Howard Hughes Medical Institute's Landscape Building

Ashburn, Virginia

Julie Thorpe
Mechanical Emphasis

Architectural Engineering
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Penn State
Senior Thesis

Presentation Outline

- Project Information
- Existing Conditions
- Design Goals
- Mechanical Design
- Lighting Design
- Cost Analysis
- Recommendations
  & Lessons Learned
- Acknowledgements
- Questions

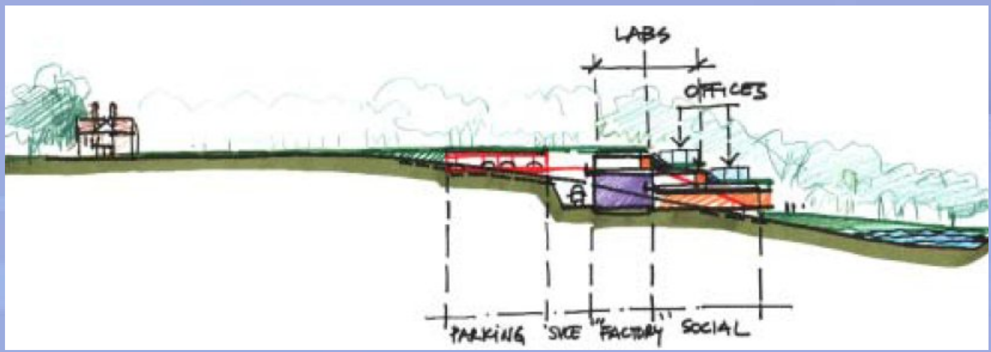
Project Information

Janelia Farm Research Campus

- First facility built for HHMI
- Designed to be a world-class biomedical research facility
- Long term goal : to achieve unconstrained scientific research
- Concept: a facility where scientists, engineers, and information technology professions could gather and reside
- There are three buildings on campus,
  - Landscape Building : laboratory
  - Conference Center : short-term stay
  - Townhouses : long-term housing

Janelia Farm

- Existing modified French-style manor
- Built in 1936 by architect Philip Smith of Boston
- Protected by the National Trust for Historic Preservation
- Protected view from dinning room window to Sugarloaf Mountain in Fredrick Country, Maryland
- Building was designed around historic requirements



Project Information

• Location	Ashburn, VA
• Size	546,436 SF
• Owner	Howard Hughes Medical Institute (HHMI)
• Architect	Rafael Vinoly Architects PC
• MEP Engineer	Burt Hill
• Project Manager	Jacobs Facilities, INC.
• Dates of Construction	Fall 2002 – Summer 2006
• Total Cost	$500M

Landscape Building

Functions

- Laboratory Space
- Support Spaces
- Vivarium
- Offices
- Conference Center
- Data Center
- Kitchen / Cafeteria

Existing Conditions

Actual Mechanical Design

Air Side

- 15 – 45,000 cfm AHU
- 1 plenum serves building
- VAV with hot water reheat
- 100% ventilation air

Major Issues:

- Current annual operating cost
- Amount of air required
- Overestimated equipment loads
- Average lighting power density

Water Side

- (7)1,200 ton centrifugal chillers
- (2)50,210 MBH & 1-30,125 MBH boilers
- (7)1,200 ton cooling towers

Design Goals

Design Goals

Primary goal:

- **Modify the existing HVAC system to reduce energy consumption and yearly utility costs for laboratory space.**

Secondary goal:

- **Reduce lighting power density**
- **Examine equipment loads**
- **Reduce life cycle cost**
- **Reduce first cost**
- **Utilize existing site**

Mechanical Design

Process

- Case 1 : Actual Design
- Case 2 : Modified Equipment Loads
- Case 3 : Reduced Lighting Loads
- Case 4 : Reduced Equipment & Lighting Loads
- Case 5 : Vertical Ground Loop
- Case 6 : Pond Loop
- Case 7 : Pond Loop and Reduced Loads

Case 1 : Actual Design

- HAP model based on design data provided by the MEP engineer.
- Annual Operating Cost : $970,000

Case 1 Mechanical System			
Cooling		Heating	
Total Coil Load [ton]	Sensible Coil Load [MBH]	Total Coil Load [MBH]	Peak Load [cfm]
684	4,635	2,602	181,933

Case 4 : Modified Equipment & Lighting Load

- Reduced equipment estimate from 20W/SF to 4W/SF (labs) and 8W/SF (support rooms) - based on research at LBNL
- Reduced lamp wattage from 188KW to 152KW (- 8.1%)
- Design based on NIH design standards
- Annual Operating Cost : $727,000
  - 25% reduction from Case 1

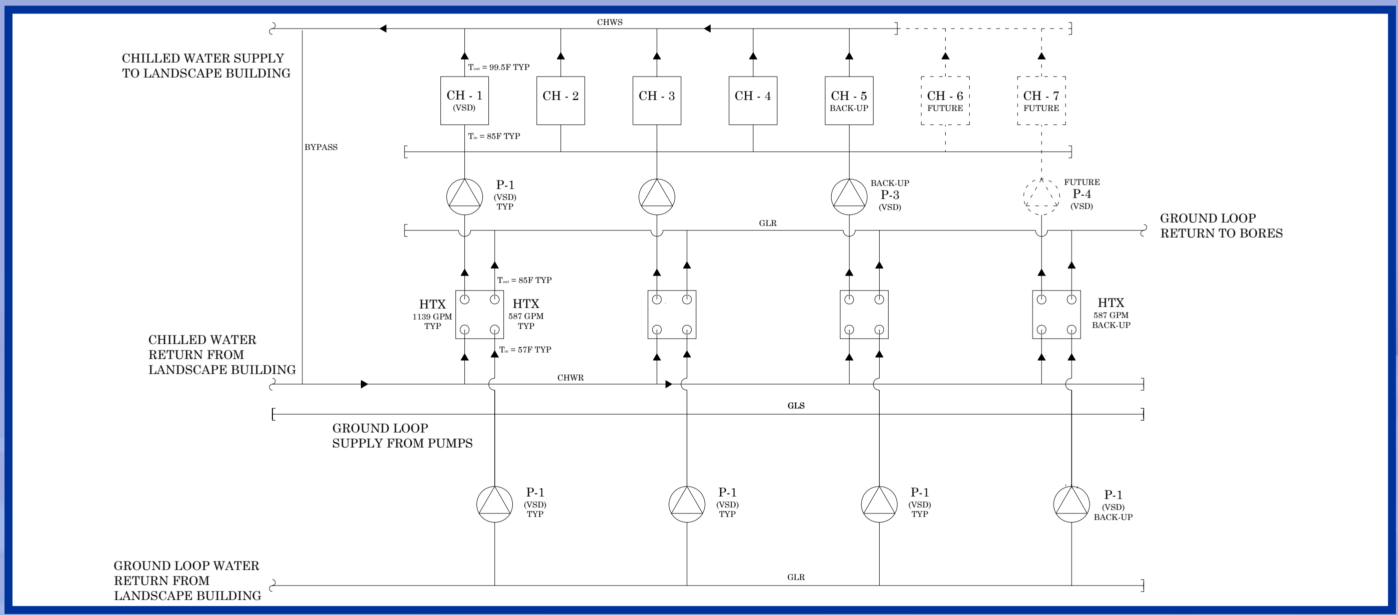
Case 4 Mechanical System			
Cooling		Heating	
Total Coil Load [ton]	Sensible Coil Load [MBH]	Total Coil Load [MBH]	Peak Load [cfm]
492	3,337	1,866	138,726

Ground-Coupled Heat Pump System

- Initially considered but ruled out due to the following:
  - Required number of heat pumps excessive
  - Boilers and chillers cannot be replaced/downsized
    - Required for specific loads: cold rooms, sterilization, etc.
  - Length of piping through the ground and building too great

Considered Alternative

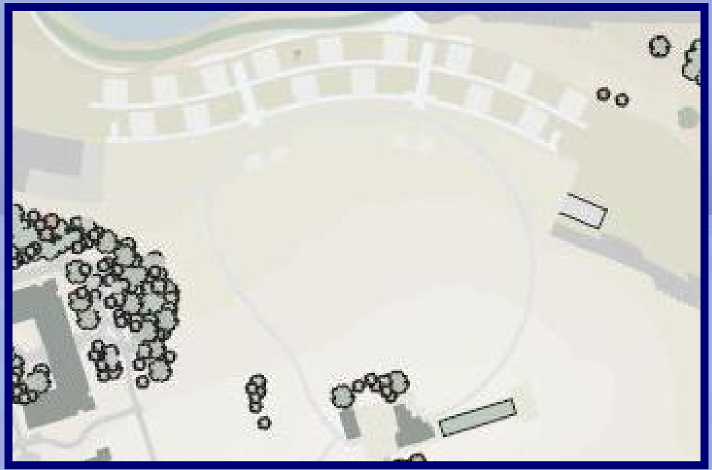
- Replacing cooling towers by connecting loop into condensing side of chiller with HTXs



Case 5 : Ground Loop

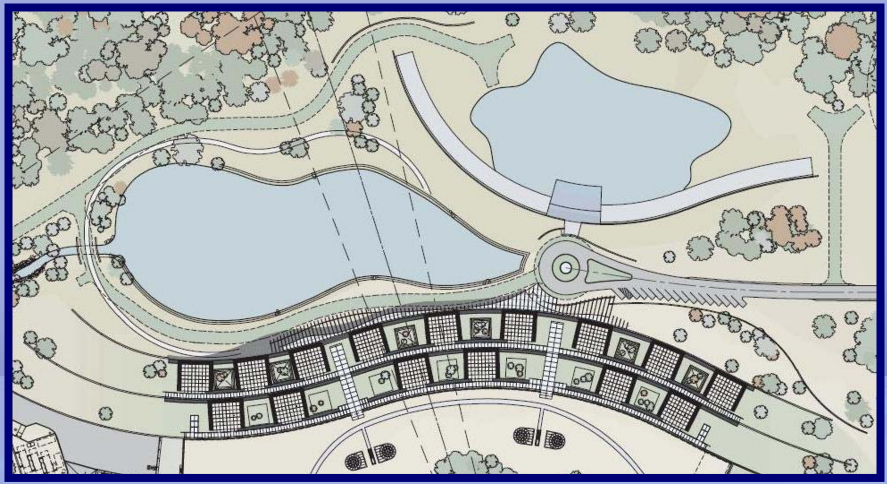
- **Standard vertical ground loop configuration**
- **Required 61,000 FT of piping to meet cooling load**
  - **15 x 34 bore array, 120 ft bores**
- **Proposed location : Field between building & mansion**

- **Annual Operating Cost : $949,000**
  - **2.0% reduction from Case 1**
- **Original Lab Cooling Towers : $159,000**
- **First Cost : $1.13M**
  - **7x actual first cost**



Case 6 : Pond Loop

- **Brainstorm : Use existing ponds!**
  - **Two ponds built for aesthetic purposes between Landscape Building & Conference Housing**
- **Upper Pond :**
  - **Depth : 18ft**
  - **Area : 1.1 Million SF**
- **Lower Pond:**
  - **Depth : 12ft**
  - **Area : 590,000 SF**

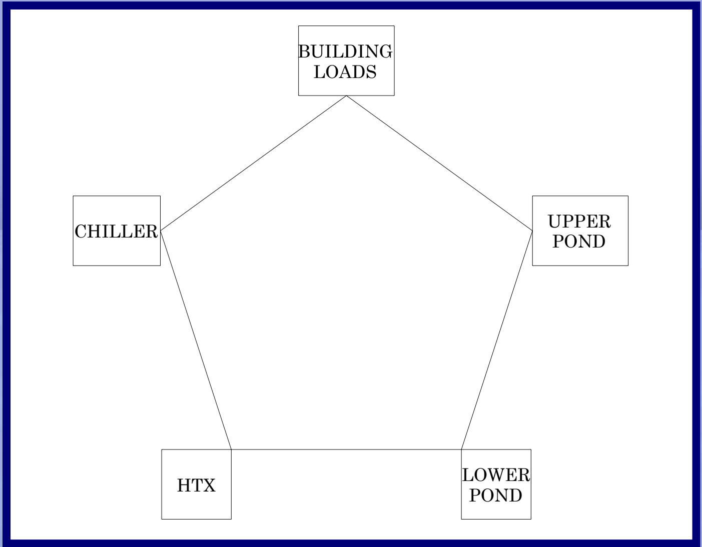


- **Designed to maintain constant water height**
- **Existing circulation pumps to prevent freezing**

Case 6 : Pond Loop

- Smaller pumps required than Case 5 due to less head
- Extra pumps needed between ponds
- Uses existing mechanical spaces for new equipment
- Minimal site work to install piping required

- Annual Operating Cost : $899,000
  - 7.2% reduction from Case 1
- Original Lab Cooling Towers : $159,000
- First Cost : $213,000
  - 34% increase



Case 7 : Pond Loop & Reduced Loads

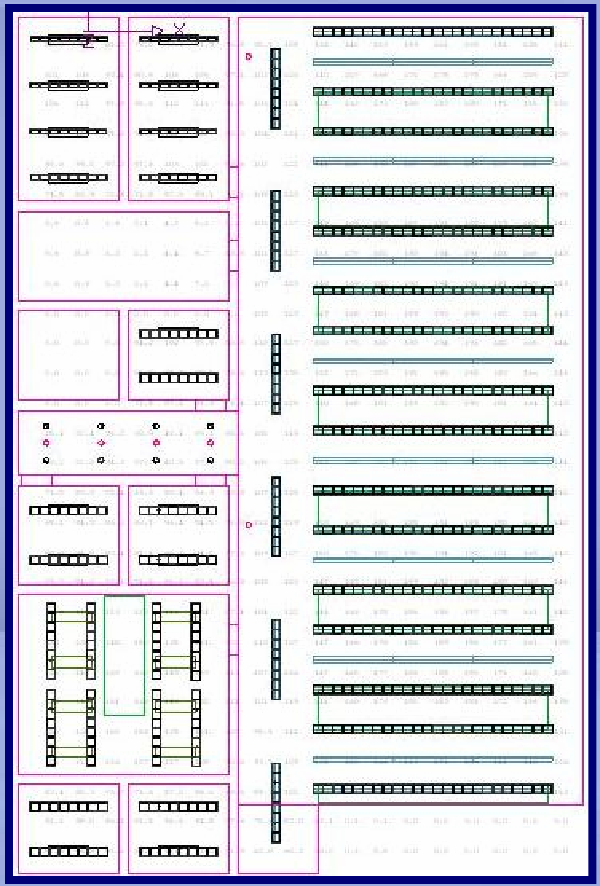
- **Resize pond loop system for reduced loads**
- **Annual Operating Cost : $683,000**
  - **29.5% reduction from Case 1**
- **Original Lab Cooling Towers & Lighting**
  - **$189,000**
- **First Cost : $234,000**
  - **24% increase**

Lighting Design

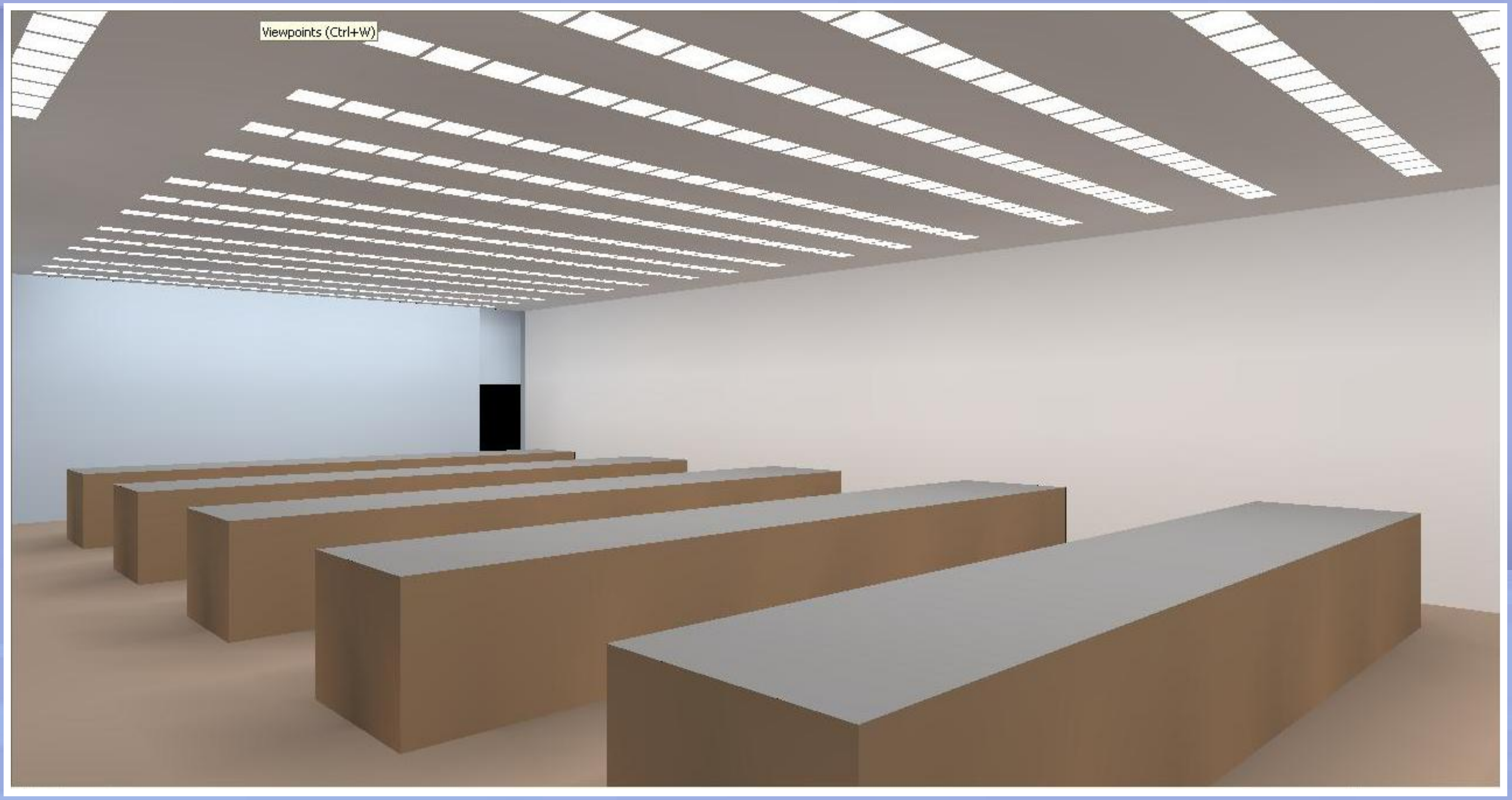
Lighting Design

- Current labs have between 1 & 5.9 W/SF
- IES Handbook recommends 50-200 f.c. for hospitals
- Lamps selected based on lumems/watt to increase amount of light on work surfaces & to decrease required power

Layout Comparison			
	Number of Fixtures	**Total Lumens**	**Total Watts**
Original	186	1,153,960	13,376
New	114	945,060	10,100
Difference	**-72**	**-208,900**	**-3,276**



Lighting Design

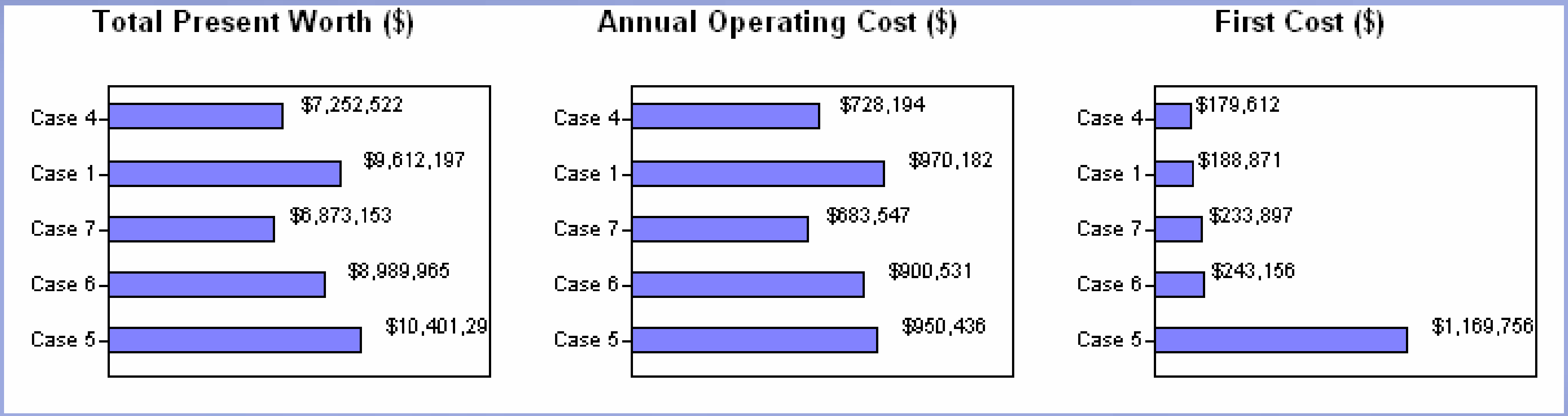


Cost Analysis

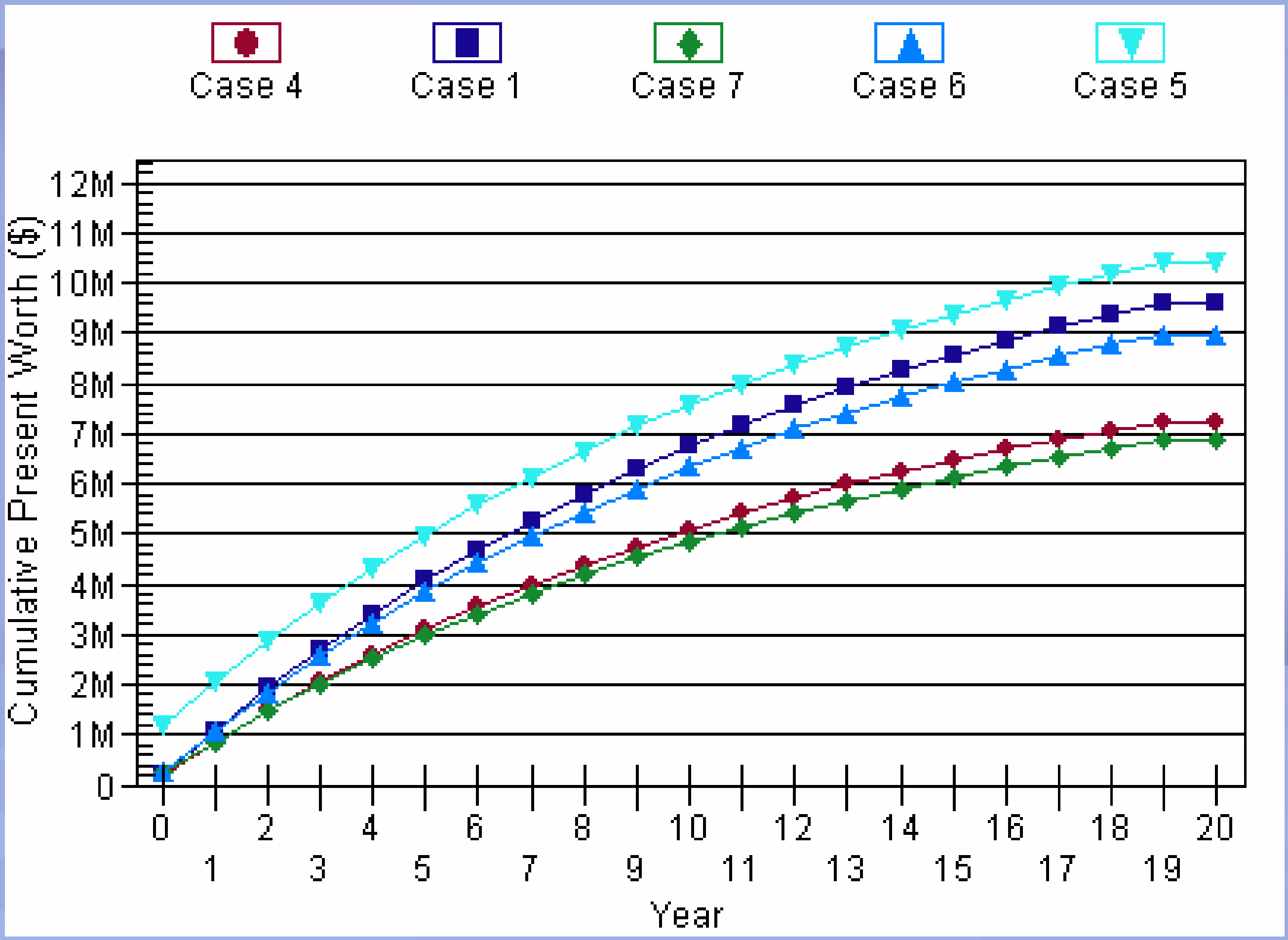
Simple Payback

Simple Payback					
	Case 1	**Case 4**	**Case 5**	**Case 6**	**Case 7**
Relative First Cost	188,871	179,612	1,169,759	243,156	233,897
Change in First Cost	0	-9,259	980,888	54,285	45,026
Annual HVAC Operating Cost	968,542	727,465	948,796	898,891	682,818
Annual Lighting Maintanance Cost	1,640	729	1,640	1,640	729
Total Annual Cost	970,182	728,194	950,436	900,531	683,547
Chance in Annual Cost	0	-241,987	-19,746	-69,651	-286,634
Simple Payback [years]	**–**	**0.0**	**49.7**	**0.8**	**0.2**

Life Cycle Cost



Life Cycle Cost



Recommendations & Lessons Learned

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Recommendations

- Case 7 best achieved goal to reduce annual energy cost.
- It can be incorporated into Landscape Building without extensive alterations and cost.

Lessons Learned

- The biggest cost savings came from carefully designing the system to actual loads and design standards.
- The Landscape Building was designed well. While the mechanical system could have been "tweaked" before construction, the building itself was designed to be adaptable.

Acknowledgements

- I would like to thank my mom for raising me a Nittany Lion and for teaching me that my school work should never interfere with my college education.
- Secondly, I would like to thank the love of my life Nate Patrick for being with me every step of the way. I love you!
- Thanks to Roni, Pappy, and “SENK” have truly made going to school every day something to look forward to. I wish y’all luck in the future.
- A special thanks to Moses who has blessed me with insight into everything from the building industry to faith.
- Scott Suktis and John Lecker for providing me with information.
- Thanks to the AE faculty.
- Thank you Class of 2006.
- Lastly, I would like to give God all the credit for guiding me into the AE program and for giving me the endurance and ability to succeed.

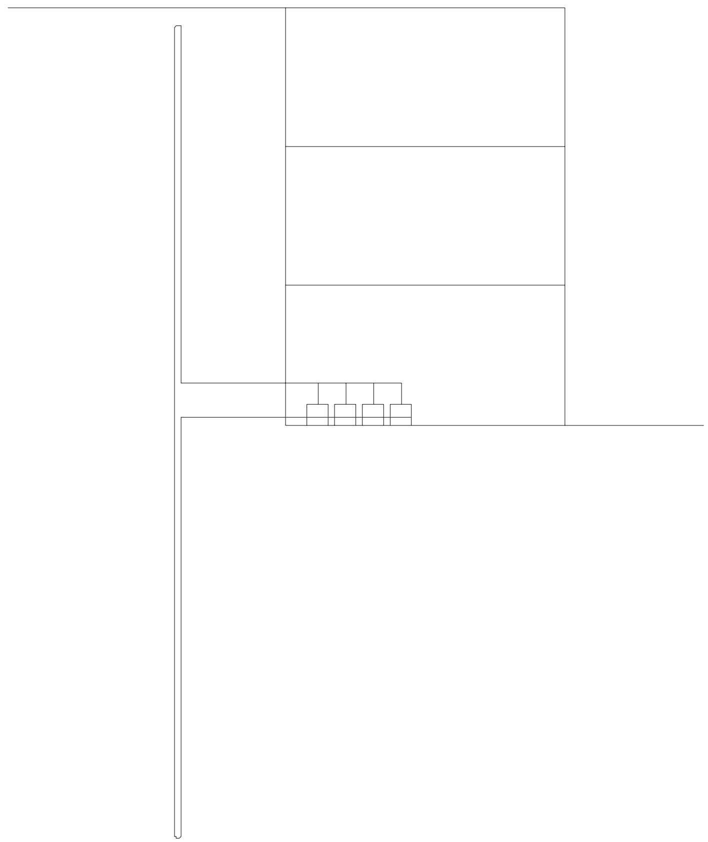
Questions

“It is a building about nature. Nature is the centerpiece of research at Janelia Farm, and the building follows that idea.”

- Rafael Vinoly, Architect

Thank you!

Vertical Bore Diagram



Emissions

Emissions : Case 1	
CO_2 [lb]	17,767,460
SO_2 [kg]	43,968
NO_x [kg]	25,863

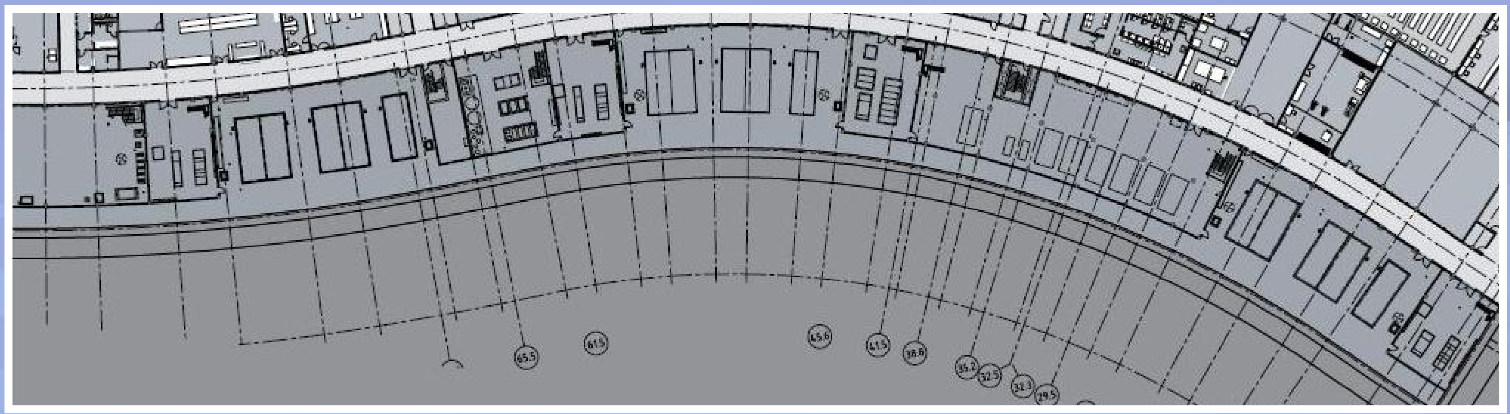
Emissions : Case 4	
CO_2 [lb]	13,454,910
SO_2 [kg]	33,316
NO_x [kg]	19,590

Emissions : Case 7	
CO_2 [lb]	12,357,992
SO_2 [kg]	30,600
NO_x [kg]	17,993

Acoustical Analysis

Conclusions from transmission loss calculations:

- Wall assembly for mechanical room with 7 chillers is adequate.
- Wall assembly for mechanical room with 7 chillers plus 4 new pumps is adequate.
- The mechanical room is isolated from all critical spaces by service corridor, other mechanical rooms, and service rooms.



Acoustical Analysis

	Noise Reduction & Transmission Loss : Actual Design [dB]					
	125 Hz	**250 Hz**	**500 Hz**	**1000 Hz**	**2000 Hz**	**4000 Hz**
Likely Noise in the Mech Room	93	95	96	98	105	98
Likely Noise in the Corridor	66	72	77	74	68	60
Required NR	27	23	19	24	37	38
Minus 10 log a2/S	-6	-7	-7	-6	-6	-6
Required TL	**33**	**30**	**26**	**30**	**43**	**44**
Actual Wall Assembly TL, 8" Concrete, painted	**34**	**40**	**44**	**49**	**59**	**64**

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Electrical System

Description	Load [VA]			Brk. Trip	LP 1				Brk. Trip	Load [VA]			Description
	A	B	C	[A]	Cond. Size	Ckt. #		Cond. Size	[A]	A	B	C	
Lab 285	4320			20	#12	1	2	#12	20	3,697			Lab Support 285
Lab 275		4320		20	#12	3	4	#12	20		3,697		Lab Support 275
Lab 255			4320	20	#12	5	6	#12	20			3,697	Lab Support 255
Lab Support 245	3,697			20	#12	7	8	#12	20	4320			Lab 245
Lab Support 225		3,697		20	#12	9	10	#12	20		4320		Lab 225
Lab Support 215			3,697	20	#12	11	12	#12	20			4320	Lab 215
Lab 270	1464			20	#12	13	14	#12	20	1253			Lab Support 270
Lab 265		1464		20	#12	15	16	#12	20		1253		Lab Support 265
Lab 240			1464	20	#12	17	18	#12	20			1253	Lab Support 240
Lab Suport 235	1253			20	#12	19	20	#12	20	1464			Lab 235
Lab Support 210		1525		20	#12	21	22	#12	20		1783		Lab 210
Lab Support 295			1754	20	#12	23	24	#12	20			2049	Lab 295
						25	26						
						27	28						
						29	30						
						31	32						
						33	34						
						35	36						
						37	38						
						39	40						
						41	42						

Total Load on Phase A	21468	[VA]
Total Load on Phase B	22059	[VA]
Total Load on Phase C	22554	[VA]
Load on Panel	82600	[kVA Demand]
	124.25	[A]
Voltage	277	[V]
Main Breaker	125	[A]
Feeder Size	(4) 1/0 @125A, 2"	
Panel Size	125	[A]

Thank you!