

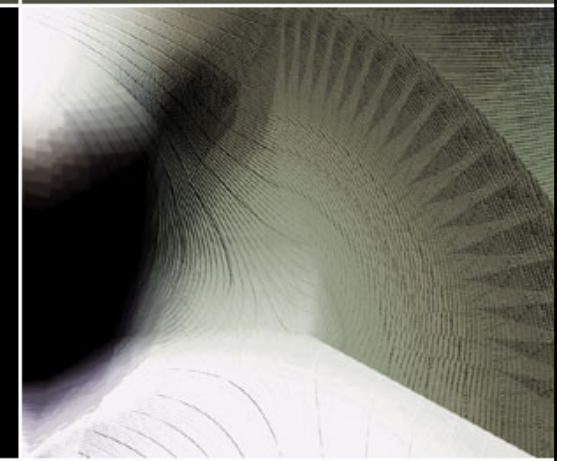
Dorrance H. Hamilton Building

Josh Kreutzberger

Lighting/Electrical

Penn State Architectural Engineering

Senior Thesis



Building Overview



- **Thomas Jefferson University (TJU)**
 - Philadelphia, PA
- **Medical Education**
- **129,000 ft² with an additional 60,000 ft² plaza area**
- **6 stories above grade with 2 story underground parking garage**
- **Architect: Burt Hill**

Presentation Outline

Lighting Depth

- Classroom
- Auditorium
- Lobby

Electrical Depth

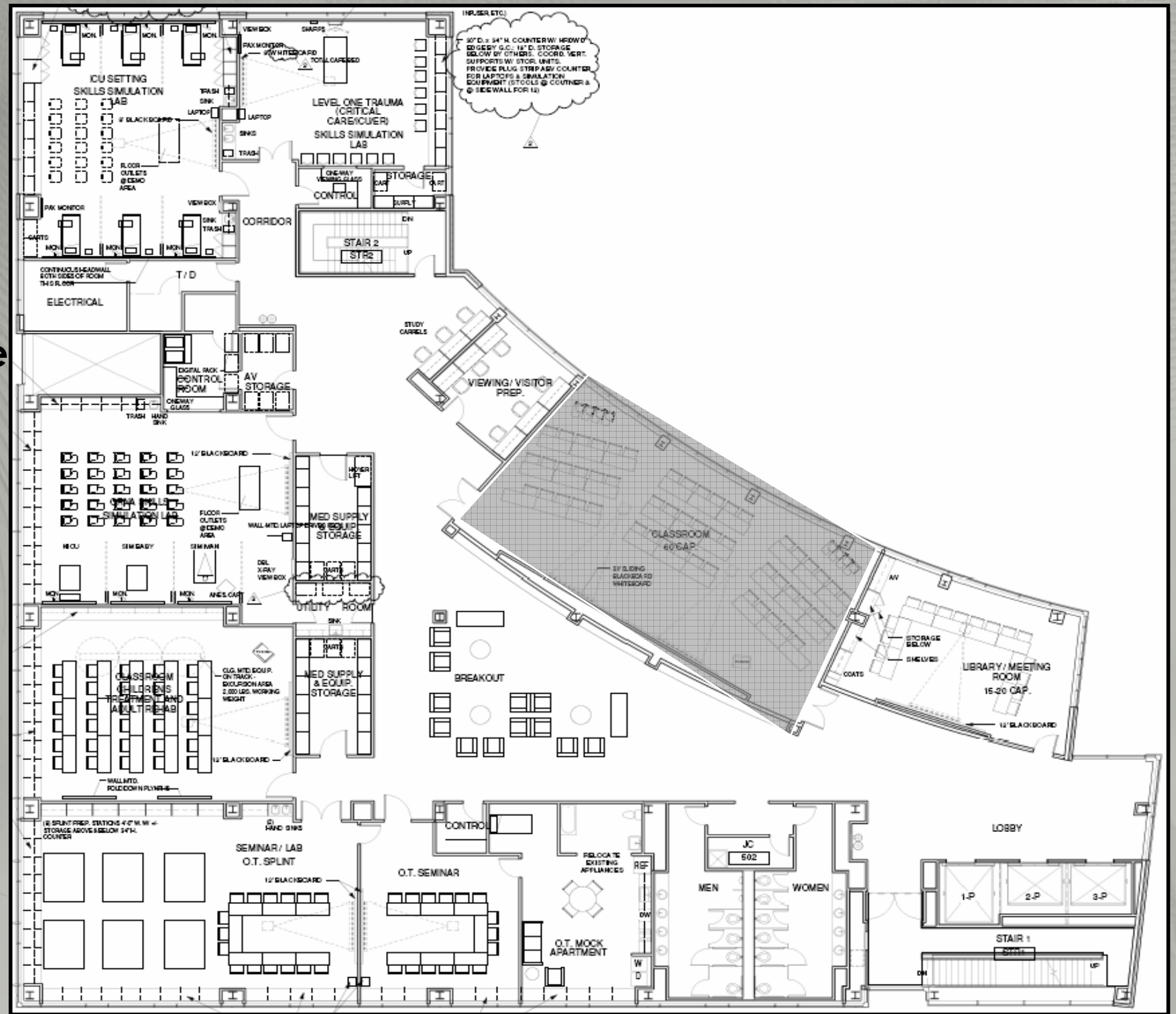
- Central Transformer vs. Distributed Transformers
 - **Construction Management Breadth**
 - Cost Analysis
- Bus Duct vs. Feeders
 - **Construction Management Breadth**
 - Cost Analysis
- Motor Control Center

Conclusions

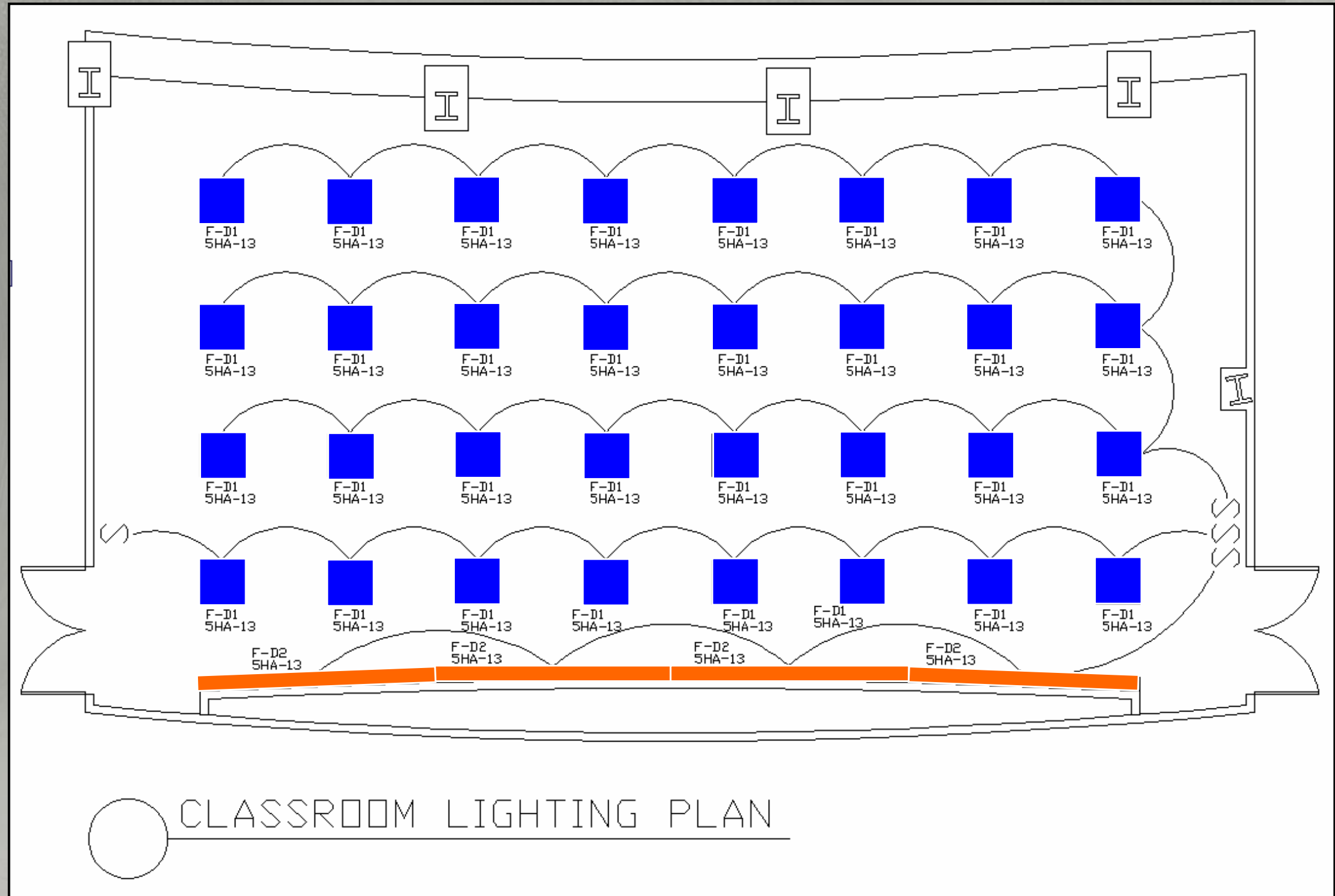
Classroom (5th Floor)

Design Objectives

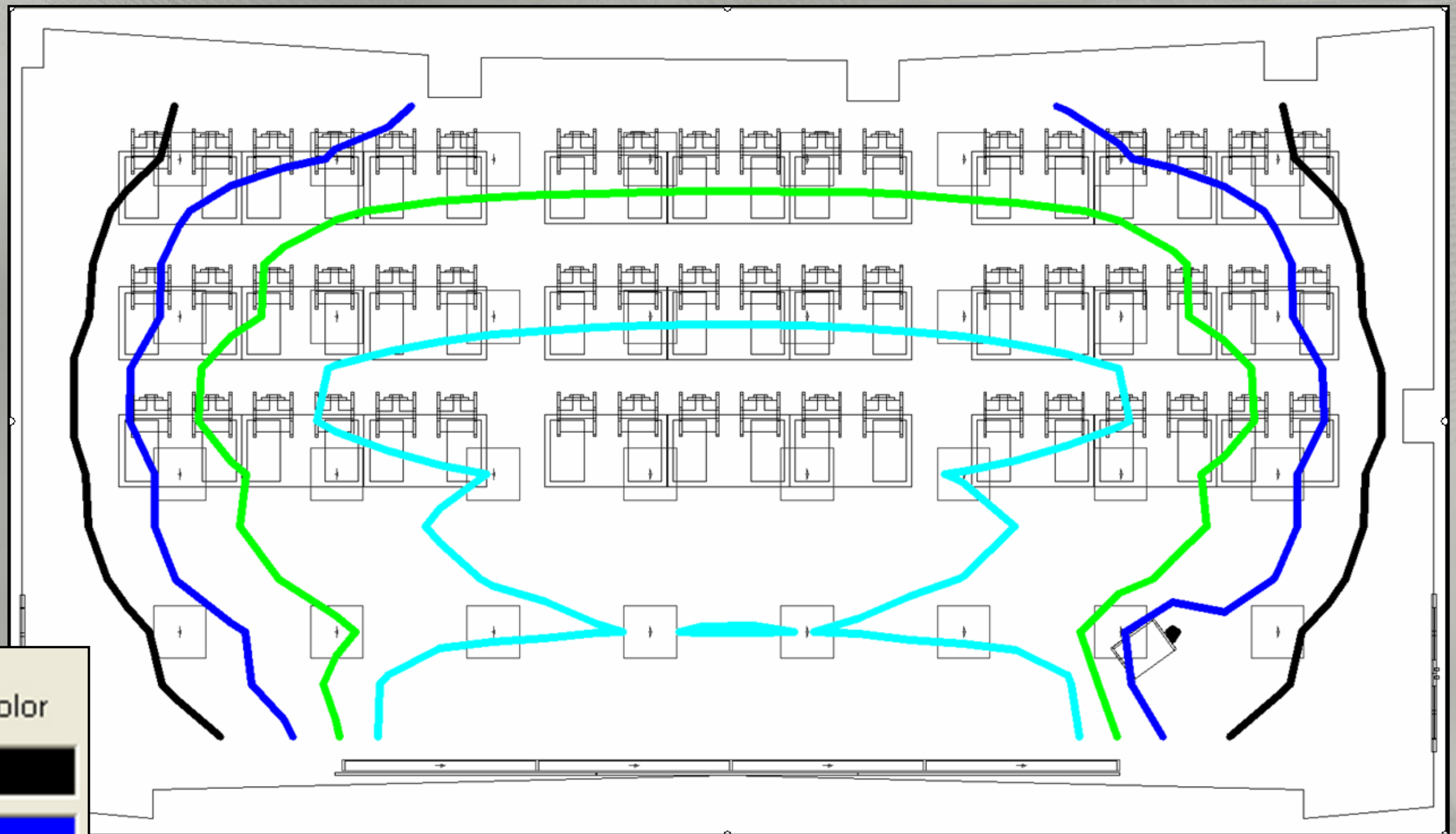
- Reading/Writing Tasks
- Illuminance target = 50fc
- Accent Blackboard
- Dimmable Fixtures for use with VDT Screen
- ASHRAE 90.1 Standards
 - 1.4 W/ft²



Classroom Lighting Plan



Classroom Isolines



Value (Fc)	Color
30	Black
40	Blue
50	Green
60	Cyan

Average Illuminance on Workplane = 49.6 fc
Power Density = 1.31 W/ft²

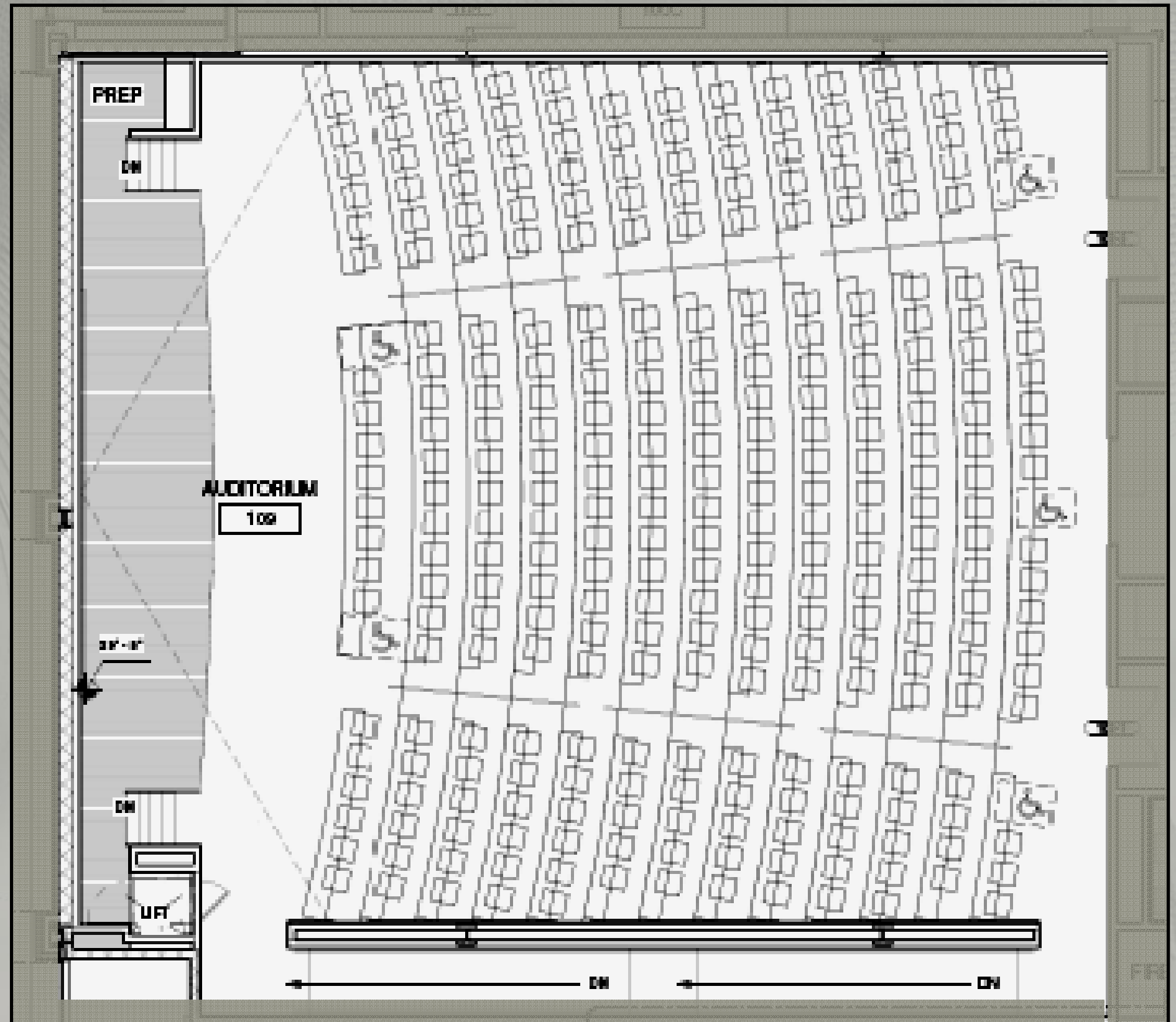
Classroom Renderings



Auditorium

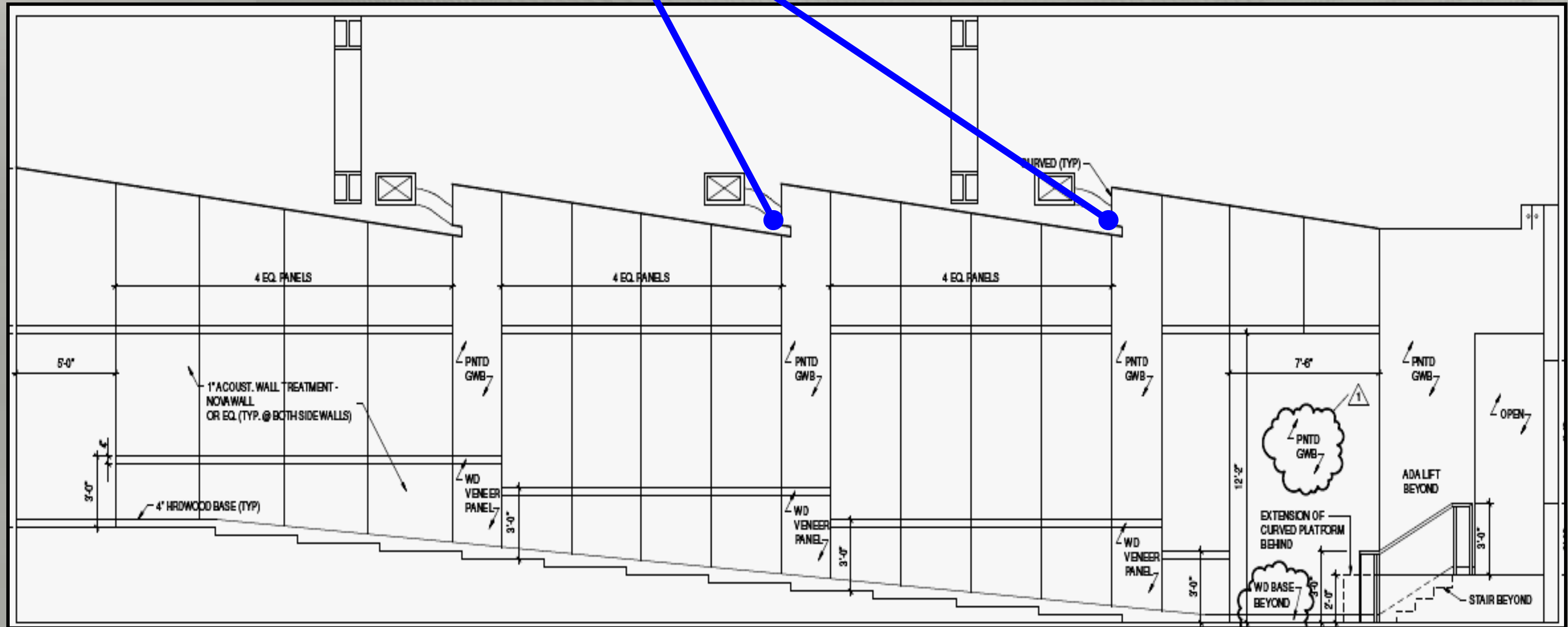
Design Objectives

- Reading/Writing Tasks
- Illuminance target = 50fc
- Accent Blackboard
- Dimmable Fixtures for use with VDT Screen
- Use Cove Luminaires
- ASHRAE 90.1 Standards
 - 1.4 W/ft²

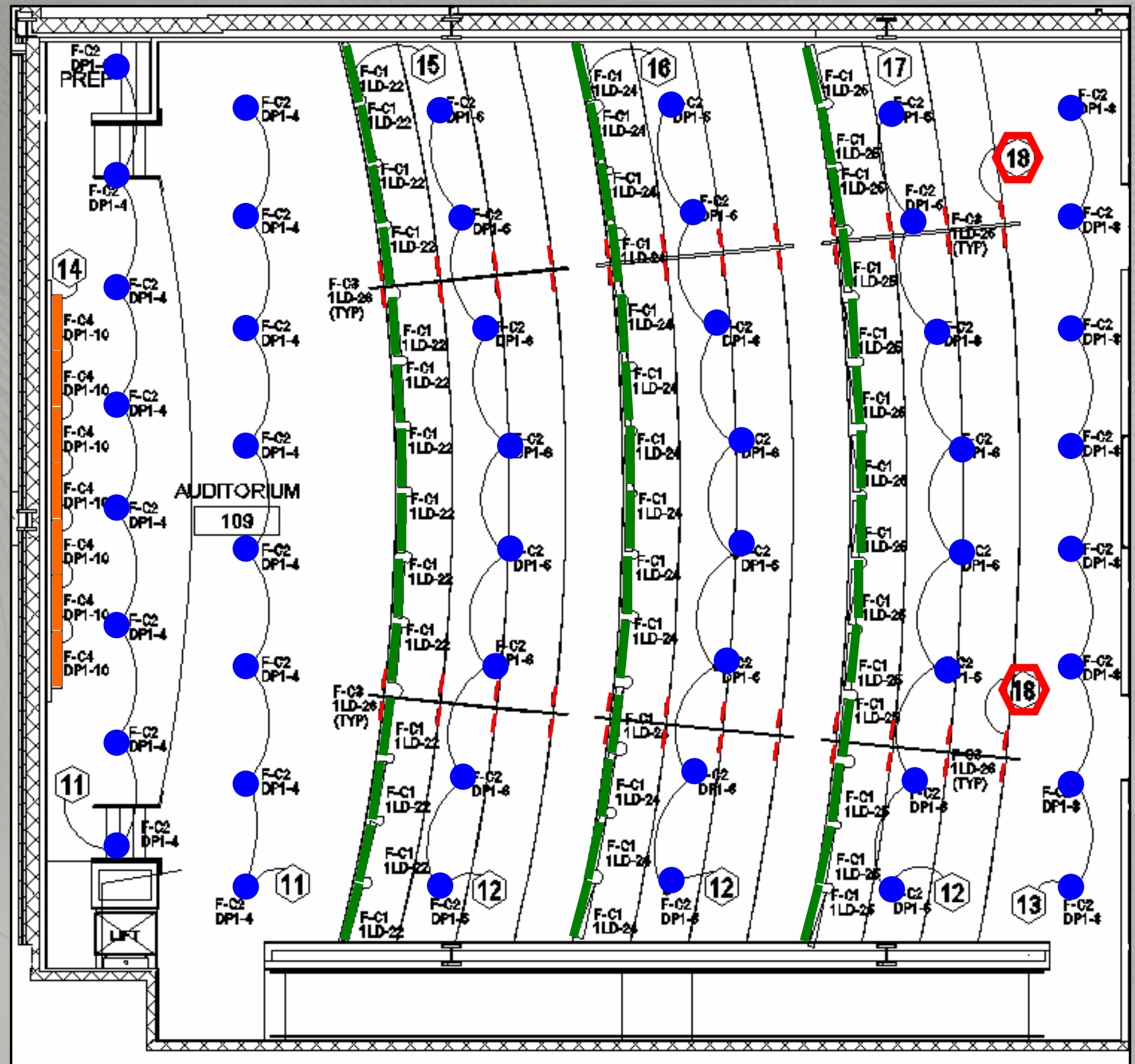


Auditorium Section

Cove Luminaires



Auditorium Lighting Plan



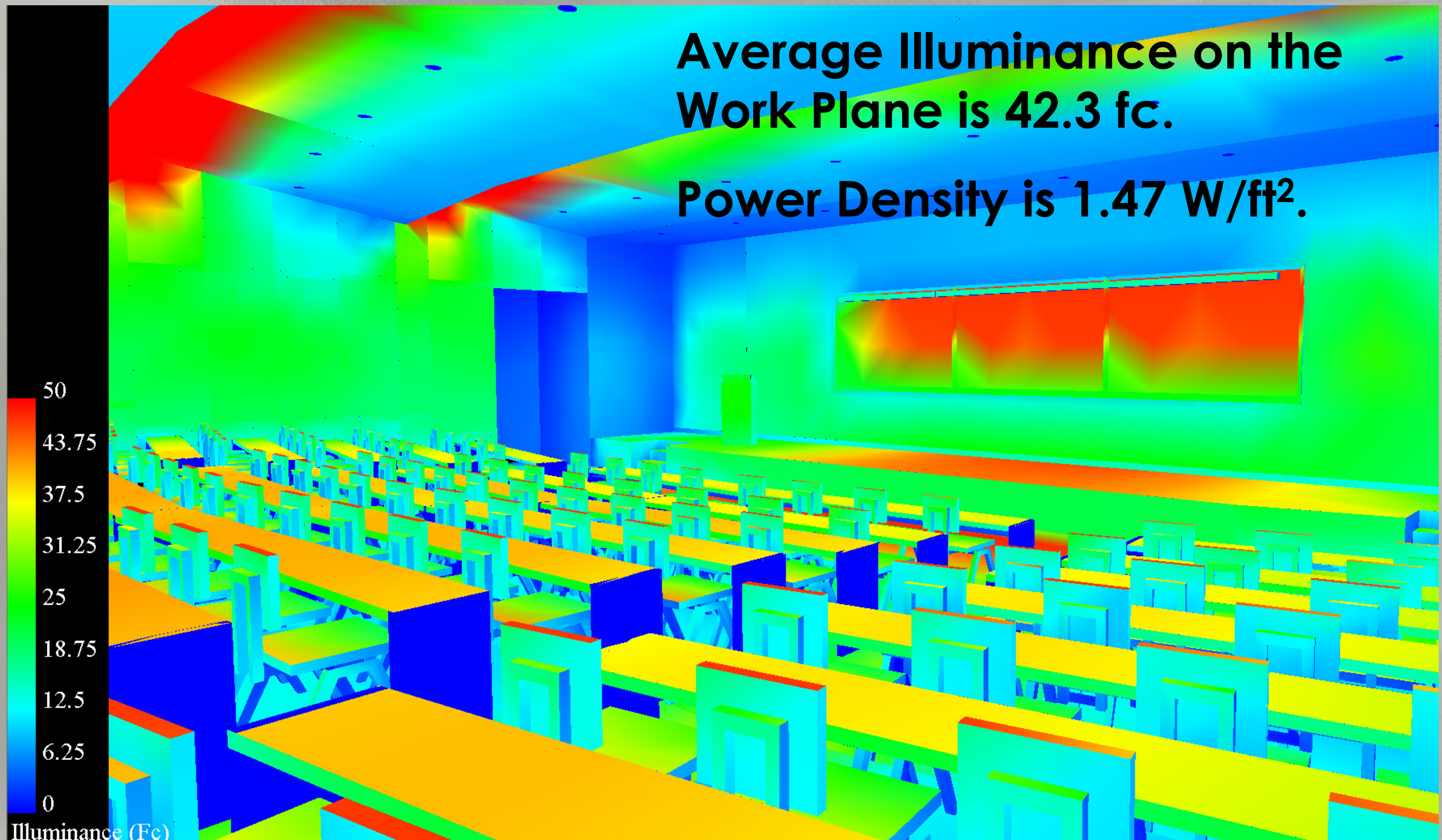
Auditorium Renderings



Auditorium Pseudo Color

**Average Illuminance on the
Work Plane is 42.3 fc.**

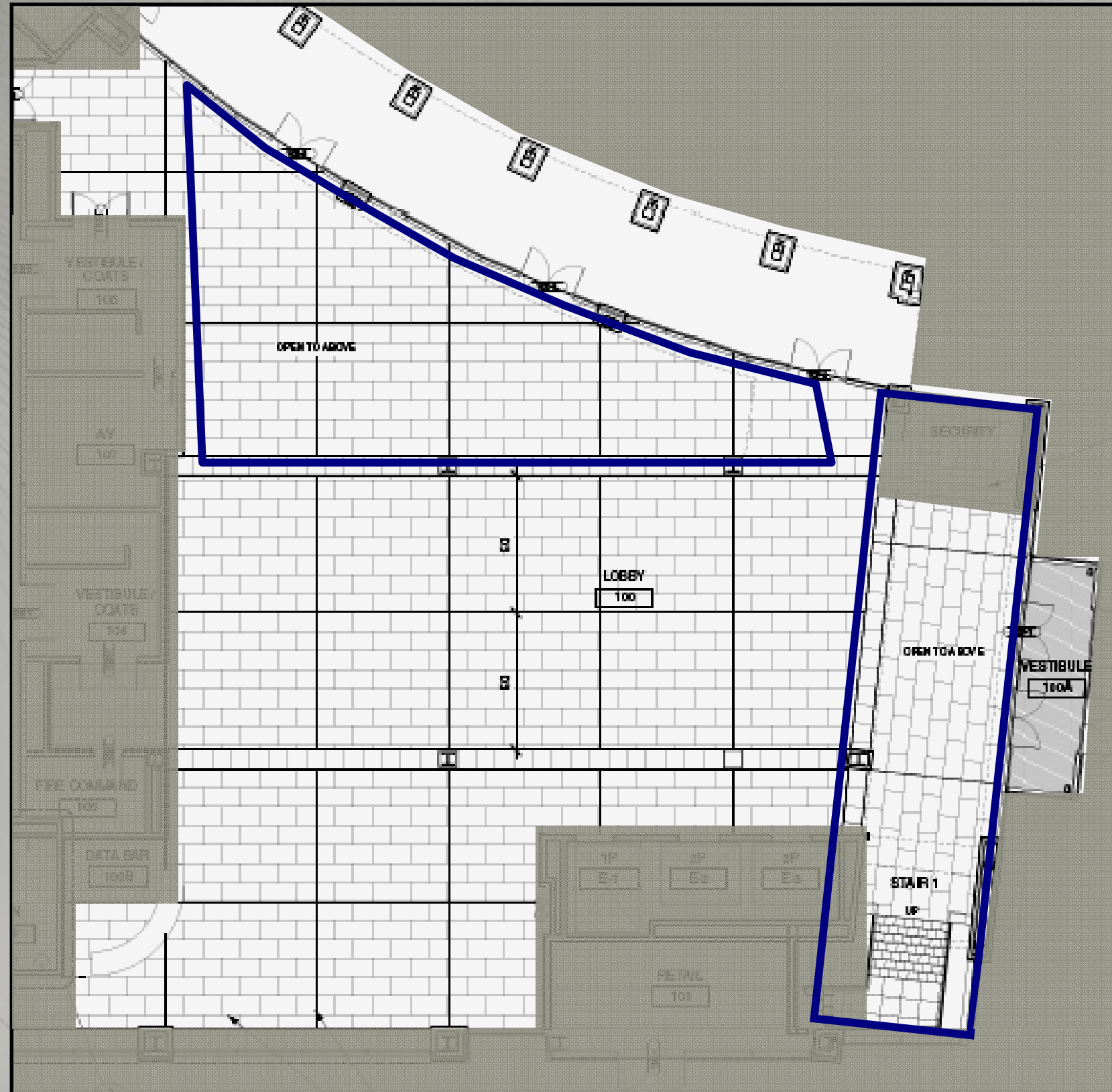
Power Density is 1.47 W/ft².



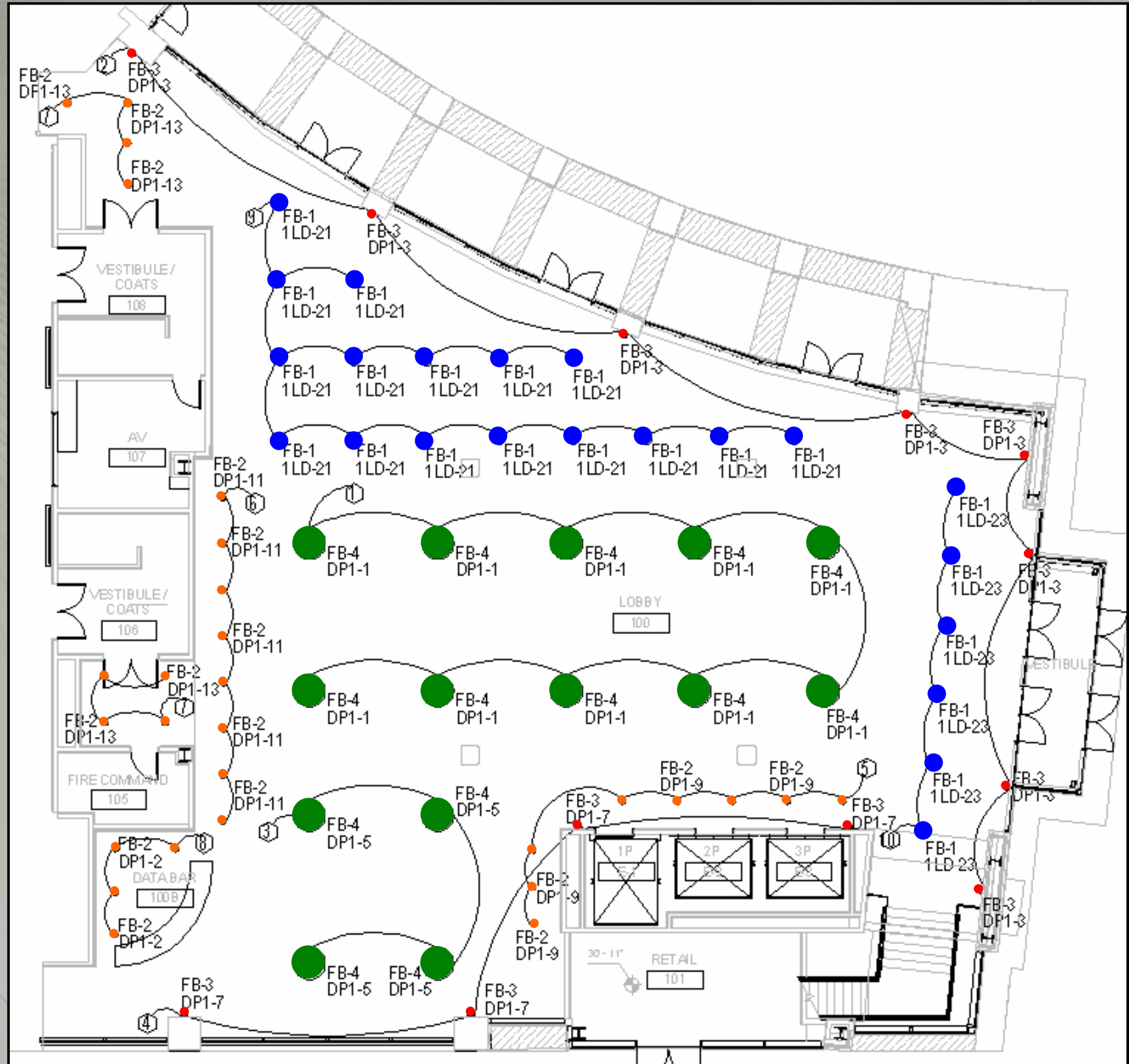
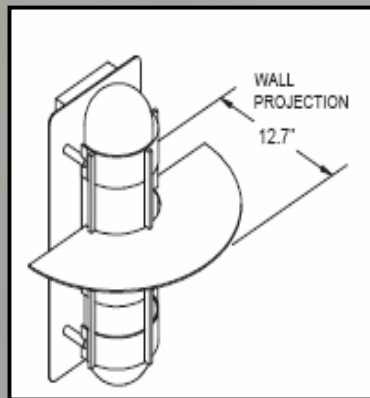
Lobby

Design Objectives

- Circulation - Task
- Illuminance target = 5fc
- Aesthetically Appealing
- Sparkle
- Accent Architecture
- Highlight Elevators & Doorways
- ASHRAE 90.1 Standards
 - 1.3 W/ft²



Lobby Lighting Plan

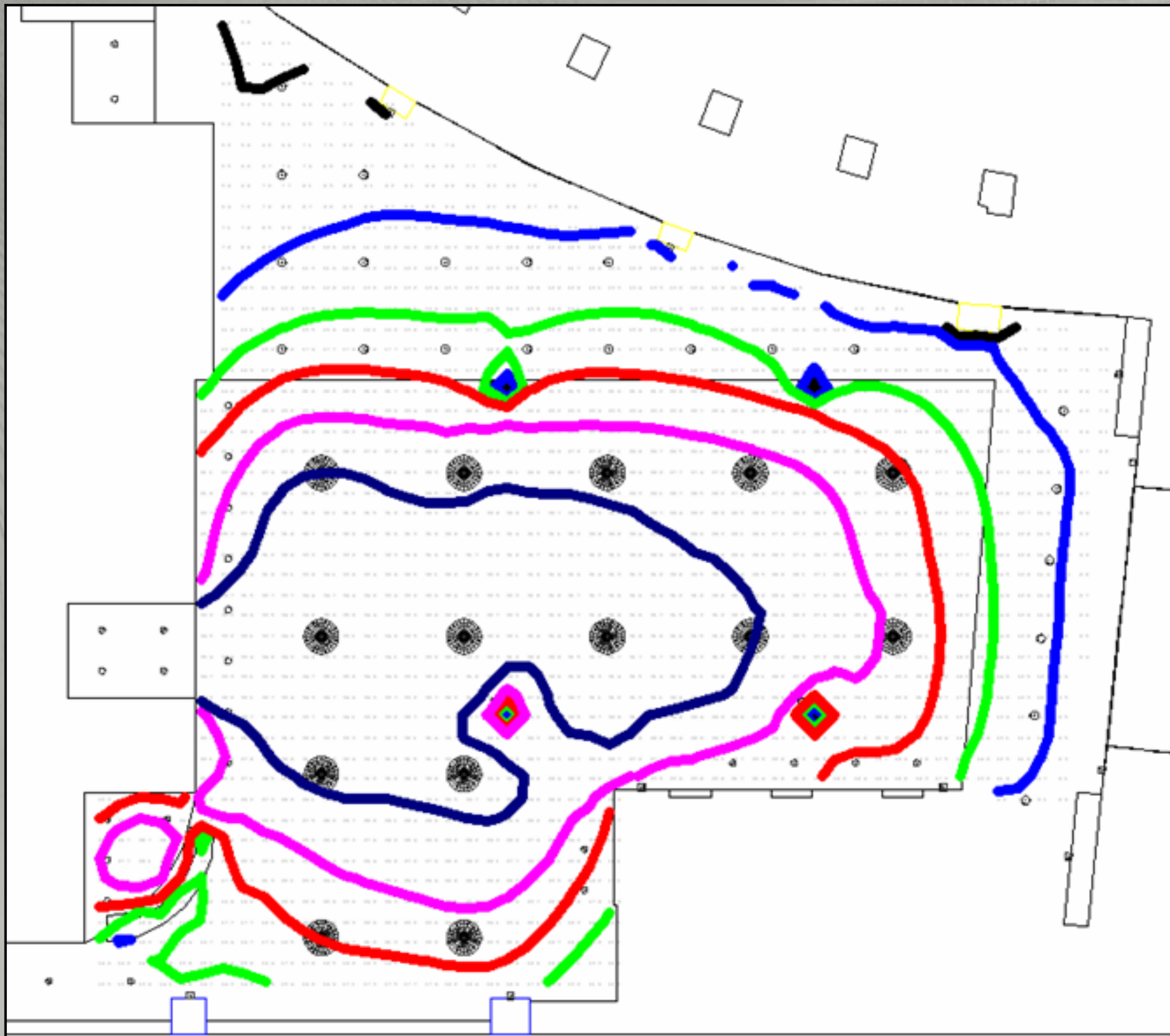


Lobby Isolines

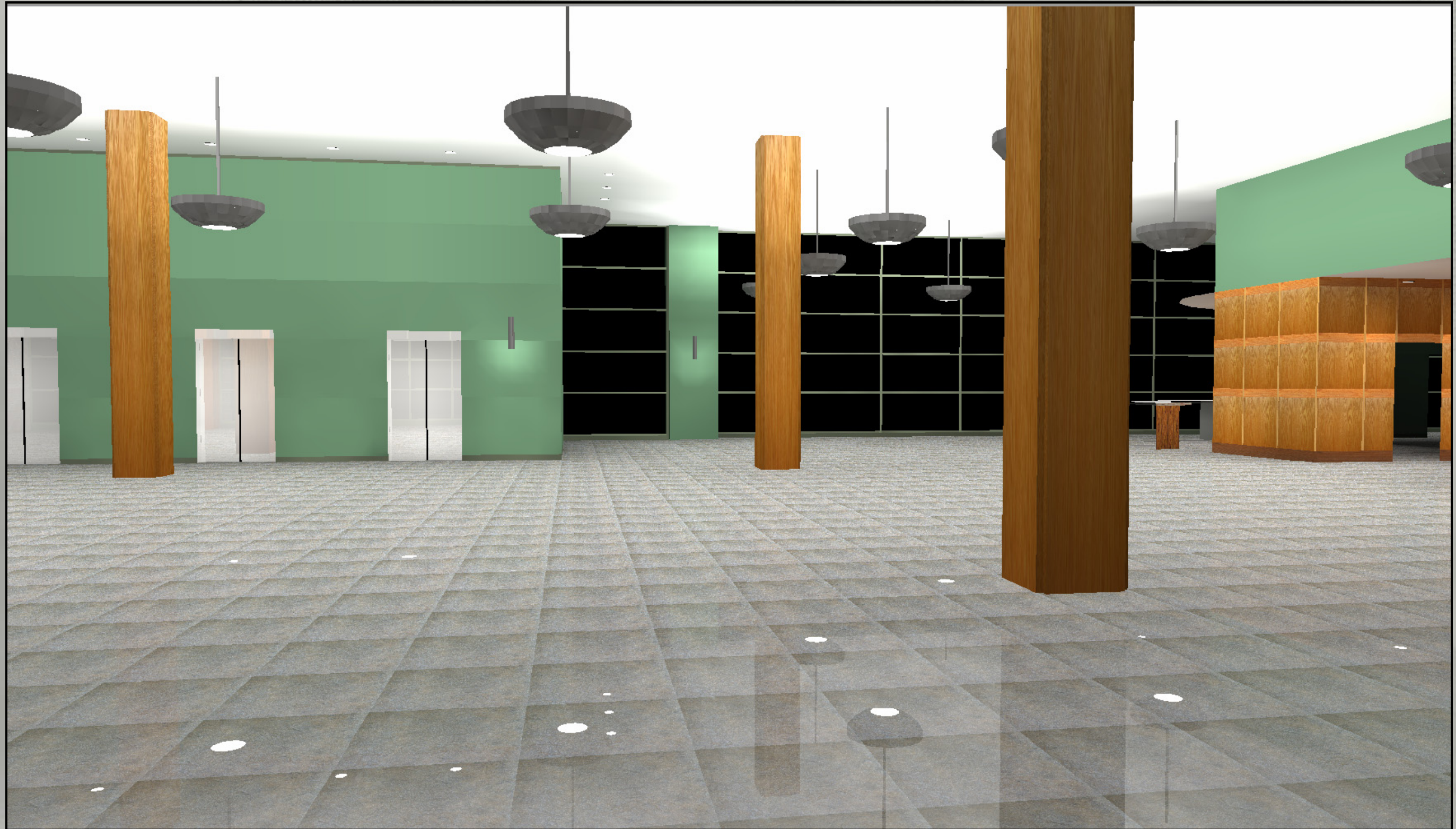
Value (Fc)	Color	Value (Fc)	Color
5	Black	20	Red
10	Blue	25	Magenta
15	Green	30	Dark Blue

Average Illuminance on the Work Plane is 22.1 fc.

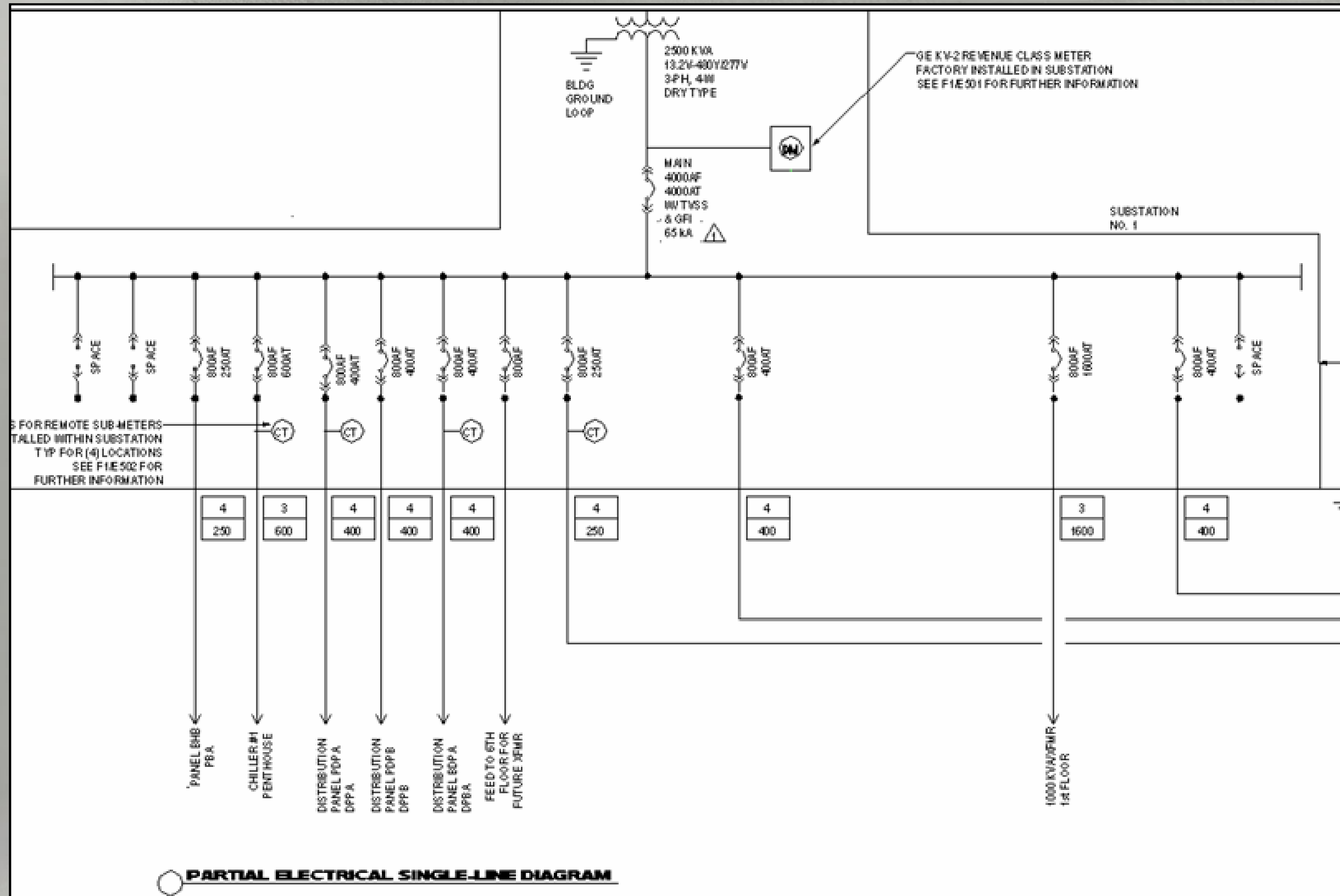
Power Density is 1.05 W/ft².



Lobby Renderings



Central vs. Distributed Transformers



Central vs. Distributed Transformers

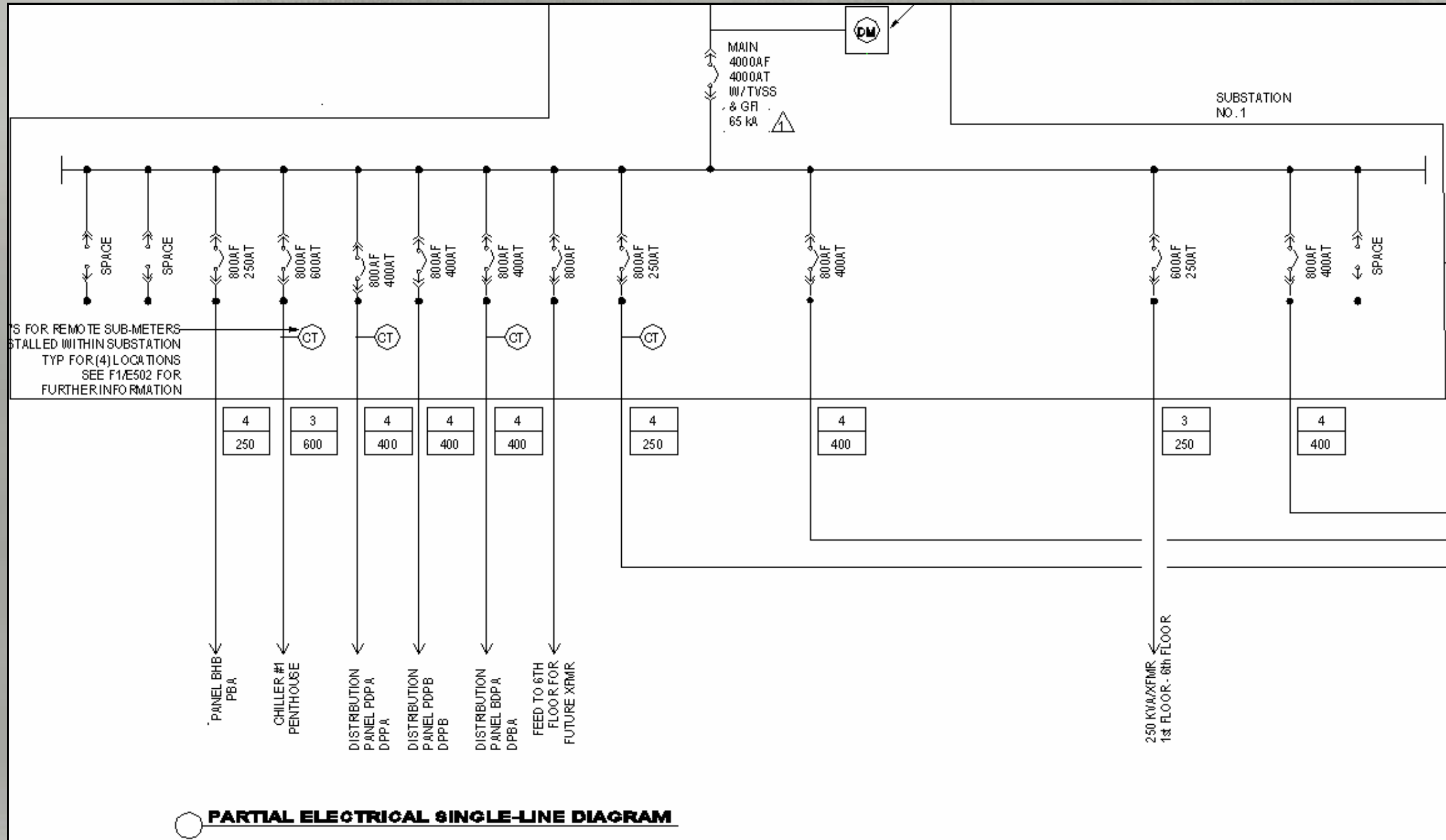
Cost Analysis – Construction Management Breadth

Distributed Transformer Estimate				
Item	Quantity	Units	Cost (Inc. O&P)	Total Cost
Transformers				
150 kVA D-Type, K-13 Rated	5.0	EA	16900.00	84,500.00
Copper Feeders (THWN)				
#4 AWG, Stranded	10.3	CLF	229.00	2,347.25
Size 1/0, Stranded	5.5	CLF	450.00	2,466.00
250 kCmil, Stranded	30.8	CLF	925.00	28,443.75
500 kCmil, Stranded	27.4	CLF	1625.00	44,525.00
Conduit (IMC)				
2-1/2"	1025.0	LF	27.00	27,675.00
4"	548.0	LF	47.50	26,030.00
TOTAL				\$215,987.00
Remarks	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kCmil Wire Minimum 3/4" Conduit 100% Neutral			

Central Transformer Estimate				
Item	Quantity	Units	Cost (Inc. O&P)	Total Cost
Transformers				
1000 kVA D-Type Transformer	1.0	EA	43200.00	43,200.00
Copper Feeders (THWN)				
#4 AWG, Stranded	0.9	CLF	229.00	201.52
Size 1/0, Stranded	13.4	CLF	450.00	6,021.00
250 kCmil, Stranded	2.6	CLF	925.00	2,442.00
500 kCmil, Stranded	66.9	CLF	1625.00	108,712.50
Distribution Panelboards				
4-Wire, 120/208V, 3000 Amp	1.0	EA	15975.00	15,975.00
Conduit (IMC)				
2-1/2"	88.0	LF	27.00	
4"	1338.0	LF	47.50	63,555.00
TOTAL				\$240,107.02
Remarks:	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kCmil Wire Minimum 3/4" Conduit 100% Neutral			

➤ Distributed Transformers are 10.0% cheaper and cost \$24,120 less than the Central Transformer.

Busduct vs. Feeders



Busduct vs. Feeders

Cost Analysis – Construction Management Breadth

Feeder Estimate				
Item	Quantity	Units	Cost (Inc. O&P)	Total Cost
Copper Feeders (THWN)				
#4 AWG, Stranded	10.5	CLF	229.00	2,393.05
250 kCmil, Stranded	31.4	CLF	925.00	28,998.75
Conduit (IMC)				
2-1/2"	1045.0	LF	27.00	28,215.00
TOTAL				\$59,606.80
Remarks	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kCmil Wire Minimumum 3/4" Conduit 100% Neutral			

Busway Estimate				
Item	Quantity	Units	Cost (Inc. O&P)	Total Cost
Indoor/Plug-in Busduct				
Copper Busduct - 600A	220.0	LF	210.00	46,200.00
Feeders				
#4 AWG	1.6	CLF	229.00	357.24
250 kCmil	4.7	CLF	925.00	4,329.00
Conduit (IMC)				
2-1/2"	156.00	LF	27.00	4,212.00
TOTAL				\$55,098.24
Remarks:	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kCmil Wire Minimumum 3/4" Conduit 100% Neutral			

➤ **Busduct is 7.6% cheaper and costs \$4,508 less than the individual feeders.**

Motor Control Center

Motor Control Center Schedule

Equipment	Motor Type	Power	NEMA Starter Size	# X Spaces	Type of VFD	FLA	Demand Factor	Total Amps	
AHU-1	VFD	75 HP	4	12X	SVX9000	71.83	1.25	89.79	
AHU-2	VFD	75 HP	4	12X	SVX9000	71.83	1.00	71.83	
AHU-3	VFD	75 HP	4	12X	SVX9000	71.83		71.83	
RF-1	VFD	50 HP	3	12X	SVX9000	48.64		48.64	
RF-2	VFD	50 HP	3	12X	SVX9000	48.64		48.64	
SF-3	FVNR	20 HP	2	1X	N/A	20.20		20.20	
SF-4	FVNR	20 HP	2	1X	N/A	20.20		20.20	
EF-7	FVNR	30 HP	3	2X	N/A	29.23		29.23	
EF-8	FVNR	30 HP	3	2X	N/A	29.23		29.23	
P-1	VFD	40 HP	3	7X	SVX9000	38.91		38.91	
P-2	VFD	40 HP	3	7X	SVX9000	38.91		38.91	
P-3	VFD	40 HP	3	7X	SVX9000	38.91		38.91	
Total Design Load								546.32	

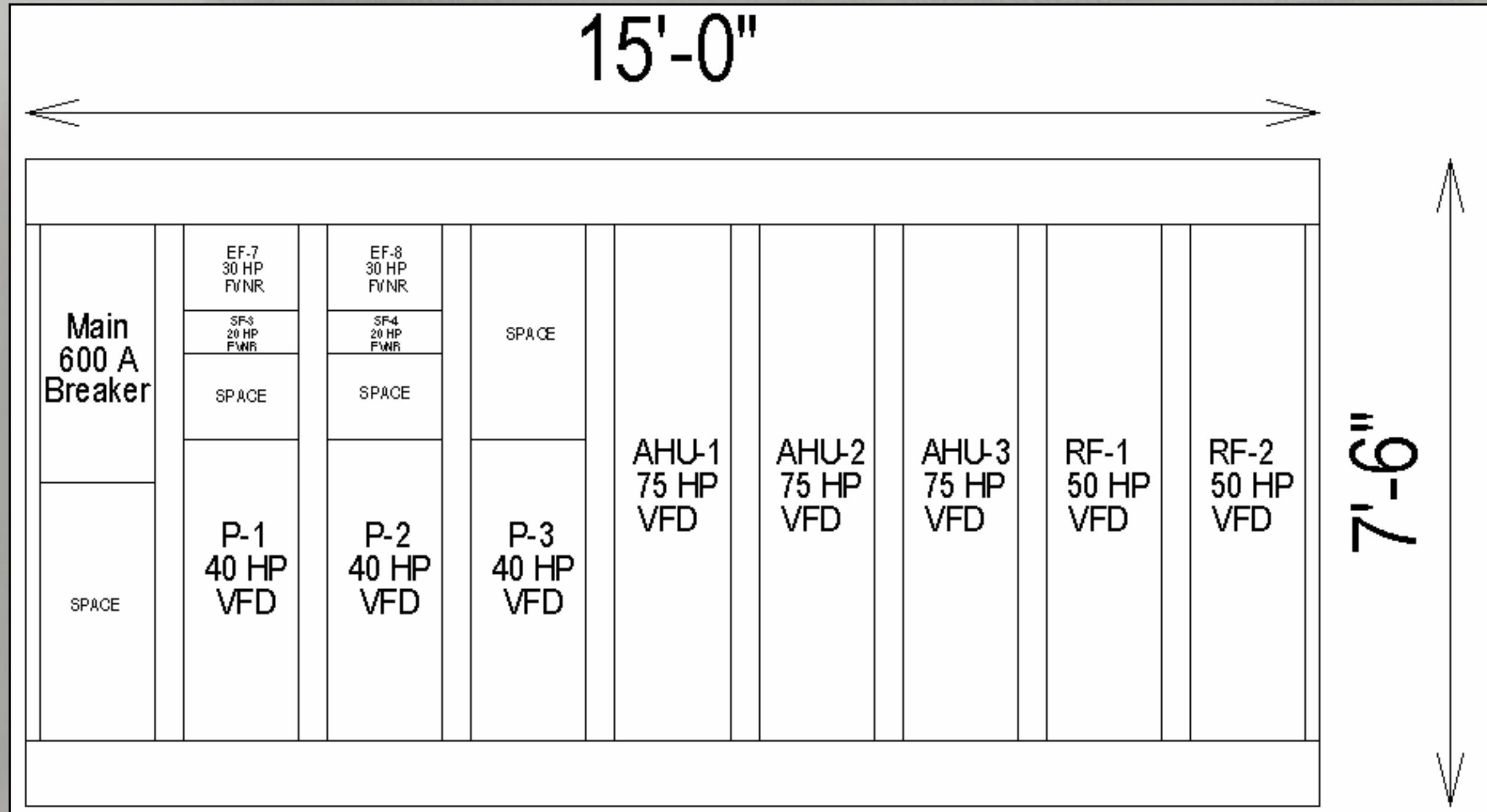
Motor Control Center - Sizing

Control Center Size

Motor Control Center	
Calculated Design Load	546.32 A
Feeder Protection Size	600 A
Wire	(2) sets of 250 kCmil & (1) #1 Ground
Conduit	3 1/2"
Secondary Protection	600 A
Primary Protection	700 A
Remarks:	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kcmil wire Minimum 3/4" conduit 100% Neutral Dry type transformers with primary and secondary feeders exceeding 25 feet

- 600 amp busduct is needed.
 - A 600-amp busduct will need 6X number of spaces.
- Total of 93X number of spaces. Since there are 12X spaces per section, I will need 8 sections.
 - Final dimensions of the motor control center are 16" deep, 90" high, and 180" long.

Motor Control Center Layout



Conclusion

➤ Lighting Depth

➤ Classroom

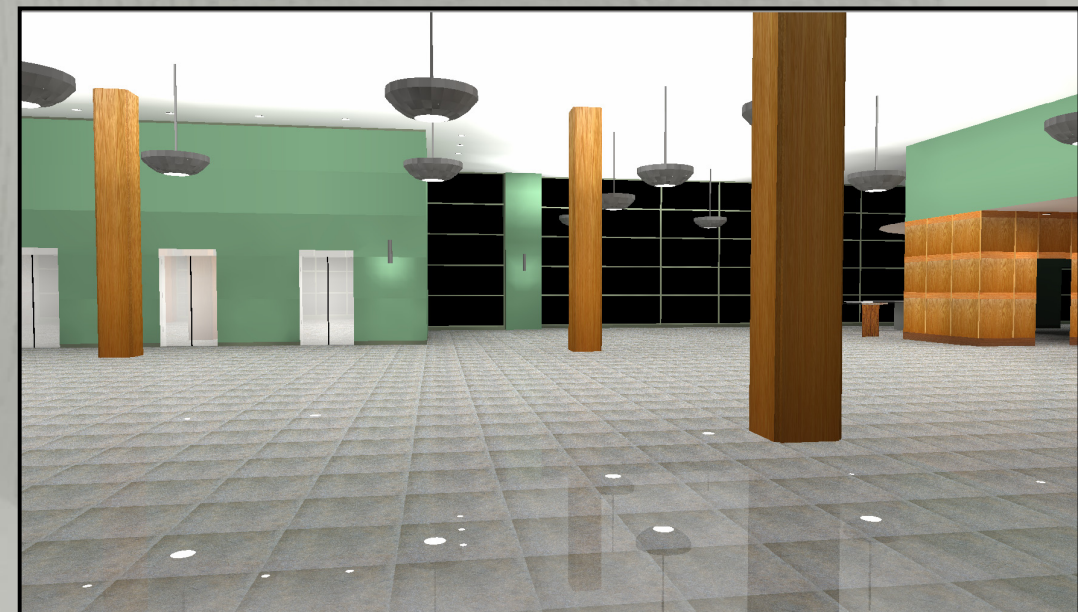
- Target Illuminance = 50 fc, 49.6 fc average
- Accent Blackboard
- Dimmable Fixtures for use with VDT Screen
- ASHRAE 90.1 Standards
 - 1.31 W/ft² calculated, 1.4 W/ft² allowed

➤ Auditorium

- Target Illuminance = 50 fc, 42.3 fc average
- Accent Blackboard
- Dimmable Fixtures for use with VDT Screen
- Use Cove Luminaires
- ASHRAE 90.1 Standards
 - 1.47 W/ft² calculated, 1.4 W/ft² allowed

➤ Lobby

- Target Illuminance = 5 fc, 22.1 fc average
- Aesthetically Appealing/Sparkle
- Accent Architecture
- Highlight Elevators and Doorways
- Dimmable Fixtures for use with controls
- ASHRAE 90.1 Standards
 - 1.05 W/ft² calculated, 1.3 W/ft² allowed



Conclusion

➤ Electrical Depth

➤ Distributed Transformers vs. Central Transformer

- Distributed Transformers are 10.0% cheaper and cost \$24,120 less than the Central Transformer.
- Recommendation: Go with the Distributed Transformers due to the cheaper system cost even when the sixth floor transformer is added.

➤ Busduct vs. Feeders

- Busduct is 7.6% cheaper and costs \$4,508 less than the individual feeders.
- Recommendation: Go with the Busduct due to the cost savings and square footage savings.

➤ Motor Control Center

- Recommendation: Go with the MCC due to the square footage savings and the organization provided with a MCC.

Thanks!

Acknowledgments

- **Design Firms**
 - **The Lighting Practice**
 - **Burt Hill**
- **AE Faculty**
 - **Dr. Mistrick**
 - **Prof. Dannerth**
 - **Prof. Parfitt**
 - **Prof. Holland**
- **Family & Friends**

Comments?

Questions?