Ft. Detrick Defense Medical Logistics Center
Building Systems Redesign

April 16, 2008
Senior Thesis Presentation

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Penn State University

Architectural Engineering
Mechanical Option

Outline

- Background
- Existing Mechanical Systems
- Redesign Summary
- Redesign Goals
- Mechanical Depth Study
- Architectural/Site Breadth Study
- Electrical Breadth Study
- Conclusions and Recommendations

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Background

Size

129,960 ft^2

Cost

$26.5 Million

Function

Office

Occupants

Top Medical Planning Organizations within the **Department of Defense**, representing the **Army**, **Navy**, **Air Force**, and **Marines**

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Background

AT/FP

Anti-Terrorism/Force Protection

SPiRiT

Sustainable Project Rating Tool

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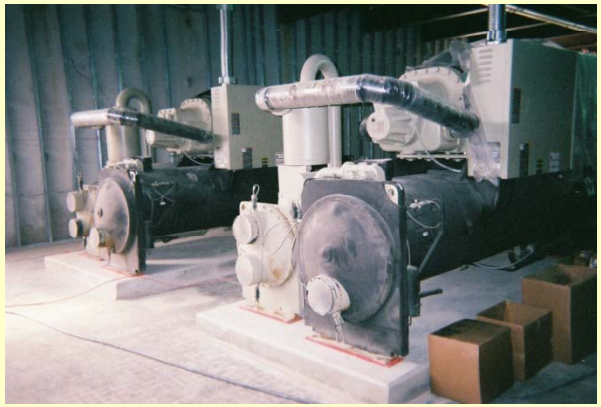
Existing Mechanical System



Personal Photo Taken 2/23/08

Chilled Water System

- 2 Water-Cooled Chillers at 220 tons each
- 42°F Leaving Water Temperature
- Serves Cooling Coils of AHU-1 thru 6

Hot Water System

- 2 Gas-Fired Boilers at 2160 MBH each
- Serves AHU heating coils, VAV reheat coils, and Unit Heaters

Personal Photo Taken 2/23/08

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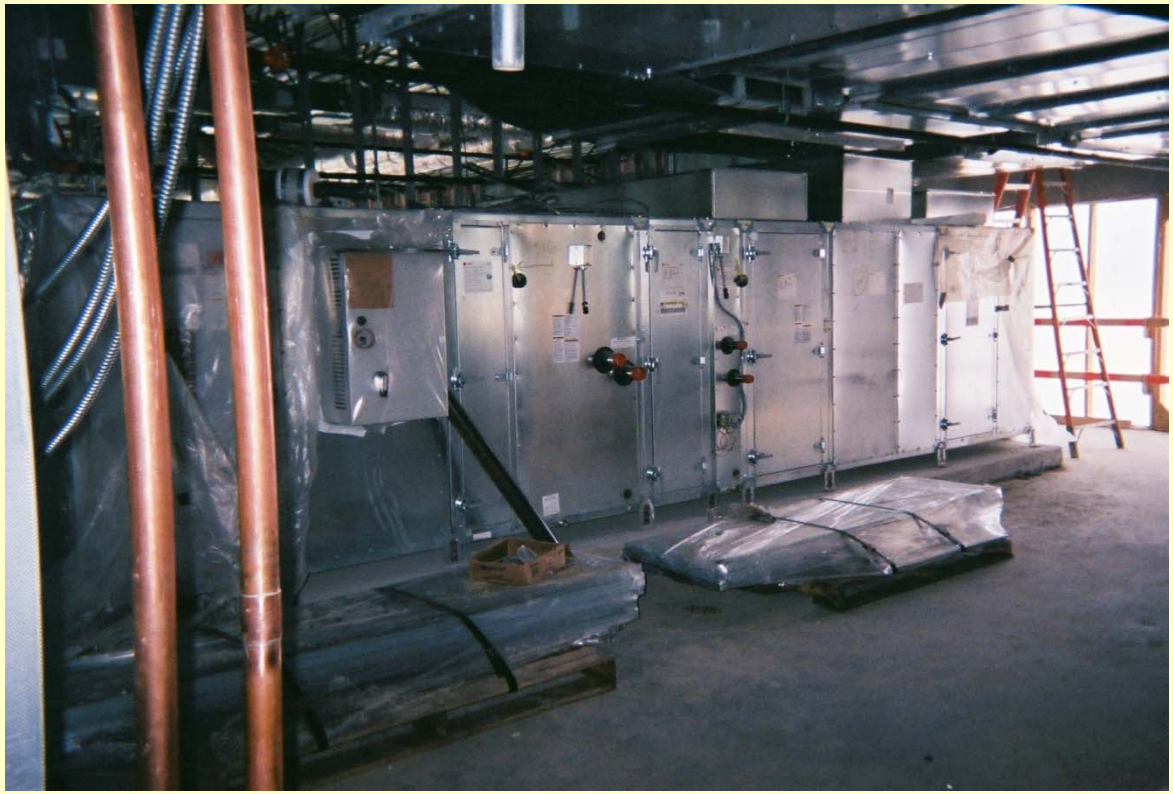
Existing Mechanical System



Personal Photo Taken 2/23/08

Airside

- 6 VAV Air Handling Units
- Water Heating and Cooling Coils
- VAV Hot Water Reheat Boxes

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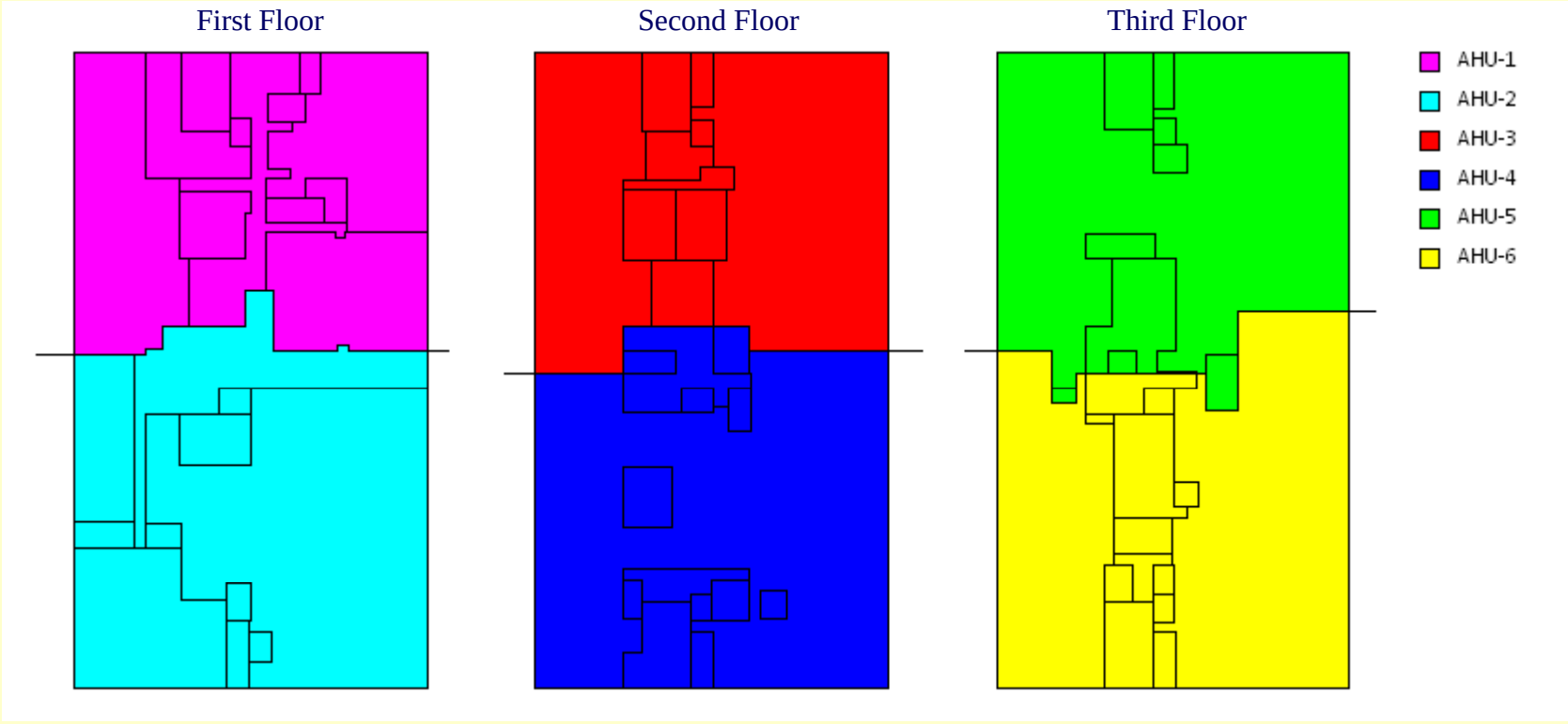
Existing Mechanical System



Redesign Goals

1. Decrease Space
2. Increase Energy Efficiency
3. Maintain Affordability
4. Maintain Occupant Safety
5. Improve Sustainability

Redesign Summary

- Mechanical Depth Study
  - DOAS/Chilled Beams/High-Induction Diffusers
- Architectural/Site Breadth Study
  - Constructed Wetland for On-Site Wastewater Treatment
- Electrical Breadth Study
  - Impact of Mechanical Redesign on Electrical System

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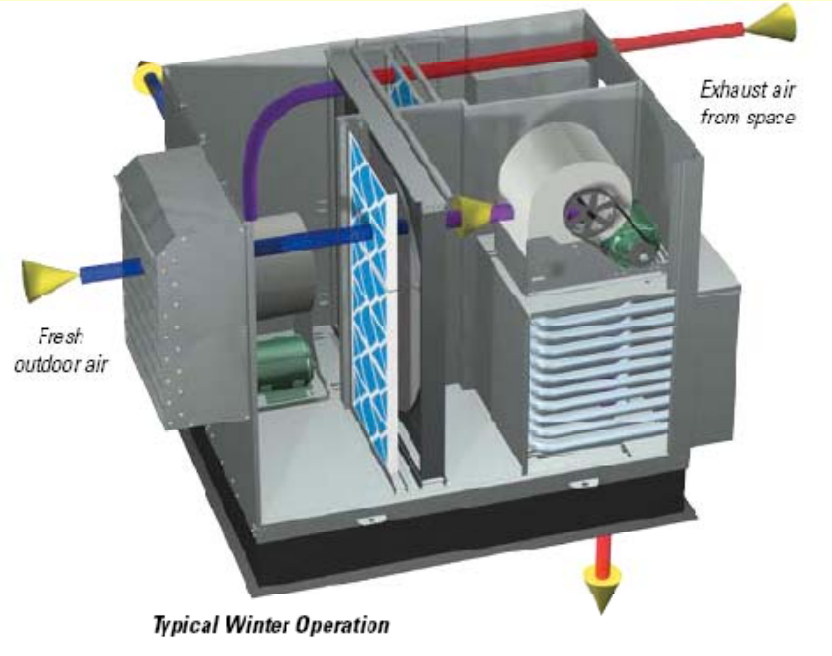
Mechanical Depth Study

Dedicated Outdoor Air System (DOAS)



Innovent Dedicated Outdoor Air Unit

- Enthalpy Wheel
  - Recovers Energy
  - Save on Utility Cost

Mechanical Depth Study

Dedicated Outdoor Air System (DOAS)

Outdoor Air Savings from DOAS-1

	Vot (current design)	Vot 100% OA (∑Voz)	Difference
AHU-1	4460	2843	
AHU-3	4975	2235	
AHU-5	4670	2120	
Total	14,105	**7198**	6907

Outdoor Air Savings from DOAS-2

	Vot (current design)	Vot 100% OA (∑Voz)	Difference
AHU-2	4210	1773	
AHU-4	4550	2092	
AHU-6	4985	2584	
Total	13,745	**6449**	7296

- 100% Outdoor Air
  - Smaller Volume of Air Required
  - Contaminants Not Recirculated

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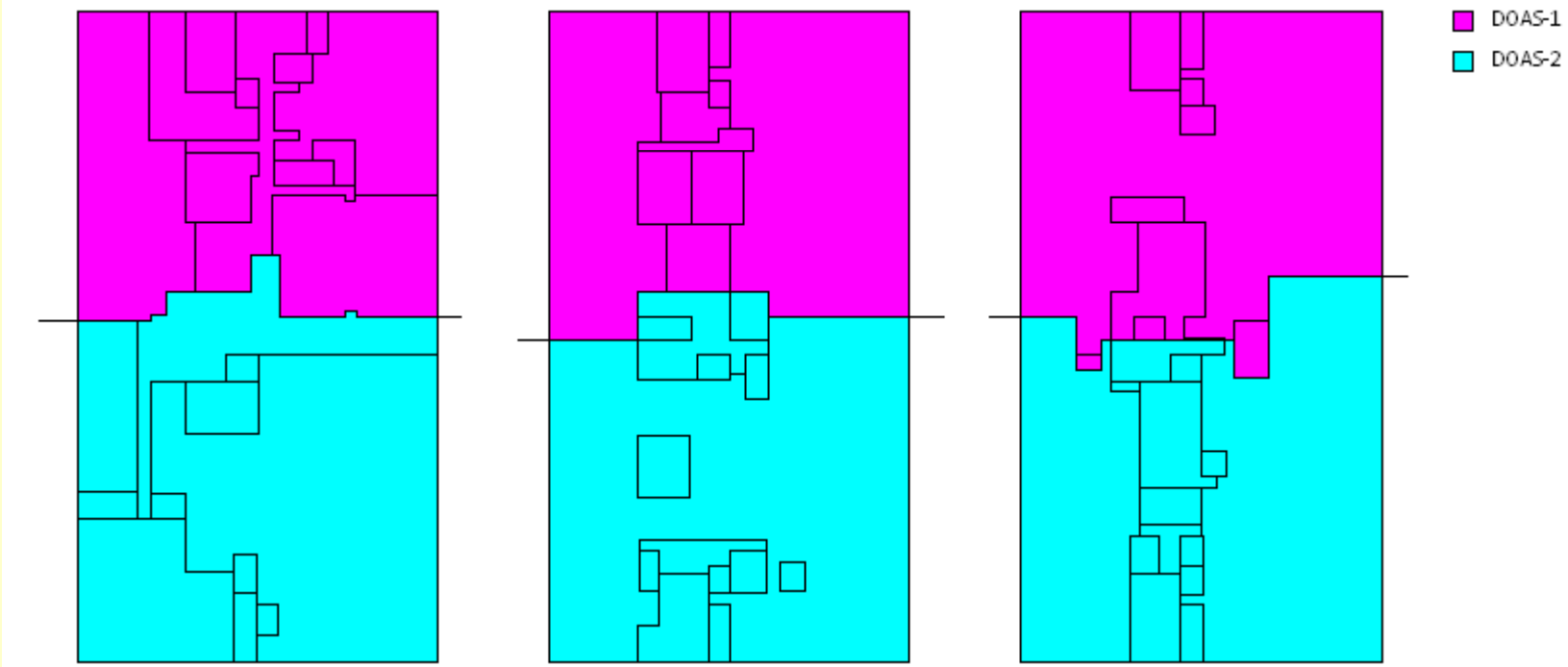
Mechanical Depth Study



Mechanical Depth Study

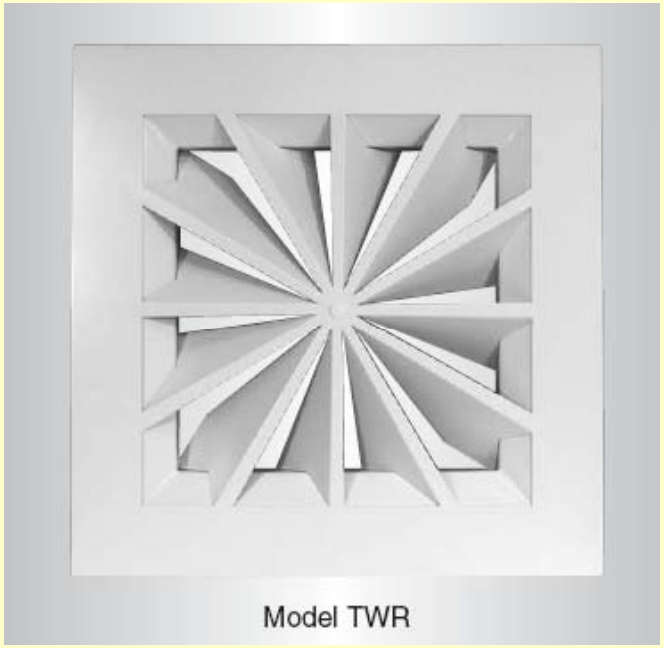
Chilled Beams

http://www.aeieng.com/services/sustainable/chilledbeam.htm

- Passive System
  - Cool by Convection and Radiation
  - Remove Sensible Loads
  - No Additional Energy to Operate

Mechanical Depth Study

High-Induction Diffusers



Nailor High-Induction Diffuser

- Cooling Supply Air Temperature = 48°F
  - Diffusers encourage mixing of air
  - Prevent “dumping” of cold air

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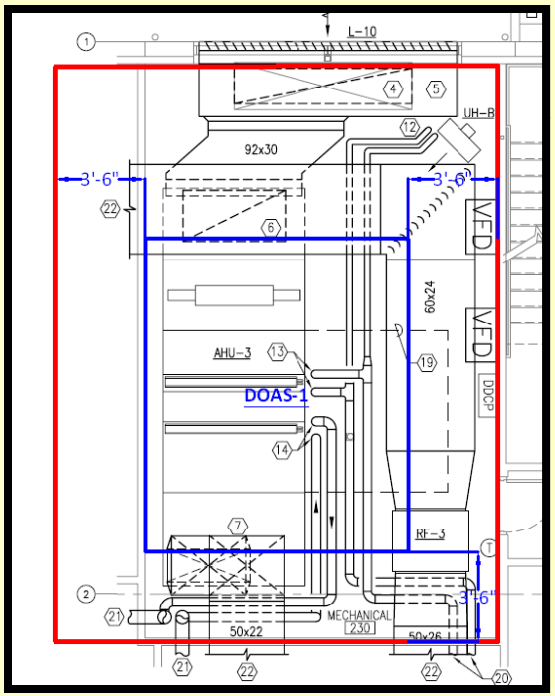
Mechanical Depth Study

Goal 1 – Decrease Space



- Existing System
  - 6 Mechanical Rooms
  - 5.2% Lost Rentable Space
- Redesigned System
  - 2 Mechanical Rooms
  - 3.3% Lost Rentable Space
- Owner saves 2392 ft^2 – 2% of Total Area

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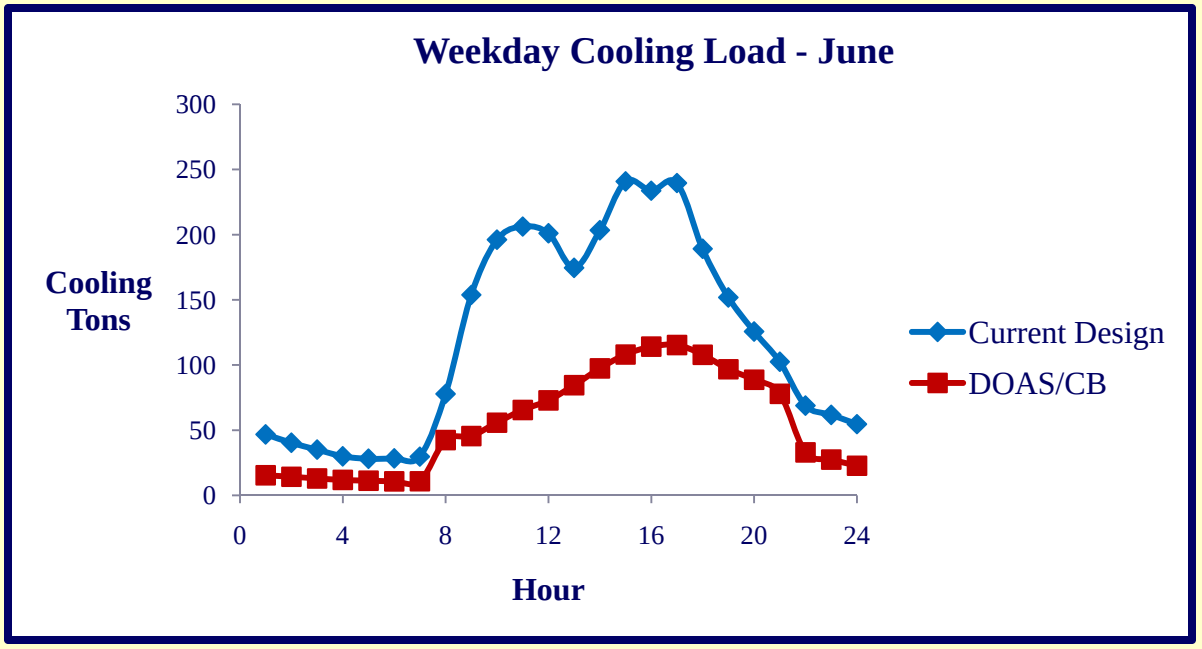
Mechanical Depth Study

Goal 2 – Increase Energy Efficiency



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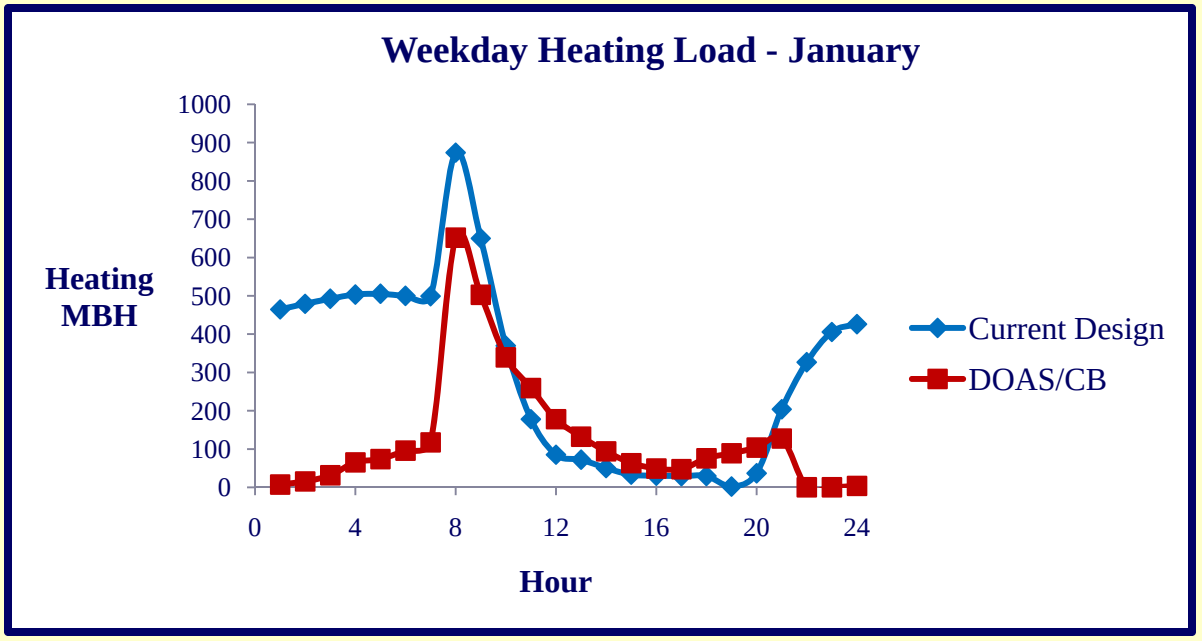
Mechanical Depth Study

Goal 2 – Increase Energy Efficiency



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Mechanical Depth Study

Goal 3 – Maintain Affordability

Utility Rates - Baltimore Gas and Electric

Utility Type	Rate Type	Summer Charge	Winter Charge
Electric Consumption	On Peak	$0.07/kWh	$0.055/kWh
Electric Consumption	Off Peak	$0.044/kWh	$0.04/kWh
Electric Demand	On Peak	$10.22/kW	$4.94/kW
Electric Demand	Off Peak	$4.94/kW	$4.94/kW
Gas Consumption	-	$0.4165/therm	

- Existing System Energy Cost: $164,529/year
- Redesigned System Energy Cost: $136,252/year
- Yearly Savings: **$28,277**

Mechanical Depth Study

Goal 3 – Maintain Affordability

Initial Cost Comparison

Equipment	Existing System	Redesign DOAS/CB	Difference
Diffusers (493)	$20,460	$21,300	-$840
VAV Boxes (164)	$87,740	$ -	$87,740
Chilled Beams (1460)	$ -	$276,750	-$276,750
VAV AHUs (6)	$187,800	$ -	$187,800
DOAS Units (2)	$ -	$86,000	-$86,000
Total	**$296,000**	**$384,050**	**-$88,050**

- Existing System First Cost: $296,000
- Redesigned System First Cost: $384,050
- First Cost Increase: **$88,050**

Mechanical Depth Study

Goal 3 – Maintain Affordability

- Existing System Life Cycle Cost: $1,696,733
- Redesigned System First Cost: $1,544,041
- 20-Year Life Cycle Cost Savings: **$152,692**
  - Payback Period: only **3.9** years

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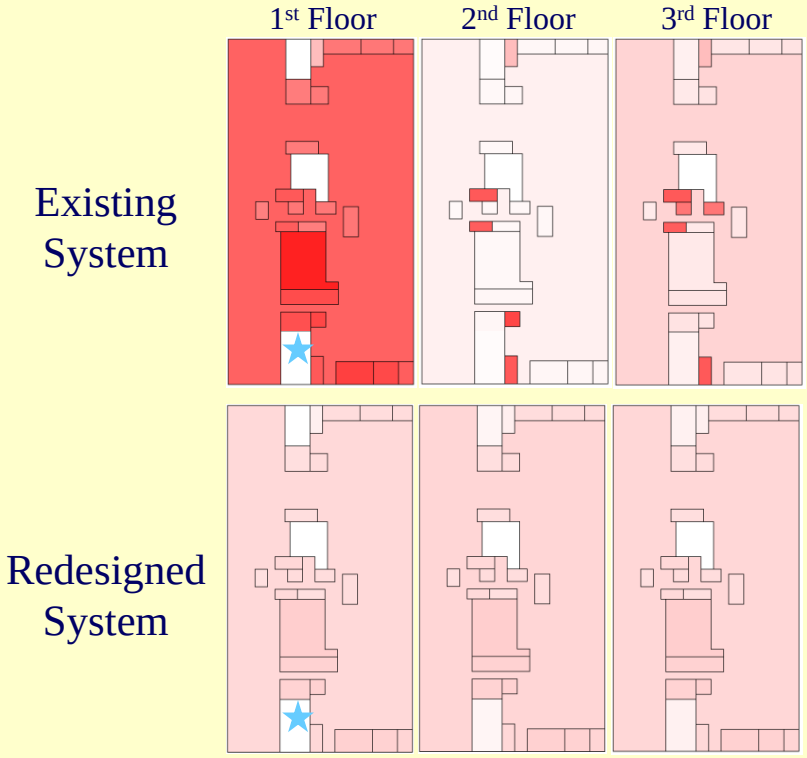
Goal 4 – Maintain Occupant Safety



- Simulation of contaminant released in outdoor air intake (star)
- Concentration of contaminants 30 minutes following release
- Existing system has higher initial concentration on first floor
  - Smaller Zones
  - Rest of contamination due to leakage

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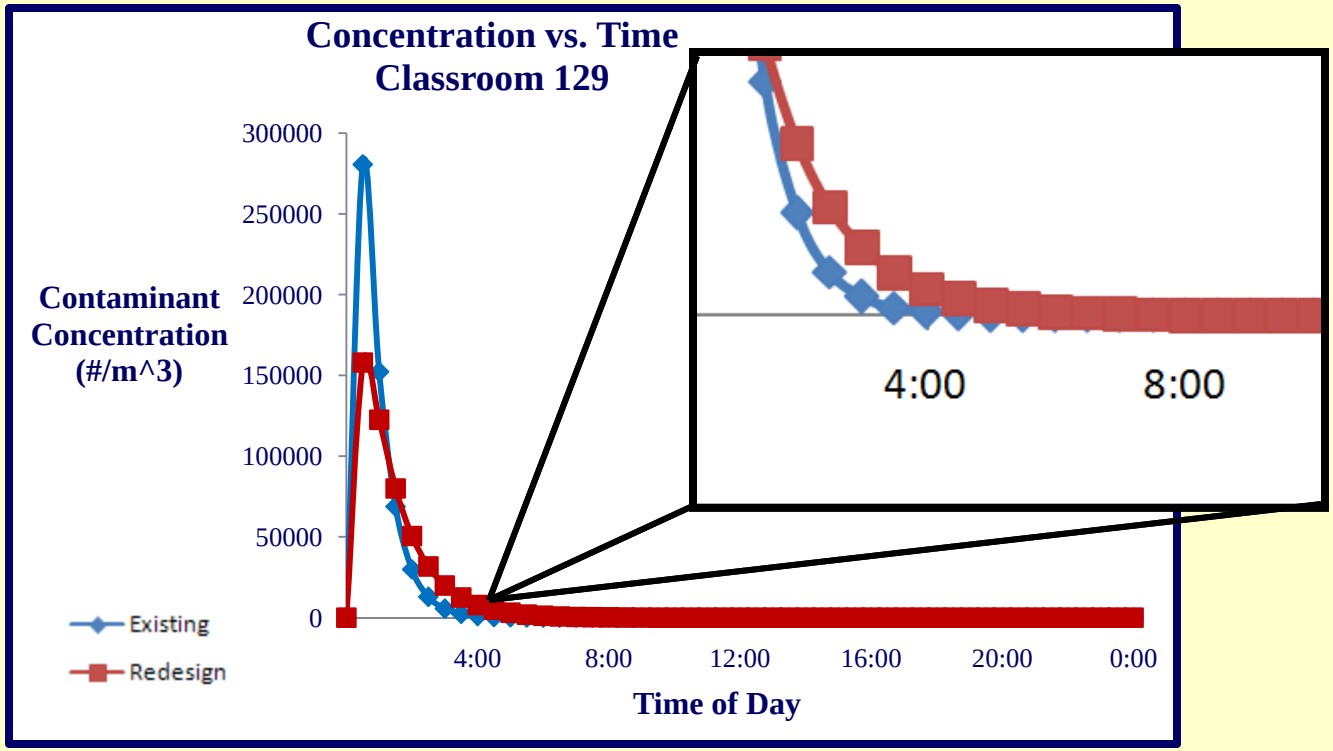
Goal 4 – Maintain Occupant Safety



- Redesign takes approximately 2 hours longer to clear the building

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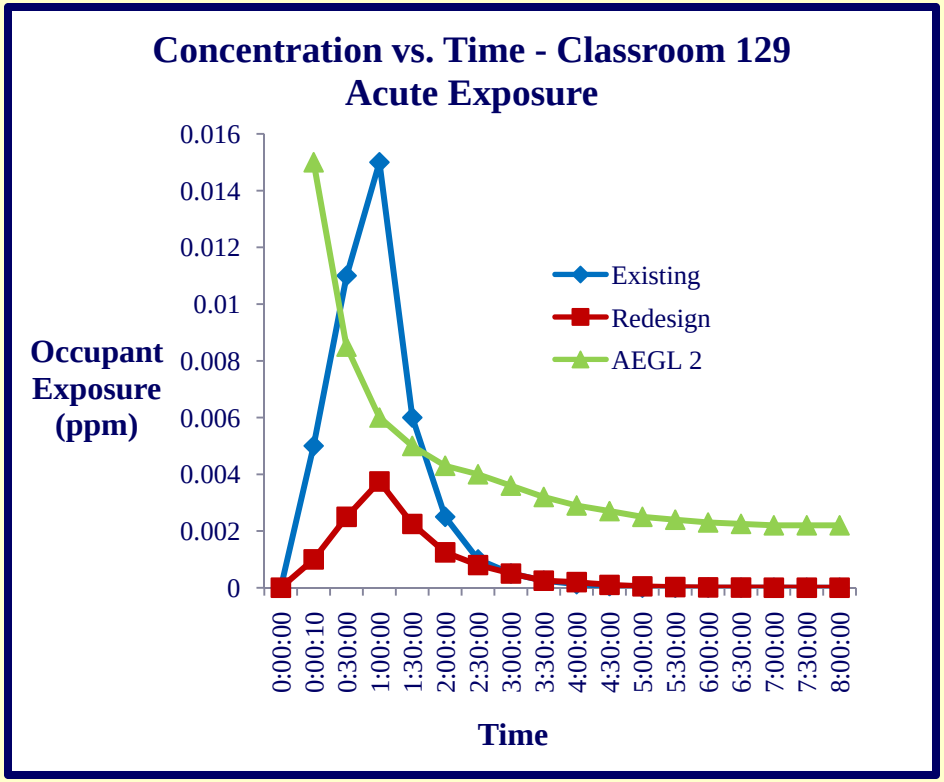
Mechanical Depth Study

Goal 4 – Maintain Occupant Safety



- Acute Exposure Guideline Level (AEGL)
  - Describe risk from one-time exposure to contaminants
- Contaminant selected arbitrarily, only intended to display relative concentration between 2 cases
- Redesign never reaches dangerous level – **2 hour difference is not critical**

Mechanical Depth Study

Goal 5 – Improve Sustainability

Existing System

- 43 points – SPiRiT **Silver**
- Need 7 points for SPiRiT **Gold**

Redesigned System

- Uses 17.2% less energy than baseline system
- 1 point awarded for every 2.5% reduction of energy
- **6** more points can be obtained, but still need **one more…**

Architectural/Site Breadth Study

Goal 5 – Improve Sustainability

http://www.dep.state.pa.us/Images/

Constructed Wetland

- Satisfies SPiRiT credit 2.C2 – Innovative use of wastewater technology
- Use planting beds of wetland vegetation to treat noxious effluents/sewage
- Free water surface – most affordable

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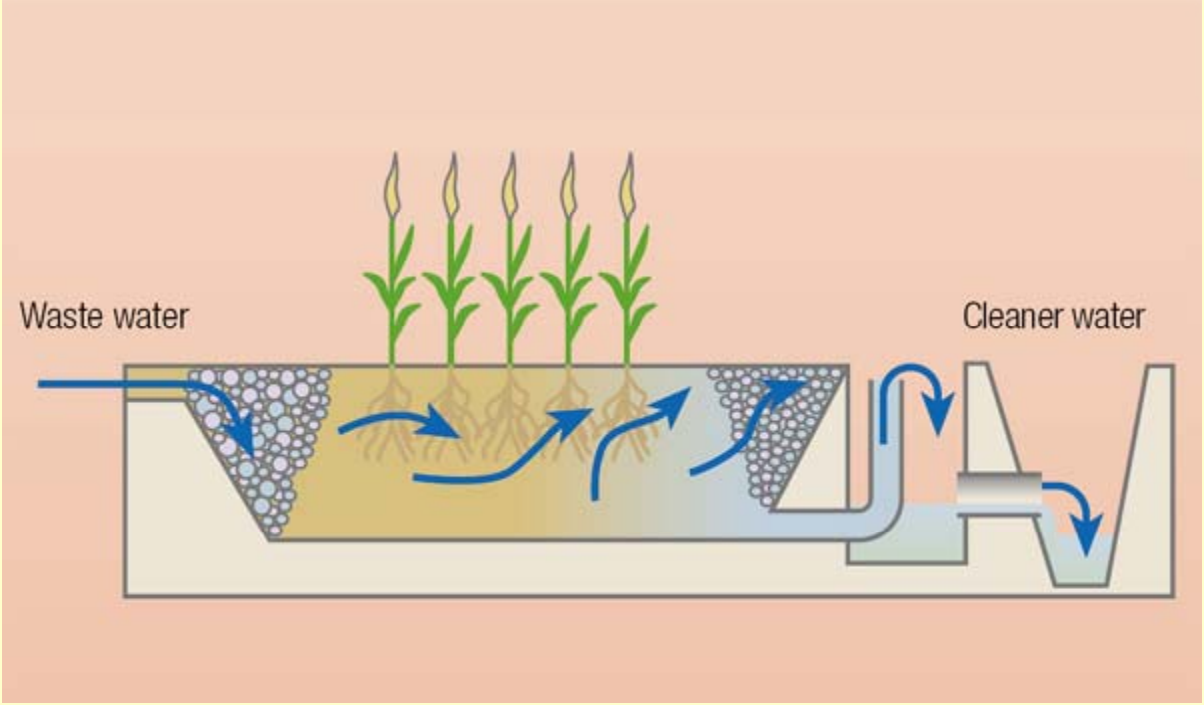
Architectural/Site Breadth Study

Goal 5 – Improve Sustainability



http://www.unep.org/geo/yearbook/yb2003/images/fresh_img_g_40.jpg

Architectural/Site Breadth Study

Goal 5 – Improve Sustainability

Construction Cost Summary - FWS Constructed Wetland

Excavation/Compaction	$8,668.80
Soil/Gravel	$2,786.40
Liner	$12,267.90
Plants	$5,495.40
Plumbing	$9,481.50
Total	**$38,700.00**

Constructed Wetland

- Building uses 24,300 gal/day (max. occupancy)
- 4300 ft^2, 3 ft deep
- Adds **$38,700** to first cost

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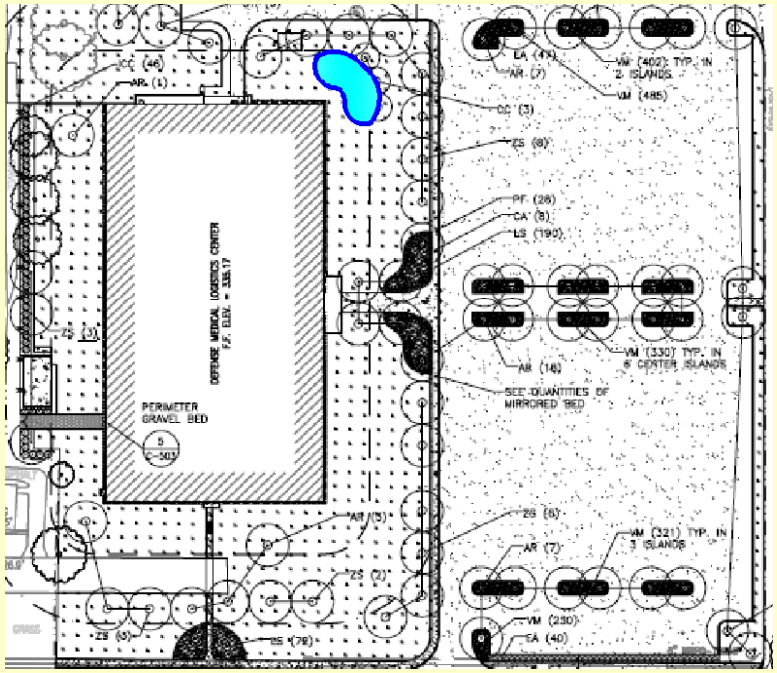
Architectural/Site Breadth Study

Goal 5 – Improve Sustainability



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Electrical Breadth Study

Goal 3 – Maintain Affordability

Cost of Electrical Additions

Added	Qty.	Cost per 100 LF	LF	Total Cost
#10 Wire	6	59.50	36	$129
25 A Breaker	6	-	-	$4,074
			Total	**$4,203**

Cost of Electrical Subtractions

Subtracted	Qty.	Cost per 100 LF	LF	Total Cost
#3 Wire	6	196.00	100	$1,176
#4 Wire	12	166.50	64	$1,279
#12 Wire	18	47.90	128	$1,104
70 A Breaker	6	-	-	$4,818
80 A Breaker	12	-	-	$4,818
15 A Breaker	18	-	-	$4,074
Panel DP5	1	-	-	$4,000
			Total	**$21,268**

- Equipment reduction means power reduction
- Panelboard DP5 can be eliminated
- Reduces first cost by $17,065
- **Total cost additions from breadth: $21,635**

Conclusions and Recommendations

- Total First Cost of Redesign: $384,050 + $21,635 = **$405,685**
- Total 20-Year Life Cycle Cost Savings: **$131,058**
  - Payback period still only **5.2 years**
- Owner would pay $109,685 more up-front, but would save $131,058 after 20 years

Conclusions and Recommendations

Goals Met:

1. Decrease Space
   - *YES. DOAS units take up 2% less space than existing AHUs*
2. Increase Energy Efficiency
   - *YES. Smaller quantity of air to condition; Enthalpy wheel provides energy recovery*
3. Maintain Affordability
   - *YES. Higher first cost pays back in 5.2 years with savings on energy.*
4. Maintain Occupant Safety
   - *YES. DOAS takes longer to clear the building, but the building never reaches a critical level.*
5. Improve Sustainability
   - *YES. 6 credits from mechanical redesign + 1 credit from wetland = 7 credits needed for SPiRiT Gold.*

Acknowledgements

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Questions?

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