

BROOKLINE
NEW DRISCOLL SCHOOL

HVAC Systems Comparison

1/28/21



Agenda

- Overview of Fossil Fuel Free HVAC Systems
- Review of HVAC Plant Equipment
- Systems Cost Comparison

Alternative Driscoll HVAC Systems Both All Electric (Fossil Fuel Free)

Base Bid: Water Source Heat Pump Heating & Cooling Displacement VAV System with Energy Recovery and Radiant Heating Panels. High efficiency water source heat pump chillers with Fluid Cooler and Supplemental Electric Hot Water Boiler.

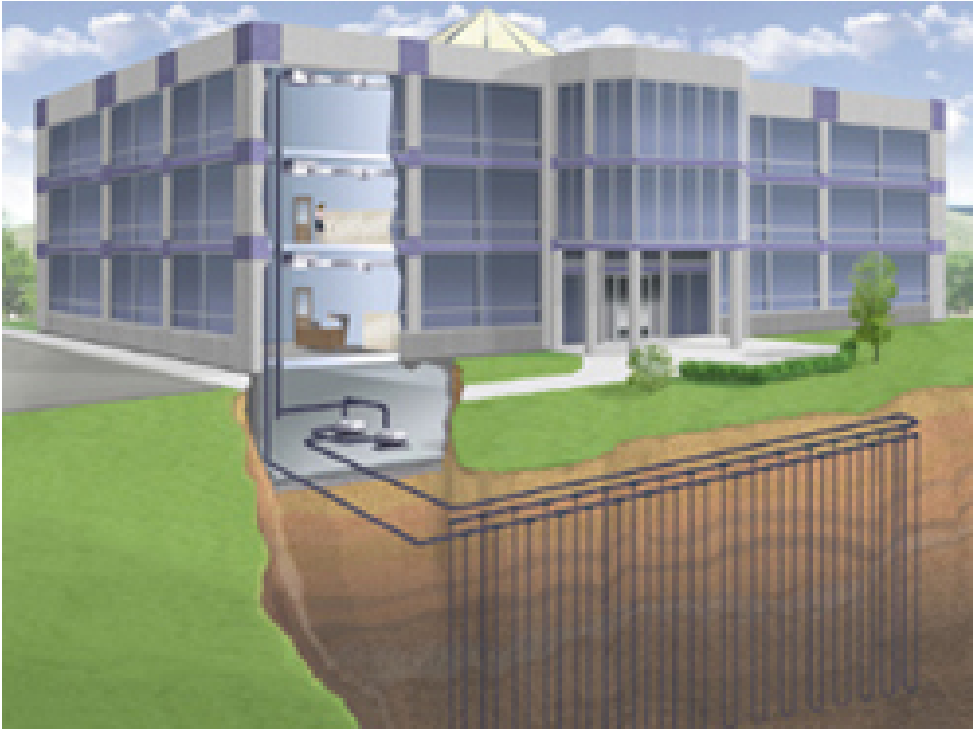
Add Alt: Ground Source Version of Base Bid Displacement System - Geothermal wells are used instead of Dry Coolers and Electric Boilers would be provided only for Back-up heating. Hot water Heating and Chilled water provided by High Efficiency Ground-source Heat Recovery Heat Pumps.

HVAC Displacement Distribution Systems are effectively identical for both systems (and Non-Fossil Fuel Free Systems)

Life Cycle Cost Analysis - Summary

- Base Bid: Water Source Heat Pump Displacement VAV System:
 - Lower First Cost
 - Maintains Benefit of Displacement Ventilation System
 - Second Lowest EUI (Energy Use Intensity) of all systems considered
- Add Alt: – Ground Source Heat Pump Displacement System:
 - Benefits of Displacement Air Ventilation
 - High Efficiency of Ground Source Plant
 - Lower Maintenance Costs
 - Lowest EUI HVAC
- Differences: Base Bid uses Cooling Tower (Dry Cooler) and Supplemental Boiler Plant for Heat Rejection & Absorption as opposed to Ground Source Wells. Electric Boilers for Ground Source would only be for Emergency Back up use.

Ground Source - Closed Loop Well Field



Vertical closed loop wells are used to provide ground source condenser water to heat recovery heat pump chiller plant, which is used to provide hot water heating and chilled water cooling

Pros:

- Lower maintenance costs
- High energy efficiency & Lower operating costs
- Lower replacement costs as pumps located within building and no Cooling Tower or Dry Cooler is required

Cons:

- Test wells required
- Increased permitting
- Higher first cost

Non-Ground Source Option Utilizes Dry Cooler and Supplemental Electric Boilers for Heat Pump Chiller Plant



Closed Cell Dry Coolers (Base Bid)

- Higher Efficiency than Open Loop Cooling Tower
- Lower Maintenance than Open Tower
- Lower Make-Up Water and Chemical Treatment Requirements

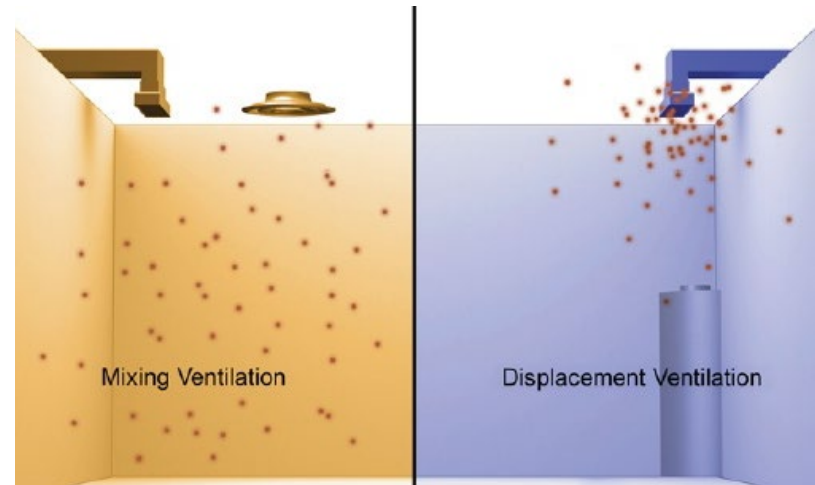


Supplemental Electric Boilers (Both Options)

- Boiler temperature reset controls
- Variable speed pumps with VFD's
- Maintain Condenser Water Loop Temperature in Winter Heating Season
- Increased Boiler use in Base. Boilers for Backup only for Ground Source.

Displacement System (Both Systems)

- Ventilation air is provided from air handling units and supply air is delivered at low velocity and at low levels within the space
- The system uses naturally occurring buoyant forces within the space to create a vertical rise of the air throughout the space.
- Supply air rises when heat source is contacted which displaces room air upward causing pollutants to be exhausted at ceiling returns.



Mixed Systems

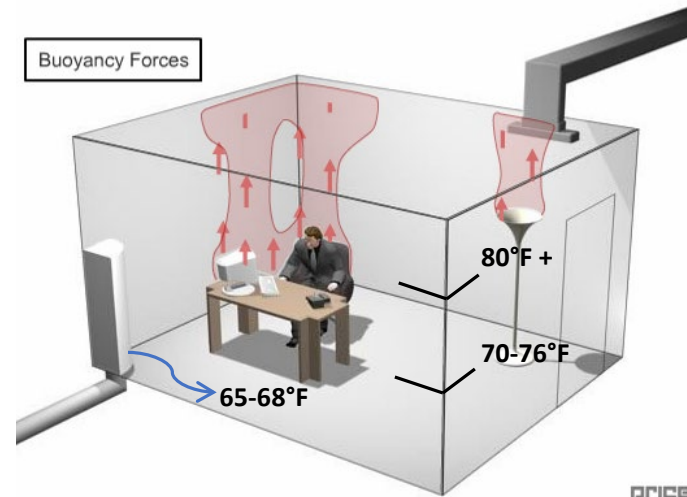
$$E_c = 0.8$$

DV Systems

$$E_c = 1.2 - 1.4$$

Pros:

- **Excellent pollution removal**
- **Low Velocity & Low Noise**
- **Reduced cooling loads**
- **High ventilation effectiveness**
- **Excellent Thermal Comfort**



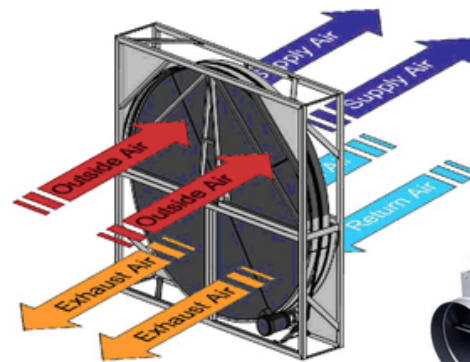
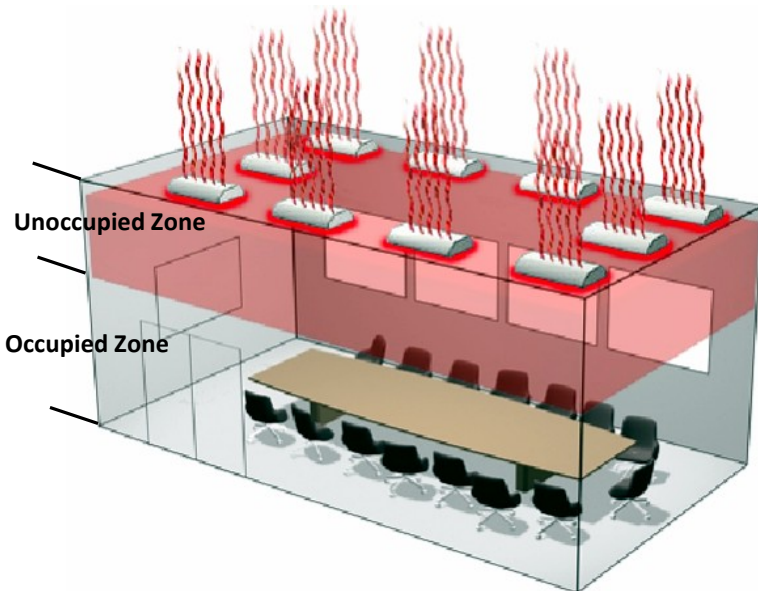
Displacement System – Energy Conservation

Load Calculation Reductions

- Conventional System: All heat generated in room is included in air flow calculation since all airflow is mixed.
- Displacement System: Only loads which occur in the Occupied Zone are factored
- Results in: Smaller equipment & systems and lower installed and operating costs for Displacement Systems

Additional Energy Efficiency Measures

- Energy Recovery: Transfers energy from the return air stream to the supply air stream to pre-heat or pre-cool the outside air.
- Variable Air Volume w/ CO2 Demand Control Ventilation: Modulates the airflow to large single zone areas in accordance to space mounted thermostat and CO2 sensors reducing energy consumption due to reduced air changes.
- Perimeter Radiation Heating – Allows use of Hot Water Heating system for Night Setback and Supplemental Heating



Lifecycle Cost Analysis

Both systems all electric (Fossil Fuel Free)

Base Bid All Electric HVAC System vs Ground Source Add Alt
 90% CD with Bid Input - 1/21/21

Using 2020 Energy Rates	Construction Cost	Elec Cost / Year	Maintenance Cost/Year	Capital Replacement Cost / Year	Combined Annual Expenses	Ground Source Payback Period- Years*
Base Bid	\$9,950,000	\$261,000	\$66,000	\$39,000	\$366,000	
Ground Source	\$12,667,000	\$170,000	\$63,000	\$13,000	\$246,000	22 Years
Delta	\$2,717,000	-\$91,000	-\$3,000	-\$26,000	-\$120,000	

Using 100% Renewable Energy Rates	Construction Cost	Elec Cost / Year	Maintenance Cost/Year	Capital Replacement Cost / Year	Combined Annual Expenses	Ground Source Payback Period- Years*
Base Bid	\$9,950,000	\$317,000	\$66,000	\$39,000	\$422,000	
Ground Source	\$12,667,000	\$211,000	\$63,000	\$13,000	\$287,000	21 Years
Delta	\$2,717,000	-\$106,000	-\$3,000	-\$26,000	-\$135,000	

*Payback period was calculated using Dept of Energy industry standards (BLCC v5.3-18) and includes future worth of each option using the DOE rates for discount (3.4%), escalation, inflation (2.0%), and interest (2.0%).

Energy Use Intensity (EUI - Lower is better)

Ridley School	28
Base Bid	27
Ground Source	21

Both Driscoll system alternatives result in a more efficient building than Brookline's most recent K-8 project

Michael Driscoll School: Brookline, MA

90% CD Cost Estimate Comparison - RECONCILED

1/26/2021

		GSF 157,950		GSF 157,950		Variance (Gilbane - CHA)	
		Gilbane Building Co.		Architect Estimator (CHA)		Total Amount Cost/SF	
		Total Amount	Cost/SF	Total Amount	Cost/SF	Total Amount	Cost/SF
03	Concrete	\$ 6,038,148	\$ 38.23	\$ 5,773,368	\$ 36.55	\$ 264,780	\$ 1.68
04	Masonry	\$ 2,009,052	\$ 12.72	\$ 2,048,050	\$ 12.97	\$ (38,998)	\$ (0.25)
05	Metals	\$ 6,699,025	\$ 42.41	\$ 6,715,698	\$ 42.52	\$ (16,673)	\$ (0.11)
06	Woods, Plastics, and Composites	\$ 3,228,965	\$ 20.44	\$ 3,282,504	\$ 20.78	\$ (53,539)	\$ (0.34)
07	Thermal and Moisture Protection	\$ 3,523,005	\$ 22.30	\$ 3,493,563	\$ 22.12	\$ 29,442	\$ 0.19
08	Openings	\$ 4,830,408	\$ 30.58	\$ 4,783,894	\$ 30.29	\$ 46,514	\$ 0.29
09	Finishes	\$ 10,427,120	\$ 66.02	\$ 10,438,475	\$ 66.09	\$ (11,355)	\$ (0.07)
10	Specialties	\$ 956,873	\$ 6.06	\$ 1,042,150	\$ 6.60	\$ (85,277)	\$ (0.54)
11	Equipment	\$ 746,322	\$ 4.73	\$ 801,021	\$ 5.07	\$ (54,699)	\$ (0.35)
12	Furnishings	\$ 178,318	\$ 1.13	\$ 174,632	\$ 1.11	\$ 3,686	\$ 0.02
14	Conveying Systems	\$ 320,000	\$ 2.03	\$ 355,000	\$ 2.25	\$ (35,000)	\$ (0.22)
21, 22, 23	Mechanical	\$ 13,216,503	\$ 83.68	\$ 13,189,742	\$ 83.51	\$ 26,761	\$ 0.17
26	Electrical	\$ 6,992,257	\$ 44.27	\$ 7,033,669	\$ 44.53	\$ (41,412)	\$ (0.26)
02	Existing Conditions	\$ 1,578,000	\$ 9.99	\$ 2,004,399	\$ 12.69	\$ (426,399)	\$ (2.70)
31	Earthwork	\$ 9,559,787	\$ 60.52	\$ 9,168,490	\$ 58.05	\$ 391,297	\$ 2.48
32	Exterior Improvements	\$ 4,558,922	\$ 28.86	\$ 4,437,322	\$ 28.09	\$ 121,600	\$ 0.77
33	Utilities	\$ 1,115,603	\$ 7.06	\$ 971,951	\$ 6.15	\$ 143,652	\$ 0.91
TOTAL CONSTRUCTION COSTS		\$ 75,978,307	\$ 481.03	\$ 75,713,928	\$ 479.35	\$ 264,379	\$ 1.67
	Design & Estimating Contingency	\$ 435,666	\$ 2.76	\$ 501,000	\$ 3.17	\$ (65,334)	\$ (0.41)
	General Conditions & General Requirements	\$ 8,960,871	\$ 56.73	\$ 8,960,871	\$ 56.73	\$ -	\$ -
	Insurances	\$ 96,230	\$ 0.61	\$ 96,230	\$ 0.61	\$ -	\$ -
	Bonds	\$ 601,680	\$ 3.81	\$ 601,680	\$ 3.81	\$ -	\$ -
	CM Fee (Overhead & Profit)	\$ 2,070,000	\$ 13.11	\$ 2,070,000	\$ 13.11	\$ -	\$ -
	CM GMP Contingency	\$ 2,058,466	\$ 13.03	\$ 2,079,000	\$ 13.16	\$ (20,534)	\$ (0.13)
	SDI / Sub Bond Pool	incl. w/ Trades		incl. w/ Trades	\$ -		
	CCIP (2.65%)	\$ 2,533,004	\$ 16.04	\$ 2,530,000	\$ 16.02	\$ 3,004	\$ 0.02
	Escalation	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
	TOTAL ESTIMATED COSTS 0.20%	\$ 92,734,224	\$ 587.11	\$ 92,552,709	\$ 585.96	\$ 181,515	\$ 1.15
	Geothermal Wells	\$ 2,717,000	\$ 17.20	\$ 2,976,100	\$ 18.84	100% DD Estimate w/ Alts	
	Delete GWB Bumper Rail, Provide Plam Bumper Rail	\$ 275,000	\$ 1.74	\$ 549,600	\$ 3.48	\$ 92,929,979	\$ 588.35
	Terrazzo ILO VCT Flooring at first floor public areas (ROM)	\$ 200,000	\$ 1.27	\$ 200,000	\$ 1.27	100% DD Estimate w/ Alts less VM	
	TOTAL ESTIMATED COSTS W/ ALTERNATES	\$ 95,926,224	\$ 607.32	\$ 96,278,409	\$ 609.55	\$ 92,137,012	\$ 583.33
	EST'D COSTS COMPARED TO BUDGET \$92,791,890	\$ (57,666)	-0.06%	\$ (239,181)	-0.26%	60% CD Estimate w/ Alts	
	EST'D COSTS + ALTS COMPARED TO BUDGET	\$ 3,134,334	3.38%	\$ 3,486,519	3.76%	\$ 93,488,672	\$ 591.89
						60% CD Estimate w/o Alts	
						\$ 89,963,672	\$ 569.57

Michael Driscoll School: Brookline, MA

90% CD vs. 100% DD Cost Estimate Comparison

1/26/2021

		GSF 157,950		GSF 157,950		Variance (90% CD - 100% DD)	
		90% CD - Gilbane Building Co.		100% DD - Gilbane Building Co.			
		Total Amount	Cost/SF	Total Amount	Cost/SF	Total Amount	Cost/SF
03	Concrete	\$ 6,038,148	\$ 38.23	\$ 6,392,818	\$ 40.47	\$ (354,670)	\$ (2.25)
04	Masonry	\$ 2,009,052	\$ 12.72	\$ 1,925,448	\$ 12.19	\$ 83,604	\$ 0.53
05	Metals	\$ 6,699,025	\$ 42.41	\$ 6,542,108	\$ 41.42	\$ 156,917	\$ 0.99
06	Woods, Plastics, and Composites	\$ 3,228,965	\$ 20.44	\$ 3,000,217	\$ 18.99	\$ 228,748	\$ 1.45
07	Thermal and Moisture Protection	\$ 3,523,005	\$ 22.30	\$ 3,467,346	\$ 21.95	\$ 55,659	\$ 0.35
08	Openings	\$ 4,830,408	\$ 30.58	\$ 5,267,240	\$ 33.35	\$ (436,832)	\$ (2.77)
09	Finishes	\$ 10,427,120	\$ 66.02	\$ 9,298,396	\$ 58.87	\$ 1,128,724	\$ 7.15
10	Specialties	\$ 956,873	\$ 6.06	\$ 1,033,067	\$ 6.54	\$ (76,194)	\$ (0.48)
11	Equipment	\$ 746,322	\$ 4.73	\$ 774,555	\$ 4.90	\$ (28,233)	\$ (0.18)
12	Furnishings	\$ 178,318	\$ 1.13	\$ 208,850	\$ 1.32	\$ (30,532)	\$ (0.19)
14	Conveying Systems	\$ 320,000	\$ 2.03	\$ 300,000	\$ 1.90	\$ 20,000	\$ 0.13
21, 22, 23	Mechanical	\$ 13,216,503	\$ 83.68	\$ 14,094,633	\$ 89.23	\$ (878,130)	\$ (5.56)
26	Electrical	\$ 6,992,257	\$ 44.27	\$ 6,871,748	\$ 43.51	\$ 120,509	\$ 0.76
02	Existing Conditions	\$ 1,578,000	\$ 9.99	\$ 1,764,900	\$ 11.17	\$ (186,900)	\$ (1.18)
31	Earthwork	\$ 9,559,787	\$ 60.52	\$ 6,014,805	\$ 38.08	\$ 3,544,982	\$ 22.44
32	Exterior Improvements	\$ 4,558,922	\$ 28.86	\$ 4,064,956	\$ 25.74	\$ 493,966	\$ 3.13
33	Utilities	\$ 1,115,603	\$ 7.06	\$ 772,824	\$ 4.89	\$ 342,779	\$ 2.17
TOTAL CONSTRUCTION COSTS		\$ 75,978,307	\$ 481.03	\$ 71,793,911	\$ 454.54	\$ 4,184,396	\$ 26.49
	Design & Estimating Contingency	\$ 435,666	\$ 2.76	\$ 3,738,124	\$ 23.67	\$ (3,302,458)	\$ (20.91)
	General Conditions & General Requirements	\$ 8,960,871	\$ 56.73	\$ 8,044,705	\$ 50.93	\$ 916,166	\$ 5.80
	Insurances	\$ 96,230	\$ 0.61	\$ 892,030	\$ 5.65	\$ (795,800)	\$ (5.04)
	Bonds	\$ 601,680	\$ 3.81	\$ 601,680	\$ 3.81	\$ -	\$ -
	CM Fee (Overhead & Profit)	\$ 2,070,000	\$ 13.11	\$ 2,070,000	\$ 13.11	\$ -	\$ -
	CM GMP Contingency	\$ 2,058,466	\$ 13.03	\$ 2,055,968	\$ 13.02	\$ 2,498	\$ 0.02
	SDI / Sub Bond Pool	incl. w/ Trades		incl. w/ Trades			
	CCIP (2.65%)	\$ 2,533,004	\$ 16.04	\$ -	\$ -	\$ 2,533,004	\$ 16.04
	Escalation	\$ -	\$ -	\$ 765,000	\$ 4.84	\$ (765,000)	\$ (4.84)
TOTAL ESTIMATED COSTS 2.99%		\$ 92,734,224	\$ 587.11	\$ 89,961,418	\$ 569.56	\$ 2,772,806	\$ 17.55
	Geothermal Wells	\$ 2,717,000	\$ 17.20	\$ 2,693,561	\$ 17.05	100% DD Estimate w/ Alts	
	Delete GWB Bumper Rail, Provide Plam Bumper Rail	\$ 275,000	\$ 1.74	\$ 275,000	\$ 1.74	\$ 92,929,979	\$ 588.35
	Terrazzo ILO VCT Flooring at first floor public areas (ROM)	\$ 200,000	\$ 1.27	\$ 200,000	\$ 1.27	100% DD Estimate w/ Alts less VM	
TOTAL ESTIMATED COSTS W/ ALTERNATES		\$ 95,926,224	\$ 607.32	\$ 93,129,979	\$ 589.62	\$ 92,137,012	\$ 583.33
EST'D COSTS COMPARED TO BUDGET \$92,791,890		\$ (57,666)	-0.06%	\$ (2,830,472)	-3.05%	60% CD Estimate w/ Alts	
EST'D COSTS + ALTS COMPARED TO BUDGET		\$ 3,134,334	3.38%	\$ 338,089	0.36%	\$ 93,488,672	\$ 591.89
						60% CD Estimate w/o Alts	
						\$ 89,963,672	\$ 569.57

Driscoll Elementary School				
Estimate Tracking				
From 90% CD Estimate to Previous DD Estimate				
	1	3	3 - 1	
Estimate / Scope adjustments	100% DD Est	90% CD Est	Variance	Comment
Support of excavation - means & methods, qty at field	\$ 1,942,500	\$ 2,575,029	\$ 632,529	braced sheeting to drilled soldier piles, increased qty due to drain line routing
Bulk Excavation / foundation excavation / interior trenching	\$ 685,000	\$ 751,046	\$ 66,046	~5,000 add'l cuyds
Lean Concrete / Overexcavation	\$ -	\$ 259,787	\$ 259,787	~4,600 add'l cuyds
Soil Management - Offsite Dispose	\$ 1,315,080	\$ 2,101,025	\$ 785,945	37,850 cuyd vs 24,200 cuyds, expanded LOW based on drain and over-ex
Dewatering	\$ 150,000	\$ 451,573	\$ 301,573	dewatering requirements greater than expected, add'l carbon filtration spec
Site Preparation / Logistics (overhead protection)	\$ 454,325	\$ 734,777	\$ 280,452	Also increase in GRs
Temporary Playground increase	\$ 20,000	\$ 79,689	\$ 59,689	
Westbourne Terrace increase	\$ 25,101	\$ 200,226	\$ 175,125	Base scope was limited repair vs bump-puts and more extensive repair
Site Furnishings	\$ 130,950	\$ 234,586	\$ 103,636	Site Benches / Planters
Site Signage	\$ -	\$ 84,000	\$ 84,000	Flashing Pedestrian Sign
Irrigation Systems	\$ 150,000	\$ 186,263	\$ 36,263	Allowance at DD, detailed qty @ CD
Domestic Water Service	\$ 94,737	\$ 179,873	\$ 85,136	2" type K copper to fields
Storm Drainage	\$ 483,874	\$ 784,362	\$ 300,488	Underdrain system, increased structure counts, unit pricing
Market adjustments / Bid Results	-	760,000.00	760,000.00	based on bidding / subcontractor feedback - sitework ~7 - 9% increase
Total			\$ 3,930,669	



Sitework Subcontractor Release options

Option	Pricing Milestone	Percent bought out	Sitework Release date*	Mobilize **	VE Bulletin needed	TCO / Substantial Completion of New Driscoll	Occupy New Driscoll	Field Complete (save a month to delete geothermal)	Time TCO -Move in
1	Leveled Site bids	12%	1/26/2021	3/1/2021	7/1/2021	5/1/2023	9/1/2023	5/1/2024	4 months
2	Concrete, Steel bids	26%	2/15/2021	3/29/2021	7/29/2021	5/29/2023	9/1/2023	5/1/2024	3 months
3	Filed Sub bids+ major subs	69%	3/15/2021	4/26/2021	8/26/2021	6/26/2023	9/1/2023	5/1/2024	2 months
4	All Sub bids	95%	4/15/2021	5/27/2021	9/27/2021	7/27/2023	9/1/2023	5/1/2024	1 month

* Release date assumes special building commission meeting

** Assume 6 weeks from building commission approval to mobilize - based on a notice to proceed right away to get the sub going. Concurrently we would get approval from school committee and select board for the contract amendment
The original schedule cushion from TCO to occupy the school was 2 months.

VE Timeline (if needed)

Start	Complete Selection of items	Complete Drawings
3/15/2021	4/15/2021	7/15/2021

Start process at receipt of filed sub bids, 3/15

1 month to come up with VE selections, price them, and have the town approve them (could be light on time)

3 months to re-do the drawings (assuming no change in square footage)

This timeline works for all but the Option 1, start following Leveled site bids. For option 1 we would have to start the VE process at the time of concrete and steel bids.