with the utilization building hot water heat and the possibility of campus chilled water.

Based on the data available on power requirements for the new lab during this study phase, we feel that there is adequate power infrastructure available to serve a new cleanroom as described within this report.

Partial EEW 113 Renovation with Additional MSC Renovation - New Power Distribution

A partial EEW 113 Renovation would only include the 87 renovation space. Under these circumstances some of the equipment proposed for the new cleanroom would be housed in the MSC facility on campus.

In EEW the 87 renovation panelboards would be demolished and reuse of the electrical system capacity to new panels would be performed. Based on the existing breakers and a 1,975 sqft renovation, the space would have the following power available:

480/277V, 3 Phase = 400A ~ 265 kVA ~ 135 VA/sqft @ 80% Rating

208/120V, 3 Phase = 800A ~ 230 kVA ~ 115 VA/sqft @ 80% Rating

Available Equipment Capacity = 495 kVA ~ 250 VA/sqft @ 80% Rating

Less the single 400A feed for proposed new mechanical equipment.

The existing 400A 480/277V, 3 Phase breaker that serves the AHU for this space would be reused to feed the new AHU.

MSC renovations would use the existing infrastructure at MSC that has been verified as adequate by PSU for the proposed equipment to be housed in the renovation areas. The renovation areas in MSC will be split into two areas as shown below. Refer to Appendix C for large scale plans and the Architectural section for preliminary new equipment layouts.

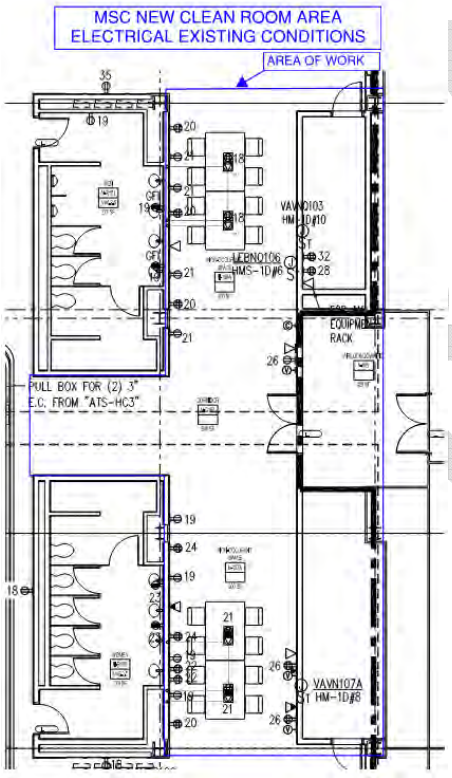

Figure 14a: MSC Existing Power Plan

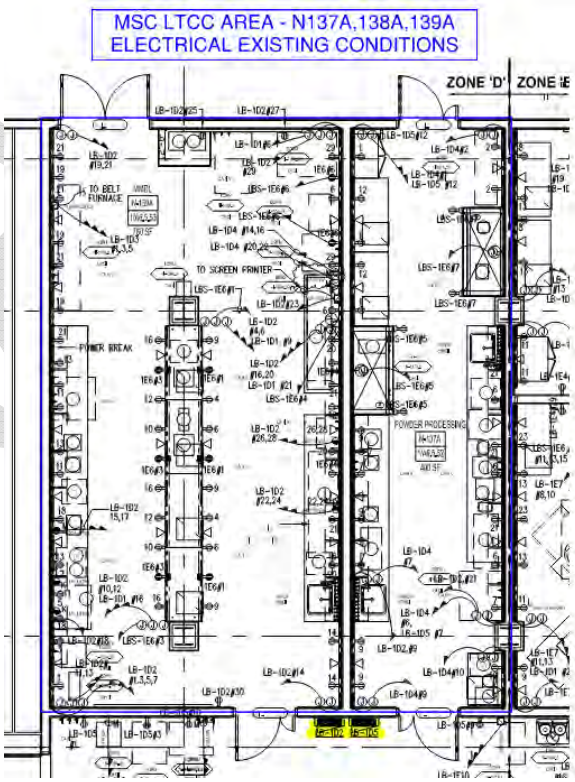

Figure 14b: MSC Existing Power Plan (LTCC)

The Clean Room Expansion Area will require a new two section 208/120V, 3 Phase panelboard for the new equipment. This panelboard is estimated as a 225A panel and feeder at this stage of the project and would be fed out of Panel SDP-1D which is located just outside of the project area on the first floor.

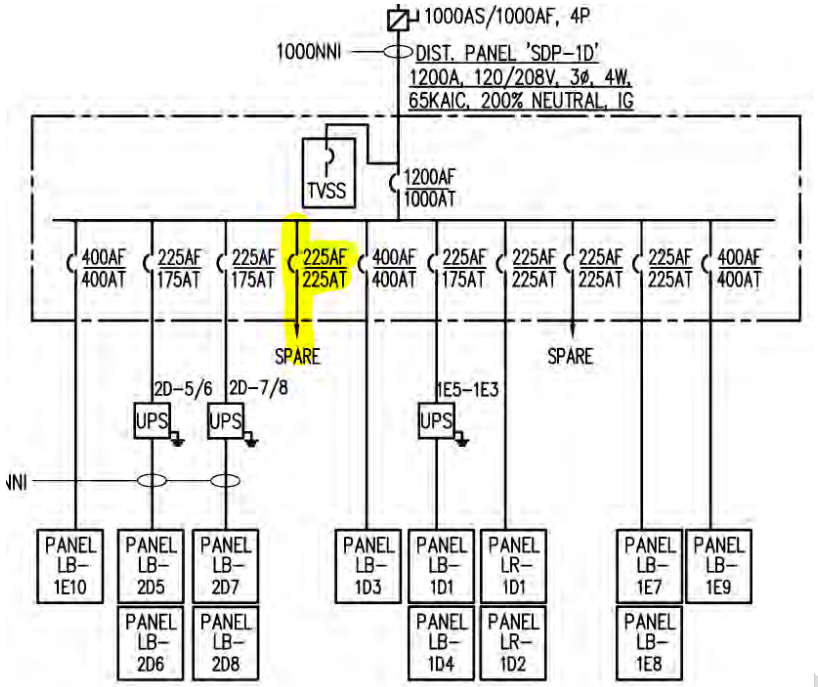

Figure 15: One-line Diagram of Power Distribution

The LTCC renovation area is in the existing cleanroom and is served by existing local panels LB-1D1 thru LB-1D5. For the purposes of the study we have assumed that these panels will be utilized to feed the new equipment for this renovation area.

Lighting & Lighting Control

EEW 113 Existing Conditions – Lighting & Control

The existing lighting within the EEW 113 Cleanroom area consists of recessed 2x4 fluorescent troffers and local manual control. Fixture lamps utilize lamp filters that have certain UV filters applied to them.

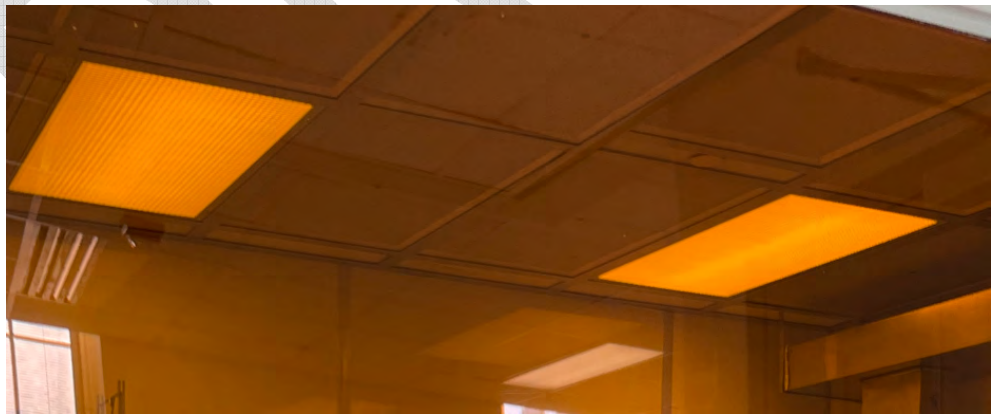

Figure 16: Photo of Existing Lighting

Lighting fixtures, lamps, wiring and local control will be demolished in the areas of work for this project.

Full EEW 113 Renovation - New Power Distribution

Lighting and controls within the cleanroom manufacturer walls and ceilings will be provided as part of the cleanroom but powered by the electrical contractor. All lighting and control outside of these areas will be based upon PSU OPP design standards.

Partial EEW 113 Renovation with Additional MSC Renovation - New Power Distribution

Renovation areas that remain within EEW sill have lighting, and control installed as described above. Lighting within MSC will follow MSC building and cleanroom standards. Lighting and control in the MSC LTCC Area will reused/reconfigured where possible.

Fire Alarm System

EEW 113 Existing Conditions

The existing Fire Alarm system is a Siemens XLS Digital Addressable fire alarm system. The main panel is located in the main electric room at appear to be in fair condition.

Full EEW 113 Renovation

The existing fire alarm devices we be demolished back to the main fire alarm panel and notification appliance circuit extenders in the basement. New notification appliances and initiation devises will be provided under the new work with wiring and conduit per PSU OPP design standards and manufacturer requirements.

Partial EEW 113 Renovation with Additional MSC Renovation

For EEW, the fire alarm renovations will be as depicted under the full renovation.

The MSC facility utilizes a similar Digital Addressable fire alarm system. Were possible, existing devices will be utilized/modified to suit the renovation areas. Additional notification appliances and initiation devises will be provided where required wiring and conduit per PSU OPP design standards and manufacturer requirements.

Communications

All existing cabling will be demolished back to the local telecommunications closet. Under the new work, new CAT 6 cabling will be provided as required for each lab space. Communications system will be installed per PSU OPP design standards.

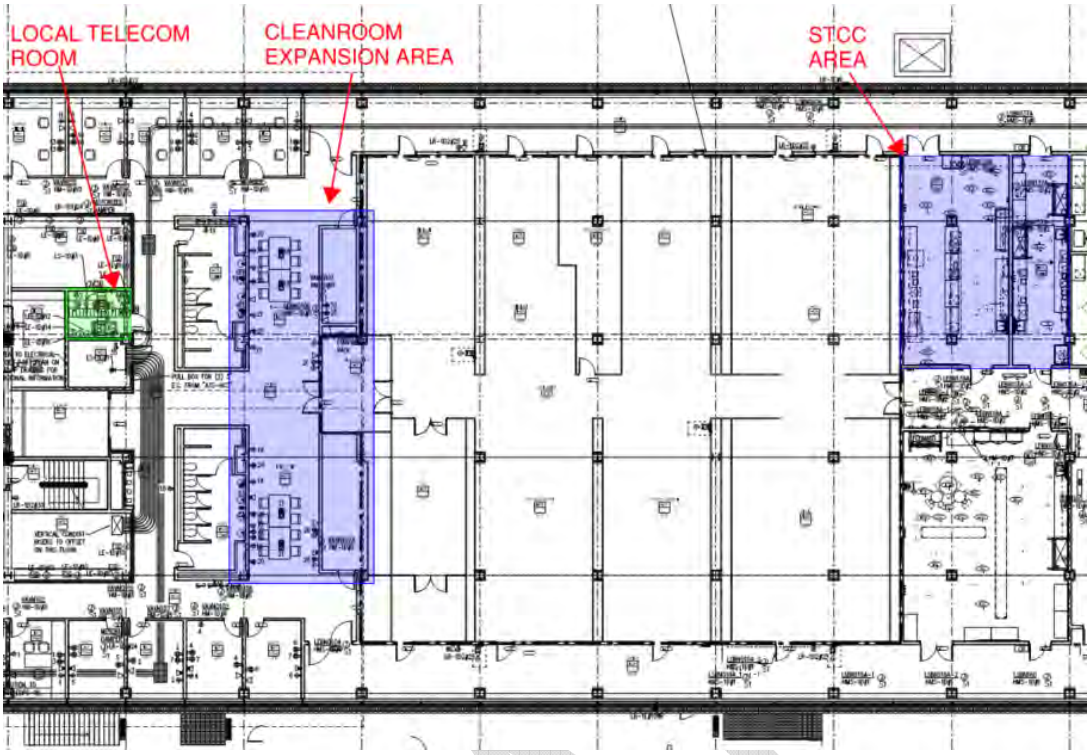

Figure 17: Telecommunications Room Location Plan

Security/Access Control

Both EEW and MSC have existing security and access control systems that are capable of serving the renovation spaces. New card readers, cameras, and associated devices/power would be added where deemed necessary by PSU. We have assumed devices would be required at the main entrances/exists of the spaces with several cameras per space for the purpose of this study and opinion of budget.

Gas Detection and Alarms

Full EEW 113 Renovation

A new gas monitoring system will be provided for the renovation for oxygen deficiency monitoring per the PSU EHS Gas Monitoring Program.

Partial EEW 113 Renovation with Additional MSC Renovation

A new gas monitoring system will be provided for the renovation for oxygen deficiency monitoring in EEW per the PSU EHS Gas Monitoring Program. New devices will be added to the existing MSC gas monitoring system and programed for the allocated space.

COST SUMMARY

Opinion of budget includes a construction contingency applied to the direct cost subtotal. Totals below include Overhead and Profit, Soft Costs, Permit Fees, Approvals, and Direct Costs to the University associated with the associated scope of work.

This budgetary estimate was completed using currently available 2022 construction costs with assumed escalation added for 2024 and 2025, which, based on the schedule, represents the time frame when project could be bid.

Market Escalation

In 2021 and 2022, the construction industry has experienced a record increase in project costs. Soaring construction demand, record inflation, pandemic-related restrictions, supply chain disruptions, labor shortages and the war in Ukraine have all contributed to these rising costs and uncertainty across the construction industry. According to the several national and global sources, construction costs in 2022 have increased approximately 15% with forecasted increases in 2023 and 2024 of approximately 5% per year. The opinion of budget numbers below are based on these speculated numbers and are subject to change based on unknown rate of market change volatility.

Opinion of Budget

Total (EEW 113/MSC)

- **2022: $6,777,381 USD**
- **2024: $8,132,857 USD**
- **2025: $8,539,500 USD**

Total (EEW 113)

- **2022: $8,953,818 USD**
- **2024: $10,744,581 USD**
- **2025: $11,281,811 USD**

See Appendix ‘B’ for additional costing information.

APPENDIX A

EEW 113 / MSC Cleanroom Hybrid Concept Layouts

- A101 - EEW 113 Partial Renovation Concept Layout
- A102 - MSC Partial Renovation Concept Layouts

A103 - EEW 113 Full Renovation Concept Layout

ELEVATION NOTES

1 MATTE FACE MASONRY SHALL BE USED AT ALL WALL MOUNTED LIGHT FIXTURES, COPINGS, AND OTHER WALL MOUNTED EQUIPMENT. COLOR TO MATCH ADJACENT MASONRY.
2 ENSURE SIZE AND LOCATIONS OF MASONRY WALL OPENINGS ARE COORDINATED WITH THE INSULATED CONCRETE FORMS.
3 ALL GUTTERS AND DOWNSPOUTS TO MATCH FASCIA COLORS.

COLOR KEY

- ASSEMBLY
- DRY PROCESSING
- INSPECTION / MEASUREMENT
- RELIABILITY TESTING
- SUPPORT

1 EEW FLOOR PLAN - HYBRID

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

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Gannett Fleming, Inc.

120 Regent Court
State College • PA • 16801
t 814 • 234 • 8625

www.gannettfleming.com

PSU BUILDING
ELECTRICAL ENGINEERING WEST (EEW) PSU Building No. 0302-000
MILLENIUM SCIENCE COMPLEX (MSC) PSU Building No. 0038-001

SEMI-CONDUCTOR LAB STUDY

PSU Project No. 00-08958.00

PennState

NO.	DATE	DESCRIPTION

REVISIONS

STUDY CONCEPT

PROJECT NUMBER: 072412

DESIGNED:	MODELED:	CHECKED:
MJS	MJS	DAS

DATE: 1/6/2023

DRAWING TITLE:
ARCHITECTURAL
EEW/MSC HYBRID
EEW FLOOR PLAN

DRAWING NO.:
A101

Local File: Autodesk Docs://State_College-2022_Projects/072412_PSU_EEW-Cleanroom_A_central_R22.rvt
\a_central_R19.rvt
Project Number: 072412
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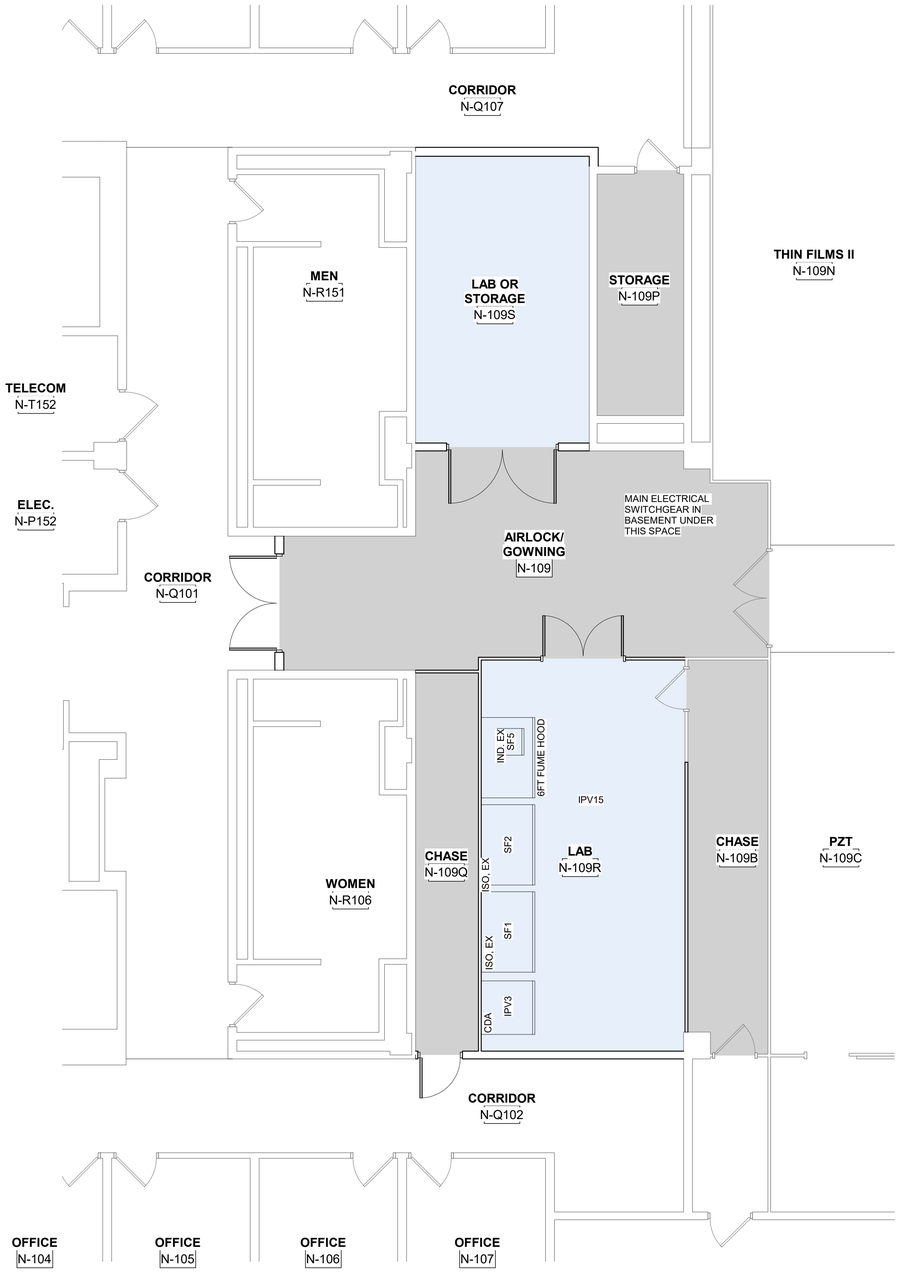
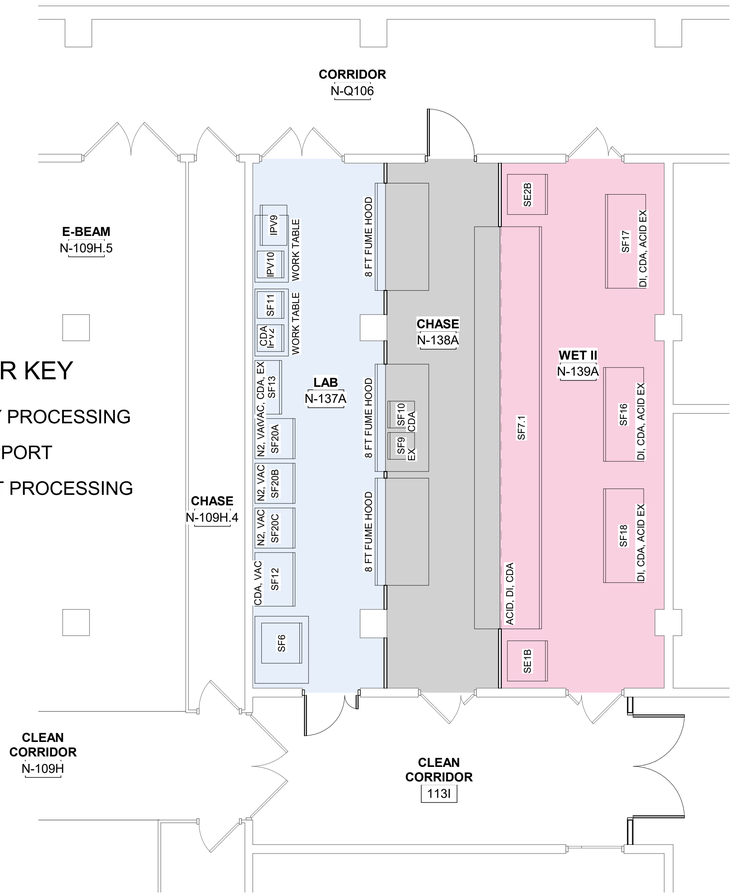


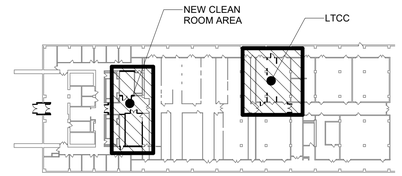
2 MSC FLOOR PLAN - NEW CLEAN ROOM AREA

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



3 MSC FLOOR PLAN - LTCC

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



1 MSC KEY PLAN

SCALE: 1/64" = 1'-0"

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MILLENIUM SCIENCE COMPLEX (MSC)
PSU Building No. 0038-001

SEMI-CONDUCTOR LAB STUDY

PSU Project No. 00-08958.00

PennState

NO.	DATE	DESCRIPTION

REVISIONS

STUDY CONCEPT

PROJECT NUMBER: 072412

DESIGNED:	MODELED:	CHECKED:
MJS	MJS	DAS

DATE: 1/6/2023

DRAWING TITLE:
ARCHITECTURAL
EEW/MSC HYBRID
MSC FLOOR PLANS

DRAWING NO.:

A102

COLOR KEY

- ASSEMBLY
- DRY PROCESSING
- EXISTING OFFICE
- INSPECTION / MEASUREMENT
- SUPPORT
- WET PROCESSING

1 EEW FLOOR PLAN

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

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PSU Building No. 0038-001

SEMI-CONDUCTOR LAB STUDY

PSU Project No. 00-08958.00

PennState

NO.	DATE	DESCRIPTION

REVISIONS

STUDY CONCEPT

PROJECT NUMBER: 072412

DESIGNED:	MODELED:	CHECKED:
MJS	MJS	DAS

DATE: 1/6/2023

DRAWING TITLE: ARCHITECTURAL
FULL EEW FLOOR PLAN

DRAWING NO.: **A103**

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Project Number: 072412
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APPENDIX B

Opinion of Budget Cost

FH Chase Quote

OPINION ON CONSTRUCTION COST
PROJECT SUMMARY

Job Name	Scenario 1: Hybrid EEW 113/MSC Renovation
Date	1/11/2023
Revision	R00
Client Proj. No.	00-08958.00
GF Proj. & Ph. No.	072412.EEW113

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SUB-CONTRACTOR

CONSTRUCTION TRADE / DESCRIPTION	% OF COSTS	MATERIAL & EQUIP COST	LABOR COST	TOTAL COST
CLEAN ROOM CONSTRUCTION (FH CHASE QUOTE)	46.0%	$1,200,000	$409,460	$1,609,460
STRUCTURAL	0.6%	$9,830	$12,070	$21,900
ARCHITECTURAL	14.2%	$219,004	$277,298	$496,302
MECHANICAL	19.1%	$391,024	$278,349	$669,373
PLUMBING	5.1%	$93,612	$84,374	$177,985
FIRE PROTECTION	0.2%	$580	$8,151	$8,731
ELECTRICAL	14.8%	$177,331	$339,444	$516,776
ADA UPGRADES (20%)	0.0%	$0	$0	$0
SUB-CONTRACTOR COST TOTAL		*$2,091,381*	*$1,409,146*	***$3,500,527***

PRIME CONTRACTOR

DESCRIPTION	ON M&E	ON LABOR	% OF COSTS	MATERIAL & EQUIP COST	LABOR COST	TOTAL COST
GENERAL CONDITIONS, DIV 1	15%	15%	75%	$313,707	$211,372	$525,079
COODINATION ITEMS WITH OWNER	5%	5%	25%	$104,569	$70,457	$175,026
PERMITS	0%	0%	0%	$0	$0	$0
		SUB-TOTAL No. 1		*$418,276*	*$281,829*	*$700,105*

DESCRIPTION	ON M&E	ON LABOR	% OF COSTS	MATERIAL & EQUIP COST	LABOR COST	TOTAL COST
OVERHEAD	10%	10%	71%	$41,828	$28,183	$70,011
PROFIT	3%	3%	21%	$12,548	$8,455	$21,003
STATE SALES TAX	0%	0%	0%	$0	$0	$0
PERFORMANCE BOND	1%	1%	7%	$4,183	$2,818	$7,001
		SUB-TOTAL No. 2		*$58,559*	*$39,456*	*$98,015*

DESCRIPTION	ON M&E	ON LABOR	% OF COSTS	MATERIAL & EQUIP COST	LABOR COST	TOTAL COST
CONTINGENCIES	20%	20%	100%	$513,643	$346,086	$859,729
OTHER	0%	0%	0%	$0	$0	$0
		SUB-TOTAL No. 3		*$513,643*	*$346,086*	*$859,729*
PRIME CONTRACTOR COST TOTAL				*$990,478*	*$667,371*	***$1,657,849***

CONSTRUCTION COST TOTAL	*$3,081,859*	*$2,076,517*	***$5,158,376***

OTHER PROJECT COSTS

DESCRIPTION	ON M&E	ON LABOR	% OF COSTS	MATERIAL & EQUIP COST	LABOR COST	TOTAL COST
A/E DESIGN COSTS	10%	10%	32%	$308,186	$207,652	$515,838
CLEAN ROOM DESIGN CONSULTANT	2%	2%	6%	$61,637	$41,530	$103,168
OWNER DIRECT COSTS				$1,000,000	$0	$1,000,000
OTHER PROJECT COSTS TOTAL				*$1,369,823*	*$249,182*	***$1,619,005***

TOTAL PROJECT COST	*$4,451,682*	*$2,325,699*	***$6,777,381***
2024 ESCALATION (20% Increase over 2022)			***$8,132,857***
2025 ESCALATION (5% Increase over 2024)			***$8,539,500***

OPINION ON CONSTRUCTION COST
PROJECT SUMMARY

Job Name	Scenario 2: EEW 113 Renovation
Date	1/11/2023
Revision	R00
Client Proj. No.	00-08958.00
GF Proj. & Ph. No.	072412.EEW113

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SUB-CONTRACTOR

CONSTRUCTION TRADE / DESCRIPTION	% OF COSTS	MATERIAL & EQUIP COST	LABOR COST	TOTAL COST
CLEAN ROOM CONSTRUCTION (FH CHASE QUOTE)	45.5%	$1,500,000	$603,860	$2,103,860
STRUCTURAL	0.7%	$14,745	$18,105	$32,850
ARCHITECTURAL	14.2%	$282,067	$373,096	$655,163
MECHANICAL	19.8%	$559,221	$355,834	$915,054
PLUMBING	4.7%	$133,576	$84,658	$218,233
FIRE PROTECTION	0.0%	$0	$0	$0
ELECTRICAL	15.2%	$234,552	$466,752	$701,304
ADA UPGRADES (20%)	0.0%	$0	$0	$0
SUB-CONTRACTOR COST TOTAL		*$2,724,160*	*$1,902,304*	***$4,626,465***

PRIME CONTRACTOR

DESCRIPTION	ON M&E	ON LABOR	% OF COSTS	MATERIAL & EQUIP COST	LABOR COST	TOTAL COST
GENERAL CONDITIONS, DIV 1	15%	15%	75%	$408,624	$285,346	$693,970
COODINATION ITEMS WITH OWNER	5%	5%	25%	$136,208	$95,115	$231,323
PERMITS	0%	0%	0%	$0	$0	$0
			SUB-TOTAL No. 1	*$544,832*	*$380,461*	*$925,293*

DESCRIPTION	ON M&E	ON LABOR	% OF COSTS	MATERIAL & EQUIP COST	LABOR COST	TOTAL COST
OVERHEAD	10%	10%	71%	$54,483	$38,046	$92,529
PROFIT	3%	3%	21%	$16,345	$11,414	$27,759
STATE SALES TAX	0%	0%	0%	$0	$0	$0
PERFORMANCE BOND	1%	1%	7%	$5,448	$3,805	$9,253
			SUB-TOTAL No. 2	*$76,276*	*$53,265*	*$129,541*

DESCRIPTION	ON M&E	ON LABOR	% OF COSTS	MATERIAL & EQUIP COST	LABOR COST	TOTAL COST
CONTINGENCIES	25%	25%	100%	$836,317	$584,007	$1,420,325
OTHER	0%	0%	0%	$0	$0	$0
			SUB-TOTAL No. 3	*$836,317*	*$584,007*	*$1,420,325*
			PRIME CONTRACTOR COST TOTAL	*$1,457,426*	*$1,017,733*	***$2,475,159***

CONSTRUCTION COST TOTAL	*$4,181,586*	*$2,920,037*	***$7,101,623***

OTHER PROJECT COSTS

DESCRIPTION	ON M&E	ON LABOR	% OF COSTS	MATERIAL & EQUIP COST	LABOR COST	TOTAL COST
A/E DESIGN COSTS	10%	10%	38%	$418,159	$292,004	$710,162
CLEAN ROOM DESIGN CONSULTANT	2%	2%	8%	$83,632	$58,401	$142,032
EQUIPMENT COSTS				$1,000,000	$0	$1,000,000
			OTHER PROJECT COSTS TOTAL	*$1,501,790*	*$350,404*	***$1,852,195***

TOTAL PROJECT COST	*$5,683,377*	*$3,270,441*	***$8,953,818***
2024 ESCALATION (20% Increase over 2022)			***$10,744,581***
2025 ESCALATION (5% Increase over 2024)			***$11,281,811***

December 6, 2022 Revised

Greg Munter

RE; Penn State Packaging Laboratory – Preliminary Programming Document

CLEANROOM WALLS, DOORS AND CEILINGS

Greg:

Below please find our preliminary budget pricing to build out the architectural components of the CR as described in Concept plan and programming provided to us.

- Cleanroom Class Level ISO6 (FED Class 1000 with local containment at Class ISO5/FED100

- Lighting – Yellow (Eliminates 500 nm and below light). Required wherever none fully exposed/developed substrates will be processed. I.E. Areas a,b below.
- Approximately 3,200 SF sq. ft. of space uinder CR grid-Tooling Footprint…Excludes areas or return air chases.
- 5 processing zones to combine like equipment support needs, a) Wet Processing for Plate/Dev/Strip/Etch) and (Surface Treatment/Surface Finish, b) Substrate Processing, c) Assembly/Inspect, Surface Analysis, d) Reliability, and e) Materials Storage and Equipment Core Area
- Provide Fan Filter Units.
- Added Costs for 3rd Party Independent Certification Company (alternate add)
- Provide temporary protection of flooring, wall, and ceiling surfaces following installation as required during subsequent construction work and activities.
- Division 11, 13, 22, 23 and 26 and the Cleanroom Contractor shall coordinate location of furnishings, equipment, mechanical, electrical, and cleanroom equipment prior to construction to eliminate any interferences.

50 Constitution Drive
Taunton, MA 02780-1070
www.fhchaseinc.com

Telephone: (508) 339-3309
Fax: (508) 339-3306
E-Mail: info@fhchaseinc.com

We look forward to the opportunity to review our proposal, qualifications and scope of this project.

Sincerely,
FH Chase, Inc.

Domenic Russo
President

Penn State Packaging Laboratory CLEANROOM WALLS, DOORS AND CEILINGS
Budget Price: One Million Seven Hundred Sixty-Six Thousand, Eighty Eight Dollars
$1,910,000.00

CONSTRUCTION ONLY WITH NO DESIGN ASSIST AS CURRENTLY PROPOSED.

STRUCTURAL SUSPENSION SYSTEM

FH Chase, Inc. will provide engineered drawings illustrating our aluminum plenum cap system supported by the existing roof structure (confirmation of load capacity by others, reinforcing of building steel by others if needed) Perimeter Cleanroom Walls allowing for a layout as shown in PDF Concept plan. The Plenum Cap will be 3" insulated panels strong enough to support maintenance personnel to access the top side during construction but does not include guardrails and is not intended as an occupied space.

The area covered by the Plenum Cap is approximately 5,000 SF. CR positive areas and return air chases.

Seismic bracing will be included per code and as needed to support our final system size and weight. Engineering costs and design is included.

A Structural engineer with the proper insurances will provide stamped drawings for the ceiling system components area, building capacity is by others.

CLEANROOM CEILING SYSTEM

We have included a complete installation of approximately 3200 SF of our UG Lite Ceiling System. The ceiling system will be installed at a 9' elevation AFF. The ceiling system is a Heavy-Duty Ceiling System that is designed to support the weight of; Lights, HEPA Filters and Cleanroom Blank Panels. (base bid is NOT a walk on ceiling)

Additional components included with the ceiling system:

- 2'x 4' Cleanroom LED light fixtures as shown on the drawings with and without amber light as needed.
- 2'x4' RSR Fan Filter Units with Cabinets or Equal with average of 40% Filter coverage or an equivalent total SF of filter media using 4'x4' units if better suited in final design or combination.
- Astro Factory control system for FFU's.
- All seismic bracing required.

CLEANROOM PARTITIONS

The perimeter wall system is designed to Skin the perimeter drywall supplied by others and epoxy painted by others. The panels will be 1/2" thick with battens 4' OC. All ceiling track, floor track and battens are epoxy coated steel or clear anodized aluminum. Wall panels have a painted steel skin on both sides with steel ribs and poly insulation interior or aluminum honeycomb core with aluminum skins.

The partition height will be 9'-0"

The Interior Partition System shall be 2" thick honeycomb with a cleanroom grade factory epoxy paint finish. Wall panels are finished on both sides. System is designed for bulkheading tools through openings and have a deflection head track direct mounted to the grid.

We Include:

- Approximately 340 LF of 9'-0" high Cleanroom Wall System perimeter liner wall.
- Approximately 406 LF of 2" Cleanroom Wall System with integral door frames.
- Corners and Battens as needed
- Protection of the modular wall system throughout the construction period using clean room approved products to properly protect walls so that it will be without any indication of use or damage at the time of substantial completion.

CLEANROOM DOORS

Cleanroom Grade Door units to interface with the wall systems. We include single door units and double door units as shown on the drawing. The finish on the Doors and Frames will be Anodized Aluminum or Powder Coat Epoxy with standard approved CR hardware.

Hardware carried for pricing purposes:

- Closers
- Vision Panels
- Push Pull Handles and Plates
- Aluminum or Steel Door Frames with CR finishes of epoxy paint or clear Anodized on aluminum.

QUALIFICATIONS

Electrical work requires a local licensed contractor to perform the work. We do not include this work.

Electrical: Electrical components to include:

1. Fan Filter Unit power wiring.
2. Power Wiring to 2'x4' LED lay-in light fixtures, 208-277vac/1-phase, including fixtures, lamps, drivers,
switches, and power wiring.
3. 120-volt duplex receptacles and back boxes.
4. 208-volt outlets receptacles and back boxes.
5. Central electrical panelboard(s) distribution with circuit breakers.
6. EMT and non-metallic conduits and electrical junction boxes.
7. Telecom data back boxes and conduit pathways to above cleanroom plenum cap.
8. All electrical components shall bear the UL label.
9. Include modular cleanroom system wiring package to central power connection(s) to the building electrical system.

- We have not carried handrail or toe boards at the perimeter of the Plenum Cap and assume this will not be accessible after construction.
- All electrical power to the light fixtures and Fan Filter Units is by others.
- Bulkheading and tool fit out is not included in this price. Room will be built and tested at rest without tools or openings. Once certified to meet base bid design criteria, tool fit out package will need to be bid and retesting if required to recertify.
- Card access system is supplied by others.
- The materials and labor for the MEP trades' any work within the cleanroom, design or installation is not included.

- We do not include any field painting of structure, walls, floors, etc.
- Perimeter Steel studs and Sheetrock walls are by others.
- Duct penetrations, the supply and installation of collars and ductwork is by others.
- Laydown area for materials will be available on site as needed to feed the project.
- We have included 40-hour work weeks, no OT.
- Doors and hardware located in drywall perimeter partitions are not included. We will trim CR skin walls to and surrounding the frames and trim out only up to the grid elevation.
- Due to the Coronavirus pandemic and the unforeseen nature of what may or may not be within our control, If either party's performance is delayed or made commercially impractical through no fault of their own by reason of labor disputes, inability to procure materials, failure of utility service, restrictive governmental laws, regulations or orders, riots, insurrection, war, adverse weather, Acts of God, epidemics, quarantine restrictions or other similar causes beyond the control of and without the fault or negligence of such party, the performance of such obligation shall be excused for the period of the delay.
- Because of ongoing supply issues many of the suppliers will require a deposit to lock in pricing and raw materials. This will be passed on to the owner.

CLEANROOM ALTERNATES

Additional Cleanroom items that should be considered but are not currently included and we highly recommend:

- Pass Throughs
- Fire Extinguisher Cabinets
- Corner Guards
- Exit Signs
- Gown-room Furniture and Tables
- Plenum Cap Access Ladder for the 12' height if service to any mechanical system may be required.

ALTERNATE # 1

We will furnish and install approximately 5,097 SF of Statlock ESD or Groundlock Conductive Flooring System. This product is designed to be installed over a sealed painted slab, existing VCT flooring or bare concrete. Access to building ground location provided by others within the perimeter of the clean space.

Add to Base Bid: One Hundred Ninety Three Thousand Seventy-Five Dollars $208,550

ALTERNATE # 2

CR Construction Protocol Management;

Majority of Cleanrooms are built using Protocol Management techniques to "build the clean in" and assure Certification. Usually found in the specifications of the Cleanzone systems and all trades must adhere to this protocol.
FH Chase, Inc. will implement and manage the protocol program per our Company standards and incorporated with any additional concerns Coward Environmental Systems, the A/E or Owner may have to assure certification at completion.

Highlights Include:

- Protocol management for Eight (8) weeks.
- Training shall be provided to all tradesmen required to work in the Clean Zone.
- Badges/Stickers will be issued for each level of training and transition on site to next levels of protocol.
- A temporary wipe down/ gowning room is included.
- One (1) protocol monitor/cleaner.
- One (1) protocol manager.
- 2-wipedowns (Intermediate and super clean).
- Allowance for consumables for 12 workers per day for 8 weeks. Turn over at completion to university monitor who's responsible for cleanroom adherence.

Add to Base Bid: One Hundred Thirty-Two Thousand Seven Hundred Forty Dollars $143,360.

ALTERNATE # 3

CR Certification – Work to be performed by an Independent NEBB's certified Independent Contractor per the specifications

CLEANROOM OPERATIONAL PERFORMANCE VALIDATION
SCOPE OF WORK

- Airflow Velocity and Uniformity Test
- HEPA Filter In-Place Integrity Leak Test
- Room Pressurization Test
- Lighting Level Test
- Airborne Particle Count Survey – ISO Cleanliness Validation
- Floor Conductivity Test

Add to Base Bid: Forty Six Thousand Seven Hundred Forty Dollars $50,500

We appreciate the opportunity to quote on your requirements.

Sincerely,
FH Chase, Inc.

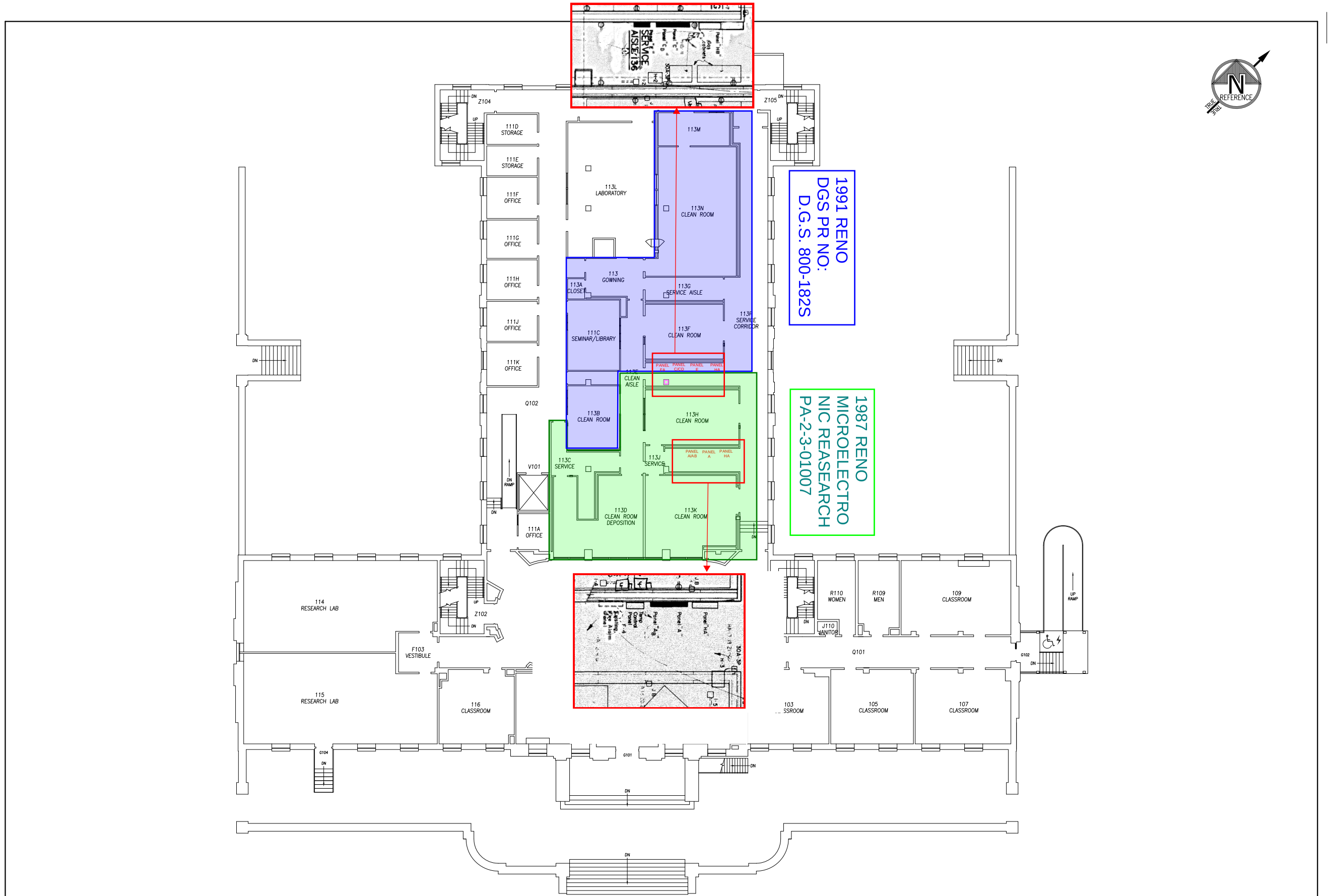
Domenic Russo
President

50 Constitution Drive
Taunton, MA 02780-1070
www.fhchaseinc.com

Telephone: (508) 339-3309
Fax: (508) 339-3306
E-Mail: info@fhchaseinc.com

APPENDIX C

Electrical Existing Documents



ELECTRICAL ENGINEERING WEST

PSU BUILDING NAME

FIRST FLOOR PLAN

BUILDING FLOOR LEVEL

UNIVERSITY PARK CAMPUS, UNIVERSITY PARK, PA

PSU CAMPUS LOCATION

PENNSTATE

FACILITIES RESOURCES AND PLANNING

THE PENNSYLVANIA STATE UNIVERSITY
BENEDICT HOUSE
UNIVERSITY PARK, PA 16802

OFFICE: 814.865.1595
FAX: 814.865.1610
www.facilities.psu.edu

SCALE 0 8' 16' 32' / 4' 12'

07/01/95 CREATION DATE

9/17/14 REVISED DATE

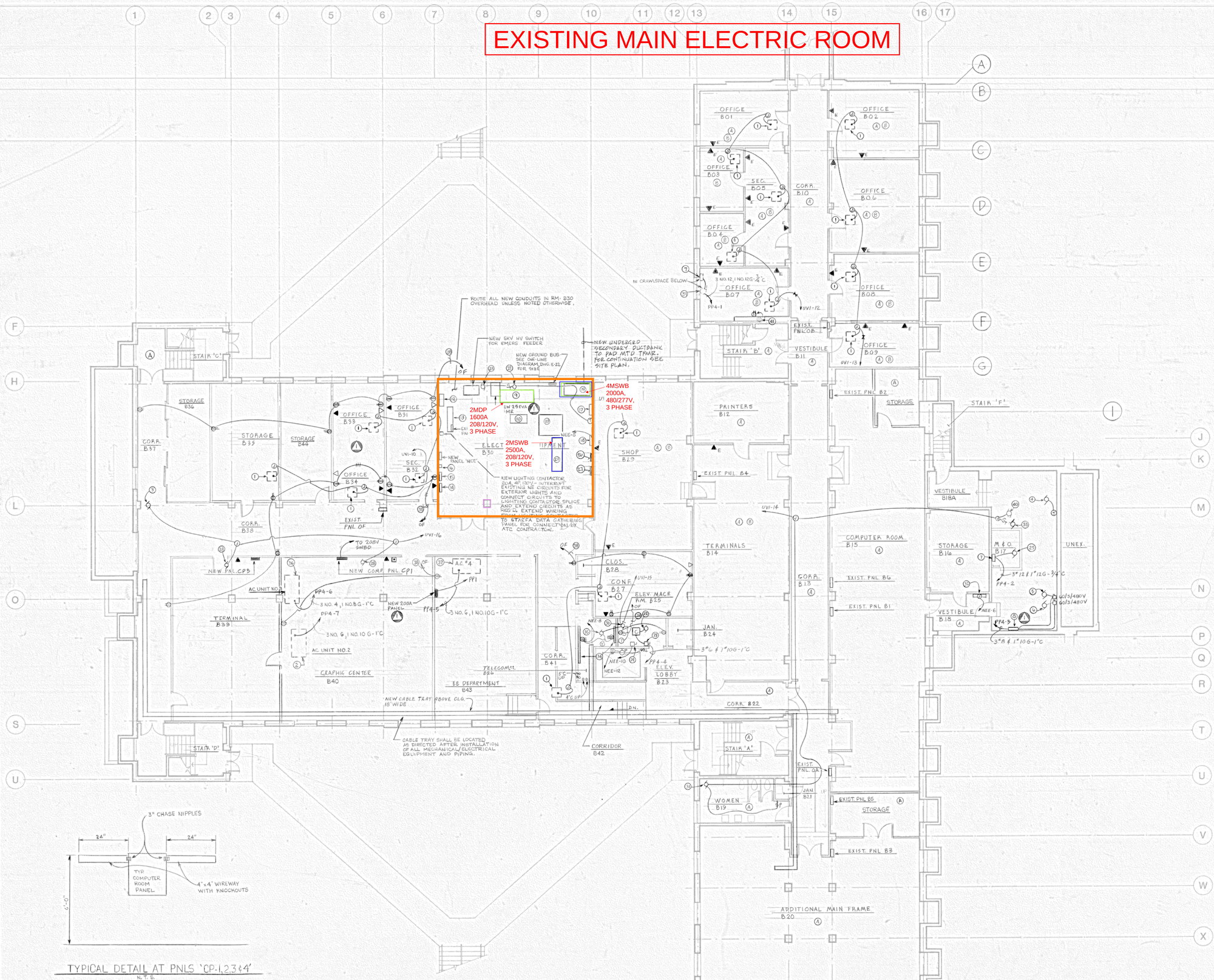
Campus block plans are for referential use only. Drawings are not to be used for architectural or engineering purposes.

0302-000 BUILDING NUMBER

3 OF 5 SHEET NUMBER

1 FLOOR LEVEL

EXISTING MAIN ELECTRIC ROOM



TYPICAL DETAIL AT PNLS 'CP-1,2 & 4'
N.T.S.

BUILDING NORTH

Basement Plan

1/8" : 1'-0"

NOTES:

1. VAV FANBOX ABOVE CLG. - 1Φ 120V-W/INTEGRAL DISCONNECT - BY H.C.
2. COMPUTER ROOM AC UNIT - BY H.C. 36.5 FLA 3Φ 480V - WITH FACTORY DISCONNECT
3. UNIT HEATER. FRAC. HP 1Φ 120V - BY H.C.
4. EXH. FAN #8 - 1Φ 120V TO REMAIN. MODIFY WIRING AS REQ'D. FOR CONTROL BY NEW REV. ACTING THERMOSTAT
5. H.W. CIRC. PUMP CP-9 - 15HP - 3Φ 480V - BY H.C.
6. H.W. CIRC PUMP CP-10 (STAND-BY) - 15HP - 3Φ 480V - BY H.C.
7. PUMP CONTROL PANEL. BY H.C.
8. VARIABLE FREQUENCY DRIVE - BY H.C.
9. EXIST. 1600A - 3Φ 4W 120/208V POWER CENTER
10. EXIST. 225KVA 3Φ 4W 120/208V POWER CONDITIONER
11. EXIST. PNL PP-1 800A 3Φ 4W 120/208V
12. EXIST. PNL PP-2 400A 3Φ 4W 120/208V
13. EXIST. CT. BKR. AND PANEL RACK
14. EXIST. AREA ZONE MONITOR PNL.
15. NEW AUTO-TRANSFER SW.
16. EXIST. EMERG. ONLY PANEL
17. EXIST. PNL PP-3
18. NEW FIRE ALARM CONTROL PNL.
19. NEW 277/480V MAIN SWBD
20. NEW 750KVA TFMR - 480-120/208V
21. NEW 120/208Y MAIN SWBD
22. ELEV. MOTOR - 40HP - 3Φ 480V - BY OTHERS
23. ELEV. DISC. SW. 100A/3/480V FUSED
24. 1Φ 120V FOR ELEV. CONTROL PNL. CAB FAN & LIGHTING 20A/1/120V FUSED DISC. SW.
25. CONDENSATE PUMP CU-2 5HP-3Φ-480V. PUMP CONTROL PANEL WITH INTEGRAL CIRCUIT BREAKERS BY H.C.
26. NEW PANEL PP-4
27. NEW PANEL UV1
28. DAMPER MOTOR - FRAC. HP 1Φ 120V - BY H.C.
29. EXH. FAN #2 - 1Φ 120V, EXIST. RELOCATED, CONN. AT NEW LOCATION WIRE THRU NEW REV. ACTING THERMOSTAT. TO EXIST. CT. FAN MOTOR STARTER BY H.C. THERMOSTAT BY H.C.
30. EXH. FAN #4 - FRAC. HP 1Φ 120V, WIRE THRU REV. ACTING THERMOSTAT. FAN AND THERMOSTAT BY H.C.
31. EXH. FAN #5 - FRAC. HP 1Φ 120V, WIRE THRU SWITCH, FAN BY H.C. SWITCH PROVIDED AND INSTALLED BY E.C.
32. 1Φ 120V FOR STAEFA DATA GATHERING PANEL - DGP. BY H.C.
33. HW'G PUMP - 1/4 HP 1Φ 120V - BY RC. - E.C. TO PROVIDE AND INSTALL THERMAL OVERLOAD SWITCH.
34. 4'x8'x 3/4" PLYWOOD - WALL MTD.
35. EXH. FAN #10 - FRAC. HP 1Φ 120V - BY H.C.
36. COMPUTER ROOM AC UNIT - 51.6 FLA 3Φ 480V - W/ FACTORY DISCONNECT SWITCH - BY H.C.
37. COMPUTER ROOM AC UNIT - 35.7 FLA 3Φ 480V - W/ FACTORY DISCONNECT SWITCH - BY E.C.
38. EXTEND & CONNECT TO SPARE 20A 1P CBS IN EXISTING PANEL 'OF.'
39. CONDENSATE PUMP CU-4 3/4 HP - 3Φ - 480V - PUMP CONTROL PANEL W/ INTEGRAL CIRCUIT BREAKERS BY H.C.
40. HEATER CIRCULATOR - 1/2 HP - 1Φ - 120V - BY RC.
41. RELOCATE EXISTING RECEPTACLE TO NEW WALL AS SHOWN. SPLICE AND EXTEND EXISTING CIRCUIT TO RELOCATED RECEPTACLE AND RECONNECT.

(A) EXISTING ELEC. WORK TO REMAIN IN THESE RMS. - SEE DEMO. DWGS.

(B) EXISTING TELEPHONE/DATA OUTLETS IN THIS ROOM TO BE MODIFIED FOR CONNECTION TO NEW TELECOMMUNICATIONS SYSTEM. SEE DETAIL, DWG E-9.

1	AS BUILTS 11-1-94		
	DESCRIPTION		DESCRIPTION

AS BUILT REVISIONS

SUBMITTED ARCHITECT

SUBMITTED ENGINEER

APPROVED UNIVERSITY

APPROVED

CHECKED BY DEPARTMENT OF GENERAL SERVICES

ARCH.	STRUCT.	H.V.A.C.	PLBG.	ELEC.	MISC.
				11-28	

REGISTERED PROFESSIONAL ENGINEER ROBERT A. MANNELLA ENGINEER 10317 COMMONWEALTH OF PENNSYLVANIA

REGISTERED ARCHITECTS PENNSYLVANIA

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF GENERAL SERVICES
HARRISBURG PENNSYLVANIA

PROJECT NO. D.G.S. 800-182

Renovation to MECHANICAL ENGINEERING BLDG. and ELECTRICAL ENGINEERING WEST BLDG.
The Pennsylvania State University
University Park, Centre County

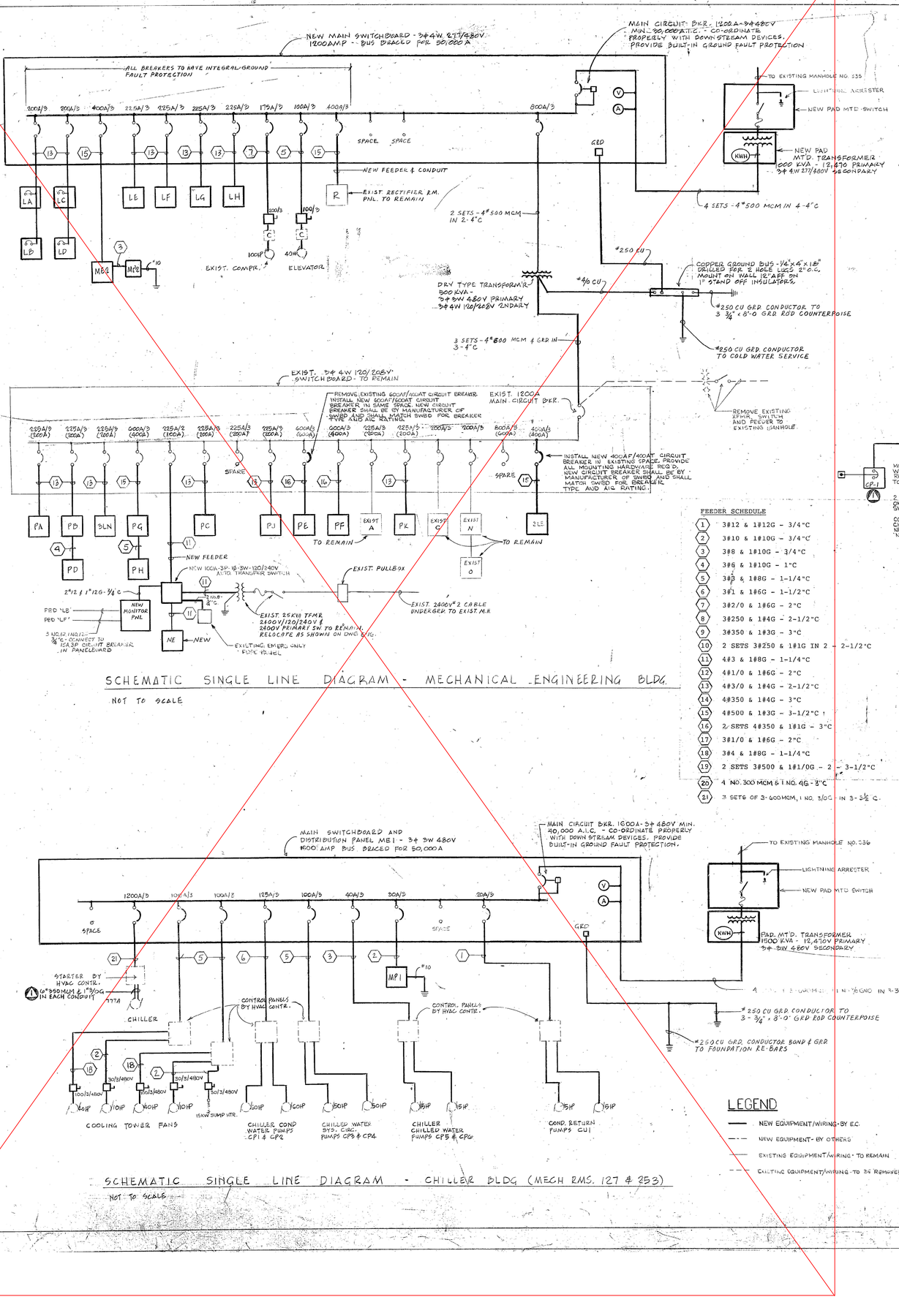
WILLIAMS TREBILCOCK WHITEHEAD
ARCHITECTS, PLANNERS, INTERIORS
TIMBER COURT, PITTSBURGH, PA

ELWOOD S. TOWER CORP.
MECH. & ELECT. ENGINEERS
PITTSBURGH, PA

Electrical Engineering West Building
Basement Floor Plan: **POWER**

DRAWN BY	DATE	DRAWING NO.
J.M.	8-29-91	E-8
CHECKED BY R.C.S.	SCALE AS NOTED	

EXISTING ELECTRICAL ONE-LINE

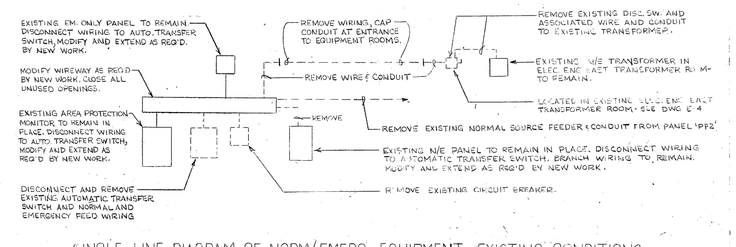


FEEDER SCHEDULE	
1	3#12 & 1#12G - 3/4"C
2	3#10 & 1#10G - 3/4"C
3	3#8 & 1#10G - 3/4"C
4	3#6 & 1#10G - 1"C
5	3#3 & 1#8G - 1-1/4"C
6	3#1 & 1#6G - 1-1/2"C
7	3#2/0 & 1#6G - 2"C
8	3#250 & 1#4G - 2-1/2"C
9	3#350 & 1#3G - 3"C
10	2 SETS 3#250 & 1#1G IN 2 - 2-1/2"C
11	4#3 & 1#8G - 1-1/4"C
12	4#1/0 & 1#6G - 2"C
13	4#3/0 & 1#4G - 2-1/2"C
14	4#350 & 1#4G - 3"C
15	4#500 & 1#3G - 3-1/2"C
16	2 SETS 4#350 & 1#1G - 3"C
17	3#1/0 & 1#6G - 2"C
18	3#4 & 1#8G - 1-1/4"C
19	2 SETS 3#500 & 1#1/0G - 2 - 3-1/2"C
20	4 NO. 300 MCM & 1 NO. 4G - 3"C
21	3 SETS OF 3-600MCM, 1 NO. 1/0G IN 3-3 1/2" C.

SCHEMATIC SINGLE LINE DIAGRAM - MECHANICAL ENGINEERING BLDG.
NOT TO SCALE

SCHEMATIC SINGLE LINE DIAGRAM - CHILLER BLDG (MECH RMS. 127 & 253)
NOT TO SCALE

SINGLE LINE DIAGRAM OF NORM/EMERG. EQUIPMENT - EXISTING CONDITIONS
ELECTRICAL ENGINEERING BLDG.
NOT TO SCALE



1	AS BUILT 11-1-94		
	DESCRIPTION		DESCRIPTION

AS BUILT REVISIONS

SUBMITTED _____ ARCHITECT

SUBMITTED _____ ENGINEER

APPROVED _____ UNIVERSITY

APPROVED _____

CHECKED BY DEPARTMENT OF GENERAL SERVICES

ARCH.	STRUCT.	H.V.A.C.	PLBG.	ELECT.	MISC.
				11-11-94	

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF GENERAL SERVICES
HARRISBURG PENNSYLVANIA

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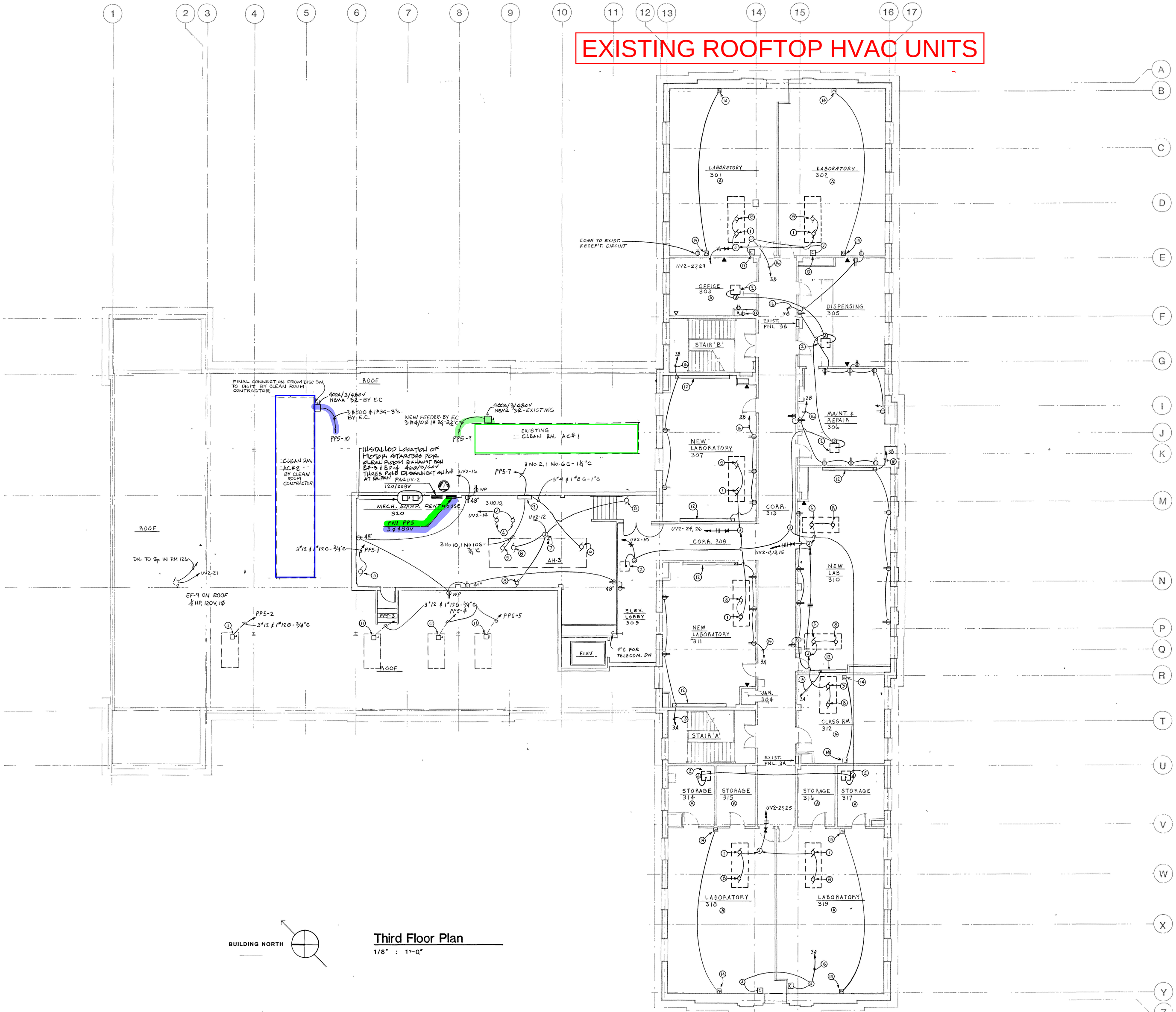
WILLIAMS TREBILCOCK WHITEHEAD	ELWOOD S. TOWER CORP.
ARCHITECTS, PLANNERS, INTERIORS	MECH. & ELECT. ENGINEERS
TIMBER COURT, PITTSBURGH, PA	PITTSBURGH, PA

Power Riser Diagrams

DRAWN BY J. M.	DATE 8-29-91	DRAWING NO. E-22
CHECKED BY P.C.S.	SCALE AS NOTED	

EXISTING ROOFTOP HVAC UNITS



BUILDING NORTH

Third Floor Plan

1/8" : 1'-0"

NOTES:

1. UNIT VENT ABV CLG. 3/4 HP 1φ 120V W/ INTEGRAL DISCONNECT-BY H.C.
2. VAV FANBOX ABOVE CLG 1φ 120V W/INTEGRAL DISCONNECT-BY H.C.
3. UNIT VENT ABV CLG - 1/2HP 1φ 120V-W/INTEGRAL DISCONNECT- BY H.C.
4. UNIT HEATER 1/20 HP 1φ 120V-BY H.C
5. AH-3 RETURN AIR FAN 7.5HP 3φ 480V-BY H.C
6. AH-3 SUPPLY AIR FAN 40 HP 3φ 480V-BY H.C
7. 1φ 120V FOR CONTROL
8. AUTO DAMPER FRAC. HP 1φ 120V - BY H.C.
9. VARIABLE FREQUENCY DRIVE W/ INTEGRAL FUSED POWER DISCONNECT-BY H.C.
10. EXH. FAN #1 - 3 HP 3φ 480V. W/ INTEGRAL DISCONNECT SWITCH. BY H.C.
11. AIR COOLED CONDENSER 4.4 FLA 3φ 480V WITH FACTORY DISCONNECT SW. - BY H.C.
12. SURFACE PLUG-IN STRIP, SINGLE CONDUIT WITH SINGLE GROUNDING TYPE RECEPT'S. 18" O.C.
13. MOTOR OPERATED PROJ. SCREEN 1φ 120V RAISE/LOWER SW FURN BY G.C INSTALLED & CONNECTED BY E.C
14. A/V OUTLET W/CONNECTORS FOR DATA TELEPHONE TV & PROJ STANDARD PROJECTOR CONTROL MODULE (SEE DETAILS, DWG. E-7).
15. EXTEND # CONN. TO 20A-1P CKT IN EXIST. PNL 3A
16. EXTEND # CONN. TO 20A-1P CKT IN EXIST. PNL 3B
17. RELOCATE EXISTING RECEPTACLE TO NEW WALL AS SHOWN. SPLICE AND EXTEND EXISTING CIRCUIT TO RELOCATED RECEPTACLE AND RECONNECT.

(A) EXISTING RECEPT/CKTING IN THESE ROOMS TO REMAIN. SEE DEMO. DWG.

(1)	AS BUILT 11-1-94		
	DESCRIPTION		DESCRIPTION

AS BUILT REVISIONS

SUBMITTED ARCHITECT

SUBMITTED ENGINEER

APPROVED UNIVERSITY

APPROVED

CHECKED BY DEPARTMENT OF GENERAL SERVICES

ARCH.	STRUCT.	H.V.A.C.	PLBG.	ELECT.	MISC.
				5-11-95	

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF GENERAL SERVICES
HARRISBURG PENNSYLVANIA

PROJECT NO. D.G.S. 800-182

Renovation to MECHANICAL ENGINEERING BLDG. and ELECTRICAL ENGINEERING WEST BLDG.
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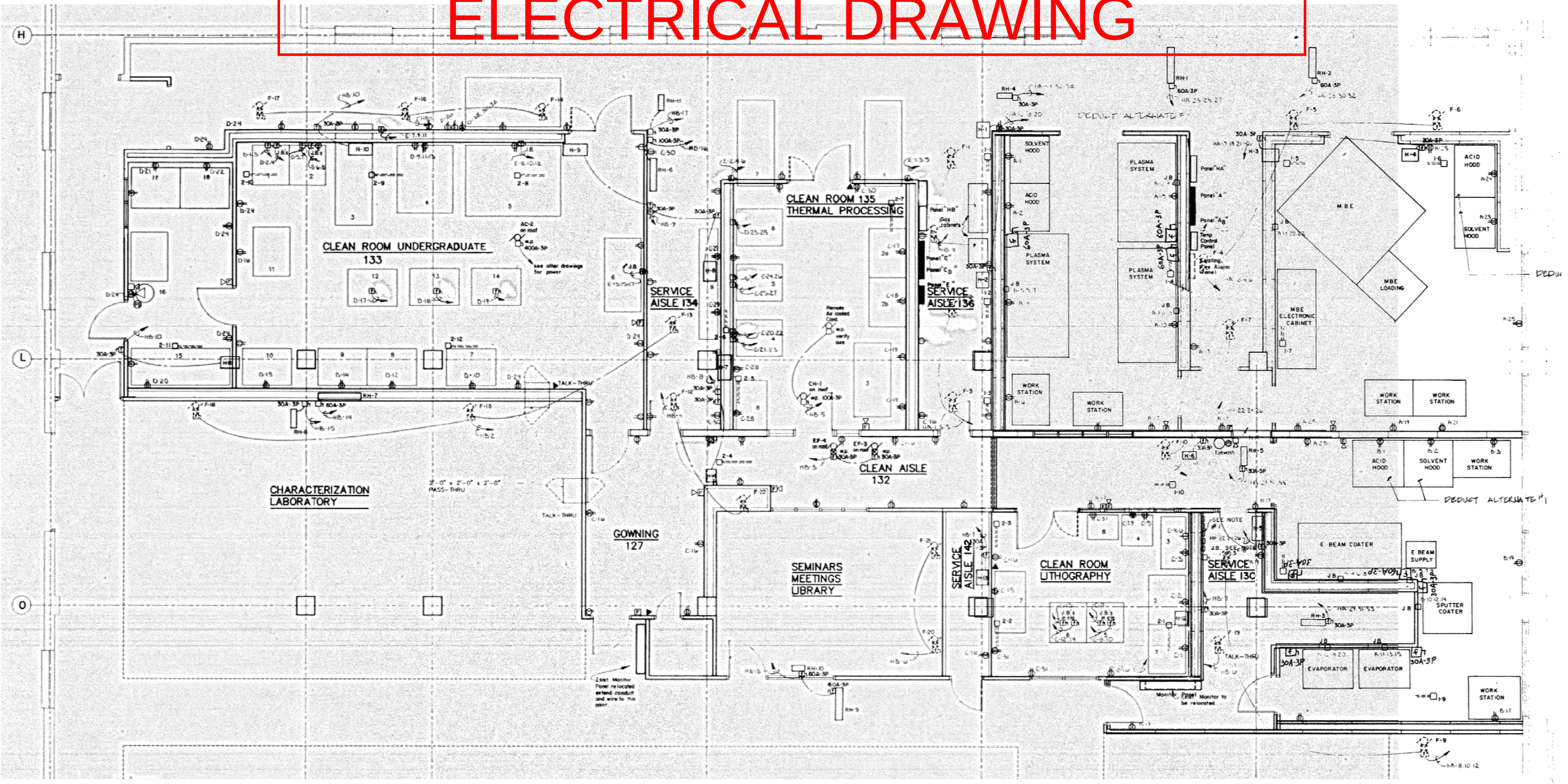
TIMBER COURT, PITTSBURGH, PA

ELWOOD S. TOWER CORP.
MECH. & ELECT. ENGINEERS
PITTSBURGH, PA

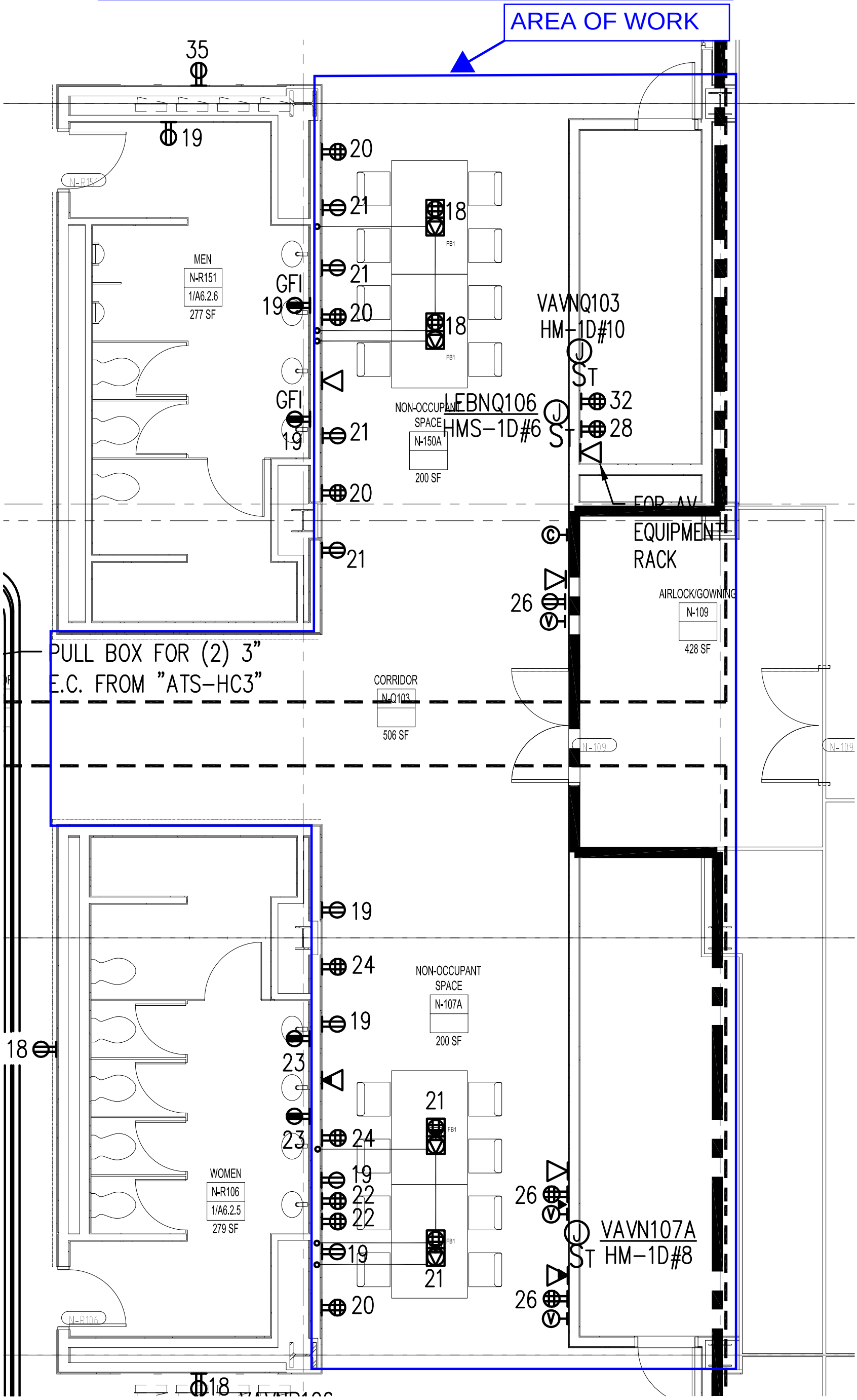
Electrical Engineering West Building
Third Floor Plan **POWER**

DRAWN BY	DATE	DRAWING NO.
J.M.	8-29-91	E-11
CHECKED BY	SCALE	
P.C.S.	AS NOTED	

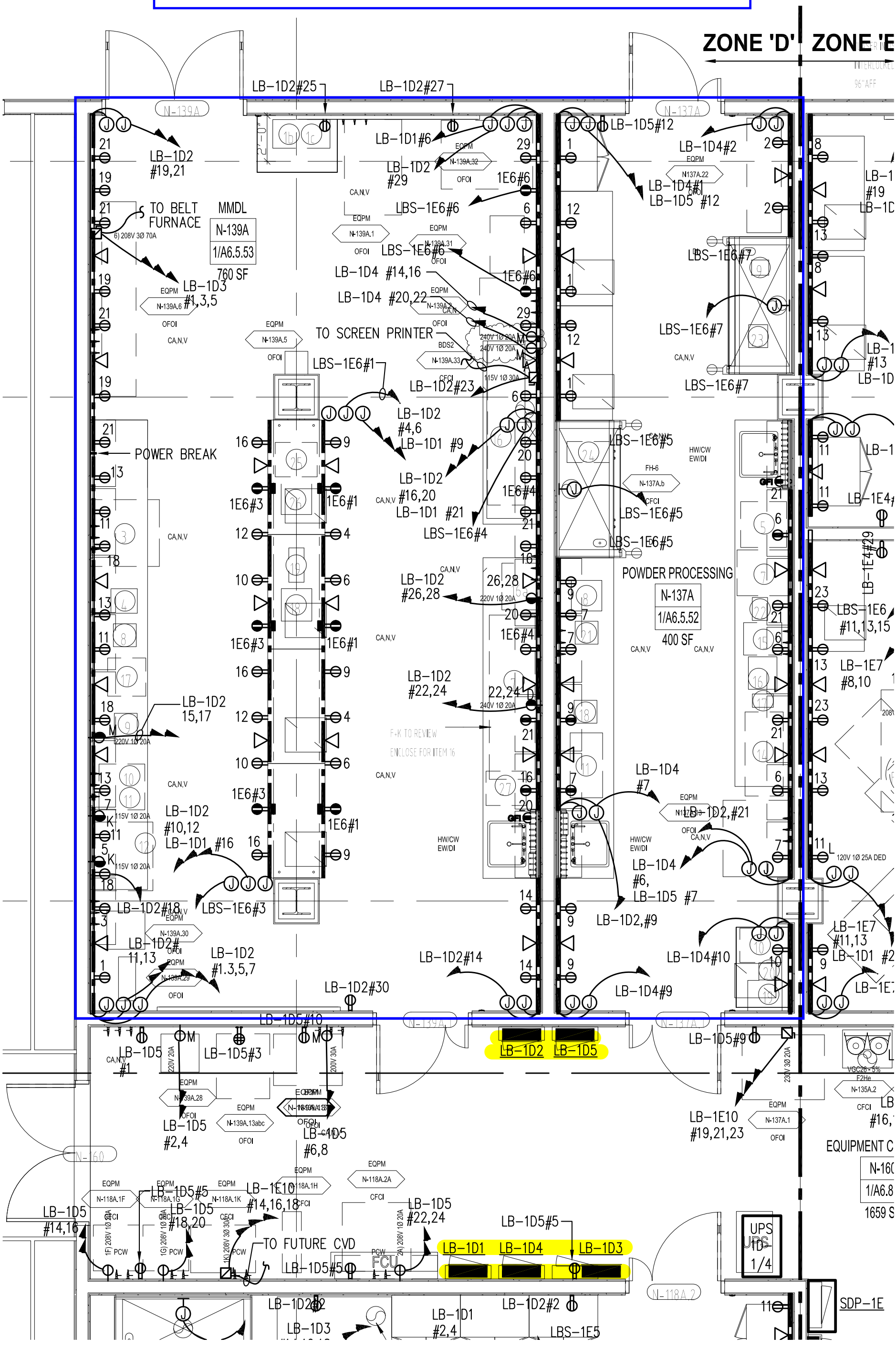
87/91 COMBINED EXISTING ELECTRICAL DRAWING



MSC NEW CLEAN ROOM AREA
ELECTRICAL EXISTING CONDITIONS



MSC LTCC AREA - N137A,138A,139A
ELECTRICAL EXISTING CONDITIONS



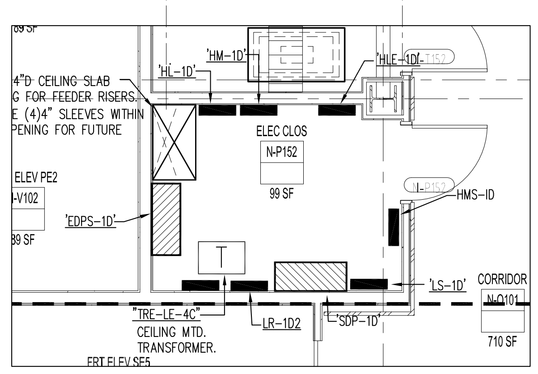
LOCAL TELECOM ROOM

CLEANROOM EXPANSION AREA

STCC AREA

NOTES

1. CIRCUIT A MAXIMUM OF (10) VAV'S, LSB'S AND LEB'S ON A SINGLE 20A/1P CIRCUIT. LSB'S AND LEB'S ARE TO BE CIRCUITED TO A 277/480V MECHANICAL STANDBY PANELS. VAV'S ARE TO BE CIRCUITED TO 277/480VOLTS MECHANICAL PANELS



ELECTRICAL CLOSET PART PLAN

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

PENNSYLVANIA STATE UNIVERSITY
MILLENNIUM SCIENCE COMPLEX

ARCHITECT:
RV ARCHITECTS IPAL LLC
50 VANDAM ST
NEW YORK, NY 10013
TEL: (212) 924-5060 FAX: (212) 924-5858
CONSULTING ARCHITECT:
PERFIDO WEISKOPF WAGSTAFF + GOETTEL
408 BOULEVARD OF THE ALLIES
PITTSBURGH, PA 15219
TEL: (412) 391-2884 FAX: (412) 391-1657
STRUCTURAL ENGINEER:
THORNTON TOMASETTI ENGINEERS
24 COMMERCE STREET
NEWARK, NJ 07102
TEL: (973) 286-6100 FAX: (973) 286-6101
MEP ENGINEER:
FLACK AND KURTZ
512 SEVENTH AVENUE
NEW YORK, NY 10036
TEL: (212) 532-3600 FAX: (212) 689-7489
TELECOMMUNICATIONS:
SHEN MILSOM WILKE
417 FIFTH AVENUE
NEW YORK, NY 10016
TEL: (212) 725-6800 FAX: (212) 725-0866
ACOUSTIC AND VIBRATION CONSULTANT:
THE PAPADIMOS GROUP, INC
818 FIFTH AVENUE, SUITE 207
SAN RAFAEL, CA 94901
TEL: (415) 456-0170 FAX: (415) 472-1079
LIGHTING CONSULTANT:
BRANDSTON PARTNERSHIP INC
122 W 26TH STREET, 5TH FLOOR
NEW YORK, NY 10001
TEL: (212) 924-6456 FAX: (212) 691-5418
LANDSCAPE ARCHITECT:
DEWBERRY
1503 EDWARDS SURREY ROAD N.E. SUITE 200
LEESBURGH, VA 20176
TEL: (703) 771-8006 FAX: (703) 771-4091
CIVIL ENGINEER:
SWEETLAND ENGINEERS & ASSOCIATES, INC.
600 SCIENCE PARK R ROAD
STATE COLLEGE, PA 16803
TEL: (814) 237-4538 FAX: (814) 237-1488
LABORATORY PLANNER:
STEVEN ROSENSTEIN ASSOCIATES, INC
70 WEST OAK LANE
WHITE PLAINS, NEW YORK 10604
TEL: (914) 697-7611 FAX: (914) 669-8636
VERTICAL TRANSPORTATION:
VAN DEUSEN AND ASSOCIATES
5 REGENT STREET, SUITE 524
LIVINGSTON, NJ 07039-1617
TEL: (973) 994-9222 FAX: (973) 994-2539
LIFE SAFETY CODE CONSULTANT:
HUGHES ASSOCIATES, INC
3610 COMMERCE DRIVE, SUITE 817
BALTIMORE, MD 21227-1652
TEL: (410) 737-8677 FAX: (410) 737-8688
E.M.I. CONSULTANT:
VITA TECH ENGINEERING
115 JULIAD COURT, SUITE 105
FREDERICKSBURGH VA 22406
TEL: (540) 286-1984 FAX: (540) 286-1985
L.E.E.D. CONSULTANT:
RMH
1820 Fulsom Street
BOULDER, CO 80304
TEL: (303) 449-5226 FAX: (303) 449-5276

PHASE: CONSTRUCTION DOCUMENTS

PSU, PROJECT NUMBER: 02-42746

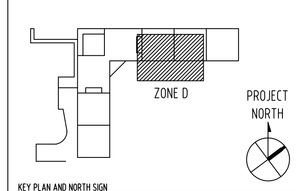
DGS, PROJECT NUMBER: 800-285

RECORD SET

ARCHITECT'S SEAL

No.	Date	Description
14	02/13/2009	
13	01/12/2009	
12	12/18/2008	
11	12/05/2008	
10A	CA / FULL REVIEW	
10	12/03/2008	
09	10/20/2008	
08	10/01/2008	
06	08/15/2008	
02	05/22/2008	
01	05/09/2008	
19	01/15/2010	
18	07/07/2009	
17	04/20/2009	

ISSUE NO. / ISSUE DATE



KEY PLAN AND NORTH SIGN

IF THIS DRAWING IS NOT 30"x42" IT IS A REDUCED PRINT;

REFER TO GRAPHIC SCALE

0 8 16

1/8"=1'-0"

SCALE:

ELECTRICAL FIRST FLOOR POWER PLAN - ZONE 'D'

SHEET TITLE:

E2.1D-P

SHEET NUMBER: AE4D