NEEDHAM HIGH SCHOOL

CLASSROOM EXPANSION FEASIBILITY STUDY

FINAL REPORT

14 APRIL 2017

DORE & WHITTIER
ARCHITECTS, INC.

260 Merrimac St. Bldg 7, 2nd Flr•Newburyport•Massachusetts
Phone: 978-499-2999 • Fax: 978-499-2944
212 Battery Street• Burlington•Vermont
Phone: 802.863.1428 • Fax: 802.863.6955
www.doreandwhittier.com

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ACKNOWLEDGEMENTS

Dore & Whittier Architects would like to acknowledge the following individuals for their dedication to the Town of Needham for their assistance to the Design Team.

Public Facilities

Carys Lustig, Acting Director – Operations **
Steve Popper, Director Design & Construction *
Hank Haff, Senior Project Manager – Construction *
John Gass, HVAC Technician

Board of Selectmen

Matt Borelli, Chairman **

Town Manager's Office

Kate Fitzpatrick, Town Manager **
Dave Davison, Asst. Town Manager – Finance **

Finance Committee

Barry Coffman *
Rick Zambone **

School Committee

Susan B. Neckes, Chair *
Heidi Black, Vice-Chair **
Michael Greis
Andrea Longo Carter
Kim Marie Nicols
Aaron Pressman

High School Admin. / Staff

Aaron Sicotte, Principal * *(on both PPBC & Task Force)*
Kerri Cence, Lead Secretary
Casey Palmer, Counselor, Special Ed. Teacher *
Andrew Lawrence, Teacher - Math Dept.
Patrick Gallagher, Chair - English Dept. *
Jennifer Regrut, Chair - Science Dept.*
Mike Hirsh, Teacher – Math Dept.**
Anne Weinstein, School Council / Parent *
Nathan Simani, Student *

Public Schools Admin. / Staff

Dan Gutenkanst, Superintendent of Schools **
Terry Duggan, Director of Student Learning **
Anne Gulati, Finance Director **

PPBC

George Kent, Chairman **
Stuart Chandler
Richard Creem
Natasha Espada
Roy Schifilliti
Roy Silverstein
Gene Voloshin
Heidi Black, School Committee Rep.**
Aaron Sicotte, High School Rep. **

* *Working Group Member*
** *Task Force Member*

Design Team:

Architect/Project Manager
Dore & Whittier Architects, Inc.
260 Merrimac Street Bldg. 7
Newburyport, MA 01950
p. 978-499-2999

Civil Engineers
Nitsch Engineering
2 Center Plaza - Suite 430
Boston, MA 02108
p. 617-338-0063

Boiler & Chiller MEP Engineers
Shekar & Associates, Inc.
775 Pleasant St., Unit 14
East Weymouth, MA 02189
p. 781- 337-2952

Structural Engineers
Engineers Design Group
350 Main Street
Malden, MA 02148
p. 781-396-9007

HVAC, Electrical, Plumbing, Fire Protection Engineers
Garcia Galuska DeSousa
370 Faunce Corner Road
Dartmouth, MA 02748
p:508-998-5700

Cost Estimating
PM&C
20 Downer Avenue; Suite 1C
Hingham, MA 02043
p. 781- 740-8007

INTRODUCTION

In August 2016 the Town of Needham submitted a Request For Qualification to review the need for a High School classroom expansion. The original high school was constructed on the existing site in 1930. In 2008 a major renovation and addition was constructed to accommodate a student population of 1450 students. The current student population is 1659 and the enrollment is projected to exceed 1800 by school year 2022-23 and peak in school year 2024-25 at 1835 students.

Since 2008 several non-instructional spaces have been converted to classrooms, and some instructional spaces have been subdivided to accommodate the growing need for teaching spaces. These spaces include storage spaces, and offices. A cafeteria expansion was completed in 2016 to help alleviate some of the over-crowding that occurs within this space and has influenced scheduling.

The Classroom Expansion RFQ requested a review of the existing school schedule to assure the efficient use of existing space, consideration of the use of technology as a means to reduce the need for additional instructional space, and to determine if there is a need for additional instructional space how much space is required to meet the projected enrollment of 1700 – 1800 students.

Dore & Whittier was awarded this project in December of 2016 and began the study of the facility existing conditions, the functional use of space, and a full analysis of the existing schedule in late December 2016. D&W developed a two prong approach to this study. The first part of the study assessed the existing building and site to determine potential locations for additions and renovations and assessed the infrastructure to develop an understanding of the necessary upgrades to both building and infrastructure that would be required for additions and renovations. In the second part of the study, which occurred simultaneously with the first, D&W studied the school schedule, met with teachers, students, and administrators, developed in-depth analysis of the use and limitations of each instructional space within the building, and arrived at an agreed upon number of additional classrooms and educational spaces needed to maintain the quality of educational delivery expected at NHS.

From these two analysis the Design Team developed several options. The options were then evaluated based on their ability to meet the program needs. Time to completion, disruption to the ongoing educational process, and project costs were also considerations in the evaluation process. Over the course of several months each of the options were refined and the final evaluation of the options determined the preferred alternative. These options and the final preferred option are outlined in the Executive Summary and shown in greater detail in the body of the report.

Building Site

Original 1930's High School Building – view from Admiral Gracey Drive

2008 Addition – view of entrance from Webster Street

2008 Gym "B" Addition – view from Admiral Gracey Way

2016 Cafeteria Expansion – view from Webster St. Entrance

EXECUTIVE SUMMARY

As part of the initial study the Design Team identified potential locations for classroom expansion and building renovations. These options included renovations and additions within the building footprint as well as additions to the existing building. Four potential locations were identified.

1) Addition of an intermediate floor within the existing two story library
2) Addition of a roof over the existing courtyard
3) Addition of a new wing on the southwest (Admiral Gracey Drive) side of the building
4) Addition of a new wing on the east (Webster Street) side of the building

Additional areas were initially identified, such as the north side of the existing gymnasiums and the southeast side of the classroom wing. However, these locations proved either to remote or did not provide buildable area for further consideration.

With these potential locations identified D&W and their consultant team of structural, mechanical, electrical, plumbing and fire protection engineers reviewed the existing conditions and documents to determine if the current facility could support the proposed additions or renovations.

FACILITY ASSESSMENT FINDINGS

The existing facility was assessed under the existing building code, the 8th Edition IEBC. It is important to note that the 9th Edition of the IEBC and IBC are scheduled to be issued in July of 2017 and are expected to have a six month implementation timeline. After January 2018 it is assumed that all construction will need to conform to the 9th Edition of the building codes.

The IEBC provides three compliance methods for additions and renovations to existing buildings. The Prescriptive Compliance Method, the Work Area Compliance Method, and the Performance Compliance Method. These methods are outlined further in the Existing Conditions Structural Report. The compliance method chosen for the renovation or additions to the building will depend largely on the final design. Options that included the placement of an intermediate floor in the library or a roof over the existing courtyard will increase the demand / capacity ratio of the existing columns and foundation. However, this increase is not greater than the code allows. Therefore, structural re-enforcement to the existing columns and footings is not expected to be required for these design options. Options that are designed to be structurally independent of the existing building will be designed to meet current codes for seismic and structural capacity. Based on the proposed options structural upgrades to the existing building will not be triggered. The Prescriptive Compliance Method has been suggested for the construction of either the addition and renovation options or the structurally independent options.

The existing heating and cooling plants are currently experiencing some malfunctions. The replacement of the chiller and one of the four boilers, as well as a resolution to the variable gas pressure currently

being supplied to the building is part a separate study that has been conducted congruent to this study. A new boiler and chiller have been proposed as part of that study. These will be sized to accommodate the renovations and additions to the building. Independent distribution units will be designed to accommodate the new addition or renovated spaces. All new systems will be tied into the Town's building management system.

The current electrical system and the stand by emergency power are adequately sized to support the renovation or addition options that have been designed. There is room in the fire alarm panel for expansion, which would be required for the each of the options developed.

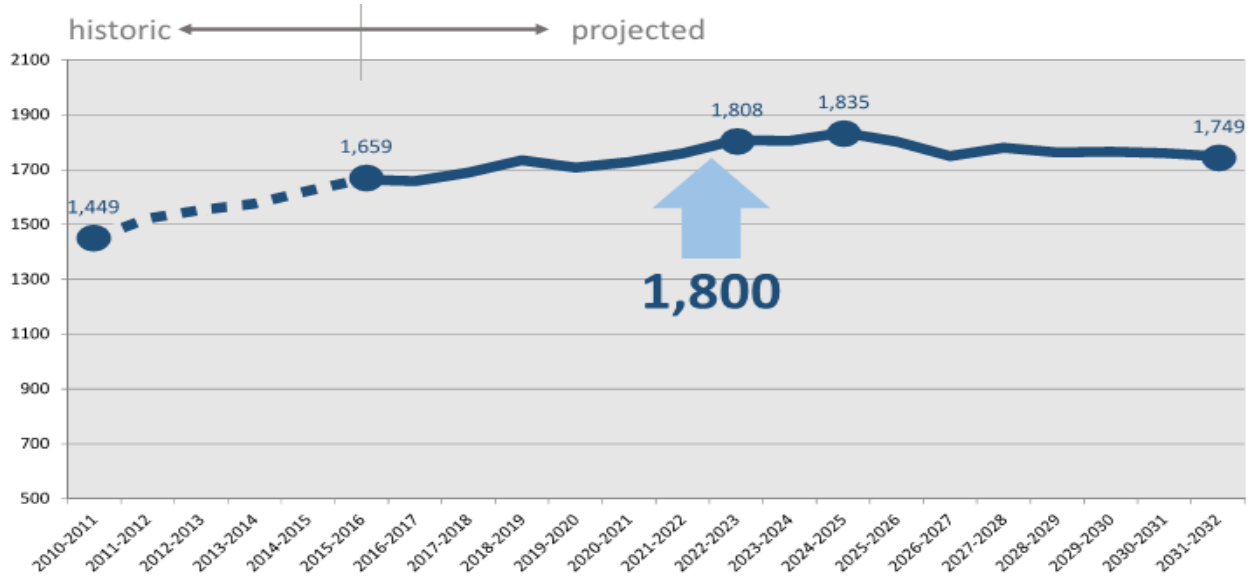
The plumbing and fire protection systems are both adequately sized for the existing building and could support the design options developed.

EDUCATIONAL SPACE NEEDS FINDINGS

Enrollment Forecast

In December of 2016, McKibben Demographics produced an enrollment forecast through the 2031-2032 school year for Needham Public Schools. Their study included forecasts by major grade groupings and for each elementary school catchment area (included in Appendix item K-4). McKibben's methodology differs slightly from other projections produced by the District in the past. It not only took into account the cohort survival ratios of students year to year, but also accounted for localized changes in the residential construction market, the demographic profiles of residents in each elementary catchment area, and the current economic conditions that may impact housing stock turnover. It was a more Needham-specific and nuanced methodology than had been provided by others previously.

McKibben's forecast concluded that the District overall will experience a growth, peak, then decline trajectory over the next fifteen years. It concluded that Needham High School will experience continued growth for the 2017-18 school year through the year 2024-2025, peaking at 1,835 for grades 9th-12th. In the latter half of the forecast, McKibben concludes that the Needham High School enrollment will begin a slow decline to 1,749 students in the 2031-2032 school year – 90 students higher than the enrollment for 2016-17 and 300 hundred higher than the original design enrollment.



Every forecast contains uncertainty. In general terms, the further into the future a forecast is, the greater the uncertainty. Significant changes in the residential interest rates or other market forces impact certainty for enrollment forecasts. For high school projections, however, there tends to be greater certainty because the majority of the students, even in a fifteen year forecast, are already attending school

in the District. Given these considerations, McKibben Demographics' forecasts are typically within 2% of actual realized enrollment.

D&W collaborated with members of the Working Group, the Permanent Public Building Committee and the School Committee to interpret McKibben's findings and to identify an enrollment planning target of 1800 9th-12th grade students. That target represents all general education, special education, and ungraded students (older than 18 who still receive services in the District).

Space Needs Analysis

In order to determine if space needs exist or will exist at Needham High School, D&W performed a detailed analysis of every instructional space and of every section of each course offered. The analysis included documentation of existing space usage, numbers of students enrolled in each course, and the utilization of each instructional space. In general terms, this analysis allowed D&W to fully understand the complexities of Needham High School's daily schedule, its class size practices, and the nuances that make Needham High School unique among its peer schools. D&W's analysis also revealed that enough complexity and nuance exists to render typical laws of averages and rules of thumb incapable of accurately determining needs. The bulleted list below documents D&W key findings:

- Typical analytical and planning benchmarks based on MSBA Guidelines:
  - 23 students per instructional space
  - 85% Utilization[1]
  - 887 SF General Education Classrooms to serve 23 students[2]
- 2016-17 Average Students per Classroom = 19.92[3]
- 2016-17 Average Utilization Rate = 84%
- Most General Education Classrooms are 725 SF (Sized for 19 students using MSBA benchmarks)
- Over-utilization and over-crowding in the Core Academic disciplines are offset by under-utilization and under-crowding in the Fine & Performing Arts departments. However, increasing the utilization of the Fine & Performing Arts spaces is challenging because doing so would result in fewer offerings and reduced access to these programs for certain students due to scheduling conflicts.[4]
- Forty-five percent of Core Academic courses have more than 23 students in each section. Some sections have as many as 28 students in a 725 SF space.
- Certain general education courses are capped at sizes well below the benchmarks to best serve the needs of students. This educational decision impacts average students per classroom calculations. Increasing these caps will negatively impact the educational experience of students.
- The greatest space needs appear to be in the Core Academic disciplines (Math, English, Social Studies, World Languages, and Science).

[1] Utilization refers to the percentage of the school day (calculated by minutes or by periods per cycle) for which students occupy instructional spaces.

[2] MSBA's guideline for high school classrooms is actually a range (800 SF – 925 SF). 877 SF is the numeric average of that range.

[3] Excludes Special Education Courses

[4] Increasing utilization for these spaces may also result in an inappropriate environment (e.g. English in a Chorus Room. Spanish in an Art Room. Math in the Midi Lab.)

- Even with the recently repurposed spaces (converting spaces designed for other purposes into classrooms), there appears to be a need for three additional general education classrooms to serve the current population.

  Math, English, Social Studies, and World Languages
  - Average Utilization Rate = 90%
  - Average Students Per Section = 20.88
  - Total Sections w/ Students ≥ 23 = 147 or 45%
  - Total Sections w/ 16 ≤ Students < 23 = 132 or 40%
  - Total Sections w/ Students < 16 = 50 or 15%
  - 329 Sections @ 85% = 55 Classrooms, 52 Existing

- To serve a population of 1800 students, 60 general classrooms and 15 Science labs are needed. Eight more classrooms and one more science lab than exist today. These spaces would relieve overcrowding in the Core Academic disciplines and allow the District to schedule a maximum of 24 students per section while still allowing lower caps in courses that are in the best interests of students. Proposed additional spaces would not relieve the over-utilization of Core Academic spaces, but would maintain the status quo for utilization even when enrollment increases. This number of classrooms will also require that spaces converted to classrooms continue to serve as classrooms and not revert to their original design purpose.

  - Given the wide variety of students per section, and to provide the greatest flexibility possible, D&W recommends that the 8 general education classrooms are executed in two different types:
    - 6 @ 925 SF (24 students x 38.5 SF per student)
    - 2 @ 1200 SF, dividable into 4 @ 600 SF (31 students x 38.5 SF per student)
  - D&W recommends that the Science Lab be generalized and capable of serving any of the Science disciplines, be 1440 SF, and include an adjacent Science Prep space at 200 SF.

- Should the District choose to absorb the enrollment forecast within its existing facility without additional space, over-utilization and over-crowding conditions would worsen.

  Math, English, Social Studies, and World Languages
  - Average Utilization Rate = 90% → 97%[5]
  - Average Students Per Section = 20.88 → 22.67[6]
  - Total Sections w/ Students ≥ 23 = 147 or 45% → 60%[7]
  - Total Sections w/ 16 ≤ Students < 23 = 132 or 40% → 28%
  - Total Sections w/ Students < 16 = 50 or 15% → 12%

[5] Extremely high utilization rates require sharing of spaces by faculty, faculty members displaced during prep times, and make it more difficult for students to locate teachers when needing assistance.

[6] Higher averages mean higher maximums, as many as 34 students in some sections, and limits the ability to cap sections at lower numbers in the best interests of students.

7 Given the square footage of existing classrooms, high students per section translates into instructional limitations. Faculty and staff will not be able to execute certain activities (e.g. small group exercises or movement activities) simply due to the volume of furniture in the space.

- It is difficult to project Special Education populations. McKibben did not provide a forecast for Special Education. D&W's analysis assumed the current percentage of the overall population would require Special Education and Student Support services in the future. Interviews with administrators, faculty and staff in the Special Education department revealed a need for an additional 5,500 net[8] square feet of instructional, testing, and administrative space to serve a population of 1800 students.

- D&W also conducted a faculty and staff survey to better understand perceived needs. The survey results corroborated the findings in D&W's analysis – that more general education spaces are needed. However, the survey also revealed a perceived need for more student collaboration spaces. This perception was corroborated by students serving on the Working Group and is consistent with current best practices for 21st Century learning places.

    - D&W recommends that design explorations include intentional student collaboration spaces with a wide variety of features.
        - Some Noisy
        - Some Quiet
        - Some Open
        - Some Enclosed
        - Access to WiFi
        - Lots of Vertical Writing Surface
        - Access to Digital Display
        - Some Hard Furnishings
        - Some Soft Furnishings
        - Highly Mobile Furnishings
        - Food Friendly

[8] Net Square Feet refers to the usable floor area of a space. It does not include wall thicknesses, corridors, toilet rooms, or any space associated with building infrastructure (e.g. boiler rooms, electrical closets, etc.)

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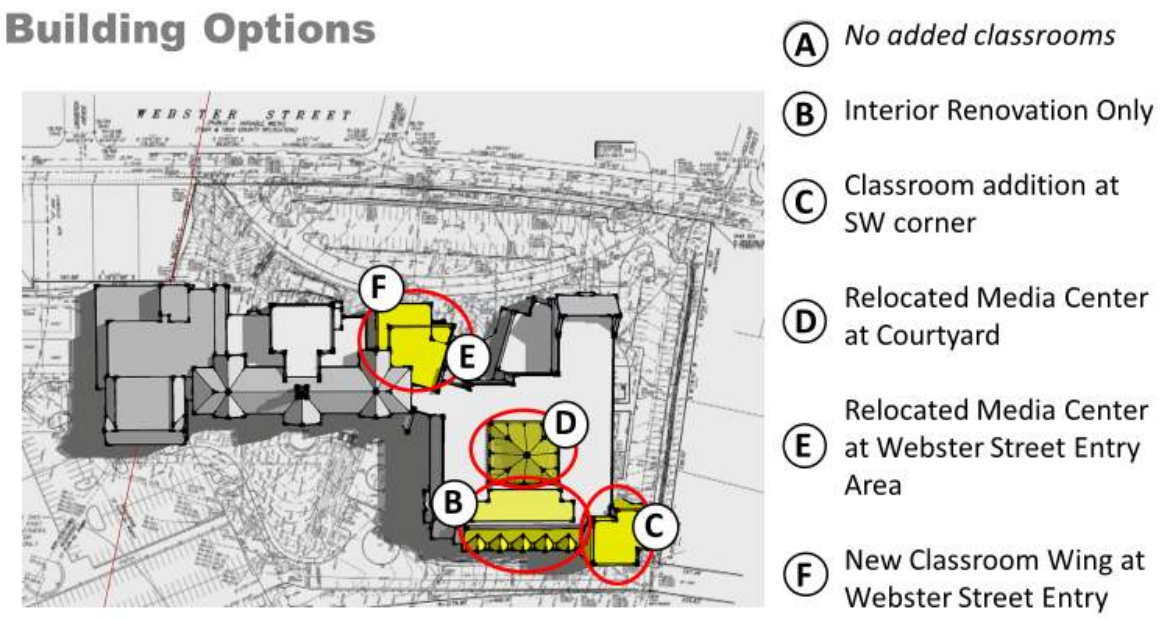
OPTION DEVELOPMENT

Based on the educational space needs the Working Group developed several goals for the design options. These goals are:

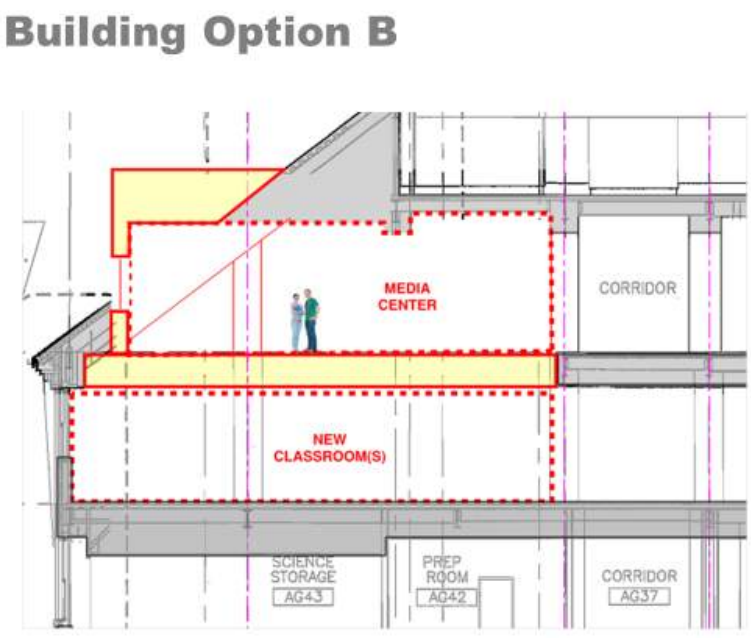
1) Reach 85% utilization rate in core academic classes (Math, English, Social Studies, and World Languages). At a minimum the utilization rate should not increase.
2) Provide 8 additional general classrooms of various sizes for flexibility.
3) Provide 1 additional science room with prep.
4) Provide up to 5,500 sq. ft. additional instructional space special education.
5) Provide student collaboration space.

As noted above the design team identified four potential locations for renovations or additions to the existing building. With the design goals as a guide several options were developed. These options are noted on the site plan below. An outlined of each option and a comparative matrix that shows to what extent each option met the goals above is included.

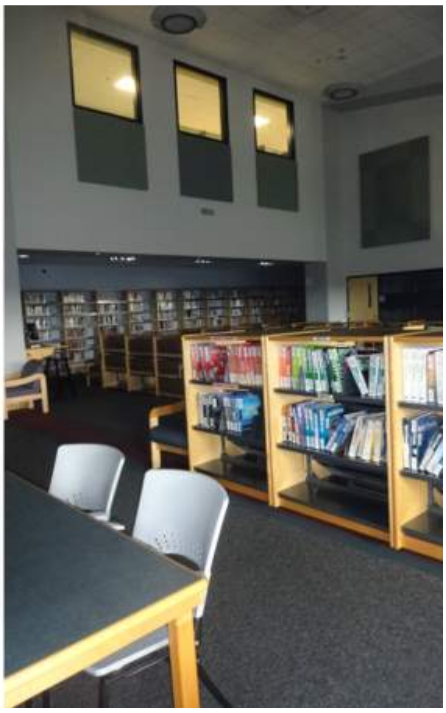


OPTION A : Do Nothing: This option reviewed the effects on the educational program if no additional classrooms were added to the facility. The effects of this option are noted on page B-1-8 and include the increase of the average utilization rate from 90% to 97%, do not provide any new classrooms or science labs, do not add additional space for special education and do not provide student collaboration space. With the anticipated enrollment increase this option does not meet the educational standards set by the Needham School District but does allow the District to assess the results of not adding space to the existing building. This Option did not meet any of the goals outlined by the Working Group.

OPTION B : Relocate Media Center to New Intermediate Floor: This option proposes that a new intermediate floor be added to the existing Media Center. The new floor and dormered roof would provide the school with a new library on the fourth floor, four additional classrooms, approximately 27% of the Special Education square foot needs and one Science and Prep Room. The estimated project cost for this Option is $8.6 million dollars. The opportunities of this option include the ability to provide additional space within the existing building footprint and keep new classrooms near the other core classroom spaces. The low cost of this option is may be considered an opportunity, however, the value achieved for the cost must be considered. Constraints include the reduced size of the new library, invasive construction within the existing building, and not meeting the design goals for the project.



PROPOSED NEW FLOOR



VIEW OF EXISTING LIBRARY

Building Option B

Net gain:

- ***(1) Science Lab + Prep***
- ***(4) Classrooms***

GAINS	LOSSES
+ 3 @1,200 sf	- 3 @ 725 sf
+ 3 @925 sf	
+ 1 @750 sf	

- ***(2) Special Ed. Classrooms***

GAINS	LOSSES
+ 2 @750 sf	none

GABLE END DORMERS

Comparative Matrix

OPTION B

(internal renovations at Media Center area(s) only)

$8.6m

SPACE(S) ADDED:			SPACE(S) LOST:			NET SPACE(S):		
qty.	*nsf size*	*type*	*qty.*	*nsf size*	*type*	*qty.*	*nsf size*	*type*
3	1,200	CLASSROOMS	0	1,200	CLASSROOMS	3	1,200	CLASSROOMS
3	925		0	925		3	925	
1	750		3	725		-2	725-750	
7	**4,728**		**3**	**2,175**		**4**	**2,553**	**TOTAL CLRMS**
2	750	SPECIAL EDUCATON	0	0	SPECIAL EDUCATON	2	750	SPECIAL EDUCATON
2	**1,500**		**0**	**0**		**2**	**1,500**	**TOTAL SPECIAL ED.**
1	1,640	SCIENCE LAB + PREP	0	0	SCIENCE LAB + PREP	1	1,640	SCIENCE LAB + PREP
1	**1640**		**0**	**0**		**1**	**1640**	**TOTAL SCI. + PREP**
1	2500	COLLABORATION	0	0	COLLABORATION	1	2500	COLLABORATION
1	**2500**		**0**	**0**		**1**	**2500**	**TOTAL COLLABORATION**
	10,368.00	**TOTAL ADD SQ. FT.**		**2,175.00**	**TOTAL LOST SQ. FT.**		**8,193.00**	**TOTAL SQ. FT.**

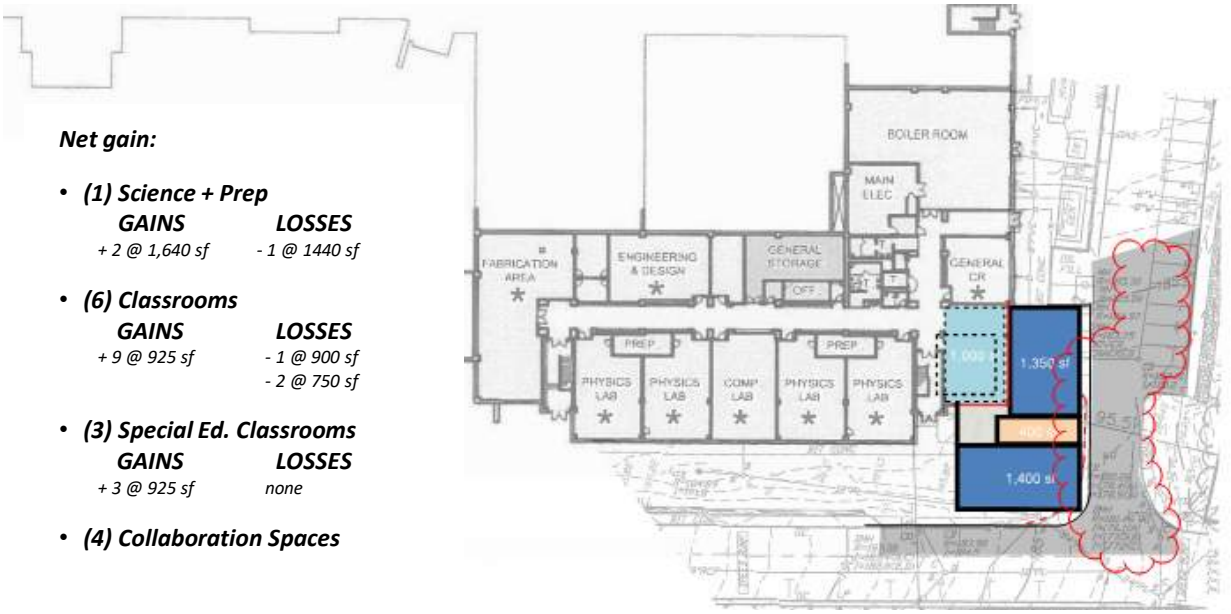
ADDITIONAL CONSIDERATIONS		
	GOALS	
CLASSROOMS	**8**	**50%**
SCI. + PREP	**1**	**100%**
SPECIAL ED.	**5,500 SF**	**27%**
CONSTRAINTS		
Extensive Construction w/in Building		
Reduced / Remote Media Center		
Reduced Department Office		
OPPORTUNITIES		
Renovations Only		

OPTION C : Classroom Addition on the Southwest Corner: This option proposes a new four story addition placed on the corner of the existing building. The lowest level would add science rooms and labs and the upper floors would add general classrooms. Access to the new space would require the demolition of existing classrooms on each floor. The new addition would require some reorganization of the existing access / delivery driveway and parking. This option achieves six general classrooms total, one additional science and prep room, approximately 50% of the Special Education instructional space and some student collaboration space. The project cost for the option is estimated at $9.8 million dollars. The opportunities of this option include the ability to provide additional space without the invasive construction within the existing building and keep new classrooms near the other core classroom spaces. The relatively low cost of this option is may be considered an opportunity, however, the value achieved for the cost must be considered since this option meets only 75% of the classroom goals and 50% of the Special Education goals. Constraints include the disruption to adjacent classrooms during construction, loss of some parking, disruption to the Admiral Gracey Drive access, and the need to provide up to four temporary classrooms until construction is completed.

Building Option C

Net gain:

- ***(1) Science + Prep***
  GAINS ***LOSSES***
  + 2 @ 1,640 sf *- 1 @ 1440 sf*
- ***(6) Classrooms***
  GAINS ***LOSSES***
  + 9 @ 925 sf *- 1 @ 900 sf*
  - 2 @ 750 sf
- ***(3) Special Ed. Classrooms***
  GAINS ***LOSSES***
  + 3 @ 925 sf *none*
- ***(4) Collaboration Spaces***



Comparative Matrix

OPTION C	SPACE(S) ADDED:			SPACE(S) LOST:			NET SPACE(S):		
(Corner addition at SW corner)	qty.	nsf size	type	qty.	nsf size	type	qty.	nsf size	type
	0	1,200		0	1,200		0	1,200	CLASSROOMS
	9	925	CLASSROOMS	1	900	CLASSROOMS	8	925-900	
	0	750		2	750		-2	750	
	9	**8,325**		**3**	**2,400**		**6**	**5,925**	**TOTAL CLRMS**
	3	925	SPECIAL EDUCATION	0		SPECIAL EDUCATION	3	925	SPECIAL EDUCATION
	3	**2775**		**0**	**0**		**3**	**2,775**	**TOTAL SPECIAL ED.**
$9.8m	2	1,540	SCIENCE LAB	1	1,440	SCIENCE LAB	1	1,640	SCIENCE LAB + PREP
	2	**3,080**		**1**	**1,440**		**1**	**1,640**	**TOTAL SCI. + PREP**
	4	1,000	COLLABORATION	0	0	COLLABORATION	4	1,000	COLLABORATION
	4	**4,000**		**0**	**0**		**4**	**4,000**	**TOTAL COLLABORATION**
		18,180.00	**TOTAL ADD SQ. FT.**		**3,840.00**	**TOTAL LOST SQ. FT.**		**14,340.00**	**TOTAL SQ. FT.**

ADDITIONAL CONSIDERATIONS		
	GOALS	
CLASSROOMS	**8**	**75%**
SCI. + PREP	**1**	**100%**
SPECIAL ED.	**5,500 SF**	**50%**
CONSTRAINTS		
Tempoary Classrooms Needd		
Impact to Adjacent Classrooms		
Impact to Adjacent Site Area		
OPPORTUNITIES		
Single Phase Construction		

OPTION D : Relocation of the Media Center to the Courtyard: This option proposes a that a skylight roof system is placed over the existing courtyard to enclose the courtyard and create a centralized library / media center. This option also includes the installation of an intermediate floor in the existing library (similar to Option B) to create additional classrooms on two levels. The relocation of office spaces to be adjacent to the library lower level would create more classrooms on the upper levels of the 2008 addition and the installation of a "Hellerup" stairway connects the second level to the center of the library creating collaboration and interactive space at the heart of the building. This option achieves eight new general classrooms, one science and prep room, and approximately 40% of the Special Education instructional space noted by the Working Group. Student collaboration space is included within the new library and in the corridors outside the existing library. The project cost for the option is estimated to be $22.3 million dollars. The opportunities of this option include the location of the media center at the heart of the building, reducing the current wayfinding issues, the ability to connect the new library to the first floor and the second floor and provide student collaboration space. Additional classrooms are provided within the core classroom areas. Constraints include the cost of this option. This option is the most costly of the five options studied. It does not achieve 100% of the goals and the construction of this option will need to be phased creating a longer period of disruption to students.

PROPOSED ELEVATION OF COURTYARD ENCLOSURE

Building Option D

Net gain:

- ***(1) Science + Prep***

GAINS	LOSSES
+ 1 @ 1,640 sf	none

- ***(8) Classrooms***

GAINS	LOSSES
+ 5 @ 750 sf	- 8 @ 750 sf
+ 2 @ 800 sf	
+ 6 @ 950 sf	
+ 3 @ 1200 sf	

- ***(3) Special Ed. Classrooms***

GAINS	LOSSES
+ 3 @ 750 sf	none

- ***(1) Collaboration Spaces***

Comparative Matrix

OPTION D
(new Media Center at Courtyard)

$22.3m

NET SPACE(S) ADDED:			NET SPACE(S) LOST:			NET SPACE(S):		
qty.	nsf size	type	qty.	nsf size	type	qty.	nsf size	type
3	1,200	CLASSROOMS	0	1,200	CLASSROOMS	3	1,200	CLASSROOMS
6	950		0	950		6	950	
2	800		0	800		2	800	
5	750		8	750		-3	750	
16	**14,650**		**8**	**6,000**		**8**	**8,650**	**TOTAL CLRMS**
3	750	SPECIAL EDUCATION	0	0	SPECIAL EDUCATION	3	750	SPECIAL EDUCATION
3	**2250**		**0**	**0**		**3**	**2,250**	**TOTAL SPECIAL ED.**
1	1,640	SCIENCE LAB	0	0	SCIENCE LAB	1	1,640	SCIENCE LAB
1	**1,640**		**0**	**0**		**1**	**1,640**	**TOTAL SCI. + PREP**
1	2,500	COLLABORATION	0	0	COLLABORATION	1	2,500	COLLABORATION
4	**2,500**		**0**	**0**		**4**	**2,500**	**TOTAL COLLABORATION**
	21,040.00	**TOTAL ADD SQ. FT.**		**6,000.00**	**TOTAL LOST SQ. FT.**		**15,040.00**	**TOTAL SQ. FT.**

ADDITIONAL CONSIDERATIONS		
	GOALS	
CLASSROOMS	8	100%
SCI. + PREP	1	100%
SPECIAL ED.	5,500 SF	41%
CONSTRAINTS		
Multi-phased Construction		
Extensive Construction w/in Building		
Reduced Media Size		
Reduced Department Offices		
OPPORTUNITIES		
Centralized Media Center		

OPTION E : Relocation of the Media Center to Webster Street Addition: Option E proposes a new addition on the Webster Street side of the building adjacent to the existing building entrance. The addition would provide space for administration on the ground / entrance level and a new library media center on two floors above the administration wing. Placing both the library and the media center at the prominent front of the building provides many advantages for after school use of the library, wayfinding to both the library and the administration office and administrative views of the entrance. The new library could be enlarged to accommodate student collaboration space and would be located at the "knuckle" of the school, strengthening the connection between the old and new areas of the school. This option also includes the installation of an intermediate floor in the existing library (similar to Option B) to create additional classrooms on two levels. This option achieves eight new general classrooms, one science and prep room, and approximately 75% of the Special Education instructional space noted by the Working Group. Student collaboration space is included within the new library and in the corridors outside the existing library. The project cost for the option is estimated to be $17.5 million dollars. The opportunities of this option include the location of the media center and the administrative offices at the front of the building, reducing the current wayfinding issues for both spaces, the ability to connect the old and new sections of the building, and provide student collaboration space. Additional classrooms are provided within the core classroom areas. Constraints include the cost of this option, and the multi-phased construction.

Building Option E

Net gain:

- ***(1) Science + Prep***

GAINS	LOSSES
+ 1 @ 1,440 sf	*none*

- ***(8) Classrooms***

GAINS	LOSSES
+ 2 @ 750 sf	*- 3 @ 750 sf*
+ 2 @ 800 sf	
+ 4 @ 950 sf	
+ 3 @ 1200 sf	

- ***(5) Special Ed. Classrooms***

GAINS	LOSSES
+ 3 @ 750 sf	*none*
+ 2 @ 950 SF	

- ***(1) Collaboration Spaces***

Comparative Matrix

OPTION E
(new Media Center at Webster St. Entry)

$17.5m

NET SPACE(S) ADDED:			NET SPACE(S) LOST:			NET SPACE(S):		
qty.	nsf size	type	qty.	nsf size	type	qty.	nsf size	type
3	1,200	CLASSROOMS	0	1,200	CLASSROOMS	3	1,200	CLASSROOMS
4	950		0	950		4	950	
2	800		0	800		2	800	
2	750		3	750		-1	750	
11	**10,500**		**3**	**2,250**		**8**	**8,250**	**TOTAL CLRMS**
2	950	SPECIAL EDUCATION	0	0	SPECIAL EDUCATION	2	950	SPECIAL EDUCATION
3	750		0	0		3	750	
5	**4150**		**0**	**0**		**5**	**4,150**	**TOTAL SPECIAL ED.**
1	1,640	SCIENCE LAB	0	0	SCIENCE LAB	1	1,640	SCIENCE LAB
1	**1,640**		**0**	**0**		**1**	**1,640**	**TOTAL SCI. + PREP**
1	2,500	COLLABORATION	0	0	COLLABORATION	1	2,500	COLLABORATION
1	**2,500**		**0**	**0**		**1**	**2,500**	**TOTAL COLLABORATION**
	18,790.00	**TOTAL ADD SQ. FT.**		**2,250.00**	**TOTAL LOST SQ. FT.**		**16,540.00**	**TOTAL SQ. FT.**

ADDITIONAL CONSIDERATIONS		
	GOALS	
CLASSROOMS	8	100%
SCI. + PREP	1	100%
SPECIAL ED.	5,500 SF	75%
CONSTRAINTS		
Extensive Construction w/in Building		
Multi Phase		
Construction impact to bus loop & parkin		
Construction impact to building entrance		
OPPORTUNITIES		
New Media Center		
Centeralized Classrooms		
Improved Admin. Connection		

OPTION F : Classroom Wing on Webster Street Addition: Option F was developed from Option E. Taking some of the important factors such as the location of the Administration area and the strengthening the connection between the old side of the school and the newer side of the school. Option F strived to achieve the each of the goals outlined and reduce the number of phases and educational impact on students during construction. The proposed new addition on the Webster Street side of the building is adjacent to the existing building entrance. The addition would provide space for administration on the ground / entrance level and new classrooms on two floors above. Placing the administration area in this location provides clear wayfinding to this space, and views of the entrance area from the administration spaces. The new wing may accommodate student collaboration space, within the design and brings general classrooms closer to the center of the building providing a connection between the old and new areas of the school. This option achieves eight new general classrooms, one science and prep room, and approximately 80% of the Special Education instructional space noted by the Working Group. The project cost for the option is estimated to be $11.4 million dollars. In assessing the value of the cost it is important to note that this option achieves the highest level of goals. Constraints include the cost of this option, and the separation of classrooms from the general classroom area.

Building Option F

Net gain:

- ***(1) Science + Prep***

GAINS	LOSSES
+ 1 @ 1000 sf	*none*

- ***(8) Classrooms***

GAINS	LOSSES
+7 @ 925 sf	*- 1 @ 925*
+2 @ 1200 sf	

- ***(4) Special Ed. Classrooms***

GAINS	LOSSES
+ 2 @ 725 sf	*none*
+ 2 @ 925 sf	
+ 1 @ 1100 sf	

- ***(2) Collaboration Spaces***

Comparative Matrix

OPTION F
(new Classroom Wing at Webster St. Entry)

$11.4m

NET SPACE(S) ADDED:			NET SPACE(S) LOST:			NET SPACE(S):		
qty.	*nsf size*	*type*	*qty.*	*nsf size*	*type*	*qty.*	*nsf size*	*type*
2	1,200		0	1,200		2	1,200	
7	925	CLASSROOMS	1	925	CLASSROOMS	6	925	CLASSROOMS
0	725		0	725		0	725	
9	**8,875**		**1**	**925**		**8**	**7,950**	**TOTAL CLRMS**
1	1,100		0	1,100		1	1,100	
2	925	SPECIAL EDUCATION	0	925	SPECIAL EDUCATION	2	925	SPECIAL EDUCATION
2	725		0	725		2	725	
4	**4400**		**0**	**0**		**4**	**4,400**	**TOTAL SPECIAL ED.**
1	1,000	SCIENCE LAB	0	0	SCIENCE LAB	1	1,000	SCIENCE LAB
1	**1,000**		**0**	**0**		**1**	**1,000**	**TOTAL SCI. + PREP**
2	800	COLLABORATION	0	0	COLLABORATION	2	800	COLLABORATION
1	**1,600**		**0**	**0**		**1**	**1,600**	**TOTAL COLLABORATION**
	15,875.00	**TOTAL ADD SQ. FT.**		**925.00**	**TOTAL LOST SQ. FT.**		**14,950.00**	**TOTAL SQ. FT.**

ADDITIONAL CONSIDERATIONS		
	GOALS	
CLASSROOMS	**8**	**100%**
SCI. + PREP	**1**	**100%**
SPECIAL ED.	**5,500 SF**	**80%**
CONSTRAINTS		
Construction impact to bus loop & parkin		
Construction impact to building entrance		
OPPORTUNITIES		
Improved Admin. Connection		
Reduced impact during construction		

CONCLUSION

Over the course of several months the analysis and Options were presented to the Working Group, NHS Task Force, Needham School Committee, and PPBC. On March 21, 2017 the School Committee voted to recommend Option F for approval by the PPBC. A joint meeting was held on March 27, 2017 for the School Committee and the PPBC and vote proceed with Option F was unanimously approved by the PPBC.

EXSITING CONDITIONS

ARCHITECTURAL

Figure 1 – Webster Street Entry

Needham High School is situated on a hill overlooking Memorial Park, and is located very nearly at the geographical center of town. The original building was completed in 1930. Following World War II, the Town experienced a period of rapid growth, necessitating additions that were opened in 1955 and in 1967. Parts of these additions were then demolished in 2008 due to a complete renovation & new addition to the school. The $62 million project consisting of a new building to the south of the original, which was opened in the fall of 2006. The next phase – a smaller wing, opened in the fall of 2007; and just recently the Cafeteria was expanded.

Figure 2 - View of original High School

The entire facility remains in relatively decent shape, and for the most part meets current building, life safety, and energy codes. The facility is a mix of architectural styles spanning from early 20th century through to the contemporary addition completed in 2008 *(see fig. 4)*. The original, and post-war era additions – including gym 'A' and adjacent portions of the structure, are constructed with masonry load bearing walls, consisting of a mix of pitched and flat roofs on 3 levels while the newer addition is of modern steel brace-frame and concrete slab construction of 4 levels for a facility total of 285,000 square feet. The lowest level – level 1, is at the west side of the newer addition and comprised mainly of science classrooms. The highest level – level 5, the top floor of the original historic school building, where four art studios, two enters, and two storage spaces exist. The three intermediate levels span from one end of the facility to the other – old and new. The main entrance, as well as administrative offices, the cafeteria, and several core academic spaces – were built as part of the 2006 expansion at level 2.

The newer addition was designed based on a target enrollment in 2004 of 1,450 students. The enrollment is now at approx. 1,650 and projected to grow to over 1,800 by 2024 / 2025 (refer to the Enrollment Projection and Space Needs sections for detailed analysis). The 2004-2008 addition was built to

Massachusetts School Building Authority guideless and continues to perform well. Part of this large addition was constructed to the north side of the original high school building; a new gymnasium (Gymnasium 'B') – adjacent to gym 'A' (which was constructed in the 1950's). Other spaces housed in the original portion of the building include athletic locker rooms, fitness spaces, music instructional areas, and the auditorium. The largest portion of the 2004-2008 addition is to the south, and forms much of the current core academic classroom space and houses department offices, guidance, administration, and the media center.

As part of the 2004-2008 large-scale renovation / addition, a completely new physical plant was constructed to provide a facility-wide heating system hot water supply, cooling system chilled water supply, domestic hot water supply, and electrical distribution. As part of the feasibility study, both the boiler and temperature controls system, and the air-cooled chiller (Fig. 2) have been reviewed in detail (see associated sections of the report for full analysis, detail, recommendations, and cost estimates). Three of the four boilers have been shown to be in good shape, and expected to perform for at least another 10 years. The fourth has been decommissioned and is used for spare parts, as the manufacturer no longer produces replacement castings for the units installed in 2006. Key to the study was determining the cause(s) of the documented under-performing heating / gas supply system and to recommend repairs, as well as investigate options for emergency back-up / dual fuel systems. The air-cooled chiller *(fig. 3)* failed several years ago, and was deemed not repairable (see section for replacement plans information).

Figure 3 – decommissioned air-cooled chiller

Figure 4 - Aerial View of High School showing building sections

The campus is surrounded by residential neighborhoods of three sides, and by Highland Avenue with Needham Memorial Park (the large open space & ball fields) in between. Primary vehicle access is to the south, via Admiral Gracey Drive – off Kingsbury Street. The bus drop-off area, as well as visitor and some staff parking, are off Webster Street on the east side. The site has both shallow and steep slopes, several parking lots, and a service area / loading dock zone outside the physical plan to the south. The facilities electrical service entrance equipment, diesel powered stand-by backup generator, gas service, as well as the air-cooled chiller unit are all located in this zone.

Figure 5 – Needham GIS Base Map of High School neighborhood

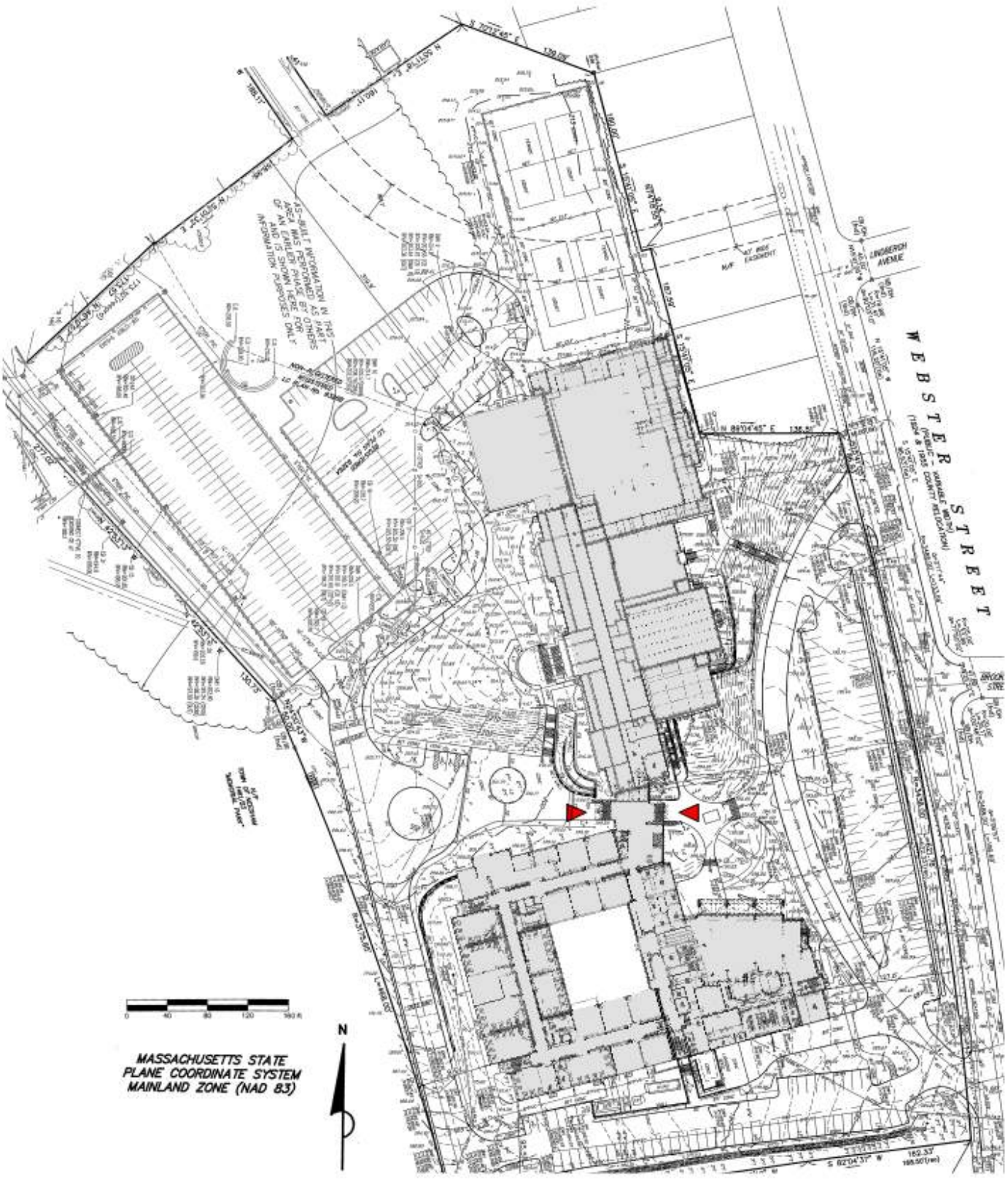
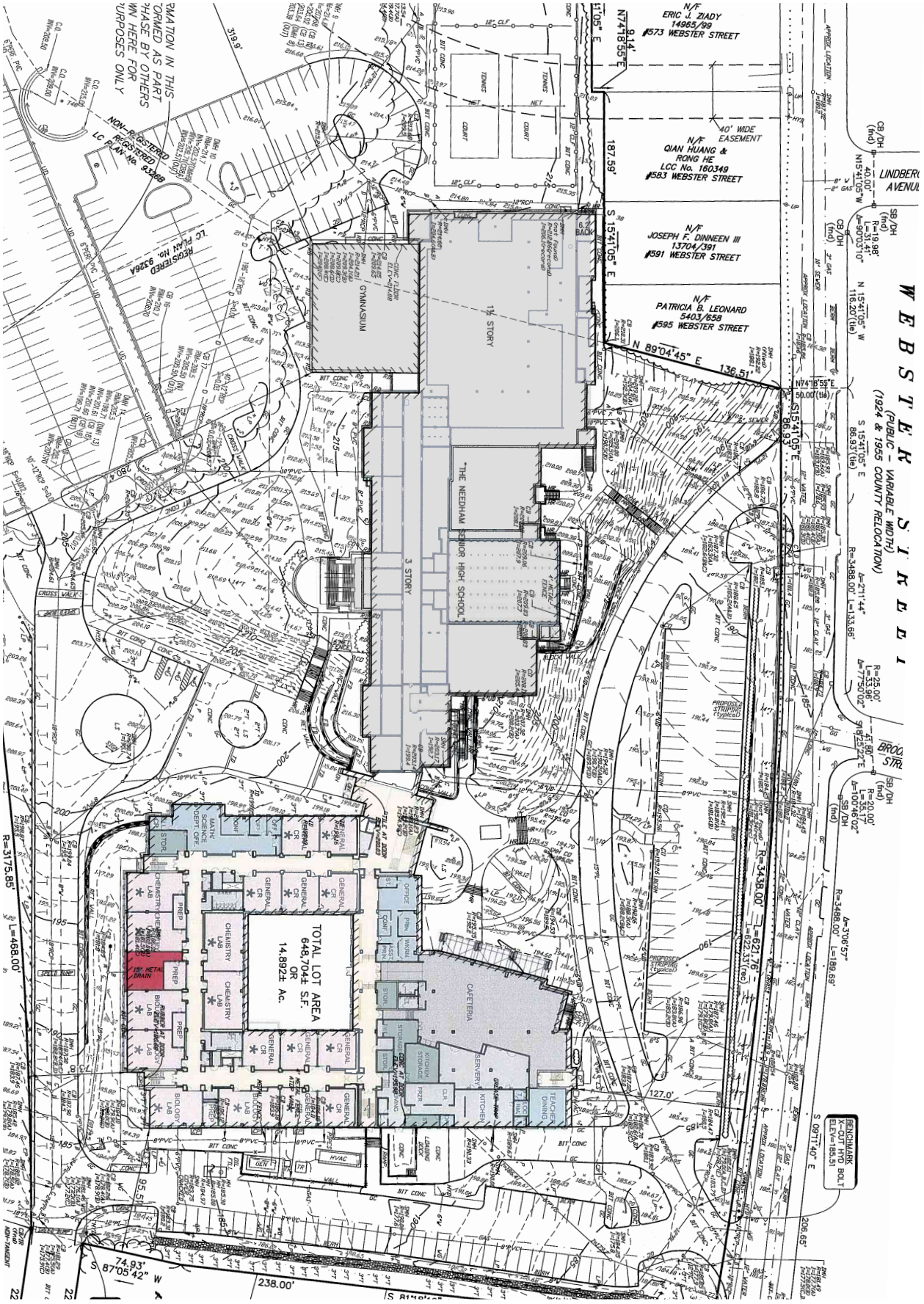
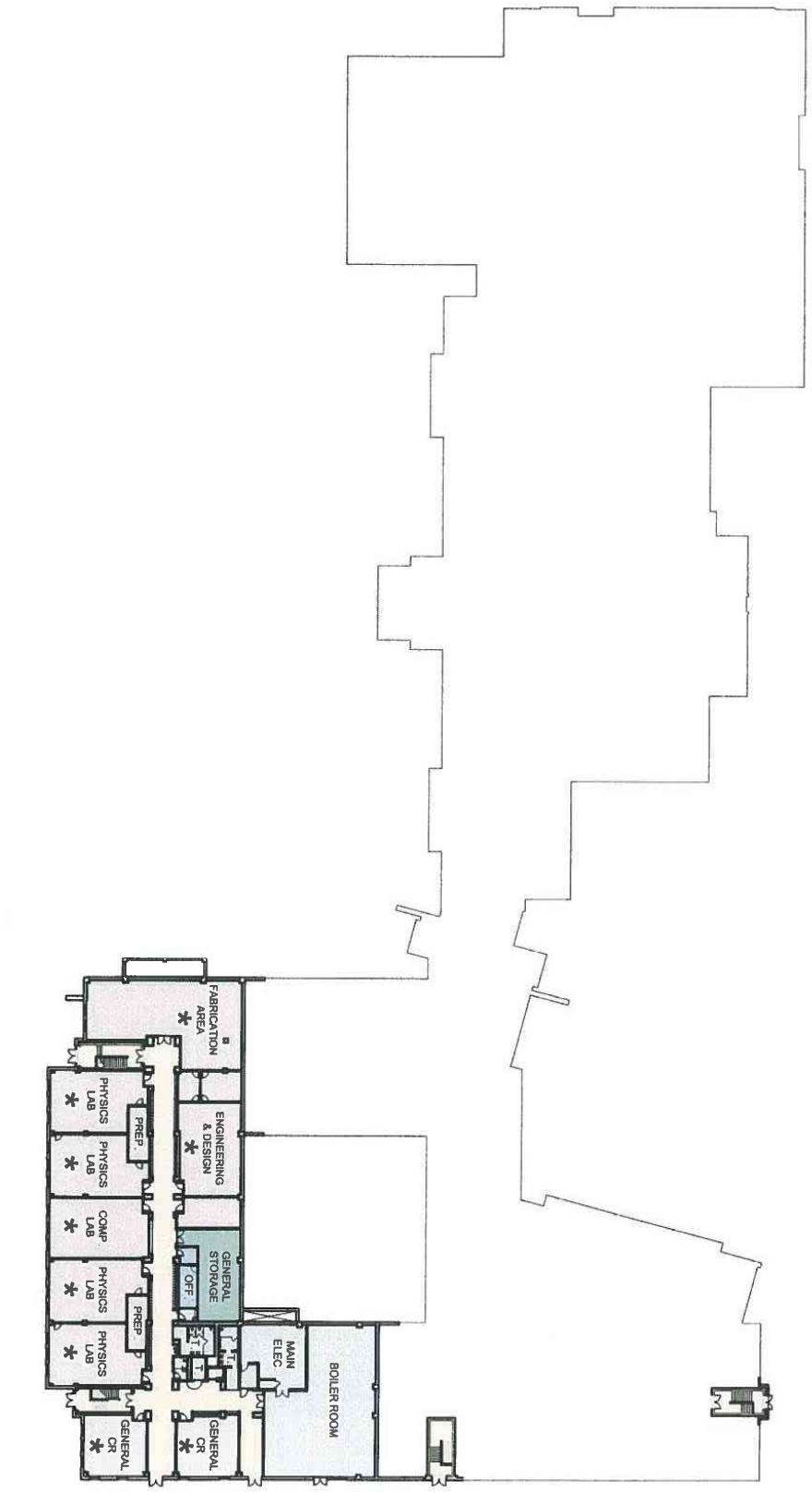


Figure 6 - Site Plan

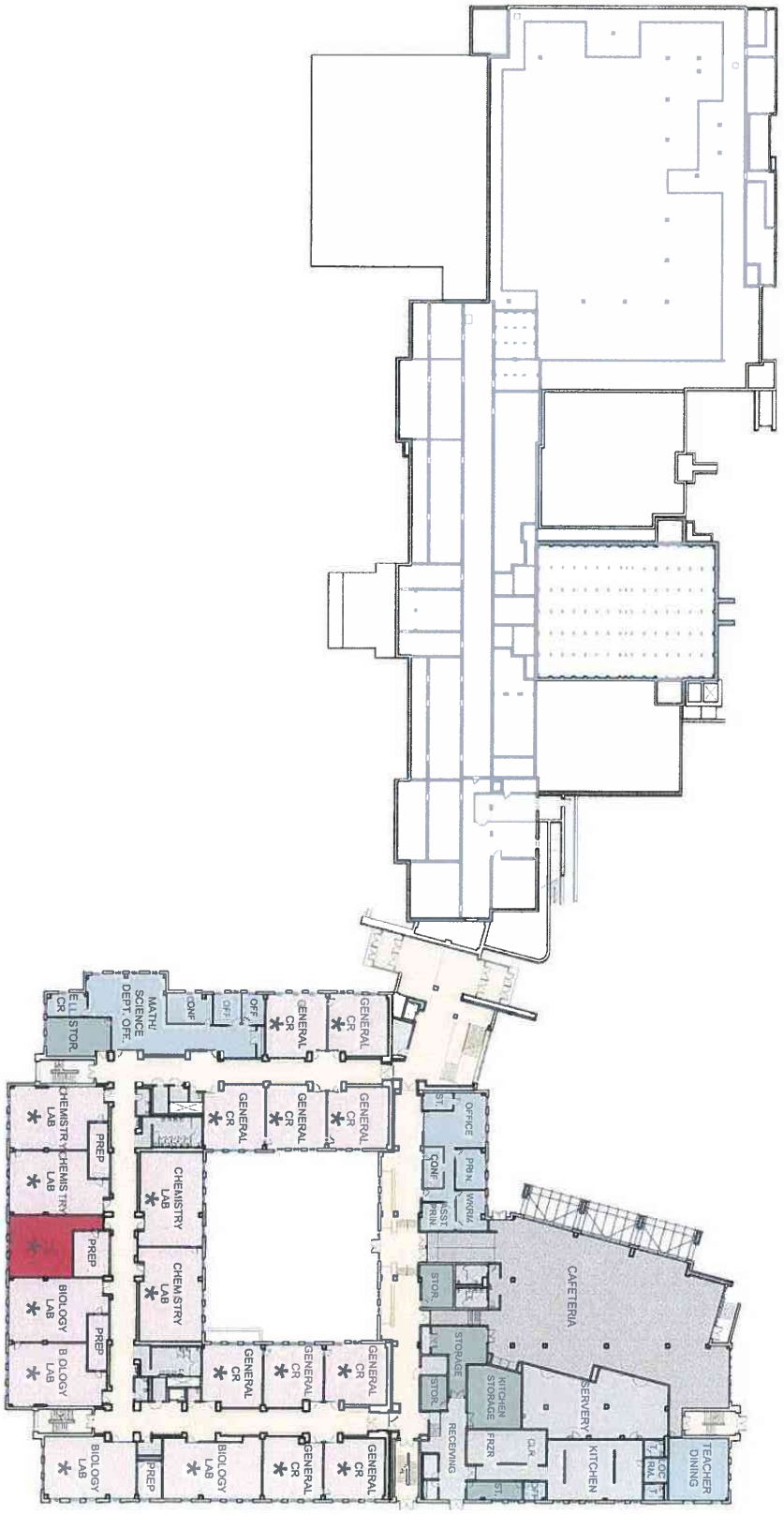
EXSITING SITE AND FLOOR PLANS



SITE PLAN - NOT TO SCALE



LEVEL 1 - NOT TO SCALE



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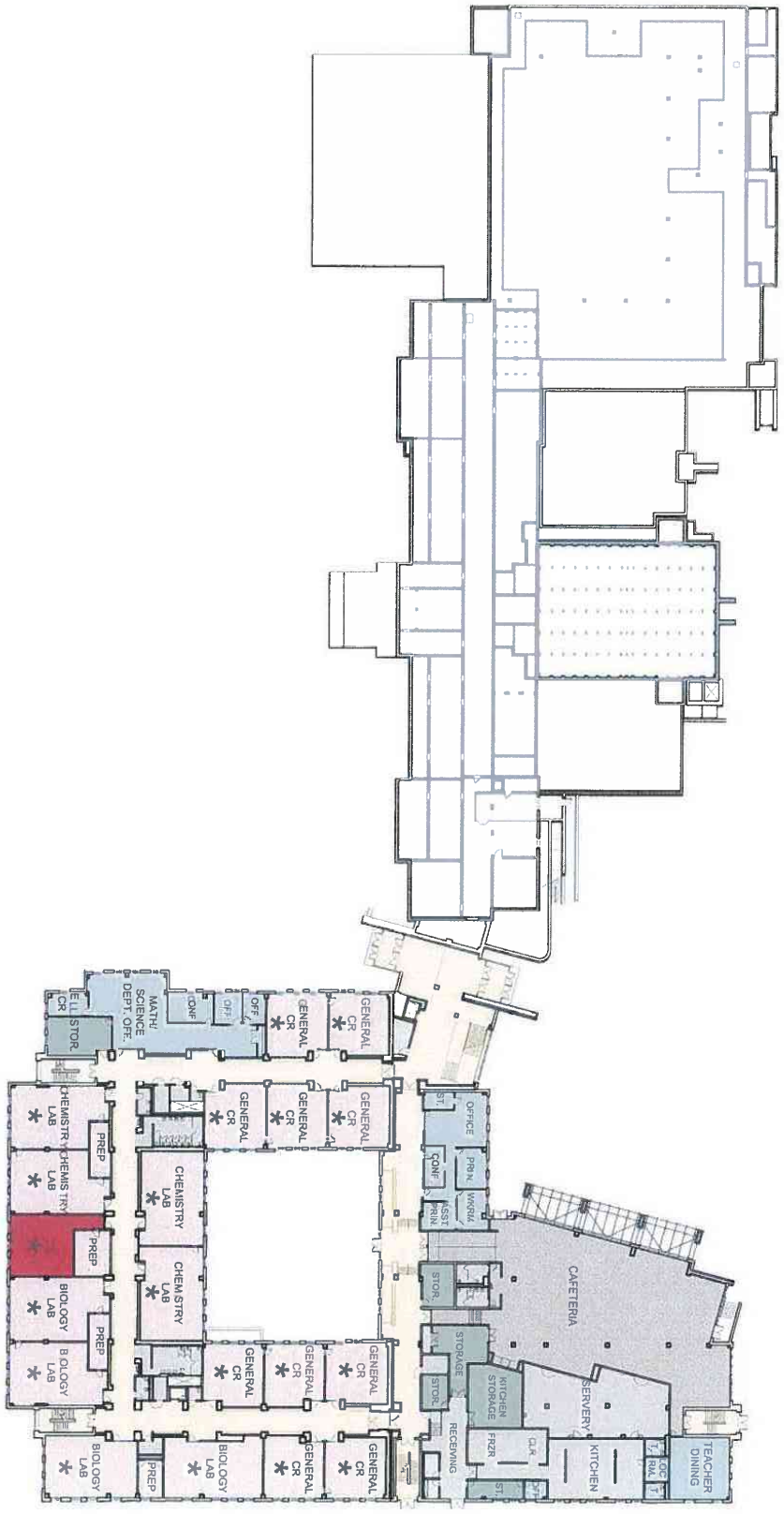

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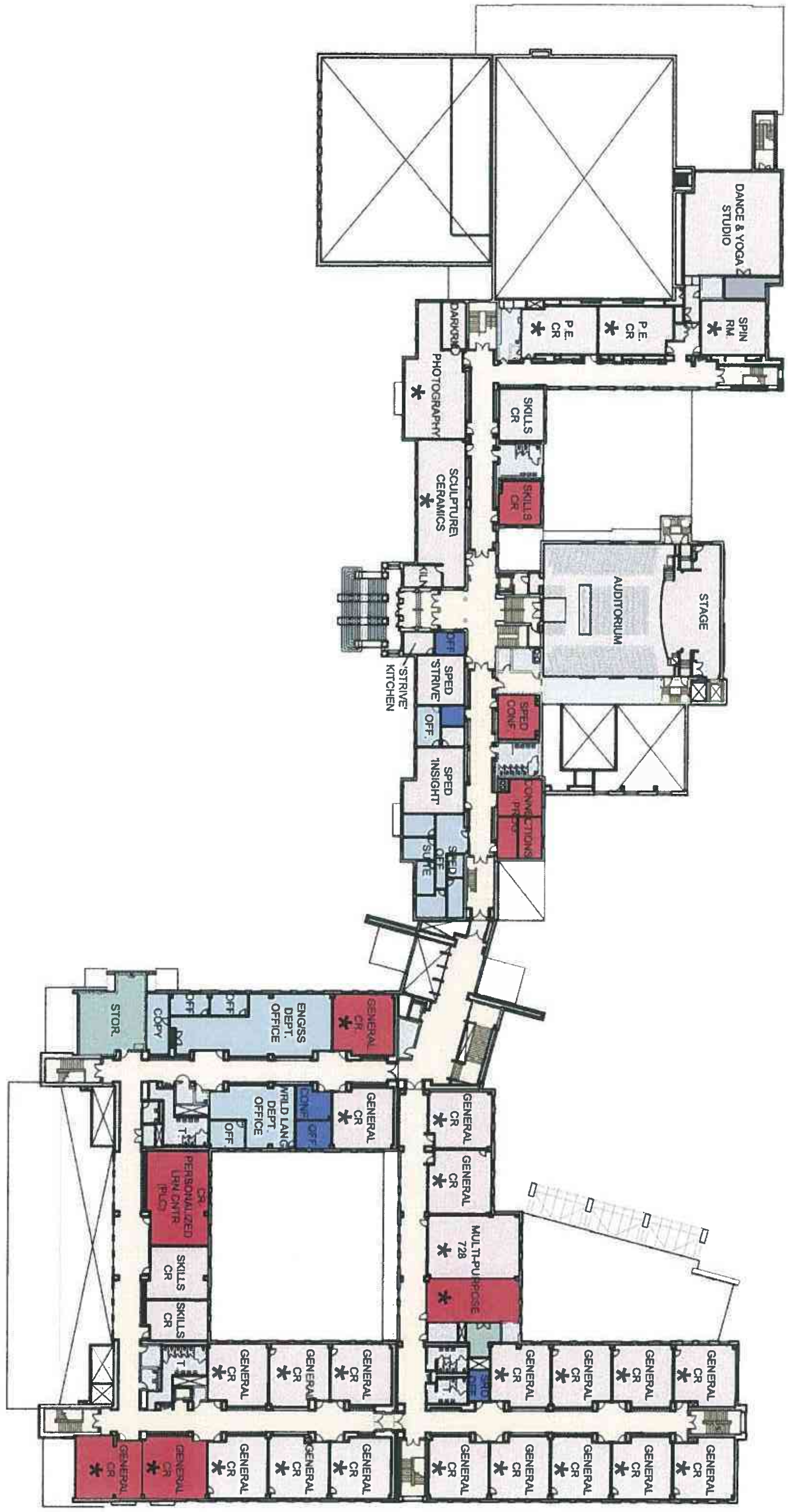
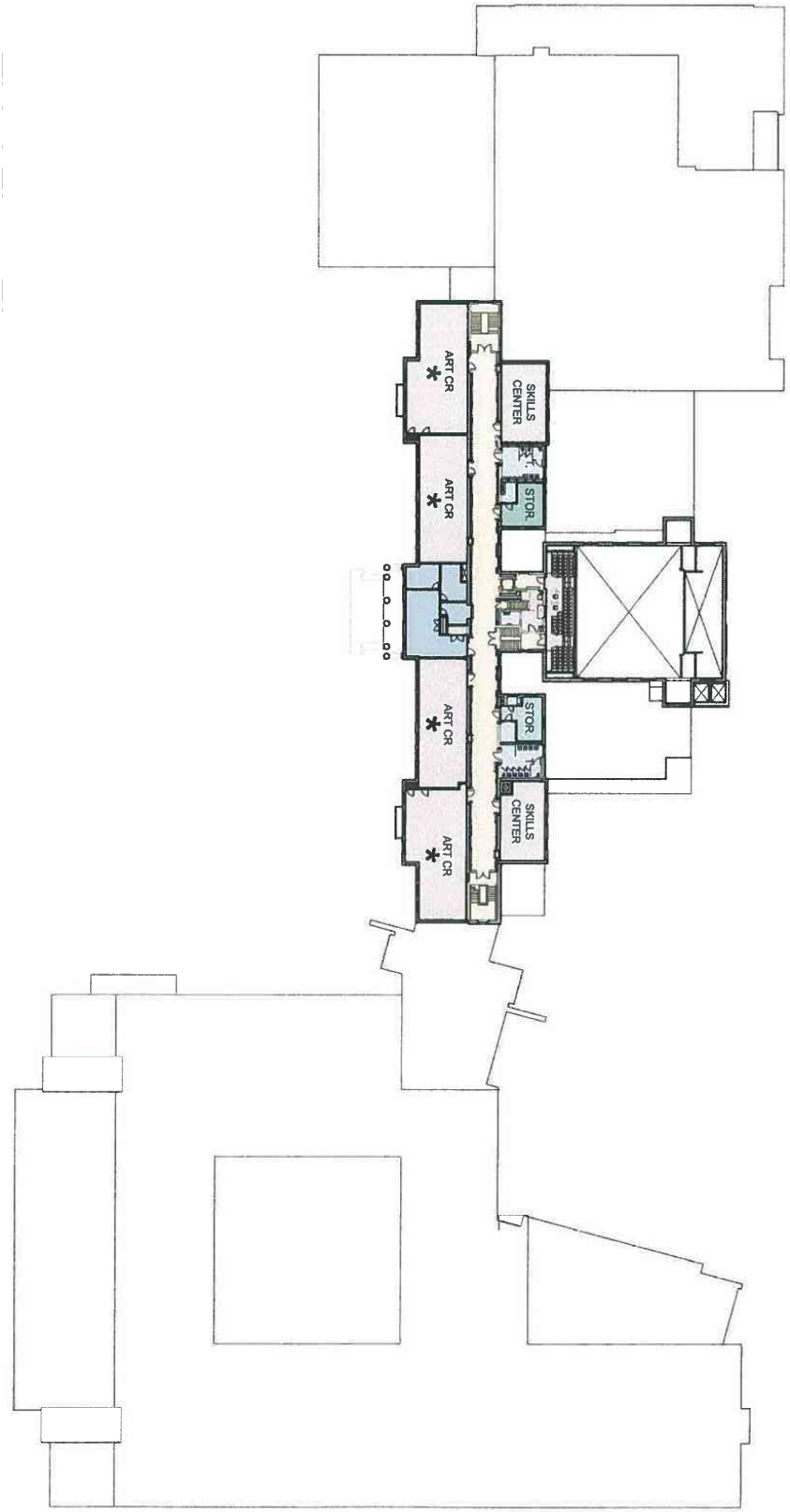


LEVEL 4 - NOT TO SCALE



LEVEL 5 - NOT TO SCALE

STRUCTURAL ASSESSEMENT

STRUCTURAL REPORT

EXECUTIVE SUMMARY:

This report is based on the structural engineer's visual observations made during a site visit in December 2016, a review of the additions and renovation drawings prepared by Engineers Design Group, dated October 8, 2004. The drawings for the original school were not available at this time. It should be noted that some of the proposed renovations are located at / near the addition constructed in 2004. The review of existing structural conditions did not involve the removal of any finishes or take measurements; report is limited to visual observations and assessment of the 2004 Structural Engineering documents.

The 2004 addition is a four-story rectangular classroom wing with an interior courtyard and a multi-story entry area / lobby. The structure consists of reinforced cast-in-place (CIP) concrete slabs supported on steel beams which span between both steel columns and girders. The columns are supported on traditional reinforced concrete spread footings.

The feasibility of renovation and expansion of the 2004 structure is dependent on the scope of the renovations to the building It may be feasible to make modifications to the existing structure without requiring full compliance with the current code requirements for new construction.

Several options for classroom expansion were developed as part of this study. In some of the schemes the proposed additions would be designed to be structurally independent of the existing structure; thus, that type of addition would not increase the seismic loads on the existing lateral load resisting system. In some of the other schemes considered as part of the study, the modifications included the addition of a new intermediate floor in a two-story space at the current Media Center space. One of the other options adds a new roof over the existing interior courtyard (the newly enclosed space would then be for the Media Center). In both of these options the new floor and the new roof would increase the demand/capacity ratio of the existing columns and foundations, but not more than the code allowed increase.

Primary Structural Code Issues Related To The Existing Structure

When repairs, renovations, additions or change of occupancy or use are made to an existing structure, a check for compliance with 780 CMR, Chapter 34 *Existing Structures* of the 8th Edition Massachusetts Amendments to the 2009 International Building Code (IBC 2009) and reference code 2009 International Existing Building Code 2009 (IEBC 2009) is required. The intent of the IEBC is to provide alternative approaches to alterations, repairs, additions and/or a change of occupancy or use without requiring full compliance with the code requirements for new construction. Depending on when the project moves forward the codes referenced may be newer versions, which the structural team would coordinate appropriately.

The IEBC provides three compliance methods for the repair, alteration, change of use or additions to an existing structure. Compliance is required with only one of the three compliance alternatives. Once the compliance alternative is selected, the project will have to comply with all requirements of that particular method. The requirements from the three compliance alternatives cannot be applied in combination with each other. The compliance method should be selected once the preferred option has been chosen.

The three compliance methods are as follows:

1. Prescriptive Compliance Method
2. Work Area Compliance Method
3. Performance Compliance Method

Proposed Scheme(s)

Multiple proposed schemes were reviewed as part of this study, details and plans which are found in later sections of this report. The options an internal 2-story re-configuration, a 4-story addition at the southwest corner, the roofed in courtyard, and two different options at the east side of the school, over the Webster Street entry.

Option B: Interior 2-story addition at current Library.

Option C: 4-story corner addition at the SW corner.

Option D: New roof structure over existing courtyard

Option E: New 3 story addition at the Webster St. Entry area (Library + Admin.)

Option F: New 3 story addition at the Webster St. Entry area (Classrooms + Admin.)

Comment

The objective is to evaluate the compliance requirements for each of the three methods and select the method that would yield the most cost effective solution for the structural scope of the project. The selection of the compliance method may have to be re-evaluated after the impact of the selected method is understood and after analyzing the compliance requirements of the other disciplines; Architectural, Mechanical, Fire Protection, Electrical and Plumbing.

Prescriptive Compliance Method

In this method, compliance with Chapter 3 of the IEBC is required. As part of the scope of this report, the extent of the compliance requirements identified are limited to the structural requirements of this chapter.

Based on the project scope, the following structural issues have to be addressed:

- All additions shall comply with the code requirements for new construction as prescribed by the IBC.

- For additions that are not structurally independent of an existing structure, the existing structure and its addition, acting as a single structure, shall meet the requirements of the code for new construction for resisting lateral loads, except for the existing lateral load carrying structural elements whose demand-capacity ratio is not increased by more than 10 %, these elements can remain unaltered.
- Any existing gravity, load-carrying structural element for which an addition or its related alterations causes an increase in the design gravity load of more than 5 percent shall be strengthened, supplemented or replaced.

Alterations

- Any existing gravity, load-carrying structural element for which an addition or its related alterations causes an increase in the design gravity load of more than 5% shall be strengthened, supplemented or replaced.
- For alterations that would increase the design lateral loads or cause a structural irregularity or decrease the capacity of any lateral load carrying structural element, the structure of the altered building shall meet the requirements of the code for new construction, except for the existing lateral load carrying structural elements whose demand-capacity ratio is not increased by more than 10%, these elements can remain unaltered.

Work Area Compliance Method

In this method, compliance with Chapter 4 through 12 of the IEBC is required. As part of the scope of this report, the extent of the compliance requirements identified are limited to the structural requirements of these chapters.

In this method, the extent of alterations has to be classified into LEVELS OF WORK based on the scope and extent of the alterations to the existing structure. The LEVEL OF WORK can be classified into LEVEL 1, LEVEL 2 or LEVEL 3 Alterations. In addition, there are requirements that have to be satisfied for additions to the existing structure.

If the work area for a project such as this were to be more than 50% of the aggregate area of the building, the LEVEL OF WORK for this project would be classified as LEVEL 3 Alterations. This would require compliance with provision of Chapter 6, 7 and 8 of the IEBC. If the scope of the project includes new additions to the existing structure; this would trigger compliance with provisions in Chapter 10 of the IEBC.

Level 3 Alterations

- Any existing gravity, load-carrying structural element for which an alteration causes an increase in the design gravity load of more than 5% shall be strengthened, supplemented or replaced. Options 'B' and 'D' entail supporting new, additional structure on existing structural systems.
- For alterations where more than 30% of the total floor area and roof areas of a building or structure have been or proposed to be involved in structural alterations within a 12 month period,

the evaluation and analysis shall demonstrate that the altered building complies with the full design wind loads as per the code requirements for new construction and with reduced IBC level seismic forces.

- For alterations where not more than 30% of the total floor and roof areas of a building are involved in structural alterations within a 12 month period, the evaluation and analysis shall demonstrate that the altered building or structure complies with the loads at the time of the original construction or the most recent substantial alteration (more than 30% of total floor and roof area). If these alterations increase the seismic demand-capacity ratio on any structural element by more than 10%, that particular structural element shall comply with reduced IBC level seismic forces.
- For alterations that involve structural alterations to more than 30% of the total floor and roof area of a building within a 12 month period, the evaluation and analysis shall demonstrate that the altered building structure complies with IBC for wind loading and with reduced IBC level seismic forces.

Additions

- Any addition shall comply with the requirements for the code for new construction as prescribed by the IBC.
- Any existing gravity, load-carrying structural element for which an addition or its related alterations cause an increase in design gravity load of more than 5% shall be strengthened, supplemented or replaced.
- For additions that are not structurally independent of any existing structures, the existing structure and its additions, acting as a single structure, shall meet the requirements of the code for new construction in the IBC for resisting wind loads and IBC Level Seismic Forces (may be lower than loads from the Code for New Construction in the IBC), except for small additions that would not increase the lateral force story shear in any story by more than 10% cumulative. In this case, the existing lateral load resisting system can remain unaltered.

Performance Compliance Method

Following the requirements of this method for the alterations and additions may be onerous on the project because this method requires that the altered existing structure and the additions meet the requirements for the code for new construction in the IBC.

PARTICULAR REQUIREMENTS OF COMPLIANCE METHODS

For the project to meet compliance with one of the two compliance methods “Prescriptive Compliance Method” or the “Work Area Compliance Method”, we would have to address the following:

Prescriptive Compliance Method

Additions:

The proposed additions would be designed to be structurally connected to the existing structure; thus, the addition will increase the seismic loads on the existing lateral load resisting system.

If the proposed alterations are such that the alterations increase the design lateral loads on the existing building or cause any structural irregularity of decrease the lateral load carrying capacity of the building, the structure of the altered building shall meet the requirements of the Code for New Construction in the IBC.

If the proposed additions increase the design gravity load on portions of the existing floor or roof members, these members would have to be reinforced and this incidental structural alteration of the existing structure would have to be accounted for in the scope of the alterations to the existing building and would trigger requirements for alterations.

Alterations:

Alterations that would increase the design gravity loads by more than 5% on any structural members would have to be reinforced.

If the proposed alterations of the structure increases the effective seismic weight on the existing structures due to the greater snow loads from the drifted snow against any proposed additions, or, by addition of equipment on the roof, the increase of the effective seismic weight from the drifted snow and the equipment would require that the existing lateral load resisting system comply with the requirements of the code for new construction in the IBC and it would increase the demand-capacity ratio on certain structural elements of the existing lateral load resisting system.

Work Area Compliance Method

If the work area for the proposed renovations for this project were to be more than 50% of the aggregate area of the building, The LEVEL OF WORK for this project would be classified as LEVEL 3 Alterations.

Level 3 Alterations:

If the proposed structural alterations of an existing structure are less than 30% of the total floor and roof areas of the existing structure, we have to demonstrate that the altered structure complies with the loads applicable at the time of the original construction and that the seismic demand-capacity ratio is not increased by more than 10% on any existing structural element. Those structural elements whose seismic demand-capacity ratio is increased by more than 10% shall comply with reduced IBC level seismic forces. The percentage increase in seismic demand-capacity ratio on any particular structural element from the added snowdrift load against a proposed addition would be fairly low, thus, this would not have any major impact on the existing lateral load resisting system, though we

would have to verify that the increase in seismic demand-capacity ratio on any of those particular structural elements is not greater than 10%.

If the proposed structural alterations of an existing structure exceed 30% of the total floor and roof areas of an existing structure, we have to demonstrate that the altered structure complies with the IBC for wind loading and with reduced IBC level seismic forces.

The masonry walls and parapets are required to be anchored to the roof structures.

Additions:

In some of the schemes the proposed additions would be designed to be structurally independent of the existing structure, as in Options C, E, and F; thus, the addition would not increase the seismic loads on the existing lateral load resisting system.

In Options B & D, the proposed work would be the addition of a new floor in a two-story space (Option B) and / or a new roof over the existing interior courtyard. In both of these cases the new addition would increase the demand/capacity ratio of the existing columns and foundations, but not more than the code allowed increase.

Comment:

The compliance requirements of the Prescriptive and Work Area Compliance Methods, in most respects, are very similar. We would recommend the Work Area Compliance Method. Depending on the scope of renovations and additions to the project, it would need to be determined if we have to upgrade the structure to essentially comply with the requirements of the Code for New Construction.

These recommendations can be revisited if the proposed scope of structural renovations differs from our understanding based our discussions; and, then it may be advantageous to follow the requirements of the Prescriptive Compliance Method for the project.

SUMMARY

The existing building structure appears to be in good condition. Based on the preliminary schemes, we understand that the renovations will be limited to minor structural modifications within the existing building, the addition of an intermediate floor and a small seismically separated addition.

Based on this, we recommend that the requirements of the Prescriptive Compliance Method are followed. As the renovations will not overstress any structural element by more than 5% from gravity loads or increase the demand to capacity ratio by more than 10% from seismic loads. No upgrades to the structure will be triggered based on the proposed schemes. Once the proposed scheme is finalized, we can reevaluate the appropriate compliance method and any upgrades to the existing structure that may be required.

HVAC ASSESSEMENT

MECHANICAL / HVAC

HVAC Executive Summary:

Presently, the HVAC Systems serving the building are a chilled water plant, a gas-fired heating hot water plant, roof-mounted air-handling units, indoor-mounted air-handling units, classroom unit ventilators, direct expansion split cooling systems, terminal hot water heating units, roof and inline mounted exhaust fan systems, & de-stratification ceiling fans. In general, the HVAC systems are in fair condition and have been well maintained. The current installations generally comply with code, and are adequately sized to support the existing building layout. All proposed renovation/ addition options will require the installation of additional cooling capacity and HVAC equipment dedicated to serve the newly-added areas, though the heating plant has adequate capacity to serve the additional space.

Boiler Plant

Many of the currently installed HVAC systems have been updated as part of a building renovation and addition project completed in 2008. Those systems that remain from prior to the 2008 renovations have likely surpassed their expected service life, such as in Gymnasium 'A' – and should be individually inspected for condition and operation (see the section later in this report about costs associated with air handling unit replacement).

Hot Water Heating Plant:

The building hot water heating plant is located in the lower level boiler room and consists of four (4) gas-fired cast iron sectional boilers manufactured by "Burnham" model V1110 (4691 MBH Input, 3739 MBH Output). The boilers are provided with all code-required safety controls and the entire installation appears to be code compliant. Heating hot water is circulated throughout the building within a fiberglass insulated combination copper and schedule 40 steel piping system. Four (4) 1.5 horsepower inline boiler circulator pumps form the primary heating hot water loop where one (1) pump circulates 215 GPM through each boiler whenever that boiler is commanded to operate. These boiler circulator pumps are not equipped with variable frequency drives and are incapable of varying speed to match the boiler staging, resulting in wasted energy. Two (2) pad-mounted 50 horsepower hot water system pumps provide the hot water flow required to meet the building heating load. These system pumps are provided with wall-mounted variable frequency

Expansion Tanks


Flue Vent Breeching Chimney


Boiler Control Panel


Combustion Air Inlet

drives for varying the speed of the pumps as the building system hot water control valves open and close. Both system pump bases are provided with spring vibration isolators to mitigate vibration transfer to the building.

Flue gases from each boiler are vented to the outdoors via a double-wall galvanized breeching system that terminates above the roof. This common vent breeching system is shared with the domestic hot water heaters and includes a barometric damper within the boiler room to enhance the stack effect in the vertical chimney. Combustion air is provided to the boiler room via an exterior sidewall louver ducted to a high and low termination point in compliance with the building code, though we recommend confirming the size / capacity of combustion air per current code(s). A motorized damper is installed in this combustion air duct system and interlocked with the boiler plant to open whenever there is a call for heat.

During our site assessment, it was reported that each of the boilers have experienced recurring issues with low-fire conditions and the current gas-supply pressure is suspected of being the culprit (Architects note: The gas pressure was confirmed to be an issue (erratic / fluctuating pressure due to malfunctioning pressure regulator) at a boiler performance test after the date of this assessment. The Town has also expressed that replacement parts for the installed boilers do not fit correctly and make maintenance difficult or impossible. Repair & optimization of the central heating plant is planned for the near future, as is the option of replacing one of the boilers so as to make parts available for the remaining three. Installing a dual-fuel type boiler would allow for extended operation during emergencies should the natural gas supply be interrupted. The properly functioning heating plant will be sufficiently sized to support the renovation/addition project.

Chilled Water Cooling Plant:

There is an air-cooled chiller mounted on a concrete pad adjacent to the boiler room in an outdoor mechanical space. The chiller is manufactured by “McQuay” and has a nominal cooling capacity of 300 Tons. Schedule 40 steel 8” insulated chilled water supply & return piping is routed underground from the chiller to penetrate the floor within the boiler room. Two (2) pad-mounted 40 horsepower chilled water system pumps provide the 44 degree chilled water flow required to meet the building

chilled water cooling load. These system pumps are provided with wall-mounted variable frequency drives for varying the speed of the pumps as the building system chilled water control valves open and close. Both system pump bases are provided with spring vibration isolators to mitigate vibration transfer to the building.

Chilled Water Pumps

Chilled Water Piping

McQuay Air Cooled Chiller

The air-cooled chiller has been non-operational for a number of years, and as part of this study the repair and / or replacement options are being investigated (see specific boiler / chiller report section for details). The currently installed chilled water system is adequately sized for the building HVAC as it is currently, but as noted above does not contain sufficient capacity to take on additional cooling loads that may be brought on by addition / renovation project options. The chilled water system would need to be up-sized – a larger chiller and larger circulating pumps would be required, or the added areas could instead be provided with their own dedicated cooling system. Gymnasiums:

Classroom, Admin, & Media Center HVAC:

In general, all classrooms, administration areas, and the Media Center are provided with tempered ventilation air mixed with re-circulated air by roof-mounted air-handling units with hot water heating coils, chilled water or split DX cooling coils, supply & return fans with VFD's, and vibration isolation curbs; none of the installed air-handling units include energy recovery sections. These air-handling units discharge 55 degree air through a fiberglass-insulated galvanized sheet metal duct system to variable air volume (VAV) boxes with hot water re-heat coils associated with each space. The VAV box damper is modulated in series with the hot water re-heat coil control valve to maintain the associated space temperature set point. As the VAV dampers open and close, the air-handling unit supply and return fan VFD's modulate to increase or reduce fan speed which directly correlates to airflow.

All spaces served by an over-head supply VAV system, with exception to the media center, also contain perimeter fin-tube hot water radiators for supplemental & un-occupied heating. A smaller percentage of classrooms utilize unit ventilators for heating, ventilation, and in some cases, air conditioning. Where these unit ventilators are remaining from prior to the 2008 renovation project have likely exceeded their expected service life. Some of the unit ventilators were outfitted with chilled water cooling coils and some are left with only hot water heating capabilities. All air-handling units existing from prior to the 2008 building renovation project have exceeded their anticipated service lives and should be replaced with new units. All renovation / addition project options would require the added HVAC air-handling capacity and will be designed as needed.

Gymnasiums:

During the 2008 building renovation project, a new Gymnasium – Gymnasium B, was constructed to the west of the original gymnasium, Gymnasium A. This gym is provided with a roof-mounted air-handling unit complete with a hot water heating coil, a filter section, and constant volume supply & return fans. Although this unit is not provided with cooling capabilities, it is in fair condition and is adequate for heating & ventilating the space. Gymnasium A was not renovated as part of the 2008 building renovation project and is in need of HVAC equipment upgrades. Gymnasium A is provided with two (2) roof-mounted air-handling units with hot water heating coils, filters, & constant volume supply & return fans. This equipment has exceeded its anticipated service life and operates at efficiencies significantly lower than that of current technologies, and replacement costs are included in the project budget (see appropriate section of the report for specific information).

Support / Service Spaces mechanical systems:

The Main Electric Room contains an inline exhaust fan ducted to an exterior wall louver and a separate make-up air louver with a motorized damper is installed on the same wall. The make-up air louver is interlocked with the exhaust fan to open whenever the fan is called to operate by the space thermostat. This system is for cooling of the space and appears to be adequately sized; however, will need to be modified or replaced by an alternative method of cooling if building renovation option 'D were to be selected. This option would occupy the courtyard where the Main Electric Room areaway louvers are currently installed.


Main Electric Room Cooling Vent Areaway

The MDF Room is provided with a Ductless Cooling unit to maintain the space temperature below a maximum point driven by the specific requirements of the Data equipment within. The entire MDF cooling installation appeared to be in good condition and adequately sized. The numerous remote IDF rooms did not include any mechanical means of cooling but do have their space

temperatures monitored by the Building Management System. Should the MDF, Electric, or IDF rooms be expanded under the renovation/ addition project, the current cooling systems and conditions should be reviewed for competence.


MDF Room Ductless Cooling Unit

Automatic Temperature Controls:

The town of Needham employs ENE Systems for the provisions of all municipal Building Management Systems; this is true for the Needham High School as well. The high school contains a fully-automated direct digital temperature control system for monitoring & controls of all HVAC systems. Each *occupiable* space includes an electronic temperature sensor that is monitored for HVAC system optimization & alarming conditions. The programming & sequencing of all HVAC building operations are viewable & changeable from a front-end computer work-station. The building management system (BMS) contains a Tridium Niagara platform with BACnet IP & MSTP communication for open protocol& integration of all systems. The BMS currently installed utilizes current technologies and has the capacity to support a renovation/ addition project.

ELECTRICAL / TELCOM ASSESSEMENT

ELECTRICAL & TELCOM

Executive Summary:

In general, the electrical systems are in fair condition, comply with code and are adequately sized to support the renovation/classroom addition options presented.

The electrical systems have been updated as part of a building renovation and addition project completed in 2008.

Electrical Distribution System:

The building is fed from a utility company owned exterior pad mounted transformer with primary and secondary service feeders installed below grade. Due to the service size and limited number of conductors that can be installed on the secondary spades of the utility company transformer an Elliot box is installed so that 12 sets of 4# 500kcm could be installed to serve the buildings 5000 ampere rated 277/480V, 3 phase service. The utility company meter is located within the main electric room, C.T.s are installed in a C.T. section of the main switchboard. There are (4) distribution panels fed from the main switchboard that then feed branch circuit panelboards. There is adequate capacity in the existing distribution system both with respect to space and electrical capacity for a renovation/addition project.

Main switchboard

Utility Meter

Main Breaker


Distribution Panel


Utility Padmount Transformer


Eliot Box

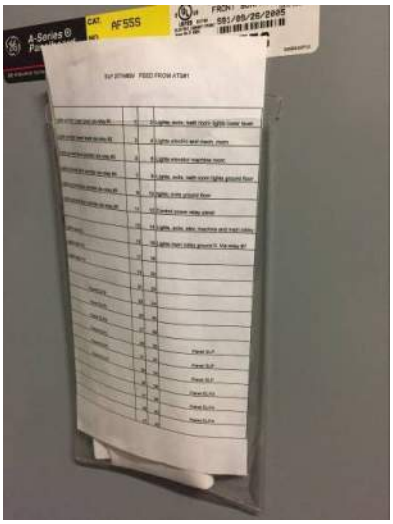
Branch Circuit Wiring Devices:

The quantity and location of branch circuit devices seems adequate. Wiring is either in conduit concealed or metal clad cable where concealed and not subject to physical damage. Branch circuit panelboards are of circuit breaker type in good condition and have adequate future capacity.

Emergency Power System:

The emergency power system consists of a 277/480V, 3 phase 750 kw diesel fired generator installed within a weatherproof sound attenuated enclosure. The generator is manufactured by Caterpillar. The generator severs both life safety loads and optional standby loads. The emergency system is code compliant. A 1600 amp 4 pole automatic transfer switch serves a 1600 amp emergency distribution panel "OEDP". There seems to be adequate capacity and space to provide both optional standby and life safety loads for a renovation/addition program.

225A Life Safety Transfer Switch



Life Safety Panel ELP Directory

1600 amp transfer switch

Generator

Interior Lighting:

Interior lighting in general is in good condition and is mainly of the fluorescent type. The building contains an automated lighting control system manufactured by Douglas Lighting Control. There is adequate capacity for expansion of the existing lighting control system.

Douglas Relay Panel

Fire Alarm System:

The fire alarm system is an addressable Edwards EST 3 system with voice evacuation. The system is code compliant and has the capacity for expansion. The method of transmission is via a digitize radio box.

FACP

Digitize Box

Data/Telephone/Classroom Intercom/Clock System:

The data backbone consists of both single mode and multi-mode cables from the MDF room to eleven IDF rooms. The multi-mode fiber is 10 gig laser optimized.

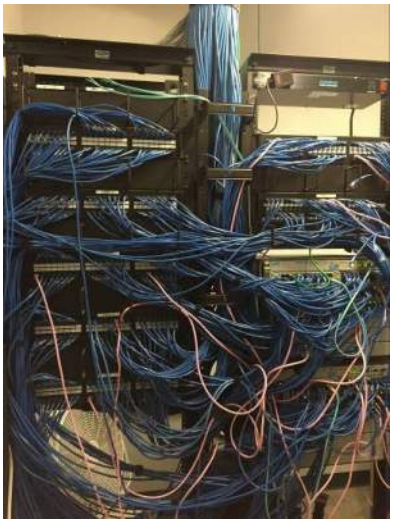
The data wiring is CAT6 throughout the building providing 1 gig to the desktop. The tel/data infrastructure is in good condition. We did note that an IDF room on the first floor nearest the main electric room did not have dedicated cooling and may not have had adequate exhaust as the room was over heating and had plug in fans to help cool some of the equipment. This should be addressed.

The telephone system is not a VOIP system. It is a Samsung PBX which is a district wide system. The system utilizes centrex lines for inter building communication which can be more costly than an VOIP system.

The classroom intercom is a Rauland telecenter and is in good condition. The Rauland system can be expanded to serve a renovation/addition project.

The clock system is a sapling system and is operational.

MDF Fiber Distribution



IDF

Fan to Keep IDF Cool

Samsung Phone

Paging System

Sapling Clock System

Security:

The school is equipped with an access control system, CCTV system and an intrusion system.

The access control system is split up into three sub-systems of different manufacturers making the system difficult to manage based on conversations with the owner. The CCTV system is antiquated as well. The existing access control and CCTV system will be upgraded to match the system that ultimately gets selected and installed at the new Needham Hillside project. Any renovation/addition should connect to this upgraded system.

The intrusion system is in good condition and can be extended to serve the renovation/addition.

PLUMBING ASSESSEMENT

PLUMBING

Executive Summary:

Presently, the Plumbing Systems serving the building are cold water, hot water, sanitary, waste and vent system, special waste and vent system, storm drain system, and natural gas. Municipal sewer and municipal water service the Building.

The plumbing systems have been updated as part of building renovation and addition project completed in 2008. The plumbing systems appear to be well maintained. It would appear all systems have the capacity to support a building renovation and/or addition project.

The plumbing fixtures are in good condition. Plumbing fixtures appear to meet code in terms of water conservation and accessibility. The code does not require these fixtures to be upgraded, but where new fixtures are installed, as may be required by other codes or concerns, the new fixtures need to be accessible and water conserving type.

Cast iron is used for sanitary and storm drainage. Rainwater from flat roof areas is collected by interior rain leaders which appear to discharge to a below grade drainage system. Where visible, the cast iron pipe appears to be in good condition. Smaller drainage pipe sizes appear to be copper tubing. In general, the drainage piping can be reused where adequately sized for the intended new use.

Fixtures:

The water closets are predominately wall hung vitreous china with flush valves.

Urinals are wall hung vitreous china with flush valves.

Lavatories are wall hung vitreous china with metering faucets.

Electric water coolers are generally wall hung, hi-lo units. Unit outside of the Gymnasium is a single drinking fountain with a bottle filling station.

Electric Water Cooler Outside of Gym Space

Water Systems:

The main domestic water service is located in the basement Mechanical Room. The service is 4-inch in size and includes a 2-inch water meter. The service is protected with two 4-inch reduced pressure backflow preventers located in a parallel configuration.

The main domestic cold-water distribution is 4-inch in size. Piping is copper tubing with sweat joints. Piping and shutoff valves are in good condition.

Domestic hot water is generated through two gas-fired water heaters. Domestic water heater #1 was installed in 2014. Domestic water heater #2 appears to be original to the renovation project of 2008.

Domestic water heater #1 is a high efficiency, tank type water heater. Water heater #1 has a natural gas input of 500,000 BTUH and a storage volume of 120 gallons. Water heater is vented to the exterior through the side wall of the Mechanical Room. Vent pipe material is schedule 40 PVC pipe, which is an acceptable material for this type of appliance.

Domestic water heater #2 is a standard efficiency, conventional fire-tube water heater. Water heater has a natural gas input of 700,000 BTUH and a storage volume of 425 gallons. Date of manufacturing is December 2005. The water heater is vented with double stainless steel vent piping which connects to the same breeching system as the four existing boilers.

The hot water system includes a thermostatic mixing valve which appears to be in good condition.

HVAC boiler water make-up system is protected with a reduced pressure backflow preventer.

Domestic Water Service & Meter

Water Service Reduced Pressure Backflow Preventers

Domestic Water Heater #1

Thermostatic Mixing Valve

Domestic Water Heater #2

Gas:

Natural gas is provided to the building. Gas serves the heating boilers, domestic water heaters, kitchen cooking equipment, and Science classrooms. The gas meter is located on the exterior of the building, outside of the Mechanical Room.

Gas piping is black steel with a combination of screwed and welded joints and fittings depending on the pipe size. Piping appears to be in good condition.

Exterior Gas Meter

Drainage Systems:

Cast iron is used for sanitary and storm drainage. Where visible, the cast iron pipe appears to be in good condition. Smaller pipe sizes appear to be copper.

In general, the cast iron drainage piping can be reused even in a major renovation where adequately sized for the intended new use.

FIRE PROTECTION ASSESSEMENT

FIRE PROTECTION

Executive Summary

The Needham High School Building, is protected by combined automatic sprinkler/standpipe system. The school underwent a full renovation and addition project which was completed in 2008. At that time the combined sprinkler/standpipe system was installed. The building appears to be fully sprinklered with the exception of electric rooms. The system is in good condition and has the capacity to be expanded to protect future building additions.

Existing Conditions:

The School building is served by a dedicated 8-inch fire water service. The service includes an 8-inch double check valve assembly and wet alarm valve. The fire distribution main to the building is 8-inch in size.

The system is a combined standpipe/sprinkler system. Standpipe risers with fire department valves are located in the stairwells. There are multiple sprinkler zones per floor. Each sprinkler zone control valve assembly includes supervised shutoff valve, check valve, flow switch, and inspector's test station.

System fire department connection is a 4-inch Storz connection.

In non-ceiling areas, sprinkler heads are typically upright brass heads. Where ceilings are provided, sprinklers are either fully concealed type or pendent type. Sprinklers are quick response type.

Piping is black steel with either grooved coupling joints or threaded joints depending on pipe sizes. Piping, where exposed, is in good condition.

All spaces within the building appear to be protected except for the electric rooms.

The existing gym area is fed by a dedicated 4" sprinkler main supplied from the corridor. Gymnasium sprinkler heads are semi-recessed type located in ceiling tiles.

System appears to be well maintained with required periodic inspections/testing performed by Owner. The existing system appears to have the capacity to be modified should renovations and/or additions occur at the building.

Building Fire Service Entrance

Typical Sprinkler Control Valve Assembly

Typical Fire Department Valve Cabinet at Standpipes

Gym Sprinkler Supply Main

Gym Ceiling Sprinklers

ENROLLMENT FORECAST

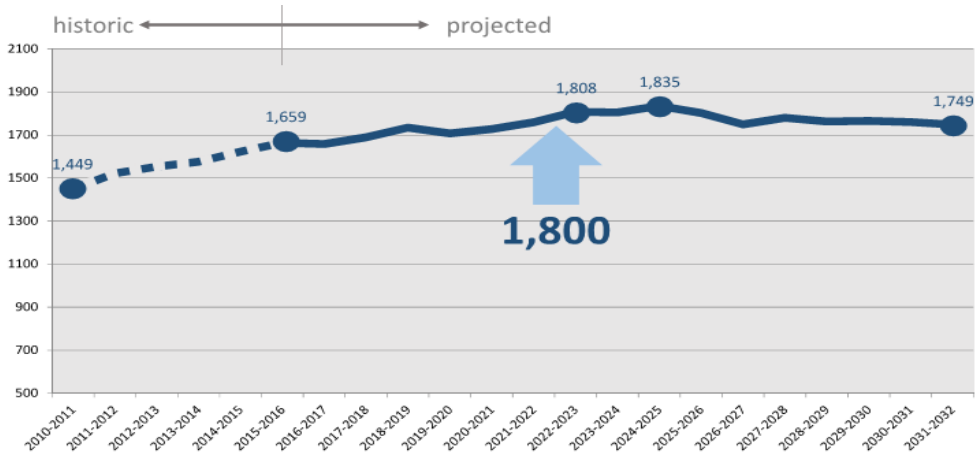
Overview

In December of 2016, McKibben Demographics produced an enrollment forecast through the 2031-2032 school year for Needham Public Schools. Their study included forecasts by major grade groupings and for each elementary school catchment area (included in Appendix Item K-4). McKibben's methodology differs slightly from other projections produced by the District in the past. It not only took into account the cohort survival ratios of students year to year, but also accounted for localized changes in the residential construction market, the demographic profiles of residents in each elementary catchment area, and the current economic conditions that may impact housing stock turnover. It was a more Needham-specific and nuanced methodology than had been provided by others previously.

Every forecast contains uncertainty. In general terms, the further into the future a forecast is, the greater the uncertainty. Significant changes in the residential interest rates or other market forces impact certainty for enrollment forecasts. For high school projections, however, there tends to be greater certainty because the majority of the students, even in a fifteen year forecast, are already attending school in the District. Given these considerations, McKibben Demographics' forecasts are typically within 2% of actual realized enrollment.

Enrollment Target

McKibben's forecast concluded that the District overall will experience a growth, peak, then decline trajectory over the next fifteen years. It concluded that Needham High School will experience continued growth for the 2017-18 school year through the year 2024-2025, peaking at 1,835 for grades 9th-12th. In the latter half of the forecast, McKibben concludes that the Needham High School enrollment will begin a slow decline to 1,749 students in the 2031-2032 school year – 90 students higher than the enrollment for 2016-17 and 300 hundred higher than the original design enrollment. The chart below depicts both the historic and projected enrollment trajectories.



D&W collaborated with members of the Working Group, the Permanent Public Building Committee and the School Committee to interpret McKibben's findings and to identify an enrollment planning target of 1800 9th-12th grade students, which represents all general education, special education, and ungraded students (older than 18 who still receive services in the District). In choosing an enrollment target, the Working Group and the Permanent Public Building Committee wanted to be both conservative and reasonable. There was a desire to choose a high enough target that any project executed would serve the needs of Needham High School students well into the future, but not so high as to be overly conservative. Dore & Whittier used this enrollment target to determine how many students may be enrolled in each course in the future and as a key input for calculating space needs across Needham High School.

SPACE NEEDS ANALYSIS

Overview

To determine if space needs exist or will exist at Needham High School, D&W performed a detailed analysis of every instructional space and of every section of each course offered. The analysis included documentation of existing space usage, numbers of students enrolled in each course, and the utilization of each instructional space. In general terms, this analysis allowed D&W to fully understand the complexities of Needham High School's daily schedule, its class size practices, and the nuances that make Needham High School unique among its peer schools. D&W's analysis also revealed that enough complexity and nuance exists to render typical laws of averages and rules of thumb incapable of accurately determining needs. The narratives, tables, charts, and illustrations that follow document D&W's analysis that formed the basis for our conclusions. In short, our findings suggest that Needham High needs:

- (6) General Education Classrooms @ 925 NSF[1] each
- (2) General Education Classrooms @ 1200 NSF each – divisible into (4) spaces @ 600 NSF each
- General-purpose Science Lab @ 1440 NSF
- Science Prep Room @ 200 NSF
- Approximately 5,500 NSF of Special Education Instructional and Administrative Space

Existing Space Usage

Needham High School administrators provided Dore & Whittier with raw data about each section of each course offered. The data was comprehensive and included the following critical information:

- Course & Section Titles
- Room Number and Geographic Location within the Building
- Number of Students Enrolled
- Maximum Number of Students Permitted to Enroll
- Time of Day Course Meets

No personal student information was included in any of the data provided. In addition to the course and section information, administrators provided information about the school's daily schedule. In general terms, each school day consists of five instructional blocks, but each cycle (which spans more than one day) is seven instructional blocks in length. This means that not every course meets every day, but meets once per seven-block cycle on a rotating basis. It takes seven school days for the rotation to return to its starting position (where 1st period falls in the first block of the day). To add nuance, Needham High Schools' schedule also includes a unique schedule on Fridays. All of this complexity makes it difficult to rely on rules of thumb or laws of averages when forming calculations. The table on the following page summarizes the High School Schedule.

[1] NSF: Net Square footage. Net Square footage refers to the usable floor area of an instructional space. It is defined as the area bounded by the interior faces of a room's walls.

	1st Block	2nd Block	3rd Block	4th Block	5th Block
A-Day: Monday	1st Period	2nd Period	3rd Period	4th Period	5th Period
B-Day: Tuesday	6th Period	7th Period	1st Period	2nd Period	3rd Period
C-Day: Wednesday	4th Period	5th Period	6th Period	7th Period	1st Period
D-Day: Thursday	2nd Period	3rd Period	4th Period	5th Period	6th Period
E-Day: Friday	7th Period	1st Period	2nd Period	3rd Period	4th Period
F-Day: Monday	5th Period	6th Period	7th Period	1st Period	2nd Period
G-Day: Tuesday	3rd Period	4th Period	5th Period	6th Period	7th Period

Dore & Whittier performed a number of analyses on the data. The assumptions, methodology and algorithms used to perform each analysis are defined below.

Teaching Station

A Teaching Station is any space where a student receives instruction and that appears on a student's schedule with the exception of those serving Special Education programs and services.[2] Study/Seminar courses and Directed Study courses fall outside this definition as well because students are not receiving instruction. A few other exceptions exist as a result of the nature of a course and number of students enrolled. These specific courses were excluded from the teaching station calculations:

- ELL Advanced English – This is not considered a Special Education course, but functions in a similar manner. Student enrollment in, and space utilization for, this course is low.
- ELL Support – This is not considered a Special Education course, but functions in a similar manner. Student enrollment in, and space utilization for, this course is low.
- Individual Study English 2 – Independent study courses can typically occur anywhere, including off campus. Including this course in the teaching station calculations would inappropriately lower outcomes.

Existing Average Students Per Classroom

A generalized representation of how many students are typically occupying a space during any one period at any given time. It is a term that can be used synonymously with Average Students Per Period or Average Students Per Section. This calculation can be applied to both general education and special education spaces.

Total sum of students occupying a space over a complete cycle ÷
Total number of occupied periods in a cycle

[2] Planning strategies for American High Schools typically size a building assuming all students will be served in the general education setting. This translates into classroom and other teaching station counts capable of housing the entire student population within general education settings. Any spaces dedicated to Special Education programs and services would be over and above teaching station counts.

Existing Average Utilization Per Classroom by Periods

A representation of how frequently instructional spaces are occupied by students as a percentage of the total periods available within the school schedule. This calculation is most often applied to general education instructional spaces only, but can be applied to special education spaces if they are regularly scheduled and appear on students' schedules. It is a calculation that can not be used for Special education spaces where students receive services on an as needed or in an ad hoc manner as in a pull out model because either no data exists or it varies so greatly to make the calculation meaningless.

Total count of periods occupied by students over a complete cycle ÷ Total number of periods in a cycle (35)

Existing Average Utilization Per Classroom by Minutes

A representation of how frequently instructional spaces are occupied by students as a percentage of the total minutes available within the school schedule. This calculation is applied and limited in exactly the same way as Average Utilization by Periods.

Total sum of minutes occupied by students over a complete rotation ÷ Total number of minutes in a rotation (2480)

Existing Average Students Per Department

A generalized representation of how many students are typically occupying a space during any one period at any given time calculated for a Disciplinary Department.

Total sum of students occupying all spaces for a single Department over a complete cycle ÷ Total number of occupied periods in a cycle

Existing Average Utilization Per Department by Periods

A representation of how frequently instructional spaces for a single Disciplinary Department are occupied by students as a percentage of the total periods available within the school schedule.

Total count of periods occupied by students in a single Department over a complete cycle ÷ Total number of periods available in that Department in a cycle

Existing Average Students for Needham High School

A generalized representation of how many students are typically occupying any general education[3] instructional space during any one period at any given time calculated for the entire Needham High School.

Total sum of students occupying all general instructional spaces for the entire school over a complete cycle ÷ Total number of occupied periods in a cycle

[3] Special education courses, services, and programs tend to have lower students per period than general education courses by design and regulation. Including special education in this calculation would artificially lower the averages for the entire building and result in a misrepresentation of any outcomes.

Existing Average Utilization for Needham High School by Periods

A representation of how frequently general education instructional spaces[2] are occupied by students as a percentage of the total periods available within the school schedule.

Total count of periods occupied by students for the entire school over a complete cycle ÷ Total number of periods available in a cycle

In addition to these definitions and algorithms, it is important to note that several other factors contributed to the determination of needs.

Section Caps

Needham High School has adopted the educational practice of capping courses based on the best interests of students. For many general education courses, the cap has been set as low as 16 students per section. Such practices result in lower than what otherwise might be anticipated averages and is evidence of why relying on rules of thumb may misrepresent actual needs.

Usage of Health & PE Instructional Spaces

Needham High School has several spaces serving its Health & Physical Education curriculum. D&W observed as many as nine spaces being used for this Department. However, students are only scheduled into one of the two gyms as an administrative practice. The remainder of the spaces are occupied based on the nature of the activities planned for the day and coordinated internally amongst the faculty of the department. While this practice appears to be working well, it makes it impossible to accurately calculate space usage for this area of the building. Dore & Whittier examined the total number of students enrolled in these courses, the size of the two gym spaces, and developed an estimated equivalent of 6 instructional spaces. We used that estimate to calculate the average number of students per period and per department. Otherwise, the high enrollments as scheduled would have resulted in a misrepresentation of the averages for the entire high school. We did, however, report that the two gym spaces were utilized 100 percent of the cycle as documented in the data provided.

General Education Room Size

Needham completed a major renovation/addition to Needham High School in 2007. At the time, guidelines for room size were significantly smaller than MSBA's guidelines are for the same spaces today.[4] D&W observed that many of the spaces serving the Core Academic disciplines are at or near 725 NSF in size but house 28 students. The following calculations and graphics attempt to put those numbers in context.

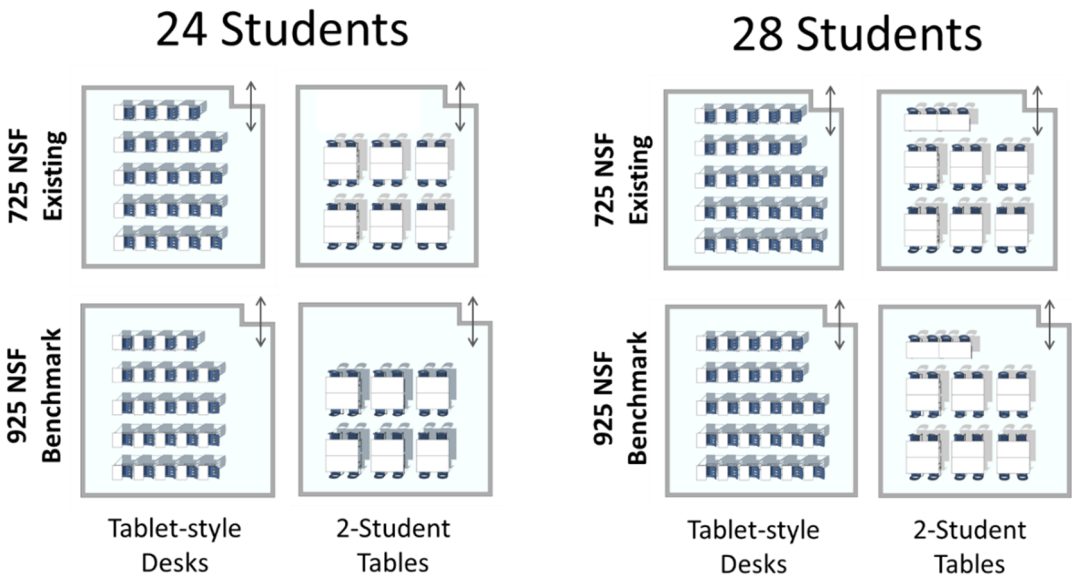
Current MSBA Guideline for General Education Classrooms

- Assumes 23 Students Per Period
- 825 NSF to 925 NSF
- 877 NSF ÷ 23 Students Per Period = 37.5 NSF per Student

Existing Needham High School General Education Classrooms

- Average Students Per Period = 20.88
- 725 NSF
- 725 NSF ÷ 37.5 NSF per Student = 19.33
- 147 Sections (45%) have more than 23 students

The illustrations below compare and contrast Needham High School's existing General Education Classrooms with those within MSBA's current guideline. They are meant to demonstrate that even without casework or a teacher desk, whether with individual student desks or two-student tables, 725 NSF classrooms are crowded at 24 students. With 28 students, 725 NSF classrooms limit teachers' ability to implement certain instructional activities, particularly those that require student regroupings or movement.



[4] 725 NSF was a typical Classroom size in 2007. MSBA's guideline for a typical classroom is 850 NSF to 925 NSF, the midpoint of which is 887 NSF.

The tables on the following pages contain both the raw data analyzed and D&W's calculations.

Needham High School - Number of Students Per Section & Utilization Analysis

Revised .2.09.17

Day				A			B		
Period		1	2	3	4	5	6	7	Total Minutes Per Cycle
Minutes, Monday - Thursday		90	90	80	50	50	90	90	
Minutes, Friday									2480

		Existing Number of Students Enrolled								
		<16		16 to 22			≥23			
Room #	Course Title								Average Students Per Period	Calculated Utilization Rate by Periods
701	General Classroom - English*	20	27	25	20	18	25	12	*21.00*	*100.00%*
702	General Classroom - English	27	20	28	23	23	26	21	*24.00*	*100.00%*
715	General Classroom - English	11	21	27	20	23	25	0	*21.17*	*85.71%*
717	General Classroom - English	21	22	25	10	0	23	23	*20.67*	*85.71%*
719	General Classroom - English	26	25	26	27	0	12	18	*22.33*	*85.71%*
720	General Classroom - English	19	20	15	28	18	25	25	*21.43*	*100.00%*
721	General Classroom - English	19	28	25	25	21	17	25	*22.86*	*100.00%*
722	General Classroom - English	23	19	29	20	15	27	24	*22.43*	*100.00%*
723	General Classroom - English	20	0	19	27	20	21	27	*22.33*	*85.71%*
724	General Classroom - English	22	25	25	27	13	28	28	*24.00*	*100.00%*
726	General Classroom - English	20	22	23	25	27	19	22	*22.57*	*100.00%*
728	Interdisciplanary Room*	28	28	31	24	28	30	0	*28.17*	*85.71%*
730	General Classroom - English	22	21	25	12	23	30	28	*23.00*	*100.00%*
732	General Classroom - English	12	8	29	20	25	26	21	*20.14*	*100.00%*
	English Department Sub-totals								*22.56*	*94.90%*
109	General Classroom - Math	21	23	23	15	22	0	24	*21.33*	*85.71%*
112	General Classroom - Math	24	17	0	21	23	24	0	*21.80*	*71.43%*
201	General Classroom - Math	25	24	23	25	23	16	20	*22.29*	*100.00%*
202	General Classroom - Math	23	17	11	23	17	18	23	*18.86*	*100.00%*
203	General Classroom - Math	19	20	23	18	19	0	17	*19.33*	*85.71%*
204	General Classroom - Math	0	17	17	24	24	17	23	*20.33*	*85.71%*
206	General Classroom - Math	21	19	22	17	24	24	15	*20.29*	*100.00%*
211	General Classroom - Math*	25	22	23	14	13	14	25	*19.43*	*100.00%*
212	General Classroom - Math	19	23	25	19	26	24	0	*22.67*	*85.71%*
214	General Classroom - Math	25	27	25	24	24	25	21	*24.43*	*100.00%*
216	General Classroom - Math	23	18	16	26	15	23	23	*20.57*	*100.00%*
221	General Classroom - Math	21	9	14	16	20	19	20	*17.00*	*100.00%*
223	General Classroom - Math	12	22	21	14	25	21	13	*18.29*	*100.00%*
	Math Department Sub-totals								*20.46*	*93.41%*
401	General Classroom - Social Studies	0	18	23	14	27	24	21	*21.17*	*85.71%*
402	General Classroom - Social Studies	24	24	0	24	23	24	21	*23.33*	*85.71%*
404	General Classroom - Social Studies	22	26	24	13	0	19	22	*21.00*	*85.71%*
406	General Classroom - Social Studies	15	24	21	24	19	21	24	*21.14*	*100.00%*
418	General Classroom - Social Studies	15	21	22	18	23	11	24	*19.14*	*100.00%*
421	General Classroom - Social Studies	20	24	0	18	23	19	0	*20.80*	*71.43%*
423	General Classroom - Social Studies	24	0	21	24	21	14	23	*21.17*	*85.71%*
424	General Classroom - Social Studies	23	24	26	24	22	21	25	*23.57*	*100.00%*
425	General Classroom - Social Studies	11	23	20	17	16	10	0	*16.17*	*85.71%*
426	General Classroom - Social Studies	23	13	0	8	16	23	24	*17.83*	*85.71%*
427	General Classroom - Social Studies	15	21	22	13	20	10	20	*17.29*	*100.00%*
428	General Classroom - Social Studies	20	18	0	11	18	22	21	*18.33*	*85.71%*
429	General Classroom - Social Studies	24	24	0	23	24	24	22	*23.50*	*85.71%*
728B	Social Studies*	0	0	30	0	0	19	0	*24.50*	*28.57%*
	Social Studies Department Sub-totals								*20.43*	*84.69%*
414	General Classroom - French	11	0	22	16	18	0	21	*17.60*	*71.43%*
415	General Classroom - Latin	25	18	26	27	24	23	20	*23.29*	*100.00%*
416	General Classroom - French	17	14	21	21	14	16	0	*17.17*	*85.71%*
417	General Classroom - Latin	22	20	27	16	18	0	22	*20.83*	*85.71%*
419	General Classroom - Chinese	12	0	24	11	16	0	25	*17.60*	*71.43%*
707	General Classroom - Spanish	15	19	0	14	18	14	0	*16.00*	*71.43%*
709	General Classroom - Spanish	20	26	0	24	24	0	22	*23.20*	*71.43%*
711	General Classroom - Spanish	19	20	18	20	16	20	24	*19.57*	*100.00%*
712	General Classroom - Spanish	16	19	21	11	23	16	0	*17.67*	*85.71%*
713	General Classroom - Spanish	25	13	0	23	21	24	24	*21.67*	*85.71%*
714	General Classroom - Spanish	0	25	19	25	13	24	26	*22.00*	*85.71%*
716	General Classroom - Spanish	10	18	0	24	13	30	14	*18.17*	*85.71%*
	World Languages Department Sub-totals								*19.67*	*83.33%*
	Core Academic Sub-totals								*20.88*	*89.22%*

				A				B		
Day										
Period		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total Minutes Per Cycle**	
Minutes, Monday - Thursday		90	90	80	50	50	90	90	2480	
Minutes, Friday										
		Existing Number of Students Enrolled								
		<16		**16 to 22**			**≥23**		**Average Students Per Period**	**Calculated Utilization Rate by Periods**
Room #	**Course Title**									
101	**Engineering Lab**	9	2	0	0	24	24	24	*16.60*	*71.43%*
102	**Physics Lab**	21	18	22	19	24	17	17	*19.71*	*100.00%*
103	**Physics Lab**	18	18	23	0	21	23	16	*19.83*	*85.71%*
104	**Physics Lab**	18	15	22	19	21	12	16	*17.57*	*100.00%*
106	**Physics Lab***	19	24	12	19	18	18	0	*18.33*	*85.71%*
108	**Physics/Bio Lab**	22	19	11	15	17	17	17	*16.86*	*100.00%*
110	**Biology Lab**	23	18	23	0	24	24	20	*22.00*	*85.71%*
207	**Chemistry Lab**	18	20	21	22	20	23	22	*20.86*	*100.00%*
208	**Chemistry Lab**	11	20	16	22	0	17	17	*17.17*	*85.71%*
209	**Chemistry Lab**	15	21	19	18	19	20	23	*19.29*	*100.00%*
210	**Chemistry Lab**	15	0	16	23	22	24	12	*18.67*	*85.71%*
213	**Biology Lab**	0	23	23	13	0	22	22	*20.60*	*71.43%*
215	**Biology Lab**	14	0	12	14	19	24	16	*16.50*	*85.71%*
217	**Biology Lab**	0	24	24	14	16	21	18	*19.50*	*85.71%*
219	**Biology Lab**	16	20	22	23	0	20	17	*19.67*	*85.71%*
	Science Department Sub-totals								*18.88*	*88.57%*
601	**Art**	20	20	20	0	18	20	0	*19.60*	*71.43%*
605	**Art**	4	0	5	19	20	0	20	*13.60*	*71.43%*
807	**Art - Ceramics**	21	21	22	0	15	21	22	*20.33*	*85.71%*
809	**Art - Photogrpahy**	16	0	14	11	16	20	19	*16.00*	*85.71%*
901	**Art**	16	0	7	15	23	0	24	*17.00*	*71.43%*
903	**Art**	0	24	24	0	24	22	0	*23.50*	*57.14%*
907	**Art**	0	11	21	19	0	15	23	*17.80*	*71.43%*
909	**Art**	16	0	13	19	0	19	14	*16.20*	*71.43%*
	Fine Arts Department Sub-totals								*17.88*	*73.21%*
612	**Chorus Room**	36	30	0	19	0	0	28	*28.25*	*57.14%*
614	**Midi Lab**	0	16	0	10	0	0	0	*13.00*	*28.57%*
616	**Band Room**	0	0	0	15	42	0	0	*28.50*	*28.57%*
Auditorium	**Auditorium** - *Excluded*	0	7	19	0	0	0	0	*13.00*	*28.57%*
	Performing Arts Department Sub-totals								*24.50*	*42.86%*
409	**Multi-media Lab**	0	11	0	0	1	1	1	*3.50*	*57.14%*
409a	**TV Studio**	8	15	15	0	0	0	0	*12.67*	*42.86%*
	Fine & Performing Arts Sub-totals								*17.51*	*61.54%*
611	**Gym - B**	76	53	78	78	51	61	48	*21.19*	*100.00%*
613	**Gym - A**	54	52	78	26	61	47	75	*18.71*	*100.00%*
	Health & PE Department Sub-totals								*19.95*	*100.00%*
	GRAND TOTALS								*19.92*	*84.03%*
205F		3	8	0	0	0	0	0	*5.50*	*28.57%*
411		11	8	0	5	5	5	5	*6.50*	*85.71%*
706		22	11	13	24	12	13	24	*17.00*	*100.00%*
707A		0	2	0	0	2	2	6	*3.00*	*57.14%*
708		3	12	6	9	7	3	5	*6.43*	*100.00%*
710		5	6	0	6	6	0	2	*5.00*	*71.43%*
802		2	4	0	3	3	8	5	*4.17*	*85.71%*
803		4	7	0	2	4	6	0	*4.60*	*71.43%*
805		3	6	3	0	3	4	0	*3.80*	*71.43%*
808		3	4	4	4	4	4	4	*3.86*	*100.00%*
810		5	4	0	5	4	0	6	*4.80*	*71.43%*
902		5	12	5	0	9	8	3	*7.00*	*85.71%*
910		5	8	6	3	16	4	5	*6.71*	*100.00%*
	Special Education Department Sub-totals								*6.36*	*79.12%*

The bulleted list below summarizes the key findings from this analysis of existing space use.

- The existing building houses 88 total teaching stations, including spaces that have been recently repurposed to be general education classrooms.

Department	Total Teaching Stations
Core Academic (English, Mathematics, Social Studies, World Languages)	52
Science	14
Fine Arts	8
Performing Arts	3
Health & Physical Education	6
Vocational & Technology[5]	2
Other[6]	3
GRAND TOTALS	**88**

- General education spaces are averaging 19.92[7] students per period for all of Needham High School
- General education spaces are averaging 84%[8] utilization for all of Needham High School
- Individual Departments Averages:

	Average Students Per Period	Utilization by Department
English Department	22.56	94.90%
Math Department	20.46	93.41%
Social Studies Department	20.43	84.69%
World Languages Department	19.67	83.33%
Science Department	18.88	88.57%
Fine Arts Department	17.88	73.21%
Performing Arts Department	24.50	42.86%
Health & PE Department	19.95	100%[9]
Multi-Media Lab[10]	3.5	57.14%
TV Studio[7]	12.67	42.86%
Special Education Department[11]	6.36	79.12%

[5] Television Studio and Fabrication Lab

[6] Auditorium, Multi-media Lab, and Interdisciplinary Classroom

[7] MSBA guideline for students per period is 23 for grades 9th-12th

[8] MSBA guideline for utilization is 85%. 85% is also a common benchmark across the country. It represents students occupying spaces 6 of seven periods per cycle.

[9] This is a misrepresentation of what is believed to be really happening across the entire department. 100%, in this context, only represents the fact that the two Gym spaces are scheduled 100% according to student schedules. In practice, these students are distributed amongst as many as nine spaces.

[10] These two spaces are unique. They are scheduled under the Performing Arts Department, but are highly specialized spaces with very few students scheduled into them. They are contributing to lower averages across the HS.

[11] Special Education spaces were excluded from overall building averages. Including special education in these calculations would artificially lower the averages for the entire building and result in a misrepresentation of the outcomes.

- Over-crowding and over-utilization in the Core Academic disciplines appears to be offset by under-crowding and under-utilization in the Fine & Performing arts departments.
- There are currently 329 sections offered in English, Mathematics, Social Studies, and World Languages. At the benchmark of 85% utilization, these sections require 55 general education classrooms. Needham High School currently possesses only 52. **This demonstrates that a current need exists for 3 general education classrooms based on the 2016-2017 enrollment.**
- At the 85% utilization and 23 students per classroom benchmarks, Science requires 15 Science Labs. Needham High School currently possesses 14. **This demonstrates that a current need exists for 1 multi-discipline Science Lab based on the 2016-2017 enrollment.**

Future Space Usage

In order to determine if spatial needs will exist at Needham High School in the future, D&W combined the agreed upon target enrollment with several assumptions and several algorithms to project how many students would be enrolled in each section. Those assumptions and algorithms are defined below.

<u>The current number and type of courses offered will continue for the foreseeable future.</u>
While the number and type of courses will likely change over the next 15 years of the school's lifecycle, it is impossible to know what those changes will be. For purposes of determining future space needs, D&W assumed the program of studies would continue.

<u>The current daily schedule will continue for the foreseeable future.</u>
Needham High School and District Administrators are currently studying revisions to the high school's daily schedule. All explorations are based on a seven period/cycle model. D&W assumed a seven period/cycle schedule in all its algorithms.

<u>The current desirability of courses will continue into the foreseeable future.</u>
D&W assumed that the same percentage of students currently enrolled in courses will continue for the foreseeable future.

<u>Section caps should be adjusted downward.</u>
Given the size of existing instructional spaces, a desire was expressed by members of the Working Group to reduce class sizes, particularly in the Core Academic Disciplines, to a maximum of 24 students per section. Class sizes and section caps that already exist to be in the best interest of students should, however, remain intact.

<u>Utilization rates should be maintained or improved.</u>
As the enrollment increases and places stresses on the existing building, a desire was expressed by the Working Group to maintain the status quo or reduce the utilization rates of instructional spaces. An overall rate of 85% or lower should be maintained for the entire Needham High School. To achieve that, however, utilization rates in the Core Academic disciplines should be no higher than they are currently. D&W incorporated these desires into its algorithms.

Inherent Inefficiencies of Certain Instructional Spaces

Certain courses require specialty spaces, spaces with inherent inefficiencies in utilization. The Auditorium is an example. A theatrical arts course that takes place in the Auditorium may have acting, stagecraft, lighting, direction, and/or writing as part of the curriculum. It is unlikely, however, that such a course will have enough students enrolled to be fully utilized as an instructional space every period of every day. Its real value is as a performance venue outside the typical school day. Even in a space like the Chorus Room, there are typically not enough students enrolled to be fully utilized. But, it would be inappropriate to offer these courses in spaces not specifically designed for the needed functions in an effort to improve utilization. It would also be difficult, if not inappropriate, to offer other courses in these specially designed spaces. Housing a World Languages course in the Auditorium might be theoretically possible, but the fixed furnishings alone would greatly limit the types of instructional activities a teacher could employ. D&W assumed these inherent inefficiencies are permissible and overcoming them as part of future solutions was not educationally viable in most circumstances.

Total Students Enrolled

A representation of the total number of students currently enrolled in a course for the 2026-1027 school year.

Total sum of students enrolled in all sections of a course over a complete cycle

Section Enrollment Cap

A generalized representation of the maximum number of students allowed to enroll in a course. It is a number determined by Departmental and School leadership to ensure the class sizes are in the best interests of students. In determining future space needs, these caps remained in effect when they were below 23. When existing caps exceeded 23, future space needs were determined based on a maximum cap of 24.

Actual Number of Sections

A representation of how many sections of a course were offered in the 2016-2017 school year. These numbers were determined by Departmental leadership based on expected course enrollments and then revised once actual enrollments were known. In many cases, more sections than necessary were offered in order to provide access to students who would otherwise have scheduling conflicts from other disciplines.

Percentage of Total Population

A representation of how many students, as a percentage of the total 2016-2017 9^{th}-12^{th} population, were enrolled in a course.

Total students enrolled ÷ Total current enrollment (1,659)

Theoretical Students Enrolled
A theoretical representation of how many students will be enrolled in a course when the total 9th-12th population reaches the target enrollment of 1800 students.

Enrollment target (1,800) X Percentage of population of total population currently enrolled in course

Theoretical Sections Needed in the Future, Decimal
A two-decimal place representation of how many sections of a course are needed in the future. For courses with a cap of 23 or less, the existing cap was used in the calculation. For courses with a cap of 24 or higher, a maximum cap of 24 was used in the calculation.

Theoretical students enrolled over a complete cycle ÷ Section Cap

Theoretical Sections Needed in the Future, Rounded
A rounded representation of how many sections of a course are needed in the future. In an effort to be conservative and ensure that sections can be scheduled, the decimal calculation for Theoretical Sections Needed was rounded up to the next whole section.

Theoretical Space Needed in the Future, Individual Course
A representation of how many rooms are needed for a course in the future. Since all future daily schedules are assumed to be based on a seven periods/cycle model, each room is capable of housing 35 sections at 100% utilization. For this calculation, D&W applied an 85% utilization.

Theoretical sections needed, rounded ÷ 7 sections per cycle ÷ 85% utilization

Theoretical Space Needed in the Future, Departmental Sub-Total
A representation of how many rooms are needed for an entire department in the future. This calculation will result in a need for single rooms to serve multiple courses in many cases.

Total sum of theoretical spaces needed for an entire department, rounded up to the nearest whole room

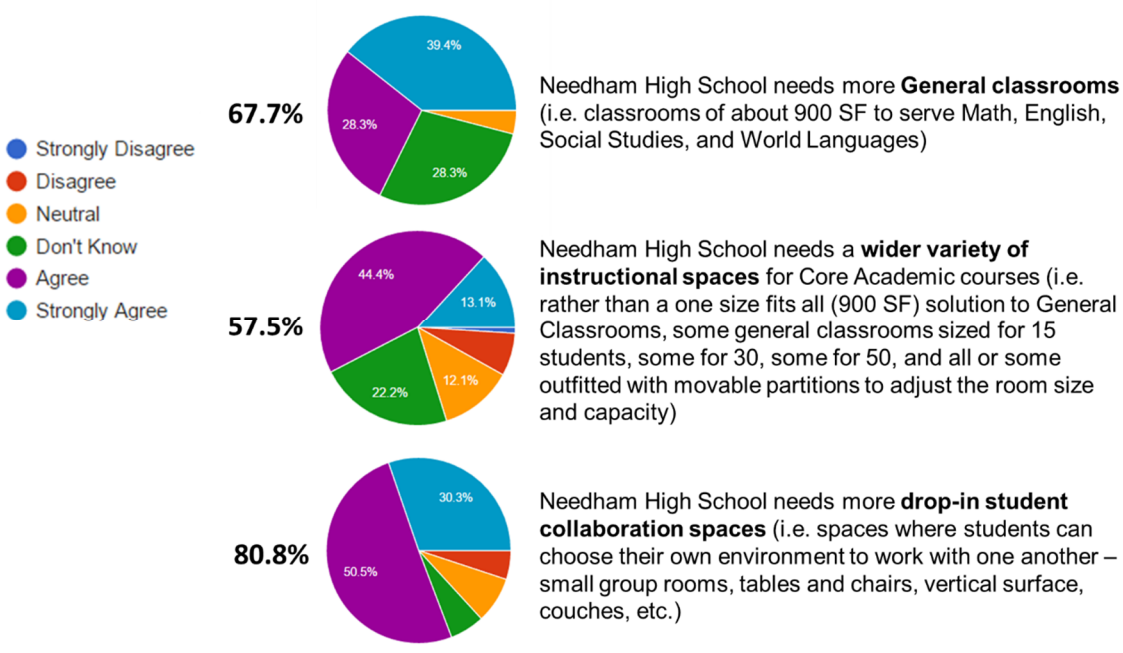
In addition to these definitions and algorithms, D&W employed two other tools to help determine if spatial needs will exist in the future:

Special Education Departmental Interviews

Special Education programs and services are unlike courses offered as part of the general education curriculum in many ways. First, they intentionally have fewer students enrolled in them as required by students IEPs[12] or 504 plans. Second, the physical space required is highly dependent on the nature of the program or service being delivered. It is, therefore, impossible to determine spatial needs strictly arithmetically using only students per section and utilization rates. D&W conducted interviews with members of the Special Education faculty, staff, and departmental leadership to better understand the nature of the programs and services being offered and to identify where spatial deficiencies may exist in the future. While D&W did perform the same existing space usage analysis on special education spaces as it did on general education spaces, D&W relied on the expertise of the special educators to identify spatial requirements.

Faculty & Staff Survey

In collaboration with the members of the Working Group, D&W developed and published an anecdotal survey and collected responses from faculty and staff related to perceived spatial needs (Appendix XXX). The intent was to ensure that the feasibility study fully explored potential needs by uncovering needs that might not otherwise be known. Statements about perceived needs were crafted in such a way to allow respondents to identify his/her individual level of agreement. While the results of the survey indicated general consensus that the high school needed more general education classrooms, the survey also revealed an unexpected outcome – a perceived need for more intentional student collaboration space.



Excerpt from Faculty and Staff Survey

[12] Individualized Education Plan (IEP)

In this context, student collaboration space refers to intentionally designed locations where students can gather to work in groups and as individuals. These spaces could be learning environments that are supplemental to general education classrooms as ways to augment their capabilities. These spaces could also be ad hoc spaces for students to use and customize at their discretion when their schedules permit. The illustration on the following page represents just one example of a series of high school collaboration spaces. In general terms, these spaces should exhibit one or more of the following characteristics.

- Some Noisy
- Some Quiet
- Some Open
- Some Enclosed
- Access to WiFi
- Lots of Vertical Writing Surface
- Access to Digital Display
- Some Hard Furnishings
- Some Soft Furnishings
- Highly Mobile Furnishings
- Food Friendly

While Needham High School has historically allowed the Cafeteria and portions of the Library to perform this function, neither space exhibits all of these characteristics and feel as if designed for an alternative function first and a collaboration space as an after-thought.

Battle Creek Area Mathematics & Science Center – Battle Creek, MI | TowerPinkster - Architects

The pages that follow contain the raw data used and calculations performed to determine future space needs.

Needham High School - Theoretical Needs by Course

Number of Students Per Section

						A				B						
Day																
Period					**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total Students Enrolled**	**Section Enrollment Cap**	**Percentage of Total Population**	**Theoretical Students Enrolled, Future**	**Theoretical Sections Needed Future (Decimal)**	**Theoretical Sections Needed Future (Rounded)**	**Theoretical Space Need Future @85%**
Minutes, Monday - Thursday					90	90	80	50	50	90	90							
Minutes, Friday					65	70	85	50	50									
					Existing Number of Students Enrolled													
Faculty Name	**Room #**	**Course Number**	**Course Title**		**<16**		**16 to 22**			**≥23**								
Katherine Maffei	717	0101.1	English 9 Acc		21													
Kelsey Bishop	717	0101.2	English 9 Acc			22												
Scott Kelly	715	0101.3	English 9 Acc			21												
Scott Kelly	715	0101.4	English 9 Acc							25		**137**	**28**	**8.26%**	**148.64**	**6.19**	**7**	**1.18**
Kelsey Bishop	722	0101.5	English 9 Acc		23													
Katherine Maffei	717	0101.6	English 9 Acc				25											
Karen McCalley	719	0102.1	English 9 Hon			25												
Jonathan Cooke	720	0102.10	English 9 Hon								25							
Kelsey McCarthy	715	0102.2	English 9 Hon				27											
Katherine Fanous	732	0102.3	English 9 Hon					20										
Elizabeth Wiedner	701	0102.4	English 9 Hon					20				**232**	**28**	**13.98%**	**251.72**	**10.49**	**11**	**1.85**
Laura Brinkmann	722	0102.5	English 9 Hon					20										
Scott Kelly	715	0102.6	English 9 Hon					20										
Katherine Fanous	732	0102.7	English 9 Hon						25									
Katherine Fanous	732	0102.8	English 9 Hon							26								
Laura Brinkmann	722	0102.9	English 9 Hon								24							
Scott Kelly	715	0103.1	English 9		10													
Jonathan Cooke	720	0103.2	English 9				15					**47**	**16**	**3.00%**	**54.00**	**3.38**	**4**	**0.67**
Kelsey Bishop	717	0103.3	English 9					10										
Karen McCalley	719	0103.4	English 9							12								
Laura Brinkmann	722	0201.1	English 10 Acc			19												
Robert Flaggert	726	0201.2	English 10 Acc			22												
Robert Flaggert	726	0201.3	English 10 Acc				23											
Kathryn Clayton	701	0201.4	English 10 Acc				25											
Jonathan Cooke	720	0201.5	English 10 Acc					28				**210**	**28**	**12.66%**	**227.85**	**9.49**	**10**	**1.68**
Jonathan Cooke	720	0201.6	English 10 Acc							25								
Kathryn Clayton	701	0201.7	English 10 Acc							25								
Elizabeth Cox	726	0201.8	English 10 Acc								22							
Katherine Fanous	732	0201.9	English 10 Acc								21							
Robert Flaggert	726	0202.1	English 10 Hon		20													
Douglas Kopcso	724	0202.2	English 10 Hon			25												
Elizabeth Brown	721	0202.3	English 10 Hon				25											
Kelsey Bishop	719	0202.4	English 10 Hon					27										
Douglas Kopcso	724	0202.5	English 10 Hon					27				**206**	**28**	**12.42%**	**223.51**	**9.31**	**10**	**1.68**
Kelsey McCarthy	715	0202.6	English 10 Hon						23									
Robert Flaggert	726	0202.7	English 10 Hon							19								
Elizabeth Brown	721	0202.8	English 10 Hon							17								
Kelsey Bishop	717	0202.9	English 10 Hon								23							
Elizabeth Wiedner	701	0203.1	English 10								12	**20**	**18**	**1.21%**	**21.70**	**1.21**	**2**	**0.34**
Katherine Fanous	732	0203.2	English 10			8												
Stephen Koup	723	0301.1	English 11 Acc		20													
Stephen Koup	723	0301.2	English 11 Acc						20			**63**	**28**	**3.80%**	**68.35**	**2.85**	**3**	**0.50**
Theresa Levy	730	0301.3	English 11 Acc						23									
Brian Herrmann	701	0302.1	English 11 Hon		20													
Karl Heckler	702	0302.2	English 11 Hon			20												
Elizabeth Cox	724	0302.3	English 11 Hon				25											
Elizabeth Cox	726	0302.4	English 11 Hon					24				**166**	**28**	**10.01%**	**180.11**	**7.50**	**8**	**1.34**
Brian Herrmann	702	0302.5	English 11 Hon						23									
Karl Heckler	702	0302.6	English 11 Hon							26								
Douglas Kopcso	724	0302.7	English 11 Hon								28							
Christopher Farnsworth	724	0303.1	English 11						13			**28**	**18**	**1.69%**	**30.38**	**1.69**	**2**	**0.34**
Douglas Kopcso	722	0303.2	English 11						15									

Number of Students Per Section

					A				B							
Day																
Period					1	2	3	4	5	6	7	Total Students Enrolled	Section Enrollment Cap	Percentage of Total Population	Theoretical Students Enrolled, Future	Theoretical Sections Needed Future (Decimal)	Theoretical Sections Needed Future (Rounded)	Theoretical Space Need Future @85%
Minutes, Monday - Thursday					90	90	80	50	50	90	90							
Minutes, Friday					65	70	85	50	50									
					Existing Number of Students Enrolled													
Faculty Name	**Room #**	**Course Number**	**Course Title**		<16		16 to 22			≥23								
Karen McCalley	719	0311.1	AP Language and Composition		26							133	28	8.02%	144.30	6.01	7	1.18
Karl Heckler	702	0311.2	AP Language and Composition		27													
Karen McCalley	719	0311.3	AP Language and Composition				26											
Laura Brinkmann	722	0311.4	AP Language and Composition							27								
Christopher Farnsworth	723	0311.5	AP Language and Composition								27							
Elizabeth Brown	721	0421.1	AP Literature and Composition			28						76	28	4.58%	82.46	3.44	4	0.67
Theresa Levy	730	0421.2	AP Literature and Composition				25											
Katherine Maffei	717	0421.3	AP Literature and Composition							23								
Brian Herrmann	701	0431.1	English 12 Acc			27						135	28	8.14%	146.47	6.10	7	1.18
Brian Herrmann	702	0431.2	English 12 Acc				28											
Elizabeth Brown	721	0431.3	English 12 Acc					25										
Elizabeth Cox	726	0431.4	English 12 Acc						27									
Patrick Gallagher	724	0431.5	English 12 Acc							28								
Theresa Levy	730	0432.1	English 12 Hon		22							139	28	8.38%	150.81	6.28	7	1.18
Christopher Farnsworth	724	0432.2	English 12 Hon		22													
Stephen Koup	723	0432.3	English 12 Hon				19											
Christopher Farnsworth	723	0432.4	English 12 Hon					27										
Stephen Koup	723	0432.5	English 12 Hon							21								
Theresa Levy	730	0432.6	English 12 Hon								28							
Katherine Maffei	719	0433.1	English 12								18	18	18	1.08%	19.53	1.08	2	0.34
Kathryn Clayton	728	0491.1	The Greater Boston Project Acc		28							28	50	1.69%	30.38	0.61	1	0.17
Elizabeth Weidner	732	0520.1	Exper Writing		12							12	28	0.72%	13.02	0.54	1	0.17
Karl Heckler	702	0530.1	Film Studies					23				23	28	1.39%	24.95	1.04	2	0.34
ENGLISH DEPARTMENT SUB-TOTAL																	88	15.00
Mary Bashir	416	1121.1	French 2 Acc						14			30	26	1.81%	32.55	1.36	2	0.34
Mary Bashir	416	1121.2	French 2 Acc							16								
Mary Bashir	416	1122.1	French 2 Hon		17							31	26	1.87%	33.63	1.40	2	0.34
Mary Bashir	416	1122.2	French 2 Hon			14												
Maurice Louis	414	1131.1	French 3 Acc						18			39	26	2.35%	42.31	1.76	2	0.34
Maurice Louis	414	1131.2	French 3 Acc								21							
Maurice Louis	414	1132.1	French 3 Hon					16				16	28	0.96%	17.36	0.72	1	0.17
Mary Bashir	416	1141.1	French 4 Acc					21				21	28	1.27%	22.78	0.95	1	0.17
Maurice Louis	414	1142.1	French 4 Hon				22					22	26	1.33%	23.87	0.99	1	0.17
Maurice Louis	414	1151.1	AP French 5		9							9	26	0.54%	9.76	0.41	1	0.17
Maurice Louis	414	1161.1	French 5 Acc		2							2	26	0.12%	2.17	0.09	1	0.17
Peter Caccavale	415	1311.1	Latin 1 Acc		25							51	26	3.07%	55.33	2.31	3	0.50
Peter Caccavale	415	1311.2	Latin 1 Acc				26											
Peter Caccavale	415	1312.1	Latin 1 Hon					27				54	28	3.25%	58.59	2.44	3	0.50
Charlotte Webber	417	1312.2	Latin 1 Hon				27											
Peter Caccavale	415	1321.1	Latin 2 Acc						24			64	26	3.86%	69.44	2.89	3	0.50
Charlotte Webber	417	1321.2	Latin 2 Acc			20												
Peter Caccavale	415	1321.3	Latin 2 Acc								20							
Lauren Downey	417	1322.1	Latin 2 Hon		22							40	26	2.41%	43.40	1.81	2	0.34
Lauren Downey	417	1322.2	Latin 2 Hon						18									
Lauren Downey	416	1331.1	Latin 3 Acc				21					43	28	2.59%	46.65	1.94	2	0.34
Lauren Downey	417	1331.2	Latin 3 Acc								22							

Number of Students Per Section

					A					B							
			Day														
			Period		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total Students Enrolled**	**Section Enrollment Cap**	**Percentage of Total Population**	**Theoretical Students Enrolled, Future**	**Theoretical Sections Needed Future (Decimal)**	**Theoretical Sections Needed Future (Rounded)**	**Theoretical Space Need Future @85%**
			Minutes, Monday - Thursday		90	90	80	50	50	90	90							
			Minutes, Friday		65	70	85	50	50									
					Existing Number of Students Enrolled													
Faculty Name	**Room #**	**Course Number**	**Course Title**		**<16**		**16 to 22**			**≥23**								
Peter Caccavale	415	1332.1	Latin 3 Hon			18						41	26	2.47%	44.48	1.85	2	0.34
Peter Caccavale	415	1332.2	Latin 3 Hon							23								
Lauren Downey	417	1341.1	Latin 4 Acc					13				13	26	0.78%	14.10	0.59	1	0.17
Lauren Downey	417	1342.1	Latin 4 Hon					3				3	6	0.18%	3.25	0.54	1	0.17
Lauren Finucane	709	1513.1	Spanish 1		20							41	20	2.47%	44.48	2.22	3	0.50
Kathleen Eschle	712	1513.2	Spanish 1				21											
Jennifer Hopkin	713	1521.1	Spanish 2 Acc		25							102	26	6.15%	110.67	4.61	5	0.84
Jennifer Hopkin	721	1521.2	Spanish 2 Acc						21									
Jennifer Hopkin	713	1521.3	Spanish 2 Acc								24							
Chatherine Street	707	1521.4	Spanish 2 Acc					14										
Chatherine Street	707	1521.5	Spanish 2 Acc						18									
Monica Sandoval	713	1522.1	Spanish 2 Hon						21			93	26	5.61%	100.90	4.20	5	0.84
Monica Sandoval	713	1522.2	Spanish 2 Hon							24								
Lauren Finucane	709	1522.3	Spanish 2 Hon			26												
Lauren Finucane	709	1522.4	Spanish 2 Hon								22							
Jennifer Hopkin	713	1523.1	Spanish 2			13						31	20	1.87%	33.63	1.68	2	0.34
Meaghan McSherry	711	1523.2	Spanish 2				18											
Meaghan McSherry	711	1531.1	Spanish 3 Acc							20		120	26	7.23%	130.20	5.42	6	1.01
Meaghan McSherry	711	1531.2	Spanish 3 Acc								24							
Monica Sandoval	714	1531.3	Spanish 3 Acc					25										
Cara Van Cott	714	1531.4	Spanish 3 Acc			25												
Cara Van Cott	714	1531.5	Spanish 3 Acc								26							
Chatherine Street	707	1532.1	Spanish 3 Hon		15							85	26	5.12%	92.22	3.84	4	0.67
Chatherine Street	707	1532.2	Spanish 3 Hon			19												
Kathleen Eschle	712	1532.2	Spanish 3 Hon			19												
Kathleen Eschle	711	1532.4	Spanish 3 Hon						16									
Kathleen Eschle	712	1532.5	Spanish 3 Hon							16								
Cara Van Cott	714	1533.1	Spanish 3						13			27	20	1.63%	29.29	1.46	2	0.34
Chatherine Street	707	1533.2	Spanish 3							14								
Kathleen Eschle	712	1541.1	Spanish 4 Acc		16							64	26	3.86%	69.44	2.89	3	0.50
Lauren Finucane	709	1541.2	Spanish 4 Acc					24										
Lauren Finucane	709	1541.3	Spanish 4 Acc						24									
Keara Eagan	716	1542.1	Spanish 4 Hon			18						101	26	6.09%	109.58	4.57	5	0.84
Cara Van Cott	714	1542.2	Spanish 4 Hon				19											
Cara Van Cott	714	1542.3	Spanish 4 Hon							24								
Meaghan McSherry	711	1542.4	Spanish 4 Hon			20												
Meaghan McSherry	711	1542.5	Spanish 4 Hon					20										
Jennifer Hopkin	713	1551.1	AP Spanish 5					23				23	26	1.39%	24.95	1.04	2	0.34
Keara Eagan	716	1561.1	Spanish 5 Acc					24				51	26	3.07%	55.33	2.31	3	0.50
Keara Eagan	716	1561.2	Spanish 5 Acc						13									
Keara Eagan	716	1561.3	Spanish 5 Acc								14							
Keara Eagan	716	1563.1	Spanish 4		10							10	20	0.60%	10.85	0.54	1	0.17
Yu-wen Wang	419	1602.1	Mandarin 1 Hon				24					24	26	1.45%	26.04	1.08	2	0.34
Yu-wen Wang	419	1612.1	Mandarin 2 Hon		2							7	6	0.42%	7.59	0.32	1	0.17
Yu-wen Wang	419	1612.2	Mandarin 2 Hon						5									
Yu-wen Wang	419	1621.1	Mandarin 2 Acc		10							21	20	1.27%	22.78	1.14	2	0.34
Yu-wen Wang	419	1621.2	Mandarin 2 Acc						11									
Yu-wen Wang	419	1622.1	Mandarin 3 Hon					5				5	13	0.30%	5.42	0.42	1	0.17
Yijie Wang	712	1631.1	Mandarin 3 Acc						23			23	26	1.39%	24.95	1.04	2	0.34
Yu-wen Wang	419	1632.1	Mandarin 4 Hon					6				6	28	0.36%	6.51	0.27	1	0.17

Number of Students Per Section

				Day			A			B									
				Period	1	2	3	4	5	6	7	Total Students Enrolled	Section Enrollment Cap	Percentage of Total Population	Theoretical Students Enrolled, Future	Theoretical Sections Needed Future (Decimal)	Theoretical Sections Needed Future (Rounded)	Theoretical Space Need Future @85%
				Minutes, Monday - Thursday	90	90	80	50	50	90	90								
				Minutes, Friday	65	70	85	50	50										
					Existing Number of Students Enrolled														
Faculty Name	Room #	Course Number	Course Title		<16			16 to 22			≥23								
Yu-wen Wang	419	1641.1	Mandarin 4 Acc								25	25	28	1.51%	27.12	1.13	2	0.34
Yijie Wang	712	1671.1	AP Mandarin 5					11				11	22	0.66%	11.93	0.50	1	0.17
Yijie Wang	712	1681.1	Mandarin 5					0				0	26	0.00%	0.00	0.00	0	0.00
WORLD LANGUAGE DEPARTMENT SUB-TOTAL																	81	14.00
Alison Borrelli	221	2002.1	Algebra 1 Hon					16				55	26	3.32%	59.67	2.49	3	0.50
Alison Borrelli	221	2002.2	Algebra 1 Hon						20									
Brett McNeice	203	2002.3	Algebra 1 Hon						19									
Jason Isaacs	211	2003.1	Algebra 1						13			27	18	1.63%	29.29	1.63	2	0.34
Jason Isaacs	211	2003.2	Algebra 1							14								
Kaitlyn Garner	223	2013.1	Geometry		12							40	18	2.41%	43.40	2.41	3	0.50
Kaitlyn Garner	216	2013.2	Geometry						15									
Adam Cole	223	2013.3	Geometry								13							
Deanna Detorie	206	2082.1	Geometry Hon		21							244	26	14.71%	264.74	11.03	12	2.02
Deanna Detorie	206	2082.2	Geometry Hon			19												
Alison Borrelli	112	2082.3	Geometry Hon			17												
David Bookston	201	2082.4	Geometry Hon						23									
Mark Dinneen	201	2082.5	Geometry Hon							16								
Jennifer Gould	216	2082.6	Geometry Hon			18												
Jennifer Gould	216	2082.7	Geometry Hon					26										
David Bookston	201	2082.8	Geometry Hon					25										
Alison Borrelli	221	2082.9	Geometry Hon							19								
Mark Dinneen	201	2082.10	Geometry Hon								20							
Mark Dinneen	211	2082.11	Geometry Hon				23											
David Bookston	203	2082.12	Geometry Hon								17							
Jennifer Carmody	212	2091.1	Geometry ACC		19							150	26	9.04%	162.75	6.78	7	1.18
Jennifer Carmody	212	2091.2	Geometry ACC			23												
Jason Isaacs	109	2091.3	Geometry Acc		21													
Richard Giacin	204	2091.4	Geometry Acc						24									
Richard Giacin	204	2091.5	Geometry Acc							17								
Brett McNeice	203	2091.6	Geometry Acc				23											
Brett McNeice	202	2091.7	Geometry Acc								23							
Jacklyn Persuit	204	2113.3	Algebra 2				17					32	18	1.93%	34.72	1.93	2	0.34
Jacklyn Persuit	206	2113.4	Algebra 2								15							
Jessica Kondrat	214	2122.1	Algebra 2 Hon		25							258	26	15.55%	279.93	11.66	12	2.02
Brett McNeice	202	2122.2	Algebra 2 Hon		23													
John Shea	201	2122.3	Algebra 2 Hon			24												
James Odierna	201	2122.4	Algebra 2 Hon				23											
Hans Batra	109	2122.5	Algebra 2 Hon					15										
Brett McNeice	203	2122.6	Algebra 2 Hon					18										
Hans Batra	109	2122.7	Algebra 2 Hon						22									
Kristen Vallieres	206	2122.8	Algebra 2 Hon						24									
Jessica Kondrat	212	2122.9	Algebra 2 Hon							24								
Hans Batra	109	2122.10	Algebra 2 Hon								24							
Robert Murphy	211	2122.11	Algebra 2 Hon			22												
Robert Murphy	223	2122.12	Algebra 2 Hon					14										
Andrew Lawrence	214	2131.1	Algebra 2 ACC						24			126	26	7.59%	136.71	5.70	6	1.01
Andrew Lawrence	214	2131.2	Algebra 2 ACC								21							
Kaitlyn Garner	223	2131.3	Algebra 2 Acc			22												
Kaitlyn Garner	223	2131.4	Algebra 2 Acc				21											
Kristen Vallieres	221	2131.5	Algebra 2 Acc		21													
Kristen Vallieres	206	2131.6	Algebra 2 Acc					17										
Richard Giacin	202	2133.1	Adv Algebra & Trig				11					11	18	0.66%	11.93	0.66	1	0.17

Number of Students Per Section

						A				B						
			Day													
			Period		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total Students Enrolled**	**Section Enrollment Cap**	**Percentage of Total Population**	**Theoretical Students Enrolled, Future**	**Theoretical Sections Needed Future (Decimal)**	**Theoretical Sections Needed Future (Rounded)**	**Theoretical Space Need Future @85%**
			Minutes, Monday - Thursday		90	90	80	50	50	90	90							
			Minutes, Friday		65	70	85	50	50									
					Existing Number of Students Enrolled													
Faculty Name	**Room #**	**Course Number**	**Course Title**		**<16**		**16 to 22**			**≥23**								
Jessica Kondrat	212	2203.1	PreCalculus					19				**37**	**18**	**2.23%**	**40.14**	**2.23**	**3**	**0.50**
Deanna Detorie	202	2203.2	PreCalculus							18								
Kaitlyn Garner	216	2212.1	PreCalculus Hon							23		**210**	**26**	**12.66%**	**227.85**	**9.49**	**10**	**1.68**
Richard Giacin	202	2212.2	PreCalculus Hon			17												
Richard Giacin	204	2212.3	PreCalculus Hon								23							
Kristen Vallieres	206	2212.4	PreCalculus Hon				22											
Kristen Vallieres	221	2212.5	PreCalculus Hon								20							
Jacklyn Persuit	204	2212.6	PreCalculus Hon			17												
Jacklyn Persuit	204	2212.7	PreCalculus Hon					24										
Jacklyn Persuit	206	2212.8	PreCalculus Hon							24								
Deanna Detorie	202	2212.9	PreCalculus Hon					23										
Deanna Detorie	202	2212.10	PreCalculus Hon						17									
Adam Cole	221	2221.1	PreCalculus AB Acc				14					**76**	**28**	**4.58%**	**82.46**	**3.44**	**4**	**0.67**
Adam Cole	223	2221.2	PreCalculus AB Acc							21								
Jennifer Gould	216	2221.3	PreCalculus AB Acc				16											
Jennifer Gould	214	2221.4	PreCalculus AB Acc							25								
Robert Murphy	223	2231.1	PreCalculus BC Acc						25			**44**	**28**	**2.65%**	**47.74**	**1.99**	**2**	**0.34**
David Bookston	203	2231.2	PreCalculus BC Acc		19													
Jane Chinnaswamy	112	2302.1	Calculus Hon		24							**137**	**26**	**8.26%**	**148.64**	**6.19**	**7**	**1.18**
Jane Chinnaswamy	112	2302.2	Calculus Hon					21										
Jane Chinnaswamy	112	2302.3	Calculus Hon						23									
Jennifer Gould	216	2302.4	Calculus Hon								23							
Jason Isaacs	109	2302.5	Calculus Hon			23												
Jason Isaacs	109	2302.6	Calculus Hon				23											
Robert Murphy	211	2311.1	AP Calculus AB								25	**78**	**26**	**4.70%**	**84.63**	**3.53**	**4**	**0.67**
Jessica Kondrat	214	2311.2	AP Calculus AB			27												
Jessica Kondrat	212	2311.3	AP Calculus AB						26									
Jennifer Carmody	212	2321.1	AP Calculus BC				25					**50**	**28**	**3.01%**	**54.25**	**2.26**	**3**	**0.50**
Robert Murphy	211	2321.2	AP Calculus BC		25													
David Bookston	203	2331.1	AP Statistics			20						**44**	**28**	**2.65%**	**47.74**	**1.99**	**2**	**0.34**
Andrew Lawrence	214	2331.2	AP Statistics					24										
Andrew Lawrence	216	2332.1	Statistics Hon		23							**48**	**26**	**2.89%**	**52.08**	**2.17**	**3**	**0.50**
Andrew Lawrence	214	2332.2	Statistics Hon				25											
Mark Dinneen	201	2481.1	AP Computer Science (Math)		25							**25**	**26**	**1.51%**	**27.12**	**1.13**	**2**	**0.34**
Jane Chinnaswamy	112	2482.1	Intro to Computer Science (Math)							24		**38**	**26**	**2.29%**	**41.23**	**1.72**	**2**	**0.34**
Mark Dinneen	211	2482.2	Intro to Computer Science (Math)					14										
Hans Barta	101	2485.1	Senior STEM Capstone			2						**2**	**15**	**0.12%**	**2.17**	**0.14**	**1**	**0.17**
Adam Cole	221	2488.1	AP Computer Science Principles			9						**9**	**26**	**0.54%**	**9.76**	**0.41**	**1**	**0.17**
Adam Cole	219	2615.1	Personal Finance (Math)					23				**52**	**26**	**3.13%**	**56.42**	**2.35**	**3**	**0.50**
Jane Chinnaswamy	219	2615.2	Personal Finance (Math)			20												
Hans Barta	101	2615.5	Personal Finance (Math)		9													
MATHEMATICS DEPARTMENT SUB-TOTAL																	**95**	**16.00**
Jennifer Regrut	104	3001.10	Biology Acc								16	**181**	**24**	**10.91%**	**196.38**	**8.18**	**9**	**1.51**
Richard Ayache	110	3001.1	Biology Acc		23													
Elliot Frank	219	3001.2	Biology Acc							20								
Richard Ayache	110	3001.3	Biology Acc			18												
Elliot Frank	108	3001.4	Biology Acc			19												
Richard Ayache	110	3001.5	Biology Acc				23											
Elliot Frank	108	3001.6	Biology Acc					15										
Scott Blanchette	215	3001.7	Biology Acc					14										
Elliot Frank	219	3001.8	Biology Acc								17							
Scott Blanchette	215	3001.9	Biology Acc								16							

Number of Students Per Section

Day					A				B						
Period					1	2	3	4	5	6	7	Total Students Enrolled	Section Enrollment Cap	Percentage of Total Population	Theoretical Students Enrolled, Future	Theoretical Sections Needed Future (Decimal)	Theoretical Sections Needed Future (Rounded)	Theoretical Space Need Future @85%
Minutes, Monday - Thursday					90	90	80	50	50	90	90							
Minutes, Friday					65	70	85	50	50									
				Existing Number of Students Enrolled														
Faculty Name	Room #	Course Number	Course Title	<16		16 to 22				≥23								
Andrew Verardo	110	3012.10	Biology Hon							20	198	24	11.93%	214.83	8.95	9	1.51
Victoria DaCosta	217	3012.1	Biology Hon					16										
Victoria DaCosta	217	3012.2	Biology Hon						21									
Victoria DaCosta	217	3012.3	Biology Hon							18								
Ashton Kazlo	217	3012.4	Biology Hon			24												
Ashton Kazlo	217	3012.5	Biology Hon		24													
Andrew Verado	213	3012.6	Biology Hon				13											
Ashton Kazlo	217	3012.7	Biology Hon				14											
Andrew Verardo	210	3012.8	Biology Hon						24									
Mary Kay Alessi	215	3012.9	Biology Hon						24									
Mary Kay Alessi	219	3023.1	Biology	16							44	18	2.65%	47.74	2.65	3	0.50	
Elliot Frank	108	3023.2	Biology			11												
Mary Kay Alessi	108	3023.3	Biology							17								
Michael Hirsh	108	3101.1	Physics Acc	22							181	24	10.91%	196.38	8.18	9	1.51	
Emily Luck	102	3101.2	Physics Acc	21														
Michael Hirsh	106	3101.3	Physics Acc		24													
Emily Luck	102	3101.4	Physics Acc			22												
Kathryn Cadavieco	104	3101.5	Physics Acc			22												
John Sherry	103	3101.6	Physics Acc			23												
Kathryn Cadavieco	102	3101.7	Physics Acc					24										
John Sherry	103	3101.8	Physics Acc						23									
John Sherry	103	3112.10	Physics Hon					21			236	24	14.23%	256.06	10.67	11	1.85	
Kathryn Cadavieco	104	3112.1	Physics Hon	18														
Kathryn Cadavieco	102	3112.11	Physics Hon						17									
Emily Luck	102	3112.12	Physics Hon							17								
John Sherry	103	3112.13	Physics Hon							16								
Daniel Smalley	106	3112.2	Physics Hon	19														
Patrick Corcoran	103	3112.3	Physics Hon	18														
Dnaiel Smalley	102	3112.4	Physics Hon		18													
Patrick Corcoran	104	3112.5	Physics Hon		15													
John Sherry	103	3112.6	Physics Hon		18													
Patrick Corcoran	104	3112.7	Physics Hon				19											
Emily Luck	102	3112.8	Physics Hon				19											
Patrick Corcoran	104	3112.9	Physics Hon					21										
Michael Hirsh	106	3123.1	Physics			12					31	11	1.87%	33.63	3.06	4	0.67	
Daniel Smalley	106	3123.2	Physics				19											
Annapurna Vakati	208	3201.1	Chemistry Acc			16					137	24	8.26%	148.64	6.19	7	1.18	
Janet Lee Fasano	207	3201.2	Chemistry Acc				22											
Janet Lee Fasano	207	3201.3	Chemistry Acc						23									
Janet Lee Fasano	207	3201.4	Chemistry Acc							22								
Robert Kiefer	210	3201.5	Chemistry Acc	15														
Robert Kiefer	210	3201.6	Chemistry Acc			16												
Robert Kiefer	210	3201.7	Chemistry Acc				23											
Janet Lee Fasano	207	3212.1	Chemistry Hon	18							225	24	13.56%	244.12	10.17	11	1.85	
Annapurna Vakati	208	3212.10	Chemistry Hon				22											
Melanie Bunda	209	3212.11	Chemistry Hon							23								
Janet Lee Fasano	207	3212.2	Chemistry Hon			21												
Jill Krajewski	207	3212.3	Chemistry Hon		20													
Melanie Bunda	209	3212.4	Chemistry Hon		21													
Kathryn Cadavieco	208	3212.5	Chemistry Hon		20													
Jill Krajewski	209	3212.6	Chemistry Hon			19												
Jill Krajewski	207	3212.7	Chemistry Hon					20										
Melanie Bunda	209	3212.8	Chemistry Hon					19										
Robert Kiefer	210	3212.9	Chemistry Hon					22										
Annapurna Vakati	208	3223.1	Chemistry	11							23	18	1.39%	24.95	1.39	2	0.34	
Robert Kiefer	210	3223.2	Chemistry							12								

Needham High School - Theoretical Needs by Course

Number of Students Per Section

			Day				A				B							
			Period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total Students Enrolled**	**Section Enrollment Cap**	**Percentage of Total Population**	**Theoretical Students Enrolled, Future**	**Theoretical Sections Needed Future (Decimal)**	**Theoretical Sections Needed Future (Rounded)**	**Theoretical Space Need Future @85%**
			Minutes, Monday - Thursday	90	90	80	50	50	90	90							
			Minutes, Friday	65	70	85	50	50									
				Existing Number of Students Enrolled													
Faculty Name	**Room #**	**Course Number**	**Course Title**	**<16**		**16 to 22**			**≥23**								
Mary Kay Alessi	219	3401.1	Physiology Acc			22					**41**	**24**	**2.47%**	**44.48**	**1.85**	**2**	**0.34**
Mary Kay Alessi	215	3401.2	Physiology Acc					19									
Scott Blanchette	215	3412.1	Physiology Hon	14							**46**	**24**	**2.77%**	**49.91**	**2.08**	**3**	**0.50**
Scott Blanchette	215	3412.2	Physiology Hon			12											
Scott Blanchette	209	3412.3	Physiology Hon						20								
Patrick Corcoran	104	3502.1	Modern Physics Hon						12		**12**	**24**	**0.72%**	**13.02**	**0.54**	**1**	**0.17**
Ashton Kazlo	101	3531.1	Environmental Science Acc						24		**48**	**24**	**2.89%**	**52.08**	**2.17**	**3**	**0.50**
Ashton Kazlo	101	3531.2	Environmental Science Acc							24							
Emily Luck	101	3532.1	Environmental Science Hon					24			**24**	**24**	**1.45%**	**26.04**	**1.08**	**2**	**0.34**
Melanie Bunda	209	3542.1	Experiencing Chemistry Hon	15							**33**	**24**	**1.99%**	**35.80**	**1.49**	**2**	**0.34**
Melanie Bunda	209	3542.2	Experiencing Chemistry Hon				18										
Richard Ayache	110	3640.1	Marine Science					24			**48**	**24**	**2.89%**	**52.08**	**2.17**	**3**	**0.50**
Richard Ayache	110	3640.2	Marine Science						24								
Jill Krajewski	213	3701.1	AP Biology						22		**45**	**24**	**2.71%**	**48.82**	**2.03**	**3**	**0.50**
Andrew Verado	213	3701.2	AP Biology		23												
Michael Hirsh	108	3801.1	AP Physics					17			**35**	**24**	**2.11%**	**37.97**	**1.58**	**2**	**0.34**
Daniel Smalley	106	3801.2	AP Physics					18									
Annapurna Vakati	208	3901.1	AP Chemistry						17		**17**	**24**	**1.02%**	**18.44**	**0.77**	**1**	**0.17**
SCIENCE DEPARTMENT SUB-TOTAL																**87**	**15.00**
Sarah Nichols	426	4101.1	World History Acc					16			**205**	**24**	**12.36%**	**222.42**	**9.27**	**10**	**1.68**
Sarah Nichols	426	4101.2	World History Acc						23								
Jennifer Nehill	418	4101.3	World History Acc		21												
Jennifer Nehill	404	4101.4	World History Acc				13										
Jennifer Nehill	404	4101.5	World History Acc							22							
Elaine Priovolos	401	4101.6	World History Acc		18												
Elaine Priovolos	401	4101.7	World History Acc				14										
Elaine Priovolos	406	4101.8	World History Acc						21								
Gabriel Swanger	418	4101.9	World History Acc	15													
Gabriel Swanger	418	4101.10	World History Acc			22											
Jesse Swanger	427	4101.11	World History Acc							20							
Brad Walker	402	4102.1	World History Hon						24		**176**	**24**	**10.61%**	**190.96**	**7.96**	**8**	**1.34**
Sarah Nichols	426	4102.2	World History Hon	23													
Brad Walker	402	4102.3	World History Hon		24												
Moore Dodge	427	4102.4	World History Hon			22											
Rosemary Calland	418	4102.5	World History Hon				18										
Kenneth Brooke	421	4102.6	World History Hon				18										
Moore Dodge	418	4102.7	World History Hon					23									
Rosemary Calland	418	4102.8	World History Hon							24							
Sarah Nichols	426	4103.1	World History		13						**32**	**16**	**1.93%**	**34.72**	**2.17**	**3**	**0.50**
Sarah Nichols	426	4103.2	World History				8										
Rosemary Calland	418	4103.3	World History						11								
Lorene Whyte	424	4201.1	World & Amer Acc						21		**244**	**24**	**14.71%**	**264.74**	**11.03**	**12**	**2.02**
Lorene Whyte	426	4201.2	World & Amer Acc							24							
Kenneth Brooke	421	4201.3	World & Amer Acc					23									
Kenneth Brooke	728A	4201.4	World & Amer Acc						19								
Paul Wexler	423	4201.5	World & Amer Acc	24													
Paul Wexler	423	4201.6	World & Amer Acc							23							
Brad Walker	402	4201.7	World & Amer Acc				24										
Brad Walker	402	4201.8	World & Amer Acc					23									
Adam Coggeshall	421	4201.9	World & Amer Acc	20													
Adam Coggeshall	421	4201.10	World & Amer Acc		24												
Adam Coggeshall	421	4201.11	World & Amer Acc						19								

Number of Students Per Section

Day					A					B						
Period					1	2	3	4	5	6	7	Total Students Enrolled	Section Enrollment Cap	Percentage of Total Population	Theoretical Students Enrolled, Future	Theoretical Sections Needed Future (Decimal)	Theoretical Sections Needed Future (Rounded)	Theoretical Space Need Future @85%
Minutes, Monday - Thursday					90	90	80	50	50	90	90							
Minutes, Friday					65	70	85	50	50									
				Existing Number of Students Enrolled														
Faculty Name	Room #	Course Number	Course Title	<16			16 to 22			≥23								
Paul Wexler	423	4202.1	World & Amer Hon			21												
Jennifer Nehill	404	4202.2	World & Amer Hon			24												
Elaine Priovolos	401	4202.3	World & Amer Hon			23												
Paul Wexler	406	4202.4	World & Amer Hon				24					170	24	10.25%	184.45	7.69	8	1.34
Paul Wexler	423	4202.5	World & Amer Hon							14								
Jennifer Nehill	404	4202.6	World & Amer Hon							19								
Elaine Priovolos	401	4202.7	World & Amer Hon								21							
Andrew Ames	406	4202.8	World & Amer Hon								24							
Joseph Schotland	425	4203.1	World & Amer							10		25	16	1.51%	27.12	1.70	2	0.34
Brad Walker	406	4203.2	World & Amer	15														
Douglas Stanczak	401	4212.1	World Since 1945						27			27	28	1.63%	29.29	1.23	2	0.34
Joseph Schotland	425	4301.1	AP US History				17					67	24	4.04%	72.69	3.03	4	0.67
Joseph Schotland	425	4301.2	AP US History					16										
Douglas Stanczak	425	4301.3	AP US History	11														
Douglas Stanczak	425	4301.4	AP US History		23													
Moore Dodge	427	4302.1	US History Hon	15								113	24	6.81%	122.60	5.11	6	1.01
Moore Dodge	427	4302.2	US History Hon		21													
Douglas Stanczak	425	4302.3	US History Hon			20												
Jesse Swanger	427	4302.4	US History Hon				13											
Jesse Swanger	427	4302.5	US History Hon					20										
Douglas Stanczak	401	4302.6	US History Hon						24									
Moore Dodge	427	4303.1	US History							10		10	16	0.60%	10.85	0.68	1	0.17
Melissa Barry	402	4311.1	US History Acc	24								200	24	12.06%	217.00	9.05	10	1.68
Melissa Barry	402	4311.2	US History Acc								21							
Jennifer Lemkin	429	4311.3	US History Acc		24													
Jennifer Lemkin	428	4311.4	US History Acc							22								
Andrew Ames	406	4311.5	US History Acc		24													
Andrew Ames	406	4311.6	US History Acc			21												
Andrew Ames	406	4311.7	US History Acc					19										
Adam Coggeshell	423	4311.8	US History Acc				24											
Adam Coggeshell	423	4311.9	US History Acc					21										
Allisyn Furano	428	4402.1	Amer Legal System Hon		18							39	24	2.35%	42.31	1.77	2	0.34
Allisyn Furano	428	4402.2	Amer Legal System Hon								21							
Joseph Schotland	404	4412.1	Economics Hon		26							48	28	2.89%	52.08	2.17	3	0.50
Joseph Schotland	404	4412.2	Economics Hon	22														
Rosemary Calland	424	4421.1	AP Psychology	23								144	26	8.68%	156.24	6.51	7	1.18
Melissa Barry	424	4421.2	AP Psychology		24													
Rosemary Calland	424	4421.3	AP Psychology			26												
Melissa Barry	424	4421.4	AP Psychology				24											
Melissa Barry	424	4421.5	AP Psychology					22										
Stephen Plasko	424	4421.6	AP Psychology								25							
Allisyn Furano	428	4422.1	Psych/Socio Hon	20								38	24	2.29%	41.23	1.72	2	0.34
Allisyn Furano	428	4422.2	Psych/Socio Hon					18										
Allisyn Furano	428	4423.1	Psych/Socio				11					11	16	0.66%	11.93	0.75	1	0.17
Catherine Dowd	429	4441.1	AP US Government						24			117	24	7.05%	126.94	5.29	6	1.01
Catherine Dowd	429	4441.2	AP US Government								22							
Jennifer Lemkin	429	4441.3	AP US Government	24														
Jennifer Lemkin	429	4441.4	AP US Government				23											
Jennifer Lemkin	429	4441.5	AP US Government					24										
Andrew Ames	728	4462.1	AFR AM Studies & Contemp Issues Hon						30			30	30	1.81%	32.55	1.09	2	0.34
SOCIAL STUDIES DEPARTMENT SUB-TOTAL																	89	15.00

Number of Students Per Section

Day					A				B						
Period					1	2	3	4	5	6	7	Total Students Enrolled	Section Enrollment Cap	Percentage of Total Population	Theoretical Students Enrolled, Future	Theoretical Sections Needed Future (Decimal)	Theoretical Sections Needed Future (Rounded)	Theoretical Space Need Future @85%
Minutes, Monday - Thursday					90	90	80	50	50	90	90							
Minutes, Friday					65	70	85	50	50									
				Existing Number of Students Enrolled														
Faculty Name	Room #	Course Number	Course Title		<16			16 to 22			≥23							
Wendy Hodge	907	7010.1	Art 1					19				81	24	4.88%	87.88	3.67	4	0.67
Linda Burke	901	7010.2	Art 1					15										
Linda Burke	901	7010.3	Art 1						23									
Linda Burke	901	7010.4	Art 1								24							
Shireen Yadollahpour	909	7022.1	Art 2 Hon					19				38	20	2.29%	41.23	2.07	3	0.50
Shireen Yadollahpour	909	7022.2	Art 2 Hon							19								
Shireen Yadollahpour	909	7031.1	AP Art 3 Portfolio								14	21	14	1.27%	22.78	1.63	2	0.34
Linda Burke	901	7031.2	AP Art 3 Portfolio				7											
Shireen Yadollahpour	909	7041.1	Art 3 Acc		16							16	20	0.96%	17.36	0.87	1	0.17
Landa Ruen	807	7100.1	Ceramics 1		21							86	22	5.18%	93.31	3.89	4	0.67
Landa Ruen	807	7100.2	Ceramics 1			21												
Landa Ruen	807	7100.3	Ceramics 1				22											
Landa Ruen	807	7100.4	Ceramics 1								22							
Landa Ruen	807	7105.1	Ceramics 2						15			36	22	2.17%	39.06	1.63	2	0.34
Landa Ruen	807	7105.2	Ceramics 2							21								
Damon Burnard	903	7120.1	Crafts 1							22		66	22	3.98%	71.61	2.99	3	0.50
Wendy Hodge	907	7120.3	Crafts 1				21											
Wendy Hodge	907	7120.4	Crafts 1								23							
Damon Burnard	903	7128.1	Drawing & Painting 1			24						72	24	4.34%	78.12	3.26	4	0.67
Damon Burnard	903	7128.2	Drawing & Painting 1				24											
Damon Burnard	903	7128.3	Drawing & Painting 1						24									
Shireen Yadollahpour	909	7136.1	Drawing & Painting 2				13					13	24	0.78%	14.10	0.59	1	0.17
Wendy Hodge	907	7141.1	Art SR Studio Acc			11						26	16	1.57%	28.21	1.77	2	0.34
Wendy Hodge	907	7141.2	Art SR Studio Acc							15								
Jon zucchi	601	7157.2	Digital Art & Design Animation						18			98	20	5.91%	106.33	5.32	6	1.01
Elizabeth Palmer	601	7157.4	Digital Art & Design Animation		20													
Elizabeth Palmer	601	7157.5	Digital Art & Design Animation			20												
Elizabeth Palmer	601	7157.6	Digital Art & Design Animation							20								
Elizabeth Palmer	601	7157.7	Digital Art & Design Animation				20											
Linda Burke	901	7158.2	Intro to Sculpture		16							16	16	0.96%	17.36	1.09	2	0.34
Elizabeth Palmer	809	7170.1	Photo 1						16			71	20	4.28%	77.03	3.86	4	0.67
Katherine Laberge	809	7170.2	Photo 1		16													
Katherine Laberge	809	7170.3	Photo 1							20								
Katherine Laberge	809	7170.4	Photo 1								19							
Katherine Laberge	809	7175.1	Photo 2				14					25	20	1.51%	27.12	1.36	2	0.34
Katherine Laberge	809	7175.2	Photo 2					11										
Robyn Briggs	605	7248.1	Commercial Design & Production				5					5	10	0.30%	5.42	0.55	1	0.17
Robyn Briggs	605	7280.1	Graphic Design 1					19				59	20	3.56%	64.01	3.21	4	0.67
Robyn Briggs	605	7280.2	Graphic Design 1						20									
Robyn Briggs	605	7280.3	Graphic Design 1								20							
Robyn Briggs	605	7290.1	Graphic Design 2		4							4	20	0.24%	4.34	0.22	1	0.17
FINE ARTS DEPARTMENT SUB-TOTAL																	46	8.00
Margaret McLallen	616	8011.1	Symphonic Band Acc		16							54	65	3.25%	58.59	0.91	1	0.17
Margaret McLallen	616	8029.1	Symphonic Band		38													
Margaret McLallen	616	8020.1	Concert Band						42			42	65	2.53%	45.57	0.71	1	0.17
Jonathan Vanderwoude	612	8051.1	Concert Chorale Acc								14	28	70	1.69%	30.38	0.44	1	0.17
Jonathan Vanderwoude	612	8074.1	Concert Chorale								14							
Jonathan Vanderwoude	612	8060.1	String Orchestra		23							36	50	2.17%	39.06	0.79	1	0.17
Jonathan Vanderwoude	612	8061.1	String Orchestra Acc		13													
Margaret McLallen	614	8070.1	Music Theory 1					10				10	16	0.60%	10.85	0.68	1	0.17
Jonathan Vanderwoude	612	8079.1	Women's Chorus					17				19	65	1.15%	20.61	0.32	1	0.17
Jonathan Vanderwoude	612	8091.1	Women's Chorus Acc					2										

Number of Students Per Section

						A				B							
			Day														
			Period			1	2	3	4	5	6	7	Total Students Enrolled	Section Enrollment Cap	Percentage of Total Population	Theoretical Students Enrolled, Future	Theoretical Sections Needed Future (Decimal)	Theoretical Sections Needed Future (Rounded)	Theoretical Space Need Future @85%
			Minutes, Monday - Thursday			90	90	80	50	50	90	90							
			Minutes, Friday			65	70	85	50	50									
						Existing Number of Students Enrolled													
Faculty Name	Room #	Course Number	Course Title			<16		16 to 22			≥23								
Jonathan Vanderwoude	612	8080.1	Chorus				28						30	65	1.81%	32.55	0.51	1	0.17
Jonathan Vanderwoude	612	8081.1	Chorus Acc				2												
Jonah LeDoux	Auditorium	8100.1	Technical Theater				7						7	20	0.42%	7.59	0.38	1	0.17
Margaret McLallen	614	8110.1	Music by Comp 1				16						16	16	0.96%	17.36	1.09	2	0.34
Jon Zucchi	616	8125.1	Guitar Class 1						15				15	16	0.90%	16.27	1.02	1	0.17
Jonah LeDoux	Auditorium	8150.1	Theater Arts 1					19					19	25	1.15%	20.61	0.83	1	0.17
PERFORMING ARTS DEPARTMENT SUB-TOTAL																		12	3.00
Natalie Guthrie	409a	8490.1	TV Communications 1				15						30	15	1.81%	32.55	2.17	3	0.50
Natalie Guthrie	409a	8490.2	TV Communications 1					15											
Natalie Guthrie	409a	8495.1	TV Communications 2		8								8	15	0.48%	8.68	0.58	1	0.17
Samantha Bookston	409	8497.1	News & The Web				11						11	15	0.66%	11.93	0.80	1	0.17
VOCATIONS & TECHNOLOGY SUB-TOTAL																		6	1.00
Denise Domnarski	611	8615.1	Wellness 10		25								445	26	26.82%	482.82	20.12	21	3.53
Denise Domnarski	611	8615.2	Wellness 10					26											
Denise Domnarski	611	8615.3	Wellness 10						25										
Denise Domnarski	611	8615.4	Wellness 10								29								
Denise Domnarski	611	8615.5	Wellness 10									24							
Timothy Walsh	611	8615.6	Wellness 10				17												
Timothy Walsh	611	8615.7	Wellness 10					26											
Timothy Walsh	611	8615.8	Wellness 10						26										
Timothy Walsh	611	8615.9	Wellness 10									24							
Glen Hopkins	611	8615.10	Wellness 10		25														
Glen Hopkins	611	8615.11	Wellness 10				17												
Glen Hopkins	611	8615.12	Wellness 10						27										
Glen Hopkins	611	8615.13	Wellness 10							26									
Glen Hopkins	611	8615.14	Wellness 10								16								
James Nix	611	8615.15	Wellness 10		26														
James Nix	611	8615.16	Wellness 10				19												
James Nix	611	8615.17	Wellness 10					26											
James Nix	611	8615.18	Wellness 10							25									
James Nix	611	8615.19	Wellness 10								16								
Aaron Dungca	613	8635.1	Wellness 12		19								393	26	23.69%	426.40	17.77	18	3.03
Aaron Dungca	613	8635.2	Wellness 12				18												
Aaron Dungca	613	8635.3	Wellness 12					26											
Aaron Dungca	613	8635.4	Wellness 12							20									
Aaron Dungca	613	8635.5	Wellness 12								18								
Timothy Walsh	613	8635.6	Wellness 12								15								
Eric Chase	613	8635.7	Wellness 12		19														
Eric Chase	613	8635.8	Wellness 12					26											
Eric Chase	613	8635.9	Wellness 12						26										
Eric Chase	613	8635.10	Wellness 12							22									
Eric Chase	613	8635.11	Wellness 12									25							
Diana Parkhurst	613	8635.12	Wellness 12				19												
Diana Parkhurst	613	8635.13	Wellness 12					26											
Diana Parkhurst	613	8635.14	Wellness 12							19									
Diana Parkhurst	613	8635.15	Wellness 12								14								
Diana Parkhurst	613	8635.16	Wellness 12									26							
Deborah Gorman	613	8635.17	Wellness 12		16														
Deborah Gorman	613	8635.18	Wellness 12				15												
Deborah Gorman	613	8635.19	Wellness 12									24							
Health & PE DEPARTMENT SUB-TOTAL																		39	7.00
TEACHING STATION GRAND TOTALS																		557	97.00

Needham High School - Theoretical Needs by Course

Number of Students Per Section

Faculty Name	Room #	Course Number	Course Title	Day / Period	A 1	A 2	A 3	A 4	B 5	B 6	B 7	Total Students Enrolled	Section Enrollment Cap	Percentage of Total Population	Theoretical Students Enrolled, Future	Theoretical Sections Needed Future (Decimal)	Theoretical Sections Needed Future (Rounded)	Theoretical Space Need Future @85%
				Minutes, Monday - Thursday	90	90	80	50	50	90	90							
				Minutes, Friday	65	70	85	50	50									
				Existing Number of Students Enrolled	<16		16 to 22		≥23									
Non-Teaching Station Spaces																		
Laura Brinkmann	722	8809.2	Study/Seminar 9			29					340	25	20.49%	368.90	14.76	15	2.52
Elizabeth Brown	721	8809.3	Study/Seminar 9							25								
Kathryn Clayton	701	8809.4	Study/Seminar 9					18										
Stephen Koup	702	8809.5	Study/Seminar 9							21								
Elizabeth Cox	721	8809.6	Study/Seminar 9	19														
Katherine Fanous	711	8809.7	Study/Seminar 9	19														
Chistopher Farnsworth	730	8809.8	Study/Seminar 9		21													
Robert Flaggert	720	8809.9	Study/Seminar 9					18										
Elizabeth Weidner	732	8809.10	Study/Seminar 9			29												
Brian Herrmann	730	8809.11	Study/Seminar 9						30									
Jonathan Cooke	720	8809.13	Study/Seminar 9		20													
Katherine Maffei	730	8809.15	Study/Seminar 9				12											
Douglas Kopcsp	720	8809.19	Study/Seminar 9	19														
Karl Hekler	728B	8809.20	Study/Seminar 9			30												
Theresa Levy	716	8809.21	Study/Seminar 9						30									
Keith Ford	Library	8819.1294	Directed Study 10 gr	6							97	28	5.85%	105.24	3.76	4	0.67	
Keith Ford	Library	8819.1295	Directed Study 10 gr		5													
Alison Borrelli	728	8819.1296	Directed Study 10 gr			31												
Meridith Welch	728	8819.1297	Directed Study 10 gr				24											
Katherine Laberge	728	8819.1298	Directed Study 10 gr					28										
Keith Ford	Library	8819.1299	Directed Study 10 gr						3									
High School Staff	Cafeteria	90162.1431	Directed Study 11/12 Gr	29							574	150	34.60%	622.78	4.16	5	0.84	
High School Staff	Cafeteria	90162.1432	Directed Study 11/12 Gr		38													
High School Staff	Cafeteria	90162.1433	Directed Study 11/12 Gr			33												
High School Staff	Cafeteria	90162.1434	Directed Study 11/12 Gr				46											
High School Staff	Cafeteria	90162.1435	Directed Study 11/12 Gr					28										
High School Staff	Cafeteria	90162.1436	Directed Study 11/12 Gr						49									
High School Staff	Cafeteria	90162.1437	Directed Study 11/12 Gr							53								
High School Staff	Cafeteria	90162.1438	Directed Study 11/12 Gr	37														
High School Staff	Cafeteria	90162.1439	Directed Study 11/12 Gr		26													
High School Staff	Cafeteria	90162.1440	Directed Study 11/12 Gr			26												
High School Staff	Cafeteria	90162.1441	Directed Study 11/12 Gr				61											
High School Staff	Cafeteria	90162.1442	Directed Study 11/12 Gr					50										
High School Staff	Cafeteria	90162.1443	Directed Study 11/12 Gr						31									
High School Staff	Cafeteria	90162.1444	Directed Study 11/12 Gr							67								
Andrew Bradley	808	9105.1	English 12P	3							27	6	1.63%	29.29	4.89	5	0.84	
Andrew Bradley	808	9106.1	Science 12P		4													
Andrew Bradley	808	9107.1	Math 12P			4												
Andrew Bradley	808	9108.1	History 12P				4											
Andrew Bradley	808	9109.1	Wellness 12P						4									
Andrew Bradley	808	9113.1	Art 12P					4										
Andrew Bradley	808	9114.1	Community Experience 12P							4								
Michele Kelly	803	9465.1	Foundations of English 10		7						7	6	0.42%	7.59	1.27	2	0.34	
Jessica Davis	910	9466.1	Foundations of Alg & Geo				3				3	8	0.18%	3.25	0.41	1	0.17	
Michele Kelly	803	9475.1	Foundations of English 11	4							4	6	0.24%	4.34	0.73	1	0.17	
Jessica Davis	910	9476.1	Foundations of Alg & Geo 2				9				9	8	0.54%	9.76	1.23	2	0.34	
Anthony Principe	706	9509.1	PLC 4 CR	8							99	10	5.97%	107.41	10.75	11	1.85	
Casey Palmer	706	9509.1	PLC 4 CR							10								
Anthony Principe	706	9509.2	PLC 4 CR		9													
Anthony Principe	706	9509.3	PLC 4 CR				10											
Anthony Principe	706	9509.4	PLC 4 CR					10										
Anthony Principe	706	9509.5	PLC 4 CR							10								
Casey Palmer	706	9509.6	PLC 4 CR	10														
Casey Palmer	706	9509.7	PLC 4 CR			10												
Casey Palmer	706	9509.8	PLC 4 CR				11											
Casey Palmer	706	9509.9	PLC 4 CR						11									
Anthony Principe	706	9519.1	PLC 2 CR	3							20	2	1.21%	21.70	10.85	11	1.85	
Casey Palmer	706	9519.11	PLC 2 CR	1														
Casey Palmer	706	9519.12	PLC 2 CR			3												
Casey Palmer	706	9519.13	PLC 2 CR				1											
Casey Palmer	706	9519.14	PLC 2 CR						2									
Casey Palmer	706	9519.15	PLC 2 CR							2								
Anthony Principe	706	9519.2	PLC 2 CR		2													
Anthony Principe	706	9519.3	PLC 2 CR				2											
Anthony Principe	706	9519.4	PLC 2 CR					2										
Anthony Principe	706	9519.5	PLC 2 CR							2								
Lauren DellaCagna	802	9608.1	Skills Center All Grades							5	25	5	1.51%	27.12	5.43	6	1.01	
Lauren DellaCagna	802	9608.2	Skills Center All Grades				3											
Lauren DellaCagna	802	9608.3	Skills Center All Grades						5									
Marina Meliones	802	9608.4	Skills Center All Grades		4													
Marina Meliones	810	9608.5	Skills Center All Grades				2											
Marina Meliones	802	9608.6	Skills Center All Grades					3										
Marina Meliones	802	9608.7	Skills Center All Grades						3									

Number of Students Per Section

				A					B						
Day											Total Students Enrolled	Section Enrollment Cap	Percentage of Total Population	Theoretical Students Enrolled, Future	Theoretical Sections Needed Future (Decimal)	Theoretical Sections Needed Future (Rounded)	Theoretical Space Need Future @85%
Period				1	2	3	4	5	6	7							
Minutes, Monday - Thursday				90	90	80	50	50	90	90							
Minutes, Friday				65	70	85	50	50									
				Existing Number of Students Enrolled													
Faculty Name	**Room #**	**Course Number**	**Course Title**	**<16**		**16 to 22**				**≥23**							
David O'Neil	810	9609.1	Skills Center 9	5													
Jamie Reynolds	902	9609.10	Skills Center 9					3									
Jamie Reynolds	902	9609.11	Skills Center 9						3								
Jamie Reynolds	902	9609.12	Skills Center 9							3							
Margo Fisher-Martin	411	9609.13	Skills Center 9		4												
Jessica Davis	910	9609.14	Skills Center 9	5													
David O'Neil	810	9609.2	Skills Center 9		4						63	5	3.80%	68.35	13.68	14	2.35
David O'Neil	810	9609.3	Skills Center 9					4									
Elizabeth Cushing	902	9609.4	Skills Center 9					6									
Elizabeth Cushing	902	9609.5	Skills Center 9						5								
Elizabeth Cushing	902	9609.6	Skills Center 9	5													
Jenna Dowling	910	9609.7	Skills Center 9		5												
Jenna Dowling	910	9609.8	Skills Center 9			6											
Jenna Dowling	910	9609.9	Skills Center 9							5							
Margo Fisher-Martin	411	9635.10	Skills Center 10	7													
Jessica Davis	910	9635.1	Skills Center 10		3												
Margo Fisher-Martin	411	9635.11	Skills Center 10						5								
Margo Fisher-Martin	411	9635.12	Skills Center 10					5									
Jessica Davis	910	9635.2	Skills Center 10					7									
Jessica Davis	910	9635.3	Skills Center 10						4								
Fran Karp	411	9635.4	Skills Center 10		4						54	6	3.25%	58.59	9.77	10	1.68
Fran Karp	411	9635.5	Skills Center 10				5										
David O'Neil	810	9635.6	Skills Center 10				3										
Jamie Reynolds	902	9635.8	Skills Center 10		6												
Jamie Reynolds	902	9635.9	Skills Center 10			5											
Fran Karp	411	9636.1	Skills Center 11	4													
Sherene Michlin	708	9636.1	Skills Center 11						3								
Sherene Michlin	708	9636.11	Skills Center 11							5							
Fran Karp	411	9636.2	Skills Center 11							5							
Jeanette Word	710	9636.3	Skills Center 11	5													
Jeanette Word	710	9636.4	Skills Center 11		6						51	5	3.07%	55.33	11.07	12	2.02
Ruth O'Shea	708	9636.5	Skills Center 11	3													
Ruth O'Shea	708	9636.6	Skills Center 11				4										
Sherene Michlin	708	9636.7	Skills Center 11		5												
Sherene Michlin	708	9636.8	Skills Center 11			6											
Sherene Michlin	708	9636.9	Skills Center 11				5										
Elizabeth Cushing	902	9637.1	Skills Center 12		6												
Ruth O'Shea	708	9637.2	Skills Center 12		7												
Ruth O'Shea	708	9637.3	Skills Center 12					7									
Jeanette Word	710	9637.4	Skills Center 12				6				40	5	2.41%	43.40	8.68	9	1.51
Jeanette Word	710	9637.5	Skills Center 12					6									
Jeanette Word	710	9637.6	Skills Center 12							2							
David O'Neil	810	9637.7	Skills Center 12							6							
Michele Kelly	803	9638.1	Foundations Skills 10						6		10	15	0.60%	10.85	0.73	1	0.17
Michele Kelly	803	9639.1	Foundations Skills 11					4									
Katherine Brady	805	9737.1	Cap Skills	3													
Katherine Brady	805	9737.2	Cap Skills		6												
Katherine Brady	805	9737.3	Cap Skills			3					19	6	1.15%	20.61	3.44	4	0.67
Katherine Brady	805	9737.4	Cap Skills					3									
Katherine Brady	805	9737.5	Cap Skills						4								
Michele Kelly	803	9755.1	Strive Eng				2				2	5	0.12%	2.17	0.44	1	0.17
Ilene Asarch	707A	9756.1	Strive Math		2						2	5	0.12%	2.17	0.44	1	0.17
Lauren DellaCagna	802	9757.1	Strive Sci	2							2	5	0.12%	2.17	0.44	1	0.17
Ilene Asarch	707A	9759.1	Strive Skills						2		2	5	0.12%	2.17	0.44	1	0.17
Ilene Asarch	707A	9760.1	Strive Vocational					2			2	5	0.12%	2.17	0.44	1	0.17
Ilene Asarch	707A	9770.1	Life Skills							6	6	15	0.36%	6.51	0.44	1	0.17
Linda Marie Lannon	205F	0980.1	ELL Advanced English	3							3	15	0.18%	3.25	0.22	1	0.17
Linda Marie Lannon	205F	0995.1	ELL Support		8						8	15	0.48%	8.68	0.58	1	0.17
Scott Kelly	715	8160.1	Ind Study English 2 CR	1							2	15	0.12%	2.17	0.15	1	0.17
Robert Flaggert	726	8160.2	Ind Study English 2 CR				1										
Samantha Bookston	409	8455.1	Tech Leaders	0													
Samantha Brookston	205	8455.2	Tech Leaders		0												
Samantha Bookston	409	8455.3	Tech Leaders			0											
Samantha Bookston	409	8455.4	Tech Leaders				0				3	15	0.18%	3.25	0.22	1	0.17
Samantha Bookston	409	8455.5	Tech Leaders					1									
Samantha Bookston	409	8455.6	Tech Leaders						1								
Samantha Bookston	409	8455.7	Tech Leaders							1							

Potential Solution Strategies

D&W's process to determine future spatial needs revealed that existing spatial needs will be exacerbated as the enrollment reaches the target of 1800 students. Physically adding more instructional spaces is only one potential solution to address those needs. D&W also explored the following other potential strategies.

More Students Per Section

The strategy attempts to absorb future increases in enrollment by increasing the number of students in each section. Three key factors limit the effectiveness of this strategy. First, the high school's administrative and departmental leadership currently cap certain courses at numbers well below the 23 students per classroom guideline defined by the MSBA. In order to increase the building's capacity by leveraging this strategy, it would be necessary to raise or eliminate those caps, which are in the best interests of students. Second, you could raise the number of students in each section where caps are already high. In order to execute this strategy, courses that currently serve 23 students would need to serve 25 or 26. Courses that serve 28 would need to serve 30 or more. Courses without low section caps already have the highest students per classroom averages. Raising them even higher would compromise the student experience and only further limit teachers' instructional activities due to the physical size of classrooms. Finally, you could raise the number of students per section in the Fine & Performing Arts Department and potentially in the Health & Physical Education department. Doing so may increase the efficient use of those spaces, but those spaces tend to be designed for specialty curriculums and less adaptable to the core academic disciplines where the need tends to be greatest. It would be difficult, for example, to deliver the Spanish curriculum in an Art classroom. In addition, increasing the number of students in each section for these departments would result in fewer sections of each course offered. While that would increase efficiency and capacity, it would also result in fewer students having access to those specialized courses. Certain courses are only offered in one or two sections. If the number of sections offered in the Fine & Performing Arts were reduced, it may limit students' ability to enroll because of scheduling conflicts.

Higher Utilization Rates

The strategy attempts to absorb future increases in enrollment by increasing the utilization rates – by using spaces more periods per cycle than is currently occurring. High utilization rates require faculty members to share space and/or for teachers to occupy more than one room per day. It is a circumstance that makes it challenging for students to find teachers when they need assistance. It also makes it more critical to have Departmental offices as landing places for teachers who are displaced from their rooms during their preparation periods. Two key factors limit the effectiveness of this strategy. First, there are limited opportunities to raise utilization rates. The overall building is averaging 84% utilization, just one percent below the common benchmark. Spaces serving the Core Academic disciplines are averaging over 90% utilization. In order to implement this strategy, it would be necessary to increase utilization rates for under-utilized spaces. Unfortunately, only the Fine & Performing Arts spaces are under-utilized. It is impractical, for example, to improve the utilization of the Auditorium or the Midi Lab or the Television studio because of their specialized nature. Second, even when opportunities do exist to increase utilization - in the Fine Arts (Art Rooms), for example – their curriculum-specific design characteristics and geographic location make them impractical for other disciplines. Even though Art shares similarities with Science, it would be extremely challenging to deliver Biology

curriculum in an Art room. Similarly, even if this type of sharing were practical, doing so would result in fewer sections of Fine Arts courses being offered, which would limit students' access to these courses.

Conversion of Non-instructional Spaces to Classrooms

The strategy attempts to absorb future increases in enrollment by repurposing non-instructional spaces into classrooms and labs – by taking storage closets and faculty spaces and renovating them into learning environments. This has proven a reasonably effect strategy to date. The District and the high school administrations have already repurposed a number of these types of spaces, often sacrificing the effectiveness or availability of faculty and storage spaces to do so. Repurposing more departmental office space or carving out additional classroom space from the Library/Media Center would only exacerbate sacrifices already made. Students would likely find it even more challenging to find faculty and staff members when they are displaced from their classrooms. Collaboration features and number of volumes may have to be reduced to repurpose the Library/Media Center. While limited opportunities to repurpose existing space still exist, members of the Working Group expressed an interest in strategies that restore repurposed space – not those that require more sacrifices.

Construction

The strategy attempts to absorb future increases in enrollment by constructing additional square footage. Such a strategy could relieve some of the over-crowding and over-utilization currently being experienced and anticipate needs necessary to serve the target enrollment in the future. D&W's options, as described in the next section, focus on this strategy.

Consequences of Doing Nothing

Needham High School could attempt to absorb the projected target enrollment without executing any of the strategies defined above. D&W calculated the impact to the average number of students per section and to utilization rates should the District choose to do nothing. In order to perform these calculations, only one variable can be considered at a time.

In the first set of calculations, D&W allowed the number of sections and utilization rates to remain the same as currently offered. D&W then calculated how many students would be in each section. In general terms, every section would experience an increase of 8.5%. This would make it necessary to eliminate or increase caps on courses. **It would result in many Core Academic courses having many sections with more than 30 students enrolled.** The tables on the following two pages illustrate these calculations.

In a second set of calculations, D&W allowed the number of students per section to be fixed at either the existing section cap or 24 students, which ever was lower and calculated a total number of sections needed. To determine the impact to utilization, D&W divided the total number of projected sections by the total sections available within the existing classrooms. **For the Core Academic Disciplines, the consequence of doing nothing results in an average utilization rate of 97%.** Or expressed another way, 41 of 52 classrooms would be occupied by students every period of every day – 353 of 364 total sections would be occupied.

Number of Students Per Section : 2024-25

Revised - 02.09.17

Day				A			B		
Period		1	2	3	4	5	6	7	Total Minutes Per Cycle
Minutes, Monday - Thursday		90	90	80	50	50	90	90	2480
Minutes, Friday									

Room #	Course Title	Existing Number of Students Enrolled <16		16 to 22			≥23		Average Students Per Period
701	General Classroom - English*	22	29	27	22	20	27	13	*22.86*
702	General Classroom - English	29	22	30	25	25	28	23	*26.00*
715	General Classroom - English	12	23	29	22	25	27	0	*23.00*
717	General Classroom - English	23	24	27	11	0	25	25	*22.50*
719	General Classroom - English	28	27	28	29	0	13	20	*24.17*
720	General Classroom - English	21	22	16	30	20	27	27	*23.29*
721	General Classroom - English	21	30	27	27	23	18	27	*24.71*
722	General Classroom - English	25	21	31	22	16	29	26	*24.29*
723	General Classroom - English	22	0	21	29	22	23	29	*24.33*
724	General Classroom - English	24	27	27	29	14	30	30	*25.86*
726	General Classroom - English	22	24	25	27	29	21	24	*24.57*
728	Interdisciplanary Room*	30	30	34	26	30	33	0	*30.50*
730	General Classroom - English	24	23	27	13	25	33	30	*25.00*
732	General Classroom - English	13	9	31	22	27	28	23	*21.86*
	English Department Sub-totals								***24.47***
109	General Classroom - Math	23	25	25	16	24	0	26	*23.17*
112	General Classroom - Math	26	18	0	23	25	26	0	*23.60*
201	General Classroom - Math	27	26	25	27	25	17	22	*24.14*
202	General Classroom - Math	25	18	12	25	18	20	25	*20.43*
203	General Classroom - Math	21	22	25	20	21	0	18	*21.17*
204	General Classroom - Math	0	18	18	26	26	18	25	*21.83*
206	General Classroom - Math	23	21	24	18	26	26	16	*22.00*
211	General Classroom - Math*	27	24	25	15	14	15	27	*21.00*
212	General Classroom - Math	21	25	27	21	28	26	0	*24.67*
214	General Classroom - Math	27	29	27	26	26	27	23	*26.43*
216	General Classroom - Math	25	20	17	28	16	25	25	*22.29*
221	General Classroom - Math	23	10	15	17	22	21	22	*18.57*
223	General Classroom - Math	13	24	23	15	27	23	14	*19.86*
	Math Department Sub-totals								***22.19***
401	General Classroom - Social Studies	0	20	25	15	29	26	23	*23.00*
402	General Classroom - Social Studies	26	26	0	26	25	26	23	*25.33*
404	General Classroom - Social Studies	24	28	26	14	0	21	24	*22.83*
406	General Classroom - Social Studies	16	26	23	26	21	23	26	*23.00*
418	General Classroom - Social Studies	16	23	24	20	25	12	26	*20.86*
421	General Classroom - Social Studies	22	26	0	20	25	21	0	*22.80*
423	General Classroom - Social Studies	26	0	23	26	23	15	25	*23.00*
424	General Classroom - Social Studies	25	26	28	26	24	23	27	*25.57*
425	General Classroom - Social Studies	12	25	22	18	17	11	0	*17.50*
426	General Classroom - Social Studies	25	14	0	9	17	25	26	*19.33*
427	General Classroom - Social Studies	16	23	24	14	22	11	22	*18.86*
428	General Classroom - Social Studies	22	20	0	12	20	24	23	*20.17*
429	General Classroom - Social Studies	26	26	0	25	26	26	24	*25.50*
728B	Social Studies*	0	0	33	0	0	21	0	*27.00*
	Social Studies Department Sub-totals								***22.24***
414	General Classroom - French	12	0	24	17	20	0	23	*19.20*
415	General Classroom - Latin	27	20	28	29	26	25	22	*25.29*
416	General Classroom - French	18	15	23	23	15	17	0	*18.50*
417	General Classroom - Latin	24	22	29	17	20	0	24	*22.67*
419	General Classroom - Chinese	13	0	26	12	17	0	27	*19.00*
707	General Classroom - Spanish	16	21	0	15	20	15	0	*17.40*
709	General Classroom - Spanish	22	28	0	26	26	0	24	*25.20*
711	General Classroom - Spanish	21	22	20	22	17	22	26	*21.43*
712	General Classroom - Spanish	17	21	23	12	25	17	0	*19.17*
713	General Classroom - Spanish	27	14	0	25	23	26	26	*23.50*
714	General Classroom - Spanish	0	27	21	27	14	26	28	*23.83*
716	General Classroom - Spanish	11	20	0	26	14	33	15	*19.83*
	World Languages Department Sub-totals								***21.37***
	Core Academic Sub-totals								***22.67***

Number of Students Per Section : 2024-25

Revised - 02.09.17

Day				A				B	
Period		1	2	3	4	5	6	7	Total Minutes Per Cycle
Minutes, Monday - Thursday		90	90	80	50	50	90	90	
Minutes, Friday									2480

		Existing Number of Students Enrolled							
		<16		16 to 22			≥23		Average Students Per Period
Room #	Course Title								
101	Engineering Lab	10	2	0	0	26	26	26	*18.00*
102	Physics Lab	23	20	24	21	26	18	18	*21.43*
103	Physics Lab	20	20	25	0	23	25	17	*21.67*
104	Physics Lab	20	16	24	21	23	13	17	*19.14*
106	Physics Lab*	21	26	13	21	20	20	0	*20.17*
108	Physics/Bio Lab	24	21	12	16	18	18	18	*18.14*
110	Biology Lab	25	20	25	0	26	26	22	*24.00*
207	Chemistry Lab	20	22	23	24	22	25	24	*22.86*
208	Chemistry Lab	12	22	17	24	0	18	18	*18.50*
209	Chemistry Lab	16	23	21	20	21	22	25	*21.14*
210	Chemistry Lab	16	0	17	25	24	26	13	*20.17*
213	Biology Lab	0	25	25	14	0	24	24	*22.40*
215	Biology Lab	15	0	13	15	21	26	17	*17.83*
217	Biology Lab	0	26	26	15	17	23	20	*21.17*
219	Biology Lab	17	22	24	25	0	22	18	*21.33*
	Science Department Sub-totals								***20.54***
601	Art	22	22	22	0	20	22	0	*21.60*
605	Art	4	0	5	21	22	0	22	*14.80*
807	Art - Ceramics	23	23	24	0	16	23	24	*22.17*
809	Art - Photogrpahy	17	0	15	12	17	22	21	*17.33*
901	Art	17	0	8	16	25	0	26	*18.40*
903	Art	0	26	26	0	26	24	0	*25.50*
907	Art	0	12	23	21	0	16	25	*19.40*
909	Art	17	0	14	21	0	21	15	*17.60*
	Fine Arts Department Sub-totals								***17.88***
612	Chorus Room	39	33	0	21	0	0	30	*30.75*
614	Midi Lab	0	17	0	11	0	0	0	*14.00*
616	Band Room	0	0	0	16	46	0	0	*31.00*
Auditorium	Auditorium - *Excluded*	0	8	21	0	0	0	0	*14.50*
	Performing Arts Department Sub-totals								***24.50***
409	Multi-media Lab	0	12	0	0	1	1	1	*3.75*
409a	TV Studio	9	16	16	0	0	0	0	*13.67*
	Fine & Performing Arts Sub-totals								***18.90***
611	Gym - B	82	58	85	85	55	66	52	*23.00*
613	Gym - A	59	56	85	28	66	51	81	*20.29*
	Health & PE Department Sub-totals								***21.64***
	GRAND TOTALS								***21.61***

Key Findings

- Needham High School Requires a total of 97 Teaching Stations to serve the target population of 1800 9th-12th students. Additional teaching stations in the Core Academic disciplines and Science will relieve the existing over-crowding conditions and position the facility to absorb the increased enrollment expected in the future. These additional teaching stations will also allow the facility to maintain the existing state of utilization even as the enrollment grows to 1800 students.

Department	**Total Existing Teaching Stations**	**Total Future Teaching Stations**
Core Academic (English, Mathematics, Social Studies, World Languages)	52	60
Science	14	15
Fine Arts	8	8
Performing Arts	3	3
Health & Physical Education	6	7[13]
Vocational & Technology[14]	2	1
Other[15]	3	3
GRAND TOTALS	**88**	**97**

- D&W recommends the following sizes and counts for the additional teaching stations based on our analysis of existing course-by-course enrollment and to provide the greatest instructional flexibility possible:

    - **(6) General Education Classrooms @ 925 NSF[16] each**
    - **(1) General Purpose Science Lab @ 1440 NSF – This lab should be outfitted so that it can serve any of the scientific disciplines**
    - **(1) Science Prep Room @ 200 NSF**

[13] While the analysis revealed a potential need for an additional Health & PE space, we believe this to be a misrepresentation of what is actually happening and the result of how Health & PE spaces are used. There are as many as 9 spaces being used for Health & PE instruction, but students are only scheduled into one of the two gyms. We believe that the existing Health & PE spaces could support a growth in enrollment without additional teaching stations.

[14] Television Studio and Fabrication Lab

[15] Auditorium, Multi-media Lab, and Interdisciplinary Classroom

[16] NSF: Net Square Footage – the amount of usable floor area within a space.

- Members of the Special Education Department identified the following space needs based on a target enrollment of 1800 9th-12th students. Some of the spaces identified already exist within the facility and could continue to serve special education students. After overlaying the future need onto the existing facilities, D&W concluded that **Needham High School requires an additional 5,500 NSF of special education space to serve the target enrollment of 1800 students**.

  Total Need Necessary to Serve 1800 Students[17]
  - (9) Classrooms @ 750 NSF
  - (20) 125 NSF Small Group/Testing Spaces
  - (1) Life Skills Classroom Suite, Size @ 1200-1500 NSF
  - (10) 500 NSF Grade-level skill center rooms
  - Administrative Suite

- D&W recommends that all options explore opportunities to create intentional student collaboration space with the characteristics identified below:

  - Some Noisy
  - Some Quiet
  - Some Open
  - Some Enclosed
  - Access to WiFi
  - Lots of Vertical Writing Surface
  - Access to Digital Display
  - Some Hard Furnishings
  - Some Soft Furnishings
  - Highly Mobile Furnishings
  - Food Friendly

[17] The Special Education Department currently occupies approximately 10,000 NSF which could continue to serve the special education curriculum.

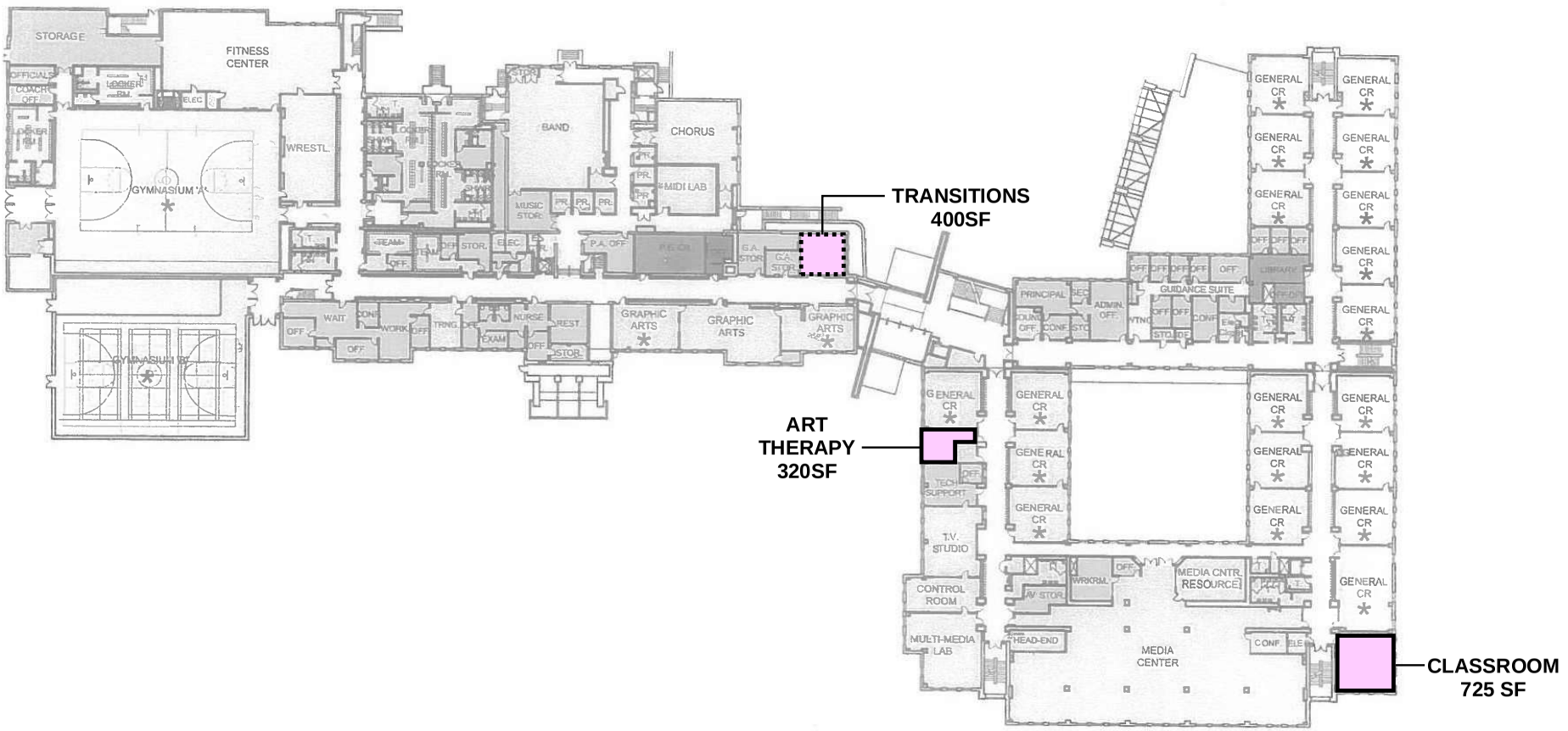
Needham High School - Feasability Study

2016 / 2017 Special Ed. Spaces					Mar. 24, 2017
Level	**Name**	**Qty.**	**Size**	**Total**	
Level 1			(none)		
			subtotal:	*0*	
Level 2			(none)		
			subtotal:	*0*	
Level 3	Art Therapy	1	320	320	
Level 3	Classroom	1	725	725	
Level 3	Transitons	1	400	400	
		3	*subtotal:*	*1,445*	
Level 4	Skills Center	2	450	900	Classrooms
Level 4	Conf. Room	1	400	400	Conference Room
Level 4	Insight	1	720	720	Classroom
Level 4	Connections	1	450	450	Classroom
Level 4	Office	1	180	180	
Level 4	Clinicians Office	1	100	100	
Level 4	Strive	1	700	700	Classroom
Level 4	Spec. Ed. Office Suite	1	1,225	1,225	Offices
Level 4	PLC	1	1,250	1,250	
Level 4	Skills Center	1	650	650	Classroom
Level 4	Skills Center	1	500	500	Classroom
		12	*subtotal:*	*7,075*	
Level 5	Skills Center	1	700	700	Classroom
Level 5	Skills Center	1	750	750	Classroom
		2	*subtotal:*	*1,450*	
				9,970	SF TOTAL

Needham High School - Feasability Study

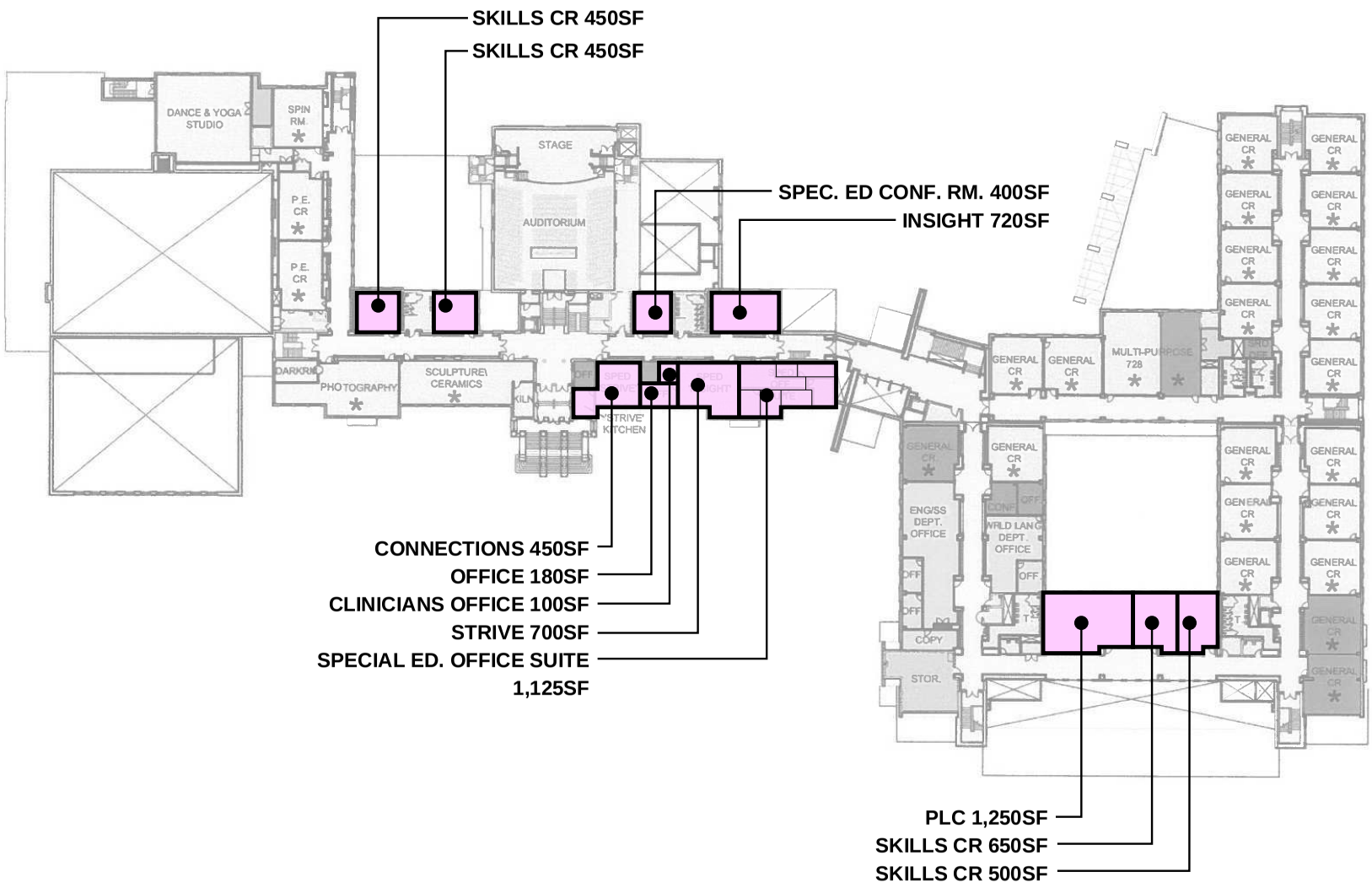
Desired Special Ed. Space Summary Mar. 24, 2017

Qty.	Size	Total	
Pathways Program			
2	750	1,500	750 NSF Classrooms w/ communicating doors between them
2	125	250	125 NSF Small Group Testing Rooms, embedded in classrooms
STRIVE and Post-grad Programs			
1	1,350	1,350	Life Skills Classroom Suite, Size TBD but likely 1200-1500 NSF
2	125	250	125 NSF Small Group Testing Rooms, embedded in classrooms
Foundations Program			
1	750	750	750 NSF Classroom
1	125	125	125 NSF Small Group Testing Room
Skills Centers			
10	500	5,000	500 NSF Grade-level skill center rooms
10	125	1,250	125 NSF Small Group Testing Room, embedded into classroom
PLCs			
2	750	1,500	750 NSF Classrooms, with communicating door between
1	125	125	NSF Small Group Testing Rooms, shared between classrooms
Administrative and Other Needs			
8	100	800	•8 Offices
1	300	300	•Conference Room for 12 (approx. 12’ x 24’)
1	80	80	•Workroom, Copier, Layout Space
1	100	100	•Files and general storage
1	150	150	•Welcome & Secretary Area
1	75	75	•Toilet
1	75	75	•Kitchenette
18	65	1,170	•TA Landing Space(s) =18 [storage area for personal belongings + small gathering area]
1	65	65	•Mailboxes
65	***Total:***	***14,915***	***Square Feet***

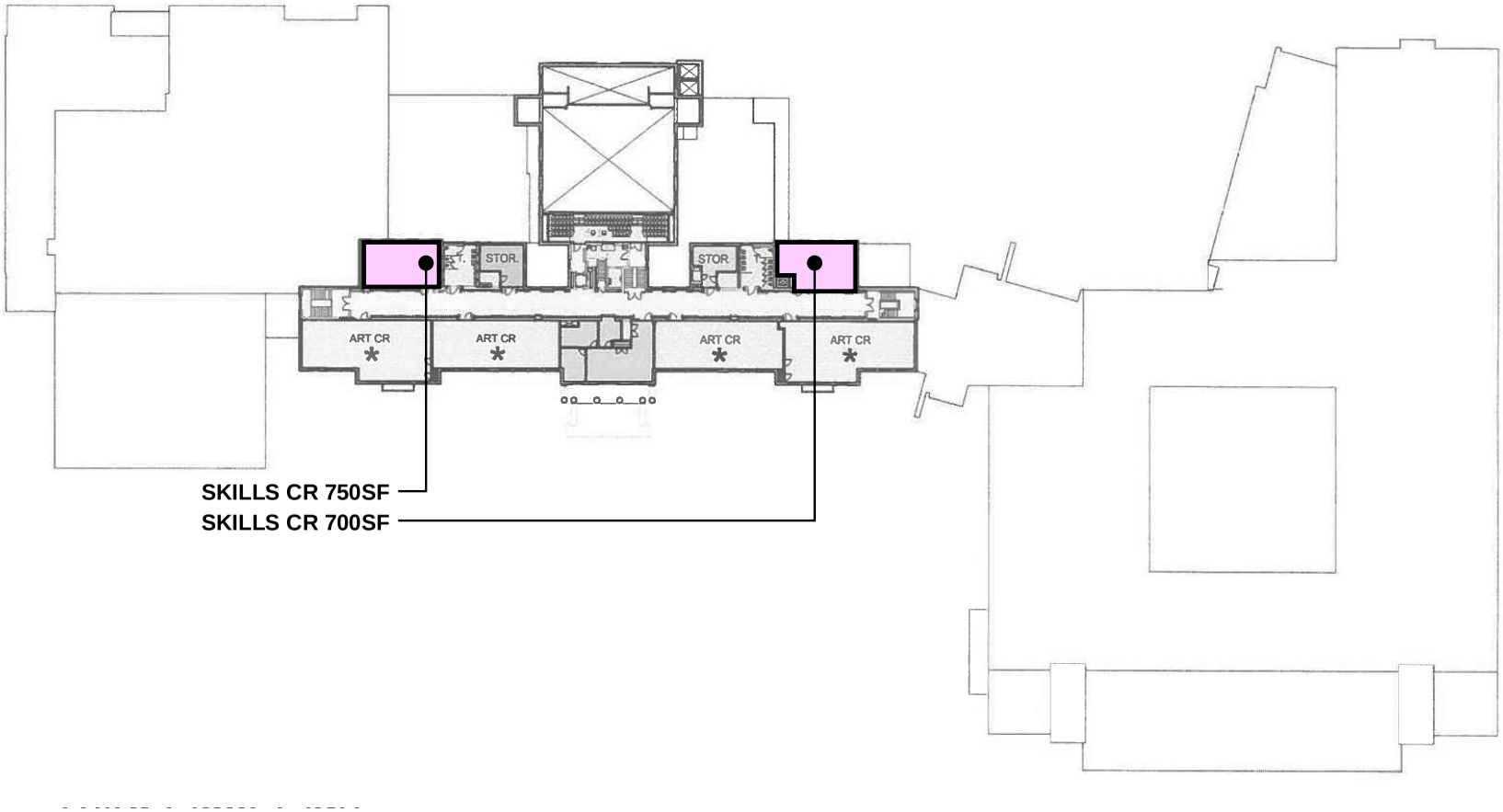


LEVEL 3 SPECIAL EDUCATION SPACES

0 40 80 120 160 ft



LEVEL 4 SPECIAL EDUCATION SPACES



LEVEL 5 SPECIAL EDUCATION SPACES

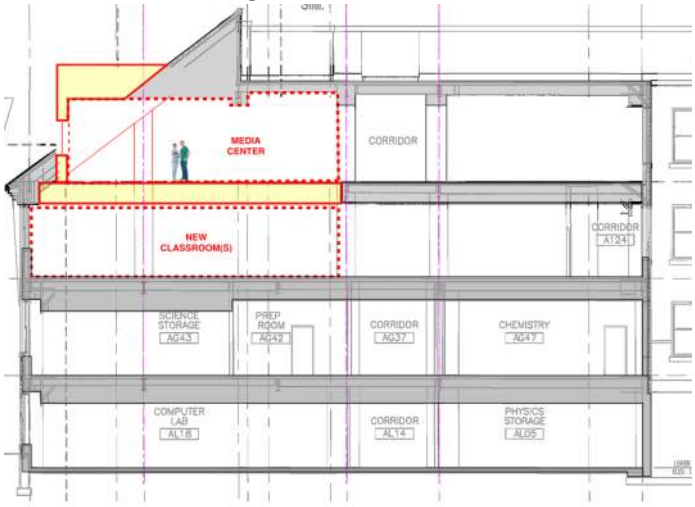
0 40 80 120 160 ft

OPTIONS SUMMARY

INTRODUCTION

With a clear understanding of the number and size of classrooms required to meet the minimum needs of an expanded high school population, the team set to work exploring avenues for adding classroom spaces. Some areas of the campus were ruled out early on, as was the case with north end of the facility (existing tennis courts location – too remote from core academic areas) as well as the east side of the new addition – facing Webster Street near the cafeteria (overly constrained site configuration). Ruling those out helped uncover several viable areas; within the existing 2-story library space, at the south-west corner, the existing courtyard space, and at the east side of the building, over the Webster Street entrance area – where two different ideas were studied.

The goal is to add 8 general classrooms – preferably (2) at 1,200 square feet that can be subdivided to form a pair of smaller seminar rooms, and (6) at 925 square feet – about 20% larger than the existing, typical sized classrooms. These larger rooms will help with the schedule, as larger class size / sections can be scheduled without feeling the classrooms feeling too 'cramped' or overcrowded. The 925 square foot size classroom is the current MSBA recommended general classroom size – but more importantly, the educational program analysis for the high school shows a need for these larger sized classrooms. This will allow for the right balance of class size and number of sections to continue to be offered at the high school. In addition to the (8) general classrooms, it was found that an additional science classroom should be built – as well as much as 5,500 square feet of mixed use special education instructional space(s).



Starting with the simplest solution, Option 'B' – the team attempted to achieve as much added classroom space as is possible within the existing building footprint. It was found to not only fall short, but it also reduced the size of the Library by about 2,000 sq. ft. (relocated to a partial new 4th floor, over the

existing Library space – which in Option B became (7) new classrooms and a collaborative space). The working group decided this was a useful exercise – but unlikely to be pursued due to the limitations, invasiveness, and the dramatic reduction in space for the Library.

The idea of using the space created by relocating the Library was one that had merit, and led to a couple of other options. The key benefit to re-purposing this space is that the 7 classrooms and collaboration spaces that would be built in the former Library location result in new classrooms central to the existing core academic areas of the building. The two options that explore this concept do so by building a new Library / Media Center at the existing courtyard (Option 'D'), or on the east side of the building over the Webster Street entry area (Option 'E'). These would be built in two phases; the first phase being the construction of the new Library, and the second being the renovation of the previous Library space into classrooms and collaboration spaces on two levels. Key to this approach is the addition of an intermediate floor structure forming additional space on Level 4, above the existing Library footprint on Level 3 – netting space for new as many as (12) new classrooms on both levels.

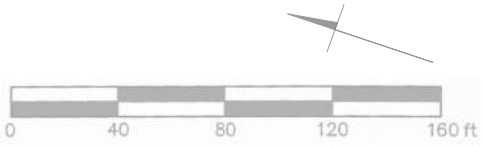
The remaining two options focused on building an addition that would house the new classrooms without the need for a multi-phased approach. The first of these is a 4-story addition (Option 'C') located at the southwest corner of the building – right along Admiral Gracey Drive. The second (Option 'F') is in the same location as Option 'E' – over the Webster Street entry area. It includes a 3-story addition that houses relocated administrative offices on the first level, and two levels of new classroom and collaboration space above. The new administrative area frees up space for added classroom space within the existing core academic areas as well, which entails minor interior renovations.

LEVEL 1

(NO CHANGE)

OPTION B

ROOF + INTERIOR - MEDIA CENTER RELOCATED TO LEVEL 4

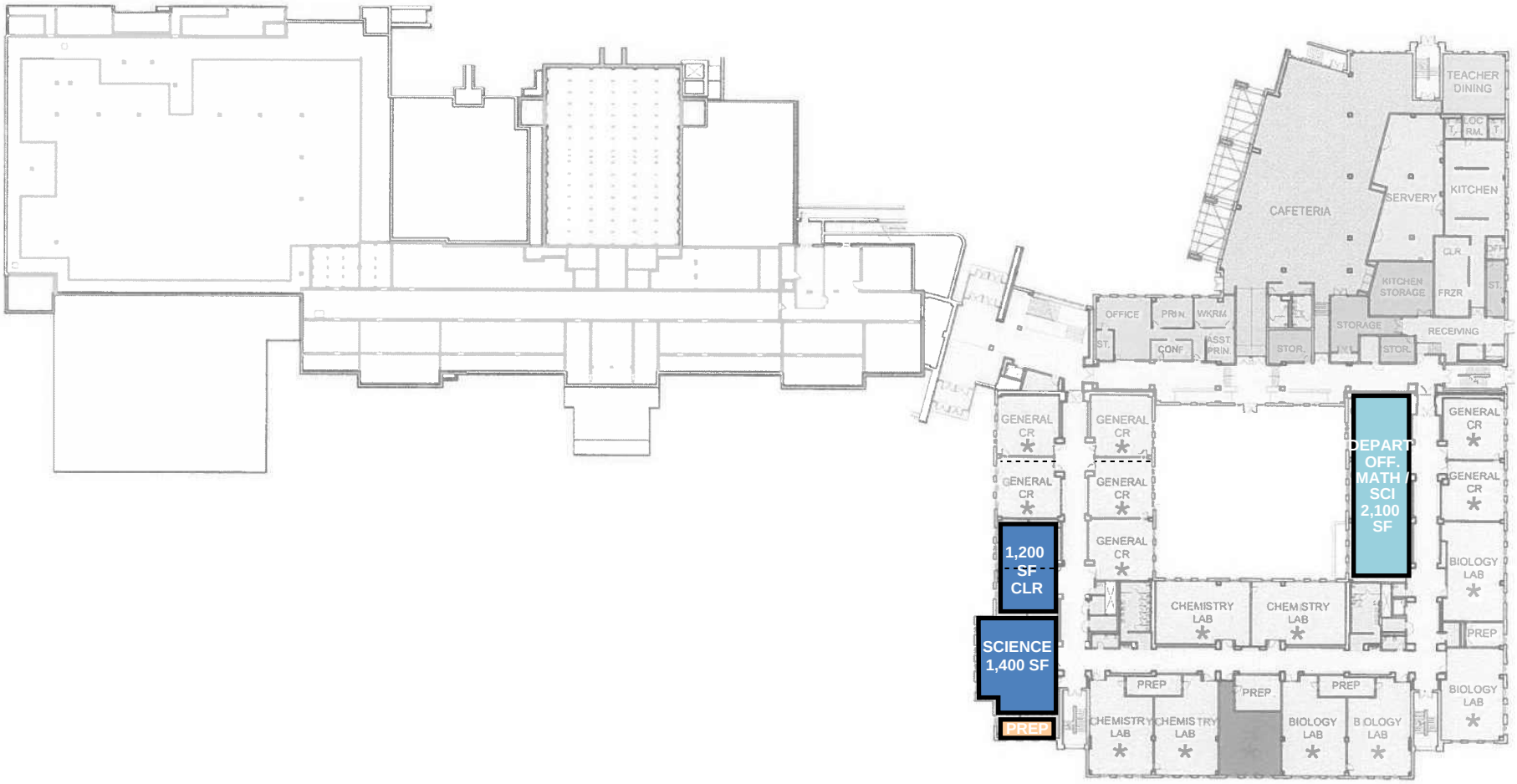


LEVEL 2

(- 3 CR'S)

CLASSROOMS

DEPT. OFFICES, ADMIN. GUIDANCE



OPTION B

ROOF + INTERIOR - MEDIA CENTER RELOCATED TO LEVEL 4

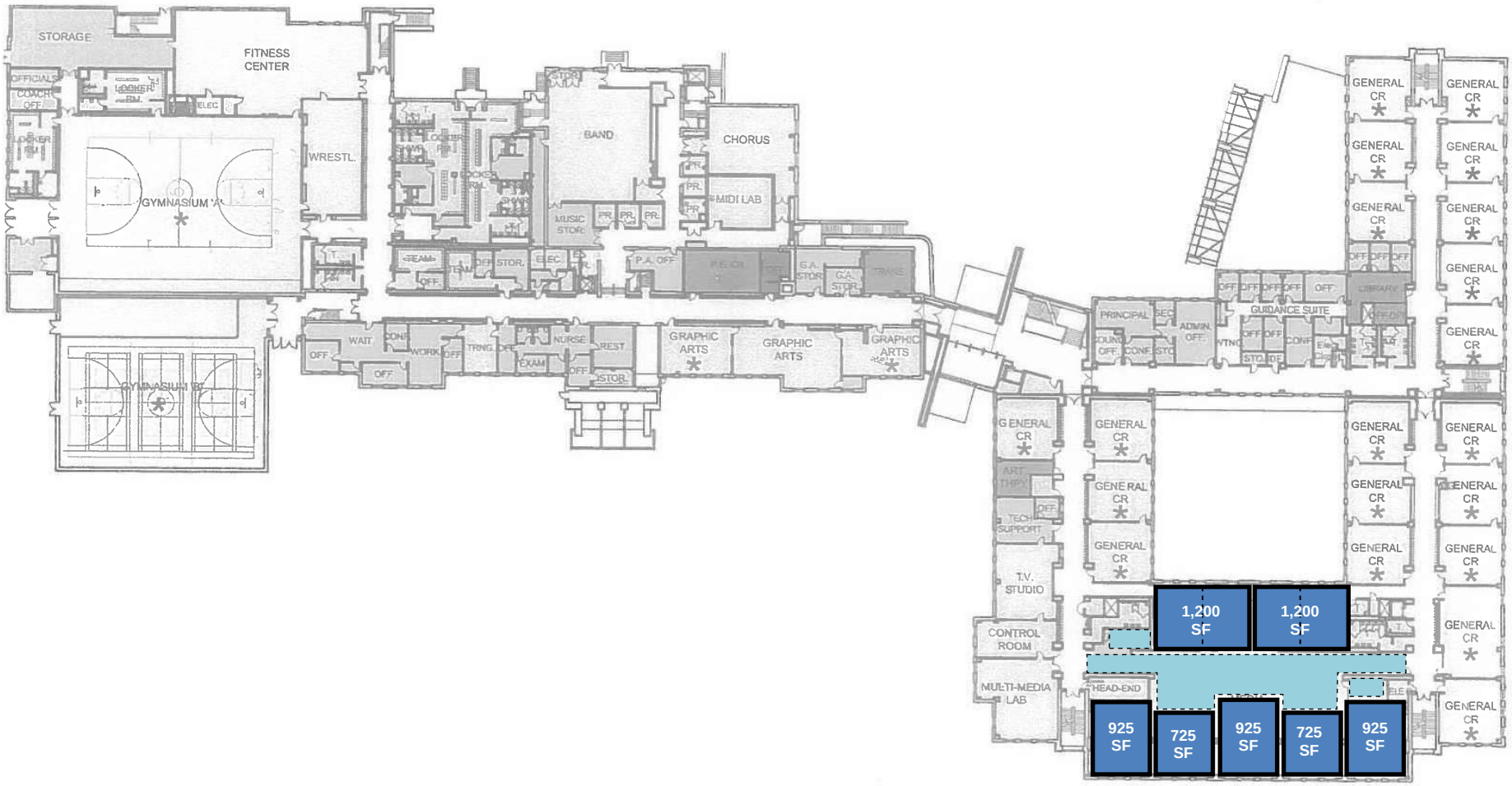
+1 CR
+1 SCR

0 40 80 120 160 ft

LEVEL 3

CLASSROOMS

SMALL GROUP / COLLABORATION SPACE



OPTION B

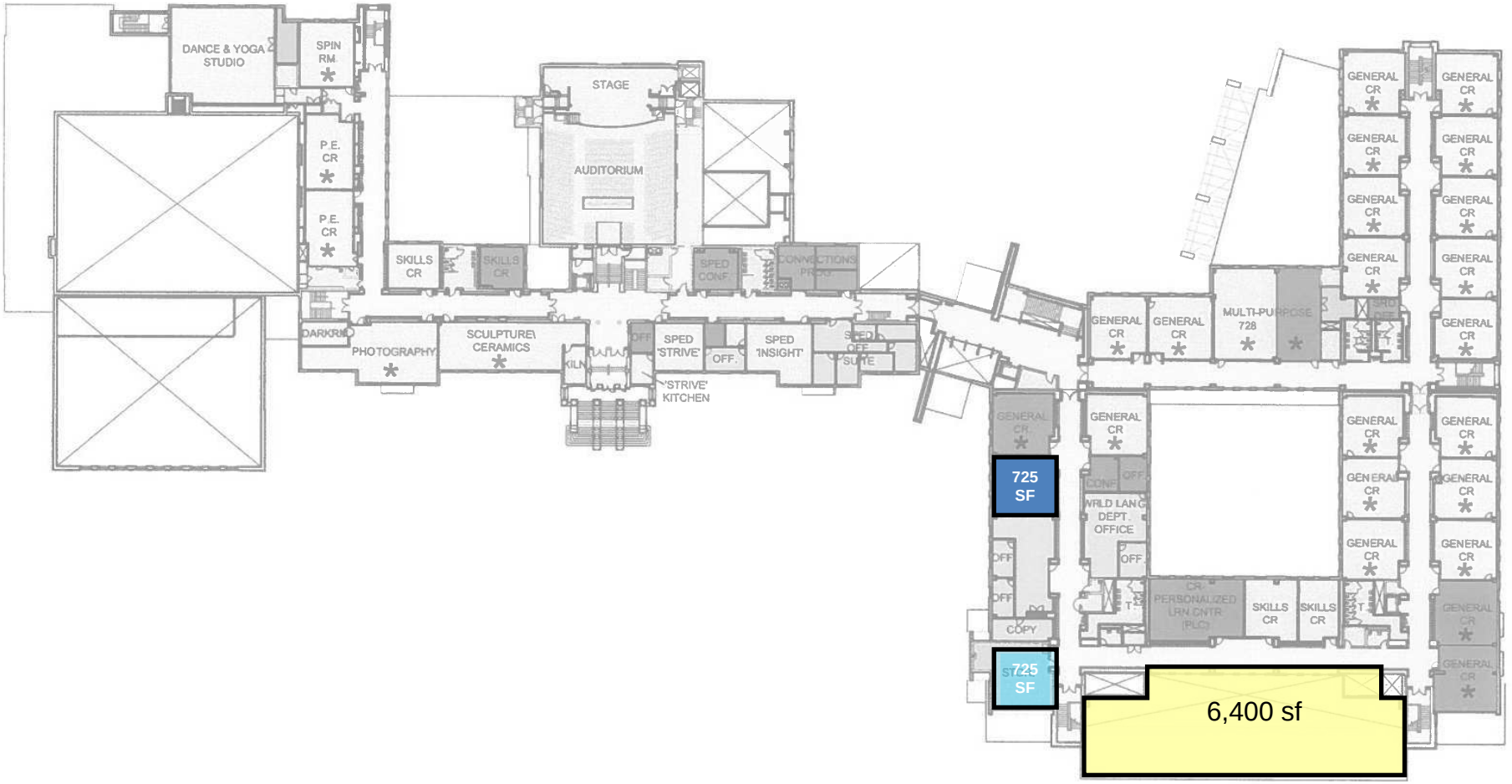
ROOF + INTERIOR - MEDIA CENTER RELOCATED TO LEVEL 4

+7 CR

0 40 80 120 160 ft

LEVEL 4

- RELOCATED DEPT. OFFICES
- CLASSROOMS
- NEW MEDIA CENTER



OPTION B

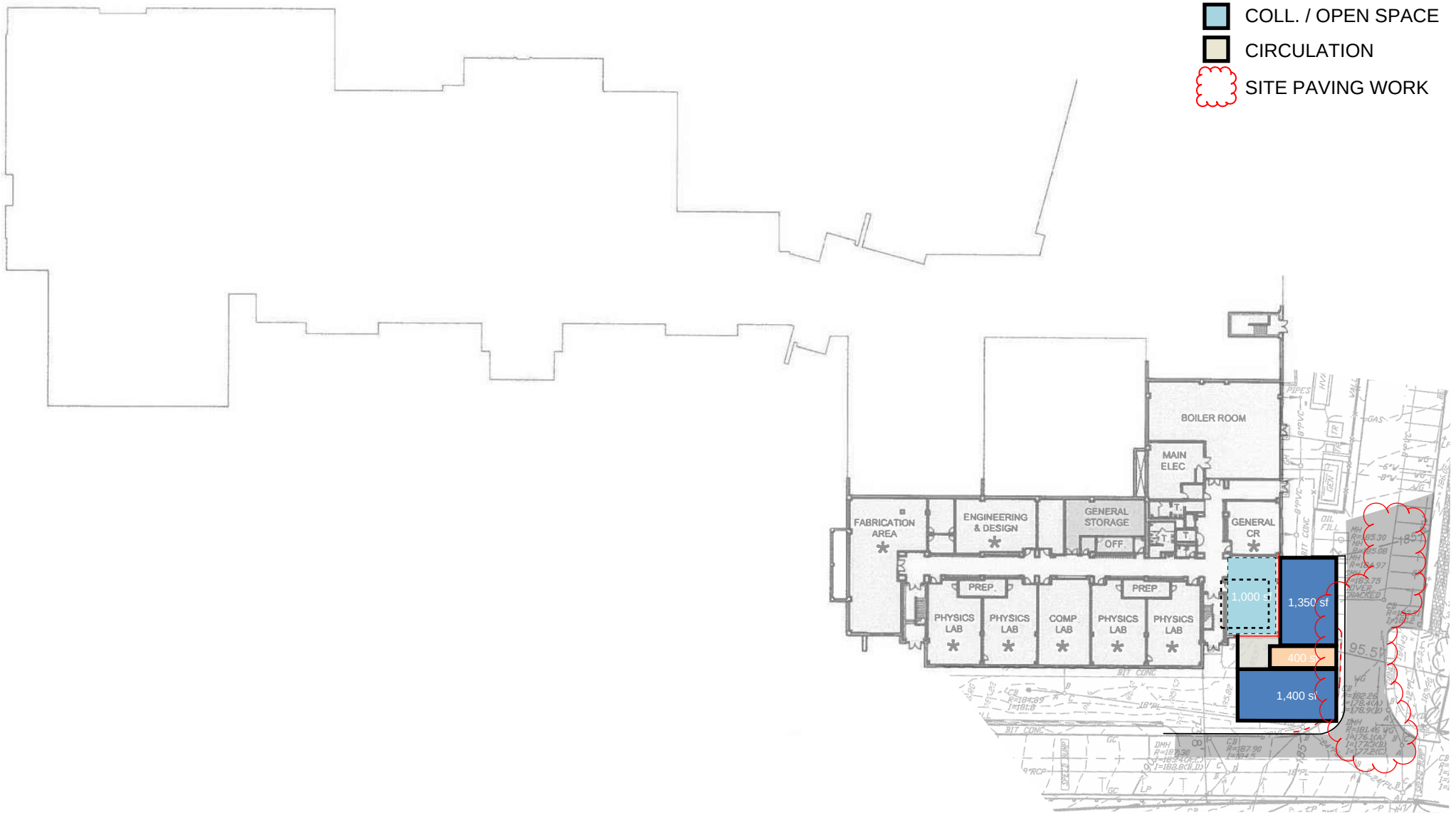
ROOF + INTERIOR - MEDIA CENTER RELOCATED TO LEVEL 4

+1 CR

0 40 80 120 160 ft

LEVEL 1

- (- 1) CR
- SCIENCE CLASSROOM
- SCIENCE PREP
- COLL. / OPEN SPACE
- CIRCULATION
- SITE PAVING WORK

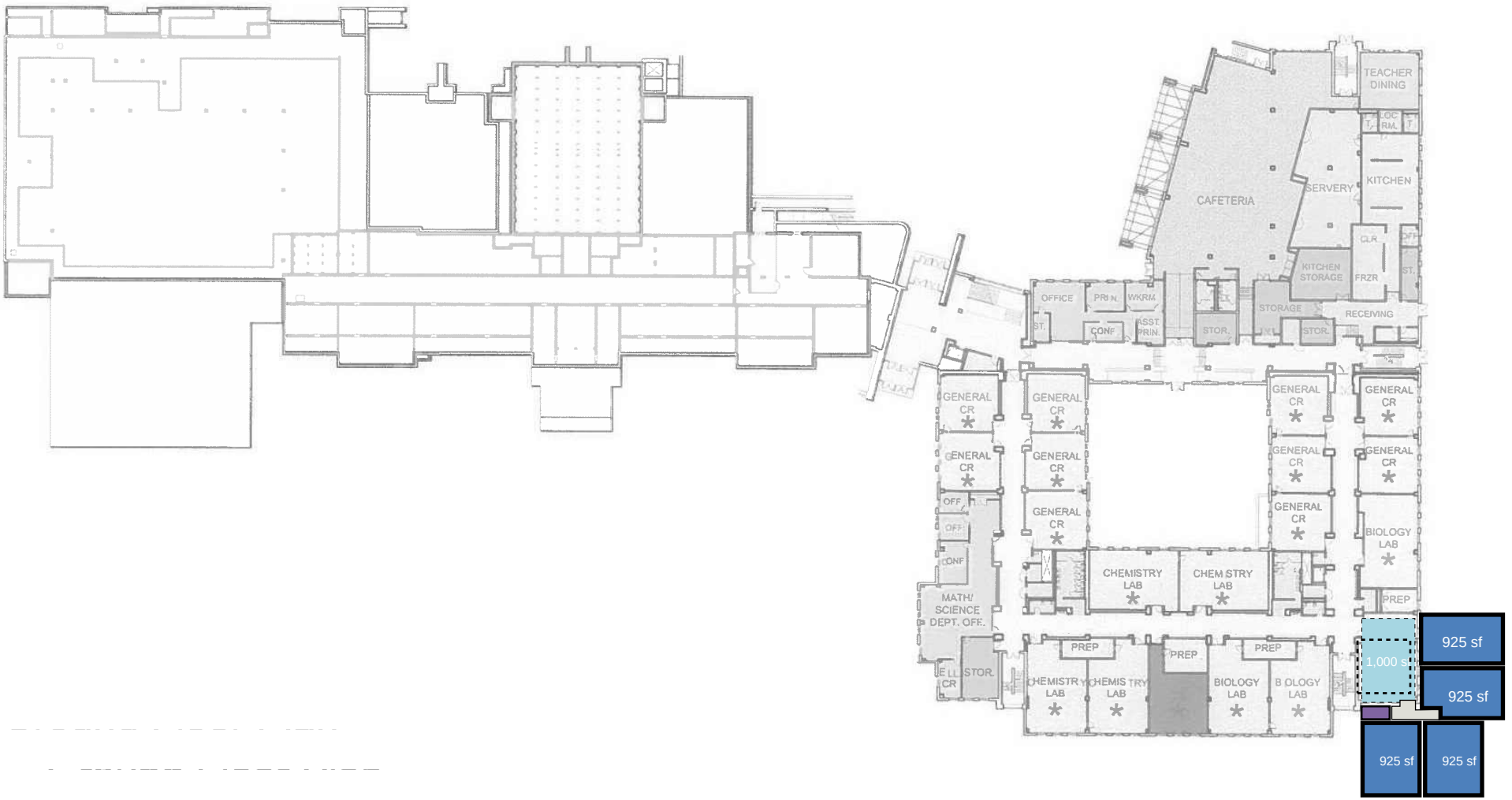


OPTION C

4-STORY CORNER ADDITION

LEVEL 2

- (- 1) CLASSROOM
- CLASSROOMS
- COLL. / OPEN SPACE
- STORAGE SPACE
- CIRCULATION



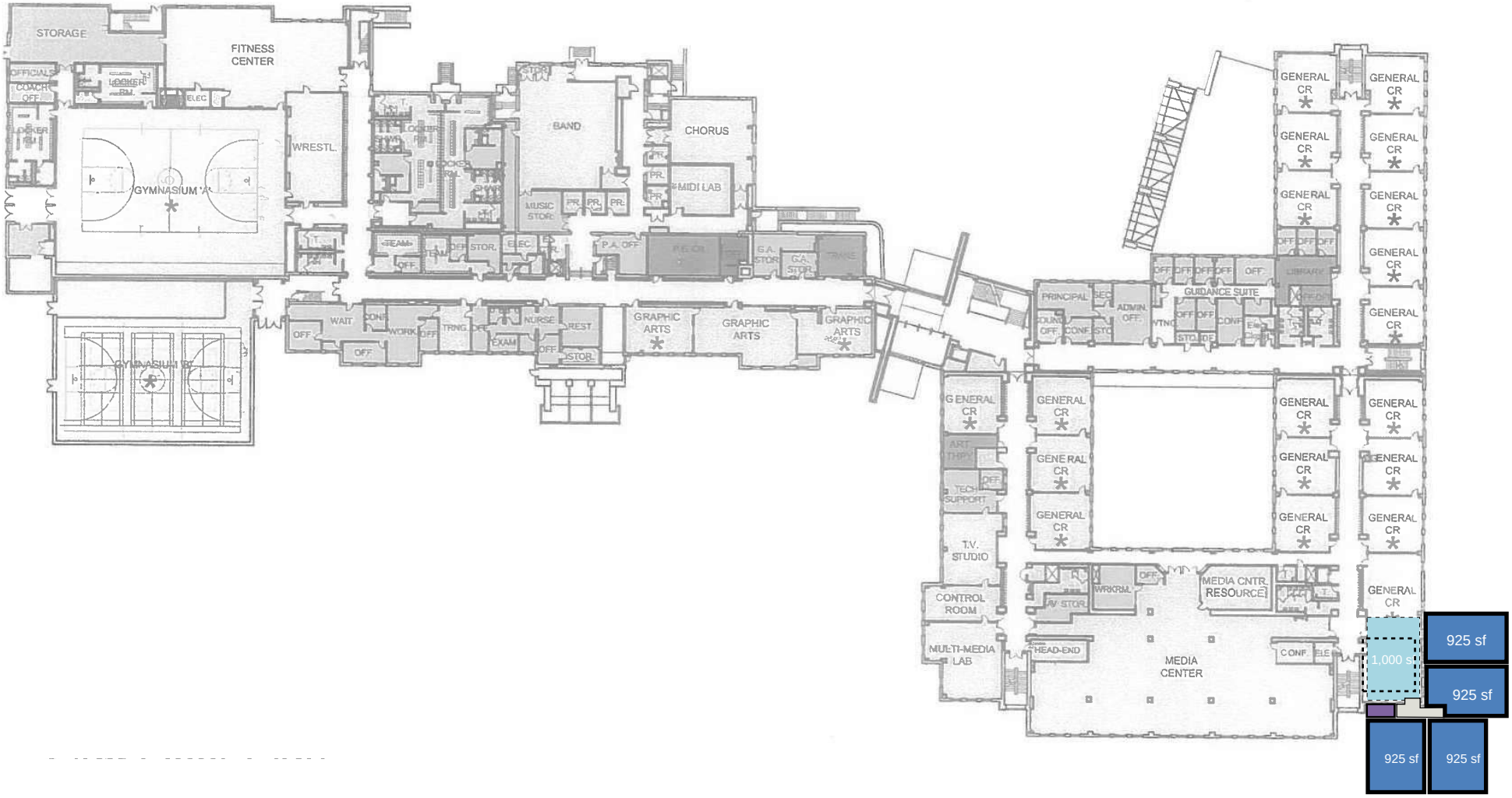
0 40 80 120 160 ft

OPTION C

4-STORY CORNER ADDITION

LEVEL 3

- (- 1) CLASSROOM
- CLASSROOMS
- COLL. / OPEN SPACE
- STORAGE SPACE
- CIRCULATION



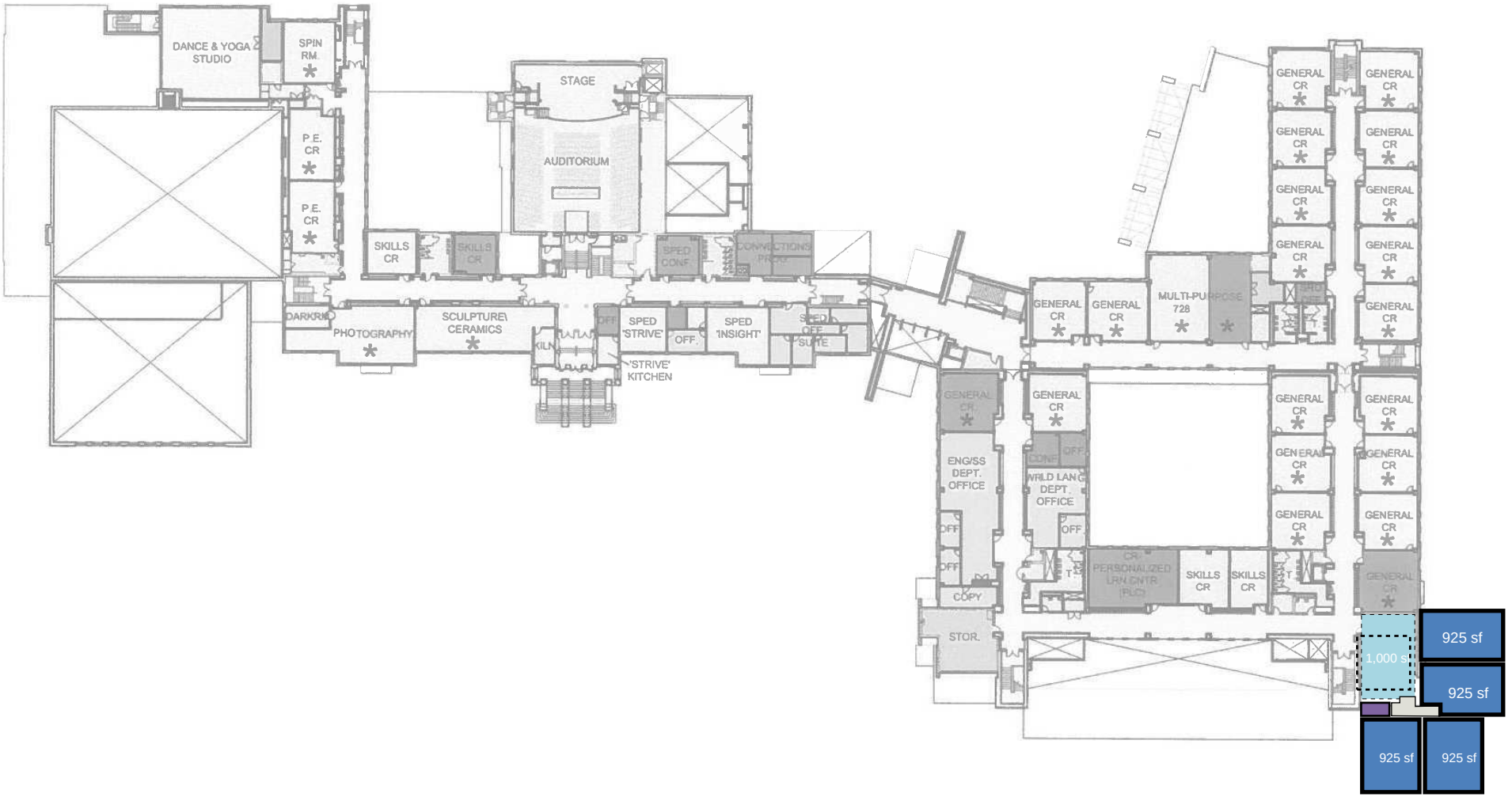
OPTION C

4-STORY CORNER ADDITION

0 40 80 120 160 ft

LEVEL 4

- (- 1) CLASSROOM
- CLASSROOMS
- COLL. / OPEN SPACE
- STORAGE SPACE
- CIRCULATION



OPTION C

4-STORY CORNER ADDITION

0 40 80 120 160 ft

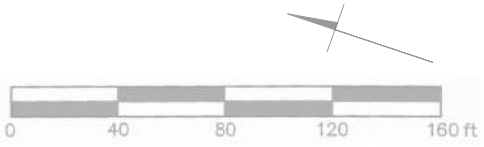

WEBSTER STREET

LEVEL 1

(NO CHANGE)

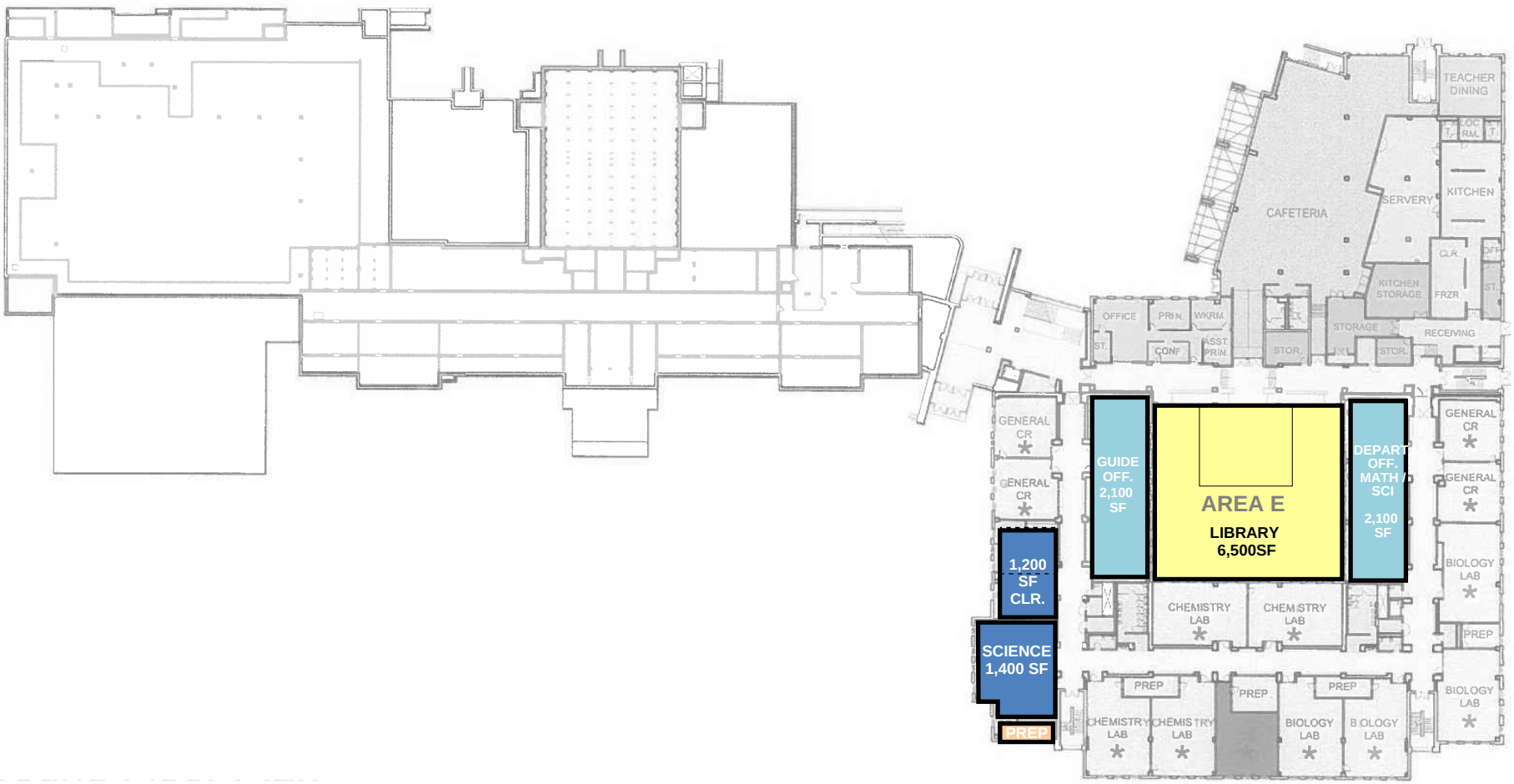
OPTION D

MEDIA CENTER MOVED TO COURTYARD



LEVEL 2

- CLASSROOMS
- DEPT. OFFICES, ADMIN. GUIDANCE
- MEDIA CENTER



OPTION D

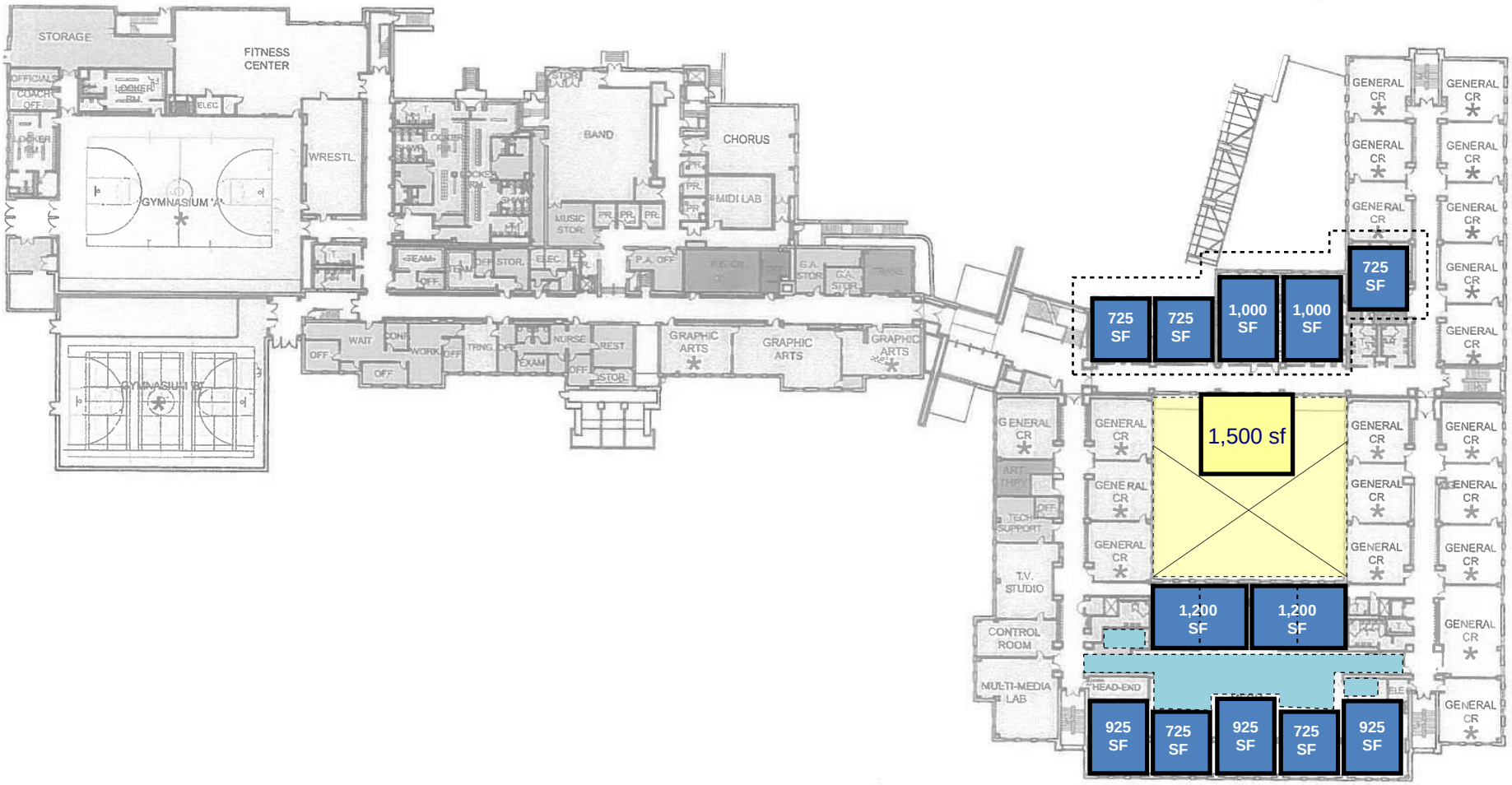
MEDIA CENTER MOVED TO COURTYARD

-6 CR
+1 CR
+1 SCR

0 40 80 120 160 ft

LEVEL 3

- RELOCATED OFFICES
- CLASSROOMS
- SMALL GROUP / COLLABORATION SPACE



OPTION D

MEDIA CENTER MOVED TO COURTYARD

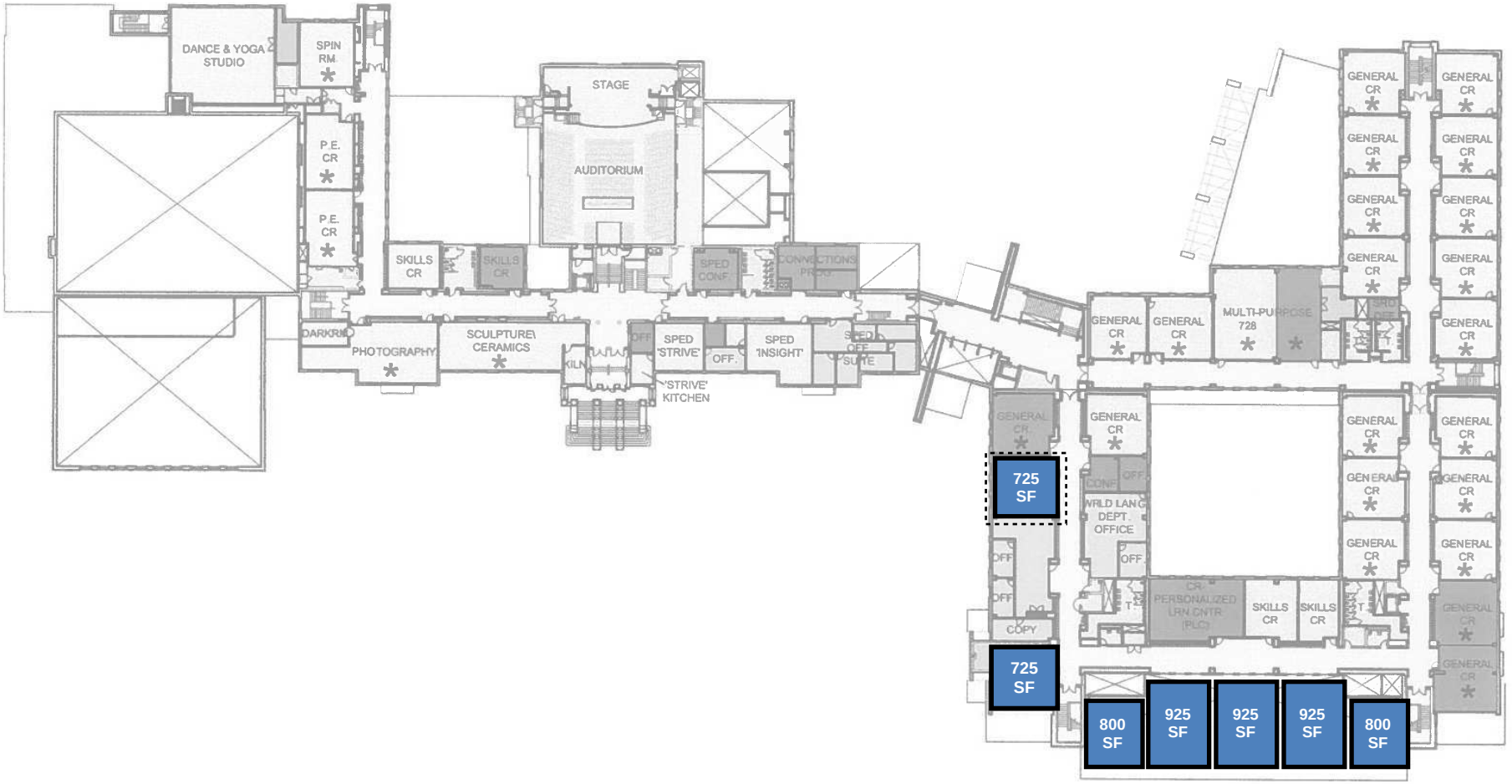
+12 CR

0 40 80 120 160 ft

LEVEL 4

RELOCATED DEPT. OFFICES

CLASSROOMS



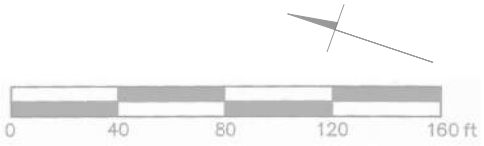
750 SF DEPT. OFFICES MOVED TO LEVEL 2

NET CHANGE (+6 CR's)

OPTION D

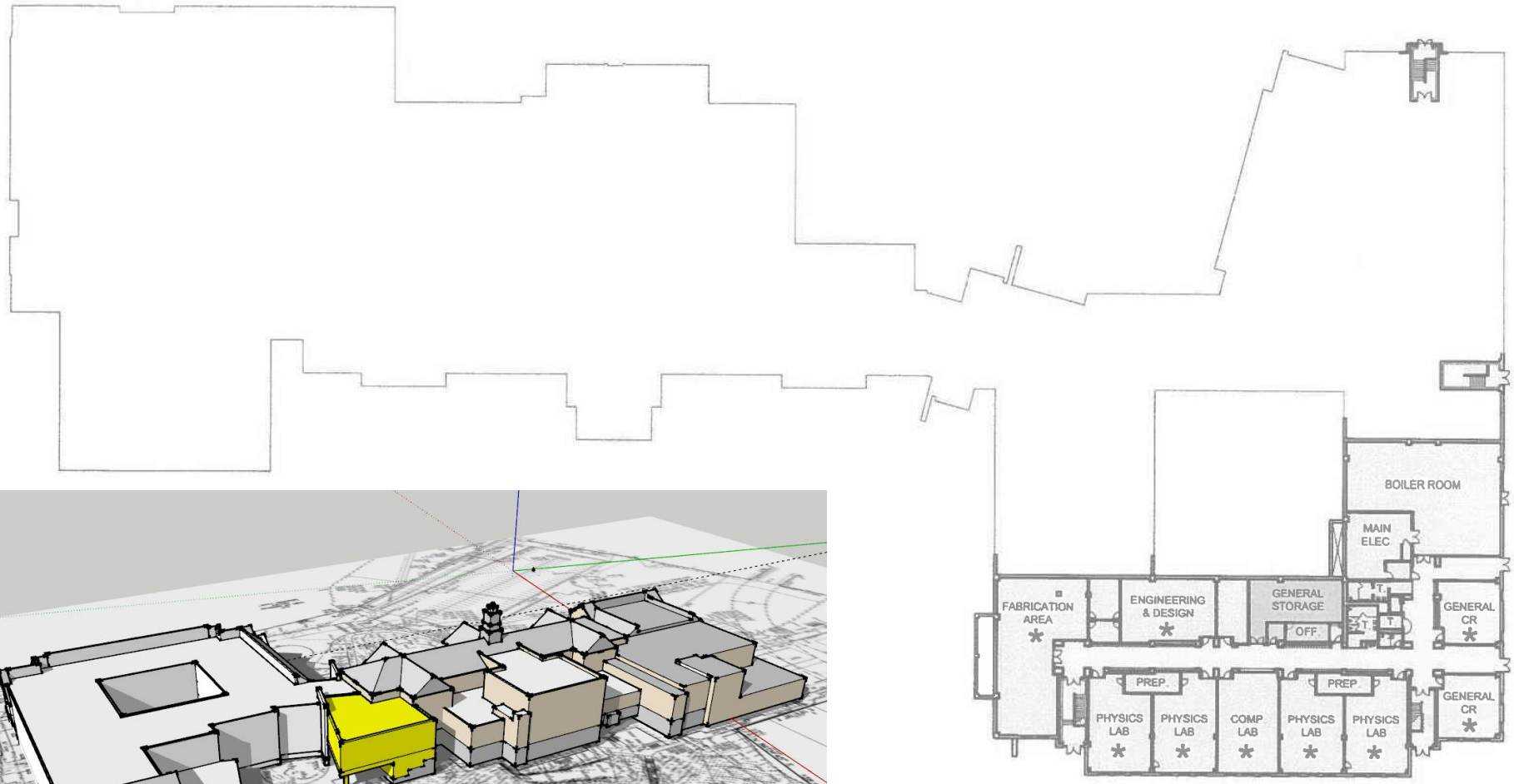
MEDIA CENTER MOVED TO COURTYARD

+7 CR



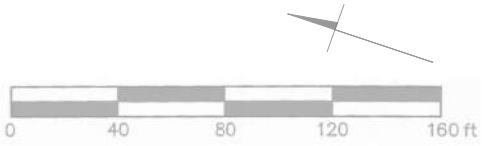
LEVEL 1

(NO CHANGE)



OPTION E

NEW MEDIA CENTER AT WEBSTER ST. ENTRY

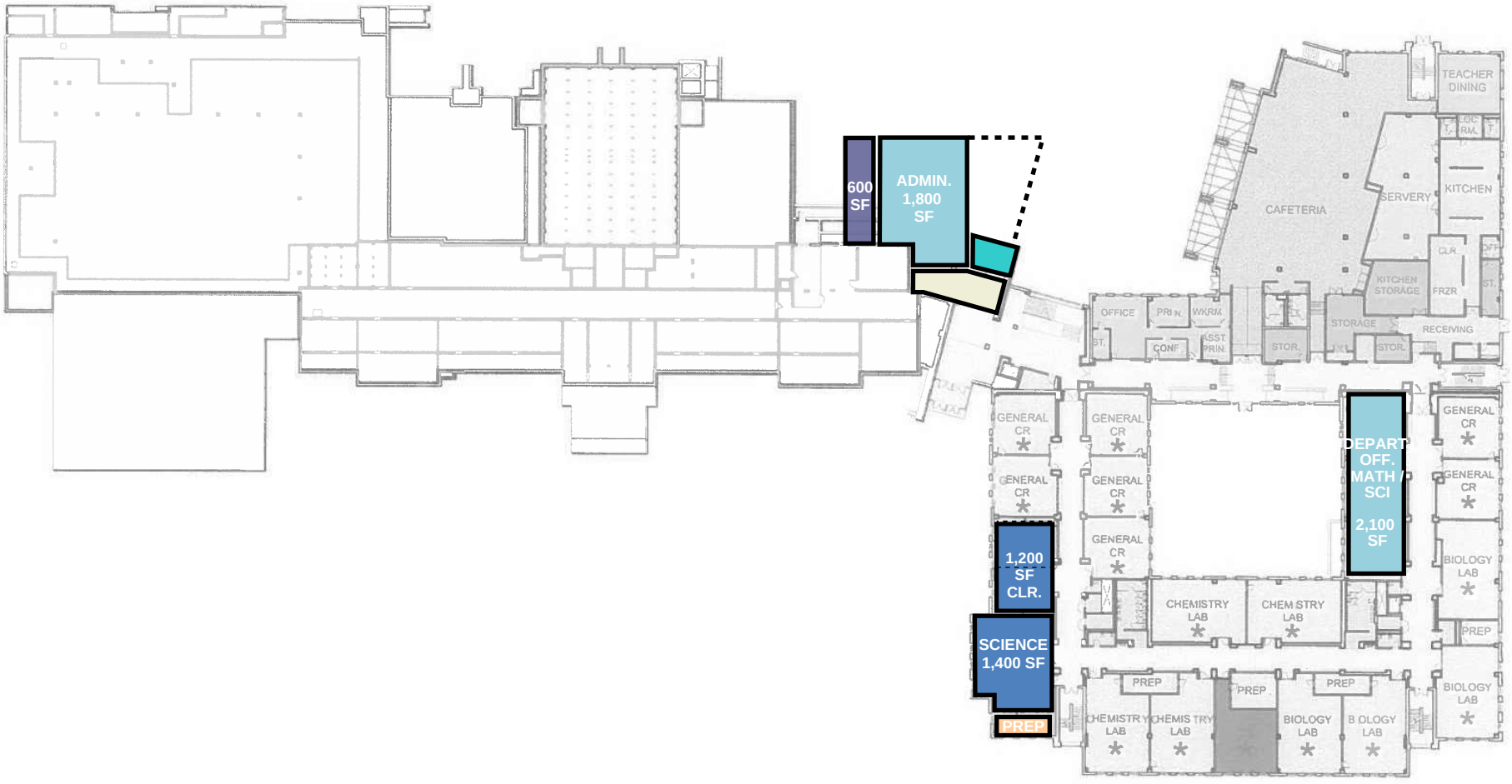


LEVEL 2

(- 3 CR'S)

CLASSROOMS

DEPT. OFFICES, ADMIN. GUIDANCE



OPTION E

NEW MEDIA CENTER AT WEBSTER ST. ENTRY

LEVEL 3

- RELOCATED ADMIN OFFICES
- CLASSROOMS
- SMALL GROUP / COLLABORATION SPACE
- NEW MEDIA CENTER - LOWER LEVEL

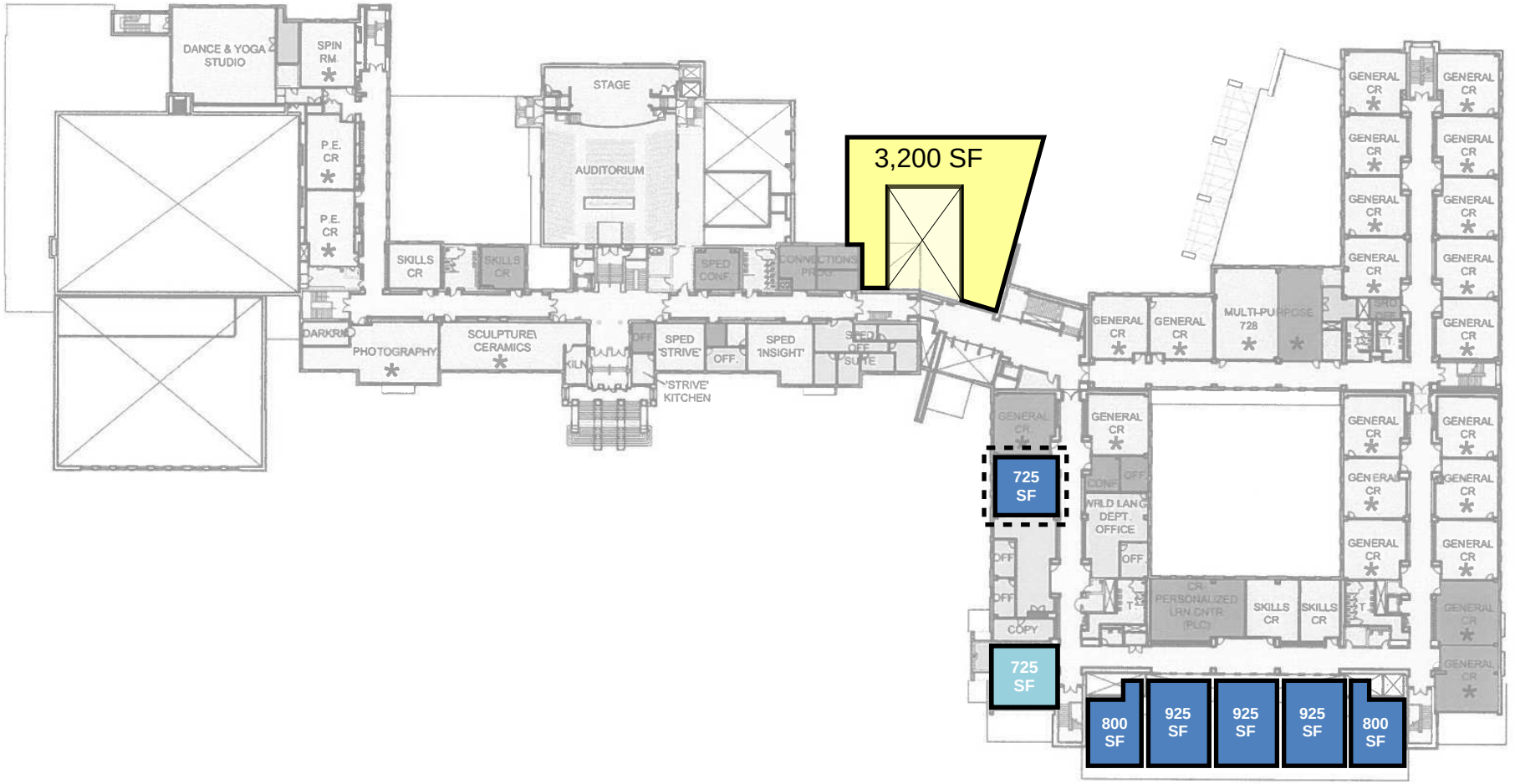
OPTION E

NEW MEDIA CENTER AT WEBSTER ST. ENTRY

0 40 80 120 160 ft

LEVEL 4

- RELOCATED DEPT. OFFICES
- CLASSROOMS
- DEPT. OFFICES
- NEW MEDIA CENTER - UPPER LEVEL



OPTION E

NEW MEDIA CENTER AT WEBSTER ST. ENTRY

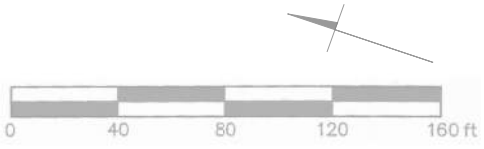
0 40 80 120 160 ft

LEVEL 1

(NO CHANGE)

OPTION F

NEW CLASSROOM WING AT WEBSTER ST. ENTRY

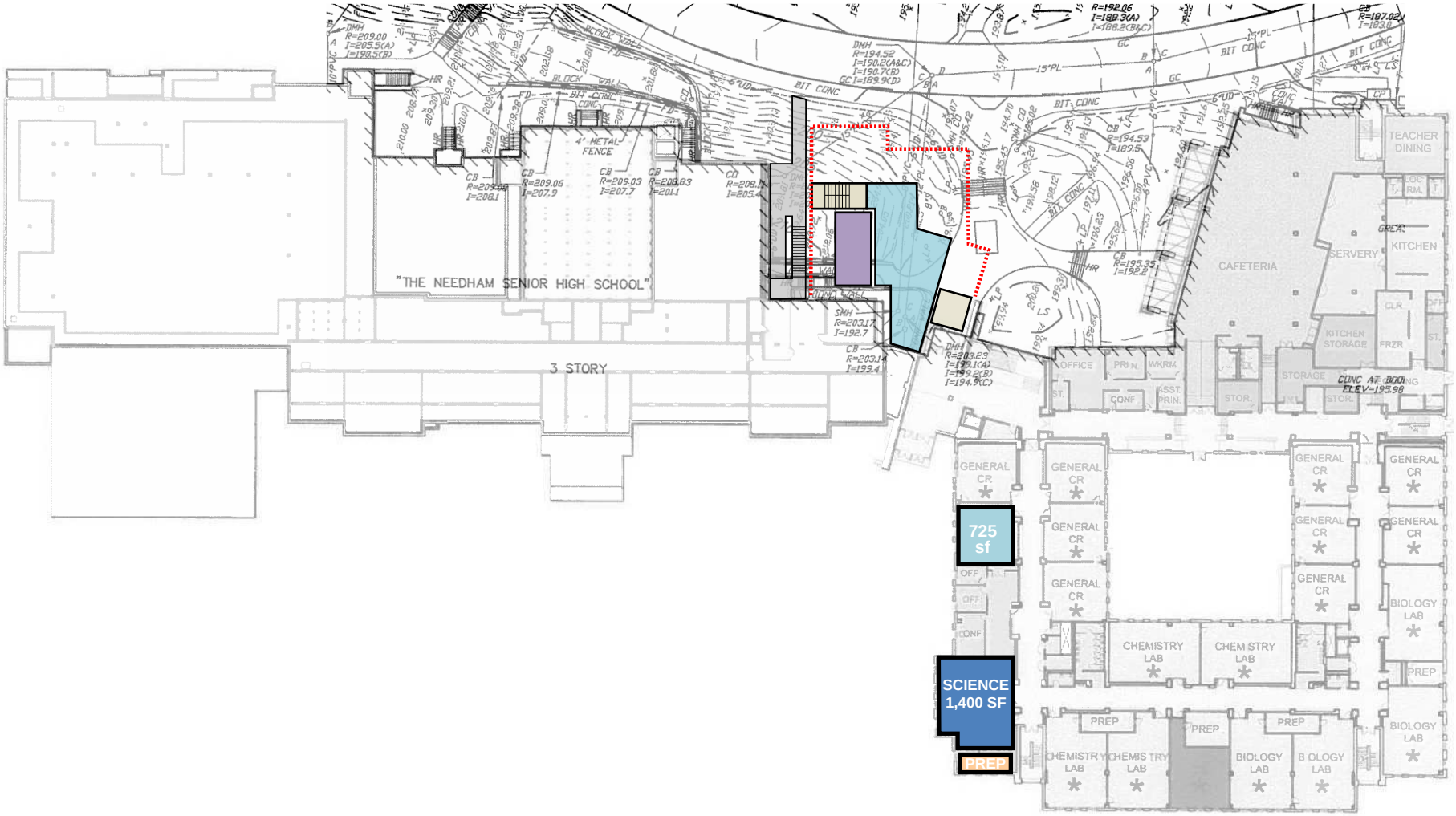


LEVEL 2

-1 CLASSROOM

+1 SC. CLASSROOM

ADMIN. / DEPT. OFFICES



OPTION F

NEW CLASSROOM WING AT WEBSTER ST. ENTRY

0 40 80 120 160 ft

LEVEL 3

- RELOCATED ADMIN OFFICES
- CLASSROOMS
- SMALL GROUP / COLLABORATION SPACE

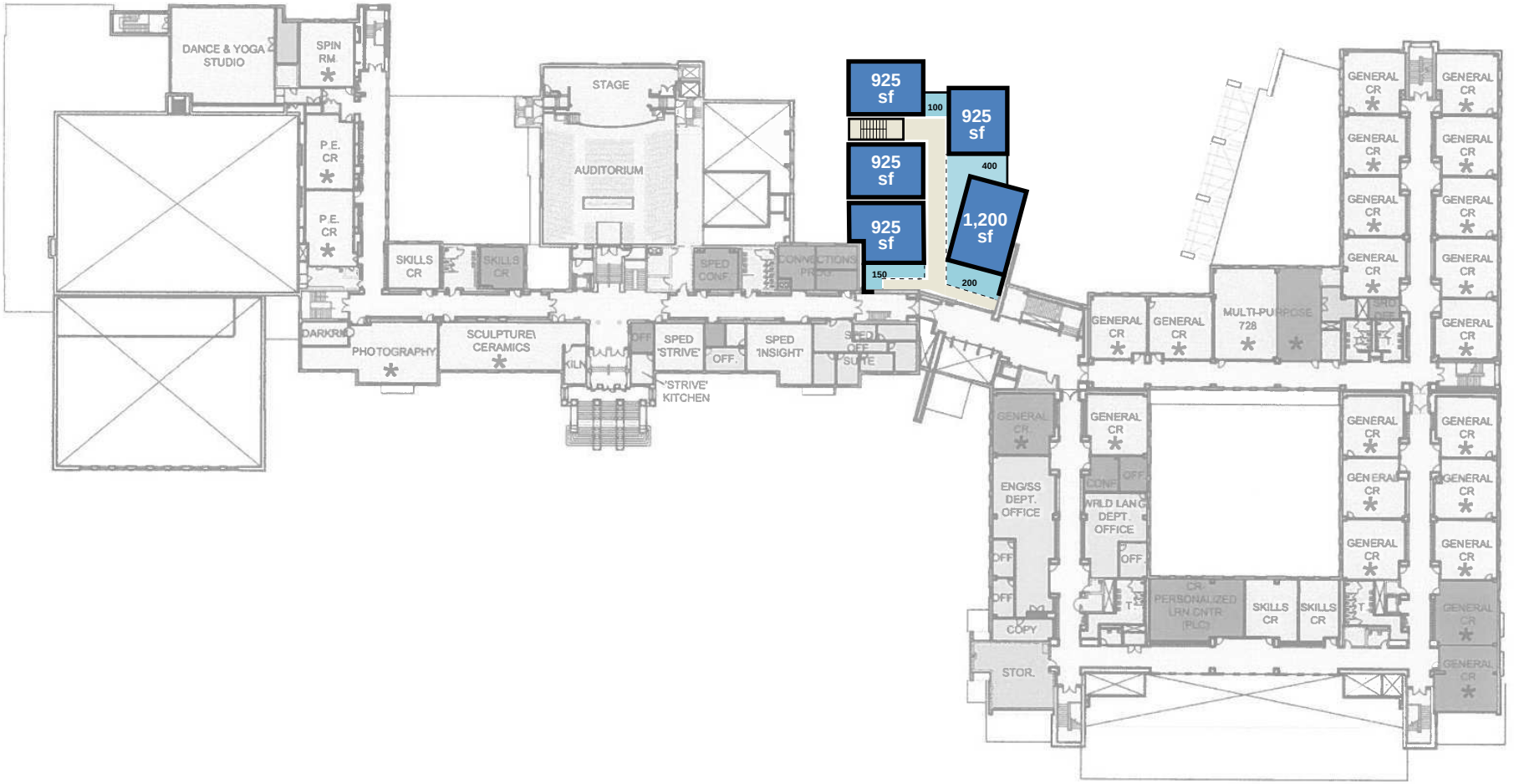
OPTION F

NEW CLASSROOMSWING AT WEBSTER ST. ENTRY

0 40 80 120 160 ft

LEVEL 4

- CLASSROOMS
- COLLABORATION SPACES
- CIRCULATION



OPTION F

NEW CLASSROOM WING AT WEBSTER ST. ENTRY

0 40 80 120 160 ft

GYMNASIUM 'A'

Gymnasium 'A' was added to the high school in the 1950's, and remains essentially in its original configuration. Minor renovations some time ago included replacement roof top ventilation units, acoustical ceiling tile (ACT), and flush mount fluorescent light fixtures. The ACT is subjected to repetitive damage due to errant balls knocking tiles and light fixture baffles out of place. The hardwood floor system is original, and as is noted in the field report below – has numerous deficiencies. There is adequate depth in the existing floor system and structure to allow for a new floor to be installed. In addition to new floor, it is desired to relocate the ceiling mounted basketball hoops to keep the main court clear of obstructions when needed. It is recommended to replace the rooftop mounted ventilation units, the lighting, the floor system, re-paint the entire space, and to install acoustic panels to the underside of the exposed steel roof deck. See complete field notes below for more detail, as well as the preliminary design and costing information in the next section of the report.

Date of Design Team walk-through:
12/21/2016

Gym Floor Notes:

- Investigated refinishing vs. replacement; specific issues noted include:
    - Gym striping is too close to side wall – no room for scoring table, hazard when playing on the side line
    - Gym floor has side wall basketball goals in the field of play
    - Gym floor has numerous dead spots that affect play
    - Striping is faded and simple sand and re-finish doesn't seem to get rid of the "ghosted" striping.
    - Bleachers were planned to go in this winter, but Town wants to wait to install new bleachers if floor replacement proceeds (planned to happen as part of the classroom addition construction contract).
- Additional observations
    - Existing floor appears to be two cross laminated tongue & groove layers of solid wood sleepers on concrete slab. Total system thickness is approximately 3"
    - No major surface defects were noted (no buckling, worn grooves from bleachers, no water damage). Some minor surface imperfections were visible.
    - Floor includes volleyball inserts, badminton inserts, and gymnastic equipment anchors which will need to remain or be installed new.
- Options discussed:
    - Option 1: Sand & refinish floor. If refinished, the Owner would want to re-paint the court layout closer to the bleachers to avoid the proximity to the far side wall. This

option would also require relocating main court basketball goals and possibly modifying fixed side goals to be operable. This option would not address or would complicate:

- Dead spots / poor ball bounce performance issues
- Location of in-floor sleeves. Volleyball inserts would not align with basketball court, or sleeves would need to be relocated & the existing floor repaired.

- Option 2: Replace gym floor.
  - Demolish existing gym floor. Abate hazardous materials if detected.
  - Pour leveling slab over existing slab, topical mitigation, and new resilient wood gym floor system.
  - Re-paint gym floor with basketball court in preferred location, coordinated with new bleacher layout.
  - Relocate volleyball and any other sleeves to coordinate with new court layout. Relocated main court basketball goals.
  - Replace existing side-wall basketball goals move out of the field of play. (See gym equipment below).

Gym Ceiling

- Town noted the following deficiencies with the ceiling:
  - Acoustic tile is constantly hit & damaged during basketball play.
  - Acoustic performance is poor – new larger speakers had to be added to the room.
  - HVAC distribution blows cold or hot air in just a few spaces – temperature is often an issue
  - Lighting is poor.
- Additional Observations:
  - Basketball goals mounted to exposed underside of roof trusses. Will make re-location relatively easy.
  - Roof drainage configuration was not noted, but assumed adequate.
- Options discussed:
  - Option 1:
    - Demolish acoustic ceiling.
    - Abate above ceiling hazardous materials if detected.
    - Paint exposed structure / HVAC / Plumbing / fire protection.
    - Install upright sprinklers
    - Install new HVAC units & distribution equipment
    - Install new lights

- Install new speaker system
- Install surface mounted acoustic treatments (tectum panels) as recommended by Acoustic Consultant.

Gym Walls

- Town noted the following deficiencies with the walls:
  - Wood paneling is old, dated, and trim is failing
  - No consistent way to hang championship banners
  - Side operating divider curtain takes up too much space (see gym equipment below)
- Additional observations:
  - CMU walls appeared to be in good condition – no major cracks noted.
  - No acoustic block or acoustic wall treatments were observed.
- Options discussed:
  - Option 1: Remove wall paneling. Demolish existing wall paneling and wood trim. Abate if hazardous materials are detected.
    - Fill / repair CMU wall as needed.
    - Paint walls
    - Install wall pads where side court is in close proximity to wall.
  - Option 2: Install additional acoustic wall treatments, if not addressed in ceiling alterations noted above.
  - Option 3: Install consistent championship banner hanging system.

Gym Equipment

- Town noted the following deficiencies with the equipment:
  - Two side mounted basketball goals are within the basketball court field of play.
  - Four operable basketball goals use different types of drill-attachment winches.
  - Side-operating divider curtain is difficult to use. Large alcove creates a junk trap for miscellaneous equipment.
  - Old basketball goals require the edge padding to be cut to fit. These pads typically last about a season.
  - Town expressed a desire to have a wrestling mat hoist.
- Additional observations:
  - Main court basketball goals would need to be re-located regardless of flooring Option pursued above.

- Volleyball net sleeves and badminton sleeves would need to be relocated regardless of flooring Option pursued above.
- Gymnastics equipment anchors could remain if floor is re-finished as they are independent of court painting.
- Basketball goal winch operation is not accessible – requires special tools above reach ranges. Recommend replacement of basketball goal systems and operators.
- Folding basketball goals are old, but still operable.
- Basketball goals do not have vertical adjustment capability.
- Bleachers are broken and under contract to be replaced. The new layout will reduce the number of rows, allowing the court to be relocated. The Owner intended to delay this contract until a flooring solution is selected.
- Mat hoist installation would be dependent on a structural analysis of the existing roof.

- Options Discussed:
  - Option 1: Replace bleachers. (Assumed regardless of flooring option selected)
  - Option 2a: replace (4) wall mounted winches with support mounted winches and new wall switches on existing folding basketball goals. Relocate main court goals to align with new court layout
  - Option 2b: replace (4) folding basketball goals with new folding basketball goals.
  - Option 2c: replace (2) folding basketball goals at main court; replace (2) wall mounted winches with equipment mounted winches and wall switches at side court operable goals.
  - Option 3: Replace two fixed wall mounted basketball goals with operable wall mounted basketball goals.
  - Option 4: Install wrestling mat hoist.

BOILER & CHILLER REPORT(S)

NEEDHAM HIGH SCHOOL

Boilers & Chiller Study

Prepared by:

S. Chandrashekar, P.E.
Sharmila C. Bail, P.E., LEED AP
SHEKAR & ASSOCIATES, INC.
775 Pleasant Street #14
East Weymouth, Massachusetts 02189

March 8, 2017

Preface

Shekar & Associates, Inc. (SAI) prepared this report for Needham Public Facilities Department. The purpose of the report was to survey the existing conditions of the cast iron boilers and air cooled chilled water at Needham High School. This report contains reported issues, analysis and recommendations for the existing boilers & associated systems and air cooled chiller.

Throughout the project SAI worked closely with representatives from Needham Public Facilities personnel (Henry Haff & Carys Lustig), Needham High School facility group (Wayne Whisler & John Gass), Dore & Whittier Architects (Michele Rogers & Glen Gollrad), Eversource (Scott Johnston), Wilkinson Companies (John Sieminski) and various boiler manufacturer representatives to achieve the project objectives.

This report covers an assessment of existing conditions, recommendations and conclusions for proposed remedies and solutions.

Acknowledgements

Project Client and End User:

Needham High School
609 Webster Street
Needham, MA 02494
Henry Haff, Project Manager/Public Facilities Department - Construction
Carys Lustig, Supervisor of Administration/DPW at Town of Needham
Wayne Whisler, Operations Division/ Town of Needham

Engineer

Mechanical, Electrical, & Plumbing Engineering:

Shekar & Associates, Inc.
775 Pleasant Street #14
East Weymouth, MA 02189
S. Chandrashekar, P.E. Principal
Sharmila C. Bail, P.E. LEED AP

Architect

Dore & Whittier Architects, Inc.
260 Merrimac Street, Building 7
Newburyport, MA 01950
Michele Barbaro-Rogers
Glen P. Gollrad, NCARB

Table of Contents

1.0 Existing Conditions Assessment

1.1 Background

1.1.1 S. Chandrashekar & Sharmila Bail visited Needham High School a number of times to collect existing information and investigate present issues with the boilers and air cooled chiller. At these visits they met with various personnel from Needham Public Facilities Department, Needham High School Operation Division, Dore & Whittier Architects, FIA and Frank I Rounds.

1.1.2 Henry Haff emailed existing Mechanical, Plumbing & Electrical drawings and other information related to the issues in the boiler room for review.

1.1.3 Needham High School is fully heated by cast iron boilers and cooled by an air cooled chiller. Present total area of the school is approximately 300,000 sq. ft. and future new addition will be between 8,000 sq. ft to 12,000 sq. ft.

1.2 Boilers & Associated Systems

1.2.1 Boilers

Four (4) cast iron boilers are located in the boiler room. Three (3) boilers are currently active and one (1) boiler is inactive due to a defective boiler burner and has been disengaged.

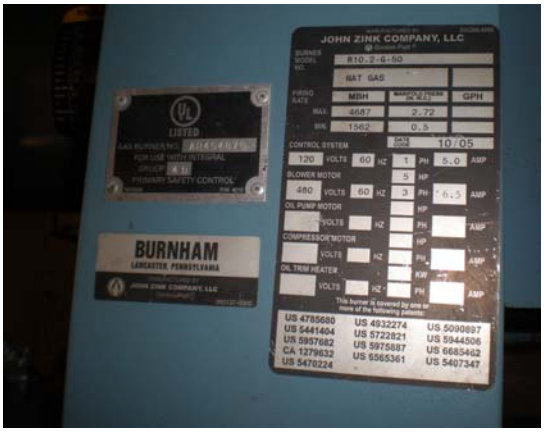
Boiler rating for each boiler is as follows:

Manufacturer: Burnham
Model No. V1119
Fuel: Natural gas
Input: 4,691 MBH
Output: 3,739 MBH
Burner: HP/480V/3P

Three Active Boilers

Fourth Inactive Boiler

Typical Boiler Burner



Burner Nameplate

1.2.2 Boiler Venting & Combustion Air

Boilers are vented through a common vent running up to the roof. Combustion air is introduced into boiler room through a combustion air intake louver with motor operated damper.

Common Venting

Combustion Air Louver

1.2.3 Boiler Recirculating Pumps

Each boiler has a recirculating pump. Pump rating is as follows:

Manufacturer: Bell & Gossett
Flow: 215 GPM
Head: 15 feet
Motor: 1 1/2 HP/480V/3P

Boiler Recirculating Pump

1.2.4 Hot Water System Pumps

There are two hot water system pumps. One pump is active and the other pump is a standby. Rating of the pump is as follows:

Manufacturer: Bell & Gossett
Flow: 1250 GPM
Head: 130 feet
Motor: 50 HP/480V/3P

Each pump is furnished with variable frequency drive (VFD).

Hot Water System Pumps

Pump Nameplate

1.2.5 Expansion Tanks

System pressure is maintained through three (3) expansion tanks. Each expansion tank has a capacity of 528 gallons.

Expansion Tanks

1.2.6 Air Separator

Hot water system includes two (2) air separators. Each air separator size is 8" with 840 GPM capacity.

1.3 Gas Service

1.3.1 Gas Service & Meter

Underground gas service is located near the boiler room. Incoming gas service configuration consists of gas shut-off valve, gas meter and pressure reducing station. As per Eversource representative, Scott Johnson, gas is served by intermediate gas pressure service.

Gas Service

Gas Meter

1.3.2 Gas Piping

10" gas service enters the building. Gas appliances include boilers, hot water heater, kitchen equipment, etc.

Incoming Gas Pipe

Gas Piping to Boilers

1.3.3 Boiler Gas Pipe

8" gas pipe services four (4) gas boilers. Total capacity at 8" gas pipe is 18,764 CFH. The pipe has the capacity to carry this load.

Typical Boiler Gas Train

1.4 Chiller & Associated Systems

1.4.1 Chiller

The air cooled chiller is located outdoors. The chiller is damaged and has not been in operation since last year. During the cooling season the school has rented temporary chillers to operate the chilled water system.

Chiller

Chiller rating is as follows:

Manufacturer: McQuay
Capacity: 300 tons
Chilled Water Flow: 720 GPM
Entering Water Temperature: 54 °F
Leaving Water Temperature: 44 °F

1.4.2 Chilled Water Pumps

There are two (2) chilled water pumps. One is a primary pump and the other a standby. Rating of pump is as follows:

Manufacturer: Bell & Gossett
Flow: 720 GPM
Head: 130 feet
Motor: 40 HP/480V/3P

Each pump is furnished with variable frequency drive (VFD).

Chilled Water Pumps

2.0 Reported Issues and Analysis

2.1 Reported Issues

2.1.1 After visiting the school several times and having discussions with various groups, reported issues can be broadly classified in the following three categories:

- Boiler operation & gas pressure
- Dirt & other contaminants in hot water and chilled water circulation piping system.
- Air cooled chiller not working.

Refer to Appendix A which includes Shekar & Associates, Inc. January 18, 2017 Meeting Notes. These meeting notes include a summary of issues at the site.

2.1.2 Boiler Operation & Gas Pressure

2.1.2.1 At present only three boilers are in operation and the fourth boiler is not working.

2.1.2.2 Needham High School facility group informed that during severe cold temperatures they can only fire two boilers at a time. Due to inadequate gas flow the third boiler cannot be fired.

2.1.2.3 Shekar & Associates, Inc. followed up with Scott Johnson of Eversource who claimed that their street gas network has adequate gas volume and gas pressure.

2.1.3 Hot & Chilled Water Contamination

2.1.3.1 Needham High School facility group showed the water collected at the hot water pump from the piping system. It was brownish in color and appeared to have sediment settled at the bottom.

2.1.3.2 John Burris, Water Treatment Manager at Frank I Rounds Co. visited the site to analyze the hot/chilled water in the piping systems. Sample taken at the boiler found impurities and discoloration.

2.1.2.3 Needham High School facility group informed the piping system may not have been properly flushed and cleaned at the end of construction. Hot and chilled water systems were commissioned without proper flushing or cleaning of either system.

2.1.4 Air Cooled Chiller

2.1.4.1 At present the outdoor air cooled chiller is not working. This may be due to damage to the condenser coils. In the interim, the school is renting temporary chiller during the cooling season.

2.2 Analysis

2.2.1 Boilers

2.2.1.1 Viewing the boilers exterior appearance and boiler piping, there were no water leaks on the floor or burn marks at the jacket. With no visible signs of damage the cast iron sections may not be cracked.

2.2.1.2 Shekar & Associates was informed three individual boilers are producing rated output capacity. This means the gas burner and cast iron sections of each individual boiler are working satisfactorily.

2.2.1.3 Gas pressure and volume in the piping system are yet to be established. Boiler operation/performance testing should be conducted in front of all parties including Needham High School personnel and Scott Johnson of Eversource to determine the source of the issues. Attempt to schedule a test date was postponed due to the mild temperatures. Any test with the mild temperatures may not be accurate due to the demand for less gas volume at the street. New test date to be determined.

2.2.1.4 Present boiler capacity should be able to handle future building addition (estimated to be 8,000 sq. ft. - 12,000 sq. ft.).

Existing 300,000 sq. ft x 30 Btu/hr/sq. ft. (avg. for well insulated bldg.) = 9,000 MBH

With the additional of 12,000 sq. ft.:

312,000 sq. ft. x 30 Btu/hr/sq. ft. = 9,360 MBH

Total output from three existing boilers (fourth boiler is a standby boiler & not in operation):

3 x 3,251 MBH = 9,753 MBH

2.2.2 Hot Water & Chilled Water Systems

2.2.2.1 At present, there are two chemical shot feeders for each system. However this equipment may not provide adequate water treatment of the hot & chilled water systems. Also, there is no monitoring of the concentration of glycol circulating in the system.

2.2.2.2 Dirt and other contaminants along with low glycol concentration in the hot & chilled water circulating system may have damaged the chiller and degraded the life of the pumps and boilers.

2.2.2.3 Refer to Appendix B for more detail on the water contamination and its components.

2.2.3 Air Cooled Chiller

2.2.3.1 One option included reusing the compressors and replacing the condenser coils in the chiller. However, after Shekar & Associates, Inc. had a series of conversations with chiller manufacturer (McQuay) and contractors the general consensus was that repair of the existing chiller was not a viable or feasible option. A new chiller will be more efficient and energy savings will justify the cost of a new chiller.

3.0 Recommendations

3.1 Boilers

3.1.1 We recommend to retain the existing cast iron boilers. This summer the boilers should be thoroughly cleaned and checked inside for any wear and tear and for any cracks at the cast iron shells.

3.1.2 After thoroughly checking the boilers the decision of replacing the existing boilers should be rechecked at that time.

3.1.3 We are still looking for a suitable date and time to conduct the boiler operation/performance testing with Wilkinson Companies and Eversource Gas. Findings from this test could determine why three boilers can not be run at the same time.

3.2 Water Treatment

3.2.1 This summer we recommend to flush and clean the hot water and chilled water piping systems.

3.2.2 Furnish and install cartridge filters in the piping systems.

3.2.3 Furnish and install chemical filter feeders (Neptune tank) for each system.

3.2.4 Furnish and install glycol feed station for piping system.

3.2.5 Refer to Appendix C for water treatment & glycol equipment cuts.

3.3 Air Cooled Chiller

3.3.1 It is our understanding the present 300 ton air cooled chiller is satisfactorily cooling the building.

3.3.2 The anticipated building addition is 8,000 - 12,000 sq. ft. Based on an average 250 sq. ft./ton, additional cooling load will be:

$$\frac{12{,}000 \text{ sq. ft.}}{250 \text{ sq. ft/ton}} = 48 \text{ additional tons}$$

3.3.3 We recommend installing a new high efficient air cooled chiller with frequency drive on the chiller and condenser fans. New chiller size should be between 350 to 375 tons. See Appendix D for chiller equipment cuts.

3.4 Conversion of 4th Boiler into Dual Fuel ([Oil/Gas Combination]

3.3.1 In our opinion, the conversion of the 4th boiler to dual fuel (including installation & space requirements of fuel oil tank and related piping) may be very costly. This option requires a detailed study.

4.0 Cost Estimate

- Cost Worksheet

Needham High School Heating and Cooling Systems Cost Worksheet

3/8/2017

Boiler / Heating System	Size / Detail	Unit Cost	Material Cost	Installation Cost	Cost
Complete hot water system treatment and flushing	Frank I. Rounds Co.				$3,425
Chemical filter feeder for hot water system	Frank I. Rounds Co.	$740	$125	$500	$1,365
(5) - 20 micron filter bags, (5) - 5 micron filter bags, (5) 1 micron filter bags	Frank I. Rounds Co.				$350
Boilers operation/performance testing - 1/2 day	Wilkinson Co.				$1,500
Option for dual fuel boiler system - either converting (1) unit or purchasing a new unit, cannibalizing Boiler #4 for spare parts for the other 3 boilers					TBD
			Total:		$6,640

Needham High School Heating and Cooling Systems Cost Worksheet

3/8/2017

Chiller	Size / Detail	Unit Cost	Material Cost	Installation Cost	Cost
1. Remove & discard from site existing McQuay 300 ton chiller. 2. Furnish and install new 375 ton air coold chiller with VFD drives. 3. Flush and clean chilled water piping. 4. Reconnect chilled water piping 5. Reconnect controls to building energy management system. 6. New power wiring, circuit breakers, etc.	Daikin - 375 TONS	$200,000.00		$200,000	$400,000
Complete chilled water system treatment and flushing	Frank I. Rounds Co.				$3,425
Chemical filter feeder for chilled water system	Frank I. Rounds Co.	$740	$125	$500	$1,365
(5) - 20 micron filter bags, (5) - 5 micron filter bags, (5) 1 micron filter bags	Frank I. Rounds Co.				$350
Glycol material direct from supplier (gallons)	5000	$4.50			$22,500
Glycol feed station	Frank I. Rounds Co.	$4,925	$750	$2,160	$7,835
			Total:		$435,475

5.0 Appendices

- Appendix A: January 18, 2017 Meeting Notes prepared by Shekar & Associates, Inc.
- Appendix B: Supplemental information on water contamination, treatment and process
- Appendix C: Water treatment & glycol equipment cuts [chemical filter feeder & glycol feed station]
- Appendix D: Air cooled chiller equipment cut

Appendix A

Shekar & Associates, Inc. January 18, 2017 Meeting Notes

SHEKAR & ASSOC. INC

Consultants
Electrical Engineering
Mechanical Engineering
Energy Studies

MEETING NOTES

PROJECT: Needham High School - Boiler Replacement Study
Needham, MA

JOB NO. 510171

DATE: January 18, 2017

PRESENT:

NAME	REPRESENTING
Hank Haff	Town of Needham
Carys Lustis	Town of Needham
Wayne	Town of Needham
John	Town of Needham
Simon	Town of Needham
Glen P. Gollrad	Dore & WhittierArchitects, Inc.
Yvon Blais	FIA, Inc.
Sharmila Bail	Shekar & Associates, Inc.
S. Chandrashekar	Shekar & Associates, Inc.

1. It is important to note that the manufacturer of the existing Burnham cast iron sectional boilers no longer supports older generations of V11 Boilers with replacement sections. If the boiler was shipped & built prior to 2004, current V11 replacement sections will not align with the existing boiler sections. However, maintenance staff did inform that boiler sections have been replaced in the past, these boilers may have been on the cusp of replacement section compatibility.

2. Even though the hot water supply and return piping was flushed and cleaned when the new heating system was installed, and chemical treatment notwithstanding, there remains a large amount of debris, sludge and scale that still remains within the piping system. This debris has been, and continues to be, detrimental to the system heating pumps damaging seals and impellers even with frequent and regular blowdowns to flush the system.

3. Maintenance staff indicated 5" W.C. of gas pressure is maintained at the inlet to the Burner gas trains. At 5.00 Ins. W.C. of inlet gas pressure, we would recommend another review of the Burner submittal data to determine if 5.00" Ins. W.C. is the actual inlet gas pressure required for this gas train/burner assembly.

4. Viewing the boilers and near boiler piping, there are no water leaks on the floor or burn marks at the jacket or other visible signs of damaged cast irons sections.

SHEKAR & ASSOC. INC
Consultants
Electrical Engineering
Mechanical Engineering
Energy Studies

MEETING NOTES
PROJECT: Needham High School - Boiler Replacement Study
JOB NO.: 510171
DATE: January 18, 2017

5. During the site visit, the outside air temperature was 40 °F. Boiler #2 was the sole Boiler in operation and the Hays/Cleveland Boiler Plant control panel displayed a return water temperature of 156 °F. Supply water (Header) temperature was unrecorded.

6. Each Boiler is equipped with a return water temperature control system with diverting valve that, when in operation, is designed to constantly blend boiler hot LWT supply water with return EWT to assist in maintaining a return water temperature to the Boiler above 140 °F. to prevent thermal shock as well as to eliminate condensing in the Boiler. This valve/setpoint control system is from the small black Burnham control panel mounted on the top right front face of each Boiler. Temperature sensor for this control is found in the return piping at the rear of each Boiler, near the lower right hand return connection (facing the back section of the boiler). Diverting valve on Boiler #4 is a leaker.

7. No visible water leaks found in the near boiler piping, valves and fittings.

8. No discernable odors of flue gas within the boiler room.

9. All four boiler side jacket panels are not burned or scorched indicating seals between boiler sections are intact and still pressure tight. No flue gas leakage from the Boilers are immediately evident.

10. Burner #4 has been determined by Service Technician (GT Wilkinson, Inc. - Rockland, MA) to not be suitable for operation and therefore is not in use. Whether this boiler could be cannibalized for parts or be converted into a dedicated oil-fired boiler with new burner was discussed. This needs to further investigated in the study.

11. During the coldest of weather, staff indicate they can only run 2 Boilers at full rate, which is dependent upon how cold the OA temperature, often times does not meet their heating needs.

12. The maintenance staff is of the opinion that the volume of gas delivered to the burners is insufficient to allow all three boilers to function at high fire. Again, a review of the manufacturers minimum inlet gas pressure should be conducted.

13. Control system is complex, and staff have resorted to some manual forms of operation in lieu of automatic controls.

14. Building size is approximately 300,000 sq. ft. The group was informed that the building wall & roof have good insulation and windows have insulating glass. The new addition will be approximately 8,000 sq. ft.

15. Shekar & Associates contacted Scott Johnson of Eversource prior to the meeting to get initial information on the present gas pressure at the school. Scott emailed Shekar & Associates gas related documentation. See attached. Shekar & Associates will continue to be in contact with the gas company regarding the lack of gas volume delivered to the building. Note: After the meeting Shekar contacted Scott again. Scott will visit the site soon and check the meter sizes and flow conditions.

SHEKAR & ASSOC. INC
Consultants
Electrical Engineering
Mechanical Engineering
Energy Studies

MEETING NOTES
PROJECT: Needham High School - Boiler Replacement Study
JOB NO.: 510171
DATE: January 18, 2017

16. Heating system components are monitored through a building energy management system. Shekar & Associates to email what components or other data (ex. boiler supply & return temperatures, prior Eversource bills indicating gas usage, etc.) they require to review the heating system.

17. In general, Hank indicated the following information should be addressed in the study report:

    a. Identifying current issues/problems.
    b. Repair or testing of gas line/pressure/volume at the high school prior to any future boiler work.
    c. Replacement of boilers time frame, if necessary.
    d. Possible oil fired boiler (4th boiler with new oil burner) option.
    e. Will the present boilers handle the capacity of the 8,000 sq. ft. addition?
    f. Improvements / recommendations to existing system.

18. Preliminary thought on the existing boiler issues can be broken down into three broad areas:

    a. There may be inadequate volume of gas into the building.
    b. Dirty water in the heating piping system. Possible cleaning or filtering of system.
    c. Automatic control issues.

Unless notified to the contrary, these notes are assumed to be accurate.

Prepared by:
Shekar & Associates, Inc.

cc: All present

775 Pleasant Street #14, East Weymouth, MA 02189 Tel (781) 337-8347 Fax (781) 337-2952
Email: shekarco@verizon.net

NSTAR ELECTRIC GAS
157 Cordaville Road Southborough, Massachusetts 01772

July 1, 2005

Needham Permanent Building Committee
Steve Popper
470 Dedham Avenue
Needham, MA 02192

Dear Mr. Popper:

This letter is in response to our conversation regarding the new gas service to the Needham High School, which is located at 609 Webster Street in Needham. **NSTAR Gas has agreed to provide gas service to the above-mentioned project. The project has been estimated at no charge to the customer.**

NSTAR Gas does have an adequate supply of natural gas available to serve your projected gas requirements of 21,600 CFH. NSTAR Gas can supply your gas requirements with a new 4-inch intermediate-pressure service. If these loads change please contact NSTAR Gas with the revised loads and the project will be re-estimated with the new load requirements. If elevated pressure is required, the Massachusetts Gas Code requires an elevated pressure application to be completed and approved by the local gas utility prior to installation of equipment. All intermediate pressure services must be located outside of the building due to NSTAR Gas Standards.

Based on an engineering estimate by NSTAR, a system improvement will be required to accept the requested load at 609 Webster Street, Needham. This system improvement is as follows:

- Install approximately 3,000 feet of new 8-inch intermediate-pressure gas main on Central Avenue, to replace the existing 4-inch intermediate-pressure main, beginning at Great Plain Ave and ending at Bess Road.
- Install a new 480 foot 4-inch intermediate-pressure service on Webster Street from the main to the building.

The new natural gas requirements cannot be accepted until both the system improvement and the new service are completed.

The gas application included in this letter must be signed on both sides by the owner of the property and returned to NSTAR Gas before any work can be started.

This offer and commitment is good until the end of the current construction season (December 31) or unless specifically revoked by NSTAR Gas. At the start of a new construction season the package will be reviewed at current construction costs and base gas rates.

There is the potential for NSTAR Gas to offer financial incentives to eligible commercial /industrial customers who incorporate pre-qualified "new technologies" within their facility. The program pays a percentage of the incremental cost for high efficiency equipment or one year's energy savings up to a pre-determined customer cap. Each project is looked at on a "case-by-case" basis to determine the incentive awarded with the potential maximum amount awarded for each job to be no more than $20,000.

The customer will need to supply NSTAR Gas with the following:

- Customer name, address, and NSTAR Gas account number
- Three (3) installation quotes
- Engineering analysis detailing annual energy savings resulting from the installation
- Specification sheet on the proposed equipment

NSTAR ELECTRIC GAS
157 Cordaville Road Southborough, Massachusetts 01772

The "New Technologies" measures include:

- Desiccant Dehumidification
- Condensing Boilers/Furnace
- Direct Contact Water Heaters
- Combustion Controls, and
- Other qualifying measures

NSTAR Gas is not responsible for restorations of lawns and driveways. Loam and seed will not be provided. NSTAR Gas will place temporary patch on the hard top that is disturbed on private property.

If you have any additional questions concerning this matter, please feel free to contact me. I may be reached at (781) 441-8750.

Sincerely,

Scott Johnson
Account Executive

C: James Ziobro-Griffith & Vary, Inc

Job Location	STREET NO. 609 Webster Street		Flr./Apt.		CITY Needham 02494			ACCT.#	
Billing Info	NAME Needham High School				PHONE 781-453-8040		TYPE OF BUSINESS		SIC#
ADDRESS	(If Different)				City		Comm.	Ind.	Mun. Yes
Credit Info	Approved	Deposit	Rate 6037	Heat Yes	Firm Yes	Interruptible	Corp	Part	Prop
Set	Turn On	Read In	Meter	CHG	New Service Yes	Fit Req'd Yes	Date Wanted 9/7/2005	Meter Loc OS4	CIC Order by:
Existing Load	Equipment							Existing MTR Size	
New Load	Equipment	**4 boilers@4474 each-2 water heaters@700 each-kitchen@1,000 2 water heaters@400 each-science rooms@440**						E.A.R $	
Future Load CFH			Diversity:		(Equipment)	**21,600 CFH**	Total	**CFH 21,600**	
Service Size			Service Req'd Yes		Street Pressure **IP**		Pressure Required **8"**		Customer Line Size
Meter Needed:	Size		Installation:		Fit	By		Date	
Regs Needed:	Size		Installation:		Meter	By		Date	

Additional Information:

Attention John Jackson
Please set fit for new meter according to Mike Forrest's specs

Memo

Internal Meter

Company Rep Scott Johnson Date 8/2/2005

Appendix B

Supplemental Information on Water Contamination, Treatment & Process

Frank I. ROUNDS COMPANY

65 York Avenue
Randolph, MA 02368
Tel: 781-963-6440
Fax: 781-963-2067

Shekar & Associates, Inc.
775 Pleasant Street, Unit 14
East Weymouth, MA 02189
Needham High School **February 20, 2017**

This letter is in response to the investigation into the water treatment and system operation of the condensing boilers and hot water system as well as the air cooled chilled water systems at the Needham High School in Needham Massachusetts.

The initial visual inspection of both the boiler water and chilled water systems produced samples that showed signs of degraded glycol and a slight bacteria smell. After flushing the sample site it was determined that the samples were also full of dirt, mud and iron.

My concern with the samples of the water is with all of these conditions. The degraded glycol will breakdown to become a source of food for normally occurring bacteria or reducing the system pH causing an attack on the system metals (Copper and iron). The dirt in the system typically acts as an abrasive eroding the system at its weakest points or restrictions; elbows, valves, threaded joints, pumps and pump seals. All of these conditions individually can wreak havoc in any water system and together will cause failures.

Moving forward I am recommending a full cleaning of both systems. Below I have outlined the procedure for the cleanings that we would conduct in conjunction with on-site staff. I will also recommend the replacement of the chemical feeders with filter feeders (See attached cut sheet). These filter feeders with the filters (Ranging from 50 down to 1 micron in size) will aid in the continued removal of dirt, mud and debris after the cleaning and flushing have been finished. After review of the system parameters I see the need for glycol in the chilled water system but not in the hot water system. The chilled water system exits the building requiring freeze protection whereas the hot water system does not exit the building. In this case the chilled water system should have and I am recommending a glycol make-up tank and system (see cut sheet) so that the chilled water system is made up with the correct percentage glycol and not water. This will eliminate the concern of the system glycol being diluted and eventually becoming a concern. I am also recommending the addition of system inhibitors (Molybdate and Nitrite) to help control the pH and protect the metals in the system.

Attached are Technical Notes from Chemtex giving more in-depth descriptions of my concerns with the system water conditions.

Please don't hesitate to contact me if you have any questions.

Thank you,

Frank I. ROUNDS COMPANY

65 York Avenue
Randolph, MA 02368
Tel: 781-963-6440
Fax: 781-963-2067

Shekar & Associates, Inc.
775 Pleasant Street, Unit 14
East Weymouth, MA 02189
Needham High School **February 20, 2017**

We are pleased to offer you pricing on the following equipment and services for the treatment of your water systems:

SERVICE

Frank I. Rounds Company will provide chemical treatment and service for the systems listed in this contract. As part of the agreement, Frank I. Rounds Company will provide the following:

Even though your system is not a new system we treat the cleaning of this system in the same way.

Clean-out Procedure for New or Fouled Piping Systems

The internal surfaces of a newly installed piping may be contaminated with oil, grease or other protective coatings used in the manufacturing process. Such coatings must be removed since they reduce the heat transfer rate and could result in the rupture from overheating. The primary objective of pre-cleaning a boiler is to remove these impurities.

We recommend that the following procedure be performed on each new or fouled piping systems put into service and on existing boilers each time tubes are replaced.

NOTE: Before beginning the clean-out procedure, the system must be flushed of existing chemicals and glycol.

PROCEDURE:

1. Clear the pipe by removing any physical debris.
2. Inspect all internal waterside surfaces, including tubes, and remove any debris. It may be necessary to use a high pressure hose to flush out any inaccessible areas.
3. Replace the regular gauge with a temporary gauge glass that can be discarded after the cleaning.
4. Attach an overflow pipe to one of the top of any boiler openings and route it to a safe point of discharge. A relief or safety valve tapping may be used.

5. Remove all water relief valves and steam safety valves in order to avoid contamination. Refer to the manual when reinstalling these valves after cleaning.
6. Fill the piping with clean water until the system is completely flushed.
7. Add the recommended amount of NeutrapHigh Plus for the system size. Add the chemical as you are adding water but never before adding the water.
8. Continue to fill the system to increase the pressure to system maximum minus ten psi (X – 10).
9. Turn on the circulating pumps to circulate the cleaning chemicals through the system for a period of not less than 24 hours and no more than 72 hours.
10. Throughout the entire process, each blow-down point or valve should be blown at least once every two hours. Blow the surface and/or the continuous blow-down points first, followed by the other blow-down points lower on the boiler. After each blow-down cycle, the water level should be brought back to full. After each blow-down cycle, the Total Alkalinity of the cleaning solution should be checked. If the level drops below 2500 ppm, additional NeutrapHigh Plus should be added to the system.
11. After the clean-out is completed then the flush out is started to remove the cleaning solution.
12. Drain the system using caution to insure that the water is discharged safely and in accordance with local, state and federal guidelines.
13. Open the make-up valve and the drain valve to maintain system volume and flush the system so that you don't drain the system completely. Test the system to get the conductivity to the same as the make-up water.
14. If the system requires glycol, add the prescribed percentage of glycol to the system at this time.
15. Add the recommended amount of Loop Guard 261-05 to maintain 1000 – 1500 ppm of Nitrite in the system for the best protection.

Caution: THE CHEMICALS USED IN THIS PROCEDURE ARE CORROSIVE TO EYES AND SKIN. ALWAYS REFER TO THE MATERIAL SAFETY DATA SHEET TO INSURE THAT THE PROPER SAFETY EQUIPMENT AND PRECAUTIONS ARE PRESENT.

Guarantee:

Frank I. Rounds Company guarantees that, following a post "Clean-Out" **visual** inspection of the equipment being treated, if the heat exchanger surfaces are not free of deposits the Frank I. Rounds Company will remove deposits at no additional cost to the owner.

Boiler Treatment:

NeutrapHigh Plus -05 –This is a concentrated Alkaline – Polymer – Surfactant product that is designed to be used to clean out new piping systems or to neutralize residual acid in older systems that have become fouled

Loop Guard 261-05 – This is a concentrated product that is a buffered solution of Sodium Nitrite designed for use in chilled or hot closed recirculating systems. This

product contains nitrite for protection for the mild steel, azole for protection of the yellow metals (bronze and copper) phosphate and an iron control polymer. This product is compatible with glycol.

Total: $3,425.00 per system
($6,850.00)
(Price includes the performance of the above "Clean-Out" procedure and Quarterly system checks for 1 year)

Chemical Equipment:

1 – Glycol Feed Station (G-50-1-A) – This system comes with a 50-gallon tank and a bronze rotary primary pump. Hand-Off-On indicator switch for the pump motor. Pump "on" and "low level" indicator lights included.
$4,925.15 each, plus any shipping and taxes.
Installation estimated at 8 hours with 2 service technicians at $135.00/hour ($2,160.00)
Installation Materials: $750.00 (Estimated)
Fire watch (If needed) is the responsibility of the School.

2 – Chemical Filter Feeders (FTF-5DB)
$739.25 each, plus any shipping and taxes.
($1,478.50)
Installation estimated at 4 hours with 2 service technicians at $135.00/hour ($1,080.00)
Installation Materials: $250.00 (Estimated)
Fire watch (If needed) is the responsibility of the School.

10 – 20 micron Filter Bags
$21.45 each, plus shipping and taxes.
($214.50)

10 – 5 micron Filter Bags
$21.45 each, plus shipping and taxes.
($214.50)

10 – 1 micron Filter Bags
$27.75 each, plus shipping and taxes.
($277.50)

If you have any questions please feel free to contact me.

Please check out our newly updated website www.frankirounds.com

John Burris

John Burris
Water Treatment Manager
FRANK I. ROUNDS COMPANY
65 York Ave
Randolph, MA 02368-0746
Office: (781) 963-6440

Fax: (781) 963-2067
Cell: (781) 706-3728
Email: JohnB@frounds.com
www.frankirounds.com

Safety Data Sheet

NEUTRApHIGH PLUS

1 – PRODUCT IDENTIFICATION

PRODUCT NAME: .....NEUTRApHIGH PLUS

MANUFACTURER'S NAME: .....International Chemtex Corporation
MANUFACTURER'S ADDRESS: .....8287 214th Street West, Lakeville, MN 55044
MANUFACTURER'S PHONE:.....952-469-4965
EMERGENCY PHONE NUMBER: .....(800) 424-9300 CHEMTREC

PRODUCT USE: .....This product is designed for use in industrial, commercial or institutional water treatment systems. This product is not for use in potable water systems.

2 – HAZARDS IDENTIFICATION

SIGNAL WORD: DANGER

POTENTIAL HEALTH EFFECTS:

H315 H320: Causes skin and eye irritation
H302: Harmful if swallowed
H335: May cause respiratory irritation

H318: Causes serious eye damage

PRECAUTIONARY STATEMENTS:
P280: Wear protective gloves/protective clothing/eye protection/face protection.
P264: Wash thoroughly after handling.
P402+404: Store in a dry place. Store in a closed container.
P403+404: Store in a well ventilated place. Keep cool.
P321: Specific treatment (see First Aid Measures on Safety Data Sheet).

3 – COMPOSITION / INFORMATION ON INGREDIENTS

HAZARDOUS INGREDIENT	PERCENT	CAS NUMBER
Sodium Hydroxide	10-20	1310-73-2

4 – FIRST-AID MEASURES

EYES: ..... Flush eyes with abundant water for 15 minutes. Consult a physician.

SKIN (DERMAL): ..... Promptly remove contaminated clothes. Wash skin with soap and water. If irritation persists, consult a physician.

SWALLOWING (INGESTION): ..... If ingested, give water. DO NOT induce vomiting. Call a physician.

BREATHING (INHALATION): ..... In case of discomfort by vapors or dusts, move to a ventilated area. Call a physician.

5 – FIRE-FIGHTING MEASURES

EXTINGUISHING MEDIA: ..... Water Spray, Foam, Dry Chemical or CO2

HAZARDOUS DECOMPOSITION PRODUCTS: ..... None known

SPECIAL FIREFIGHTING PROCEDURES: ..... None

UNUSUAL FIRE AND EXPLOSION DATA: ..... Adding water may generate heat.

6 – ACCIDENTAL RELEASE MEASURES

LEAK AND SPILL PROCEDURES: ..... Use specified protective equipment. Contain and absorb with inert material. Sweep up spill and reclaim or place in a covered waste disposal container. Wash area with water.

WASTE DISPOSAL: ..... Dispose of contaminated product via an approved chemical waste disposal firm and in accordance with all federal, state and local regulations.

7 – HANDLING and STORAGE

HANDLING PROCEDURES AND EQUIPMENT: ..... Handle an open container with care. See section 8 for personal protection equipment. Avoid all skin contact and wash thoroughly after handling.

STORAGE REQUIREMENTS: ..... Store in a tightly sealed container in a cool, dry and well-ventilated area.

SPECIAL CONSIDERATIONS: ..... None

8 – EXPOSURE CONTROLS / PERSONAL PROTECTION

ENGINEERING CONTROLS: ..... Local exhaust

RESPIRATORY PROTECTION: ..... Not required for normal use.

PROTECTIVE GLOVES: ..... Chemical resistant gloves (neoprene, nitrile, PVC, natural rubber).

EYE PROTECTION: ..... Face shield with chemical splash goggles.

ADDITIONAL MEASURES: ..... Wear suitable chemical resistant protective clothing

9 – PHYSICAL / CHEMICAL PROPERTIES

PHYSICAL STATE:.....Liquid
BOILING POINT: .....NE
FLASHPOINT: .....NE
AUTOIGNITION TEMP: .....NA
UPPER EXPLOSION LIMIT (% BY VOL): .....NA
LOWER EXPLOSION LIMIT (% BY VOL): .....NA
VAPOR PRESSURE: .....NE
VAPOR DENSITY (air=1): .....NE
EVAPORATION RATE: .....NE
SOLUBILITY IN WATER: .....Complete
VOLATILITY INCLUDING WATER: .....NE
pH:.....12-14
SPECIFIC GRAVITY:.....1.155-1.205
ODOR:.....No appreciable odor
APPEARANCE:.....Light Tan

10 – STABILITY and REACTIVITY

CHEMICAL STABILITY:.....Stable
HAZARDOUS POLYMERIZATION: .....Will not occur
INCOMPATIBLE MATERIALS: .....Avoid strong acids
HAZARDOUS DECOMPOSITION PRODUCTS:.....None known

11 – TOXICOLOGICAL INFORMATION

ROUTES OF ENTRY:
- **BY EYE CONTACT:**.....Possible
- **BY SKIN CONTACT:** .....Possible
- **BY SKIN ABSORPTION:**.....NA
- **BY INHALATION:** .....NA
- **BY INGESTION:**.....Possible

THRESHOLD LIMIT VALUE (UNITS): .....NE
ACUTE OVER EXPOSURE EFFECTS: .....Eye irritant. Risk of serious damage to eyes. Skin irritant.
CHRONIC OVER EXPOSURE EFFECTS: .....NE

CARCINOGENIC ACCORDING TO THE FOLLOWING:
- **NTP?** .....No
- **IARC MONOGRAPHS?** .....No
- **OSHA REGULATED**.....No

12 – ECOLOGICAL INFORMATION

None available

13 –DISPOSAL CONSIDERATIONS

Any disposal practice must be in compliance with local, state and federal laws and regulations (contact local or state environmental agency for specific rules).

14 – TRANSPORTATION INFORMATION

DOT (Department of Transportation)
UN NUMBER: UN1824
DOT SHIPPING NAME: .....Sodium Hydroxide Solution
HAZARD CLASS: 8
PACKAGING GROUP: II
LABEL REQUIRED:.....Corrosive

15 – REGULATORY INFORMATION

TSCA STATUS: .....ALL COMPONENTS OF THIS PRODUCT ARE LISTED IN THE TSCA INVENTORY OR EXEMPT.

SUPERFUND AMMENDMENTS AND REAUTHORIZATION ACT OF 1986 (SARA) TITLE III

Ingredients covered under the following sections:

CERCLA HAZARDOUS SUBSTANCE: .....Sodium Hydroxide, RQ = 1000 lbs.

SARA Toxic Chemical – SECTION 313 :.....None

16 – OTHER INFORMATION

HMIS Rating Scale:
0=Minimal
1=Slight
2=Moderate
3=Serious
4=Severe

PREPARED BY.....MR
DATE OF PREPERATION 4/29/15
DATE OF LAST REVISION.....8/24/10
PHONE NUMBER OF PREPARER.....952-469-4965

DISCLAIMER:
The above information and recommendations are accurate to the best of our knowledge. However, the company assumes no liability for the accuracy or completeness of the information contained herein and disclaims all liability for the reliance thereon. All chemicals present unknown health hazards and should be used with caution. The user should satisfy himself by independent investigation that he has all current data relevant to his particular use.

UN – Unavailable NA – Not Applicable NE – Not Established

Safety Data Sheet

LoopGuard 261

1 – PRODUCT IDENTIFICATION

PRODUCT NAME: .....LoopGuard 261

MANUFACTURER'S NAME: .....International Chemtex Corporation
MANUFACTURER'S ADDRESS: .....8287 214th Street West, Lakeville, MN 55044
MANUFACTURER'S PHONE:.....952-469-4965
EMERGENCY PHONE NUMBER: .....(800) 424-9300 CHEMTREC

PRODUCT USE: .....This product is designed for use in industrial, commercial or institutional water treatment systems. This product is not for use in potable water systems.

2 – HAZARDS IDENTIFICATION

SIGNAL WORD: DANGER

POTENTIAL HEALTH EFFECTS:

H315: Causes skin irritation
H335: May cause respiratory irritation
H303: May be harmful if swallowed

.....

H318: Causes serious eye damage

PRECAUTIONARY STATEMENTS:
P280: Wear protective gloves/protective clothing/eye protection/face protection.
P264: Wash thoroughly after handling.
P402+404: Store in a dry place. Store in a closed container.
P403+404: Store in a well ventilated place. Keep cool.
P321: Specific treatment (see First Aid Measures on Safety Data Sheet).
P285: In case of inadequate ventilation wear respiratory protection

3 – COMPOSITION / INFORMATION ON INGREDIENTS

HAZARDOUS INGREDIENT	PERCENT	CAS NUMBER
Sodium Hydroxide	>1	1310-73-2
Sodium Nitrite	20-40	7632-00-0

4 – FIRST-AID MEASURES

EYES: Flush eyes with abundant water for 15 minutes. Consult a physician.

SKIN (DERMAL): Promptly remove contaminated clothes. Wash skin with soap and water. If irritation persists, consult a physician.

SWALLOWING (INGESTION): If ingested give plenty of water, induce vomiting if possible. Call a physician.

BREATHING (INHALATION): In case of discomfort from dusts or vapors, move to a well ventilated area. Get immediate medical attention if signs of suffocation, irritation or other symptoms develop.

5 – FIRE-FIGHTING MEASURES

EXTINGUISHING MEDIA: Water Spray, Foam, Dry Chemical or CO_2

HAZARDOUS DECOMPOSITION PRODUCTS: Gaseous nitrogen oxides

SPECIAL FIREFIGHTING PROCEDURES: Wear full protective suit with self contained breathing apparatus.

UNUSUAL FIRE AND EXPLOSION DATA: Material is an oxidizing agent when dried

6 – ACCIDENTAL RELEASE MEASURES

LEAK AND SPILL PROCEDURES: Use specified protective equipment (see section8). Contain and absorb with inert material. Sweep up spill and reclaim or place in a covered waste disposal container. Wash area with water.

WASTE DISPOSAL: Dispose of contaminated product via an approved chemical waste disposal firm and in accordance with all federal, state and local regulations.

7 – HANDLING and STORAGE

HANDLING PROCEDURES AND EQUIPMENT: Handle an open container with care. See section 8 for personal protection equipment. Avoid all skin contact and wash thoroughly after handling.

STORAGE REQUIREMENTS: Store in a tightly sealed container in a cool, dry and well-ventilated area. Keep from freezing if at all possible.

SPECIAL CONSIDERATIONS: In the event product is to freeze, thaw at room temperature then agitate prior to use.

8 – EXPOSURE CONTROLS / PERSONAL PROTECTION

ENGINEERING CONTROLS: .....Local exhaust
RESPIRATORY PROTECTION: .....Ventilate adequately, otherwise wear an appropriate breathing apparatus.
PROTECTIVE GLOVES: .....Chemical gloves (neoprene, nitrile, PVC, natural rubber).
EYE PROTECTION: .....Face shield with chemical splash goggles.
ADDITIONAL MEASURES: .....Wear suitable chemical resistant protective clothing.

9 – PHYSICAL / CHEMICAL PROPERTIES

PHYSICAL STATE: .....Liquid
BOILING POINT: .....212°F
FLASHPOINT: .....None
AUTOIGNITION TEMP: .....NA
UPPER EXPLOSION LIMIT (% BY VOL): .....NA
LOWER EXPLOSION LIMIT (% BY VOL): .....NA
VAPOR PRESSURE: .....NE
VAPOR DENSITY (air=1): .....NE
EVAPORATION RATE: .....NE
SOLUBILITY IN WATER: .....Complete
VOLATILITY INCLUDING WATER: .....NE
pH: 6.5-9.5
SPECIFIC GRAVITY: 1.18-1.21
ODOR: .....Slight odor
APPEARANCE: .....Light Yellow - Yellow

10 – STABILITY and REACTIVITY

CHEMICAL STABILITY: .....Stable
HAZARDOUS POLYMERIZATION: .....Will not occur
INCOMPATIBLE MATERIALS: .....Avoid strong acids and ammonium compounds
HAZARDOUS DECOMPOSITION PRODUCTS: .....None known

11 – TOXICOLOGICAL INFORMATION

ROUTES OF ENTRY:

- **BY EYE CONTACT:** .....Possible
- **BY SKIN CONTACT:** .....Possible
- **BY SKIN ABSORPTION:** .....NA
- **BY INHALATION:** .....NA
- **BY INGESTION:** .....Possible

THRESHOLD LIMIT VALUE (UNITS): .....NE
ACUTE OVER EXPOSURE EFFECTS: .....Eye irritant. Risk of serious damage to eyes. Skin irritant.
CHRONIC OVER EXPOSURE EFFECTS: .....Long term skin or eye contact may result in dermatitis or eye irritation (redness or swelling).

CARCINOGENIC ACCORDING TO THE FOLLOWING:

NTP? ..... No
IARC MONOGRAPHS? ..... No
OSHA REGULATED ..... No

12 – ECOLOGICAL INFORMATION

None available

13 –DISPOSAL CONSIDERATIONS

Any disposal practice must be in compliance with local, state and federal laws and regulations (contact local or state environmental agency for specific rules).

14 – TRANSPORTATION INFORMATION

DOT (Department of Transportation)
UN NUMBER: .....NA
DOT SHIPPING NAME: ..... Non-hazardous
HAZARD CLASS: .....NA
PACKAGING GROUP: .....NA
LABEL REQUIRED:..... Non-Corrosive

15 – REGULATORY INFORMATION

TSCA STATUS: .....ALL COMPONENTS OF THIS PRODUCT ARE LISTED IN THE TSCA INVENTORY OR EXEMPT.

SUPERFUND AMMENDMENTS AND REAUTHORIZATION ACT OF 1986 (SARA) TITLE III

Ingredients covered under the following sections:

CERCLA HAZARDOUS SUBSTANCE: ..... Sodium Hydroxide, RQ = 1000 lbs
Sodium Nitrite, RQ=100 lbs

SARA Toxic Chemical – SECTION 313 : ..... None

16 – OTHER INFORMATION

HMIS Rating Scale:
0=Minimal
1=Slight
2=Moderate
3=Serious
4=Severe

Safety Data Sheet

LoopGuard 261

PREPARED BY.....MR
DATE OF PREPERATION 5/26/15
DATE OF LAST REVISION.....8/5/14
PHONE NUMBER OF PREPARER.....952-469-4965

DISCLAIMER:
The above information and recommendations are accurate to the best of our knowledge. However, the company assumes no liability for the accuracy or completeness of the information contained herein and disclaims all liability for the reliance thereon. All chemicals present unknown health hazards and should be used with caution. The user should satisfy himself by independent investigation that he has all current data relevant to his particular use.

UN – Unavailable NA – Not Applicable NE – Not Established

Closed Loop Water Systems

TT-017-0414

A closed recirculating system is one in which the water is recirculated in a closed loop without evaporation or exposure to the atmosphere. The only make-up normally required is that needed to replace small water losses from leakage at pump packings (seals), expansion tank overflows, or surface evaporation from system vents.

These types of systems, though easy to treat, can cause serious problems if neglected. The most common problems are excess electrical costs as a result of lost heat transfer, and major downtime due to piping and heat exchanger leaks. A Midwest firm recently experienced a failure in a 2" pipe. The water that leaked from that failure destroyed a $3 million dollar mainframe computer!

Many times these systems are neglected since leaks take time to develop, heat transfer efficiency isn't always easy to monitor and the internal system itself is not visible. With a little effort, proper pre-cleaning and initial treatment, a new system can continue to give good service decades after it is installed. An existing system, dirty due to negligence, can often be restored to an acceptable working condition that is relatively problem free with minimal effort and expense.

New Systems

A preoperational cleaning of closed systems is recommended to remove contaminants before start up. With all areas open to flow, an alkaline cleaner should circulate for 24-48 hours to remove cutting oils and greases. The system should then be flushed (Federal, State and Local guidelines should be observed during the flushing or draining of any chemical(s) from a system). An appropriate chemical inhibitor, such as nitrite, molybdate or a combination of the two, should be added to sufficient levels to maintain corrosion protection.

If the new system contains excessive amounts of mill scale, an acid based cleaner would follow the alkaline cleaning.

Existing Systems

A water analysis should be performed to identify existing or future problems within the system. This analysis should include pH, conductivity, alkalinity, hardness, iron (and any metals specific to the system), sulfate, nitrate and ammonia. The specific corrosion inhibitor used should also be identified. If a freeze protection solution such as glycol is incorporated, a baseline analysis to include reserve alkalinity, freeze protection point and percentage glycol should be performed. With this information, a sound recommendation can be made as to the best course of action to prevent future problems or correct existing problems before they reach the point of failure.

If the analysis indicates past corrosion has occurred and is still on-going, it will be necessary to chemically arrest the problem and clean-up existing deposition and byproducts. A mild acid specifically designed for this application should be introduced to the system to slowly remove and clean the corrosion by-products. After the chemical cleaning is complete, the solution should be flushed from the system (Federal, State and Local guidelines should be observed during flushing or draining of any chemical(s) from a system). When the entire residual chemical has been flushed from the system, an appropriate chemical inhibitor, such as nitrite, molybdate or a combination of the two, should be added to sufficient levels to maintain corrosion protection.

After chemical treatment is added to a system, a baseline water analysis should be performed. This analysis should include pH, conductivity, alkalinity, hardness, iron (and any metals specific to the system), sulfate, nitrate and ammonia, along with the specific corrosion inhibitor used. From then on, routine tests should include, at a minimum, pH, iron levels and chemical residuals. Many problems will manifest itself through one of these tests; then a more in depth analysis can be performed to help identify the source of the problem. By performing tests on a routine basis, many problems can be identified long before they progress to the point of failure.

It is also recommended that corrosion monitoring with the use of corrosion coupons be performed on a routine basis. This inexpensive method of corrosion monitoring can provide valuable insight as to system integrity. Side-stream filtration is often employed to maintain system cleanliness, especially with previously fouled systems. The unit should be sized to filter the entire volume of the system 5-10 times per day. The filter media should be appropriately sized to match the foulant. If the filter media is sized too small in the beginning, filters will plug often, causing not only a maintenance problem, but increased costs due to filter replacement.

Any closed system has the potential to become contaminated with microbes. These microbes can be introduced to the system in many ways. Whatever the cause, microbiological corrosion in a closed system can become a serious problem in a very short time and should be addressed immediately.

Various microbes will produce acidic by-products that will suppress pH and increase corrosion. Others can produce ammonia that will increase pH and cause corrosion. By establishing baseline data as previously mentioned, a determination can be made with good assurance as to the exact process taking place; thereby allowing proper adjustments in the treatment of the system to be made.

If a closed system becomes contaminated with microbes, the system should be sanitized with a biocide. Isothiazalone and glutaraldehyde biocides have been shown to control most types of microorganisms found in closed systems. Chlorine dioxide is also highly effective in sanitizing closed systems, including critical applications. Filtration is also recommended in order to remove to the dead microbes which eliminates a source of nutrients in the system.

Sometimes it might be necessary to change treatment programs to help reduce microbial problems, i.e. replacing nitrite with molybdate to alleviate nitrifying bacteria problems.

This paper does not cover the subject of water treatment for closed systems in its entirety. It does contain some basic steps that will, under normal circumstances provide answers to most situations and allow for relatively trouble-free systems for years to come.

Glycol Treated Closed Loops

TT-016-0891

In recent years the industry has seen an increased use of glycol for freeze protection in many closed loop applications. Whether closed loop systems are completely filled with glycol and water or coils are just treated for protection; problems still occur in these systems.

Three types of glycols have been used for closed loops. The two major types now used are Ethylene and Propylene. Automotive anti-freeze has also been used but is not recommended for this type of application.

Ethylene glycols are used for most HVAC applications. These glycols are used because they offer the most efficient heat exchange media. In general a 20% ethylene glycol solution will result in a 6% loss of heat transfer where as a 40% glycol solution will result in a 14.5% loss of heat transfer. Ethylene glycol should not be used where it could contaminate potable water, food processing or other products meant for human consumption.

Propylene glycol was developed to replace ethylene glycol where possible contact with potable water and food could occur. Propylene glycol does not have the heat transfer efficiency that ethylene glycol has. It also takes slightly more propylene glycol to provide the same freeze protection as ethylene glycol.

It should be realized that all glycols oxidize when exposed to air and heat. When this occurs an organic acid is formed. If not properly inhibited, this fluid is very corrosive. Inhibitors are added to the glycol to act as buffers preventing low pH attack on system metals. Certain types of inhibitors also passivate the metal surfaces protecting them from corrosion. These inhibitors can be tested for activity level with a basic test called Reserve Alkalinity. This test checks the buffering capacity of the inhibitor. If complete breakdown has not occurred fresh inhibitor can be added to restore corrosion protection.

Glycol based automotive anti-freeze is different because it is inhibited with silicates. This type of inhibitor is excellent for protection of aluminum at high temperatures and where an agitated environment is present. In a HVAC system where circulation is low and copper and steel are present, it can gel causing loss of heat transfer and system plugging. It is designed to be changed every three to four years which cannot be done in most HVAC systems.

Besides inhibitor breakdown, biological fouling can also occur. Bacterial slime will grow by feeding on the organic carbohydrates of the glycol. Certain inhibitors also provide nutrients for bacterial growth. Once a bacterial slime starts system corrosion will increase.

In systems where a glycol solution is maintained on a continuous basis an extra corrosion inhibitor such as borate-nitrite and molybdate should still be added. This extra protection will help prevent corrosion if basic inhibitor breakdown occurs. This system should be monitored for freeze protection, reserve alkalinity, inhibitor level and biological contamination on a routine basis.

In systems where coils need to be drained and glycol flushed through to protect low areas against freezing, more serious problems tend to occur. In most cases the main loop becomes contaminated with glycol that has broken down when spring start-up occurs. Even if the glycol is properly inhibited at the start, exposure to air for 4 to 6 months will result in oxidation of the glycol. Not only will this glycol have broken down to form an organic acid but bacterial contamination is more likely. Before the spring start-up, each coil should be flushed with fresh water at least three times to remove as much of the residual glycol as possible.

If the system is started up and glycol contamination occurs resulting in a low pH excursion and biological contamination, the system should be drained and flushed if possible. If this is not possible because of the size or design of the system further steps need to be taken. A by-pass filter system should be installed to remove the corrosion by-products. Filters as low as one micron maybe required to remove contaminants.

An appropriate biocide such as isothiazalone should be slug fed to provide biological control. The system pH should be gradually brought up to at least 8.5 with the addition of an alkalinity builder. If the pH is brought up too quickly or too high the iron in solution may precipitate and cause system plugging. Your corrosion inhibitor should be brought up to maximum strength. Continued monitoring is required to make sure recontamination doesn't occur.

Closed loop systems cannot be neglected. It is just as important that they be maintained corrosion and foulant free as it is with open condenser systems.

Iron Reducing Bacteria

TT-011-0490

Iron bacteria is a group of microorganisms found in industrial waters, streams, lakes, wells and potable water supplies. Recently, these organisms have gained recognition in the industry due to their effect on process equipment and finished products.

Iron bacteria is considered to be capable of withdrawing iron present in waters and depositing it, in the form of hydrated ferric hydroxide on or in their mucilaginous secretions. These large secretions, commonly referred to as slime, will impart an unpleasant odor to drinking water. As these microorganisms increase in number, the water may become more turbid, and the color of the water will turn "brick-red" . Hence, the common reference of "red water".

In addition to discoloring the water, this group of microorganisms produces undesirable accumulations in pipes, nozzles, ponds, etc. These deposits will in time slough off and plug lines, foul pumps, valves and/or effect the quality of finished products. These bacteria oxidize ferrous ions to ferric, which is precipitated as ferric hydrate. Iron may be obtained from the pipe itself or from the water being carried. These bacteria may initiate pitting and tuberculation in iron pipes. They are partial to wells, or outfalls where water enters a stream. While these microorganisms are considered as aerobic, requiring oxygen to survive, they have been found to grow in waters with very low oxygen content.

The principal distinguishing characteristics between iron bacteria and other types of microorganisms is their ability to absorb and accumulate iron and/or manganese, when grown in environments which contain these elements. These organisms deposit iron and manganese salts around their cells which result in the characteristic reddish brown-black color. Iron bacteria are considered autotrophic (self-sufficient) organisms, oxidizing iron compounds as a source of energy. In general, the bacteria prefer lower temperatures but are known to grow at temperatures which range from 0-40°C, with an optimum temperature of 6-25°C. Their pH range for growth will vary from 5.5 to 8.2 with an optimum pH around 6.5. These organisms are not affected by light and have been found to grow in exposed areas, in shade as well as complete darkness.

Identification of iron bacteria is extremely difficult. While these organisms grow extremely well in recirculating water, laboratory attempts using usual cultural media methods have not been successful in the past. Therefore, it is not possible to evaluate the number of these organisms in water supplies with the usual bacteriological procedures. The satisfactory procedure for examining the population index of these organisms is direct microscopic analysis of the water after staining. This method also proves difficult due to difficulties in culturing large quantities for analysis.

Usually surrounded by a tubular "mucilaginous" sheath that hardens and becomes impregnated with ferric hydroxide, iron bacteria can be difficult to control. Chlorination has been used for control in bulk waters for many years; however, there are inherent drawbacks in the use of these products. High chlorine demand due to organic matter and iron levels has shifted the emphasis for control to the use of non-oxidizing biocides, such as quaternary ammonium compounds, as well as organo-sulfur compounds.

Appendix C

Water Treatment & Glycol Equipment Cuts
[Chemical Filter Feeder & Glycol Feed Station]

By-Pass & Filter Feeders

Neptune
A DOVER COMPANY

By-Pass Feeders

Neptune By-Pass Feeders are a convenient method of introducing treatment chemicals into closed circulating water systems.

Neptune By-Pass Feeders are ideal for treating hot and chilled water circulating loops used in heating and air conditioning systems, process heating and cooling or large engine water jackets.

Neptune offers two styles of By-Pass Feeders: A vertical style with dish bottom in and a vertical style with dish bottom out.

Filters are available for system cleanup and monitoring.

A high pressure cap rated to 300 psi is now standard. The first closure improvement in over two decades.

BY-PASS FEEDERS – VERTICAL STYLE

DISH BOTTOM IN
MODEL VTF-10HP

DISH BOTTOM OUT
MODEL DBF-5HP

NEW

FILTER FEEDER
MODEL FTF-5DB

Neptune's FIRST Filter Feeder with Full Bottom Drain and Anchor Bolt Holes

Filter Feeders

The Neptune Filter Feeder combines chemical addition and high capacity filtering in one piece of equipment. It is a convenient way to introduce solid or liquid chemicals into hot or cold water closed circulating systems.

- Eliminates need for separate By-Pass Feeder and filter.
- Filtration can be achieved at the same time as chemical addition.
- Extended neck with top inlet allows simple installation of filter bag and basket.
- Filter bags are available in 50, 20, 5 and 1 micron ratings. (Order separately.)
- Filter bags are quickly and easily replaced.

By-Pass Feeders

OLD STYLE CAPS
Three lug, ⅓ turn design rated to 200 psi.

NEPTUNE HIGH PRESSURE CAP
Coarse thread, 2½ turn design rated to 300 psi.

Caps

All Neptune By-Pass Feeders offer the new style, quick opening, high pressure closure.

These closures offer better sealing with less force and eliminate the need for tools. Design binds cap tightly when under pressure making it necessary to bleed pressure from tank before removing cap.

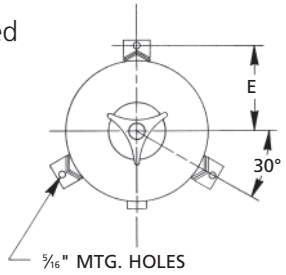
Underside of cap which contacts liquid is *epoxy-coated.*

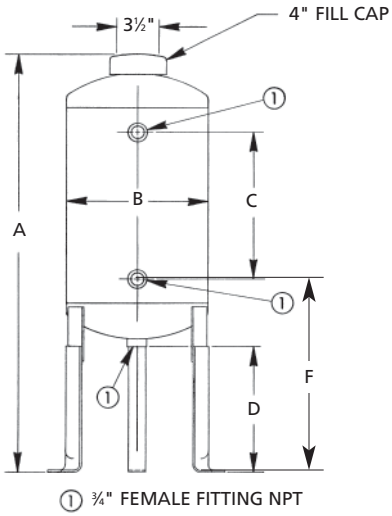
Vertical Style – Dish Bottom Out

The **"DBF"** series features wide-mouth caps manufactured by Neptune. These caps utilize a square section "O" ring seal and will ***close easily by hand.*** Advantages of this series are demountable leg extensions and a ***full bottom drain.*** Optional Filter Bag Kit may be added.

"DBFC" models include a built-in support and mounting for a cartridge filter (order cartridge separately).

See page 3 for filter specifications.





MODEL NUMBER	FILTER	APPROX. CAPACITY	MAX. PRESSURE*	A	B	C	D	E	F	SHIP WEIGHT
DBF-2HP	Optional†	2 Gallons	300 psi	31¼"	6"	12¾"	8⅝"	4⅛"	13¼"	23 lbs.
DBFC-2	Cartridge	2 Gallons	300 psi	31¼"	6"	12¾"	8⅝"	4⅛"	13¼"	23 lbs.
DBF-5HP	Optional†	5 Gallons	300 psi	29¾"	10"	10½"	8"	6⅛"	13"	38 lbs.
DBFC-5	Cartridge	5 Gallons	300 psi	29¾"	10"	10½"	8"	6⅛"	13"	38 lbs.
DBF-10HP	Optional†	10 Gallons	300 psi	45¾"	10"	26½"	8"	6⅛"	13"	61 lbs.

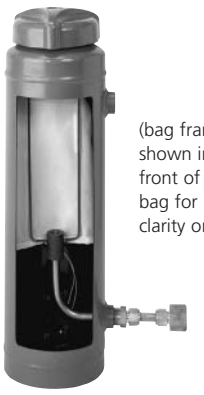
*At 200°F Max. †Filter support not included with base unit. Purchase optional filter bag kit.

Filter Bag Kits

Available for all **"VTF"** and **"DBF"** models up to 10 gallons. Kit includes bag, bag frame, tubing and connectors. The addition of a filter bag allows the By-Pass Feeder to function simultaneously as a side stream filter. (A clean bag is rated at approximately 30 microns.) Cannot be used with DBFC models.

VTF-2HP with filter bag kit installed

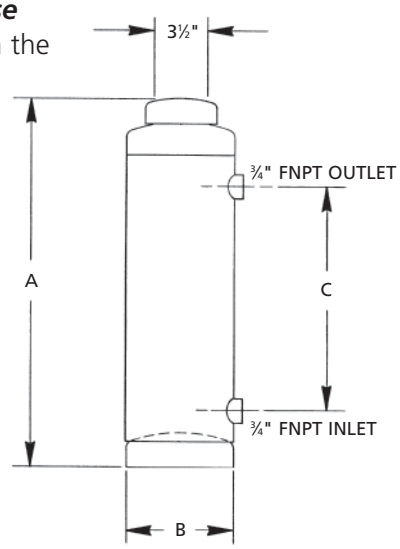
MODEL	FOR USE ON
FBK-2	VTF-2HP, DBF-2HP
FBK-5	VTF-5HP, DBF-5HP
FBK-10	VTF-10HP, DBF-10HP



(bag frame shown in front of bag for clarity only)

Vertical Style – Dish Bottom In

The **"VTF"** series is the most popular and economical of the by-pass feeders available from Neptune. The series uses the same wide mouth ***easy close*** caps described in the "Dish Bottom Out" style. Optional Filter Bag Kit may be added.



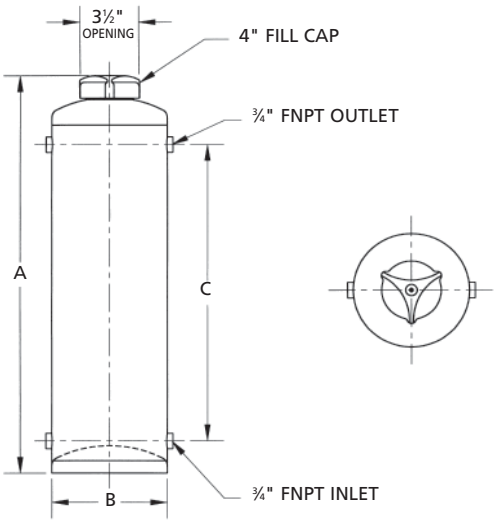
Specifications – All Models

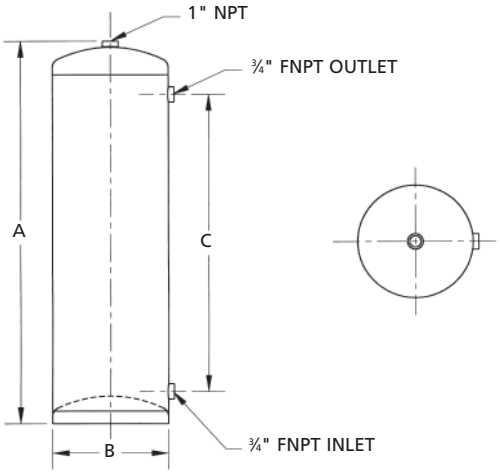
- Working pressure: to 300 PSI max. at 200°F
- Tank shell:
  2 gallon unit – 11 gauge steel 10 gallon unit – 10 gauge steel
  5 gallon unit – 10 gauge steel 12 gallon unit – 10 gauge steel
- Tank heads:
  2 gallon unit – 11 gauge steel 10 gallon unit – 9 gauge steel
  5 gallon unit – 9 gauge steel 12 gallon unit – 9 gauge steel
- Cap: cast iron with Buna N "□" ring.
  Wide mouth, easy open/easy close.

Standard Models

MODEL NUMBER	FILTER	APPROX. CAPACITY	MAX. PRESSURE*	A	B	C	SHIP WEIGHT
VTF-2HP	Optional†	2 Gallons	300 psi	21¼"	6"	12¾"	23 lbs.
VTF-5HP	Optional†	5 Gallons	300 psi	19¾"	10"	10½"	37 lbs.
VTF-10HP	Optional†	10 Gallons	300 psi	35¾"	10"	26½"	60 lbs.
VTF-12HP	N/A	12 Gallons	300 psi	42"	10"	32¾"	68 lbs.

*At 200°F Max. †Filter support not included with base unit. Purchase optional filter bag kit.





Four Fitting Models

MODEL NUMBER	APPROX. CAPACITY	MAX. PRESSURE*	A	B	C	SHIP WEIGHT
VTF-2X4HP†	2 Gallons	300 psi	21¼"	6"	12¾"	23 lbs.
VTF-5X4HP†	5 Gallons	300 psi	19¾"	10"	10½"	37 lbs.

*At 200°F Max. †No filter included with base unit. Purchase optional filter bag kit.

Feeder Bodies

MODEL NUMBER	APPROX. CAPACITY	MAX. PRESSURE*	A	B	C	SHIP WEIGHT
VTF-2-1	2 Gallons	300 psi	20"	6"	12¾"	23 lbs.
VTF-5-1	5 Gallons	300 psi	18"	10"	10½"	37 lbs.

*At 200°F Max.

Cartridge Filter Units

"DBFC" models include a built-in support and mounting for a cartridge filter. (Order cartridge separately.)

Cartridge filter modification cannot be installed in DBF models; model DBFC must be ordered for use with cartridge filter.

PART NO.	DESCRIPTION
107290	5 Micron Pleated Filter
107287	20 Micron Pleated Filter

DBFC-5 with cartridge filter installed

Filter Assembly

Filter Feeders

MODEL FTF-5HP

MODEL NUMBER	APPROX. CAPACITY	MAX. PRESSURE*	DIAM.	CONN. SIZE	DIMENSIONS A	B	C	D
FTF-2HP	2½ gals.	300 psi	6"	¾" FNPT	—	—	N/A	—
FTF-2DB	2 gals.	300 psi	6"	¾" FNPT	— N/A —		4¾"	8½"
FTF-2CL	2½ gals.	300 psi	6"	¾" FNPT	5¾"	7"	— N/A —	
FTF-5HP	7½ gals.	300 psi	10"	¾" FNPT	—	—	N/A	—
FTF-5DB	5 gals.	300 psi	10"	¾" FNPT	— N/A —		5¼"	12½"
FTF-5CL	7½ gals.	300 psi	10"	¾" FNPT	10¾"	12"	— N/A —	
FTF-5150HP	7½ gals.	300 psi	10"	1½" FNPT	—	—	N/A	—
FTF-5150CL	7½ gals.	300 psi	10"	1½" FNPT	10¾"	12"	— N/A —	

*At 200°F Max.

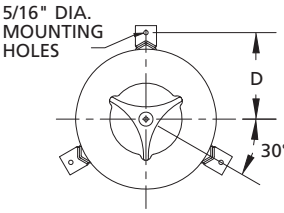
Features

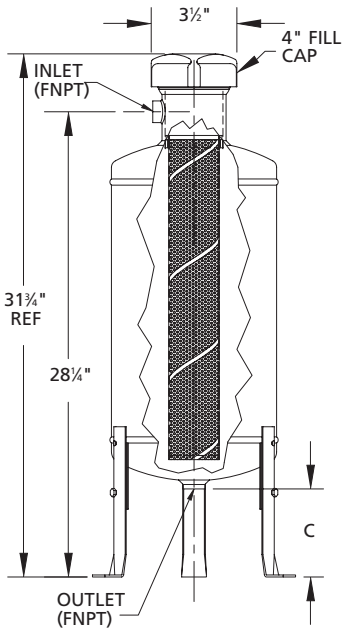
- Stainless steel dissolving basket holds and fully supports the filter bag inside (order bag separately).
- Ring-top bags feature handles for easy removal.
- "DB" type feeders have a full bottom drain and bolt on legs with anchor bolt holes.
- Model FTF-5150HP features oversize 1½" inlet and outlet connections. Can be used for system cleanup with high volume pumps where high flow rates are desired for fast clean-up or flush-out prior to start-up.
- "CL" Models feature a welded base to allow bolting to the floor or other mounting surface. Four holes for ⅜" bolts are provided on each Anchor Bolt Plate.

See page 3 for specifications.

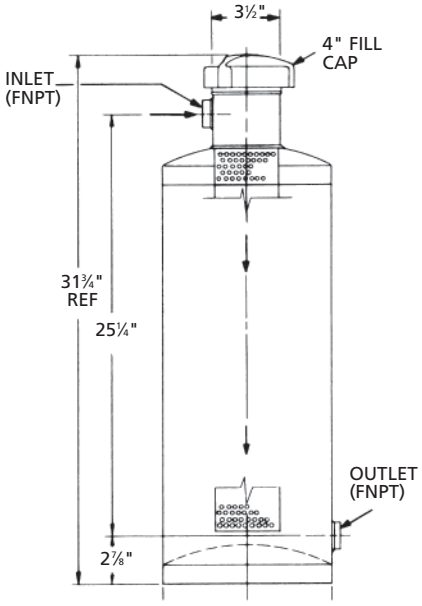
MODEL FTF-2CL

MODEL FTF-2DB

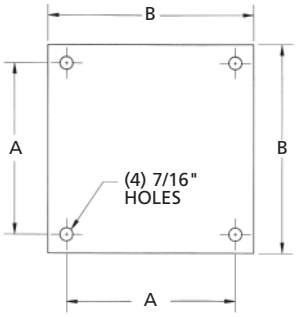




ALL "DB" MODELS



ALL MODELS (except "DB" type)



ANCHOR BOLT PLATE FOR "CL" MODELS

STAINLESS STEEL BASKET

FILTER BAG

Filter Bags

All bags fit any "FTF" model.

PART NO.	TYPE	QUANTITY	DESCRIPTION
107026	Ultra Fine	Pkg. of 1	1-micron ring-top bag
106453	Fine	Pkg. of 1	5-micron ring-top bag
107289	Medium	Pkg. of 1	20-micron ring-top bag
107231	Coarse	Pkg. of 1	50-micron ring-top bag

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E-mail: pump@neptune1.com

NEPTUNE MEMBER OF PSG™ PUMP SOLUTIONS GROUP A DOVER COMPANY

 Bulletin BF-08 P/N ZL105622 Printed in U.S.A.

Glycol Feed Systems

Purpose

Neptune Glycol Feeders are designed for the addition of glycol solution to closed loop chilled or hot water systems. The system automatically maintains pressure in the loop by adding glycol solution to make up for losses which occur due to leakage.

Glycol addition is controlled by a pressure switch with adjustable low and high set points.

Standard Pressure Switch:
Cut-In Range: 10-45 PSI Cut-Out Range: 20-60 PSI
Adjustable Differential: 10-30 PSI
Other pressure switches available.

When the pressure in the loop reaches the low set point, the pump begins to feed glycol into the system until the high pressure set point is achieved and stops the pump.

Features

- 50 gallon polyethylene tank mounted in a steel frame
- Bronze rotary gear pump (1.5 gpm @ 100 psi)
- Float switch for low level pump shutoff and alarm
- NEMA 4X control panel

Panel includes:

- Hand-off-auto selector switch for pump motor
- Pump "on" indicator light
- "Low" tank level indicator light
- Dry contact for remote low level indication
- Power cord with plug, 115V 60C

Optional audible alarm and push button silence available.
(Audible alarm is not watertight.)

Neptune
A DOVER COMPANY

MODEL
G-50-1

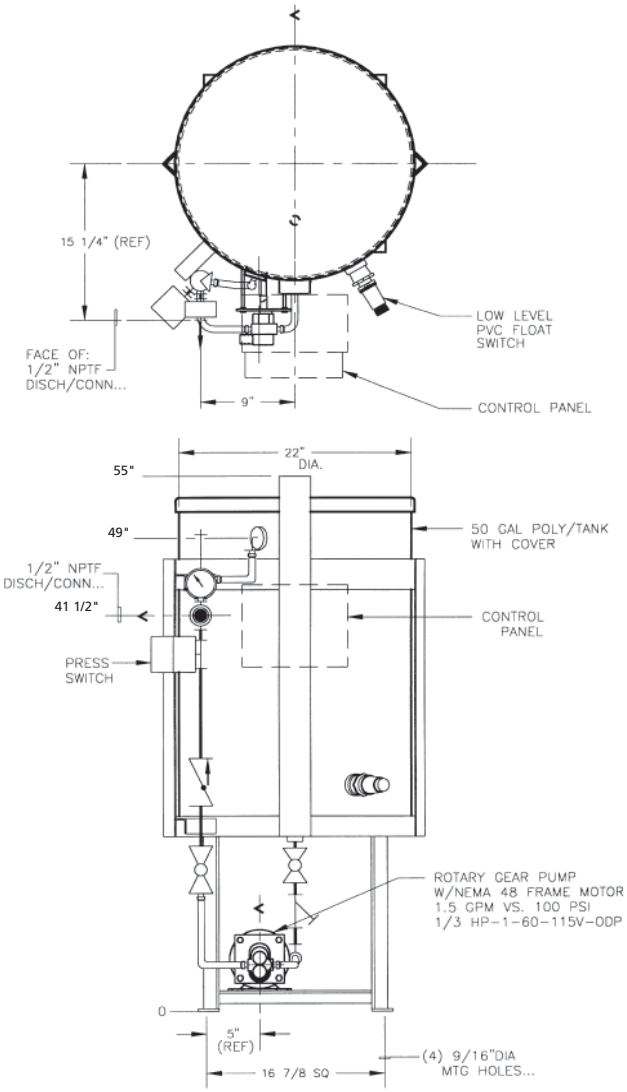
Each Neptune Glycol Feeder is fully piped and wired with the following components:

Suction assembly includes:

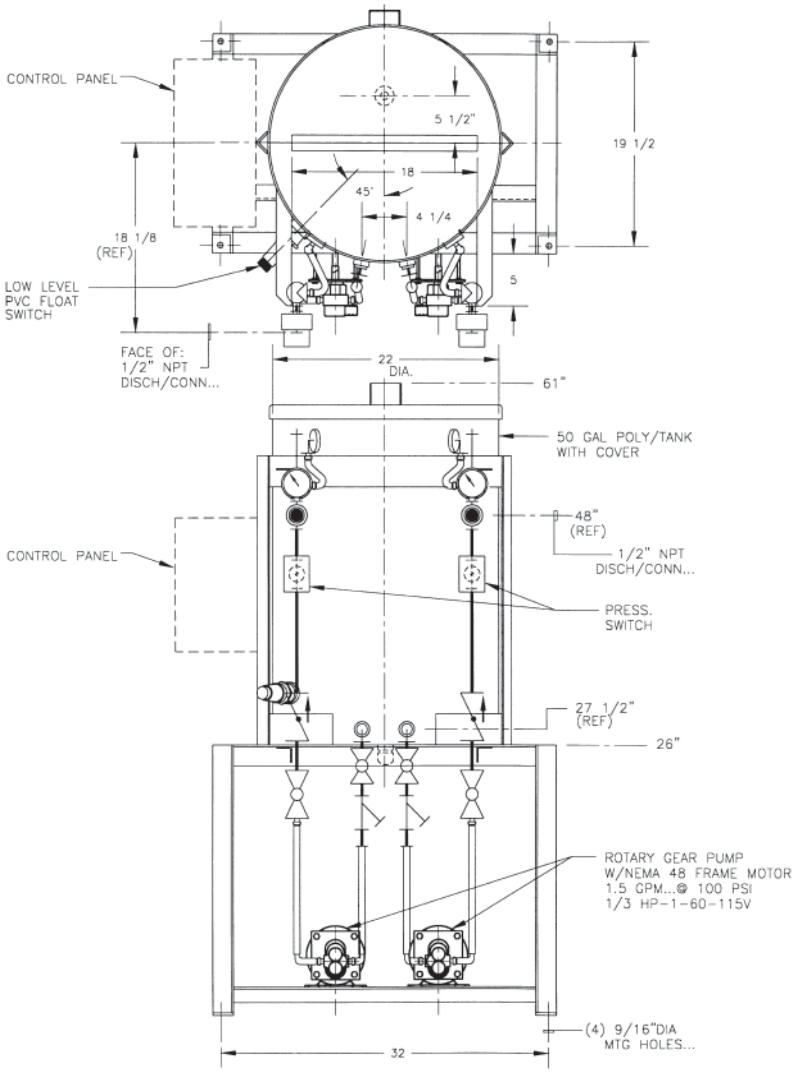
- PVC tubing and fittings
- PVC ball valve
- Cast iron "Y" strainer

Discharge assembly includes:

- Schedule 40 brass pipe and fittings
- PVC ball valve • Brass check valve • Pressure gauge
- Brass relief valve with return to tank tubing



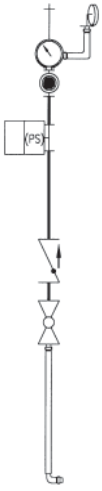
MODEL G-50-1 & G-50-1A



MODEL G-50-2A

SELECTION CHART

MODEL	DESCRIPTION
G-50-1	Complete system including 1.5 gpm (@ 100 psi) pump and low level light.
G-50-1A	Complete system including 1.5 gpm (@ 100 psi) pump, low level light and audible alarm.
G-50-2A	Complete system including two 1.5 gpm (@ 100 psi) pumps, low level light and audible alarm. Separate discharges and pressure switches allow feeding two separate closed loop systems independently from a single tank.
LP	Option to furnish larger pump rated 3.75 gpm (@ 100 psi). Add "LP" to Model Number to specify larger pump; Example G-50-1-LP.



EACH DISCHARGE ASSEMBLY CONTAINS:

- ½" S40/BRASS/PIPE w/NPT FITTINGS
- ½" BALL VALVE/PVC
- ½" CHECK VALVE/BRASS
- ½" RELIEF VALVE/BRASS (SET @ 100 PSI) w/PVC RETURN LINE
- PRESSURE GAUGE (0–100 PSI)
- PRESSURE SWITCH

EACH SUCTION ASSEMBLY CONTAINS:

- ½" S80/PVC/PIPE w/NPT FITTINGS & PVC TUBING
- ½" BALL VALVE/PVC
- ½" Y-STRAINER/CAST IRON

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 Bulletin GLY-08 P/N ZL106837 Printed in U.S.A.

Appendix D

Air Cooled Chiller Equipment Cut
[Daikin 375 Ton Unit]

PATHFINDER® Air-Cooled Screw Chiller

Job Information	*Technical Data Sheet*
Job Name	Needham High School - Chiller Replacement
Date	3/6/2017
Submitted By	Justin Thorpe
Software Version	07.20
Unit Tag	AWV030 - 375 tons - 12 EER - 21.4 IEER

Unit Overview

Model Number	Capacity ton	IPLV.IP* EER	Voltage	Unit Starter Type	ASHRAE 90.1	LEED EA Credit 4
AWV030A	375.0	21.40	460 / 60.0 / 3	VFD	'07, '10, '13	Pass

** IPLV reflects AHRI standard rating conditions and may change with user defined conditions due to AWV product optimized configurability.*

Unit

Unit Type	Platform	Unit Revision
Air-Cooled Screw Compressor Chiller	Packaged	00

Head Pressure	Tubing
DC Fan Motors / All Fan VFD	No Liquid Solenoid Valves & No Suction Shut-off Valves

Display
On Controller only

Compressor	Economizer
RRN	TTN

Refrigerant Type	Refrigerant Weight
R134a	615 lb (per unit)

Approval
ETL/cETL, AHRI & ASHRAE 90.1

Evaporator

Evaporator Modell:	EV6639A1411
Water Volume:	271.3 gal
Connection Hand:	Grooved / Left Hand
Connection Size:	10.0 in
Insulation:	Single Layer Insulation on Evaporator

Entering Fluid Temperature	Leaving Fluid Temperature	Fluid Type	Glycol Concentration	Fluid Flow	Fluid Flow (with glycol) Min / Max	Pressure Drop	Fouling Factor
54.00 °F	44.00°F	Water & Propylene	35.0 %	965.4 gpm	281.1 / 1124.3 gpm	45.0 ft H_2O	0.000100 °F.ft².h/Btu

Condenser

Number of Fans:	30
Coil Fins:	MicroChannel
Guards:	Condenser Coil Wire Grilles & Base Frame Wire Grilles

Design Ambient Air Temperature	Altitude	Fan Diameter	Fan Motor Horsepower	Minimum Design Ambient Temperature
95.0 °F	0 ft	31.5 in	1.4 hp	32.0 °F

Unit Performance

Design

Capacity	Input Power	Efficiency	IPLV.IP*
375.0 ton	374.8 kW	12.00 EER	21.40 EER

Performance Points rated at AHRI Ambient Relief

Unit							Evaporator				Condenser	
Point #	% Load	Capacity ton	Input Power kW	Efficiency EER	Economizer Status #1; #2	Compressor RPS #1; #2	Fluid Flow gpm	Pressure Drop ft H_2O	Entering Fluid Temperature °F	Leaving Fluid Temperature °F	Ambient Air Temperature °F	Altitude ft
1	100.0	375.0	374.8	12.00	On; On	49; 46	965.4	45.0	54.00	44.00	95.0	0
2	75.0	281.3	212.4	15.90	Off; Off	37; 35	965.4	45.0	51.50	44.00	80.0	0
3	50.0	187.5	95.80	23.50	Off; Off	23; 22	965.4	45.0	49.00	44.00	65.0	0
4	25.0	93.80	38.10	29.50	Off; Off	21	965.4	45.0	46.50	44.00	55.0	0

** IPLV reflects AHRI standard rating conditions and may change with user defined conditions due to AWV product optimized configurability.*

Sound Data (Internal Discharge Compressor Muffler with Sound Wrap on Discharge Line)

Sound Pressure (*at 30 feet*)

% Load	63 Hz db	125 Hz db	250 Hz db	500 Hz db	1 kHz db	2 kHz db	4 kHz db	8 kHz db	Overall dBA
100	79	73	72	70	69	64	57	48	73
75	78	72	71	69	67	60	54	46	71
50	74	67	64	64	62	52	47	39	65
25	71	63	61	61	58	48	43	35	62

Sound Power

% Load	63 Hz db	125 Hz db	250 Hz db	500 Hz db	1 kHz db	2 kHz db	4 kHz db	8 kHz db	Overall dBA
100	106	100	99	97	96	91	84	75	100
75	105	99	98	96	94	87	81	73	98
50	101	94	91	91	89	79	74	66	93
25	98	90	88	88	85	76	70	62	89

One-third Octave Band Sound Power

% Load	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz
100	105	93	86	94	91	97	94	96	92	92	91	94	92	89	93	88	85	83	82	78	75	74	68	62
75	105	92	85	93	91	97	96	92	89	91	90	92	91	86	90	84	82	80	79	75	73	72	66	60
50	101	87	81	89	85	91	89	85	83	85	85	88	87	80	82	76	74	73	72	68	66	64	60	55
25	98	84	77	86	81	87	86	82	80	82	82	85	83	77	79	72	70	69	68	64	62	60	56	51

Octave band is non 'A' weighted and overall readings are 'A' weighted. Sound data rated in accordance with AHRI Standard-370.

Physical

Unit

Length*	Height	Width*	Shipping Weight*	Operating Weight*
599 in	100 in	88 in	26110 lb	28374 lb

* *Shipping and operating weights do not include the weights of any Options or Accessories. Contact Chiller Applications for additional information.*

Electrical

Unit Electrical Data

Voltage	Starter Type	Fan Motor Quantity	LRA Fan Motor (each)	FLA Fan Motors (each)
460 / 60.0 / 3	VFD	30	4A	2.6A

Power Connection Type:	Single Point Disconnect Switch with Circuit Protection
Short Circuit Current Rating:	10 kA
Drive Type(#1;#2):	CIMR-AU4A0515;CIMR-AU4A0515
Phase Voltage:	Phase & Under/Over Voltage Protection with LED

Single Point Power Connection

MCA:	619 A
Fuse Size (*recommended*):	700 A
Fuse Size (*maximum*):	800 A
Connector Wire Range:	(3) 2/0-400MCM

Compressor Electrical Data

Compressor Type	Compressor Quantity	Starter Type
Screw	2	VFD

	Compressor #	
	1	2
RLA:	244 A	231 A
Inrush Current:	244 A	231 A

Note: Power wiring connections to the chiller may be done with either copper or aluminum wiring. Wire should be sized per NEC and/or local codes. Wire sizing and wire count must fit in the power connection lug sizing listed in latest installation manual. Please contact your local sales office for more information.

Options

Control

Communication:	BACnet MS/TP

Electrical

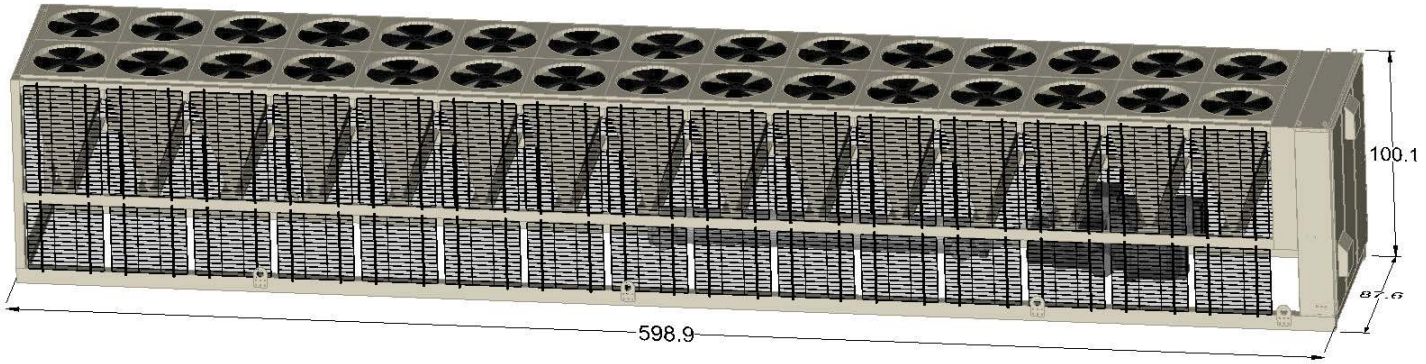
Ground Fault:	Unit Ground Fault Protection
Unit Options:	115V Convenience Outlet
Water Flow Indicator:	Evaporator only (Thermal Dispersion)

Warranty

Unit Startup	Domestic
Standard Warranty:	1st Year Entire Unit Parts & Labor
Extended Compressor Warranty:	Compressor Only; extended 4 years parts & labor

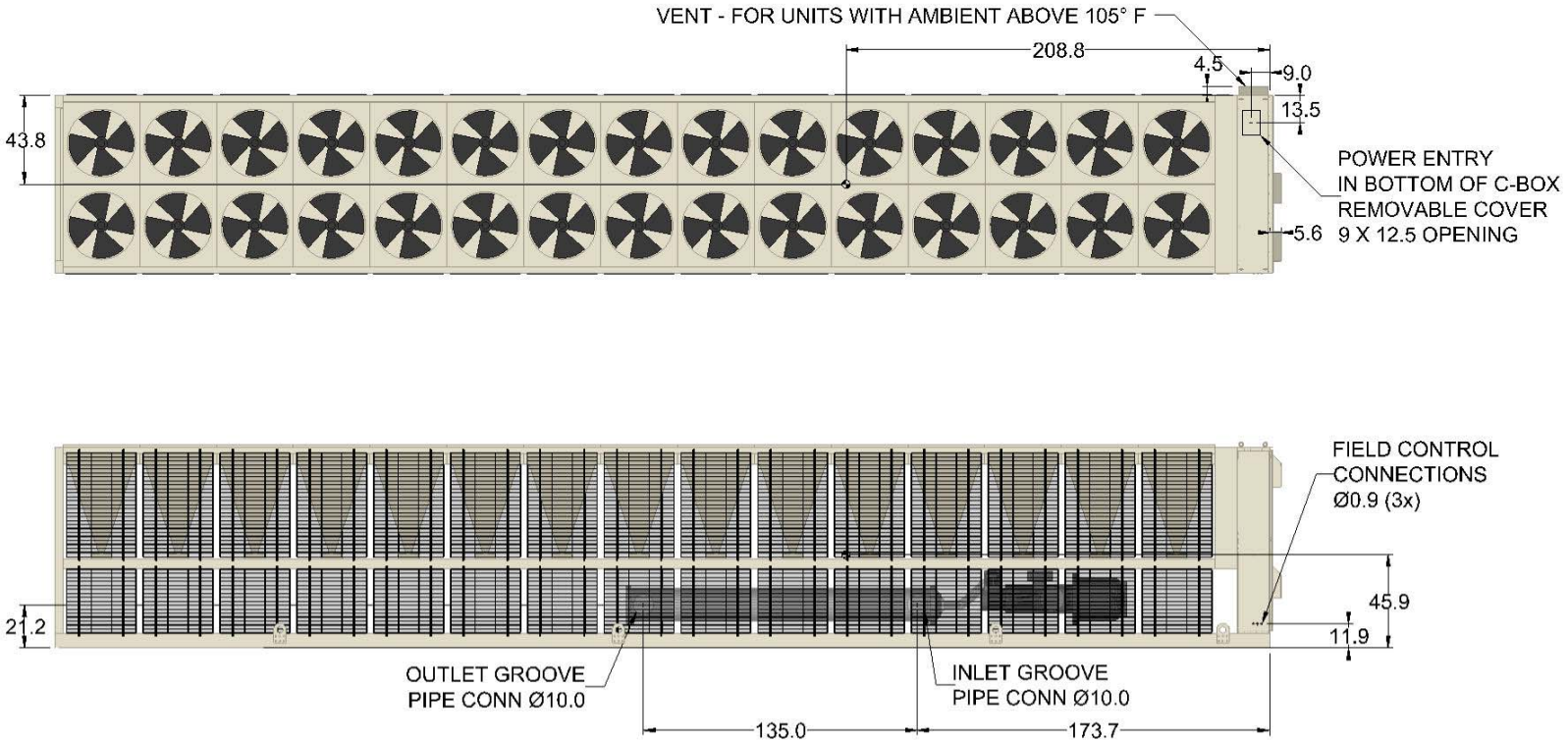
AHRI Certification

Certified in accordance with the AHRI Air-Cooled Water-Chilling Packages Using Vapor Compression Cycle Certification Program, which is based on AHRI Standard 550/590 (I-P) and AHRI Standard 551/591 (SI). Unit containing freeze protection fluids in the condenser or in the evaporator with a leaving chilled fluid temperature above 32°F [0°C] is certified when rated per the Standard with water. Certified units may be found in the AHRI Directory at www.ahridirectory.org.



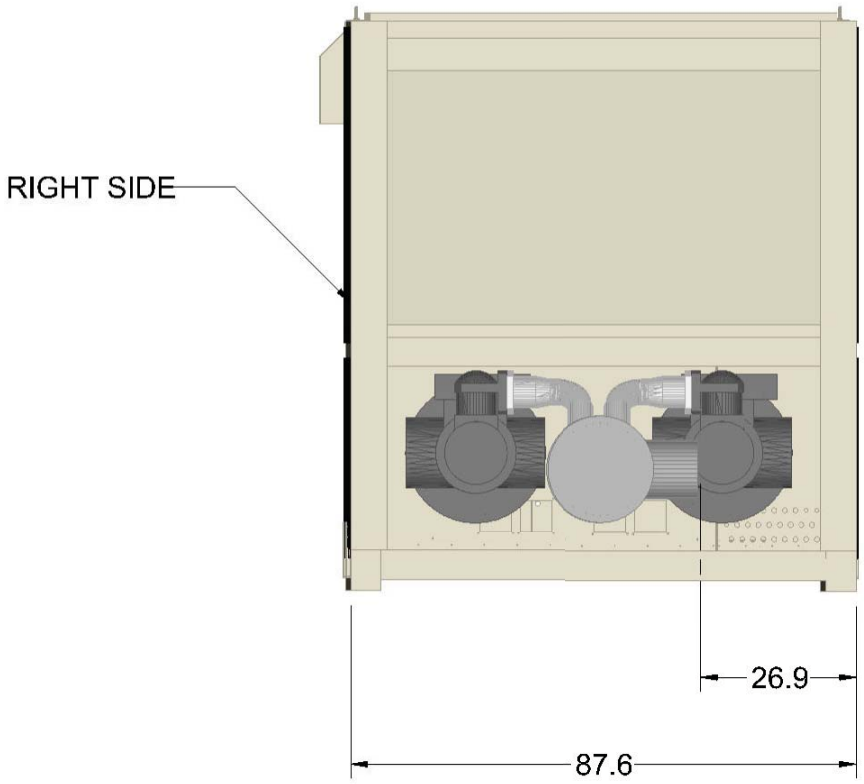
NOTE: A water strainer must be installed at the inlet of the evaporator to protect it from damage. Please refer to the IOM for additional details.

Product Drawing	Unit Tag: AWV030 - 375 tons - 12 EER -			Sales Office: HTS New England (Boston)			DAIKIN
Product:	Project Name: Needham High School - Chiller			Sales Engineer:			13600 Industrial Park Blvd. Minneapolis, MN 55441
Model: AWV030A	Mar. 06, 2017	Ver/Rev:	Sheet: 1 of 1	Scale: NTS	Tolerance: +/- 0.25"	Dwg Units: (in)	www.DaikinApplied.com Software Version: 07.20



Product Drawing	Unit Tag: AWV030 - 375 tons - 12 EER -			Sales Office: HTS New England (Boston)			DAIKIN
Product:	Project Name: Needham High School - Chiller			Sales Engineer:			13600 Industrial Park Blvd. Minneapolis, MN 55441
Model: AWV030A	Mar. 06, 2017	Ver/Rev:	Sheet: 1 of 1	Scale: NTS	Tolerance: +/- 0.25"	Dwg Units: (in)	www.DaikinApplied.com Software Version: 07.20

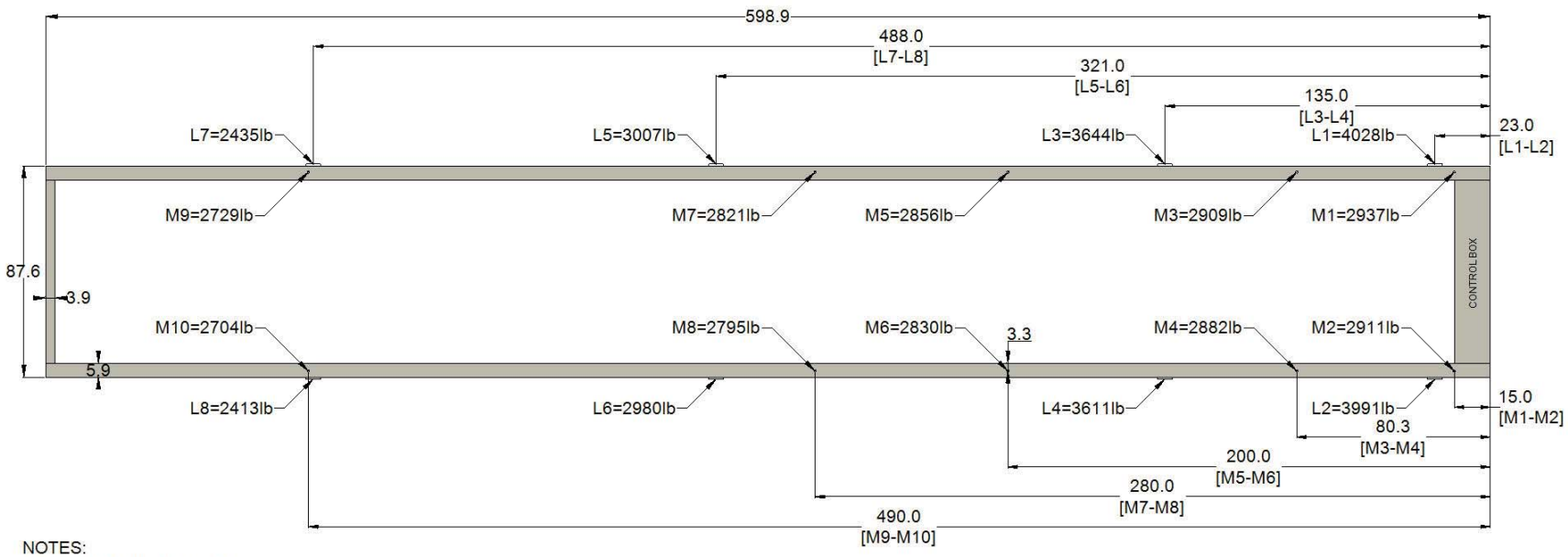
REAR VIEW



Product Drawing	Unit Tag: AWV030 - 375 tons - 12 EER -			Sales Office: HTS New England (Boston)			DAIKIN
Product:	Project Name: Needham High School - Chiller			Sales Engineer:			13600 Industrial Park Blvd. Minneapolis, MN 55441
Model: AWV030A	Mar. 06, 2017	Ver/Rev:	Sheet: 1 of 1	Scale: NTS	Tolerance: +/- 0.25"	Dwg Units: (in)	www.DaikinApplied.com Software Version: 07.20

Mounting and Lifting

BASE FRAME PLAN VIEW



NOTES:
1) L = LIFTING WEIGHT
2) M = MOUNTING LOAD
3) UNIT SHIPPING WEIGHT = 26110lb
4) UNIT OPERATING WEIGHT = 28374lb

Product Drawing	Unit Tag: AWV030 - 375 tons - 12 EER -			Sales Office: HTS New England (Boston)			DAIKIN
Product:	Project Name: Needham High School - Chiller			Sales Engineer:			13600 Industrial Park Blvd. Minneapolis, MN 55441
Model: AWV030A	Mar. 06, 2017	Ver/Rev:	Sheet: 1 of 1	Scale: NTS	Tolerance: +/- 0.25"	Dwg Units: (in)	www.DaikinApplied.com Software Version: 07.20

PROJECT COST INFORMATION

Estimated Project Costs - Feasibility Study				
Needham High School				
Needham, Massachusetts				
Feasibility Study Summary Sheet				
Option	**Bldg Sq Footage**	**Construction Cost**	**Cost per SF**	**Project Cost**
Option B - Renovations Only	**31,250**	**$ 5,987,079**	**$ 191.59**	**$ 8,681,000**
New construction	0			
Renovation	31,250			
Option C - Southwest Corner Addition	**17,800**	$ 6,770,850	$ 380.38	**$ 9,818,000**
New construction	17,800			
Renovation	0			
Option D - Courtyard Library	**45,600**	**$ 15,370,544**	**$ 337.07**	**$ 22,287,000**
New construction	8,000			
Renovation	37,600			
Option E - Webster Street Library	**43,904**	**$ 12,068,998**	**$ 274.90**	**$ 17,500,000**
New construction	11,154			
Renovation	32,750			
Option F - Webster Street Classrooms	**19,400**	**$ 7,863,620**	**$ 405.34**	**$ 11,402,000**
New construction	18,400			
Renovation	1,000			
Chiller Replacement Project:		**$ 569,796**		**$ 768,000**
Boiler Repairs & Optimization Project:	**	**$ 99,454**	**	**$ 142,000**
*** Boiler project costs include optional work that may / may not be included TBD*				

Estimated Project Costs - Feasibility Study							Updated 4/13/17	
Needham High School								
Needham, Massachusetts								
Option B - Renovations Only								
		1800	**students**					
		31,250	**Sq Footage:**	**sq.ft.**	**Estmated Cost:**		**Comments:**	
Construction Costs:								
1	Site Development				$ -		Not included	
2	Hazardous Materials Abatement				$ -			
3	Building Demolition				$ -			
4	Construction							
		Area A-General Renov		5,150	$ 360,923		$ 70.08	per sf
		Area B-General Renov		1,500	$ 20,250		$ 13.50	per sf
		Area C-Exist Library		24,600	$ 4,390,200		$ 178.46	per sf
	Subtotal			31,250	$ 4,771,373		$ 152.68	per sf
	Escalation to Mid-Point (5% PA)			5%	$ 238,569			
	CM @ Risk Premium			5%	$ 238,569			
	Additional escalation time (5%)			5%	$ 238,569		For invasive renovations	
	Design and Pricing Contingency						Included in constr est.	
	Construction Phasing Costs:				$ 500,000			
Total Construction Cost					**$ 5,987,079**		$ 191.59	per sf
Project Contingency:	(Construction+ Owner)							
	Construction				$ 598,708		10%	
	Owner				$ 299,354		5%	
Total Project Contingency					**$ 898,062**		15%	
Soft Costs:	Owner's Project Manager,							
	Arch/engineering, Owner direct,							
	Survey, Geotechnical, Hazardous							
	Materials, Printing, Legal, etc.							
Total Soft Cost					**$ 1,496,770**		25%	
Fixtures Furnishings and Equipment (FF&E):								
Total FF&E Cost					**$ 299,354**		5%	
Project Cost Summary:								
	Construction Costs				**$ 5,987,079**		$ 191.59	per sf
	Project Contingency				**$ 898,062**			
	Soft Costs				**$ 1,496,770**			
	FF&E Costs				**$ 299,354**			
Estimated Total Project Costs					**$ 8,681,000**			

Estimated Project Costs - Feasibility Study							Updated 4/13/17	
Needham High School								
Needham, Massachusetts								
Option C - Southwest Corner Addition								
		1800	**students**					
		17,800	**Sq Footage:**	**sq.ft.**	**Estmated Cost:**		**Comments:**	
Construction Costs:								
1	Site Development				$ 202,500			
2	Hazardous Materials Abatement				$ -			
3	Building Demolition				$ -			
4	Construction							
		Area A-Add/Renov		17,800	$ 5,271,000	$	296.12	per sf
	Subtotal			17,800	$ 5,473,500	$	307.50	per sf
	Escalation to Mid-Point (5% PA)			5%	$ 273,675			
	CM @ Risk Premium			5%	$ 273,675			
	Design and Pricing Contingency					Included in constr est.		
	(4) Tempory Classrooms				$ 250,000			
	Construction Phasing Costs:				$ 500,000			
Total Construction Cost					**$ 6,770,850**	$	380.38	per sf
Project Contingency:	(Construction+ Owner)							
	Construction				$ 677,085		10%	
	Owner				$ 338,543		5%	
Total Project Contingency					**$ 1,015,628**		15%	
Soft Costs:	Owner's Project Manager,							
	Arch/engineering, Owner direct,							
	Survey, Geotechnical, Hazardous							
	Materials, Printing, Legal, etc.							
Total Soft Cost					**$ 1,692,713**		25%	
Fixtures Furnishings and Equipment (FF&E):								
Total FF&E Cost					**$ 338,543**		5%	
Project Cost Summary:								
	Construction Costs				**$ 6,770,850**	$	380.38	per sf
	Project Contingency				**$ 1,015,628**			
	Soft Costs				**$ 1,692,713**			
	FF&E Costs				**$ 338,543**			
Estimated Total Project Costs					**$ 9,818,000**			

Estimated Project Costs - Feasibility Study						Updated 4/13/17		
Needham High School								
Needham, Massachusetts								
Option D - Courtyard Library								
		1800	**students**					
		45,600	**Sq Footage:**	**sq.ft.**	**Estmated Cost:**	**Comments:**		
Construction Costs:								
1	Site Development				$ -	Not included		
2	Hazardous Materials Abatement				$ -			
3	Building Demolition				$ -			
4	Construction							
		Area A-General Renov		7,250	$ 502,673	$ 69.33	per sf	
		Area B-General Renov		1,500	$ 75,735	$ 50.49	per sf	
		Area C-Exist Library		24,600	$ 4,390,200	$ 178.46	per sf	
		Area D-General Renov		4,250	$ 503,550	$ 118.48	per sf	
		Area E-Courtyard Libr		8,000	$ 7,458,750	$ 932.34	per sf	
	Subtotal			45,600	$ 12,930,908	$ 283.57	per sf	
	Escalation to Mid-Point (5% PA)			5%	$ 646,545			
	CM @ Risk Premium			5%	$ 646,545			
	Additional escalation time (5%)			5%	$ 646,545	Invasive renovations		
	Design and Pricing Contingency					Included in constr est.		
	Construction Phasing Costs:				$ 500,000			
Total Construction Cost					**$ 15,370,544**	$ 337.07	per sf	
Project Contingency:	(Construction+ Owner)							
	Construction				$ 1,537,054	10%		
	Owner				$ 768,527	5%		
Total Project Contingency					**$ 2,305,582**	15%		
Soft Costs	Owner's Project Manager,							
	Arch/engineering, Owner direct,							
	Survey, Geotechnical, Hazardous							
	Materials, Printing, Legal, etc.							
Total Soft Cost					**$ 3,842,636**	25%		
Fixtures Furnishings and Equipment (FF&E):								
Total FF&E Cost					**$ 768,527**	5%		
Project Cost Summary:								
	Construction Costs				**$ 15,370,544**	$ 337.07	per sf	
	Project Contingency				**$ 2,305,582**			
	Soft Costs				**$ 3,842,636**			
	FF&E Costs				**$ 768,527**			
Estimated Total Project Costs					**$ 22,287,000**			

Estimated Project Costs - Feasibility Study							Updated 4/13/17	
Needham High School								
Needham, Massachusetts								
Option E - Webster Street Library								
		1800	**students**					
		43,904	**Sq Footage:**	**sq.ft.**	**Estmated Cost:**	**Comments:**		
Construction Costs:								
1	Site Development					Not included		
2	Hazardous Materials Abatement				$ -			
3	Building Demolition				$ -			
4	Construction							
		Area A-General Renov		5,150	$ 360,923	$ 70.08	per sf	
		Area B-General Renov		1,500	$ 55,485	$ 36.99	per sf	
		Area C-Exist Library		24,600	$ 4,390,200	$ 178.46	per sf	
		Area D-General Renov		1,500	$ 179,820	$ 119.88	per sf	
		Area E-Webster Libr		11,154	$ 5,073,570	$ 454.87	per sf	
	Subtotal			43,904	$ 10,059,998	$ 229.14	per sf	
	Escalation to Mid-Point (5% PA)			5%	$ 503,000			
	CM @ Risk Premium			5%	$ 503,000			
	Additional escalation time (5%)			5%	$ 503,000	For invasive renovations		
	Design and Pricing Contingency					Included in constr est.		
	Construction Phasing Costs:				$ 500,000			
Total Construction Cost					**$ 12,068,998**	$ 274.90	per sf	
Project Contingency:	(Construction+ Owner)							
	Construction				$ 1,206,900	10%		
	Owner				$ 603,450	5%		
Total Project Contingency					**$ 1,810,350**	15%		
Soft Costs:	Owner's Project Manager,							
	Arch/engineering, Owner direct,							
	Survey, Geotechnical, Hazardous							
	Materials, Printing, Legal, etc.							
Total Soft Cost					**$ 3,017,249**	25%		
Fixtures Furnishings and Equipment (FF&E):								
Total FF&E Cost					**$ 603,450**	5%		
Project Cost Summary:								
	Construction Costs				**$ 12,068,998**	$ 274.90	per sf	
	Project Contingency				**$ 1,810,350**			
	Soft Costs				**$ 3,017,249**			
	FF&E Costs				**$ 603,450**			
Estimated Total Project Costs					**$ 17,500,000**			

Estimated Project Costs - Feasibility Study							Updated 4/13/17		
Needham High School									
Needham, Massachusetts									
Option F - Webster Street Classrooms									
		1800	**students**						
		22,500	**Sq Footage:**	**sq.ft.**	**Estmated Cost:**		**Comments:**		
Construction Costs:									
1	Site Development				$ 100,000				
2	Hazardous Materials Abatement				$ -				
3	Building Demolition				$ -				
4	Construction								
		Area A-General Renov		1,000	$ 100,000		$ 100.00		per sf
		Area B-General Renov		0	$ -		$ -		per sf
		Area C-Exist Library		0	$ -		$ -		per sf
		Area D-General Renov		0	$ -		$ -		per sf
		Area E-Webster CR's		18,400	$ 6,494,200		$ 352.95		per sf
	Subtotal			19,400	$ 6,694,200		$ 345.06		per sf
	Escalation to Mid-Point (5% PA)			5%	$ 334,710				
	CM @ Risk Premium			5%	$ 334,710				
	Design and Pricing Contingency						Included in constr est.		
	Construction Phasing Costs:				$ 500,000				
Total Construction Cost					**$ 7,863,620**		$ 405.34		per sf
Project Contingency:	(Construction+ Owner)								
	Construction				$ 786,362		10%		
	Owner				$ 393,181		5%		
Total Project Contingency					**$ 1,179,543**		15%		
Soft Costs:	Owner's Project Manager,								
	Arch/engineering, Owner direct,								
	Survey, Geotechnical, Hazardous								
	Materials, Printing, Legal, etc.								
Total Soft Cost					**$ 1,965,905**		25%		
Fixtures Furnishings and Equipment (FF&E):									
Total FF&E Cost					**$ 393,181**		5%		
Project Cost Summary:									
	Construction Costs				**$ 7,863,620**		$ 405.34		per sf
	Project Contingency				**$ 1,179,543**				
	Soft Costs				**$ 1,965,905**				
	FF&E Costs				**$ 393,181**				
Estimated Total Project Costs					**$ 11,402,000**				

Estimated Project Costs - Feasibility Study							Updated 4/13/17	
Needham High School								
Needham, Massachusetts								
Gymnasium 'A' Renovation								
		9,500	**Sq Footage:**	**sq.ft.**	**Estmated Cost:**		**Comments:**	
Construction Costs:								
1	Site Development				(none incl.)			
2	Hazardous Materials Abatement				(none incl.)			
3	Building Demolition				(none incl.)			
4	Construction							
		New Hardwood Floor		9,500	$ 285,000	$	30.00	per sf
		New HVAC RTU's		9,500	$ 120,000	$	12.63	per sf
		New Lighting		9,500	$ 60,000	$	6.31	per sf
		Accoustic Panel System		9,500	$ 86,000	$	9.05	per sf
		New Basketball Goals		9,500	$ 80,000	$	8.42	per sf
	Subtotal			9,500	$ 631,000	$	66.42	per sf
	Escalation to Mid-Point (5% PA)			5%	$ 31,550			
	CM @ Risk Premium			5%	$ 31,550			
	Design and Pricing Contingency						Included in constr est.	
	Construction Phasing Costs:				$ -			
Total Construction Cost					**$ 694,100**	$	73.06	per sf
Project Contingency:	(Construction+ Owner)							
	Construction				$ 69,410		10%	
	Owner				$ 34,705		5%	
Total Project Contingency					**$ 104,115**		15%	
Soft Costs:	Owner's Project Manager,							
	Arch/engineering, Owner direct,				$ 59,397			
	Survey, Geotechnical, Hazardous				(none incl.)			
	Materials, Printing, Legal, etc.				(none incl.)			
Total A/E Cost					**$ 59,397**			
Fixtures Furnishings and Equipment (FF&E):								
Total FF&E Cost					**$ -**		0%	
Project Cost Summary:								
	Construction Costs				**$ 694,100**	$	73.06	per sf
	Project Contingency				**$ 104,115**			
	Soft Costs				**$ 59,397**			
	FF&E Costs				**$ -**			
Estimated Total Project Costs					**$ 858,000**			

Estimated Project Costs - Feasibility Study						Updated 4/12/17	
Needham High School							
Needham, Massachusetts							
Chiller Replacement Project							
					Estmated Cost:	**Comments:**	
Construction Costs:							
1	Site Development				$ 10,000		
2	Hazardous Materials Abatement				(none)		
3	Building Demolition				(none)		
4	Construction:						
		New air-cooled chiller(s)			$ 450,000		
		(incl. piping, electrical, prep., etc.)					
		Complete system flush &treatment			$ 3,425		
		New filter & Glycol feed systems			$ 9,550		
		Glycol material (aprx. 5,000 gal)			$ 22,500		
	Subtotal				$ 495,475		
	Escalation to Mid-Point (5% PA)			5%	$ 24,774		
	Design and Pricing Contingency			5%	$ 24,774		
	Construction Phasing Costs:				$ -		
Total Construction Cost					**$ 545,023**		
Project Contingency:	(Construction+ Owner)						
	Construction				$ 54,502	10%	
	Owner				$ 27,251	5%	
Total Project Contingency					**$ 81,753**	15%	
Soft Costs:							
	Architect PM, Specs, Cost estimating, CA fees:				$38,000		
	MEP / Structural / Civil Engineering fees:				$61,500		
	Owners Project Management:				$24,774	5%	
	Commissioning:				$7,500		
	Site Survey (if required - TBD)				$5,280		
Total Soft Cost Cost					**$ 137,054**		
Project Cost Summary:							
	Construction Costs				**$ 545,023**		
	Project Contingency				**$ 81,753**		
	Soft Costs				**$ 137,054**		
Estimated Total Project Costs					**$ 764,000**		

Estimated Project Costs - Feasibility Study						Updated 4/12/17	
Needham High School							
Needham, Massachusetts							
Boiler Repair & Heating System Optimization Project							
					Estmated Cost:	**Comments:**	
Construction Costs:							
1	Site Development				(none)		
2	Hazardous Materials Abatement				(none)		
3	Building Demolition				(none)		
4	Construction:						
	a.	Install new gas 'train':			$ -	*by utility co.*	
	b.	Complete system flush, treatment:			$ 3,425		
	c.	Filter system, Media, Chemical Feed			$ 1,715		
	d.	Install add'l make-up air opening incl.			$ 30,000		
		louvers, ducting, masonry					
	e.	New CO sensor w/ remote indicator			$ 2,500	*none exst.*	
	f.	New connected data logging			$ 10,000	*also includes periodic*	
		gas pressure / flow meter				*gas sample testing*	
	g.	New DHW Heater:			$ 10,000		
	h.	Install pressure gauges at each boiler			$ 5,500		
	Subtotal				$ 63,140		
	Optional Controls Upgrades				*$ 30,000*	*see options 1a & 1b*	
	Escalation to Mid-Point (5% PA)			5%	$ 3,157		
	Design and Pricing Contingency			5%	$ 3,157		
	Construction Phasing Costs:				$ -		
Total Construction Cost					**$ 99,454**		
Project Contingency:	(Construction+ Owner)						
	Construction				$ 9,945	10%	
	Owner				$ 4,973	5%	
Total Project Contingency					**$ 14,918**	15%	
Soft Costs:							
	Architect PM, Specs, Cost estimating, CA fees:				$11,000		
	MEP Engineering fees:				$16,200		
Total Soft Cost Cost					**$ 27,200**		
Project Cost Summary:							
	Construction Costs				**$ 99,454**		
	Project Contingency				**$ 14,918**		
	Soft Costs				**$ 27,200**		
Estimated Total Project Costs					**$ 142,000**	**	
(** Boiler Optimization Project cost range = $109k - $142k pending final options selected (see next page))							

(Boiler Optimization cont.)				
Option 1a: *(incl. engineering & trades work)*		**$ 15,000**		
Option: Review EXISTING boiler control panel, programming, and / or internal components; repair, reset, connect and configure to function properly with Needham BMS.				
Option 1b: *(incl. engineering & trades work)*		**$ 30,000**		
Option: Install NEW boiler control panel; connect and configure to optimize function fully with Needham BMS				

APPENDIX

FEASIBILITY STUDY TIMELINE

FEASABILITY STUDY TIMELINE

DECEMBER – DATA GATHERING AND ANALYSIS

12/06/16 Working Group Meeting
Review of Schedule, Utilization Analysis Progress, Survey Strategies

12/20/16 Working Group Meeting
Analysis Progress, Enrollment Target

JANUARY – NEEDS IDENTIFICATION

1/05/17 *D&W Complete Structural Facility Assessment*

1/10/17 Working Group Meeting
Questionnaires due back to D&W

1/17/17 Working Group Meeting
Report out on questionnaires

1/31/17 *D&W Complete MEP/FP Facility Assessments*

1/31/17 Working Group Meeting
Initial Presentation of Space Needs and Facility Needs

FEBRUARY – NEEDS CONFIRMATION

2/13/17 **PPBC Presentation**
Update of progress, analysis, initial space & facility needs

2/14/17 Working Group
Update of progress, analysis, initial space & facility needs

2/27/17 **PPBC Presentation**
With preliminary costs – define the need, provide the options, give range of cost – what happens if we do nothing?

2/28/17 Working Group / Task Force
With preliminary costs – define the need, provide the options, give range of cost – what happens if we do nothing?

MARCH – OPTIONS DEVELOPMENT

3/13/17 **PPBC Presentation**
Review further costs refinement

3/14/17 Working Group
Review of options

3/20/17 Task Force
Presentation of space needs, facility needs, options narrative

3/21/17 **School Committee**
Presentation of space needs, facility needs, options narrative

3/27/17 **School Committee / PPBC joint meeting**
Presentation of options and Comparative Cost Estimates

APRIL – OPTIONS REFINEMENT & COST

4/10/17 **School Committee / PPBC joint meeting**
Presentation of Final Option and Cost

4/17/17 Delivery of Final Draft Report

4/25/17 District to Return any Edits to the Report

MAY – REPORT PUBLICATION AND TOWN VOTE

5/01/17 PPBC: May Town Meeting

5/08/17 D&W to deliver FINAL REPORT

5/08/17 D&W to start Phase II – Schematic Design

FINAL PRESENTATION

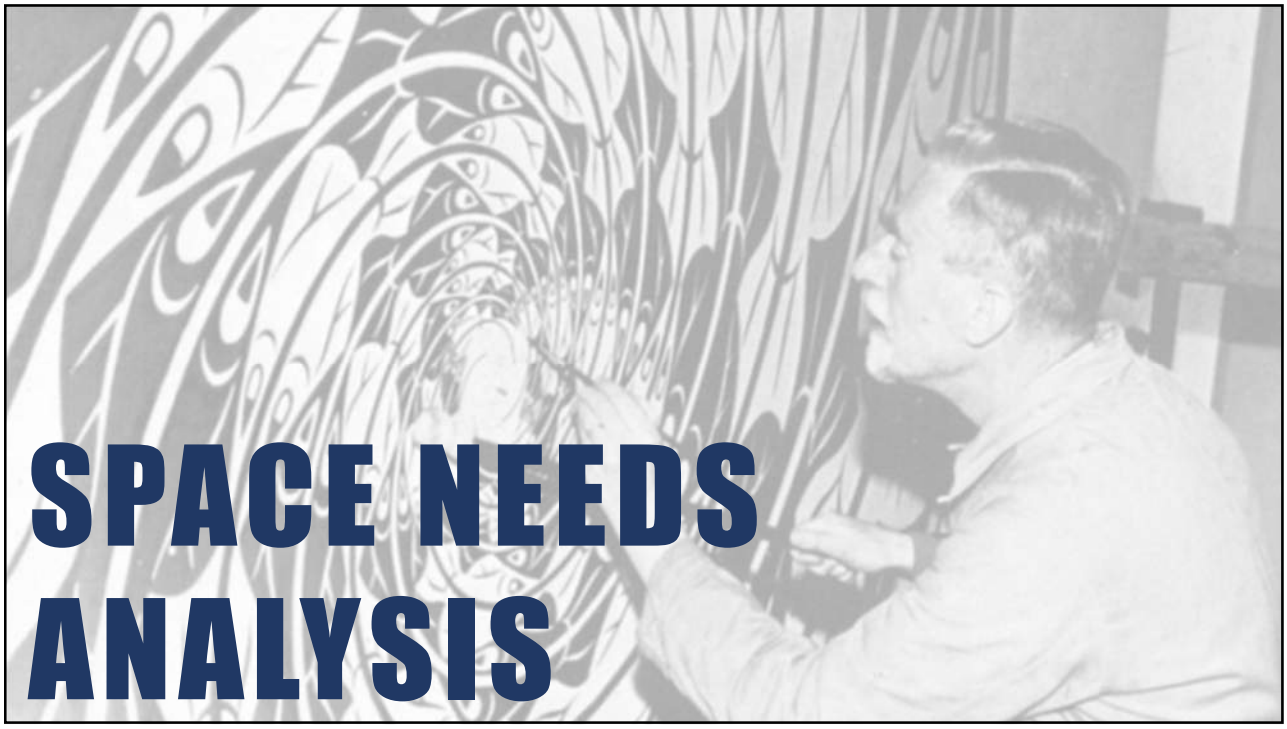
The following Power Point presentation was given at the Joint School Committee / PPBC meeting on 27 March 2017, in the Public Library large meeting room.

Scope of Work

- Conduct Educational Analysis to Determine Space Needs
  - Utilization, Schedule, Program & Existing Space
- Develop Options to Meet Needs
- Develop Cost Estimates of Options
- Evaluate Options to Determine Preferred Options

Agenda

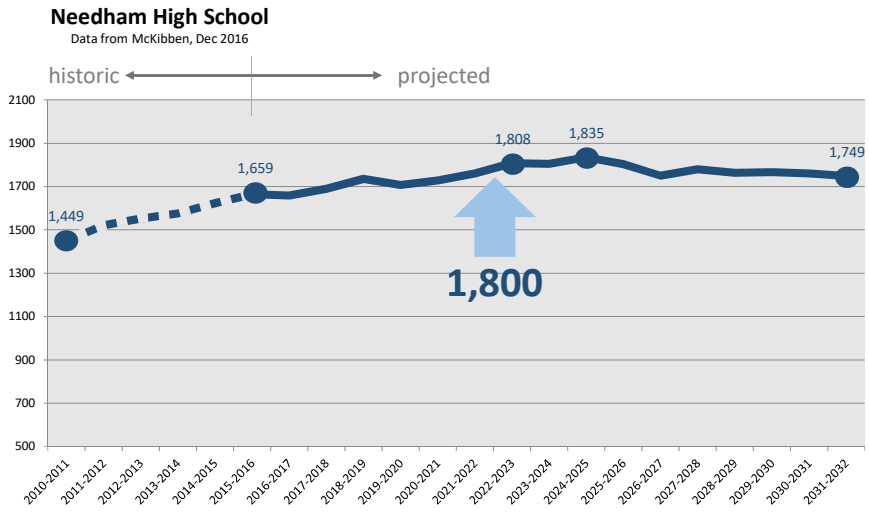
- Space Needs Analysis
- Options
- Review of Cost Estimates
- Evaluation of Options



Analytical Scope

- Review Enrollment Projections and Determine an Enrollment Target
- Review utilization, schedule, & program to determine if / how many additional classrooms are required to meet enrollment target

Enrollment Assumptions



Planning & Programming Tasks

- Develop an Understanding of Programs & Services
- Develop an Understanding of Schedule & Section Caps
- Interview Special Education Department
- Deep Dive – Analyze every space where instruction occurs
  - Utilization
  - Students Per Section
- Survey Faculty & Staff about Perceived Needs
- **Determine if Spatial Needs Exist Today**
- **Project Course Offerings and Schedule into the Future**
- **Determine if Spatial Needs Exist in the Future**

Core Academic, Key Findings

Math, English, Social Studies and World Languages

Average Utilization Rate = **90%**

Average Students Per Section = **20.88**

Total Sections w/ Students ≥23 = **147** or **45%**

Total Sections w/ 16 ≤ Students < 23 = **132** or **40%**

Total Sections w/ Students <16 = **50** or **15%**

329 Sections @85% = 55 Classrooms, 52 Existing

Solutions Toolkit

- More students per section on average
  - Educational decision to cap certain course offerings to best serve students
- Higher utilization per room
  - Core academic already over 90%
  - Improve utilization at fine & performing arts… might limit access to students and not attractive geographically
- Fewer sections to increase students per section
  - Might result in less access to students because of specialty conflicts
- Increase the number of classrooms

Basic Information – Macro Scale

Existing 2016		Needham 2024
Enroll: 1659		Enroll: 1,800
Building GSF: 285,000		Building GSF: TBD
General CRs: 52	→	**General CRs: 60**
Science Labs: 14	→	**Science Labs: 15**
Art Studios: 8		Art Studios: 8
Music CRs: 3		Music CRs: 3
PE: 6*		PE: 7
Vo Tech: 2		Vo Tech: 2
Other: 3**		Other: 3
Total = 88 Stations		Total = 97 Stations

- **18.5** Students/ Teaching Station Average
- **24** Students/ Teaching Station (Max Core Academic Courses)
- **85%** Utilization Rate max

Space Summary Goals:

Core Academic Space Needs

(6) 925 NSF Classrooms
(2) 1,200 NSF Classrooms
(1) 1,640 NSF Science Lab w/ Prep Area

(8+1) **Total: 7,940 NSF**

Special Education Space Needs

Classrooms, Life Skills, Small Group, Testing Rooms 120 NSF – 750 NSF
Expanded Department Office Space

Total: 5,500 NSF

Collaboration Space(s)

In addition to existing

- **As Options Allow**
- **Some Noisy**
- **Some Quiet**
- **Some Open**
- **Some Closed**
- **Lots of vertical writing surface**
- **Access to Wifi**
- **Access to Digital Display**
- **Some Hard Furnishings**
- **Some Soft Furnishings**
- **Highly Mobile Furnishings**
- **Food Friendly**

Core Academic, Enrollment Growth Without More Classrooms

Math, English, Social Studies and World Languages

Average Utilization Rate = **90%** → **97%**

Average Students Per Section = **20.88** → **22.67**

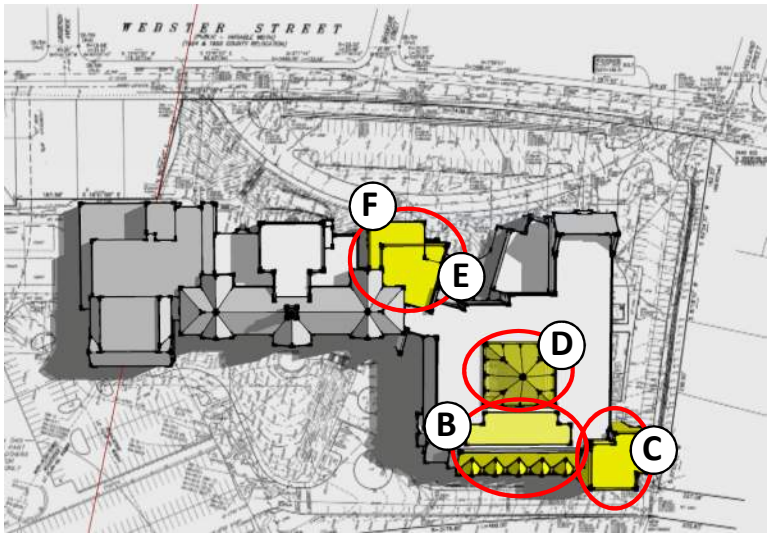
Total Sections w/ Students ≥23 = **147** or **45%** → **60%**

Total Sections w/ 16 ≤ Students < 23 = **132** or **40%** → **28%**

Total Sections w/ Students <16 = **50** or **15%** → **12%**

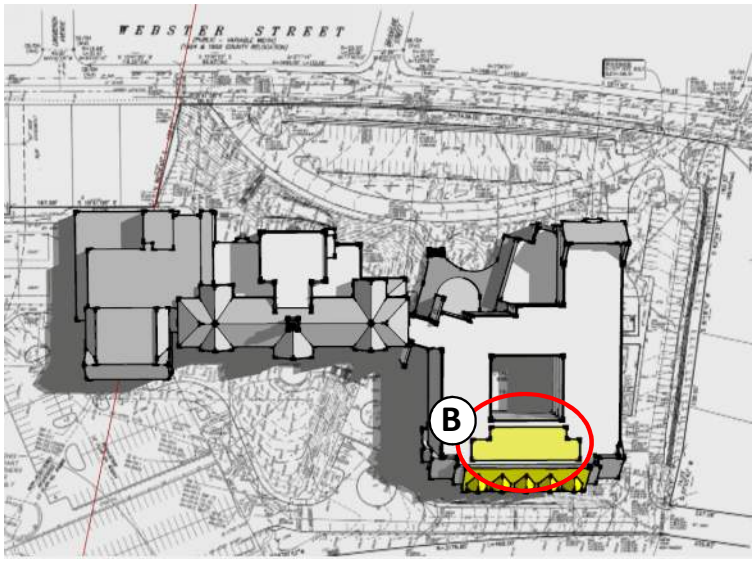
OPTIONS

Updated Building Options



- (A) *No added classrooms*
- (B) Interior Renovation Only
- (C) Classroom addition at SW corner
- (D) Relocated Media Center at Courtyard
- (E) Relocated Media Center at Webster Street Entry Area
- (F) New Classroom Wing at Webster Street Entry

Building Option B



B Interior Renovations – new floor & roof structure at Level 4 for new Media Center plus new Classrooms at Level 3 (exst. Media Center area)

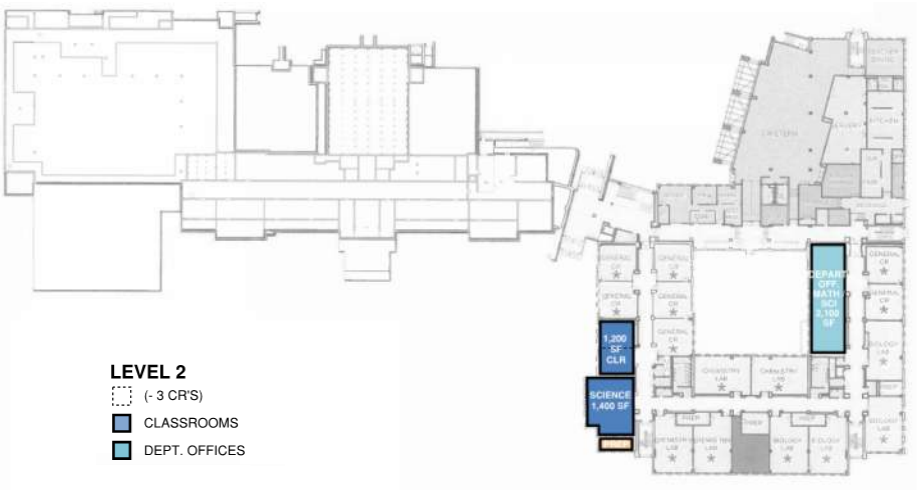
Building Option B

*(*no change to Level 1)*

LEVEL 2: *RE-PURPOSE DEPT. OFFICE SPACES & (3) EXST. CLRMS*

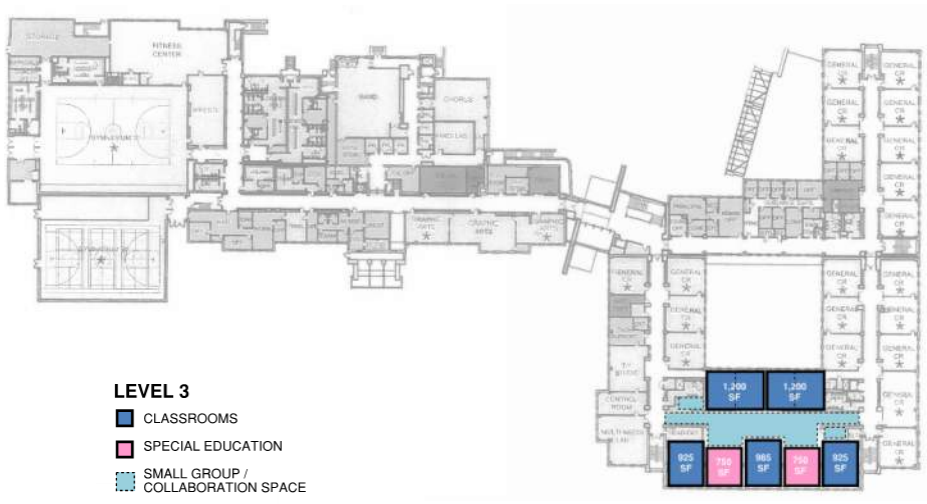
+ (1) NEW SCIENCE & PREP
+ (1) NEW 1,200 SF CLRM

- (3) 750 CLASSRMS
- REDUCED DEPARTMENTAL OFFICE SPACE



Building Option B

LEVEL 3: *RE-PURPOSE EXST. LIBRARY VOLUME*

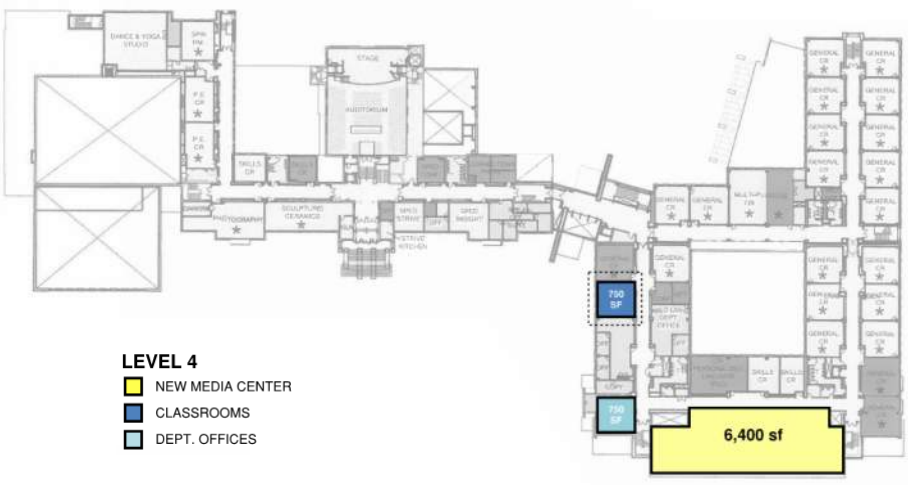


+ (2) NEW 1,200 SF CLRMs
+ (3) NEW 925 SF +/- CLRMs
+ (2) NEW 750 SF SPECIAL EDUCATION CLRMs
+ NEW 2,500 SF STUDENT COLLABORATION SPACE

- EXISTING MEDIA CENTER
- (2) CONFERENCE RMS
- (1) WORKROOM

Building Option B

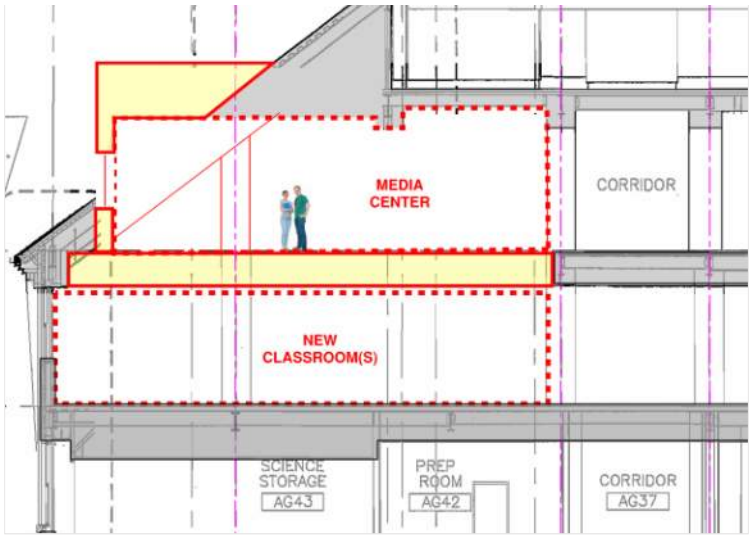
LEVEL 4: *RE-LOCATED MEDIA CTR.*

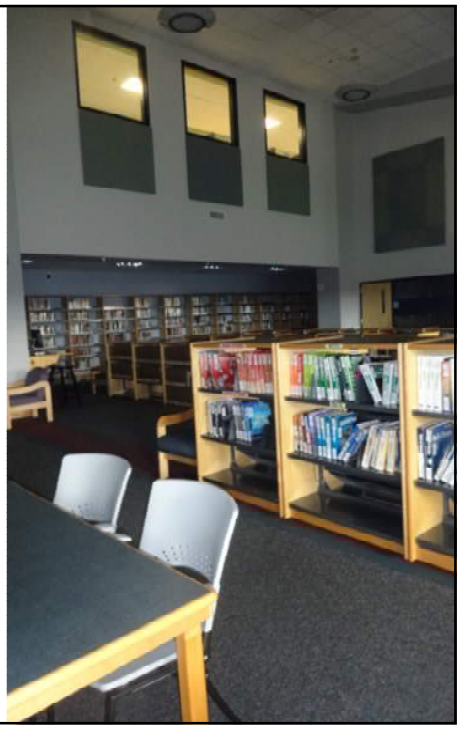


+ (1) 750 SF CLRM
+ NEW 6,400 SF MEDIA CENTER
+ ADDITION TO DEPARTMENT OFFICE

- STORAGE RM

Building Option B





Building Option B

Net gain:

- ***(1) Science Lab + Prep***
- ***(4) Classrooms***

GAINS	***LOSSES***
+ 3 @1,200 sf	*- 3 @ 725 sf*
+ 3 @925 sf	
+ 1 @750 sf	

- ***(2) Special Ed. Classrooms***

GAINS	***LOSSES***
+ 2 @750 sf	*none*

GABLE END DORMERS

Building Option B

+/- *8 – 12 months duration*

Constraints:
- *Invasive construction*
- *Media Center reduced size*
- *Reduced Departmental Offices*

Opportunities:
- *Renovations Only*

GABLE END DORMERS

Building Option C *(revised)*

Ⓒ Classroom addition at SW Corner of Building

Building Option C

LEVEL 1: *RE-PURPOSE (1) GENERAL CLASSROOM*

+ (2) NEW SCIENCE & PREP
+ APRX. 1,000 SF COLLABORATION SPACE

- (1) CLASSROOMS

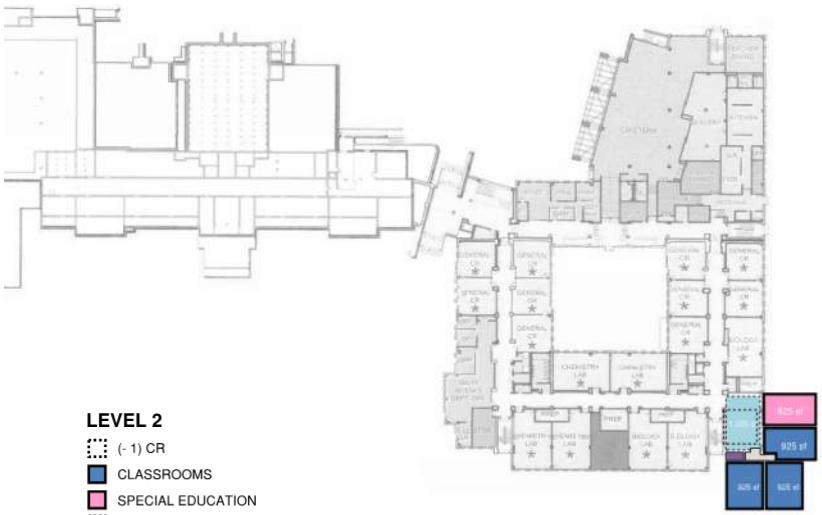
LEVEL 1
- (- 1) CR
- +2 SCIENCE CR
- +1 SCIENCE PREP
- +1 COLL. / OPEN SPACE
- CIRCULATION
- SITE PAVING WORK

Building Option C

LEVEL 2: *RE-PURPOSE (1) SCIENCE CLASSROOM*

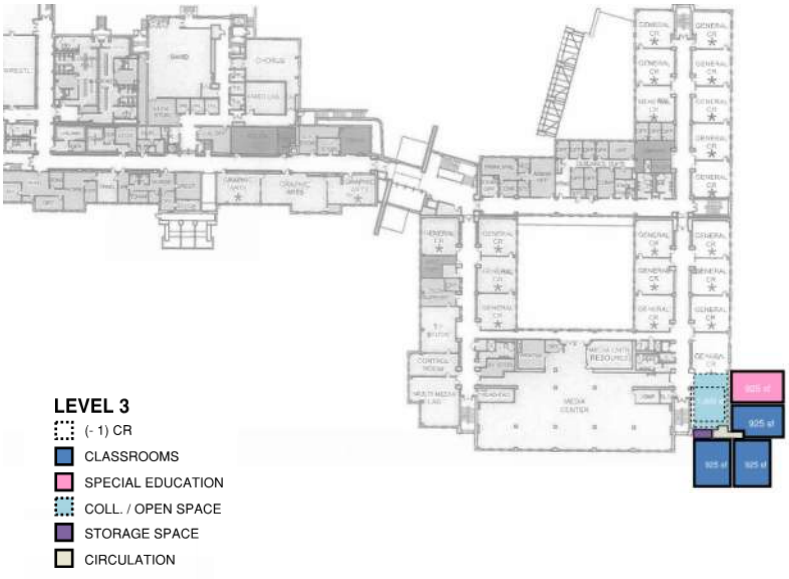
+ (3) NEW 925 SF CLRM
+ (1) NEW 925 SF SPECIAL EDUCATION CLRM
+ (1) NEW APRX. 1,000 SF COLLABORATION SPACE

- (1) SCIENCE ROOM



LEVEL 2
- (- 1) CR
- CLASSROOMS
- SPECIAL EDUCATION
- COLL. / OPEN SPACE
- STORAGE SPACE
- CIRCULATION

Building Option C

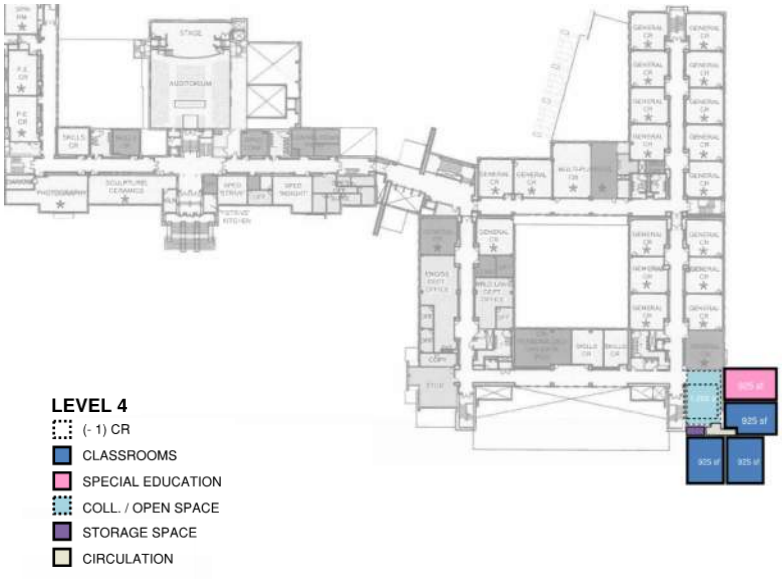


LEVEL 3: *RE-PURPOSE (1) GENERAL CLASSROOM*

+ (3) NEW 925 SF CLRM
+ (1) NEW 925 SF SPECIAL EDUCATION CLRM
+ (1) NEW APRX. 1,000 SF COLLABORATION SPACE

- (1) CLASSROOMS

Building Option C



LEVEL 4: *RE-PURPOSE (1) GENERAL CLASSROOM*

+ (3) NEW 925 SF CLRM
+ (1) NEW 925 SF SPECIAL EDUCATION CLRM
+ (1) NEW APRX. 1,000 SF COLLABORATION SPACE

- (1) CLASSROOMS

Building Option C

Net gain:

- ***(1) Science + Prep***

GAINS	LOSSES
+ 2 @ 1,640 sf	*- 1 @ 1440 sf*

- ***(6) Classrooms***

GAINS	LOSSES
+ 9 @ 925 sf	*- 1 @ 900 sf*
	- 2 @ 750 sf

- ***(3) Special Ed. Classrooms***

GAINS	LOSSES
+ 3 @ 925 sf	*none*

- ***(4) Collaboration Spaces***

Building Option C

+/- 12 – 16 months Duration

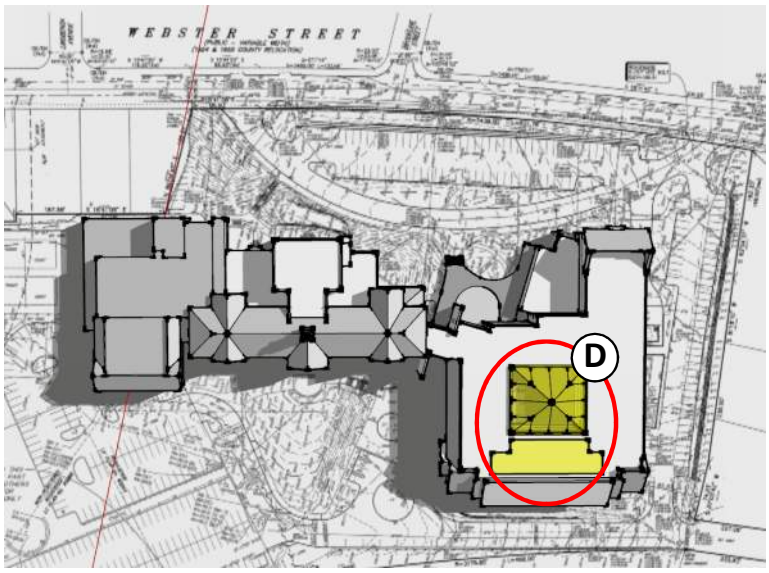
Constraints:

- *Temporary Classrooms Required*
- *Impact to Adjacent Classrooms*
- *Parking / Circulation impact*

Opportunities:

- *Single Phase*

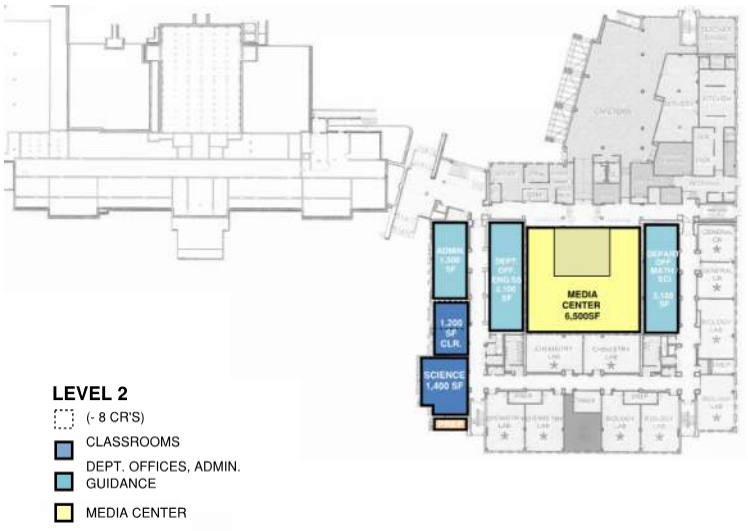
Building Option D



Ⓓ Relocated Media Center at Courtyard

Building Option D

*(*no change to Level 1)*

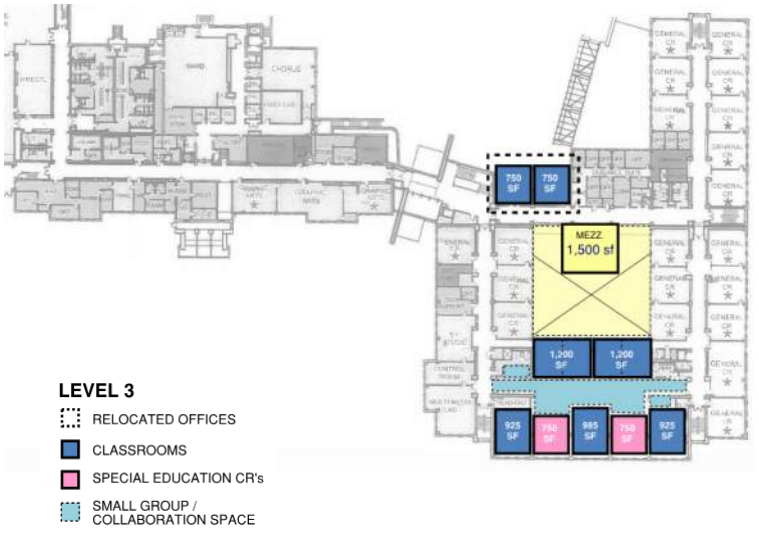


LEVEL 2: *DEMO (8) CR's TO CREATE (3) OFFICE SUITES*

+ (1) NEW 6,500 SF MEDIA CENTER
+ (1) NEW SCIENCE & PREP
+ (1) NEW 1,200 SF CLRM
+ 1500 SF ADMIN SPACE

- (8) CLASSROOMS
- REDUCED DEPARTMENT OFFICE SPACE

Building Option D

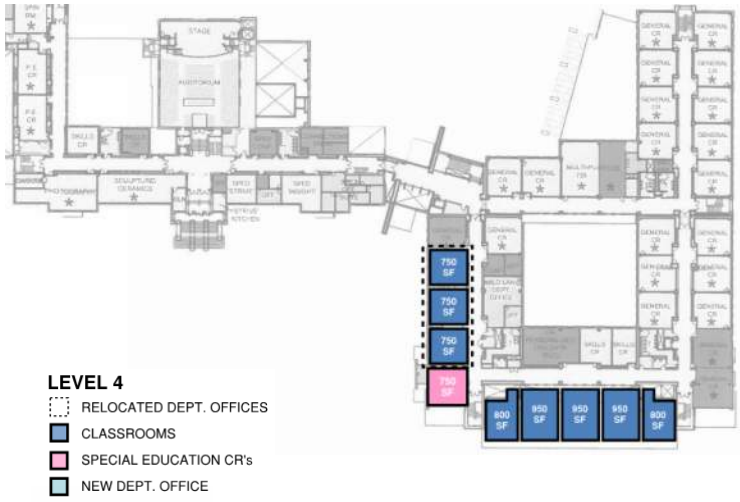


LEVEL 3: *RELOCATE ADMIN TO LEVEL 2*

+ (2) 750 SF CLRMS
+ (2) 1200 SF CLRMS
+ (3) 925 SF CLARMS
+ (2) 750 SF SPECIAL ED. CLASSROOMS
+ 1500 SF MEDIA CENTER
+ 2500 SF COLLABORATION SPACE

- 1500 SF ADMIN
- EXISTING MEDIA CENTER
- (2) CONFERENCE RMS
- (1) WORKROOM

Building Option D



LEVEL 4: *RENOVATED ROOF, NEW FLOOR STRUCTURE*

+ (3) 750 SF CLASSROOMS
+ (2) 800 SF CLASSROOMS
+ (3) 950 SF CLASSROOMS
+ (1) 750 SF SPECIAL ED. CLASSROOM

- REDUCED DEPARTMENT OFFICE SPACE
- STORAGE

Building Option D

Net gain:

- ***(1) Science + Prep***

GAINS	LOSSES
+ 1 @ 1,640 sf	*none*

- ***(8) Classrooms***

GAINS	LOSSES
+ 5 @ 750 sf	*- 8 @ 750 sf*
+ 2 @ 800 sf	
+ 6 @ 950 sf	
+ 3 @ 1200 sf	

- ***(3) Special Ed. Classrooms***

GAINS	LOSSES
+ 3 @ 750 sf	*none*

- ***(1) Collaboration Spaces***

Building Option D

+/- 14– 18 months Duration

Constraints:

- *Multiple areas impacted*
- *Multiple phases necessary*
- *Construction Access*
- *Reduced size Media Center*
- *Reduced Departmental Offices*

Opportunities:

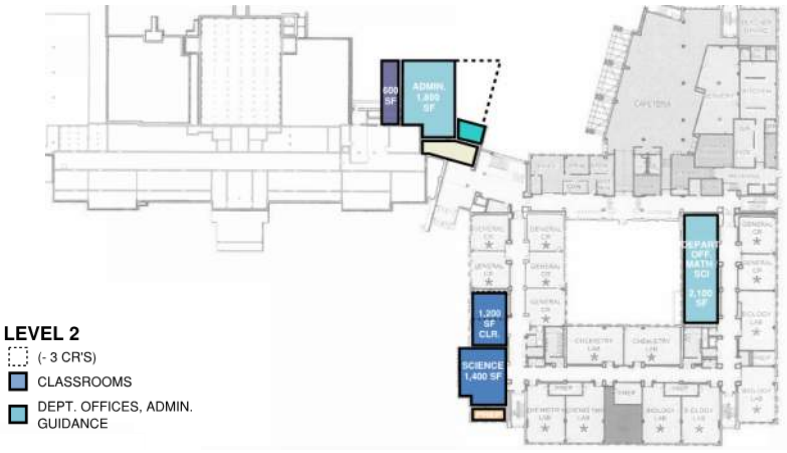
- *Create Central Media Center*
- *Classrooms in Core Area*

Building Option E

Ⓔ Relocated Media Center at Webster Street Entry Area

Building Option E

*(*no change to Level 1)*



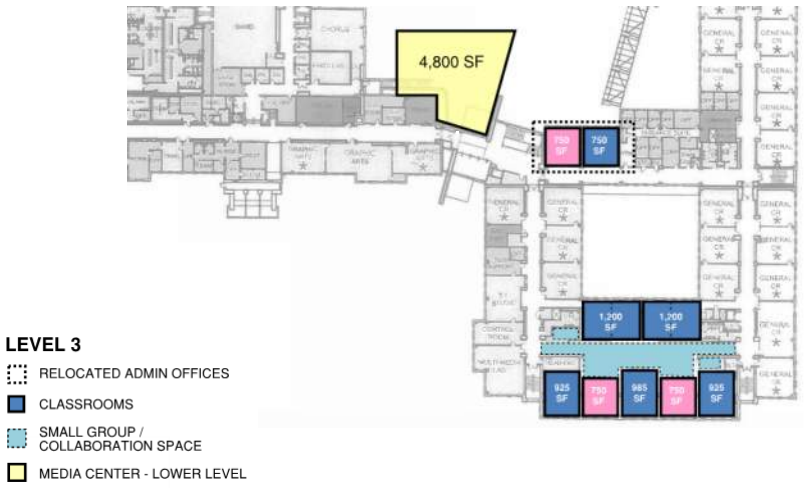
LEVEL 2: *DEMO (3) CR's FOR (1) DEPT. OFFICE SUITE*

+ (1) 1200 SF CLASSROOM
+ (1) SCIENCE + PREP
+ 1800 SF ADMIN SPACE
+ STORAGE

- (3) 750 SF CLASSROOMS
- REDUCED DEPARTMENT OFFICE SPACE

Building Option E

LEVEL 3: *RELOCATE ADMIN TO LEVEL 2*



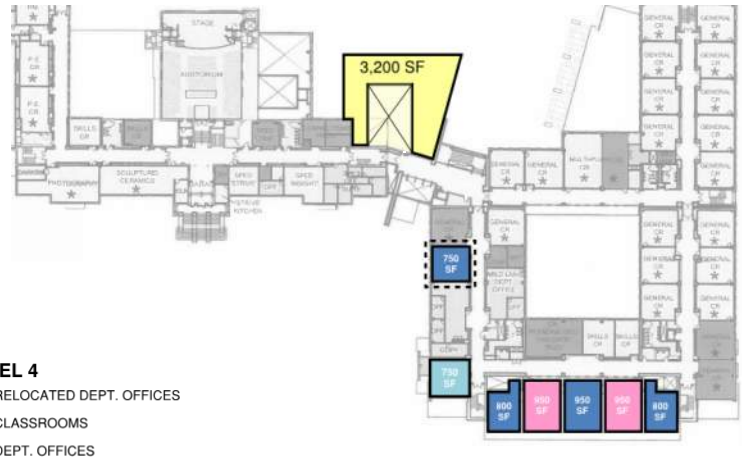
LEVEL 3
- RELOCATED ADMIN OFFICES
- CLASSROOMS
- SMALL GROUP / COLLABORATION SPACE
- MEDIA CENTER - LOWER LEVEL

+ (1) 750 SF CLASSROOM
+ (3) 950 SF CLASSROOM
+ (2) 1200 SF CLASSROOMS
+ (3) 750 SF SPECIAL ED. CLASSROOMS
+ COLLABORATION SPACE
+ MEDIA CENTER

- 1500 SF ADMIN OFFICE
- EXISTING MEDIA CENTER
- (2) CONFERENCE RMS
- (1) WORKROOM

Building Option E

LEVEL 4: *NEW UPPER LEVEL MEDIA*



LEVEL 4
- RELOCATED DEPT. OFFICES
- CLASSROOMS
- DEPT. OFFICES
- NEW MEDIA CENTER - UPPER LEVEL
- SPECIAL EDUCATION

+ (1) 750 SF CLASSROOM
+ (2) 800 SF CLASSROOM
+ (1) 950 SF CLASSROOM
+ (2) 950 SF SPECIAL ED. CLASSROOMS
+ MEDIA CENTER

- REDUCED DEPARTMENT OFFICE SPACE
- STORAGE

Building Option E

Net gain:

- ***(1) Science + Prep***

GAINS	LOSSES
+ 1 @ 1,440 sf	*none*

- ***(8) Classrooms***

GAINS	LOSSES
+ 2 @ 750 sf	*- 3 @ 750 sf*
+ 2 @ 800 sf	
+ 4 @ 950 sf	
+ 3 @ 1200 sf	

- ***(5) Special Ed. Classrooms***

GAINS	LOSSES
+ 3 @ 750 sf	*none*
+ 2 @ 950 SF	

- ***(1) Collaboration Spaces***

Building Option E

+/- 20 – 24 months Duration

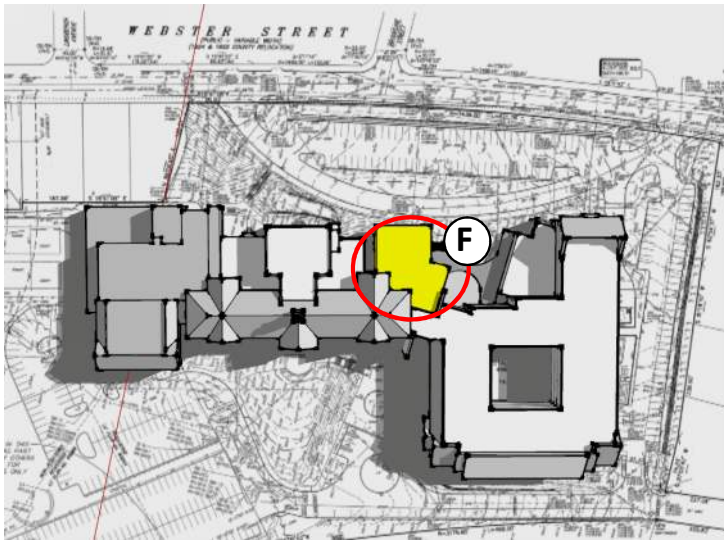
Constraints:

- *Multiple areas impacted*
- *Multiple phases necessary*
- *Construction Access / Impact*

Opportunities:

- *Properly sized Media Center*
- *New Classrooms located in core academic area*

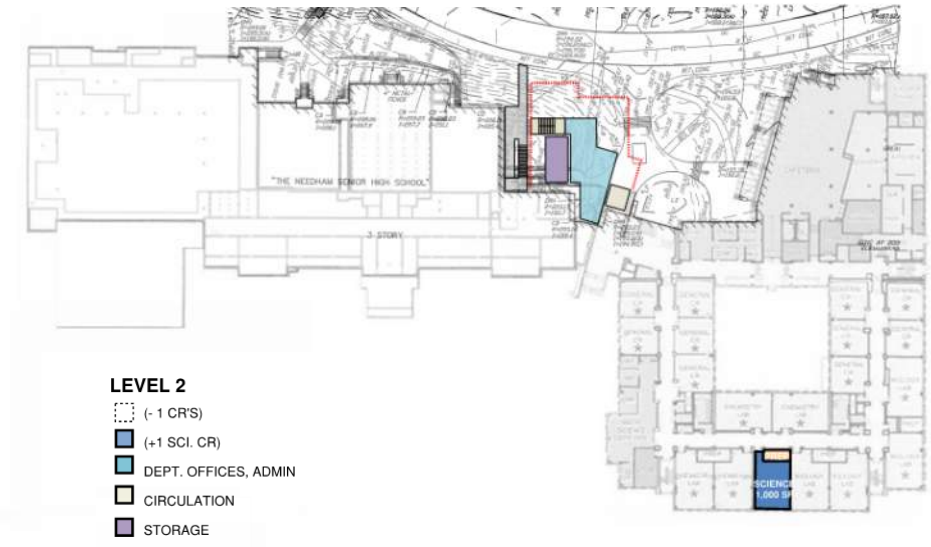
Building Option F



Ⓕ New Classroom Wing at Webster Street Entry

Building Option F

*(*no change to Level 1)*



LEVEL 2:

+ (1) SCIENCE + PREP
+ 1500 SF ADMIN
+ STORAGE

- SMALL SCIENCE + PREP

Building Option F

LEVEL 3:

+ (4) 925 SF CLRMS
+ (1) 1,200 SF CLRM
+ (1) 1450 SF SPECIAL ED. CLRMS
+ STUDENT COLLABORATION

- 1500 SF ADMIN OFFICE

Building Option F

LEVEL 4:

+ (3) 925 SF CLSSRMS
+ (1) 1,200 SF CLRM
+ (1) 925 SF SPECIAL ED. CLASSROOM
+ (1) 1100 SF SPECIAL ED. CLASSROOM
+ STUDENT COLLABORATION

- STORAGE SPACE

Building Option F

Net gain:

- ***(1) Science + Prep***

GAINS	LOSSES
+ 1 @ 1000 sf	*none*

- ***(8) Classrooms***

GAINS	LOSSES
+7 @ 925 sf	*- 1 @ 925*
+2 @ 1200 sf	

- ***(4) Special Ed. Classrooms***

GAINS	LOSSES
+ 2 @ 725 sf	*none*
+ 2 @ 925 sf	
+ 1 @ 1100 sf	

- ***(2) Collaboration Spaces***

Building Option F

+/- 12 – 14 months Duration

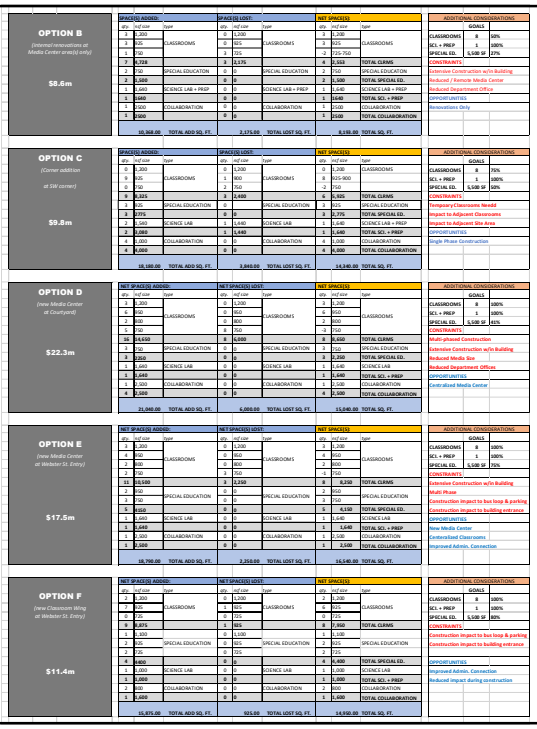
Constraints:

- *Construction Access / Impact at Webster St. Parking Lot*

Opportunities:

- *No impact on Media Center*
- *Single major phase*
- *Few areas impacted*

Comparative Matrix



OPTION B
(internal renovations at Media Center area(s) only)
$8.6m

SPACE(S) ADDED:			SPACE(S) LOST:			NET SPACE(S):		
qty.	nsf size	type	qty.	nsf size	type	qty.	nsf size	type
3	1,200		0	1,200		3	1,200	
3	925	CLASSROOMS	0	925	CLASSROOMS	3	925	CLASSROOMS
1	750		3	725		-2	725-750	
7	**4,728**		**3**	**2,175**		**4**	**2,553**	**TOTAL CLRMS**
2	750	SPECIAL EDUCATON	0	0	SPECIAL EDUCATON	2	750	SPECIAL EDUCATON
2	**1,500**		**0**	**0**		**2**	**1,500**	**TOTAL SPECIAL ED.**
1	1,640	SCIENCE LAB + PREP	0	0	SCIENCE LAB + PREP	1	1,640	SCIENCE LAB + PREP
1	**1640**		**0**	**0**		**1**	**1640**	**TOTAL SCI. + PREP**
1	2500	COLLABORATION	0	0	COLLABORATION	1	2500	COLLABORATION
1	**2500**		**0**	**0**		**1**	**2500**	**TOTAL COLLABORATION**
	10,368.00	**TOTAL ADD SQ. FT.**		**2,175.00**	**TOTAL LOST SQ. FT.**		**8,193.00**	**TOTAL SQ. FT.**

ADDITIONAL CONSIDERATIONS		
	GOALS	
CLASSROOMS	8	50%
SCI. + PREP	1	100%
SPECIAL ED.	5,500 SF	27%
CONSTRAINTS		
Extensive Construction w/in Building		
Reduced / Remote Media Center		
Reduced Department Office		
OPPORTUNITIES		
Renovations Only		

Comparative Matrix

OPTION B
(internal renovations at Media Center area(s) only)
$8.6m

SPACE(S) ADDED:			SPACE(S) LOST:			NET SPACE(S):		
qty.	nsf size	type	qty.	nsf size	type	qty.	nsf size	type
3	1,200		0	1,200		3	1,200	
3	925	CLASSROOMS	0	925	CLASSROOMS	3	925	CLASSROOMS
1	750		3	725		-2	725-750	
7	**4,728**		**3**	**2,175**		**4**	**2,553**	**TOTAL CLRMS**
2	750	SPECIAL EDUCATON	0	0	SPECIAL EDUCATON	2	750	SPECIAL EDUCATON
2	**1,500**		**0**	**0**		**2**	**1,500**	**TOTAL SPECIAL ED.**
1	1,640	SCIENCE LAB + PREP	0	0	SCIENCE LAB + PREP	1	1,640	SCIENCE LAB + PREP
1	**1640**		**0**	**0**		**1**	**1640**	**TOTAL SCI. + PREP**
1	2500	COLLABORATION	0	0	COLLABORATION	1	2500	COLLABORATION
1	**2500**		**0**	**0**		**1**	**2500**	**TOTAL COLLABORATION**
	10,368.00	**TOTAL ADD SQ. FT.**		**2,175.00**	**TOTAL LOST SQ. FT.**		**8,193.00**	**TOTAL SQ. FT.**

ADDITIONAL CONSIDERATIONS		
	GOALS	
CLASSROOMS	8	50%
SCI. + PREP	1	100%
SPECIAL ED.	5,500 SF	27%
CONSTRAINTS		
Extensive Construction w/in Building		
Reduced / Remote Media Center		
Reduced Department Office		
OPPORTUNITIES		
Renovations Only		

Comparative Matrix

OPTION C

(Corner addition at SW corner)

$9.8m

SPACE(S) ADDED:			SPACE(S) LOST:			NET SPACE(S):		
qty.	nsf size	type	qty.	nsf size	type	qty.	nsf size	type
0	1,200		0	1,200		0	1,200	CLASSROOMS
9	925	CLASSROOMS	1	900	CLASSROOMS	8	925-900	
0	750		2	750		-2	750	
9	**8,325**		**3**	**2,400**		**6**	**5,925**	**TOTAL CLRMS**
3	925	SPECIAL EDUCATION	0		SPECIAL EDUCATION	3	925	SPECIAL EDUCATION
3	**2775**		**0**	**0**		**3**	**2,775**	**TOTAL SPECIAL ED.**
2	1,540	SCIENCE LAB	1	1,440	SCIENCE LAB	1	1,640	SCIENCE LAB + PREP
2	**3,080**		**1**	**1,440**		**1**	**1,640**	**TOTAL SCI. + PREP**
4	1,000	COLLABORATION	0	0	COLLABORATION	4	1,000	COLLABORATION
4	**4,000**		**0**	**0**		**4**	**4,000**	**TOTAL COLLABORATION**
	18,180.00	**TOTAL ADD SQ. FT.**		**3,840.00**	**TOTAL LOST SQ. FT.**		**14,340.00**	**TOTAL SQ. FT.**

ADDITIONAL CONSIDERATIONS		
	GOALS	
CLASSROOMS	8	75%
SCI. + PREP	1	100%
SPECIAL ED.	5,500 SF	50%
CONSTRAINTS		
Tempoary Classrooms Needd		
Impact to Adjacent Classrooms		
Impact to Adjacent Site Area		
OPPORTUNITIES		
Single Phase Construction		

Comparative Matrix

OPTION D

(new Media Center at Courtyard)

$22.3m

NET SPACE(S) ADDED:			NET SPACE(S) LOST:			NET SPACE(S):		
qty.	nsf size	type	qty.	nsf size	type	qty.	nsf size	type
3	1,200		0	1,200		3	1,200	
6	950	CLASSROOMS	0	950	CLASSROOMS	6	950	CLASSROOMS
2	800		0	800		2	800	
5	750		8	750		-3	750	
16	**14,650**		**8**	**6,000**		**8**	**8,650**	**TOTAL CLRMS**
3	750	SPECIAL EDUCATION	0	0	SPECIAL EDUCATION	3	750	SPECIAL EDUCATION
3	**2250**		**0**	**0**		**3**	**2,250**	**TOTAL SPECIAL ED.**
1	1,640	SCIENCE LAB	0	0	SCIENCE LAB	1	1,640	SCIENCE LAB
1	**1,640**		**0**	**0**		**1**	**1,640**	**TOTAL SCI. + PREP**
1	2,500	COLLABORATION	0	0	COLLABORATION	1	2,500	COLLABORATION
4	**2,500**		**0**	**0**		**4**	**2,500**	**TOTAL COLLABORATION**
	21,040.00	**TOTAL ADD SQ. FT.**		**6,000.00**	**TOTAL LOST SQ. FT.**		**15,040.00**	**TOTAL SQ. FT.**

ADDITIONAL CONSIDERATIONS		
	GOALS	
CLASSROOMS	8	100%
SCI. + PREP	1	100%
SPECIAL ED.	5,500 SF	41%
CONSTRAINTS		
Multi-phased Construction		
Extensive Construction w/in Building		
Reduced Media Size		
Reduced Department Offices		
OPPORTUNITIES		
Centralized Media Center		

Comparative Matrix

OPTION E

(new Media Center at Webster St. Entry)

$17.5m

NET SPACE(S) ADDED:			NET SPACE(S) LOST:			NET SPACE(S):		
qty.	nsf size	type	qty.	nsf size	type	qty.	nsf size	type
3	1,200	CLASSROOMS	0	1,200	CLASSROOMS	3	1,200	CLASSROOMS
4	950		0	950		4	950	
2	800		0	800		2	800	
2	750		3	750		-1	750	
11	**10,500**		**3**	**2,250**		**8**	**8,250**	**TOTAL CLRMS**
2	950	SPECIAL EDUCATION	0	0	SPECIAL EDUCATION	2	950	SPECIAL EDUCATION
3	750		0	0		3	750	
5	**4150**		**0**	**0**		**5**	**4,150**	**TOTAL SPECIAL ED.**
1	1,640	SCIENCE LAB	0	0	SCIENCE LAB	1	1,640	SCIENCE LAB
1	**1,640**		**0**	**0**		**1**	**1,640**	**TOTAL SCI. + PREP**
1	2,500	COLLABORATION	0	0	COLLABORATION	1	2,500	COLLABORATION
1	**2,500**		**0**	**0**		**1**	**2,500**	**TOTAL COLLABORATION**
	18,790.00	**TOTAL ADD SQ. FT.**		**2,250.00**	**TOTAL LOST SQ. FT.**		**16,540.00**	**TOTAL SQ. FT.**

ADDITIONAL CONSIDERATIONS		
	GOALS	
CLASSROOMS	**8**	**100%**
SCI. + PREP	**1**	**100%**
SPECIAL ED.	**5,500 SF**	**75%**
CONSTRAINTS		
Extensive Construction w/in Building		
Multi Phase		
Construction impact to bus loop & parking		
Construction impact to building entrance		
OPPORTUNITIES		
New Media Center		
Centeralized Classrooms		
Improved Admin. Connection		

Comparative Matrix

OPTION F

(new Classroom Wing at Webster St. Entry)

$11.4m

NET SPACE(S) ADDED:			NET SPACE(S) LOST:			NET SPACE(S):		
qty.	nsf size	type	qty.	nsf size	type	qty.	nsf size	type
2	1,200	CLASSROOMS	0	1,200	CLASSROOMS	2	1,200	CLASSROOMS
7	925		1	925		6	925	
0	725		0	725		0	725	
9	**8,875**		**1**	**925**		**8**	**7,950**	**TOTAL CLRMS**
1	1,100		0	1,100		1	1,100	
2	925	SPECIAL EDUCATION	0	925	SPECIAL EDUCATION	2	925	SPECIAL EDUCATION
2	725		0	725		2	725	
4	**4400**		**0**	**0**		**4**	**4,400**	**TOTAL SPECIAL ED.**
1	1,000	SCIENCE LAB	0	0	SCIENCE LAB	1	1,000	SCIENCE LAB
1	**1,000**		**0**	**0**		**1**	**1,000**	**TOTAL SCI. + PREP**
2	800	COLLABORATION	0	0	COLLABORATION	2	800	COLLABORATION
1	**1,600**		**0**	**0**		**1**	**1,600**	**TOTAL COLLABORATION**
	15,875.00	**TOTAL ADD SQ. FT.**		**925.00**	**TOTAL LOST SQ. FT.**		**14,950.00**	**TOTAL SQ. FT.**

ADDITIONAL CONSIDERATIONS		
	GOALS	
CLASSROOMS	**8**	**100%**
SCI. + PREP	**1**	**100%**
SPECIAL ED.	**5,500 SF**	**80%**
CONSTRAINTS		
Construction impact to bus loop & parking		
Construction impact to building entrance		
OPPORTUNITIES		
Improved Admin. Connection		
Reduced impact during construction		

Comparative Matrix

OPTION B

(internal renovations at Media Center area(s) only)

$8.6m

ADDITIONAL CONSIDERATIONS		
	GOALS	
CLASSROOMS	8	50%
SCI. + PREP	1	100%
SPECIAL ED.	5,500 SF	27%
CONSTRAINTS		
Extensive Construction w/in Building		
Reduced / Remote Media Center		
Reduced Department Office		
OPPORTUNITIES		
Renovations Only		

OPTION D

(new Media Center at Courtyard)

$22.3m

ADDITIONAL CONSIDERATIONS		
	GOALS	
CLASSROOMS	8	100%
SCI. + PREP	1	100%
SPECIAL ED.	5,500 SF	41%
CONSTRAINTS		
Multi-phased Construction		
Extensive Construction w/in Building		
Reduced Media Size		
Reduced Department Offices		
OPPORTUNITIES		
Centralized Media Center		

OPTION F

(new Classroom Wing at Webster St. Entry)

$11.4m

ADDITIONAL CONSIDERATIONS		
	GOALS	
CLASSROOMS	8	100%
SCI. + PREP	1	100%
SPECIAL ED.	5,500 SF	80%
CONSTRAINTS		
Construction impact to bus loop & parking		
Construction impact to building entrance		
OPPORTUNITIES		
Improved Admin. Connection		
Reduced impact during construction		

OPTION C

(Corner addition at SW corner)

$9.8m

ADDITIONAL CONSIDERATIONS		
	GOALS	
CLASSROOMS	8	75%
SCI. + PREP	1	100%
SPECIAL ED.	5,500 SF	50%
CONSTRAINTS		
Tempoary Classrooms Needd		
Impact to Adjacent Classrooms		
Impact to Adjacent Site Area		
OPPORTUNITIES		
Single Phase Construction		

OPTION E

(new Media Center at Webster St. Entry)

$17.5m

ADDITIONAL CONSIDERATIONS		
	GOALS	
CLASSROOMS	8	100%
SCI. + PREP	1	100%
SPECIAL ED.	5,500 SF	75%
CONSTRAINTS		
Extensive Construction w/in Building		
Multi Phase		
Construction impact to bus loop & parking		
Construction impact to building entrance		
OPPORTUNITIES		
New Media Center		
Centeralized Classrooms		
Improved Admin. Connection		

THANK YOU!

MCKIBBEN REPORT

Needham Public Schools, MA
Demographic Study

January 2017

McKibben Demographics

Table of Contents

Executive Summary

1. The resident total fertility rate for Needham Public Schools over the life of the forecasts is below replacement level. (1.87 vs. the replacement level of 2.1)

2. Most in-migration to the district continues to occur in the 0-to-9 and 30-to-44 year old age groups.

3. The local 18-to-24 year old population continues to leave the district, going to college or moving to other urbanized areas. This population group accounts for the largest segment of the district's out migration flow.

4. The primary factor causing the district's enrollment to slightly decline over the next 15 years is a substantial increase in the number of empty nest households (home owners age 70+) "turning over", however this will still be smaller than the number of homes (homeowners age 50-59) that also become empty nest households.

5. Changes in year-to-year enrollment over the next five years will primarily be due to the size of the grade cohorts entering and moving through the school system in conjunction with the size of the cohorts leaving the system.

6. The elementary enrollment will begin a slight decline after the 2021-22 school year. This will be due primarily to the fact that the rising 5th grade cohorts will be greater the 400 in size while the incoming grade cohorts will decline slightly.

7. The median age of the population will increase from 42.9 in 2010 to 43.9 in 2030.

8. Even if the district continues to have some of annual new home construction (even if that construction is rental units), the rate, magnitude and price of existing home sales will become the increasingly dominant factor affecting the amount of population and enrollment change.

9. Total district enrollment is forecasted to increase by 108 students, or 1.9%, between 2016-17 and 2021-22. Total enrollment is forecasted to decline by 138 students, or -2.4%, from 2021-22 to 2026-27. The total enrollment is forecasted to decline by 172 students, or -3.1%, from 2026-27 to 2031-32.

INTRODUCTION

By demographic principle, distinctions are made between projections and forecasts. A projection extrapolates the past (and present) into the future with little or no attempt to take into account any factors that may impact the extrapolation (e.g., changes in fertility rates, housing patterns or migration patterns) while a forecast results when a projection is modified by reasoning to take into account the aforementioned factors.

To maximize the use of this study as a planning tool, the ultimate goal is not simply to project the past into the future, but rather to assess various factors' impact on the future. The future population and enrollment changes for each school district are influenced by a variety of factors. Not all factors will influence the entire school district at the same level. Some may affect different areas at dissimilar magnitudes and rates causing changes at varying points of time within the same district. The forecaster's judgment, based on a thorough and intimate study of the district, has been used to modify the demographic trends and factors to more accurately predict likely changes. Therefore, strictly speaking, this study is a forecast, not a projection; and the amount of modification of the demographic trends varies between different areas of the district as well as within the timeframe of the forecast.

To calculate population forecasts of any type, particularly for smaller populations such as a school district, realistic suppositions must be made as to what the future will bring in terms of age specific fertility rates and residents' demographic behavior at certain points of the life course. The demographic history of the school district and its interplay with the social and economic history of the area is the starting point and the basis of most of these suppositions particularly on key factors such as the age structure of the area. The unique nature of each district's and attendance area's demographic composition and rate of change over time must be assessed and understood to be factors throughout the life of the forecast series. Moreover, no two populations, particularly at the school district, have exactly the same characteristics.

The manifest purpose of these forecasts is to ascertain the demographic factors that will ultimately influence the enrollment levels in the district's schools. There are of course, other non-demographic factors that affect enrollment levels over time. These factors include, but are not limited to: transfer policies within the district; student transfers to and from neighboring districts, placement of "special programs" within school facilities that may serve students from outside the attendance area, state or federal mandates that dictate the movement of students from one facility to another (No Child Left Behind was an excellent example of this factor), the development of charter schools in the district, the prevalence of home schooling in the area, and the dynamics of local private schools.

Unless the district specifically requests the calculation of forecasts that reflect the effects of changes in these non-demographic factors, their influences are held constant for the life of the forecasts. Again, the main function of these forecasts is to determine what impact demographic changes will have on future enrollment. It is quite possible to calculate special "scenario" forecasts to measure the impact of school policy modifications as well as planned economic and financial changes. However in this case the results of these population and enrollment forecast are meant to represent the most likely

scenario for changes over the next 10 years in the district and its attendance areas.

The first part of the report will examine the assumptions made in calculating the population forecasts for the Needham Public Schools. Since the results of the population forecasts drive the subsequent enrollment forecasts, the assumptions listed in this section are paramount to understanding the area's demographic dynamics. The remainder of the report is an explanation and analysis of the district's population forecasts and how they will shape the district's grade level enrollment forecasts.

DATA

The data used for the forecasts come from a variety of sources. The Needham Public Schools provided enrollments by grade and attendance center for the school years 2010-2011 to 2016-17. Birth and death data for the years 2000 through 2014 were obtained from the Massachusetts Department of Health. The net migration values were calculated using Internal Revenue Service migration reports for the years 2000 through 2013. The data used for the calculation of migration models came from the United States Bureau of the Census, 2005 to 2010, and the models were designed using demographic and economic factors. The base age-sex population counts used are from the results of the 2010 Census.

Recently the Census Bureau began releasing annual estimates of demographic variables at the block group and tract level from the American Community Survey (ACS). There has been wide scale reporting of these results in the national, state and local media. However, due to the methodological problems the Census Bureau is experiencing with their estimates derived from ACS data, particularly in areas with a population of less than 60,000, the results of the ACS are not used in these forecasts. For example, given the sampling framework used by the Census Bureau, each year only 110 of the over 3,400 current households in the district would have been included. For comparison 570 households in the district were included in the sample for the long form questionnaire in the 2000 Census. As a result of this small sample size, the ACS survey results from the last 5 years must be aggregated to produce the tract and block group estimates.

To develop the population forecast models, past migration patterns, current age specific fertility patterns, the magnitude and dynamics of the gross migration, the age specific mortality trends, the distribution of the population by age and sex, the rate and type of existing housing unit sales, and future housing unit construction are considered to be primary variables. In addition, the change in household size relative to the age structure of the forecast area was addressed. While there was a slight drop in the average household size in the Needham Public Schools as well as most other areas of the state during the previous 20 years, the rate of this decline has been forecasted to slow over the next ten years.

ASSUMPTIONS

For these forecasts, the mortality probabilities are held constant at the levels calculated for the year 2010. While the number of deaths in an area are impacted by and will change given the proportion of the local population over age 65, in the absence of an extraordinary event such as a natural disaster or a breakthrough in the treatment of heart disease, death rates rarely move rapidly in any direction, particularly at the school district or

attendance area level. Thus, significant changes are not foreseen in district's mortality rates between now and the year 2026. Any increases forecasted in the number of deaths will be due primarily to the general aging of the district's population and specifically to the increase in the number of residents aged 65 and older.

Similarly, fertility rates are assumed to stay fairly constant for the life of the forecasts. Like mortality rates, age specific fertility rates rarely change quickly or dramatically, particularly in small areas. Even with the recently reported rise in the age 30 to 39 year old fertility rates of the United States, overall fertility rates have stayed within a 10% range for most of the last 40 years. In fact, the vast majority of year to year change in an area's number of births is due to changes in the number of women in child bearing ages (particularly ages 20-34) rather than any fluctuation in an area's fertility rate.

The total fertility rate (TFR), the average number of births a woman will have while living in the school district during her lifetime, is estimated to be 1.87 for the total district for the ten years of the population forecasts. A TFR of 2.1 births per woman is considered to be the theoretical "replacement level" of fertility necessary for a population to remain constant in the absence of in-migration. Therefore, in the absence of migration, fertility alone would be insufficient to maintain the current level of population and enrollment within the Needham Public Schools over the course of the forecast period.

A close examination of data for the Needham Public Schools has shown the age specific pattern of net migration will be nearly constant throughout the life of the forecasts. While the number of in and out migrants has changed in past years for the Needham Public Schools (and will change again over the next 10 years), the basic age pattern of the migrants has stayed nearly the same over the last 30 years. Based on the analysis of data it is safe to assume this age specific migration trend will remain unchanged into the future. This pattern of migration shows most of the local out-migration occurring in the 18-to-24 year old age group as young adults leave the area to go to college or move to other urbanized areas. The second largest group of out-migrants are those householders aged 70 and older who are downsizing their residences. Most of the local in-migration occurs in the 0-to-9 and 30-44 age groups (the bulk of the which come from areas within 75 miles of the Needham Public Schools) primarily consisting of younger adults and their children.

As the Norfolk County area is not currently contemplating any major expansions or contractions, the forecasts also assume that the current economic, political, social, and environmental factors, as well as the transportation and public works infrastructure (with a few notable exceptions) of the Needham Public Schools and its attendance areas will remain the same through the year 2026. Below is a list of assumptions and issues that are specific to the Needham Public Schools. These issues have been used to modify the population forecast models to more accurately predict the impact of these factors on each area's population change. Specifically, the forecasts for the Needham Public School assume that throughout the study period:

a. There will be no short term economic recovery in the next 18 months and the national, state or regional economy does not go into deep recession at any time during the 10 years of the forecasts; (Deep recession is defined as four

consecutive quarters where the GDP contracts greater than 1% per quarter)

b. Interest rates have reached a historic low and will not fluctuate more than one percentage point in the short term; the interest rate for a 30 year fixed home mortgage stays below 5.0%;
c. The rate of mortgage approval stays at 1999-2003 levels and lenders do not return to "sub-prime" mortgage practices;
d. There are no additional restrictions placed on home mortgage lenders or additional bankruptcies of major credit providers;
e. The rate of housing foreclosures does not exceed 125% of the 2005-2007 average of Norfolk County for any year in the forecasts;
f. All currently platted and approved housing developments are built out and completed by 2025. All housing units constructed are occupied by 2026.
g. The unemployment rates for the Norfolk County and the Boston Metropolitan Area will remain below 4.5% for the 10 years of the forecasts;
h. The rate of students transferring into and out of the Needham Public Schools will remain at the 2011-12 to 2016-17 average;
i. The inflation rate for gasoline will stay below 5% per year for the 10 years of the forecasts;
j. The town of Needham will average approximately 75 new housing units constructed annually until 2020. The average will drop to 50 per year between 2021 and 2035.
k. There will be no building moratorium within the district;
l. Businesses within the district and the Needham Public Schools area will remain viable;
m. The number of existing home sales in the district that are a result of "distress sales" (homes worth less than the current mortgage value) will not exceed 20% of total homes sales in the district for any given year;
n. Housing turnover rates (sale of existing homes in the district) will remain at their current levels. The majority of existing home sales are made by home owners over the age of 60;
o. Private school and home school attendance rates will remain constant;
p. The rate of foreclosures for commercial property remains at the 2004-2008 average for Norfolk County;

If a major employer in the district or in the Greater Boston Metropolitan Area closes, reduces or expands its operations, the population forecasts would need to be adjusted to reflect the changes brought about by the change in economic and employment conditions. The same holds true for any type of natural disaster, major change in the local infrastructure (e.g., highway construction, water and sewer expansion, changes in zoning regulations etc.), a further economic downturn, any additional weakness in the housing market or any instance or situation that causes rapid and dramatic population changes that could not be foreseen at the time the forecasts were calculated.

The high proportion of high school graduates from the Needham Public Schools that attend college or move to urban areas outside of the district for employment is a significant demographic factor. Their departure is a major reason for the extremely high out-migration in the 18-to-24 year old age

group, and was taken into account when calculating these forecasts. The out-migration of graduating high school seniors is expected to continue over the period of the forecasts and the rate of out-migration has been forecasted to remain the same over the life of the forecast series.

Finally, all demographic trends (i.e., births, deaths, and migration) are assumed to be linear in nature and annualized over the forecast period. For example, if 1,000 births are forecasted for a 5-year period, an equal number, or proportion of the births are assumed to occur every year, 200 per year. Actual year-to-year variations do and will occur, but overall year to year trends are expected to be constant.

METHODOLOGY

The population forecasts presented in this report are the result of using the Cohort-Component Method of population forecasting (Siegel, and Swanson, 2004: 561-601) (Smith et. al. 2004). As stated in the **INTRODUCTION**, the difference between a projection and a forecast is in the use of explicit judgment based upon the unique features of the area under study. Strictly speaking, a cohort projection refers to the future population that would result from a mathematical extrapolation of historical trends. Conversely, a cohort-component forecast refers to the future population that is expected because of a studied and purposeful selection of the components of change (i.e., births, deaths, and migration) and forecast models are developed to measure the impact of these changes in each specific geographic area.

Five sets of data are required to generate population and enrollment forecasts. These five data sets are:

1. a base-year population (here, the 2010 Census population for Needham Public Schools);
2. a set of age-specific fertility rates for the district and the attendance areas to be used over the forecast period;
3. a set of age-specific survival (mortality) rates for the district and the attendance areas;
4. a set of age-specific migration rates for the district and the attendance areas, and;
5. the historical enrollment figures by grade.

The most significant and difficult aspect of producing enrollment forecasts is the generation of the population forecasts in which the school age population (and enrollment) is embedded. In turn, the most challenging aspect of generating the population forecasts is found in deriving the rates of change in fertility, mortality, and migration. From the standpoint of demographic analysis, the Needham Public Schools is classified as a "small area" population (as compared to the population of the state of Massachusetts or to that of the United States). Small area population forecasts are more complicated to calculate because local variations in fertility, mortality, and migration may be more irregular than those at the regional, state or national scale. Especially challenging is the forecast of the migration rates for local areas, because changes in the area's socioeconomic characteristics can quickly change from past and current patterns (Peters and Larkin, 2002.)

The population forecasts for Needham Public Schools were calculated using a cohort-component method with the populations divided into male and female groups by five-year age cohorts that range from 0-to-4 years of

age to 85 years of age and older (85+). Age- and sex-specific fertility, mortality, and migration models were constructed to specifically reflect the unique demographic characteristics of each of the attendance areas in the Needham Public Schools.

The enrollment forecasts were calculated using a modified average survivorship method. Average survivor rates (i.e., the proportion of students who progress from one grade level to the next given the average amount of net migration for that grade level) over the previous five years of year-to-year enrollment data were calculated for grades two through twelve. This procedure is used to identify specific grades where there are large numbers of students changing facilities for non-demographic factors, such as private school transfers or enrollment in special programs.

The survivorship rates were modified or adjusted to reflect the average rate of forecasted in and out-migration of 5-to-9, 10-to-14 and 15-to-17 year old cohorts to each of the attendance centers in Needham Public Schools for the period 2010 to 2016. These survivorship rates then were adjusted to reflect the forecasted changes in age-specific migration the district should experience over the next five years. These modified survivorship rates were used to project the enrollment of grades 2 through 12 for the period 2017 to 2021. The survivorship rates were adjusted again for the period 2021 to 2026 to reflect the predicted changes in the amount of age-specific migration in the district for the period. The procedure is repeated again for the 2026 to 2031 time period.

The forecasted enrollments for kindergarten and first grade are derived from the 5-to-9 year old population of the age-sex population forecast at the elementary attendance center district level. This procedure allows the changes in the incoming grade sizes to be factors of forecasted population change and not an extrapolation of previous class sizes. Given the potentially large amount of variation in Kindergarten enrollment due to parental choice, changes in the state's minimum age requirement, and differing district policies on allowing children to start Kindergarten early, first grade enrollment is deemed to be a more accurate and reliable starting point for the forecasts. (McKibben, 1996) The level of the accuracy for both the total population and total enrollment forecasts at the school district level is estimated to be ±2.0% for the life of the forecasts.

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Appendix A: Population Forecasts

Needham Public Schools: Total Population

Males	2010	2015	2020	2025	2030
0-4	919	870	810	800	770
5-9	1,279	1,120	1,160	1,090	1,040
10-14	1,270	1,310	1,160	1,200	1,120
15-19	990	1,020	1,040	910	960
20-24	554	630	670	670	560
25-29	361	450	570	580	570
30-34	420	560	650	760	780
35-39	858	620	760	830	930
40-44	1,093	890	650	810	880
45-49	1,208	1,080	860	630	830
50-54	1,161	1,180	1,070	850	620
55-59	997	1,140	1,150	1,040	840
60-64	887	930	1,040	1,090	970
65-69	545	780	820	940	980
70-74	376	410	610	660	750
75-79	367	330	340	540	570
80-84	308	350	290	310	480
85+	331	320	320	320	310
Total	13,924	13,990	13,970	14,030	13,960

Females	2010	2015	2020	2025	2030
0-4	952	840	790	780	750
5-9	1,209	1,160	1,140	1,080	1,030
10-14	1,197	1,240	1,200	1,180	1,100
15-19	873	940	970	950	940
20-24	427	490	610	590	590
25-29	352	320	440	510	500
30-34	559	550	520	650	710
35-39	897	760	760	700	820
40-44	1,200	920	790	810	760
45-49	1,315	1,190	920	790	840
50-54	1,258	1,300	1,190	910	790
55-59	1,048	1,240	1,280	1,170	910
60-64	914	1,000	1,170	1,230	1,110
65-69	640	840	910	1,080	1,140
70-74	498	540	720	800	940
75-79	463	430	450	620	690
80-84	468	450	400	420	580
85+	710	750	740	730	720
Total	14,980	14,960	15,000	15,000	14,920

Total	2010	2015	2020	2025	2030
0-4	1,871	1,710	1,600	1,580	1,520
5-9	2,488	2,280	2,300	2,170	2,070
10-14	2,467	2,550	2,360	2,380	2,220
15-19	1,863	1,960	2,010	1,860	1,900
20-24	981	1,120	1,280	1,260	1,150
25-29	713	770	1,010	1,090	1,070
30-34	979	1,110	1,170	1,410	1,490
35-39	1,755	1,380	1,520	1,530	1,750
40-44	2,293	1,810	1,440	1,620	1,640
45-49	2,523	2,270	1,780	1,420	1,670
50-54	2,419	2,480	2,260	1,760	1,410
55-59	2,045	2,380	2,430	2,210	1,750
60-64	1,801	1,930	2,210	2,320	2,080
65-69	1,185	1,620	1,730	2,020	2,120
70-74	874	950	1,330	1,460	1,690
75-79	830	760	790	1,160	1,260
80-84	776	800	690	730	1,060
85+	1,041	1,070	1,060	1,050	1,030
Total	28,904	28,950	28,970	29,030	28,880
Median Age	42.9	44.4	44.3	43.8	43.9

	2010 to 2015	2015 to 2020	2020 to 2025	2025 to 2030
Births	1,070	1,070	1,180	1,190
Deaths	1,410	1,490	1,520	1,580
Natural Increase	-340	-420	-340	-390
Net Migration	390	380	340	310
Change	50	-40	0	-80

Differences between period Totals may not equal Change due to rounding.

Broadmeadow Elementary

Males	2010	2015	2020	2025	2030
0-4	196	180	170	170	160
5-9	280	250	240	220	220
10-14	287	290	260	240	220
15-19	172	220	230	200	190
20-24	67	70	130	110	100
25-29	50	40	40	80	70
30-34	52	80	70	100	130
35-39	182	120	140	130	150
40-44	222	190	130	150	130
45-49	249	220	180	120	150
50-54	205	240	220	180	120
55-59	203	200	240	210	180
60-64	165	190	190	230	200
65-69	92	140	170	170	200
70-74	77	60	100	140	130
75-79	61	70	40	90	120
80-84	58	60	60	40	80
85+	38	50	50	60	50
Total	2,652	2,670	2,660	2,640	2,600

Females	2010	2015	2020	2025	2030
0-4	195	170	160	170	160
5-9	282	250	230	220	220
10-14	258	290	260	240	220
15-19	168	190	230	200	190
20-24	71	60	100	110	100
25-29	47	40	40	50	70
30-34	75	80	70	100	100
35-39	197	140	140	130	150
40-44	243	200	150	150	140
45-49	263	240	200	150	150
50-54	236	260	240	200	150
55-59	191	230	260	240	200
60-64	164	190	230	250	230
65-69	116	140	170	200	230
70-74	95	90	120	150	170
75-79	94	80	70	100	130
80-84	85	90	80	60	100
85+	70	100	110	120	120
Total	2,846	2,840	2,860	2,840	2,830

Total	2010	2015	2020	2025	2030
0-4	391	350	330	340	320
5-9	562	500	470	440	440
10-14	545	580	520	480	440
15-19	340	410	460	400	380
20-24	138	130	230	220	200
25-29	97	80	80	130	140
30-34	127	160	140	200	230
35-39	378	260	280	260	300
40-44	465	390	280	300	270
45-49	512	460	380	270	300
50-54	441	500	460	380	270
55-59	394	430	500	450	380
60-64	329	380	420	480	430
65-69	207	280	340	370	430
70-74	172	150	220	290	300
75-79	155	150	110	190	250
80-84	142	150	140	100	180
85+	107	150	160	180	170
Total	5,498	5,510	5,520	5,480	5,430
Median Age	41.9	43.7	44.5	44.5	44.9

	2010 to 2015	2015 to 2020	2020 to 2025	2025 to 2030
Births	170	170	180	180
Deaths	230	250	270	280
Natural Increase	-60	-80	-90	-100
Net Migration	70	60	60	50
Change	10	-20	-30	-50

Differences between period Totals may not equal Change due to rounding.

Eliot Elementary

Males	2010	2015	2020	2025	2030
0-4	135	150	130	140	130
5-9	196	170	200	190	180
10-14	184	200	180	210	200
15-19	116	160	170	150	180
20-24	82	80	90	100	90
25-29	80	90	90	100	100
30-34	102	120	140	140	150
35-39	137	130	150	170	160
40-44	197	130	140	170	190
45-49	178	190	130	130	170
50-54	183	170	190	130	130
55-59	141	180	170	190	130
60-64	125	120	150	150	160
65-69	75	100	90	130	120
70-74	52	50	70	70	100
75-79	73	40	40	60	50
80-84	56	70	30	30	50
85+	59	60	60	50	40
Total	2,168	2,210	2,220	2,310	2,330

Females	2010	2015	2020	2025	2030
0-4	147	140	130	130	130
5-9	175	180	200	190	170
10-14	167	180	190	210	190
15-19	130	140	150	160	170
20-24	60	90	80	70	100
25-29	77	70	100	80	80
30-34	123	110	120	150	130
35-39	142	150	150	150	170
40-44	188	140	160	170	170
45-49	191	190	140	160	170
50-54	201	190	190	140	160
55-59	165	200	190	180	140
60-64	120	140	170	170	160
65-69	85	100	120	150	140
70-74	85	70	80	100	130
75-79	93	70	50	60	80
80-84	85	90	60	50	60
85+	138	140	140	130	110
Total	2,369	2,390	2,420	2,450	2,460

Total	2010	2015	2020	2025	2030
0-4	281	290	260	270	260
5-9	370	350	400	380	350
10-14	350	380	370	420	390
15-19	245	300	320	310	350
20-24	142	170	170	170	190
25-29	157	160	190	180	180
30-34	225	230	260	290	280
35-39	279	280	300	320	330
40-44	385	270	300	340	360
45-49	369	380	270	290	340
50-54	384	360	380	270	290
55-59	306	380	360	370	270
60-64	245	260	320	320	320
65-69	160	200	210	280	260
70-74	137	120	150	170	230
75-79	165	110	90	120	130
80-84	141	160	90	80	110
85+	197	200	200	180	150
Total	4,537	4,600	4,640	4,760	4,790
Median Age	42.8	42.6	40.8	40.6	40.9

	2010 to 2015	2015 to 2020	2020 to 2025	2025 to 2030
Births	200	210	220	220
Deaths	240	250	230	220
Natural Increase	-40	-40	-10	0
Net Migration	90	90	80	80
Change	50	50	70	80

Differences between period Totals may not equal Change due to rounding.

Hillside Elementary

Males	2010	2015	2020	2025	2030
0-4	169	170	170	150	140
5-9	205	200	220	200	190
10-14	199	210	200	230	210
15-19	240	160	130	150	170
20-24	207	170	130	100	130
25-29	95	150	140	110	80
30-34	100	140	180	160	130
35-39	170	160	200	230	210
40-44	202	190	160	200	230
45-49	210	200	180	160	200
50-54	222	210	200	180	150
55-59	199	220	200	190	180
60-64	171	190	210	190	180
65-69	113	150	170	180	170
70-74	76	90	130	130	140
75-79	64	70	80	110	120
80-84	80	60	60	80	100
85+	129	100	80	70	70
Total	2,848	2,840	2,840	2,820	2,800

Females	2010	2015	2020	2025	2030
0-4	173	170	160	150	140
5-9	205	210	220	200	190
10-14	174	210	210	220	200
15-19	205	140	130	160	170
20-24	146	130	110	100	130
25-29	96	90	100	80	80
30-34	130	140	120	130	110
35-39	167	190	200	170	180
40-44	214	180	190	200	170
45-49	265	210	180	190	200
50-54	242	260	210	180	190
55-59	188	240	260	210	180
60-64	191	180	230	250	200
65-69	125	180	170	210	230
70-74	103	110	160	140	180
75-79	102	90	100	140	120
80-84	137	100	80	90	130
85+	320	290	250	210	190
Total	3,182	3,120	3,080	3,030	2,990

Total	2010	2015	2020	2025	2030
0-4	341	340	330	300	280
5-9	410	410	440	400	380
10-14	373	420	410	450	410
15-19	445	300	260	310	340
20-24	353	300	240	200	260
25-29	191	240	240	190	160
30-34	230	280	300	290	240
35-39	337	350	400	400	390
40-44	416	370	350	400	400
45-49	475	410	360	350	400
50-54	463	470	410	360	340
55-59	388	460	460	400	360
60-64	362	370	440	440	380
65-69	238	330	340	390	400
70-74	179	200	290	270	320
75-79	165	160	180	250	240
80-84	217	160	140	170	230
85+	449	390	330	280	260
Total	6,030	5,960	5,920	5,850	5,790
Median Age	44.0	44.6	44.9	44.8	45.4

	2010 to 2015	2015 to 2020	2020 to 2025	2025 to 2030
Births	270	250	240	230
Deaths	400	370	350	350
Natural Increase	-130	-120	-110	-120
Net Migration	60	60	50	50
Change	-70	-60	-60	-70

Differences between period Totals may not equal Change due to rounding.

Mitchell Elementary

Males	2010	2015	2020	2025	2030
0-4	171	140	130	130	140
5-9	216	210	210	200	190
10-14	212	220	220	220	210
15-19	144	180	190	190	200
20-24	74	80	110	130	110
25-29	40	50	60	70	70
30-34	72	80	90	90	110
35-39	142	90	100	110	120
40-44	188	150	100	100	120
45-49	202	190	150	100	110
50-54	182	200	180	140	100
55-59	170	180	190	180	140
60-64	148	160	150	180	170
65-69	87	130	140	140	170
70-74	49	60	100	110	120
75-79	46	40	50	90	100
80-84	32	40	40	40	80
85+	31	30	40	40	40
Total	2,203	2,230	2,250	2,260	2,300

Females	2010	2015	2020	2025	2030
0-4	173	130	130	130	130
5-9	246	210	210	200	190
10-14	206	250	220	220	210
15-19	126	170	220	190	190
20-24	46	60	110	160	110
25-29	45	20	40	70	100
30-34	76	90	60	70	110
35-39	153	100	110	80	100
40-44	212	160	110	110	90
45-49	205	210	160	110	120
50-54	201	200	210	160	110
55-59	182	200	190	210	160
60-64	151	180	180	190	200
65-69	87	140	150	170	180
70-74	67	70	110	140	150
75-79	40	60	50	100	120
80-84	47	40	60	50	90
85+	58	70	70	80	80
Total	2,318	2,360	2,390	2,440	2,440

Total	2010	2015	2020	2025	2030
0-4	344	270	260	260	270
5-9	461	420	420	400	380
10-14	417	470	440	440	420
15-19	270	350	410	380	390
20-24	120	140	220	290	220
25-29	85	70	100	140	170
30-34	148	170	150	160	220
35-39	294	190	210	190	220
40-44	400	310	210	210	210
45-49	407	400	310	210	230
50-54	383	400	390	300	210
55-59	351	380	380	390	300
60-64	299	340	330	370	370
65-69	174	270	290	310	350
70-74	116	130	210	250	270
75-79	86	100	100	190	220
80-84	79	80	100	90	170
85+	88	100	110	120	120
Total	4,521	4,590	4,640	4,700	4,740
Median Age	41.5	43.5	42.6	42.1	41.9

	2010 to 2015	2015 to 2020	2020 to 2025	2025 to 2030
Births	160	150	190	210
Deaths	170	190	210	220
Natural Increase	-10	-40	-20	-10
Net Migration	80	80	70	60
Change	70	40	50	50

Differences between period Totals may not equal Change due to rounding.

Newman Elementary

Males	2010	2015	2020	2025	2030
0-4	249	230	210	210	200
5-9	383	290	290	280	260
10-14	389	390	300	300	280
15-19	319	300	320	220	220
20-24	125	230	210	230	130
25-29	96	120	240	220	250
30-34	95	140	170	270	260
35-39	229	120	170	190	290
40-44	285	230	120	190	210
45-49	370	280	220	120	200
50-54	369	360	280	220	120
55-59	284	360	350	270	210
60-64	278	270	340	340	260
65-69	178	260	250	320	320
70-74	123	150	210	210	260
75-79	124	110	130	190	180
80-84	83	120	100	120	170
85+	75	80	90	100	110
Total	4,053	4,040	4,000	4,000	3,930

Females	2010	2015	2020	2025	2030
0-4	266	230	210	200	190
5-9	302	310	280	270	260
10-14	394	310	320	290	280
15-19	245	300	240	240	220
20-24	105	150	210	150	150
25-29	87	100	160	230	170
30-34	155	130	150	200	260
35-39	238	180	160	170	220
40-44	344	240	180	180	190
45-49	391	340	240	180	200
50-54	379	390	340	230	180
55-59	323	370	380	330	230
60-64	288	310	360	370	320
65-69	228	280	300	350	360
70-74	148	200	250	270	310
75-79	135	130	180	220	240
80-84	115	130	120	170	200
85+	125	150	170	190	220
Total	4,266	4,250	4,250	4,240	4,200

Total	2010	2015	2020	2025	2030
0-4	514	460	420	410	390
5-9	685	600	570	550	520
10-14	783	700	620	590	560
15-19	563	600	560	460	440
20-24	230	380	420	380	280
25-29	183	220	400	450	420
30-34	249	270	320	470	520
35-39	467	300	330	360	510
40-44	628	470	300	370	400
45-49	761	620	460	300	400
50-54	749	750	620	450	300
55-59	607	730	730	600	440
60-64	566	580	700	710	580
65-69	406	540	550	670	680
70-74	271	350	460	480	570
75-79	259	240	310	410	420
80-84	197	250	220	290	370
85+	201	230	260	290	330
Total	8,319	8,290	8,250	8,240	8,130
Median Age	43.9	46.2	47.0	46.3	45.3

	2010 to 2015	2015 to 2020	2020 to 2025	2025 to 2030
Births	270	290	350	350
Deaths	370	430	460	510
Natural Increase	-100	-140	-110	-160
Net Migration	90	90	80	70
Change	-10	-50	-30	-90

Differences between period Totals may not equal Change due to rounding.

Appendix B: Enrollment Forecasts

Needham Public Schools: Total District Enrollment

	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32
PK	76	74	82	84	82	82	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
K	363	398	414	406	365	404	369	384	388	389	382	380	375	369	367	362	362	358	355	350	344	349
1	439	384	419	441	449	387	433	408	411	415	416	409	404	399	393	390	385	380	376	373	367	361
2	422	447	390	419	444	471	397	444	418	421	425	427	420	415	410	404	403	397	392	389	386	378
3	436	417	450	413	416	450	473	401	448	422	425	430	432	425	420	415	411	410	404	399	396	393
4	485	431	419	444	409	415	455	474	402	449	423	426	431	433	426	421	421	417	415	409	404	401
5	430	491	427	436	439	415	425	458	478	405	452	425	428	433	435	428	425	425	421	419	413	408
Total: K-5	**2,575**	**2,568**	**2,519**	**2,559**	**2,522**	**2,542**	**2,552**	**2,569**	**2,545**	**2,501**	**2,523**	**2,497**	**2,490**	**2,474**	**2,451**	**2,420**	**2,407**	**2,387**	**2,363**	**2,339**	**2,310**	**2,290**
6	448	438	482	427	451	451	421	436	469	490	415	463	436	439	444	446	439	434	434	429	427	421
7	424	413	421	467	404	439	445	419	434	467	488	413	461	434	437	442	442	435	430	430	425	423
8	405	419	410	404	457	400	431	438	413	427	460	483	409	456	430	433	440	440	433	428	428	423
Total: 7-8	**829**	**832**	**831**	**871**	**861**	**839**	**876**	**857**	**847**	**894**	**948**	**896**	**870**	**890**	**867**	**875**	**882**	**875**	**863**	**858**	**853**	**846**
9	380	400	420	414	400	449	416	440	447	421	436	472	495	419	467	439	442	449	449	442	437	437
10	373	371	398	417	418	396	446	414	438	445	419	434	470	493	417	465	437	440	447	447	440	435
11	367	378	369	382	416	407	396	442	410	434	441	415	430	465	488	413	460	433	436	443	443	436
12	329	373	366	363	389	412	401	394	440	408	432	439	413	428	463	486	411	458	431	434	441	441
SP	-	-	9	6	8	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total: 9-12	**1,449**	**1,522**	**1,562**	**1,582**	**1,631**	**1,672**	**1,659**	**1,690**	**1,735**	**1,708**	**1,728**	**1,760**	**1,808**	**1,805**	**1,835**	**1,803**	**1,750**	**1,780**	**1,763**	**1,766**	**1,761**	**1,749**
Total: K-12	**5,377**	**5,434**	**5,476**	**5,523**	**5,547**	**5,586**	**5,588**	**5,632**	**5,676**	**5,673**	**5,694**	**5,696**	**5,684**	**5,688**	**5,677**	**5,624**	**5,558**	**5,556**	**5,503**	**5,472**	**5,431**	**5,386**
Total: K-12	**5,377**	**5,434**	**5,476**	**5,523**	**5,547**	**5,586**	**5,588**	**5,632**	**5,676**	**5,673**	**5,694**	**5,696**	**5,684**	**5,688**	**5,677**	**5,624**	**5,558**	**5,556**	**5,503**	**5,472**	**5,431**	**5,386**
Change		57	42	47	24	39	2	44	44	-3	21	2	-12	4	-11	-53	-66	-2	-53	-31	-41	-45
%-Change		1.1%	0.8%	0.9%	0.4%	0.7%	0.0%	0.8%	0.8%	-0.1%	0.4%	0.0%	-0.2%	0.1%	-0.2%	-0.9%	-1.2%	0.0%	-1.0%	-0.6%	-0.7%	-0.8%
Total: K-5	**2,575**	**2,568**	**2,519**	**2,559**	**2,522**	**2,542**	**2,552**	**2,569**	**2,545**	**2,501**	**2,523**	**2,497**	**2,490**	**2,474**	**2,451**	**2,420**	**2,407**	**2,387**	**2,363**	**2,339**	**2,310**	**2,290**
Change		-7	-49	40	-37	20	10	17	-24	-44	22	-26	-7	-16	-23	-31	-13	-20	-24	-24	-29	-20
%-Change		-0.3%	-1.9%	1.6%	-1.4%	0.8%	0.4%	0.7%	-0.9%	-1.7%	0.9%	-1.0%	-0.3%	-0.6%	-0.9%	-1.3%	-0.5%	-0.8%	-1.0%	-1.0%	-1.2%	-0.9%
Total: 6	**448**	**438**	**482**	**427**	**451**	**451**	**421**	**436**	**469**	**490**	**415**	**463**	**436**	**439**	**444**	**446**	**439**	**434**	**434**	**429**	**427**	**421**
Change		-10	44	-55	24	0	-30	15	33	21	-75	48	-27	3	5	2	-7	-5	0	-5	-2	-6
%-Change		-2.2%	10.0%	-11.4%	5.6%	0.0%	-6.7%	3.6%	7.6%	4.5%	-15.3%	11.6%	-5.8%	0.7%	1.1%	0.5%	-1.6%	-1.1%	0.0%	-1.2%	-0.5%	-1.4%
Total: 7-8	**829**	**832**	**831**	**871**	**861**	**839**	**876**	**857**	**847**	**894**	**948**	**896**	**870**	**890**	**867**	**875**	**882**	**875**	**863**	**858**	**853**	**846**
Change		3	-1	40	-10	-22	37	-19	-10	47	54	-52	-26	20	-23	8	7	-7	-12	-5	-5	-7
%-Change		0.4%	-0.1%	4.8%	-1.1%	-2.6%	4.4%	-2.2%	-1.2%	5.5%	6.0%	-5.5%	-2.9%	2.3%	-2.6%	0.9%	0.8%	-0.8%	-1.4%	-0.6%	-0.6%	-0.8%
Total: 9-12	**1,449**	**1,522**	**1,562**	**1,582**	**1,631**	**1,672**	**1,659**	**1,690**	**1,735**	**1,708**	**1,728**	**1,760**	**1,808**	**1,805**	**1,835**	**1,803**	**1,750**	**1,780**	**1,763**	**1,766**	**1,761**	**1,749**
Change		73	40	20	49	41	-13	31	45	-27	20	32	48	-3	30	-32	-53	30	-17	3	-5	-12
%-Change		5.0%	2.6%	1.3%	3.1%	2.5%	-0.8%	1.9%	2.7%	-1.6%	1.2%	1.9%	2.7%	-0.2%	1.7%	-1.7%	-2.9%	1.7%	-1.0%	0.2%	-0.3%	-0.7%

Forecasts Developed January 2017
Green Cells (2016-17 and earlier) are historical data
Blue Cells (2017-18 and later) are forcasted years

Broadmeadow Elementary

	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32
K	79	83	100	84	76	81	71	76	78	79	78	79	78	77	77	76	77	78	78	77	76	75
1	116	84	89	108	104	83	89	83	84	86	87	86	86	85	84	84	83	83	84	84	83	82
2	87	117	88	92	106	107	84	91	85	86	88	89	88	88	87	86	87	85	85	87	87	85
3	107	87	119	94	93	104	110	85	92	86	87	89	90	89	89	88	87	88	86	86	88	88
4	117	105	87	120	89	91	107	109	84	91	85	86	88	89	88	88	87	86	87	85	85	87
5	104	115	105	87	113	92	92	106	108	83	90	83	84	86	87	86	86	85	84	85	83	83
Total K-5	**610**	**591**	**588**	**585**	**581**	**558**	**553**	**550**	**531**	**511**	**515**	**512**	**514**	**514**	**512**	**508**	**507**	**505**	**504**	**504**	**502**	**500**

Total K-5	**610**	**591**	**588**	**585**	**581**	**558**	**553**	**550**	**531**	**511**	**515**	**512**	**514**	**514**	**512**	**508**	**507**	**505**	**504**	**504**	**502**	**500**
Change		-19	-3	-3	-4	-23	-5	-3	-19	-20	4	-3	2	0	-2	-4	-1	-2	-1	0	-2	-2
% Change		-3.1%	-0.5%	-0.5%	-0.7%	-4.0%	-0.9%	-0.5%	-3.5%	-3.8%	0.8%	-0.6%	0.4%	0.0%	-0.4%	-0.8%	-0.2%	-0.4%	-0.2%	0.0%	-0.4%	-0.4%

Forecasts Developed January 2017
Green Cells (2016-17 and earlier) are historical data
Blue Cells (2017-18 and later) are forcasted years

Eliot Elementary

	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32
K	53	62	59	58	57	61	57	60	62	63	61	61	60	59	58	57	57	56	56	55	54	56
1	73	54	65	65	67	61	64	62	64	66	67	65	64	63	62	61	60	59	58	58	57	56
2	69	68	56	67	71	73	57	65	63	65	67	69	67	66	65	64	63	62	61	60	60	59
3	70	69	66	61	63	72	73	58	66	64	66	68	70	68	67	66	65	64	63	62	61	61
4	83	70	70	62	67	63	74	74	59	67	65	67	69	71	69	68	67	66	65	64	63	62
5	61	86	71	74	65	65	67	75	75	60	68	66	68	70	72	70	69	68	67	66	65	64
Total: K-5	**409**	**409**	**387**	**387**	**390**	**395**	**392**	**394**	**389**	**385**	**394**	**396**	**398**	**397**	**393**	**386**	**381**	**375**	**370**	**365**	**360**	**358**

Total: K-5	**409**	**409**	**387**	**387**	**390**	**395**	**392**	**394**	**389**	**385**	**394**	**396**	**398**	**397**	**393**	**386**	**381**	**375**	**370**	**365**	**360**	**358**
Change		0	-22	0	3	5	-3	2	-5	-4	9	2	2	-1	-4	-7	-5	-6	-5	-5	-5	-2
% Change		0.0%	-5.4%	0.0%	0.8%	1.3%	-0.8%	0.5%	-1.3%	-1.0%	2.3%	0.5%	0.5%	-0.3%	-1.0%	-1.8%	-1.3%	-1.6%	-1.3%	-1.4%	-1.4%	-0.6%

Forecasts Developed January 2017
Green Cells (2016-17 and earlier) are historical data
Blue Cells (2017-18 and later) are forcasted years

Hillside Elementary

	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32
K	61	73	72	71	57	82	76	79	80	81	79	76	75	73	73	71	71	69	68	66	64	65
1	64	67	76	73	79	62	82	82	84	85	86	84	82	81	79	78	76	75	73	72	70	68
2	73	63	66	72	75	88	71	85	85	87	88	89	87	85	84	82	81	79	78	76	75	72
3	72	76	61	73	72	80	87	72	86	86	88	90	91	89	87	86	84	83	81	80	78	77
4	100	68	77	59	76	76	79	88	73	87	87	89	91	92	90	88	89	87	85	83	82	80
5	59	98	67	81	62	77	77	80	89	74	88	89	91	93	94	92	90	91	89	87	85	84
Total: K-5	**429**	**445**	**419**	**429**	**421**	**465**	**472**	**486**	**497**	**500**	**516**	**517**	**517**	**513**	**507**	**497**	**491**	**484**	**474**	**464**	**454**	**446**

Total: K-5	**429**	**445**	**419**	**429**	**421**	**465**	**472**	**486**	**497**	**500**	**516**	**517**	**517**	**513**	**507**	**497**	**491**	**484**	**474**	**464**	**454**	**446**
Change		16	-26	10	-8	44	7	14	11	3	16	1	0	-4	-6	-10	-6	-7	-10	-10	-10	-8
% Change		3.7%	-5.8%	2.4%	-1.9%	10.5%	1.5%	3.0%	2.3%	0.6%	3.2%	0.2%	0.0%	-0.8%	-1.2%	-2.0%	-1.2%	-1.4%	-2.1%	-2.1%	-2.2%	-1.8%

Forecasts Developed January 2017
Green Cells (2016-17 and earlier) are historical data
Blue Cells (2017-18 and later) are forcasted years

Mitchell Elementary

	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32
K	71	78	80	74	78	82	77	77	76	75	74	74	73	72	72	71	71	70	69	68	67	69
1	84	77	80	88	75	79	91	82	81	80	79	78	77	76	75	75	74	73	72	71	70	69
2	81	89	80	79	86	79	82	94	84	83	82	81	80	79	78	77	78	77	76	75	74	73
3	86	79	90	87	78	89	80	84	96	86	85	84	83	82	81	80	79	80	79	78	77	76
4	71	85	81	88	87	78	89	81	85	97	87	86	85	84	83	82	82	81	82	81	80	79
5	81	74	84	82	86	86	76	88	80	84	96	86	85	84	83	82	83	83	82	83	82	81
Total K-5	**474**	**482**	**495**	**498**	**490**	**493**	**495**	**506**	**502**	**505**	**503**	**489**	**483**	**477**	**472**	**467**	**467**	**464**	**460**	**456**	**450**	**447**

Total K-5	**474**	**482**	**495**	**498**	**490**	**493**	**495**	**506**	**502**	**505**	**503**	**489**	**483**	**477**	**472**	**467**	**467**	**464**	**460**	**456**	**450**	**447**
Change		8	13	3	-8	3	2	11	-4	3	-2	-14	-6	-6	-5	-5	0	-3	-4	-4	-6	-3
% Change		1.7%	2.7%	0.6%	-1.6%	0.6%	0.4%	2.2%	-0.8%	0.6%	-0.4%	-2.8%	-1.2%	-1.2%	-1.0%	-1.1%	0.0%	-0.6%	-0.9%	-0.9%	-1.3%	-0.7%

Forecasts Developed January 2017
Green Cells (2016-17 and earlier) are historical data
Blue Cells (2017-18 and later) are forcasted years

Newman Elementary

	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32
K	99	102	103	119	97	98	88	92	92	91	90	90	89	88	87	87	86	85	84	84	83	84
1	102	102	109	107	124	102	107	99	98	98	97	96	95	94	93	92	92	90	89	88	87	86
2	112	110	100	109	106	124	103	109	101	100	100	99	98	97	96	95	94	94	92	91	90	89
3	101	106	114	98	110	105	123	102	108	100	99	99	98	97	96	95	96	95	95	93	92	91
4	114	103	104	115	90	107	106	122	101	107	99	98	98	97	96	95	96	97	96	96	94	93
5	125	118	100	112	113	95	113	109	126	104	110	101	100	100	99	98	97	98	99	98	98	96
Total K-5	**653**	**641**	**630**	**660**	**640**	**631**	**640**	**633**	**626**	**600**	**595**	**583**	**578**	**573**	**567**	**562**	**561**	**559**	**555**	**550**	**544**	**539**

Total K-5	**653**	**641**	**630**	**660**	**640**	**631**	**640**	**633**	**626**	**600**	**595**	**583**	**578**	**573**	**567**	**562**	**561**	**559**	**555**	**550**	**544**	**539**
Change		-12	-11	30	-20	-9	9	-7	-7	-26	-5	-12	-5	-5	-6	-5	-1	-2	-4	-5	-6	-5
% Change		-1.8%	-1.7%	4.8%	-3.0%	-1.4%	1.4%	-1.1%	-1.1%	-4.2%	-0.8%	-2.0%	-0.9%	-0.9%	-1.0%	-0.9%	-0.2%	-0.4%	-0.7%	-0.9%	-1.1%	-0.9%

Forecasts Developed January 2017
Green Cells (2016-17 and earlier) are historical data
Blue Cells (2017-18 and later) are forcasted years

High Rock School

	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32
6	448	438	482	427	451	451	421	436	469	490	415	463	436	439	444	446	439	434	434	429	427	421
Total: 6	**448**	**438**	**482**	**427**	**451**	**451**	**421**	**436**	**469**	**490**	**415**	**463**	**436**	**439**	**444**	**446**	**439**	**434**	**434**	**429**	**427**	**421**

Total: 6	**448**	**438**	**482**	**427**	**451**	**451**	**421**	**436**	**469**	**490**	**415**	**463**	**436**	**439**	**444**	**446**	**439**	**434**	**434**	**429**	**427**	**421**
Change		-10	44	-55	24	0	-30	15	33	21	-75	48	-27	3	5	2	-7	-5	0	-5	-2	-6
% Change		-2.2%	10.0%	-11.4%	5.6%	0.0%	-6.7%	3.6%	7.6%	4.5%	-15.3%	11.6%	-5.8%	0.7%	1.1%	0.5%	-1.6%	-1.1%	0.0%	-1.2%	-0.5%	-1.4%

Forecasts Developed January 2017
Green Cells (2016-17 and earlier) are historical data
Blue Cells (2017-18 and later) are forcasted years

Pollard Middle School

	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32
7	424	413	421	467	404	439	445	419	434	467	488	413	461	434	437	442	442	435	430	430	425	423
8	405	419	410	404	457	400	431	438	413	427	460	483	409	456	430	433	440	440	433	428	428	423
Total: 7-8	**829**	**832**	**831**	**871**	**861**	**839**	**876**	**857**	**847**	**894**	**948**	**896**	**870**	**890**	**867**	**875**	**882**	**875**	**863**	**858**	**853**	**846**

Total: 7-8	**829**	**832**	**831**	**871**	**861**	**839**	**876**	**857**	**847**	**894**	**948**	**896**	**870**	**890**	**867**	**875**	**882**	**875**	**863**	**858**	**853**	**846**
Change		3	-1	40	-10	-22	37	-19	-10	47	54	-52	-26	20	-23	8	7	-7	-12	-5	-5	-7
% Change		0.4%	-0.1%	4.8%	-1.1%	-2.6%	4.4%	-2.2%	-1.2%	5.5%	6.0%	-5.5%	-2.9%	2.3%	-2.6%	0.9%	0.8%	-0.8%	-1.4%	-0.6%	-0.6%	-0.8%

Forecasts Developed January 2017
Green Cells (2016-17 and earlier) are historical data
Blue Cells (2017-18 and later) are forcasted years

Needham High School

	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28	2028-29	2029-30	2030-31	2031-32
9	380	400	420	414	400	449	416	440	447	421	436	472	495	419	467	439	442	449	449	442	437	437
10	373	371	398	417	418	396	446	414	438	445	419	434	470	493	417	465	437	440	447	447	440	435
11	367	378	369	382	416	407	396	442	410	434	441	415	430	465	488	413	460	433	436	443	443	436
12	329	373	366	363	389	412	401	394	440	408	432	439	413	428	463	486	411	458	431	434	441	441
Total: 9-12	**1,449**	**1,522**	**1,553**	**1,576**	**1,623**	**1,664**	**1,659**	**1,690**	**1,735**	**1,708**	**1,728**	**1,760**	**1,808**	**1,805**	**1,835**	**1,803**	**1,750**	**1,780**	**1,763**	**1,766**	**1,761**	**1,749**

Total: 9-12	**1,449**	**1,522**	**1,553**	**1,576**	**1,623**	**1,664**	**1,659**	**1,690**	**1,735**	**1,708**	**1,728**	**1,760**	**1,808**	**1,805**	**1,835**	**1,803**	**1,750**	**1,780**	**1,763**	**1,766**	**1,761**	**1,749**
Change		73	31	23	47	41	-5	31	45	-27	20	32	48	-3	30	-32	-53	30	-17	3	-5	-12
% Change		5.0%	2.0%	1.5%	3.0%	2.5%	-0.3%	1.9%	2.7%	-1.6%	1.2%	1.9%	2.7%	-0.2%	1.7%	-1.7%	-2.9%	1.7%	-1.0%	0.2%	-0.3%	-0.7%

Forecasts Developed January 2017
Green Cells (2016-17 and earlier) are historical data
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Town of Needham
Massachusetts
School Districts

WELLESLEY

NEWTON

BOSTON

DEDHAM

DOVER

WESTWOOD

Eliot ES

Hillside ES

Mitchell ES

Needham HS

Newman ES

Broadmeadow ES

Pollard MS

High Rock G6

Cutler Lake

Rosemary Lake

Charles River

Sabrina Lake

Morse Pond

Water Lake

EXIT 20

EXIT 19

EXIT 18

EXIT 17

N

W E

S

Miles

0 0.25 0.5 1 1.5

1 inch = 1,000 feet

Legend

- Schools
- Interstate Highways
- Major Roads
- Minor Roads & Ramps
- Railroads
- Waterbodies
- Town Boundaries
- Road Index Grid

School Districts

- Broadmeadow
- Eliot
- Hillside
- Mitchell
- Newman

ROAD INDEX

All data is for display and planning purposes only and should not be considered accurate, current or complete. The Town of Needham assumes no liability for misuse or alteration of this data.

School district data shown on this map was modified in 2017. This map portrays roads that have been constructed and are in general use for vehicular traffic.

Road data was updated based on April 2009 aerial photographs & includes data from the Town of Needham Department of Public Works, Engineering Division.

Town of Needham GIS
Information Technology Center
Town of Needham
1471 Highland Avenue, Needham, MA 02492
www.NeedhamMA.gov/GIS
(781) 455-7500

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