BROOKLINE HIGH SCHOOL EXPANSION

SCHEMATIC DESIGN SUSTAINABILITY OVERVIEW APPENDIX
APRIL 3, 2018

TABLE OF CONTENTS

CYPRESS BUILDING LEED SCORECARD

LEED v4 for Schools Project Scorecard

Project: BHS Cypress Building
Address: Cypress St, Brington Rd, Tappan St
Date: March 30, 2018

LEED Goal	LEED Silver
Bldg Area	118,000 gsf
Parking	no new parking aside from HC spaces, street parking permits
Site Area	56,670 sf (per WRA 3.21.18 dwg)
Staff	45
Students	700
Visitors	20

POINT TOTALS

Phase	Yes	M +	M -	No
	49	6	32	23

Notes from 03.20.18 meeting.
Credit not applicable or not pursued

Phase										
					GENERAL PROJECT DOCUMENTATION				Responsible	03.20.18 Meeting Notes
D	Y				PIf1		Minimum Program Requirements	Req'd	Team	
	Yes	M +	M -	No						
	0	0	1	0	INTEGRATIVE PROCESS			1	Responsible	03.20.18 Meeting Notes
D			1		IPc1		Integrative Process	1	Team	Credit Reqs: Perform energy and water-use analysis in early design through the use of a "simple box" model and development of a water budget, respectively. Team to review worksheet and determine which additional measures need to be analyzed to meet credit requirements.
	Yes	M +	M -	No						
	6	0	2	7	LOCATION & TRANSPORTATION			15	Responsible	03.20.18 Meeting Notes
D				N	LTc1		LEED for Neighborhood Development Location	15	Team	
D	1				LTc2		Sensitive Land Protection	1	Civil	Credit Reqs: Locate the development footprint on land that has been previously developed. Located on a previously developed site.
D	1			1	LTc3		High Priority Site	1-2	Env. Eng.	Credit Reqs: Locate on a brownfield where soil or groundwater contamination has been identified, and where the local, state, or national authority (whichever has jurisdiction) requires its remediation. 3.30.18 Moved 1 point to 'No'. Report from GZA indicates soil + groundwater analysis did not exceed allowable limits and therefore remediation was not required. Project is located in a Difficult Development Area (DDA) and will qualify for 1 pt.
D	1			4	LTc4		Surrounding Density and Diverse Uses	1-5	TGE	Credit Reqs: Avg. surrounding density >22,000 sf (2pts) or >35,000 (4pts) and/or within 1/2 mile walking distance of at least 8 diverse uses (2pts). Project is within 1/2 mi walking distance of 4+ diverse uses and does not have an avg. 1/4 mi density of >22,000 sf/acre.
D	2			2	LTc5		Access to Quality Transit	1-4	TGE	Credit Reqs: 1pt - 72 wkdy; 3 pts - 140 wkdy; 4 pts - 360 wkdy. Project is within 1/2 mi walking distance of the MBTA Green Line D that provide >144 rides/weekday. Not enough rides to provide >360 rides/weekday for all points.
D			1		LTc6		Bicycle Facilities	1	Owner/Arch	Credit Reqs: Locate building within 200 yds of bicycle network and provide long-term bike storage (covered, within 100 yards of a main building entrance) for at least 5% of all regular building occupants. Provide one shower for the first 100 staff members and one additional for every 150 thereafter. 03.30.18 Moved to 'M-'. One (1) shower must be provided on-site in order to qualify towards credit. Based on the updated occpuant count, the required long-term bicycle storage would be a minimum of 25 spaces. Connection to bicycle network is available (short term bike storage not required for schools).
D	1				LTc7		Reduced Parking Footprint	1	Owner/Civil	Credit Reqs: Do not exceed the minimum local code requirements for parking capacity. Provide parking capacity that is a 40% reduction below the base ratios recommended by the Parking Consultants Council. Provide preferred parking for carpools for 5% of the total parking capacity. No new parking, aside from HC spaces. TGE to confirm that these can be exempt from LEED calculations. Team to confirm all parking for project is on-street public parking. (On-street parking in public rights-of-way is excluded from these calculations. Preferred parking for carpools is not required if NO off-street parking is provided.)
D			1		LTc8		Green Vehicles	1	Owner/Arch	Credit Reqs: Designate 5% of all parking spaces as preferred parking for green vehicles (a discounted parking rate of at least 20% for green vehicles is an acceptable substitute). In addition, install electrical vehicle supply equipment (EVSE) in 2% of all parking spaces used by the project. No new parking, aside from HC spaces. TGE to confirm that these can be exempt from LEED calculations. Because there is no new parking on either site (aside from HC), a discounted parking rate of at least 20% for green vehicles is an acceptable method to meet credit requirements. Owner to confirm whether parking discount will be pursued.

	Yes	M +	M -	No						
	5	1	5	1	SUSTAINABLE SITES		12	Responsible	03.20.18 Meeting Notes
C	Y				SSpr1	Construction Activity Pollution Prevention	Req'd	Civl/CM	REQUIRED: Create/implement an ESC plan for all construction activities associated with the project. The plan must conform to the requirements of the 2012 U.S. EPA Construction General Permit (CGP). A compliant ESC plan must be created and implemented for the project.
D	Y				SSpr2	Environmental Site Assessment	Req'd	Owner/Civil	REQUIRED: Conduct a Phase I ESA and, if contamination is suspected, conduct a Phase II ESA. Project must complete a Phase I ESA.
D	1				SSc1	Site Assessment	1	Arch/Civil/LA	Credit Reqs: Complete and document a site assessment that includes: Topography, Hydrology, Climate, Vegetation, Soils, Human Use, Human health effects. Team to review Site Assesment worksheet to confirm early site-analysis meets credit requirements.
D			2		SSc2	Site Development - Protect or Restore Habitat	1-2	LA	Credit Reqs: Preserve and protect from all development and construction activity 40% of the greenfield area on the site (if such areas exist) and restore 30% (including the building footprint) of the previously developed site area with native & adaptive vegetation OR provide financial support equivalent to at least $0.40 per square foot for the total site area to a nationally or locally recognized land trust or conservation organization. LB to look into the are of vegetation (non-turf). Due to the urban location, this credit may be difficult to achieve. Owner to determine if Option 2 is an option.
D		1			SSc3	Open Space	1	LA	Credit Reqs: Provide outdoor space greater than or equal to 30% of the total site area (including building footprint). A minimum of 25% of that outdoor space must be vegetated (turf grass does not count as vegetation) or have overhead vegetated canopy. The outdoor space must be physically accessible. LB to determine if enough vegetation (non-turf) is provided to meet credit requirements.
D			3		SSc4	Rainwater Management	2-3	Civil	Credit Reqs: On site, manage the runoff from the developed site for the 95th percentile (2pts) or 98th percentile (3pts) of regional or local rainfall events using LID & GI strategies that best mimic natural site hydrology OR manage on site the annual increase in runoff volume from the natural land cover condition to the post developed condition. (3 pts). Credit is very difficult to achieve. Carrying 95-98th percentile as Maybe. Requires managing all stormwater onsite using LID/GI approaches to rainwater management. Nitsch indicated that preliminary calculations show that reaching 95th percentile may be attainable.
D	2				SSc5	Heat Island Reduction	1-2	Arch/LA	Credit Reqs: Use any combination of non-roof Measures, high-Reflectance roof, or vegetated roof to be equal to or greater than the total roof + hardscape area on-site AND/OR place a minimum of 75% of parking spaces under cover. Assume project will provide light-colored roof membrane along with SR compliant hardscape materials.
D	1				SSc6	Light Pollution Reduction	1	MEP	Credit Reqs: Do not exceed allowable backlight, uplight or glare (BUG) ratings for all exterior lighting as determined by the project's lighting zone (LZ). Assume project will meet BUG requirements for LZ2.
D				1	SSc7	Site Master Plan	1	Owner	Credit Reqs: Meet 4 out of 6 LT/SS credits. Develop a site master plan for the school must be develope in collaboration with the school board or other decision-making body. Projects where no future development is planned are not eligible for this credit. Project does not meet 4 LT/SS credits. Assume no planned future development.
D	1				SSc8	Joint Use of Facilities	1	Owner	Credit Reqs: Make the building space open to the general public for 3 space types, contract a specific organization(s) to share at least 2 spaces, OR ensure students have access to at least 2 shared space owned by other organizations. Assume project will provide at least 3 communal space types within project. Must provide secure areas and after-hours access to restrooms. WRA/Owner to confirm which areas will be shared used spaces.

	Yes	M +	M -	No						
	2	3	4	3	WATER EFFICIENCY		12	Responsible	03.20.18 Meeting Notes
D	Y				WEpr1	Outdoor Water Use Reduction	Req'd	LA	REQUIRED: Install landscape that does not require a permanent irrigation system beyond a maximum two-year establishment period OR reduce the project's landscape water requirement by at least 30% from the calculated baseline for the site's peak watering month. Project must meet minimum reductions in outdoor potable water use.
D	Y				WEpr2	Indoor Water Use Reduction	Req'd	MEP/TGE	REQUIRED: Flush and flow fixtures must reduce aggregate water consumption by 20% from the baseline. All newly installed toilets, urinals, private lavatory faucets, and showerheads that are eligible for labeling must be WaterSense labeled. Meet prescriptive requirements for all commercial kitchen equipment. Project must meet minimum reductions in indoor potable water use + prescriptive process water use criteria. BOD indicates the following flush/flow fixtures: WC - 1.28; UR - 0.125; Lav - 0.35; KS - 0.5 gpm.
D	Y				WEpr3	Building-level Water Metering	Req'd	Owner/MEP	REQUIRED: Install permanent water meters that measure the total potable water use for the building and associated grounds. Commit to sharing with USGBC the resulting whole-project water usage data for a five-year period. Project must install whole-building water meters & commit to sharing whole-building water use data with USGBC.

D	1			1	WEc1	Outdoor Water Use Reduction	1-2	LA	Credit Reqs: Show that the landscape does not require a permanent irrigation system beyond a maximum two-year establishment period (2pts) OR reduce the project's landscape water requirement (LWR) by at least 50% (1pt) or 100% (2pts) from the calculated baseline for the site's peak watering month. Assume project will achieve a 50% reduction in potable water use for irrigation - excluding athletic fields.
D		3	4		WEc2	Indoor Water Use Reduction	1-7	MEP/TGE	Credit Reqs: Further reduce fixture and fitting water use from the calculated baseline in WE Prerequisite Indoor Water Use Reduction and install process equipment that meets the minimum requirements. 1-5 pts for water fixture use reduction. 1-2 pts for process water use reduction. Based on preliminary calculations by TGE, Cypress is only meeting the Prerequisite with the possibility to achieve 1-3 points. See preliminary water calculor.1.1 gpf water closets to be considered. RFS/Crabtree to review process water requirements to determine which additional points can be met.
						25% Water Use Reduction	1		
						30% Water Use Reduction	2		
						35% Water Use Reduction	3		
						40% Water Use Reduction	4		
						45% Water Use Reduction	5		
D				2	WEc3	Cooling Tower Water Use	1-2	MEP	Credit Reqs: Conduct a one-time potable water analysis, measuring at least the five control parameters required. Calculate the number of cooling tower cycles by dividing the maximum allowed concentration level of each parameter by the actual concentration level of each parameter found in the potable makeup water. Limit cooling tower cycles to avoid exceeding maximum values for any of these parameters. Cooling tower not within project scope.
D	1				WEc4	Water Metering	1	MEP	Credit Reqs: Install permanent water meters for two or more of the following water subsystems: irrigation, indoor plumbing fixtures and fittings, domestic hot water, boiler, reclaimed water, and/or other process water. Project will install meters for 2 or more of the required subsystems. Most likely for irrigation and boiler make-up water. To be confirmed by RFS / team.

	Yes	M +	M -	No					
	20	0	10	1	ENERGY & ATMOSPHERE		31	Responsible	03.20.18 Meeting Notes
C	Y				EApr1	Fundamental Commissioning and Verification	Req'd	CxA	REQUIRED: A qualified CxA must be engaged by end of DD to perform Cx services for all base-building HVAC&R equipment serving the project. An OPR document, BoD, and Current Facilities Requirements and Operations and Maintenance Plan must be prepared with information necessary to keep the building operating efficiently. A qualified CxA must be engaged by end of DD to perform all fundamental Cx-related tasks.
D	Y				EApr2	Minimum Energy Performance	Req'd	MEP/TGE	REQUIRED: Demonstrate an improvement of at least 2% in the proposed building performance rating compared with the ASHRAE 90.1–2010 baseline. Project will comply as Massachusetts Stretch Code exceeds LEED prerequisite requirements.
D	Y				EApr3	Building-level Energy Metering	Req'd	MEP	REQUIRED: Install new or use existing base building-level energy meters, or submeters that can be aggregated to provide base building-level data representing total building energy consumption and commit to sharing whole-building energy-use data with USGBC for 5 years. Project must install whole-building water meters & commit to sharing whole-building water use data with USGBC.
D	Y				EApr4	Fundamental Refrigerant Management	Req'd	MEP	REQUIRED: Do not use chlorofluorocarbon (CFC)-based refrigerants in new HVAC&R systems. Project will not use CFCs in newly-installed HVAC&R systems.
C	5		1		EAc1	Enhanced Commissioning	2-6	CxA	Credit Reqs: Perform Enhanced Cx services for all base-building HVAC&R equipment (3pts) AND/OR develop monitoring-based procedures and identify points to be measured and evaluated to assess performance of energy- and water-consuming systems (1pt) AND/OR complete all required Cx process activities for the building's thermal envelope (2pts). A qualified CxA must be engaged before the end of DD to perform Enhanced Cx related tasks. BECx assumed to be pursued. Owner to determine if MBCx will be pursued.
D	14		2		EAc2	Optimize Energy Performance	1-16	MEP/TGE	Credit Reqs: Demonstrate an improvement of at least 6% (1pt) to 42% (16pts) on an energy-cost basis in the proposed building performance rating compared with the ASHRAE 90.1–2010 baseline. SD energy model report shows 37% energy cost savings over ASHRAE 90.1-2010. Preliminary EUI 29.5.. (MSBA requirements are 20% improvement over ASHRAE 90.1-2013. For reference only, this is not an MSBA project.)
						6% Improvement in Energy Performance	1		
						8% Improvement in Energy Performance	2		
						10% Improvement in Energy Performance	3		
						12% Improvement in Energy Performance	4		
						14% Improvement in Energy Performance	5		
						16% Improvement in Energy Performance	6		
						18% Improvement in Energy Performance	7		
						20% Improvement in Energy Performance	8		

							22% Improvement in Energy Performance	9		
							24% Improvement in Energy Performance	10		
							26% Improvement in Energy Performance	11		
							29% Improvement in Energy Performance	12		
							32% Improvement in Energy Performance	13		
						x	35% Improvement in Energy Performance	14		EM prelim indicating 36.9% cost savings.
							38% Improvement in Energy Performance	15		
							42% Improvement in Energy Performance	16		
D	1				EAc3		Advanced Energy Metering	1	MEP	Credit Regs: Permanent advanced energy metering must be installed for all energy sources used by the base building. In addition, tenants must be capable of independently measuring energy consumption for all systems dedicated to their space on a floor by floor basis at minimum. Assume advanced metering will be pursued per 90.1-2013 metering requirements. Team to confirm metering approach.
C			1	1	EAc4		Demand Response	1-2	Owner	Credit Regs: Participate in an existing demand response (DR) program and design a system with the capability for real-time, fully-automated DR based on external initiation by a DR Program Provider (2pts) OR, if a DR program is not available, provide infrastructure to take advantage of future demand response programs or dynamic, real-time pricing programs and develop a comprehensive plan for shedding at least 10% of building estimated peak electricity demand (1pt). Owner to determine if DR infrastructure is desired.
D			3		EAc5		Renewable Energy Production	1-3	Owner	Credit Regs: Use renewable energy systems to offset building energy costs by 1% (1pt), 3% (2pts), or 5% (3pts). Owner to confirm if renewables/PV's will be included in project.
							1% Renewable Energy Production	1		
							5% Renewable Energy Production	2		
							10% Renewable Energy Production	3		
D			1		EAc6		Enhanced Refrigerant Management	1	MEP	Credit Regs: Select refrigerants that are used in HVAC&R equipment to minimize or eliminate the emission of compounds that contribute to ozone depletion and climate change (1 pt). Calculations to be run once final HVAC&R equipment selections are made. Kitchen equipment, particularly walk-in freezers, to be considered.
C			2		EAc7		Green Power and Carbon Offsets	1-2	Owner	Credit Regs :Purchase green power and/or carbon offsets through a 5-year contract to offset 50% (1pt) or 100% (2pts) of the building's energy use with renewable sources. Owner decision. Typically a low-cost approach to earn points if needed.
	Yes	M +	M -	No						
	2	2	4	5	MATERIALS & RESOURCES			13	Responsible	03.20.18 Meeting Notes
D	Y				MRpr1		Storage & Collection of Recyclables	Req'd	Owner/Arch.	REQUIRED: Provide dedicated areas for the collection and storage of recyclable materials for the entire building that includes mixed paper, corrugated cardboard, glass, plastics, and metals. Safe collection, storage, and disposal measures must also be provided for two of the following: batteries, mercury-containing lamps, and electronic waste. Project must provide storage/collection areas for required materials, including hazardous waste.
C	Y				MRpr2		Construction and Demolition Waste Management Plan	Req'd	CM	REQUIRED: Develop and implement a compliant construction and demolition waste management plan that establishes waste diversion goals for the project by identifying at least five materials targeted for diversion, approximate a percentage of the overall project waste that these materials represent, whether materials will be separated or commingled, descriptions of the diversion strategies planned, and describe where the material will be taken/how the recycling facility will process the material. A compliant CWM plan must be developed by the CM.
C			3	2	MRc1		Building Life-Cycle Impact Reduction	2-5	Arch/TGE	Credit Regs: Conduct a life-cycle assessment of the project's structure and enclosure that demonstrates a minimum of 10% reduction, compared with a baseline building, in at least three of the six impact categories one of which must be global warming potential (3pts). Team to confirm if whole-building LCA will performed.
							Historic Building Reuse	5	Arch	
							Renovation of Abondonded or Blighted Building	5	Arch	
							Building and Material Reuse - 25% (2pt), 50 (3pt), 75% (4pt)	2-4	Arch	
							Whole-Building Life-Cycle Assessment	3	Arch/TGE	
C	1			1	MRc2		Building Product Disclosure & Optimization-EPD's	1-2	Arch/CM	Credit Regs: Provide EPDs for at least 20 different permanently-installed products from 5 or more manufacturers. Assume project will specify materials with compliant EPDs.
						x	Environmental Product Declarations	1	Arch/CM	
							Multi-Attribute Optimization	1	Arch/CM	

C			1	1	MRc3	Building Product Disclosure & Optimization-Raw Materials	1-2	Arch/CM	Credit Reqs: Use products that meet at least one of the responsible extraction criteria materials re-use; bio-based, recycled content, certified wood, for at least 25%, by cost, of the total value of permanently installed building products in the project. For credit achievement calculation, products sourced (extracted, manufactured, purchased) within 100 miles (160 km) of the project site are valued at 200% of their base contributing cost. Structure and enclosure materials may not constitute more than 30% of the value of compliant building products. Credit is difficult to achieve for projects due to limits on structure & enclosure materials.
						[ ] Raw Materials Source & Extraction Practices	1	Arch/CM	
						[ ] Leadership Extraction Practices	1	Arch/CM	
C	1			1	MRc4	Building Product Disclosure & Optimization-Material Ingredients	1-2	Arch/CM	Credit Reqs: Provide HPDs or C2C certification for at least 20 different permanently-installed products from 5 or more manufacturers. Assume project will specify materials with compliant HPDs or C2C certification.
						[x] Material Ingredient Reporting	1	Arch/CM	
						[ ] Material Ingredient Optimization	1	Arch/CM	
						[ ] Product Manufacturer Suppy Chain Optimization	1	Arch/CM	
C		2			MRc5	Construction and Demolition Waste Management	1-2	CM	Credit Reqs: Divert at least 50% of the total construction and demolition material; diverted materials must include at least three material streams. (1pt), 75% & four material streams (2pts). Assume project will meet 50% & 3 streams threshold. Need better understanding of on-site collections strategy before additional threshold can be confirmed. Building demolition will be a big contributor to the LEED points and should be tracked as part of the LEED projects. Commingled waste counts as only one waste stream.

Yes	M +	M -	No						
8	0	2	6	INDOOR ENVIROMENTAL QUALITY			16	Responsible	03.20.18 Meeting Notes
D	Y				EQpr1	Minimum IAQ Performance	Req'd	MEP	REQUIRED: Comply with the requirements of ASHRAE 62.1-2010, Ventilation for Acceptable Indoor Air Quality. Projects must meet the minimum ventilation requirements as determined by ASHRAE 62.1-2010.
D	Y				EQpr2	Environmental Tobacco Smoke (ETS) Control	Req'd	Owner	REQUIRED: Prohibit smoking on-site. Post signage at the property line conveying no-smoking policy. Project must prohibit smoking on-site.
D	Y				EQpr3	Minimum Acoustical Performance	Req'd	Acoust. Eng.	REQUIRED: Meet acoustical requirements for HVAC background noise, exterior noise, and reverberation time. Project must meet minimum acoustical requirements.
D	2				EQc1	Enhanced IAQ Strategies	1-2	Arch/MEP	Credit Reqs: Comply with the following requirements for 1pt: Entryway Systems, Interior Cross-Contamination Prevention, and Filtration. For an additional point, comply with the one of the following: Exterior Contamination Prevention, Increased Ventilation, Carbon Dioxide Monitoring, Additional Source Control, or Monitoring. Project will meet requirements for entryway systems, interior-cross contamination prevention, and filtration. CO2 monitoring confirmed in HVAC systems narrative.
						[x] 10' Entryway Systems; Int-Cross Contamination Prevention; I	1	Arch/CM	
						[x] One of: Ext. Contamination Prev; Inc. Ventilation; CO2 Monit	1	Arch/CM	
C	1		1	1	EQc2	Low-Emitting Materials	1-3	Arch/MEP	Credit Reqs: Project must install compliant products that meet the (1) emissions testing requirements AND (2) VOC content standards for 3 (1pt), 5 (2pts), or all 6 (3pts) of the following categories: adhesives/sealants, paints/coatings, flooring, composite wood, ceilings/walls/thermal/acoustic insulation, and exterior applied products. Project manual will include language requiring compliance with at least 3 of the 5 categories listed above. School projects have the most success tracking paints and coatings, flooring systems, composite wood, and exterior applied products. WRA to consider tracking 5 categories for possible 2nd point.
						[x] Paints & Coatings		Arch/CM	
						[?] Adhesives & Sealants		Arch/CM	
						[x] Flooring		Arch/CM	
						[x] Composite Wood		Arch/CM	
						[?] Ceilings, Walls, Thermal & Acoustic Insulation		Arch/CM	
						[N/A] Furniture		Arch/CM	
						[x] Exterior Products		Arch/CM	
C	1				EQc3	Construction IAQ Management Plan	1	CM	Credit Reqs: Develop and implement an IAQ management plan that requires compliance with all applicable control measures of the SMACNA IAQ Guidelines for Occupied Buildings under Construction, 2nd edition, 2007, ANSI/SMACNA 008–2008, Chapter 3. Assume CM will develop and implement a compliant IAQ Management Plan.
C	1		1		EQc4	IAQ Assessment	1-2	Owner/CM	Credit Reqs: O1) Perform whole-building flushout before occupancy (14,000cf/sf; 60-80F;<60%RH) or during occupancy (Pre: 3,500cf/sf; Post: 14,000cf/sf; 60-80F;<60%RH) after interior finishes are installed. O2) After substantial completion but before occupancy, conduct baseline IAQ testing for all occupied spaces, as outlined in the LEED reference guide. CM/Owner/RFS to determine if flush-out will be pursued, scheduling and logistics. Option 2, Air Testing is not recommended due to more stringent requirements and complicated scheduling logistics.

						x	Flush-Out		1	CM	
							IAQ Testing		2	CM	
D	1				EQc5	Thermal Comfort			1	MEP	Credit Reqs: Design project to meet ASHRAE 55-2010 AND provide thermal controls for 50% of ind. occupant spaces and 100% of multi-occupant spaces. Project will meet ASHRAE 55 reqs and provide thermal controllability where required.
D	1			1	EQc6	Interior Lighting			1-2	MEP	Credit Reqs: (1) Provide lighting controls for 90% of ind. occupant spaces and 100% of multi-occupant spaces AND/OR (2) meet lighting quality criteria for 4 of the 7 measures listed in the LEED Reference Guide. Project will provide lighting controllability where required. Reqs for (2) quality are extremely difficult to meet. WRA/lighting designer to review credit requirements.
						x	Controllability		1	MEP	
							Lighting Quality		1	Arch/MEP	
D				3	EQc7	Daylight			1-3	Arch/MEP	Credit Reqs: O1) Demonstrate through simulation that sDA of at least 55% (2pt) or 75% (3pts) is achieved. O2) Demonstrate through modeling that illuminance levels will be between 300 lux and 3,000 lux for 9 a.m. and 3 p.m., both on a clear-sky day at the equinox, for 75% (1pt) or 90% (2pts) of the regularly occupied floor area. O3) With furniture, fixtures and equipment in place, conduct an on-site measurement that demonstrates the project achieves illuminace levels equal to O2 for 75% (2pts) or 90% (3pts) of the regularly occupied floor area. Assume project will not conduct daylight modeling or perform an on-site measurement post-construction.
D	1				EQc8	Quality Views			1	Arch/TGE	Credit Reqs: Achieve a direct line of sight to the outdoors via vision glazing for 75% of all regularly occupied floor area that meets at least two of the four kinds of views outlined in the reference guide. Assume project layout will provide adequate access to quality views for building occupants.
D				1	EQc9	Acoustic Performance			1	Acoust. Eng.	Credit Reqs: Meet additional acoustical requirements for HVAC background noise, and sound transmission. Project must meet minimum acoustical requirements.. Assume project will not meet additional acoustical criteria. Significant added-cost.

Yes	M +	M -	No					
5	0	1	0	**INNOVATION IN DESIGN**		6	Responsible	03.20.18 Meeting Notes
D 1				INc1.1	Innovation: TBD, Green Cleaning and IPM Plan	1	Team	Assumes 1.1 - 1.4 will be achieved. Options include: Exemplary Performance; School as a Teaching Tool; Green Building Education; Low-Mercury Lighting; Occupant Comfort Survey; O+M Starter Kit, Walkable Project Site, Design for Active Occupants
D 1				INc1.2	Innovation: TBD, Lamp Purchasing, Low-Mercury Lighting	1	Team	Refer to INc1.1
D 1				INc1.3	Innovation: TBD, Design for Active Occupants	1	Team	Refer to INc1.1
C 1				INc1.4	Innovation: TBD, Green Education	1	Team	Refer to INc1.1
C		1		INc1.5	Pilot Credit: TBD	1	Team	Options include: Integrative Analysis of Building Materials, Water Restoration Certificates, Learning Controls for Thermal Comfort
C 1				INc2	LEED Accredited Professional	1	Team	Various team members are LEED-Aps.

Yes	M +	M -	No					
1	0	3	0	**REGIONAL PRIORITY**		4	Responsible	03.20.18 Meeting Notes
				02445 - Brookline, MA: LTc3 (2 pts), SSc4 (2 pts), WEc2 (4 pts), MRc1 (2 pts), EAc2 (8 pts), EAc5 (2 pts)				
D		1		RPc1	LTc3 High Priority Site (2 pts)	1	TGE	See LTc3.
D		1		RPc2	EAc5 Renewable Energy Production (2 pts / 5%)	1	TGE	See EAc5.
D		1		RPc3	SSc4 Rainwater Mgmt (2 pts)	1	TGE	See SSc4.
D 1				RPc4	EAc2 Optimize Energy Performance (8 pts / 20%)	1	TGE	See EAc2.

Yes	M +	M -	No		
49	6	32	23	**PROJECT TOTALS (Certification Estimates)**	110

Certified: 40-49 points Silver: 50-59 points Gold: 60-79 points Platinum: 80+ points

STEM WING LEED SCORECARD

LEED v4 for Schools Project Scorecard

Project: **BHS STEM Wing Addition**
Address: Greenough St and Tappan St
Date: March 30, 2018

LEED Goal	LEED Silver
Bldg Area	70,000 gsf
Parking	no new parking aside from HC spaces, street parking permits
Site Area	36,640 sf (per WRA 3.21.18 dwg)
Staff	20
Students	480
Visitors	20

Notes from 03.20.18 meeting.
Credit not applicable or not pursued
Credit status change (indicates previous position)

POINT TOTALS

Phase	Yes	M +	M -	No
	50	7	30	23

GENERAL PROJECT DOCUMENTATION

Phase	Yes	M +	M -	No					Responsible	03.20.18 Meeting Notes
D	Y				Plf1		Minimum Program Requirements	Req'd	Team	

INTEGRATIVE PROCESS

Phase	Yes	M +	M -	No				1	Responsible	03.20.18 Meeting Notes
	0	0	1	0						
D			1		IPc1		Integrative Process	1	Team	Credit Regs: Perform energy and water-use analysis in early design through the use of a "simple box" model and development of a water budget, respectively. Team to review worksheet and determine which additional measures need to be analyzed to meet credit requirements.

LOCATION & TRANSPORTATION

Phase	Yes	M +	M -	No				15	Responsible	03.20.18 Meeting Notes
	6	0	2	7						
D				N	LTc1		LEED for Neighborhood Development Location	15	Team	Credit not applicable to this project.
D	1				LTc2		Sensitive Land Protection	1	Civil	Credit Regs: Locate the development footprint on land that has been previously developed. Located on a previously developed site.
D	1			1	LTc3		High Priority Site	1-2	Env. Eng.	Credit Regs: Locate on a brownfield where soil or groundwater contamination has been identified, and where the local, state, or national authority (whichever has jurisdiction) requires its remediation. 03.30.18 Moved 1 pt to 'No'. No groundwater/soil contamination at STEM. Project is located in a Difficult Development Area (DDA) and will be eligible for 1 pt under Option 2.
D	1			4	LTc4		Surrounding Density and Diverse Uses	1-5	TGE	Credit Regs: Avg. surrounding density >22,000 sf (2pts) or >35,000 (4pts) and/or within 1/2 mile walking distance of at least 8 diverse uses (2pts). Project is within 1/2 mi walking distance of 4+ diverse uses and does not have an avg. 1/4 mi density of >22,000 sf/acre.
D	2			2	LTc5		Access to Quality Transit	1-4	TGE	Credit Regs: 1pt - 72 wkdy; 3 pts - 140 wkdy; 4 pts - 360 wkdy. Project is within 1/2 mi walking distance of the MBTA Green Line D that provide >144 rides/weekday. Not enough rides to provide >360 rides/weekday for all points.
D			1		LTc6		Bicycle Facilities	1	Owner/Arch	Credit Regs: Locate building within 200 yds of bicycle network and provide long-term bike storage (covered, within 100 yards of a main building entrance) for at least 5% of all regular building occupants. Provide one shower for the first 100 staff members and one additional for every 150 thereafter. 03.30.18 Moved to 'M-'. One (1) shower must be provided on-site in order to qualify towards credit. Based on the updated occpuant count, the required long-term bicycle storage would be a minimum of 25 spaces. Connection to bicycle network is available (short term bike storage not required for schools).
D	1				LTc7		Reduced Parking Footprint	1	Owner/Civil	Credit Regs: Do not exceed the minimum local code requirements for parking capacity. Provide parking capacity that is a 40% reduction below the base ratios recommended by the Parking Consultants Council. Provide preferred parking for carpools for 5% of the total parking capacity. No new parking, aside from HC spaces. TGE to confirm that these can be exempt from LEED calculations. Team to confirm all parking for project is on-street public parking. (*On-street parking in public rights-of-way is excluded from these calculations. Preferred parking for carpools is not required if NO off-street parking is provided.)*
D			1		LTc8		Green Vehicles	1	Owner/Arch	Credit Regs: Designate 5% of all parking spaces as preferred parking for green vehicles (a discounted parking rate of at least 20% for green vehicles is an acceptable substitute). In addition, install electrical vehicle supply equipment (EVSE) in 2% of all parking spaces used by the project. No new parking, aside from HC spaces. TGE to confirm that these can be exempt from LEED calculations. Because there is no new parking on either site (aside from HC), a discounted parking rate of at least 20% for green vehicles is an acceptable method to meet credit requirements. Owner to confirm whether parking discount will be pursued.

SUSTAINABLE SITES

Phase	Yes	M +	M -	No				12	Responsible	03.20.18 Meeting Notes
	5	3	3	1						
C	Y				SSpr1		Construction Activity Pollution Prevention	Req'd	Civl/CM	REQUIRED: Create/implement an ESC plan for all construction activities associated with the project. The plan must conform to the requirements of the 2012 U.S. EPA Construction General Permit (CGP). A compliant ESC plan must be created and implemented for the project.

D	Y				SSpr2	Environmental Site Assessment	Req'd	Owner/Civil	REQUIRED: Conduct a Phase I ESA and, if contamination is suspected, conduct a Phase II ESA. Project must complete a Phase I ESA.
D	1				SSc1	Site Assessment	1	Arch/Civil/LA	Credit Regs: Complete and document a site assessment that includes: Topography, Hydrology, Climate, Vegetation, Soils, Human Use, Human health effects. Team to review Site Assesment worksheet to confirm early site-analysis meets credit requirements.
D			2		SSc2	Site Development - Protect or Restore Habitat	1-2	LA	Credit Regs: Preserve and protect from all development and construction activity 40% of the greenfield area on the site (if such areas exist) and restore 30% (including the building footprint) of the previously developed site area with native & adaptive vegetation OR provide financial support equivalent to at least $0.40 per square foot for the total site area to a nationally or locally recognized land trust or conservation organization. LB to look into the are of vegetation (non-turf). Due to the urban location, this credit may be difficult to achieve. Owner to determine if Option 2 is an option.
D		1			SSc3	Open Space	1	LA	Credit Regs: Provide outdoor space greater than or equal to 30% of the total site area (including building footprint). A minimum of 25% of that outdoor space must be vegetated (turf grass does not count as vegetation) or have overhead vegetated canopy. The outdoor space must be physically accessible. LB to determine if enough vegetation (non-turf) is provided to meet credit requirements.
D		2	1		SSc4	Rainwater Management	2-3	Civil	Credit Regs: On site, manage the runoff from the developed site for the 95th percentile (2pts) or 98th percentile (3pts) of regional or local rainfall events using LID & GI strategies that best mimic natural site hydrology OR manage on site the annual increase in runoff volume from the natural land cover condition to the post developed condition. (3 pts). Credit is very difficult to achieve. Requires managing all stormwater onsite using LID/GI approaches to rainwater management. Unlikely that credit will be met for STEM bldg.
D	2				SSc5	Heat Island Reduction	1-2	Arch/LA	Credit Regs: Use any combination of non-roof Measures, high-Reflectance roof, or vegetated roof to be equal to or greater than the total roof + hardscape area on-site AND/OR place a minimum of 75% of parking spaces under cover. Assume project will provide light-colored roof membrane along with SR compliant hardscape materials.
D	1				SSc6	Light Pollution Reduction	1	MEP	Credit Regs: Do not exceed allowable backlight, uplight or glare (BUG) ratings for all exterior lighting as determined by the project's lighting zone (LZ). Assume project will meet BUG requirements for LZ2.
D				1	SSc7	Site Master Plan	1	Owner	Credit Regs: Meet 4 out of 6 LT/SS credits. Develop a site master plan for the school must be develope in collaboration with the school board or other decision-making body. Projects where no future development is planned are not eligible for this credit. Project does not meet 4 LT/SS credits. Assume no planned future development.
D	1				SSc8	Joint Use of Facilities	1	Owner	Credit Regs: Make the building space open to the general public for 3 space types, contract a specific organization(s) to share at least 2 spaces, OR ensure students have access to at least 2 shared space owned by other organizations. Assume project will provide at least 3 communal space types within project. Must provide secure areas and after-hours access to restrooms. WRA/Owner to confirm which areas will be shared used spaces.
	Yes	M +	M -	No					
	5	2	2	3	WATER EFFICIENCY		12	Responsible	03.20.18 Meeting Notes
D	Y				WEpr1	Outdoor Water Use Reduction	Req'd	LA	REQUIRED: Install landscape that does not require a permanent irrigation system beyond a maximum two-year establishment period OR reduce the project's landscape water requirement by at least 30% from the calculated baseline for the site's peak watering month. Project must meet minimum reductions in outdoor potable water use.
D	Y				WEpr2	Indoor Water Use Reduction	Req'd	MEP/TGE	REQUIRED: Flush and flow fixtures must reduce aggregate water consumption by 20% from the baseline. All newly installed toilets, urinals, private lavatory faucets, and showerheads that are eligible for labeling must be WaterSense labeled. Meet prescriptive requirements for all commercial kitchen equipment. Project must meet minimum reductions in indoor potable water use + prescriptive process water use criteria. BOD indicates the following flush/flow fixtures: WC - 1.28; UR - 0.125; Lav - 0.35; KS - 0.5 gpm.
D	Y				WEpr3	Building-level Water Metering	Req'd	Owner/MEP	REQUIRED: Install permanent water meters that measure the total potable water use for the building and associated grounds. Commit to sharing with USGBC the resulting whole-project water usage data for a five-year period. Project must install whole-building water meters & commit to sharing whole-building water use data with USGBC.
D	1			1	WEc1	Outdoor Water Use Reduction	1-2	LA	Credit Regs: Show that the landscape does not require a permanent irrigation system beyond a maximum two-year establishment period (2pts) OR reduce the project's landscape water requirement (LWR) by at least 50% (1pt) or 100% (2pts) from the calculated baseline for the site's peak watering month. Assume project will achieve a 50% reduction in potable water use for irrigation - excluding athletic fields. Irrigation will be included in project.

D	3	2	2		WEc2	Indoor Water Use Reduction	1-7	MEP/TGE	Credit Regs: Further reduce fixture and fitting water use from the calculated baseline in WE Prerequisite Indoor Water Use Reduction and install process equipment that meets the minimum requirements. 03.20.18: Preliminary calculations show STEM receiving 3 points with a possibility to reach 4 + 1 RP point. Based on preliminary calculations by TGE, STEM receiving 3 points with a possibility to reach 4 + 1 RP point. See preliminary water calculor.1.1 gpf water closets to be considered. RFS/Crabtree to review process water requirements to determine which additional points
							25% Water Use Reduction	1	
							30% Water Use Reduction	2	
						x	35% Water Use Reduction	3	
							40% Water Use Reduction	4	
							45% Water Use Reduction	5	
D				2	WEc3	Cooling Tower Water Use	1-2	MEP	Credit Regs: Conduct a one-time potable water analysis, measuring at least the five control parameters required. Calculate the number of cooling tower cycles by dividing the maximum allowed concentration level of each parameter by the actual concentration level of each parameter found in the potable makeup water. Limit cooling tower cycles to avoid exceeding maximum values for any of these parameters. Cooling tower not within project scope.
D	1				WEc4	Water Metering	1	MEP	Credit Regs: Install permanent water meters for two or more of the following water subsystems: irrigation, indoor plumbing fixtures and fittings, domestic hot water, boiler, reclaimed water, and/or other process water. Project will install meters for 2 or more of the required subsystems. Most likely for irrigation and boiler make-up water. To be confirmed by RFS / team.
	Yes	M +	M -	No					
	17	0	13	1	ENERGY & ATMOSPHERE		31	Responsible	03.20.18 Meeting Notes
C	Y				EApr1	Fundamental Commissioning and Verification	Req'd	CxA	REQUIRED: A qualified CxA must be engaged by end of DD to perform Cx services for all base-building HVAC&R equipment serving the project. An OPR document, BoD, and Current Facilities Requirements and Operations and Maintenance Plan must be prepared with information necessary to keep the building operating efficiently. A qualified CxA must be engaged by end of DD to perform all fundamental Cx-related tasks.
D	Y				EApr2	Minimum Energy Performance	Req'd	MEP/TGE	REQUIRED: Demonstrate an improvement of at least 2% in the proposed building performance rating compared with the ASHRAE 90.1–2010 baseline. Project will comply as Massachusetts Stretch Code exceeds LEED prerequisite requirements.
D	Y				EApr3	Building-level Energy Metering	Req'd	MEP	REQUIRED: Install new or use existing base building-level energy meters, or submeters that can be aggregated to provide base building-level data representing total building energy consumption and commit to sharing whole-building energy-use data with USGBC for 5 years. Project must install whole-building water meters & commit to sharing whole-building water use data with USGBC.
D	Y				EApr4	Fundamental Refrigerant Management	Req'd	MEP	REQUIRED: Do not use chlorofluorocarbon (CFC)-based refrigerants in new HVAC&R systems. Project will not use CFCs in newly-installed HVAC&R systems.
C	5		1		EAc1	Enhanced Commissioning	2-6	CxA	Credit Regs: Perform Enhanced Cx services for all base-building HVAC&R equipment (3pts) AND/OR develop monitoring-based procedures and identify points to be measured and evaluated to assess performance of energy- and water-consuming systems (1pt) AND/OR complete all required Cx process activities for the building's thermal envelope (2pts). A qualified CxA must be engaged before the end of DD to perform Enhanced Cx related tasks. BECx assumed to be pursued. Owner to determine if MBCx will be pursued.
D	11		5		EAc2	Optimize Energy Performance	1-16	MEP/TGE	Credit Regs: Demonstrate an improvement of at least 6% (1pt) to 42% (16pts) on an energy-cost basis in the proposed building performance rating compared with the ASHRAE 90.1–2010 baseline. SD energy model report shows 24.2% energy cost savings over ASHRAE 90.1-2010. Preliminary EUI 66.4. (Project is required to demonstrate a 20% improvement over ASHRAE 90.1-2013 to meet MSBA requirements.)
							6% Improvement in Energy Performance	1	
							8% Improvement in Energy Performance	2	
							10% Improvement in Energy Performance	3	
							12% Improvement in Energy Performance	4	
							14% Improvement in Energy Performance	5	
							16% Improvement in Energy Performance	6	
							18% Improvement in Energy Performance	7	
							20% Improvement in Energy Performance	8	
							22% Improvement in Energy Performance	9	
							24% Improvement in Energy Performance	10	
						x	26% Improvement in Energy Performance	11	EM prelim 26.5% energy cost savings.
							29% Improvement in Energy Performance	12	

						32% Improvement in Energy Performance	13		
						35% Improvement in Energy Performance	14		
						38% Improvement in Energy Performance	15		
						42% Improvement in Energy Performance	16		
D	1				EAc3	Advanced Energy Metering	1	MEP	Credit Regs: Permanent advanced energy metering must be installed for all energy sources used by the base building. In addition, tenants must be capable of independently measuring energy consumption for all systems dedicated to their space on a floor by floor basis at minimum. Assume advanced metering will be pursued per 90.1-2013 metering requirements. Team to confirm metering approach.
C			1	1	EAc4	Demand Response	1-2	Owner	Credit Regs: Participate in an existing demand response (DR) program and design a system with the capability for real-time, fully-automated DR based on external initiation by a DR Program Provider (2pts) OR, if a DR program is not available, provide infrastructure to take advantage of future demand response programs or dynamic, real-time pricing programs and develop a comprehensive plan for shedding at least 10% of building estimated peak electricity demand (1pt). Owner to determine if DR infrastructure is desired.
D			3		EAc5	Renewable Energy Production	1-3	Owner	Credit Regs: Use renewable energy systems to offset building energy costs by 1% (1pt), 3% (2pts), or 5% (3pts). Owner to confirm if renewables/PV's will be included in project.
						1% Renewable Energy Production	1		
						5% Renewable Energy Production	2		
						10% Renewable Energy Production	3		
D			1		EAc6	Enhanced Refrigerant Management	1	MEP	Credit Regs: Select refrigerants that are used in HVAC&R equipment to minimize or eliminate the emission of compounds that contribute to ozone depletion and climate change (1 pt). Calculations to be run once final HVAC&R equipment selections are made. Kitchen equipment, particularly walk-in freezers, to be considered.
C			2		EAc7	Green Power and Carbon Offsets	1-2	Owner	Credit Regs :Purchase green power and/or carbon offsets through a 5-year contract to offset 50% (1pt) or 100% (2pts) of the building's energy use with renewable sources. Owner decision. Typically a low-cost approach to earn points if needed.
	Yes	M +	M -	No					
	2	2	4	5	MATERIALS & RESOURCES		13	Responsible	03.20.18 Meeting Notes
D	Y				MRpr1	Storage & Collection of Recyclables	Req'd	Owner/Arch.	REQUIRED: Provide dedicated areas for the collection and storage of recyclable materials for the entire building that includes mixed paper, corrugated cardboard, glass, plastics, and metals. Safe collection, storage, and disposal measures must also be provided for two of the following: batteries, mercury-containing lamps, and electronic waste. Project must provide storage/collection areas for required materials, including hazardous waste.
C	Y				MRpr2	Construction and Demolition Waste Management Plan	Req'd	CM	REQUIRED: Develop and implement a compliant construction and demolition waste management plan that establishes waste diversion goals for the project by identifying at least five materials targeted for diversion, approximate a percentage of the overall project waste that these materials represent, whether materials will be separated or commingled, descriptions of the diversion strategies planned, and describe where the material will be taken/how the recycling facility will process the material. A compliant CWM plan must be developed by the CM.
C			3	2	MRc1	Building Life-Cycle Impact Reduction	2-5	Arch/TGE	Credit Regs: Conduct a life-cycle assessment of the project's structure and enclosure that demonstrates a minimum of 10% reduction, compared with a baseline building, in at least three of the six impact categories one of which must be global warming potential (3pts). Team to confirm if whole-building LCA will performed.
						Historic Building Reuse	5	Arch	
						Renovation of Abondonded or Blighted Building	5	Arch	
						Building and Material Reuse - 25% (2pt), 50 (3pt), 75% (4pt)	2-4	Arch	
						Whole-Building Life-Cycle Assessment	3	Arch/TGE	
C	1			1	MRc2	Building Product Disclosure & Optimization-EPD's	1-2	Arch/CM	Credit Regs: Provide EPDs for at least 20 different permanently-installed products from 5 or more manufacturers. Assume project will specify materials with compliant EPDs.
					x	Environmental Product Declarations	1	Arch/CM	
						Multi-Attribute Optimization	1	Arch/CM	
C			1	1	MRc3	Building Product Disclosure & Optimization-Raw Materials	1-2	Arch/CM	Credit Regs: Use products that meet at least one of the responsible extraction criteria materials re-use; bio-based, recycled content, certified wood, for at least 25%, by cost, of the total value of permanently installed building products in the project. For credit achievement calculation, products sourced (extracted, manufactured, purchased) within 100 miles (160 km) of the project site are valued at 200% of their base contributing cost. Structure and enclosure materials may not constitute more than 30% of the value of compliant building products. Credit is difficult to achieve for projects due to limits on structure & enclosure materials.
					x	Raw Materials Source & Extraction Practices	1	Arch/CM	

							Leadership Extraction Practices	1	Arch/CM	
C	1			1	MRc4		Building Product Disclosure & Optimization-Material Ingredients	1-2	Arch/CM	Credit Regs: Provide HPDs or C2C certification for at least 20 different permanently-installed products from 5 or more manufacturers. Assume project will specify materials with compliant HPDs or C2C certification.
						x	Material Ingredient Reporting	1	Arch/CM	
							Material Ingredient Optimization	1	Arch/CM	
							Product Manufacturer Suppy Chain Optimization	1	Arch/CM	
C		2			MRc5		Construction and Demolition Waste Management	1-2	CM	Credit Regs: Divert at least 50% of the total construction and demolition material; diverted materials must include at least three material streams. (1pt), 75% & four material streams (2pts). Assume project will meet 50% & 3 streams threshold. Need better understanding of on-site collections strategy before additional threshold can be confirmed. Building demolition will be a big contributor to the LEED points and should be tracked as part of the LEED projects. Commingled waste counts as only one waste stream.
	Yes	M +	M -	No						
	8	0	2	6	INDOOR ENVIROMENTAL QUALITY			16	Responsible	03.20.18 Meeting Notes
D	Y				EQpr1		Minimum IAQ Performance	Req'd	MEP	REQUIRED: Comply with the requirements of ASHRAE 62.1-2010, Ventilation for Acceptable Indoor Air Quality. Projects must meet the minimum ventilation requirements as determined by ASHRAE 62.1-2010.
D	Y				EQpr2		Environmental Tobacco Smoke (ETS) Control	Req'd	Owner	REQUIRED: Prohibit smoking on-site. Post signage at the property line conveying no-smoking policy. Project must prohibit smoking on-site.
D	Y				EQpr3		Minimum Acoustical Performance	Req'd	Acoust. Eng.	REQUIRED: Meet acoustical requirements for HVAC background noise, exterior noise, and reverberation time. Project must meet minimum acoustical requirements.
D	2				EQc1		Enhanced IAQ Strategies	1-2	Arch/MEP	Credit Regs: Comply with the following requirements for 1pt: Entryway Systems, Interior Cross-Contamination Prevention, and Filtration. For an additional point, comply with the one of the following: Exterior Contamination Prevention, Increased Ventilation, Carbon Dioxide Monitoring, Additional Source Control, or Monitoring. Project will meet requirements for entryway systems, interior-cross contamination prevention, and filtration. CO2 monitoring confirmed in HVAC systems narrative.
						x	10' Entryway Systems; Int-Cross Contamination Prevention; Fi	1	Arch/CM	
						x	One of: Ext. Contamination Prev; Inc. Ventilation; CO2 Monitor	1	Arch/CM	
C	1		1	1	EQc2		Low-Emitting Materials	1-3	Arch/MEP	Credit Regs: Project must install compliant products that meet the (1) emissions testing requirements AND (2) VOC content standards for 3 (1pt), 5 (2pts), or all 6 (3pts) of the following categories: adhesives/sealants, paints/coatings, flooring, composite wood, ceilings/walls/thermal/acoustic insulation, and exterior applied products. Project manual will include language requiring compliance with at least 3 of the 5 categories listed above. School projects have the most success tracking paints and coatings, flooring systems, composite wood, and exterior applied products. WRA to consider tracking 5 categories for possible 2nd point.
						x	Paints & Coatings		Arch/CM	
						?	Adhesives & Sealants		Arch/CM	
						x	Flooring		Arch/CM	
						x	Composite Wood		Arch/CM	
						?	Ceilings, Walls, Thermal & Acoustic Insulation		Arch/CM	
						N/A	Furniture		Arch/CM	
						x	Exterior Products		Arch/CM	
C	1				EQc3		Construction IAQ Management Plan	1	CM	Credit Regs: Develop and implement an IAQ management plan that requires compliance with all applicable control measures of the SMACNA IAQ Guidelines for Occupied Buildings under Construction, 2nd edition, 2007, ANSI/SMACNA 008–2008, Chapter 3. Assume CM will develop and implement a compliant IAQ Management Plan.
C	1		1		EQc4		IAQ Assessment	1-2	Owner/CM	Credit Regs: O1) Perform whole-building flushout before occupancy (14,000cf/sf; 60-80F;<60%RH) or during occupancy (Pre: 3,500cf/sf; Post: 14,000cf/sf; 60-80F;<60%RH) after interior finishes are installed. O2) After substantial completion but before occupancy, conduct baseline IAQ testing for all occupied spaces, as outlined in the LEED reference guide. CM/Owner/RFS to determine if flush-out will be pursued, scheduling and logistics. Option 2, Air Testing is not recommended due to more stringent requirements and complicated scheduling logistics.
						x	Flush-Out	1	CM	
							IAQ Testing	2	CM	
D	1				EQc5		Thermal Comfort	1	MEP	Credit Regs: Design project to meet ASHRAE 55-2010 AND provide thermal controls for 50% of ind. occupant spaces and 100% of multi-occupant spaces. Project will meet ASHRAE 55 reqs and provide thermal controllability where required.

D	1			1	EQc6		Interior Lighting	1-2	MEP	Credit Regs: Provide lighting controls for 90% of ind. occupant spaces and 100% of multi-occupant spaces AND/OR meet lighting quality criteria for 4 of the 7 measures listed in the LEED Reference Guide. Project will provide lighting controllability where required. Reqs for (2) quality are extremely difficult to meet. WRA/lighting designer to review credit requirements.
							x Controllability	1	MEP	
							Lighting Quality	1	Arch/MEP	
D				3	EQc7		Daylight	1-3	Arch/MEP	Credit Regs: O1) Demonstrate through simulation that sDA of at least 55% (2pt) or 75% (3pts) is achieved. O2) Demonstrate through modeling that illuminance levels will be between 300 lux and 3,000 lux for 9 a.m. and 3 p.m., both on a clear-sky day at the equinox, for 75% (1pt) or 90% (2pts) of the regularly occupied floor area. O3) With furniture, fixtures and equipment in place, conduct an on-site measurement that demonstrates the project achieves illuminace levels equal to O2 for 75% (2pts) or 90% (3pts) of the regularly occupied floor area. Assume project will not conduct daylight modeling or perform an on-site measurement post-construction.
D	1				EQc8		Quality Views	1	Arch/TGE	Credit Regs: Achieve a direct line of sight to the outdoors via vision glazing for 75% of all regularly occupied floor area that meets at least two of the four kinds of views outlined in the reference guide. Assume project layout will provide adequate access to quality views for building occupants.
D				1	EQc9		Acoustic Performance	1	Acoust. Eng.	Credit Regs: Meet additional acoustical requirements for HVAC background noise, and sound transmission. Project must meet minimum acoustical requirements.. Assume project will not meet additional acoustical criteria. Significant added-cost.
	Yes	M +	M -	No						
	5	0	1	0	INNOVATION IN DESIGN			6	Responsible	03.20.18 Meeting Notes
D	1				INc1.1		Innovation: TBD, Green Cleaning and IPM Plan	1	Team	Assumes 1.1 - 1.4 will be achieved. Options include: Exemplary Performance; Design for Active Occupants; School as a Teaching Tool; Green Building Education; Low-Mercury Lighting; Occupant Comfort Survey; O+M Starter Kit, Walkable Project Site, Design for Active Occupants
D	1				INc1.2		Innovation: TBD, Lamp Purchasing, Low-Mercury Lighting	1	Team	Refer to INc1.1
D	1				INc1.3		Innovation: TBD, Design for Active Occupants	1	Team	Refer to INc1.1
C	1				INc1.4		Innovation: TBD, Green Education	1	Team	Refer to INc1.1
C			1		INc1.5		Pilot Credit: TBD	1	Team	Options include: Integrative Analysis of Building Materials, Water Restoration Certificates, Learning Controls for Thermal Comfort
C	1				INc2		LEED Accredited Professional	1	Team	Various team members are LEED-Aps.
	Yes	M +	M -	No						
	2	0	2	0	REGIONAL PRIORITY			4	Responsible	03.20.18 Meeting Notes
					02445 - Brookline, MA: LTc3 (2 pts), SSc4 (2 pts), WEc2 (4 pts), MRc1 (2 pts), EAc2 (8 pts), EAc5 (2 pts)					
D			1		RPc1		LTc3 High Priority Site (2 pts)	1	TGE	See LTc3.
D			1		RPc2		EAc5 Renewable Energy Production (2 pts / 5%)	1	TGE	See EAc5.
D	1				RPc3		WEc2 Indoor Water Use Reduction (4 pts / 40%)	1	TGE	See WEc2.
D	1				RPc4		EAc2 Optimize Energy Performance (8 pts / 20%)	1	TGE	See EAc2.
	Yes	M +	M -	No						
	50	7	30	23	PROJECT TOTALS (Certification Estimates)			110		

Certified: 40-49 points Silver: 50-59 points Gold: 60-79 points Platinum: 80+ points

LEED PATHWAY TO SILVER MEMORANDUM

The Green Engineer, Inc.
Sustainable Design Consulting

Memo

Project:	**Brookline High School** **Cypress and STEM Buildings**
Re:	**Pathway to Silver - Revision 1**
Date Issued:	March 30, 2018
Prepared by:	Allison Zuchman, The Green Engineer, Inc. Brad Newkirk, The Green Engineer, Inc. Antonio Sciarratta, The Green Engineer, Inc.

This memo outlines the necessary steps for determining which of the '**Maybe**' credits can be moved to '**Yes**' in order to target LEED-NC v4 Silver certification.

CURRENT LEED-NC v4 SCORECARD

Cypress Building

The current Cypress project scorecard is tracking credit points as follows:
49 '**Yes**', **38** '**Maybe**', **23** '**No**'
A project must earn a minimum of **50 points** to achieve LEED Silver certification under LEED-NC v4. The project should carry a point cushion to allow for unforeseen circumstances as the project moves forward. If Silver certification is the target, the project should track a minimum of **54-55** points.

STEM Building

The current STEM project scorecard is tracking credit points as follows:
50 '**Yes**', **37** '**Maybe**', **23** '**No**'
A project must earn a minimum of **50 points** to achieve LEED Silver certification under LEED-NC v4. The project should carry a point cushion to allow for unforeseen circumstances as the project moves forward. If Silver certification is the target, the project should track a minimum of **54-55** points.

Currently, the LEED credit points being carried on the Cypress and STEM scorecards are the same except for the Indoor Water Use Reduction and Optimize Energy Performance credits (plus the associated Regional Priority credits). The difference in water and energy use is attributed to the different use type and occupant load of each building. Once the projects advance into design development, other credit points may vary slightly as well from building to building.

The table on the following pages indicates a strategy for the '**Maybe**' credits (and a few '**Yes**' credits where strategies need to be confirmed). The credits are organized into one of three categories based on general degree of difficulty of achievement, as follows:

1. **Low:** "**Low Hanging Fruit**" *(shown in yellow)* - Credits that should be easier to achieve and should be considered first.

2. **Medium:** "**More Difficult**" *(shown in orange)* - Credits that are more difficult to achieve and might require design decisions and/or have an impact on schedule or cost.

3. **High:** "**Most Difficult**" *(shown in purple)* - Credits that may not be possible or require significant design changes, operational adjustments, and/or additional cost.

Degree of Difficulty	Possible Points	Credit	Issue	Next Actions	Resp. Party
Medium	1	IPc1 Integrative Process	A preliminary box-model energy analysis must be completed before SD is complete. Potential load reduction strategies must be assessed for each of the 7 features outlined in the LEED reference guide (site, massing, envelope, lighting, thermal comfort, plug and process loads, program and operational parameters). Preliminary water analysis must be completed as well (indoor, outdoor, process and supply).	TGE to distribute USGBC Integrative Process worksheet. Team to review worksheet and determine which additional measures need to be analyzed to meet credit requirements.	WRA RFS Nitsch TGE
Medium	1	LTc6 Bicycle Facilities	Project must be located within 200 yards of bicycle network and provide long-term bike storage (covered, within 100 ft. of any main entrance) for at least 5% of all regular building occupants. Provide one on-site shower for the first 100 FTE and additional 150 thereafter.	Based Cypress Building occupant count of 45 FTE, 700 students, and 20 visitors a minimum of **38** bike spaces and 1 on-site shower are required. Based STEM Building occupant count of 20 FTE, 480 students, and 20 visitors a minimum of **25** bike spaces and 1 on-site shower are required. WRA / Owner to determine if at least one (1) shower will be provided in each building. LB / WRA to provide current bicycle storage count per building and determine where required covered storage (i.e. extended canopy) can be located.	LB WRA Owner
Medium	1	LTc8 Green Vehicles	Because there is no new parking on either site (aside from HC), a discounted parking rate of at least 20% for green vehicles is an acceptable method to meet credit requirements.	Owner to determine if discounted parking permits can be offered by the Town for LEFE vehicles. TGE to confirm that Handicapped spaces can be exempt from LEED parking calculations.	Owner WRA TGE

High	1-2	SSc2 Site Development- Protect or Restore Habitat	Option 1 (2 pts.): Preserve and protect from all development and construction activity 40% of the greenfield area on the site (if such area exists) and restore 30% (including building footprint) of the previously developed site area with native & adaptive vegetation (turf does not count) OR Option 2 (1 pt.): Provide financial support equivalent to at least $0.40 per square foot for the total site area to a nationally or locally recognized land trust or conservation organization.	LB to look into the possibility of achieving the credit. Due to the urban location, this credit may be difficult to achieve. Owner to determine if Option 2 is an option.	LB Owner
Medium	1	SSc3 Open Space	Based on preliminary calculations, physically accessible open space (both hardscape and vegetated) equals at least 30% of the total site area. To meet the credit requirements, 25% of that open space must be vegetated (non-turf).	LA to determine if enough vegetation (non-turf) is provided to meet credit requirements.	LB
Medium	2	SSc4 Rainwater Management	Manage on site the runoff from the developed site for the [95th percentile (2pts) / 98th percentile (3pts)] of regional or local rainfall events using low-impact development (LID) and green infrastructure.	Cypress: Nitsch indicated that preliminary calculations show that reaching 95th percentile may be attainable on the Cypress Building. 98th percentile will be more challenging to meet. Nitsch / LA to look into viable options to reach 95% and 98%. Nitsch/LB to consider LID measures where appropriate, such as porous pavers and pitching pedestrian areas to rain garden. STEM: Unlikely to meet credit for STEM building.	Nitsch LB
High	1				
Medium	1-7	WEc2 Indoor Water Use reduction	Reduce indoor water use from the calculated baseline in WE Prerequisite Indoor Water Use Reduction. All newly installed toilets, urinals, private lavatory faucets, and showerheads that are eligible for labeling must be WaterSense labeled. Process water fixtures to meet LEED requirements for additional 1-2 points.	Team to review water efficient fixtures and fittings selections. Preliminary calculations show STEM receiving 3 points with a possibility to reach 4 + 1 RP point. Cypress is only meeting the Prerequisite with the possibility to achieve 1-3 points. 1.1 gpf water closets to be considered. RFS/Crabtree to review process water requirements to determine which additional points can be met. WRA/Owner to confirm occupant load and annual days of operation for each building.	RFS WRA Crabtree Owner

Carried as 'Yes'	5	EAc1 Enhanced Commissioning: Enhanced HVAC&R and BECx	CxA to be hired by 100% DD to perform fundamental and enhanced Cx services for all base-building HVAC&R equipment and the building envelope (5 points carried as 'Yes").	It is assumed that enhanced HVAC&R and BECx will be pursued and CxA will be engaged before the end of DD. Owner to confirm.	Owner
Medium	1	EAc1 Enhanced Commissioning: Monitor-based CxA	Monitor-based CxA is an option for one additional point. Monitoring-based commissioning is the integration of three components: permanent energy monitoring systems, real-time energy analysis, and ongoing commissioning.	Owner to determine if Monitor-based CxA will be pursued for one additional point. If yes, RFS to create plan and include metering and monitoring requirements in design, and CxA to review as part of Cx scope.	Owner RFS
High	2-5	EAc2 Optimize Energy Performance	Preliminary energy analysis indicates the following: Cypress: 37% LEED cost savings. 14 points carried as 'Yes.' 2 points carried as 'Maybe.' (29.5 EUI) STEM: 26.5% LEED cost savings. 11 points carried as 'Yes.' 5 points carried as 'Maybe.' (66.4 EUI) 2-5 additional points available (16 total per project).	Additional savings and potential Energy Conservation Measures (ECMs) to be discussed as the project moves forward. PV's will contribute to energy cost savings if included in project.	WRA RSF TGE Owner
Medium	1	EAc4 Demand Response	Provide infrastructure to participate in a future demand response program. Design system with the capabilities for real life, fully automated DR. Develop a comprehensive plan for shedding at least 10% of building estimated peak electricity demand. DR is not yet available through Eversource, but the infrastructure can be set up to earn 1 point.	Owner to determine if DR is desired. If yes, RFS to provide information on design and cost implications.	WRA Owner RFS
High	1-3	EAc5 Renewable Energy Production	Install renewable energy systems to offset building energy cost. Use PVs to offset 1% of total building energy cost for 1 point, 5%/2pts, 10%/3pts.	Preliminary PV analysis was completed by TGE. Owner to determine if PV system will be installed on either building, or located at another location and attributed to these projects.	Owner
Low	1	EAc6 Enhanced Refrigerant Management	Select refrigerants that are used in HVAC&R to minimize or eliminate the emissions of compounds that contribute to ozone depletion	A calculation to be run by RFS once final HVAC&R equipment is selected. Crabtree to review kitchen equipment, particularly walk-in freezers.	RFS Crabtree

Low	1-2	EAc7 Green Power and Carbon Offsets	Purchase Green power and/or carbon offsets though a 5-year contract to offset 50% (1 pt.) or 100% (2 pts.) of the buildings energy use	Owner decision. A low-cost approach to achieve points and support renewable grid.	Owner
High	3	MRc1 Building Life Cycle-Impact Reduction	Conduct a whole building life-cycle assessment of the project's structure and enclosure that demonstrates a minimum of 10% reduction compared to building baseline in at least 3 impact categories, one being global warming potential.	Team to determine if whole building material LCA will be performed. Tally, a plug in to Revit, or the Athena online tool can be used for the LCA analysis. Significant soft cost to complete analysis. At this point will probably not influence the design.	WRA TGE
High	1	MRc3 Building Product Disclosure and Optimization-Raw Materials	Requires 25% of permanently installed building materials to meet responsible extraction criteria (e.g. FSC, regional and recycled content, etc.) Structure and enclosure contribution is capped at 30% of the sustainable materials value. Regional materials are within a 100-mile radius in LEEDv4.	Careful specification development, material selection, and submittals/costs tracking during construction. CM LEED Manager required to track LEED submittals, complete USGBC Calculator, and provide updates at regular intervals during construction. This credit is difficult to achieve. Team will not know if credit requirements are met until end of construction once all material submittals/costs have been tracked. WRA to confirm if this credit will be tracked.	WRA CM
Medium	1-2	MRc5 Construction and Demolition Waste management	Divert at least 50% of the total construction and demolition material; diverted materials must include at least three material streams. (1pt), 75% & four material streams (2pts). Commingled waste counts as only one waste stream.	Assume the project will minimally meet 50% & 3 streams threshold, and 75% and 4 streams should be targeted. There needs to be a better understanding of the on-site CWM collection strategy before either threshold can be confirmed. Building demolition will be a big contributor to the LEED points and should be tracked as part of the LEED projects. WRA to include in specifications. CM to confirm strategy.	WRA CM

High	1 point carried as 'Yes' 1 point carried as 'Maybe' (High difficulty)	EQc2 Low-Emitting Materials	Project must install compliant products that meet and VOC content requirement and emissions testing requirements Assume project manual will include language requiring compliance with at least 3 of 5 categories (1 point). Schools most successful tracking paints and coating, flooring systems, composite wood, and exterior applied products. Additional 2 categories can be tracked for 1 additional point.	WRA to determine if additional 2 categories will be tracked for 1 possible additional point. Careful specification development, material selection, and submittals/costs tracking during construction. CM LEED Manager required to track LEED submittals, complete USGBC Calculator, and provide updates at regular intervals during construction. This second point is difficult to achieve. Team will not know if credit requirements are met until end of construction once all material submittals/costs have been tracked. WRA to confirm if the second point will be tracked.	WRA CM
Medium	1	EQc4 IAQ Assessment	Perform a whole building flush-out by supplying an air volume of 14,000 cu.ft./sf and RH no higher than 60%, prior to occupancy after interior finishes are installed. If desired, the building can be occupied before flush-out is completed as long as a minimum of 3,500 cu.ft./sf of air has been delivered.	CM/Owner/RFS to determine if flush-out will be pursued, scheduling and logistics. Option 2, Air Testing is not recommended due to more stringent requirements and complicated scheduling logistics.	Owner CM RFS
Carried as "Yes"	1	IN Green Cleaning and Integrated Pest Management Plan	Assumes the school will implement a Green Cleaning and Integrated Pest Management Plan. Assumes this IN point will be earned. If this IN credit option is not pursued, another IN credit strategy needs to replace it.	TGE to provide policy templates. Owner to confirm credit will be met.	TGE Owner
Carried as "Yes"	1	IN Design for Active Occupants	Improve the health of building users through physical activity while reducing environmental impacts. The requirements are related primarily to the design of the main lobby and staircase design. Likely on Cypress. Assumes this IN point will be earned. If this IN credit option is not pursued, another IN credit strategy needs to replace it.	TGE to provide summary of credit requirements. WRA to review requirements to confirm if credit can be met.	WRA Owner

Carried as "Yes"	1	IN Green Building Education	The following elements must be included in the education program: comprehensive signage program, and educational outreach program and/or guided tour. Assumes this IN point will be earned. If this IN credit option is not pursued, another IN credit strategy needs to replace it.	TGE to provide summary of credit requirements. Owner/WRA to confirm if credit will be pursued.	WRA Owner
High	1	INc1.5 Pilot Credit	A Pilot Credit from the USGBC Pilot Credit Library must be pursued to earn INc1.5. This credit is difficult to achieve.	TGE to review Pilot credit catalogue to determine if there are any Pilot credits applicable to the project(s).	TGE

LEED Silver certification can be challenging to achieve but is possible. Both projects are currently at or just above the minimum threshold of 50 LEED points to achieve Silver (assuming credits listed as '**Yes**' on the scorecards will be pursued). Each project should target 4 or 5 additional points at minimum to have a safe buffer of 54-55 points.

CRITICAL PATH NEXT STEPS

1. Team members to review '**Maybe**' credit strategies and determine which credits/points can be moved to '**Yes**'**.**
2. Current '**Yes**' point strategies to be confirmed.
3. Brookline High School to confirm which Owner strategies will be pursued.

END OF MEMO

CYPRESS BUILDING SCHEMATIC DESIGN ENERGY MODEL REPORT

Memorandum

To: Andrew Jonic, William Rawn Associates
From: Peter Levy, Vipul Singh, The Green Engineer Inc.
Date: 03.22.2018
Re: Schematic Design Energy Model Report – Revision 1
Project: Brookline High School Cypress Building, Brookline, MA

I. Executive Summary

The Cypress building is a five story, 118,000 square foot academic building consisting of classrooms, library, cafeteria, office, and support spaces. The project is located on the Brookline high school campus in Brookline MA.

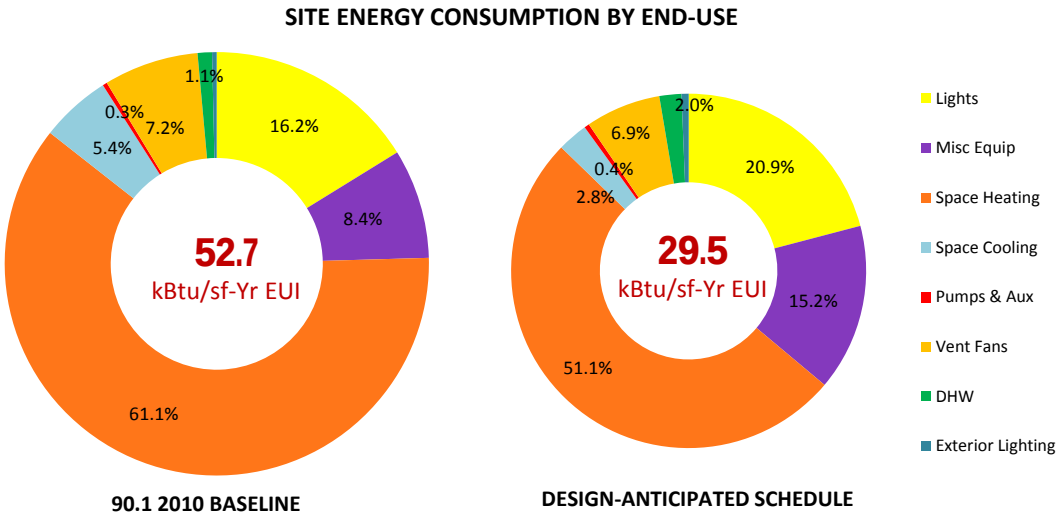
This phase of the energy modeling is based on the SD Drawings dated 31 January 2018, project narrative dated 12 January 2018, and inputs from the design team. The modeling was performed in accordance with ASHRAE Standard 90.1-2013, Appendix G modeling guidelines.

The purpose of presenting this information is to provide a gauge for the project in terms of potential energy performance and an opportunity for the design team to review the energy model assumptions for accuracy. The overall energy savings and estimated annual energy consumption for the project is likely to change as the design moves forward and final decisions are made.

The results of the modeling indicate that the current design uses 1,670 MMBtu's of electricity and 1,800 MMBtu's of natural gas, resulting in a total annual energy use of 3,470 MMBtu's. This equates to an energy use intensity (EUI) of **29.5 kBtu/SF-yr**.

The building as-designed is expected to show total energy-cost savings of **37%** as compared to an ASHRAE 90.1-2010 compliant Baseline. The percentage annual site and source energy savings are estimated at **44%** and **39%,** respectively. Additionally, the greenhouse gas (GHG) emissions for the proposed design are estimated at **223.5 MTCO2e**, an approx. **42.7%** reduction from the Baseline emissions.

Summaries of these results are presented in the following sections.



Further, the team was interested in how much of an impact the extended hours of operation (evenings, Saturdays, and summer) had on the annual energy use, so a version of the model was run in which the school was only used for academic purposes (Monday-Friday 8:00am-3:00pm).

In addition, five scenarios were studied in which the window area of the building was reduced, as well as one scenario in which higher performing windows were used.

Simulation results for the standard academic-use schedule and the window iterations are provided in Appendix-B of this report.

II. Modeling Methodology

Annual energy cost estimates are projected based on energy modeling results, using eQUEST version 3.65 modeling software. eQUEST uses the DOE-2 calculation engine to estimate annual energy consumption by simulating a year of building operations based on a typical weather year and user inputs.
It is important to keep in mind the limitations of energy models when reviewing this information. Energy consumption is highly dependent on weather conditions and the actual operating schedule of the building. The numbers generated will not necessarily be an accurate projection of actual energy costs, but should serve as an accurate comparison between alternatives.

III. Description of alternatives modeled

ASHRAE 90.1-2010 Baseline: The building as designed, except that the envelope constructions, mechanical equipment, and lighting meet the minimum requirements of ASHRAE 90.1-2010.

Design Case: The building as designed. The design inputs are based on the Schematic Design drawing and documents, the SD narratives and information provided by the design team. Every effort has been made to use reasonable assumptions for building components and systems where details were not available.

Please refer to Appendix-A for model inputs.

Utility Rates:

The following EIA State Average Rates for electricity and natural gas have been used for estimating annual energy cost savings for the project:

Electricity: $ 0.157 /kWh *(2017 EIA Average for MA)*
Gas: $9.89 /MBTU *(2017 EIA Average for MA)*

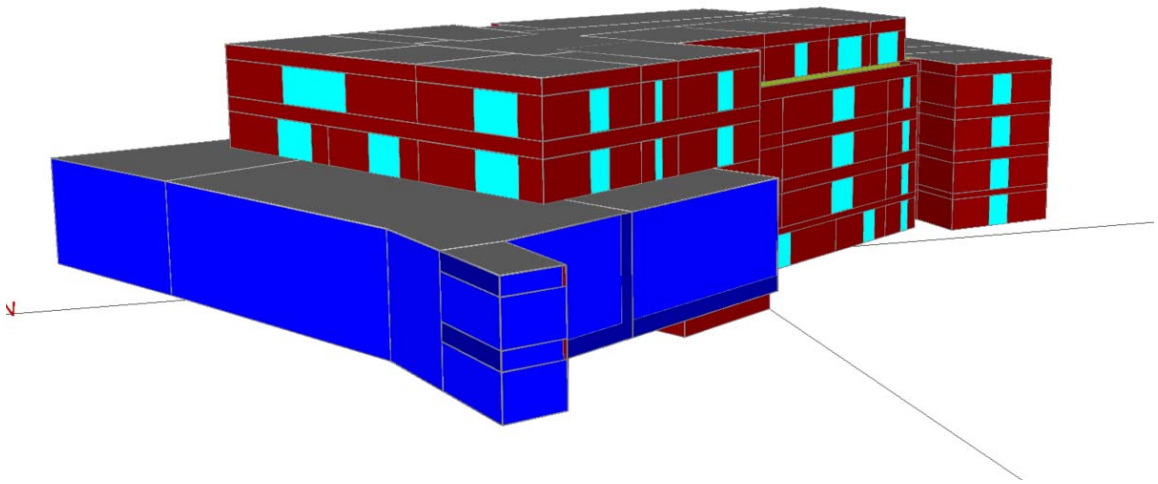


Image 1: Cypress Building 3D View

Hours of Operation:

The estimated annual energy use is based on the following hours of operation:

Table 1: Schedule Alternatives

	Academic School			Summer		
	Monday - Friday	Saturday	Sunday/Holidays	Monday - Friday	Saturday	Sunday/Holidays
Anticipated Schedule	Level 1-2: 8:00am – 10:00pm Rest of Building: 8:00am – 3:00pm	Level 1-2: 9:00am – 3:00pm Rest of Building: Closed	Level 1-2: Closed Rest of Building: Closed	Level 1-2: 8:00am – 3:00pm Rest of Building: 8:00am – 3:00pm	Level 1-2: 9:00am – 3:00pm Rest of Building: Closed	Level 1-2: Closed Rest of Building: Closed
Standard Academic Schedule (Refer to Appendix-B)	Whole Building: 8:00am – 3:00pm	Whole Building: Closed	Whole Building: Closed	Whole Building: Closed	Whole Building: Closed	Whole Building: Closed

IV. Energy Conservation Measures

The following ECM's have been identified for the project:

- Improved envelope assemblies and fenestration
- Reduced interior lighting through the use of high efficiency LED fixtures
- High efficiency VAV with energy recovery better than ASHARE 90.1 requirements
- The design includes partial cooling for all classroom spaces. This results in a lower overall energy use for the project.
- Supply air temperature reset
- Perimeter finned tube radiators (FTR's) with hot water heating.
- Perimeter FTR's meet space loads during unoccupied periods eliminating the need for roof top VAV units to cycle on at night and unoccupied periods.
- High efficiency condensing boilers and optimized hot water loop parameters
- High efficiency air-cooled chiller and optimized chilled water loop parameters

V. Simulation Results

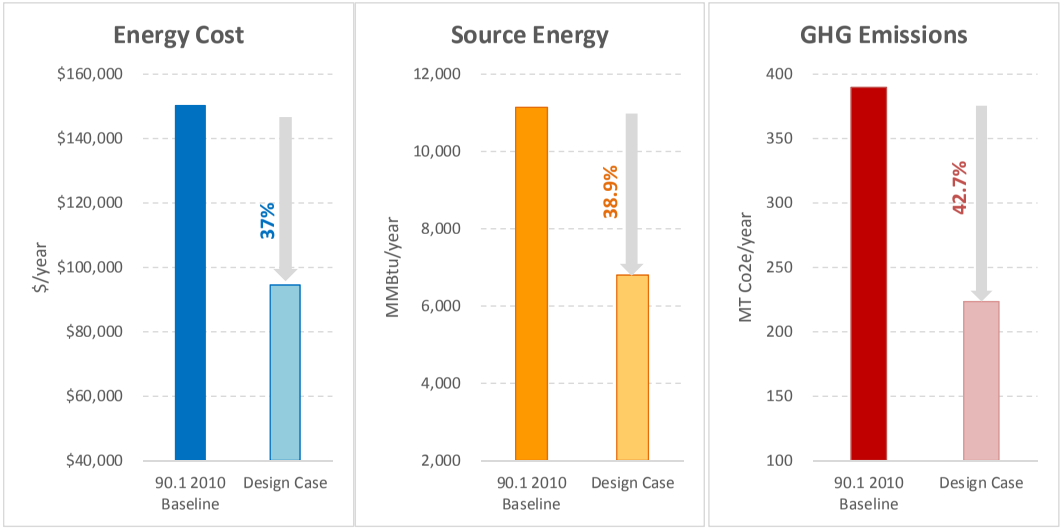
The following Tables summarize the energy use results between Baseline and Proposed Design. Please refer to Appendix A - for Baseline and Design Case model inputs.

Table 2: Annual Energy Use Savings

Energy Use Savings (MMBtu/Yr)										
Description	Lights	Misc Equip	Space Heating	Space Cooling	Pumps & Aux	Vent Fans	DHW	Exterior Lighting	Total	% Savings
90.1 2010 Baseline	1,009.0	580.0	3,741.0	341.2	20.5	472.9	68.8	21.8	6,255.2	
Design Case	717.0	580.0	1,746.0	95.3	15.3	239.5	68.9	21.8	3,483.8	
									Energy Use Savings (%)	44%

Table 3: Energy Use, GHG Reduction and Energy Cost Summary

Energy Use, GHG Reduction and Cost Summary			
Description		90.1 2010 Baseline	Design Case
Annual Site Energy Summary			
Electricity	kWh	716,607	488,912
Natural Gas	MMBtu	3,810	1,801
Total Site Energy use	MMBtu	6,255.2	3,484
Annual Energy Cost Reduction			
Electricity	$/year	$112,507	$76,759
Natural Gas	$/year	$37,679	$17,808
Total Energy Cost	$/year	**$150,186**	**$94,567**
		Site Energy Cost Savings (%)	37.0%
Annual Source Energy Reduction			
Total Source Energy use	MMBtu	11,145	6,805
		Source Energy Savings (%)	38.9%
Green House Gas (GHG) Reduction			
Total GHG Emissions	MTCO2e	389.7	223.5
		GHG Reduction(%)	42.7%



Appendix-A: Model Input Summary

The following envelope parameters, internal load assumptions, and HVAC system inputs in the energy model are based on the drawings and documents available to us and inputs from the design team.

Brookline Cypress Building: Schematic Design Model Inputs		
Project Area	118,000 SF	
Building Envelope	**Baseline Case (ASHRAE 90.1 2010)**	**As Designed**
Roofs	ASHRAE 90.1 2010, Table 5.5-5 (CZ 5A): Insulation entirely above Deck. R-20 c.i. Assembly U-Value: 0.048	R-40 Rigid Insulation Assembly U-Value:0.024
Walls - Above Grade	ASHRAE 90.1 2010, Table 5.5-6 (CZ 5A): Steel-framed Construction. R-13.0 + 7.5 c.i. Assembly U-Value: 0.064	Brick Veneer Assembly U-0.036 Spandrel Assembly U-0.045
Slab on Grade	Unheated, 6" slab on grade floor F-0.73	Modeled same as Baseline
Fenestration and Shading	**Baseline Case (ASHRAE 90.1 2010)**	**As Designed**
Vertical Glazing Description	Curtain Walls and Punched Windows	Curtain Walls and Punched Windows
Vertical Glazing U-factor	ASHRAE 90.1 2010, Table 5.5-5 Metal Framing (Curtain Wall): Assembly U-value: 0.45 Metal Framing (Punched): Assembly U-Value: 0.55	Curtain Wall: Assembly U-0.39 Punched: Assembly U-0.39
Vertical Glazing SHGC	0.4	CW: 0.38 Punched: 0.27
Visual Light Transmission	0.9	0.7
Lighting and Equipment	**Baseline Case (ASHRAE 90.1 2010)**	**As Designed**
Lighting Power Calc Method	Building Area Method	Building Area Method
Lighting Power Density	0.99W/SF	0.7 W/SF 20% Below ASHRAE 90.1 2013
Occupancy Sensor	-	Yes
Daylight Dimming Controls	Included where required by ASHRAE 90.1 2010	Perimeter Zones: Stepped dimming to 70% and 35% of full power
Equipment Power Density	Same as design	Kitchen: 5 W/SF Office: 1.5 W/SF Classroom: 0.75 W/SF
HVAC - Air Side	**Baseline Case (ASHRAE 90.1 2010)**	**As Designed**
Primary HVAC Type	System #5: Packaged VAV with Reheat (DX/HW)	VAV with Reheat
Unitary Cooling Capacity / Efficiency	Cooling equipment capacities auto-sized and oversized by 15%.	NA – Air cooled chiller in design

	Min DX Cooling Efficiency as per ASHRAE 90.1 2010	
Total Heating Capacity and Efficiency	Heating capacities auto-sized and oversized by 25%. Heating source modeled as HW Plant with natural draft boilers.	Heating capacities auto-sized and oversized by 25%. Heating source modeled as HW Plant with boiler efficiency condensing boilers.
Fan System Operation	Variable volume fans, 30% min turn-down or ventilation requirement, whichever is higher. Supply and return fans operate continuously whenever spaces are occupied and cycle to meet loads during unoccupied periods.	Supply and return fans operate continuously whenever spaces are occupied. Perimeter FTR meets loads during unoccupied periods.
Outdoor Air Design Min Ventilation	Same as design *Note: There is energy penalty from increased ventilation under LEEDV4. This iteration of the model assumes that the ventilation is in line with ASHRAE 62.1 2010 minimum requirements.*	RTU-1.1: 6,000 CFM RTU-1.2: 16,500 CFM RTU-1.3: 8,000 CFM RTU-2.1: 900 CFM RTU-3.1: 1,950 CFM RTU-4.1: 3,070 CFM RTU-5.1: 8,000 CFM RTU-6.1: 5,000 CFM
Economizer	Economizer with high-limit shutoff of 70 deg F	Economizer with high-limit shutoff of 70 deg F
System Fan Power	As per ASHRAE 90.1 2010 Fan Allowance: Supply: 0.9 W/CFM Return: 0.5 W/CFM Pressure credit: Fully ducted retun/exhaust; MERV 13 filter on OA; energy recovery; sound attenuation.	Supply: 1.2 W/cfm Return: 1.0 W/cfm
Supply Air	System design supply air flow rates based higher of a supply-air-to-room-air temperature difference of 20 degF, or min ventilation requirements.	RTU-1.1: 6,000 CFM RTU-1.2: 16,500 CFM RTU-1.3: 8,000 CFM RTU-2.1: 5,000 CFM RTU-3.1: 6,500 CFM RTU-4.1: 14,300 CFM RTU-5.1: 8,000 CFM RTU-6.1: 5,000 CFM
Supply Air Temperature Reset Parameters	The air temperature for cooling shall be reset higher by 5F under minimum cooling load conditions	Included identical to Baseline
ERV	50% Recovery Effectiveness, where applicable	70% effective ERV on all RTU's
HVAC - Water Side	**Baseline Case (ASHRAE 90.1 2010)**	**As Designed**
Number of Boilers	Two - Natural Draft Boilers Thermal Efficiency: 80%	Two 3000 MBH Condensing Boilers with an efficiency of 95.4%
Hot Water Loop Temperatures	Design HW Temp: 180 F Loop Design DT: 50 F	Design HW Temp: 140 F Loop Design DT: 30 F
HHW Loop Reset	180F @ 20F outdoor, 150F @ 50F outdoor	140F @ 20F outdoor, 100F @ 60F outdoor
Number of Primary HHW Pumps	One @ 19W/gpm	Two @24 Watts/ gpm
Pump Speed Control	VSD on Pumps	VSD on Pumps

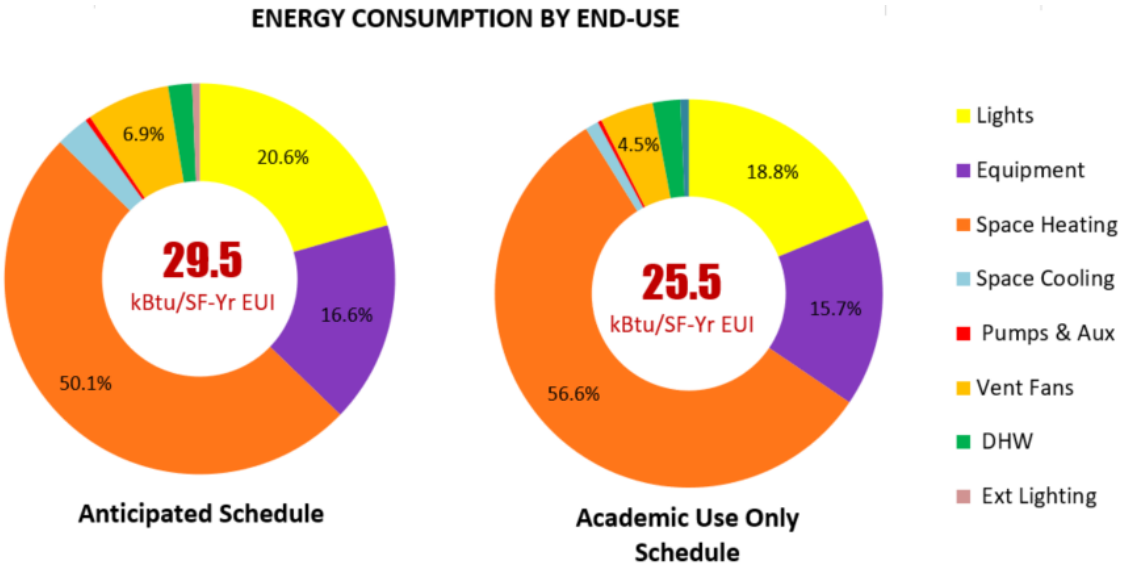
Number of Chillers	NA	1 210 Ton Air Cooled Screw chiller with a COP of 5.3 FL, 8.0 IPLV
Chilled Water Supply Loop Temp	-	44F
Chilled Water Loop Delta T	-	10F
Number of Primary CHW Pumps	-	2 @21 Watts/gpm
Number of Cooling Towers / Fluid Coolers	NA	NA

Appendix-B: Energy Model Alternatives

B.1. Standard Academic Use Assessment

In order to understand how much of an impact the extended hours of operation have on energy use, an iteration of the model was run in which the hours of operation were limited to academic purposes. See Table 1 for details of Anticipated Schedule and Academic Use Only Schedule.

In this scenario, the building used 1,250 MBTU's of electricity and 1,761 MBTU's of natural gas, resulting in a total annual energy use of 3,011 MBTUs. This equates to an EUI of **25.5 kBtu/SF-yr,** compared to the 29.5 kBtu/SF-yr estimated for the anticipated use.



B.2. Window Iterations

In addition, the team was interested in how a reduction of window area as well as window performance would affect annual energy use. The following six (6) options were studied:

Option-1:

Facades with 25% WWR reduced to 20% WWR

Facades with 15% WWR reduced to 10% WWR

Option-2:

Facades with 25% WWR reduced to 15% WWR

Facades with 15% WWR reduced to 5% WWR

Option-3:

A-307 Change 1,000 sf of CW to Spandrel

A-305 Change 1,000 sf of CW to Spandrel

Option-4:

Option-1 & Option-3

Option-5:

Remove all windows from building (to demonstrate total impact of windows)

Option-6:

Window assembly U-value reduced from 0.39 to 0.30

The following Tables summarize the energy use for the As Designed, and As Designed with various WWR % scenarios.

Table 4: As Designed Energy and EUI per End-Use

As Designed Energy per End-Use									
End-Use	Lights	Equip	Heat	Cool	Pumps	Fans	DHW	Ext Lt	Total
MBTU	717	580	1,746	95	16	240	69	22	3,484
EUI	6.1	4.9	14.8	0.8	0.1	2.0	0.6	0.2	29.5

Table 5: Design Alternatives Energy per End-Use and EUI

Energy per End-Use										
	Lights	Equip	Heat	Cool	Pumps	Fans	DHW	Ext Lt	Total	**EUI**
As-Designed	717	580	1,746	95	16	240	69	22	3,484	**29.5**
Option-1	728	580	1,705	94	15	237	69	22	3,451	**29.2**
Option-2	751	580	1,660	94	16	236	69	22	3,427	**29.0**
Option-3	721	580	1,727	93	14	235	69	22	3,461	**29.3**
Option-4	733	580	1,687	92	16	232	69	22	3,431	**29.0**
Option-5	809	580	1,338	84	15	213	69	22	3,129	**26.5**
Option-6	717	580	1,529	97	14	251	69	22	3,279	**27.7**

STEM WING SCHEMATIC DESIGN ENERGY MODEL REPORT

Memorandum

To: Andrew Jonic, William Rawn Associates
From: Peter Levy, Vipul Singh - The Green Engineer Inc.
Date: 03.22.2018
Re: Schematic Design Energy Model Report - Revision 1
Project: Brookline High School-STEM Wing Addition, Brookline, MA

I. Executive Summary

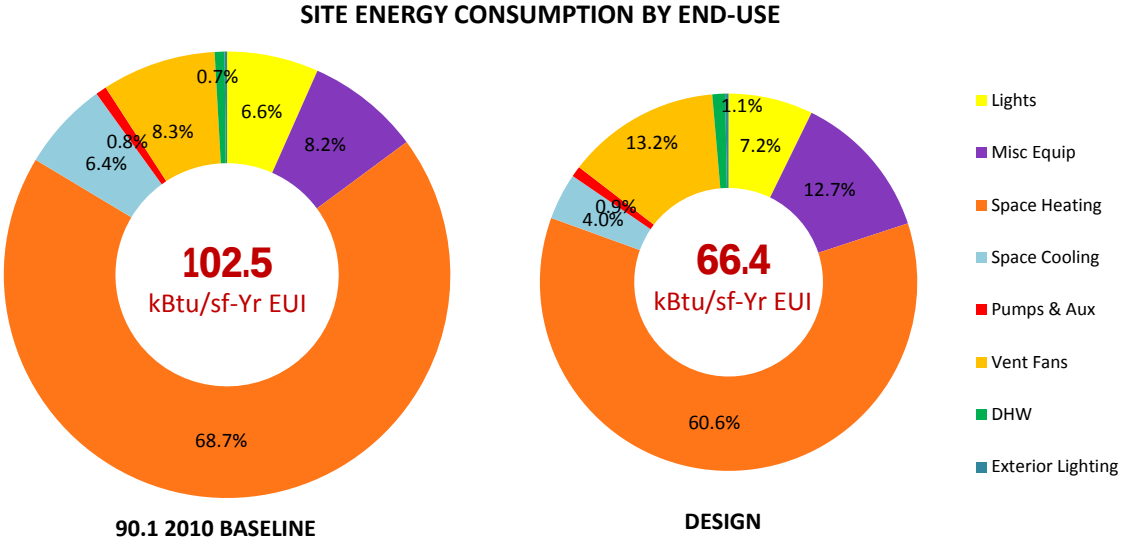
The three-story new STEM Wing is a new addition to the existing Robert's Wing. The approx. 70,000SF addition will include a new culinary arts kitchen/café, science classrooms, biology and chemistry labs, maker spaces, teacher planning areas and collaborative spaces. The project scope also includes a below grade floor for back-of-house and electrical/mechanical support spaces. The proposed addition will connect to the existing building at two locations - at the stair near the cafeteria and auditorium and at the connecting corridors at the central administration, library and the academic building.

This phase of the energy modeling is based on the SD Pricing Set dated 31st January 2018, project narrative dated 12th January 2018, and information provided by the design team. The modeling was performed in accordance with ASHRAE Standard 90.1-2010, Appendix G modeling guidelines.

The purpose of presenting this information is to provide a gauge for the project in terms of potential energy performance and an opportunity for the design team to review the energy model assumptions for accuracy. The overall energy savings and estimated annual energy consumption for the project is likely to change as the design moves forward and final decisions are made.

The results of the modeling indicate that the as-designed building is expected to show total energy-cost savings of **26.5%** as compared to an ASHRAE 90.1-2010 compliant Baseline. The percentage annual site and source energy savings are estimated at **35.2%** and **29%,** respectively. Additionally, the greenhouse gas (GHG) emissions for the proposed design are estimated at **287.7 MTCO2e**, an approx. **33.3%** reduction from the Baseline emissions.

Summaries of these results are presented in the following sections.



II. Modeling Methodology

Annual energy cost estimates are projected based on energy modeling results, using eQUEST version 3.65 modeling software. eQUEST uses the DOE-2 calculation engine to estimate annual energy consumption by simulating a year of building operations based on a typical weather year and user inputs.

It is important to keep in mind the limitations of energy models when reviewing this information. The results are based on the current design assumptions and utility rates described within this report. Further, energy consumption is highly dependent on weather conditions and the actual operating schedule of the building. The numbers generated will not necessarily be an accurate projection of actual energy costs, but should serve as an accurate comparison between alternatives.

III. Description of alternatives modeled

ASHRAE 90.1-2010 Baseline: The building as designed, except that the envelope constructions, mechanical equipment, and lighting meet the minimum requirements of ASHRAE 90.1-2010.

Design Case: The building as designed. The design inputs are based on the Schematic Design drawing and documents, the SD narratives and information provided by the design team. Every effort has been made to use reasonable assumptions for building components and systems where details were not available.

Please refer to Appendix-A for model inputs.

Utility Rates:

The following EIA State Average Rates for electricity and natural gas have been used for estimating annual energy cost savings for the project:

Electricity: $ 0.157 /kWh *(2017 EIA Average for MA)*

Gas: $9.89 /MBTU *(2017 EIA Average for MA)*

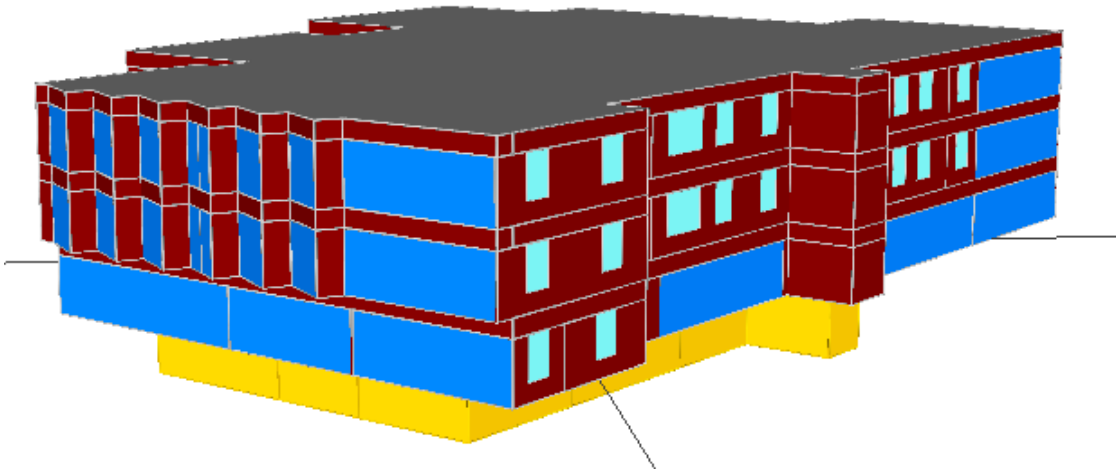


Image 1: STEM Wing Addition - Energy Model 3D View

Hours of Operation:

The estimated annual energy use is based on the following hours of operation:

Academic School Year: Building in Full Use

School Day:	8am – 3pm
After hours:	3pm – 10pm (only public areas, bathrooms, makerspace, and culinary arts classroom are available for use – all labs are closed)
Saturdays:	Partial Use between 8am & 3pm (only 1st floor spaces noted above)
Kitchen:	Operational from 8am-3pm during the academic year; closed in the evenings
Sundays:	Closed

Holidays, Winter Break, Spring Break: Closed

Summer: Partial Building in Full Use

School Day:	8am – 3pm (only 1st floor spaces noted above, labs are not in use)
Saturdays:	Partial Use between 8am - 3pm (only 1st floor spaces noted above)
Sundays:	Closed
Kitchen:	Closed in the summer

IV. Energy Conservation Measures

The following ECM's have been identified for the project:

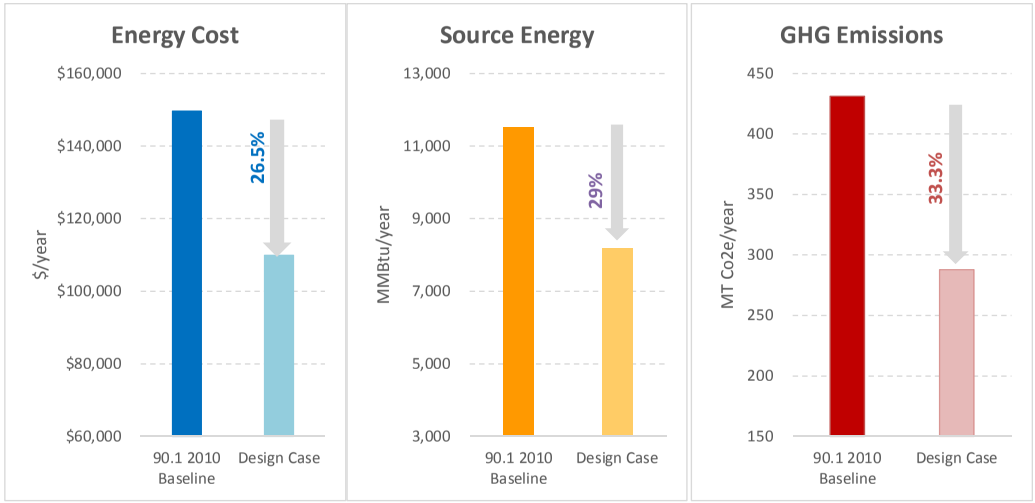
- Improved envelope assemblies and fenestration
- Reduced interior lighting through the use of high efficiency LED fixtures
- High efficiency 100% outside air VAV energy recovery units for ventilation
- The design includes partial cooling for all areas, except the faculty spaces that have full air-conditioning. This results in a lower overall energy use for the project.
- Supply air temperature reset
- Perimeter finned tube radiators (FTR's) with hot water heating.
- Perimeter FTR's meet space loads during unoccupied periods eliminating the need for roof top VAV units to cycle on at night and unoccupied periods.
- Un-occupied ACH in lab spaces lower than ASHARE 90.1 2010 requirements
- High efficiency boilers and optimized hot water loop parameters
- High efficiency air-cooled chiller and optimized chilled water loop parameters

V. Simulation Results

The following Tables summarize the energy use results between Baseline and Proposed Design. Please refer to Appendix A - for Baseline and Design Case model inputs.

Energy Use Savings (MMBtu/Yr)										
Description	**Lights**	**Misc Equip**	**Space Heating**	**Space Cooling**	**Pumps & Aux**	**Vent Fans**	**DHW**	**Exterior Lighting**	**Total**	**% Savings**
90.1 2010 Baseline	474.5	588.8	4,916.0	460.8	56.5	590.9	50.5	13.4	7,151	
Design Case	335.4	588.8	2,807.0	185.0	42.5	610.3	50.5	13.4	4,633	
									Energy Use Savings (%)	**35.2%**

Energy Use, GHG Reduction and Cost Summary			
Description		**90.1 2010 Baseline**	**Design Case**
Annual Site Energy Summary			
Electricity	kWh	640,174	520,179
Natural Gas	MMBtu	4,967	2,857
Total Site Energy use	MMBtu	7,151.4	4,633
Annual Energy Cost Reduction			
Electricity	$/year	$100,507	$81,668
Natural Gas	$/year	$49,123	$28,257
Total Energy Cost	$/year	**$149,630**	**$109,925**
		Site Energy Cost Savings (%)	**26.5%**
Annual Source Energy Reduction			
Total Source Energy use	MMBtu	11,520	8,181.65
		Source Energy Savings (%)	**29.0%**
Green House Gas (GHG) Reduction			
Total GHG Emissions	MTCO2e	431.2	287.7
		GHG Reduction(%)	**33.3%**



- The results of the modeling indicate that the Design Case is expected to show total energy-cost savings of 26.5% as compared to an ASHRAE 90.1 2010 compliant Baseline building. This energy cost reduction is equivalent to 11 LEED points. The percentage annual energy-use savings are estimated at 35.2% of the Baseline building.

- The Site EUI for the design, based on the current model inputs, is estimated at 66.4 kBtu/sf-yr. The higher EUI compared to a typical high-school is due to the inclusion of chemistry and biology labs in the design. The GHG emissions for the Proposed Design is estimated at 287.7 MTCO2e, an approximately 33.3% reduction from the Baseline GHG emissions estimated at 431.2 MTCO2e.

- Note that the EUI for this project is predicted higher than a typical high-school project but is lower than typical high intensity laboratory projects.
  - The design includes partial cooling for all areas except the faculty spaces that have full air-conditioning. This results in a lower overall energy use for the project.
  - Lab spaces account for only about 40% of the total project area.
  - Lab spaces are used only 8a.m. to 3p.m during the school academic year and remain closed in the summer.
  - Fume hoods are expected to be in use for only 2 hours per week.

Appendix-A: Model Input Summary

The following envelope parameters, internal load assumptions, and HVAC system inputs in the energy model are based on the drawings and documents available to us and inputs from the design team.

Brookline STEM Building: Schematic Design Model Inputs		
Project Area	70,000 SF	
Building Envelope	**Baseline Case (ASHRAE 90.1 2010)**	**As Designed**
Roofs	ASHRAE 90.1 2010, Table 5.5-5 (CZ 5A): Insulation entirely above Deck. R-20 c.i. Assembly U-Value: 0.048	Insulation entirely above Deck: R-40 c.i. Assembly U-Value:0.024
Walls - Above Grade	ASHRAE 90.1 2010, Table 5.5-6 (CZ 5A): Steel-framed Construction. R-13.0 + 7.5 c.i. Assembly U-Value: 0.064	Brick Veneer Wall: R-27.62 Effective R-Value Assembly U-0.036
Slab on Grade	Unheated, 6" slab on grade floor F-0.73	Modeled same as Baseline
Fenestration and Shading	**Baseline Case (ASHRAE 90.1 2010)**	**As Designed**
Vertical Glazing Description and WWR%	Curtain Walls and Punched Windows	Curtain Walls and Punched Windows
Vertical Glazing U-factor	ASHRAE 90.1 2010, Table 5.5-5 Metal Framing (CW) Assembly U-value: 0.45 Metal Framing (Punched): Assembly U-Value: 0.55	CW: Assembly U-0.39 Punched: Assembly U-0.39
Vertical Glazing SHGC	0.4	CW: 0.38 Punched: 0.27
Visual Light Transmission	0.9	0.7
Lighting and Equipment	**Baseline Case (ASHRAE 90.1 2010)**	**As Designed**
Lighting Power Calc Method	Building Area Method	Building Area Method
Lighting Power Density	0.99W/SF	0.7 W/SF (20% Below ASHRAE 90.1-2013 allowance)
Occupancy Sensor		Yes
Daylight Dimming Controls	Included, where required by ASHRAE 90.1 2010	Perimeter Zones: Stepped dimming to 70% and 35% of full power
Equipment Power Density	Same as design	Kitchen: 5.0 W/SF Office: 1.5 W/SF Chemistry Lab: 2.5 W/SF Biology Lab: 2.5 W/SF Cafeteria: 2.5 W/SF

HVAC - Air Side	Baseline Case (ASHRAE 90.1 2010)	As Designed
Primary HVAC Type	System #5: Packaged VAV with Reheat (DX/Purchased HTHW)	VAV with Reheat (air cooled chiller/ Purchased HTHW) RTU-1.1: Addition floors: B,1,2,3 RTU-2.1: Culinary arts kitchen and dining
Fan System Operation	Variable volume fans, 30% min turn-down or ventilation requirement, whichever is higher. Supply and return fans operate continuously whenever spaces are occupied and cycle to meet loads during unoccupied periods.	Variable volume fans. Supply and return fans operate continuously whenever spaces are occupied. Perimeter Finned Tube Radiators meets loads during unoccupied periods.
Unitary Cooling Capacity / Efficiency	Cooling equipment capacities auto-sized and oversized by 15%. Min DX Cooling Efficiency as per ASHRAE 90.1 2010	NA – Air cooled chiller in design
Total Heating Capacity and Efficiency	Heating capacities auto-sized and oversized by 25%. Heating source modeled as Purchased High Temperature Hot Water (HTHW)	Heating capacities auto-sized and oversized by 25%. Heating source modeled as Purchased High Temperature Hot Water (HTHW)
Outdoor Air Design Min Ventilation	Same as design *Note: There is energy penalty from increased ventilation under LEEDV4. This iteration of the model assumes that the ventilation is in line with ASHRAE 62.1 2010 minimum requirements.*	RTU-1.1: 40,000 CFM RTU-2.1: 2,800 CFM Kitchen MAU: 5500 CFM Lab Spaces: 6ACH occupied/2ACH unoccupied and 4ACH when occupied but chemicals are not in use. Non-Lab Spaces: Ventilation as per ASHRAE 62.1 requirements.
Fume Hoods	Modeled same as design	Fume Hoods: On/Off type, variable volume. Current iteration assumes 850CFM exhaust when fume hood is turned on. Fume hoods modeled to operate on an average 2 hours per week.
Economizer	Economizer high-limit shutoff: 70F	Economizer high-limit shutoff: 70F
System Fan Power	As per ASHRAE 90.1 2010 Fan Allowance: Supply (estimate): 0.9-1.0 W/cfm Return (estimate): 0.5 W/cfm	Supply (estimate): 1.0 W/cfm Return (estimate): 0.8 W/cfm
Supply Air	System design supply air flow rates based higher of a supply-air-to-room-air temperature difference of 20 degF, or min ventilation requirements.	RTU-1.1: 40,000 CFM RTU-2.1: 4,500 CFM Kitchen MAU: 5,500 CFM

Supply Air Temperature Reset Parameters	The air temperature for cooling shall be reset higher by 5F under minimum cooling load conditions	Included identical to Baseline
Exhaust Air Energy Recovery	50% Recovery Effectiveness, where applicable	Laboratory RTU: 50% sensible effective Culinary RTU: 70% effective ERV
HVAC - Water Side	**Baseline Case (ASHRAE 90.1 2010)**	**As Designed**
Number of Boilers	2 Natural Draft Boilers Thermal Efficiency: 80%	2 HW Boilers w/Draft Thermal Efficiency: 85%
Hot Water Loop Temperatures	180F; 50F dT	180F; 40F dT
HHW Loop Temp Reset Parameters	180F @ 20F outdoor, 150F @ 50F outdoor	Fixed supply (To be confirmed).
Number of Primary HHW Pumps	One @ 19W/gpm	Two @24 Watts/ gpm
Pump Speed Control	Riding the pump curve	VSD on Pumps
Number of Chillers	NA	One 180 Ton Air Cooled Screw chiller with a COP of 5.3 FL, 8.0 IPLV
Chilled Water Supply Loop Temp	-	44F
Chilled Water Loop Delta T	-	10F
Number of Primary CHW Pumps	-	2 @21 Watts/gpm
Number of Cooling Towers / Fluid Coolers	NA	NA

LIFE CYCLE COST ANALYSIS

The Green Engineer, Inc.
Sustainable Design Consulting

Memorandum

To: Andrew Jonic, William Rawn Associates
From: Vipul Singh, The Green Engineer Inc.
Date: 03.22.2018
Re: Life Cycle Cost Analysis
Project: Brookline High School, Brookline, MA

I. Executive Summary

The Brookline High School project includes the construction of a new 118,000 GSF Cypress Building which will be a four-story academic building with classrooms, administrative spaces, and community spaces such as dining/kitchen, maker space, art, music and library. The project scope also includes the construction of a new 70,000 SF STEM Wing addition to the existing Robert's Wing of the BHS Greenough building, some renovation of the third floor science wing at Greenough building, and renovation and small additions to the Tappan Athletic Complex.

Preliminary energy modeling was performed to compare the performance of four HVAC system options under consideration for the Cypress academic building. *The results presented in this report are based on a simplified block model developed for typical classroom area.* The energy use and costs from the simplified model have been extrapolated to estimate the total annual energy use and energy costs for the project and perform life cycle cost analysis (LCCA) for the HVAC design options.

This report compares the energy use and cost for the following HVAC design options:

- Option A: Full cooling – all air VAV (DX rooftop), condensing boilers
- Option B: Partial cooling/ dehumidification – rooftop AHU's, air cooled chiller, condensing boilers
- Option C: All electric VRF (full cooling) and DOAS unit
- Option D: Chilled beams (full cooling), DOAS (chilled water/ hot water)

The results of the LCCA show that Option B: Partial Cooling has the lowest life cycle cost, primarily due to low annual energy use and energy costs compared to other HVAC options as well as reduced maintenance costs.

Summaries of these results are presented in the following sections.

II. Modeling Description

The annual energy cost estimates are projected based on results from a simplified block energy modeling created using the eQUEST v3.65 modeling software. eQUEST uses the DOE-2 calculation

engine to estimate annual energy consumption by simulating a year of building operations based on a typical weather year and user inputs.

It is important to keep in mind the limitations of energy models when reviewing this information. Energy consumption is highly dependent on weather conditions and the actual operating schedule of the building. The numbers generated will not necessarily be an accurate projection of actual energy costs, but should serve as an accurate comparison between alternatives.

Description Of Alternatives Modeled:

The purpose of this energy modeling exercise is to compare four (4) HVAC options under consideration. Other model inputs like the building envelope assemblies, internal loads, lighting, etc. are assumed to be identical for all options and are based on design specifications.

- Basic Assumptions: 40% Glazed, R-30 Roof, R-27 Walls, U-0.40 Windows
- Typical HS Schedule, with heavy summer use

Option A: Full cooling – all air VAV (DX rooftop), condensing boilers
The building will be served by roof top packaged variable air volume units with DX/Hot Water coils. This option assumes that ALL spaces in the building will be provided heating, mechanical ventilation and air-conditioning (i.e. full cooling). The building heating will be provided from hot water heating plant using high efficiency condensing boilers.

Option B: Partial cooling/ dehumidification – rooftop AHU's, air cooled chiller, condensing boilers
The building classrooms will be heated, ventilated and dehumidified only, providing partial cooling. Full air conditioning will be provided only in some spaces such as faculty offices. The roof top AHU's serving the building will be variable air volume type. The building heating will be provided from hot water heating plant using condensing boilers. Cooling and dehumidification will be provided by air-cooled chiller.

Option C: VRF (full cooling) and DOAS unit - All Electric Option
The system consists of a heat recovery VRF system with a packaged DX/Heat pump rooftop ERU for ventilation air. The heating and cooling for classrooms and offices is provided by cassette type indoor units with refrigeration piping distribution from outdoor units.

Option D: Chilled beams (full cooling), DOAS (chilled water/ hot water)
The building will be served by active chilled beams. A roof top energy recovery unit (ERU), connected to the building CHW/HW loop, will provide ventilation air to the chilled beams in classrooms and offices. Chilled water is provided by a high efficiency air-cooled chiller. Hot water is provided by a high efficiency condensing boiler.

III. Life Cycle Costing Analysis Methodology

The method used for life cycle costing analysis (LCCA) is called Total Equivalent Annual Cost (TEAC) methodology. The TEAC is defined as the annual cost of owning, operating and maintaining a system over its entire life and allows comparison of the cost effectiveness of different options with unequal lifespans.

It amortizes the upfront cost over the life span of the equipment, and adds that to the operating cost. Another way to think of it is the operating cost + the bond payment on the capital cost. The IESNA recommends this specifically for comparisons of lighting options, but it works well for comparing HVAC alternatives with different life spans.

The Basic Formula is:

$$TEAC = Annual\ Operating\ Cost + Initial\ Costs \times [(i\ (1+i)^n)/((1+i)^n-1)]$$

Where;

i = *Discount rate*

n = *Expected service life*

IV. Life Cycle Costing Analysis (LCCA) Results

A comparison of life cycle cost between the four alternatives was conducted. The TEAC was determined for each option, based on annual energy cost estimated from the simplified energy models, capital costs for the HVAC equipment, and estimates of maintenance costs provided by the design team.

The following Table summarizes the result of the analysis:

Option	Site EUI[1] kBtu/SF-yr	Energy Costs[2] $/SF-yr	Capital Cost[3] $/SF	Maintenance[4] $/SF-yr	Expected Overall Service Life	Total Annual Equivalent Cost[5] $/SF-yr
Option A: VAV (Full Cooling)	39.7	$1.58	$52.0	$0.23	20 Years	$5.31
Option B: Partial Cooling	36.4	$1.45	$52.0	$0.20	20 Years	$5.14
Option C: VRF	35.2	$1.66	$42.0	$0.33	15 Years	$5.51
Option D: Chilled Beams	38.7	$1.56	$54.0	$0.28	20 Years	$5.47

1 Estimated site EUI (kBtu/SF-yr) - based on simplified block energy models.
2 Estimated annual energy cost ($/SF-yr) - based on simplified block energy models.
3 Based on Brookline HS Feasibility HVAC Study (dated Dec 2017) by Miyakoda Consulting.
4 Based on Maintenance Cost Summary provided by RFS Engineering.
5 Discount Rate of 3% has been used for the TEAC calculation.

Discussion of Results:

- The analysis results show that Option B: Partial Cooling has the lowest TEAC at $5.14/SF and Option C: VRF (full cooling) has the highest TEAC of $5.51/SF. This implies that the partial cooling option will save $0.37/SF annually, over the life cycle of the system (assumed to be 20 years for this analysis), compared to the VRF option.

- The initial capital investment for Option B: Partial Cooling is estimated same as Option A: All Air VAV (full cooling). However, lower annual energy costs and reduced maintenance costs result in a lower overall life cycle cost for the partial cooling option. The estimated life cycle cost savings for the partial cooling option are estimated at $0.17/SF annually compared to the full cooling VAV option that has the second lowest life cycle cost.

- Option C: VRF has the highest life cycle cost amongst the four options that were analyzed. This is primarily due to the shorter expected service life and high maintenance costs associated with this system. The VRF option has the lowest initial capital costs bit it must be replaced five years sooner.

SOLAR PHOTOVOLTAICS & NET ZERO FEASIBILITY ANALYSIS

Memorandum

To: Andrew Jonic, William Rawn Associates
From: Peter Levy, Vipul Singh, The Green Engineer Inc.
Date: 03.22.2018
Re: Solar Photovoltaics Analysis
Project: Brookline High School, Brookline, MA

I. Summary

The Brookline High School is considering rooftop mounted photovoltaic (PV) arrays on the Cypress and STEM buildings. Based on the PV panel layouts provided by the team, the Cypress building PV would provide approximately 150,500 kWh annually. The value of the electricity generated would be approximately $23,625 per year.

The STEM building PV would provide approximately 127,275 kWh annually. The value of the electricity generated would be approximately $19,982 per year.

The estimated cost of installation is $466,076 and $377,104 for Cypress and STEM, respectively. This results in a 19.7 and 18.8 years payback for the two systems (see Table 1). This does not include any solar incentives that may be available to the project to offset costs.

Table 1: PV Generation

	System Area (SF)	Peak Capacity (kW)	Azimuth (deg)	Tilt (deg)	Annual Production (kW)	Electricity Value Generated ($)	Estimated Installed Cost ($)	Simple Payback (Years)
Cypress	8,963	117	180	42	150,480	$23,625	$466,076	19.7
STEM	7,252	94	180	42	127,273	$19,982	$377,104	18.9

Based on the anticipated energy use indicated by the SD energy models, the Cypress PV system would account for 30.5% of the electrical use from the Cypress Building, and 14.7% of the total (electrical and gas) energy use of the building.

The STEM PV system would account for 24.5% of the electrical use from the STEM Building, and 9.4% of the total energy use of the building.

Table 2: Building Energy Offset

	Annual Electrical Use (kWh)	Total Annual Energy Use (kWh)	PV Production (kWh)	PV % of Electrical Use	PV % of Total Energy Use
Cypress	493,005	1,020,607	150,480	30.5%	14.7%
STEM	520,179	1,357,469	127,273	24.5%	9.4%

II. Analysis Assumptions and Methodology:

Assumed PV performance - 13 watts (peak)/sf
Estimated Installation Cost: $4/Watt (Peak).
Estimated Utility Rate - $0.157 kWh

Solar access analysis for potential PV locations were studied using Ecotect® and appropriate obstruction factors were assessed. The PV potential was then calculated using the PV Watts program. The systems would be mounted at 42 degrees above horizontal with an azimuth of 180 degrees.

III. Net Zero Feasibility:

The State of Massachusetts' definition for a zero net energy building is "*one that is optimally efficient and, over the course of a year, generates energy onsite, using clean renewable resources, in a quantity equal to or greater than the total amount of energy consumed onsite*". This analysis provides an estimate of the PV system capacity required to achieve a zero net energy building based on site energy use.

Following Table provides a summary of the additional PV requirement for the projects to achieve zero net site energy.

Table 3: Additional PV to Reach Net Zero Site Energy

	Total Annual Energy Use (kWh)	PV Production from Roof (kWh)	Energy Use Not Met by Roof PV (kWh)	Additional kW PV to Reach Net Zero Site	Additional Installation cost ($)
Cypress	1,020,607	150,480	870,127	677	$2,706,136
STEM	1,357,469	127,273	1,230,196	956	$3,825,968

Based on the anticipated energy use estimate from the SD energy models, the Cypress building would require an additional 677kW PV system. At 13 Wp/SF, an additional area of approx. 104,000 SF will be required to accommodate the solar PV system capacity to achieve zero net site energy for the building. Note that typical PV coverage on rooftops is about 50% after accounting for setbacks, space between panels etc.

The STEM building would require an additional 956kW PV system. At 13 Wp/SF, additional space of 147,000 SF will be required to install the additional PV system capacity required to achieve zero net site energy.

Buildings that consume natural gas either directly (as in the case of Cypress), or indirectly through plant HW (as in the case of STEM), do not meet some definitions of net zero regardless of how much solar they generate. For example, the Living Futures Institute defines a "Zero Energy Building" as one in which "*one hundred percent of the building's energy needs on a net annual*

basis must be supplied by onsite renewable energy. No combustion is allowed." Others define a "Net Zero Ready" building as one in which no fossil fuels are used.

Since the proposed design uses natural gas as the fuel source for heating, achieving these stricter definitions of zero net will not be feasible for these projects.