City of Cambridge Department of Public Works

Municipal Facilities Improvement Plan No. 6657

Adaptive Capacity Report for CRLS, War Memorial and Library

Issue | June 28, 2019

Job number 245396-06

Arup USA, Inc
60 State Street
Boston MA 02109
United States of America
www.arup.com

ARUP

Contents

Appendices

Appendix A

Existing Infrastructure

Appendix B

The Study

Appendix C

Requirements

Appendix D

Example Flood Protection Measures

1 Executive Summary

1.1 Overview

As part of the City of Cambridge's (City) on-going climate preparedness and resilience planning efforts, the City is conducting an adaptive capacity evaluation of the Cambridge Rindge and Latin School (CRLS), War Memorial Recreation Center (War Memorial) and Cambridge Public Library complex as a community emergency response center. The City has existing plans to use the CRLS and War Memorial as an Emergency Shelter and an Emergency Dispensing Site for medication. The intent of this study is to expand the City's emergency planning work to include the impact of climate change risks on the sheltering and dispensing capacity at CRLS and War Memorial, and to identify opportunities to enhance the site's emergency response functions.

The focus of this study has been on the buildings and their physical systems, not the emergency planning and operational considerations of the site. Recommendations for operational enhancements were identified throughout the course of this study and meetings with various City officials and have been recorded in Section 5. Where applicable, those recommendations have also been included in this study. The following table provides a general overview of the proposed enhancements for increasing the adaptive capacity of the site, the associated complexity of implementation and the recommended ones in **red bold**.

	Proposed Enhancement with Recommendations in Red Bold		Location	Complexity
Power	**1**	**Back Up Power – Minimum Upgrade**	**All Buildings**	**Low**
	2	Back Up Power – Medium Upgrade	All Buildings	Medium
	3	**Back Up Power – Maximum Upgrade – Microgrid – Study**	**All Buildings**	**High**
	4	**Solar Photovoltaics on War Memorial roof**	**War Memorial**	**High**
	5	**Lighting Upgrades for better control**	**War Memorial**	**Medium**
	6	**Generator Testing – Load banks**	**All Buildings**	**Medium**
	7	Cogeneration systems	CRLS	High
Medication	**8**	**Additional refrigeration capacity**	**CRLS**	**Low**
Shelter	9	Structural assessment of War Memorial for Category IV	War Memorial	Low
	10	**Library cooling shelter**	**Library**	**Low**
	11	**Dual fuel boilers**	**All Buildings**	**Medium**
Communications	**12**	**Communication upgrades**	**All Buildings**	**Low**
Sitewide	13	Backflow prevention on drainage	CRLS & WM	Low
	14	Flood protection of garage entrance	War Memorial	Low
	15	**Sealing utility conduits, wall penetrations, and structure walls**	**Library**	**Medium**
	16	Anti-seep collars on utility trenches	Library	Medium

1.2 Background Information and Data Collection

As part of this assessment, the Arup team reviewed climate change projections, as-built drawings, site information, and existing emergency shelter and emergency dispensing site plans; held two charrettes with City of Cambridge stakeholders; set up meetings with City of Cambridge officials; and completed site visits for the CRLS, War Memorial, and Library facilities.

1.2.1 Climate Change Projections

This adaptive capacity assessment used data provided by the Cambridge Climate Change Vulnerability Assessment (CCVA) to understand the climate change risks associated with rising temperatures, extreme precipitation, and sea level rise and storm surge. This climate change data was reviewed against the site and infrastructure to understand the potential direct impacts to the complex as well as the overall impacts to the community that may result in increased reliance on this facility. The following table outlines the climate change risks that were considered.

Climate Change Impacts	CRLS Complex	Community
Temperature (Extreme Heat)	No increased risk at the site compared to the community as a whole. There may be increased demand on energy and cooling infrastructure, and the current shelter may see more frequent use as a cooling shelter.	By 2070, there is potential for a 600% increase in the number of extreme heat days over 90 degrees, from approximately 11 days annually to close to 70 days per year.
Precipitation	Limited expected flood impacts to the buildings, but access to the site may be affected.	Expected increase in stormwater flooding throughout the community, which may result in increased demand for the facility to be used as an emergency shelter.
Sea Level Rise & Storm Surge	Little to no risk of flood impacts to the site as a result of sea level rise and storm surge.	Expected increase in flood impacts to the community at-large and other emergency shelter sites, which may result in increased demand for this facility to be used as an emergency shelter in a flood event.

1.2.2 Stakeholder Charrettes

A kick-off charrette was conducted to understand the City's needs and desires related to the emergency response functions of the site. A further charrette was conducted to present the draft findings and proposals for comment.

Participants in the charrettes included Community Development Department, Department of Public Works, Department of Public Health, Fire Department, Electrical Department, Cambridge Rindge and Latin School, Public Library, Emergency Management, Human Services, and the Recreation Department.

1.2.3 Existing Conditions

To supplement the outcomes of the charrette, Arup conducted an assessment of the existing conditions of the site through a review of the as-built drawings and individual site visits to each of the buildings. The following table highlights the key findings for each of the building systems and further descriptions can be found in Section 3 of this Report.

System	Summary
Structural	The CRLS, War Memorial, and Library buildings were constructed over a wide timeframe (1931, 1955 and 2007, respectively with further renovations to CRLS and War Memorial in 2009 and 2011) and appear to be in good condition overall. It is unknown when the War Memorial was designated as an emergency shelter, however, it is understood this occurred before 2001. Based on the information provided, it could not be confirmed that the structure has ever been assessed for this use with respect to the increased snow, wind, and seismic load requirements by the latest Massachusetts building code. Though there is little structural concern related to using the War Memorial as an emergency shelter in events such as heat waves, cold snaps, hurricanes, floods, or fires, it is recommended the structural systems be evaluated for seismic load capacity if the building is intended to be used as a shelter after a seismic event. The CRLS and Library should similarly be assessed if their spaces are intended to be used for emergency dispensing or housing people –discussions with the Department of Public Health suggest that these spaces are not suitable for emergency dispensing and would not be required as long as the War Memorial is available. Additions or renovations to the War Memorial that significantly modify the structure or add any weight to the structure would require the building to be evaluated for an increased risk occupancy category and the corresponding increase of snow, wind, and seismic loads on the structural systems. Due to the code requirements when the buildings were originally designed, this kind of structural analysis may result in the need for upgrades to the building to resist the increased loads based on current codes.
Civil and Drainage	There have been a few isolated historic flood events that impacted the Library building; however, it has been reported that these were caused by failures of the infrastructure –water main breaks and cooling tower failure. In addition, the War Memorial roof has experienced leaks in the past.
Plumbing	The plumbing systems appear to be in good condition and there are sufficient numbers of restrooms and showers to operate the emergency shelter facility. The critical equipment for plumbing systems like pumps, water heaters, etc. is provided with emergency or standby power.
Electrical	The electrical systems have adequate capacity and separate incoming power and distribution systems. There is back-up power in each building serving fire pumps and life safety systems with some limited additional provisions in CRLS and the Public Library. A preliminary analysis of the power provisions on-site suggests that the generator capacity at CRLS could adequately operate the entire building on emergency power and that the on-site fuel oil storage could run the generator for approximately 9 days before additional fuel deliveries would be needed. Similarly, the installed and temporary generator capacity at War Memorial could serve the entire load of the building if one of the CFD's 2 temporary generators is provided.
Mechanical	There is adequate capacity within the mechanical systems and adequate ventilation in each of the buildings. Redundant heating and cooling equipment is also provided. In addition, one chiller in CRLS is connected to back-up power which could provide cooling to the whole building in mild conditions or a level of cooling in extreme conditions.
Communications	There are existing dead spots for cellular and radio coverage.

1.3 Findings & Proposed Enhancements

Based on feedback from the various City stakeholders and a review of existing conditions, the following enhancements were identified as opportunities for the City to improve the resilience and adaptive capacity of the CRLS, War Memorial, and Library complex. The column on the left identifies the minimum requirements for operating an Emergency Shelter or Emergency Dispensing Site and the column on the right details the Arup team's proposals for enhancing the adaptive capacity of the current site. The color-coding indicates compliance with minimum requirements and complexity of the adaptive capacity proposals:

- Green = compliant, or low complexity
- Yellow = compliant but could be improved, or medium complexity
- Red = not compliant, or high complexity

Minimum Requirements (MEMA/MDPH/Checklist)	Focus Area	Adaptive Capacity Proposal
ADA accessibility in public spaces including restrooms/bathing areas, dining facilities, and dormitories	Accessibility	None
Heating and cooling to provide comfortable temperatures inside facilities.	Shelter	
Queueing space prior to registration. Larger queueing areas are required when emergency dispensing site is active.		Acquire portable tents that allow sheltered spaces to be provided for exterior queuing during inclement weather
Loading dock access.		
Dormitory space (overnight patrons and staff).		Amend lighting controls and fixtures in Field House and Gymnasium to be locally controlled
Recreation (overnight patrons) and quiet/break areas (patrons and staff).		Structural building assessment of War Memorial for Category IV compliance if seismic events are a concern and if structural works are required as part of these enhancements
Administrative offices.		
Bathing facilities (overnight patrons).		

Minimum Requirements (MEMA/MDPH/Checklist)	Focus Area	Adaptive Capacity Proposal
Shall not be separated from owners. Provisions shall be supplied (food/water, hygienic disposal of waste, location for exercise).	Service animals	None
Refrigeration required for both food and medication storage. Any storage for medication shall be locked and items shall be stored separately to any food. Dedicated and locked refrigeration for vaccine storage. Basic Triage and First Aid care. Private screening areas.	Medication	Upgrade all refrigerators used for medication to be lockable
Charging stations for mobile devices are recommended Back-up power is recommended but not essential Access to backup power (for light, heat, medication refrigeration, and medical equipment).	Power	Photovoltaics on War Memorial roof and associated storage (eg batteries) Repair and reconnect Cogeneration System on CRLS roof Increase Generator Provision (e.g. install additional emergency receptacles, add emergency connections to generator backed boards and implement load shedding logic) Installation of Microgrid – refer to Section 5.1.1 for more details Improve generator testing - install load banks Add chillers and cooling pumps to Back Up Power
Public telephone access. Internal PA system.	Communications	Improve signal strength across the entire site to eliminate dead spots.

Minimum Requirements (MEMA/MDPH/Checklist)	Focus Area	Adaptive Capacity Proposal
Cell phone service. Emergency responder 2-way radio service. Internet (wireless or otherwise)		
Kitchen preparation space, food supplier, or food vendor (overnight patrons and staff). Refrigeration required for both food and medication storage. Any storage for medication shall be locked and items shall be stored separately to any food. Dining space. Food/snacks to be provided at heating/cooling shelters.	Food	Amend food service proposal to include food/snack delivery to the Library in the event of an active heating/cooling shelter. Operational adaptive capacity for consideration
Parking (including ADA compliant spaces) shall be provided for general public. Vehicular flow around the facilities shall be regulated and controlled to increase efficiency.	Transportation / Site Access	Add Backwater Valves (BWVs) to War Memorial and CRLS Flood mitigation strategies at parking garage
Security to enforce facility rules and prevent theft. Law enforcement command center (Dispensing Site only).	Operations	Operational planning, including combined operations of shelter and emergency dispensing site, planning for food and delivery, and planning for animals Communications planning for site operations and communicating with residents Education of Cambridge residents to understand emergency resources Training of staff to clearly define roles and responsibilities and specialized training needs

2 Overview

2.1 Project Goals

As part of the City of Cambridge's on-going climate preparedness and resilience planning efforts, the City is conducting an adaptive capacity evaluation of the Cambridge Rindge and Latin School (CRLS), War Memorial Recreation Center (War Memorial) and Cambridge Public Library complex as a community emergency response and resilience center. The City has existing plans to use the CRLS and portions of the War Memorial as a community emergency shelter that can accommodate up to 556 individuals in the event of an emergency. In addition, portions of the two facilities have also been designated as an emergency dispensing site for medication by the Cambridge Public Health Department.

These plans were developed through the traditional emergency management and public health planning processes but have not considered the potential impacts of climate change identified through the City's Climate Change Vulnerability Assessment (CCVA). The intent of this study is to expand the City's emergency planning work to include the impacts of climate change on the sheltering and emergency dispensing capacity at CRLS and War Memorial, and to evaluate the existing capacity of the complex to determine whether additional measures can create more robust resiliency.

The CRLS, War Memorial, and Public Library complex is uniquely positioned to serve the City as an effective emergency response and resilience center because the complex is located outside the identified areas of flood risk and heat island impacts according to the CCVA. Therefore, there are opportunities to use this complex in creative ways to address traditional emergency response activities as well as the new and increasing risks to the community as a result of climate change.

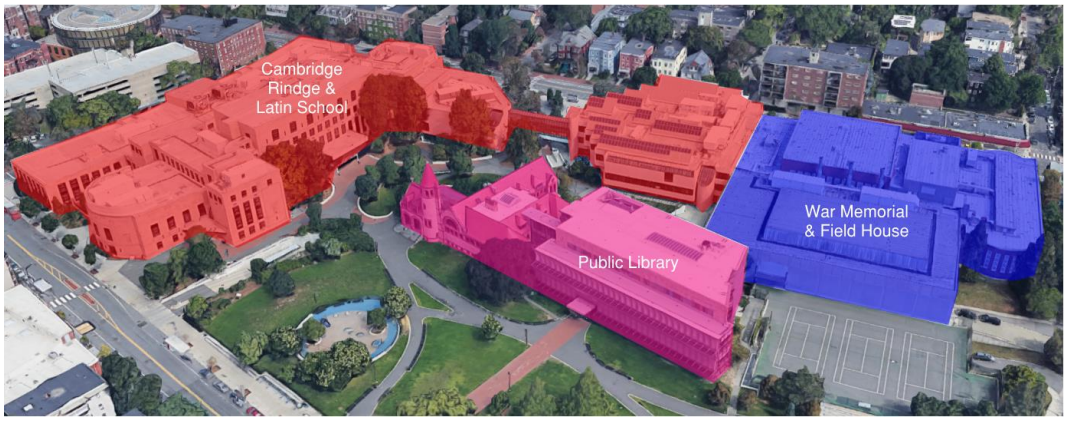
The focus of this study has been on the buildings and their physical systems, not the emergency planning and operational considerations of the site. Recommendations for operational enhancements were identified throughout the course of this study and meetings with various City officials and have been recorded in Section 5. Where applicable, those recommendations have also been included in this study.

2.2 Site Overview

The complex includes the Cambridge Rindge and Latin School, the War Memorial Recreation Facility, and the Cambridge Public Library, which was developed over a number of years:

- Cambridge Public Library – 1888
- Cambridge & Rindge Latin School – 1933 with renovations in 2011
- War Memorial – 1955 with renovations in 2009
- Media Center & Arts Center – 1976
- Field House, Tennis Courts & Parking Garage – 1976
- Cambridge Public Library Expansion – 2009

The following images show the layout and site plan for the complex.



2.3 Stakeholder Charrettes and Meetings

In order to effectively evaluate the emergency response functions of the complex and understand the City's needs for the functionality and operation of the site, coordination with key staff members at the City of Cambridge was essential. This coordination was accomplished through three main feedback loops:

1. A stakeholder charrette on February 26, 2019, which was intended to understand the City's goals for this complex and bring together the various departments with a vested interest in the site – both from the perspective of day-to-day operations and for its emergency response capabilities
2. Individual follow-up meetings were held with the Cambridge Fire Department, Department of Public Works, Electrical Department, and Human Services and Recreation Department
3. A stakeholder charrette on May 21, 2019 to present the initial findings and proposals to get feedback in advance of issuing the final report

The stakeholder charrette included key representatives from the following City of Cambridge Departments:

- Community Development Department
- Department of Public Works
- Fire Department
- Electrical Department
- Department of Public Health
- Cambridge Rindge and Latin School
- Public Library
- Emergency Management
- Human Services
- Recreation Department

The charrettes included a discussion of the drivers for this project, the current emergency response plans, any issues or concerns from City staff related to the facilities and their operations, proposed enhancements and general observations on the operation of the facilities under emergency conditions.

2.4 Data Collection and Document Review

In conjunction with the stakeholder charrettes and individual meetings with City Departments, the Arup team also reviewed the existing plans, as-built drawings, and applicable regulations and requirements that govern emergency shelters. The following section provides an overview of that document review.

2.4.1 Existing Emergency Shelter and Emergency Dispensing Plans

The CRLS and War Memorial are designated to serve as a community shelter and emergency dispensing site for medication. The following plans have been developed to define the operations and use of the two facilities for the emergency shelter and emergency dispensing functions:

- Cambridge Public Health Department Emergency Dispensing Site (EDS) Guidance – revised May 2015
- Cambridge Emergency Management Shelter Facility Resource: Cambridge Rindge and Latin School – updated June 2013

The two emergency plans currently use many of the same spaces to serve their purposes, including the 1st Floor Field House and 2nd Floor Gymnasium.

It has been discussed and confirmed by the Department of Public Health that the two operations would NOT occur simultaneously on this site. An Emergency Dispensing Site is for Biological, Chemical or Pandemic exposure to an act of terrorism or pandemic disease eg Anthrax, Avian Flu. It is not encouraged to have people congregating and sheltering in place in large numbers if such an event has ever taken place. They should be encouraged to stay in isolation as much as possible.

The War Memorial is the only location in Cambridge that provides such good access for the delivery of tractor trailers and pallets of medication so should take priority over the Emergency Shelter if both operations were ever required simultaneously in the City.

The following table provides more detail on the areas of the facilities that have been designated for use.

Location	Emergency Shelter Plan	Emergency Dispensing Site
Field House / 1st Floor	• Dorm Area – 396 people	• Dispensing • Medical Services • Ambulance Exit
War Memorial / 1st Floor	• Intake Registration • Command Center • Mental Health/ Quiet Space • Restrooms – 17 standard/ 6 accessible • Showers – 22 standard/ 20 accessible	
War Memorial / 2nd Floor	• Staff Break and Staff Dorm Area • Restrooms – 5 standard/ 2 accessible	
War Memorial / 2nd Floor (Gymnasium)	• Dorm Area – 160 people	• Dispensing • Medical Services

Location	Emergency Shelter Plan	Emergency Dispensing Site
CRLS (Arts Center) / 1st Floor	• Staff Break and Dorm Area	• Triage • Registration
CRLS (Arts Center) / 1st Floor (Auditorium)		• Additional Inclement Weather Staging
CRLS (Media Center) / 1st Floor (Cafeteria)	• Food Service • Recreation Area • Mental Health/ Quiet Space	• Cafeteria
Temporary location – South East corner of Field House	• Pet Trailer	

2.4.2 Applicable Requirements

The current emergency plans for the site are guided by the following documents.

- Department of Public Health – Emergency Dispensing Sites (EDS) – A guide for Local Health on Planning for Medical Countermeasure (MCM) Dispensing Operations – October 2017 (DPH)
- Massachusetts Statewide Mass Care and Shelter Coordination Plan: Local Shelter Toolkit – July 2018 (MEMA)

The key requirements of the documents describe good practice around:

- Accessibility – for all members of the population
- Shelter – sleeping accommodation
- Medication – access to medication to maintain health, mental health and function
- Power – Redundant source should be available but is not a requirement
- Communication – so all members of the population can be helped and informed
- Food – provision on site for a range of dietary requirements
- Service animals – providing food and supplies
- Transportation – access to all members of the population

Based on the requirements from MEMA and MDPH, the three buildings at the complex were evaluated in their current capabilities. The table below identifies the current uses of each building, the important capabilities based on these two guidance documents, and any additional recommended functions of services. Items in red text identify areas where the existing emergency response plans may need additional considerations to be in line with the guidance documents.

Buildings in Complex	Current Use	Important Capabilities	Other Recommended Functions or Services
War Memorial Recreation Center	• Emergency Shelter & Emergency Dispensing Site	• ADA accessible • Shared parking for 300 vehicles • Backup power • Dormitories for 556 • Only pre-prepared and delivered full meals • Loading dock • No inside queueing area capabilities • Dedicated refrigeration for vaccines is delivered	• Heating/cooling • Water • Charging stations • Showers • Triage • Pet sheltering services
Cambridge Rindge and Latin School	• Cafeteria is used for emergency shelter & dispensing site • Portions are used for inclement weather staging for emergency dispensing	• ADA accessible • Shared parking for 300 vehicles • Backup power • Kitchen/food preparation services • Large inside queuing area capabilities	• Heating/cooling • Water • Full meals able to be prepared on-site • Charging stations
Cambridge Public Library	• Not used	• ADA accessible • Parking garage under building • Backup power	• Heating/cooling • Water • No food or snacks are available; restricted to areas without carpeting • Charging stations

3 Climate Change Projections and Impacts

The City of Cambridge has a long-standing commitment to addressing the unavoidable impacts of climate change on the community. The City's Climate Change Vulnerability Assessment (CCVA) developed an understanding of the physical and social implications of our changing climate and established a technical foundation to make the City more resilient. The CCVA, developed in two parts, assesses the risks posed by increasing temperatures and precipitation as well as sea level rise and storm surge, and provides the technical foundation that underpins the City's climate change preparedness and resilience planning efforts.

This adaptive capacity evaluation is one component of the City's larger resilience planning efforts. The intent of this analysis is to assess the ability of these emergency response facilities to continue to operate and provide the necessary community support services to the City in the face of our changing climate.

This report not only assesses the potential direct impacts of climate change on the CRLS, War Memorial, and Library facilities and infrastructure, but also looks at the larger context of climate change impacts to the City of Cambridge and how those impacts may result in the need for more robust resiliency measures to accommodate the increased need for sheltering as a result of impacts to other areas of the City.

The following section outlines the expected future climate conditions within the City of Cambridge that form the basis of this analysis.

3.1 Rising Temperatures

Average and extreme temperatures are expected to increase significantly over the next 50 years. By 2070, we may see close to a 600% increase in the number of extreme heat days over 90 degrees, from approximately 11 days annually to close to 70 days per year, as demonstrated in the image below.

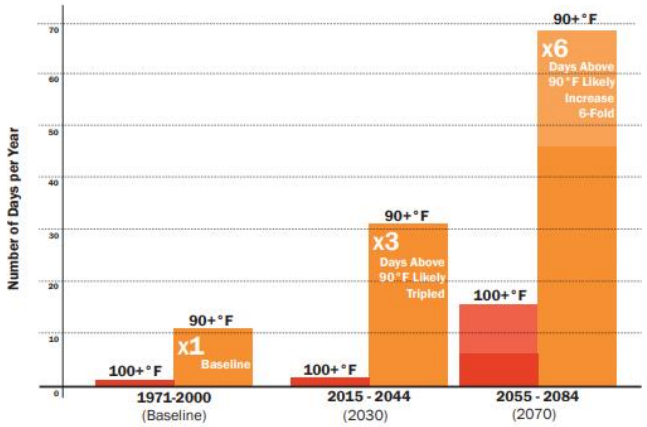


Fig. 15 **Number of days above 90°F** (Source: Kleinfelder based on ATMOS research, November 2015)

These rising temperatures have significant public health implications for the community and are likely to cause significant heat-related illnesses and deaths throughout the community, particularly in higher-risk populations like children, elderly, and lower-income communities with limited access to cooling. While the site is not expected to experience an increased impact due to exacerbated heat island effects in that area of the City, there is likely to be increased demand on the energy and cooling infrastructure of each of the buildings and an increased need to provide cooling shelters and services to the community at-large.

The existing cooling infrastructure appears adequate to cope with the current temperatures; however, equipment sizes and cooling capacity on-site may need to be increased as temperatures increase throughout the century. Additional upgrades to the building envelopes may also be needed to provide better insulation and passive cooling to the buildings.

3.2 Increased Precipitation

The site, and specifically the Public Library, has experienced some isolated historic flood events over the last 10 years. These recent events demonstrate a need to review the drainage infrastructure and flood protection measures on site in order to minimize any stormwater-related impacts to the site or the buildings.

While the impact of precipitation on the building infrastructure appears to be limited, accessibility to the Library site may well be affected and therefore alternative entry routes to the Library from Cambridge Street rather than Broadway should be considered if it is to be used as part of the Emergency Shelter or for general access.

The CCVA estimates that rainfall 24-hour rainfall events may increase by approximately 30% over the next 50 years. However, that increase in rainfall is not expected to cause a significant increase in precipitation-based flood events on-site between the present-day and 2070. The Cambridge FloodViewer shows that the 2070 100-year precipitation-based flood elevation on the site is 34.5’ CCB, which is the same as the present-day 1:100 flood elevation.

While the precipitation-based flood risk on-site may not increase significantly over the next 50 years, there is an expected increase in stormwater flooding throughout the community (as displayed in the 2070 100-year flooding from precipitation map below), which may result in increased demand on the shelter if shelters in affected neighborhoods are impacted or over populated.

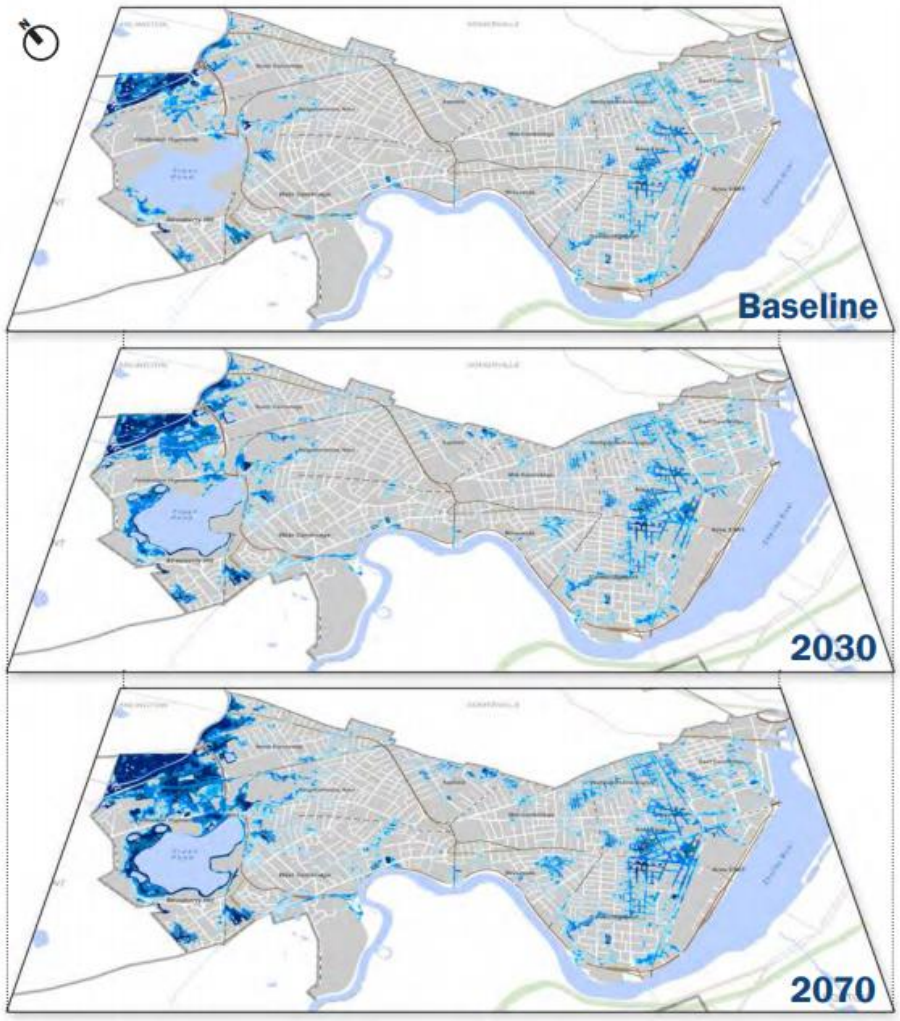


Fig. 10 **Inland Flooding – 100-year 24-hour storm** (Source: Kleinfelder with manhole flooding by MWH, riverine flooding by VHB, November 2015)

3.3 Rising Sea Levels

The site of the CRLS, War Memorial & Public Library is currently in an area that shows no risk of flooding from sea level rise and storm surge. Therefore, there is little future flood risk to the buildings. However, the increasing flood risk to the community may increase the frequency and capacity needs for using the site as an emergency shelter for the community. Therefore, operations planning should consider the impact on other emergency shelters in Cambridge that may be displaced in the event of flooding and might need to use this facility instead.

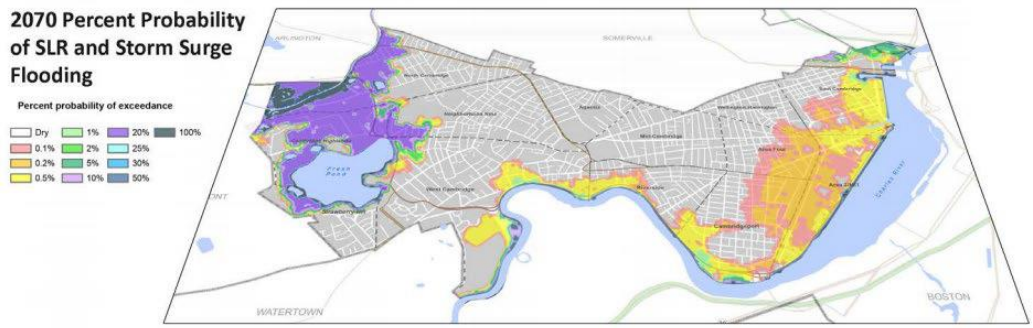
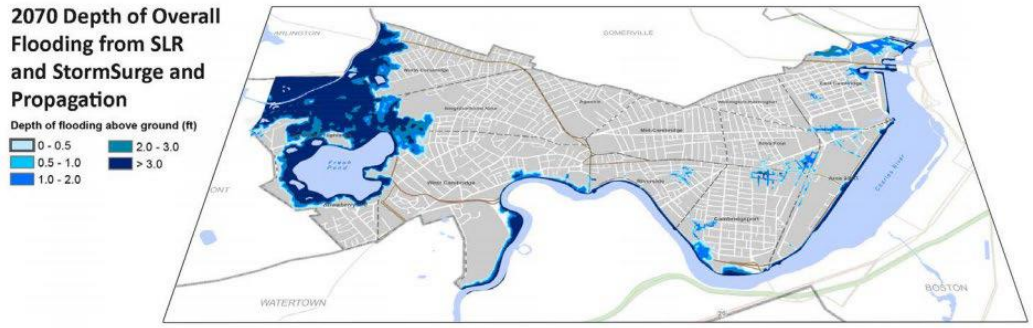


Fig. 9 Top map: **2070 Depth of Flooding from SLR and Storm Surge at 1% Probability** Bottom map: **2070 Percent Probability of Sea Level Rise and Storm Surge Flooding** (Source: Kleinfelder, February 2017, based on WHG MassDOT Boston Harbor Flood Risk Model)



4 Existing Conditions

A review of the existing conditions of the site was conducted to determine the current infrastructure and its ability to meet current requirements and future risks to the buildings and their functionality as emergency response facilities.

4.1 Structural

4.1.1 War Memorial

The current shelter layout is situated primarily inside of the War Memorial which was built in 1955. The primary structure is concrete construction with the fieldhouse as steel construction with CMU infill built in 1976. Minor structural renovations and mechanical penthouse rooms were built in 2009.

It is unknown when the building was first designated as an emergency shelter for the City of Cambridge, but it is understood that this occurred before 2001. To date we have been unable to locate any records surrounding this decision including any structural inspections or analysis of the building that have been produced. Based on this information, it could not be confirmed that the structure has ever been assessed as an emergency shelter with respect to the increased snow, wind, and seismic loads since the state of Massachusetts adopted the IBC and ASCE 7 as a base code.

Due to the code and building use changes increased loading on the building for equipment or PV or major alterations to the building would require an assessment of the building's structural capacity with regards to the increased loads and include evaluating the increased risk category for the building. Based on the current Massachusetts Building Code – CMR 780 9th edition, which provides amendments to the International Building Code – 2015 (IBC), the school would fall under a risk category of III and need to be increased to a IV as an emergency shelter. Snow, seismic, and wind loads each use importance factors in their calculations that are directly related to the building risk category and a change from a III to IV would increase snow loads by 9% and seismic loads by 20%. By alteration requirements, affected structural elements and systems are required to be evaluated if the gravity load increases by more than 5% and the lateral load increases by more than 10%, therefore any change to the building that triggers an alteration/renovation assessment by CMR 780 would result in an analysis of the affected structural members. Due to the code requirements when the building was originally designed these increased loads may result in the need for upgrades to the building to resist the increased loads.

From visual inspections, the building appears to be in good condition and its designation as an emergency shelter for events including heat waves, cold snaps, hurricanes, or fires is not of concern structurally. However, it is recommended that the War Memorial structural systems be evaluated for seismic load capacity in the

future if the building is intended to be used as an emergency shelter after a seismic event. Built in 1955, the building would not have been designed for seismic loads, and in the event of an earthquake sections of the building may be damaged and considered structurally unsafe.

4.1.2 Cambridge Rindge & Latin School

The CRLS was originally built in 1932 of concrete construction with additions and minor renovations to the structure in 1976. Building design was completed prior to modern code standards for wind and seismic lateral forces, and without any recent renovations the building has most likely never been assessed for increased forces and code requirements. The structure has been designated as a FEMA emergency shelter and assessed separately for those requirements.

Currently, the kitchen is the only part of the structure which is designated as part of the city emergency therefore we would not recommend that the building need to comply with emergency shelter loading requirements. However, should the CRLS be considered for housing people or medical dispensing, the structure should be reevaluated for the change in risk category.

4.1.3 Cambridge Public Library

The Library is mixed steel and concrete construction designed in 2006 under the CMR 780 6th edition. No major renovations have taken place since original construction and the structure has been maintained in good condition.

Currently the library is not being used for emergency sheltering or as part of a wider “campus” for emergency response and the proposed uses of the structure would not include housing people or medical dispensing. Therefore, we would not recommend that the building need to comply with emergency shelter loading requirements. However, should the library be considered for housing people or medical dispensing, the structure should be evaluated for the change in risk category.

4.2 Mechanical

4.2.1 War Memorial

The War Memorial and Field House mechanical design currently consists of three air handling units (AHU), one chiller, and five boilers located in the War Memorial mechanical room and two AHUs on the Field House roof. Together these pieces of equipment service the War Memorial building with 31,700 CFM conditioned air, 20,200 CFM ventilation, and 10-million tons of heating max.

The system is appropriately sized for the expected capacity of the building, with some flexibility and redundancy built in. All AHUs are variable volume and the second AHU on the Field House roof is usually offline, only turning on if needed based on CO2 sensors. There are 5 boilers total but the building can run on 3, providing backup capacity in the event of failure or unexpected demand. Finally, heating hot water (HHW) and chilled water (CHW) are interconnected between the War Memorial and CRLS providing extra resilience, but not full redundancy.

4.2.2 Cambridge Rindge & Latin School

The CRLS mechanical system is comprised of 2 chillers with 750 ton cooling capacity each, located in the S112 Chiller Room, 7 boilers with both primary and secondary loops located in the S231 Boiler Room, and 21 rooftop units (RTU) located on the CRLS roof, 11 of which are on standby power.

The system provides a sufficient amount of heating and cooling for the building occupancy, with resilience built in via the interconnected CHW and HHW system with the War Memorial, as well as having 7 boilers with the building only needing 3 to have sufficient heat. Further, there is a cogen on the CRLS roof that is currently offline due to the expense it takes to run as well as the state of the system with inefficiencies like bent rods and not enough ways to dissipate heat.

4.2.3 Cambridge Public Library

The Library mechanical system is currently set up with AHUs split between the old and new sections of the library, with HHW and CHW all being served from the boilers and chillers in the new basement mechanical room. The AHUs have a combined capacity of 109,200 CFM conditioned air, with 43,500 CFM ventilation. There are 4 AHUs total, AHU-1 and 2 in the new mechanical basement, and AHU-5 and 6 in the old mechanical attic. All are VAV except for AHU-6.

There are 2 gas-fired boilers, with a combined heating capacity of about 5,800 MBH. For cooling, the building has 2 chillers from 2007 that provide a combined 450 tons cooling to the whole library. Neither runs on emergency power.

4.3 Electrical

The table below summarizes the power provision and resilience on site. It is based on site visits, reviews of the as-built electrical drawings and electricity bills for the facilities. The numbers are all approximate as the exact power factors of all equipment are not known.

Building	Normal Supply	Back Up Power	Peak Load	Average Load (over a year)
War Memorial	~1900kW	Generator – 355kW Generator connection – 160kW	490kW	180kW
CRLS	~2400kW	Generator – 1500kW Cogen – 70kW PV – 30kW	1480kW	350kW
Library	~1600kW	Generator – 300kW PV – 65kW	595kW	200kW

Refer to section 5.1.1 for a detailed analysis of the existing facility electrical loading.

4.3.1 War Memorial

The War Memorial's main electrical service is provided by Eversource and is fed from a 13.8kV unit substation located in the parking garage. The main switchboard is rated for 2,500 amps at 480/277 volts. The maximum capacity of the switchboard is approximately 1,662 kVA.

An existing 300 kVA diesel generator is located on the roof and provides power for the fire pump only. War memorial life safety and critical loads such as fire alarm, emergency lighting, boilers, sump pumps, and selected plug loads are powered from the CRLS emergency generator. Equipment currently backed up by the generator include emergency lighting, fire pump, five boilers, and two sump pumps.

An existing docking station is located on the exterior to provide additional backup power to the building. The docking station is rated for 200 amps and sized for connection to a maximum 150 kVA temporary generator.

4.3.2 Cambridge Rindge & Latin School

The CRLS's main electrical service is provided by Eversource and is fed from a 2,500 kVA utility transformer located in a dedicated vault located on level 1. The transformer feeds two main switchboards each rated for 3,000 amps at 480/277 volts. The two main switchboards have the capacity for approximately 4,000 kVA however, the utility transformer serving the two switchboards is only rated for 2,500 kVA.

An existing 1,500 kVA diesel generator is located on the roof and provides emergency (life safety) and optional standby power for the facility. Equipment currently backed up by the generator include emergency lighting, fire pump, majority of power to the kitchen, about half the roof top units, one chiller, and majority of the air conditioning units.

Existing photo-voltaic (PV) panels are located on the roof of the CRLS Arts Center. There are two inverters each rated for 15 kW each, for a total capacity of 30 kW.

4.3.3 Cambridge Public Library

The Library's main electrical service is provided by Eversource and is fed from a utility transformer located in a dedicated vault located in the basement. The transformer feeds a main switchboard rated for 2,000 amps at 480/277 volts. The maximum capacity of the switchboard is approximately 1,300 kVA.

An existing 300 kVA diesel generator is located on the basement and provides emergency (life safety) and optional standby power for the facility. Equipment currently backed up by the generator include emergency lighting, exhaust fans, and sump pumps.

4.4 Plumbing

4.4.1 War Memorial

The incoming services, sanitary and storm outfalls exist on the Cambridge Street side. The sanitary and storm mains route in the basement and appear to drop before existing the building. Branches connecting to the storm main that are susceptible to flooding have backwater valves to prevent the ingress of water into the building during a flood. The storm main does not have a backwater valve; however, due to the drop in elevation before exiting the building, flooding of the municipal storm drainage in the street is not expected to affect the building operation. There has been no indication that flooding is an issue in the War Memorial. There sump pumps and ejectors in the basement are on emergency power.

The War Memorial has two (2) gas-fired hot water heaters located on level 2 which helps the resiliency of this facility during flooding or power outages. The hot water is a recirculating system that appears to be on standby power; the gas equipment/accessories also appear to be on standby power. Due to the current use and occupancy of the War Memorial there are more than enough ADA and non-ADA showers, restrooms, and sinks to support the emergency shelter and the emergency dispensing functions from a plumbing stand point.

4.4.2 Cambridge Rindge & Latin School

This section focuses on the CRLS Arts Center as it is connected to the War Memorial and will be the most sensible facility to occupy if the need arises. The Arts Center has numerous storm and sanitary outfalls in the lower level that connect to the civil drainage for the general CRLS campus. There does not appear to be backwater valves on the sanitary or storm outfalls to civil but there has been no indication of flooding in this facility in the past. There are sanitary and storm ejector pits and pumps on the basement level which are on emergency power.

There are two (2) incoming water feeds to CRLS, which support the Arts Center as well, these are a 5” service on the Broadway Street side and a 4” service on the Cambridge Street side. The hot water is a recirculating system fed from two (2) gas fired water heaters on the second level of CRLS. The primary boilers, recirculation equipment, and associated gas equipment are currently on standby power. There are also stand-alone electric water heaters that are used as backup in case the gas water heaters malfunction. The Arts Center has an adequate amount of restroom facilities to support the emergency shelter and emergency dispensing, in conjunction with the War Memorial. The Arts Center has plenty of non-lavatory sinks that can be utilized for emergency dispensing purposes.

4.4.3 Cambridge Public Library

The Library, from a plumbing perspective, has adequate fixtures and equipment to act as an amenity space to compliment the War Memorial and CRLS Arts Center. Flooding has been noted in the library but the source of this seems to be through other utilities (electrical conduit) and is addressed under the Civil Engineering narrative of this report.

4.5 Civil and Drainage

4.5.1 Overview of Drainage Infrastructure

This section describes the state of the existing civil and drainage infrastructure serving the complex. It has been compiled based on the record as-built information, site visits and desk top studies.

The existing storm drainage serving the site is collected from the neighborhoods northeast and southeast of Lorentz Park and conveyed by gravity into a large circular stormwater storage tank in Lorentz Park near the main entrance to the Library. The stormwater storage tank is approximately 30 feet deep and is assumed to be constructed water tight. The storage tank is dewatered by a 4 HP duplex pump system with a 4-inch discharge forcemain to the municipal separate storm sewer system in Broadway.

The Broadway storm sewer system conveys flows westerly along Broadway, then southerly along Quincy Street and DeWolf Street, ultimately discharging to the Charles River. The major stormwater carrier pipes serving the neighborhood are indicated on the image below in blue.

4.5.2 Historic Flooding

City of Cambridge staff have indicated infrastructure failures, including a water main break and a cooling tower failure, have previously caused flooding at the site, including:

- Storm water runoff entering the garage entrance and ponding at the bottom of the garage ramp;
- Groundwater was conveyed along utility wall penetrations in the garage, causing water to drip on the electrical panel in the garage; and,
- Water seepage entering the south side of the stone library building in the staff area

Feedback from attendees at the Charrette suggested that stormwater and groundwater are not known to have caused any flooding at the site.

4.5.3 Present-day Precipitation Impacts

City of Cambridge FloodViewer indicates present-day 1:100 probability flooding (i.e. 100-year event) is anticipated adjacent to the site along Broadway and Ellery Street (indicated in green in Image 2). FloodViewer also identifies the Ellery Street driveways to the loading dock and to the garage below the Field House and Tennis Courts as being at risk of flooding during a present-day 1:100 precipitation event. This flooding may cut off access to the Ellery Street loading dock during a flood event, and presents a flood risk to the electrical substation and switchgear located in the garage below the Field House and Tennis Courts.

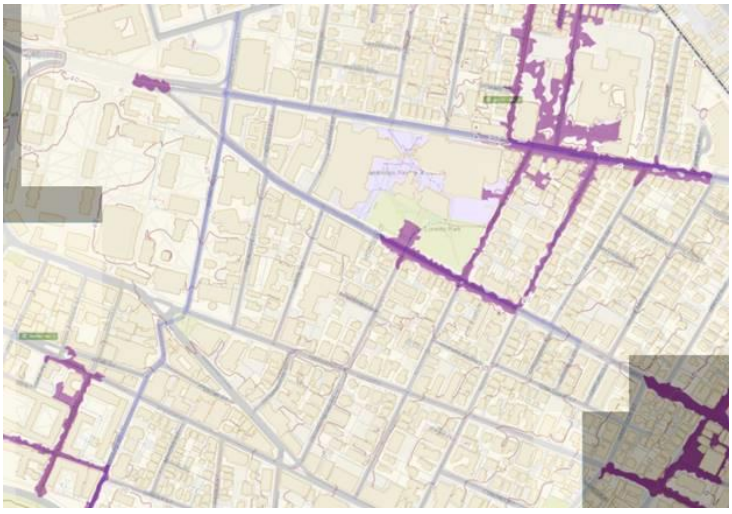
The Present Day 100-Year Precipitation flood elevation for the property is identified in Cambridge FloodViewer as elevation 34.5’ Cambridge City Base (CCB). We note the Present Day 100-Year Precipitation flood elevation for 96 Ellery Street (directly across the street from the loading dock and garage driveways) is identified as elevation 29.1’ CCB.

We consider it likely that the existing pipe networks in Broadway and Ellery Street and/or the Lorentz Park stormwater storage tank has insufficient capacity to convey and store the present-day stormwater runoff from the 1:100 probability flood event. We note that increasing the capacity of these stormwater management systems to discharge stormwater away from this area may increase the flood risk to properties downstream.

The image below displays the potential present-day flood risk to the site from the 1:100 precipitation event.

4.5.4 2070 Precipitation Impacts

The City of Cambridge FloodViewer indicates no significant local increase in flooding at the site between the 1:100 present-day and the 1:100 precipitation event in 2070. The 2070 100-Year Precipitation flood elevation on the site is identified in Cambridge FloodViewer as elevation 34.5' CCB, which is the same as the present-day 1:100 flood elevation. However, adjacent properties and the surrounding neighborhoods do experience increased flooding during the 2070 scenario (indicated in purple in the image below). Of particular note, increased flooding is anticipated along DeWolf Street, indicating any increase in stormwater flows away from the site may exacerbate downstream flooding during the 2070 scenarios.



5 Proposed Enhancements

This focus of this assessment was a review of potential physical improvements to the complex to improve the resilience and adaptive capacity of the site. The following table provides a brief overview of the recommended enhancements and how those enhancements should be assessed in relation to each other. These projects should also be assessed against and coordinated with the City's net zero and climate mitigation goals.

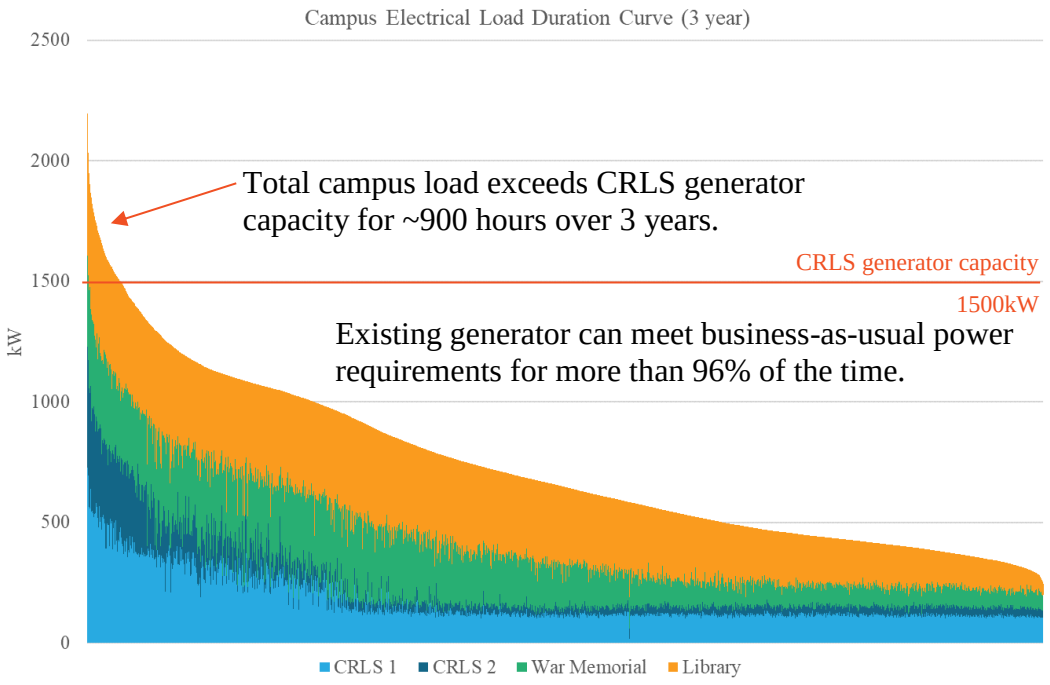
	Proposed Enhancement		Location	Complexity
Power	1	Back Up Power – Minimum Upgrade	All Buildings	Low
	2	Back Up Power – Medium Upgrade	All Buildings	Medium
	3	Back Up Power – Maximum Upgrade – Microgrid – Study	All Buildings	High
	4	Solar Photovoltaics on War Memorial roof	War Memorial	High
	5	Lighting Upgrades for better control	War Memorial	Medium
	6	Generator Testing – Load banks	All Buildings	Medium
	7	Cogeneration systems	CRLS	High
Medication	8	Additional refrigeration capacity	CRLS	Low
Shelter	9	Structural assessment of War Memorial for Category IV	War Memorial	Low
	10	Library cooling shelter	Library	Low
	11	Dual fuel boilers	All Buildings	Medium
Communications	12	Communication upgrades	All Buildings	Low
Sitewide	13	Backflow prevention on drainage	CRLS & WM	Low
	14	Flood protection of garage entrance	War Memorial	Low
	15	Sealing utility conduits, wall penetrations, and structure walls	Library	Medium
	16	Anti-seep collars on utility trenches	Library	Medium

5.1 Physical & Infrastructure Enhancements

The following section provides an overview of the proposed infrastructure enhancements based on our review of the existing conditions of the site and the feedback received from City staff on the needs of the site.

5.1.1 Power

Existing load data for the CRLS campus has been provided by the City of Cambridge and shows that the peak combined electrical load for all three buildings exceeds 1,500kW for less than 900 hours over the three years. This means that, if reconfigured, the existing 1,500kW generator located within the School could power the whole facility in a business-as-usual manner for all but ~300 hours per the year. If the Library were not connected to a centralized system, the load is less than 1,500kW for all but ~80 hours during the three-year period (approximately 26 hours per year). The load duration curve below shows the hourly facility load sorted by magnitude for a three-year period. This graph is used to show how frequently a facility's load is above or below specific thresholds. In this case, the graph shows that the overall facility load is larger than the CRLS generator for less than 900 hours over the course of the 3-year period. This means that the CRLS generator has a high probability of being able to meet the business-as-usual facility load (>96% of the time).



Based on this, it appears that the existing 1500kW generator can power the facility during a power outage. Some load-shedding is recommended (option 2 or option 3 on the following pages) in order to allow the system to accommodate higher-than-usual loads which may be present during a shelter-in-place condition.

Additional capacity and redundancy could also be added by connecting the existing 300kW Library generator to a microgrid to provide a total of 1,800kW. The combined generator capacity could power the facility in a business-as-usual manner for all but ~50 hours a year. Automatic curtailment of critical loads would allow the system to operate as long as a diesel fuel supply is available. Furthermore the addition of the Library generator to the system will provide increased resilience in the event of a failure of one of the generators – the facility would still be able to power critical loads.

Furthermore, addition of one or more battery energy storage systems (BESS) could provide additional resilience in the form of fuel diversity in the case of a generator failure. Combining a BESS with the existing PV systems would allow them to participate in the upcoming DOER Clean Peak Standard which provides an incentive for using clean energy (batteries charged from the PV system) to offset peak grid loads. This would provide an additional revenue stream and thereby decrease the expected payback period. Depending on the technology used and configuration of the system, the addition of a BESS could also provide an un-interruptible power source for the most critical loads on the campus as needed. A BESS system could also be configured as a redundant power-source to the existing generators, such that critical power could be provided for select loads in the event of a generator failure, in order to ensure that a minimum of loads could remain powered while the generator is repaired, or a temporary generator procured.

It is recommended that a more detailed microgrid study be completed to determine the optimal system configuration in order to better understand the operational benefits and costs associated with the backup schemes discussed below.

1. Back Up Power – Option 1 – Limited backup power								
Enhancement	Provide additional critical receptacles for backup power throughout the facility							
Focus Area	Accessibility	Shelter	Service Animals	Medication	Power	Communications	Food	Transport/ Site
Location	All buildings							
Scope Description	Provide receptacles connected to a new optional standby system in critical locations throughout the buildings.							
Complexity	Low		Medium			High		
Assessment	Feasibility of this option is based on final metering of the panels within the existing optional standby system. Refer to the sketch below for potential panels which could be used to feed new receptacles							

Figure 1: Panels within the War Memorial

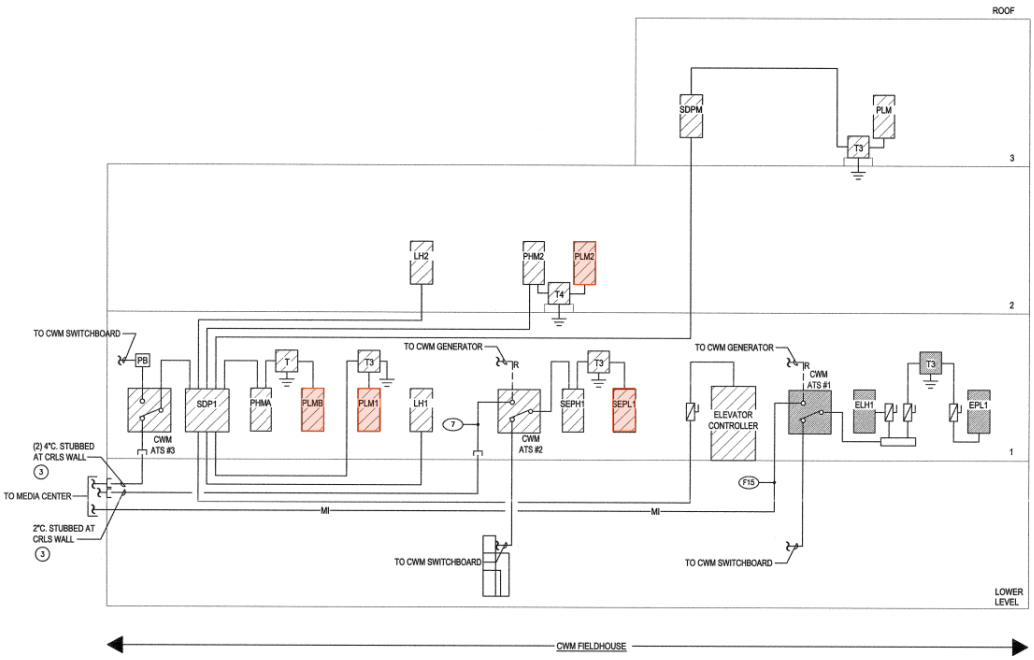
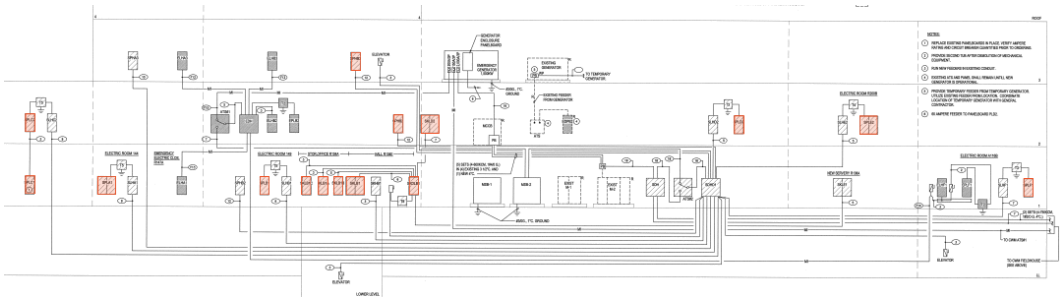


Figure 2: Panels within the CRLS



Based on the overall facility load information provided, it appears to be likely that the indicated panels should have sufficient electrical capacity to accommodate new loads. Further site visits are required to confirm the feasibility of using the indicated panels.

2. Back Up Power – Option 2 – Full Manual Back Up								
Enhancement	Use existing generators to provide complete backup to the building using manual control and load shedding							
Focus Area	Accessibility	Shelter	Service Animals	Medication	**Power**	Communications	Food	Transport/ Site
Location	All buildings							
Scope Description	Provide an additional feed from the CRLS emergency generator to the War Memorial and Library main switchboards. Provide provisions to power the main switchboard from the generator when utility power is lost. Include a remote shunt-trip from the fire pump start circuit to remove optional standby power and ensure the generator has capacity for the fire pump.							
Complexity	Low			**Medium**		High		
Assessment	This option will allow full building backup, although manual control will be required to ensure that the generator does not overload as the existing load indicates that during certain times of the year the facility load will exceed the capacity of the CRLS generator. As it is anticipated that shelter-in-place scenarios may require additional power than business-as-usual, it is likely that some areas within the building may need to be isolated and de-energized. To keep operations of this system manageable, the option does not include provisions to connect the Library generator.							

Figure 3: Work Required within the Library

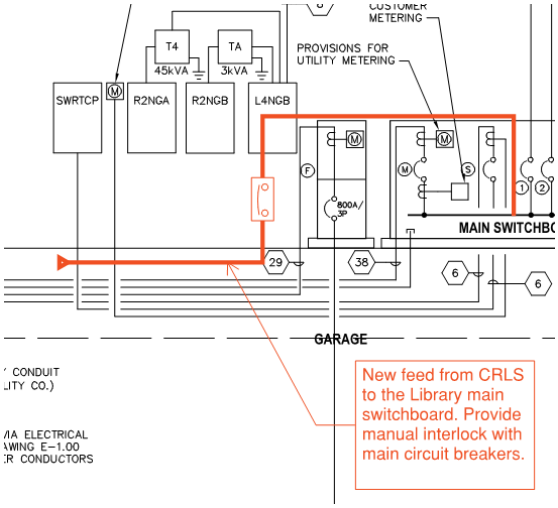


Figure 4: Work Required with the CRLS Building

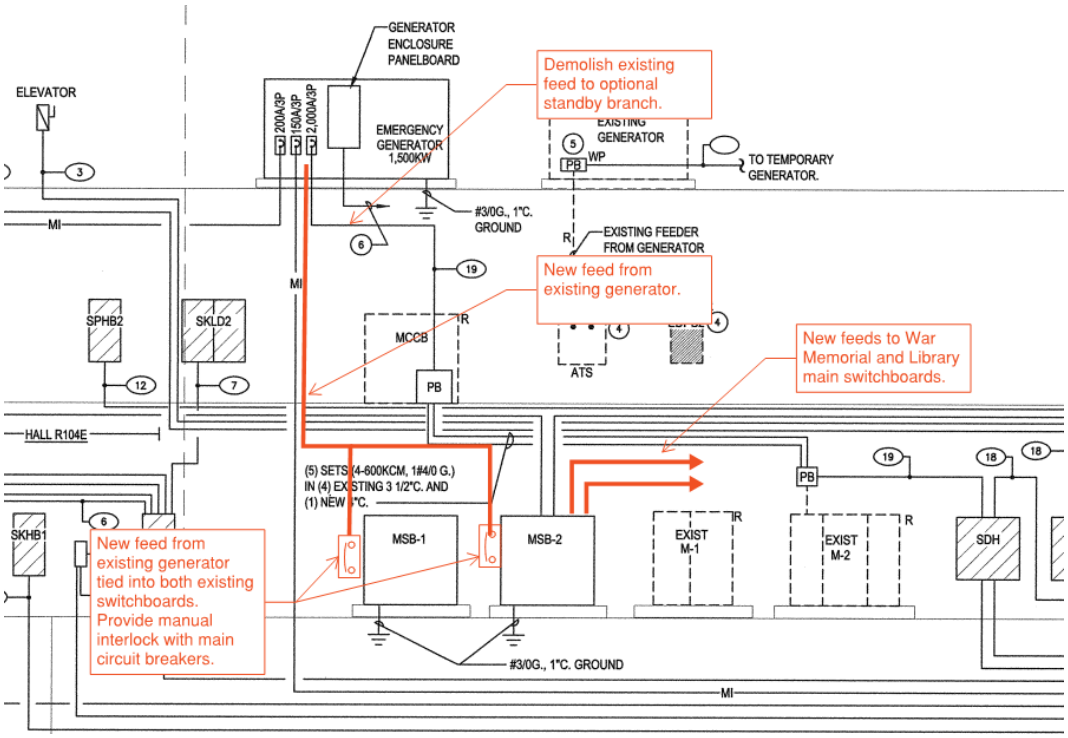
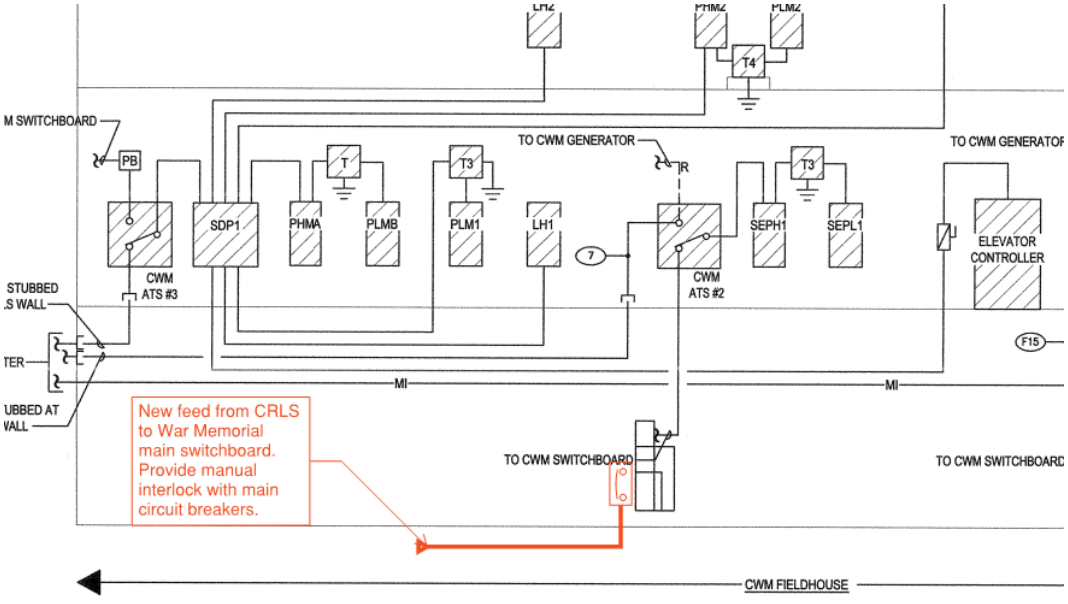


Figure 5: Work Required within the War Memorial

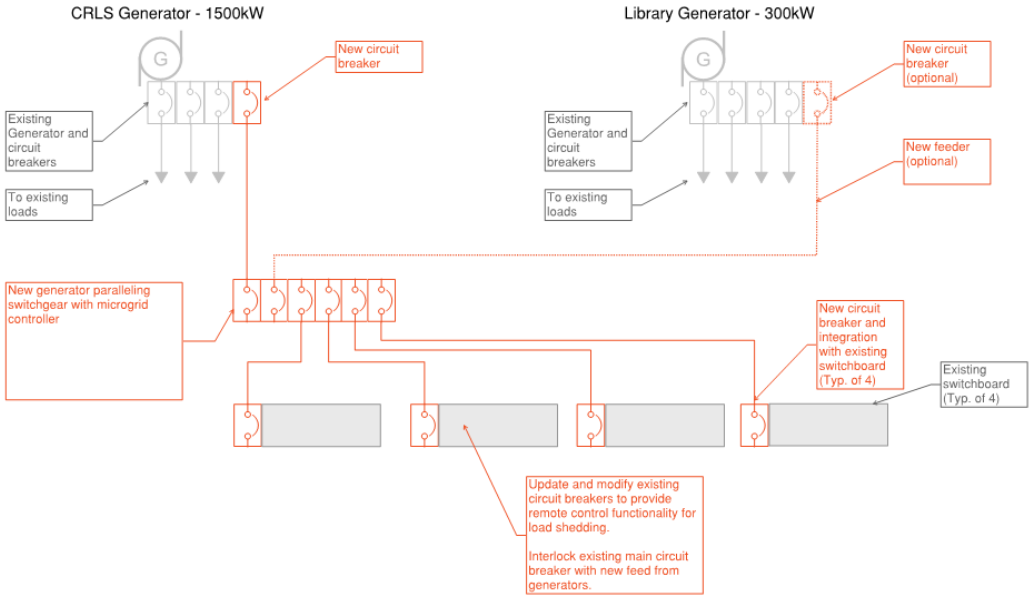


3. Back Up Power – Option 3 – Microgrid								
Enhancement	Use existing generators to provide complete backup to the building using automatic controls via a microgrid for load shedding and control							
Focus Area	Accessibility	Shelter	Service Animals	Medication	Power	Communications	Food	Transport/ Site
Location	All buildings							
Scope Description	This option is similar to Option 2, however additional metering and automatic controls are provided to allow the system to control generating capacity and loads on the fly. Scope includes: Provide an additional feed from the CRLS emergency generator to the War Memorial and Library main switchboards. Provide provisions to power the main switchboard from the generator when utility power is lost. Include automatic load control to load-shed any loads which exceed generator capacity. As an additional option, the Library generator could be connected to increase the expected diversity and therefore allow more loads to be served at any time. Additional on-site generating capacity could also be included to allow more loads to be served, increase the number of hours per year during which all loads could be powered, increase resilience. Integrating a gas generator, and/or a battery energy storage system to the microgrid would also provide fuel diversity in addition to the other benefits described above.							
Complexity	Low			Medium			High	
Assessment	This option will provide the best control of on-site generation and allow more loads to be powered when the utility power is lost. This option will also require the most significant interventions and costs.							

Figure 6 summarizes one method for interconnecting and controlling the microgrid. Further detailed study is required to determine the feasibility of interconnecting all systems as shown.

Further study is also required to determine the feasibility of interconnecting the existing PV and cogeneration systems to a microgrid. This would provide additional resilience and backup power capacity; however, the extra benefits may not outweigh the additional costs and complexity which would result.

Figure 6: Possible Method for Interconnecting and Controlling the Microgrid



4. Installation of PV on War Memorial Roof								
Enhancement	Improve power resilience							
Focus Area	Accessibility	Shelter	Service Animals	Medication	Power	Communications	Food	Transport/ Site
Location	War Memorial Roof							
Scope Description	Install 200kW rooftop PV system capable of producing 283.1 MWh per year. The integration of a PV array with a microgrid or local energy storage would be required in order for the PV system to be able to provide a resilience benefit.							
Complexity	Low			Medium		High		
Assessment	Installation of PV on the War Memorial has a high level of complexity due to the structural implications of adding load to the building as described previously in this report. The increased load on the roof would result in an assessment of the affected structural members and may result in upgrades to the structural system.							

Figure 7: Potential PV Installation on War Memorial Roof

5. Lighting upgrades								
Enhancement	Increase controllability for shelter-in-place areas							
Focus Area	Accessibility	Shelter	Service Animals	Medication	Power	Communications	Food	Transport/ Site
Location	Field house and gymnasium							
Scope Description	Replace existing controls (and luminaires/ballasts/drivers as required) in order to allow enhanced control to shelter-in-place areas located in the first floor field house and second floor war memorial gymnasium.							
Complexity	Low			Medium			High	
Assessment	This will require re-work of the existing circuits and controls. If existing luminaires in these spaces are not compatible with dimming then replacement/retrofit of luminaires will be required.							

6. Load banks								
Enhancement	Provide exterior load banks to facilitate generator testing.							
Focus Area	Accessibility	Shelter	Service Animals	Medication	Power	Communications	Food	Transport/ Site
Location	All buildings							
Scope Description	Provide new load banks to allow for 50% load testing of all generators. Alternatively, provide provisions for connection of trailer-mounted generators during testing. Any new generators provided for any options above should be provided with 50% load banks.							
Complexity	Low			Medium			High	
Assessment	This option will ensure that generators can be tested under load and will therefore reduce the likelihood of wet stacking from running generators loads below manufacturer's recommendations.							

7. Cogeneration System								
Enhancement	Repair or replace existing cogeneration equipment							
Focus Area	Accessibility	Shelter	Service Animals	Medication	Power	Communications	Food	Transport/ Site
Location	CRLS Roof							
Scope Description	Repairing or replacing the existing cogeneration (power and heat) equipment on CRLS roof and connecting it into the power and heat distribution network where it would be most beneficial and cost effective.							
Complexity	Low		Medium		High			
Assessment	Bringing the CRLS Cogen (CHP) online would provide an extra 75 kW (maximum) electrical output and 511,000 Btu/h (maximum) extra thermal capacity in the event of the school being used as a shelter. Information received during the charrette suggest that the unit has never been set up to deliver quite as much heat and power as the name plate suggests but could still provide additional resilience. The additional power from the unit would be very beneficial if the power supply to site was lost. However how to use the heat is the harder part. In winter, the heat could be used in the general heating hot water system as it is currently connected. In summer or shoulder months, the heating load is much lower and this heat is not used. This could be overcome by installing a plate heat exchanger between the cogen plant and the domestic hot water system to produce hot water for sinks, taps and showers or to connect the system to the swimming pool (although in summer, the pool is rarely heated) Due to the distance between the Cogen and the pool, however, this option would likely be an expensive system to run and a further study on relocation of the CHP would be recommended in this case. In the event of a relocation the scope and cost would be greatly increased, with all systems running to and from the cogen needing relocation as well. Another contribution to the complexity of this recommendation is the current state of the cogen system being in slight disrepair. According to the facilities manager there are bent rods and when running, not a robust enough system in place to effectively distribute the waste heat. If relocation of the cogen is being seriously considered, it is recommended a cost benefit assessment be completed on relocation vs. replacement.							

5.1.2 Medication

8. Additional Refrigeration Capacity								
Enhancement	Kitchen refrigeration backup							
Focus Area	Accessibility	Shelter	Service Animals	Medication	Power	Communications	Food	Transport/ Site
Location	CRLS R138 Media Cafeteria and 1413 Culinary Arts Kitchen							
Scope Description	Further emphasis on security and redundancy needed for CRLS refrigeration capacity							
Complexity	Low			Medium			High	
Assessment	It has been confirmed by CH Alliance and Cambridge Public Health Department that no onsite refrigeration is required on site for medication. In the context of receiving medication to inoculate thousands of Cambridge residents over a short period of time, the anticipation would be the receipt of medication in tractor trailer trucks from the State and Federal governments. However, the current EDS plan states that 3 refrigerators should be available at the site so this recommendation stands in lieu of an agreement as to whether additional refrigeration is required on site. In either event, security measures such as locks on the storage units would also need to be implemented to maintain safe operation.							

5.1.3 Shelter

9. Structural building assessment of War Memorial for Category IV compliance								
Enhancement	Carry out structural structural building assessment of War Memorial for Category IV compliance							
Focus Area	Accessibility	Shelter	Service Animals	Medication	Power	Communications	Food	Transport/ Site
Location	War Memorial & Field House							
Scope Description	Carry out structural assessment of War Memorial and Field House to determine building safety and compliance to seismic event and Category IV compliance in latest codes							
Complexity	Low		Medium			High		
Assessment	It is unknown when the War Memorial was designated as an emergency shelter, however, it is understood this occurred before 2001. Based on the information provided we do not believe the structure has ever been assessed for this use with respect to the increased snow, wind, and seismic load requirements by the latest Massachusetts building code. Though there is little structural concern related to using the War Memorial as an emergency shelter in events such as heat waves, cold snaps, hurricanes, flood events, or fires, we do recommend the structural systems be evaluated for seismic load capacity if the building is intended to be used as a shelter after a seismic event.							

10. Cooling Shelter in Library								
Enhancement	Upgrading library mechanical equipment to emergency power							
Focus Area	Accessibility	Shelter	Service Animals	Medication	Power	Communications	Food	Transport/ Site
Location	Library							
Scope Description	Library basement mechanical room equipment enhancements.							
Complexity	Low		Medium			High		
Assessment	The library currently has 109,200 CFM (43,500 OA) capacity of cooling with all four (4) AHUs online (AHU-1 & AHU-2 in new library basement, and AHU-5 & AHU-6 in old library attic mechanical room). The two (2) chillers have a combined capacity of 450 tons of cooling. The square footage of the full library totals 103,200 sq ft which gives us an overall cooling factor of about 1 CFM/sq ft or 1 ton of cooling for about every 230 sq ft, which is greater than the standard design capacity for mechanical systems of about 1 ton/400 sq ft. The mechanical system of the library is therefore above the needed capacity, allowing it to have flexibility to cover the increased heat gain due to a higher capacity of occupants when being used as a cooling shelter. Further recommendations in this proposed scenario include backing up both the chillers and duty/standby pumps on emergency power as they reportedly are not currently on							

11. Dual Fuel Boilers								
Enhancement	Increase flexibility of boiler operation to allow for usage of onsite oil as fuel							
Focus Area	Accessibility	Shelter	Service Animals	Medication	Power	Communications	Food	Transport/ Site
Location	Boilers in all buildings							
Scope Description	Enhancement to existing boilers and associated piping scope. Further exploration into onsite oil storage capacity and availability for use.							
Complexity	Low	Medium	High					
Assessment	This would be a straightforward, yet somewhat invasive process by which to add resilience on site in the event of disrupted gas service. Converting the boilers to dual-fuel would allow any of the buildings to be heated from oil (already stored onsite for generator fuel), until more fuel is able to be brought in from an outside source. The upgrade would consist of purchasing and replacing each boiler burner to a dual-fuel burner for gas and oil. Further, new fuel oil lines would need to be run to the closest storage tanks and all associated equipment and accessories (pumps, filters, controls, etc) would need to be installed. This would require an initial investigation into the capacity of the storage tanks and quantities already there and an assessment on the actual resilience improvement vs cost and difficulty of this upgrade. These assessments should be done separately for the three buildings.							

5.1.4 Communications

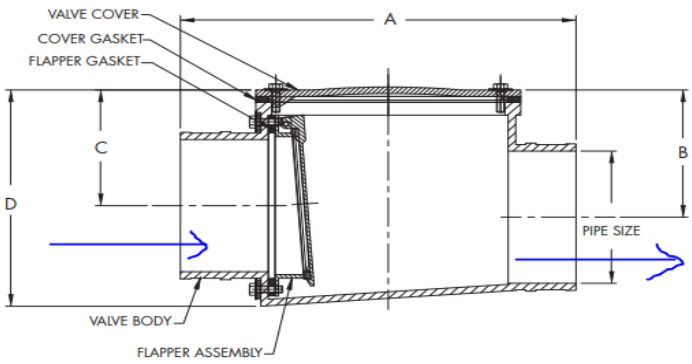
12. Communications Upgrades								
Enhancement	Assess and improve cellular and radio coverage in CRLS, War Memorial and Library							
Focus Area	Accessibility	Shelter	Service Animals	Medication	Power	Communications	Food	Transport/ Site
Location	CRLS, War Memorial and Library							
Scope Description	Survey of existing coverage and installation of additional antennae to achieve necessary coverage in all areas of the facilities							
Complexity	Low			Medium			High	
Assessment	It has been advised that the communications signal strength for cellular phone, radio and walkie-talkies is intermittent within the main CRLS building and across the site including a number of deadspots where all signal is lost. We recommend that a full survey is carried out across the site to determine the signal strength in all areas. That survey can then be used to assess what specific head end hardware and antennae are required in which locations in order to achieve an acceptable signal strength throughout. The antennae could be selected as multi-frequency to cover a range of devices or multiple antennae could be used. There should be consideration for bi-directional amplifiers (BDA) to be considered as well antennas to ensure all areas of the foot print can communicate via cell phones given the high reliance on these devices and the footprint.							

5.1.5 Flood Protection

13. Backflow Prevention on Drainage								
Enhancement	Adding backwater valves on the storm and sanitary drainage branches							
Focus Area	Accessibility	Shelter	Service Animals	Medication	Power	Communications	Food	Transport/ Site
Location	CRLS basement, War Memorial basement							
Scope Description	Most of the low-level storm and sanitary waste fixtures do not have backflow prevention on the individual branch lines. Depending on how susceptible Cambridge Street and the CRLS campus is to surface flooding there is the possibility of an ingress of water or waste back into the building. Backwater valves would mitigate this risk by providing local backflow prevention on the most susceptible fixtures and drainage stacks.							
Complexity	Low		Medium			High		
Assessment	CRLS and War Memorial do not have a history of flooding during storms so this is a lower priority. The complexity is dependent on the access of the numerous waste stacks in the basement and crawlspace areas in CRLS and War Memorial. The storm system should take priority over other waste streams as the storm sewers in Cambridge Street and Ellery Street are anticipated to be surcharged during the Present-Day 100-Year precipitation flood event. This proposed enhancement is for safe measures in case of significant surface flooding where the municipal drainage in the area has been overwhelmed.							

A second option for backflow protection of the sanitary and storm systems would be to install larger backwater valves on the main outfalls leaving the building. This would stop any backflow closer to the source, require fewer backwater valves, and would be easier to install in many cases due to access in the basement/crawlspaces; lowering the complexity of this enhancement.

Figure 8: Detail of Intended Backwater valve



<table>
<tr><th colspan="9">14. Flood Protection of Garage Entrance</th></tr>
<tr><td>Enhancement</td><td colspan="8">Improved flood protection and decreased flood risk to the building</td></tr>
<tr><td>Focus Area</td><td>Accessibility</td><td>Shelter</td><td>Service Animals</td><td>Medication</td><td>Power</td><td>Communications</td><td>Food</td><td>Transport/ Site</td></tr>
<tr><td>Location</td><td colspan="8">War Memorial – Entrances to the Garage and Loading Dock from Ellery Street</td></tr>
<tr><td>Scope Description</td><td colspan="8">Investigate the flood elevation at the entrances to the Garage and Loading Dock from Ellery Street (Cambridge Floodviewer indicates a 2070 100-Year Precipitation flood elevation of 34.5’ BCB at the site property, and 29.3’ BCB directly across the street at 96 Ellery Street).

Investigate installing permanent and/or deployable flood barriers to a height of 12-inches above the flood elevation to cut off the overland flow path of flood water from Ellery Street into the garage including:

• Raised speed hump on the two garage entrance driveways and the loading dock driveway, to be located near the Ellery Street sidewalk, or
• Raise the elevation of the garage and loading dock driveways, or
• Deployable flood gates across the garage and loading dock driveways, and
• Earth berm or structural flood wall in the landscape areas adjacent to the two loading dock driveways

Develop an alternative Field House Loading Dock delivery plan (e.g., temporarily redirect deliveries to Cambridge Street) in case Ellery Street becomes impassable during a flood event.</td></tr>
<tr><td>Complexity</td><td colspan="3">Low</td><td colspan="2">Medium</td><td colspan="3">High</td></tr>
<tr><td>Assessment</td><td colspan="8">Cambridge FloodViewer identifies the garage and loading dock entrances on Ellery Street as being at risk of flooding during the 2070 100-year precipitation storm, placing electrical infrastructure in the garage at risk of flood damage, and potentially restricting access to the Field House Loading Dock. Cutting off the surface flow pathway from Ellery Street to the garage may mitigate the flooding.</td></tr>
</table>

<table>
<tr><th colspan="9">15. Sealing Utility Conduits, Utility Wall Penetrations, and Structure Walls</th></tr>
<tr><td>Enhancement</td><td colspan="8">Improved flood protections for the site and decreased flood risk to the building</td></tr>
<tr><td>Focus Area</td><td>Accessibility</td><td>Shelter</td><td>Service Animals</td><td>Medication</td><td>Power</td><td>Communications</td><td>Food</td><td>Transport/ Site</td></tr>
<tr><td>Location</td><td colspan="8">Library</td></tr>
<tr><td>Scope Description</td><td colspan="8">Investigate sealing of wall penetrations (e.g. utility wall penetrations, wall joints, floor joints, sump pits, etc.), sealing of utility conduits at manholes located outside of building, and installing waterproof sealants or membranes on structure walls. Sealants and plugs should be designed to withstand pressure associated with a water elevation of 35.5’ CCB (includes 1’ of freeboard above present-day and 2070 100-year flood elevations). Investigate joints and openings in walls and floors (including floor drains) as potential additional seepage locations.</td></tr>
<tr><td>Complexity</td><td colspan="2">Low</td><td colspan="3">Medium</td><td colspan="3">High</td></tr>
<tr><td>Assessment</td><td colspan="8">Historic water infiltration at the library is likely caused by water flow pathways along and through utility conduits. Sealing utility conduits at manholes on site may cut off the flow pathway through the utility conduits and sealing below-ground wall penetrations within the building may cut off flow pathways along the exterior of utility conduits. As water may find alternate flow paths if a single wall opening is sealed, all potential wall openings near historically flood-prone areas should be investigated to be sealed.

This strategy may be considered low-priority as the historic flooding is assumed to have been caused by infrastructure failures, and there is no known risk of groundwater or surface water flooding.</td></tr>
</table>

16. Installation of Anti-Seep Collars on Utility Trenches								
Enhancement	Improved flood protection and decreased flood risk to the building							
Focus Area	Accessibility	Shelter	Service Animals	Medication	Power	Communications	Food	Transport/ Site
Location	Library							
Scope Description	Investigate installing concrete or bentonite anti-seep collar (a.k.a "trench dam") on utility trenches associated with wall openings near historically flood-prone areas. Anti-seep collars should extend a minimum of 24-inches beyond the side and bottoms of existing utility trenches to cut off flow of water along the utility trenches to the buildings. Anti-seep collars to be installed the lesser of the following distances: 20 feet from the building, or between utility manholes and the building.							
Complexity	Low			Medium				High
Assessment	Historic water infiltration at the library is likely caused by water flow pathways along and through utility conduits. Utility conduits are typically installed with a bedding of granular material, which creates a preferential flow pathway from the surrounding site to the building. Installing anti-seep collars on underground utility connections to the building may cut off the flow pathway along the utility conduits. This strategy may be considered low-priority as the historic flooding is assumed to have been caused by infrastructure failures, and there is no known risk of groundwater or surface water flooding.							

5.2 Operational Enhancements

In additional to the potential physical improvements to the facility discussed above, several opportunities for operational enhancements were noted:

- **Prioritization**. It was noted that the War Memorial is the only location in Cambridge that provides such good access for the delivery of tractor trailers and pallets of medication so should take priority over the Emergency Shelter if both operations were ever required simultaneously in the City. This should be clearly communicated as part of any Incident Command Structure.
- **Combined operations plan**. In reviewing the documents for the Emergency Shelter and the Emergency Dispensing Site facility, it was noted that there is no combined operations plan for how the shelter and the dispensing facility could operate together. It has been discussed and confirmed that the two operations would NOT occur simultaneously in the same location. An Emergency Dispensing Site is for Biological, Chemical or Pandemic exposure to an act of terrorism or pandemic disease eg Anthrax, Avian Flu. The site would be used to dispense the needed medication for families to heads of households while families shelter in place. It would not be wise to have people congregating and sheltering in place in large numbers if such an event has ever taken place. They should be encouraged to stay in isolation as much as possible. The City should undertake a study to determine alternative Emergency Shelter sites if the War Memorial is being used as an Emergency Dispensing Site.
- **Staff training**. During the workshop with key City of Cambridge staff, it became clear that there is a need for additional staff training to ensure that everyone understands how the shelter and dispensing facility are intended to operate and how the operations may change depending on the nature of the emergency event. This includes clearly defined roles and responsibilities for all shelter and emergency dispensing staff, including a better understanding of who is in charge in certain situations and the hierarchy of staff and decision-makers. Both operational plans include an Incident Command Structure but these should be reviewed, updated and clearly communicated to ensure everyone is clear what their roles are.

  It is understood that the Fire Department recently conducted an emergency training for approximately 20 City of Cambridge staff with Red Cross officials, and a separate training was conducted for 5 Cambridge employees related to managing animals in an emergency. In addition, food-specific training will also be scheduled. These trainings set a great foundation for ensuring that staff understand what to do in an emergency and should continue to be conducted at regular intervals in the future.

- **Operational planning exercise**. To facilitate staff training, a desktop planning exercise could be a useful tool to bring together the different staff and departments and make sure there is a clear understanding of each staff members role during an emergency.
- **Food and delivery considerations**. As noted above, there are several constraints related to use of the kitchen facilities, availability of kitchen staff, and needs for regular food delivery. These are important considerations for effective operations of the shelter and there should be clear guidelines for how food will be provided at various levels of shelter operations.
- **Occupant comfort**. Changes to the operations or layout of the shelter and dispensing facility should consider occupant comfort wherever possible. The design and layout of the shelter can be used to create spaces that will provide more comfort to the shelter occupants, including quiet spaces, family areas, areas where lighting levels can be better controlled, etc. In addition, if tents are used for queuing outside during warm weather, close attention should be paid to the residents in the queue to ensure that they are not suffering from heat-related impacts.
- **Acoustic considerations.** There are a wide variety of auditory needs (ranging from hearing loss to inability to cope with loud noises) that the City may need to accommodate during an emergency shelter situation. Specific consideration should be given to acoustic considerations to address these auditory needs, including availability of quiet spaces and ear plugs for those residents who are unable to cope with loud noises, alternative communication methods for those with hearing loss, and permanent or temporary alterations to the site that help mitigate noise impacts.
- **Clearly communicate staff roles to residents**. During shelter operations, it is important to make sure that staff roles are clearly communicated to shelter residents, so that they know who is in charge of certain tasks and understand who to ask for assistance.
- **Transportation, shuttles and wayfinding.** Consideration should be given to how residents can access the shelter and dispensing facility. The City should develop plans for shuttles and/or pick-up services for residents without access to a car. There should also be directions available for how to get to the facility via public transportation and there should be clear signage and wayfinding throughout the City to direct people to the shelters. It's possible the transit system may not be operating effectively in an emergency, so the City should also have a back-up plan if additional shuttles and other transportation accommodations are required. These transportation plans should be readily accessible to residents and clearly communicated via trainings and other educational opportunities.
- **Site access.** Access to the shelter or emergency dispensing facility could be restricted in the event of an emergency. The City of Cambridge should review site access concerns, including potential stormwater flooding along Cambridge

Street, and develop a plan for how to access the shelter if normal access to the site is restricted because of street flooding or other limited events.

- **Resident education**. Education and resources for Cambridge citizens may also help in ensuring efficient operations of the shelter and dispensing facility. If residents have training on what to do in certain emergencies, the types of resources they should keep in their homes and where to get those resources, and are aware of the resources provided by the City of Cambridge, including the location of shelters and when and how to use them, we expect that all of Cambridge's emergency shelters will be able to operate more effectively and efficiently and that all of Cambridge's residents will be safer and better prepared in an emergency.
- **Planning for animals**. During emergencies, a key concern for many residents is the safety of their pets and that often affects the decisions people are willing to make in terms of evacuation and using shelters. It is critical to have clear plans for how animals can be accommodated within the shelter, including considerations for service animals and people with allergies to pets, both of which may provide limitations on where pets can be sheltered. The shelter plans noted a location for a pet trailer, but no other information on accommodations for animals.
- **Special accommodations.** The operations plan and all staff training should ensure that staff are aware of procedures for any special accommodations that may be needed by residents using the shelter. Some examples of special accommodations that may be needed include: religious needs, dietary restrictions, mental health, medical conditions, physical limitations, homeless, elderly, nursing mothers, and young children.
- **Specialized training.** Specific staff should be identified who have the resources to deal with residents who have unique needs. This may include dealing with the homeless population, elderly, residents with mental health issues, etc.

- **Communications and satellite phones.** The operations plans should provide clear guidance on the available communications systems and how they are intended to operate. There should also be a back-up plan in the event that the communications lines go down and/or the system is overloaded, and it becomes difficult to use the main communications system. There are a limited number of satellite phones in the City, perhaps 5. There may be consideration to acquire additional satellite phones or additional radios for the purpose of onsite communication in the event of an emergency. An emergency communications plan should be developed in conjunction with the necessary training and table top exercise
- **Communications.** It has been confirmed that the City of Cambridge website is hosted in Healy Building so would not be affected and could continue to be used a means to communicate messages to the local population if any of these buildings were to go down. The site is planned to be moved onto the cloud in December 2019 which would further enhance its resilience.
- **External coordination.** There are several external resources located nearby to CRLS that could be leveraged to provide additional services in the event of an emergency, including the nearby pharmacy, food providers, and hospital and medical facilities. The City should consider discussing its emergency plans with some of these external partners to determine if there's an opportunity to work together and to put a place in place to ensure effective coordination and partnership during an emergency.

5.3 Additional Enhancements

5.3.1 Charging Station

The facilities could be used as a Charging Station for local residents in case of power outage or during the Emergency Shelter or Dispensing operations

- Smart phones use approximately 5W to charge for approximately 2 hours
- Tablets use approximately 10W to charge

There is plenty of normal electrical capacity to serve this amount of power.

If the charging station were to be required when power had been lost then dedicated connections could be made to some of the standby power equipment:

- Additional standby power receptacles could be installed within the War Memorial
- The cogen plant (70kW) would be able to charge in excess of 4000 smart phones and 4000 tablets
- The PV on the War Memorial (30kW) would be able to charge in excess of 1500 smart phones and 1500 tablets
- The PV on the Library (65kW) would be able to charge in excess of 3000 smart phones and 3000 tablets

For each solution, the purchase of a number of charging stands and setting up dedicated tables would be recommended.

5.3.2 Additional Community Resilience Opportunities

From a community resilience perspective, the complex has a unique opportunity to serve a variety of community needs for Cambridge residents, even if they don't need sheltering or emergency dispensing services. Some of the potential opportunities to expand the usage of the site are detailed below.

- Provide charging stations for the community at-large to charge phones and other devices
- Provide public internet access for the community at-large
- Provide on-site medical services and basic medical provisions for the community at-large
- Provide pick-up area for the provision of basic resources for the community at-large – bottled water, packaged foods, flashlights, etc.
- Provide public washroom and shower facilities to the public at-large during an emergency (potentially limited to certain "walk-in" hours)
- Clearly designate the Public Library as a cooling shelter and direct community members there during extreme heat events
- Investigate opportunities to use the Public Library during the operations of the emergency shelter for entertainment, provision of quiet space, better occupant comfort, etc.
- Investigate opportunities for green roofs, increased green infrastructure, installation of a community garden on-site, etc.

The site is particularly well-positioned to also assist with community training, education, and provision of resources during normal operations in order to help facilitate enhanced community preparedness efforts. Some of the potential community preparedness opportunities include:

- Coordinate with the Public Library to provide regular information to the public on emergency services planning efforts, provide home preparedness kits, hold emergency preparedness trainings, etc.
- Install public art exhibitions at the buildings and within the complex to help educate the community on climate change and to help communicate that the site is a community resource for emergency services.
- Coordinate these efforts with the City's on-going community resilience hubs initiative and consider ways for the Library, School, or War Memorial facility to also serve some or all of the functions of a community resilience hub.

6 Next Steps

The intent of this study and report is to review the Emergency Shelter and Emergency Dispensing Site functions at the Cambridge Rindge Latin School, War Memorial and Public Library against current and future impacts of climate change and to identify opportunities to enhance the resilience of the site's emergency response functions.

Given the cross-department roles in operating the facility as an emergency shelter or emergency dispensing site, this report's recommendations should be reviewed by an inter-departmental staff group to decide how to implement them including prioritization and possible phasing and which departments need to be involved in each action

The recommended next steps are:

- Review Proposed Physical & Infrastructure Enhancements to further develop the strategies and provide cost estimates to enable decision on which should be implemented

	Proposed Enhancement with Recommendations in Red Bold		Location	Complexity
Power	**1**	**Back Up Power – Minimum Upgrade**	**All Buildings**	**Low**
	2	Back Up Power – Medium Upgrade	All Buildings	Medium
	3	**Back Up Power – Maximum Upgrade – Microgrid – Study**	**All Buildings**	**High**
	4	**Solar Photovoltaics on War Memorial roof**	**War Memorial**	**High**
	5	**Lighting Upgrades for better control**	**War Memorial**	**Medium**
	6	**Generator Testing – Load banks**	**All Buildings**	**Medium**
	7	Cogeneration systems	CRLS	High
Medication	**8**	**Additional refrigeration capacity**	**CRLS**	**Low**
Shelter	9	Structural assessment of War Memorial for Category IV	War Memorial	Low
	10	**Library cooling shelter**	**Library**	**Low**
	11	**Dual fuel boilers**	**All Buildings**	**Medium**
Communications	**12**	**Communication upgrades**	**All Buildings**	**Low**
Sitewide	13	Backflow prevention on drainage	CRLS & WM	Low
	14	Flood protection of garage entrance	War Memorial	Low
	15	**Sealing utility conduits, wall penetrations, and structure walls**	**Library**	**Medium**
	16	Anti-seep collars on utility trenches	Library	Medium

- Review Operational Enhancements to determine which should be implemented

Operational Enhancement	
1	Prioritization
2	Combined operations plan
3	Staff training
4	Operational planning exercise
5	Food and delivery considerations
6	Occupant comfort
7	Acoustic considerations
8	Clearly communicate staff roles to residents
9	Transportation, shuttles and wayfinding
10	Site access
11	Resident education
12	Planning for animals
13	Special accommodations
14	Specialized training

- Review Other Uses for the Site to determine which should be implemented

Other Uses	
1	Provide charging stations for the community at-large to charge phones and other devices
2	Provide public internet access for the community at-large
3	Provide on-site medical services and basic medical provisions for the community at-large
4	Provide pick-up area for the provision of basic resources for the community at-large – bottled water, packaged foods, flashlights, etc.
5	Provide public washroom and shower facilities to the public at-large during an emergency (potentially limited to certain “walk-in” hours)
6	Clearly designate the Public Library as a cooling shelter and direct community members there during extreme heat events
7	Investigate opportunities to use the Public Library during the operations of the emergency shelter for entertainment, provision of quiet space, better occupant comfort etc.
8	Investigate opportunities for green roofs, increased green infrastructure, installation of a community garden on-site etc.

Appendix A

Existing Infrastructure

A1 Existing Infrastructure

This section describes the state of the existing infrastructure serving the site. It has been compiled based on the record as-built information, site visits and desk top studies

A1.1 CRLS

A1.1.1 Electrical

Existing Normal Power Distribution:

- Two existing main switchboards each rated for 3,000 amps at 480/277 volts.
- Existing switchboards are fed from a 2,500 kVA utility transformer located in a dedicated transformer vault.

Existing Generator:

- 1,500 kW diesel generator located on roof
- Three output breakers on the generator
  - 200A – NEC 700 Emergency (life safety)
  - 150A – NEC 700 Emergency (life safety) for War Memorial
  - 2,000A – NEC 701 Optional Standby
- Contract in place that guarantees 20,000 gallons of fuel to be delivered
- Two (2) 10,000 gallon fuel tanks on site
- No docking station
- No load banks on campus - generators are exercised once a week on no load, wet-stacking likely

Existing Emergency Distribution:

- Majority of kitchen equipment
- Majority of building heating and freeze protection systems
- Select rooftop units
- Electric water heaters
- Sump pumps
- Select exhaust fans
- Majority of building split AC units

Existing PV:

- PV on roof
- 2 inverters in Level 0
- Each one is 15kW capacity but generates max 11-12kW

Existing Lighting:

- Lighting - majority of fixtures have been retrofitted with LED lamps
- All lighting is controlled via manual wall switches and occupancy sensors
  - Some controlled via circuit breakers

A1.1.2 Mechanical

- Two (2) York chillers (CH-1 & CH-2), model YKFQFTQ7-CPGS, located in S112 Chiller Room
  - 750 ton capacity each (1500 combined)
  - 523-1591gpm evaporator
  - 973-2898gpm condenser
  - 302kW motor
  - One (1) Heat Exchanger (HX) from cooling towers
- Seven (7) AERCO 3.0 low NOx, gas-fired, Benchmark boilers, located in S231 Boiler Room
  - Building can run on three (3) boilers, built in redundancy
  - Primary & secondary loops
  - Six (6) 1000 gallon expansion vessels
  - Two (2) HX for DHW and two (2) DHW vessels, 250 gallons each
  - One (1) electric water heater
- One (1) Tecogen, Inc. Cogen (CHP), Model CM-75 from 2008, on roof
  - 75 kW electrical output
  - 511,000 Btu/hr thermal output
  - Not currently in use
  - One (1) HX in Boiler Room
- Served by 21 rooftop units (RTU)
  - RTU-1N-21N
  - RTUs 1N-9N, 13N & 14N on stand-by power

A1.1.3 Plumbing

- Equipment
  - Sanitary Ejector pit with pumps located in the basement
  - Storm ejector pit with pumps located in the basement
  - Two (2) Gas-fired Water Heaters and (2) independent recirculation pumps are all on back-up power and located on the second floor of the main CRLS and supports the Arts Center
- Fixtures (Arts Center only)
  - Women' Water Closets: 15
  - Men's Water Closets: 8
  - Unisex/Private Water Closets: 7
  - Urinals: 22
  - Showers (ADA): 1

- Lavatories: 25
- Non-lavatories sinks: 17, majority are sinks in classrooms on Level 3

Outfalls/Connections to Municipal

- Storm outfalls from Arts Center do not appear to have Backwater Valves (BWV) on connections to Civil drainage

A1.1.4 Structure

The CRLS was originally built in 1932 of concrete construction with additions and minor renovations to the structure in 1976. Building design was completed prior to modern code standards for wind and seismic lateral forces, and without any recent renovations the building has most likely never been assessed for increased forces and code requirements.

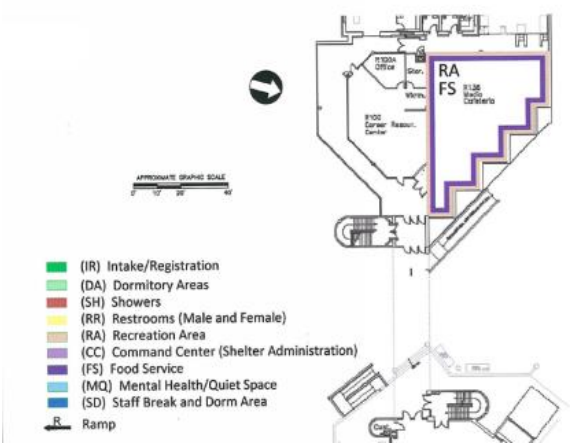
Currently, the kitchen is the only part of the structure which is designated as part of the city emergency shelter is the kitchen which is not considered to be "essential" and therefore would not need to comply with the structural criteria. The structure has been designated as a FEMA emergency shelter and assessed separately for those requirements. However, should the CRLS be considered for housing people or medical dispensing, the structure should be reevaluated for the change in risk category.

A1.1.5 Refrigeration

The existing food service and refrigeration capacity of the school as observed is as follows.

- R138 Media Cafeteria
  - Capacity for 156 people
  - Serving area at front, multiple kitchens (working/ teaching) behind
  - When building is used as a shelter, there are no school kitchen staff so operating procedure is needed for who staffs the space
- 1413 Culinary Arts Kitchen
  - Two (2) Kolpak walk-in cold storage refrigerators at 41 deg F
  - Two (2) Kolpak walk-in freezers at 3 deg F
  - Three (3) standalone roller refrigerators, Traulsen, Beverage Air, and Continental
  - If war memorial is being used as a shelter the plan is to use this kitchen for food and storage

The Emergency Shelter Plan specifically calls out the Level 1 kitchen for food service (as shown below).



A1.2 War Memorial

A1.2.1 Electrical

Existing Normal Power Distribution:

- Existing main switchboard is rated for 2,500 amps at 480/277 volts.
- Existing 13.8kV unit substation is located in parking garage

Existing Generator:

- 355kW/444kVA Kohler diesel generator located on roof
- Three output breakers located on the generator:
  - 400A – Fire Pump
  - 150A – Spare
  - 150A – Spare
- NEC 700 Emergency system is now fed from CRLS generator which provides power for life safety and critical loads such as fire alarm, emergency lighting, boilers, sump pumps, and selected plug loads within the War Memorial.
- Docking station is located on exterior wall outside of Fire Pump Room - Trystar 200A 480/277V 3-phase

Existing Lighting:

- All lighting is currently controlled via manual wall switches and occupancy sensors
- CPSD prefers occupancy controls for all lights but understands need for different field house lighting control during shelter operation
- There is a lighting control system, but it is not used
- Field house light fixtures have OS mounted on fixtures

A1.2.2 Mechanical

- Three York AHUs (AHU-1, 2, & 3) in WM303 Mechanical Room
  - AHU-1
    - Capacity: 14000 CFM (OA 14000 CFM)
    - ESP 2.5 in w.g.
    - SF motor - 30 HP
    - Serves 1st floor pool, locker rooms, and showers
  - AHU-2
    - Capacity: 10700 CFM (3750 OA)
    - ESP - 2.5 in w.g.
    - SF motor - 20 HP
    - Serves 2nd floor wrestling / multipurpose room
  - AHU-3
    - Capacity: 7000 CFM (2450 OA)
    - ESP 2.5 in wg
    - SF motor - 15 HP
    - Serves 1st floor offices, classrooms
- Two (2) York AHUs on roof serving Field House (FH)
  - FH-1 – Main AHU serving FH
  - FH-2 – Only used when FH in high occupancy (like graduation), CO2 censors will bring it online
  - Both variable volume
- One (1) York Chiller (CH-1) in WM303 Mechanical Room, from 2008
  - YK Model, Centrifugal chiller
  - Currently 1070 max gpm in use
  - Variable primary flow
  - Serving AHU-1-3 (War Memorial), 5-8 (Gym), FH1-2 (Field House), AHU-4 , and RT-18 (BOH)
  - Outfit with valves for future connection/extension of scope
- Five (5) AERCO 2.0 low NOx, gas-fired, Benchmark boilers, located in WM202 Mechanical Room
  - 2-million ton capacity each
  - War Memorial & Field house can run on three (3) so there is extra capacity built in
  - Two hot water pumps (P-1 & P-2) also in WM202 serving these

A1.2.3 Plumbing

- Equipment
  - Sanitary ejector pit and pump located in the basement
  - Sanitary sump pit and pump located in the basement
  - Sanitary ejector pit and pump located on Level 1
  - Two (2) gas fired water heaters located on Level 2
  - Gas meter and equipment on Level 1
  - Hot water recirculation pump located on Level 2
- Fixtures
  - Women's Water Closets: 14
  - Men's Water Closets: 7
  - Unisex/Private Water Closets: 6
  - Urinals: 7
  - Showers (non-ADA): 32
  - Showers (ADA): 10
  - Lavatories: 24
  - Non-lavatories sinks: 4
- Outfalls/Connection to Municipal
  - Storm outfalls appear to have Backwater valves (BWV) on lines susceptible to backflow from flood events
    - The main building storm drainage typically drops 5' to the outfall elevation in the basement but has no BWV

A1.2.4 Structure

The current shelter layout is situated primarily inside of the War Memorial which was built in 1955. The primary structure is concrete construction with the fieldhouse as steel construction with CMU infill. Minor structural renovations and mechanical penthouse rooms were built in 2007.

It is unknown when the building was first designated as an emergency shelter for the City of Cambridge, but it is understood that this occurred before 2001. To date we have been unable to locate any records surrounding this decision including any structural inspections or analysis of the building that have been produced. Based on this information, we do not believe the structure has ever been assessed as an emergency shelter with respect to increased snow, wind, and seismic loads since the state of Massachusetts adopted the IBC and ASCE 7 as a base code.

A1.3 Library

A1.3.1 Electrical

Existing Normal Power Distribution:

- Existing main switchboard is rated for 2,000 amps at 480/277 volts
- Utility transformer located in NStar vault

Existing Generator:

- 300kW/475kVA Cummins diesel generator located in the basement
- Five output breakers on the generator:
  - 175A – NEC 701 Legally Required
  - 100A – Fire pump
  - 60A – NEC 702 Optional Standby
  - 225A – NEC 700 Emergency (Life safety)
  - 20A – Remote radiator
  - 20A – Cooling system pump
  - 20A – Cooling system pump
- No docking station
  - 1,000 gallon fuel tank on site
  - Generator runs every Wednesday on no load - wet stacking likely
  - No load bank

Existing Lighting:

- LV Lighting Control System - Lutron Grafik Eye 5000
  - Warren wants to replace, says “system is obsolete”
- Lighting controlled via time clock and occupancy sensors
- Most light fixtures are retrofitted with LED lamps

A1.3.2 Mechanical

- Two (2) Weil McLain boilers located in basement Mechanical Room (in new section of library)
  - 2,867 MBH output each (290 gpm)
  - Gas-fired
  - Five (5) Baldor HHW pumps, 3 primary and 2 secondary
  - Two (2) expansion vessels

- Two (2) Trane rotary-screw chillers in basement Mechanical Room, from 2007
  - 225 tons each (450 gpm)
  - Don't run on emergency power
  - Two (2) CHW pumps (CHW-1,2)
  - Three (3) Baldor condenser water pumps (CWP-1,2,3), not insulated throughout
  - Two (2) BACC Cooling Towers on roof, from 2018
- Two (2) Trane AHUs (AHU-1 & AHU-2) in basement Mechanical Room
  - 43,000 CFM (17,800 OA) each
  - Both VAV systems with perimeter radiation
  - AHU-1: Primary, serves ~2/3 of new library
  - AHU-2: Secondary, serves ~1/3 of new library
- Two (2) Trane AHUs (AHU-5 & AHU-6) in attic Mechanical Room (old section of library)
  - Water pumped from new boilers & chillers in basement mech room
  - AHU-5
    - 20,000 CFM (4,700 OA)
    - VAV system
  - AHU-6
    - 3,200 CFM
    - Outdoor air only, CAV with FCU ventilation

A1.3.3 Structures

The Library is mixed steel and concrete construction designed in 2006 under the CMR 6th edition. No major renovations have taken place since original construction and the structure has been maintained in good condition.

Currently the library is not being used for emergency sheltering or as part of a wider "campus" for emergency response and the proposed uses of the structure would be considered "unessential", therefore the structure should not have to comply with the requirements for emergency shelter structures. However, should the library be considered for housing people or medical dispensing, the structure should be reevaluated for the change in risk category.

Appendix B

The Study

B1 The Study

This study has been included members of the following parties:

- Community Development Department
- Department of Public Works
- Fire Department
- Electrical Department
- Department of Public Health
- Cambridge Rindge and Latin School
- Public Library
- Emergency Management
- Human Services
- Recreation Department
- Arup

B1.1 Charrettes

- Charrette – 02/26/2019
- Charrette – 04/21/2019

B1.2 Meetings

The following meetings have taken place:

- CFD – 03/01/2019
- DPW – 03/01/2019
- City Electrical – 03/21/2019
- Human Services & Recreation Department – 03/21/2019
- DPH – 06/10/2019

B1.3 Site Visits

The following site visits have taken place:

- CRLS & War Memorial – 04/03/2019 & 06/31/2019
- Public Library – 04/11/2019

B1.4 Information Received

- Initial Brief
- Existing Emergency Shelter and Emergency Dispensing Site Plans
- Existing Buildings Information – Architectural, MEP, Structural, Civil
- Electrical Bills for CRLS, War Memorial and Public Library
- Energy Data for CRLS, War Memorial and Public Library

Appendix C

Requirements

C1 Recommendations for Emergency Facilities in the Commonwealth of Massachusetts

This section describes the guidance documentation and minimum requirements for the provision of Emergency Facilities in Massachusetts.

C1.1 Emergency Shelter

MEMA created a local shelter toolkit that contains recommendations that all shelters in the state of Massachusetts should meet. The intent of this toolkit is to ensure that emergency shelters are prepared to provide care and shelter operations for citizens experiencing impacts from snowstorms, tornadoes, heat waves, flooding, power outages, and fires.

Based on current operations at the emergency shelter at the War Memorial Recreation Center, the following capabilities shall be provided depending on the purpose for activating the shelter:

Table 1. Emergency Shelter Capabilities per MEMA

	Personal Care Site	Local-Initiated Overnight Shelter
Activation Conditions	• Extreme Heat • Extreme Cold • Temporary loss of public utilities (e.g. power outage)	• Short- to moderate-term residential displacement • Moderate to major residential destruction • Extended loss of public utilities (e.g. water main failure)
Important Capabilities	• ADA accessibility • Functional needs support services • Parking	• ADA accessibility • Functional needs support services • Parking • Backup power • Dormitories • Kitchen/food preparation services
Other Recommended Functions or Services	• Temporary comfort • Cooling or heating • Water • Basic food/snacks • Charging stations	• Water, full meals • Charging stations • Dormitory • Showers • Triage • Pet sheltering services

Additionally, the toolkit includes the following assumptions that shelters should take into account when planning:

- Approximately 3-5% of a local population will attend a local shelter for natural disasters like ice storms, tornadoes, and flooding.
- Individuals with access and functional needs that are able to independently care for themselves at home, may not be able to do so in a shelter setting and may require additional assistance.
- Families should not be separated in a shelter.
- Individuals may arrive at the shelter with a contagious disease or may become ill while at the shelter.
- Service animals should not be separated from their owners while at the shelter. Provisions should be made to support service animals, including food/supplies, hygienic disposal of waste, and location for exercise.
- Detailed operational plans and procedures should exist for the operation of the shelter.

C1.2 Emergency Dispensing Site

MDPH created a guide that provides local communities with technical assistance to develop and maintain emergency dispensing site plans. Each city and town in Massachusetts is expected to have a written plan to dispense emergency medical countermeasures to its residents, workers, and visitors. An emergency dispensing site may be initiated to respond to a range of health threats to the public, including:

- Exposure to infectious diseases (e.g. Hepatitis A in a food handler)
- Infectious disease outbreaks (e.g. Influenza pandemic)
- Acts of terrorism (e.g. biological, chemical, radiological, nuclear)
- Disease outbreaks resulting from natural disasters

The primary function to be provided at an emergency dispensing site is the dispensing of medical countermeasures. The guide urges local communities to keep in mind that on-site inventory management is key to the success of the emergency dispensing site and the ability to receive, securely store, and possibly redistribute medical countermeasures to other emergency dispensing sites is paramount.

The War Memorial Recreation Center currently serves as a "pull-method" or "open" emergency dispensing site, meaning it serves the general public of the City of Cambridge. The current plan in place shows that the facility will operate the dispensing site in one of the two following manners:

Table 2. War Memorial Emergency Dispensing Site Models

	Individual Walk-Thru Model	**Head-of-Household Model**
Description	All citizens requiring care must attend the shelter and wait in line to receive medication or vaccine	An individual from each household is allowed to pick up medication for all household members
Activation Conditions	• Dispensing all medicine • Dispensing all vaccinations	• Dispensing medicine for health threats that do not require medical screening
Important Factors to Consider	• Increased number of attendees • Increased duration of stay due to queuing and screening	• Single caregivers may need to bring children, older adults, persons with disabilities • Unaccompanied minors • Evaluation of requests for multiple unit-of-use medicines
Important Capabilities	• ADA accessibility • Backup power • Loading Dock • Dedicated refrigeration for vaccines • Large queuing area (with preparations in case of inclement weather)	• ADA accessibility • Backup power • Loading Dock • Dedicated refrigeration for vaccines • Small queuing area (with preparations in case of inclement weather)

Other additional concerns include security, communication, vehicular flow/parking, and break areas for staff.

C1.3 Overlapping Requirements

The table below provides more specific information on the recommendations from both MEMA and MDPH. The center column identifies requirements that overlap between the two organizations.

Table 3. Comparison of Recommended Capabilities of Emergency Shelters & Dispensing Sites

MEMA Recommendations	Overlapping Recommendations	MDPH Recommendations
Characteristics		
• One toilet per 20 people • One sink per every two toilets • One shower stall for every 25 people with at least one ADA compliant shower stall per shower room • Public telephone access	• Bathroom facilities • ADA accessible facility in public spaces • Refrigeration for food • Heating/cooling to provide comfortable temperature inside facility • Access to backup power (for light, heat, medication refrigeration, and medical equipment) • Security • Parking • Internal PA system	• Functional loading dock • Refrigeration for vaccines • Cell phone service • Emergency responder 2-way radio service • Internet/wireless internet • Sinks not in bathroom areas
Available Spaces		
• Dormitory (shelter visitors and staff) • Food: kitchen space, food supplier, or food vendor • Dining area • Information services • Recreation spaces • Pet facilities	• Registration • First Aid • Screening/triage • Counseling area • Staff break area • Quiet space for emotional/spiritual care • Storage for supplies • Administrative office	• Queueing area for large amounts of people • Dispensing area or appropriate vaccination space • Law enforcement command center • Food services for staff only

C1.4 Compliance Assessment

Before enhancements can be determined for the Cambridge Rindge and Latin School Complex, it is important to first understand the requirements for Emergency Shelters and Emergency Dispensing Sites. Based on the requirements from MEMA and MDPH, the three buildings at the complex were evaluated in their current capabilities and the following areas of enhancement were identified:

Table 4. Complex Buildings Evaluated Against MEMA and MDPH General Recommendations

Buildings in Complex	Current Use	Important Capabilities	Other Recommended Functions or Services
War Memorial Recreation Center	• Emergency Shelter & Dispensing Site	• ADA accessible • Shared parking for 300 vehicles • Backup power • Dormitories for 556 • Only pre-prepared and delivered full meals • Loading dock • No inside queueing area capabilities • Dedicated refrigeration for vaccines is delivered	• Heating/cooling • Water • Charging stations • Showers • Triage • Pet sheltering services
Cambridge Rindge and Latin School	• Cafeteria is used for emergency shelter & dispensing site • Portions are used for inclement weather staging for emergency dispensing	• ADA accessible • Shared parking for 300 vehicles • Backup power • Kitchen/food preparation services • Large inside queuing area capabilities • Use of high school for emergency shelter & dispensing disrupts normal school functions	• Heating/cooling • Water • Full meals able to be prepared on-site • Charging stations
Cambridge Public Library	• Not used	• ADA accessible • Parking garage under building • Backup power	• Heating/cooling • Water • No food or snacks are available; restricted to areas without carpeting • Charging stations

As noted in the table above, the War Memorial does not contain any kitchen or food preparation facilities. The emergency shelter relies on the Cambridge Rindge and Latin School for use of those spaces or deliveries of pre-prepared food. Additionally, the War Memorial does not have the capacity for the indoor queueing of any amount of people. In the case of inclement weather, the War Memorial relies on the high school for this as well.

It is important to note that any use of the high school for emergency shelter or dispensing services causes disruptions of normal school functions. It would be preferred to not interfere with high school operation as much as possible. For this purpose, the current use during emergency shelter & dispensing services has been limited to the cafeteria area closest to the War Memorial. If the War Memorial is intended to be used exclusively and no use of the high school is desired, tents or enclosed spaces at the exterior of the War Memorial will need to be supplied for queueing in inclement weather.

The Cambridge Public Library is not currently used for emergency shelter & dispensing services. There is no qualified area to dedicate for dormitory space and no shower facilities present. In its current capacity, the library is suitable only for use during temporary shelter needs like extreme heating and cooling. It should be noted that there are no food or snack distribution spaces in the building. Outside food and beverage is permitted in the building but is restricted to areas without carpeting. Food and/or snacks will need to be available to visitors if the library is intended to be used for emergency shelter capabilities.

Appendix D

Example Flood Protection Measures

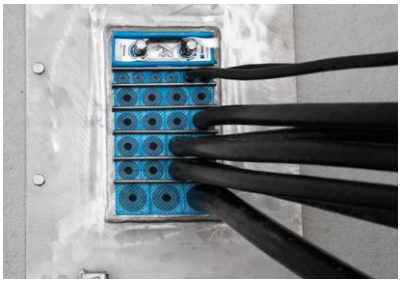
D1 Example Flood Protection Measures

D1.1 Sealing of Utility Conduits

There are several potential options for sealing utility conduits, including:

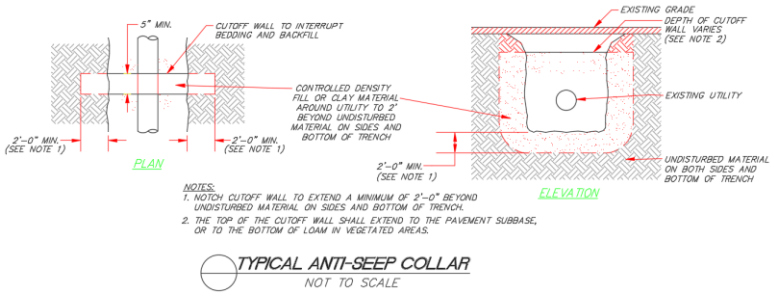
- Polywater FST seals or similar for sealing abandoned/unused conduits that will not be needed in the future:

- Roxtec seals or similar for conduits in-use or planned to be in-use:



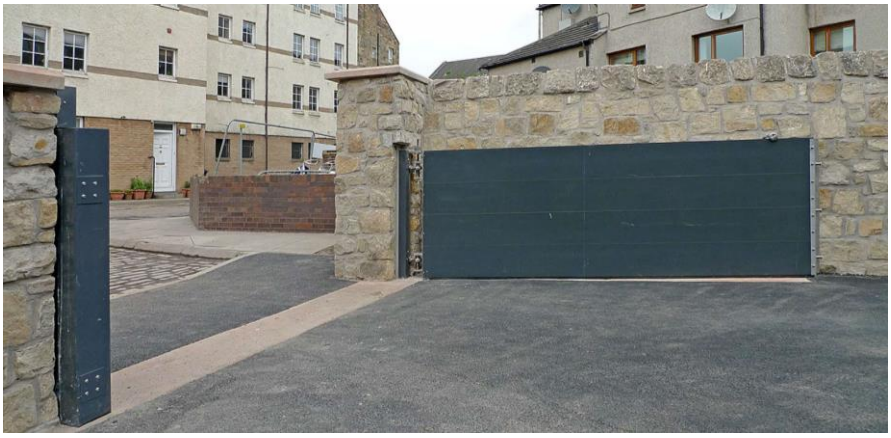
D1.2 Anti-Seep Collar for Utility Trenches

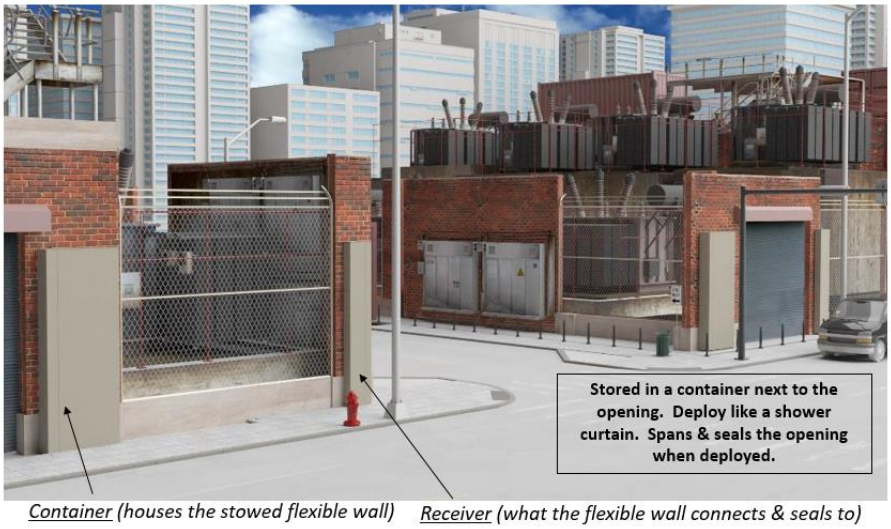
Anti-seep collars should extend a minimum of 24-inches beyond the side and bottoms of existing utility trenches to cut off flow of water along the utility trenches to the buildings. The following is a detail of an anti-seep collar.

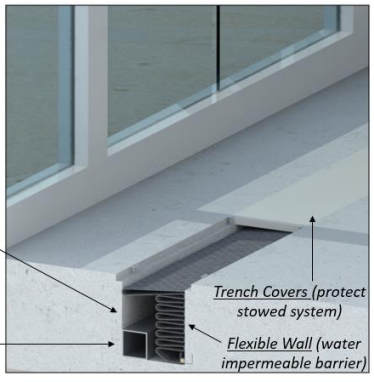


D1.3 Deployable Flood Gates and Barriers

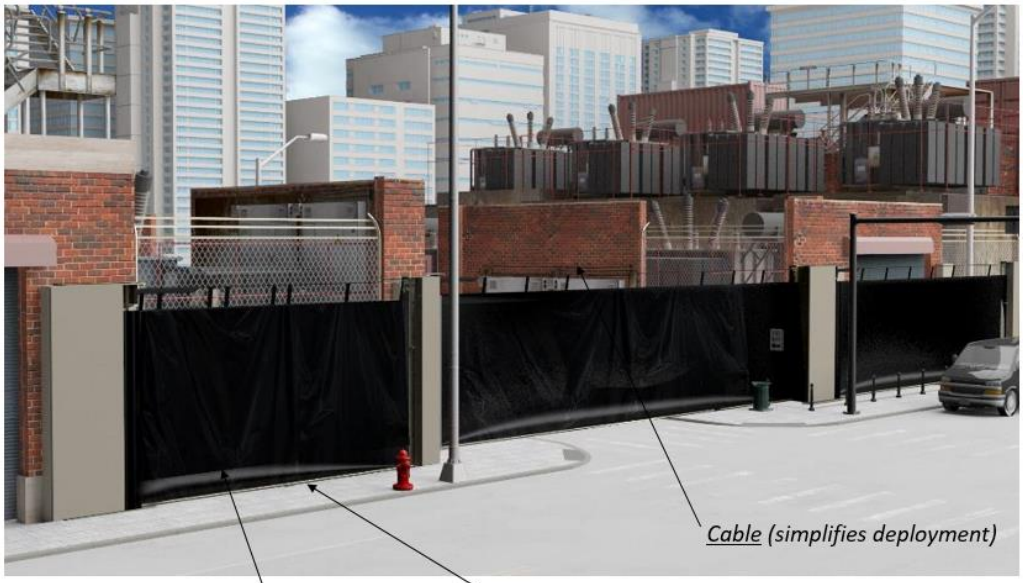
The following are potential options for installing deployable flood gates or barriers at garage and building entrances.







ARUP



D1.4 Seepage through Structure Walls

The following image provides a sample of potential waterproof sealants or membranes on structure walls.