

Julia Broskey
Mechanical Option
AE 482 – Senior Thesis



Berks Classroom and Lab Building

Reading, Pennsylvania



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Building Statistics

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Architectural

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CM Breadth

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- Location: Penn State Berks Campus Reading, PA
- Building Occupant: Penn State Berks Students & Faculty
- Occupancy: New Building Group B – Business
- Size: 62,188 Sq Ft
- Dates of Construction: April 2010 – August/September 2011
- Project Delivery Method: Design – Bid - Build



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- Owner: The Pennsylvania State University Berks Campus
- General Contractor: Alvin H. Butz, Inc.
- Construction Cost Estimator: Becker & Frondorf
- Building Architect: RMJM Hiller
- Structural Engineer: Greenman-Pedersen, INC
- MEP Engineer: H.F. Lenz Company
- Civil: Gannett Fleming Engineers

Consultants:

Lighting: Illumination Arts, LLC

Acoustical: Shen Milsom Wilke, Inc.

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Architectural

The new facility is constructed using steel framing and is expected to be a LEED Silver certified building. The Berks Classroom and Lab Building is a 3 story building consisting of classroom and laboratory space for the Commonwealth Campus to utilize.

The white portion of the façade is a terracotta rain screen

The lower portion of the façade uses precast concrete panels



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Analyzed system

- Variable Air Volume System
- 3 electric roof top units
 - RTU-1: 281.1 load in ton
 - RTU-2: 98.7 load in ton
 - RTU-3: 59.1 load in ton
- VAV terminal units

Other Equipment

- Computer Room Air Conditioner – Server Room
- 4 Split System Air-conditioning Units
 - 1 ton unit – 1
 - 1.5 ton unit – 3
- Boilers 2 – 6.2 gallon boilers
- Hot Water Pumps
 - 3 – 2 duty and 1 stand-by Boiler
 - 2 – 1 duty and 1 stand-by domestic hot water & VAV Boxes

Proposal: Mechanical Depth

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- System: Ground Source Heat Pump
 - System Type: Compare Closed Vertical & Horizontal
- Total Load: 439.1 Ton
 - For the 3 RTU
- Pipe: Polyethylene Pipe
- Units: Carrier 50YDS064NCP301



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Proposal: Electrical Breadth

- Size the major electrical equipment needed to make the proposed mechanical system work

- Wire – Lowes 8 AWG

- Panels – SquareD

Proposal: Construction Breadth

- Cost and Schedule analysis

- Does not include actual cost for the building
 - At owners request

- Included

- Ground Source Heat Pump

- Electrical Work

- Construction Equipment

Mechanical Redesign: Site

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- Location: Penn State Berks Campus outside of Reading, PA

- Location for Pipe: Blue Circle

Mechanical Redesign: Site

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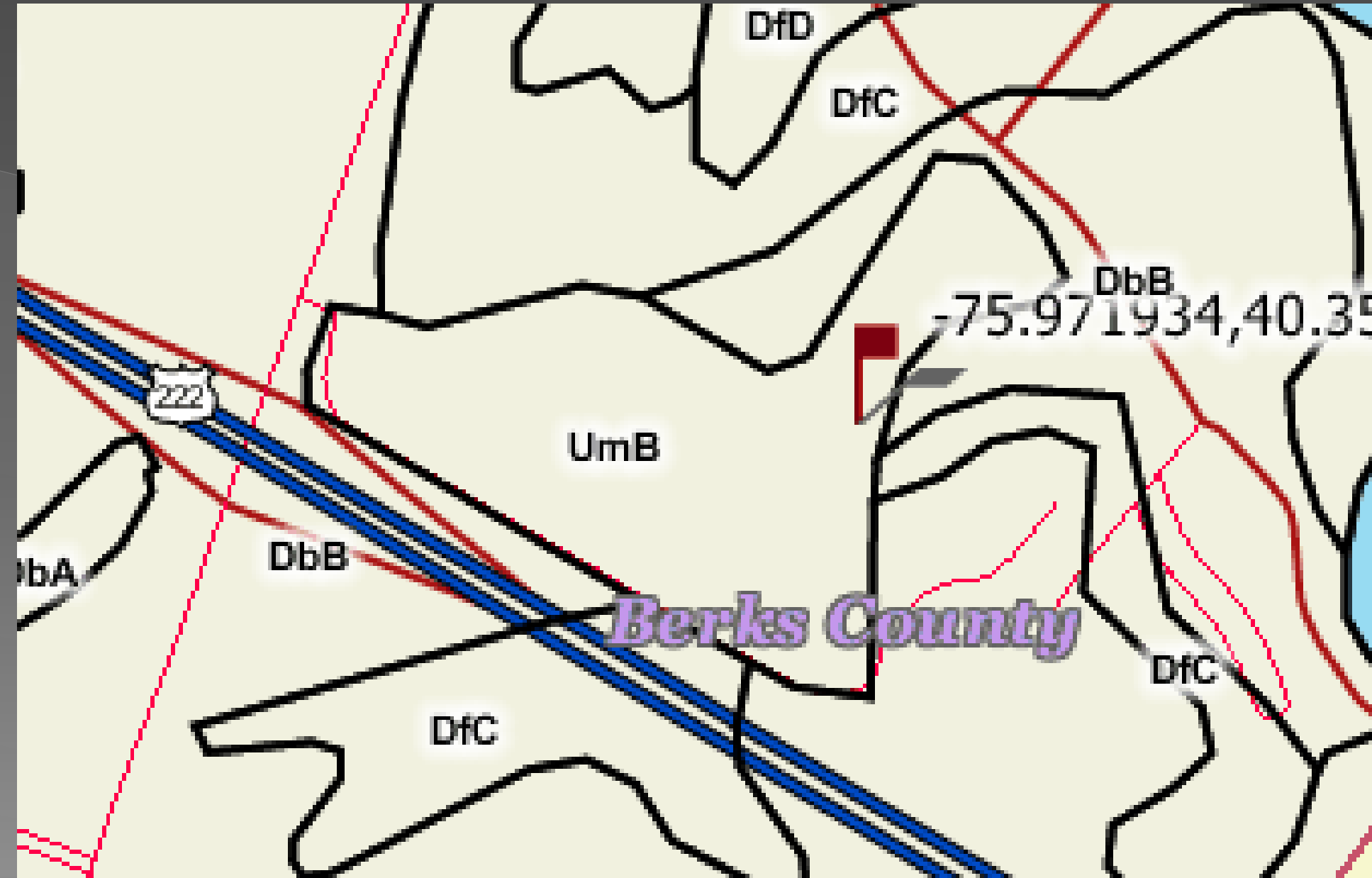
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- Flag: Location of Building

- Soil Types:

- UmB: Urban Land Duffield Complex

- Urban Land:

- Depth: 10 – 100” lithic bedrock

- Water: Very Low about 0”

- Duffield Land:

- Depth: 48 – 120” lithic bedrock

- Water: High about 10.4”

Mechanical Redesign: Pumps

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RTU	Quantity of Pumps	Cost per Pump	Total Cost
RTU-1	57	\$6,066	\$345,762
RTU-2	20	\$6,066	\$121,320
RTU-3	12	\$6,066	\$72,792
Total	89		\$539,874

- Manufacturer: Carrier
- Unit: 50YDS064NCP301
- Size: 5 ton
- Compressor: Copeland UltraTech Two Stage Scroll
- Refrigerant: 168 ounces Puron
 - Connections: 5/8 inch
- Weight: 265 pounds
- Water Connections: 1 inch Swivel

Mechanical Redesign: Pipe

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Vertical Requirements

- Minimum Well Depth: 150 ft
 - Minimum Pipe:
 - 1' Pipe: 14,670 ft @ \$14,097.87
 - 3/4" Pipe: 131,750 ft @ \$55,440.40
- Maximum Well Depth: 250 ft
 - Maximum Pipe:
 - 1' Pipe: 14,670 ft @ \$14,097.87
 - 3/4" Pipe: 395,190 ft @ \$166,295.95

Horizontal Requirements

- Minimum 1" Pipe: 175,640 ft @ \$168,790.04
- Maximum 1" Pipe: 263,460 ft @ \$253,185.06
- Area: 2,500 Sq ft per ton
- Two Rows of horizontal pipe
 - Depth 1st layer: 3'
 - Depth 2nd layer: 5'

Mechanical Redesign: Annual Energy Comparison

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Design	Energy Type	Consumption	Total Cost
Original Design	Electrical	8,620,166 kWh	\$ 877,249.75
Original Design	Gas	903,312 kBtu	\$ 6.77
Proposed Design	Electrical	7,812,779 kWh	\$ 795,731.31
Proposed Design	Gas	0 kBtu	\$ 0

- Total Original Cost: \$ 877,256.52

- Cost per Square Foot Original: \$14.12

- Total Proposed Cost: \$ 795,731.31

- Cost per Square Foot Proposed: \$12.80

- Savings: \$ 82,240.50

- Cost per Square foot: \$ 1.32

- Payback period: 37 years

Mechanical Redesign: Recommendation

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- 72 Pumps would need another location besides the mechanical room

- Result: Structural Analysis of the roof to enclose the roof for at least 72 pumps of the 89 pumps

- Total cost of system installed: \$ 3,039,707.31

- Result: cost is in addition to the total building cost, who pays for it?

- 37 years to see any payback on energy savings

Overall Recommendation:

- good idea for one or all of the roof top units, if design was utilized prior to construction

- 37 year payback not bad considering the university park campus still has buildings build in the 1950s or earlier on campus



Electrical Breadth

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Model	HWG Pump FLA	External Pump FLA	Total Unit FLA	Min Circuit Amps	Max Fuse/HACR (2)	Supply Wire (2)	
						Min AWG	Max Length ft. (3)
064	0.4	4.0	30	36.4	60	8	81

- Total FLA 30
- Min circuit Amps 36.4
- 30 Amps is the max for 10 AWG wire NEC 2008
- Min circuit amps is greater than 30 but less than the max for 8 AWG wire

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Material	Total Quantity	Cost per unit	Total cost
8 AWG wire	3,693.5 LF	\$176 /125 LF	\$5,200.45
Panels	5 Panels	\$205.07/Panel	\$1,025.35

Assumptions:

- Panels are located in the mechanical room
- All units are to be located in the mechanical room
- Panels can take up to 20 circuits

Construction Breadth

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Material	Amount	Unit Cost	Total Cost
1" PE Pipe	263,460 LF	\$ 0.961/ LF	\$ 253,185.06
Carrier 50YDS, 5 ton Unit	89 Units	\$ 6,066 / Unit	\$ 539,874
Excavation work	127,055 CY	\$ 6.74 / CY	\$ 856,276
Wire	3,693.50 LF	\$ 176 / 125 LF	\$ 5,200.45
Panels	5 Panels	\$ 205.07 / Panel	\$ 1,025.35
Total			\$ 1,655,560.86

Construction Breadth

Material	Amount	Labor	Crew	Total Time	Cost	Total Cost
1" PE Pipe	2,179,800 LF	79.923 LF / Day / Plumber	3 Plumbers	1,099 Days	\$33.25 / Hr / Plumber	\$1,096,252.50
Carrier 50YDS, 5 ton Unit	89 Units	9 Hrs / Unit	1 HVAC tech	81 Days	\$ 33.25 / hr	\$ 26,932.50
Excavation work	127,055 CY	1 Excavator	1 driver	80 Days	\$28.50 / driver / hr	\$ 22,800
		6 Dozers	6 drivers	79 Days	(both types)	\$ 135,090
Wire	3,693.50 LF	79.923 LF / Day / Electrician	1 Electrician	47 Days	\$ 33.00 / hr/ electrician	\$ 15,510
Panels	5 Panels	8 hrs / panel	1 Electrician	4 Days	\$ 33.00 / hr/ electrician	\$ 1,320
Total						\$ 1,297,905

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Material	Amount	Total Time
1" PE Pipe	2,179,800 LF	1,099 Days
Carrier Units	89 Units	81 Days
Excavation work	127,055 CY	80 Days
Wire	3,693.50 LF	47 Days
Panels	5 Panels	4 Days

Equipment	Total Used	Total Time
Excavator	1	80 Days
Dozers	6	79 Days
Crane	1, 25 Ton	103 Days Rented 89 Days on Site

Conclusions

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- Proposed system would save on energy costs
 - Total cost is over \$3 million more than building costs
 - Additional mechanical space would be required
 - Payback period is 37 years
 - Critical Item on schedule is the pipe installation
- Horizontal GSHP is used due to low depth of bedrock
 - 2 layers were used due to lack of space around the building

Questions?