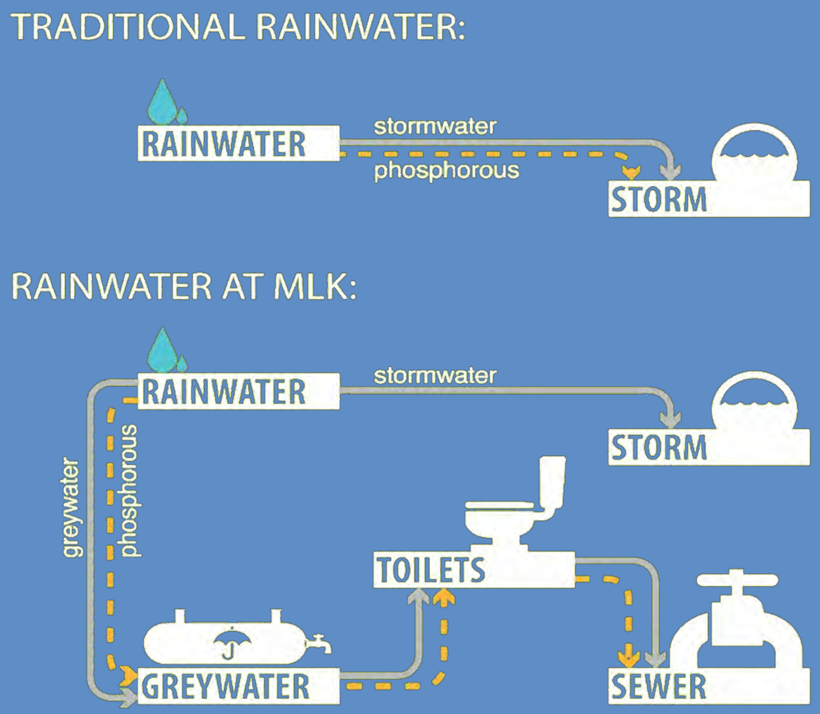
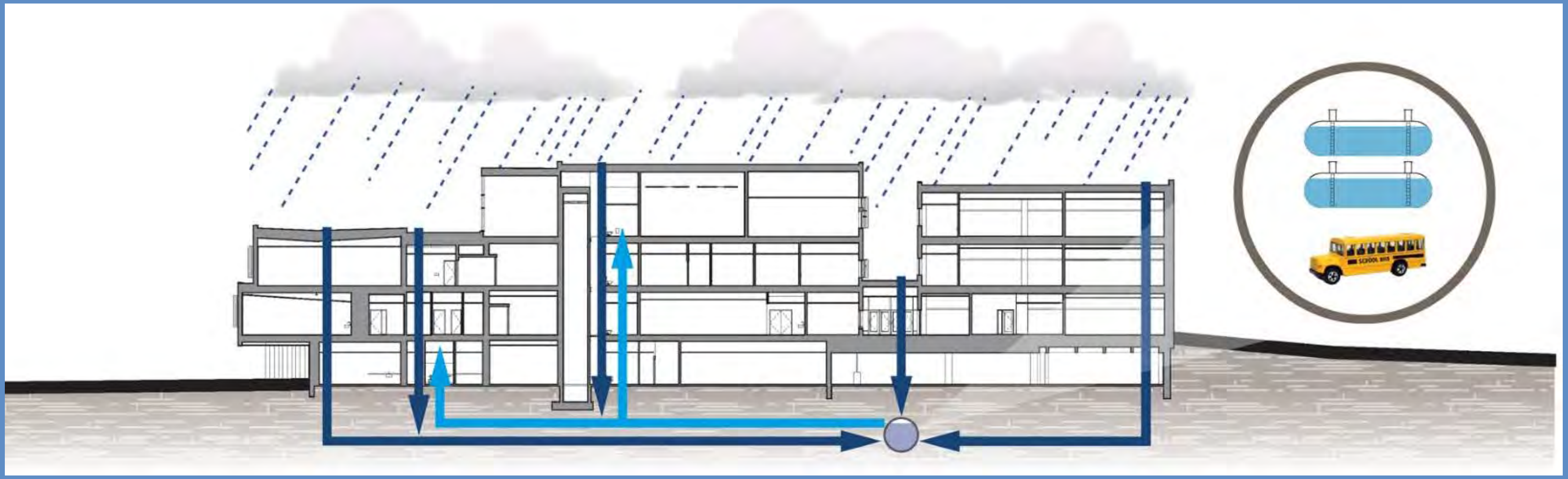
SYNERGIES & SYSTEMS THINKING

MLK / PUTNAM AVE SCHOOL, CAMBRIDGE MA

- Rainwater Capture & Reuse
  - 2x 10,000 tanks & Greywater System
  - +85% Potable Water Use Reduction
  - $ - Cost Neutral





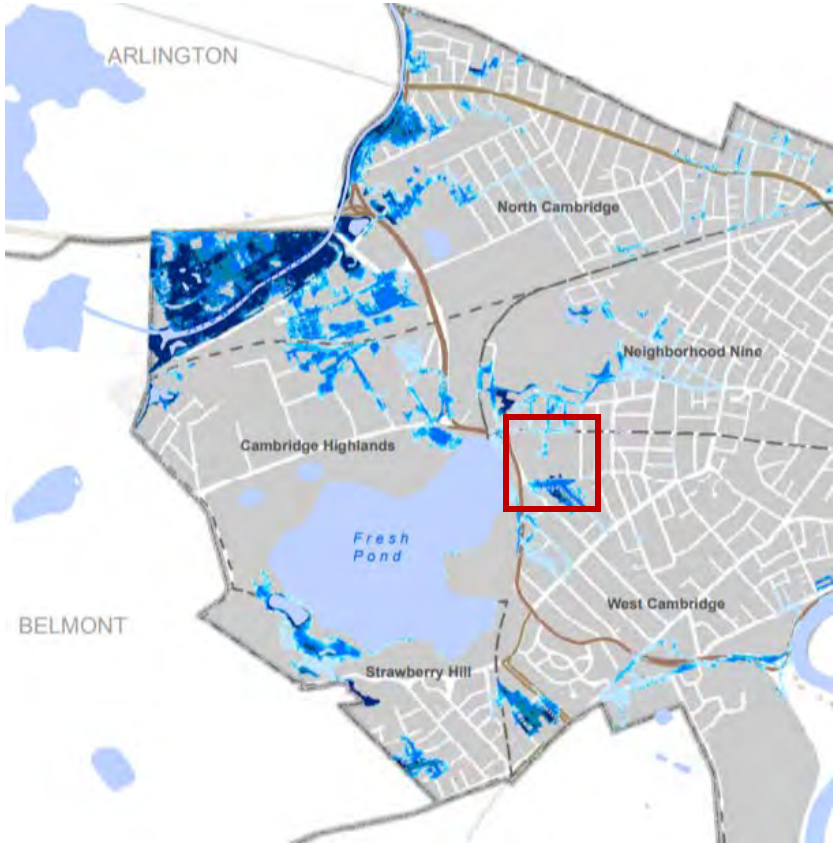
NEXT CHALLENGE

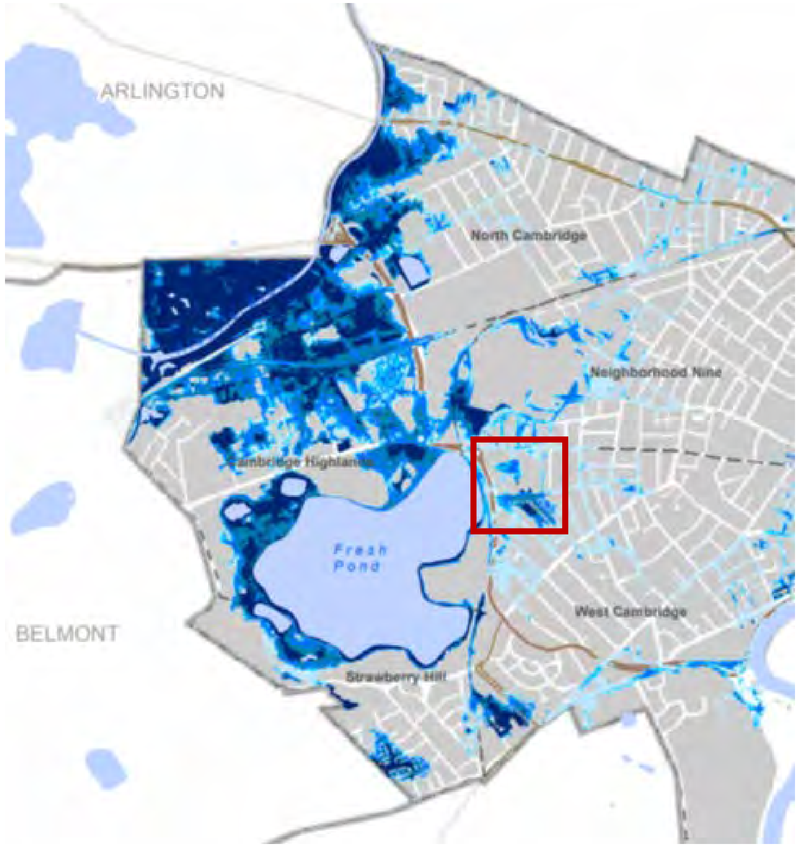
TOBIN SCHOOL, CAMBRIDGE, MA

WASTE PIT

STORMWATER

REGIONAL CONTEXT AND RESILIENCE



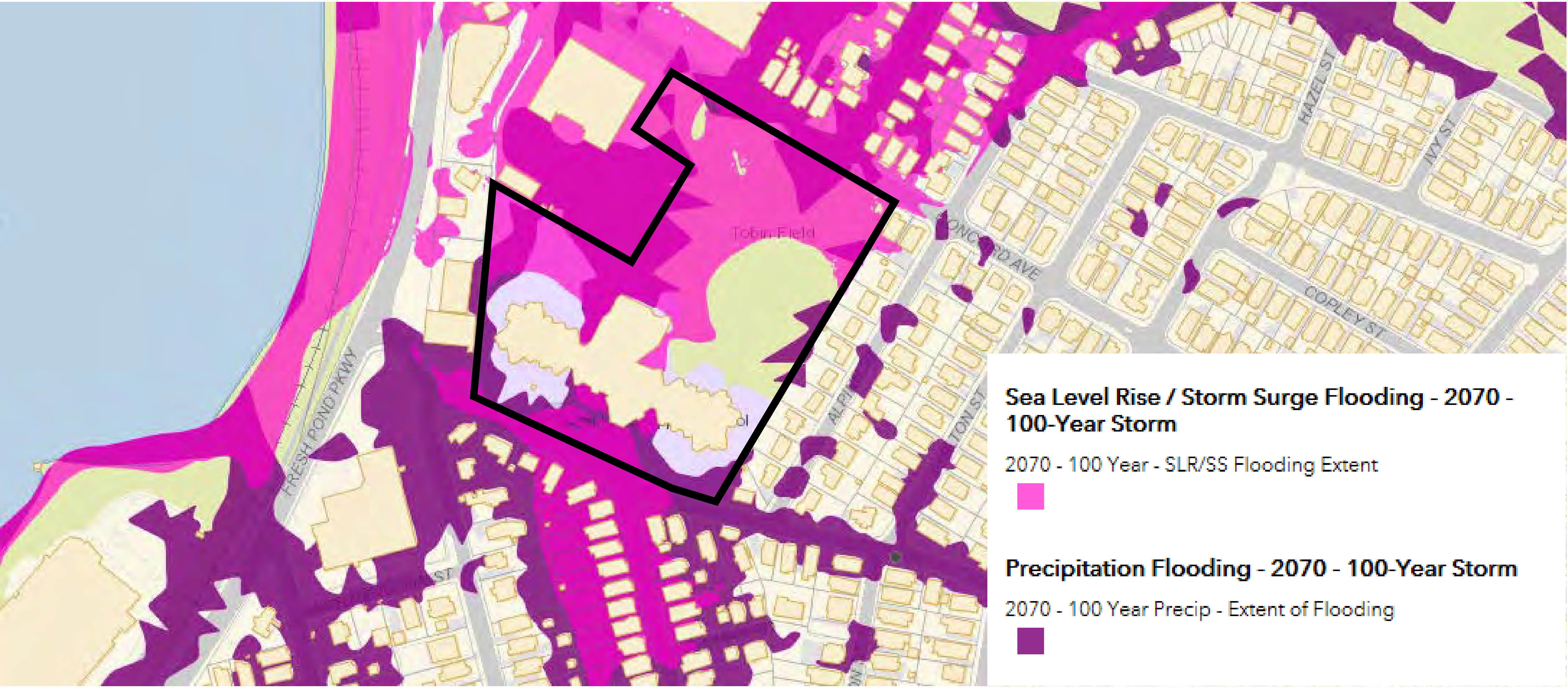


CURRENT 100-YEAR STORM

2070 100-YEAR STORM

STORMWATER

2070 100-YEAR STORM PRECIPITATION AND STORM SURGE



Sea Level Rise / Storm Surge Flooding - 2070 - 100-Year Storm

2070 - 100 Year - SLR/SS Flooding Extent

Precipitation Flooding - 2070 - 100-Year Storm

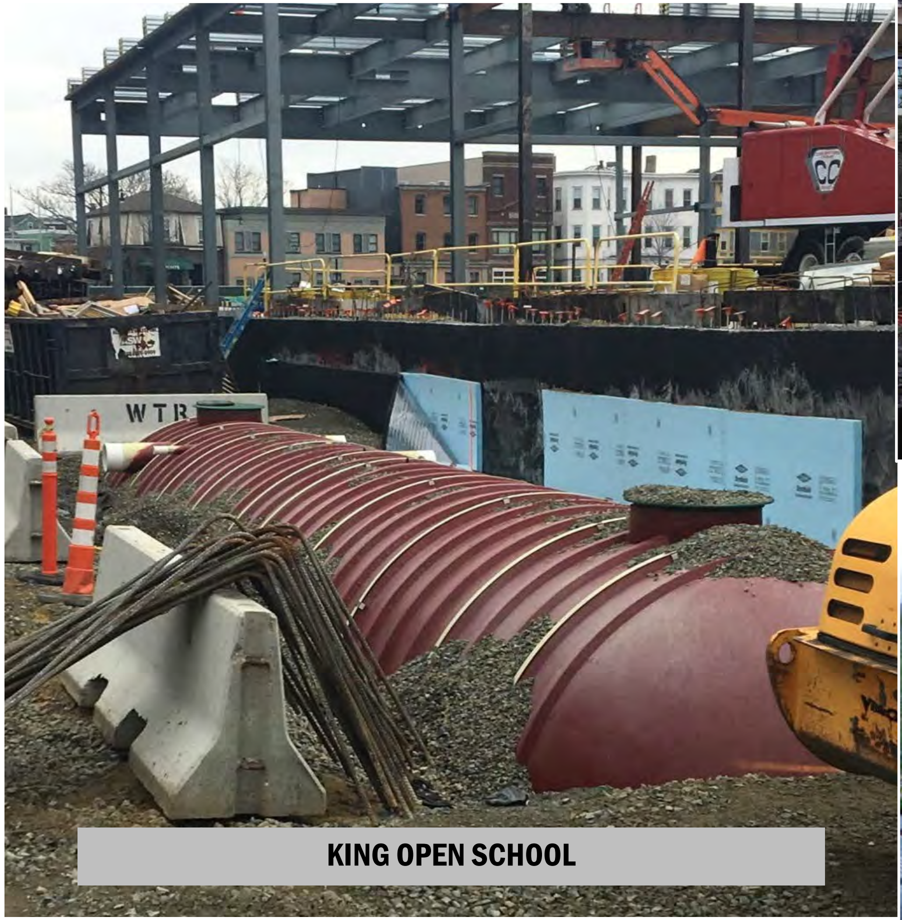
2070 - 100 Year Precip - Extent of Flooding

STORMWATER

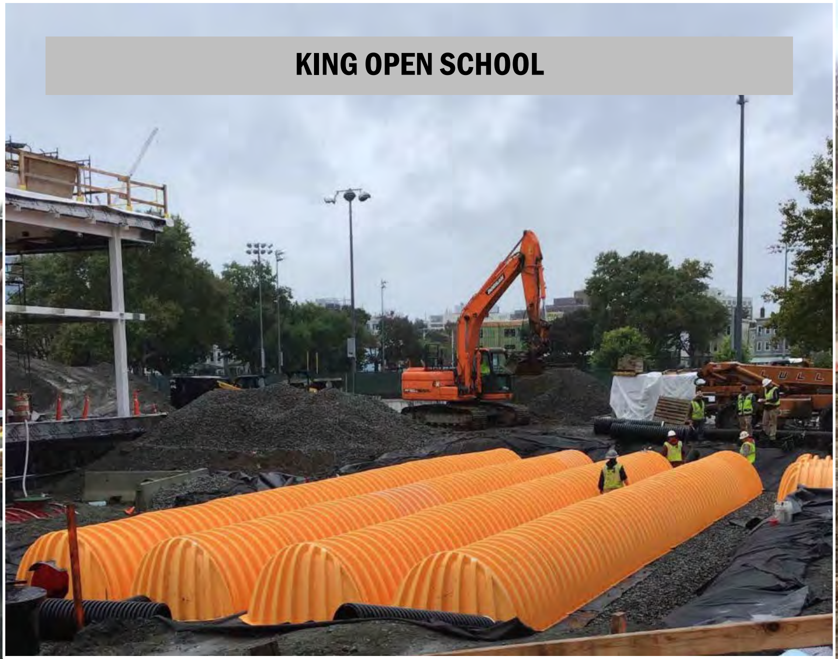
STORAGE AREA

STORMWATER

FLEXIBLE STRATEGIES TO OVERCOME URBAN CHALLENGES



KING OPEN SCHOOL



KING OPEN SCHOOL

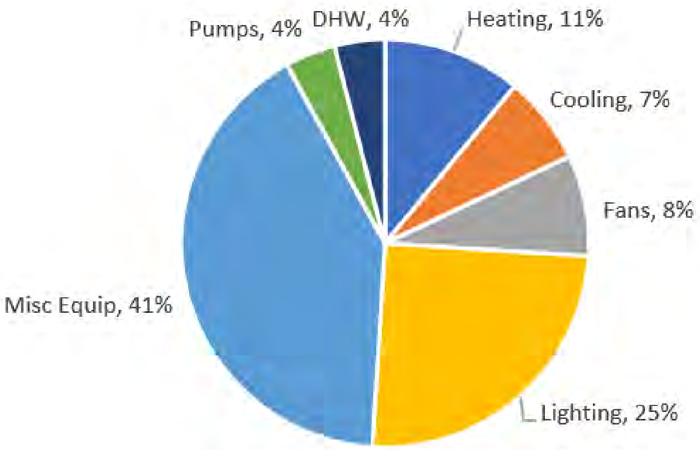
NORTH CORRIDOR, MIT

MLK SCHOOL

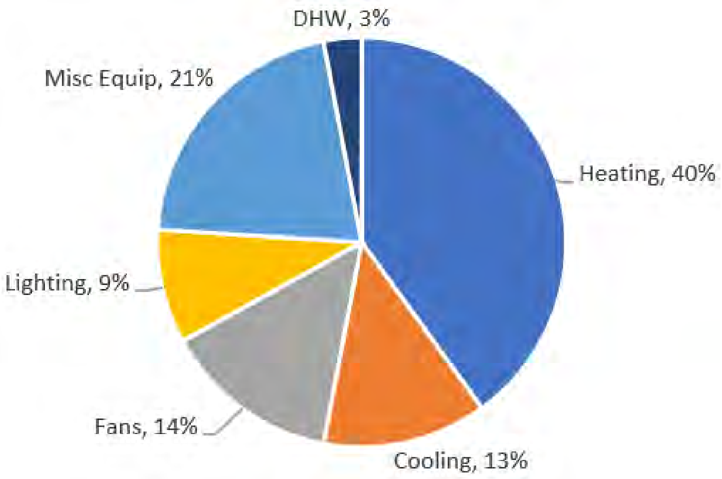
ENERGY + ENVELOPE

TARGETED DESIGN EFFORT

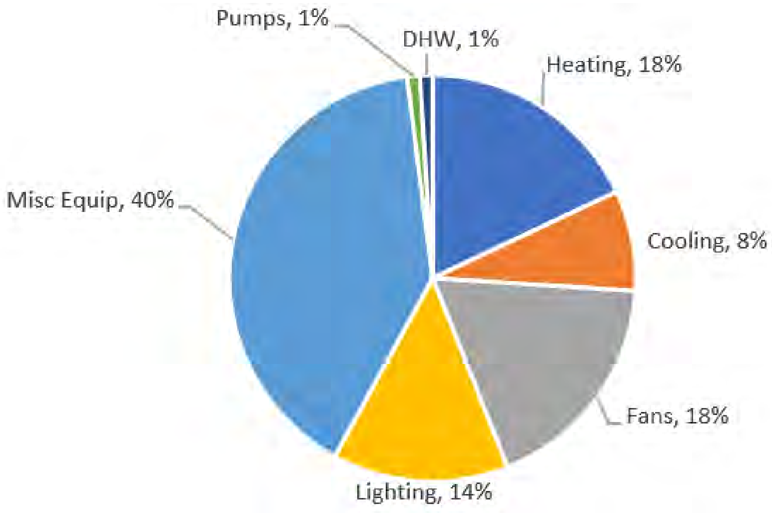
IN HONOR OF PI DAY



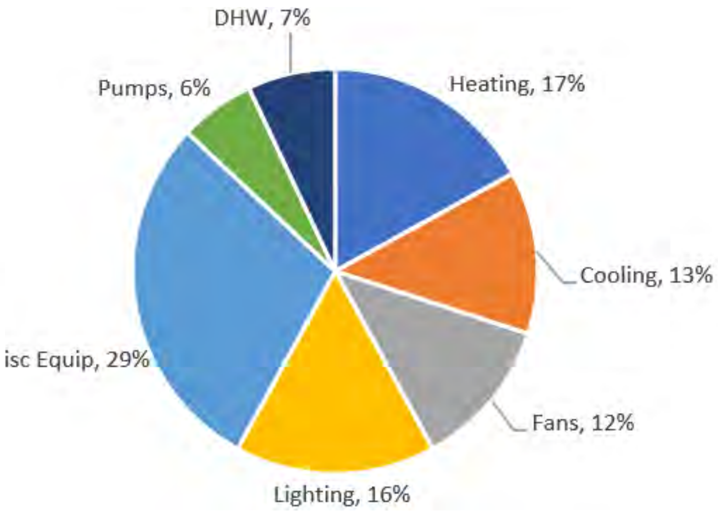
Classroom Building



Office Building

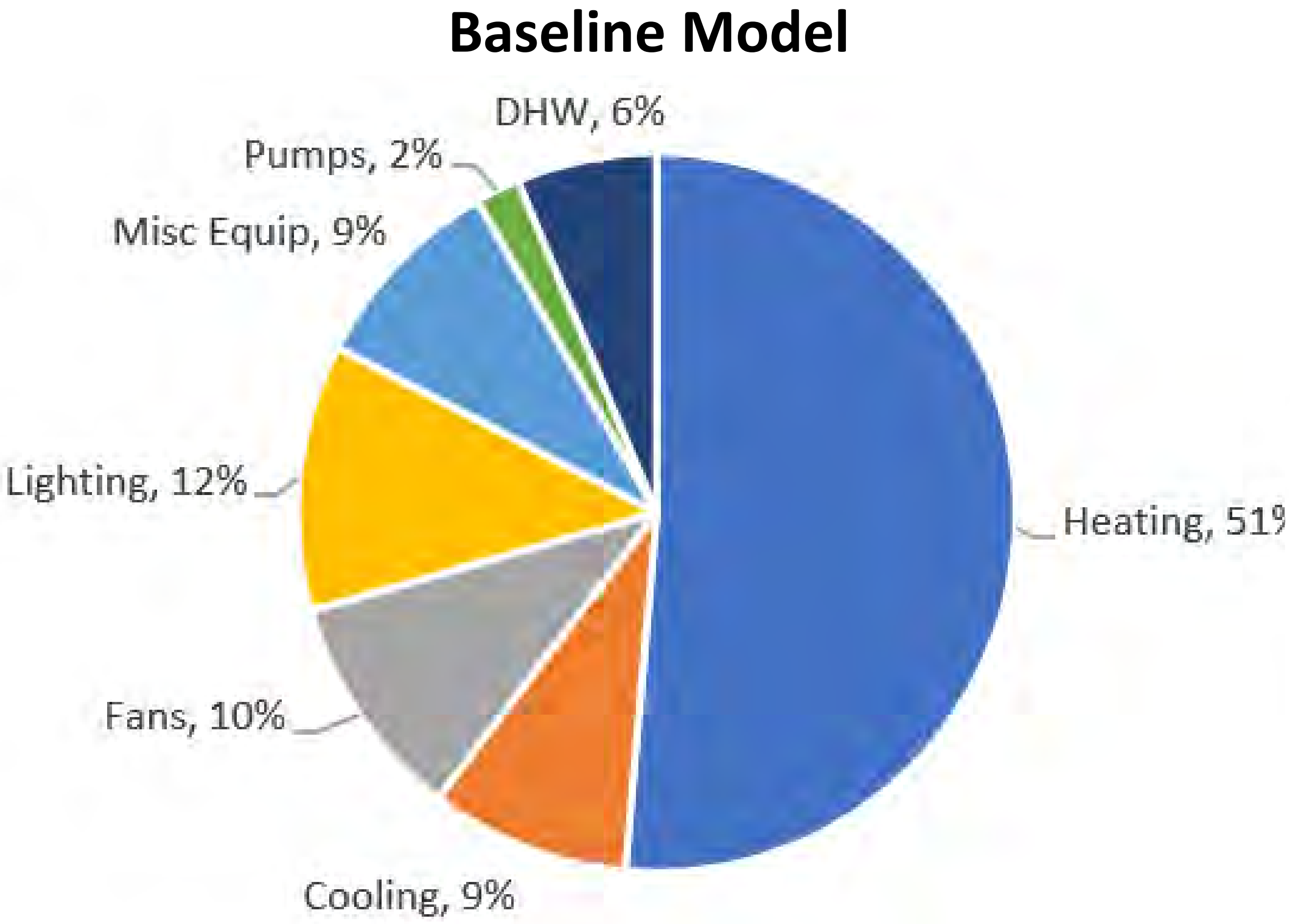


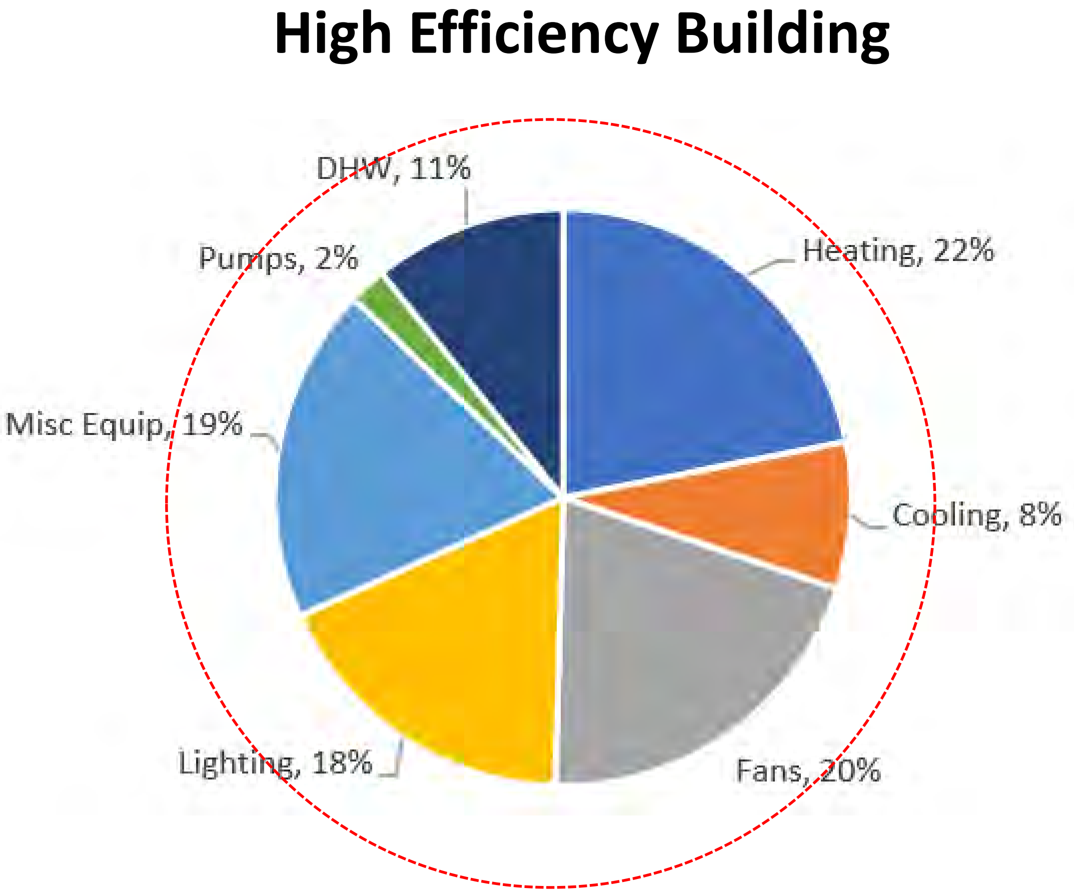
Lab



Multi-Family

TARGETED DESIGN EFFORT





PASSIVE STRATEGIES

WEST ELEMENTARY

Location: Washington, DC

Use: Elementary School

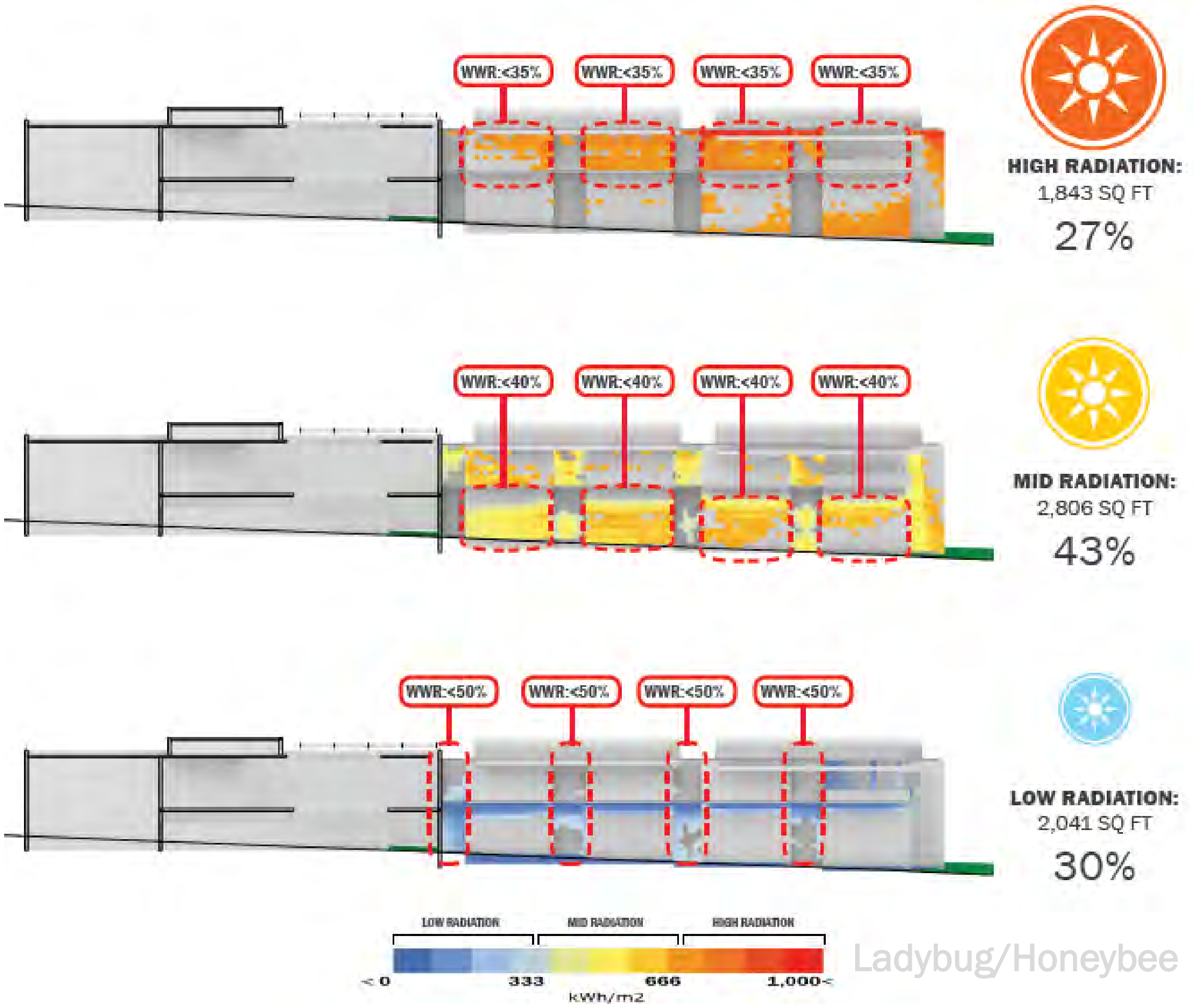
Square Footage: 90,000 sf

Floors: 2

STARTING FAÇADE DESIGN RIGHT

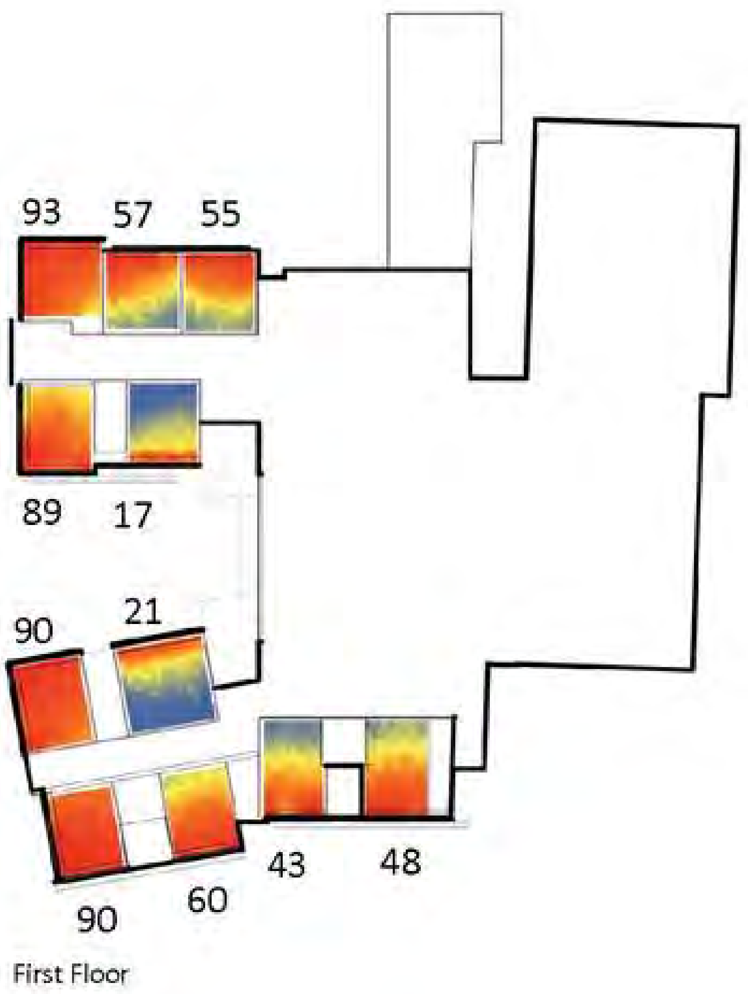
USE DATA TO INFORM WWR

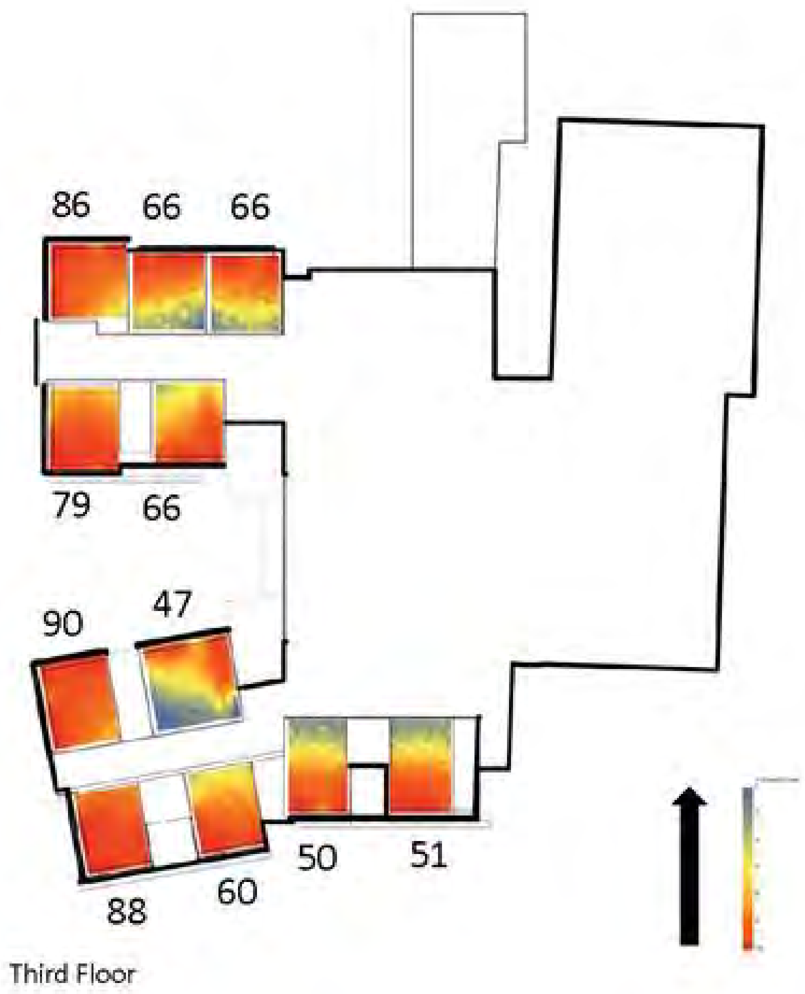
WINDOW TO
WALL RATIOS



STARTING FAÇADE DESIGN RIGHT

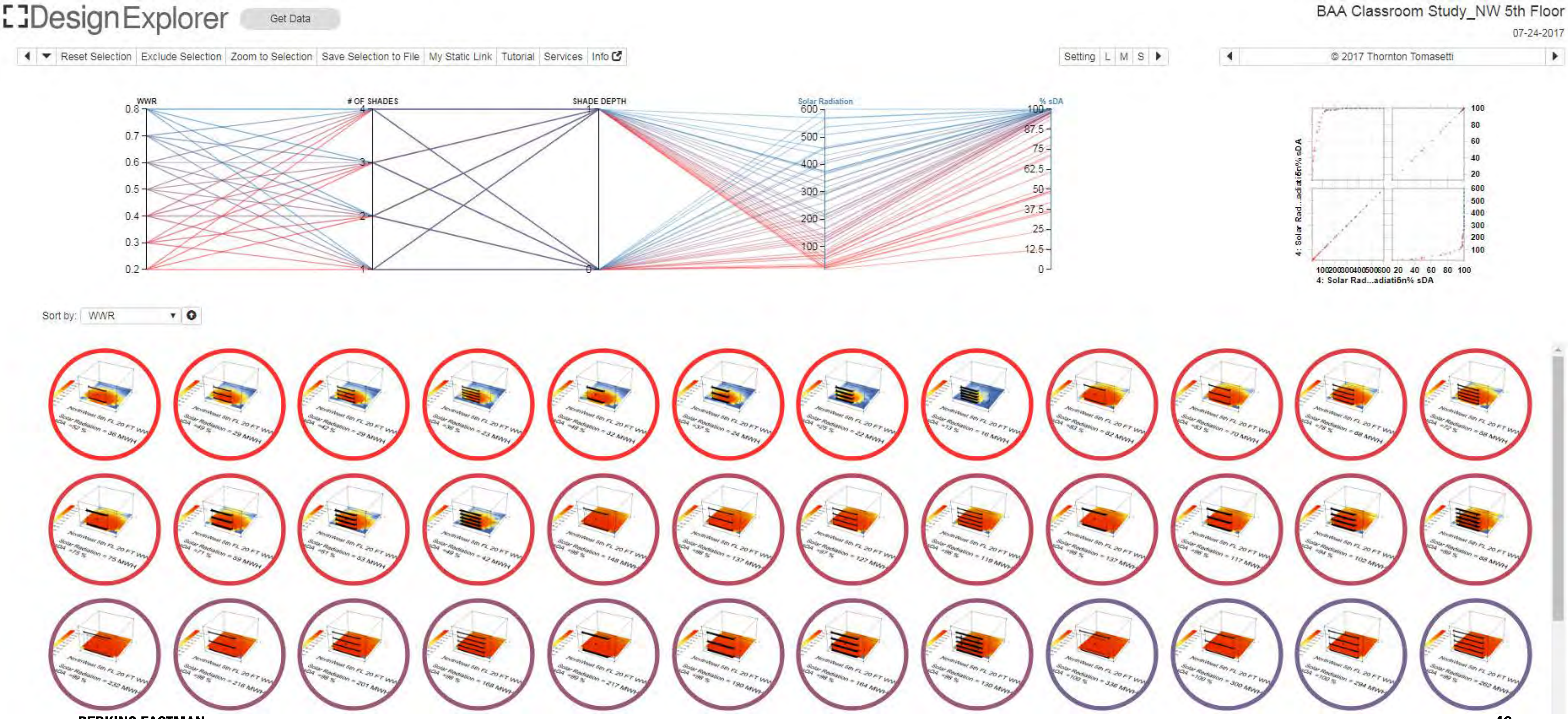
THEN ADD SHADING





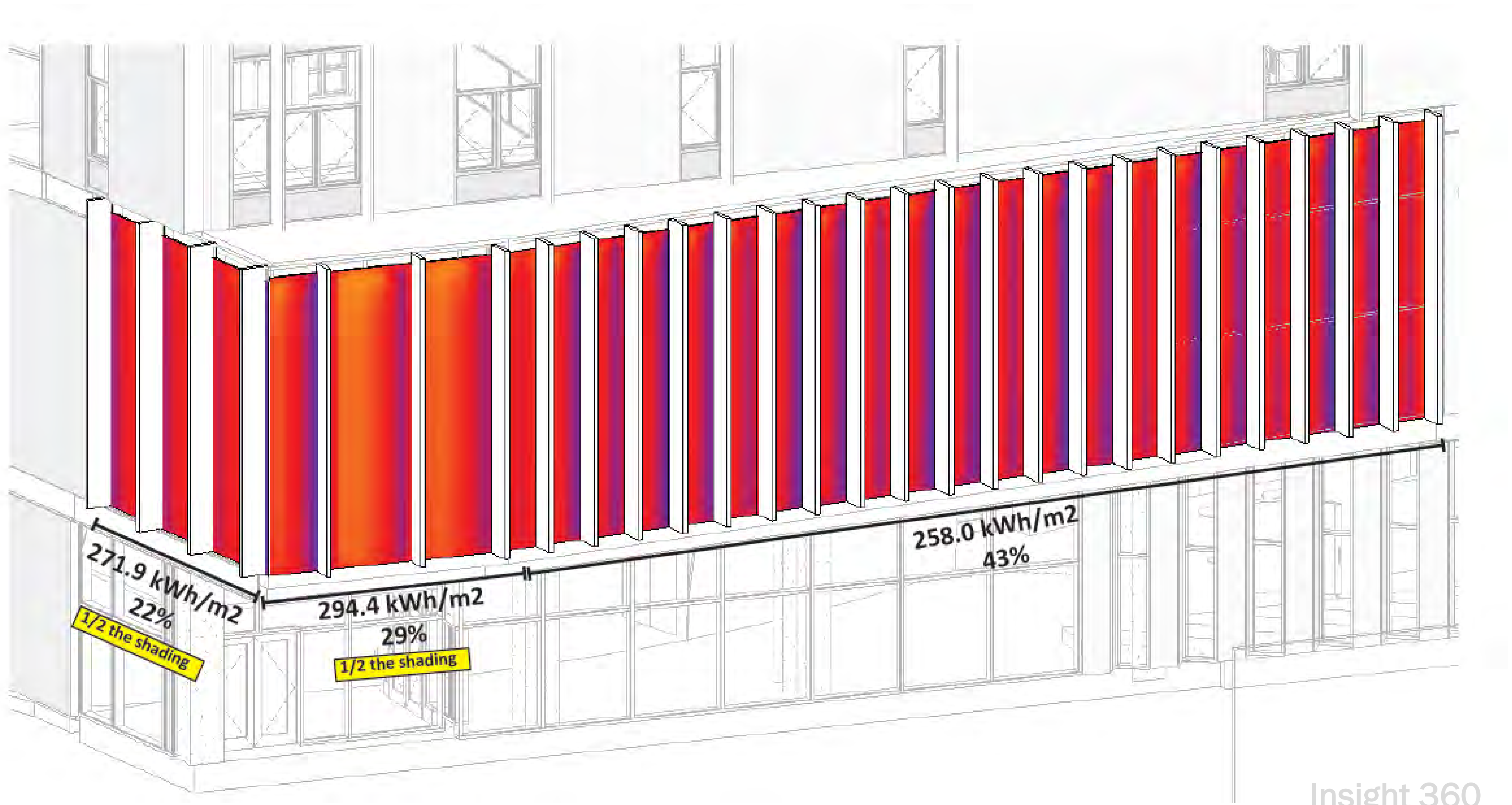
STARTING FAÇADE DESIGN RIGHT

THEN ADD SHADING



STARTING FAÇADE DESIGN RIGHT

BUT ONLY WHERE NECESSARY



BOSTON ARTS ACADEMY (BAA)

Location: Boston, MA

Use: High School – Arts

Number of Students: 500

Square Footage: 153,000 sf

Floors: 5

Boston Arts Academy
Perkins Eastman

PROVING THE IDEAL WALL

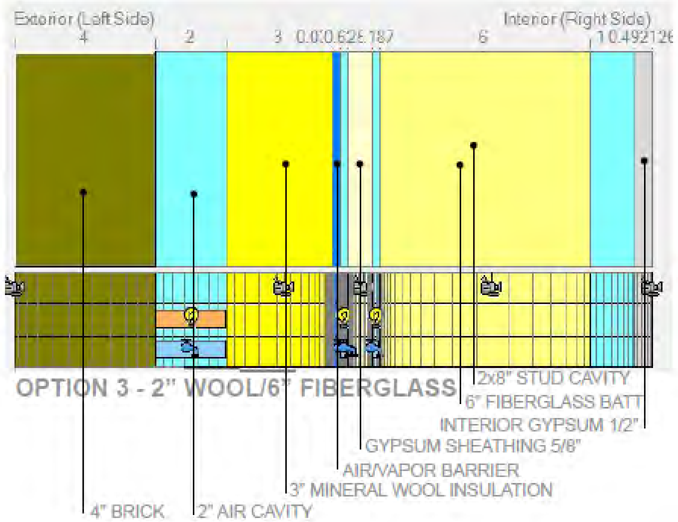
- Owner/OPM request VE to exterior wall type w/4” exterior insulation + cavity insulation in lieu of basis of design 6” exterior insulation
- WUFI/THERM analysis shows risk of water in cavity with VE wall

Run the analysis to prove BETTER PERFORMANCE & REDUCED RISK.

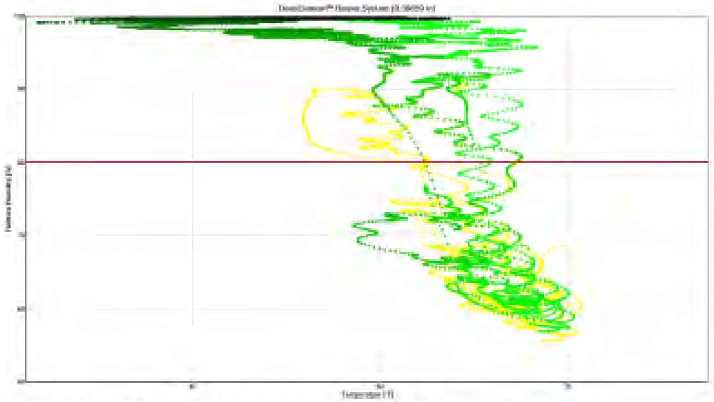
PROVING THE IDEAL WALL

USING HYGROTHERMAL ANALYSIS TO JUSTIFY EXTERIOR CONTINUOUS INSULATION

CURRENT STANDARD



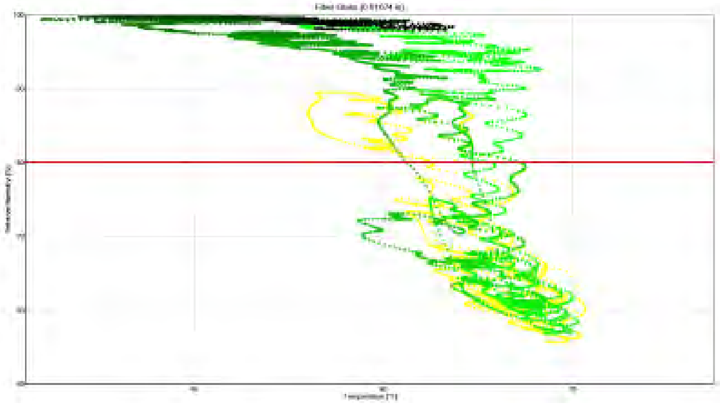
SHEATHING LAYER



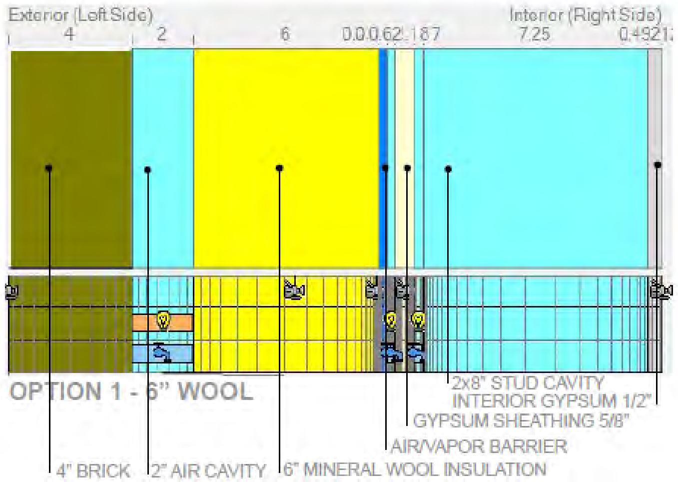
OPTION 3 - 2" WOOL/6" FIBERGLASS

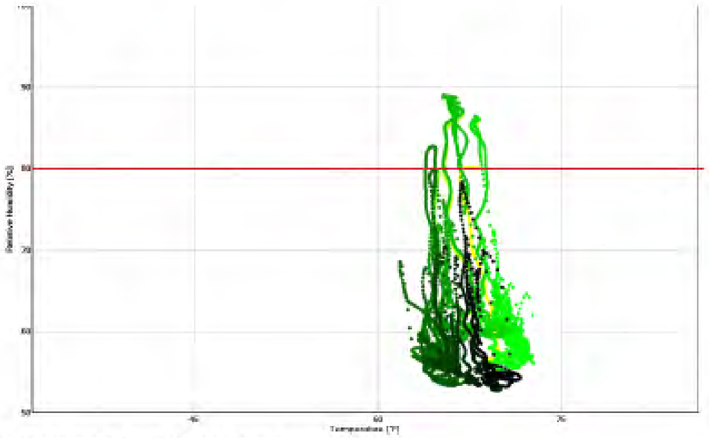
Option 3	Start	End	% red	Min	Max
Gypsum Sheathing	0.35	6.95	-1,886%	0.16	8.36

BATT INSUL LAYER



RECOMMENDED





OPTION 1 - 6" WOOL

Option 1	Start	End	% red	Min	Max
Gypsum Sheathing	0.35	0.21	40%	0.15	2.11

WUFI

YARDS PARCEL I

Location: Washington, DC

Use: Multi-Family

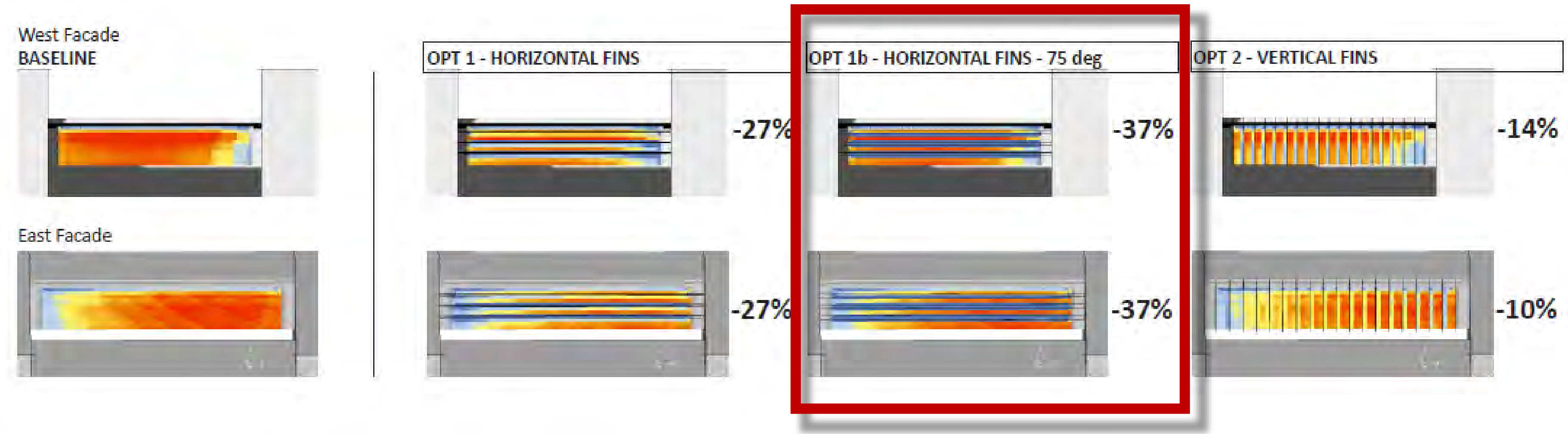
Square Footage: 517,000 sf

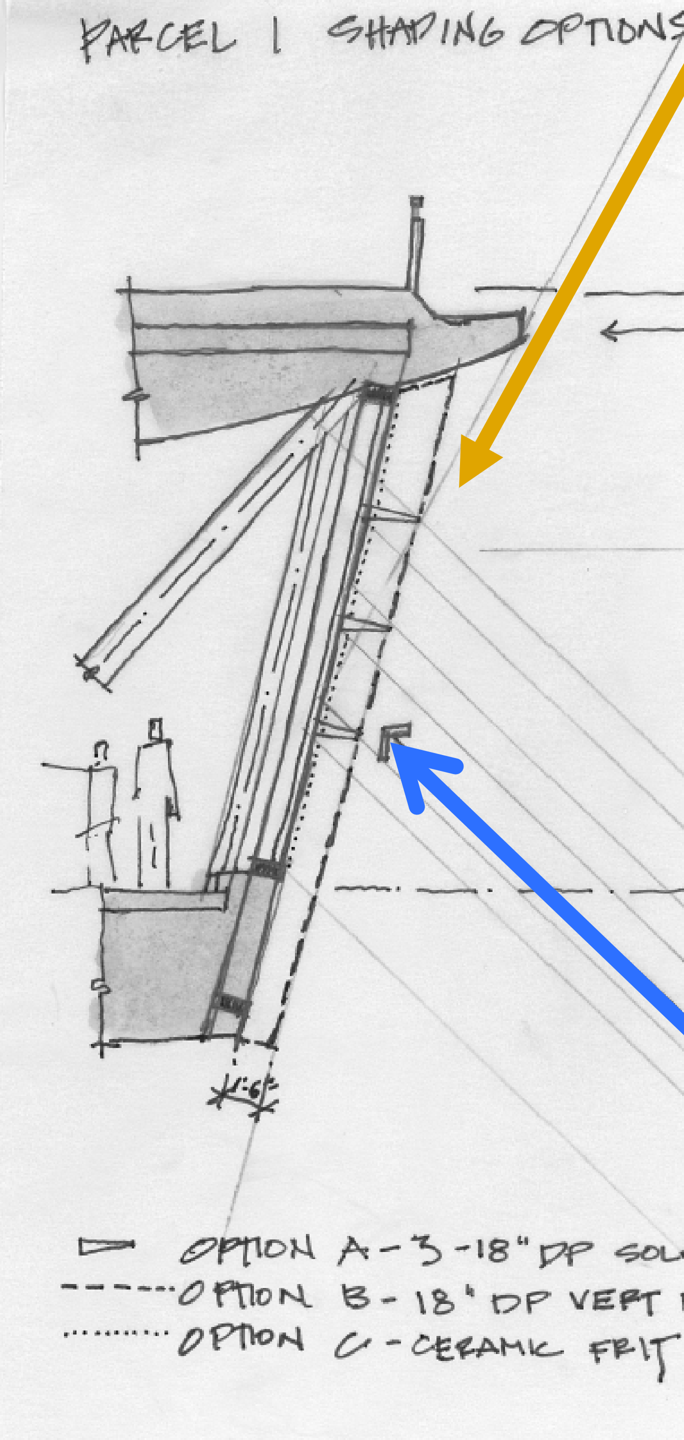
Floors: 11

DON'T LISTEN TO RULES OF THUMB

HORIZONTALS MAY WORK BETTER ON EAST/WEST

*** 37% Less Heat Gain**





ACTIVE STRATEGIES

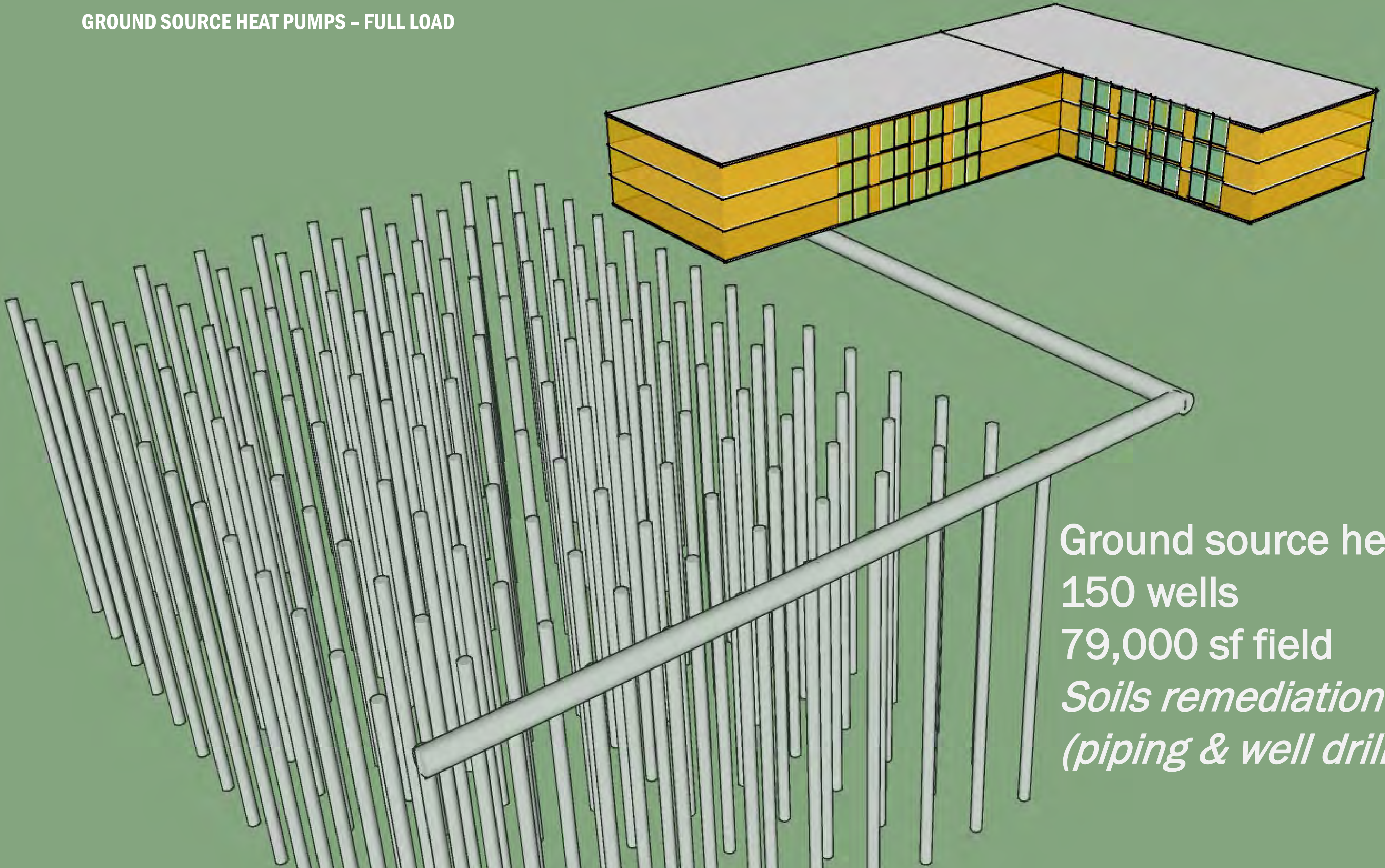
ALTERNATIVE "FACTS" ABOUT GROUND SOURCE HEAT PUMPS

ALTERNATIVE “FACTS” ABOUT GROUND SOURCE HEAT PUMPS

- They are renewable energy
- They require a lot of maintenance
- You can’t use them if you have a high water table
- The payback is 100 years
- They make your building sustainable

SYSTEM COMPARISON

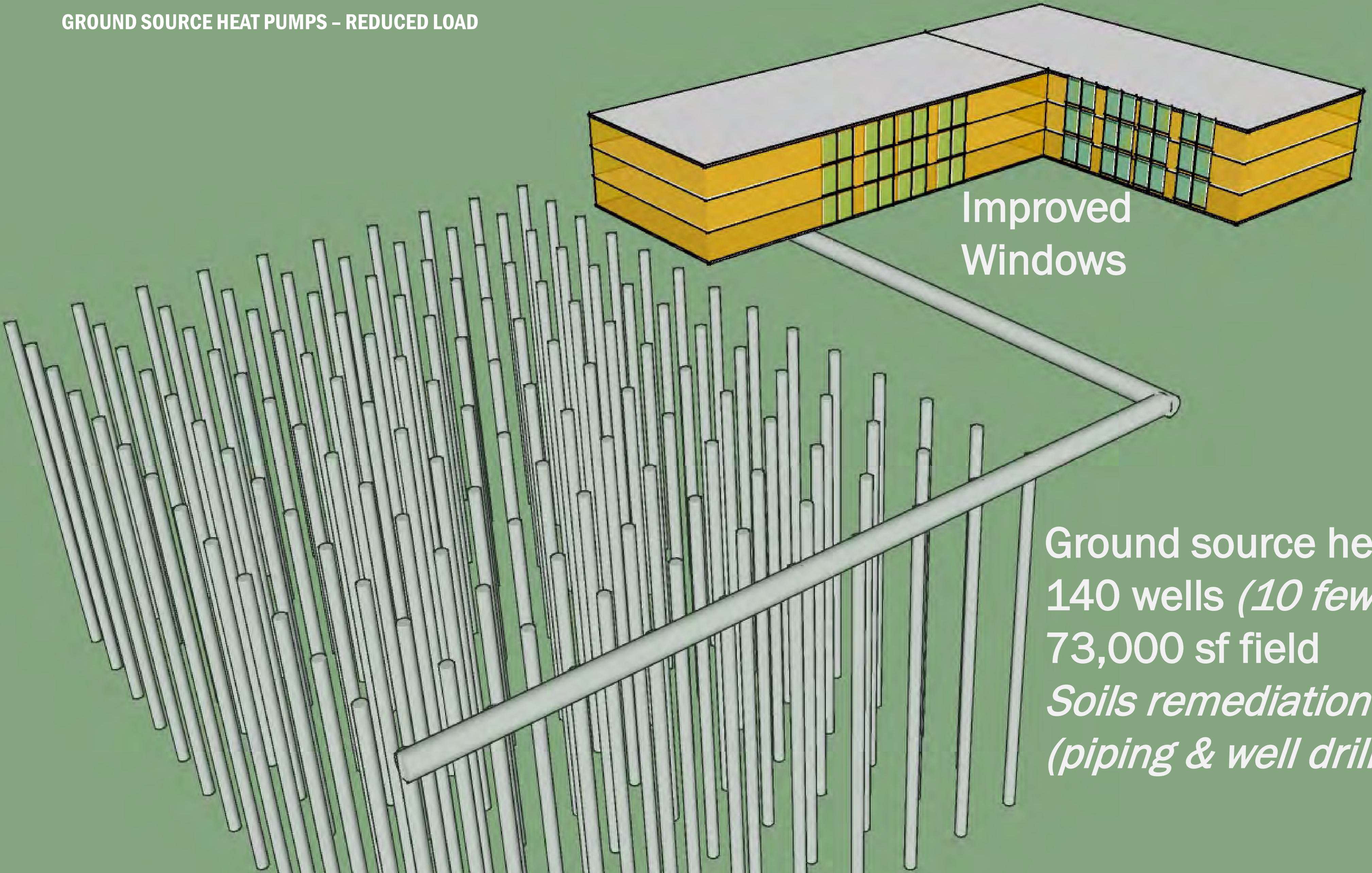
GROUND SOURCE HEAT PUMPS – FULL LOAD



Ground source heat pump
150 wells
79,000 sf field
Soils remediation
(piping & well drilling)

SYSTEM COMPARISON

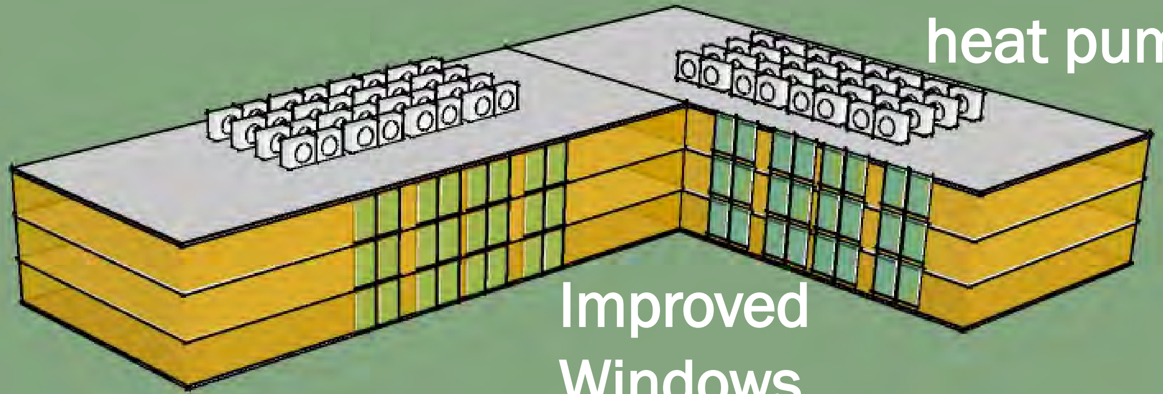
GROUND SOURCE HEAT PUMPS – REDUCED LOAD



Ground source heat pump
140 wells *(10 fewer)*
73,000 sf field
Soils remediation
(piping & well drilling)

SYSTEM COMPARISON

25% GROUND + 75% AIR SOURCE HEAT PUMPS



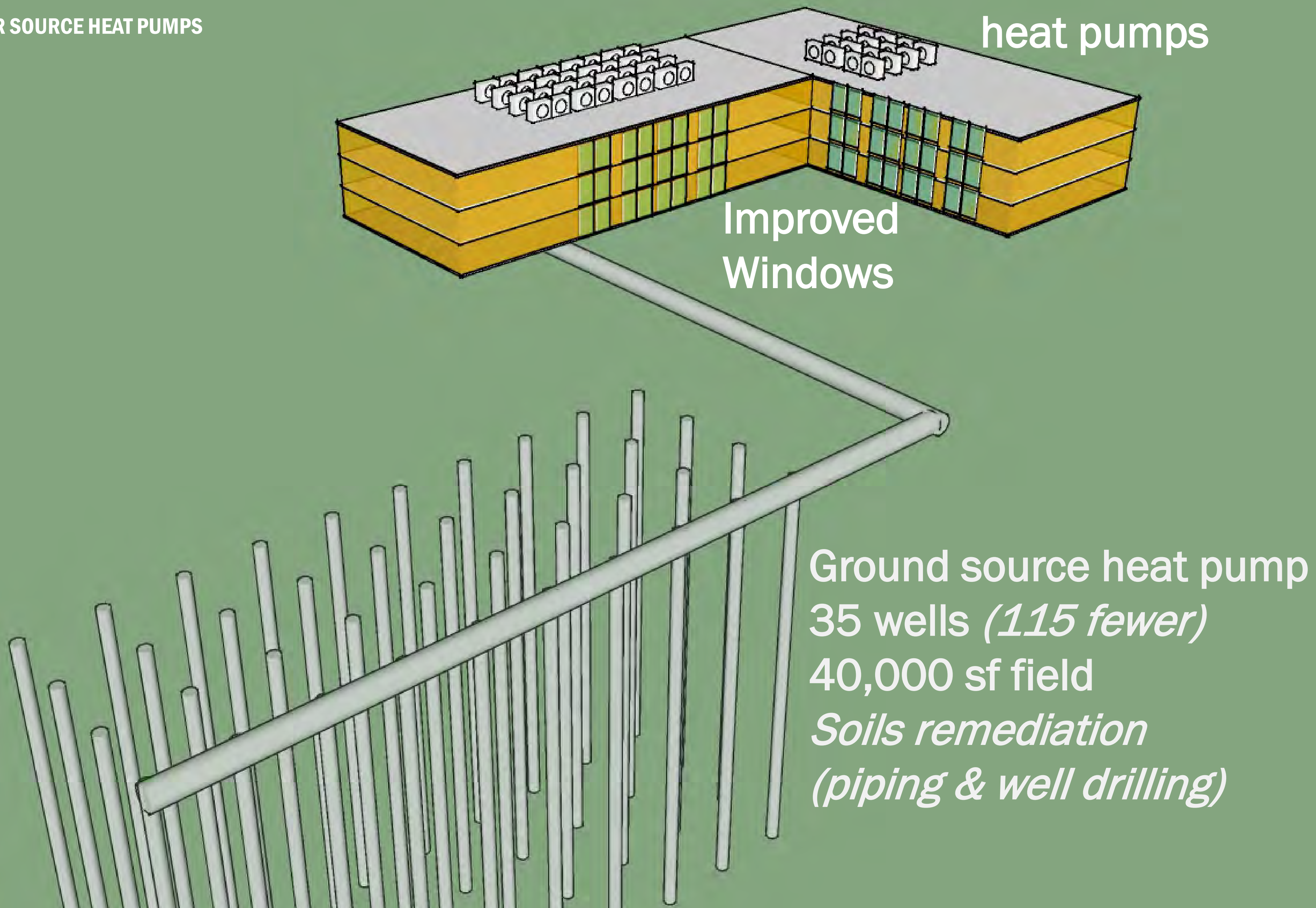
Air source heat pumps

Improved Windows

No Ground source heat pump
0 wells

SYSTEM COMPARISON

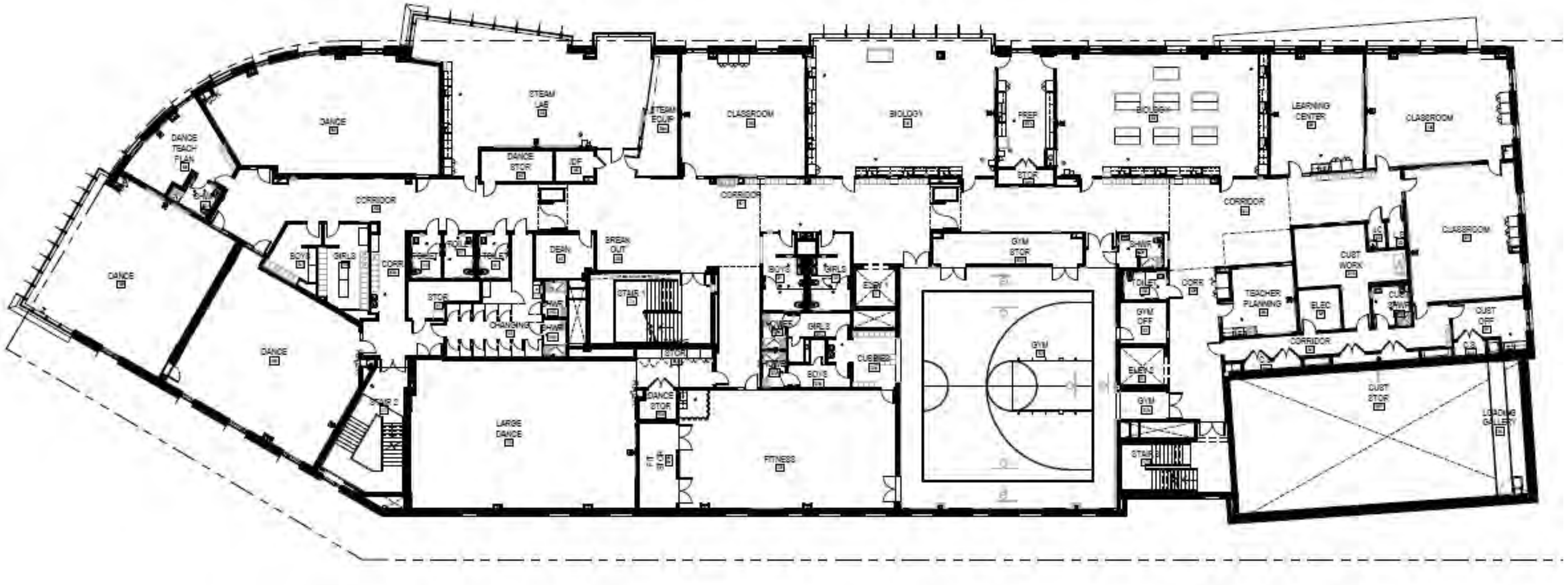
25% GROUND + 75% AIR SOURCE HEAT PUMPS



SYSTEM SELECTION PROCESS

System Options			Thermal Comfort	Acoustics	Fast Response	Air Quality (Ventilation)	Low Transport Energy	Low Heating & Cooling Energy	Low 1st Cost	Low Life-Cycle Cost	Reliability	Maintainability	Life Expectancy	Ease of Commissioning	Redundancy	Simplicity	Controllability	Floor to Floor Limitations	Floor Area Needed, esp @ 1st Fl	Rating Averaged by Category		Weighted Rating	
			Indoor Environment 15%				Energy 15%		Cost 25%		Operations 30%							Bldg Impact 15%					
OPTION 1: Water-cooled Chillers, Condensing Boilers																							
1 (62.1vent)	Central Heating / Cooling Equipment	Water-cooled Chillers Heat Recovery Chiller Condensing Boilers	3	2	3	2	1	1	2	2	2	2	3	2	2	2	3	3	1	1.96	3	2.01	3
	Ventilation System [Note 1]	CHW and HW coils																					
	Classroom/Dance zone equipment	FCU's plus Displacement Ventilation [Note 3]																					
	Lab zone equipment [Note 2]	Ceiling mounted FCU's																					
1a (550 ppm)	Central Heating / Cooling Equipment	Water-cooled Chillers Heat Recovery Chiller Condensing Boilers	3	3	3	3	0	0	2	1	3	3	3	3	2	3	3	1	1	1.67	5	1.83	4
	Ventilation System [Note 1]	CHW and HW coils																					
	Classroom/Dance zone equipment	All air displacement ventilation [Note 3] with reheat																					
	Lab zone equipment [Note 2]	All air, mixed system																					
OPTION 2: Air-source Heat Pumps, Dx/Gas Ventilation																							
2 (62.1vent)	Central Heating / Cooling Equipment	Air-source Heat Pumps with VRF units	3	2	2	2	2	2	3	2	1	1	2	2	3	2	1	1	3	2.09	2	2.08	1
	Ventilation System Note 1	DX cooling coil + gas or VRF preheat																					
	Classroom/Dance zone equipment	Ceiling mounted VRF units with mixed air																					
	Lab zone equipment [Note 2]	Ceiling mounted VRF units with mixed air																					
OPTION 3: Ground-source Heat Pumps + DX/Gas Ventilation																							
3 (62.1vent)	Central Heating / Cooling Equipment	Water-source Heat Pumps with VRF units Vertical closed-loop geothermal wells	3	2	3	2	2	3	1	1	2	2	2	2	3	2	2	3	2	2.13	1	2.02	2
	Ventilation System Note 1	Water-source DX cooling coil + gas preheat																					
	Classroom/Dance zone equipment	Ceiling mounted watersource VRF units with mixed air																					
	Lab zone equipment [Note 2]	Ceiling mounted watersource VRF units with mixed air																					
OPTION 4: Ground-source Heat Pumps + CHW/HW Ventilation																							
4 (62.1vent)	Central Heating / Cooling Equipment	Ground source Chiller-Heater Plant (Vertical closed-loop geothermal wells)	3	2	3	2	2	2	0	1	1	1	3	2	2	1	2	3	1	1.74	4	1.61	5
	Ventilation System [Note 1]	CHW and HW coils																					
	Classroom/Dance zone equipment	Floor mounted FCU's with displacement ventilation [Note 3]																					
	Lab zone equipment [Note 2]	Ceiling mounted fan coil units with mixed air																					
4a (550 ppm)	Central Heating / Cooling Equipment	Ground source Chiller-Heater Plant (Vertical closed-loop geothermal wells)	3	3	3	3	0	1	0	1	1	2	3	2	2	1	2	1	1	1.37	6	1.36	6
	Ventilation System [Note 1]	CHW and HW coils																					
	Classroom/Dance zone equipment	All air displacement ventilation [Note 3]																					
	Lab zone equipment [Note 2]	All air, mixed system																					

EXTERIOR ENVELOPE VS HVAC SIZING/COST



- Engineer Proposes Perimeter Heat
- Triple-glazed windows reduces hours of potential “discomfort” to 18 hours/year within 5’ of windows w/o perimeter heat
- High-performance envelope reduces # of Air-Source Heat Pumps

BENCHMARK

	MSBA	BAA
Ext.	14.01%	15.24%
HVAC	14.37%	10.77%
Total	28.38%	26.01%

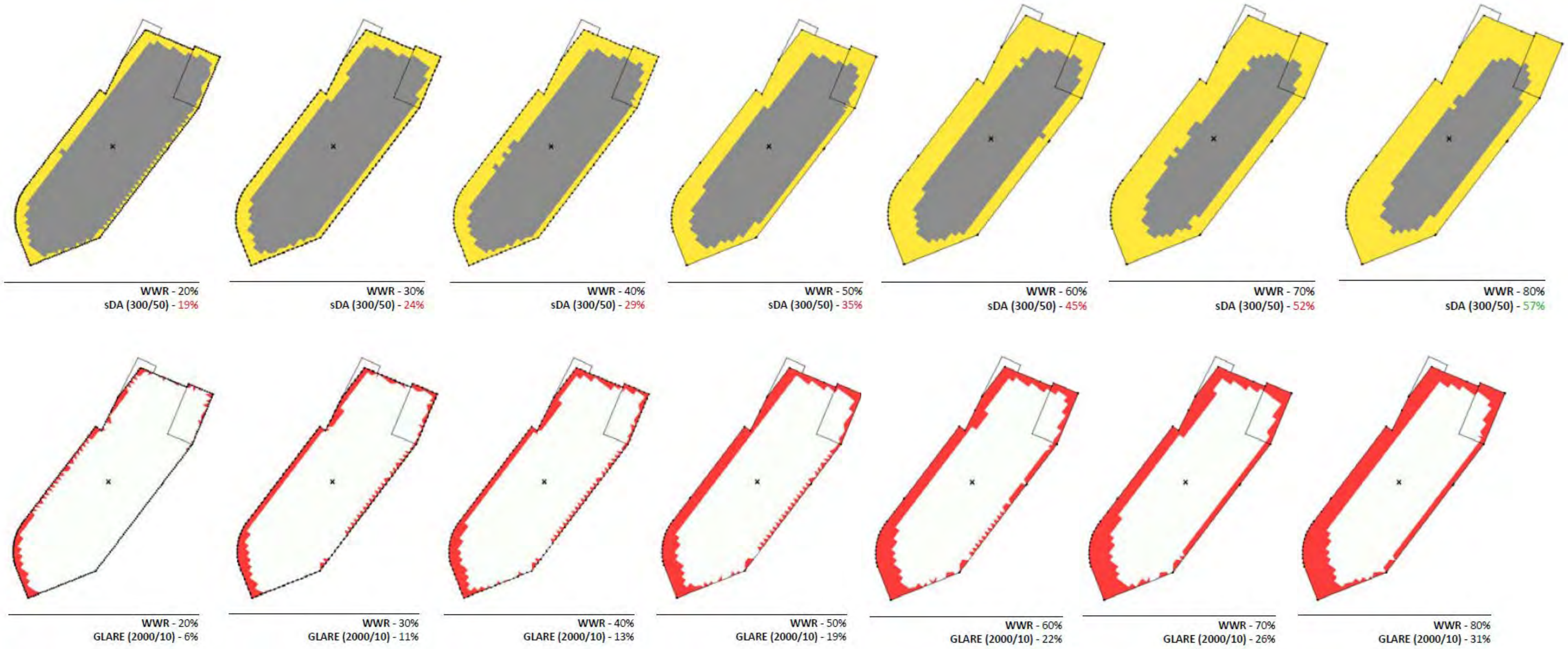
RESULTS

- Savings in HVAC balances cost in exterior envelope
- Reduced HVAC Equipment = Reduced Maintenance
- Invest in items that last (50 yr vs 20 yr)
- Passive Survivability

INDOOR ENVIRONMENT

PREDICTIVE ANALYSIS

DAYLIGHT/WWR TARGETS SET PER ROOM



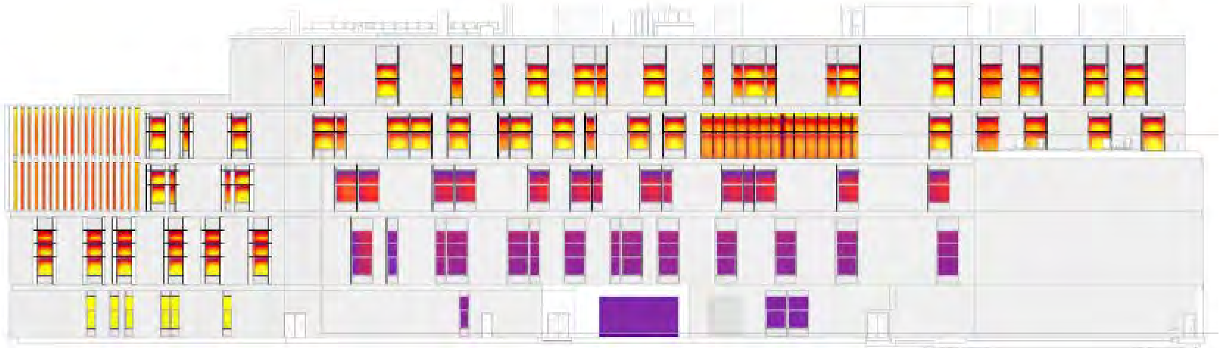
Ladybug/Honeybee

PREDICTIVE ANALYSIS

TRACKING FAÇADE DESIGN AS IT PROGRESSES

SOUTHEAST - Current Design

SOUTHEAST - Improvement 1



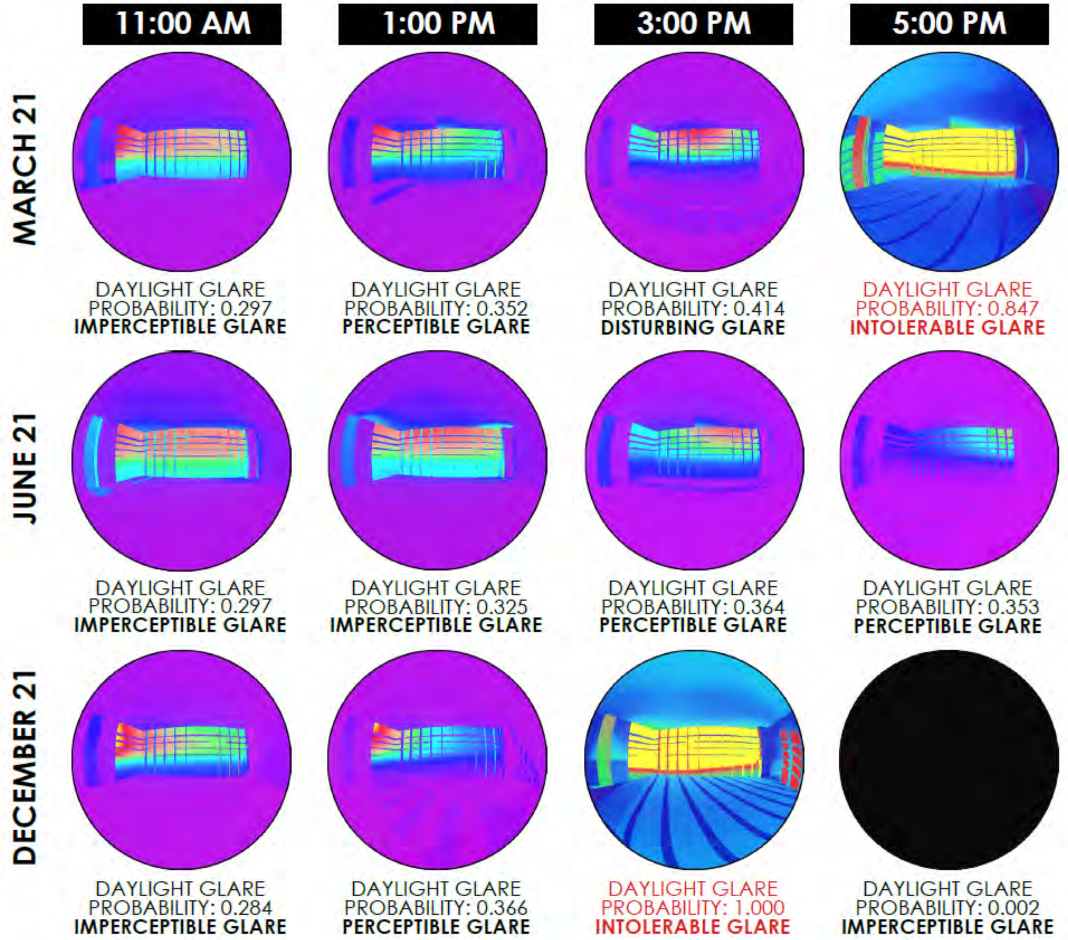
SOUTHEAST - Improvement 2

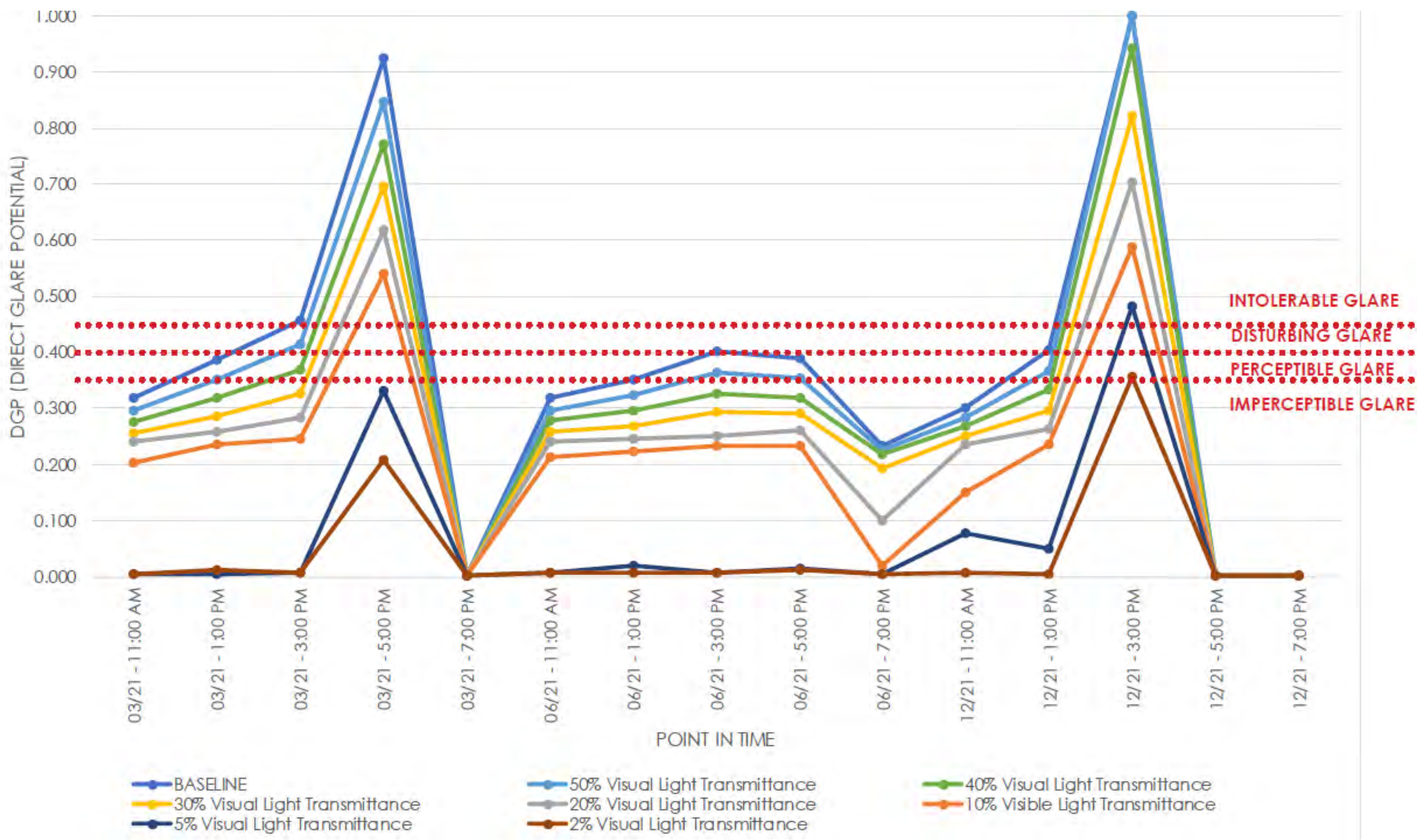
5th Floor	Window to Wall Ratio (actual)	Window to Wall Ratio (target)	Over/Under	Linear Feet of Window needed	Shading Needed
Band/Recital Hall	0.40	0.3	0.10	-13.5	Y
Recording Studio	0.19	0.3	-0.11	6.3	N
MIDI Lab	0.30	0.3	0.00	1.0	N
Music Teach Plan	0.80	0.2	0.60	-11.8	Y
Classroom 1	0.53	0.3	0.23	-7.8	Y
Classroom 2	0.26	0.4	-0.14	7.5	N
Classroom 3	0.26	0.4	-0.14	7.5	N
Project Classroom	0.41	0.3	0.11	-8.2	Y
Small Group	0.80	0.3	0.50	-9.0	N
Classroom 4	0.19	0.3	-0.11	12.1	Y
Classroom 5	0.26	0.5	-0.24	12.1	Y
Corridor	0.13	0.2	-0.07	2.6	N
Stairwell	0.08	0	0.08	-5.0	N
Choral	0.34	0.3	0.04	-1.5	Y
M Practice	0.15	0.2	-0.05	2.0	Y
Small Ensemble	0.20	0.3	-0.11	4.2	Y
Percussion	0.31	0.3	0.01	0.8	Y
Piano Lab	0.27	0.3	-0.03	2.2	Y
L Practice	0.14	0.2	-0.06	2.3	Y
Large Ensemble	0.23	0.2	0.03	-1.5	Y

Insight 360

PREDICTIVE ANALYSIS

VERIFYING INTERIOR CONDITIONS

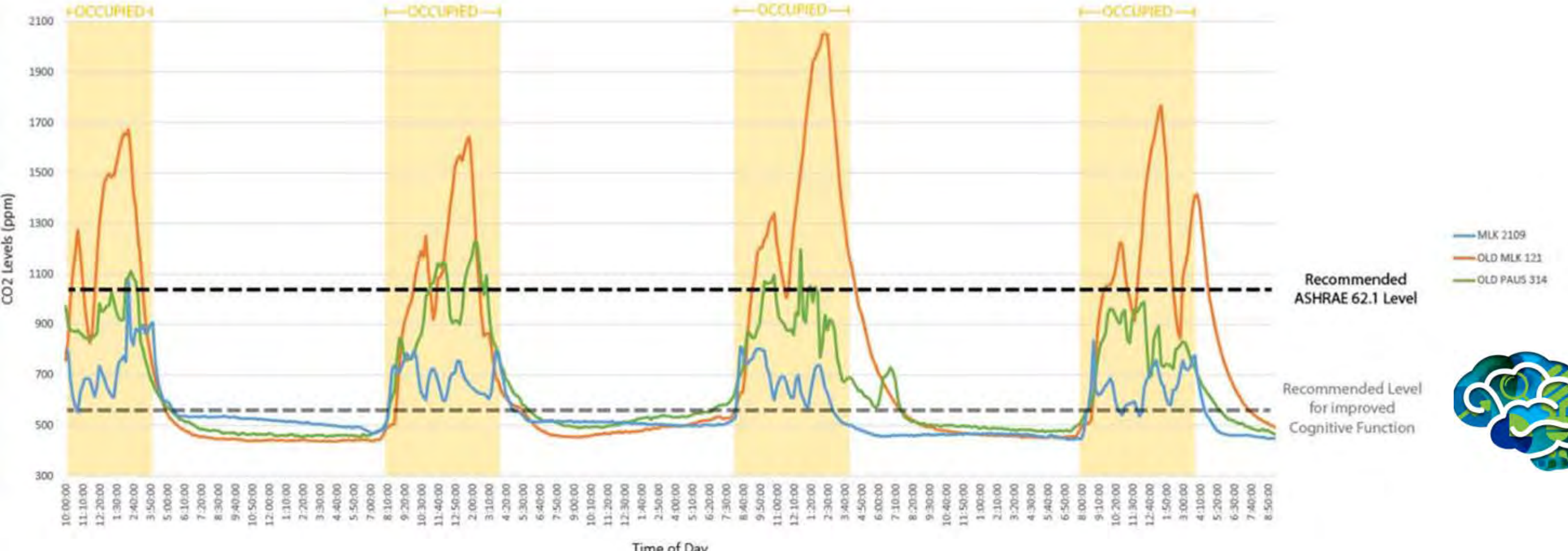




Ladybug/Honeybee

POST-OCCUPANCY EVALUATIONS

CO2 LEVELS

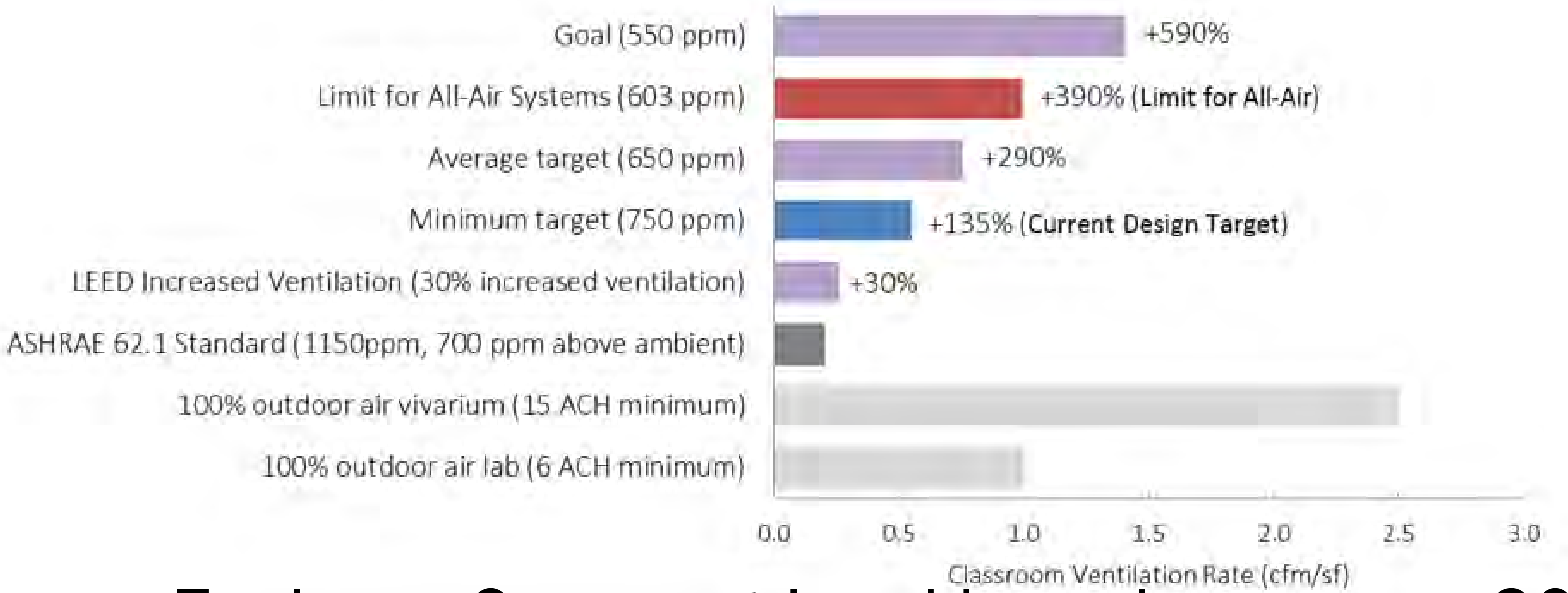


THE IMPACT OF GREEN BUILDINGS ON
COGNITIVE FUNCTION

City of Cambridge, MLK School
Perkins Eastman

QUESTIONING CALCULATIONS

AIR QUALITY (BAA CO2 CONVERSATIONS)



ASSUMPTIONS

Classroom occupancy: 22 people

Classroom size: 900 square feet, 10 feet floor to ceiling height

Ventilation Effectiveness: 1.2 (displacement ventilation)

Ambient CO2 Concentration: 450 ppm

Occupant metabolic rate: 1.0 (seated, quiet)

ASHRAE 62.1 Minimum ventilation: 7.5 cfm/p + 0.06 cfm/sf

- Engineer Occupant Load based on area = 3000 occupants
- Actual Occupancy: 640 Students, 150 Staff = 790 Occupants
- 6 AHU to 3

- What is your design load for Code?
- What is your design load for 550 ppm in Classrooms?

POST-OCCUPANCY EVALUATIONS

ACOUSTICS

All schools tested designed to LEED acoustics prerequisite

Average	Peak	Satisfaction Rate
52 dBA	>80 dBA	30%

WHERE TO NEXT?

THANK YOU

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Jana Silsby j.silsby@perkinseastman.com