VOLUME 1

supporting the innovation agenda

FEASIBILITY STUDY

Martin Luther King, Jr. School Construction Project

JULY 31, 2012

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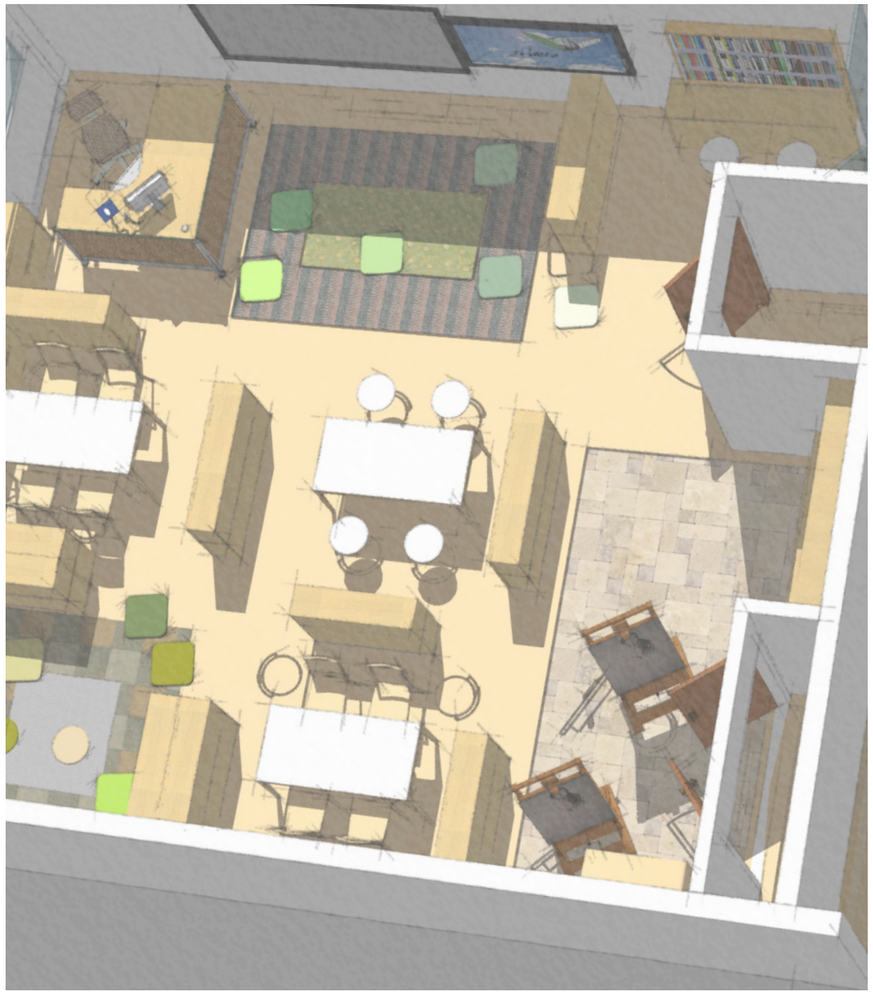

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1.0 EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

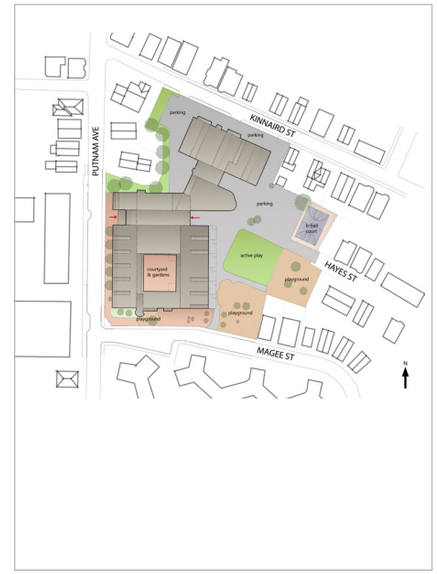
The City of Cambridge in collaboration with the Cambridge Public Schools has begun the process of renewing the Martin Luther King, Jr. School campus. Currently the site of a Preschool and two JK-8th grade programs, the campus is being reprogrammed and redesigned to support the City's vision and CPS' Innovation Agenda.

The renewal of the campus will enhance educational opportunities and achievement for the children and families of Cambridge and prepare students for future success in high school and throughout their lives in the 21st Century. The design will create high performance learning environments that are healthy, supportive and sustainable. These settings will enhance the preschool, lower and upper school's programs and support extended learning opportunities and active community use of the campus after school hours. As a center of community, the renewed campus will feature a building and open space that together create an appropriate "civic presence" symbolically representing the importance of the activities occurring within for the future of the community and better integrating with the adjacent neighborhood.

This report summarizes the open process and the conclusions of the feasibility study used to define the programmatic needs, establish principles and goals and determine the best strategy to realize the City's and CPS' vision.

Project Definition

The project site, located at 100 Putnam Avenue, currently houses the existing MLK, Jr. School, the Amigos School, and the Martin Luther King, Jr. Preschool. Until the end of this past school year, June, 2012, there were 662 students total and 50 instructional spaces within the existing building. When complete, the new school will accommodate up to 740 students as follows: Lower School (JK-5th) = 400 students, Upper School (6th – 8th) = 300 students and Preschool = 40 students and a total of 64 instructional spaces. The Preferred Option calls for demolishing most of the existing school building, retaining approximately 20,000 gsf of the underground basement for use as parking, and building a new school of approximately 157,000 gsf. The new school will be better suited to accommodate the City of Cambridge's Education Innovation Agenda, and more in harmony with the neighborhood.



Process

This 5-6 month Feasibility Study was conducted between February and July 2012. The study team comprised education specialists, architects, civil, land surveyor, traffic, geotechnical, structural, mechanical, electrical, and plumbing/fire-protection engineers, as well as acoustic, audiovisual, commissioning, cost estimators, embodied energy, foodservice, hazardous materials, Net Zero energy, and scheduling consultants. The existing site and building were analyzed while the schools were in-session to ensure that the data represents typical in-use patterns and conditions. Education programming and design experts worked collaboratively with focus groups consisting of Principals, CPS department heads, representative teachers and staff, CPS administrative personnel and City Human Services staff to create an Educational Specification that embodies the educational and social needs of the preschool, the lower school and the upper school.

Multiple meetings, focus groups and conference calls with stakeholders were held during this period including the following:

- 35 Focus Groups meetings
- 3 Utilities meetings
- 1 Building & Grounds Committee meeting
- 9 Steering Committee meetings
- 2 Budget Overview meetings
- 9 Traffic / Zoning meetings
- 2 Geotechnical / Environmental meetings
- 2 OPR with Owner's Commissioning Agent meetings

Sub-Total: 63 meetings
- Plus 4 Community meetings*
- Total: 67 meetings

*In addition to the visioning and practical programming meetings with educators, administrators and City officials, the design team presented the evolving concepts to members of the community at publicly advertised meetings held in the school auditorium, and the Cambridge Community Center. Attendance grew from a low of about 20 people at the first meeting to as many as 80 in the third meeting. The community participated actively; their comments were recorded and evaluated and incorporated into the design wherever possible and appropriate.

Design Principles, Program Philosophy - K-8 Innovation Agenda
Superintendent Young, the Cambridge Public School District and the community have established a vision for transforming Cambridge's public schools. The goals of this transformation include providing all Cambridge Public School students, including special populations like English language learners with a superior academic and social experience in their elementary and middle grade years to raise student achievement, eliminate achievement gaps, and develop 21st century skills. The agenda seeks to expand professional development and collaboration opportunities for the Cambridge Public School educators, improving their experience and quality.

From the creation of a distinct Upper School and the provision of space for the Lower School's Chinese immersion and enrichment programs, to the ability to provide rich after school programming and foster professional and learning communities, the design for the Preferred Option of the Martin Luther King, Jr. School campus renewal will directly support the Innovation Agenda.

This Feasibility Study Report and Education Specification summarize the resources that will be made available in the building to accommodate this vision. The information it contains is derived from numerous focus groups and surveys with administrators, teachers and parents as well as information from professional practice.

Options Studied
Multiple options were studied including the following:
- Option#1 Existing Refurbished – rejected
- Option #2 Existing Modified – rejected
- Option#3 Clover Option – rejected
- Option #4 Pi Option – selected as Preferred Option

Option#1 Existing Refurbished

Why not renovate the existing building? This question has been asked by the design team, some members of the community as well as special interest preservation groups. In short, merely renovating and repairing the existing building will not advance the City's Education Innovation Agenda. The existing building houses 50 instructional rooms, while the program as outlined in the Educational Specification calls for 64 instructional spaces to accommodate the new learning and teaching environments for the three new schools. This program cannot be accommodated within the existing building in its current configuration. Likewise, significant structural reconfiguration would be required for the gyms and the auditorium to bring them into compliance with seismic design criteria. Altering the existing building to accommodate the program and comply with code triggers impacts that lead Option#1 to become Option#2.

Option #2 Existing Modified

This option is feasible, and can be made to accommodate the program satisfactorily, although not ideally. However, the extent of the changes required to accommodate the program are sufficient to require full demolition of approximately 40% of the existing building (Part B). Because of the obsolete and outdated condition of all the building systems including windows, roofs and mechanical systems, and the complete lack of insulation, the remaining approximately 60% of the existing building (Part A) must be stripped down to the structure. Therefore, the cost of this option is within a statistically insignificant variance from the Preferred Option (0.8% variance). However, because of existing structural constraints relative to a new building, this option requires significant compromises in the design including low floor-to-floor heights, reduced energy efficiency, less open space for landscaping and recreation and less than optimal programmatic adjacencies not easily remedied because of existing condition constraints.

Option#3 Clover Option

This new building option would provide for all of the requirements of the Educational Specification and the City's Educational Innovation Agenda. It meets most of the Design Principles identified for the project, and it has some compelling features such as the central indoor gathering and amphitheater space between the Lower and Upper Schools that connects to the Community portions of the building. In the end, the Clover Option was a close second to the Pi Option for a number of reasons including its slightly higher construction cost, slightly larger footprint which yields less useable outdoor space, its lower underground parking yield (approximately 30 spaces) which necessitates approximately 50 additional parking spaces outdoors on-grade, its slightly lower PV yield, and its slightly less integrated circulation route connecting to Kinnaird Street.

Preferred Option - Pi Option

The Preferred Option is a new building option that provides for all of the requirements of the Educational Specification and the City's Educational Innovation Agenda. It best meets all of the Design Principles such as creating separate entrances for each school on Putnam Avenue, locating the Administration and Offices in a manner that provides for subtle security and has adequate and appropriate teacher work and support space to encourage teaming and professional development. Additionally, it fits the program within the smallest footprint on the site, has the potential to achieve Cambridge's sustainable design goals including net-zero potential, provides for a majority of the parking (approximately 60 spaces) to be located underground in the basement requiring only 20 on-grade, resulting in greater landscaping and recreation space. This Pi option creates a clear Public/Community Center zone within the building that can be separated from the two academic wings which house the Upper and Lower Schools and delineates clear entrance locations from the surrounding public ways.

There are two key features in the design of the Preferred Option: the first is the entry court along Putnam that will enhance the public and student experience as it softens the street edge; the second is the glass enclosed atrium that contains the circulation spine which connects all of the Community Center and After School Program spaces. This atrium will be light filled and provide visual connection between the floors as well as into public spaces so that wayfinding is effortless. The compact footprint and massing also sets back from side yard lot lines to minimize the impact of shadows on adjacent neighbors.

Zoning

As with many public schools in the City of Cambridge, the existing MLK, Jr. School building does not meet the dimensional requirements of the current zoning bylaw for Res-C1 in many respects, including height, setbacks, FAR and parking. The City is in the process of creating new zoning regulations for K-8 public schools. These new regulations will allow the existing school building to be used as a baseline dimensional template for renovating, altering or creating a new school on the site. Additionally, by a special permit granted by the Planning Board, certain additional dimensional regulations are made available to optimize site use and minimize impact on abutting residential properties. As currently conceived in the early stage concepts of the Feasibility Study, subject to change as the design evolves, the design of the proposed Preferred Option for the new MLK, Jr. School will create a better school for the students and staff, improve the critical setbacks and create enhanced outdoor spaces over those currently afforded by the existing building and site configuration. When it is designed, the preferred option will comply with all requirements of the new zoning regulations by special permit.

Building Systems/Sustainability/Net Zero

Sustainability is very important to the progressive residents of Cambridge and the City's sustainability goals for this project reflect this. The primary sustainability goals for this project are Energy Efficiency/Net Zero Potential, Site and Storm Water Control, Integrated Parking/Traffic Management and Indoor Environmental Quality (fresh air, daylight and views) and the Ability to be Maintained. An integrated approach to design is essential to achieve a truly effective high-performance building. For instance, balancing the amount of glass for daylighting and views with the amount of insulated wall that performs better in resisting heat gain and loss is essential, and already in the Preferred Option this balance is being designed into the exterior wall systems. Green roofs are included in the design as a strategy to control storm water. As the project unfolds the benefits of the green roof will be quantified to ensure that it is a cost effective method to control storm water. The building mechanical systems are being designed to be as energy efficient as possible, as well as easily maintained so that they can perform at optimal levels for the length of their expected life. Electrical and lighting systems will include efficiencies such as daylighting sensors and occupancy sensors and controls so that lights are only turned on when needed. Water conservation, non-toxic materials and construction waste management are just a few of the many strategies that will be developed as the project continues in Schematic Design.

During this Feasibility Study the different Options were evaluated in their relative abilities to achieve Net Zero energy on site, or in other words, the ability to produce as much energy on the site through photovoltaic panels as would be used by the building. While the Preferred Op-

tion performed best in these initial studies, much more work is essential to understand what can truly be achieved. A Net Zero project usually achieves between 70-75% better energy efficiency than a typical building designed to meet the energy code. To achieve this, design is part of the equation, but additionally, the users of the building must be engaged and aware of how they can optimally use the building to reduce energy use. This is not a burden, but an opportunity for the building to become a teaching tool that educates students and teachers on how energy and water can be saved. Even at this early stage, the biggest energy user, foodservice, has been engaged to discuss the potential strategies to reduce energy in this area.

Parking

One of the key advantages of the Preferred Option is the approximately 60 underground parking spaces created by retaining a portion of the existing building basement. Retaining this portion of the basement has the added advantage of reducing shoring-and-bracing and fill-replacement along Putnam Avenue. This very low-cost indoor parking solution allows for far fewer cars outdoors. Sufficient spaces to provide for conveniently-located accessible surface parking, as well as short-term drop-off and pick-up primarily for the preschool will be provided on grade. Currently, the site plan shows approximately 20 spaces to satisfy these needs, but further study in the Schematic Design stage will be required to optimize this number.

Adequate bicycle parking will be provided at the main entrances to be used by students and the public. Bicycle routes to those spaces with be provided on site; however, it is desired that for safety reasons, people act appropriately and walk their bicycles within the site, especially when small children are present, either arriving or at play.

Cost

A cost estimate was prepared for the Existing Modified Option, the Clover Option and the Preferred Option (Pi Option). The difference in cost between the Existing Modified and the Preferred "Pi" Option is less than one tenth of one percent, which at a Feasibility Study stage is such a small differential that it falls within an acceptable margin of error and therefore deemed to be insignificant when comparing the options. The Clover Option was most expensive, but still less than 2% more than the other options.

SELECTION PROCESS RANKING MATRIX

At the end of the process, a matrix was prepared that ranked Options #1 through #4. Values of 0 through 3 were assigned to a list of comparable attributes and the highest score was selected as the Preferred Option. Pi with 47 was highest, followed by Clover with 38, Existing Modified scoring 30, and Existing Refurbished scoring 15.

While any individual's personal preference was not part of the selection process, it is interesting to note that both the Lower and Upper school principals independently selected Pi as the option that they preferred.

Feasibility Study Design Options Comparative Matrix

CRITERIA	EXISTING REFURBISHED	EXISTING MODIFIED	CLOVER	PI
COST	3	2	1	2
OVERALL SUSTAINABILITY	1	2	2	3
NET ZERO	0	1	3	2
EMBODIED ENERGY	3	2	1	1
OPEN SPACE	0	2	1	3
PARKING	0	1	2	3
SCHEDULE	3	2	2	2
URBAN DESIGN / ZONING	0	1	2	3
PEDAGOGY / ORGANIZATIONAL DESIGN PRINCIPLES:				
LOWER, UPPER AND PRESCHOOLS EACH HAVE A DISTINCT ENTRANCE AND IDENTITY.	1	1	2	3
THE CAMPUS IS ZONED INTO COMMUNITY / SCHOOL AND SCHOOL-DEDICATED AREAS ORGANIZED AROUND A CAMPUS COMMONS.	0	1	2	3
EACH SCHOOL ADMINISTRATION CONTROLS THE FRONT DOOR(S) AND THE CAMPUS COMMONS.	0	1	2	3
THE PRESCHOOL HAS ITS OWN ENTRY BUT IS ALSO INTEGRATED INTO THE CAMPUS-COMMUNITY COMMONS.	0	1	2	3
THE LEARNING COMMONS IS THE HEART OF EACH SCHOOL.	1	1	3	2
THE LOWER SCHOOL IS ORGANIZED INTO TWO TEAMS: JK-2, 3-5.	1	2	3	2
THE UPPER SCHOOL IS ORGANIZED INTO THREE GRADE-LEVEL TEAMS.	1	3	3	3
EACH SCHOOL IS ORGANIZED TO BUILD A PROFESSIONAL COMMUNITY.	0	2	2	2
THE GARDEN, DINING, SERVERY, KITCHEN AND FOOD LAB COMBINE TO FOSTER A COMPREHENSIVE EXPERIENCE AND EDUCATION ABOUT HEALTHY EATING AND AN ACTIVE LIFE-STYLE.	1	2	2	2
THE EXPERIENCE OF DINING IS SMALLER SCALED, LESS INSTITUTIONAL AND MORE FAMILY-STYLE.	*	*	*	*
NATURAL LIGHT SHOULD BE PERVASIVE THROUGHOUT THE CAMPUS.	0	2	1	3
EDUCATION SHOULD FLOW SEAMLESSLY FROM INDOORS TO OUTDOORS.	0	1	2	2
THE SCHOOL FOSTERS "SUBTLE SECURITY".	*	*	*	*
ADMINISTRATORS SHOULD BE DISPERSED THROUGHOUT THE BUILDING AND HAVE "OPEN DOORS".	*	*	*	*
TOTAL	15	30	38	47

* TO BE DEFINED IN SUBSEQUENT DESIGN PHASE

2.0 DESIGN PRINCIPLES

INTRODUCTION

Drawn from user input during the programming process, the design team and the steering committee articulated the following design principles. These principles guided the design of each of the concepts developed for this feasibility study and they will continue to inspire the creation of a high performance campus for the children, families, staff and community that actively use this site.

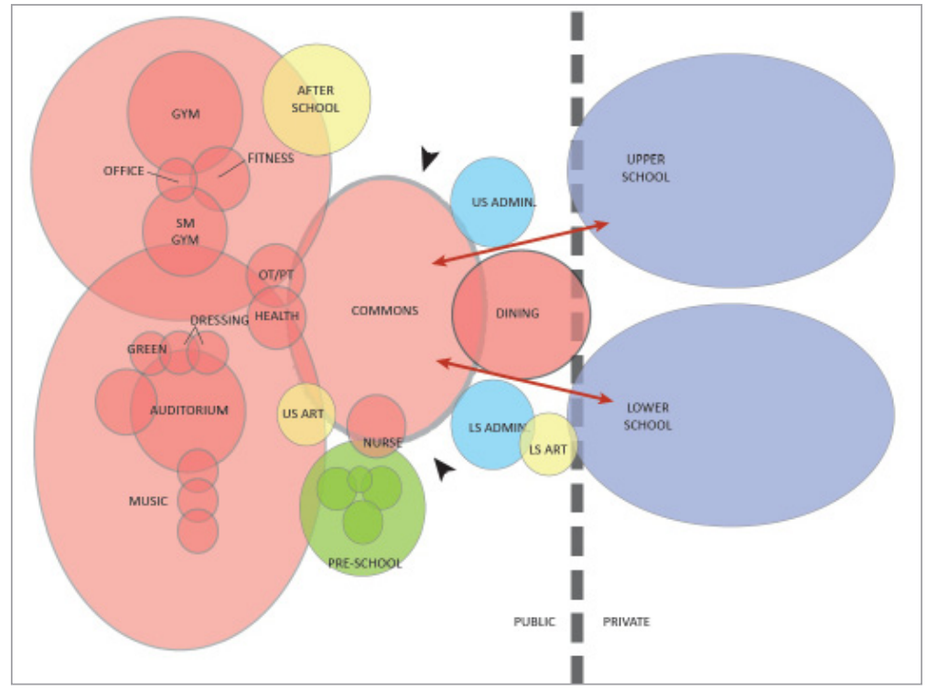
DESIGN PRINCIPLES

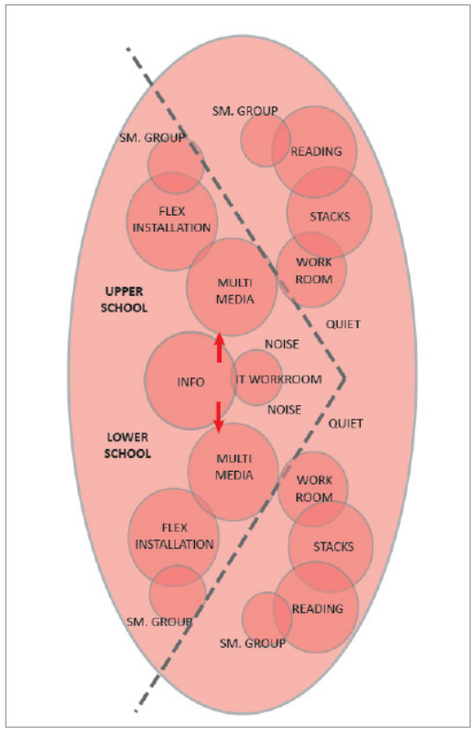
1. **The Upper, Lower and Preschools each have a distinct entrance and identity.** By having distinct entrances, each school will establish its own identity and reduce the perceived scale of the campus for the children and families. This distinction will also help the children and their families recognize their achievement as they advance through the schools.

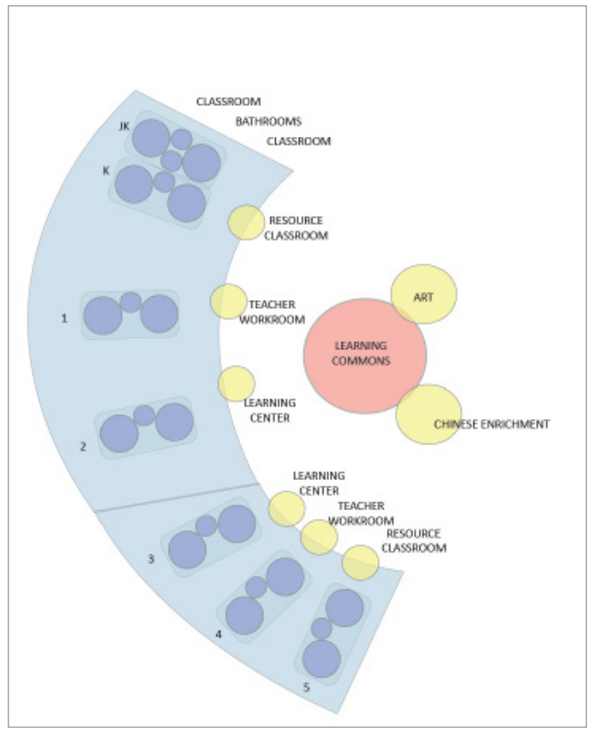
2. **The campus is zoned into community/school and school-dedicated areas organized around a campus commons.** The campus is already actively used after school hours and this robust and varied programming will continue on the renewed campus. To foster after school and community use and to ease maintenance and enhance security, the renewed campus will zone program spaces into community/school use and school-dedicated areas. Between the two zones, unobtrusive but secure barriers will be located to prevent people from entering the other zone without permission.

3. **Each school administration controls the front door(s) and the campus commons.** One of the problems with the existing building is that the main office is remote from the front door. This reduces the "eyes on the street" that support a subtle, proactive form of security, it causes confusion for visitors to the building and it provides visitors with access to the entire building as soon as they enter. The new building will locate the administration for each school at the threshold of the entrance, ensuring that staff can see the public space in front of the building and greet visitors upon arrival.

4. **The Preschool has its own entry but is also integrated into the campus-community commons.** Like the Lower and Upper Schools, the Preschool will have its own front door establishing its own identity, facilitating arrivals and pick up, and making the campus more secure. The Preschool will also be located to enable easy access to the resources shared at times with the larger campus like the gym, without disruption or the need to access to the rest of the facility. This will reduce the movement needed for Preschoolers across the campus and simplify security.







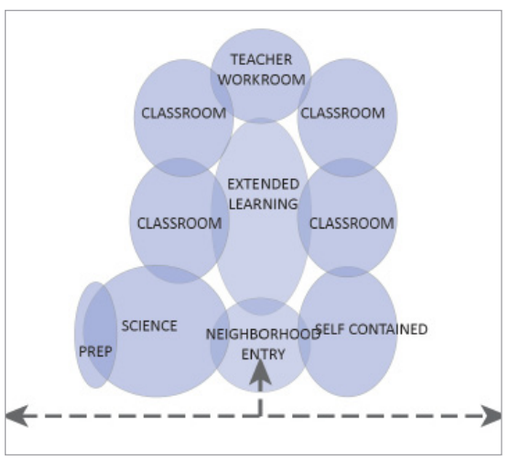
5. **The learning commons is the heart of each school.** As technology increasingly permeates daily life and education, new media and ways of collaborating are emerging. What once was a library, then became a media center. The library/media center has now become a place for creativity and collaboration a place where, as Ontario School Library Association says, "learners read, research, experiment, discover, perform and create… collaborate with others to test, confirm and enrich their learning." These ideas help make this place central to the academic life of each of the schools and the building should fully engage the Learning Commons.

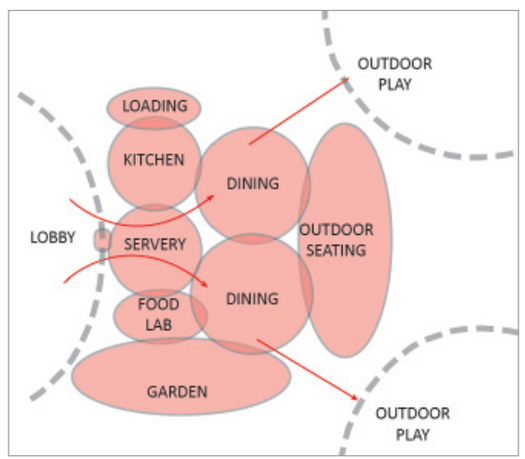
6. **The Lower School is organized into two teams: JK-1; 2-5.** Each school continues to reduce in scale as you progress from the school, to the team, to the class, and the individual. The team enables teachers to collaborate and should be supported through adjacency and by encouraging interaction. Teacher workrooms within the team provide a place for colleagues to meet and interact serendipitously and purposefully. The teams will be further enhanced by the design of academic neighborhoods that will further break down the scale of the school and foster positive interaction and collaboration.

7. **The Upper School is organized into three grade-level teams.** Likewise, the Upper school will be structured around three grade level teams that will enable the teachers to get to know each student better and to share insights and understanding with other teachers. The grade level teams will be organized into small, scale, interdisciplinary "neighborhoods" that will foster communication and learning among students and teachers.

8. **Each school is organized to build a professional community.** In building a learning community on campus, the building will also foster communication and collaboration among the faculty and staff by providing convenient places to gather formally and informally. Key among these opportunities will be the centrally located teacher workrooms within each neighborhood.

9. **The garden, dining, servery, kitchen, and food lab combine to foster a comprehensive experience and education about healthy eating and an active lifestyle.** With considerable concern about growing issues of childhood obesity, the school has an opportunity to engage several resources including the City Sprouts garden, a new kitchen and servery, and the food lab into a comprehensive vision of wellness.





10. **The experience of dining is smaller scaled, less institutional and more family-style.** In conversations with all of the teachers, a common theme was to make the dining experience more small-scaled, less institutional and more appropriate and inviting for the children. For the younger grades that could mean sitting family style with adults and for the older children it could mean having the opportunity to choose from a variety of seating types.

11. **Natural Light should be pervasive throughout the campus.** Daylight and views will enhance the experience of the building as well as its energy performance. Studies also indicate that students in daylit learning environments outperform those in environments without natural light. Natural light should be present in nearly every space within the building including stairs and especially circulation.

12. **Education should flow seamlessly from indoors to outdoors.** With a small, urban site, every square foot should be made useful as a setting for education. Strong connections between indoor and outdoor learning environments should ensure their active use and enhance the children's education. The school garden is one example, but spaces for gross motor skill development and outdoor dining could be part of a system of outdoor places.

13. **The school fosters "subtle security."** The school is being designed to foster learning communities. One of the attributes of the learning community is student engagement with adults both in and out of the classroom to encourage social and emotional growth and reduce bullying. The placement of certain programs near entrances and throughout the building and appropriate transparency (glazing) will enable staff, students and visitors to see and be seen. This encourages people to model appropriate behavior and engage if they see something inappropriate. This proactive, community based approach doesn't replace more reactive technologies like video, but it should create a more positive place to learn.

14. **Offices should be dispersed throughout the building and have "open doors."** One of the approaches to fostering subtle security is to locate certain offices throughout the building. This brings adults other than teachers closer to the students and encourages them to interact and engage. It also encourages adults to be moving through the building further enhancing subtle security.

3.0 PREFERRED OPTION

EVALUATION

The Preferred Option is the result of evaluating and comparing 3 different development strategies for the Martin Luther King, Jr. School project that included: Existing Refurbished, Existing Building Modified (remove portions + additions) and New Building. Within the New Building strategy we looked at two different options, "Pi" & "Clover", whose names represent their organizational parti. As a result, a total of 4 options were considered and evaluated against the 14 Design Principles established as part of the Educational Specification and several other criteria including:

- Urban Design/Zoning (Impact on Neighbors)
- Parking
- Open Space (Landscaping & Recreation/Play Areas)
- Schedule
- Overall Sustainability (Site, Water Efficiency, Materials & Resources, Indoor Environmental Quality)
- Net Zero Potential (Energy Use Intensity & Alternative Energy)
- Cost

During the earliest stages of the Feasibility Study process the evaluation criteria matrix was proposed as a means to objectively compare the various options. It allowed for some options to be rated higher (or better) in meeting some criteria while rating lower (or worse) in other criteria, and for the various stakeholders to see one option that clearly overall rated best in the evaluation by receiving the highest total score. The matrix prevented any one criteria or point of view from dominating the evaluation process and ensured that various issues raised by all parties, including the concerns of the neighbors and community were included in the evaluation. At the end of the evaluation the Pi Option overall best fulfilled the Design Principles and evaluation criteria and scored highest on the evaluation matrix. City Administrators, Steering Committee and the School Principal, and the Design Team agreed that the Pi Option was the preferred option and was selected to be further developed as the project continues through the next phases of design and approvals.

Preferred Ground Floor Plan

DESCRIPTION

The basis of the Pi Option parti is that the Upper School (6-8) and the Lower School (JK-5) are housed in two separate wings of the building running perpendicular from Putnam Avenue while the community spaces and Preschool are organized along a circulation spine that crosses the site north/south connecting both schools and forming the top of a shape approximating the Greek letter π (pi). As the design developed, this circulation spine evolved into a metaphorical "learning street". This multi-story, glass enclosed, indoor atrium connects Magee Street to Kinnaird Street, enhancing pedestrian experience within the site and providing protection from rain and snow for children and parents alike. It serves as the Community Commons for the greater school campus. Metaphorically, this "street" which connects all parts of the school, represents the educational journey that our children take starting in Preschool, progressing through Lower and Upper School to the wider community including high school, college, and beyond. For now, we will call it "King Street", in honor of the great man whose legacy is so strongly linked to this school.

Distinct Entrances and Identity

This configuration with the two wings and a top allows for both the Upper School and Lower School to have separate entrances from a courtyard created by the massing on Putnam Avenue. This feature of two separate schools with separate entrances was very important to the school administration and faculty as well as to the majority of the parent community that responded to the questionnaire/survey issued by the City. Additionally, the Pi configuration allows the classrooms to have exterior walls with windows facing a north/south orientation. This orientation allows for the greatest amount and control of natural light coming into the classrooms, which in turns reduces energy needed for artificial lighting and improves student outcomes. Furthermore, the massing addressing Putnam Avenue and the new courtyard allows for the scale of the building and its presence along the street edge to be more in-keeping with the scale and patterns of the surrounding neighborhood context. It further allows for the introduction of more positive and softer landscaping at the "front door" which will contribute to greater curb appeal over the existing hard streetscape.

The massing of the lower and upper school wings that face neighbors to the north and south are stepped back or rotated so that the mass along these faces are broken down into smaller pieces. The Upper School mass was purposefully kept further away from the neighbor to the north than the existing building since that is the direction shadows are cast. The building corner closest to Magee Street will not cast any shadows onto neighbors as it is located to the north across the street from the Magee neighbors.

Community Spaces organized around Community Commons

The multi-story glass-enclosed "King Street" connects an entrance on the ground floor facing Kinnaird to an entrance on the first floor facing Magee. All the spaces that are used by the community after school hours are accessed directly from "King Street" which serves as the community commons. Internal doors separate this public zone from the academic classroom wings of the Upper and Lower Schools which allows for after-hours security. During the school day the Preschool has visual control at the Kinnaird Street entrance and the Health Office has visual control at the Magee Street entrance. Also on the first floor of "King Street" are the after school program classrooms. This gives students arriving by bus or by parent drop-off quick access from the Magee Street entrance and the drop-off lane located along that street.

The massing at each end of this atrium lowers down to one and two stories as seen from the facing street. The existing grade is highest at Putnam and gradually drops along Magee to a low point at the center of the existing outdoor space. The proposed new massing of the community spaces takes advantage of the grade drop by nestling the double height space of the Lower School gym into the hill along Magee. This results in only about 1-story of this gym being visible from across Magee Street. At the other end of "King Street" the 1-story Preschool and a 2-story Upper School gym have been pulled away from Kinnaird Street by more than 50′ further than the existing building. This reduces any shadows that would be cast upon homes along Kinnaird. This also improves views from the back of homes on Putnam Avenue looking east and from the adjacent neighbor immediately north whose windows on the long west side of the house currently look directly at the 3-story massing of the existing gymnasium wing. The same is true of the house immediately adjacent to the school on Kinnaird Street, which will benefit by the relocation of the gym, currently very close to its western façade further into the school property. Proposed new landscaping in that area will enhance views from that home.

Pi has a more compact footprint in comparison to other options studied. This feature is achieved by positioning the auditorium, which is the only large program space that does not require any natural light, at the center of the complex, between the Lower and Upper schools and "King Street." This location is optimal as the auditorium will be used by students of both schools as well as members of the community, who can access it directly from "King Street" after hours without entering either school. The auditorium is surrounded by support spaces including those directly serving it, as well as other school support spaces which do not require natural light. Corridors for circulation surround these spaces, serving naturally lit and ventilated classrooms and other instructional spaces. This layout, with "dark" spaces at

the core, surrounded by light spaces on the perimeter, creates a compact and efficient floor plan. The circulation systems are double and triple-loaded and the building enclosure is as compact as possible while still providing natural light and ventilation to every classroom and instructional space.

Location of School Administration
Of all options, Pi was most successful in locating the offices of both the Lower and Upper schools for subtle (but effective) security. Offices of both schools are positioned directly at the front door of their respective school with windows facing directly onto the entry courtyard enabling an unimpeded view of all comings and goings. The courtyard design allows the entrances, and hence, the offices, to be positioned towards the middle of each school, rather than at one end. Additionally, both offices are located at the intersection of an intentional bend in the internal corridor that serves each school. This allows direct views from the offices down the relatively short lengths of the corridors in both directions. At one end of the corridor, within direct visual sight-line, are the doors that connect each school to "King Street." So, in addition to direct views of the front entrance and the entry-level classroom corridors, Pi allows direct views from the offices of each school to the second entrance of each school on "King Street."

Preschool
The Preschool is located in an appropriately-scaled 1-story portion of the building fronting Kinnaird Street. It has its own front door establishing its identity, facilitating drop-off and pick-up and making the campus more secure. Its location fronting onto the internal "King Street," allows preschoolers direct access to shared resources like the gym and food-lab, located on the same floor, without disruption or the need to access the rest of the facility. The new building is located sufficiently far back from the sidewalk on Kinnaird Street to accommodate a proper drop-off and pick-up area for the Preschool on school property right outside the Preschool front door. Additionally it will have its own contained play area that will be accessed directly from Preschool classrooms, providing a safe and secure setting for the youngest members of the school community.

Learning Commons
One of the most important instructional spaces serving both Lower and Upper schools is the Learning Commons. Replacing the library of former schools, this space will continue to house the schools' paper books but additionally it will offer an environment suitable for interactive learning and teaching using the latest technologies. The importance of this space is expressed in Pi by its location at the vertical center of both schools on "King Street", midway between them. Students from any grade only have to walk a short distance and up or down a maximum of one story to get from their classrooms to the Learning Commons. Additionally, to emphasize its importance as the "heart of the schools", the Learning Commons is located to provide natural light and views on three of its four sides, and direct access to a rooftop terrace for outdoor instructional space. Its fourth side engages "King Street" which will provide ample opportunity to be visually and physically open to this Community Commons during the day while secured after hours. During Schematic Design, this space will be designed to create opportunities for separate appropriately-scaled spaces for the Lower and Upper schools, while still allowing them to function as a whole when required.

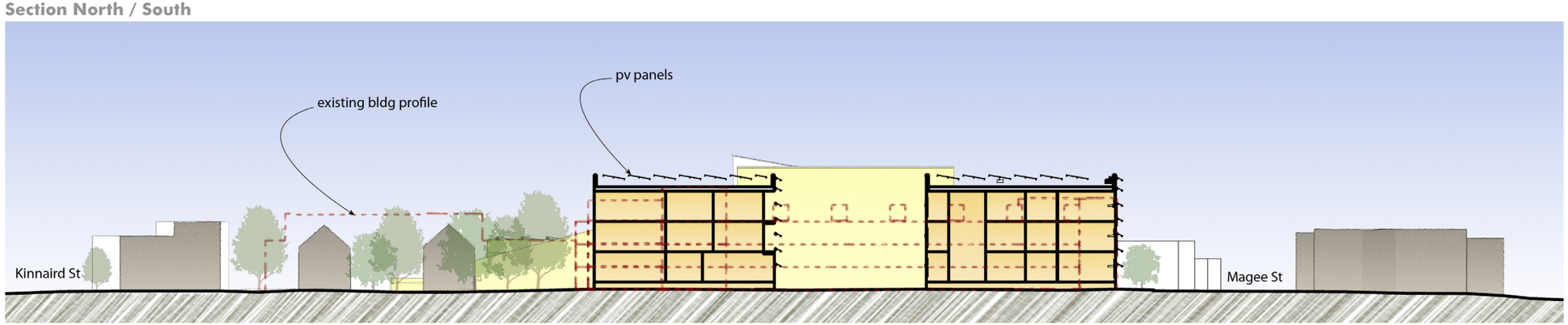
Lower School Organized into Two Teams: JK/K – 2nd & 3rd – 5th
The Pi Option strove to create a compact footprint while affording classrooms access to as much natural light as possible on the exterior and at the same time providing convenient access to teacher work and support spaces at the interior. To achieve this the Lower School was located on three floors. The five JK/K classrooms are located on the first floor along with the Main Office. This location provides direct access to the outdoors and there is potential for outdoor instructional space within the landscape areas. The rest of this team, the three 1st grade and three 2nd grade classrooms, is directly above on the second floor which can be quickly accessed through a stair internal to the Lower School, or an elevator at the nexus where the Lower School meets "King Street". The second team comprised of a total of six classrooms serving 3rd through 5th grade is all on the third floor of the Lower School academic wing. Where ever possible on the second and third floors there are outdoor green roofs and balconies occurring between classrooms that can provide a small garden space to be used for instructional purposes.

On each floor of the Lower School are two extended learning areas that can be used for collaborative project work by small groups. The extended learning areas gather ample natural light from the outside, but are also strategically located so that they can be supervised from adjacent classrooms, teacher work areas and other offices which are distributed on each floor to enhance the subtle security of the school.

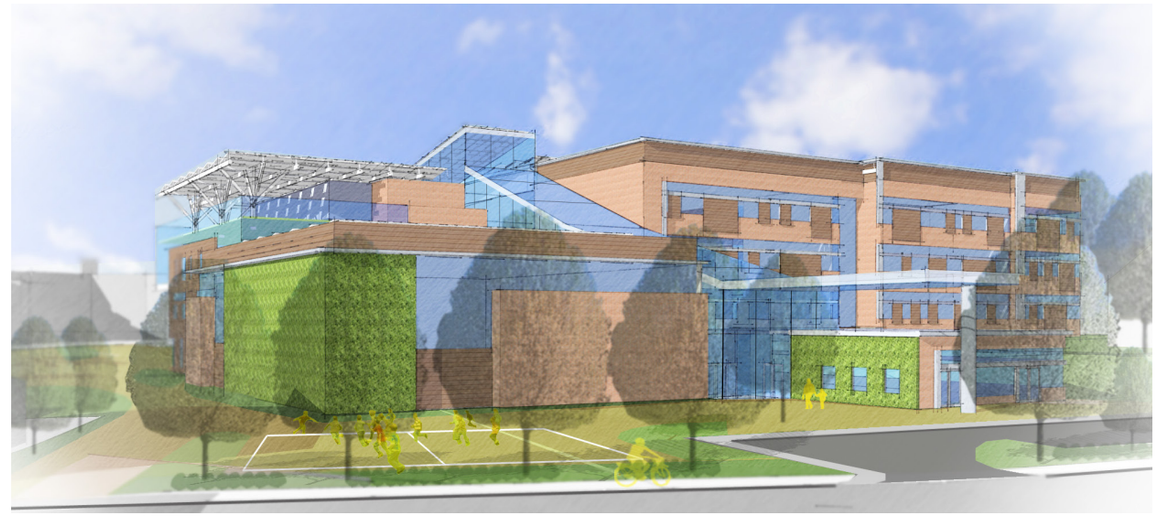
Preferred Site Plan

View from Putnam at Entry

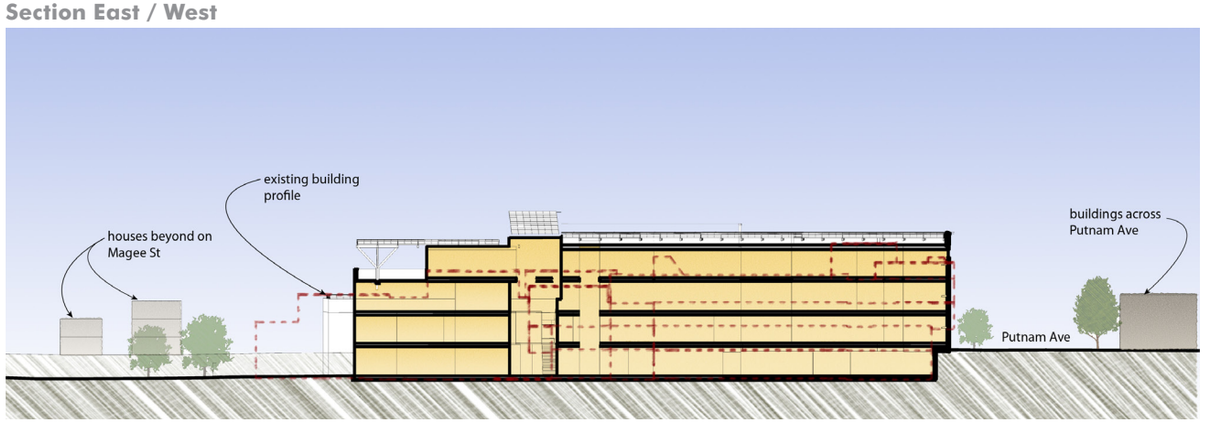
Section North / South



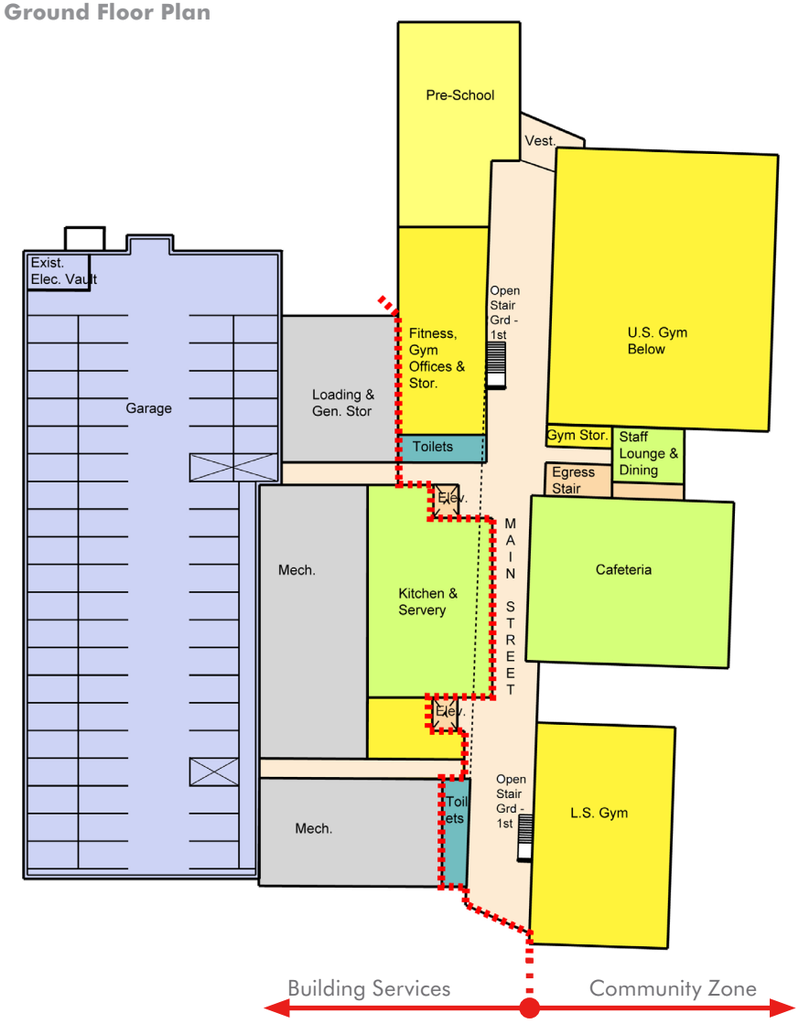
View from Kinnaird



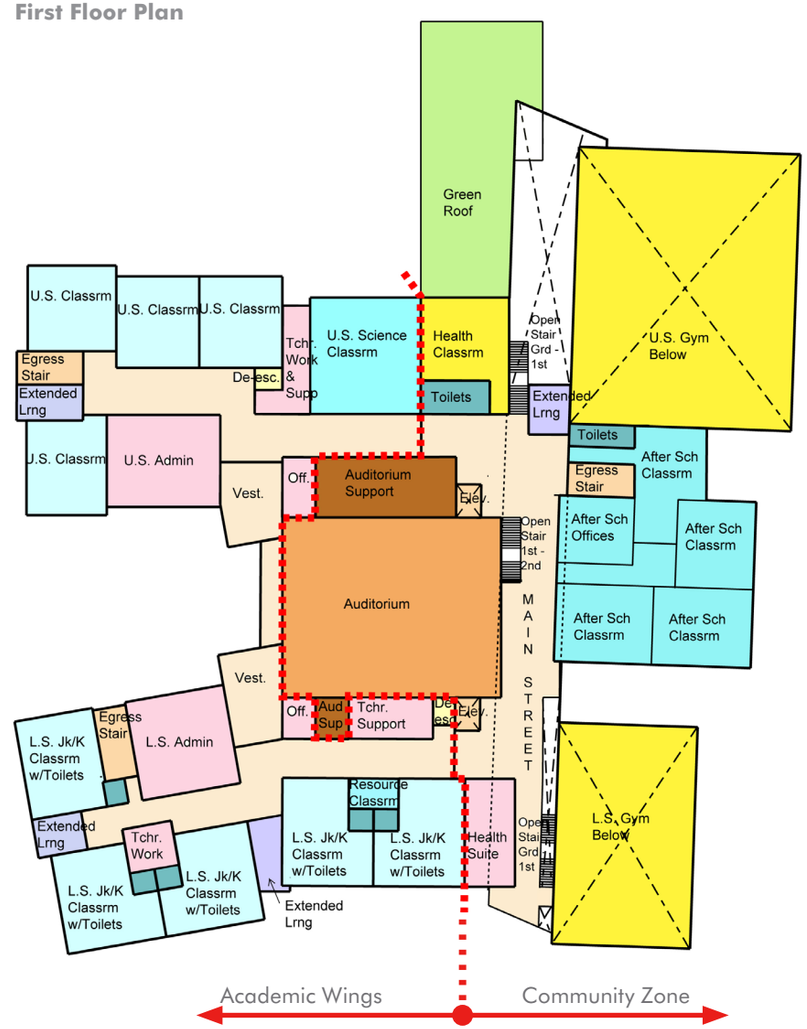
Section East / West



Ground Floor Plan



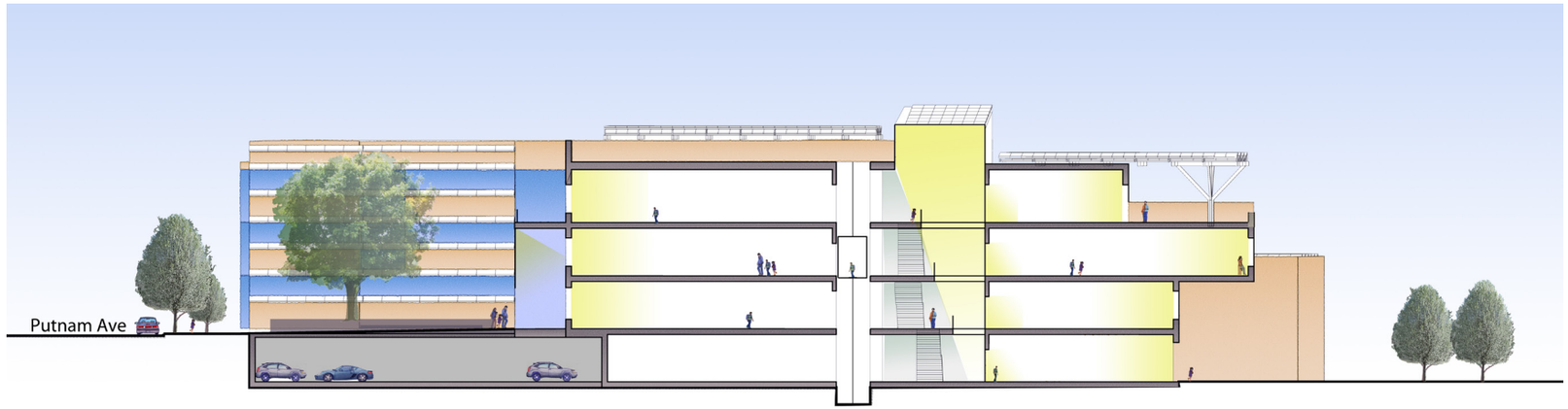
First Floor Plan



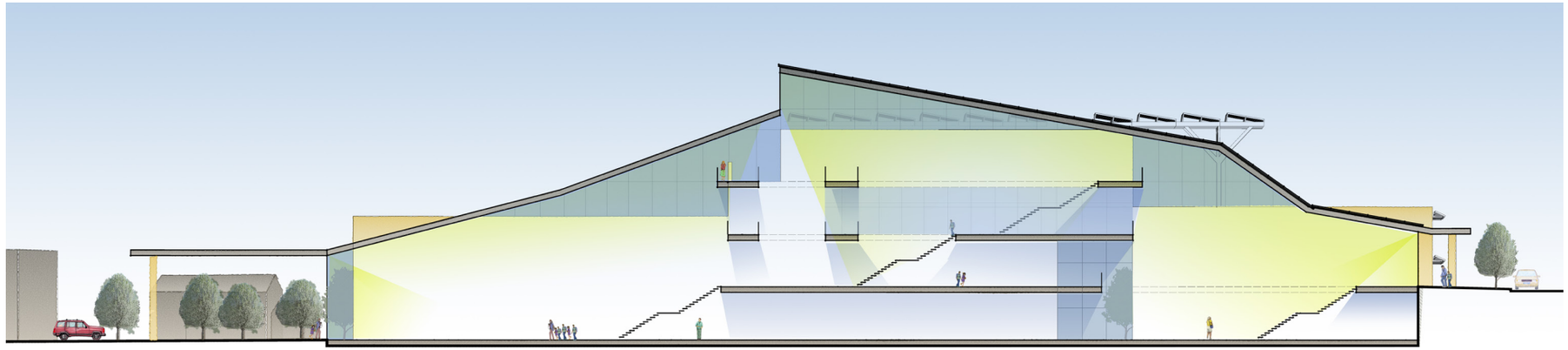
Second Floor Plan

Third Floor Plan

Section West / East



Section "King Street" North / South

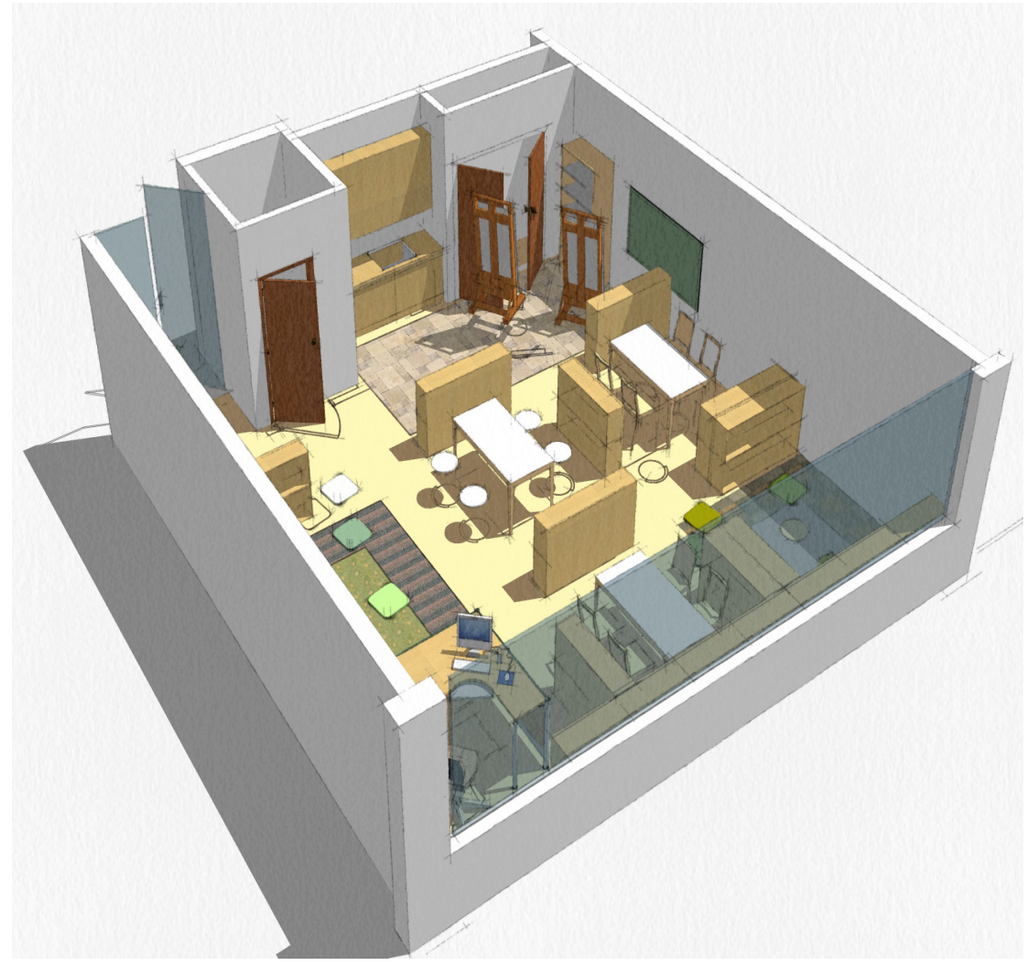


Upper School Organized into Three Grade Level Teams
The Pi Option locates one grade level team on each floor of the Upper School academic wing. The teams are connected through a stair internal to the Upper School and an elevator at the nexus where the Upper School meets "King Street." Each team is complete with teacher work and support spaces as well as extended learning areas which are also strategically located to provide for natural light and ease of supervision. As in the Lower School, green roofs and balconies are provided where possible to extend the instructional space outside.

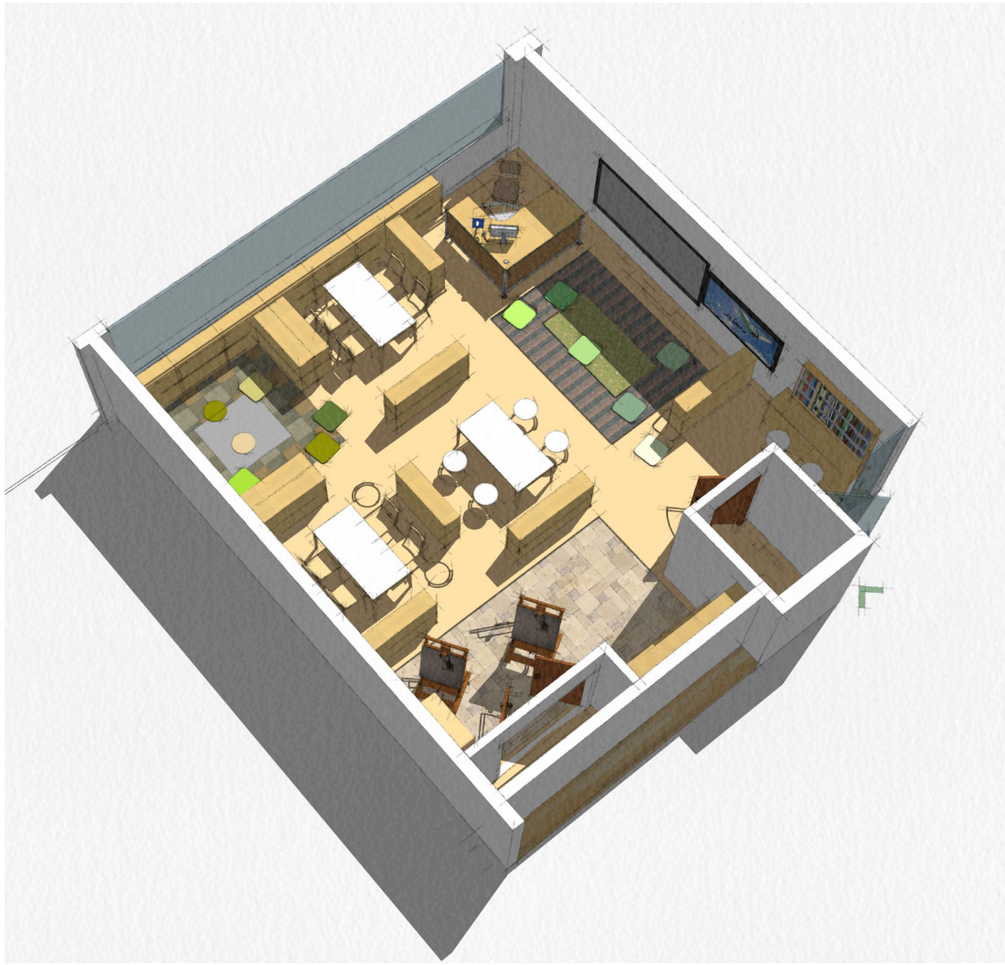
Developing a Professional Community
In order to allow for collaboration among teachers to foster curriculum interconnectivity and professional development, properly located support spaces are included in the design of the preferred option. The teacher work spaces become the heart of each floor within each academic wing. Additionally, teacher coaching offices are located centrally so they can advise and support in an integral way. Each school is provided with a conference room within the support space so that larger meetings can occur among teachers or with parents, faculty and the administration. Lastly, a dedicated teacher lounge is located near, but separate from the cafeteria to allow for staff to decompress and relax. The lounge has a direct connection to a small private outdoor garden space as well.

Garden, Dining and Food Lab
Just as the Learning Commons is more than a library, MLK's vision for dining is more than a cafeteria. As an important shared teaching and learning opportunity, it is similarly centrally located, directly below the Learning Commons. Its on-grade location, with abundant natural light and ventilation, also allows direct access to outdoor seating, and for students to participate in maintaining a garden appropriate for the seasons. This garden can become an outdoor classroom while at the same time providing fresh herbs to be used in the main kitchen. As with the Learning Commons, during Schematic Design, the design team will explore ways to break up the space into smaller and larger scales to accommodate the Lower and Upper School students and also integrate the Food Lab.

View of Classroom



View of Classroom 2



Site Amenities

The following are site amenities identified in the Pi Option to be developed at the Schematic Design stage:

- Play and Recreation areas for the various schools benefit from the reduced site area dedicated to parking and the building footprint. A variety of outdoor play and recreation spaces are envisaged, including passive spaces, areas with play equipment, and very active spaces for running and ball-play. The Lower School play area with play equipment is shown closest to the Lower School to the east of the site behind the Magee Street neighbors. This space and equipment is shared with the community and is as easily accessed from Magee, Hayes and Kinnaird Streets. The synthetic turf field is shown adjacent and conveniently located close to the Upper School gym with a paved basket-ball court and landscape area on its north side towards Kinnaird Street. The Preschool has its own dedicated and enclosed outdoor play area.
- Teacher Garden is an enclosed outdoor space directly adjacent to the teacher lounge which allows for the teachers, like the students, to open their lounge doors in pleasant weather and spill out onto a paved private terrace.
- Landscaping for the entire site will be an important part of the Schematic Design phase when a landscape architect will be brought onto the team. Besides landscaping within the site for the benefit of the schools, an equally important consideration will be the land-scaping surrounding the site and the positive benefits that it can bring to the neighboring community.
- The Courtyard located between the two schools on Putnam, a significant outdoor space, it forms the front entrance court to both schools, and helps to give each school its own separate identity, but could potentially also function as a useable outdoor teaching space. This concept will be explored during the Schematic Design phase when the space is designed. For security after hours when the school shuts down for the night, the courtyard will be enclosed with large decorative gates.
- Bicycles are to be encouraged for students and staff of the new MLK school. Bike routes within the site are to be clearly marked, leading from all site entry points to bike parking areas located strategically near all entrances to the school. Fun sculptural bike racks can be used throughout the site to encourage bike use and create elements of interest within the landscape.
- Parking is one of the reasons that Pi was selected as the Preferred Option. By maintaining approximately 20,000 gsf of the ground floor of the existing building an underground parking garage for approximately 60 cars can be economically created and easily

accessed via a door adjacent to the proposed loading area. This minimizes the number of parking spaces required on-grade to approximately 20. These few spaces do not require much of the site and can be located between Kinnaird Street and the building, using only a small amount of that space to accommodate them along with the pick-up and drop-off area for the Preschool.

BUILDING COMPONENTS

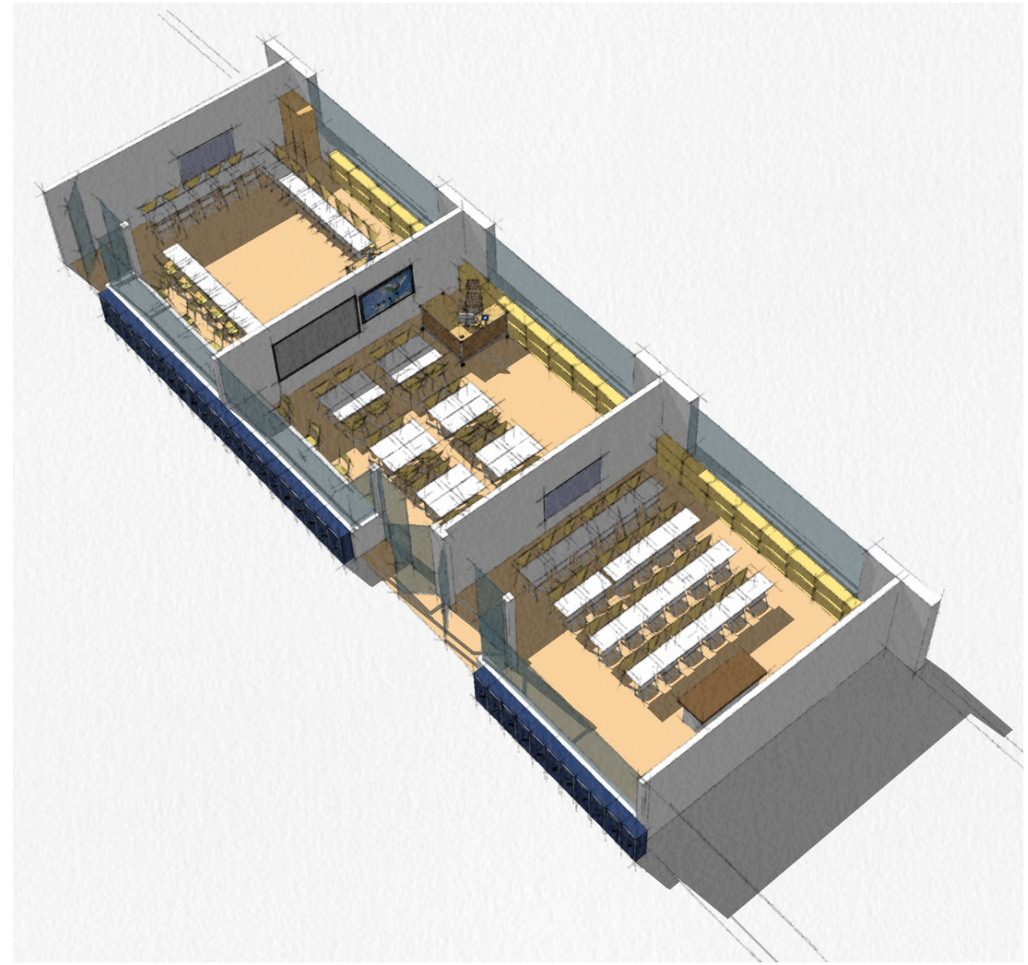
Even at this early stage in the design process, the team is already considering options for materials, exterior wall and roof systems, exterior window and curtainwall systems, light-shelves, shading devices, skylights, interior door and window systems, casework and technology. The City of Cambridge expects this building to have a minimum of a 50 year life expectancy. Of course, this does not mean that every component will last that long, but that overall the building will have inherent energy efficiency, flexibility to meet changing curriculum needs, inherent durability and is able to be maintained.

Inherent Energy Efficiency:
In addition to the north/south orientation of classrooms which is the best for utilizing natural light within the classrooms, other features also must be employed to effectively control glare and heat gain/loss through the walls. To balance the wall to window ratio certain targets have been established which will help guide the design of the façade in the next phase of schematic design:

South facing façades:	+/- 30% glazing or windows
North facing façades:	+/- 35% glazing or windows
East/West façades	+/- 25% glazing or windows

The windows and curtain walls systems currently being proposed all have the large thermal break within the frame that give it a higher than average R-value. The shading coefficients and visual transmittance values will be adjusted to respond to the orientation on the building. Currently areas with curtainwall that face east/west also have a layer of ceramic frit proposed on the glazing to help with heat gain and glare. Additionally, the remaining walls have insulation (approx. R-20 for insulation only) applied to the exterior of the structure to minimize thermal bridging from inside to outside through the structure. An air/water/vapor barrier will be installed on the warm side of the insulation and the exterior cladding will be installed as a rain-screen systems which has an air space between the cladding and the insulation to allow

View of Classroom 3



View of "King Street"

any water that may migrate through the cladding to be managed and directed back to the outside before it ever has an opportunity to reach the wall.
To allow natural light to penetrate deep within the classrooms a clerestory window systems is being proposed that will have a light-shelf at its bottom edge on the inside of the classroom to bounce light back up to the ceiling. The higher floor to floor distance of 14′ that is in the Preferred Option allows for the bounced light to penetrate deeper within the room and has the added benefit of providing ample space for building systems such as ventilation ducts and sprinklers to be more easily coordinated during construction and accessed for maintenance once the building opens. On the outside of south facing exterior walls, photovoltaic panels will be mounted so that they act as sun-shading devices as well as capturing the sun's rays for electricity production.

At the atrium enclosing the internal "King Street", the skylight roof will be selected to include advanced insulating technologies such as nano-gel, which can be selected to have varying degrees of translucency/opacity. In the next stage of the design this space will be carefully designed to ensure that light levels are pleasant on even the sunniest of days.

The roof construction also plays an important role in the energy efficiency of the building. Currently insulation with an R-value of R-40 is being proposed, plus the additional value of a green roof system. The green roof not only helps to keep the roof cool and control storm water, but it also protects the membrane from harmful UV rays of the sun which eventually cause the degradation of the roof over time. PV panels will be accommodated on a structure that "floats" above green roofs.

Flexibility to Meet Changing Curriculum:
The size of the classrooms has been developed to comfortably accommodate the maximum number of students allowed by contract within the City of Cambridge while allowing instructional set-up flexibility within. Ample storage will be provided, as well as wall space for display and writing surfaces.

Acoustics within and between classrooms and offices will be studied and optimized through wall construction and materials selection, and isolating sound within very noisy spaces such as the band/orchestra rooms will be integral parts of the design. Additionally, great care will be taken in the selection of materials for the atrium space so that the acoustics within the space are active and yet comfortable even at the busiest of times.

The spaces within that will serve both the school during the day and the community after school and on weekends are all located within the community commons we are calling "King Street." These spaces will be zoned for flexible use within the security systems, the lighting systems, and the mechanical systems to accommodate a variety of uses at a variety of times. Also, the design of community spaces will be given special attention so that storage for daytime school use will be separate from after school program use and the transition can easily occur.

At every opportunity, the Preferred Option has tried to also tried to provide outdoor space that can be accessed from the instructional spaces to further increase the curriculum flexibility. Balconies and roof spaces can become integral teaching spaces in addition to the on-grade opportunities such as the garden outside the cafeteria and food lab.

Durability and Maintenance

Both interior and exterior materials will be selected to be both durable and beautiful. Flooring choices for public spaces are crucial for a long lasting low-maintenance school. During Schematic Design and Design Development the design team would like to show that the long term benefits of a product like terrazzo out-weighs the initial cost increase to the project. Materials such as this will be evaluated through a cost/benefit analysis that will often also include a "return on investment" or "life-time cost" analysis when appropriate. Other items such as finishes on railings will be selected so that the on-going need for repainting and finishing will be either eliminated or kept to a minimum.

The physical placement of building system components that require maintenance and controls that require monitoring will also be important criteria as the design evolves so that filters and parts can be replaced without undue disruption and anomalies in the systems performance can be identified early. Even the type, location and lifespan of light bulbs becomes important to keep an energy efficient building at peak performance.

View of Extended Learning

ZONING ANALYSIS

Overview

As with many public schools in the City of Cambridge, the existing MLK, Jr. School building does not meet the dimensional requirements of the current zoning bylaw for Res-C1 in many respects, including height, setbacks, FAR, and parking. The City is in the process of creating new zoning regulations for K-8 public schools. These new regulations will allow the existing school building to be used as a baseline dimensional template for renovating, altering or creating a new school on the site. Additionally, by a special permit granted by the Planning Board, certain additional dimensional regulations are made available to optimize site use and minimize impact on abutting residential properties. As currently conceived in the early stage concepts of the Feasibility Study, subject to change as the design evolves, the design of the proposed Preferred Option for the new MLK, Jr. School will create a better school for the students and staff, improve the setbacks and create enhanced outdoor spaces over those currently afforded by the existing building and site configuration.

Zoning Compliance Form

ZONING CRITERIA	EXISTING BUILDING / EXISTING ZONING				NOTES	EXISTING BUILDING / PROPOSED ZONING			PREFERRED OPTION / PROPOSED ZONING		
ZONING DISTRICT: RES - C1	EXISTING ZONING REQUIREMENTS	EXISTING BUILDING REQUIRED	EXISTING BUILDING ACTUAL	COMPLIANCE ANALYSIS		PROPOSED ZONING REQUIREMENTS	EXISTING BUILDING ACTUAL	COMPLIANCE ANALYSIS	PROPOSED ZONING REQUIREMENTS	PROPOSED BUILDING ACTUAL	COMPLIANCE ANALYSIS
USE	Per 4.33.b.1			Allowed		Per 5.50		Allowed	Per 5.50		Allowed
TOTAL GROSS FLOOR AREA	"147,543 (.75) 110,657.3"	"147,543 (.75) 110,657.3"	153,736	Nonconforming		Existing gfa or 1.25 (with Special Permit S.P) Total allowed with S.P is 147,543 (1.25)=184,428	153,736	Complies	Existing gfa or 1.25 (with S.P) Total allowed with S.P is 147,543 (1.25)=184,428	approx. 161,000	Will Comply
LOT AREA MINIMUM REQUIREMENT	5,000	5,000	147,543	Complies		5,000	147,543	Complies	5,000	147,543	Complies
FLOOR AREA RATIO	0.75	0.75	"153,736/ 147,543.3 = 1.04"	Nonconforming		"1.04 (AOR) 1.25 (with S.P) "	1.04	Complies	"1.04 (AOR) 1.25 (with S.P)"	1.09	Will Comply w/ S.P
FRONT SETBACK PUTNAM	H+L/4, Min 10	50+226.9/4=69	14.7+20.6=35.3	Nonconforming	Note 1	10	14.7	Complies	10	20.5'	Will Comply
LEFT SIDE SETBACK PUTNAM	H+L/5	50+81.6/5=26.3	9.6	Nonconforming	Note 1	15	9.6	Complies (does not meet 10' min.)	15	15.5'	Will Comply
FRONT SETBACK KINNAIRD	H+L/4, Min 10	50+167.9/4=54.5	21.9+17.5=39.4	Nonconforming	Note 1	10	21.9	Complies	10	73'	Will Comply
LEFT SIDE SETBACK KINNAIRD	H+L/5	50+ 74.5/5= 24.9	27.4	Complies	Note 1	15	27.4	Complies	15	27.5'	Will Comply
RIGHT SIDE SETBACK KINNAIRD	H+L/5	50+74.4 /5= 24.9	30.3	Complies	Note 1	15	30.3	Complies	15	54.5'	Will Comply
FRONT SETBACK MAGEE	H+L/4, Min 10	50+168.7/4=54.7	17.4+19.7=37.12	Nonconforming	Note 1	10	17.4	Complies	10	10'	Will Comply
RIGHT SIDE SETBACK MAGEE	H+L/5	50+ 54.3/5= 20.9	41	Complies	Note 1	15	41	Complies	15	41.5'	Will Comply
FRONT SETBACK HAYES	H+L/4, Min 10	50+110 /4= 40.0	168+15=183	Complies	Note 1	10	168	Complies	10	126'	Will Comply
OPEN SPACE	Not required										
HEIGHT	35	35	50' assumed bldg height	Nonconforming		"45' (AOR) 55'/65' with S.P"	50' assumed bldg height (formulae required)	Complies	"45' (AOR) 55'/65' (with S.P)"	45' +/- from Putnam Ave*	Will Comply
PARKING SPACES	3 per 2 instructional rooms (50 rooms exist)	75	49	Nonconforming		3 per 2 Instructional Rooms or Existing	49	Complies	3 per 2 Instructional Rooms (64 rooms proposed) or Existing	80	Will Comply

NOTE 1: FOR REQ SETBACKS NO MULTIPLANE FORMULAE OR AVERAGE HEIGHT CALCULATIONS WERE APPLIED
* AVERAGE GRADE NOT YET DETERMINED, FROM PUTNAM AVENUE EXISTING GRADE THE HEIGHT IS +/- 45'.
S.P = SPECIAL PERMIT
AOR = AS OF RIGHT

4.0 EDUCATIONAL AND SPACE NEEDS SUMMARY

A BUILDING DESIGNED TO SUPPORT THE INNOVATION AGENDA

Superintendent Young, the Cambridge Public School District and the community have established a vision for transforming Cambridge's public schools. The goals of this transformation are:

- To provide all Cambridge Public School students with a superior academic and social experience in their elementary and middle grade years that raises student achievement, eliminates achievement gaps, and develops 21st century skills
- To build a grade 6-12 pathway that ensures all Cambridge Public School students are well prepared for academic and social success in high school and post-secondary education
- To provide all students in special populations, such as students with special needs and English language learners, with the same quality school experience provided to other students
- To expand professional development and collaboration opportunities for the Cambridge Public School educators, improving experience and quality
- To ensure that Cambridge Public School facilities fully support the expectations and
- demands of the academic programs
- To ensure that Cambridge Public Schools make the best and most efficient use of resources in providing superior service to students

From the creation of a distinct Upper School and the provision of space for the Lower School's Chinese immersion and enrichment programs, to the ability to provide rich after-school programming and foster professional and learning communities, the design for the renewal of the Martin Luther King, Jr. School campus will directly support the Innovation Agenda.

The table included in this section summarizes the resources that will be made available in the building to accommodate this vision. The information it contains is derived from over 18 focus groups and surveys with administrators, teachers, and parents as well as information from professional practice.

The spaces listed in this table are further defined in Volume 2 of this report. Together with the other components of this study this document will provide the basis for the design team to create the 21st Century learning environments that will help prepare all Cambridge's students for life in a rapidly evolving world and achieve its goals for academic excellence and social justice.

Area Summary

		NET AREA TOTAL	GROSSING FACTOR	GROSS AREA TOTAL
A.	**Area Summary**			
3.	Program area (without Structured Parking)	111,755 nsf	1.40	156,457 gsf
	Structured Parking Estimated SF		Structured Parking Estimate	19,600 gsf
	Total Projected GSF			**176,057 gsf**

FACILITY SPACE PROGRAM

SPACE DESCRIPTION		PROPOSED NUMBER OF SPACES, CAPACITY AND SIZE								NOTES
		SPACES		STUDENTS		NET SQUARE FEET			Priority	
		total spaces	total staff	each room	total students	sq. ft per student (staff)	sq. ft per room	square feet sub-total		
1	**LOWER SCHOOL**									
A	**Lower School (LS) Classroom Space**									
1.	JK/K	5	2	20	100	50	1,000	5,000		Toilet + sink & bubbler in classroom
2.	Grade 1	3	2	25	75	45	1,125	3,375		Toilet + sink & bubbler in classroom - connecting Girls & Boys toilet rooms between shared classrooms
3.	Grade 2 to 5	9	2	25	225	40	1,000	9,000		Sink & bubbler
4.	Extended Learning Space	17	0	0	0	0	100	1,700		
5.	Learning Center	2	1	5		40	200	400		
6.	Resource Classroom	3	3	8		40	320	960		
Lower School Classroom Spaces:		39			400			20,435		
B	**Arts, Language and Instructional Support**									
1.	Chinese Enrichment (Ni Hao)	2	1	24	48	40	960	1,920		
2.	Visual Art	1	1	24	24	50	1,200	1,200		
4.	Laptop Cart Storage	3					50	150		
5.	De-escalation Room	3		1	1	75	75	225		
6.	Teacher Workroom	2					250	500		
7.	Bookroom	1					250	250		
8.	Conference Room	1	10				250	250		
9.	Coaching Office	1	4			60	220	220		Math, Literacy & District Coaches
9a	Conference Room	1	4			30	120	120		Attached small conference room for 3-5 people to meet - necessary?
10.	Family Liaison	1	1			100	100	100		
Lower School Instructional Support Spaces:		15						4,935		

4.2 FACILITY SPACE PROGRAM TABLE

SPACE DESCRIPTION		PROPOSED NUMBER OF SPACES, CAPACITY AND SIZE								NOTES
		SPACES		STUDENTS		NET SQUARE FEET			Priority	
		total spaces	total staff	each room	total students	sq. ft per student (staff)	sq. ft per room	square feet sub-total		
C	**Lower School Administration**									
1.	Main Office									
1a	Clerk	1	1			80	80	80		
1b	Mailboxes	1					50	50		
1c	Supply Storage	0					0	0		
1d	Reception	1					100	100		
1e	Workroom & Copier	1	1				200	200		
1f	Master Clock/PA Room	1					100	100		
2.	IEP/Conference Room	1	20				400	400		
3.	Bathroom	1					65	65		
4.	Itinerant Staff	1	1				120	120		Use by Social Worker. Others
5.	Principal's Office	1	1				200	200		
6.	Administrative Assistant	1	1				120	120		
7.	Child Waiting Room	1	0				100	100		
Lower School Administrative Spaces:		11						1,535		
D	**Distributed Administration - Counseling**									
1.	Counseling	1	1			140	150	150		Adjustment Counselor/Social Worker
2.	Interns	1	4		-	120	150	150		
Lower School Distributed Administration Spaces:		2						300		

SPACE DESCRIPTION		PROPOSED NUMBER OF SPACES, CAPACITY AND SIZE								NOTES
		SPACES		STUDENTS		NET SQUARE FEET			Priority	
		total spaces	total staff	each room	total students	sq. ft per student (staff)	sq. ft per room	square feet sub-total		
2	**UPPER SCHOOL**									
A	**Upper School (US) Classroom Space**									
1.	Self Contained Classrooms	3	3	12	36	80	960	2,880		
2.	6th Grade Math	1	1	25	25	40	1,000	1,000		
3.	6th Grade Science	1	1	25	25	60	1,500	1,500		
3a.	Science Prep Room	1	1	25		10	250	250		Prep room may be shared between two labs
4.	6th Grade ELA, Social, World Lang.	2	2	25	50	40	1,000	2,000		
5.	7th Grade Math	1	1	25	25	40	1,000	1,000		
6.	7th Grade Science	1	1	25	25	60	1,500	1,500		
6a.	Science Prep Room	1	1	25		10	250	250		
7.	7th Grade ELA, Social	2	2	25	50	40	1,000	2,000		
8.	7th Grade World Lang.	1	2	25	25	40	1,000	1,000		
9.	8th Grade Math	1	1	25	25	40	1,000	1,000		
10.	8th Grade Science	1	1	25	25	60	1,500	1,500		
10a	Science Prep Room	1	1	25		10	250	250		
11.	8th Grade ELA, Social	2	2	25	50	40	1,000	2,000		
12.	8th Grade World Lang.	1	2	25	25	40	1,000	1,000		
13.	Extended Learning Space	17	0	0	0	0	100	1,700		
14.	Lockers	1		300			300	300		In corridors; provided for all US students
Upper School Classroom Spaces:		19			386			21,130		

4.2 FACILITY SPACE PROGRAM TABLE

SPACE DESCRIPTION		PROPOSED NUMBER OF SPACES, CAPACITY AND SIZE								NOTES
		SPACES		STUDENTS		NET SQUARE FEET			Priority	
		total spaces	total staff	each room	total students	sq. ft per student (staff)	sq. ft per room	square feet sub-total		
B	**Arts, Language and Instructional Support**									
1.	Visual Art	1	1	24	24	50	1,200	1,200		
1a	Kiln Room	1					75	75		
2.	De-Escalation Room	3					75	225		
3.	Laptop Cart Storage	3					100	300		
4.	Teacher Workroom	3					250	750		
5.	Bookroom	1					250	250		
6.	Conference Room	1	10				250	250		
7.	Coaching Office	1	4			60	220	220		Math, Literacy & District Coaches
7a	Conference Room	1	4			30	120	120		Attached small conference room for 3-5 people to meet
8.	Family Liaison	1					100	100		
Upper School Instructional Support Spaces:		16						3,490		
C	**Upper School Administration**									
1.	Main Office									
1a	Clerk	1	1			80	80	80		
1b	Mailboxes	1					50	50		
1c	Supply Storage	0					0	0		
1d	Reception	1					100	100		
1e	Workroom & Copier	1	1				200	200		
1f	Master Clock/PA Room	1					100	100		
2.	IEP/Conference Room	1	20				400	400		
3.	Bathroom	1					65	65		
4.	Itinerant Staff	1	1				120	120		Use by Social Worker, others.
5.	Principal's Office	1	1				200	200		
6.	Assistant Principal	1	1				120	120		
7.	Child Waiting Room	1	1				100	100		
Upper School Administrative Spaces:		11						1,535		

SPACE DESCRIPTION		PROPOSED NUMBER OF SPACES, CAPACITY AND SIZE								NOTES
		SPACES		STUDENTS		NET SQUARE FEET			Priority	
		total spaces	total staff	each room	total students	sq. ft per student (staff)	sq. ft per room	square feet sub-total		
D	**Distributed Central Administration - Counseling**									
1.	Counselor's Office	2	1				150	300		Adjustment Counselor
2.	Interns	1	4				140	140		
Upper School Distributed Administration Spaces:		3						440		
3	**HUMAN SERVICES**									
A	**PreSchool**									
1.	Classrooms	2		20	40	50	1,000	2,000		
2.	Bathrooms	2					65	130		
3.	Office	1					140	140		
4.	Pantry	1					140	140		
5.	Reception	1					150	150		
6.	Staff Bathroom	1					65	65		
7.	Stroller Storage	1					50	50		
8.	General Storage	1					150	150		Large enough to include cots
9.	Mudroom	1					100	100		
10.	Laundry	1					50	50		Washing machine/dryer
Human Services Preschool Spaces:		12			40			2,925		

4.2 FACILITY SPACE PROGRAM TABLE

SPACE DESCRIPTION		PROPOSED NUMBER OF SPACES, CAPACITY AND SIZE								NOTES
		SPACES		STUDENTS		NET SQUARE FEET			Priority	
		total spaces	total staff	each room	total students	sq. ft per student (staff)	sq. ft per room	square feet sub-total		
B	**Human Services Program Dedicated Instructional Space**									
1.	After School Classroom	2	2	24	48	40	960	1,920		
2.	Community School	2	2	24	48	40	960	1,920		Shared during day with schools?
3.	Storage	4					50	200		
4.	Laptop Cart Storage	1					50	50		
Human Services Instructional Support Spaces:		9						4,090		
C	**Human Services Administration (After School Programs)**									
1.	Main Office									
1a	Office	1	3				140	140		
1b	Conf Room	1					250	250		
1c	Teacher Workroom	1					140	140		
Human Services Administrative Spaces:		3						530		

SPACE DESCRIPTION		PROPOSED NUMBER OF SPACES, CAPACITY AND SIZE								NOTES
		SPACES		STUDENTS		NET SQUARE FEET			Priority	
		total spaces	total staff	each room	total students	sq. ft per student (staff)	sq. ft per room	square feet sub-total		
4	**SHARED RESOURCES**									
A	**Learning Commons**									
1.	Flexible Instructional Space	2	1	24		40	960	1,920		
2.	Small Group Room	3		4		40	160	480		
3.	Multimedia Studio	1	1	24		40	960	960		
4.	Book Stacks	2					600	1,200		
5.	Reading	2					500	1,000		
6.	Information	1					150	150		
7.	Workroom / Storage	1					400	400		
8.	Office	2					120	240		
9.	IT Workroom/Office	1					250	250		
10.	Telecomm Room	3					150	450		
Total learning commons spaces:		18						7,050		
B	**Gym/Health Center**									
1.	Multi-Purpose Gymnasium	1					8,000	8,000		200 seat bleacher
2.	Small Gym	1					4,000	4,000		
3.	Storage	1					500	500		
4.	P.E. Office	1					120	120		
5.	Locker Rooms	2					600	1,200		
6.	Fitness Center	1					1,600	1,600		
7.	Health Classroom	0	1	25		40	1,000	0		
8.	Staff Changing Room/Shower	1					120	120		Locate off of or adjacent to Fitness Center
Total Gym/Health Center Spaces:		8						15,540		

4.2 FACILITY SPACE PROGRAM TABLE

SPACE DESCRIPTION		PROPOSED NUMBER OF SPACES, CAPACITY AND SIZE								NOTES
		SPACES		STUDENTS		NET SQUARE FEET			Priority	
		total spaces	total staff	each room	total students	sq. ft per student (staff)	sq. ft per room	square feet sub-total		
C	**Dining**									
1.	Dining	2					1,500	3,000		100 x 15 sf/student - allows one LS and one US seating: 3 seatings
2.	Kitchen	1					1,500	1,500		Placeholder
2a	Food Prep									
2b	Dry Storage									
2c	Ware Washing									
2d	Refrigerator									
2e	Freezer									Walk-in
2f	Recycling									
2g	Office									
2h	Breakroom									
2i	Bathroom									
2j	Changing/Locker Room									
3.	Servery	1					1,600	1,600		Placeholder
4.	Food Lab	1	1	24		40	960	960		Use Dining as extension of the lab?
Total Dining Spaces:		5						7,060		
D	**Auditorium**									
1.	Lobby	1					500	500		
2.	Auditorium	1	100		300	10	4,000	4,000		sq ft based on 10 net sf per seat
2a	Projection/Control Room	1					150	150		
3.	Stage	1					1,000	1,000		
4.	Scene & Prop Storage/Shop	1					500	500		
5.	Dressing Rooms	2					250	500		
Total Auditorium Spaces:		7						6,650		

SPACE DESCRIPTION		PROPOSED NUMBER OF SPACES, CAPACITY AND SIZE								NOTES
		SPACES		STUDENTS		NET SQUARE FEET			Priority	
		total spaces	total staff	each room	total students	sq. ft per student (staff)	sq. ft per room	square feet sub-total		
E	**Performing Arts & Vo-Tech Instructional Space**									
1.	LS General Music room	1	1	24		40	960	960		
2.	US Chorus & General Music	1	1	24		50	1,200	1,200		
3.	US Band & Orchestra	1	1	24		50	1,200	1,200		
3a.	Instrument Storage	1					200	200		Shared with MP and Band/orchestra room
4.	MP Performance Room	1	1	24		40	960	960		Theater and orchestra/band
5.	Vo-Tech Lab	1	1	24		50	1,200	1,200		
Total Performing Arts Instructional Spaces:		6						5,720		
F	**Nurse's Suite**									
1.	Office	1	1				120	120		
2.	Reception/Waiting	1	1	4			140	140		With counter for additional staff
3.	Rest Areas	3		1			80	240		
4.	Bathroom	1					75	75		
5.	Storage	1					30	30		
Total Nursing Suite spaces:		7						605		
G	**Student Support Services**									
1.	Psychologist's Office	1					140	140		Admin mtg stated need for 1 per each school (two positions @ .6 FTE)
2.	Speech Therapist's Office	1					140	140		
3.	OT/PT									
4.	Office	1	2				120	120		
5.	Storage	1					100	100		
6.	LS OT/PT Room	1	1	6		120	720	720		
7.	US OT/PT Room	1	1	6		100	600	600		
Total Student Support Service Spaces:		6						1,820		

4.2 FACILITY SPACE PROGRAM TABLE

SPACE DESCRIPTION		PROPOSED NUMBER OF SPACES, CAPACITY AND SIZE								NOTES
		SPACES		STUDENTS		NET SQUARE FEET			Priority	
		total spaces	total staff	each room	total students	sq. ft per student (staff)	sq. ft per room	square feet sub-total		
H	**Other**									
1.	Entry Lobby	2					1,200	2,400		
2.	Security/Reception	2					80	160		Include locking storage
3.	Staff Lounge /Lunchroom?	2					250	500		
4.	Staff Bathrooms	5					65	325		
Total Other Spaces:		11						3,385		
I	**Building & Grounds**									
1.	Office, Lunchroom	1					160	160		
2.	Toilet / Shower / Locker	1					120	120		
3.	General Storage	1					1,200	1,200		
4.	Supply Storage / Receiving	1					200	200		
5.	Loading Dock	1					200	200		Shared with Kitchen but separate entrances
6.	Outdoor Storage	1					200	200		
7.	Janitor's Closets	5					50	250		
8.	Distributed Storage	5					50	250		
Total Buildings & Grounds Spaces:		16						2,580		

SPACE DESCRIPTION		PROPOSED NUMBER OF SPACES, CAPACITY AND SIZE								NOTES
		SPACES		STUDENTS		NET SQUARE FEET			Priority	
		total spaces	total staff	each room	total students	sq. ft per student (staff)	sq. ft per room	square feet sub-total		
OUTDOOR SPACES										
	Entry Plaza									
	Grassy Play Space									With Running Loop around; Convenient to both LS and US and gymnasiums
	Hardscape Playspace									Convenient to both LS and US or Provide separate areas for each; For games like hopscotch, foursquare
	Basketball Court									
	Community Playground/Play Stuctures									LS
	Preschool Playspace*									Dedicated Playspace - serves both Preschool classrooms; required to have both shaded and sunny areas
	Outdoor Eating Area									Adjacent to Cafeteria
	Outdoor Classroom									
	Garden									Adjacent to Cafeteria; Proximate to LS; Visible from Library
VEHICULAR REQUIREMENTS										
	Dropoff / Pickup Zone(s)									
	Outdoor Secure Bike Storage									
	Loading Dock									
	Kitchen Deliveries									
	Waste and Recycling									
	Receiving									
	Service / Mechanical Access									
	Service / Mechanical Access									
PARKING										
				# of spaces						
	Structured Parking (Approximate)			60						
	Surface Parking (Approximate)			20						
	Other Parking			0						
	TOTAL			**80**						

5.0 EXISTING CONDITIONS SUMMARY

5.1 ARCHITECTURE

OVERVIEW

This section contains summaries of the existing conditions reports for each discipline. The existing conditions reports were based upon site visits that occurred during the Feasibility Study from February – June of 2012 and review of the existing conditions documents made available by the City of Cambridge. The full Existing Conditions reports are contained within Volume 3 – Appendices. In addition, Section 7.1 of Volume 1 also a Design Option which explores the Refurbishment of the Existing Building in greater detail.

ARCHITECTURE

The Martin Luther King, Jr. School is located at 100 Putnam Avenue, Cambridge MA. The building is a Brutalist concrete structure designed by Sert Jackson and Associates that was built in 1971. The current program includes 662 students that include the combined Martin Luther King, Jr. School for grades JK-8, the Amigos school for grades JK-8, as well as the Martin Luther King, Jr. Preschool. The existing three and four story structure contains a partial mechanical equipment basement with crawl space and has a total gross square footage of approximately 159,000sf. The sloping urban 147,543 sf site is in a residential neighborhood of apartment buildings and single family homes and is bounded by Putnam Avenue to the West, Kinnaird Street to the North, McGee Street to the South, and Hayes Street to the East. The site contains parking, loading, playing fields, and is adjacent to a City of Cambridge playground that is utilized by the school and the City. The building is comprised of two distinct parts Parts "A" & "B". Part A fronts and is orthogonal to Putnam Avenue and contains the classroom donut, and dining facilities organized around a central courtyard, and Part B fronts and is orthogonal to Kinnaird Street and contains program such as the gymnasiums and auditorium.

As currently configured, the existing building is ill-suited to meet the target student population of 740 students, the Educational Specification, Design Principles, and the Net Zero Energy goals for the Martin Luther King, Jr. School Construction project that were developed during the Feasibility Study. The existing building is comprised of components that are obsolete, and past their useful life. The uninsulated wall construction with no vapor barrier, antiquated windows and mechanical, electrical, plumbing, fire protection, and foodservice systems do not meet current energy codes, the City of Cambridge's goal of a Net Zero Energy school, LEED Silver Minimum Certification, nor good practice and energy efficiency. In addition, the technology infrastructure is also out of date. The sloping site, coupled with a high water table and no under slab drainage system under Part B makes the existing building prone to flooding. The concrete block structure supporting Part B should be replaced if modified as noted in the Structural portion of the report.

The existing building configuration with approximately 50 instructional spaces does not allow for the 64 spaces required by the new and enriched learning and teaching environments as defined in the Educational Specification. Only 4 of the 14 Design Principals outlined as very important to the learning environment for the school can be adequately achieved by keeping the existing building with no substantial modification of structure. The east and west orientation of classrooms coupled with the low existing floor to floor height of 10'-6", hampers optimizing natural light into the classrooms. Studies have shown that naturally lit classrooms where light levels and glare can be controlled foster better concentration and retention in students. The exposed concrete construction also provides a poor acoustical environment that does not meet the Acoustical Prerequisites of LEED for Schools and would require considerable acoustic upgrades to meet these prerequisites.. The existing casework and finishes are past their useful life and require replacement. There are many items within the building that do not meet accessibility codes including but not limited to: accessible parking, toilet rooms, and signaling systems. Finally, visual inspections conducted during the Feasibility Study indicate the potential for moderate to substantial Hazardous Materials that will need to be remediated.

The site contains 49 striped spaces, but the Traffic Report counted as many as 88 cars parked on site. This ad-hoc existing parking and loading configuration is not optimal and cannot be improved without taking over student play and recreation space to relocate parking, or substantially reducing the existing parking supply well below the demonstrated need.

TRAFFIC

The existing Martin Luther King, Jr. (MLK) School is sited with its frontage on Putnam Avenue. The site is bounded on the south by Magee Street, on the north by Kinnaird Street and on the east by the properties located on Hayes Street.

The existing bus drop-off takes place on Putnam Avenue, which serves a significant level of local traffic. The bus drop-off can take 2-3 minutes per bus for students to unload, and all traffic on Putnam Avenue is stopped during this time. The existing bus pick-up occurs on Magee Street, a small local roadway. Buses will typically get there well in advance of the pick-up and wait 20-30 minutes for students to load. It has been noted that during the winter, the snow on Magee Street can prevent buses from pulling over enough to allow through traffic. In addition, some of the parking on Magee Street is restricted during school hours to allow buses to maneuver safely onto Putnam Street. The majority of the vehicular pick-up and drop-off takes place on Kinnaird Street. Some vehicles were observed using Putnam Avenue and Magee Street for this purpose, as there is no official designated area. The preferred pick-up/drop-off scenario is to separate buses from vehicles so that they do not conflict with each other during this time. The vehicles using Kinnaird Street either pull into the on-street parking areas, or occasionally pull up onto the sidewalk in front of the school. They generally do not block traffic on Kinnaird Street, but they do block pedestrians from using the sidewalk.

Pedestrian Accommodations including crosswalks and accessible ramps are provided at all study area intersections. At the intersection of Magee Street and Putnam Avenue, the crosswalks and pedestrian ramps are not aligned properly. Pedestrians using the ramp will walk into traffic on Magee Street, as the ramp is located prior to the stop line and crosswalk. The existing sidewalk infrastructure is sufficient to handle the volume of students that were walking through. There are two bicycle racks located at the front entrance of the school adjacent to Putnam Avenue. They were both occupied, with three total bicycles at the time of the count. However, there were a number of additional bicycles attached to street signs on Putnam Avenue and Kinnaird Street. It is unclear if they were associated with the school or other local residents. No other bicycle racks were present on site.

There are two parking lots off Kinnaird Street utilized by school traffic. The western parking lot contains 20 designated spaces and the eastern lot contains 29 spaces. However, during the site visit 28 vehicles were parked in the eastern lot and 60 vehicles were parked in the western lot, with vehicles double parked and parked on the curb. The total parking occupancy rate for the site is 180%.

The average speed on all roadways is under or at the posted speed limit of 20mph. In addition, the 85% design speed is within 5 mph of the posted speed limit indicating that speeding is not a significant issue in the study area. During school hours the roadways are too congested for vehicles to travel quickly. During off-peak hours the roadways do not see significant increases in speeding. Under the existing conditions, all of the intersections and intersection approaches operate at acceptable Levels of Service. This indicates that the existing roadway infrastructure has sufficient capacity for the current school. Although there is some queuing during the pick-up/drop-off times, the traffic dissipates quickly and does not cause significant delay for other vehicles.

MORNING DROP-OFF

AFTERNOON PICK-UP

CIVIL

The existing MLK School is sited with its frontage on Putnam Avenue. The site is bounded on the south by Magee Street, to the north by Kinnaird Street and to the east by the properties located on Hayes Street. The existing MLK school building occupies most of the project site. There is a playground area located at the southeast corner of the site along Magee Street. Located at the rear of the building on the east side of the site are an artificial playfield, basketball court and a parking lot area.

The existing utilities feeding the MLK School building:

- A 4-inch cast iron domestic water line is fed off of the existing 16" cast iron water main in Putnam Avenue.
- A 6-inch fire service line (sprinkler/standpipe supply) is fed off the 16" water main in Putnam Avenue.
- An 8-inch sanitary sewer line that connects to the existing 8" sanitary sewer main located east of the school site in Hayes Street.
- A gas line of unknown size connects to the existing 8" gas main located in Putnam Avenue.

The existing MLK School building is located on an urban site that is 100% developed. With the exception of the small artificial grass play surface located at the rear of the school near Hayes Street, the entire site consists of impervious surface. The site topography slopes down from Magee Street and Putnam Avenue at the southwest corner of the site to a lower elevation at Kinnaird Street at the northeast corner of the site. The change in grade from the southwest corner to the northeast corner is approximately ten feet (10').

Stormwater runoff is collected and conveyed to the existing 12-inch combined sewer line in Hayes Street, the 8-inch combined sewer in Putnam Avenue, and to the existing storm sewer line in Kinnaird Street. Stormwater from the existing site is discharged untreated to the city systems as described above.

The soils in the area of the MLK School contain high amounts of clay and are generally not well draining and there may be possible groundwater issues in the area. School officials reported multiple instances when standing water has been observed in the open areas beneath the existing gymnasium space at the school. A report prepared by CDM Smith recommends using a ground water design level of approximately 5' below surface grade.

PERVIOUS AND IMPERVIOUS SURFACES

SITE TOPOGRAPHY

STRUCTURAL

Foley Buhl Roberts & Associates, Inc. (FBRA) is collaborating with Perkins Eastman (PE) in the review and evaluation of structural issues/conditions at the Martin Luther King, Jr. School in Cambridge, Massachusetts. The purpose of this report is to identify and describe the structural systems of the various parts of the facility and to comment on the structural issues/conditions observed. General comments relating to potential renovations, alterations and additions to the building (governed by the Massachusetts Existing Building Code (MEBC – 8th Edition) are presented as well.

Structural conditions at the Martin Luther King, Jr. School were reviewed at the site on April 2, 2012. Original Structural and Architectural Drawings were made available to the Design Team by the City of Cambridge. No exploratory demolition or structural materials testing was conducted in conjunction with this existing conditions structural review.

The Martin Luther King, Jr. School is a three to four-story, flat roof, reinforced concrete structure with a spread footing foundation, constructed in 1971 as a K through 8 facility on a sloping site (downwards from the southwest to the northeast). The gross floor area is approximately 159,000 square feet. The school is composed of two basic sections: Part A (South Wing) is a three and four-story classroom wing which also includes the Kitchen/Cafeteria, a Boiler Room, Mechanical Rooms and Storage Rooms at the Ground Floor level. Part B (North Wing) includes the Industrial Arts, Computer and Music Departments, Administrative Offices and an Exercise Room (all at the Ground Floor). The Gymnasium and the Auditorium are located at the (Main) First Floor level of this wing. Exterior walls in each wing consist of exposed, cast-in-place reinforced concrete panels and reinforced concrete columns and spandrel beams, infilled with a blend of vertically grooved, precast panels (backed up by an unreinforced concrete masonry wall) and windows. The distinction between Part A & B is that in Part A the block back-up is infill between the structural concrete frame and is non-bearing versus in Part B, the un-reinforced block is load-bearing and not attached to any concrete frame.

Subsurface soils at the site were recently investigated by CDM Smith and found to consist of a fill layer (as much as 18 feet deep), along with organic soils (locally present), sand and gravel (locally present) and marine clay (Boston blue clay) overlying glacial till. Groundwater was encountered 6.5 to 10 feet below the existing grade.

The foundations and superstructure appear to be in satisfactory condition. There are no signs of overstressed/failed members and no evidence of significant deterioration. Foundations appear to be performing as intended; however, there are water issues in Part B. The design live loads noted on the original Structural Drawings are appropriate for public school use and are consistent with the structural design. The building was designed and constructed prior to the introduction of seismic design codes in Massachusetts. There is no clearly defined lateral load resisting system and the building does not meet current seismic code requirements. Seismic reinforcing/upgrades to the building would be required in conjunction with a major renovation to the facility; particularly in Part B, where the floor and roof structure is primarily supported by unreinforced concrete masonry bearing walls.

EACH WING (PART A & PART B) OF BUILDING.

5.5 MECHANICAL, ELECTRICAL, AND PLUMBING / FIRE PROTECTION

MECHANICAL, ELECTRICAL, PLUMBING, AND FIRE PROTECTION

The existing mechanical, electrical, plumbing and fire protection systems at the school are all original to the building and reflect industry standards at the time of construction. The systems were designed to be integrated into the physical construction of the building with risers and main supplies installed in walls, chases and tunnels which proved to make servicing of the systems difficult. Maintenance and repairs have been performed on an "as-needed" basis throughout the years and some of the components such as pumps and pipe and fittings have reached the end of their useful life. The systems do not meet current energy efficiency codes or standards and do not reflect the proposed goal of high efficiency, "Net Zero" energy systems. As such, the MEP/FP systems shall be taken out of service and completely demolished including all utility services from the streets. It is the design intent that no portions of the existing systems will be re-used as part of the new construction.

HVAC:
As discussed in the existing condition narrative, the existing HVAC systems are original to the building and appear to have reached the end of their useful lives: in discussions with the existing building maintenance staff it appears the equipment is prone to failure, expensive to maintain and is no longer considered energy efficient.

The existing boilers have fuel leaks and are frequently going off line. The cooling towers, tower dunnage and associated piping all show signs of corrosion. Most of the roof exhaust fans appear to be original to the building and in disrepair. There is no master control management system to regulate or trend the mechanical systems leading to spotty maintenance and service. Additionally, some of the systems were designed to be installed integral to the building architecture leaving them inaccessible. Some systems were installed in a series of tunnels below the building which have since been compromised, minimizing accessibility.

The existing ductwork systems would not be able to be re-used based on the more stringent design standards. Also, some ductwork sealants may contain traces of asbestos.

Electrical:
The existing incoming main service terminates in a main switchboard located in the mechanical room. The switchboard is antiquated, difficult to maintain and difficult to obtain parts for and is not located in a dedicated room. The normal distribution including wiring and panelboards, are also antiquated likely in poor condition to be able to re-used. Transformers are not energy efficient which is required per today's codes.

The emergency generator is located in front of the main switchboard and is also not located in a dedicated, 2-hour rated room. The generator is antiquated, difficult to maintain and past its useful life.

The fire alarm system is a zoned, non-addressable system that does not meet today's current codes and will need to be replaced. The existing system is likely not able to be expanded to meet the requirements for a code compliant system.

Lighting is mostly T-12 technology, which per today's standards consumes the most energy efficient in terms of fluorescent lighting. For a Net Zero building and to meet the energy code, more energy efficient lights such as fluorescent T-5 and LED lights should be utilized.

Plumbing:
As discussed in the existing system narrative, the existing plumbing systems at the MLK School are original to the building and there have been no major upgrades or enhancements to these systems over the years. The existing domestic hot water system consists of a large gas fire storage type heater and in-line circulation pumps that has reached the end of their useful life. At a minimum the domestic hot water source equipment should be replaced.

Distribution mains and branches are in fair condition and some may be able to be re-used. However, some mains and branch piping may be undersized based on the proposed uses of the new school. Additionally, the proposed use of high-efficiency fixtures which operate at higher pressures may limit the capacity of the existing pipe sizes. It is recommended that mains be replaced and sized appropriately.

The existing gravity and storm systems are approaching 30+ years in age and scale/blockages in piping of this age will limit its availability in supporting a major renovation such as the one proposed. At a minimum the main sanitary and storm mains exiting the building may be salvaged. However, reusing these mains would require detailed coordination to meet the existing inverts.

Fire Protection:
As discussed in the existing system narrative, the existing fire protection system is limited to a partial sprinkler system and fire department valves and occupant hose valve assemblies. The piping and valve assemblies are in fair condition and are consistent with fire protection systems for the period installed.

The majority of the system cannot be upgraded to meet the current code required demand of complete sprinkler protection. The mains are undersized and there are no provisions for zoning of sprinkler systems.

The existing 6" service could be utilized to support a new full automatic sprinkler system in compliance with the latest Building Codes and NFPA Standards. However, it is recommended that the existing double check valve assembly and main alarm check valve be replaced with new.

FOOD SERVICE

Crabtree McGrath Associates, the foodservice consultant, completed a review of the existing kitchen and serving area and found the conditions to be poor and in need of complete replacement and reorganization. In general, the existing equipment that has failed has not been replaced; certain functions of the kitchen have been off line for some time. Various tables, sinks, and food preparation equipment has failed but not been replaced. With regard to health code, many violations exist due to the condition of the facility and the standards used during its original construction. Though very clean, the facility does not have adequate hand wash sinks within the kitchen or serving area.

The serving system is original construction. There have been no serving equipment upgrades over the years and not much of the original configuration has changed other than a partial decommissioning of the serving area. The architectural finishes within the kitchen are in need of replacement, but have held up well in some areas. It is our recommendation that the facility be completely renovated and reorganized to comply with current food preparation practices and regulations.

5.7 COMMUNITY NOISE CONDITIONS

COMMUNITY NOISE CONDITIONS

The existing community noise conditions were documented by performing a series of measurements at the Martin Luther King, Jr. School site in Cambridge over a period of several days, in April 2012. Based on these measurements and in accordance with the Massachusetts DEP noise policy, it was determined that, for most locations, the maximum criteria for the control of exterior background noise levels will be 50 dBA. In some specific areas, the maximum criteria will be lowered to 47 dBA.

AUDIOVISUAL SYSTEMS

The existing fixed audiovisual systems are past or will pass their operational life expectancy and need to be replaced with current technologies. A few of the audiovisual systems components can be reused in other facilities during renovations such as the video projectors and the few smart boards that exist. Items such as projections screens are for the most part of the wrong types for today's technology and usage. Many of the fixed systems are at or past their operational life expectancy and need to be replaced with current technologies. There are some items of equipment that can be re-cycled to other facilities during the renovation to the school, such as the video projectors and the few smart boards. There is little to no audiovisual systems meeting current ADA assisted listening standards for classrooms and other facilities. Only a few classrooms have fixed audiovisual systems of various types, age, and capability. Most of the audiovisual systems do not meet current digital standards or have limited capabilities. Larger fixed systems such as in the auditorium are quite outdated and need of replacement. While the school system is moving to Apple based computing systems for the classrooms the MLK School is still using an out-dated PC based laptop cart.

The current systems do comply with the Owner's future requirements for; presentation capabilities for digital computers, laptops, and "iPad" type devices along with audio and assistive listening systems to meet the current requirements of the Americans with Disabilities Act (ADA), or the capability to be remotely managed over the school's LAN network which has not been coordinated to date

HAZARDOUS MATERIALS

Fuss & O'Neill EnviroScience, LLC (EnviroScience) conducted a physical inventory from April 17 - 18, 2011 and April 23, 2012, for potential hazardous building materials as part of architectural/structural assessment and feasibility study for the Dr. Martin Luther King, Jr. Middle School project. EnviroScience's Asbestos Inspectors performed a visual survey of all areas of the school building made accessible by on-site custodial staff. It should be noted that as requested no bulk sampling was performed as part of this inspection. Prior to renovation or demolition the U.S. Environmental Protection Agency (USEPA) in accordance with the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations requires a thorough inspection for asbestos. Recent knowledge also indicates that many building materials may also contain polychlorinated biphenyls (PCBs). A limited lead determination of representative building components was also conducted utilizing portable X-Ray Fluorescence (XRF) Analyzer.

EnviroScience identified 106 homogeneous material types that are presumed to contain asbestos until sampled and analyzed. Representative sampling should include collection of approximately 300 samples in order to meet required NESHAP standards. Sampling will involve the collection of multiple samples of each identified homogenous building materials utilizing Polarized Light Microscopy (PLM) with confirmatory analysis using Transmission Electron Microscopy (TEM) as recommended by the USEPA. Many of the identified materials may also contain PCBs and samples should be collected to determine PCB content.

Sampling of building materials for polychlorinated biphenyls (PCBs) is presently not mandated by the USEPA. However, significant liability risk for improperly disposing of a PCB-containing waste material exists. Recent knowledge and awareness of PCBs within matrices such as caulking, glazing compounds, paints, adhesives, and ceiling tiles has become more prevalent especially among remediation contractors, waste haulers, and disposal facilities. Many property owners have become subject to large changes in schedule, scope, and costs as a result of failure to identify these possible contaminants prior to renovation or demolition. We recommend testing for PCBs as a continuation of this architectural/structural assessment and feasibility study for the Dr. Martin Luther King, Jr. Middle School. The USEPA requirements apply and require removal of PCBs once identified regardless of project intent as an unauthorized use of PCBs. In other words, if buildings are to remain for re-use and PCBs are identified, the USEPA still requires removal of the PCB materials once it is determined that PCBs are present. In addition to identification of source materials containing PCBs, if PCBs are present at certain concentrations, additional testing of adjacent surfaces in contact with PCB sources or which may have been contaminated from a source of PCBs (e.g. soil) must also be performed or remediated.
USEPA requirements apply only if PCBs are present in concentrations above a specified level. Presently materials containing PCBs at concentrations equal to or greater than (≥) 50 parts per million (ppm) or equivalent units of milligrams per kilogram (mg/kg) are regulated. Note materials containing less than (<) 50 ppm may also be regulated unless proven to be an "Excluded PCB Product". The definition of an Excluded PCB Product includes those products or source of the products containing <50 ppm concentration PCBs that were legally manufactured, processed, distributed in commerce, or used before October 1, 1984.

A significant number of suspect asbestos and/or PCB containing materials were identified and identified in the full Existing Conditions report included in the Volume 3 – Appendices.

Lead paint was found on few building components including, but not limited to, metal doors and metal stair components. Note that metal materials containing lead paint may be recycled as scrap metal. EnviroScience understands that there are no proposed selective demolition or renovation activities scheduled at this time; the lead determination was carried out as part of a preliminary investigation for the feasibility study.

Physical sampling and additional hazardous materials investigations will occur in Schematic Design to determine the final Hazardous Materials abatement scope.

6.0 PREFERRED OPTION SYSTEMS RECOMMENDATIONS

CIVIL ENGINEERING

Following are Civil Engineering considerations for the preferred design option, the Pi Scheme.

Water Systems:
Based on preliminary discussions with the Cambridge Water Department (CWD) the project will require redundant water feeds (two domestic water feeds and two fire service feeds). One set of feeds will connect to the existing 16-inch cast iron water main that runs in Putnam Avenue. As discussed in the existing conditions narrative there is an existing 4-inch cast iron domestic service and a 6-inch sprinkler and standpipe service that feeds the existing MLK School from Putnam Avenue. These services could be reused as part of this project if the plumbing engineer determines that they would provide adequate flows and pressures. Otherwise a new set of services would need to be connected to the Putnam Avenue main. If the existing connections are to be reused they should be protected in place during construction. If they are to be removed and replaced with new services the existing connections should be removed all the way to and cut out of the main in Putnam Avenue and replaced with a straight section of piping. The second set of feeds will connect to a new 8-inch loop between Hayes Street and Magee Street. This new 8-inch loop will be constructed as part of this project and will connect the 6-inch dead end line that currently terminates at the end of Hayes Street to the existing 6-inch water main in Magee Street.

The CWD will also require that the portion of the Magee Street water main that currently runs through the MLK School property (southwest corner) be relocated and replaced with a new 8-inch line outside of the property line and in the Magee Street right-of-way.

There is likely adequate fire protection volume and pressures in the existing 16" water line in Putnam Avenue. According to CWD, the static water pressure in the vicinity of the school is approximately 65 psi. However, a flow test will need to be performed to confirm that the existing water line will be sufficient for proposed fire and domestic water demands for the project.

There are multiple fire hydrants located on all of the streets surrounding the MLK School site that will remain.

Sanitary Sewer:
As stated in the existing conditions narrative, the MLK School is currently serviced by an 8" cast iron sanitary sewer line that connects to an 8" sanitary sewer main in Hayes Street. The project should continue to use the Hayes Street connection point for any new sanitary services for the new building. Other connection points may be available in Magee Street and Kinnaird Street but connecting to those lines would need to be discussed with the City of Cambridge DPW (CDPW).

The new school will provide food services within the building that will require the installation of a grease trap and associated piping and venting. The size of the grease trap will depend on the confirmed number of students meals served per day but will likely be approximately 5000-6000 gallons. The grease trap will likely be installed outside the building and will be connected into the proposed sanitary service to Hayes Street.

Site Grading/Drainage:
The proposed site grading should attempt to meet existing elevations of the surrounding streets and create positive drainage away from the proposed building to avoid sloping grades towards doorways and creating low spots close to the building structure. Proposed grading schemes should also not create situations where abutting properties would potentially receive more stormwater flow from the project site than they do under existing conditions.

There are three separate and distinct issues with regards to stormwater design that need to be addressed as part of the proposed project; Stormwater Quantity, Stormwater Quality, and Phosphorus Removal.

The City of Cambridge has a requirement that is used to control stormwater quantity leaving a proposed site. The City requires that stormwater runoff rates from the post development 25-year storm event be reduced to the pre-development 2-year storm event rate. The project will be required to mitigate flows as described above from the new school building and project site. The preferred option will reduce the amount of impervious surface on the site which helps control peak runoff rates from the site however mitigation will also require the project to construct a stormwater detention system to store and slowly release the stormwater runoff collected on the site. The proposed detention system would be located in the area of the existing turf field or in the open space/parking lot area along Kinnaird Street. The proposed detention system would include perforated plastic pipe surrounded by crushed

stone and geotextile fabric installed underground that would be used as volume to detain stormwater runoff from the site. Based on projects of similar size and site characteristics a system consisting of 300-350 linear feet of 48-inch perforated PVC pipe would be a good first approximation of system size that could be used for initial cost estimating purposes. Overflow from the underground system would be piped to the existing storm drain infrastructure in Kinnaird Street (referred to as the Flagg Street system by the City). The CDPW has requested that the stormwater design for this project attempt to have all flows tie into the Flagg Street system to remove the current stormwater flows from the combined sewer system in the area.

It should be assumed that all stormwater conveyance pipes will be 12" CPP pipe except the connection pipe to the Flagg Street system which would be RCP in lieu of CPP.

Stormwater quality will be addressed through the use of catch basins with deep sumps and hoods, green roofs, proprietary structural BMP's (Stormceptor®) and an overall greening of the project site. The Massachusetts Stormwater Handbook requires that a volume of 0.5-inches multiplied by the impervious area on the site be treated by water quality BMP's to remove 80% TSS annually. The chosen BMP's will be sized to treat the required volume of stormwater to meet the standard.

Phosphorous removal will need to be addressed as part of the project. The EPA requires that an existing site, being redeveloped, be designed to remove 65% of phosphorus annually that would normally runoff the site and discharge into receiving waters. Phosphorus removal can be achieved through the use of infiltration BMP's (underground pipe infiltration systems, rain gardens, etc…). Based on preliminary discussions with the CDPW and early geotechnical investigations high groundwater elevation and silt/clay heavy soils in this area may make infiltration BMP's less viable on this site. More in-depth geotechnical analysis, perk testing, and infiltration testing will be required in the areas where infiltration BMP's will be proposed to determine their feasibility for the project. Other methods of phosphorus removal would need to be explored if the infiltration BMP's are not feasible such as:

- The use of proprietary phosphorus removal units such as a Jellyfish®.
- Rainwater Harvesting and Reuse: Collection of rainwater from all the roof areas, to be reused as make-up water for irrigation and/or toilet flushing would mitigate for stormwater quantity, quality, and phosphorus removal. Large capacity tanks and associated appurtenances (piping, pumps, etc…) would be required. Refer to Mechanical Narrative for more information.
- Injection Wells: The use of injection wells to return stormwater collected on-site back to the groundwater table would mitigate for stormwater quantity, quality, and phosphorus removal. Drilling injection wells, holding tanks and associated appurtenances (piping, pumps, etc…) would be required. Coordination with the geotechnical engineer would be required to determine if this solution is feasible for the project.

One other item of note is the long term dewatering for the project. The new construction of the preferred option will allow for perimeter foundation drains and underslab drainage to be installed under the lower levels of the proposed building allowing for greater protection from high groundwater conditions for the new building. The City of Cambridge does not allow collected groundwater (from underslab drainage and/or perimeter drainage systems) to be discharged to its municipal storm water system. Therefore any groundwater that is collected in these type of systems will need to be discharged on site and not allowed to find its way to the municipal storm drains. Infiltration BMP's (if feasible) and/or rainwater harvesting and reuse are ways to accomplish this requirement.

Gas Service:
The project should plan for the gas service to come off of the existing 8" gas main located in Putnam Avenue. Other connection points may be available in Hayes Street and Kinnaird Street but connecting to those lines would need to be discussed with the gas company.

Green Roofs:
The Pi design scheme will include green roofs on the proposed building structure. A combination of extensive and intensive green roofs will be used. The extensive green roofs will be of the tray type green roof systems with minimal soil capacity. The more intensive green roofs will contain approximately 6 to 8-inches of planting materials. Refer to the attached sketch for locations of each green roof type being considered. The installation of the intensive type Green Roofs would also play a role in mitigating stormwater runoff quantity from the project site by providing some storage capacity within the soils of the green roofs. This storage capacity would likely offset the need for additional storage capacity elsewhere on site.

Irrigation:
The intent of the project will be to choose drought resistant, native plant species on the majority of the site and green roofs that would require no irrigation. However, there may be portions of the site landscape, such as street trees and/or portions of the intensive green roofs, that would require some irrigation. This irrigation could be fed from an on-site rainwater collection tank if the rainwater reuse tanks are ultimately included in the project. The project should include an allowance for a standard irrigation system that would irrigate approximately 18,000 Square Feet:

Site Features:
The following is a list of proposed site features that should be noted for the purposes of cost estimating. The level of finish for the project shall be function over form and all materials chosen shall be durable and as maintenance free as possible. The project should include:

- Elementary Sized Basketball Court
- Flag Pole
- Safety Bollards near pick up and drop off areas
- Trash Receptacles around the site
- Site Curbing shall be vertical granite curbing per City of Cambridge standards
- Two (2) School Signs at Putnam Street Entrance
- Miscellaneous Site Signage (handicap accessible signs, do not enter signs, traffic pattern signs, etc..)
- Playground equipment and surfacing for the Tot Lot at the preschool
- Playground equipment and surfacing for the Lower School playground (existing playground equipment may be retained for reuse in another location, pending further coordination with the City shall be required. Feasibility Study estimate includes installation of new equipment.);
- Site Furniture (benches)
- Porous Paving/Pavers in Plaza areas and Bituminous Pavements in Roadways/Parking Lots/Bus Drop Off Areas (all pavement and pavers shall be consistent with City of Cambridge standards)
- Site Landscaping: The majority of the site will be grass and play areas for the students but there will be some areas of intensive plantings around the building and used as screening in the parking lot areas;
- Bicycle Racks (number of required bicycle racks shall be per City of Cambridge Standard)
- Site fencing shall include chain link fencing (per City of Cambridge standards) around basketball court and ornamental screening fence at the property lines with direct abutters consistent with City of Cambridge zoning requirements (e.g. 6-foot high wooden plank fence). Actual fence selection pending further discussion with the City.

Earthwork:
The Pi Scheme with the underground parking option included will require very little large scale cut/fill earthwork. The majority of the site will remain at the existing grades and the area between Putnam Street and the new lower level of the proposed school building will be occupied by the proposed 60 space underground parking garage. The lower level of the school will be at the approximate grade of the existing lower levels of the current school building but will not extend all the way to Putnam Street creating room for the underground garage to occupy. Small localized areas of cut/fill will be required to construct parking areas and other site related features.

Site Circulation:
The Pi scheme will maintain the existing circulation patterns within and around the project site. The proposed parking area off of Kinnaird Street will be reconfigured, with the western most entrances in the existing location and eastern curb cut being new. The number of on-grade outdoor spaces will be reduced from the existing. The bus pick-up will likely continue to take place on Magee Street where an off-road dedicated lane will be provided adjacent to Magee. The bus drop-off will likely continue at the front entrance on Putnam Avenue where an off-road dedicated bus lane will be studied,. Final drop-off and pick-up pending further discussions with the City. Emergency Access will possibly be provided from Kinnaird Street to Hayes Street in the rear of the school through the playground and recreation area pending discussions with the Fire Department and Inspectional Services Departments The design will also provide emergency access from Kinnaird, Putnam and Magee Streets. Loading and deliveries will take place off of Kinnaird Street and enter the site at the existing curb cut.

KINNAIRD ST
PUTNAM AVE
HAYES ST
MAGEE ST
BIT. CONC. PAVING (TYP.)
DMH
CB
parking (20 spaces)
preschool playground
b-ball court
loading/ underground parking
active play
garden
playground equip.
4' bike path
PLAZA AREA
bike racks
drop off & pick up
sliding gate
existing bldg overhang
existing bldg footprint
property line
LEGEND
EXTENSIVE GREEN ROOF
INTENSIVE GREEN ROOF
EXISTING WATER
PROPOSED WATER
EXISTING SEWER
PROPOSED SEWER
EXISTING GAS
PROPOSED GAS
EXISTING DRAIN
PROPOSED DRAIN
RAINWATER HARVESTING TANK
UNDERGROUND PIPE DETENTION
CATCH BASIN
DRAIN MANHOLE
JELLYFISH UNIT AND OUTLET CONTROL STRUCTURE
GRANITE CURB
ORNAMENTAL SCREENING FENCE
GREASE TRAP
WATER LINE TO BE REMOVED
N

STRUCTURAL REPORT

Introduction

The purpose of this narrative is to summarize the basis of the structural design and to describe the primary structural systems and scope of structural work for the Preferred Option. Outline Structural Specifications have also been included. Proposed new construction and renovations will be designed and constructed under the provisions of the Massachusetts State Building Code (780 CMR – 8th Edition, based on the 2009 IBC) and the Massachusetts Existing Building Code (8th Edition, based on the 2009 IEBC). This Structural Narrative should be used in conjunction with the Conceptual Design Architectural documents and those of the other disciplines, as well as the FBRA *Existing Conditions Structural Report* of May 14, 2012.

The **Pi Option** has been chosen as the **Preferred Option** and is all new construction, requiring the full demolition of the existing building, except as noted below. Upper School and Lower School spaces border a "U"-shaped corridor, with a centrally located Auditorium. The programmed common spaces are located along the east side of a linear, north-south corridor ("King Street") in this option. The new, four-level facility accommodates the sloping site, locating several of the larger common spaces (Large and Small Gymnasiums and Dining) at grade, along the (low) east side. Approximately 60 parking spaces will be provided below the building. Portions of the Basement, First Floor and foundation construction in Part A of the existing building will be retained to reduce the extent of temporary lateral earth support along Putnam Avenue. The total floor area is approximately 157,000 square feet plus 20,000 sf for the underground parking.

New construction will be steel framed, for reasons of economy, performance, flexibility and speed of construction. Steel framing will be fire protected, as required to meet the requirements of Type 2A Construction. Foundations are expected to be conventional, shallow spread footing construction.

Roof forms are typically flat and are pitched for drainage, except the roof of the north-south, “Main Street” corridor will be pitched. The roof structure will be designed to accommodate a green roof system and photovoltaic (PV) panels. Exterior walls will be a combination of Aluminum Composite Panels (ACP), Trespa Panels and Terra Cotta Planks (all with a steel stud backup) and curtainwall. A Net Zero Energy facility is being pursued.

Structural Systems – General Description

New construction will be steel framed, for reasons of economy, performance, flexibility and speed of construction. Typical floor construction will be a concrete slab on composite steel deck, supported by composite, structural steel beams and girders. Main roof areas will be framed with steel roof deck supported by structural steel beams and girders. A concrete slab on composite steel floor deck will be provided below rooftop equipment for acoustic purposes. Screens (visual and acoustic) surrounding the rooftop equipment will be structured with horizontal and vertical, galvanized HSS (tube) steel members, braced down to the main roof structure. Gymnasium roofs will be framed with acoustical steel deck, supported by structural steel purlins, which span to steel trusses. The Auditorium roof will be similarly structured, with standard, non-acoustical roof deck.

The new, steel framed construction will be classified as Type 2A (Noncombustible, Protected). Typical steel floor and roof members (beams, columns and bracing) and steel roof deck (except where the height exceeds 20 feet) require fire protection. Typical floor and roof steel framing will be surface prepped and be left unpainted, except exposed steel in the Gymnasium spaces, which will receive one shop coat of primer, compatible with the finish paint.

Typical columns will be wide flange sections or hollow steel tubes (HSS). Lateral stability for wind and seismic loads will be provided by steel bracing in each direction.

Foundations are expected to be conventional, shallow spread footing construction bearing on natural soils or compacted structural fill, per the February 3, 2012 *Preliminary Geotechnical Report and Environmental Evaluation*, prepared by CDM Smith. Lowest level floor construction will be a concrete slab on grade. Existing foundations will typically be removed (except as noted above) and existing utilities will be removed and relocated to accommodate the new construction. Temporary lateral earth support and dewatering will be required during construction.

Exterior walls will be a combination of Aluminum Composite Panels (ACP), Trespa Panels and Terra Cotta Planks (all with a steel stud backup) and curtainwall.

BASIS OF STRUCTURAL DESIGN

Codes and Design Standards:

Building Code: Massachusetts Building Code – Eighth Edition (2009 IBC with Massachusetts Amendments)
Massachusetts Existing Building Code – Eighth Edition (2009 IEBC with Massachusetts Amendments)

Concrete: ACI 318 and ACI 301; listed standards, latest editions.

Structural Steel: AISC "Specification for Structural Steel Buildings" and AISC "Code of Standard Practice".

Steel Deck: Steel Deck Institute (SDI); listed standards, latest editions.

Design Loads/Parameters:

Live Loads:

Auditorium (Fixed Seating):	60 PSF
Classrooms (with partition allowance):	70 PSF
Corridors:	100 PSF
Flexible, Open Plan Areas (Including the Gymnasiums):	100 PSF
Stairs:	100 PSF
Mechanical Equipment Rooms:	150 PSF

Snow Loads:

Basic Ground Snow Load (Cambridge):	45 PSF (35 PSF Flat Roof Design Snow Load)

Wind Loads:

Basic Wind Speed (Cambridge):	105 MPH

Seismic Parameters:

Short Period Spectral Response Acceleration(Ss):	0.28
1.0 Sec. Spectral Response Acceleration (S1):	0.068
Seismic Occupancy Category	III
Seismic Design Category:	B
Site Class:	D
Structural System:	Building Frame System
Lateral Load Resisting System:	Concentrically Braced Frames (Not Specifically Detailed for Seismic Resistance)
Response Modification Factor (R):	3.0
System Overstrength Factor (Ω0):	3.0
Deflection Amplification Factor (Cd):	3.0

Foundations:

The preliminary foundation design is based on an assumed allowable bearing capacity of 4.0 kips per square foot (2.0 TSF) on natural soils or compacted structural fill as recommended in the referenced, CDM Smith Preliminary Geotechnical Report.

Construction Classification:

New construction will be classified as Type 2A (Noncombustible, Protected), pending confirmation by the Design Team. Typical steel floor and roof members (beams, columns and bracing) and steel roof deck (except where the height exceeds 20 feet) require applied fire protection. All steel framed construction is considered to be *restrained*.

Sustainable Design Considerations:

Sustainable design considerations will be incorporated into the building design; it is intended that the project will be designed to LEED Silver standards (minimum). Green roofs are proposed in nearly all areas.

STRUCTURAL SYSTEMS DESCRIPTION

A SUBSTRUCTURE

A10 Foundations (Refer to the Preliminary Geotechnical Engineering Report):

1. Groundwater was encountered 6.5 to 10 feet below the existing grade (in soil borings and an observation well), and is controlled by the Charles River (there is a gradient from the site, downwards to the river). Groundwater will be an issue during construction; temporary dewatering will be required. Perimeter and underslab drainage systems will be required at below grade areas.

2. New construction will be supported on a spread footing foundation, designed for an allowable bearing pressure of 2.0 TSF.

3. Lowest level floor construction will be a concrete slab on grade.

4. Structural fill will be required below all new footings, following the removal of unsuitable fills and soils. The existing soil materials can potentially be screened and used as ordinary fill (outside the building footprint) or perhaps in the lower zones below new slabs on grade, (reducing the amount of imported fill required).

5. The site is considered to be Site Class D, for seismic design. Liquefaction is not an issue.

6. It may be possible to crush demolished concrete elements on site and re-use in common fill (not structural fill), to avoid hauling it away. Noise may be an issue.

7. Temporary lateral earth support may be required during construction. The Geotechnical Engineer (CDM Smith) recommends a pre-construction survey along with vibration monitoring during construction.

8. Parking for approximately 60 cars will be provided below the building. Portions of the Basement, First Floor and foundation construction in Part A of the existing building will be retained (the westernmost structural bay) to reduce the extent of temporary lateral earth support along Putnam Avenue.

A1010 Standard Foundations

- Typical perimeter frost wall: *16" thick, with an 8" wide masonry shelf (under study) with horizontal and vertical reinforcing each face (4.0+/- psf). The outside surface of perimeter foundation walls should receive a trowelled-on bituminous mastic.*
- Typical perimeter frost wall continuous footing: *2'- 6" wide, by 12" deep, with continuous reinforcing bars, plus dowels to the foundation wall (10.0+/- plf). The bottom of the footing will be placed 4'- 0" minimum below the exterior finish grade for frost protection.*
- Typical, average interior column footings: *12'- 0" x 12'- 0" x 2'- 8" deep, with 1700 pounds of reinforcing, based on a 900 square foot average structural bay. The bottom of the footing will be approximately 3'- 8" below the top of floor slab.*
- Typical, average perimeter column footings: *9'- 0" x 9'- 0" x 2'-2" deep, with 750 pounds of reinforcing, based on a 900 square foot average structural bay. The bottom of the footing will be approximately 5'-2" below the exterior finish grade.*
- Typical piers/pilasters at interior/perimeter columns: *24 inches square, reinforced concrete with 50 plf reinforcing.*
- Anchor Bolts: Anchor bolts at column base plates shall conform to ASTM F1554 – Grade 36 and shall be headed type, 18" long. Provide a minimum of four (4), ¾" diameter anchor bolts at all columns; additional bolts and/or larger diameter/longer bolts will be required at bracing locations.

A1020 Special Foundations

- Elevator pits: Elevator pit construction will consist of 12" thick, reinforced concrete walls and a 24" thick, reinforced concrete foundation mat, with an integral sump pit. Waterstops will be provided at all construction joints and all interior surfaces of the elevator pit will be waterproofed. Elevator shaft walls will be 100% solid grouted, reinforced CMU construction (8" thick).
- Foundations for the western end of the new building (adjacent to the below grade parking) may need special consideration, due to the adjacency of Putnam Avenue and the presumption that the existing soils in this zone consist of uncontrolled fill and are not suitable for bearing. Mini– piles or rammed aggregate piers may be required, to avoid the need to remove the existing fill and replace with compacted structural fill (temporary lateral earth support would be required). Alternately, the floors of the building may cantilever, to minimize/eliminate the need for foundations in this zone.

A1030 Slabs On Grade

Lowest Level Floor Construction will typically be a 5" thick concrete slab on grade, reinforced with welded wire fabric. The slab will be underlain by a vapor barrier, rigid insulation and 6" of compacted gravel fill. Saw cut control joints (1.25" deep) will be provided in each direction at each column line. Full depth isolation joints will be constructed around columns. Mechanical Room floors will be similar construction, with a 6" thick concrete slab on grade. Perimeter and underslab drainage will be provided at the lowest level, as previously noted.

- Welded wire fabric for slabs on grade: *6x6-W2.9xW2.9.*
- Slab On Grade Thermal Insulation: *R=5 extruded polystyrene foamed plastic board.*
- Slab On Grade Vapor Retarder: *ASTM E1745 Standard for Specification for Water Vapor Retarders Used In Contact With Soil or Granular Fill Under Concrete Slabs; Class A.*

A20 Below Grade Construction

A2020 Foundation Walls

- Cantilever retaining walls (along the western edge of the lowest level: *14" thick, with horizontal and vertical reinforcing each face (8.0 +/- psf*). Cantilever retaining walls are provided to facilitate backfilling below the level above (to the west) and to resist lateral earth pressures, reducing lateral loads imparted to the lateral force resisting system (bracing). As noted earlier, portions of the Basement, First Floor and foundation construction in Part A of the existing building will be retained to reduce the extent of temporary lateral earth support along Putnam Avenue.
- Cantilever retaining wall continuous footing: *7'- 6" wide, by 1'-6" deep, with 8.0 psf reinforcing. The bottom of the footing will be 2'-6" below the top of floor slab.*
- Foundation Wall Dampproofing: *ASTM D1227 Standard Specification for Emulsified Asphalt Used as a Protective Coating for Roofing; Type II , Class I, non-asbestos fibers.*

B SHELL

B10 SUPERSTRUCTURE

Structural Bays/Spans: Typical structural bay size/configuration has not yet been determined; however, it is anticipated that rectangular structural bays will average approximately 900 square feet in area. Long span construction over the (Large and Small) Gymnasium and Auditorium spaces varies.

Story Heights: The preliminary story height for the upper levels has been established at 14'-0".

Steel Framing Connections: Type 2 simple framing connections (shear only); double clip angles typically.

Columns: Typical columns will be wide flange steel sections or steel tubes (HSS).

Lateral Force Resisting System: Lateral (wind and seismic) forces will be resisted by steel bracing, for reasons of economy, stiffness, reduced structural depth and smaller column sizes. Bracing members will be square or rectangular HSS sections. Brace configurations may include chevrons, inverted chevrons ("V"), or single diagonals in short bays, as required by structural and architectural considerations.

Expansion (Seismic) Joints: Due to the relatively compact massing of the Preferred (Pi) Option, it does not appear that expansion/seismic joints will be required.

Fire Protection: As previously noted, new construction is classified at Type 2A Construction (Noncombustible, Protected). Typical steel floor and roof members (beams, columns and bracing) and steel roof deck (except where the height exceeds 20 feet) require fire protection. All steel framed construction is considered to be restrained.

B1010 Floor Construction

Second Floor and Third Floor Construction consists of a 4" (minimum) thick, normal weight concrete topping slab with welded wire fabric, on 2" deep, 18 gauge galvanized steel composite steel floor deck (6" minimum total slab thickness), supported by composite steel beams and girders. Slabs on steel deck will be placed at the required elevation, adding concrete to compensate for the deflection of the (unshored) steel framing (approximately ¾" average, additional concrete in each structural bay). Composite action between the steel beams/girders and the concrete slab on steel deck will be achieved by field welding ¾" diameter, 4½" long headed shear connectors to the top flanges.

- Welded wire fabric for slabs on composite steel deck: *6x6-W2.9xW2.9.*
- The estimated total weight of structural steel for the structured floor levels of the new construction (including beams, columns, bracing, plates, angles, miscellaneous frames, connections, etc., but excluding entry canopies, loose lintels, etc.) is as follows:

Estimated Weight of Structural Steel: 13.5 PSF

B1020 Roof Construction

Typical Roof Construction (flat roof areas and sloping, "Main Street" roof) consists of a 3" deep, 18 gauge, Type DR, galvanized steel roof deck, supported by wide flange steel beams and girders. As noise and vibration will be a concern where roof top mechanical equipment is located, these sections of the roof will be framed with a 4" (minimum) deep, regular weight concrete topping slab on a 2" deep, 18 gauge, composite type galvanized steel floor deck (6" minimum total slab thickness), supported by composite, wide flange steel beams and girders. Composite action between the steel beams/girders and the concrete slab on steel deck will be achieved by field welding ¾" diameter, 4½" long headed shear connectors to the top flanges. Roof drainage will be achieved by pitching the steel framing to low points at selected interior columns, wherever practical.

Gymnasium and Auditorium Roof Construction consists of a 3" deep, 18/20 gauge, galvanized, cellular acoustic deck, spanning to structural steel beams. Steel beams span to steel trusses (with a sloped top chord). Trusses clear span the Gymnasium floor below and are supported by 12" square, HSS steel columns. Steel framing for the Gymnasium roof will be Architecturally Exposed Structural Steel (A.E.S.S.). The Auditorium roof will be similarly structured (but not A.E.S.S.), with standard, non-acoustical roof deck.

- Welded wire fabric for slabs on composite steel deck: *6x6-W2.9xW2.9*.
- The estimated total weight of structural steel for the various roof areas of the new building (including beams, columns, trusses, bracing, plates, angles, miscellaneous frames, connections, etc., but excluding equipment screens, loose lintels, etc.) is as follows:

Estimated Weight of Structural Steel: 13.5 PSF

B20 Exterior Enclosure

B2010 Exterior Walls

Exterior walls will be a combination of Aluminum Composite Panels (ACP), Trespa Panels and Terra Cotta Planks (all with a steel stud backup) and curtainwall. A masonry veneer "base" (also with a steel stud backup) may be provided. Exterior wall materials and details continue to be studied by the Project Team. In areas where a steel stud backup wall system is utilized, framing should be 16 gauge minimum studs, designed for an H/600 deflection limitation at masonry veneer or terra cotta plank conditions or H/360 elsewhere, as applicable. Vertical slip joints will be provided in the metal stud backup system at each level. Ties to the brick veneer (as applicable) will be installed at 16" o.c. horizontally and vertically. The estimated structural steel weights noted previously do not include allowances for horizontal girts, relieving angles, hangers, bracing, etc., as may be required to support and brace the exterior wall system.

OUTLINE STRUCTURAL SPECIFICATIONS

Concrete:

- All concrete shall be normal weight, 4,000 psi at 28 days, except foundation walls and footings, which shall be normal weight, 3,000 psi and exterior (exposed) concrete (paving) which shall be normal weight, 4,500 psi.
- Portland Cement: ASTM C150, Type I or II.
- Fly Ash: ASTM C618, Class F. Replacement of cement content with fly ash is limited to 20% (by weight). Fly ash is not permitted in exterior, exposed concrete, or in concrete for slabs on grade and slabs on composite steel deck.
- All concrete shall be proportioned with 3/4" maximum aggregate, ASTM C 33, except 3/8" maximum aggregate shall be used at toppings less than 2" thick (e.g. metal pan stairs).
- All reinforcing shall be ASTM A 615 deformed bars, Grade 60.
- All welded wire fabric shall conform to ASTM A 185.
- Reinforcing bars, steel wire, welded wire fabric, and miscellaneous steel accessories shall contain a minimum of 25% (combined) post-industrial/post-consumer recycled content (the percentage of recycled content is based on the weight of the component materials). Certification of recycled content shall be in accordance with Submittal Requirements.
- Concrete products manufactured within 500 miles (by air) of the project site shall be documented in accordance with Submittal Requirements.
- Cure all concrete by moisture retention methods, approved by Architect; curing compounds shall not be used.

Reinforced Concrete Masonry (Elevator Shaft):

- Masonry construction (elevator shaft) shall conform to ACI 530/ASCE 5/TMS 402 "Building Code Requirements for Masonry Structures", latest edition.
- Masonry strength, (f'm) shall not be less than 1350 psi.
- Requirements for load bearing block strength shall be as required for specified masonry strength (f'm) but shall not be less than 2000 psi on the net area of the block.
- Grout shall conform to ASTM C476, Type Fine, and shall be of strength required for specified masonry strength (f'm) but not less than 3000 psi.
- Mortar for reinforced masonry shall conform to ASTM C 270 Type S and shall be of strength required for specified masonry strength (f'm) but not less than 1800 psi.
- Reinforcing bars shall conform to ASTM A 615 Grade 60 deformed bars. Lap all continuous bars 48 diameters.
- Joint reinforcing shall be 9 gauge ladder type conforming to ASTM A 82. Provide prefabricated corners and tees. Walls shall be reinforced horizontally with joint reinforcing at 16 inches on centers unless otherwise noted.
- Reinforcing bar, steel wire, welded wire fabric, and miscellaneous steel accessories shall contain a minimum of 25% (combined) post-industrial/post-consumer recycled content (the percentage of recycled content is based on the weight of the component materials). Certification of recycled content shall be in accordance with Submittal Requirements.
- Masonry products manufactured within 500 miles (by air) of the project site shall be documented in accordance with Submittal Requirements.
- Elevator shaft walls shall be 100% solid grouted (all cores).

Structural Steel:

- Structural steel shapes shall conform to ASTM A 992, Fy = 50 ksi.
- Steel tubes (HSS) shall conform to ASTM A 500, Grade B, Fy=46 ksi.
- Structural steel plates and bars shall conform to ASTM A 36, Fy = 36 ksi.
- Steel members shall contain a minimum of 25% (combined) post-industrial/post-consumer recycled content (the percentage of recycled content is based on the weight of the component materials). Certification of recycled content shall be in accordance with the Submittal Requirements.
- Steel manufactured within 500 miles (by air) of the project site shall be documented in accordance with the Submittal Requirements.
- Anchor Bolts: Anchor bolts at column base plates shall conform to ASTM F1554 – Grade 36 and shall be headed type. Provide a minimum of four (4), ¾" diameter anchor bolts at all columns; additional bolts and/or larger diameter/longer bolts will be required at bracing locations.
- Bolted connections shall be ASTM A 325, Type N (bearing) bolts, except slip-critical bolts shall be used at lateral brace beam connections.
- Shop and field welding shall be AWS D1.1 E70XX electrodes.
- Shear connectors shall be ¾" diameter, 4½" long, headed Nelson studs conforming to ASTM A 108.
- Surface treatment for typical structural steel: SSPC Surface Preparation No. 3 (Power Tool Cleaning). Structural steel shall be left unpainted. .
- Structural steel for the Gymnasium roofs shall be Architecturally Exposed Structural Steel (A.E.S.S.) and shall meet the requirements of Section 10 of the AISC manual.
- Surface treatment for Architecturally Exposed Structural Steel: SSPC Surface Preparation No. 6 (Commercial Blast Cleaning). Exposed structural steel shall be primed with a premium architectural primer, compatible with the finish paint.
- All exterior, exposed structural steel shall be hot-dip galvanized (e.g. brick relieving angles (as applicable) and steel rooftop equipment supports).

Steel Deck:

- Typical steel roof deck shall be 3" deep, 18 gauge, Type DR, conforming to ASTM A 653, Grade 33 (minimum), galvanized in accordance with ASTM A 653, coating class G-60. Exposed steel roof deck in the Gymnasiums shall be 3" deep (18/20 gauge) cellular acoustic deck and shall have a factory applied primer on the exposed bottom surface.
- Steel floor deck shall be 2" deep, 18 gauge, composite type, conforming to ASTM A 653, Grade 33, galvanized in accordance with ASTM A 653, coating class G-60.
- All steel floor deck and roof deck accessories (pour stops, finish strips, closures, etc.) shall be the same finish as the deck; 18 gauge minimum.
- Steel deck shall contain a minimum of 25% (combined) post-industrial/post-consumer recycled content (the percentage of recycled content is based on the weight of the component materials). Certification of recycled content shall be in accordance with the Submittal Requirements.
- Steel deck manufactured within 500 miles (by air) of the project site shall be documented in accordance with the Submittal Requirements.
- Provide 14 gauge sump pans at all roof drains.

MECHANICAL, ELECTRICAL, AND PLUMBING / FIRE PROTECTION

The following HVAC, Electrical, Plumbing and Fire Protection system descriptions are to provide basic concepts for the systems that will be installed in the Martin Luther King, Jr. School. The system descriptions acknowledge the intent of the City of Cambridge, MA to build a Net Zero Energy Building. The systems will also be designed to support the goal of achieving a LEED Platinum target with a minimum level of Silver certification under the LEED for Schools Green Building rating system.

The systems described in the narrative represent the mechanical, electrical, plumbing and fire protection systems that will be installed in the building under the proposed architectural scheme.

The Mechanical and Electrical systems are to be planned based on the following guidelines:

- Minimizes energy consumption
- Logical pathways for utilities that won't disrupt school life and programs as changes are made or upgrades occur
- Flexibility to accommodate both known program elements and those yet to be identified
- Zoning of the Mechanical and Electrical systems to isolate the school use and community use, providing flexibility, after hours and year-round, maximizing energy efficiency
- Systems that are easy to maintain and contain the fewest moving parts
- Standardization of building design guidelines so the building has an established energy budget

In general, the building is anticipated to contain 157,000 +/- square feet of space and will include Classrooms, Science Rooms, Student Support and Administration Support Services, Kitchen and Dining services, Gymnasium, Auditorium and Performing Arts Center. The building also contains approximately 20,000 sf of underground parking.

HVAC

As a result of the City of Cambridge's goal to achieve Net Zero Energy (NZE) operation, the HVAC systems will be designed with the primary goal of reducing energy, while still maintaining optimal space conditions and thermal comfort for an effective learning environment. Achieving Net Zero energy is not just about one year of operation, rather, the high performance built into the building needs to be retained so that the building continues to achieve Net Zero energy over time. Systems need to be reliable and maintainable and should provide long life in order to help insure the persistence of high performance. Control sequences shall recognize equipment and operational efficiencies such as turn-down of air handlers in low occupant periods and providing the capability of kitchen systems to be coordinated with Food Service programs such as "Cold food days". The systems proposed have been selected based on an analysis of several options for high performance HVAC systems that would meet the required energy performance target, achieve the required learning environment and minimize operating complexity and maintenance. In the event that NZE is not pursued, many of the system designs and efficiencies described above will still be implemented in the final design with the goal of meeting a minimum level of LEED Silver.

HVAC Systems Analysis

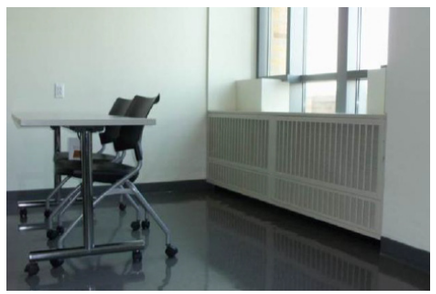
Three different HVAC system alternates were analyzed in a qualitative analysis. Systems were compared based on their ability to provide a quality indoor environment that would enhance the learning objectives of the school, the relative energy use and cost of the systems, the ease of maintenance and operations for the systems and the impact of integrating the systems into the building.

NZE buildings typically operate at annual energy intensities well below the energy code and standards such as ASHRAE 90.1. NZE buildings typically have annual energy use that is 50% to 70% below a building built to ASHRAE 90.1. This level of building energy performance requires high performance HVAC systems. One common system type to most NZE schools that have been built to date is an HVAC system utilizing geothermal heat pumps.

The three systems that were compared all utilized geothermal heat pumps in various configurations to provide heating and cooling to the school. The systems were selected based on performance parameters such as transport energy – the amount of energy required to move heating and cooling around the school, indoor environmental quality including thermal comfort, air quality and acoustics, maintenance and operations. All three systems analyzed utilized dedicated outside air systems to ensure quality ventilation of the building, good humidity and dehumidification control and the ability to provide ventilation to meet the actual demand rather than provide a constant amount of ventilation regardless of actual space occupancy. In general, large, assembly type spaces such as the Auditorium, Gymnasiums and

Cafeteria may be served by variable air volume (VAV) type air handling systems that receive chilled water and hot water from centrally located water-to-water geothermal heat pumps. The main variation in systems is in how spaces such as classrooms are treated. The three HVAC system alternates for classrooms that were analyzed are as follows:

- **Water-to-air geothermal heat pumps with dedicated outside air system.** – Heat pumps would be located in utility closets with access from the corridor. Each classroom would have a dedicated heat pump. Conditioned outside air would be ducted to each heat pump as required for the ventilation needs of the space served.
- **Water-to-water geothermal heat pumps with induction / displacement units and dedicated outside air system** – Induction / displacement units would be located along the perimeter of each classroom and conditioned outside air (primary air) would be ducted to each unit. The units would have heating and cooling coils supplied by the water-to-water heat pumps.
- **Water-to-water geothermal heat pumps with radiant panel heating and cooling and dedicated outside air system** – Ceiling mounted radiant panels would be provided to provide room sensible heating and cooling. Conditioned outside air would be delivered to each room via displacement (low velocity air delivered at or near the floor and at temperatures just below room temperature).


PERIMETER INDUCTION / DISPLACEMENT UNIT

The systems were compared and ranked in a qualitative analysis with individual categories weighted based on their overall importance. The un-weighted and weighted comparison matrices are at the end of this section. The systems judged to be most appropriate for the MLK School based on our analysis is the perimeter induction / displacement system.

Proposed HVAC System
Based on our initial analysis of HVAC system options, we propose the following:

- Hybrid system of ground source water-to-water heat pumps for chilled water and hot water generation with supplemental gas fired condensing type boilers
- Perimeter Induction / Displacement air distribution in classroom areas
- Utilization of efficient total energy heat recovery for Dedicated Outside Air (DOAS) ventilation systems
- Variable Air volume systems for the Public Assembly Areas (Gymnasiums, Auditorium and Cafeteria)
- Demand Control Ventilation for classrooms, assembly areas and kitchen ventilation

For the Non-Assembly area HVAC systems, a perimeter induction / displacement system will be used to condition the space. These systems utilize conditioned 100% outside air required for ventilation to induce room air across heating & cooling coils to provide additional space conditioning without the need for a fan. The units are very quiet, do not require filters and generally operate without condensation on the coil. These systems utilize a displacement cooling approach which limits the heat gain seen in the occupied areas, therefore reducing cooling loads and energy use. Because the perimeter induction displacement units can be designed to occasionally operate with “wet coils” there is a reduced concern over humidity levels and condensation on the coils within the space as compared to other terminal cooling approaches such as chilled beam systems or radiant cooling panels. There are several benefits to the ability to use “wet-coils” in the space, including, the ability to limit supply air to ventilation requirements alone, no need to over cool the supply air to provide dehumidification and the ability to pursue natural ventilation when appropriate. The induction /displacement units can provide heating without a supply of primary air so off-hour heating can be accomplished without the need to operate centralized fan systems.

PROGRAMMATIC AREAS

a. Non-assembly spaces
The general layout of the non-assembly areas will be as follows. All Classrooms, Offices and Non-Assembly areas will be conditioned by perimeter induction/displacement units. Ground source water-to-water heat pumps with vertical, closed loop geo-exchange wells will provide both chilled water and hot water, as a four pipe system to the perimeter induction/displacement units.

Dedicated rooftop Direct Outdoor Air Systems (DOAS) will supply conditioned or tempered air to the perimeter induction/displacement units at 66°F DB / 43 Dewpoint. The DOAS units will be equipped with supply and return fans, economizer dampers, a chilled water / hot water coil (seasonal changeover) as well as total energy recovery wheel. The units will also be sized to minimize face velocity and thus pressure drop across filters, coils and heat exchanger sections. The minimal face velocity and lower static pressures will help reduce fan power.

Supply airflow and capacity will be sized to meet the minimum ventilation requirements of the spaces served. The minimum outdoor air ventilation requirements for each non assembly area shall be based on the maximum of the International Mechanical Code Section 403.3 ventilation requirements, based on code occupancy densities, or 30% over the outdoor air requirement of ASHRAE 62.1-2007 Ventilation for Acceptable Indoor Air Quality, whichever is greater.

During heating season, the rooftop DOAS units will supply tempered ventilation air through the perimeter induction units, further space heating will be provided by running hot water through the perimeter induction unit hot water coils to add additional space heating as necessary. The perimeter units will satisfy the envelope / skin heating load of the space.

The DOAS will be able to modulate the ventilation air supply volume dependent on space occupancy, as determined by the CO2 sensor system. When classroom or office areas are unoccupied, but the DOAS system is in use, a variable volume terminal box within the distribution ductwork will throttle down the quantity of ventilation air to the space. During occupied hours, the minimum quantity of ventilation air supplied will be based on the ASHRAE 62 required cfm per square foot for classroom spaces. The actual air supplied to the space will be dependent on the air required to maintain the space temperature setpoint. This is expected to significantly reduce energy usage during hours that the building is only partially occupied, such as night and summer usage.

The proposed controls scheme for the classroom ventilation air supply will maintain setpoint within the space during all regularly occupied building hours. During time periods when students are out of the classroom, during the normally occupied school day, the ventilation supply air to the space will throttle up or down as required to maintain space temperature and CO2 setpoint.

b. Public Corridors
All public corridor areas will also be conditioned by displacement induction units, providing supplemental cooling and heating to the space or displacement air alone, depending on the corridors orientation and exterior wall area. These systems receive chilled and hot water from the water to water heat pump systems similar to the classrooms and ventilation air will be provided from the DOAS units that also serve the classrooms.

c. Public Assembly areas
Gymnasiums, Auditorium and Cafeteria will be served by variable volume rooftop units, providing heating and air conditioning for the assembly areas. These units will be equipped with supply and return fans, economizer dampers, a chilled water / hot water coil (seasonal changeover) as well as total energy recovery wheel. The units will also be sized to minimize face velocity and thus pressure drop across filters, coils and heat exchanger sections. The minimal face velocity and lower static pressures will help reduce fan power.

Each gymnasium will have a dedicated unit, which will also serve Locker rooms and stage area. The Locker rooms are to be negatively pressurized and all air removed from the lockers will be exhausted (not re-circulated). Code mandated outside ventilation requirements apply.

The Cafeteria and Auditorium will also have dedicated rooftop units with a similar arrangement to the Gymnasium Units.

The rooftop units serving the Gymnasium, Auditorium and Cafeteria may be variable air volume and will modulate the supply air flow based on the space load in order to provide proper thermal comfort in the space. In order to reduce energy use as much as possible, but also address potential air velocity and distribution issues within these large volume spaces, the systems will damper off ductwork sections or supply diffusers when the supply air goes below a certain flow thus maintaining appropriate velocity for an overhead distribution system under low-flow operation.

All rooftop units serving the Public Assembly areas shall have nominally 55°F air discharge (out of air conditioning unit and into the supply duct) in the cooling mode, and shall be equipped with un-housed airfoil plug type supply and return fans. All rooftop units will be equipped with MERV 13 filters, air flow stations and humidity control (to be compliant with ASHRAE-55).

All units shall have insulated double walls. Rooftop units will be provided with pre-filters with a minimum efficiency reporting value (MERV) of 7, and final filters having minimum efficiency reporting value (MERV) of 13.

Carbon dioxide occupancy sensors will be located in each assembly space to reduce the outside air intake when the spaces are not occupied. The minimum outside air intake ventilation rate that the carbon dioxide sensors can throttle the outside air intake rate down to is the space specific cfm per square foot requirements as defined in ASHRAE 62.1-2007.

The fresh air capacity will be the maximum of the International Mechanical Code Section 403.3 ventilation requirements as compared to 30% over the outdoor air requirement of ASHRAE 62.1-2007 Ventilation for Acceptable Indoor Air Quality with the exception of Cafeteria, Auditorium and Multi- Purpose Spaces which will provide ventilation rates equal to the maximum of the International Mechanical Code Section 403.3 ventilation requirements as compared to ASHRAE 62.1-02007 (without the 30% increase). The outside air ventilation rate is never permitted to drop below the space specific cfm per square foot times the space square footage.

Gymnasiums supply and return fans and air distribution ductwork will be designed for a maximum of 1.5 inches of w.c. external static pressure for supply air, and 1.0 inches of w.c. external static pressure for return air.

A humidity sensor(s) shall be utilized to maintain 60 +/- 2 % relative humidity conditions during occupied periods and 65 +/- 2% relative humidity conditions during unoccupied periods (after experiencing 70% relative humidity for at least 8 hours). Return duct humidity sensors shall be utilized during occupied periods. Space humidity sensors shall be utilized during unoccupied periods.

The Cafeteria and Auditorium areas will each be served by a single variable-volume rooftop unit (RTU) with supply and return fans, economizer dampers, a chilled water / hot water coil (seasonal changeover) as well as total energy recovery wheel. The RTU provides heating, cooling and ventilation for the cafeteria and auditorium spaces. The Kitchen area will be conditioned by fan coil units located within the space. The fan coils will receive hot/chilled water from the water-to-water heat pumps serving the perimeter radiation units.

The Kitchen will receive minimum ventilation air from the main buildings DOAS unit. The kitchen hood will be variable flow, utilizing a demand control based kitchen hood exhaust system in place of switch control. The flow from the kitchen hood will be varied based on the intensity of cooking. This will be controlled by temperature and air quality sensors within the hood. When the air temperature under the hood increases or the air quality diminishes, the hood exhaust volume will increase.

Kitchen hood exhaust capacity shall be listed and labeled in accordance with UL 710. There will be a separate kitchen hood make-up air unit located on the roof, which will provide tempered air to the hood, the volume of tempered air will vary, dependent on the exhaust flow to maintain the appropriate pressure relationship across the face of the hood. The make-up air will be tempered to 55°F (adjustable) during winter operation, as to avoid over cooling the kitchen workers operating at the face of the hood.

The Cafeteria and Auditorium will be provided with a hardwired space temperature sensor and space relative humidity sensor(s) to control the unit during unoccupied time periods. The unit will be provided with return air duct mounted temperature sensor and duct mounted relative humidity sensor to control the unit during occupied time periods.

The maximum heating discharge air temperature shall be nominally 95°F and the cooling discharge air temperature shall be nominally 55°F.

Cafeteria and Auditorium supply and return fans and air distribution ductwork will be designed for a maximum of 1.5 inches of w.c. external static pressure for supply air, and 1.0 inches of w.c. external static pressure for return air.

Inside Occupied Kitchen design temperatures: 72°F (Winter), 82°F (Summer).
Inside Occupied Cafeteria and Auditorium design temperatures: 72°F (Winter), 78°F (Summer).

The Kitchen Storeroom will be maintained at a space temperature between 50°F - 70 by an electrical heat pump system with the outdoor unit located next to the walk-ins air cooled condensing units. The Kitchen Storeroom will have both a space temperature sensor and a space relative humidity sensor integrated into the BMS/DDC network.

Corridor Ventilation Strategy

The outside air component of the total supply air to the Corridors shall be exhausted by Toilet exhaust, Janitor's Closet exhaust and the corridor roof-top packaged unit.

The Toilet exhaust system and Janitor's Closet exhaust system will be combined. The component of the total air supplied to the Corridor that is not directly exhausted will be recirculated back to the ventilation unit.

The DOAS ventilation systems serving the Classrooms will have all of the supply air returned to the DOAS unit in order to utilize the total energy recovery wheels that recover both sensible and latent energy.

Underground Parking Garage

The parking garage will require mechanical exhaust and ventilation.

The garage will have approximately 4 new mechanical exhaust fans and supply fans. The exhaust fans and supply fans shall connected to a plenum on each end of the garage. The exhaust and supply fans shall be independently controlled for each level. Each exhaust fan will be sized for 1.0 inches of total pressure which will provide the code required .75 CFM of exhaust per square foot of garage. The fans shall have sheet-metal intake plenums with wire mesh screens, and discharge sound attenuators. The fans shall be provided with variable frequency drives located in the mechanical rooms. To meet the current building code, the fans will be controlled by carbon monoxide as well as nitrogen dioxide detectors. There shall be an area detector located to cover a 10,000 square foot zone each. A new gas detection control system shall be provided and located in the mechanical room to control the fans. Per the current building code the fans are to operate to provide a minimum of .05 CFM per square foot of garage area, up to .75 CFM per square foot of garage area to maintain safe levels of carbon monoxide and nitrogen dioxide.

HVAC Design Requirements for Special Spaces

The Main Telecom Room, and all Intermediate Telecommunications Closets will be provided with a ductless split air-conditioning system that shall maintain a maximum of 75°F space temperature, and a maximum of 55% relative humidity, 24 hours a day, 7 days a week in accordance with ANSI/TIA/EIA – 569 - A. Space temperature sensors and space relative humidity sensors (which only monitor) will be located in the Main Telecom Room, and in all Intermediate Telecom Closets. Space temperature sensors and space relative humidity sensors will be integrated into the BMS/DDC system. The air conditioning equipment capacity for the Main Telecom Room shall be able to handle a load of Electrical Distribution Rooms (EDR) and Elevator Machine Rooms will be provided with an independent split air-conditioning or exhaust system that shall maintain the space temperatures (24 hours a day, 7 days a week) in accordance with the equipment manufacturer's recommendations.

Hoistways of elevators will be provided with vents in the hoistway enclosures in order to prevent the accumulation of smoke and hot gases in case of fire. Hoistway enclosures may be vented in accordance with the following:

Location of vents:

a. The vents in the side of the hoistway enclosure below the electric elevator machine room floor or in the roof of all hoistways shall open either directly to the outer air or through noncombustible ducts to the outer air.

b. The vents in the wall or roof of an overhead electric elevator machine room through the smoke hole in the top of the elevator hoistway shall be vented to the outer air through noncombustible ducts.

The area of vents in all hoistways or the electric elevator machine room and the smoke hole will be at minimum 3-1/2 percent of the area of the hoistway or 3 square feet (0.28 m2) for each elevator car, whichever is greater. Such vents shall comply with the following requirements:

a. Open Vents. Of the total required vent area, not less than one-third will be permanently open or equipped with an openable hinged damper. The smoke hole shall be permanently open.

b. Closed Vents. The two-thirds closed portion of the required vent area either in all hoistway enclosures or in the electric elevator machine room may consist of windows or skylights glazed with annealed glass not more than 1/8-inch (3.2 mm) thick. A closed damper that opens upon the activation of a smoke detector placed at the top of the hoistway shall be considered closed.

An electric unit heater will be provided in the Water Meter Room and Crawl Spaces to maintain a minimum 50°F space temperature. Sloping top convectors will be used in Janitor's Closets that are located at the perimeter. Janitor Closets will be exhausted at airflow of 5 minutes per change.

Entrance Vestibules and Main Entrances will be provided with floor mounted recessed hot water cabinet heaters or equal.

Special Education spaces will be maintained at 72ºF during the cooling season during occupied periods (as opposed to the 78ºF provided in other spaces).

Heating and Cooling Design Parameters

Heating and Cooling Systems will be designed in accordance with International Mechanical Code 2009, Heating and Cooling Load Calculations, LEED for Schools reference standards and Massachusetts Building Code 8th Edition using the following criteria:

Heating

The fresh air requirements per occupant shall be the maximum of the International Mechanical Code 2009 ventilation requirements as compared to 30% over the outdoor air requirement of ASHRAE 62.1-2007 Ventilation for Acceptable Indoor Air Quality with the exception of Cafeterias, Auditoriums and Multi-Purpose Spaces which shall be designed to provide ventilation rates equal to the maximum of the International Mechanical Code 2009 Section 403.3 ventilation requirements as compared to ASHRAE 62.1-04 (without the 30% increase).

Number of occupants based on International Mechanical Code2009 maximum occupancy per net floor area of occupied space (Table 403.3).

Inside ambient design parameters:
72°F DB

Outside ambient design parameters:
9°F DB (Based on Wind at 15 MPH)

Cooling

The fresh air requirements per occupant shall be the maximum of the International Mechanical Code 2009 Section 403.3 ventilation requirements as compared to 30% over the outdoor air requirement of ASHRAE 62.1-2007 Ventilation for Acceptable Indoor Air Quality with the exception of Cafeterias, Auditoriums and Multi-Purpose Spaces which shall be designed to provide ventilation rates equal to the maximum of the International Mechanical Code 2009 Section 403.3 ventilation requirements as compared to ASHRAE 62.1-2007 (without the 30% increase).

Inside ambient design parameters:
78°F DB, 45% RH

Outside ambient design parameters:
88°F DB, 74°F WB

Sizing of Equipment

Heating Capacity:
The heating capacity for rooftop units will be increased by 10% to account for duct losses (duct insulation losses, duct air leakage) and general building pick-up.
The water-to-water heat pump system will be supplemented with a condensing boiler to achieve heating in the most effective and efficient way possible while also minimizing the size of the well field to help control costs. Reserve capacity will be 25% to account for piping losses and pickup, capacity will be based on total connected capacity.
The water-to-water heat pump / condensing boiler heating system will also utilize the solar thermal hot water, whose primary purpose is to heat the domestic hot water, as a pre-heat for the building heating loop. Thus utilizing the solar thermal HW loop when it is not needed to meet the domestic water load.

Cooling Capacity:
The cooling capacity for roof top units will be increased by 10% to account for duct losses (duct insulation losses, duct air leakage) and general building pull-down.
Water-to-Water Heat Pumps will be provided with a reserve capacity of 25% to account for piping losses. Cooling capacity will be based on total connected capacity.

HVAC Capacities and Loads

The modular water-to-water heat pumps will be split into two banks, one serving the interior of the building, and thus able to be a pure water system and the second serving the Roof Top Units, and thus being a glycol based system. Each bank of water-to-water heat pumps will use the closed loop geothermal well as the heat rejection/addition device. The splitting of the systems into two separate loops, one with glycol and one without, removes the need for heat exchangers for the glycol loop and as a result reduces pumping energy associated with the pressure drop of the heat exchangers. Both water-to-water heat pump loops will be supplemented by the condensing boiler system. The system capacities are represented in the tables below.

Water-to-Water Heat Pumps

TYPE	QUANTITY	MODULAR COOLING CAPACITY	TOTAL COOLING CAPACITY	MODULAR HEATING CAPACITY	TOTAL HEATING CAPACITY
Water-to-Water modular heat pump	18	30 Tons	540 Tons	925 MBH	6480 MBH

Supplemental Boiler

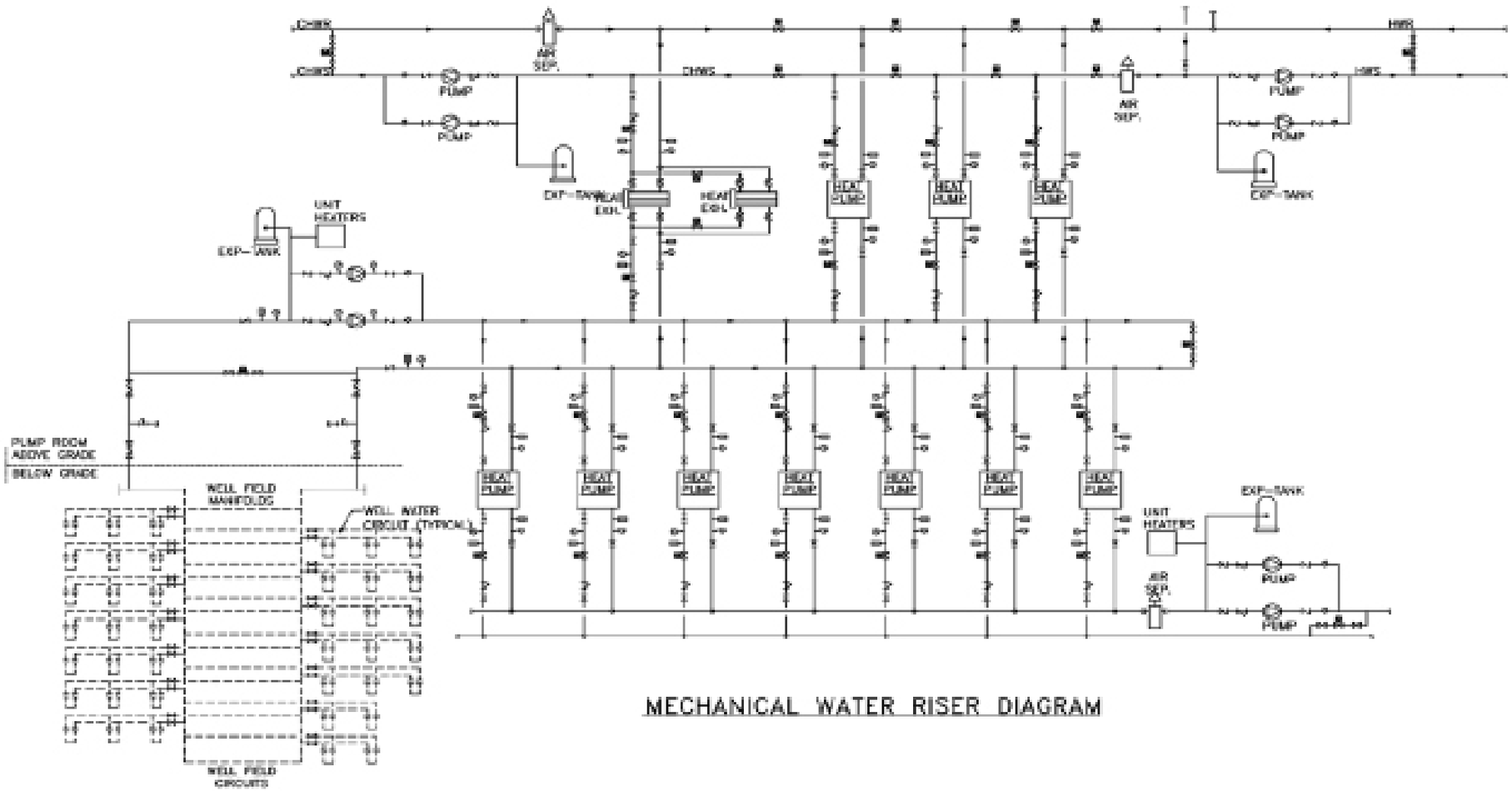
BOILER	NOMINAL CAPACITY (MBH)	QUANTITY	TOTAL HEATING CAPACITY (MBH)
Viessman Vitocrossal	6,600	1	6,600

Custom Roof Mounted HVAC Units

AREA SERVED	TOTAL AIR FLOW	COOLING CAPACITY (TONS)	HEATING CAPACITY (MBH)
Cafeteria	6,000	20	50
Multi-Gymnasium	12,000	35	85
Small Gymnasium	6,000	20	50
Auditorium	6,000	20	50

Dedicated Outdoor Air System (DOAS)

AREA SERVED	TOTAL AIR FLOW	COOLING CAPACITY (TONS)	HEATING CAPACITY (MBH)
DOAS Units	19,000	80	1100



MECHANICAL WATER RISER DIAGRAM

HVAC Systems Comparison Matrix

System Options	Indoor Environment			Energy			Cost	Operations				Impact	Rating
	Thermal Comfort	Acoustics	Ventilation	Low Transport Energy	Fast Response	Low Heating & Cooling Energy	Low Life-Cycle Cost	Reliability	Maintainability	Life Expectancy	Simplicity	Floor - to - floor limitations	
Water-to-air gaothermal heat pumps with dedicated outside air system	1	1	1	1	3	1	3	3	3	1	3	1	22
Water-to-water geothermal heat pumps with induction / displacment units and dedicated outside air system	2	2	2	2	2	3	2	2	2	2	2	2	25
Water-to-water geothermal heat pumps with radiant panel heating and cooling and dedicated outside air system	3	3	3	3	1	2	1	1	1	3	1	3	25

HVAC Systems Weighted Comparison Matrix

System Options	Indoor Environment			Energy			Cost			Operations			Impact			Overall Rating
	Raw Score	Weighting	Score	Raw Score	Weighting	Score	Raw Score	Weighting	score	Raw Score	Weighting	Score	Raw Score	Weighting	Score	
Water-to-air geothermal heat pumps with dedicated outside air system	3	15%	0.45	5	25%	1.25	3	20%	0.6	10	35%	3.5	1	5%	0.05	5.85
Water-to-water geothermal heat pumps with induction / displacment units and dedicated outside air system	6	15%	0.9	7	25%	1.75	2	20%	0.4	8	35%	2.8	2	5%	0.1	5.95
Water-to-water geothermal heat pumps with radiant panel heating and cooling and dedicated outside air system	9	15%	1.35	6	25%	1.5	1	20%	0.2	6	35%	2.1	3	5%	0.15	5.3

Electrical

Normal Power Distribution Systems

Two new primary feeders will be brought in from the utility company to a utility owned primary switchgear which will house two primary switches and an automatic transfer switch. This will automatically switch between the two primary utility circuits to reduce power losses at the facility. A new secondary feeder shall be brought in from a new utility owned pad mounted transformer or utility transformer vault via a concrete encased ductbank to a new main switchboard to serve lighting, power and mechanical equipment throughout the school. The re-use of the existing electrical vault shall be analyzed in conjunction with the owner, architect and utility company and if possible shall be considered in the final design. The main switchboard will be rated 480/277 volt, 3-phase, 4-wire, 3000A. The switchboard will be service entrance rated with copper bussing and TVSS. The main circuit breaker shall be a fixed insulated-case, 100% rated with field adjustable LSIG settings. All feeder breakers shall be molded case type with field adjustable LSIG settings. The distribution switchboard will feed distribution and branch circuit panels located at various locations throughout the building. All switchgear and distribution equipment including transformers shall be mounted on a 4" high concrete housekeeping pad. All distribution equipment shall be provided by one manufacturer.

A 277/480V and 120/208V power distribution system will be provided to supply normal power to all lighting, receptacles, mechanical equipment, kitchen equipment, laboratory equipment, low-voltage systems, and other loads throughout the building.

The power distribution equipment will be installed primarily in the Main Electric Switchboard Room and electrical closets located on each level. There will be minimum one electrical closet per floor, centrally located to minimize the length of branch circuits. Additional panelboards will be provided in special load intensive areas such as the kitchen.

The power distribution equipment will consist of the following:

a. Main Distribution Switchboards installed in the Main Electric Switchboard Room to supply lighting, receptacles, and power panelboards located in each level's electrical closet, and for panels serving large mechanical loads. All panels shall be surface mounted in electric closets or flush mounted in finished spaces.
b. 277/480V lighting panels which will be circuit breaker type will also be installed in the Main Electric Switchboard Room and in each level's electrical closet. Lighting circuits on each level will be provided by the panel on the associated floor.
c. 120/208V receptacle panels via energy efficient self-cooling dry-type step down transformers to panels which will also be circuit breaker type, and installed in the Main Electric Switchboard Room and in each level's electrical closet, will provide branch circuits for receptacles and other miscellaneous loads on the associated floor.
d. 277/480V mechanical panels which will also be circuit breaker type and installed in the Main Switchboard Room, the Boiler Room, and various electrical closets throughout the building as required. They will provide branch circuits for mechanical loads such as fan-powered VAV boxes, electric unit heaters, cabinet unit heaters, and exhaust fans, etc.
e. 277/480V and 120/208V kitchen power panels shall be circuit breaker type and supply power for all kitchen equipment. A dedicated panel for all equipment beneath the kitchen exhaust hood will also be provided with provisions for emergency exhaust fan shut-down.
f. Panels supplying computer equipment will have transient voltage surge suppression (TVSS) devices.

Emergency Power Distribution Systems

A 250-400 kw diesel fired emergency generator will likely be located in the building near the main electric room. Two separate automatic transfer switches and distribution panels will be required for emergency and optional stand-by branches. A 260A, 277/480-volt ATS will be required for the emergency branch and a 100A, 277/480-volt ATS will be required for the optional stand-by branch. The emergency system distribution equipment shall be located in separate 2-hour rated rooms located on each floor and will provide branch circuits for the emergency system. All emergency system wiring shall be in conduit and physically separated from the normal systems. The optional stand-by branch distribution shall be feed panels located in the kitchen space for emergency backup power for refrigeration and freezer equipment.

Wiring Methods

All wiring will be installed in a conduit system including empty conduits for sound, data and communications wiring located above accessible ceilings. The minimum conduit size shall be ¾" for branch circuits, switch legs and control wiring. All feeder and branch circuits shall be installed in electrical metallic tubing (EMT) conduits. All exterior conduits shall be threaded, rigid galvanized steel conduit. EMT fittings shall be compression type. Set screw fittings shall not be permitted.

Complete systems of branch circuit wiring shall be provided for all lighting, power and miscellaneous requirements. Conductors are to be single conductor 600 volt, THHN/THWN insulation (with continuous color coding), copper, minimum #12 AWG. Larger conductors shall be provided to suit specific loads which exceed the capacity of the #12 conductors. #14 AWG conductors may be used for control circuits and fire alarm system. All wire #10 and

smaller shall be spliced with threaded on plastic or nylon insulated connectors. #8 and larger shall be spliced with compression type connectors and insulated with electrical tape. Type MC metal clad cable may be utilized for "whips" to lighting fixtures.

Liquid tight flexible conduit shall be utilized for the final connections to motors, transformers and other vibrating equipment.

Fire Alarm System

The fire alarm system for the building shall be a new multiplex addressable, ADA compliant microprocessor based, voice evacuation system including all required power supplies, peripheral devices, elevator status panel, generator annunciator for a complete system in compliance strict compliance with Massachusetts State Building Code, NFPA 72 and all applicable local codes and standards. System shall be programmed, tested, and be in fully operational condition including all required hardware, software, raceways and inter-connecting wiring. All fire alarm wiring shall be class "A" in conduit. System shall include automatic smoke detectors, manual pull stations, water flow and tamper switches to monitor the fire suppression system. Magnetic door holders and smoke detectors shall be provided at fire doors to release the doors in the event of a fire alarm. Duct smoke detectors shall also be provided in air handling equipment rated 2000 CFM or higher. The fire alarm system shall monitor the status of the kitchen hood suppression system. The fire alarm system shall have an elevator recall sequence to return the elevator to a designated level for evacuation.

Equipment and Locations:

a. Fire Alarm Control Panel (FACP) – Placed in the main lobby, near the main entrance
b. Printer – Placed in Custodian's Office
c. Remote Annunciator – Placed in the general office or rear entrance.
d. Manual Pull Station – Placed in accordance with Massachusetts State Building Code. Specifically, they shall be provided within 5'-0 of each door leading to legal exit in corridors, lobbies, places of assembly and as required to meet the travel limitations of 200'. The height of the manual pull stations shall be a minimum of 42" and a maximum of 48" measured vertically from the floor level of the activating handle. All manual pull stations shall be single-action type. False alarm stopper covers shall be provided over all manual pull stations.
e. Visual Annunciator (Strobes) – Placed in accordance with BC 907.9.1. Specifically, they shall be wall-mounted in places of instruction, corridors, places of assembly, library, shops, music rooms, toilets, and elsewhere where required by the Building Code. Strobes shall be unobstructed by other objects, visible from any position in the area and shall be a maximum of 15 ft from end of the corridor. Strobes shall be wall-mounted such that the entire strobe lens is located 96" above the finished floor or 6" below the ceiling, whichever is less in height. Strobe lights shall not be required in staircases. If three or more strobes are in the same room or adjacent space within the field of view, they shall be synchronized. Ceiling-mounted strobes are allowed where wall-mounted strobes cannot provide proper coverage.
f. Audible and Visual Notification Appliances (Speaker/Strobes) – Combination speaker/strobe type devices shall be installed in all locations throughout the building open to the public. Speaker/strobes shall be wall-mounted such that the entire lens is located 96" above the finished floor or 6" below the ceiling, whichever is less in height. All strobes are in the same room or adjacent space within the field of view shall be synchronized.
g. Smoke Detectors – Placed in all mechanical rooms, electrical switch gear rooms, electric closets, telecommunications room and closets, audio/video storage rooms, elevator lobbies, elevator machine rooms and elevator shafts if required by current state elevator code, storage rooms containing flammable materials (book storage, grounds equipment room, custodian's storage) and over fire doors where magnetic door holders are provided. Smoke detector layout shall comply with NFPA 72 and the Massachusetts State Building Code.
h. Metal Wire Guards – Provide in all gymnasiums and playrooms for visual and audible notification appliances.
i. Kitchen Hood Fire Suppression System (Ansul system) – Shall be interconnected to the fire alarm system and the activation of the fire suppression system shall be indicated as an alarm on the Fire Alarm System.
j. Master Box – located per local fire department regulations.

Lighting

Lighting fixtures will be installed throughout the building providing illumination levels in accordance ASHRAE 90.1 and all associated subsections for various spaces and the Massachusetts Energy Conservation Code.

The lighting fixtures will likely be high efficiency fluorescent, LED or HID or other fixtures that meet the light levels and energy requirements. In general, fluorescent lamps will likely be low mercury super T-5 triphosphor type, with solid state electronic ballasts suited for the application. Compact Fluorescent lamps will be used in lieu of incandescent in down lights and in enclosed, explosion proof type incandescent globes, where necessary. Incandescent fixtures shall be limited to theatrical lighting in the Auditorium and controlled/dimmed with a dedicated theatrical dimming system.

General lighting in classrooms, other spaces of instruction, offices, and similar spaces may be pendant mounted, direct/indirect fixtures with 70-80% uplight and 20-30% downlight distribution. Light fixtures in storage rooms and mechanical/electrical rooms may be surface or pendant- mounted type. Kitchen light fixtures will be recessed, gasketed type, suitable for installation in suspended grid type ceilings and for use in wash down environments. Perimeter exterior offices with windows shall be provided with step-dim ballasts for 100%/50% light levels and wall mounted occupancy sensors to allow the occupant to turn lights to 50% light levels.

All non-emergency interior lighting will be controlled by programmable lighting relay control panels located adjacent to each lighting panel on every floor. Emergency corridor and stairway lighting throughout the building will also be automatically controlled with a Bodine GTD20A type device to transfer automatically from normal power to emergency power during a loss of power. Emergency lighting will also be provided in the electrical and telecommunications rooms as well as in the General Offices, Medical Suite, and Custodian's Office. LED Edge-lit exit signs shall be provided throughout the school to indicate the designated path of egress and connected to the emergency system.

A daylighting control system will be provided in classrooms and other applicable areas to allow for daylight energy savings. Classrooms and any other areas will be provided with photocell sensors that will automatically adjust the lighting levels based on the amount of daylight. Lighting in areas not implementing daylighting controls will be controlled by ceiling mounted occupancy sensors. Lighting will be only automatically controlled via the programmable lighting relay control panels In areas such as corridors, lobbies, restrooms, library, cafeteria, etc.

Light pollution per LEED requirements shall be met by maintaining all indoor candela values shall fall within the building footprint (not through the windows). All maximum candela values for all outdoor lighting shall fall within the property lines. Shields will be provided for specify shielding for any fixture within a distance of 2.5 times its mounting height from the property boundary, so that no light spills over the property boundary.

Exterior lighting shall be provided for the building's façade. All exterior doors shall be provided with a light fixture connected to the emergency system for illumination from the building exit to the public way. Parking lot lighting shall be provided utilizing pole mounted LED light fixtures. The parking lot will be illuminated to achieve 1 fc minimum. All exterior lighting shall be controlled via the lighting control relay panel and an exterior photocell. All exterior lighting provided will be energy efficient, glare free, reduce sky glow and impact on nocturnal environment, durable and easy to maintain. Selection of luminaires will complement architectural features of the building.

Receptacles

Receptacles for educational use will be provided in classrooms, offices, and other spaces for typical room layouts. Convenience receptacles will be provided for cleaning and other functions. Special purpose receptacles will be provided as required by the respective equipment, such as in the kitchen.

Classrooms for general instruction shall be provided with the following minimum convenience outlets:

a. One 20A, 125 Volt, specification grade, duplex receptacle under the white or chalk board at the front teaching wall
b. One 20 Amp, 125 Volt, specification grade, quad receptacle located near the teacher's computer station at the front teaching wall
c. One 20 Amp, 125 Volt, specification grade duplex receptacles at the rear wall
d. Two 20 Amp, 125 Volt, specification grade duplex receptacles located on the window wall
e. One 20 Amp, 125 Volt, specification grade duplex receptacle on the corridor-side wall near entry, for cleaning purposes
f. Ten 20 Amp, 125 Volt, specification grade, duplex receptacles for computer stations, one printer and one scanner for the students use under the computer counter. Two dedicated circuits shall be provided for the ten receptacles. Receptacles shall be provided in a two-channel surface mounted raceway mounted under the computer counter.

Note: For kindergarten and classrooms, safety type tamper proof receptacles shall be installed.

Corridors, Lobbies, Mechanical/Electrical rooms and Roofs

Receptacles for maintenance, 20 Amp, 125 Volt, specification grade, duplex type, shall be provided so that all areas in the spaces are accessible by a 50' extension cord. Roof tops and toilet room receptacles shall be GFCI protected.

HVAC Equipment
Receptacles for servicing HVAC equipment, 20 Amp, 125 Volt, specification grade, duplex type, shall be installed within 25' of the equipment. Those receptacles shall not be connected to the load side of the HVAC equipment disconnecting means.

Main Telecommunication Room and IT Closets
A minimum of ten quad receptacles dedicated, 20 Amp, 125 Volt receptacles will be provided at the Main Telecommunications Room data racks and cabinets. The receptacles will be placed near the data racks and cabinets, a minimum of two quad receptacles for each rack or cabinet. Two 20 Amp, 208 Volt circuits with L6-20R twist lock receptacles will be provided in the Main Telecommunications Room at the main data racks.

Empty Conduit Systems
Junction boxes, pull boxes and empty raceways (EMT) with a pull string shall be provided throughout the school for the installation of data, voice, clock, sound, and audio visual and security systems. Quantity and locations shall be determined by the furniture, equipment and use of each room. Raceway shall extend from the junction boxes up the wall to 6" above an accessible ceiling. An insulated bushing shall be provided on each open end conduit. All communications wiring shall be provided and installed by the owner.

Lightning Protection System
A lightning protection system, with UL Master Label Certificate, shall be provided in accordance with NFPA 780 and UL96A. The lightning protection system shall consist of the following:

- Air Terminals (interception points) along the roof, roof perimeter, and selected roof mounted mechanical equipment
- Ground rods (dissipation points) and down conductors (low-impedance conductors interconnecting the interception and dissipation points)

Energy Savings Strategies
A programmable lighting control relay system will be installed to automatically turn off all non-emergency interior lighting during unoccupied hours in all areas. Occupancy sensors will also be located in smaller individual rooms to maximize energy savings. Lighting controls shall minimize as much as possible the illumination of unoccupied spaces or spaces not requiring illumination during daylight hours. The lighting control system will be utilized for large open and public areas such as the lobby, corridors, library, gymnasium and the auditorium. Occupancy sensors will be utilized in smaller individual rooms such as classrooms, offices, storage and janitors closets.

A daylight harvesting system shall be utilized to automatically turn dim lighting in areas where the amount of measured daylight is sufficient.

LEED considerations
In an effort to provide for the accountability and optimization of building energy consumption, metering will be required for each type of load being served. Metering will need to be installed on the feeder breakers that serve the following loads:

- Lighting
- HVAC
- Power (Receptacles)
- Elevator(s)
- Kitchen Equipment

In addition to metering loads at the main switchboard, metering at the branch circuit level for each branch circuit shall be included to monitor the energy use for lighting, receptacles and equipment loads. This will allow a comparison to be made for different areas such as the lower school classrooms vs. upper school classrooms, or even 6th grade vs. 7th grade class rooms. It shall also provide indication of what the cooling, heating or ventilation energy usage is for panels serving mechanical loads. This level of metering shall utilize a product similar to the Square D Branch Circuit Power Meter (BCPM). Solid Core CT's shall be used for a high level of accuracy. All distribution as well as each lighting and power panel shall be provided with the BCPM system and networked together with an RS485 string to the energy dashboard.

A grid-connected photovoltaic system utilizing net metering, is being considered. The system shall include, but not be limited to, roof-mounted PV panels, wiring, inverters and disconnect switches. The exact quantity and locations of the inverters shall be determined on the quantity and location of the PV panels. The option of locating them locally on the roof as opposed to centrally in the electric room shall be considered. The system shall be installed to comply with NEC Article 690, the Uniform Solar Energy Code-ICC, UL 1703, IEEE 1547, and UL 1741. A design evaluation shall be performed to determine the load, available sunlight, and size of the PV array by the vendor. All interconnection and service equipment shall be provided by the electrical contractor in adherence with strict requirements with NGRID regulations.

Energy Metering will be provided to monitor the school's energy use in order to target inefficiencies and reduce energy costs. Dashboards will be provided throughout the school to inform and educate the staff, faculty, students, parents and the community about the school's sustainable initiatives and building resource use.

Classroom receptacle and lighting power will be metered on a classroom-by-classroom basis. Individual classroom energy performance will be displayed on the dashboard located in the wing the classroom is located in and will be shown relative to the other classrooms in that wing. In addition, the total classroom energy use for each individual wing will be compared to the total energy use for each of the other wings

Meters and Energy Dashboards will be provided for the following:

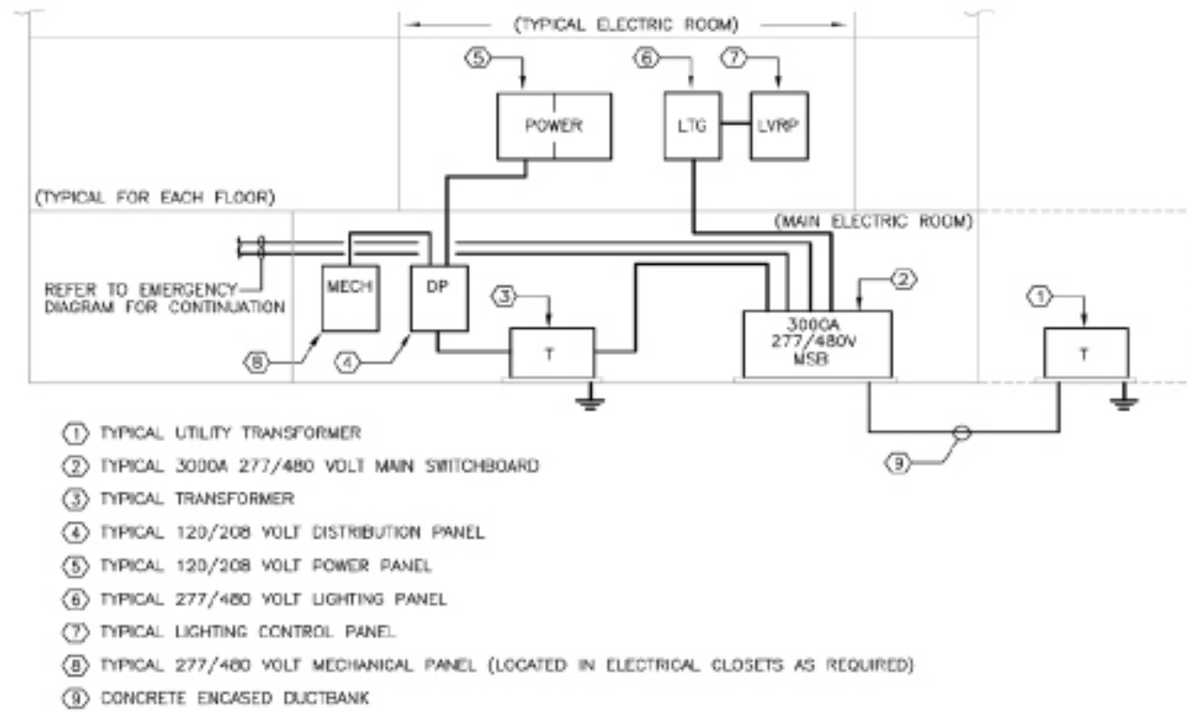
Meters
- Electric kitchen equipment
- Gas fired kitchen equipment
- Elevators
- Pumps
- RTU supply and return fans
- Boilers- gas fired

Equipment loads broken down as follows:
- Each Individual Classroom
- All other (administrative, health suite, gymnasium, etc.)

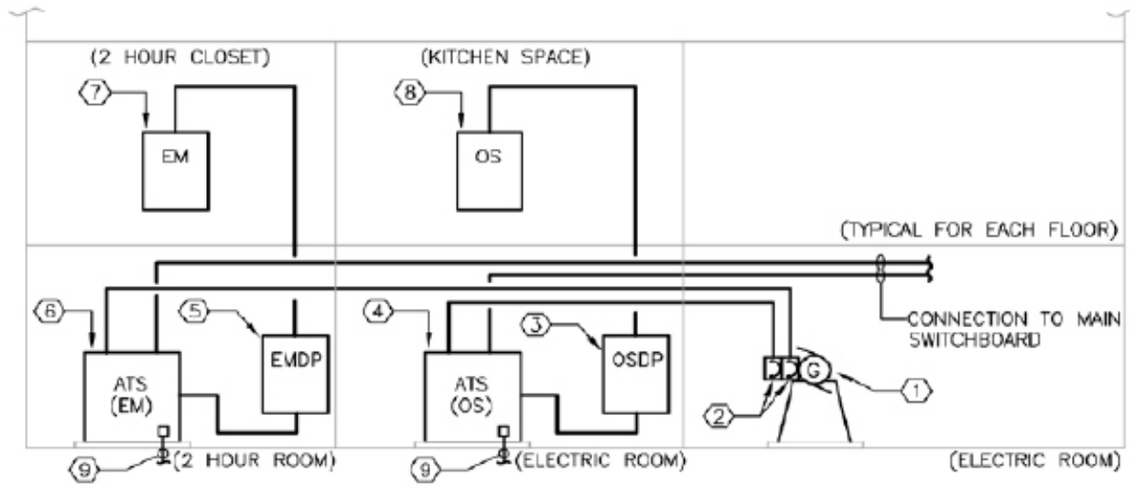
Lighting loads broken down as follows:
- Each Individual Classroom
- Kitchen/cafeteria lighting
- All other (admin, health suite, gymnasium, etc)
- Exterior lighting

Energy Dashboards (Touch screen).
- Dashboards will be located in each wing identifying:
- Lighting and power use of each classroom
- Kitchen/Servery/Cafeteria (lighting, power, equipment)
- Elevators
- Mechanical Heating, Cooling and Ventilation
- Photovoltaics: realtime energy being produced.
- Whole Building

Normal Power Distribution



Emergency Power Distribution



1. TYPICAL 250–400 KILOWATT DIESEL FIRED EMERGENCY GENERATOR
2. TYPICAL CIRCUIT BREAKER (IN SEPARATE BARRIERED ENCLOSURES)
3. TYPICAL OPTIONAL STANDBY DISTRIBUTION PANEL
4. TYPICAL 100 AMP, 277/480 VOLT AUTOMATIC TRANSFER SWITCH FOR OPTIONAL STANDBY POWER
5. TYPICAL EMERGENCY DISTRIBUTION PANEL
6. TYPICAL 260 AMP 277/480 VOLT AUTOMATIC TRANSFER SWITCH FOR EMERGENCY POWER
7. TYPICAL EMERGENCY POWER PANEL
8. TYPICAL OPTIONAL STANDBY POWER PANEL
9. TO GENERATOR START SIGNAL

Plumbing

In general the plumbing systems include the following:

- Domestic water
- Sanitary waste and vent including sewage ejector.
- Acid Waste and Vent System
- Storm Water including sump pump and gray water
- Natural gas

Domestic Water:

The building will be served by new redundant 4 inch metered water services from the water mains in Putnam Avenue and Magee Street. The services will be protected by duplex reduced pressure backflow preventer assembly. The location of the point of entrance shall be coordinated with the site civil engineer.

Water will be distributed through mains and branches to plumbing fixtures and equipment. The piping system shall be Type 'L' copper tube with wrought copper or brass fittings and lead free solder joints. Pipes 2 inch and larger may be joined by roll groove mechanical couplings. The system will be designed to maintain a maximum velocity of 8 fps at design flow conditions.

Pressure reducing valves, if required, will be provided to limit pressure to approximately 50 psi at fixtures and equipment.

The domestic water system will be designed to prevent water hammer conditions by providing air chambers for fixtures and shock arrestors for quick closing valves.

A minimum of 30 psi will be provided at the most remote fixture.

Shutoff valves will be provided at each branch take-off, equipment connection and fixture battery.

Reclaimed storm water shall be used for flushing fixtures such as water closets and urinals. The water shall be collected and stored in a storm water cistern as described in the Storm Water section below. The storm water shall be filtered and dyed in accordance with the local codes and then pressurized thru duplex distribution pumps to the flushing fixtures. The gray water system shall be completely independent of the domestic water systems and identified as such. (Refer to gray water system schematic sketch).

A flat plate solar thermal system will be provided to produce domestic hot water for the building. A total of 36 flat plate panels will be provided, with a daily production of 11,000 BTU per panel. The panels will be located on the building's roof

Gas fired, condensing water type heaters will be provided as a back-up to the solar thermal system. The domestic hot water system will produce 140°F water, which will supply the kitchen. The storage tanks will be 130 gallon and will be provided with an electronic ignition. Temperature/pressure relief valve will be provided for the hot water heater.

Hot water temperature will be maintained throughout the system by circulation utilizing fractional horsepower pumps.

Internal water meters will be provided for cold water supplying domestic hot water system, hot water supplying the kitchen and the hot water return from the kitchen. Water meters will have pulse type output to provide connected to building automation system. Meter readings shall be done either at the meter's total registry or logging of the building automation system.

Sanitary Drainage and Vent Systems:

The sanitary waste collected from the plumbing fixtures and equipment will be drained, via gravity, through a connection to the site sanitary system. The locations of the point of exit shall be coordinated with the site civil engineer. At a minimum, there shall be (2) 6" sanitary sewers exiting the building.

Sanitary waste collected from fixtures and equipment located below the level of the gravity system will drain to an ejector pit. The pit will be evacuated by duplex submersible sewage ejectors which will pump the waste to the site sanitary system. Pumps shall be minimum of 3 hp, 480 v, 3-phase 50 gpm @ 25 ft of head

The sanitary drainage system within the building will be vented with terminations to atmosphere above the roof.

The above ground piping system shall be hubless service weight cast iron pipe and fittings

with heavy duty neoprene gasketed couplings with stainless steel corrugated jackets and a minimum of (4) stainless steel clamps per coupling. Buried piping within the building shall be service weight hub and spigot cast iron soil pipe with neoprene gasketed joints. Sump pump and ejector discharge piping shall be schedule 40 galvanized steel pipe and fittings with either threaded or roll groove connections.

Piping in finished areas exposed at fixtures or by opened cabinet doors shall be chromium plated brass pipe with 125 pound SWP screwed chromium plated brass fittings.

Kitchen drainage will be provided with grease interceptors to remove fat/oil/grease, from the effluent prior to draining through the building sanitary system. Grease interceptors will be sized according to DEP requirements.

All kitchen sinks associated with food preparation or processing shall drain indirectly to a floor sink type of receptor. The receptor shall be 10-inch deep with dome and strainer. An air gap, twice the diameter of the pipe draining into the receptor will be maintained. Floor sinks shall sit 1-inch above the floor and shall be located under the sink where it will not be a tripping hazard.

Acid Waste System:
Acid waste effluent generated in the Science Classrooms will be piped independent of the sanitary waste system in an acid resistant waste and vent system. Effluent shall flow to a central pH Adjustment System consisting of a 150 gallon dilution/mix tank, acid/alkaline injection pumps, mixer, recorder, etc in compliance with the Massachusetts State Plumbing Code. Treated acid waste from the mix tank shall extend from the building out to the site sanitary main independent of the sanitary system in compliance with the State codes. The tank and the entire system shall be vented to atmosphere independent of the sanitary vent system. (Refer to Acid Waste System Schematic Sketch).

Pipe and fittings shall be Schedule 40 Polypropylene. Fittings for above ground pipe shall be mechanical joint. Fittings below grade will be fusion welded joints.

Garage Drainage
The new underground parking garage shall include garage drains to collect run-off from the vehicles. Garage drains shall be located at low points on the floor plate and shall extend to a gas and sand interceptor as required by the Massachusetts Department of Environmental Protection. The gas and sand interceptor shall be located exterior to the building. Effluent from the garage drains shall run independently to the interceptor. The discharge from the interceptor shall then connect to the site sanitary sewer. (2) 4" vents shall extend from the trap back to the building and run express thru the roof to atmosphere.

Storm Water System:
Rain water from roofs, plaza drains and area drains shall collect interior of the building and flow by gravity to a storm water cistern for re-use. Overflow from the cistern shall flow to the site storm drain. The locations of the point of exit shall be coordinated with the site civil engineer. At a minimum, there shall be (4) 10" storm drains exiting the building

A sump pit will be provided to collect the discharge from the foundation/footing/under slab drainage systems as well as any areaway/plenum drains that cannot drain by gravity. The clear water waste will be pumped to the gravity system by duplex submersible sump pumps. Pumps shall be minimum of 5 hp, 480 v, 3-phase 100 gpm @ 25 ft of head.

Roofs with parapets shall include secondary roof drainage. This secondary system shall be independent of the primary drainage system and shall spill to grade.

Rain Water shall collect in a 40,000 gallon underground cistern for use in a rain water reclamation system. The reclaimed water shall be used for either irrigation needs or for use in flushing toilet room fixtures.

If the system is to be used for irrigation, the landscape/civil engineer shall connect to the cistern for distribution to the site.

If the system is to be used for flushing, it shall include a treatment component that will be located in the building. The treatment system will include filters, dye injection and pressurization pumps for distribution to the plumbing fixtures. See Domestic Water section above. (Refer to Gray Water System Schematic sketch).
The piping system above grade shall be hubless service weight cast iron pipe and fittings with heavy duty neoprene gasketed couplings with stainless steel corrugated jackets and minimum of (4) stainless clamps per couplings. Buried piping within the building shall be service weight hub and spigot cast iron soil pipe with neoprene gasketed joints.

Natural Gas System:
The building will be served by a new metered low pressure gas service. The service shall be coordinated with the utility and site/civil engineer. The meter assembly will be located on

the exterior of the building. The gas service and meter shall be provided by the local gas company. The plumbing contractor shall connect to the house side of the meter.
Natural gas will be distributed through mains and branches to required mechanical equipment, water heaters and gas fired kitchen equipment
The piping system will be schedule 40 black steel with threaded connections for gas pressures below 2 PSI and welded connections for pressures 2 PSI and above. All piping 4 inches in diameter and larger shall have welded connections.

Plumbing Fixtures:

- Fixtures will be vitreous china, enamel coated cast iron or stainless steel, wall hung or counter top type with chrome plated brass trim and individual stop valves
- Water closets in public restrooms shall be of the elongated type with open front seats and no lids
- Sinks and other fixtures and equipment furnished by others will be provided with all required trim and connection to services
- Fixtures and trim accessible to the handicapped will be provided where applicable
- All fixtures will be provided with water conserving features
- Water closet flush valves will be Dual Flush type
- Urinals shall be pint flush type
- Lavatory faucets will be low flow type with 0.25 GPM aerators
- Exact type and finish of all fixtures shall be coordinated with the Architect

Fixture quantities shall be in compliance with the Massachusetts State Plumbing Code as a minimum. The following table represents the minimum fixtures based on the current programming needs:

Minimum Facilities

WATER CLOSETS FEMALE	WATER CLOSETS MALE	URINALS	LAVATORIES FEMALE	LAVATORIES MALE	SHOWERS	DRINKING FOUNTAINS	JANITORS SINKS
30	16	11	19	19	3	25	8

In addition to the core facilities included in the table above, all classrooms will be equipped with (1) stainless steel sink for hand washing. The classroom sink shall also include a water bubbler fitting.

All Art Room classroom sinks shall be equipped with Solids Interceptors similar to J.R. Smith model 8710. The interceptors shall be located below the sink and shall have a removable cover for cleaning.

Science Room Sinks shall be equipped with swing-away type deck mounted emergency eyewash units similar to Speakman model SE 570. The eyewash units shall include point of use mixing valves located below the lab sink in the casework similar to Speakman model SE-TW-EW. Additionally, the sink faucets will be fitted with vacuum breaker spouts.

Emergency Showers shall be located in each Science room within required travel distances. The shower outlets shall spill to floor drains located immediately adjacent to the unit and the floor drains shall include automatic trap priming devices to prevent sewer gases from migrating into the space.

Fire Protection

Water Supply:
All fire suppressions systems within the building will be supplied by redundant 8 inch fire services from the water mains located on Putnam Avenue and Magee Street. The point of entrance shall be coordinated with the site civil engineer. The services will be protected by a double check valve assembly for backflow prevention.

A fire department connection will be provided to allow fire department pumpers to augment the water supply if required. Sprinkler spacing shall be in accordance with the Massachusetts Building Code and NFPA 13.

If required, the building will be equipped with a fire water storage tank. The tank shall be an underground fiberglass tank sized to provide the sprinkler water demand and hose stream allowance for the building in compliance with NFPA-13 Ordinary Hazard Occupancy (30 min. duration) and the Massachusetts State building Code 8th Edition. The tank shall be a 45,000 gallon tank and shall include all connections, manways, fill valves, overflows as required. (Refer to Attached sketch).

Additionally, if the tank system is required a 75 HP, 480v, 3-phase, 750 gpm fire pump rated at 60 psi shall be provided in compliance with NFPA-20. The pump system shall include a jockey pump, test header, relief valves and all associated controllers as required.

Code requirements for the storage tank shall be verified and the costs associated with this system shall be carried as a separate line item

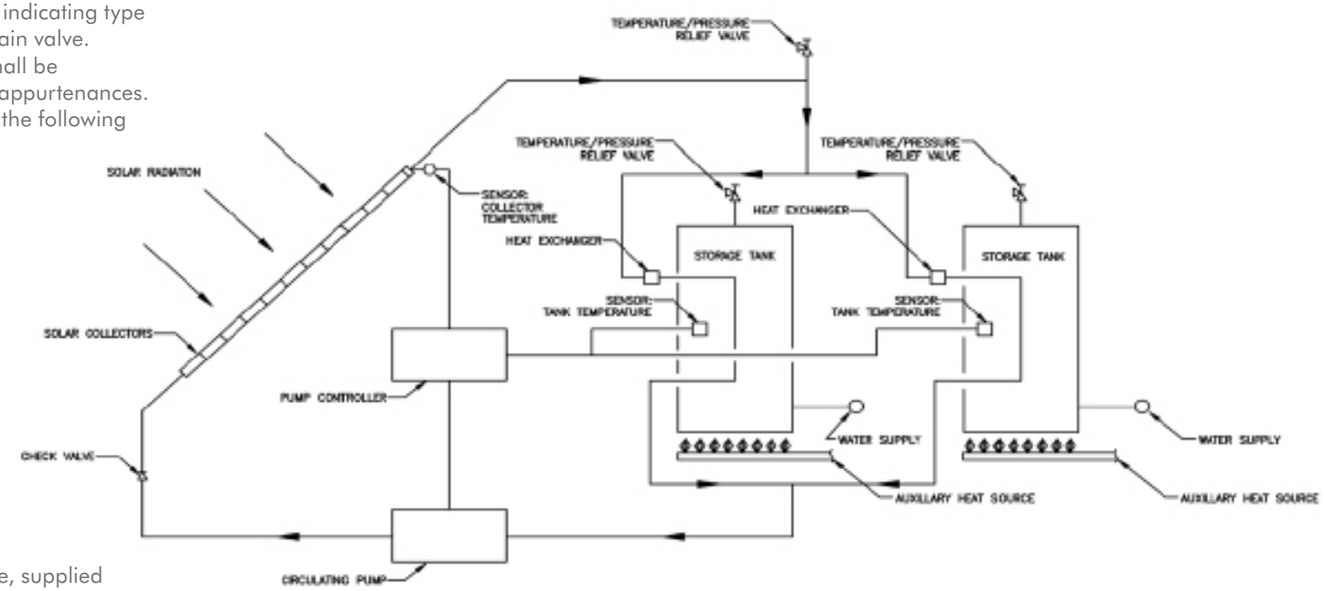
Sprinkler:
The building will be protected throughout by an automatic wet sprinkler system. Each floor will be provided with a floor control valve assembly (FCVA) which will consist of an indicating type control valve with tamper switch, water flow switch, pressure gauge and test/drain valve.
In areas subject to freezing, such as the Loading Dock, dry sprinkler systems shall be provided. The dry systems shall include all dry alarm valves, compressors and appurtenances. The systems shall be designed and hydraulically calculated in accordance with the following criteria:

Classification: Ordinary Hazard.
- Coverage: 130 sq ft per head.
- Density: 0.16 gpm per sq ft
- Area of application: 1,500 sq ft
- Hose allowance: 250 gpm
- Spaces: Storage rooms and mechanical spaces

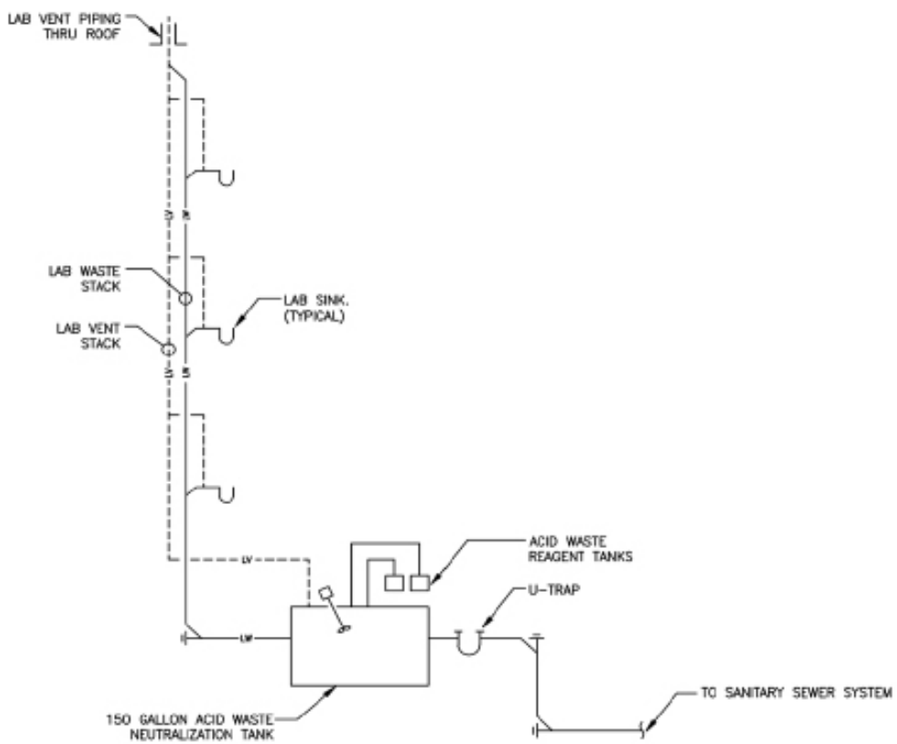
Classification: Light Hazard
- Coverage: 225 sq ft per head
- Density: 0.10 gpm per sq ft
- Area of application: 1500 sq ft
- Hose allowance: 100 gpm
- Spaces: classrooms, offices, corridors, lobbies, auditoriums.

Sprinkler protection in the garage shall be a dry type system with a 4" dry valve, supplied from the wet system, located in a heated closet adjacent to the garage. Sprinkler protection shall be ordinary hazard as described above.

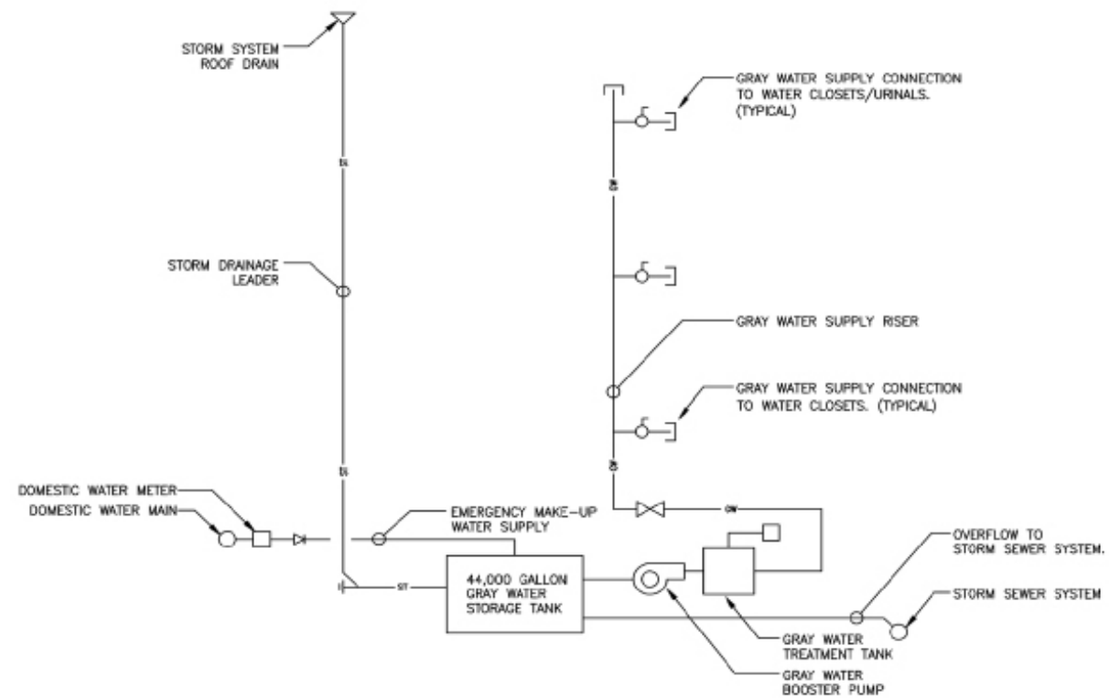
The piping system shall be Schedule 40 black steel pipe with malleable iron fittings and either threaded joints or roll groove mechanical couplings. Dry system piping shall be galvanized
In areas with ceilings sprinkler piping will be run concealed and all heads shall be concealed type similar to Reliable model G4. In areas without ceilings, piping shall be exposed and painted with upright heads. All sprinklers shall be Quick Response type similar to Reliable model F1FR.



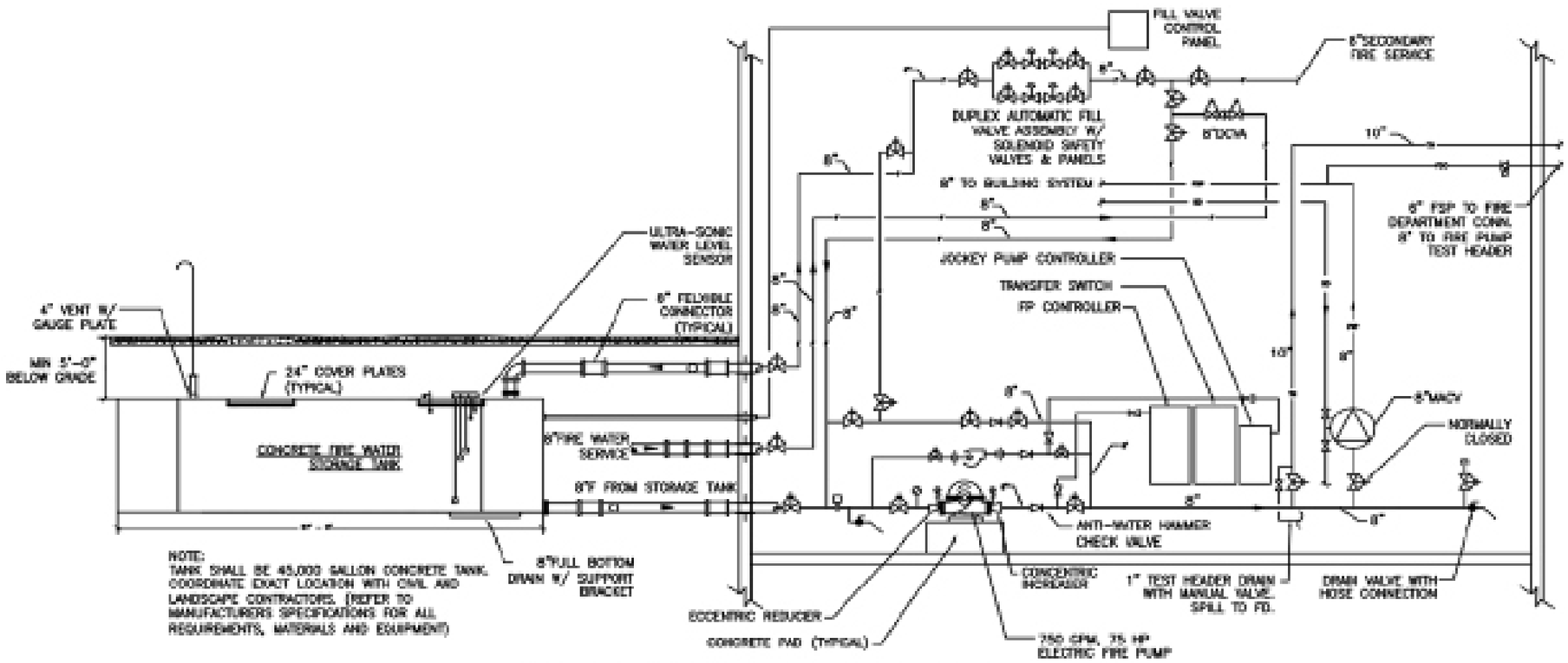
PUMP CIRCULATING SYSTEM, SERVICE WATER HEATING APPLICATION, DIRECT.
SCALE: N.T.S.



ACID WASTE PIPING SYSTEM RISER DIAGRAM
SCALE: N.T.S.



GRAY WATER PLUMBING SYSTEM RISER DIAGRAM
SCALE: N.T.S.



FIRE PUMP, STORAGE TANK AND ASSOCIATED PIPING AND EQUIPMENT

FOODSERVICE

Kitchen and Food Preparation Area

The new kitchen facility shall include all the necessary components of a functional kitchen to include: a receiving area to be used as a staging point for the breakdown and distribution of delivered goods; refrigerated rooms for storage of refrigerated and frozen products are to be offered and sized to accommodate the needs of the facility; and dry goods storage for the keeping of canned, boxed, and other non-refrigerated food items. Food grade storage shelving and dunnage platforms shall be provided for dry goods storage and for storage of disposable items like plastic utensils, serving trays, and other paper related items.

Food preparation shall take place on stainless steel tables of various sizes and configurations. Tables may be fashioned with sinks, drawers, shelves, and overhead pot storage hook racks. Motorized food preparation equipment such as a food slicer, food cutter, and mixer shall be provided. Sizing of this equipment will be based on the scope of food preparation and tailored to fit the designed operation.

Cooking shall take place in a common location adjacent to both food storage and preparation. Equipment shall consist of standard pieces such as convection ovens, cooking kettles, braising pans, steamers, and open burner range tops. Adjustments shall be made to cooking equipment to suite the specific desired menu, including but not limited to possible cold food menus to conserve energy as part of the Net Zero goals for the facility The facility will include the necessary ware washing equipment to process ware, pots, trays, and pans.

Other support facilities located in or adjacent to the kitchen will include a staff toilet for men and women, a dedicated kitchen slop sink with enough space for the storage of mops, buckets and detergents. A clothes washer and dryer will be provided for the washing of mop heads, aprons, and kitchen hand towels. Typically grouped with this equipment are employee locker accommodations for the storage of personal items such as coats, handbags, or shoes.

In focus group meetings with the kitchen staff it was noted that the staff would be preparing meals from scratch as opposed to thaw and cook. Approximately 80% will be scratch and 20% will be processed. This will require that the cooler in this case be larger than the freezer. Fresh produce and locally sourced farm to table products will be utilized when possible. A small on site garden is expected to provide and additional source of scratch ingredients and will be utilized as a teaching tool.

Ware washing will take place as two separate functions: pot washing and dish washing. A three-compartment sink with equal sized drain-boards will provide a place for washing and sanitizing heavily soiled pots and pans; A dish machine will be used for washing and sanitizing reusable trays and utensils. The ware washer shall also be specified so that it will double as a utensil washer when appropriate. Mobile storage shelving for storing clean ware will be placed at various locations throughout the kitchen.

Other equipment typically required and specifically requested include:

- 20 and 30 quart mixer, automatic food slicer, and food processor
- A small blast chiller for preparing meals to be served at a later time and to quickly chill food through the danger zone; a blast chiller increases food safety as well as improves food quality
- Four decks of combi ovens, a braising pan, and 40 gallon kettle
- Each kitchen must be provided with a mechanical means to wash and sanitize ware with a 180-degree rinse water process rather than a chemical rinse

Serving Area

Serving will take place in two or three separate lines on various counters, organized into linear configurations, allowing for orderly and secure serving of food products. Counters are grouped into multiple hot food serving lines that will serve the typical school lunch. These lines shall include the necessary equipment needed to provide cold side offerings such as fruit, salads, and beverages. Salad bar portion will be the focal point of the serving are. Students will be encouraged to take second helpings from the salad bar thus it must be conveniently accessed to the cafeteria seating area.

Each of the lines will funnel into a common area large enough to accommodate the flow of traffic where the transaction is to take place. Mobile counters with tray slides will be provided to accept “Point of Sale” terminals, where students can check out using a code that is linked to a declining balance pre-paid system.

Serving line configurations will include a separation of cold and hot items as well as a separation of grade levels. Due to varying tray slide heights and menu needs, the K-4 students shall be served in a dedicated line. The 5th-8th grade level shall be served on the remaining two lines. In each instance, an adequate amount of mechanical cold pans and appropriate hot holding equipment will be provided.

LEED Checklist and Commercial Kitchens - Potential Points and Equipment Technology

The WEc4 Process water use reduction credit in LEED for Schools can be achieved by specifying equipment that meets or exceeds the following criteria.

- No refrigeration equipment using once-through cooling with potable water.
- No garbage disposals
- At least 4 process items where water use is at or below the levels set forth in the credit criteria.
- This credit criterion consists of the following additional items
- Boiler less steamer (one that uses less than 2 gallons per hour)
- Aerators for all hand sinks and prep sink faucets that limit water flow
- A high efficiency clothes washer in the kitchen. (Typically have one in the kitchen dedicated to washing aprons, hand towels and mop heads. This washer is dedicated to the kitchen so that cross contamination is not a factor)
- A high efficiency sprayer at the pre rinse sprayer
- A ware washer using 1 gallon or wash water per rack or less, and an efficient ice maker

Other energy reduction considerations

- Open burner ranges – Gas fired equipment will not be used for this Net Zero Energy project. Range tops will be ceramic plate range top burners or induction type. Consideration shall be given to eliminating the oven base to limit energy consumption.
- Steamers – We only consider high efficiency units. They are 70% more efficient and are approximately 20% more productive. Due to technical advances in burner technology. In the northeast the utility company may offer up to a $1000 rebate for each steamer purchased. The specified steamer will consume no more than 2 gallons of water per hour.
- Walk-in refrigerated rooms – The mechanical refrigeration systems for these rooms are typically controlled with simple time clock defrosts at the freezer coils. These work well but it is not an intelligent system. We specify a Smart Defrost system that is designed to defrost the refrigerated room only when they are needed. Typical time clock controlled electric defrost systems have four defrosts per day. Using a Smart Defrost system can reduce the number of defrosts from none to two per day. This system represents an average savings of 75% in energy. In addition to the smart defrost we recommend the use of PSC or ECM motors in all refrigeration room blower coils. These motors last longer and represent a 72% energy consumption reduction, and run quieter than traditional motors.
- Exhaust hoods – The typical hood system run at full capacity the entire time it is in operation. This is in most cases more than eight hours per day. We specify technologies that allow us to realize savings without restricting the type of hood availability. These systems are called Energy Management Systems or EMS. What EMS controls do is modulate the speed of the exhaust and MAU fan motors with variable frequency drives (VFD's). In simple terms the control system senses heat at the exhaust duct and increase or decreases the amount of exhaust rate based on demand rather than running at 100% capacity 100% of the time. EMS systems have been shown to significantly reduce the energy consumption and electrical demands associated with operating the hood systems. On average this represents a 62% reduction in electrical demand.
- In addition to electrical energy savings there would be an energy savings gained from the reduced heating load at the make up air units. Typically the average fan speed associated airflow of the MAU will drop 30% resulting in a significant amount of air that does not need to be heated. The average pay back for these systems is less than one year. In most cases the local utility will reimburse the owner for a portion of the added cost to include an EMS.
- Hood End Panels – Adding end skirts to the end of each hood would allow us to reduce the exhaust air volume and is also a way to improve capture and containment. Another benefit of end panels is to mitigate the negative effect that cross drafts can have on hood performance. Lastly less exhausted air means less make up air and a reduction in reheating that air in the winter.
- Hood Lights – By replacing the incandescent light bulbs in exhaust hoods significant reductions in energy usage can be realized. Incandescent bulbs transform about 85% of energy they use into heat. The life spans of these lights are approximately 750 to 1000 hours. Consider the constant vibration at the hood and this is reduced even further. The initial cost of a 60 watt incandescent bulb is about 50 cents each and assuming the typical hood has eight lights in it we can calculate that these eight bulbs will cost about $525 dollars per year to operate. In addition compact fluorescent lights CFL's are much more efficient. They convert only about 25% of energy put into them into heat. The lifespan of a CFL is 7,500 to 10,000 hours but the initial cost is about $10 each. This initial high cost is quickly recovered since the cost to operate CFL is about $160 per year. Compact fluorescents should be specified for all new hoods going forward but consider the savings if the change was implemented to include all existing hoods system wide.
- LED lighting will be specified inside all walk-in refrigerated rooms.

ACOUSTICS

Goals

Following are acoustical goals for compliance with LEED for Schools 2009:

IEQ.P3 – Minimum Acoustical Performance (prerequisite):

- 0.6-second reverberation time for classrooms with volumes up to 20,000 ft3
- 1.5 second reverberation time for classrooms with volumes above 20,000 ft3
- Background noise level goal: 45 dBA (Leq)

IEQ.C9 – Enhanced Acoustical Performance (optional):

Compliance with the sound isolation requirements referenced in ANSI S12.60-2002, except for windows which must meet and Sound Transmission Class (STC) rating of at least 35:

- STC 50 between adjacent learning spaces. This requirement is also needed for composite walls, including any interconnecting doors that may exist.
- STC 45 between a learning space and adjacent corridor, staircase, office or conference room. This requirement is needed for the basic wall exclusive of the door. Doors need to be provided with full perimeter gaskets and drop bottom.
- STC 60 for the music room walls.
- Floor/ceiling constructions above core learning spaces must achieve a minimum Impact Insulation Class (IIC) of 50.
- GWB partitions to run from floor to deck above.

Improved background noise conditions:

- Background noise level goal: 40 dBA (Leq)
- Background noise level goal: 35 dBA (Leq) – for 1 additional point.

Note: Additional more stringent criteria may be established by the Design Team, for more sound sensitive spaces such as Auditorium or music rooms. These are to be determined during the subsequent design phases of the project.

AUDIOVISUAL

General Summary

General:
This Feasibility Study report describes the audiovisual systems in general terms for the Martin Luther King, Jr. School building in Cambridge. The report defines the audiovisual system technologies utilized for the different spaces, and presents a preliminary budget for the systems. The program report also provides general costs for audiovisual system components and installation. The document will provide the baseline for client review and conformity to user needs. It must also be compiled with other related budgets such as network data distribution, furniture, millwork, electrical, and mechanical systems to provide a complete picture of the associated costs.

Defining Add-Alternates:
At this early stage of the project it is important to capture as much of the requirements as possible for the various rooms in the in the school. As the project moves forward we will update and expand the descriptions for the audiovisual systems and costs, along with any changes in needed capability. The School will need to determine their priorities in setting the Add-Alternate schedule for final purchase. We do expect at the time of final audiovisual systems design to have complete systems designs which would include selected and optional Add-Alternates. We will integrate into our design as much of the school's furnished equipment as reasonably possible as "Owner Furnished Equipment" (OFE).

Introduction

Infrastructure Vs. Equipment:
The distinction between infrastructure and equipment must be emphasized:
Infrastructure is part of the building construction and includes conduit, raceways, junction and device boxes, as well as electrical power and grounding required exclusively for audiovisual systems cabling and equipment. Properly designed AV infrastructure allows for not only the installation of the initially specified equipment, but for the evolution of the systems over many years. If proper infrastructure is provided, additional capabilities and equipment can be efficiently added later as technology progresses.
Equipment refers to the devices that can be connected through the infrastructure. Equipment includes microphones, loudspeakers, mixers, signal processing gear, video projectors, flat-panel displays, cameras, VCRs, DVD players, AV control systems, patch bays, equipment racks, and many other devices that comprise an AV system, including cabling interconnections to AV devices.

Equipment Notes And Definitions:
This report is not a technical specification and is insufficient to bid or build an AV system. Except where useful to illustrate a standard of performance or a specific user requirement, equipment manufacturers and model numbers are not used.

Permanently-installed refers to equipment that will be part of the room systems and cannot easily be removed for use elsewhere.

Portable refers to equipment that will be available for connection at one or more locations, but will be not hard-wired to the system. Portable equipment can be disconnected by the user or technical personnel and stored or used with systems elsewhere in the facility.

Future Provisions refers to equipment that may be purchased and used or installed at a future date.

OFE (Owner Furnished Equipment) refers to equipment that will be either already owned, or may be purchased in the future as needs arise.

FBO (Furnished by Others or "by others") refers to any service or equipment (e.g. lighting) required but not a part of the AV system design or installation.

The team will finalize the equipment list in subsequent design phases.

Lighting And Acoustical Recommendations
Lighting and room acoustic recommendations are guidelines only as related to the best performance of the audiovisual systems and should be reviewed by the architect and other consultants. These guidelines do not include considerations for the installation of the audiovisual equipment which should be considered as additional points of light and noise.

General Technology Overview
At this time audiovisual systems have begun a transition from analog-formatted signals to an all digital system. While there is some need to maintain compatibility and usability between both the analog and digital worlds, the transition is proceeding and the analog "sundown"

(the discontinued use of analog video signals) is fast approaching. The School may be using of some analog VHS machines for playback. We strongly suggest that the School develop and implement a plan to transfer their VHS content (within copyright limitations) to an appropriate digital platform.

Presentation Systems:
Presentation systems are the source, routing, and display devices that provide highly intelligible communication of speech, music, information, and graphics to groups of people. This includes equipment such as microphones, loudspeakers, video projectors, flat-panel displays, DVD players, computers, and the interfacing, mixing, routing and control equipment that connects these devices together and allows the user to select the appropriate sources and operate the system.

Videoconference And Streamings Systems:
Videoconferencing, streaming (i.e. "Skype" and other formats), and classroom capture equipment (cameras, video encoding/decoding hardware, and related devices) are not provided as part of the base proposal. However, videoconference capability in both the conference rooms and classrooms are proposed as options that may be added. Infrastructure (conduit, junction boxes, camera niches, etc.) required to support this equipment should be included if there is any possibility that such capabilities may be desired in the future.
It is important to note that in the use of HDMI or DVI type digital video signals that recordings (including capture, streaming, and conferencing) and transmissions may not be possible if the electronic signal has a High-Definition Copy Protection (HDCP) signal present.

Broadcast Systems:
Broadcast quality equipment and systems generally refer to audio and video devices (cameras, video recorders and editing equipment) of the highest quality, specifically designed for the recording, editing, and production at the commercial level, such as in cable and network television studios. In general, broadcast quality equipment will be an order of magnitude more expensive than "professional" quality equipment. Such equipment is not anticipated for this project. Some level of production capability is expected.

Assistive Listening Systems:
Permanently installed Assistive Listening Systems (ALS) are required by the ADA (American with Disabilities Act), a 1990 federal law (2010 update) that forbids discrimination against persons who are hearing handicapped. ALS systems are required in rooms that include permanently installed sound systems and the content (voice and program) is part of the transmission of information.

Audiovisual Control Systems:
Audiovisual control systems used in these facilities may be as simple as the handheld display control for very simple systems to more integrated control panels for the more complicated room systems.

Audiovisual control systems can be used to unify and simplify the operation of the various functions of the AV system. This may includes environmental controls such as lighting presets and shade and drape controls, as well as audiovisual functions such as system and projector power, source selection and media transport controls, volume controls, and many other operational functions identified by the design team before the equipment will be installed.

Advanced functions of the AV control system include multi-level password protection for system operation to prevent unauthorized use, control of automatic system shut-down sequences (to reduce unnecessary wear and tear), and a help system interface for user experiencing technical problems.

Control System Management Network:
Networked AV management systems automate and streamline many technical support functions. Built-in reporting provides the ability to track resource usage for more effective purchasing, scheduling and resource allocation. These systems can reduce response times for service calls and technical supports issues, because system users and presenters can send help requests directly from the touch panels. Technicians can respond with built-in instant messaging, then service and control devices remotely.

Computer And Network Equipment:
Computers (desk-tops, laptops, and i-Pad type devices), their monitors and peripheral equipment are assumed to be provided by the owner or covered under the information technology budget. Also, network devices such as LAN switches, routers, and servers are assumed to be provided by the owner or covered under the information technology budget.

Classrooms

Description:
The classrooms located throughout the building and are equipped with movable seating for 20 to 25 students and a teacher's station. These rooms will be equipped with audiovisual equipment to support presentations, including a single front interactive white-board with integrated video projector for their source materials including DVD, local computer, a laptop input, and i-Pad interface. The instructor will have access to a wireless microphone for sound reinforcement in the classroom and control of audio levels for reproduction of the various audio sources through recessed ceiling loudspeakers. The instructor will have full control of the audiovisual technology using a touch-button control panel at the teacher's station as well as remote support from the media center when needed. An assistive listening system will be provided in each classroom to meet the requirements of the Americans with Disabilities Act. Portable receivers will be stored centrally and issued to students as required. These receivers are for use by the students with hearing impairments. The classrooms with this basic capability include:

- Lower school classrooms: 20
- Lower school arts and language: 3
- Upper school classrooms: 17
- Upper school arts and language: 1
- Human services classrooms: 6
- Learning commons flex instruction: 2
- Food Lab 1
- Music and Performance: 4
- Vocational Technology: 1
- TOTAL: 55

Note: The music, chorus, and band classrooms will have upgraded sound playback loud-speaker system for greater audio fidelity.

Audiovisual Systems:
The audiovisual system for the classrooms will include the capabilities described above and will be detailed as the design process continues:
Refer to the budget section for estimated audiovisual equipment costs.

Room Lighting:
Though not part of the audiovisual system design or installation, the classroom should have dimmable or controllable lighting with multiple zones for chalkboards, projection surface, presentation areas, and the student area. All lighting in the classrooms should use the same color temperature lighting. Special lighting may be considered to support presentation and future video events. Ambient light on the projection screens should not exceed 7 lumens.

Room Acoustics:
Acoustical conditions should be reviewed by an acoustical consultant for acceptable background noise criteria (NC) and reverberation time (RT). Future recordings may be made in the classrooms and we recommend no higher than a NC-25 rating and a low reverb time. It should be noted that movable walls have limited isolation capabilities and there may be some acoustical issues between rooms when both sides are in use at the same time.

Audiovisual Electrical Load:
The electrical load for the audiovisual equipment in these classrooms is not expected to exceed 2,500 watts. A more detailed breakdown will be made as the project progresses.

General Contractor, Owner, And Misc. Scope:
The general contractor will supply all infrastructure requirements and the School will supply all LAN and workstation electronics.

Auditorium

Description:
The Auditorium will be used for used for a variety of events including live music and theater performances, multimedia presentations with audio and video, and presentation/lecture type events.

The audiovisual system in the Auditorium will consist of a sound system used for speech reinforcement and program audio playback. It will include wired microphone inputs and four wireless microphones, an automatic microphone mixer (for simple presentations), a manually controlled digital mixing console (for production type events), and associated processing and amplifiers.

A central loudspeaker cluster will be located above and in front of the proscenium opening. It will be used for speech reinforcement and playback of audio. The loudspeaker system will provide uniform audio coverage through the audience area; allowing the system to provide high levels of speech intelligibility and musical clarity.

Connections for wired microphones and other audiovisual sources will be located on wall-mounted receptacle panels and within floor boxes. These will be located on the stage (upstage and downstage walls, and front face of the stage), the catwalk (if applicable), and the within the house. Audio press feeds will be available at receptacle panels.

An intercom system will be used for communication between production crew members at control locations, and relevant backstage spaces such as the Green Room, Theater Storage, Woodshop, dressing rooms, and other backstage areas. The typical intercom system includes either two or four channels. AV connection panels within the Auditorium will include receptacles for the connection of intercom belt packs. Wall-mounted stations will be located in the other spaces. The system will be provided with four single-channel belt packs and 2 dual-channel belt packs with headsets and cables.

A high-brightness video projector will display motion video and still images onto a motorized projection screen. The system will support playback and distribution of digital and analog video formats including VGA, HDMI, DVI, composite, and S-Video. AV sources devices, housed in the main AV equipment rack, will include a high-definition DVD player (Blu-Ray), and will include owner-provided sources such as a cable television receiver or AppleTV. Additional audiovisual connections for portable AV equipment, such as a presenter's laptop computer, will be available on receptacle panels (two on stage floor-boxes, and one in the Control Booth). An integrated control system will allow components of the audiovisual system to be operated from selected uniform control points; one wireless panel for use at the auditorium house control position, the control booth, or at the Lectern, and a wall-mounted panel at the stage manager position on the stage. The control points will provide the end-user with easy control and configuration of the regular functions of the audiovisual system, such as:

The typical control system user interface is a color liquid crystal display (LCD) panel with a touch sensitive overlay. Graphics displayed on the panel will easily guide the user through the operation of the audiovisual system. A wireless assistive listening system is included to meet the requirements of the Americans with Disabilities Act. Portable receivers will be stored centrally and issued to participants as required. These receivers are for use by the students with hearing impairments.

AV system processing, switching, control, and amplification equipment will be located in equipment racks located in the Auditorium Control Booth.

Audiovisual Systems:
The audiovisual system for the auditorium will include the capabilities described above and will be detailed as the design process continues:
Refer to the budget section for estimated audiovisual equipment costs.

Room Lighting:
Though not part of the audiovisual system design or installation, the auditorium should have dimmable or controllable lighting with multiple zones. All lighting in the auditorium should use the same color temperature lighting. Special lighting may be considered to support presentation and production events. Ambient light on the projection screens should not exceed 7 lumens.

Room Acoustics:
Acoustical conditions should be reviewed by an acoustical consultant for acceptable background noise criteria (NC) and reverberation time (RT). Recordings may be made in the auditorium and we recommend no higher than a NC-25 rating and a low reverb time.

Audiovisual Electrical Load:
The electrical load for the audiovisual equipment in the auditorium is not expected to exceed 8,000 watts. A more detailed breakdown will be made as the project progresses.

General Contractor, Owner, And Misc. Scope:
The general contractor will supply all infrastructure requirements and the School will supply all LAN and workstation electronics.

Gymnasium (Total 2)

Description:
The sound system for each of the gymnasiums will provide for speech reinforcement and music playback. It will consist of distributed overhead loudspeakers covering the main gym floor and seating areas. The loudspeakers will be zoned accordingly.

Playback sources will include a CD player, MP3 connection, general paging and background music.

Volume controls and source selects controls will be wall-mounted. In addition, a wired microphone location will be located on the main floor for game announcements. A wireless microphone system with a hand-held transmitter will also be available.

The amplifier and audio processing equipment will be located in the equipment racks in a nearby equipment closet or other appropriate location. A small, portable equipment rack containing CD player and a portable mixer will be supplied for local source mixing and control.

An assistive listening system will be provided in each gymnasium to meet the requirements of the Americans with Disabilities Act. Portable receivers will be stored centrally and issued to students as required. These receivers are for use by the students with hearing impairments.

Audiovisual Systems:
The audiovisual system for the gymnasiums will include the capabilities described above and will be detailed as the design process continues:
Refer to the budget section for estimated audiovisual equipment costs.

Room Lighting:
Though not part of the audiovisual system design or installation, the gymnasiums should have controllable lighting with multiple zones. All lighting.

Room Acoustics:
Acoustical conditions should be reviewed by an acoustical consultant for acceptable background noise criteria (NC) and reverberation time.

Audiovisual Electrical Load:
The electrical load for the audiovisual equipment in the gymnasium is not expected to exceed 2,000 watts. A more detailed breakdown will be made as the project progresses.

General Contractor, Owner, And Misc. Scope:
The general contractor will supply all infrastructure requirements and the School will supply all LAN and workstation electronics.

Dining – Cafeteria (Total 2)
Description:

The sound system for each cafeteria will provide for speech reinforcement and music playback. It will consist of distributed overhead loudspeakers covering the seating areas. The loudspeakers will be zoned accordingly.

Playback sources will include a CD player, MP3 connection, general paging and background music.

Volume controls and source selects controls will be wall-mounted. In addition, a wired microphone location will be located on the main floor for announcements. A wireless microphone system with a hand-held transmitter will also be available.

The amplifier and audio processing equipment will be located in the equipment racks in a nearby equipment closet or other appropriate location.

An assistive listening system will be provided in each cafeteria to meet the requirements of the Americans with Disabilities Act. Portable receivers will be stored centrally and issued to students as required. These receivers are for use by the students with hearing impairments.

Audiovisual Systems:
The audiovisual system for the cafeteria will include the capabilities described above and will be detailed as the design process continues:

Refer to the budget section for estimated audiovisual equipment costs.

Room Lighting:
Though not part of the audiovisual system design or installation, the cafeterai should have controllable lighting with multiple zones. All lighting.

Room Acoustics:
Acoustical conditions should be reviewed by an acoustical consultant for acceptable background noise criteria (NC) and reverberation time.

Audiovisual Electrical Load:
The electrical load for the audiovisual equipment in the cafeteria is not expected to exceed 1,500 watts. A more detailed breakdown will be made as the project progresses.

General Contractor, Owner, And Misc. Scope:
The general contractor will supply all infrastructure requirements and the School will supply all LAN and workstation electronics.

Mulitmedia Studio

Description:
The multimedia studio is a suite of small spaces which include a small television studio space for multi-camera recordings, a sound booth for audio recordings, and a control room space for equipment and operators, and a small multi-station editing room.
The multimedia space will be equipped with a small two camera video production system and audio mixer and microphones for making recordings to digital formats. The control room will also include a digital encoder to provide live feeds to the classrooms over the school's LAN network.

The students will be able to edit their recorded material on computer based editing systems located in adjacent area.

Audiovisual Systems:
The audiovisual system for the multimedia area will include the capabilities described above and will be detailed as the design process continues:
Refer to the budget section for estimated audiovisual equipment costs.

Room Lighting:
Though not part of the audiovisual system design or installation, the multimedia area should have dimmable or controllable lighting with multiple zones. All lighting in the multimedia should use the same color temperature lighting. Special lighting may be considered to support presentation and production events.

Room Acoustics:
Acoustical conditions should be reviewed by an acoustical consultant for acceptable background noise criteria (NC) and reverberation time (RT). Recordings will be made in the multimedia area and we recommend no higher than a NC-20 rating and a low reverb time.

Audiovisual Electrical Load:
The electrical load for the audiovisual equipment in the multimedia area is not expected to exceed 8,000 watts. A more detailed breakdown will be made as the project progresses.

General Contractor, Owner, And Misc. Scope:
The general contractor will supply all infrastructure requirements and the School will supply all LAN and workstation electronics.

Conference And Group Rooms (Total 10)

Description:
The conference and group rooms will support 8 to 12 people at a table with movable chairs. The conference and group rooms will have a presentation system for display of media from portable laptop computers and other portable video equipment.

Audiovisual Systems:
The audiovisual system for the conference and group rooms will include the capabilities described above and will be detailed as the design process continues:
Refer to the budget section for estimated audiovisual equipment costs.

Room Lighting:
Though not part of the audiovisual system design or installation, the conference and group rooms should have dimmable or controllable lighting. All lighting in the conference and group rooms should use the same color temperature lighting. Special lighting may be considered to support presentation and production events. Ambient light on the display screens should not exceed 7 lumens.

Room Acoustics:
Acoustical conditions should be reviewed by an acoustical consultant for acceptable background noise criteria (NC) and reverberation time.

Audiovisual Electrical Load:
The electrical load for the audiovisual equipment in the conference and group rooms is not expected to exceed 1,000 watts. A more detailed breakdown will be made as the project progresses.

General Contractor, Owner, And Misc. Scope:
The general contractor will supply all infrastructure requirements and the School will supply all LAN and workstation electronics.

Electronic Information Displays (Tbd)

Description:
There are a variety of applications for electronic informational displays which include entry kiosk's, event and directional displays, daily menus, and multi-panel branding displays. The new building offers a wide array of possible location for these displays and each of the options need to be explored with the owner.

Audiovisual Equipment: Determined At This Time

Room Type	Qty	Basic Description
Classrooms	55	Display Systems, Speakers, Assistive Listening, Control Systems, Input Interfaces, Signal Switchers, Amplifier, Rack, Portable Cables
Auditorium	1	Projector, Screen, Speakers, Assistive Listening, Cables Miser, Control System, Input Interfaces, Signal Switchers, Rack, Portable Cables
Gymnasium	2	Speakers, Amplifier, Rack, Control Panels, Assistive Listening, Cables Microphones, Portable Cables
Cafeteria	2	Speakers, Amplifier, Rack, Control Panels, Assistive Listening, Cables Microphones, Portable Cables
Multi-Media Studio	1	Speakers, Backdrop Curtain, Cables Video Cameras, Intercom, Video Switcher, Audio Mixer, Video Recorders, Racks, Monitors, Software
Conference & Group Rooms	10	Display Systems, Speakers, Assistive Listening, Cables Control Systems, Input Interfaces, Portable Cables
Electronic	5	Display Systems, Speakers, Assistive Listening, Cables, Approximately
Info. Displays		5 Displays, Software

Note: counts and equipment to be confirmed in subsequent phases.

SUSTAINABILITY SUMMARY AND LEED©

Sustainability is very important to the residents of Cambridge and the City's sustainability goals for this project reflect this. The primary sustainability goals for this project are Energy Efficiency/Net Zero Potential, Site and Storm Water Control, Integrated Parking/Traffic Management and Indoor Environmental Quality (fresh air, daylight and views) and the Ability to be Maintained. To achieve a truly effective high-performance building and integrated approach to design is essential. The design team will study how one system affects another, how they interact and how they must perform in an integrated way. For instance balancing the amount of glass for daylighting and views with the amount of insulated wall that performs better in resisting heat gain and loss is essential, and already in the Preferred Option this balance is being designed into the exterior wall systems. In an effort to control storm water, the use of green roofs is included in the design. As the project unfolds the benefits of the green roof will be quantified to ensure it is a cost effective method to control storm water. The building mechanical systems are being designed to be as energy efficient as possible as well as easily maintained so that they can perform at optimal levels for the length of their expected life. Electrical and lighting systems include efficiencies such as day lighting sensors and occupancy sensors and controls so that lights are only turned on when needed.

Although USGBC LEED© Silver Certification is a minimum requirement for the project, it is anticipated that the project will be able to achieve many more points than the 50 credit points required. It can be seen in the preliminary LEED© Checklist that there are very few credits marked in the NO column, i.e. we don't at this time believe we will be able to achieve those credits. This indicates that many of the fundamental features of the project are inherently sustainable and there are very few that won't be pursued. Although every credit needs development and verification, it is anticipated, even at this early stage of design, that the project could achieve as many as 57 credit points as indicated in the YES column. However, the real potential are those credits marked as a maybe in the "?" column. At this early stage the design team is unable to predict how many of the "maybe" credits will be achieved, but past experienced has shown that it is very positive for the project to have so many credits to develop and work toward. Additionally, it speaks to the overall sustainability of the project that credits are being achieved in all of the six basic categories, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality and Innovation and Design Process, as well as in the Regional Priority Credits category. Water use reduction, non-toxic materials, construction waste management are just a few of the many strategies that will be developed as the project continues in schematic design through an integrated, iterative and collaborative process. Further detail on some of these anticipated strategies can be found in sections describing the Preferred Option design, building components and systems recommendations.

During this Feasibility Study the different options were evaluated in their relative abilities to achieve Net Zero energy on site, or in other words, the ability to produce as much energy on the site through photovoltaic panels as would be used by the building. While the Preferred Option performed best in these initial studies, much more work is essential to understand what can truly be achieved. A Net Zero project usually achieves between 70-75% better energy efficiency than a typical building designed to meet the energy code. To achieve this, the users of the building must be engaged and aware of how they can optimally use the building to reduce energy use. The building can become a teaching tool that educates students on how energy and water can be saved. Even at this early stage the biggest energy user, food service, has been engaged to discuss the potential strategies to reduce in this area.

LEED 2009 for Schools New Construction and Major Renovations

Project Checklist

Martin Luther King, Jr School

FS Checklist 06/21/2012

Sustainable Sites — Possible Points: 24

Y	?	N				
10	13	1				
Y			Prereq 1	Construction Activity Pollution Prevention		
Y			Prereq 2	Environmental Site Assessment		
1			Credit 1	Site Selection	1	
4			Credit 2	Development Density and Community Connectivity	4	
1			Credit 3	Brownfield Redevelopment	1	
	4		Credit 4.1	Alternative Transportation—Public Transportation Access	4	
1			Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1	
	2		Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	2	
	2		Credit 4.4	Alternative Transportation—Parking Capacity	2	
		1	Credit 5.1	Site Development—Protect or Restore Habitat	1	
	1		Credit 5.2	Site Development—Maximize Open Space	1	
1			Credit 6.1	Stormwater Design—Quantity Control	1	
	1		Credit 6.2	Stormwater Design—Quality Control	1	
	1		Credit 7.1	Heat Island Effect—Non-roof	1	
1			Credit 7.2	Heat Island Effect—Roof	1	
	1		Credit 8	Light Pollution Reduction	1	
	1		Credit 9	Site Master Plan	1	
1			Credit 10	Joint Use of Facilities	1	

Water Efficiency — Possible Points: 11

Y	?	N				
4	5	2				
Y			Prereq 1	Water Use Reduction—20% Reduction		
2	2		Credit 1	Water Efficient Landscaping	2 to 4	
		2	Credit 2	Innovative Wastewater Technologies	2	
2	2		Credit 3	Water Use Reduction	2 to 4	
	1		Credit 3	Process Water Use Reduction	1	

Energy and Atmosphere — Possible Points: 33

Y	?	N				
21	12					
Y			Prereq 1	Fundamental Commissioning of Building Energy Systems		
Y			Prereq 2	Minimum Energy Performance		
Y			Prereq 3	Fundamental Refrigerant Management		
19			Credit 1	Optimize Energy Performance	1 to 19	
	7		Credit 2	On-Site Renewable Energy	1 to 7	
2			Credit 3	Enhanced Commissioning	2	
	1		Credit 4	Enhanced Refrigerant Management	1	
	2		Credit 5	Measurement and Verification	2	
	2		Credit 6	Green Power	2	

Materials and Resources — Possible Points: 13

Y	?	N				
4	4	5				
Y			Prereq 1	Storage and Collection of Recyclables		
		2	Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 2	
		1	Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Elements	1	
2			Credit 2	Construction Waste Management	1 to 2	

Materials and Resources, Continued

Y	?	N				
		2	Credit 3	Materials Reuse	1 to 2	
1	1		Credit 4	Recycled Content	1 to 2	
1	1		Credit 5	Regional Materials	1 to 2	
	1		Credit 6	Rapidly Renewable Materials	1	
	1		Credit 7	Certified Wood	1	

Indoor Environmental Quality — Possible Points: 19

Y	?	N				
10	9					
Y			Prereq 1	Minimum Indoor Air Quality Performance		
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control		
Y			Prereq 3	Minimum Acoustical Performance		
1			Credit 1	Outdoor Air Delivery Monitoring	1	
	1		Credit 2	Increased Ventilation	1	
1			Credit 3.1	Construction IAQ Management Plan—During Construction	1	
	1		Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1	
3	1		Credit 4	Low-Emitting Materials	1 to 4	
	1		Credit 5	Indoor Chemical and Pollutant Source Control	1	
1			Credit 6.1	Controllability of Systems—Lighting	1	
1			Credit 6.2	Controllability of Systems—Thermal Comfort	1	
1			Credit 7.1	Thermal Comfort—Design	1	
	1		Credit 7.2	Thermal Comfort—Verification	1	
1	2		Credit 8.1	Daylight and Views—Daylight	1 to 3	
	1		Credit 8.2	Daylight and Views—Views	1	
1			Credit 9	Enhanced Acoustical Performance	1	
	1		Credit 10	Mold Prevention	1	

Innovation and Design Process — Possible Points: 6

Y	?	N				
5	1					
1			Credit 1.1	Innovation in Design: Exemplary Energy Performance	1	
	1		Credit 1.2	Innovation in Design: Exempary Renewable Energy Performance	1	
1			Credit 1.3	Innovation in Design: Green Housekeeping	1	
1			Credit 1.4	Innovation in Design: Integrated Pest Management	1	
1			Credit 2	LEED Accredited Professional	1	
1			Credit 3	The School as a Teaching Tool	1	

Regional Priority Credits — Possible Points: 4

Y	?	N				
3	1					
	1		Credit 1.1	Regional Priority: EAc2	1	
1			Credit 1.2	Regional Priority: SSc3	1	
1			Credit 1.3	Regional Priority: SSc6.1	1	
1			Credit 1.4	Regional Priority: SSc7.2	1	

Total — Possible Points: 110

Y	?	N				
57	45	8				

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110

PREFERRED OPTION

NET ZERO SUMMARY

The Martin Luther King, Jr. School in Cambridge, MA is scheduled to be replaced. As part of this project, the school district would like to have the new building be a Net Zero energy building. In order to achieve this goal, the building and building site will need to produce as much energy as the building uses on an annual basis.

The design team developed three different schemes for evaluation. As a result of that process, one scheme has emerged as the preferred option. The preferred option was previously referred to as the Pi option during the initial study period.

This report provides an overview of the preferred option for several different performance potentials. These performance areas relate to either the ability to produce energy onsite, or the ability of the scheme to reduce the energy used.

Since the site has very limited land area, every amount of energy saved by improving building energy efficiency improves the potential for meeting the Net Zero energy goal with energy produced onsite. This means that in many ways energy savings are more important than energy production. This report reviews the preferred option on the following general areas of building performance: building envelope, daylight, glare potential, solar radiation, natural ventilation, photovoltaic energy production and overall building energy usage.

Based on this analysis, achieving Net Zero energy operation with renewable energy generated strictly on site does not appear feasible. Achievement of Net Zero energy would require additional off-site renewable energy sources. It is likely that with further development and refinement of the building design and renewable energy systems that the percentage of annual energy use generated on site can be increased by a combination of reducing the annual energy requirement and increasing the annual renewable energy generation.

BUILDING PERFORMANCE ANALYSIS

One of the goals for the new Martin Luther King, Jr. School in Cambridge Massachusetts is for the new school building to be a Net Zero energy building. In order to meet this goal, the building will need to produce as much energy on site on an annual basis as it uses. This means the project site must be studied to understand the potential for energy generation while the building must be designed to use less energy than typical schools. Other sections of this report specifically address the site energy generation potential and the preliminary building energy usage. This section addresses several other aspects of potential building performance that could reduce energy savings and improved indoor environmental quality. Areas of analysis are:

- Building Envelope
- Daylight
- Solar Radiation
- Natural Ventilation

Overall the climate in Cambridge, MA is a moderate, humid climate. Average winter days are in the 30-35 deg F range while summer days are in the 80-83 deg F range. Average humidity is around 72% in the morning and 57% in the afternoon. Precipitation is very even with around 3-4 inches of each month. With the colder winters, this precipitation results in snow, with January typically the snowiest month with about 13 inches of snow. The annual average snow total is 42 inches.

Preferred Option Massing Scheme

The preferred option has "U"-shape that opens to the west. The massing allows for double loaded corridors for the classrooms so that each room has north or south facing windows. One gym is on the north side while the other is on the south east side. The auditorium is located in the center of the building with a west wall and the kitchen and cafeteria are on the lower level.

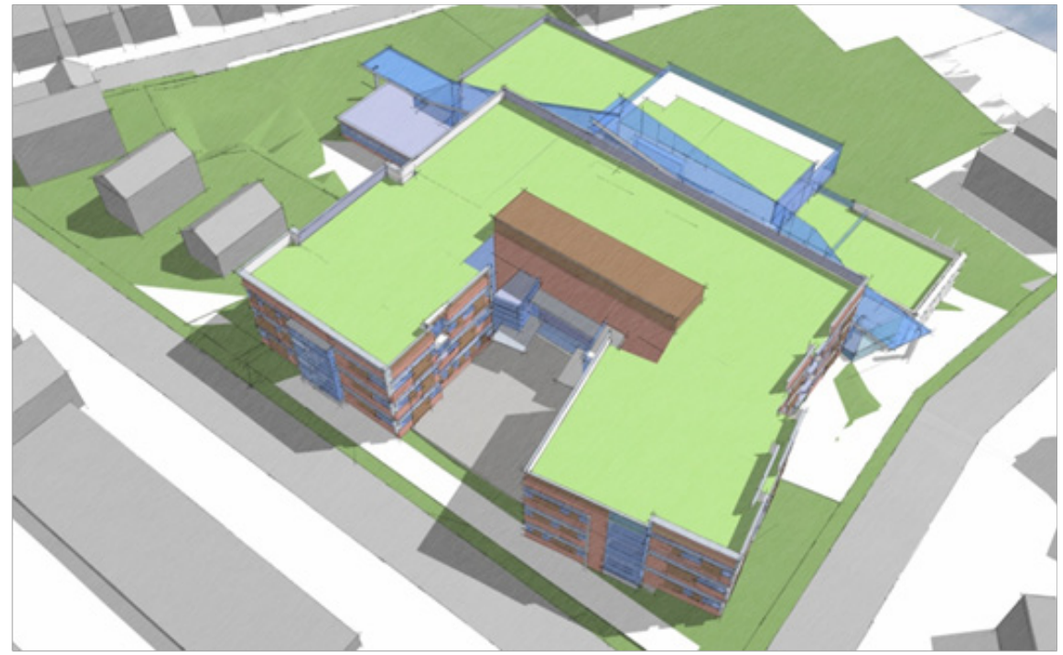
Building Envelope: The preferred option provides 157,00 square feet of usable, conditioned space. A unique feature is the reuse of 20,000 square feet of existing basement area for underground, enclosed parking. The building envelope is approximately 137,700 sf above ground. This is a 88% ratio of building envelope to conditioned floor area. This means this scheme has medium potential for impact from solar radiation.

Daylight: Overall the preferred option has a high potential for daylight harvesting. Almost all classrooms have daylight access and have north or south windows, which are best for daylight. The Auditorium is located in the center of the building with a west wall so does not impact daylight access to other spaces that could benefit from the light. The locations of the gyms allow for both to be daylit.

The preferred option has relatively low glare potential. There are limited spaces with east or west windows. There are also fewer spaces with floor to ceiling glass and few spaces with glass ceilings. However, some glare control will still be required in order to provide comfortable, well lit spaces.

Solar Radiation: This scheme has a med/low potential impact from solar radiation. The average daily building surface solar radiation is 121.5 kBtu/sf for the school year. Much of this time the building will be in heating mode so this load will help. The average daily summer solar radiation is 156 kBtu/sf and will need to be offset by cooling.

Natural Ventilation: The natural ventilation potential of the preferred option is medium/low. The double loaded corridors of the classrooms could have some potential for natural air flows, however they are 86′ deep so will not allow air to flow all the way through each wing. If the corridors are designed to maximize natural ventilation flows, air may move through the classrooms beyond the 5′-10′ zone by the windows. The gyms have the potential for some natural ventilation as well, but some centrally located spaces have no potential.



PREFERRED OPTION

PHOTOVOLTAIC FEASIBILITY ANALYSIS

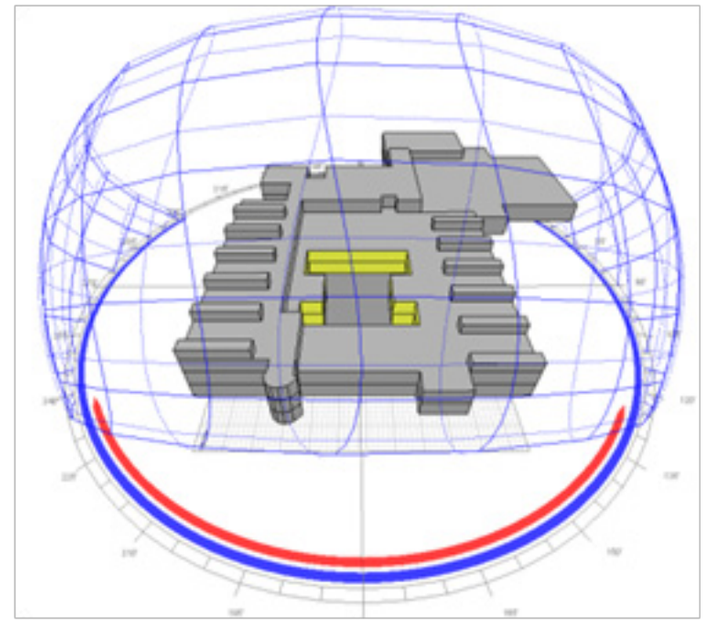
Photovoltaics (solar electric panels or PV) have been selected as the means for onsite energy generation to meet the Net Zero energy goal. Cambridge has an average of only 98 clear days, however there are many partly cloudy days with good solar access and PV provides a steady means for energy generation. While Cambridge is windier than the average US city, the wind speeds and consistency are not adequate to ensure economically feasible power production from wind.

Photovoltaic energy generation potential is based on several factors. Many of these are climate related, while the actual solar panels selected also have an impact. Currently the average solar panel can convert about 13-15% of the sun's energy to electricity while the best panels convert as much as 20%. The orientation and angle of the panels also has an impact on energy generation potential. Panels produce the most energy when they are mounted perpendicular to the sun. For this location, that would mean that our panels should be south facing and mounted at an angle of 30-40 degrees (fixed) for maximum generation per panel.

PV panels only produce energy when they are in full sun. This means that shading must be minimized at all costs. It is important that any panels mounted at an angle be spaced so that even at low sun angles the panels do not shade one another. While mounting panels at an angle of 30-40 degrees maximizes the energy generation potential of each panel, when evaluated on an energy generation per ground area required to mount the panels (kwh/sf), the spacing required to prevent shading reduces the energy generated per square foot. If the panels are mounted flat and lined up continuously across a surface, each panel will produce less energy per panel, but the kwh/sf will be maximized. Since this project has a limited sized site, the PV should be designed to maximize the kwh/sf.

The amount of sun and the length of days impact how much energy a PV system can generate. Snow is also an issue in northern climates. Cambridge averages 42 inches of snow per year. In order to minimize the number of days of lost energy generation due to snow, it is recommended that the solar panels be mounted at a tilt of no less than 10 degrees. Mounting the panels at 10 degrees will provide a higher kwh/sf while limiting the number of days lost to snow. In addition, elevating the panels above the roof level will reduce losses due to snow drifts.

Based on preliminary calculations, the estimated annual energy requirement for this project, including contingency, is 1,582,200 kWh/year. In the Boston area, PV panels mounted at 10 degrees can generate approximately 1,040 kWh/year for every kW of peak capacity installed. Based on estimated annual energy needs, a PV array with a peak capacity of 1,520 kW is required. Using the most efficient PV panels currently on the market, this will require approximately 122,500 square feet of area for the PV panels, including spacing between rows when mounted two panels high in each row at 10 degrees. To put this into perspective, the entire project site is only about 147,540 sf.

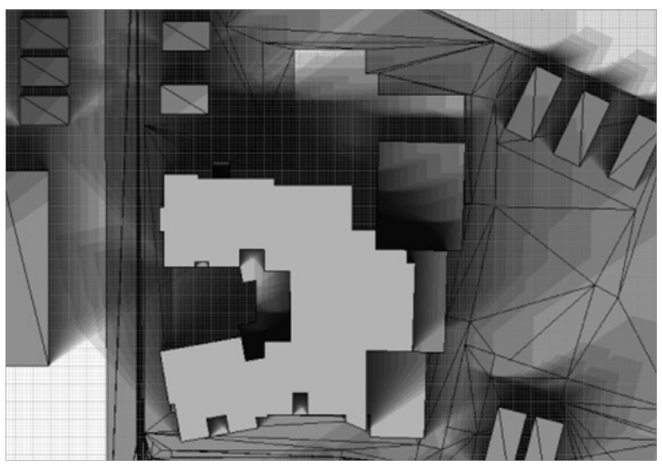


Renewable Energy Generation Potential

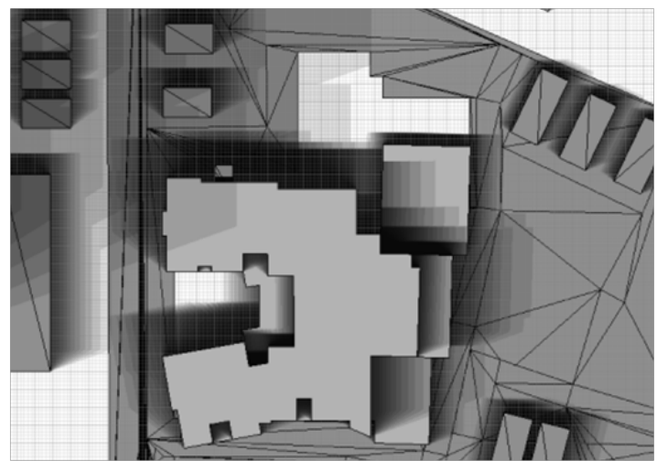
The ideal location for the installation of PV is the building roof. Roof mounted PV has relatively low installation costs compared to other options. The preferred option roof is large and flat with limited obstructions that can cast shadows. The design includes a large flat roof on the third floor that will allow a large area for PV. There are some lower, tiered roofs that shade one another. There is a smaller northern portion of the building with a lower roof elevation than the southern portion of the building and a few smaller low roofs that will be unusable due to self shading issues.

A shading study was performed for the preferred option in order to determine the potential impact of self shading and shading from existing neighboring structures. The results of this shading study can be found on the next page. The shading study reviews shading through the hours of 9am to 4pm for December 21st, March 21st and June 21st. This range of dates covers the shortest day of the year (Dec.) where the sun angles are lowest in the sky, the average day of the year (March) and the longest day of the year (June) when the sun is highest in the sky. As expected, the there is the least amount of shading in June as the sun is highest in the sky so the shadows tend to be short. However, unlike the other two schemes, December is not the limiting month. March is the worst month for shadows for this scheme. This is due to shading from neighboring buildings. These shadows impact the roof in the later afternoon when the sun is setting near due west or further north. The shadows from the western buildings end up resulting in more shaded roof area then the long December shadows.

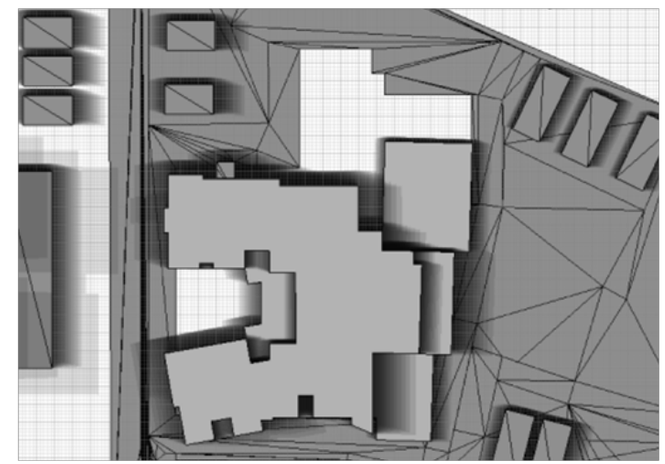
In order to maximize the potential roof area for PV, the design incorporates limited areas of elevated structure to increase the amount of surface area suitable for PV. This increases the available area for PV but does not allow for PV panels to be installed on every roof area. The estimated area available for PV panels is approximately 43,729 square feet with annual generation potential of 609,849 kWh for panels mounted with 2 panels high per row at a 10 degree mounting angle.



DECEMBER 21ST SHADE STUDY: 9AM TO 4PM.
35,750 SF OF AVAILABLE ROOF



MARCH 21ST SHADE STUDY: 9AM TO 4PM.
33,750 SF OF AVAILABLE ROOF

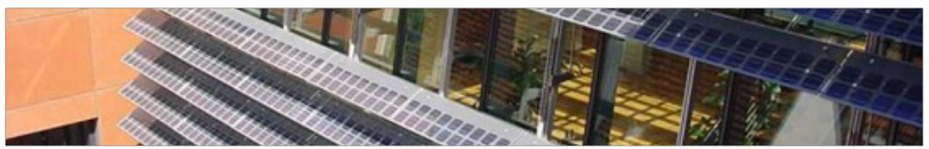


JUNE 21ST SHADE STUDY: 9AM TO 4PM.
41,560 SF OF AVAILABLE ROOF

An alternate for PV mounted on a structural system that would cover the footprint of the majority of the roof surfaces was reviewed. This PV structure would be very tall and would be costly to construct and therefore is not feasible. This alternate increases the roof area for PV to a maximum of 65,082 sf with annual output of 907,641 kWh.

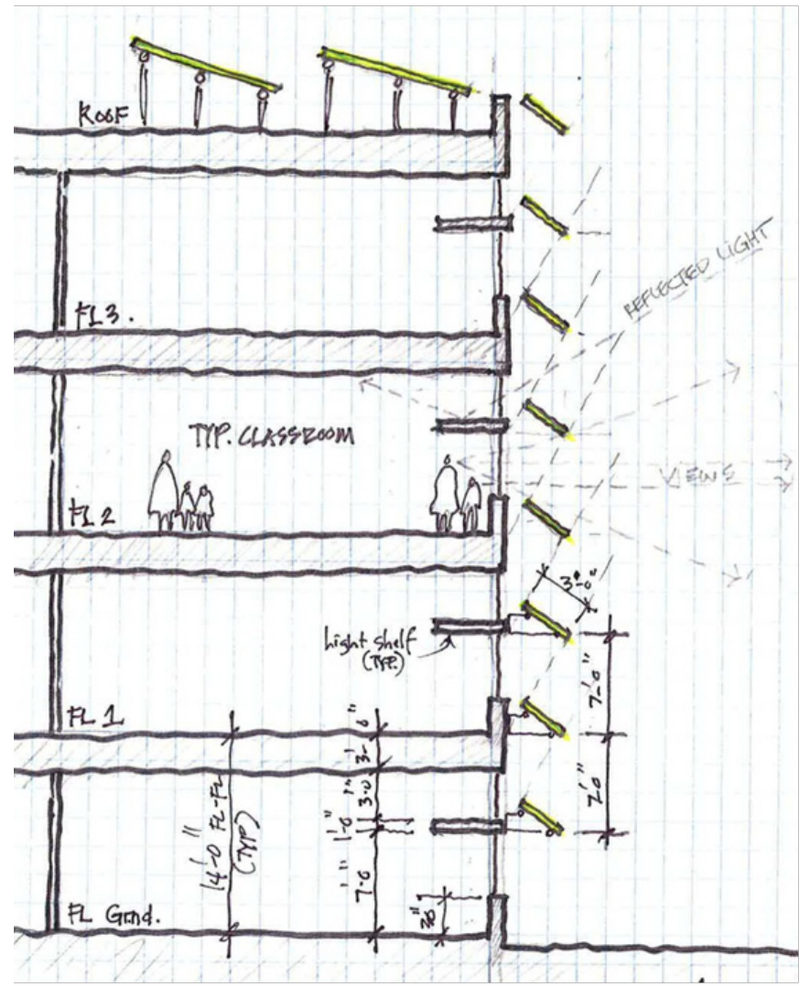
Preferred Option Roof PV Study - 10 degree panels		
Roof Area	Roof Area for PV (sf)	Energy Generated Annually (kwh)
Mounted On Roof (worst month shading)	43,729	609,849

In addition to roof mounting of PV, the south façade was analyzed for the potential to mount PV panels. Also, free-standing site mounted structures "Solar Trees" are being proposed to increase the on-site renewable energy production without negatively impacting the site.



Vertical Façade Mounted Solar Shade and PV
Due to limited roof areas and the limited space on the site for mounting PV panels, additional locations for mounting PV along the south façade have been evaluated. This will also help reduce glare issues for daylighting. There are a few products that are available today that seemlessly integrate the PV into the shading system.

In order to limit the impact on daylight and views, the proposed façade mounting strategy utilizes a continuous band of PV panels mounted with their long dimension parallel to the building face and at a 35 degree mounting angle. Two rows of panels are proposed for each floor with lower row just below the view window elevation and the upper row mounted at the top of the view window and below the upper daylight window. Both rows of façade mounted PV will function as a solar shading devices helping reduce direct solar radiation during peak cooling months.



Overall this is a good integrated strategy that should be considered for this project. This strategy provides much needed additional space to mount PV and provides needed glare protection for better daylighting quality. The south façade can accommodate up to 4,905 square feet of PV panels with annual energy generation of approximately 52,636 kWh/year.

Photovoltaic Feasibility Summary

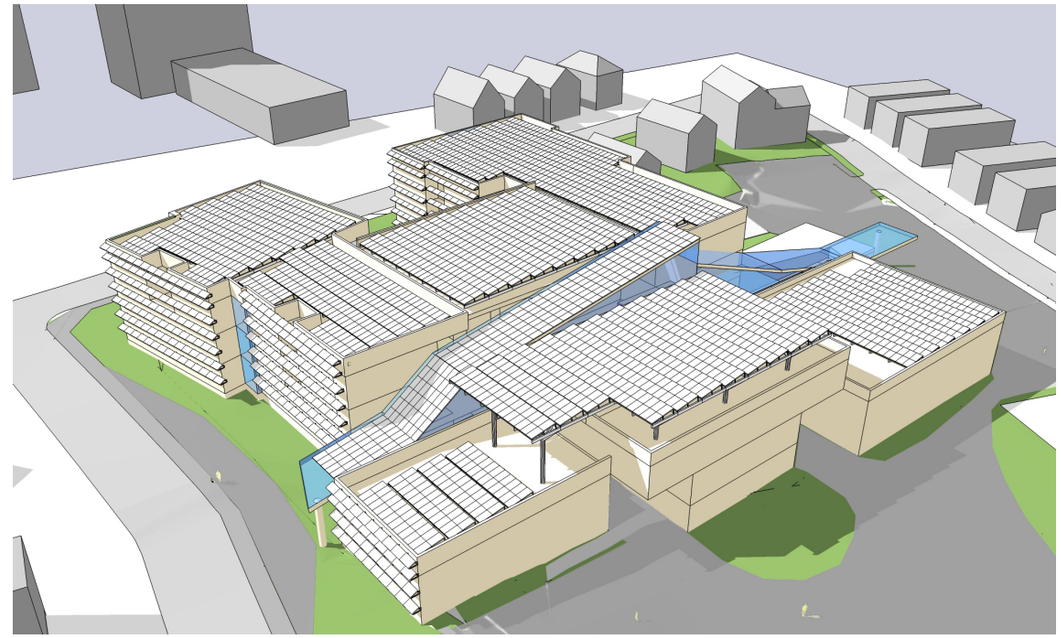
The amount of renewable energy that can be harvested on the project site is a function of the area available, the type and angle of mounting used and the efficiency of the PV panel. For this feasibility study, a mounting angle of 10 degrees has been selected for roof mounted PV in order to balance annual output losses due to snow fall with the amount of area required for the system. For the façade mounted PV a mounting angle of 35 degrees has been used and for the site mounted structures, a mounting angle of 25 degrees has been used.

The feasibility study is also based on utilizing the most efficient PV panel now available. PV efficiency is increasing at a rapid pace and while there is only one manufacturer presently providing panels with at this efficiency, it is anticipated that by the time the PV panels are purchased for the school, there will be more than one option.

The study assumes that for some limited areas of the building it will make sense to increase the roof mounting opportunities by use of structural supports that will elevate the PV in order to limit shading due to the building massing. The study also accounts for mounting of PV panels on the south facing façade as well as the use of free-standing structures holding PV panels and located on site.

This approach will result in the maximum reasonable annual energy generation for the site. Based on the available area for PV mounting that has been identified, it will not be possible to generate enough energy to meet the annual energy needs of the school and the shortfall will need to be made up with additional PV located off-site.

PV Feasibility Summary - 1,582,200 kWh/year Target							
Max Roof Generation	South Façade Generation	Building Total	Solar Trees	Site Total	Max. Possible Percentage on Site	Shortfall based on 2 panels high per row and 10 degree mounting angle	
kWh/year	kWh/year	kWh/year	kWh/year	kWh/year		kWh/year	SF for Panels
609,849	52,636	662,485	65,562	728,047	46.0%	854,153	66,132



ENERGY CONSUMPTION ANALYSIS

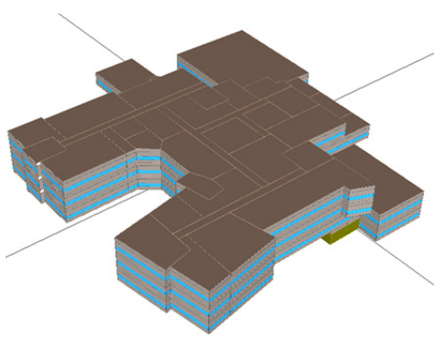
Projected energy performance for the preferred option was studied using the eQUEST energy modeling software tool. eQUEST calculates annual energy use for a building based on typical year weather data and hourly calculations for 8,760 hours per year. Building energy modeling is a comparative tool used for understanding the relative impact of alternate strategies on annual energy use and cost. At the conceptual level, the information gained should be considered qualitative rather than quantitative.

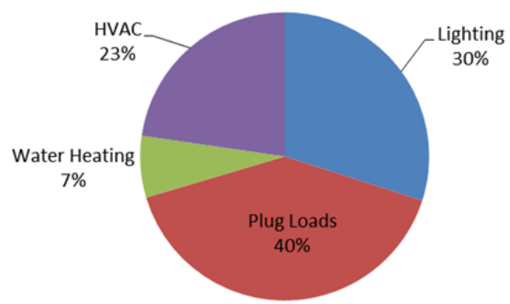
The conceptual energy model is based on a high performance building design using higher than code required levels of insulation, high performance glazing, efficient lighting system with daylight harvesting, energy recovery and a geothermal heat pump system using water-to-air heat pumps.

Preferred Option Energy Performance

The projected energy use for the preferred option is consistent with high-performance school buildings with high levels of use. The predicted preliminary energy usage intensity (EUI) for this scheme is 30.7 kBtu/sf/year. Overall the preliminary energy prediction for this building is 1,405,900 kWh annually.

Net Zero energy school buildings typically have energy use intensities somewhere in the range of 20 to 30 kBtu/sf/year. The EUI for a particular school has a lot to do with the hours per year the building is occupied. Schools, such as MLK, with extended school days and evening and weekend use fall at the higher end of the range.





PREFERRED OPTION

CONCLUSIONS AND RECOMMENDATIONS

Based on this preliminary evaluation of the preferred option for the new MLK School, the achievement of Net Zero energy operation with on-site renewable energy generation alone may not be possible. The building area is relatively large for the available site area and the building use is relatively intense. Both factors together, make the goal of Net Zero energy less achievable. The limited site limits the amount of renewable energy generation potential without overwhelming the site with PV panels. The intensity of use, in terms of the hours per year the school is occupied, increases the amount of energy required on an annual basis.

The preferred option has many features that will enhance the building performance. The design is conducive to daylighting and the relative compactness of the massing frees up site space that can more readily accommodate site mounted PV. The building roof provides relatively large areas for the mounting of PV panels and the south façade provides additional PV mounting opportunities.

In order to get as close to the achievement of Net Zero energy with site generated renewable energy as possible, the annual energy needs of the building will need to be reduced as low as possible and the potential for renewable energy generation will have to be optimized.

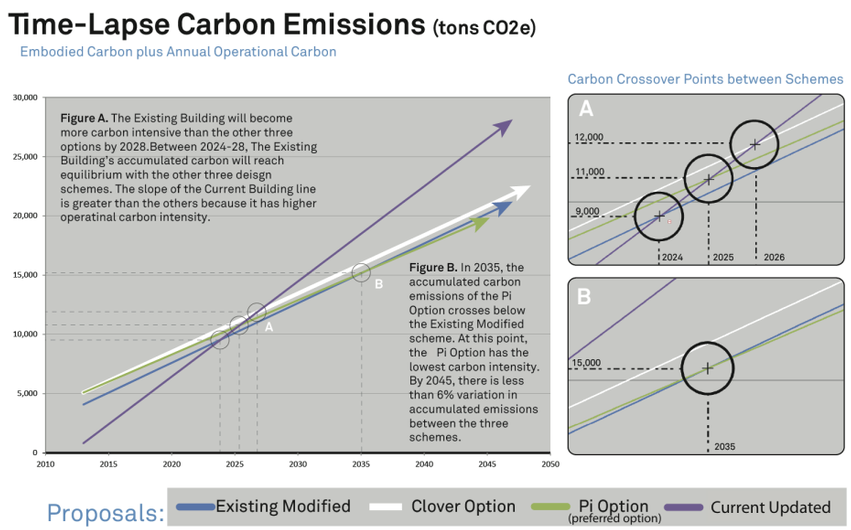
The following strategies are recommended for further development during the next phase of design:

- Optimize the building envelope and glazing systems particularly the thermal performance of the curtain wall systems.
- Optimize daylight and natural ventilation performance through careful glass selection, optimal window to wall ratios and strategic shading.
- Develop HVAC systems that have the highest efficiency, lowest transport energy requirements and the ability to adjust to varying occupancy and use on a space by space basis.
- Work with building occupants and users to limit plug loads in the building.
- Work with the food service director to reduce the overall energy requirements of the food service program.
- Work with the various building user groups and stakeholders to schedule and zone afterhours use in a way that limits energy use.
- Optimize renewable energy generation by maximizing PV mounting opportunities (within reason) and minimizing shading impacts.

Conclusions

This study looks at the embodied carbon and the operational carbon emissions in the three proposed design options against the current Martin Luther King, Jr. School (MLK) building upgraded to use approximately 30% less energy than the current building.

The upgraded current MLK building is estimated to surpass all three of the proposed design options in total emitted carbon dioxide equivalent emissions after 15 years of expected operation.



This graph shows the total accumulated carbon equivalent emissions for each of the three building options, as well as for the existing building with energy use upgrades. The upgraded current building surpasses the total carbon emissions for the three design options after approximately 15 years of operation. The three design options are essentially equivalent over time.

Figure 1
Total combined carbon equivalent emissions comparison for the three design options and the current building, upgraded for energy efficiency.

Introduction to Carbon Analysis

This study looks at the actions related to materials manufacture, transport, construction, operation and the demolition and disposal of building materials and the building assemblies that they make up for the proposed options for the Martin Luther King, Jr. School in Cambridge. This study provides comparisons expressed in terms of carbon equivalent emissions that many scientists and policy makers suggest are related to climate change. This framework enables a look at how building life span and building operating energy efficiency may affect the decision to reuse buildings versus build new.

The goal of this study is to provide an embodied energy and embodied carbon analysis for the Martin Luther King, Jr. School Project in Cambridge, MA.

Becoming aware of environmental issues and actively participating in reducing Cambridge's carbon footprint is crucial work towards restoring the Earth's natural systems on a local level. While the effects of any carbon reduction strategies undertaken on this project won't be instantaneous, this report recognizes our responsibility to reduce carbon emissions resulting from our activities over time.

This is a preliminary analysis of the building options. The calculations are based on information provided by Perkins Eastman and their subcontractors, and the City of Cambridge. Energy use characteristics of both the existing building and the design options are estimates and have not been verified. The information about the building design options and energy reduction strategies for the existing building are also preliminary, and thus, should not be considered as exact and definitive, but rather, useful for comparison.

Introduction to Embodied Carbon

Embodied energy is required to produce a building. It includes the up-front energy investment for extraction of natural resources, manufacturing, transportation, installation, and disposal of materials, referred to as initial embodied energy.

Embodied carbon represents the carbon emitted by the fossil fuel used to extract, manufacture, transport, and dispose of the materials used to produce a building. Since different materials use different types and amounts of energy, determining the embodied carbon for each material, or in this case, each set of materials that make up parts of the building (called

"building assemblies") is a complex process. For this study, Linnean has used several carefully researched databases of material and assembly carbon values, including:

- The Athena Sustainable Materials Institute's Impact Estimator and EcoImpact Calculator
- The Inventory of Carbon and Energy (ICE) from University of Bath, UK
- Boston Community Greenhouse Gas Inventories, portion of the 2009 City of Boston Climate Action Plan
- The City of Cambridge Climate Protection Plan
- The Greenest Building, a recent study from Preservation Green Lab
- The Influence of Construction Materials on Life-Cycle Energy Use and Carbon Dioxide Emissions, a thesis submitted to Victoria University of Wellington, New Zealand

This study uses the "Avoided Impacts" methodology, as described in The Greenest Building study of building Life Cycle Assessment.

The Avoided Impacts methodology considers any building or equipment already in place as having no environmental impact. Impacts can be "avoided" by re-using materials and systems. Only newly constructed materials and systems are counted as having an embodied energy and CO2e impact in this study.

Building Options Data and Analysis

Analysis Scope

The current building, with some updates, and the three building design options were analyzed for embodied carbon equivalent emissions and embodied fossil fuel energy. Operational energy characteristics for the three design options were based on the energy modeling report provided by In Posse.

This study considers energy and carbon effects over a projected 50-year life for the MLK School building.

The energy and carbon analysis includes materials and activities associated with constructing the three building options and updating of the current (or "existing") building. Some activities and materials that are projected to be the same for all 3 options were not included in this preliminary analysis – such as walkway and parking lot materials and site-work, playgrounds, installed kitchen equipment, woodshop equipment, etc. This carbon analysis is based on materials listed in the Feasibility Study Cost Estimate prepared by Davis Langdon.

The energy use of the current MLK building is based on information provided by the City of Cambridge.

This analysis was done using the Athena EcoCalculator to look at building assemblies, the ICE Carbon Database to look at specific materials, and the Retroficiency Automated Energy Analysis to look at the energy and carbon emissions of the existing building.

The current building option (also called the "Current Updated" building to distinguish it from the design options – also referred throughout the document as Existing Refurbished) assumes that systems and infrastructure for the building are updated to provide lower operating energy, and that changes are made to the interior and exterior finishes of the building to both help with energy improvements and upgrade the building, in general.

Proposed Changes:

- Updated plumbing systems and fixtures
- New heating and cooling equipment and systems
- Updated fire and IT infrastructure
- Added insulation to the foundation and exterior
- Replacement of up to 30% of interior walls and fittings
- Replacement of all interior paint, flooring and surfaces
- Other minor changes

Effects of these changes to the operational energy and carbon emissions of the existing building were modeled using the Retroficiency Automated Energy Audit software system. Results of that audit are in the appendix. Changes and updates to the building that do not affect the building energy performance were not modeled.

The embodied energy and carbon associated with these changes were modeled using the Athena EcoCalculator and the ICE database.

Category	Tons CO2e
Building Systems	256.0
Insulation	33.2
Equip (incl. Kitchen)	150.0
Interior Finish	591
Casework	50.0
Misc.	270.0
Total	**1350.3**

Table 1
Embodied CO2e accounting for upgrades to the current updated building.

The Existing Modified option assumes that some portion of the existing building is demolished, the rest of the existing building is stripped to the structure, and the new building is constructed with a mix of new and re-used structure, as described in the Perkins Eastman documents.

The operational energy of the Existing Modified option was modeled by In Posse for Perkins Eastman. Operational carbon emissions were modeled using the Boston Community Greenhouse Gas Emissions data, by Linnean.

The embodied energy and carbon associated with the Existing Modified option was modeled using the Athena EcoCalculator and the ICE database.

The Clover and Pi options assume that all of the existing building is demolished except a portion of the foundation, to be replaced with new construction.

The operational energy of the Clover and Pi options were modeled by In Posse for Perkins Eastman. Operational carbon emissions were modeled using the Boston Community Greenhouse Gas Emissions data, by Linnean.

The embodied energy and carbon associated with the Existing Modified option was modeled using the Athena EcoCalculator and the ICE database.

Embodied and Operational Energy and Carbon

Operating energy is a prime factor in evaluating building-related energy and CO2e impacts. Analyses of building operating energy and related impacts have become common, as concern about resource depletion and climate change have grown. The operating energy of buildings varies greatly, due to differences in building envelope and system performance, as well as building management and maintenance, occupant behavior and building life span. Thus, the ratio of buildings' annual operating energy to total embodied energy can diverge substantially – between 5:1 and 30:1.

According to The Greenest Building study, schools typically have a lower ratio of embodied to operational energy. In other words, schools use a lot of energy relative to the energy to make the building. This study cites their research showing that school buildings in cold climates (like Cambridge's) take only 10 to 15 years of operational efficiency to pay back the embodied energy in a new building.

Year Of Carbon Equivalency For Existing Building Reuse Versus New Construction

This study finds that it takes between 10 to 80 years for a new building that is 30 percent more efficient than an average-performing existing building to overcome, through efficient operations, the negative climate change impacts related to the construction process. This table illustrates the numbers of years required for new, energy efficient new buildings to overcome impacts.

Building Type	Chicago	Portland
Urban Village Mixed Use	42 years	80 years
Single-Family Residential	38 years	50 years
Commercial Office	25 years	42 years
Warehouse-to-Office Conversion	12 years	19 years
Multifamily Residential	16 years	20 years
Elementary School	10 years	16 years
Warehouse-to-Residential Conversion*	Never	Never

*The warehouse-to-multifamily conversion (which operates at an average level of efficiency) does not offer a climate change impact savings compared to new construction that is 30 percent more efficient. These results are driven by the amount and kind of materials used in this particular building conversion. As evidenced by the study's summary of results, as shown on page VII, the warehouse-to-residential conversion does offer a climate change advantage when energy performance for the new and existing building scenarios are assumed to be the same. This suggests that it may be especially important to retrofit warehouse buildings for improved energy performance, and that care should be taken to select materials that will maximize environmental savings.

Table 2
From The Greenest Building, a Life Cycle Assessment study of building re-use by Preservation Green Lab, 2012.

As noted above, embodied carbon is determined by the fuel types and amounts used in materials and construction of the building, whereas operational carbon is calculated from the energy types and amounts used to operate the building.

Preliminary Comparisons

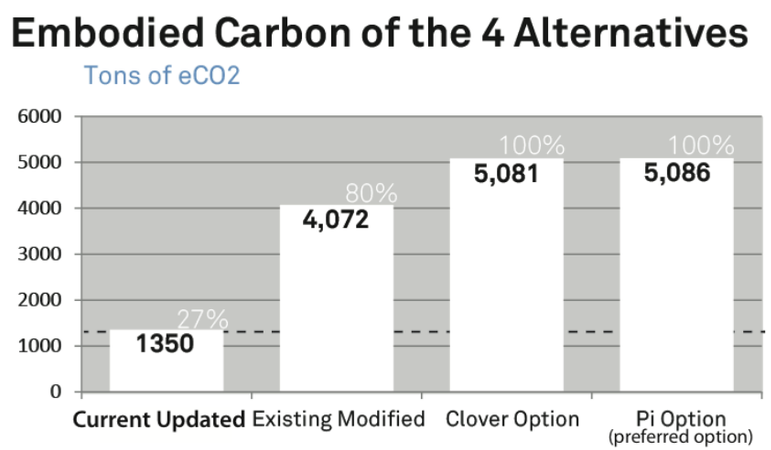


Figure 2
This figure shows the scale of the relative carbon dioxide equivalents (CO2e) embodied in updating the existing building and building each of the three design options. The embodied CO2e for the existing building upgrades is substantially lower than that for the other options because this option does not include new construction, only new systems, finishes, and some interior walls.

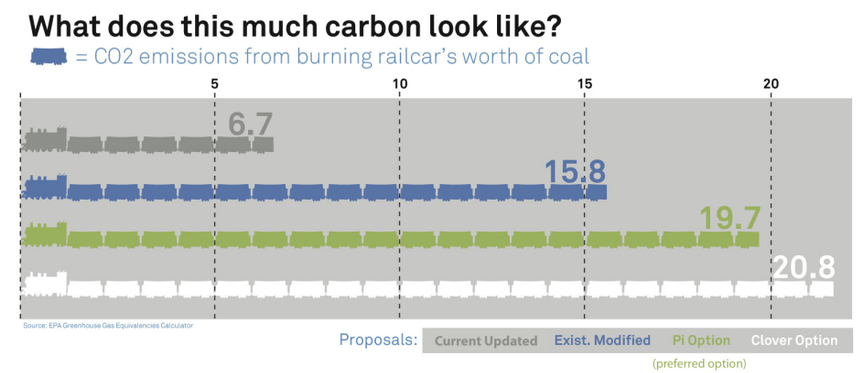


Figure 3
This figure provides a way to understand how much CO2e each building option embodies.

Carbon Equivalents Embodied in Constructing the 4 Building Options
The CO2e embodied in the updating of the current updated building is substantially lower than any of the three building design options. This reflects the fact that much less work and materials go into updating the existing building than in constructing the design options.

Of the design options, the Existing Modified option embodies less CO2e than the Clover and Pi options, due to the re-use of substantial structure in the Existing Modified option.

Annual Carbon Equivalent Emissions from Building Operations

The annual CO2e emissions from operating each of the four building options are shown below. This analysis includes the operational CO2e reductions from proposed photovoltaic electricity production on the Existing Modified, Clover, and Pi design options. Even with updating to reduce the operating energy of the existing building, it performs substantially worse than the design building options.

	EUI	Total KWh	Solar Contribution	Operational CO2e
Current Updated	44.0	2,049,810	—	804 tons
Existing Modified	30.9	1,430,110	328,310	504 tons
Clover Option	30.2	1,392,980	316,125	492 tons
Pi (preferred) Option	30.7	1,405,980	403,473	458 tons

Table 3
This table show the Solar PV contribution to operational energy for the four building options, and the operational CO2e in tons. All forms of operational energy have been converted to KWh for this table.

Note also that carbon emissions from electricity use are higher per unit of energy used at the existing building, due to electricity transmission losses. This is factored in to the CO2e figures.

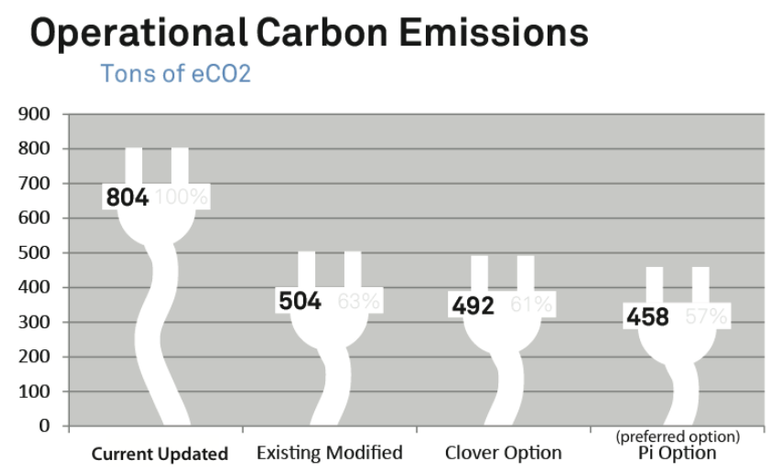


Figure 4
This figure shows the estimated CO2e emissions from the annual operations of the four building options: the current updated building, the Existing Modified option, the Clover option, and the Pi (preferred) option.

Embodied and Annual Operational Energy for the Four Options (in KBtu)

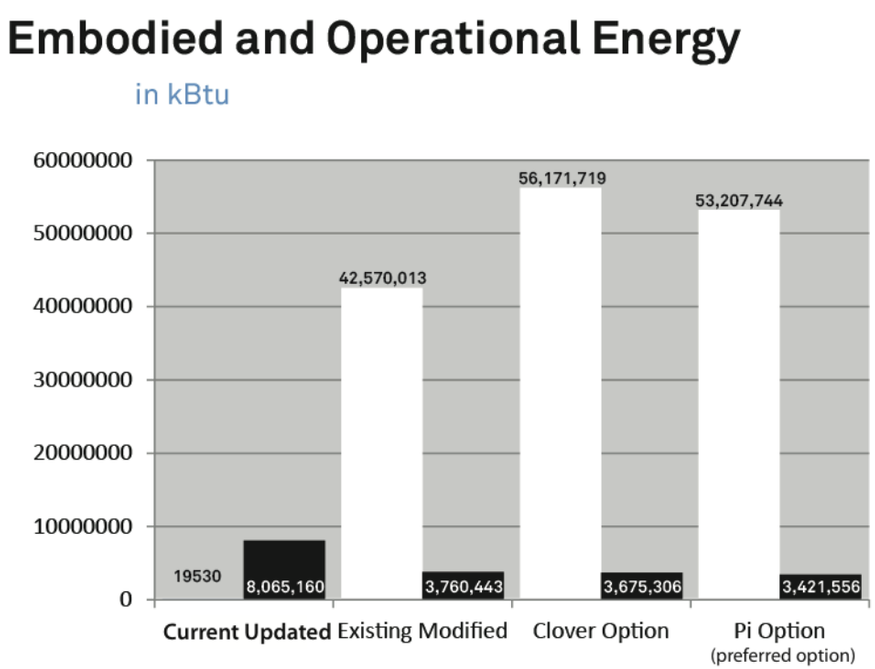


Figure 5
This figure shows the estimated embodied and operational energy for each building option: the current updated building, the Existing Modified option, the Clover option, and the Pi (preferred) option. Energy and CO2e emissions are equivalent, because of differences in carbon emissions from different energy sources.

Distributions of CO2e Emissions for Each Building Option

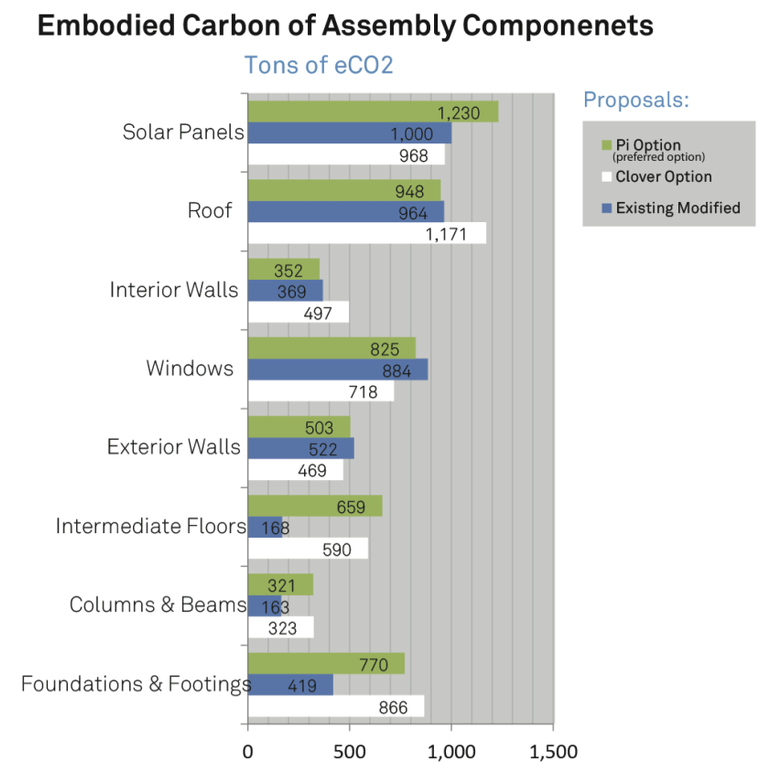


Figure 6
This figure shows the relative estimated contribution of 8 building assemblies to the estimated embodied CO2e emissions for the three building design options: the Existing Modified option, the Clover option, and the Pi (preferred) option.

Energy Analysis of the Existing Building

Linnean Solutions calculated the Energy Use Intensity (EUI) of the existing Martin Luther King, Jr. School (MLK) building by examining the energy record for the building for the previous 10 months and then adjusting the data for a standard weather year. (The heating load was low due to a warm winter and the cooling load was approximately right.) A modeling study was done to determine the possibility of improving the energy performance of the existing MLK building by 30%. The energy improvements suggested by this study are shown here. The goal of the study was to test the feasibility of gaining a 30% reduction in energy use, and not to consider the cost of doing so.

ENERGY USE INTENSITY COMPARISON						
KBTU PER SQUARE FOOT						
Current Building (as is)	**Current Updat-ed**	**TCB Unaltered**	**TGB Up-dated**	**Existing Modified**	**Clover**	**Pi (pre-ferred)**
61	**44**	**80**	**56**	30.7	30.2	30.4
			Solar PV Contributions	-6.9	-6.9	-8.5
			Design Option Totals	**23.8**	**23.3**	**21.9**

Table 4
This table shows a comparison of Energy Use Intensities (EUI) for the current MLK building and the current building with 30% reduction in EUI (Current Updated), compared to an un-improved and an updated building in a similar cold climate (Chicago) from The Greenest Building (TGB) study, as well as the three proposed design options for MLK. The estimated reductions in EUI from the proposed solar arrays for the proposed design options are shown, as well.

It proved difficult in the study to get greater than a 30% energy use reduction in the current MLK building. Greater levels of insulation did not yield greater savings, primarily due to the overall energy load structure of the school operations.

Potential Kitchen Energy Use	
Cooking (gas)	337,400
Washing (hot water)	420,000
Equipment (electric)	269,968
Total Kbtu	**1,027,368**
% Current	10,6%
% Current Updated	14.7%
% Existing Modified	27.3%
% Clover	28.0%
% Pi (Preferred)	30.0%

Table 5
This table shows the estimated energy load from the existing kitchen operations at the MLK School. These loads are likely to stay approximately the same under any of the design scenarios. The table show what proportion of the EUI these loads represent under the different scenarios. The percentages do not reflect energy use effects of the proposed solar arrays.

Energy Use Reduction Strategies

Suggested energy use reduction strategies include a number of options. The information below includes changes to the current MLK building that affect the energy use of the building. They do not include any analysis of necessary upgrades to the building that do not affect the energy use or CO2e emissions of the building.

Suggested Current Building Load Reduction	
Heating System	6.5%
Cooling System	1.0%
Lighting Systems	1.7%
Insulation	12.0%
Hot Water	5.9%
Ventilation	0.5%
Total Reduction	**27.5%**

Table 6
This table shows the percentage of load reduction in each category, from the suggested energy use upgrades to the current MLK building. The total load reduction from the suggested upgrades is 27.5%.

The recommendations in this study are estimated to reduce overall energy usage from 9,699 MMBtu to 6,996 MMBtu, a savings of about 27.5%.

Suggested energy upgrades to the current MLK building include the following Energy Conservation Measures for lowering energy use. The modeling process also takes into account the interactive effects of multiple measure, such as the way in which lowering the lighting load in the building will also lower the cooling load and increase the heating load.

Hot Water	Replace existing water heater with electric water heater with R-24 insulation, insulate pipe near tank, aerators
The existing distillate oil water heater consumes 4,055 gal of distillate oil per year. A electric water heater with r-24 insulation, insulate pipe near tank, aerators will consume 14,377 kwh of electricity per year. (combined with faucet aerators and additional insulation on piping).	
CO2 Equivalent Reduction	4%
Annual Energy Savings	5.9%

Heating	Replace distillate oil conventional boiler with new gas boiler
The distillate oil conventional boiler consumes 42,374 gal of distillate oil per year. A gas boiler with a 84% combustion efficiency will consume only 55,907 therms of natural gas per year.	
CO2 Equivalent Reduction	12%
Annual Energy Savings	3%

Lights	Upgrade to new Super T8 fluorescent lighting with electronic ballasts
A T12 fixture with 4 40-watt lamps and electronic ballasts consumes 124 watts. Converting to Super T8 fixture with 3 30-watt lamps and electronic ballasts reduces the electricity consumption to 78 watts.	
CO2 Equivalent Reduction	8%
Annual Energy Savings	2%

Lights	Upgrade to new 0.35-watt electroluminescent exit sign retrofit kits
The existing 40-watt incandescent exit signs will consume 18,923 kWh per year. Converting to 0.35-watt electroluminescent exit signs reduces the electricity consumption to 166 kWh per year.	
CO2 Equivalent Reduction	< 1%
Annual Energy Savings	< 1%

Roof	Insulate built-up roof surface and re-roof
	Insulating the built-up roof with R-20 insulation and re-roofing will increase the existing roof insulation R-value from 5 to 25.
CO2 Equivalent Reduction	11%
Annual Energy Savings	10%

Floor	Insulate perimeter of slab on grade with R-15 insulation
Adding insulation to the perimeter of the slab on grade will increase the existing floor	
CO2 Equivalent Reduction	< 1%
Annual Energy Savings	< 1%

Wall	Add interior masonry surface insulation
Adding R-12.4 insulation to the interior masonry surface will increase the existing wall insulation R-value from 5.5 to 17.9.	
CO2 Equivalent Reduction	2%
Annual Energy Savings	2%

Cooling	Upgrade to a new ultra high efficiency water-cooled centrifugal electric chiller
Replacing the electric water-cooled centrifugal chiller with a COP of 6 with a water-cooled centrifugal electric chiller having a COP of 7.37 will decrease cooling energy consumption by 1,875 kWh of electricity annually.	
CO2 Equivalent Reduction	< 1%
Annual Energy Savings	< 1%

7.0 OTHER DESIGN OPTIONS

DESIGN OPTIONS #1: EXISTING REFURBISHED

In evaluating this option, the history, size, configuration and condition of the existing building were key factors when considering whether the building could remain largely "as is" and be renovated to suit the new student population and enhanced education programs. Community and environmental impacts were very important considerations when comparing this with other options that retained less of the existing structure, and met the program through partial retention with additions or minor retention with mostly new construction.

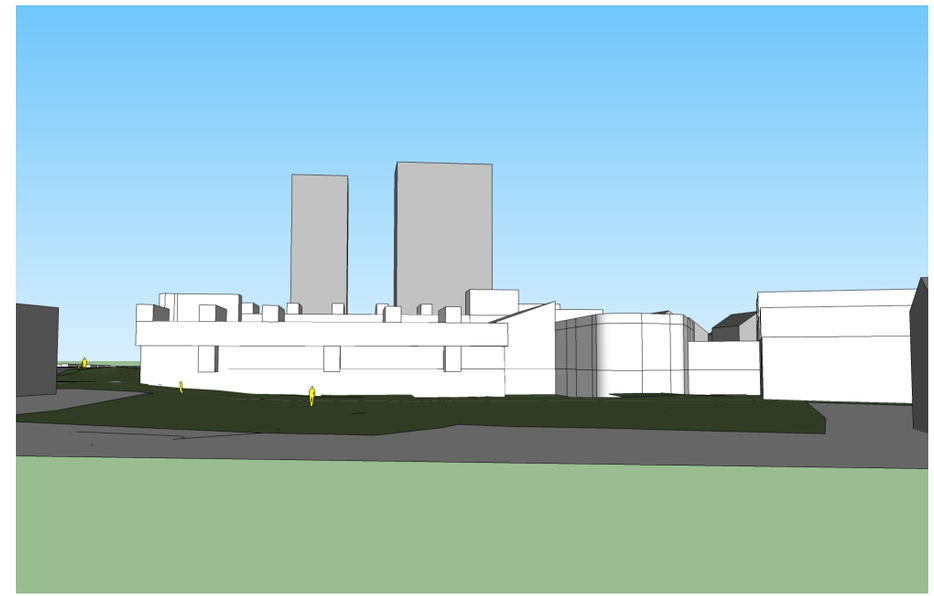
History Of Existing Building

This building was designed by Jose Louis Sert, of Sert Jackson and Associates in 1971. The style conforms to the design principals of the Modern Movement, and in particular a subset known as Brutalism characterized by cantilevered cubistic forms rendered in concrete in this case, and in brick-masonry in the case of Boston City Hall. Peabody Terrace, the Harvard-owned graduate student residence across Putnam Avenue was also designed by J.L.Sert in the same style. This style of architecture was executed in an era when energy was cheap and was short-lived, spanning approximately 1952 – late 1970's. Members of a preservationist group and a concerned local architect have spoken in favor of preserving the building as an example of this style and J.L. Sert's work. The MLK, Jr. School is less than 50 years old and not subject to historic preservation regulations, so can be altered or demolished.

Description (Size And Configuration)

The existing building measures approximately 159,000 gsf with a zoning gross floor area of approximately 157,740 sf (add overhangs, minus mechanical spaces). The building is generally perceived as three stories but is technically four stories by virtue of a site that slopes down one story from Putnam Avenue on the west to the playground at the terminus of Hayes Street on the east between Magee and Kinnaird Streets. The existing building comprises 2 distinct parts noted on the diagram as Part A (60% of building footprint) and Part B (40% of building footprint).

Part A fronts onto and is orthogonal to Putnam Avenue and consists of a classroom "donut" with classrooms oriented east and west surrounding an internal courtyard. This configuration provides for abundant natural light to the corridors, but less direct light and ventilation to the classrooms. Protruding rooftop monitors provide reflected indirect north light to top floor classrooms. At the Ground Floor which is below grade on the Putnam avenue side, is loading, receiving, storage and mechanical space with. At the ground floor adjacent to the natural light



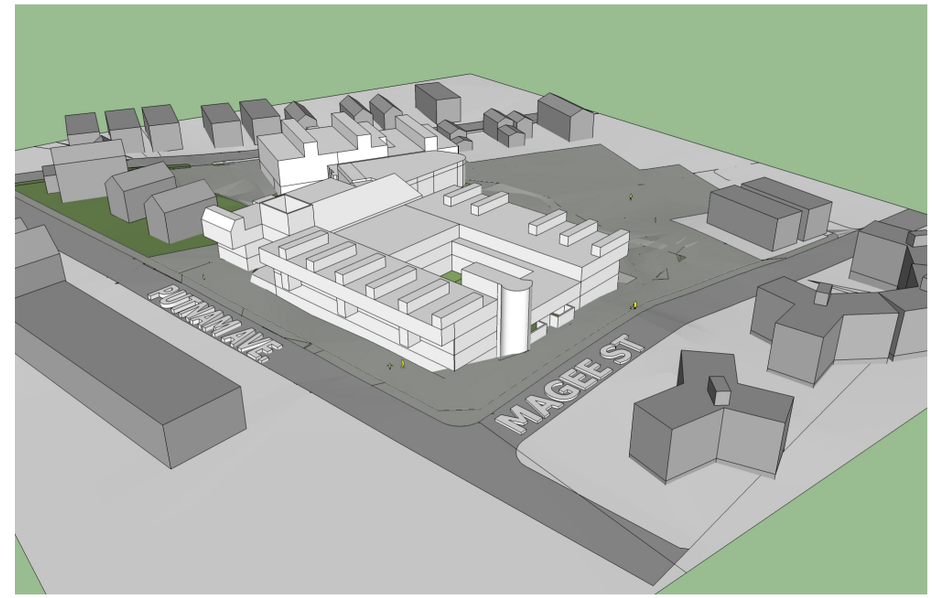
provided by the courtyard, is the dining facility shared by both schools. At the first floor, across the primary entrance and public circulation space, are administrative and support spaces for the MLK, Jr. School.

Part B fronts onto and is orthogonal to Kinnaird Street and houses all the shared and public parts of the program, like gyms with support spaces, the auditorium, and the music programs. Additionally, adjacent to the back entrance between the mass of the Lower Gym and Auditorium/Music Rooms is the entrance to the entrance and administration space for the Amigos School. This location for the second school is problematic as it is difficult for visitors to find. Even package and mail delivery had been problematic since this entrance is not visible from Kinnaird or Magee Streets.

Condition of Existing Building
A more detailed outline of the condition of the existing building is contained in the Appendix Volume of this report. To summarize, the concrete structure of columns and slabs with integral beams (beam/slabs) which supports Part A of the building is in good condition, but on-grade slabs and retaining walls enclosing ground level have neither under-drains nor vapor barriers. The unreinforced concrete-block walls supporting Part B of the building must be replaced or significantly reinforced if modified as outlined under Seismic Considerations below.

All other building components are obsolete, past their life expectancy and in need of replacement. This includes the roof, windows, mechanical systems, electrical systems, plumbing and fire-protection systems. Approximately half of all classroom walls consist of demountable partitions that are never used and do not provide adequate levels of acoustic separation. Visual sampling, conducted during the Feasibility Study indicates the potential for moderate to substantial hazardous material content. The actual extent will be ascertained during sampling to be conducted as part of the upcoming Schematic Design Phase. Based on the condition of the building alone, extensive demolition, new construction and expense would be required to retain the existing building and re-use it for the three new schools. While clearly possible to upgrade the building to overcome condition deficiencies, other factors listed below are of greater significance when evaluating retention versus new options.

Water Table
The low elevation of the site and it's proximity to the Charles River results in a Water Table that is close to the surface. Additionally, the ground floor level of the existing building is approximately two and a half feet below the lowest grade level of the site. The existing grades slope down towards the building to provide accessibility to the Ground Floor of the building. The existing slabs on grade have no system of under drains to allow water to flow away from the building when the underground water or surface water is high. The combination of these factors results in a condition where the ground floor level of the building floods on a regular basis. The lower school gym wood-floor has been repeatedly replaced during the last 10 years alone as a result of water damage. During a heavy storm that occurred during the preparation of this study, the entire 4 ft deep crawlspace tunnels under the school filled with water and had to be pumped out by the fire department. This crawlspace houses the plumbing, and other mechanical systems. Mold studies have not been conducted because retention of the crawlspace was deemed inadvisable. The City requested that the crawlspace/tunnels not be used for building infrastructure or any other use but rather be eliminated because of their concern for the working conditions for contractors during construction and post-construction maintenance, and also to ensure that air quality within the building is not compromised.



Energy and Insulation
The existing building is not insulated. To meet current energy codes, the City of Cambridge's goal of a Net Zero Energy school, good practice and increase energy efficiency, the entire building envelope must be insulated. This includes wall panels, foundation walls, windows and roofs and soffit overhangs. It is impractical to properly insulate this entire building from the inside without extensive resultant thermal bridging. By the nature of its very integrated construction, the concrete columns, beams/slabs and panels form both the outside and the inside of the building. This results in a direct transfer of heat/cold from the interior to the exterior and vice versa. Partial insulation can be achieved at exterior walls and roofs from the inside alone, but not at points where the structure passes from inside to outside (i.e. at the cantilevered floor slabs). Additionally, this "partial" insulation solution does not allow for a continuous warm-side vapor barrier, which could lead to uncontrolled dew-point locations and condensation within the building. Besides negatively impacting finishes, condensation can lead to mold growth.

The only way to properly insulate this structure, and have a chance of achieving a net-zero energy building, is to do so by placing a continuous layer of thick rigid or closed-cell spray-foam insulation on all the exterior non-glazed surfaces of the building. An exterior cladding system would be added over the top, to protect and hide the insulation, and to create a pleasing aesthetic. This re-cladding, along with the installation of new larger insulated windows, would solve energy considerations, but it would negate re-use of the building based on any historic considerations, as the building would be altered beyond recognition. Additionally, the new structure required to hang or attach the new cladding could negatively impact the lateral forces on the building which would contribute to the need for a seismic up-grade.

Embodied Energy Vs. Energy Efficiency/ Cost And Net Zero

The existing building contains embodied energy by virtue of its constituent materials that have been mined, grown or manufactured, transported and installed. Demolishing the building and removing the materials to another location, whether for re-cycling or land-fill will use energy, as will the mining, growing, manufacturing and installation of materials to renovate the existing or construct a new building. Depending on the extent of the renovations and the way in which the renovated building is insulated, it could be fairly- to substantially- more energy efficient than it is now. This will result in fairly to substantially lower annual energy consumption and costs. However, concerned environmental groups have requested that the project team analyze the larger picture, which combines the issue of embodied energy with annual energy consumption to create a total energy picture over the life of the building. The City has agreed to fund this additional analysis, and the results are in Section 6.7. These results show that while initially the embodied energy to refurbish the existing building, the long term energy saving of all of the other design Options, but in particular the Preferred Option (Pi Option) surpasses the Existing Refurbished Option in overall energy savings at year 15.

Achieving the City's goal of Net Zero energy school for this project would be much more difficult if the existing building were refurbished as compared to the other three options. It would use more energy since there is more exterior wall and at the same time less windows into instructional spaces. More wall causes there to be greater heat loss in winter and heat gain in summer over the more compact footprints of the other options, and simultaneously fewer windows allows less natural light and therefore requires more energy for the artificial light required. Additionally none of the existing slabs on grade can be insulated without removing them and pouring new, so this would be another source of heat loss resulting in greater energy use. It would therefore take more photovoltaic panels to meet the yearly energy needs, making this option more expensive to achieve this goal.

Seismic Considerations

As discussed above, the existing building consists of two distinct parts, each with very different construction types. Part A, the classroom "donut", is constructed with concrete columns supporting concrete slabs with integral beams occurring regularly at 8'6" intervals. This part of the building is able to be economically upgraded to meet current seismic codes. The un-reinforced concrete-block bearing walls supporting Part B of the building with little or no anchorage to the roof structure, comprising the gyms and auditorium, is inherently less stable than Part A and does not conform to the current seismic codes for Massachusetts. This type of construction which requires significant reinforcement cannot be economically upgraded to meet current seismic codes. Given no change-of-use for the building, the Massachusetts State Building Code does permit the City to avoid upgrading the building to meet seismic codes, as long as certain thresholds and all applicable Appendices' requirements are met. Under the Work Area method of compliance (IEBC 2009), if more than 30% of the total floor and roof areas will be structurally altered (i.e. a Substantial Structural Alteration as defined in Section 807.4.2 of IEBC 2009), the altered structure must be capable of resisting full IBC 2009 wind forces and 75% of IBC 2009 seismic forces. In addition, Part B with it's masonry bearing walls is subject to the MA Building Code Section 101.10 which requires compliance with Appendix A1 of the 2009 IEBC. Even if the project were not a Substantial Structural Alteration, Appendix A would require significant structural work. FBRA's Design Option Report concluded that if Part B were to be renovated, it would likely be classified as a substantial structural alteration, because the auditorium is substantially undersized and would need to be expanded by 60%, and the entire Part B of the building has no under-drains and is subject to flooding which can only be remediated by removal of the on-grade slabs. Further complicating any potential remediation is the fact that the structural expansion joint between Parts A and B is undersized, which cannot be increased without difficult and expensive demolition where the two parts of the building meet. Additionally a large part of the existing ground floor teaching spaces located in Part B have no windows (no natural light or ventilation) and adding appropriate windows to these instructional spaces would also cause the load bearing structural walls to be modified. Given the considerable changes required to accommodate the new program, maintaining the existing building largely "as-is" is not feasible. The structural engineer for the project has recommended demolishing Part B of the existing building and rebuilding it. Additionally, the City of Cambridge has indicated that they do not wish to avoid seismic up-grade of the building, given long-term safety concerns for the children.

Program Fit

The existing building houses the current MLK, Jr. School (294 students), the Amigos School (334 students), and the MLK, Jr. Preschool (34 students). When complete, the new school will accommodate up to 740 students as follows: JK-5th = 400 students, 6th – 8th = 300 students and Preschool = 40 students. The combined 3 existing schools have a total of 50 instructional spaces, versus the combined new schools which have 64 instructional spaces. This is partially a result of the increased student population and partially a result of new and enriched learning and teaching environments as defined in the Educational Specification. The existing classroom "donut" is simply too small and not properly configured to accommodate the proposed increase in student numbers or the variety of enhanced learning and teaching spaces. The spaces remaining in the Ground Floor Part B area of the building have no windows and are unsuitable for instructional spaces. Only 4 of the 14 Design Principals outlined as very important to the learning environment for the school can be adequately achieved by keeping the existing building with no substantial modification of structure.

Building Orientation, Natural Light and Floor To Floor Heights

Part A of the existing building contains all of the classrooms, with the majority of windows facing due-east and due-west, accessed by naturally-lit corridors that overlook an internal courtyard. The courtyard is very pleasant, as are the corridors, but the classrooms are less optimally lit. This east and west orientation is the least desirable for classrooms, as the low morning and afternoon sun penetrates deep into the classrooms, disturb teaching and learning, and result in blinds being drawn. Once the blinds are drawn, they are rarely opened again after the sun moves. To compensate, all lights must be turned on, which in turn uses unnecessary energy. Studies have demonstrated that well ventilated, naturally lit classrooms where light levels and glare can be controlled foster better concentration and retention in students.

Studies such as, "Daylighting in Schools: An Investigation into the Relationship Between Daylighting and Human Performance" by Heschong Mahone Group 1999 have demonstrated that well ventilated, naturally lit classrooms foster better concentration and retention in students. ("….we found that students with the most daylighting in their classrooms progressed 20% faster on math tests and 26% on reading tests in one year than those with the least. Similarly, students in classrooms with the largest window areas were found to progress 15% faster in math and 23% faster in reading than those with the least. And students that had a well-designed skylight in their room, one that diffused the daylight throughout the room and which allowed teachers to control the amount of daylight entering the room, also improved 19-20% faster than those

Existing Site Plan

students without a skylight. We also identified another window-related effect, in that the students in classrooms where windows could be opened were found to progress 7-8% faster than those in rooms with fixed windows. This occurred regardless of whether the classroom also had air conditioning".)

The orientation of the existing building cannot be changed and it is very difficult to effectively control natural light on east and west façades, as opposed to the north which has no direct sun, or the south which is easily controlled with overhangs. This factor was a major consideration when evaluating re-use of the existing building. Optimizing natural light into classrooms is further hampered by the low 10'-6" floor-to-floor height of the existing classrooms. The new building options proposed 14'-0" floor-to-floor heights for classrooms, which allows for internal light-shelves to reflect light into the full depth of the classrooms. This feature, which along with the proper north and south orientation can create classrooms that are filled with natural light and may not require any artificial lighting, except on gray and dark days, can only be achieved in new construction.

Parking Vs. Usable Open Space
The existing site contains 49 striped parking spaces, but based on the parking study conducted as part of the overall Feasibility Study, up to 88 cars are parked on site daily. The official striped parking is located in a paved lot adjacent to the basketball court, internal to the site and along the drive leading to the loading dock. The unofficial parking occurs primarily along the strip of paved land between the existing gym wing and the Kinnaird Street sidewalk. This ad-hoc parking arrangement is not optimal. This condition cannot be improved without taking over student play and recreation space to relocate parking, or substantially reducing the existing parking supply well below the demonstrated need. Neither the teachers nor the neighbors favor either of these compromises. The issue of compromised useable outdoor space for students factored heavily in deciding that this re-use option was substantially less optimal than the Existing Modified Option or either of the new build options. In particular, the Preferred Option, which is able to provide most of the required parking underground, leaves more of the site free as useable outdoor space.

Zoning (Setbacks and Height)
As with many public schools in the City of Cambridge, the existing MLK, Jr. School building does not meet the dimensional requirements of the current zoning bylaw for Res-C1 in many respects, including height, setbacks, FAR, and parking. However, given that this option seeks to retain the existing in its current configuration and use, the project becomes a repair and is not subject to any zoning review at all.

Aesthetics and Functionality
A number of parents, neighbors, and members of the community at each of the three meetings, have expressed their strong distaste for the brutal concrete aesthetic of the building. Many have also complained about the functional shortfalls of the existing building design. By contrast, members of an international preservation group have spoken in favor of preserv-

ing the existing building as an example of Jose Luis Sert's work. However, the very nature of the modifications proposed in this Existing Refurbished Option to meet the, and requirements renders preservation of the historic kind moot. On the other hand, keeping the existing building in place results in a building that would be so energy inefficient it would not make sense from a sustainability point of view. However, the most important reason to remove the existing building is that it falls very short of meeting the program functional requirements of the three schools and community center.

Cost
A cost model was not created for simply refurbishing the existing building. Because the educational program for the three new schools is not able to be accommodated within the existing building without additions, this option was eliminated early in the process, in favor of Option #2, the Existing Modified Option. A cost model for this second option, which accommodates the new educational programs and solves the seismic issues, was created.

Existing Refurbished pros:
1) It's there – folks are "used-to-it" – quick permitting process
2) Lower floor to floor height creates lower massing – but existing monitors and rooftop mechanical spaces add height to be similar to proposed new-construction options
3) Less demolition required results in less trucking, dust, noise for neighborhood
4) Good general layout of classroom donut around inner court– plenty of natural light to corridors and cafeteria
5) Monitors provide quality natural light to upper floor classrooms
6) Solid structure contains embodied energy
7) Dining has good relationship to contained garden

Existing Refurbished cons:
1) Does not meet proposed program: 50 instructional spaces in existing building vs. 64 instructional spaces needed; can't achieve adjacencies needed of teacher work and support spaces in the classroom wings (Part A)
2) Putnam "presence" less than optimal
3) Brutalist façade very close to street remains on Kinnaird – limited landscape opportunity due to shadows and limited light, shadows continue to be cast on neighbors.
4) Single entry identity on Putnam – split of schools occurs internally and existing door to Amigos is not easily found at the back (problem for visitors, security and even mail delivery)
5) Water issues – existing underground crawlspace susceptible to flooding and existing ground floor subject to repeated flooding.
6) Inefficient single-loaded corridor layout of classroom donut
7) Ground floor Part B instructional spaces have no windows/natural light
8) Upper floor classrooms have very few and small windows
9) Classrooms orient due East and West which causes glare and heat gain issues
10) Monitors require floating PV's at higher elevation means added height and reduced light to monitors
11) Lower floor to floor height means lower ceiling heights and mechanical coordination issues and less natural light penetration into classrooms
12) No below-grade parking opportunity – all parking on site – less useable site for kids especially if real parking need is addressed on site
13) Learning commons is not the heart of the school – would be relocated to currently unused area of Ground Floor to make more room for classrooms at 2nd floor.
14) Organization of Public/Community Center functions is not optimal; spaces are not immediately accessible from main public space of building (Part B circulation is circuitous) and separation of school academic spaces from community spaces is exceedingly difficult since the academic program located on both sides of atrium corridors and therefore not contained within a discreet wing of the building.

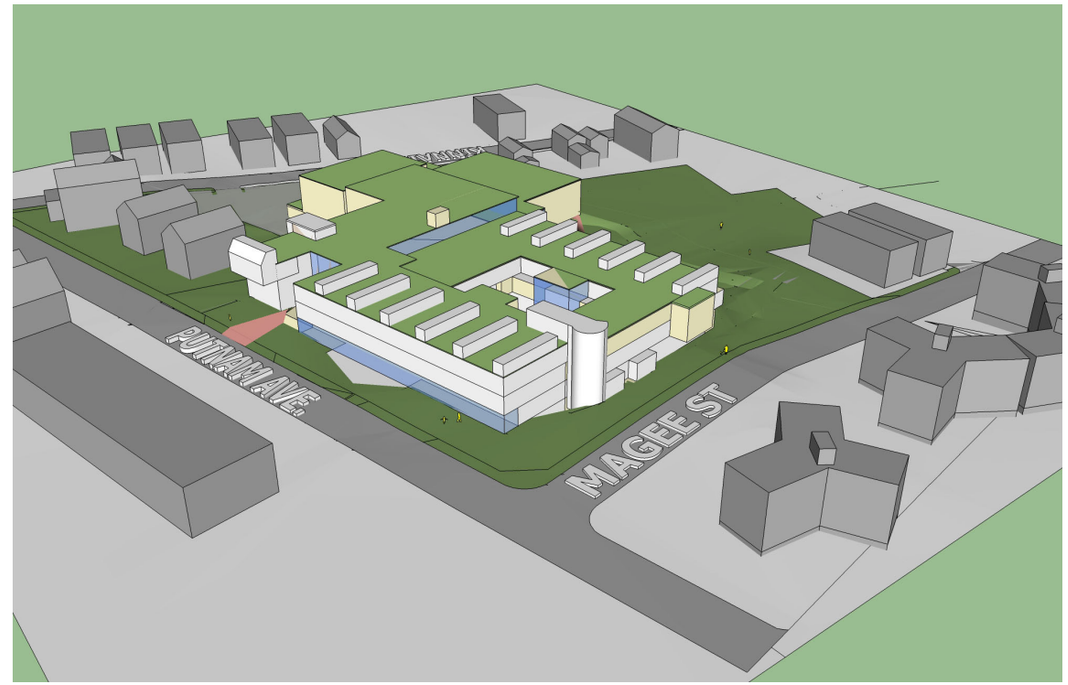
OPTION #2 EXISTING MODIFIED

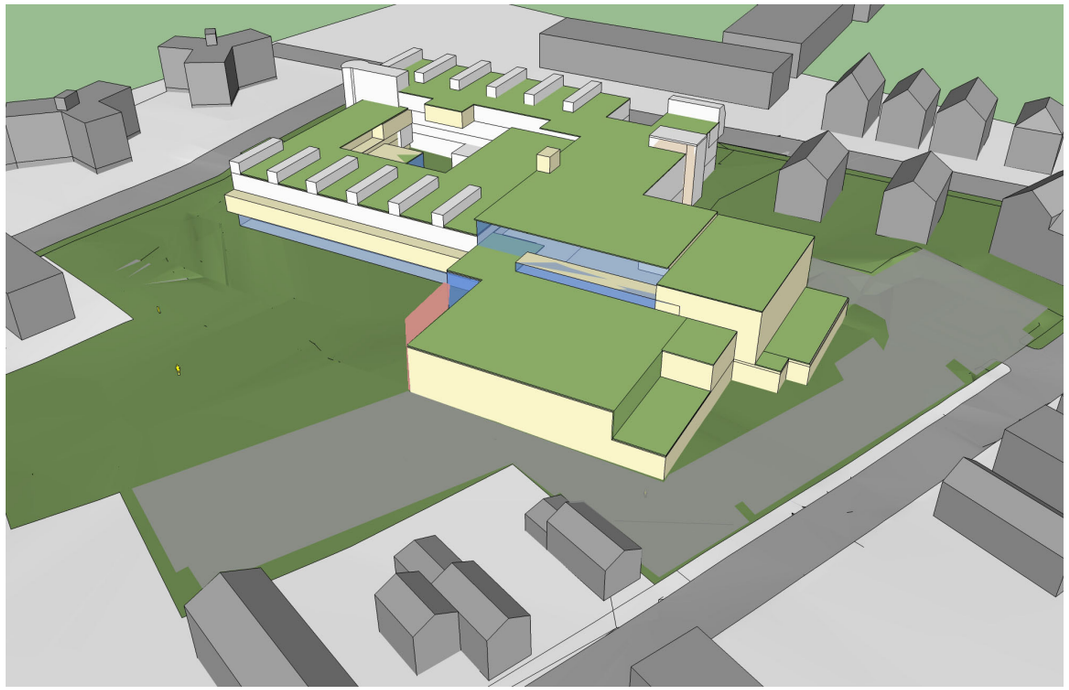
Description (Size and Configuration)
This option proposes to maintain Part A of the existing building (classroom "donut" fronting onto and orthogonal to Putnam Avenue), demolish Part B of the existing building (gyms and auditoria fronting onto and orthogonal to Kinnaird Street), and create multiple new additions to accommodate the required program area of approximately 157,000 gsf.

The new design provides for the Lower School and the Upper School to be housed in Part A of the existing building, with a single shared primary "front door" on Putnam Avenue like the current school. Within the building, the Lower School and Upper School each have their own separate front doors. Each school is organized as a self-contained unit, layered vertically on the three available floors. The Upper School is located in the wing closest to Putnam Avenue and the Lower School in the wing closest to the playground. For educational and social reasons outlined in the Educational specification, it is important that the Lower and Upper schools have their own self-contained identity and separate teaching environments. In order to fit the new classrooms and break-out spaces within this existing classroom "donut" a series of additions must be constructed to expand the available footprint. These additions take the form of infill additions under the existing cantilevers, infill additions within the existing courtyard and rooftop additions in a number of locations.

Adjacent to the classrooms, across the primary entrance and public circulation space, are administrative and support spaces shared by both schools. At the far end of this central circulation spine, directly opposite the main entrance on Putnam, is the primary entrance from the East. This entrance serves students, parents and members of the community coming from the playground, Kinnaird, Hayes and Magee Streets.

Community spaces such as the auditorium, the small and large gyms, the after-school classrooms and the preschool, are provided in newly constructed space in the center of the site and towards Kinnaird Street.





Retention of Part A of Existing Building

In this option, the following issues contributed to the rationale for retaining Part A of the existing building:

- The concrete structure of columns and beams/slabs which supports Part A of the building is in good condition and may not require seismic upgrades: FBRA's Design Option Report assumed that Part A renovations would not be classified as a Substantial Structural Alteration; however, it was recommended that the building be at least capable of resisting full, IBC 2009 wind forces and 50% of IBC 2009 seismic forces. Ultimately, however, if significant alterations are necessary to fit the Program and introduce natural light into Part A, this renovation may in fact be classified as a substantial structural alteration.
- The embodied energy of the existing concrete mass has environmental value

Demolition of Part A of Existing Building

In this option, the following issues contributed to the rationale for demolishing some portions of Part A of the existing building:

- All other building components besides the structure are obsolete, past their life expectancy and in need of replacement. This includes the roof, windows, mechanical systems, electrical systems, plumbing and fire-protection systems. Approximately half of all classroom walls consist of demountable partitions that are never used and do not provide adequate levels of acoustic separation.

Demolition of Entire Part B Of Existing Building

In this option, the following significant issues contributed to the rationale for demolishing Part B of the existing building in its entirety:

- Part A, the classroom "donut", is constructed with concrete columns supporting concrete slabs with integral beams occurring regularly at 8'6" intervals. This part of the building is able to be economically upgraded to meet current seismic codes. The un-reinforced concrete-block bearing walls supporting Part B of the building with little or no anchorage to the roof structure, comprising the gyms and auditorium, is inherently less stable than Part A and does not conform to the current seismic codes for Massachusetts. This type of construction which requires significant reinforcement cannot be economically upgraded to meet current seismic codes. Given no change-of-use for the building, the Massachusetts State Building Code does permit the City to avoid upgrading the building to meet seismic codes, as long as certain thresholds and all applicable Appendices' requirements are met. Under the Work Area method of compliance (IEBC 2009), if more than 30% of the total floor and roof areas will be structurally altered (i.e. a Substantial Structural Alteration as defined in Section 807.4.2 of IEBC 2009), the altered structure must be capable of

resisting full IBC 2009 wind forces and 75% of IBC 2009 seismic forces. In addition, Part B with it's masonry bearing walls is subject to the MA Building Code Section 101.10 which requires compliance with Appendix A1 of the 2009 IEBC. Even if the project were not a Substantial Structural Alteration, Appendix A would require significant structural work. FBRA's Design Option Report concluded that if Part B were to be renovated, it would likely be classified as a substantial structural alteration, because the auditorium is substantially undersized and would need to be expanded by 60%, and the entire Part B of the building has no under-drains and is subject to flooding which can only be remediated by removal of the on-grade slabs. Further complicating any potential remediation is the fact that the structural expansion joint between Parts A and B is undersized, which cannot be increased without difficult and expensive demolition where the two parts of the building meet. Additionally a large part of the existing ground floor teaching spaces located in Part B have no windows (no natural light or ventilation) and adding appropriate windows to these instructional spaces would also cause the load bearing structural walls to be modified. Given the considerable changes required to accommodate the new program, maintaining the existing building largely "as-is" is not feasible. The structural engineer for the project has recommended demolishing Part B of the existing building and rebuilding it. Additionally, the City of Cambridge has indicated that they do not wish to avoid seismic up-grade of the building, given long-term safety concerns for the children.

- The large massing of harsh, Brutalist, window-less gyms close to the Kinnaird Street sidewalk which cannot be easily or economically altered because of its construction type
- The very high water table, low floor elevation without under-drains, sloped entrances and underground crawlspace tunnel that floods regularly
- The undersized and inadequate auditorium space which cannot be easily or economically altered because of its construction type
- The City of Cambridge and parents in public meetings have stated that they do not want to maintain the existing Part B

Program Fit

The existing building houses the current MLK, Jr. School (294 students), the Amigos School (334 students), and the MLK, Jr. Preschool (34 students). When complete, the new school will accommodate up to 740 students as follows: JK-5th = 400 students, 6th – 8th = 300 students and Preschool = 40 students. The combined 3 existing schools have a total of 50 instructional spaces, versus the combined new schools which have 64 instructional spaces. This is partially a result of the increased student population and partially a result of new and enriched learning and teaching environments as defined in the Educational Specification. The existing classroom "donut" is simply too small and not properly configured to accommodate the proposed increase in student numbers or the variety of enhanced learning and teaching spaces.

In order to accommodate this shortfall, this design option creates additional square footage in a number of locations contiguous with the existing classrooms. These locations include infilling under the cantilevers at first and second floors on Putnam Avenue, infilling at the ground and first floors on the east facade, building over the existing one-story preschool on Magee Street, numerous bays projecting into the existing courtyard on all floors, and additions on top of the roof at the third floor. The aggregation of the large number of small additions was able to provide sufficient area to meet the program, but rendered a compromised design that cost as much as a new building customized to fit the program. This issue of compromised program accommodation, along with others described below, was a big factor in deciding against this re-use option.

Zoning (Setbacks And Height)

As stated elsewhere in this document, the proposed new zoning regulations for K-8 schools will allow the existing school building to be used as a baseline dimensional template for creating a new school on the site and further, by a special permit granted by the Planning Board, certain additional dimensional regulations are made available to optimize site use and minimize impact on abutting residential properties. The Existing Modified Option will improve certain setbacks and create slightly better useable outdoor spaces over those currently afforded by the existing building and site configuration. This option is designed to conform to all of the proposed new zoning regulations for K-8 Schools allowed by special permit.

Building Orientation, Natural Light and Floor To Floor Heights

Part A of the existing building contains all of the classrooms, with windows facing due-east and due-west, accessed by naturally-lit corridors that overlook an internal courtyard. The courtyard is very pleasant, as are the corridors, but the classrooms are less optimally lit. This east and west orientation is the least desirable for classrooms, as the low morning and afternoon sun penetrates deep into the classrooms, disturb teaching and learning, and result in blinds being drawn. Once the blinds are drawn, they are rarely opened again after the sun moves. To compensate, all lights must be turned on, which in turn uses unnecessary energy. Studies have demonstrated that well ventilated, naturally lit classrooms foster better concentration and retention in students. See reference to Heschong Mahone Group 1999 study under Option 1: Refurbish Existing Building. The orientation of the existing building cannot be changed and it is very difficult to effectively control natural light on east and west facades, as opposed to

the north which has no direct sun, or the south which is easily controlled with overhangs. This factor was a major consideration when evaluating even partial re-use of the existing building. Optimizing natural light into classrooms is further hampered by the low 10'-6" floor-to-floor height of the existing classrooms. The new building options proposed 14'-0" floor-to-floor heights for classrooms, which allows for internal light-shelves to reflect light into the full depth of the classrooms. This feature, which along with the proper north and south orientation can create classrooms that are filled with natural light and may not require any artificial lighting, except on gray and dark days, can only be achieved in new construction.

Energy, Insulation and Net Zero
In this option, after full demolition of Part B and partial demolition of Part A, the resultant concrete foundations, columns and beams/slabs will form the skeleton of the new building. A completely new light-weight, externally-insulated, high-performance exterior envelope will be provide to completely encapsulate the existing construction, enabling it to function similarly to new construction in terms of insulation opportunities. The roof area available for PV panels on this option is slightly less than the Preferred Option and made more complicated by the existing roof monitors and extreme roof level variations that shade PV's. However, the design calls for creating a PV "canopy" floating above the monitors and above outdoor roof terraces to maximize the amount or PV area. This option did relatively well considering the inherent issues, but less well than the Preferred Option.

Parking Vs. Usable Open Space
The existing site contains 49 striped parking spaces, but based on the parking study conducted as part of the overall Feasibility Study, up to 88 cars are parked on site daily. The official striped parking is located in a paved lot adjacent to the basketball court, internal to the site. The unofficial parking occurs primarily along the strip of paved land between the existing gym wing and the Kinnaird Street sidewalk. This ad-hoc parking arrangement is not optimal. This condition cannot be much improved without taking over student play and recreation space to relocate parking, or substantially reducing the existing parking supply well below the demonstrated need. Neither the teachers not the neighbors favor either of these compromises. The issue of compromised useable outdoor space for students factored heavily in deciding that this partial re-use option was substantially less optimal than both new build options, and particularly when compared to the Preferred Option, which is able to provide most of the required parking underground, leaving more of the site free as useable outdoor space. The final design of these important outdoor program spaces will occur in the upcoming Schematic and Design Development phases.

Aesthetics and Functionality
A number of parents, neighbors, and members of the community at each of the three meetings, have expressed their strong distaste for the brutal concrete aesthetic of the building. Many have also complained about the functional shortfalls of the existing building design. By contrast, members of an international preservation group have spoken in favor of preserving the existing building as an example of Jose Luis Sert's work. However, the very nature of the modifications proposed in this Existing Modified Option to meet the space and energy requirements renders preservation of the historic kind moot. That argument is addressed under Option #1: Refurbish Existing Building

Cost

A cost model was created for this option. The total cost of this option was within a statistically insignificant variance from the Preferred Option (0.8% variance) given the preliminary nature of the Feasibility Study cost model.

Existing Modified pros:

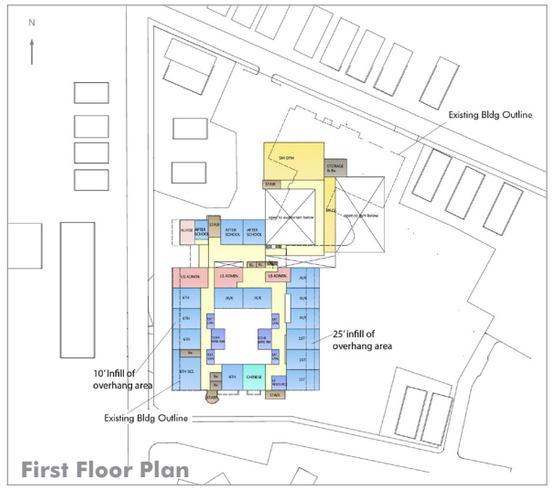
1) It's there – folks are "used-to-it" – may expedite permitting process
2) Lower floor to floor height creates lower massing – but existing monitors and rooftop mechanical spaces add height to be similar to proposed new-construction options
3) Less demolition required results in less trucking, dust, noise for neighborhood
4) Good general layout of classroom donut around inner court – plenty of natural light
5) Monitors provide good natural light to upper floor classrooms
6) Concrete structure to remain contains embodied energy
7) Dining and food-lab has good relationship to contained garden

Existing Modified cons:

1) Putnam "presence" less than optimal
2) Single entry identity on Putnam – split of schools occurs internally
3) Water issues – existing underground crawlspace susceptible to flooding
4) Inefficient single-loaded corridor layout of classroom donut
5) Classrooms orient due East and West which causes glare and heat gain issues
6) Monitors require floating PV's at higher elevation means added height and reduced light to monitors
7) Lower floor to floor height means lower ceiling heights and mechanical coordination issues and less natural light penetration into classrooms
8) No below-grade parking opportunity – all parking on site – less useable site for kids, especially if parking reflects real need (currently 80-90 cars park on site)
9) Learning commons is not the heart of the school
10) Organization of Public/Community Center functions is not optimal, some spaces, such as Lower School gym, is remote
11) Administration not located at front door to building, but instead at internal entrance to each school – distance to front door is similar to existing condition which has been problematic.

7.2 EXISTING MODIFIED

Ground Floor Plan



First Floor Plan

Second Floor Plan

Third Floor Plan

Site Plan

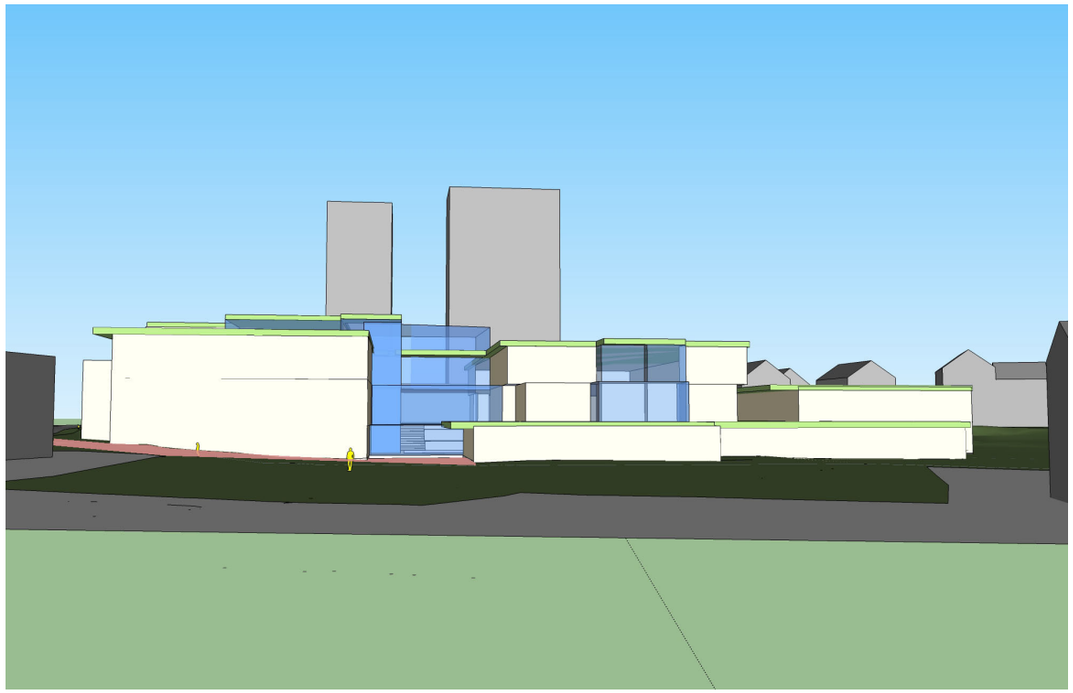
OPTION #3 CLOVER

Description (Size and Configuration)
This option is one of the New Building options studied in which the majority of the existing building would be demolished, leaving only a portion of the existing Ground Floor to be used for underground parking. The design for the new building is configured in three parts, loosely resembling a 3-leafed clover, around a centrally located internal gathering space with a stepped amphitheater. This internal space connects the upper west portion of the site adjacent to Putnam Avenue, with the lower east playground portion of the site. A courtyard on Putnam breaks up the building massing into two parts, the Lower School (JK-5), located to the left of a courtyard forms one leaf of the clover, while the Upper School (6-8) to the right of the courtyard and facing Magee Street, forms a second clover leaf. The shared and Community Spaces located on the lower east side form the third clover leaf.

The main entrance to the building is located at the end of the courtyard. All students, staff and parents would enter here directly into the central gathering space. Immediately to the left is the entrance to the Lower School with the LS office controlling access. Immediately to the right is the entrance to the Upper School with its own office controlling access. Each school is a self-contained learning and teaching environment, stacked vertically and accessible via dedicated internal stairs and shared elevators.

As this is new construction the design was able to provide for classrooms to orient north and south, which is optimal for both harvesting of natural light and sun control. In accord with the program, the Lower School is 2 stories allowing the school to be conveniently broken down into 2 teaching teams, while the Upper School is 3 stories, matching the 3 grade level teaching teams.

Program Fit
This Clover Option provides all of the program elements in accord with the dimensions and adjacencies specified in the Educational Specification, which is designed to further the City's Innovation Agenda. One deficiency which contributed to its rejection, was that while every classroom was provided with windows, a few of these windows opened onto interior spaces, rather than directly to outdoors.



Zoning (setbacks and height)
As stated elsewhere in this document, the proposed new zoning regulations for K-8 schools will allow the existing school building to be used as a baseline dimensional template for creating a new school on the site and further, by a special permit granted by the Planning Board, certain additional dimensional regulations are made available to optimize site use and minimize impact on abutting residential properties. The Clover option would create a better school for the students and staff, improve certain setbacks and create better useable outdoor spaces over those currently afforded by the existing building and site configuration. The height of the building is approximately 45′ as measured from the existing grade along Putnam Avenue (an average grade for the site was not established at this early stage, but it was estimated to be 2.5′ higher than the existing average grade). This height is similar to the height of the existing monitors on the existing building. This option is designed to conform to all of the proposed new zoning regulations for K-8 schools allowed by special permit.

Parking Vs. Usable Open Space
This option is able to accommodate approximately 30 parking spaces within the retained portion of the Ground Floor of Part A of the existing building. Retaining this portion of the basement has the added advantage of reducing shoring-and-bracing and fill-replacement along Putnam Avenue. This low-cost underground parking solution allows for fewer cars outdoors; approximately 45 on-grade parking spaces provides for conveniently-located accessible parking, short-term drop-off and pick-up for the preschool as well as planned teacher parking with the real parking demand occurring on site at the existing school. It should eliminate the ad-hoc parking in the pedestrian areas and landscape areas which occurs currently along Kinnaird Street. This parking arrangement is superior to Option #2 Existing Modified, as more of the site is available for useable open space.

Sustainability/Net Zero
Both new construction options feature the same high performance building construction technologies and systems. There is little difference between the Clover Option and the Pi Option when it comes to overall sustainability. All the same building systems, insulation, solar shading and light shelves, green roofs, etc. would be utilized if this option were developed. The greatest difference from the PI option is less site area available for landscaping & recreation due to a larger building footprint and more on-grade parking which impacts storm water control as well as open space. With specific regard to Net Zero potential, Clover had slightly more PV shadowing than the Pi Option because of more variegated roof heights. Refer to the Sustainability Massing Study in Volume 3, Appendix for a more complete analysis of this option with regards to energy use and photovoltaics.

Cost
The cost of this option was slightly higher than Option#2 Existing modified and Option #4 Pi (the selected Preferred Option), but once again, the costs of all options were quite similar, and all ranked with equal weight when selecting the Preferred Option.

Clover pros:
1) Good Putnam "presence" with 2 building masses flanking entry court
2) 2-story Lower School massing adjacent to "close" neighbor to the north
3) 2 teams for Lower School – one per floor
4) Large roof area allows more PV on rooftop than Existing Modified
5) Good direct access to/from Magee for drop-off & pick-up
6) Interior stepped "amphitheater" connects first floor and ground floor spatially
7) Classrooms orient due North and South (optimal sun orientation for simple control)
8) Learning Commons at heart of schools
9) Preschool outdoor play area can be separated and screened from site parking

Clover cons:
1) Single entry identity on Putnam – split of schools occurs internally
2) Acoustic issue at large interior common space between schools & near classrooms
3) Smaller exterior skin with less window area results in no direct natural light and ventilation to some important spaces
4) Less opportunity/higher cost for below grade parking (28 spaces) than Pi option
5) Largest footprint results in smallest remaining site area
6) Auditorium on exterior wall, while fitness internal – access to light reversed
7) Compromised community garden location

N
Ground Floor Plan

N
First Floor Plan

N
Second Floor Plan

N
Third Floor Plan

N
KINNAIRD ST
PUTNAM AVE
HAYES ST
MAGEE ST
parking
(20 spaces)
loading
preschool
playground
active play
basketball
court
garden
bike
racks
bike
racks
playground
equip.
bike racks
Site Plan

supporting the innovation agenda

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Perkins Eastman