Senior Thesis Presentation

Hunter's Point South School

Queens, New York

Britt Kern
Mechanical Option
Advisor: Dr. Treado

Outline

Building Summary

- **Introduction**
  - **i. Building Summary**
  - ii. Site Plan
  - iii. Existing Mechanical
- Proposed Redesign
- Mechanical Depth
- Breadth – Electrical
- Conclusion

Size:	153,769 sf
Occupancy:	IM/HS Schoolhouse
Levels:	5 Stories/No Cellar/Penthouse
Cost:	$61,098,000
Construction Dates:	Jan 10, 2011 to Oct 7, 2013

<u>Project Team</u>

Architect:	FXFOWLE Architects
Structural	Ysreal A. Seinuk
MEP:	Kallen & Lemelson
CM:	Skanska

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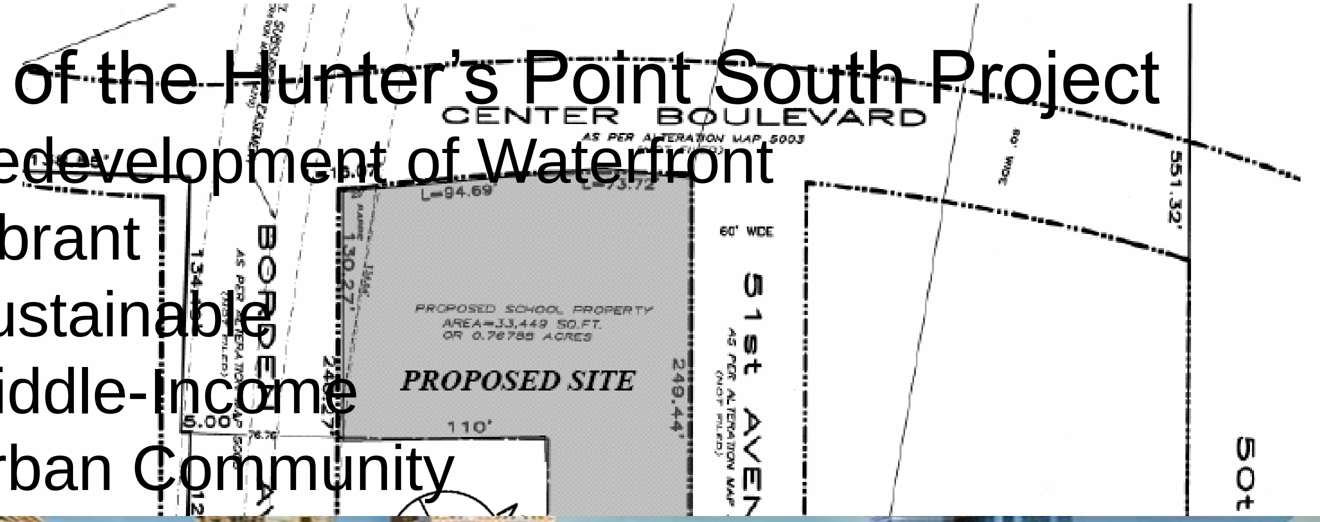
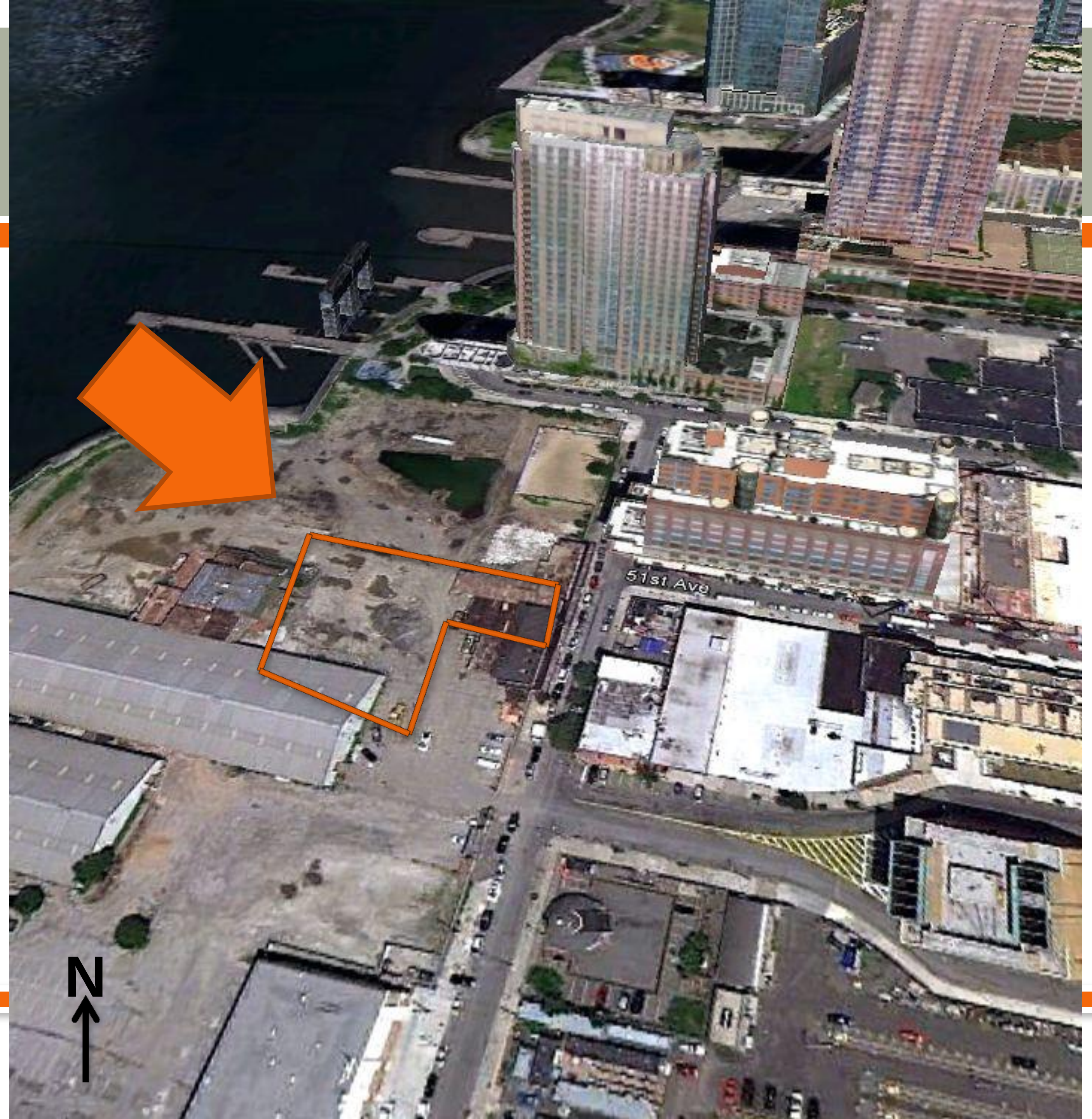
Building Summary

- Part of the Hunter's Point South Project
  - Redevelopment of Waterfront
  - Vibrant
  - Sustainable
  - Middle-Income
  - Urban Community





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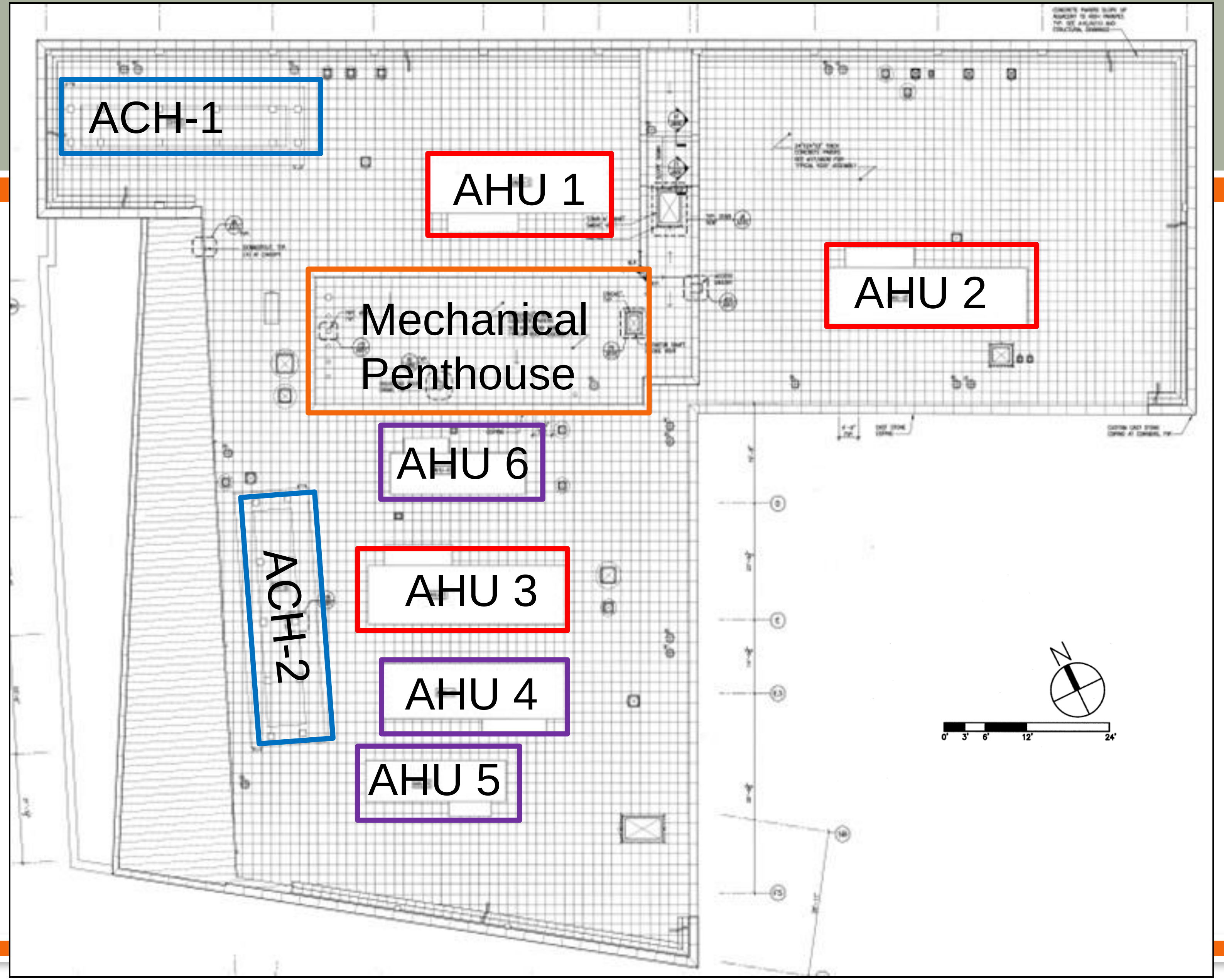
Existing Mechanical

- AHU's 1, 2, and 3 = VAV
- AHU's 4, 5, and 6 = CAV
- 4 Condensing Boilers
- Fin Tube Radiators
- (2) 276 ton chillers

Problems?

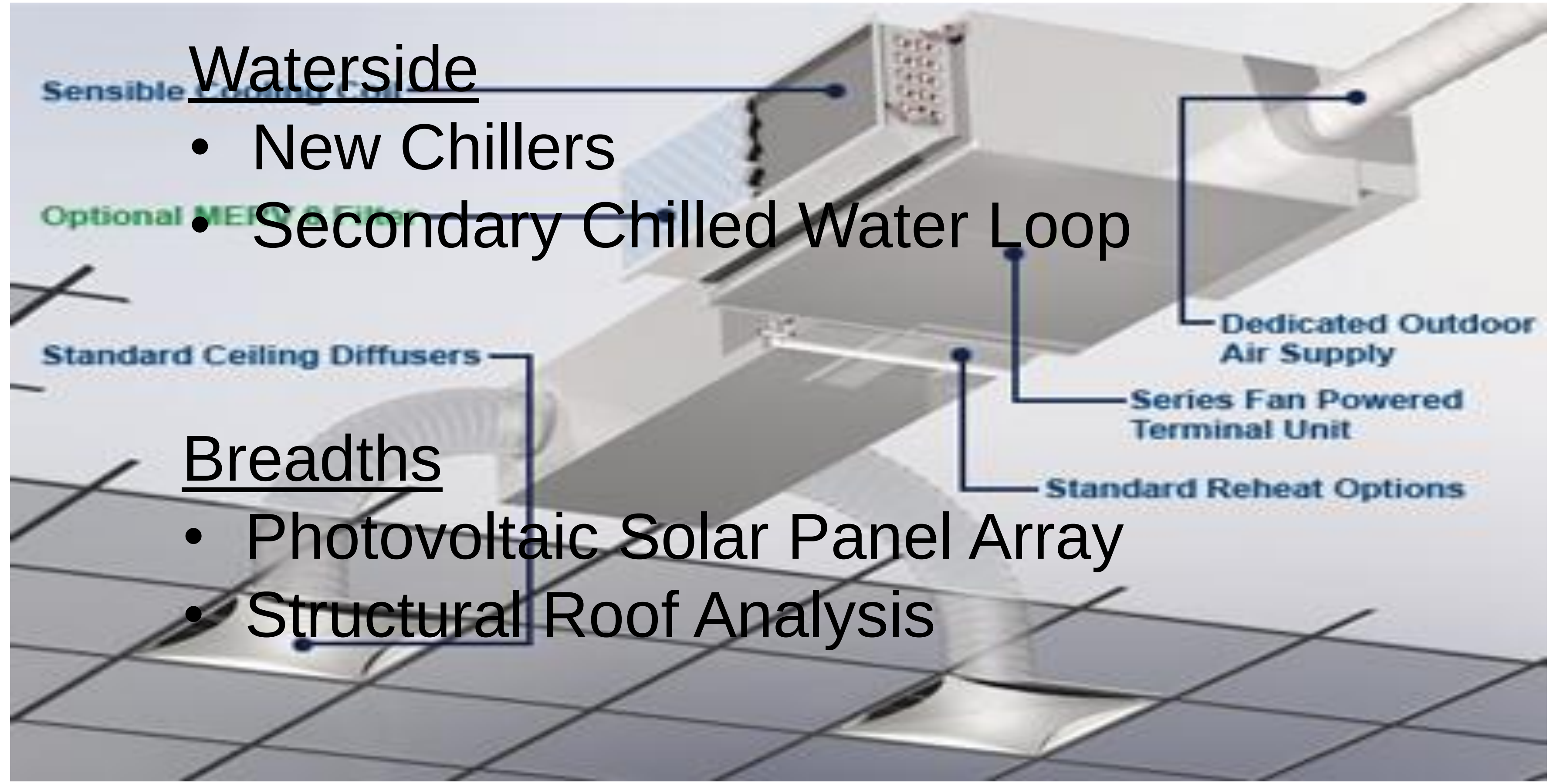
- Minimum Ventilation
- No Energy Recovery



Proposed Redesign

<u>Goals</u>
- Ventilation Always Met
- Increase Sustainability
- Better Room Comfort Control

<u>Airside</u>
- Replace AHU's 1-3 with DOAS
- Total Energy Recovery Wheel
- Fan-Powered Induction Units (FPIU's)



<u>Waterside</u>
- New Chillers
- Secondary Chilled Water Loop

<u>Breadths</u>
- Photovoltaic Solar Panel Array
- Structural Roof Analysis

Mechanical Depth

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- **Mechanical Depth**
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  - ii. FPIU
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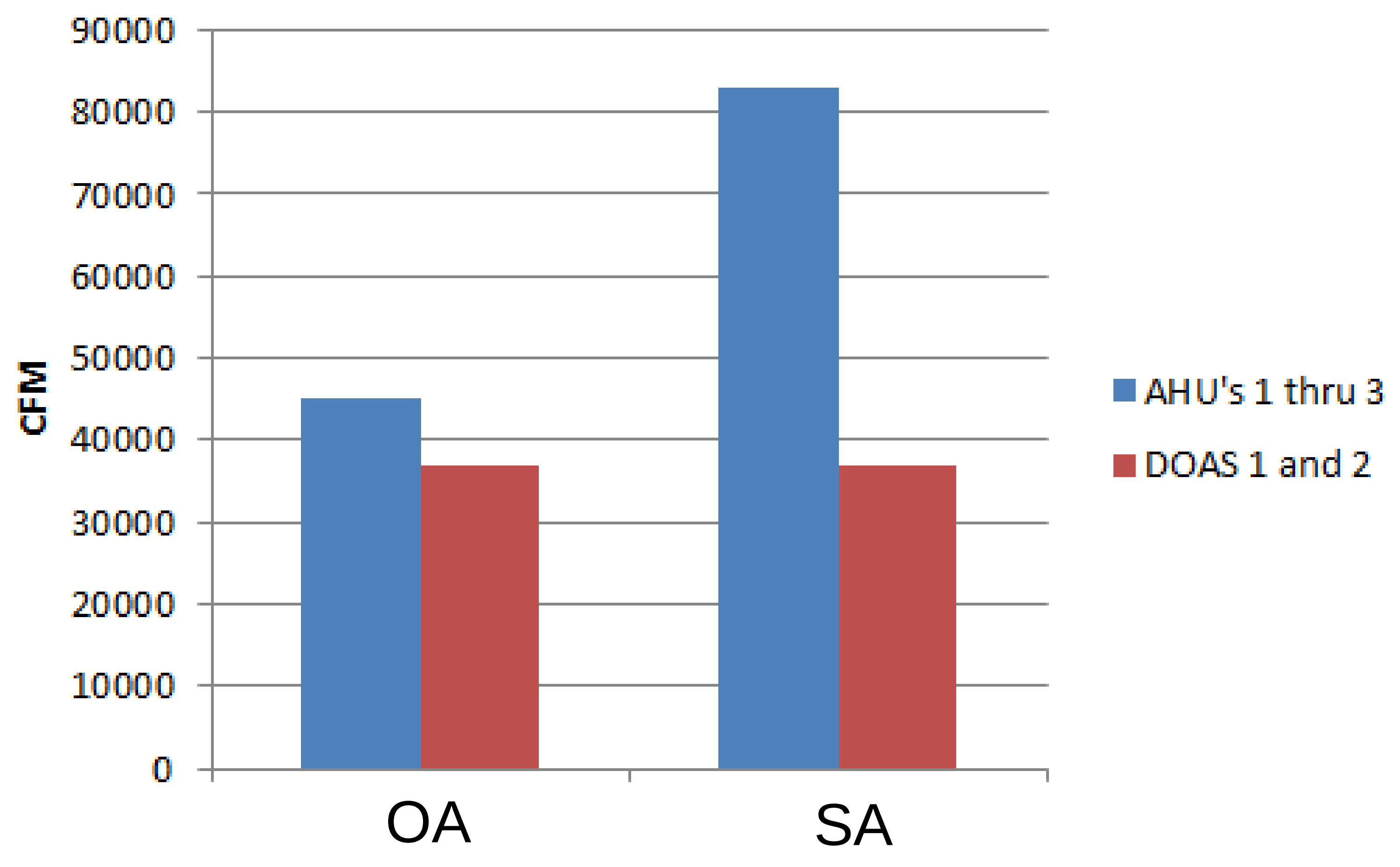
- Ventilation Air Based On:
  - NYC Mechanical Code
  - 30% Above ASHRAE Std. 62.1
  - Latent Load
- Reduction in 18% OA and 55% SA
- Exhaust Rates and ESP of Fans



Mechanical Depth

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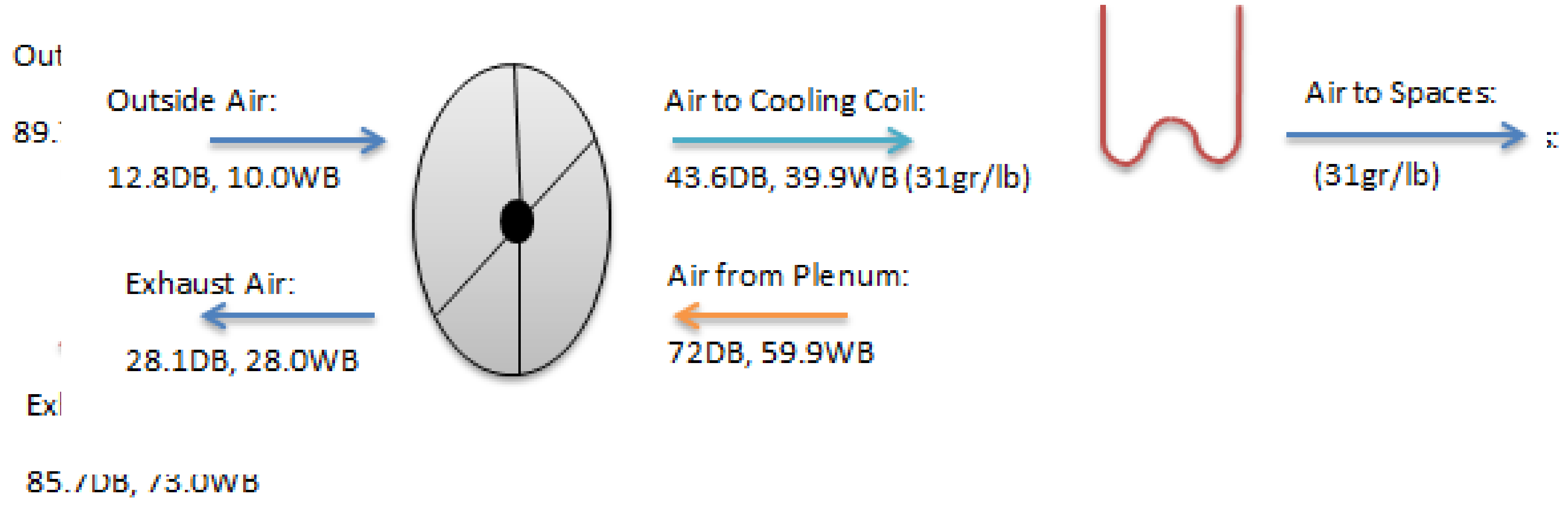
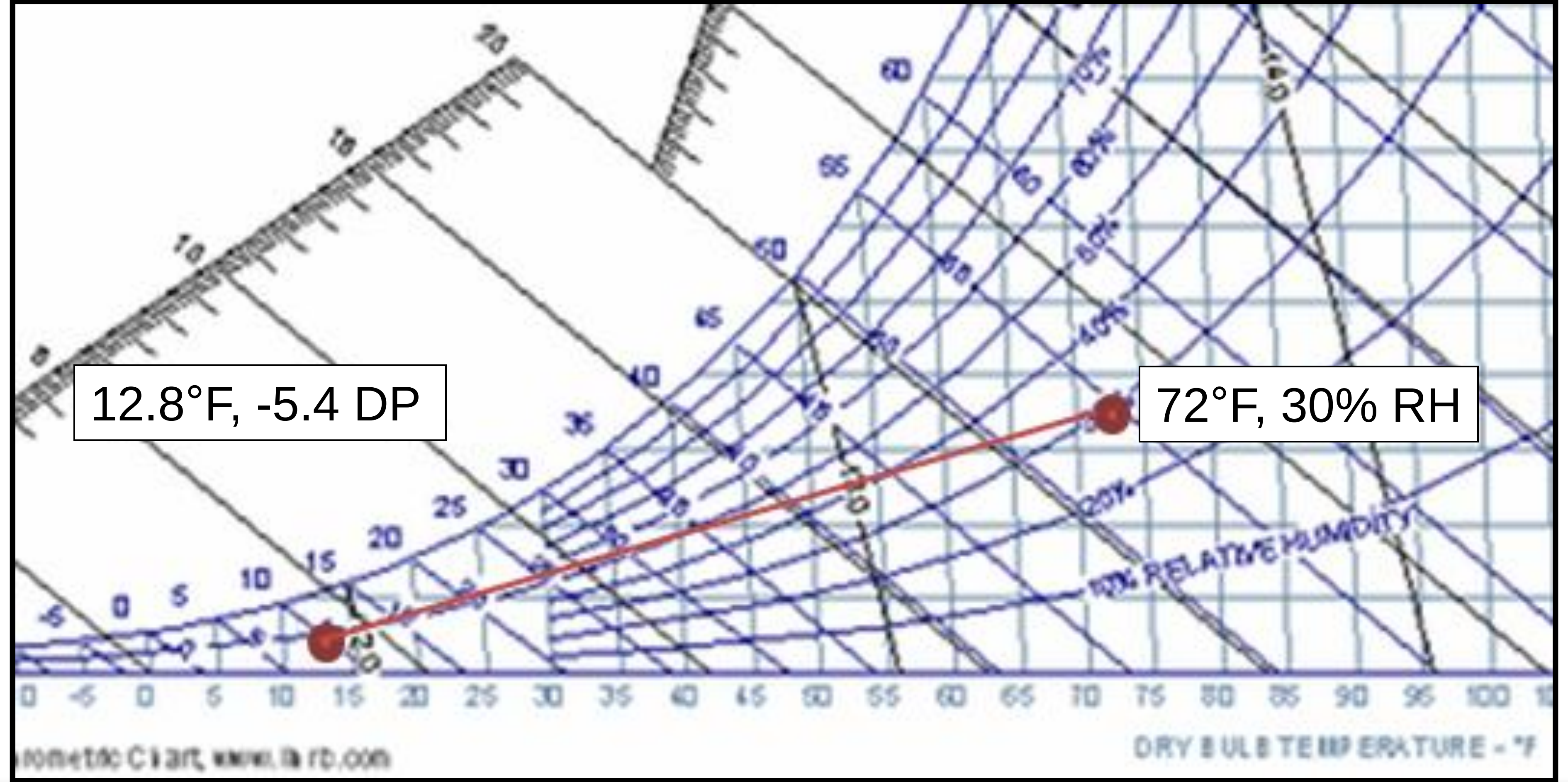


Winter Design

	DOAS 1	DOAS 2
Supply Air (cfm):	13230	23635
Return Air (cfm):	9436	16856
OA design Conditions:		
Hot Water Leaving (F):	120	120
Units outside:	Yes	Yes



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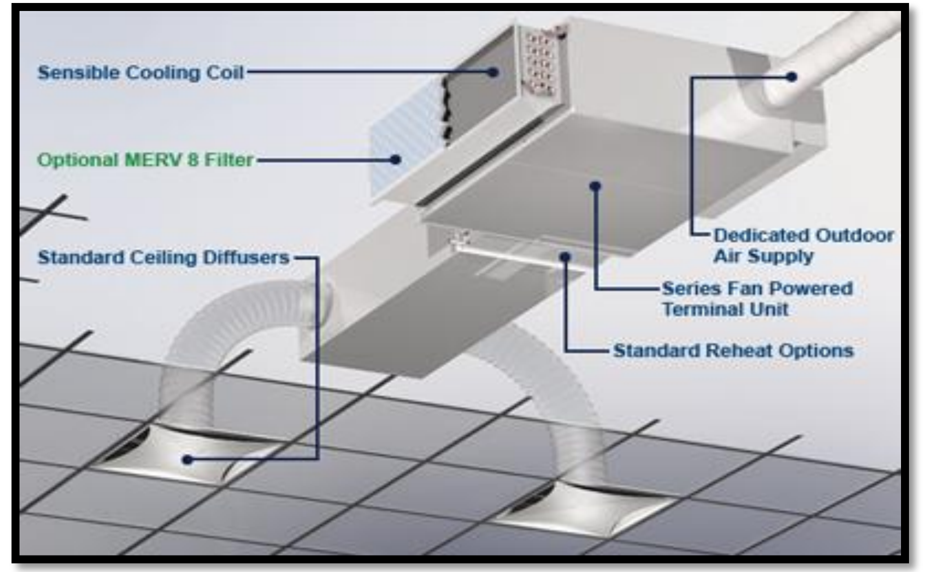
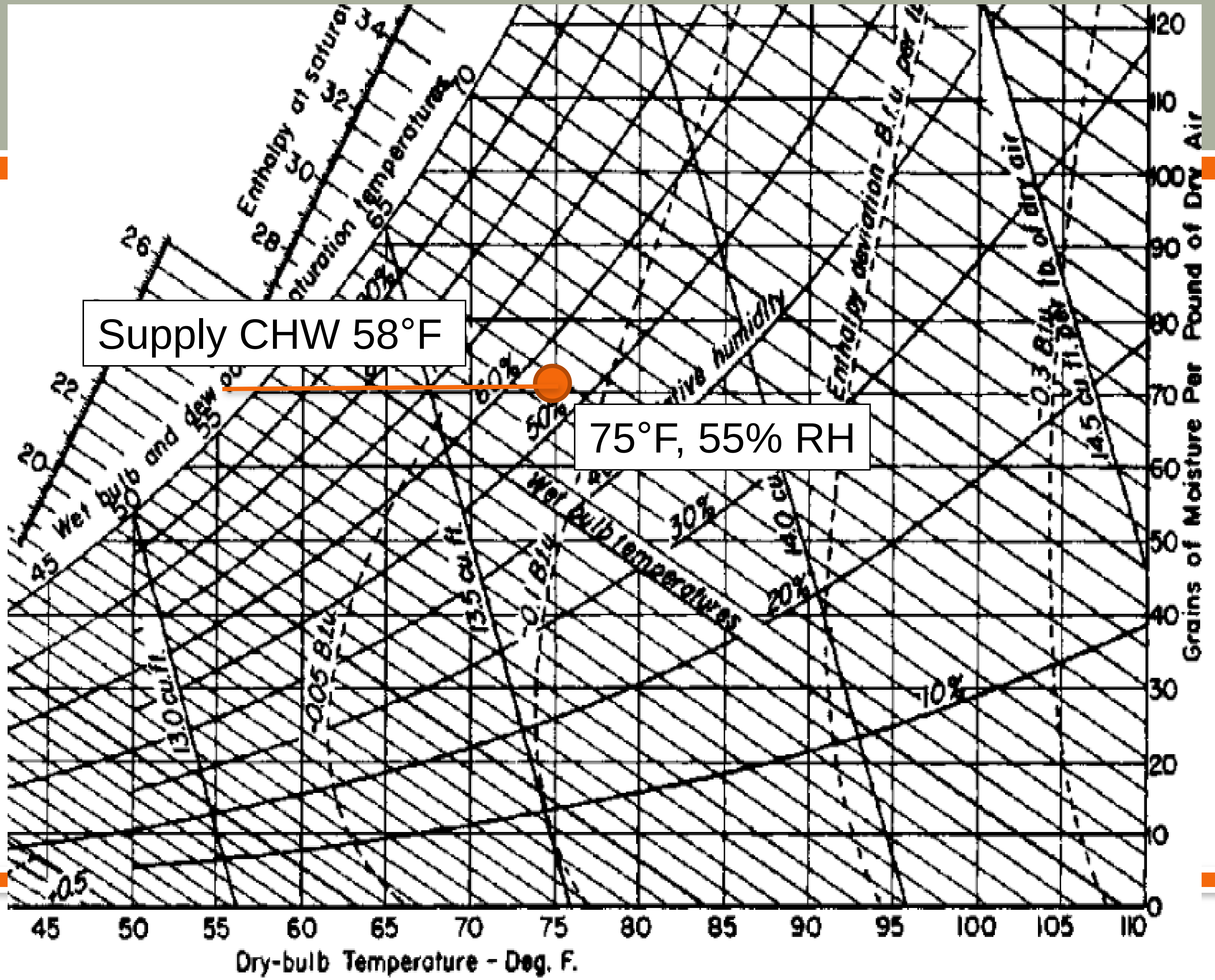
Mechanical Depth

- Find CHW Supply Temp
- Size Coils for Heating and Cooling
- Optional MERV 8 filter – 1 LEED Point





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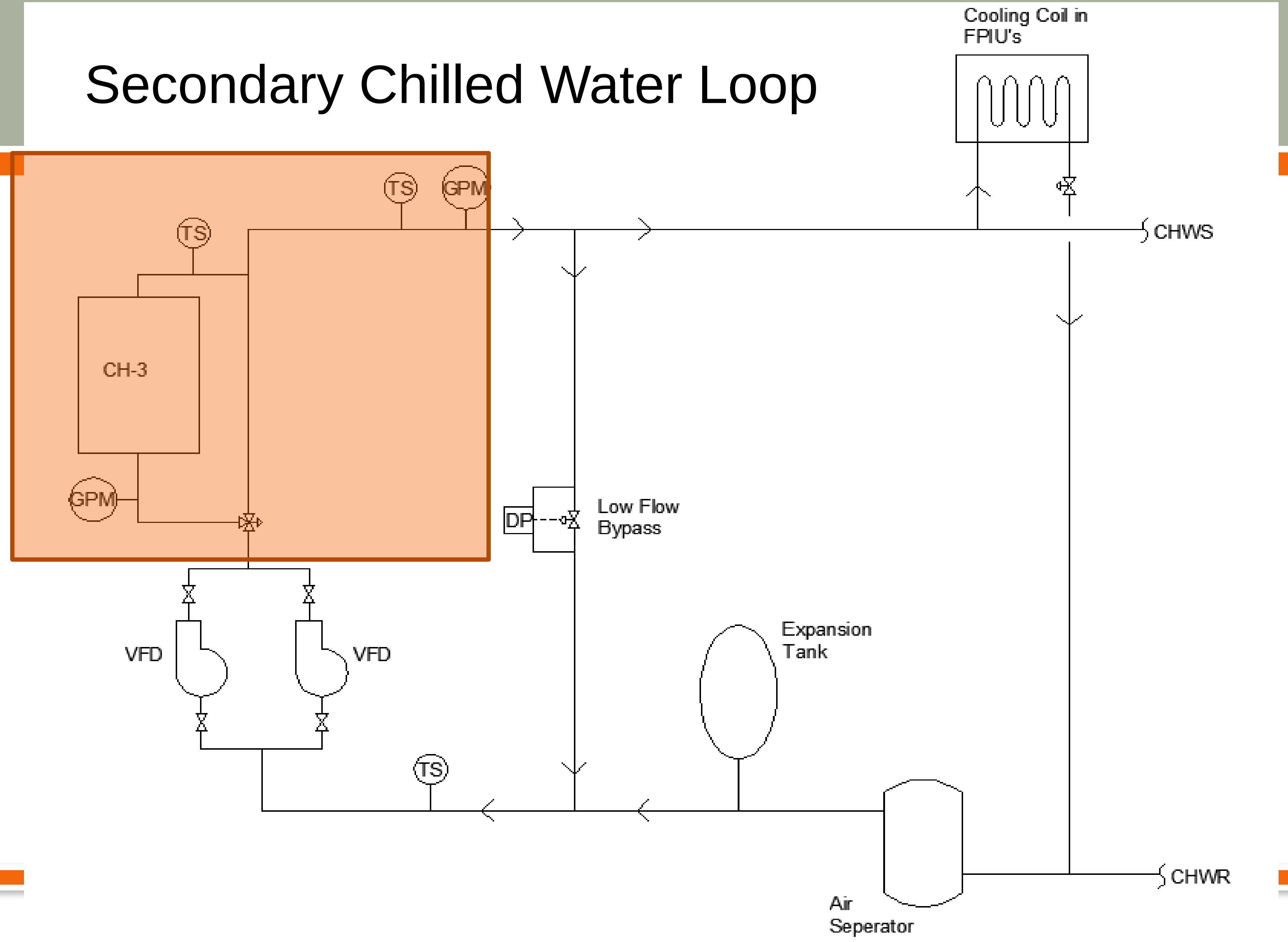
Mechanical Depth

- Current CHW Loop Re-Used:
  - a. (2) 225 ton chillers
  - b. LWT 44°F
- Higher CHW Temp for FPIU's
- Secondary CHW Loop Created
  - 33.5 ton chiller
  - LWT 58°F

Secondary Chilled Water Loop



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Mechanical Depth

Energy Balance:

$$\dot{m}_{chiller} \times LWT_{chiller} + \dot{m}_{bypass} \times 62°F = \dot{m}_{supply} \times 58°F$$

ρ = constant

$$GPM_{chiller} \times LWT_{chiller} + GPM_{bypass} \times LWT_{bypass} = GPM_{supply} \times LWT_{supply}$$

$$GPM_{chiller} \times LWT_{chiller} + GPM_{bypass} \times 62°F = 178\ GPM \times 58°F$$

Chiller						
Tons	LWT (deg F)	EWT (deg F)	delta T	GPM thru Chiller	GPM to FPIU's	GPM Bypass
32	40	62	22	35	178	143
32	41	62	21	37	178	141
32	42	62	20	38	178	140
32	43	62	19	40	178	138
32	44	62	18	43	178	135
32	45	62	17	45	178	133
32	46	62	16	48	178	130
32	47	62	15	51	178	127
32	48	62	14	55	178	123
32	49	62	13	59	178	119
32	50	62	12	64	178	114
32	51	62	11	70	178	108
32	52	62	10	77	178	101
32	53	62	9	85	178	93
32	54	62	8	96	178	82

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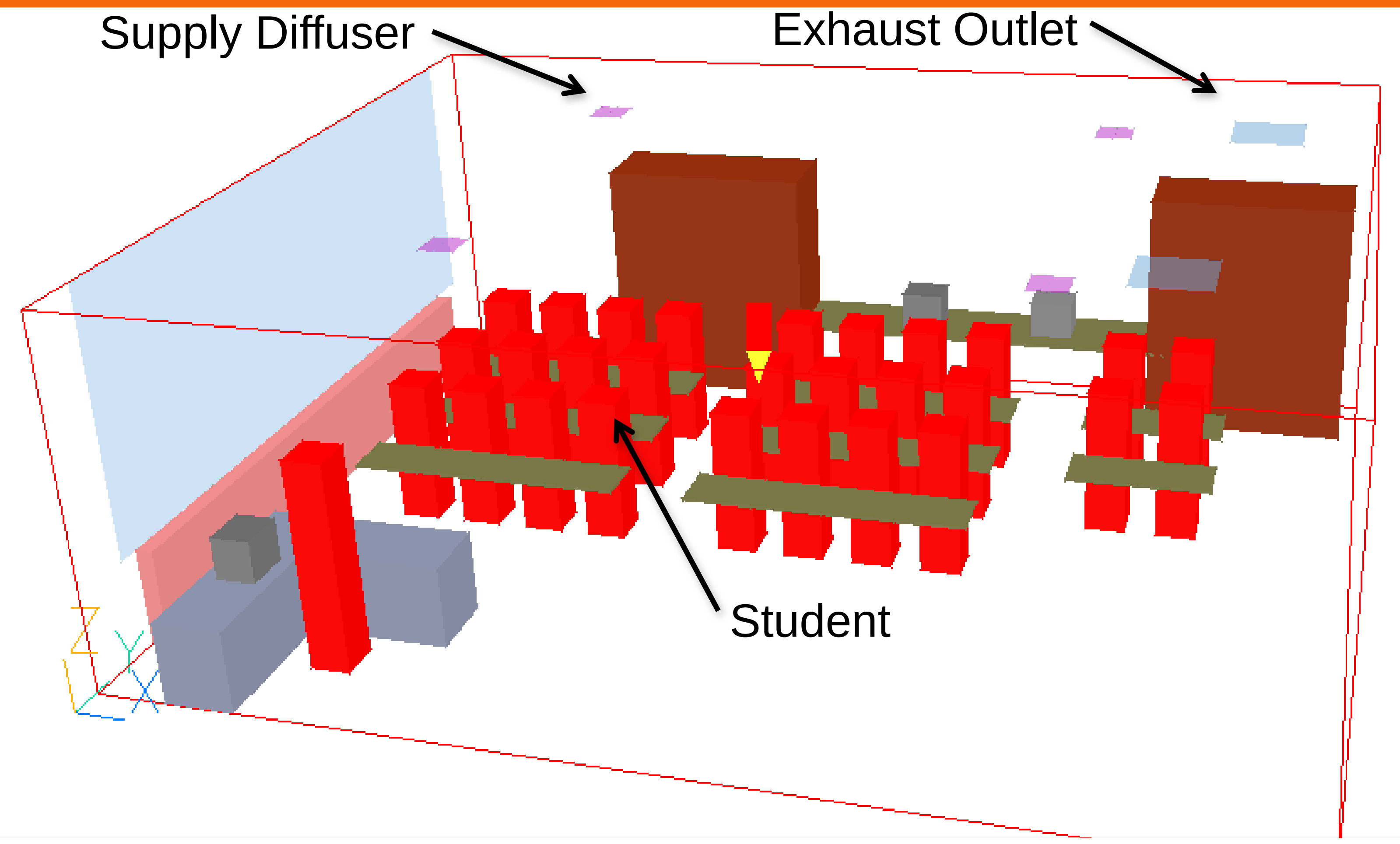
Mechanical Depth

- Compare Old and New Systems
- Validate New System
- 3 Models:
  - VAV 100% Flow
  - VAV 30% Flow
  - FPIU
- Criteria:
  - No Drafts (<40 fpm)
  - Uniform Temperature (Setpoint 72°F)
  - Minimal Temperature Stratification



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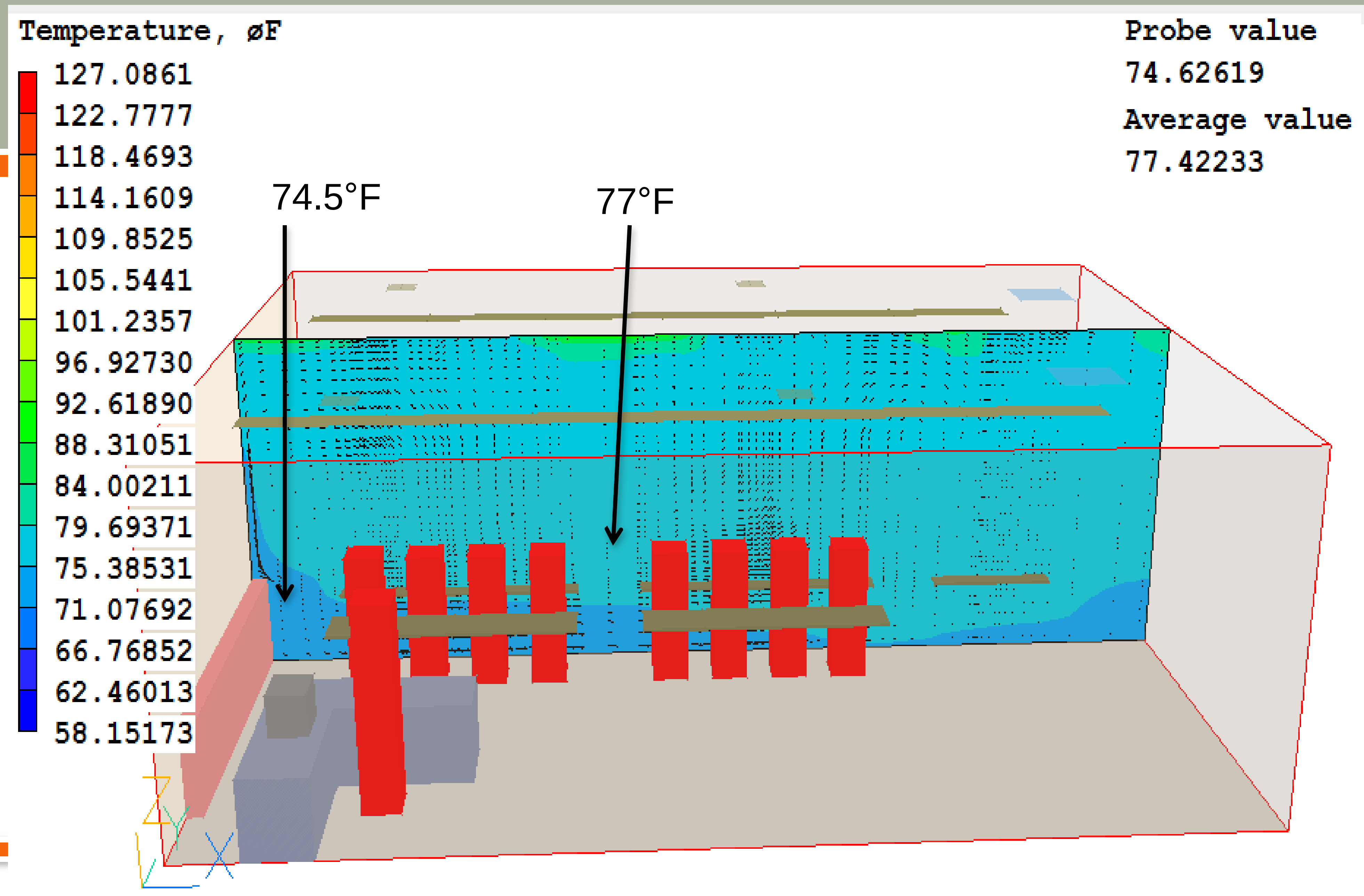
Mechanical Depth

- Results:
  - VAV 100% Flow
    -Some Drafts
    -High Room Temp
  - VAV 30% Flow
    -Lots of Drafts
    -High Room Temp



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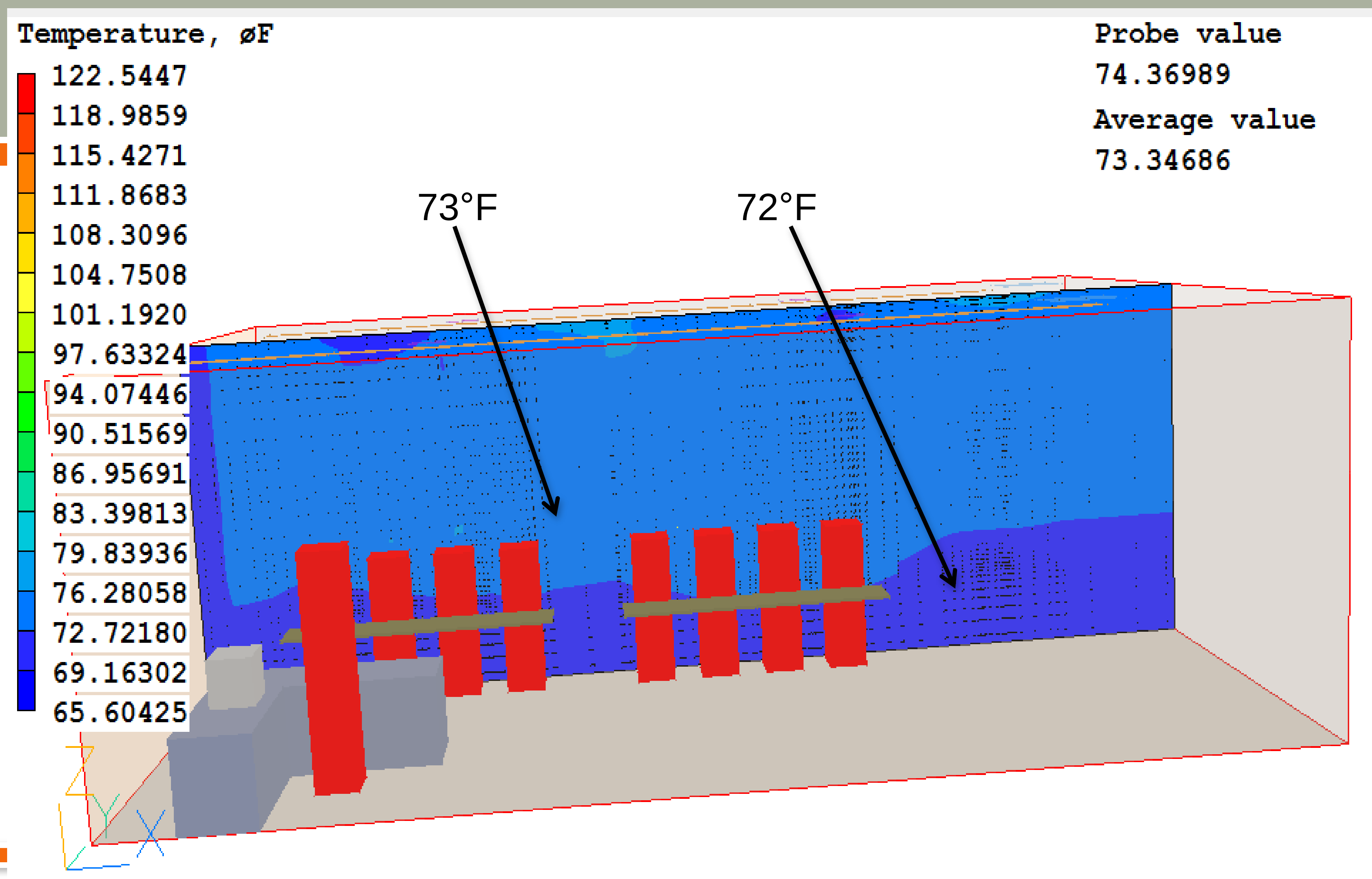
Mechanical Depth

- Results:
  - FPIU
    - ✓ No Drafts
    - ✓ Steady Room Temp (72-73°F)
- Conclusions:
  - VAV is Problematic
  - FPIU = Good Air Distribution/Thermal Comfort



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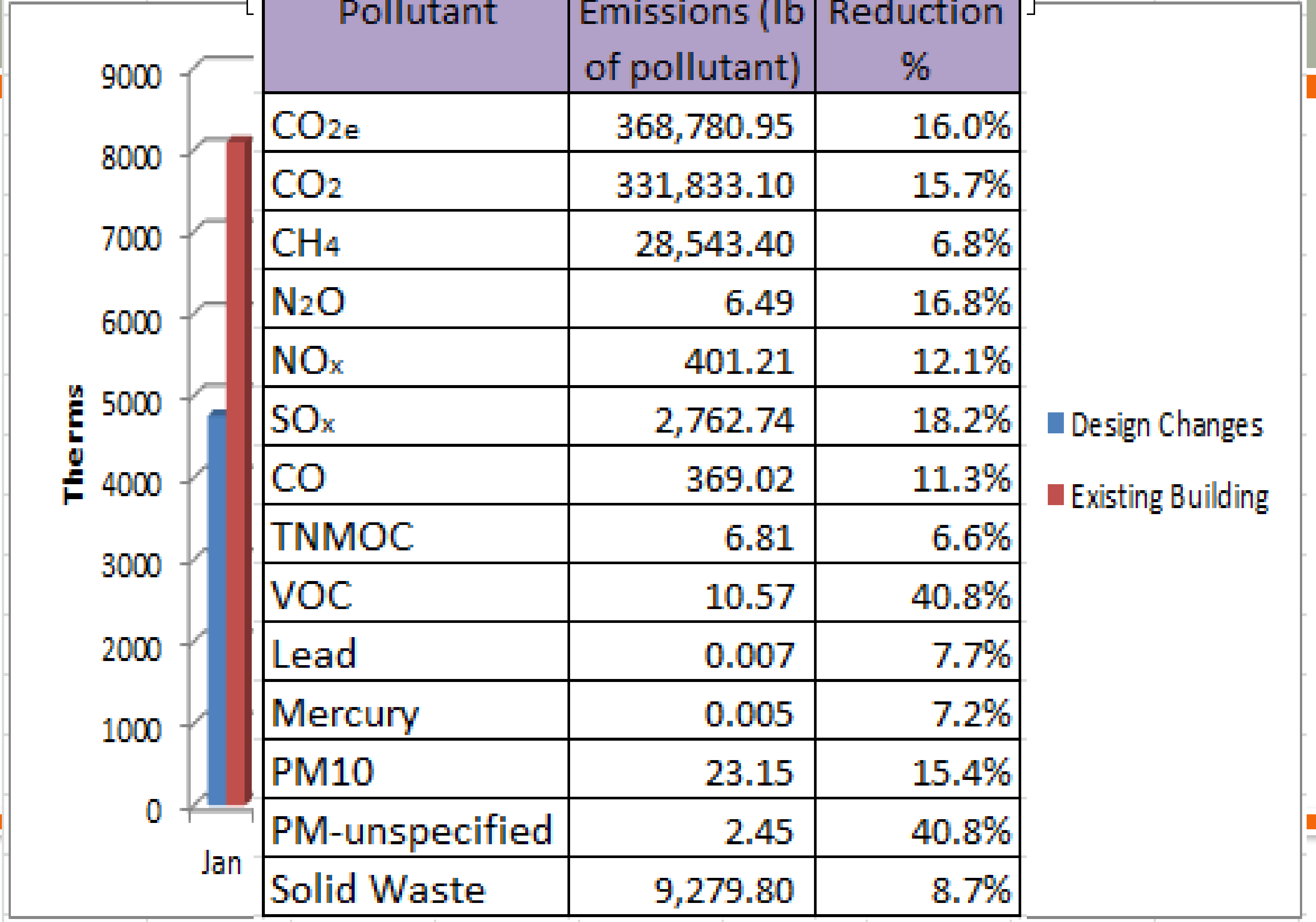
Mechanical Depth

- Reduction in:
  - Electricity = 7% (5% due to solar)
  - Natural Gas = 41%
  - Emissions = 16% CO_{2e}

	Electricty (kWh per year)	Natural Gas (BTU x 10^6 per year)	Electricity Cost per year	Natural Gas Cost per year	Total Cost per year	Cost per Square Foot of Building
Existing Building	1,614,418	4,228	$ 306,739	$ 65,202	$ 371,941	$ 2.43
Design Changes	1,508,917	2,504	$ 286,694	$ 38,604	$ 325,298	$ 2.13
Differnce	105,501	1,725	$ 20,045	$ 26,598	$ 46,643	$ 0.31
Reduction in %	7%	41%	7%	41%	13%	13%



Pollutant	Reduction in Emissions (lb of pollutant)	Reduction %
CO_{2e}	368,780.95	16.0%
CO_2	331,833.10	15.7%
CH_4	28,543.40	6.8%
N_2O	6.49	16.8%
NO_x	401.21	12.1%
SO_x	2,762.74	18.2%
CO	369.02	11.3%
TNMOC	6.81	6.6%
VOC	10.57	40.8%
Lead	0.007	7.7%
Mercury	0.005	7.2%
PM10	23.15	15.4%
PM-unspecified	2.45	40.8%
Solid Waste	9,279.80	8.7%

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Mechanical Depth

- Costs New Rooftop Units
  - Savings = $622,174
- Costs Associated with FPIU's
  - Savings = $651,137
- Initial Cost Savings = $1,273,311
- Enough Savings to Finance Solar Array

New Design

FPIU's Cost	New Duct Cost Total	Additional Piping	2 New Pumps Cost	Extra HVAC Controls	Total New Cost
$241,809.18	$227,498.00	$209,130.00	$ 11,601.00	$136,500.00	$826,538.18

CH-2	$ 155,000
CH-3	
Tota	
Total=	$ 963,476

Base Building

VAV Box Cost	Old Duct Cost	Fin Tube Radiators	Old Total Cost
$216,000.00	$961,675.00	$300,000.00	$1,477,675.00

Total =	$ 1,585,650

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  - i. **Roof Layout**
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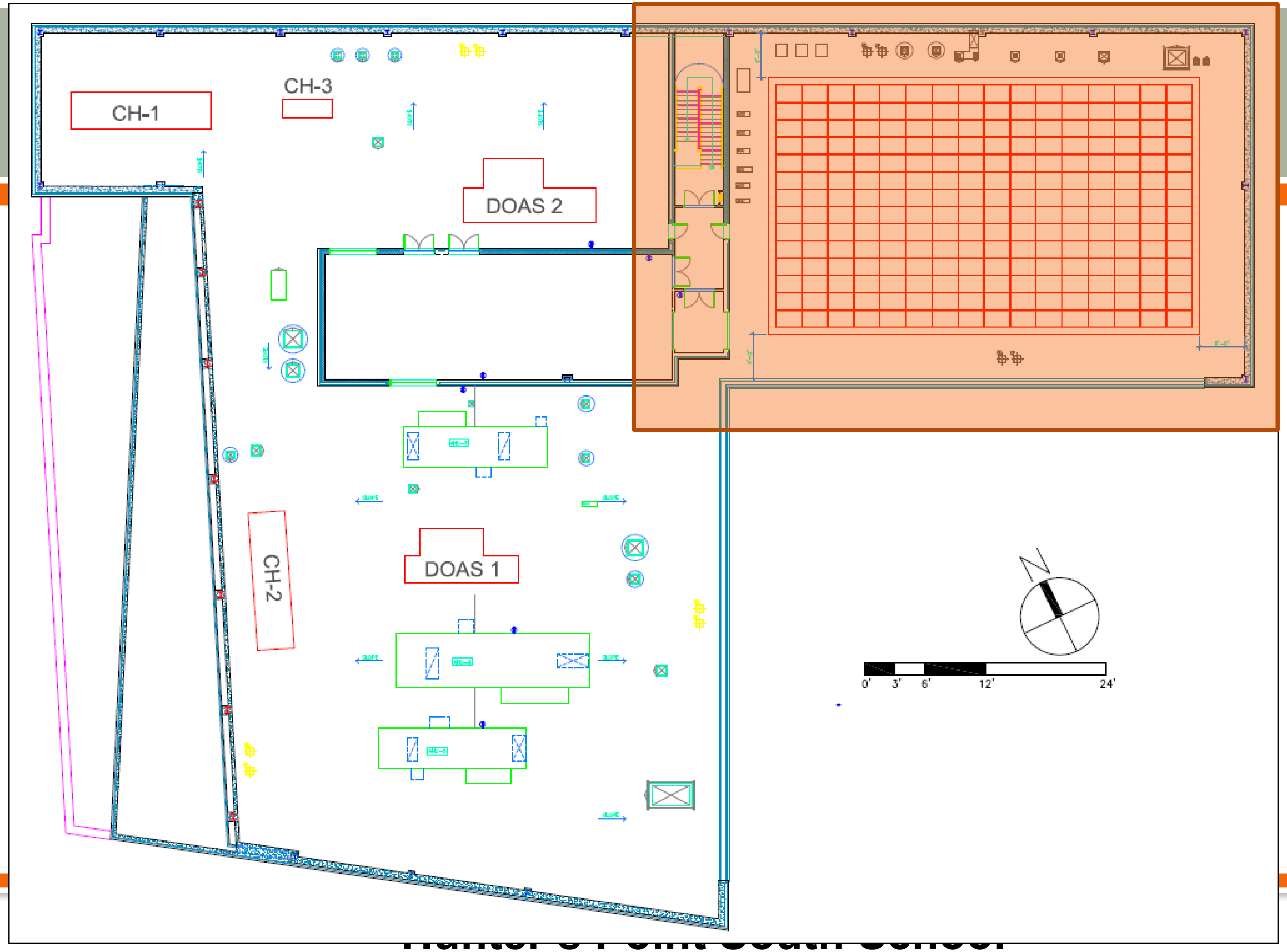

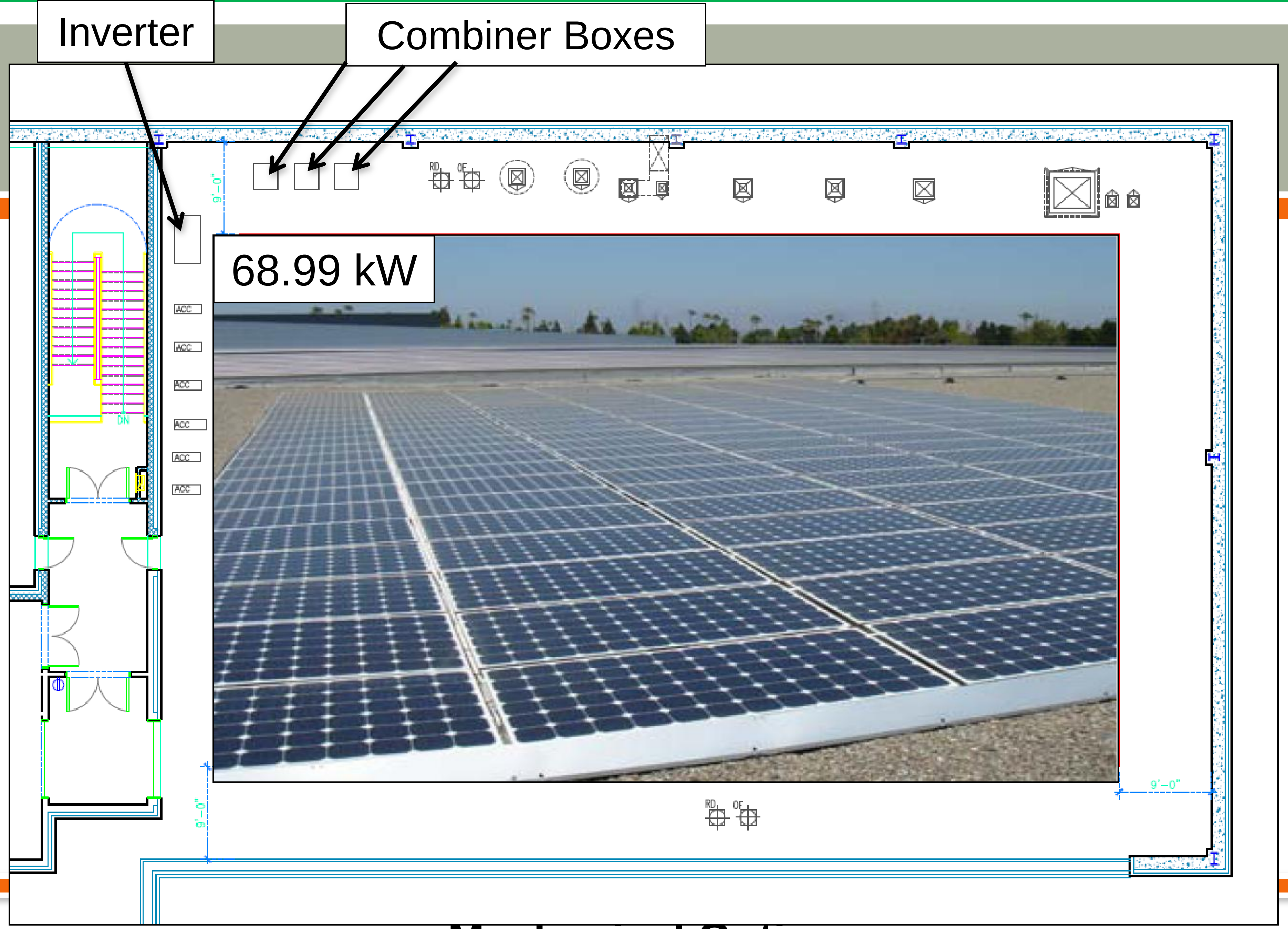

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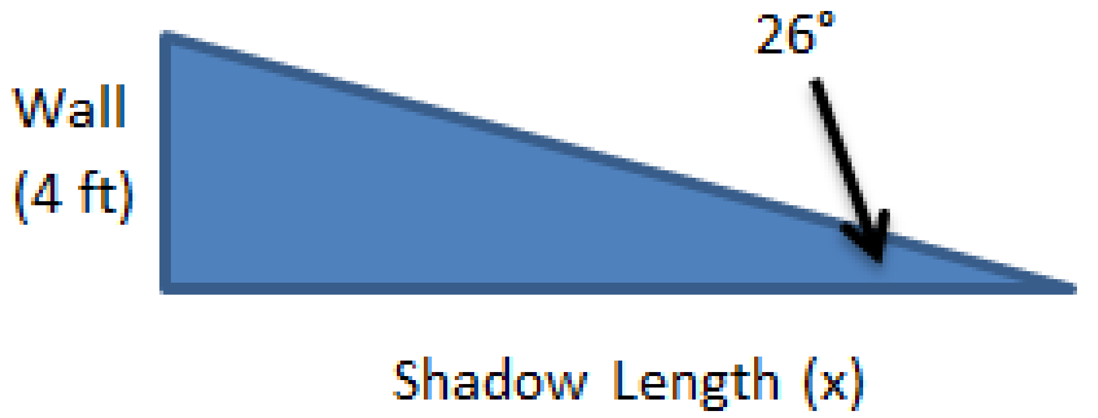
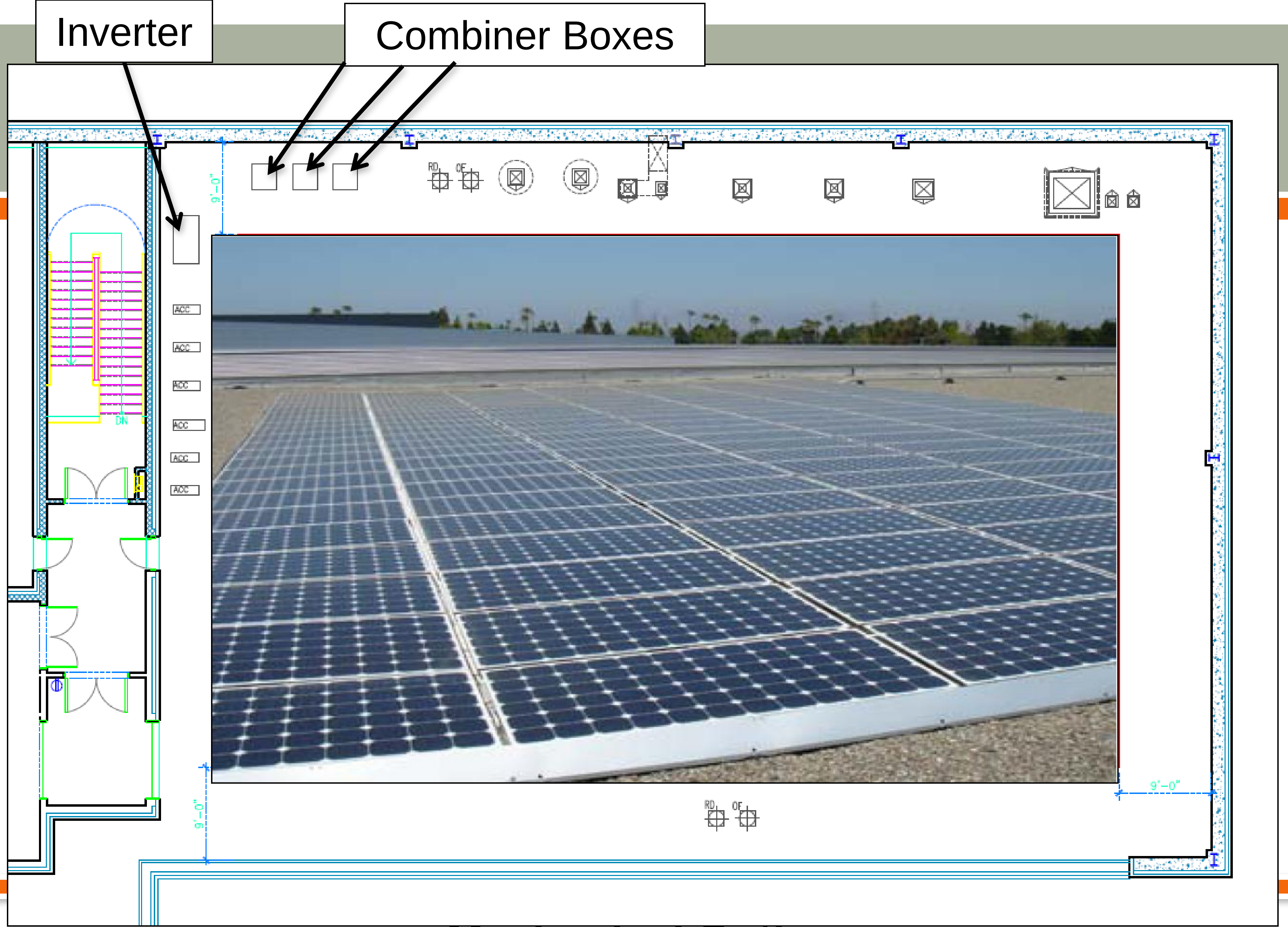
Electrical Breadth



SohCahToa:

$$Tan(26°) = 4' \div x$$

$$x = 8.2' < 9' \text{ setback}$$



Outline

Electrical Breadth

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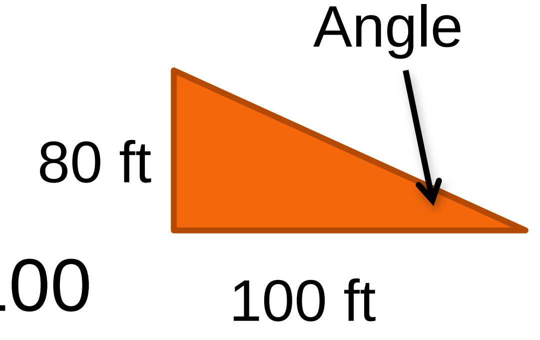
100 feet away

Difference in Height = 153 ft - 73 ft = 80 ft

SohCahToa:



Tan(x degrees) = 80 / 100
x = 38.7 degrees

From 8:25 am on no shading.

Electrical Breadth

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    1. Roof Layout
    2. **Schematic**
    3. Payback Analysis
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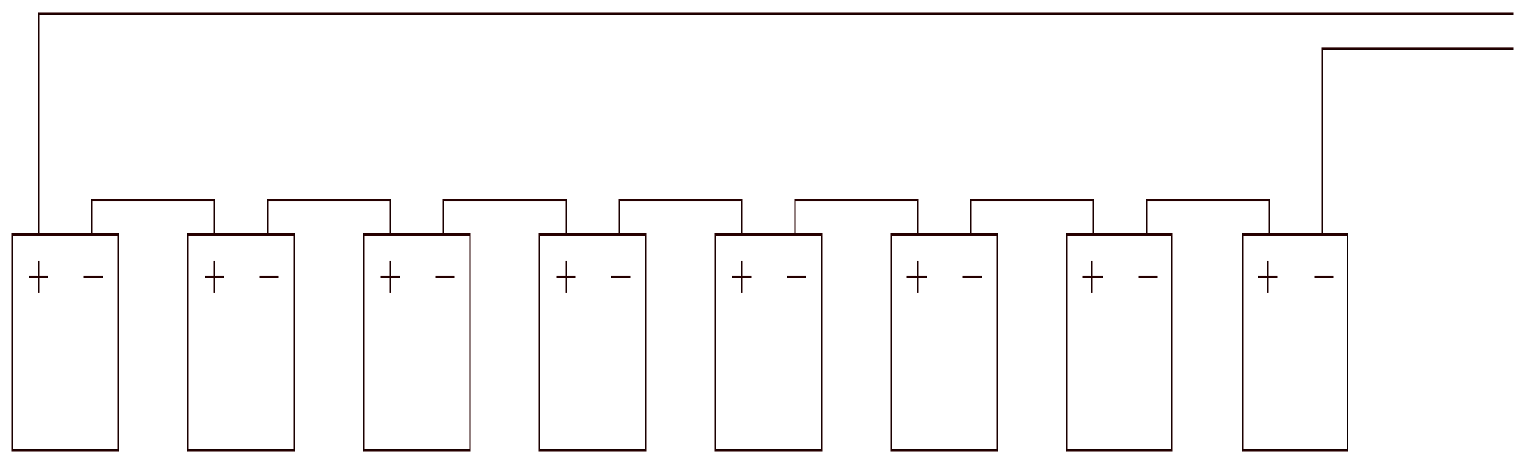

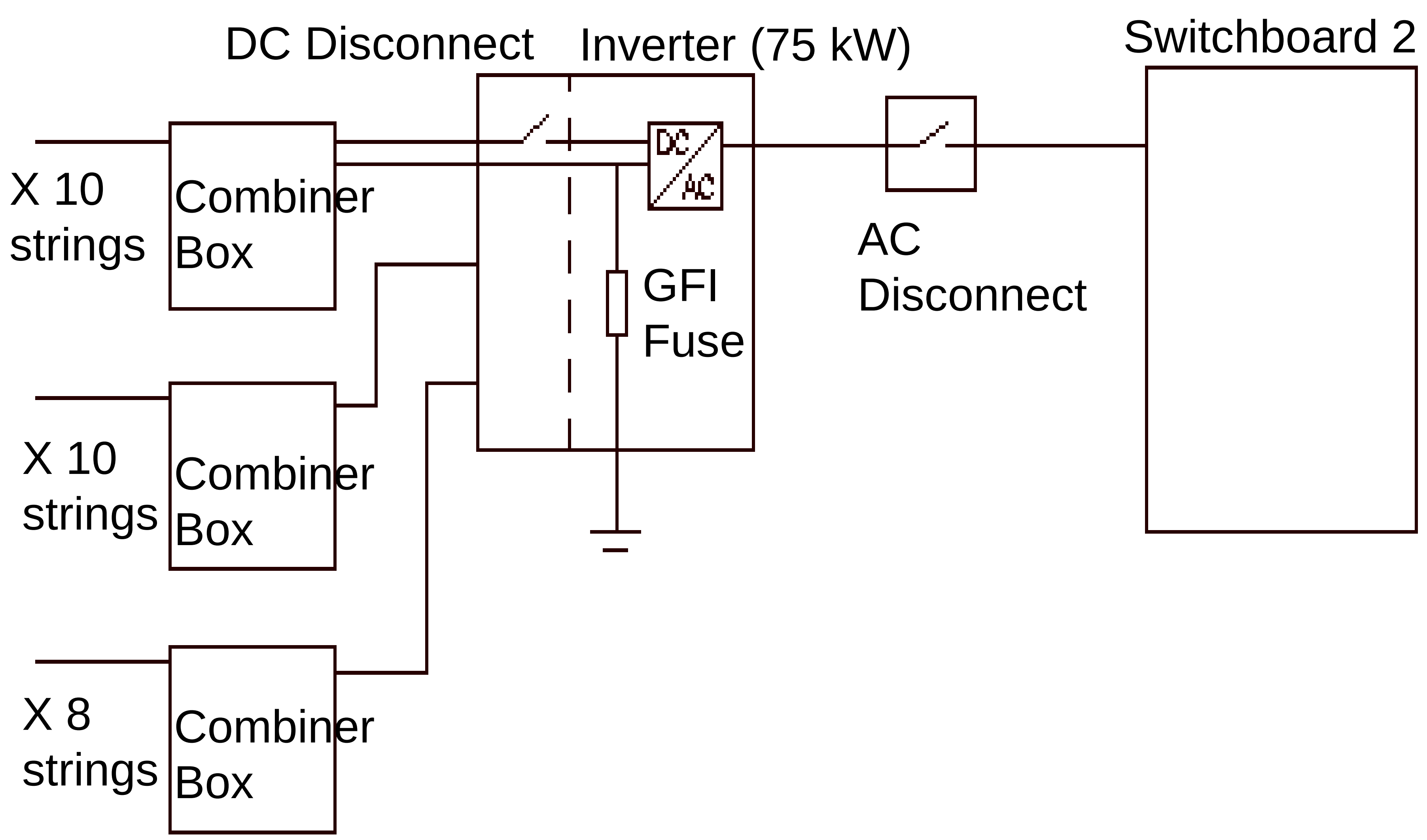

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Electrical Breadth

- Initial Costs $296,666
  - After Incentives = $60,075
- $14,987 Savings/year
- 188% Life Cycle Payback
  - Profit = $260,745

Year:	0	1	2	3	4	5	6	7	8	9	10
Maintenance	$ -	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300
Renewable Energy Grant (Treasury)	$ -	$ 89,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
NY City Property Tax Abatement	$ -	$ 14,833	$ 14,833	$ 14,833	$ 14,833	$ -	$ -	$ -	$ -	$ -	$ -
MACRS Depreciation	$ -	$ 52,955	$ 14,121	$ 8,826	$ 5,295	$ 7,061	$ -	$ -	$ -	$ -	$ -
Electric Savings	$ -	$ 13,939	$ 13,639	$ 13,639	$ 13,489	$ 13,489	$ 13,489	$ 13,639	$ 13,789	$ 13,939	$ 14,089
Payments	$ 296,666	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Annual Cash Flow	$(296,666)	$ 170,427	$ 42,293	$ 36,998	$ 33,317	$ 20,250	$ 13,189	$ 13,339	$ 13,489	$ 13,639	$ 13,789
Cumulative Cash Flow	$(296,666)	$(126,239)	$(83,946)	$(46,948)	$(13,631)	$ 6,619	$ 19,809	$ 33,148	$ 46,637	$ 60,275	$ 74,064

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  - i. **LCC Analysis**
  - ii. Acknowledgments
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Conclusion

- Structural: Girders/Non-Composite Deck
- 25 Year LCC Analysis Performed
- **NPV Savings = $2,018,185**

Structural Upgrade Costs			
Lightweight Conrete	Steel Deck	Girders	Total Cost
$ 8,392.23	$9,398.36	$711.20	$18,501.79

LCC Savings over 25 Years (NPV)	
Initial Cost:	$ 958,143
Electricity:	$ 350,815
Natural Gas:	$ 496,347
Solar Maintenance and Inverter:	$ 20,089
Solar Incentives:	$ 232,969
Total:	$ 2,018,185

Conclusion

- Contacts:
  - Patrick Murphy — Vanderweil Engineers
  - Chris Bratz — Meta Engineers
  - Carter Tse — Kallen & Lemelson
  - Sharvil Patel — Skanska
- Manufacturers:
  - Tim Dorman (DOAS/Wheels)
  - David Cunningham (Chillers)
  - Justin Anderson (FPIU)

- Advisor: Dr. Stephen Treado
- AE Professors/Faculty and Fellow Students
- Family and Friends

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LCC Analysis

Britt Kern

Year	25 Year LCC	Escalation		Cost Each Year	
		Electricity	Natural Gas	Electricity	Natural Gas
1	2013	0.93	0.95	$ 285,267	$ 61,942
2	2014	0.91	0.91	$ 279,132	$ 59,334
3	2015	0.91	0.90	$ 279,132	$ 58,682
4	2016	0.90	0.90	$ 276,065	$ 58,682
5	2017	0.90	0.91	$ 276,065	$ 59,334
6	2018	0.90	0.92	$ 276,065	$ 59,986
7	2019	0.91	0.93	$ 279,132	$ 60,638
8	2020	0.92	0.94	$ 282,200	$ 61,290
9	2021	0.93	0.95	$ 285,267	$ 61,942
10	2022	0.94	0.97	$ 288,335	$ 63,246
11	2023	0.94	0.98	$ 288,335	$ 63,898
12	2024	0.94	0.99	$ 288,335	$ 64,550
13	2025	0.94	1.00	$ 288,335	$ 65,202
14	2026	0.94	1.01	$ 288,335	$ 65,854
15	2027	0.94	1.02	$ 288,335	$ 66,506
16	2028	0.94	1.03	$ 288,335	$ 67,158
17	2029	0.93	1.04	$ 285,267	$ 67,810
18	2030	0.93	1.05	$ 285,267	$ 68,462
19	2031	0.93	1.06	$ 285,267	$ 69,114
20	2032	0.94	1.07	$ 288,335	$ 69,766
21	2033	0.94	1.08	$ 288,335	$ 70,418
22	2034	0.95	1.09	$ 291,402	$ 71,070
23	2035	0.95	1.09	$ 291,402	$ 71,070
24	2036	0.95	1.11	$ 291,402	$ 72,374
25	2037	0.95	1.12	$ 291,402	$ 73,026
			NPV:	$5,368,339	$1,216,738
			Total NPV:	$6,585,077	

Year	25 Year LCC	Escalation		Cost Each Year		Initial Costs			Maintenance		Solar Incentives		
		Electricity	Natural Gas	Electricity	Natural Gas	Mechanical	Solar	Structural	Solar	Inverter	Renewable Energy Grant (Treasury)	NYC Property Tax Abatement	MARCS Depreciation
1	2013	0.93	0.95	$ 266,625	$ 36,674	$ 1,273,311	$296,666	$ 18,502	$ 300		$ 89,000	$ 148,333	$ 52,955
2	2014	0.91	0.91	$ 260,892	$ 35,130				$ 300			$ 148,333	$ 14,121
3	2015	0.91	0.90	$ 260,892	$ 34,744				$ 300			$ 148,333	$ 8,826
4	2016	0.90	0.90	$ 258,025	$ 34,744				$ 300			$ 148,333	$ 5,295
5	2017	0.90	0.91	$ 258,025	$ 35,130				$ 300				$ 7,061
6	2018	0.90	0.92	$ 258,025	$ 35,516				$ 300				
7	2019	0.91	0.93	$ 260,892	$ 35,902				$ 300				
8	2020	0.92	0.94	$ 263,758	$ 36,288				$ 300				
9	2021	0.93	0.95	$ 266,625	$ 36,674				$ 300				
10	2022	0.94	0.97	$ 269,492	$ 37,446				$ 300				
11	2023	0.94	0.98	$ 269,492	$ 37,832				$ 300				
12	2024	0.94	0.99	$ 269,492	$ 38,218				$ 300				
13	2025	0.94	1.00	$ 269,492	$ 38,604				$ 300				
14	2026	0.94	1.01	$ 269,492	$ 38,990				$ 300				
15	2027	0.94	1.02	$ 269,492	$ 39,376				$ 300	$ 20,300			
16	2028	0.94	1.03	$ 269,492	$ 39,762				$ 300				
17	2029	0.93	1.04	$ 266,625	$ 40,148				$ 300				
18	2030	0.93	1.05	$ 266,625	$ 40,534				$ 300				
19	2031	0.93	1.06	$ 266,625	$ 40,920				$ 300				
20	2032	0.94	1.07	$ 269,492	$ 41,306				$ 300				
21	2033	0.94	1.08	$ 269,492	$ 41,692				$ 300				
22	2034	0.95	1.09	$ 272,359	$ 42,078				$ 300				
23	2035	0.95	1.09	$ 272,359	$ 42,078				$ 300				
24	2036	0.95	1.11	$ 272,359	$ 42,850				$ 300				
25	2037	0.95	1.12	$ 272,359	$ 43,236				$ 300				
			NPV:	$5,017,524	$720,391	$ 1,273,311	$296,666	$ 18,502	$5,656	$ 14,433	$ 89,000	$ 573,752	$ 86,595
			Total NPV:	$4,050,515									

Exhaust Rates

Room Type	Minimum Exhaust Rates (cfm/sf)
Art Classrooms	0.70
Copy/Printing Rooms	0.50
Educational Science Laboratories	1.00
Janitor Closets	1.00
Dressing Rooms	0.25
Locker Rooms	0.50
Toilets - public	50 cfm/toilet

NC for Ducts

Run Type	Air Velocity (fpm)	Design RC (NC)
Riser	1700	25
Main	1500	25
Branch	1000	35
After FPIU	500	25
Diffuser	350	25
Return	425	25

Cost Breakdown/Floor Plan

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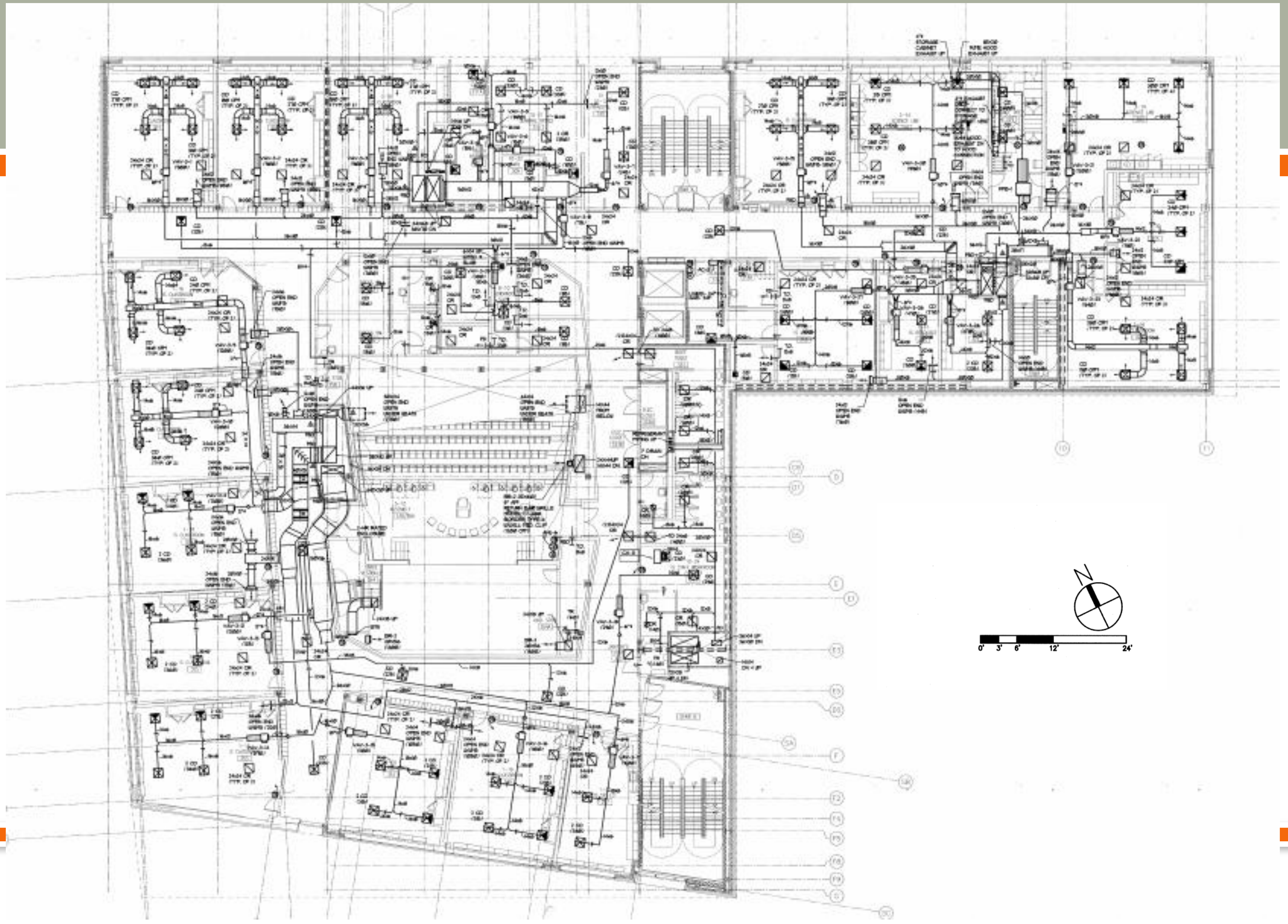
Mechanical Cost Breakdown		
Type	Cost ($)	Cost per square foot ($/sf)
AHU's	1,190,000	7.74
Chillers	820,000	5.33
Boilers	260,000	1.69
Heat Pumps	49,000	0.32
Fin Tube Radiators	300,000	1.95
Unit/Cabinet Heaters	143,000	0.93
VAV Boxes	216,000	1.40
Fan Powered Boxes	16,000	0.10
HVAC Piping	1,250,000	8.13
Ducts	1,479,500	9.62
HVAC Controls	910,000	5.92
Pumps	32,000	0.21
Convectors	14,000	0.09
Fans	80,000	0.52
Dampers	55,000	0.36
Diffusers/Grills	100,000	0.65
Emergency Generator/Fuel Oil	182,000	1.18
Glycol	35,000	0.23
Miscellaneous	38,500	0.25
Overhead	580,000	3.77
Total	**7,750,000**	**50.40**

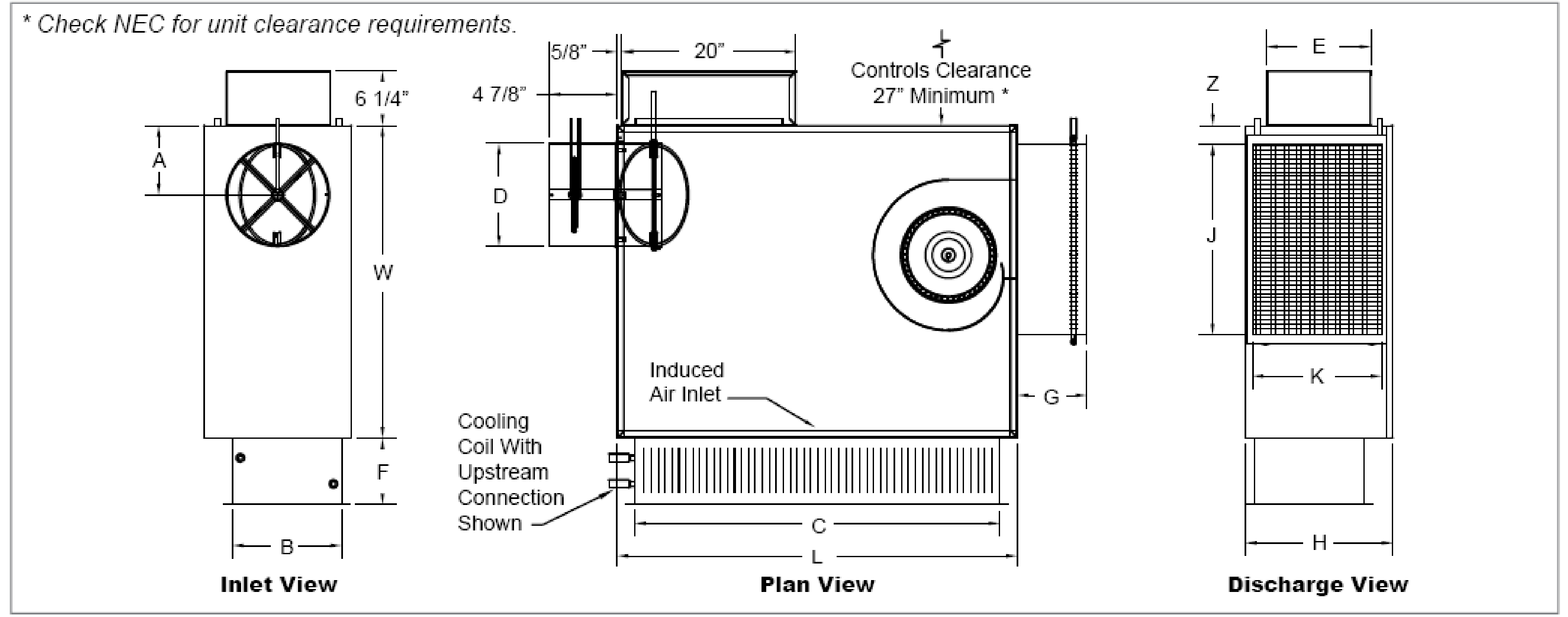


FPIU Dimensions

KRUEGER
Excellence in Air Distribution

Unit Size	Max Primary CFM	Max Fan CFM	Dimensions		
			L	W	H
3	920	1100	40"	26"	11"
5	1430	1660	46"	36"	17"

KLPS-D UNIT WITH HOT WATER HEAT, INLET, PLAN, AND DISCHARGE VIEWS



Comparing Ventilation

Energy Prices

Room No.	Room Name	NYC Mechancial Code	30% above ASHRAE Std 62.1	Latent Load	Max Required CFM	Round Up to a multiple of 5 CFM
101	Is Project Room	525	580	507	580	580
103	Is Project Room	525	572	507	572	575
105	Is Art	810	957	978	978	980
107	Is Art Storage	20	69	18	69	70
113	Hs Parents/Community Office	100	64	72	100	100
115	Is Parents Coordinator Room	100	64	72	100	100
116	School Safety Office/Locker Rooms	60	57	43	60	60
118	Is Receiving Room	40	26	29	40	40
119	Custodial Office	60	44	54	60	60
120	Is General Supply Room	34	52	0	52	55
141	Custodian Storage	45	64	54	64	65
205	Library	720	615	696	720	720
206	Office	40	30	29	40	40
207	Staff Development/Literacy Coaches	940	761	681	940	940
209	Cw - Activities for Daily Living	180	234	174	234	235
213	Special Education Classroom	375	403	362	403	405

Energy Prices	
Type	Price
Electricity (from NYPA)	$0.19/kWh
Natural Gas (based on National Grid firm charges)	$1.542/therm

ESP of Fans

	Fan External Static Pressure (inches water gauge)	
	DOAS 1	DOAS 2
Supply Fan	2.77	1.84
Return Fan	1.50	1.18

Section	Type	Run type	Air velocity (fpm)	Q (cfm)	Duct (inches x inches)	Length of Run (ft)	Friction Loss (in. wg per 100 ft run)	FRICTION LOSSES (in wg)	2009 Fundamentals Page/Type	Pv (velocity pressure, in wg)	C (local loss coefficient)	DYNAMIC LOSSES (in wg)	
1	Grille											0.02	
2	Elbow 90 Deg	Riser	1700	56	4 x 4	0	0	0	21.52/CR3-1	0.18	0.21	0.0378	
3	Fire Smoke Damper (FSD)	Riser	1700	56	4 x 4	0	0	0	21.57/CR9-6	0.18	0.19	0.0342	
4	Shaft - 1st to 2nd	Riser	1700	56	4 x 4	10	1.6	0.16			0	0	
5	Tee Transition	Riser	1700	56	4 x 4	0	0	0	21.42/ED5-3	0.18	1.63	0.2934	
6	Shaft - 2nd to 3rd	Riser	1700	2266	22 x 10	14	0.24	0.0336			0	0	
7	Tee Transition	Riser	1700	2266	22 x 10	0	0	0	21.43/ED5-3	0.18	1.07	0.1926	
8	Shaft - 3rd to 4th	Riser	1700	6086	26 x 22	14	0.14	0.0196			0	0	
9	Tee Transition	Riser	1700	6086	26 x 22	0	0	0	21.43/ED5-3	0.18	0.7	0.126	
10	Shaft - 4th to 5th	Riser	1700	9805	30 x 30	15	0.1	0.015		0.18	0	0	
11	90 Deg Elbow with Vanes	Riser	1700	9805	30 x 30	0	0	0	21.54/CR3-12	0.18	0.33	0.0594	
12	Fire Smoke Damper (FSD)	Riser	1700	9805	30 x 30	0	0	0	21.57/CR9-6	0.18	0.19	0.0342	
13	90 Deg Elbow with Vanes	Riser	1700	11217	36 x 30	0	0	0	21.54/CR3-12	0.18	0.33	0.0594	
14	Shaft - 5th to AHU	Riser	1700	11217	36 x 30	5	0.08	0.004		0.18	0	0	
15	Fire Smoke Damper (FSD)	Riser	1700	11217	36 x 30	0	0	0	21.57/CR9-6	0.18	0.19	0.0342	
16	Inlet to Fan	Riser	1700					0		0.18	0	0.18	
								0.2322	in. wg			1.0712	in. wg
										Total E.S.P. :	1.3034	in. wg	
										Safety Factor =	15	%	
									E.S.P. w/ Safety Factor:		1.49891	in. wg	

Winter Solstice

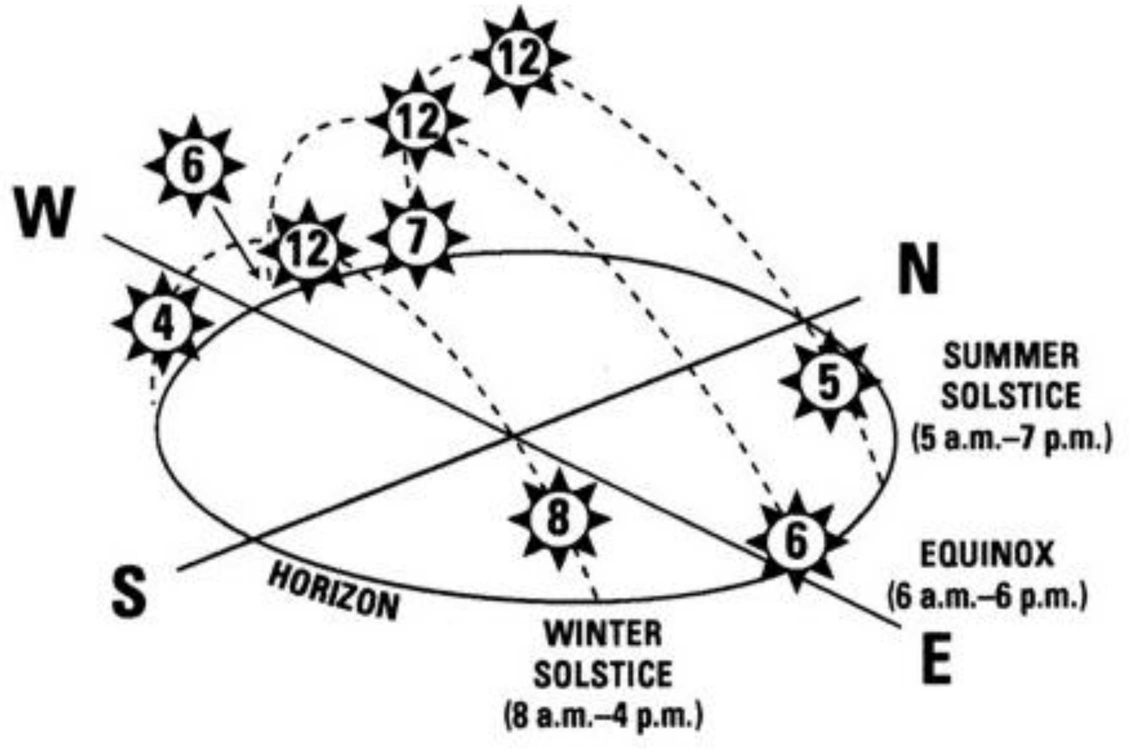
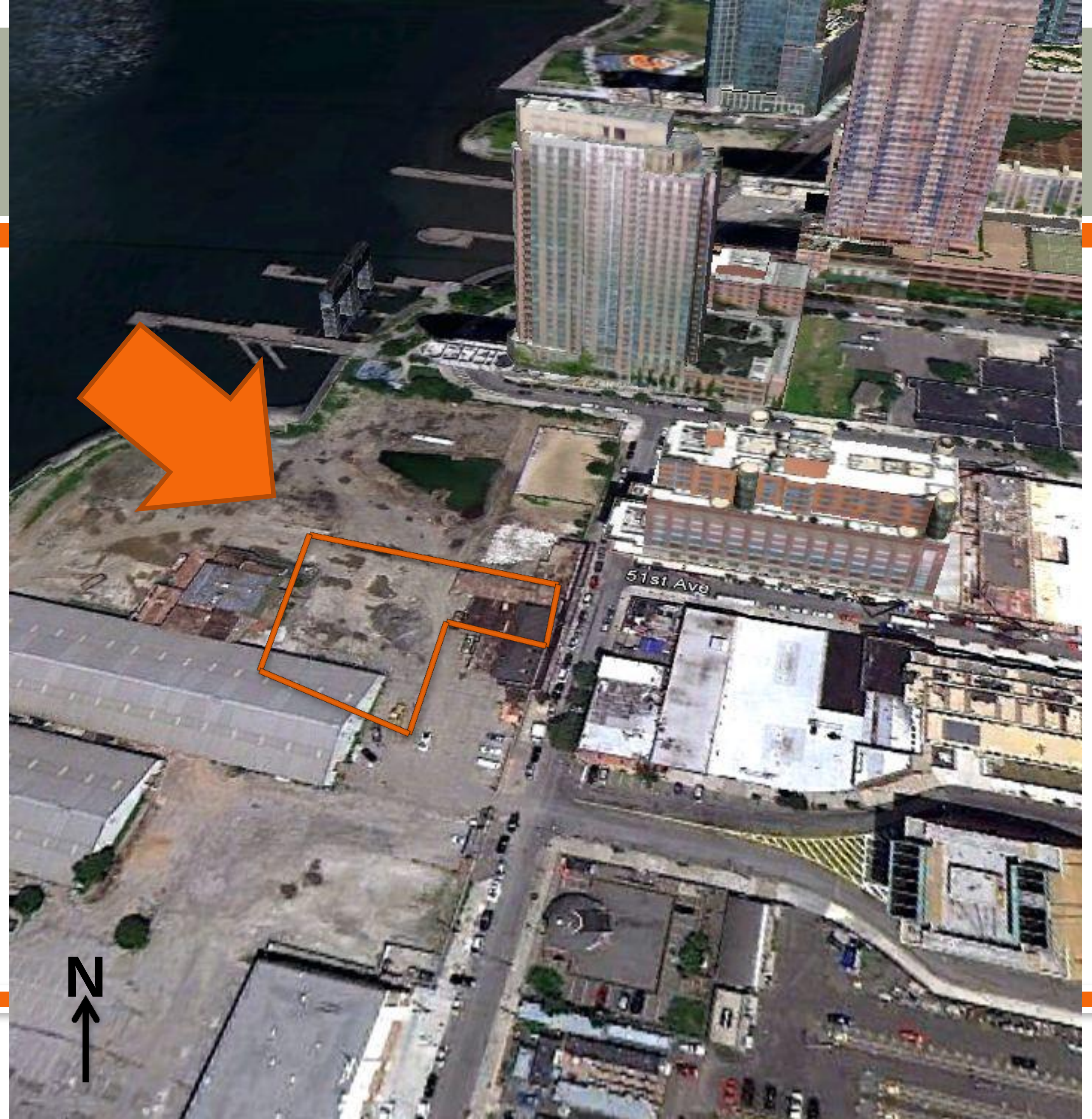


Figure 3-1

THE SUN'S PATH THROUGHOUT THE YEAR—NORTHERN LATITUDES



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Equinox

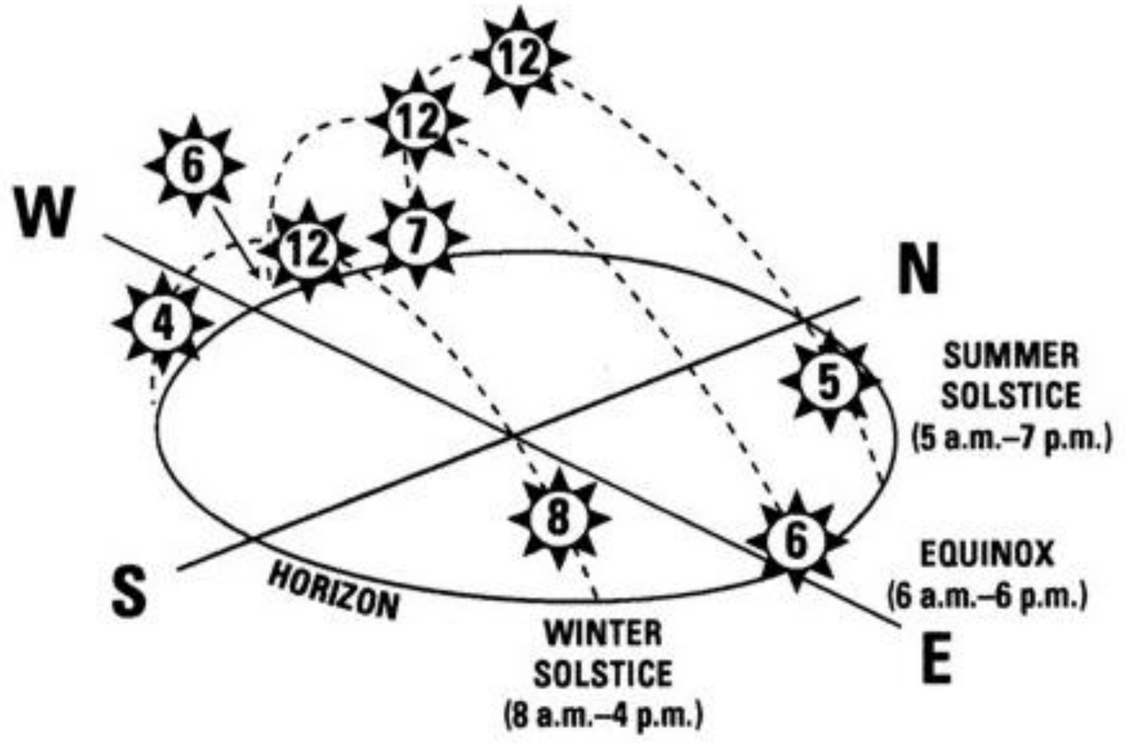
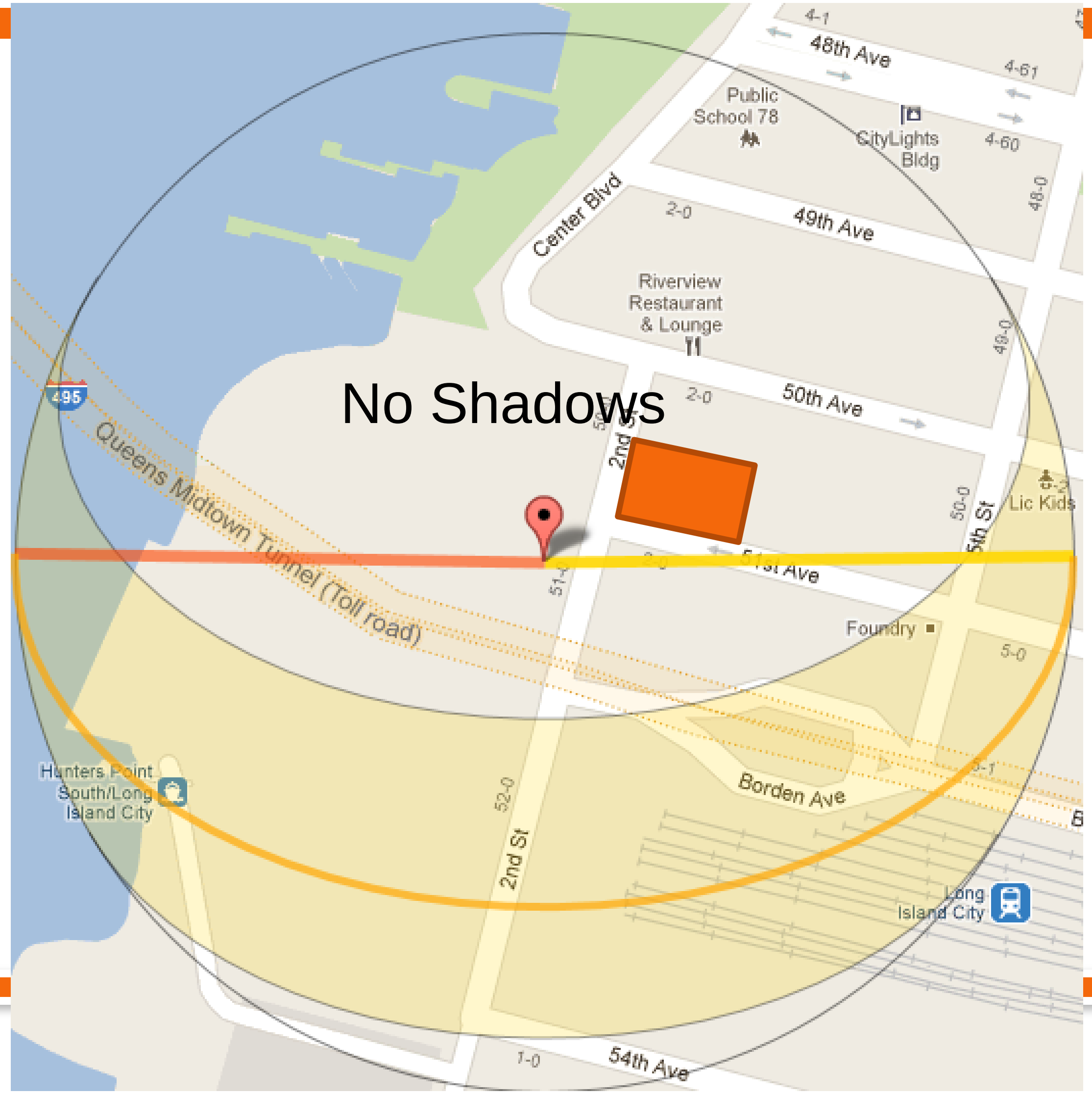
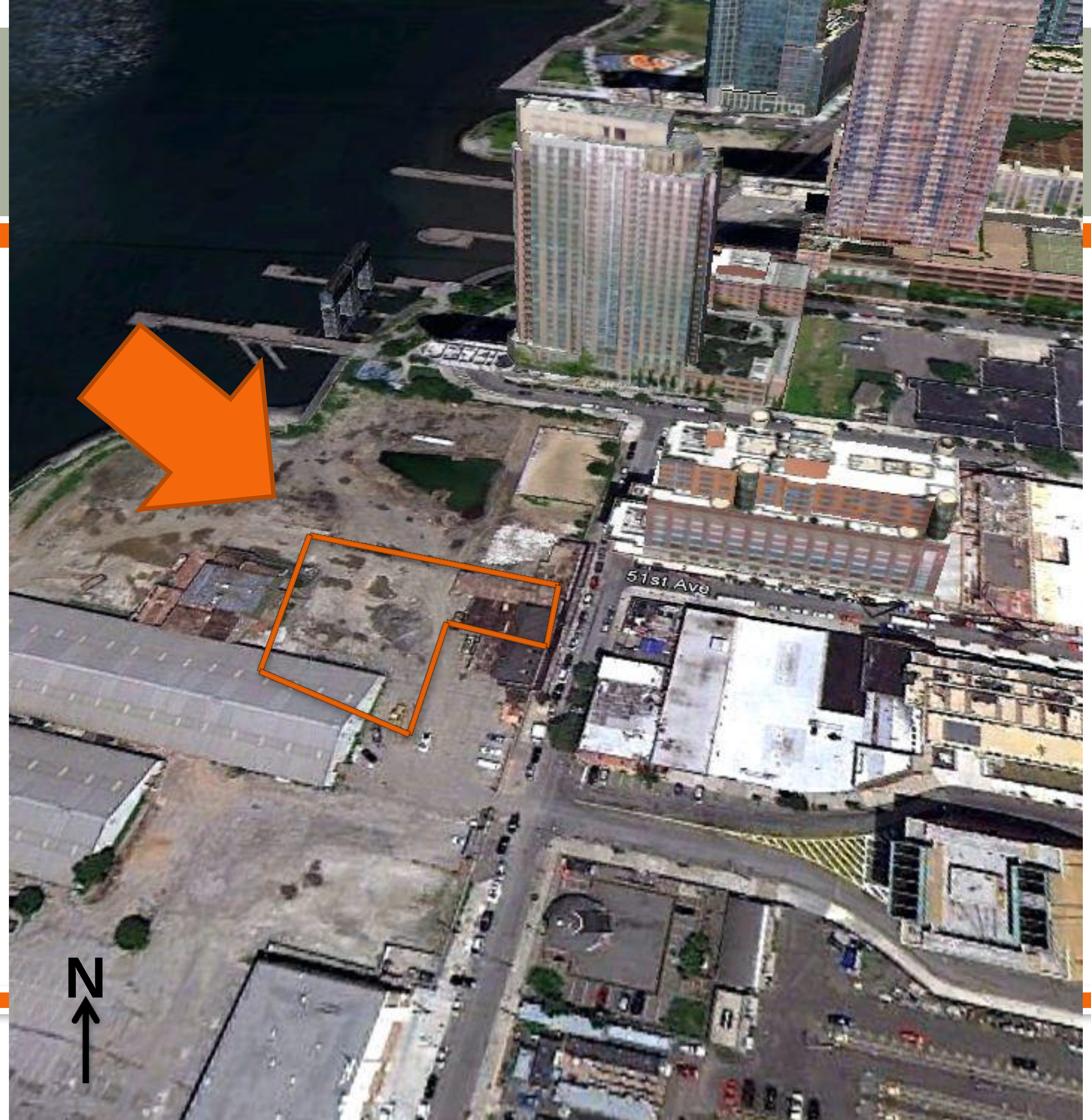


Figure 3-1
THE SUN'S PATH THROUGHOUT THE YEAR—NORTHERN LATITUDES





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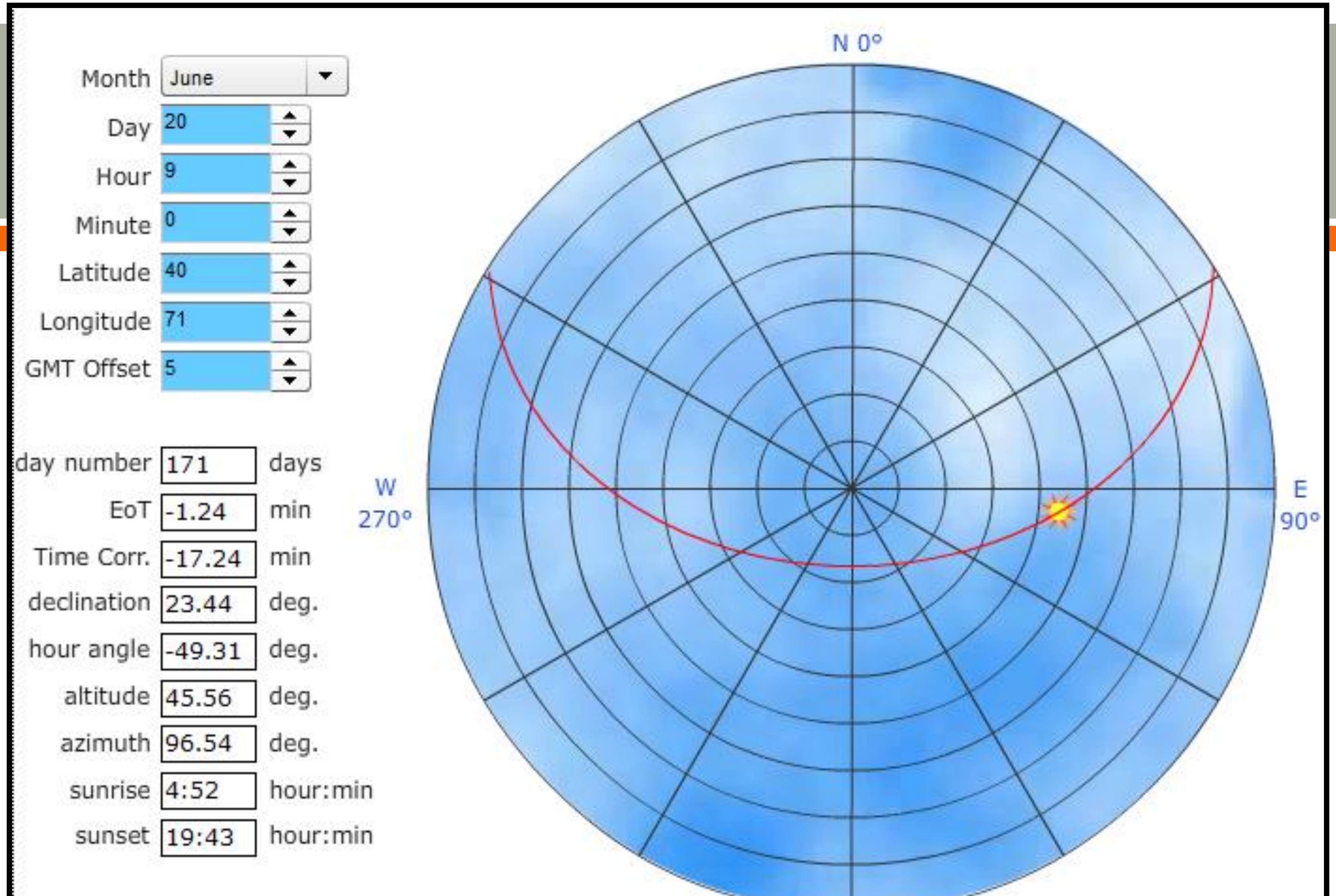
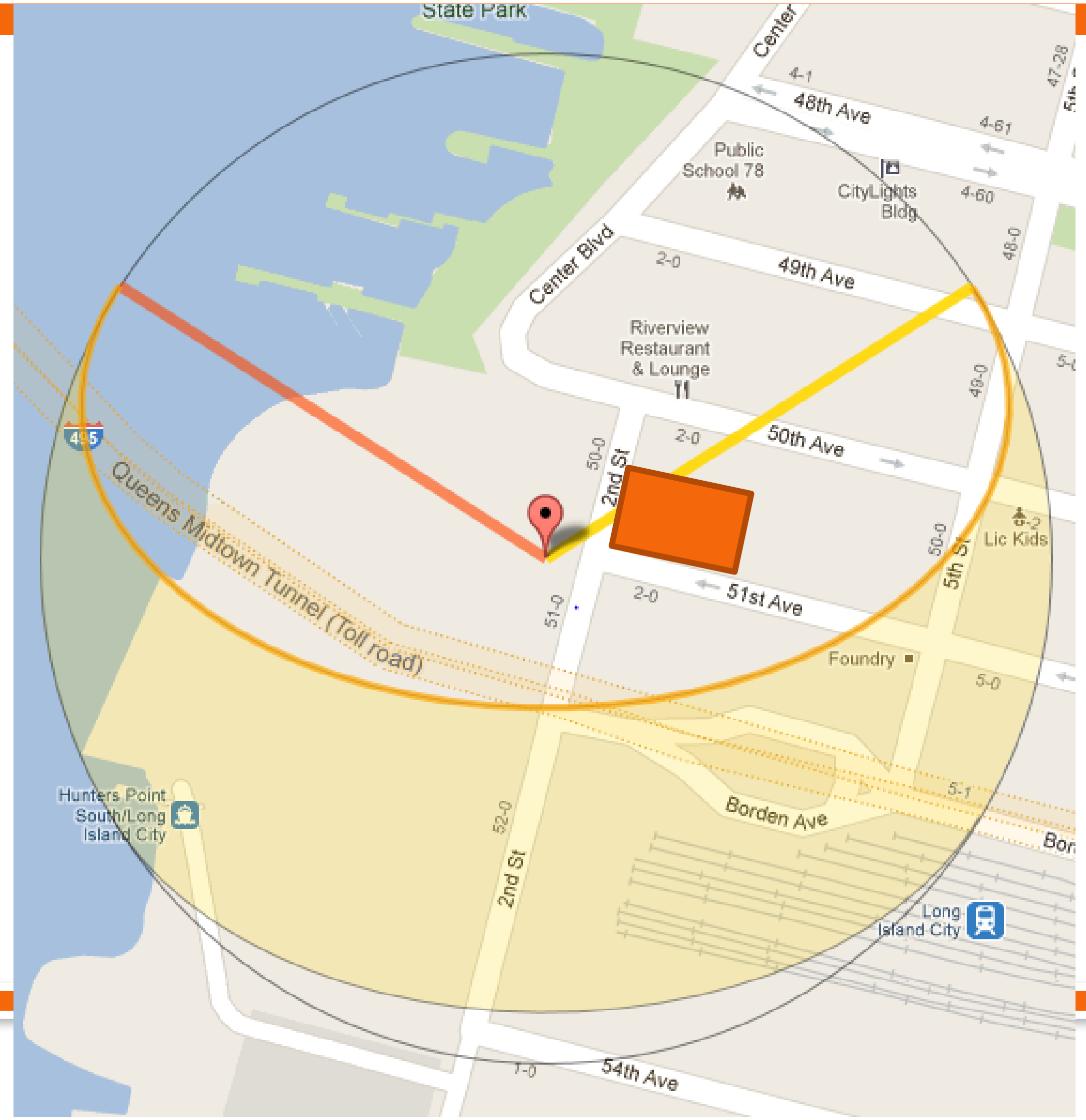
Summer Solstice



9 am, Summer Solstice



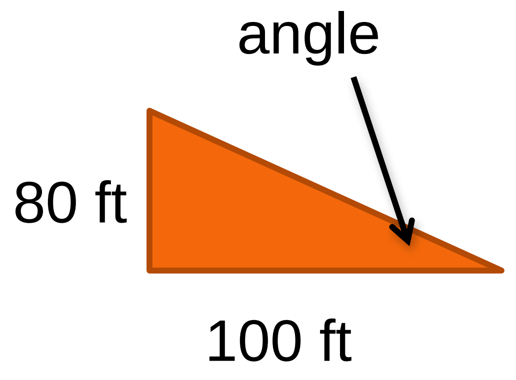
100 feet away

Difference in Height = 153 ft - 73 ft = 80 ft

SohCahToa:

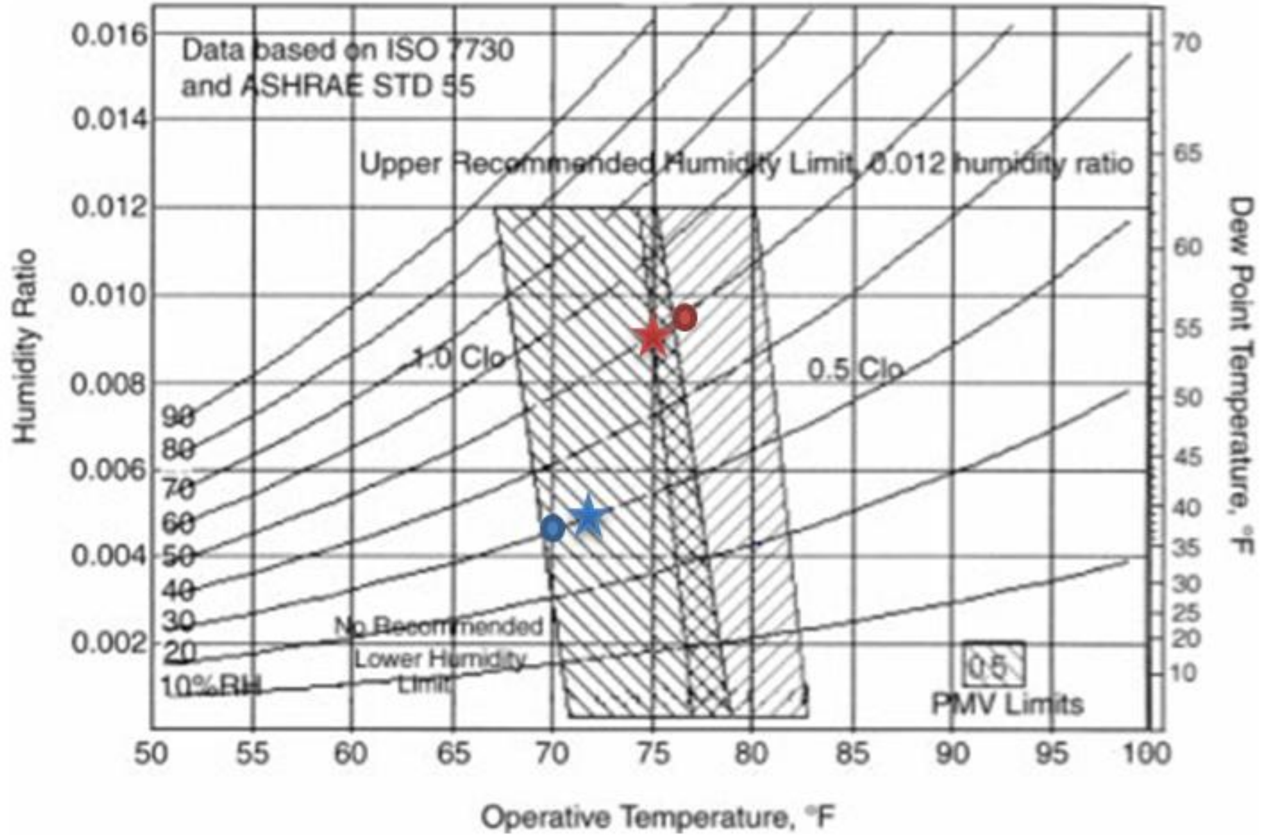
Tan(x degrees) = 80 / 100
x = 38.7 degrees

From 8:25 am on no shading.



Mechanical Option

Room Conditions

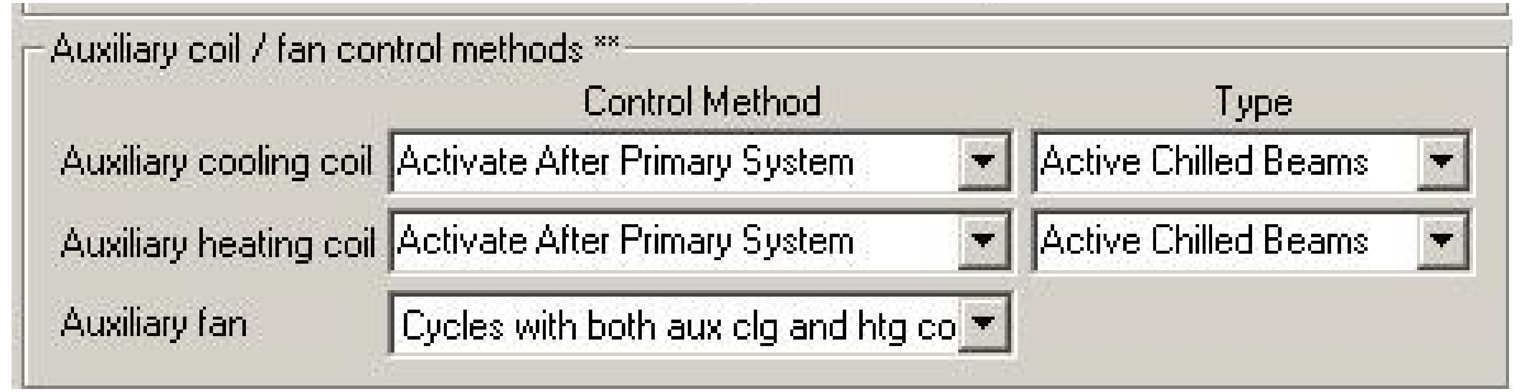


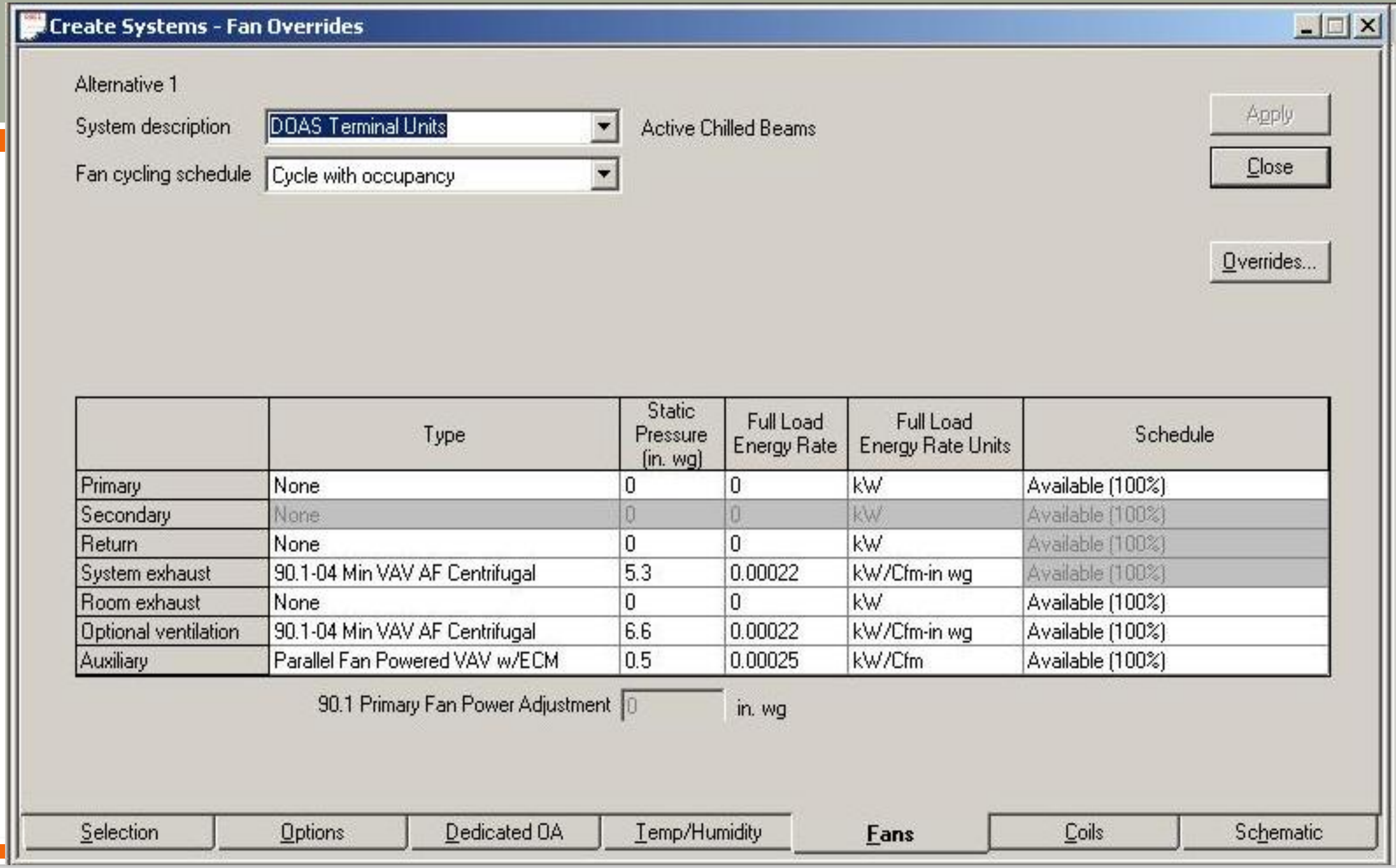
Room Conditions: Summer (cooling) - 75 F, 50% relative humidity (star)– drift 77 F (dot)

Winter (heating) – 72 F, 30% relative humidity (star) – drift 70 F (dot)

Trace Modeling FPIU

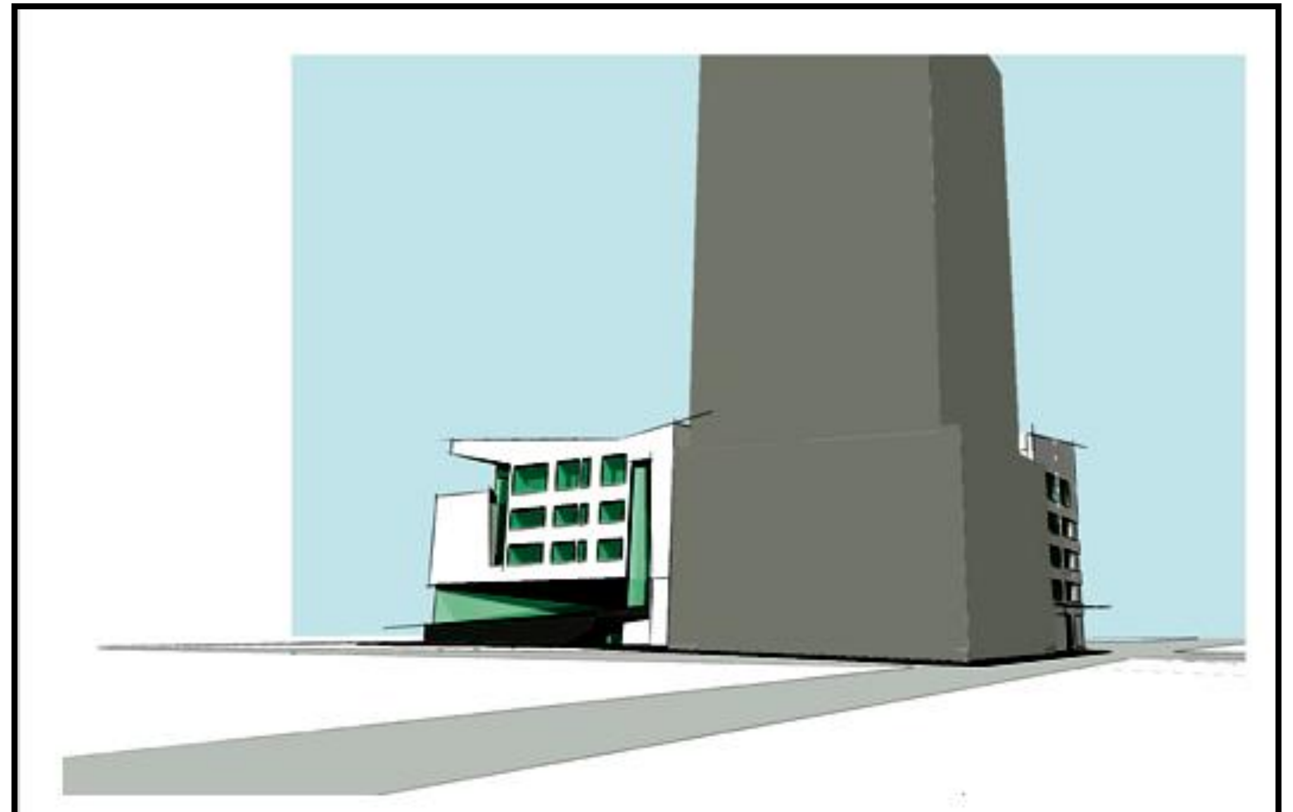
Under Create Systems → Option Tab → Advanced Options





	Type	Static Pressure (in. wg)	Full Load Energy Rate	Full Load Energy Rate Units	Schedule
Primary	None	0	0	kW	Available (100%)
Secondary	None	0	0	kW	Available (100%)
Return	None	0	0	kW	Available (100%)
System exhaust	90.1-04 Min VAV AF Centrifugal	5.3	0.00022	kW/Cfm-in wg	Available (100%)
Room exhaust	None	0	0	kW	Available (100%)
Optional ventilation	90.1-04 Min VAV AF Centrifugal	6.6	0.00022	kW/Cfm-in wg	Available (100%)
Auxiliary	Parallel Fan Powered VAV w/ECM	0.5	0.00025	kW/Cfm	Available (100%)

Adjacent New Buildings


View of new HPS Middle/High School from 2nd St & Borden Ave, LIC