4.1 Sustainability Narrative & LEED Scorecard

MIT Volpe C1
Article 22 Submission
April 13th, 2023

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SODEN SUSTAINABILITY
617.372.7857| colleen@sodensustainability.com

INTRODUCTION

Continuing MIT's commitment to sustainable development in the Kendall Square area, the Volpe district will be one of the largest LEED developments in the Cambridge and Boston areas. The Volpe C1 building ("Volpe C1" or "C1") is committed to achieving a minimum LEED Gold rating under the LEED version 4 system.

The Volpe Masterplan will register an overall LEED Master Site that will take advantage of combined site, landscape, and transportation strategies. Then each individual building will achieve the remaining credits required for a Gold rating under either the LEED v4 for Core and Shell system or LEED v4 for New Construction. The site will be registered with the USGBC and target several credits which span the nine LEED version 4 categories (Integrative Process, Location & Transportation, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation in Design Process and the additional Regional Priority Credits) to enable the project to meet the zoning requirements. The project is committed to earn the buildings at least 60 credit points under the LEED v4 system to achieve a LEED Gold rating.

The C1 building will meet the requirements for these credits with shared amenities as well as local amenities to ensure minimum requirements are met for each building's designated occupants and visitors.

Consistent with Section 22.25.1 of the Cambridge Zoning Ordinance, MIT has prepared this Green Building Report package to include the following:

- Green Building Checklist
- Credentials of the Green Building Project's designated Green Building Professional and affidavit
- Green Building Rating System Narrative + Scorecard
- Net Zero Narrative

Consistent with Sections 22.25.2 and 22.25.3 of the Cambridge Zoning Ordinance, updated versions of these documents will be provided before applications for a building permit and for a certificate of occupancy.

EXECUTIVE SUMMARY

This executive summary highlights the key sustainable design categories discussed in the report with references to the sections and page numbers where additional information can be found.

GREEN BUILDING REQUIREMENTS

The C1 project is pursuing LEED v4 BD+C: Core and Shell certification targeting LEED Gold at a minimum. With 75 LEED points in the 'high probability' category, C1 exceeds well beyond the LEEDv4 Gold certification requirements. The team is substituting LEED v4.1 credit pathways where applicable. As the design progresses, the project team is committed to exploring opportunities to pursue additional credits under the Energy & Atmosphere, Water Efficiency, and Indoor Environmental Quality categories as a potential path to LEED platinum. MIT will pursue enhanced commissioning, including envelope and monitoring based commissioning to maintain performance and ensure maximum energy savings and emissions reductions as outlined in LEED v4 Enhanced Commissioning Requirements.

See following sections on more information:

- Green Building Rating System Narrative + Scorecard – page 11
- GBR Narrative – Building Certification – page 31

ENERGY PERFORMANCE - ENERGY SOURCES + EFFICIENCY

MIT has designed a best-in-class laboratory building in terms of energy performance, with a projected 41% reduction in energy use over the baseline, in addition to being all-electric ready for future conversion. The building conversion timeline depends on grid reliability as Eversource prepares to expand capacity for the local grid. Limited natural gas use will be required until the grid reliability is sufficient for operations. As designed, efficient electrification with heat pumps allows the C1 building to take advantage of renewable energy and the increasingly renewable regional electrical grid to reduce carbon emissions every year. The current design shows a 41% reduction (according to a ASHRAE 90.1-2019 PRM baseline) in operational carbon today, which is anticipated to increase to 59% by 2035 with further greening of the grid. If 100% renewable electricity is purchased, there would be a 99% carbon reduction by 2035. MIT is committed to the purchase of green power, RECs, and/or offsets.

The project is committed to achieving an approximately 10% reduction in embodied carbon compared to the baseline. The embodied carbon analysis will be refined further in the Construction Documents phase.

See following sections on more information:

- GBR Narrative - Energy + Emissions – page 21
- GBR Narrative – Energy Efficiency – page 23
- GBR Narrative - Embodied Carbon – page 24
- Net Zero Narrative – page 33

POTENTIAL FOR SOLAR ENERGY GENERATION

The C1 design team is exploring potential rooftop locations for solar photovoltaic (PV) to provide on-site renewable energy systems where feasible. As designed, the roof houses cooling towers, generators, stair pressurization H&V units, exhaust fans, and air source heat pumps, as well as space identified for installation of additional air source heat pumps and all-electric equipment, resulting in limited space available for renewable installations. The team has identified the potential roof surfaces that could support PV installation. The team will continue to explore additional potential areas on the rooftop for PV.

See following sections on more information:

- GBR Narrative – Green Roof & Rooftop Solar – page 33
- Net Zero Narrative – Solar Ready Rooftop Assessment – page 41

HEAT RESILIENCE

C1 and the Volpe development are committed to mitigating heat risk and the urban heat island effect by providing green spaces throughout the site and selecting highly reflective paving and roofing materials. C1 addresses the heat island effect by maximizing green space on the roof where feasible, optimizing the façade for solar radiation, as well as reducing the window-to-wall ratio to 35%. Furthermore, shading and solar heat gain is addressed by selecting high-performance glass coatings combined with interior roller shades to reduce glare and allow for a comfortable working environment.

See following sections on more information:

- GBR Narrative - Heat Risk + Urban Heat Island – page 30
- Net Zero Narrative – Building Energy Performance Measures – page 36

GREEN BUILDING CHECKLIST

Green Building Project Checklist

Green Building Project Location: MIT Volpe Redevelopment Building C1

Applicant

Name: Massachusetts Institute of Technology

Address:

Contact Information

Email Address: Maureen McCaffrey (mmccaffrey@mitimco.mit.edu)

Telephone #: 617-253-4900

Project Information (select all that apply):

- ☑ New Construction - GFA: ~407,162 SF
- ☐ Addition - GFA of Addition:
- ☐ Rehabilitation of Existing Building - GFA of Rehabilitated Area:
  - ☐ Existing Use(s) of Rehabilitated Area:
  - ☐ Proposed Use(s) of Rehabilitated Area:
- ☐ Requires Planning Board Special Permit approval
- ☐ Subject to Section 19.50 Building and Site Plan Requirements
- ☐ Site was previously subject to Green Building Requirements

Green Building Rating Program/System:

- ☑ Leadership in Energy and Environmental Design (LEED) - Version: v4 Gold
  - ☑ Building Design + Construction (BD+C) - Subcategory: Core & Shell
  - ☐ Residential BD+C - Subcategory:
  - ☐ Interior Design + Construction (ID+C) - Subcategory:
  - ☐ Other:
- ☐ Passive House - Version:
  - ☐ PHIUS+
  - ☐ Passivhaus Institut (PHI)
  - ☐ Other:
- ☐ Enterprise Green Communities - Version:

Project Phase

☒ **SPECIAL PERMIT**

Before applying for a building permit, submit this documentation to CDD for review and approval.

Required Submissions

All rating programs:

- ☒ Rating system checklist
- ☒ Rating system narrative
- ☒ Net zero narrative (see example template for guidance)
- ☒ Affidavit signed by Green Building Professional with attached credentials – use City form provided (Special Permit)

GREEN BUILDING PROFESSIONAL AFFIDAVIT

Affidavit Form for Green Building Professional Special Permit

Green Building Project Location: Volpe Redevelopment Project Parcel 1A "South Parcel" Building C1

Green Building Professional

Name: Stephen Jay Siebenmorgen, AIA, LEED AP

☒ Architect

☐ Engineer

License Number:

Company: NBBJ LP

Address: One Center Plaza, Suite 800 Boston MA 02108

Contact Information

Email Address: jsiebenmorgen@nbbj.com

Telephone Number: (617) 378-4800

I, Stephen Jay Siebenmorgen, as the Green Building Professional for this Green Building Project, have reviewed all relevant documents for this project and confirm to the best of my knowledge that those documents indicate that the project is being designed to achieve the requirements of Section 22.24 under Article 22.20 of the Cambridge Zoning Ordinance.

(Signature) March 20, 2023 (Date)

Attach either:

☒ Credential from the applicable Green Building Rating Program indicating advanced knowledge and experience in environmentally sustainable development in general as well as the applicable Green Building Rating System for this Green Building Project.

☐ If the Green Building Rating Program does not offer such a credential, evidence of experience as a project architect or engineer, or as a consultant providing third-party review, on at least three (3) projects that have been certified using the applicable Green Building Rating Program.

nbbj

www.nbbj.com

March 20, 2023

City of Cambridge
795 Massachusetts Avenue
Cambridge Ma 02139

RE: Volpe Redevelopment Project Parcel 1A "South Parcel" Building C1

Dear City of Cambridge,

As a Design Principal for NBBJ, I am leading the planning and design of the Volpe South Parcel Building C1. I, Stephen Jay Siebenmorgen, certify that I am knowledgeable of the project's green building strategies, designs, plans and details and to the best of my knowledge this project has been planned and designed to meet the prerequisites and earn the credits necessary to achieve Gold Level (minimum of 60 points) using the LEED BD+C for Core and Shell and New Construction V4 Rating systems. The referenced project is being planned to meet the Green Building Project requirements under Article 22 of the Cambridge Zoning Ordinance.

Sincerely,

Stephen Jay Siebenmorgen AIA, LEED®AP
Design Principal
NBBJ Architects

ONE CENTER PLAZA SUITE 800 **BOSTON** MA 02108 T) 617 378 4800

GBCI

2/13/2023

Stephen Siebenmorgen
75 Jamaica St
Jamaica Plain, MA 02130

Dear Stephen,

The Green Business Certification Institute's records indicate that you passed the LEED® Professional Exam™. Please see the details for your exam achievement, below:

Exam Track	Exam Date	Result
LEED AP (New Construction)	9 FEB 2009	Pass

In passing the LEED AP exam, you became recognized as a LEED AP by GBCI. For your reference, your GBCI # is 0010358218.

Thank you for your participation in the LEED®Professional Credentialing program. We wish you all the best in your work to create and sustain a thriving built environment.

Sincerely,

Green Business Certification Inc.

GREEN BUSINESS CERTIFICATION INC. 2101 L Street, NW Suite 500 Washington, DC 20037 T: 800.795.1746 F: 202.828.5110 gbci.org

GREEN BUILDING RATING SYSTEM NARRATIVE + SCORECARD

The project will pursue the LEED v4 BD+C: Core and Shell (CS) rating system, which is tailored for buildings that include exterior shell and core mechanical, electrical, and plumbing units, without a complete interior fit-out within the project scope. MIT is committed to achieving LEED Gold certification which requires the project to earn all 12 prerequisites and at least 60 credit points.

The LEED Scorecard provided in the following section serves as a platform for tracking the project's targeted LEED strategies and credit status throughout design and construction. Currently, the LEED appraisal indicates the following point breakdown:

- High probability: 75 points
- Medium probability: 22 points
- Not possible: 15 points

With seventy-five (75) LEED v4 points (with select v4.1 upgrades) in the 'high probability' category, the project is poised to meet the LEED v4 Gold certification requirements. As the design progresses, the project team is committed to exploring opportunities to pursue additional credits under the Energy & Atmosphere, Water Efficiency, and Indoor Environmental Quality categories.

LEED CREDIT NARRATIVES – MASTER SITE

The project will meet the LEED v4 Minimum Program Requirements and each of the required Prerequisites. All credit points described below are being pursued with the probability of achievement noted as 'High, Medium, or Low' next to each credit. All items captured in the LEED credits will also adhere to the requirements of the Special Permit where requirements exceed LEED.

Location & Transportation

The Volpe Development site is a previously developed site in urban Cambridge, close to several public transportation services including an MBTA transit stop and public bus services. Occupants shall have access to bicycle racks and showers, as well as preferred parking for electric, hybrid and/or low- emitting vehicles.

Credit 3: High Priority Site (v4.1) - 3 High Achievability Points

- McPhail has identified various locations across the site that are contaminated. Site remediation will be completed in accordance with applicable laws including LEED requirements.

Credit 6: Bicycle Facilities (v4.1) – 1 High Achievability Point

- Short-term and long-term bicycle parking will be provided for occupants and visitors. In addition, showers will be located in each building to serve their full-time occupants (R1-R3 will provide at least 1 shower, C1- 8 showers, C2-9 showers, and C1- 9 showers). Site and roadway access will be provided to further enhance the City of Cambridge's already extensive bicycle network.

Credit 7: Reduced Parking Footprint (v4.1) – 1 Medium Achievability Point

- The parking area is designed to meet the code requirement, but with reduced capacity compared to the Institute of Transportation Engineers' Transportation Planning Handbook. 5% of the total parking spaces will provide preferred parking for carpools to meet the credit's requirements.

Credit 8: Green Vehicles (v4.1) – 1 High Achievability Point

- The design will provide at least 10% of total parking spaces are EVSE ready or will provide installed EVSE charging stations at 5% of total parking spaces.

Sustainable Site

MIT is taking a comprehensive approach to site, landscape, habitat creation, stormwater management, and human use.

Credit 1: Site Assessment (v4.1) – 1 High Achievability Point

- The civil and landscape teams have conducted a comprehensive site survey to study topography, hydrology, climate, vegetation, soils, human use, and human health effects to achieve credit requirements. A credit template has been circulated to the design teams.

Credit 2: Site Development: Protect or Restore Habitat (v4.1) – 2 Not Achievable Points

- The design strives to restore landscape by maximizing opportunities for native and adapted vegetation while improving tree canopy. Green roofs are studied to further add green space to the site.

Credit 3: Open Space (v4.1) – 1 High Achievability Point

- Based on the current design, the open space will exceed the 30% credit threshold for this credit requirement. Additional vegetated and tree canopy overhead in the community areas helps to achieve 30% of the open space as vegetated, over the 25% threshold for vegetated open space. This credit is anticipated.

Credit 4: Rainwater Management (v4.1) – 1 High Achievability Point, 2 Medium Achievability Points

- The current design for stormwater management collects roof and site water to be directed into infiltration areas for phosphorous removal and ground water recharge. The stormwater management systems are designed such that the mechanical and/or green technologies meet the LEED v4 requirement as well as local watershed requirements.

Credit 5: Heat Island Reduction (v4.1) – 2 High Achievability Points

- Roofs are designed with high-albedo materials to reflect heat and mitigate urban heat island effects. The site design includes high SRI and permeable pavers, which complies with the credit requirements. Trees and shading elements are optimized to further reduce heat island effects on hard scape areas.

Credit 6: Light Pollution Reduction (v4.1) – 1 High Achievability Point

- All exterior luminaires are carefully selected and designed to improve nighttime visibility, and to avoid light pollution.

Water Efficiency

Water Efficiency credits are mostly pursued on a building-by-building approach. However, the Master Site area uses a single approach to outdoor water use for the shared open space.

Prerequisite 1 and Credit 1: Outdoor Water Use Reduction (v4.1) – 1 High Achievability Point, 2 Medium Achievability Points

- The target reduction of outdoor water use will be achieved by native plants with low water demand, as well as efficient irrigation systems.

Credit 3: Cooling Tower Water Use (v4)/ Cooling Tower and Process Water Use (v4.1) - 1 High Achievability Point, 2 Medium Achievability Points

- Water analysis will be used to optimize cooling tower cycles to meet the credit's requirement of >10 cycles or 20% non-potable water use.

Materials and Resources

Prerequisite 1: Storage and Collection of Recyclables

- The Project will provide dedicated areas accessible to waste haulers and building occupants for the collection and storage of recyclable materials for the entire building.
- Collection and storage areas may be separate locations. Recyclable materials will include mixed paper, corrugated cardboard, glass, plastics, and metals.
- The Project will also take appropriate measures for the safe collection, storage, and disposal of two of the following: batteries, mercury-containing lamps, and electronic waste.

Prerequisite 2: Construction and Demolition Waste Management Planning

- The construction team will develop a construction and demolition waste management plan to reduce waste disposed of in landfills by recovering, reusing, and recycling materials. The development will create a global Construction and Demolition Waste Management specification section and sample plans to the CM.
- The Project will develop and implement a construction and demolition waste management plan that will identifying at least five materials (both structural and nonstructural) targeted for diversion and approximate a percentage of the overall Project waste that these materials represent.

Indoor Environmental Quality

Prerequisite 2: Environmental Tobacco Smoke (ETS) Control (v4.1)

- The prerequisite will be documented at the Master Site where smoking is prohibited site-wide within 25 ft of major entrances or air intakes.

LEED SCORECARD – MASTER SITE CREDITS

LEED v4 for BD+C: Core and Shell (CS)
Project Checklist - Master Site

Project Name: Volpe Master Site
Date: 2/21/23

Achievability (CS)

5	1	0		Location and Transportation	6
3			Credit	High Priority Site	3
1			Credit	Bicycle Facilities	1
	1		Credit	Reduced Parking Footprint	1
1			Credit	Green Vehicles	1
6	2	2		Sustainable Sites	10
1			Credit	Site Assessment	1
		2	Credit	Site Development - Protect or Restore Habitat	2
1			Credit	Open Space	1
1	2		Credit	Rainwater Management	3
2			Credit	Heat Island Reduction	2
1			Credit	Light Pollution Reduction	1
2	3	0		Water Efficiency	5
Y			Prereq	Outdoor Water Use Reduction	Required
1	1		Credit	Outdoor Water Use Reduction	2
1	2		Credit	Cooling Tower Water Use	3
1	0	0		Energy and Atmosphere	1
Y			Prereq	Fundamental Commissioning and Verification	Required
1			Credit	Enhanced Refrigerant Management	1

Achievability (CS)

0	0	0		Materials and Resources	
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management Planning	Required
0	0	0		Indoor Environmental Quality	
Y			Prereq	Environmental Tobacco Smoke Control	Required
5	0	0		Innovation	5
1			Credit	Innovation - Green Education	1
1			Credit	Innovation - O+M Starter Kit	1
1			Credit	Innovation - Purchasing Lamps	1
1			Credit	Innovation - Exemplary Performance, TBD	1
1			Credit	Innovation - Pilot Credit, TBD	1
2	0	0		Regional Priority	2
1			Credit	Regional Priority: High Priority Site	1
1			Credit	Regional Priority: Rainwater Management	1
21	6	2		TOTALS Possible Points:	29

MS Credit Total ONLY

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

LEED CREDIT NARRATIVES – BUILDING CREDITS

Sustainability/Green Building Design Approach

To meet the requirements of Article 22, the following section describes how the Project complies with the LEED Building Design & Construction v4 criteria.

The Project will demonstrate compliance with the LEED Certifiably Requirements. Further study over the coming weeks and months will determine and confirm final credit achievement. At this stage in the project, we are tracking 75 points in the 'high probability' category for the project.

Overview

Sustainability informs every design decision. Enduring and efficient buildings conserve embodied energy and preserve natural resources. The Project embraces the opportunity to positively influence the urban environment. Its urban location takes advantage of existing infrastructure while access to public transit will reduce dependence on single-occupancy vehicle trips and minimize transportation impacts.

The LEED v4 for Building Design and Construction (BD&C) rating system tracks the sustainable features of a Project by achieving points in following categories: Integrative Process; Location & Transportation; Sustainable Sites; Water Efficiency; Energy and Atmosphere; Materials and Resources; Indoor Environmental Quality; and Innovation and Design Process.

Integrative Process

The proponent and project team are committed to an integrated design approach using early modeling and extensive design team coordination to achieve synergies across disciplines and building systems. The project will be involved in integrative processes at multiple levels - the individual project level as well as district level coordination. The Integrative Process credit will be targeted at the individual project level.

Credit 1: Integrative Process – 1 High Achievability Point

- Both a "simple box" energy model and water budget analysis showing reductions in indoor and outdoor water use were completed before the end of the Schematic Design phase. Narratives describing how these preliminary analyses informed design decisions will be documented in the OPR and BOD.

Location and Transportation

The Location and Transportation credit category encourages development on previously developed land, minimizing a building's impact on ecosystems and waterways, regionally appropriate landscaping, and smart transportation choice.
The project site has been previously developed, meeting the criteria for the sensitive land protection credit.

Credit 2: Sensitive Land Protection (v4.1) – 2 High Achievability Points

- The project is located within a site that has been previously developed.

Credit 4: Surrounding Density and Diverse Uses (v4.1) – 6 High Achievability Points

- The project site area exceeds the density requirements of 35,000 SF/acre and has access to at least 8 different facilities within a ½ mile walk.

Credit 5: Access to Quality Transit (v4.1) – 6 High Achievability Points

- The Project will achieve 6 points in the access to quality transit credit having access to the Red Line rail service and 64, 68, 85, CT2, and EZRide bus services. There are a total of 541 daily weekday trips and 325 daily weekend trips from compliant nearby transit stops. Future construction of additional public transportation infrastructure is planned to begin in early 2023 and will supplement the existing nearby transit stops.

Sustainable Sites

The development of sustainable sites is at the core of sustainable design. Sustainable Site design provides quality open space with active landscape elements that can both mitigate stormwater and provide shade and thermal comfort for the building occupants.

Prerequisite 1: Construction Activity Pollution Prevention

- The project will create and adhere to an erosion and sedimentation control plan for all construction activities. The plan will conform to the erosion and sedimentation requirements of the 2012 U.S. Environmental Protection Agency (EPA) Construction General Permit (CGP) or local equivalent, whichever is more stringent.

Credit 7: Tenant and Construction Guidelines (v4.1) – 1 High Achievability Point

- The project team will compile a set of tenant design and construction guidelines to ensure quality, high performance fit-outs for future building tenants.

Water Efficiency

Buildings are major users of our potable water supply and conservation of water preserves a natural re-source while reducing the amount of energy and chemicals used for sewage treatment. The goal of the Water Efficiency credit category is to encourage smarter use of water, both inside and outside.

Prerequisite 2 and Credit 2: Indoor Water Use Reduction – 3 High Achievability Points, 1 Medium Achievability Point, 2 Not Achievable Points

- The Project will incorporate water conservation strategies that include low-flow plumbing fixtures for water closets and faucets. The project is expected to achieve a 35% water use reduction.

Prerequisite 3 and Credit 4: Water Metering (v4.1) – 1 High Achievability Point

- The Project will install permanent water meters that measure the total potable water use for the building and associated grounds in addition to evaluating water meters for two or more of the following water sub-systems, as applicable to the project: irrigation, indoor plumbing fixtures and fittings, domestic hot water, and the boiler for additional metering. Metering data will be compiled into monthly and annual summaries, and the resulting whole-project water usage data will be shared with USGBC.

Energy & Atmosphere

According to the U.S. Department of Energy, buildings use 39 percent of the energy and 74 percent of the electricity produced each year in the United States. The Energy and Atmosphere credit category encourages a wide variety of energy strategies: commissioning; energy use monitoring;

efficient design and construction; efficient appliances, systems and lighting; the use of renewable and clean sources of energy, generated on-site or off-site; and other innovative practices.

Prerequisite 1 and Credit 1: Enhanced Commissioning – 6 High Achievability Points

- Fundamental Commissioning and Enhanced & Envelope Commissioning will be pursued for the Project.

Prerequisite 2 and Credit 2: Optimize Energy Performance (v4.1) – 12 High Achievability Points, 4 Medium Achievability Points, 2 Not Achievable Points

- A whole-building energy simulation will be performed for the Project. Using ASHRAE 90.1-2010, we expect to achieve 26% energy cost savings, which will result in 12 LEED Points.

Prerequisite 3: Building-Level Energy Metering (v4.1)

- The Project will install new building-level energy meters, or submeters that can be aggregated to provide base building-level data representing total building energy consumption (electricity, natural gas, chilled water, steam, fuel oil, propane, etc.).
- The Proponent will commit to sharing energy consumption and electrical demand data (if metered) with USGBC for a five-year period at one-month intervals.

Credit 4: Grid Harmonization (v4.1) – 1 Medium Achievability Points, 1 Not Achievable Point

- Team will continue to evaluate strategies for demand response, but credit is not likely to be achieved.

Credit 5: Renewable Energy/Green Power (v4.1) – 3 Medium Achievability Points, 2 Not Achievable Points

- Design team is exploring all potential solar zone areas for solar photovoltaic (PV) to provide on-site renewable energy systems where feasible.

Prerequisite 4 and Credit 6: Fundamental & Enhanced Refrigerant Management – 1 High Achievability Point

- The Project will not use chlorofluorocarbon (CFC)-based refrigerants in new heating, ventilating, air-conditioning, and refrigeration (HVAC&R) systems. The Project will target the use of refrigerants used in heating, ventilating, air-conditioning, and refrigeration (HVAC&R) equipment that minimize or eliminate the emission of compounds that contribute to ozone depletion and climate change.

Materials & Resources

During both construction and operations, buildings generate tremendous waste and use many materials and resources. The Materials & Resources credit category encourages the selection of sustainable materials, including those that are harvested and manufactured locally, contain high-recycled content, and are rapidly renewable. It also promotes the reduction of waste through building and material reuse, construction waste management, and ongoing recycling programs.

Credit 1: Building Life-Cycle Impact Reduction (v4.1) – 3 High Achievability Points, 1 Low Achievability Point, 2 Not Achievable Points

- The team is performing a Life Cycle Assessment to determine the embodied carbon reduction that will be achieved by the design, focusing on the project's foundation structure, and enclosure in alignment with the LEED Life Cycle Impact Reduction Credit. The team will be targeting a minimum 10% Global Warming Potential (GWP) reduction for three (3) points under the LEEDv4.1 methodology.
- Embodied carbon reduction strategies that will be explored include, but are not limited to:

- Reduced carbon steel products
- Reduced carbon insulative materials
- Identifying locally-sourced products

Credit 2: Building Product Disclosure and Optimization – Environmental Product Declarations (v4.1) – 1 High Achievability Point, 1 Not Achievable Point

- The Project will evaluate products that have Environmental Product Declarations (EPDs) to meet the LEED Criteria. Compliance will be confirmed during the construction phase.

Credit 3: Building Product Disclosure and Optimization – Sourcing of Raw Materials (v4.1) – 2 Medium Achievability Points

- The project will evaluate products with high recycled content to meet the LEED Criteria. Compliance will be confirmed during the construction phase.

Credit 4: Building Product Disclosure and Optimization – Material Ingredients (v4.1) – 1 High Achievability Point, 1 Medium Achievability Point

- The project will evaluate products with Material Ingredients disclosures to meet the LEED Criteria. Compliance will be confirmed during the construction phase.

Credit 5: Construction and Demolition Waste Management (v4.1) – 1 High Achievability Point, 1 Medium Achievability Point

- The Project will divert a minimum of 50 percent of the total construction and demolition material; diverted materials will include at least three material streams. The project will also track total waste reduction to determine the pounds of waste generated per square foot of development.

Indoor Environmental Quality

The U.S. Environmental Protection Agency estimates that Americans spend about 90 percent of their day in-doors, where the air quality can be significantly worse than outside. The Indoor Environmental Quality credit category promotes strategies that can improve indoor air through low emitting materials selection and increased ventilation. It also promotes access to natural daylight and views.

Prerequisite 1: Minimum Indoor Air Quality Performance

- The Project will meet the minimum requirements of ASHRAE Standard 62.1–2010, Sections 4–7, Ventilation for Acceptable Indoor Air Quality (with errata), or a local equivalent, whichever is more stringent.

Credit 1: Enhanced Indoor Air Quality Strategies - 2 High Achievability Points

- The Project will provide entryway systems, interior cross-contamination prevention, and MERV-13 filtration.
- The Project will also provide CO2 sensors in all densely occupied spaces.

Credit 2: Low-Emitting Materials (v4.1) – 3 High Achievability Points

- The Project will ensure the use of low emitting materials and, at minimum, meet the threshold level of compliance with emissions and VOC content standards for multiple product categories.
- The categories tracked will include paints and coatings, adhesives and sealants, flooring systems, ceilings, and composite wood.
- The specifications will include requirements for products with compliant VOC content and general emissions limits. Compliance will be confirmed during the construction phase.

Credit 3: Construction Indoor Air Quality Management Plan – 1 High Achievability Point

- The Project will develop and implement an indoor air quality (IAQ) management plan for the construction and preoccupancy phases of the building, meeting or exceeding all applicable recommended control measures of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines for Occupied Buildings under Construction, 2nd edition, 2007, ANSI/SMACNA 008–2008, Chapter 3.
- The Project will follow strict IAQ guidelines and protect absorptive materials stored on-site from moisture damage.

Credit 5: Quality Views (v4.1) – 1 High Achievability Point

- The Project will evaluate the ability to provide views with a direct line of sight to the outdoors for at least 75 percent of all regularly occupied floor area.

Innovation and Design Process

The Innovation in Design and Innovation in Operations credit categories provide additional points for projects that use new and innovative technologies, achieve performance well beyond what is required by LEED credits, or utilize green building strategies that are not specifically addressed elsewhere in LEED. This credit category also rewards projects for including a LEED Accredited Professional on the team to ensure a holistic, integrated approach to design, construction, operations, and maintenance. The following credits are being pursued and/or evaluated for the project:

- Innovation in Design: Green Education - 1 High Achievability Point
- Innovation in Design: O+M Starter Kit - 1 High Achievability Point
- Innovation in Design: Sustainable Purchasing – Low Mercury Lamps - 1 High Achievability Point
- Innovation in Design: EP BPDO – EPD's - 1 High Achievability Point
- Innovation in Design: EP Heat Island Reduction - 1 High Achievability Point
- Innovation in Design: LEED Accredited Professional (Colleen Soden) - 1 High Achievability Point

Regional Priority

The Project anticipates the following probabilities of achieving the below Regional Priority credits:

- Regional Priority: Optimize Energy Performance – 1 High Achievability Point
- Regional Priority: High Priority Site - 1 High Achievability Point
- Regional Priority: Building Life-Cycle Impact Reduction - 1 High Achievability Point
- Regional Priority: Rainwater Management - 1 High Achievability Point

LEED SCORECARD – BUILDING CREDITS

LEED v4 for BD+C: Core and Shell
Project Checklist - C1

Project Name: Volpe C1
Date: 3/17/23

Y	?	N			
1			Credit	Integrative Process	1
19	**1**	**0**		**Location and Transportation**	**20**
2			Credit	Sensitive Land Protection (v4.1)	2
			Credit	High Priority Site (v4.1)	3
6			Credit	Surrounding Density and Diverse Uses (v4.1)	6
6			Credit	Access to Quality Transit (v4.1)	6
			Credit	Bicycle Facilities (v4.1)	1
	1		Credit	Reduced Parking Footprint (v4.1)	1
			Credit	Green Vehicles (v4.1)	1
7	**2**	**2**		**Sustainable Sites**	**11**
Y			Prereq	Construction Activity Pollution Prevention	Required
			Credit	Site Assessment (v4.1)	1
		2	Credit	Site Development - Protect or Restore Habitat (v4.1)	2
			Credit	Open Space (v4.1)	1
	2		Credit	Rainwater Management (v4.1)	3
			Credit	Heat Island Reduction (v4.1)	2
			Credit	Light Pollution Reduction (v4.1)	1
1			Credit	Tenant Design and Construction Guidelines (v4.1)	1
6	**5**	**2**		**Water Efficiency**	**13**
Y			Prereq	Outdoor Water Use Reduction (v4.1)	Required
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering (v4.1)	Required
	2		Credit	Outdoor Water Use Reduction (v4.1)	3
3	1	2	Credit	Indoor Water Use Reduction	6
	2		Credit	Cooling Tower Water Use (v4.1)	3
1			Credit	Water Metering (v4.1)	1
19	**8**	**6**		**Energy and Atmosphere**	**35**
Y			Prereq	Fundamental Commissioning and Verification (v4.1)	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering (v4.1)	Required
Y			Prereq	Fundamental Refrigerant Management (v4.1)	Required
6			Credit	Enhanced Commissioning	6
12	4	2	Credit	Optimize Energy Performance	18
		1	Credit	Advanced Energy Metering (v4.1)	1
	1	1	Credit	Grid Harmonization (v4.1)	2
	3	2	Credit	Renewable Energy Production (v4.1)	5
			Credit	Enhanced Refrigerant Management	1
			Credit	~~Green Power and Carbon Offsets~~	2
6	**5**	**3**		**Materials and Resources**	**13**
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management Planning	Required
3	1	2	Credit	Building Life-Cycle Impact Reduction (v4.1)	5
1		1	Credit	Building Product Disclosure and Optimization - Environmental Product Declarations (v4.1)	2
	2		Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials (v4.1)	2
1	1		Credit	Building Product Disclosure and Optimization - Material Ingredients (v4.1)	2
1	1		Credit	Construction and Demolition Waste Management (v4.1)	2
7	**1**	**2**		**Indoor Environmental Quality**	**10**
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control (v4.1)	Required
2			Credit	Enhanced Indoor Air Quality Strategies	2
3			Credit	Low-Emitting Materials (v4.1)	3
1			Credit	Construction Indoor Air Quality Management Plan	1
	1	2	Credit	Daylight (v4.1)	3
1			Credit	Quality Views (v4.1)	1
6	**0**	**0**		**Innovation**	**6**
			Credit	Innovation	5
1			Credit	LEED Accredited Professional	1
4	**0**	**0**		**Regional Priority**	**4**
			Credit	Regional Priority: High Priority Site	1
1			Credit	Regional Priority: Optimize Energy	1
			Credit	Regional Priority: Rainwater Management	1
1			Credit	Regional Priority: Building Life-Cycle Impact Reduction	1
75	**22**	**15**		**TOTALS** Possible Points:	**113**

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

GREEN BUILDING REPORT -

1. Project + Sustainability Overview

The C1 tower is a high-performance lab/office commercial building of approximately 407,162 GFA located on the southwest corner of the Massachusetts Institute of Technology's (MIT) Volpe redevelopment district. The building is a core and shell lab project that incorporates ground-floor retail to encourage a vibrant mixed-use district with access to below-grade parking.

The building will be designed with high-performance building strategies to meet or exceed the City of Cambridge's Article 22 Special Green Building Permit and Planning Unit Development (PUD) District 7 zoning requirements. Further, the building will be designed to meet or exceed the energy efficiency standards of the Massachusetts (MA) Stretch Energy Code and will incorporate net zero carbon emissions, district black water reuse, and a path to full electrification.

The project is pursuing LEED v4 Core and Shell certification and will be part of a LEED Master Site along with two other commercial buildings and three residential towers.

Integrated Design

The C1 design team will use an integrated design process to support efficient and cost-effective project outcomes through an iterative analysis of the interrelationships among systems. The C1 design team coordinates on a weekly basis to discuss design developments and associated considerations. Frequent communication among design team members ensures that each sustainability goal is met efficiently and at lowest possible cost. Beyond the regular team meetings and discussions incorporating sustainability concepts, the design process included numerous workshops centered on sustainability.

- Global Sustainability Workshop – August 10, 2022
- Façade and Daylighting Meeting – October 13, 2022
- Water Use Reduction conversations – October 13, 2022
- SD Energy Analysis Meeting – October 13, 2022
- Sustainability/ LEED approach meeting – October 13, 2022
- Building electrification discussions – October 13, 2022
- Renewable Energy feasibility studies/meetings – October 1, 2022
- Sustainability (LCA, LEED, Energy, Code, Solar, Water Reuse) Meetings – Weekly consultant coordination meetings

Code Requirements & Evolving Standards

The C1 project will be designed in alignment with the City of Cambridge sustainability initiatives and requirements of Section 13.96.4 of the Planned Unit Development 7 District and Article 22 of the Cambridge Zoning Ordinance.

As required under the PUD-7 Zoning Regulations from the City of Cambridge, the buildings shall achieve a minimum of LEED Gold. As a part of the Volpe Masterplan design process, MIT is exploring district energy heating and cooling systems as well as individual building and site level energy conservation measures. The district system analysis includes the evaluation of potential on-site energy generation within the PUD-7 District.

In addition, MIT continues to enthusiastically engage in the City's numerous ongoing sustainability initiatives such as the City of Cambridge Net Zero Action Plan. The Volpe Project's approach to energy, electrification, and resilience is consistent with the goals and objectives of the City of Cambridge.

The team has been tracking the progress of the Specialized Code and is aware that the City Council adopted the Specialized Stretch Code on January 23rd, 2023, with an effective date of July 1st, 2023. The design team is evaluating the different pathways available for compliance for commercial construction under 225 CMR 23 Appendix CC, as applicable.

Further, the C1 tower will be designed to meet or exceed the Massachusetts Stretch Energy code through an optimized, high-performance building design and highly efficient active systems. The 10th Edition of the code based on IECC 2021 will be met. The design team is coordinating closely to ensure the code, envelope backstop, and the net-zero energy requirements of the MA Stretch Energy code can be met depending on the applicable code iteration.

2. Energy + Emissions

The Volpe C1 Tower will be designed to meet the ambitious requirements of the Massachusetts Stretch Energy Code (10th Edition), City of Cambridge's Net Zero Action Plan, and City of Cambridge's Green Roof Ordinance. Beyond code requirements, the performance of the building systems will have environmental and financial benefits because reducing energy use for the project will lessen associated carbon emission offsets and operating costs. Decoupled HVAC, energy recovery, high performance heating and cooling equipment, and high-performance lighting, are some of the many energy conservation measures (ECMs) being considered in C1's basis of design.

District Energy

As a part of the Volpe Masterplan design process, MIT has explored district energy heating and cooling systems as well as individual building and site-level energy conservation measures. The district system analysis included the evaluation of potential on-site geothermal, the use of vicinity steam for Day-1 heating prior to feasibility of full electrification, and a district condenser water loop. The design team evaluated these district energy opportunities based on efficiency improvements, carbon emissions, feasibility, and construction and operating costs. Given the competing infrastructure below grade, such as the Eversource electric transmission line, I&I culvert, and groundwater infiltration tanks (see Figure 1), the feasibility of ground source heat pumps is limited at the site. The team will continue to investigate advances in technologies that may provide district solutions; however, a standalone approach for efficiency and resiliency will be pursued in line with flexibility in construction timeline and ownership factors.

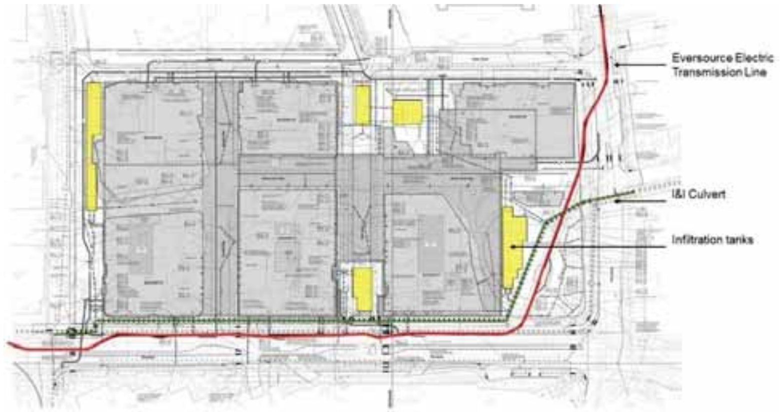

Figure 1 – District Utility Plan

Electrification

The C1 tower energy targets include the design for an all-electric future by providing flexibility to accommodate all-electric MEP equipment in the coming decades when the makeup of the Massachusetts energy grid is anticipated to shift more towards renewable energy sources. This approach will not only prevent a costly design change, but also will avoid the use of excess materials and associated embodied carbon.

The design involves all-electric base heating and cooling on Day 1 with natural gas boilers used only for supplemental heating on peak cold days. The natural gas supplemental heating will eventually be phased out for an all-electric Day 1 scenario.

Renewable Energy

Refer to Net Zero Narrative section.

MIT is committed to purchasing green power, RECs, and/or offsets. The project team will evaluate carbon offsets from venders with third-party verification including Green-e certified offsets.

Energy Storage

The opportunity exists for the project to utilize on-site energy storage strategies as part of a holistic all-electric system. Energy storage systems, particularly battery storage, could be phased into excess below grade spaces as the demand for automobile parking decreases. The team continues to evaluate infrastructure needs to accommodate future flexibility in below grade spaces.

Building Efficiency

The C1 tower will incorporate a hybrid electrification approach with rooftop air source heat pumps, a dedicated outside air system with premium efficiency, glycol run-around energy recovery system energy, and at least one heat recovery chiller to offer high energy efficiency and reduce the need for natural gas consumption. ECMs being incorporated into the base building's design include, but are not limited to:

<u>Architectural</u>

- Highly efficient insulation with a roof construction assembly with effective R-40
- Triple pane glass for all glazing; with a solar heat gain coefficient (SHGC) of 0.30 and an assembly U-value of U-0.25.
- Operable windows for natural ventilation are not recommended due to the lab program's pressurization requirements and it's required tightly controlled thermal environment.

<u>Electrical</u>

- 10% lighting power density (LPD) reductions from 10th Edition baseline
- Occupancy sensors
- Receptacle controls

<u>Mechanical</u>

- Dedicated outside air system with energy recovery system
- Heat recovery chiller for base heating and cooling
- Air-to-water heat pumps for 25% of the building's peak heating capacity
- High efficiency condensing gas-fired boilers to supplement air-to-water heat pumps and heat recovery chiller

- Premium efficiency water-cooled chiller plant

Controls

- Smart building automation system
- Reset air handling unit supply and return fan pressure setpoints
- Discharge air temperature reset

Energy Efficiency

C1 is a best-in-class large laboratory building in terms of energy performance. An energy analysis, conducted at the end of the Design Development indicates that the basis of design (BOD) achieves a 48% reduction in overall site energy compared to the 2023 MA stretch code (10th Ed.) baseline (see figure 2).

By incorporating the energy efficiency measures listed above in the "Building Efficiency" section, the C1 project has achieved an overall Energy Use Intensity (EUI) of 109.7 kBtu/sf-yr and reflects a high energy efficiency design reducing the need for natural gas consumption. Note, the EUI of 109.7 kBtu/sf-yr. is based on the design team's DD documentation, and the energy model will continue to be refined throughout the design process. The results are considered best-in-class performance for a laboratory-intensive building.

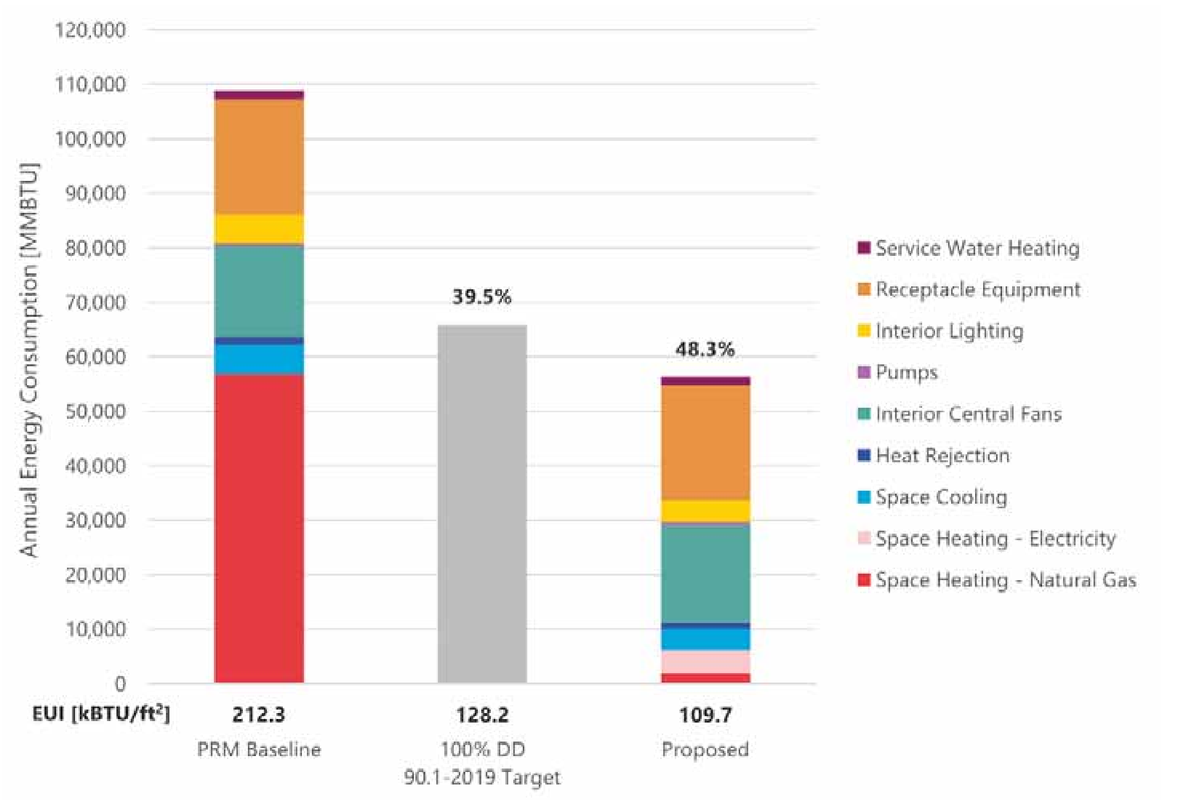

Figure 2 – Annual Site-Energy by End-Use (2023 MA Stretch Code)

Monitoring

C1 intends to be proactive in energy use management and identifying opportunities for additional energy savings through installation of energy meters and smart building controls. C1 will provide electricity meters to monitor all whole-building energy sources used by the building as well as tenant submeters. MIT will continue to explore feasibility of installing further sub-metering broken down by end use for significant energy demands.

Embodied Carbon

During the planning stages, the team acknowledged the importance of embodied emissions expended through construction and manufacturing of building materials. During the design process, the C1 project has identified several Impact Reduction Measures (IRMs) to reduce the building's embodied carbon impacts through material efficiency and the specification of low-embodied carbon materials. The project team has focused on two primary embodied carbon life cycle centers: Structure and Façade comprises approximately 58% of the building's embodied carbon. The anticipated outcome is that the C1 project will likely achieve a targeted 10% reduction in Global Warming Potential associated with Embodied Carbon when compared to the project baseline.

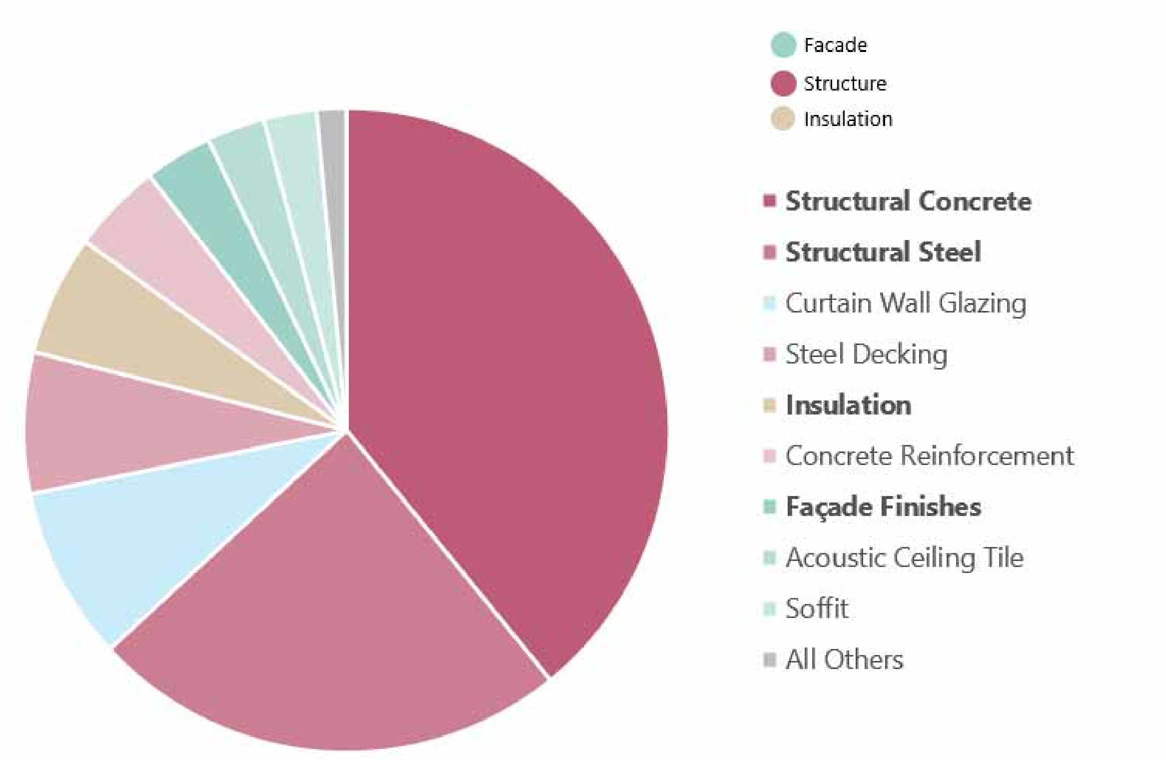

Figure 3 - Preliminary Embodied Carbon Lifecycle Analysis Results
(Primary Embodied Carbon Centers targeted for reduction as part of the C1 design are shown bolded)

The structural design utilizes an efficient highly recycled steel frame that addresses the massing guidelines detailed within the Volpe Masterplan. The result is a structural design that targets a significant reduction of transfer beam conditions significantly reducing the overall tonnage of the building. As part of this effort, the C1 project has eliminated transfer conditions at levels 2, 6 and 7 while still achieving a responsive design solution that responds to the broader urban context. This approach is illustrated within the following progressive diagram:

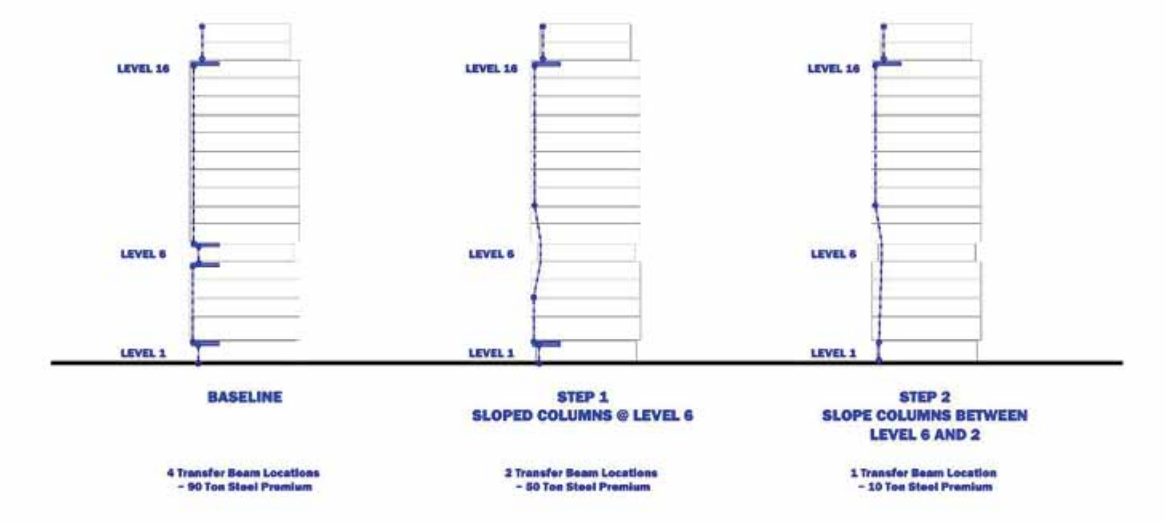

Figure 4 – Volpe C1 Structural Design's Efficiency Approach

The approach to limit embodied carbon associated with the enclosure has coincided with the envelope's iterative approach to meet the proposed 10th Edition of the Massachusetts Building Code's prescriptive requirements. The new code required the design to transition from the industry standard 5' or 5'-6" module to a 7'-4" module as illustrated below:

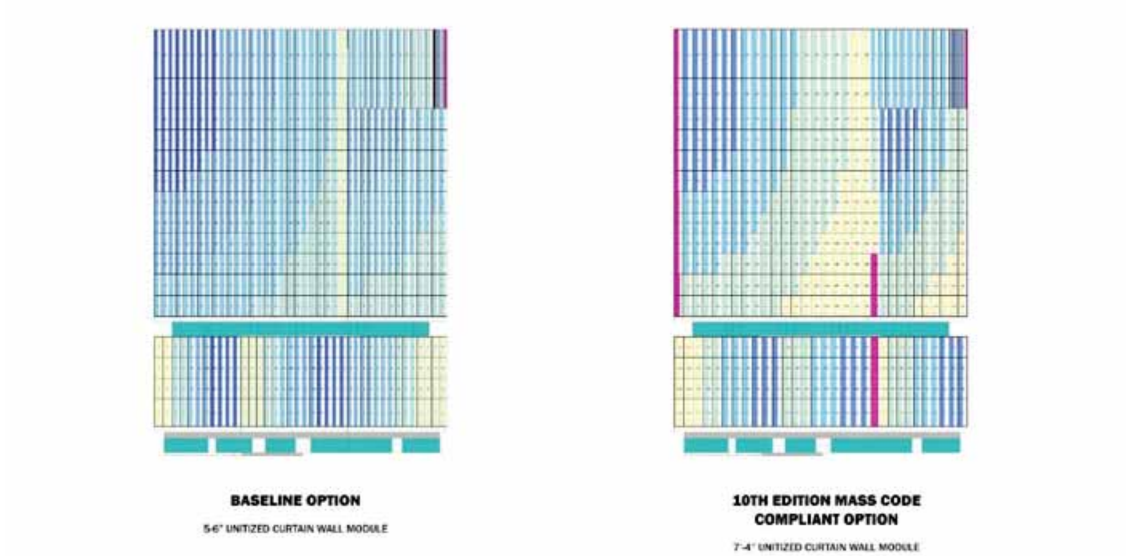

Figure 5 – Façade Optimization

The result is a modified module size that achieves the same design intent while reducing the amount of aluminum used as part of the framing. Additionally, the project has performed a cladding pressure wind tunnel analysis that is allowing the project to further optimize components of the façade including the glazing unit makeup.

In addition to these two primary moves, the C1 project also looks to reduce its embodied carbon footprint by specifying recycled materials within its concrete mix and using low-carbon insulation

options.

3. Water Use Reduction

In the U.S., buildings use about 14 percent of all potable water which equates to approximately 15 trillion gallons of water per year. Water efficiency and reduction efforts in green building design can serve to drastically reduce this metric. The C1 tower will exceed the average green building's water use reduction to contribute to water conservation and reuse even more substantially.

Water Efficiency

The C1 tower will utilize the "Efficiency First" approach to water use reduction through the selection of low flow plumbing fixtures, targeting a minimum 35% reduction from the EPA baseline through efficiency alone. The design team will be selecting a combination of low flow and ultra-low flow fixtures during the Design Development phase to meet this plumbing fixture goal. Using low flow and ultra-low flow fixtures, the project reduces both its water use and energy use associated with the project's plumbing fixtures. Additionally, potable water use reduction will be further supported by specifying ENERGY STAR appliances and installing cooling towers equipped with makeup water meters, conductivity controllers and overflow alarms, and efficient drift eliminators.

Water Reuse

The MIT Volpe Redevelopment represents an impressive case study in water reuse as the design includes the largest urban district-scale blackwater treatment plant in the northeast and will reuse all building water on-site. The C1 tower will contribute to and benefit from the district blackwater system which will collect and recycle all building water (except lab wastewater) from both commercial and residential towers (see Figure 6).

While the design of the blackwater system is still being coordinated on the global-project level, the intent is to collect water from all building plumbing fixtures to be reused to meet the commercial building's cooling tower make-up water demand. Ultimately, the C1 building will have a day-tank that will receive a non-potable water supply from the district reuse system to divert the water to the reuse demand of its choosing. In the case of the C1 tower, most of this water will be directed toward cooling tower makeup supply, however, additional non-potable water allocation to meet plumbing fixtures and irrigation demand is under consideration.

Figure 6 - C1 Water Flow Diagram

4. Health + Wellness

Buildings with improved indoor environmental quality protect the health and comfort of occupants and are known to enhance productivity, decrease absenteeism, and increase the building's value. For commercial office facilities in particular, the creation of healthy interiors is paramount to the physical and mental wellness of those who will occupy the space daily. The C1 Tower will integrate daylight, views of the natural environment, a healthy selection of materials, and noise mitigation to promote occupant health, productivity, and comfort.

Daylight + Views

The project is designed to enhance natural daylight and quality views while mitigating glare. The building's balanced window-to-wall ratio of 35% allows access to daylight and views in regularly occupied spaces while minimizing glare and reducing energy use. The regularly occupied areas of the floorplate to the south and east receive useful daylight illuminance throughout the year. It should be noted, however, they the depth of the floorplate required to support the laboratory program in combination with the surrounding buildings limit the extent to which daylight can penetrate to building's central core.

Materials

A healthy and sustainable material palette will be specified for permanently installed products improving air quality, reducing embodied carbon, and avoiding chemicals of concern. The C1 design team will examine materials in Design Development to ensure products are specified that create healthy indoor environments. Materials will be low emitting, avoiding hazardous chemicals often found in building materials, and selected based on their potential to reduce embodied emissions.

The team is targeting at least 1 point under each LEED Building Product Disclosure and Optimization credits, as well as a minimum of 1 point for the LEED Low-Emitting Materials credit.

Air Quality

The C1 tower will be designed to meet or exceed ASHRAE Standard 62.1-2010 or the local equivalent, whichever is more stringent, to provide enhanced air quality. Lab exhaust rates have been optimized to allow for various tenant programs while minimizing energy consumption. Additional air quality measures include, but are not limited to, providing entryway systems, such as walk-off mats, to reduce exterior pollutants in interior spaces by capturing dirt and particulates from entering the building. The project will also provide measures against interior cross-contamination in spaces where hazardous gases or chemicals are present: not only in labs, but also copy and printing rooms, loading dock entries, and cleaning supplies storage spaces.

Noise Mitigation

The C1 design team will incorporate acoustic performance considerations into the building design to promote occupants' well- being, productivity, and communications. Occupied spaces will be prioritized in acoustic performance provisions, including criteria such as minimized HVAC background noise, acoustic privacy, and reverberation time to comply with 2011 HVAC Handbook, HVAC applications, Chapter 48, Table 1.

5. Site + Transportation

The Volpe site will revitalize publicly beneficial open space and create a landscape that provides habitat & pedestrian tree canopy cover and active outdoor recreation areas while incorporating stormwater management and reuse strategies. Similarly, design measures will be provided to encourage alternative transportation by enhancing bicycle networks, supporting carpool/carshare, and improving pedestrian connectivity to public transit stations. While many of these strategies are being coordinated at the district-level, the C1 tower will support these aims through localized site strategies, for example by providing bicycle facilities on site.

Surrounding Site Strategies

The project will feature infiltration tanks located below grade on multiple areas of the site, as well as integrated green infrastructure, efficient drip irrigation, and native and adapted vegetation throughout the site. The C1 project will also directly benefit from the adjacent Third Street Park immediately to the west of the building including multiple different types of play spaces, passive parks, a half basketball court, and a dog park.

Outdoor Comfort

MIT has engaged RWDI to assess predicted wind conditions on-site for the Volpe development.

RWDI conducted a pedestrian wind assessment for the proposed Volpe Master plan and issued a report on 2/16/23. The wind conditions have been tested based on wind-tunnel testing of the project with partial and full buildout configurations along with landscaping based on local wind conditions. Based on the results, the majority of areas around the C1 building are in the comfortable range for sitting and standing pedestrians.

The design actively contributes to the creation of a comfortable outdoor microclimate in concert with the Volpe redevelopment and the existing surrounding structures.

Bicycle Facilities

Cambridge, MA is the host of an expansive bike network that is continuously being improved. The C1 tower is planning to provide 89 long-term and 28 short-term bike parking spaces as well as 31 shower facilities to encourage occupant's use of the existing bicycle network with the aim of reducing reliance on motor vehicles for transportation to and from work. Bike facilities for C1's occupants will be provided in the below-grade parking garage.

Surrounding Connections

The C1 tower is located near numerous transit stations served by the Red Line rapid transit service, MBTA buses, and an EZ ride stop. Occupants will have the option to take the Red Line at the Kendall/MIT station and ride downtown to Boston as a destination or as a connection point to the Green, Orange, or Silver Lines. The transit services currently available within walking distance of the site provide 541 daily weekday trips and 325 daily weekend trips (see Figure 7) and will increase as a result of a forthcoming bus line expected to begin construction in early 2023.

Additionally, the Volpe redevelopment district is within a 0.5-mile walking distance of many diverse services such as the MIT museum, Bright Horizons Childcare Center, and Brothers Marketplace.

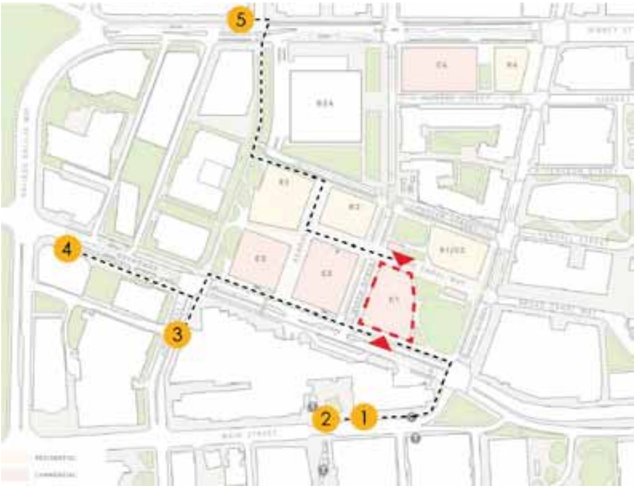

Figure 7 - Existing Surrounding Transit Connect

Green Roof & Rooftop Solar

The team is continuing to identify areas to comply with the City of Cambridge Green Roof Ordinance. There is 4,500 SF of roof area available on Day 1 after exclusions, including mechanical areas identified in the Green Roof Ordinance itself. To meet the 80% threshold identified in the ordinance, the project will allocate at least 3,600 SF of space to Green Roof, Biosolar Green Roof Area, or Solar Energy Systems on Day 1.

The Day 1 available roof area includes spaces that are allocated for all-electric equipment. In these areas the team will consider non-permanent installations. In the spaces shown in orange, a permanent PV installation may be considered.

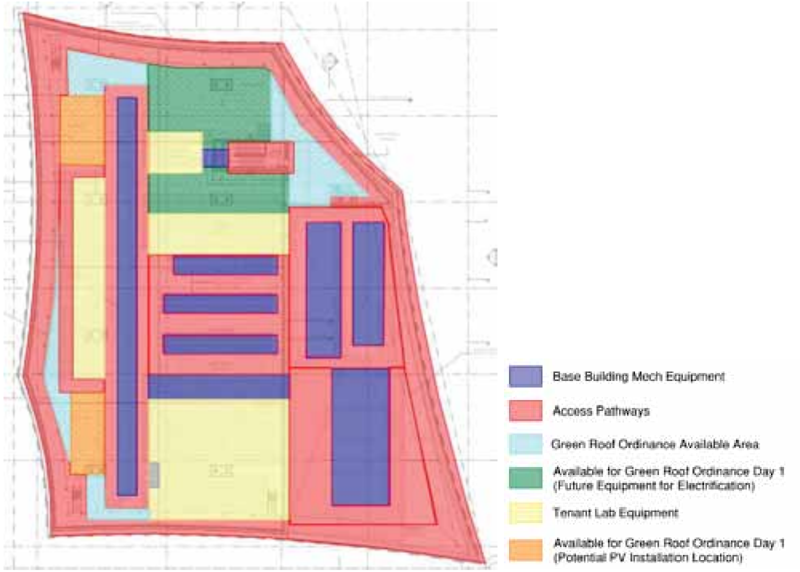

Figure 8 – C1 Roof Area

6. Resilience

The C1 project will embrace climate resilient strategies including elevating critical equipment, incorporating stormwater mitigation strategies, providing standby power for critical equipment, and mitigating urban heat island through integrated site and building strategies.

Flood Mitigation

The project will be designed to manage at least the 100-year 2070 precipitation storm event so that it is prepared for future flooding. The majority of C1's building footprint is located within the future 2070 100-year precipitation floodplain as per the Cambridge Flood Viewer. Elevating MEP infrastructure will be critical for designing the project to withstand such a storm. The C1 design will prioritize passive flood mitigation systems such as floodgates as part of site-wide resilience efforts in addition to below-grade infiltration tanks (See Figure 9).

Figure 9 - Volpe Site Flood Mitigation Strategies

Additionally, the project's access to reused blackwater will contribute to resilience efforts since the building's reliance on potable water resources will decrease. Reducing C1's dependence on municipal resources in tandem with self-sufficient systems will promote a sustainable semi-closed loop water cycle.

Heat Risk + Urban Heat Island

C1 will contribute to mitigating heat risk and the urban heat island effect by providing green spaces throughout the site and selecting highly reflective paving and roofing materials. Heat risk is a substantial threat to thermal comfort, human health, and can be deadly in extreme cases. C1 will address the heat island effect by maximizing green space in the site landscape, providing overhangs, and shading, and specifying light-colored roofing materials.

7. Building Certification

Sustainable buildings consume 30-50% less energy, consume 40% less water, produce 35-40% less carbon dioxide, and produce 50-70% less solid waste than conventionally constructed buildings.[1] In addition to these reductions, LEED certified buildings are proven to increase efficiency, save money, and create healthier spaces for people. The C1 tower will pursue LEED certification in alignment with these goals.

LEED

The C1 project will pursue the LEED Version 4 Building Design + Construction (BD+C): Core and Shell (CS) rating system along with the other Volpe Redevelopment parcels at the Master Site (MS) level. Where possible, we will upgrade credits to version 4.1, but registering the project as version 4 is advisable as v4.1 is in beta. Based on a preliminary LEED assessment, Soden Sustainability has established a current estimate of 75 high-achievability points, 22 medium-achievability points, and 15 low- achievability points. Currently, 21 high-achievability points are being pursued at the MS level, with the remaining 54 points set to be pursued at the project-level. The minimum threshold to achieve LEED Gold is 60 points.

In addition, the project will explore opportunities to utilize LEED v4.1 credit substitutions to take advantage of clarified and updated achievement pathways where viable.

WELL

A primary goal of the C1 project is to foster health and well-being among its occupants through building design as well as policies and protocols that promote these values. The C1 project team is evaluating pursuing the WELL rating system as the vehicle for adopting these changes. While the C1 project team is not pursing certification for the WELL rating system, the design team is evaluating and integrating aspects of WELL into the project as a complement and a supplement to LEED design interventions. Additionally, the C1 project is evaluating certification and alignment with the FitWel healthy building standard.

Below are a few examples of WELL credits that the C1 project is aligned with:

- Smoke Free Environment
- Construction Pollution Management
- Enhanced Ventilation
- Thermal Performance
- Hazardous Material Abatement
- Integrative Design

[1] *Environmental Protection Agency. (n.d.). Greenhouse Gas Equivalencies Calculator: Convert emissions or energy data into concrete terms you can understand – such as the annual CO2 emissions of cars, households, and power plants. EPA. Retrieved October 24, 2022, from https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator#results*

8. Above and Beyond

The C1 tower will be designed to exceed the energy efficiency standards of the Massachusetts (MA) Stretch Energy Code and will include district blackwater reuse, future electrification, and advanced flood mitigation strategies.

Water Reuse

As noted, the MIT Volpe Redevelopment will be the host to the largest urban district-scale blackwater treatment plant in the northeast. All building water (except lab wastewater) will be reused on site. The water will first be collected in infiltration tanks below grade and will be distributed to storage tanks allocated to individual buildings. The C1 design team is at liberty to decide where to direct its allocated treated blackwater, as are the remaining district parcels. It is C1's intent to allocate a majority of this water supply toward cooling towers as makeup water, significantly reducing required potable water for cooling tower processes.

All Electric Day 1 Feasibility

The Cambridge Net Zero Action Plan requires buildings to be at least all-electric ready for a streamlined transition in adoption of an all-electric building system. The C1 tower intends to be equipped with all necessary infrastructure for an all-electric design.

Advanced Resilience Measures

The C1 electrical vault and other MEP infrastructure will be elevated above the flood plain so in the event of a flood, these critical building components are protected. Master Site flood mitigation strategies go above and beyond elevated infrastructure through the incorporation of flood gates at critical flood locations, and elevated ground floor program areas where most applicable. Strategies for passive mitigation are being studied to protect against 3-4 ft storm surges.

NET ZERO NARRATIVE

PROJECT PROFILE

The information included in this Net Zero narrative submission is based on 100% Design Development Phase analysis of the MIT Volpe C1 project. Performance values and systems included in this documentation are subject to change through the final design.

Development Characteristics

Lot Area (sq.ft.):	*116,260 SF*
Existing Land Use(s) and Gross Floor Area (sq.ft.), by Use:	Existing Federal Government Building
Proposed Land Use(s) and Gross Floor Area (sq.ft.), by Use:	Lab/Office: 407,162 sf Active Use/Retail: ~6,983 sf
Proposed Building Height(s) (ft. and stories):	250' – 16 stories (not including mechanical penthouse level)
Proposed Dwelling Units:	0
Proposed Open Space (sq.ft.):	Approx. 3.5 acres (master plan area)
Proposed Parking Spaces:	Approx. 303 spaces provided (proposed parking will be shared with other uses in the future)
Proposed Bicycle Parking Spaces (Long-Term and Short-Term):	89 long-term, 28 short-term

Green Building Rating System

Choose the Rating System selected for this project:

LEED-Leadership in Energy & Environmental Design (U.S. Green Building Council)			
Rating System & Version:	LEED Core and Shell v4	Seeking Certification?*	Yes
Rating Level:	Gold	# of Points:	75 points

Enterprise Green Communities			
Rating System & Version:		Seeking Certification?*	No
Rating Level:		# of Points:	

Passive House Institute US (PHIUS) or Passivhaus Institut (PHI)			
Rating System & Version:		Seeking Certification?*	No

*(*NOTE: Certification is not required through the Green Building Requirements. However, you may choose to indicate if the Project Team intends to pursue formal certification through these Green Building Rating Programs (or their affiliates).)*

PROPOSED PROJECT DESIGN CHARACTERISTICS

Building Envelope

Assembly Descriptions:

Roof:	High albedo roof membrane over underlayment board and R-40 polystyrene insulation
Foundation:	Concrete slurry wall with rigid insulation at base of building to 4' below grade.
Exterior Walls:	Unitized curtainwall with triple insulating glass, 4" mineral fiber insulation at spandrel areas to achieve minimum R-6.25 Uniform Wall assemblies in accordance with the proposed 10th Edition of the Massachusetts Building Code and it's associated stretch code.
Windows:	Triple insulating glass with low-e coating conforming to the prescriptive U-Value (0.25) within the proposed 10th Edition of the code.
Window-to-Wall Ratio:	35% WWR
Other Components:	External shading - Storefront system at levels 1 and 6 consisting of a thermally broken mullion system with triple glazing with a U value of 0.25. All doors within the storefront consist of a thermally broken frame.

Envelope Performance:

	Proposed		Baseline (ASHRAE 90.1-2019 PRM)	
	Area (sf)	U-value	Area (sf)	U-value
Window	60,273	0.25	61,870	0.57
Wall	111,935	0.100	92,806	0.064
Roof	29,476	0.02	29,476	0.063

Envelope Commissioning Process:

MIT understands the lasting value of strong commissioning practices. MIT will pursue envelope commissioning in line with LEED v4 Enhanced Commissioning Requirements, including Envelope Commissioning. To ensure the building is constructed in alignment with the design and energy efficiency goals, MIT will engage a Building Envelope Commissioning Agent, (BECxA). The BECxA will review the project documents, provide suggestions to the design team, and conduct on-site testing to confirm the constructed building envelope meets the Owner's project requirements.

Building Mechanical Systems

Systems Descriptions:

Airside Systems:	- Hydronic dedicated outdoor air supply (DOAS) unit for ventilation air - Hydronic terminal units for space condition of office and lab zones (by tenant) - Hydronic terminal units for lobbies - Water-source heat pump/Packaged single zone units for retail spaces (by tenant)
Space Heating:	- Hot water will be generated using three (3) 6,000MBH high efficiency gas fired condensing boilers, (6) 48-ton water-cooled modular heat pump chillers and (27) 30-ton air source heat pump modules (Multistack ARP or equivalent) to provide an all electric base systems solution.
Space Cooling:	Chilled water (CHW) from (3) 950-ton high-efficiency water-cooled centrifugal chillers each with VSD drives and (6) 48-ton water cooled modular heat pump chillers
Heat Rejection:	-(4) 2800 GPM evaporative cross flow cooling towers w/ variable speed fan motors;
Pumps & Auxiliary:	- Variable speed pumps for CHW, HW, and CW
Ventilation:	- Ventilation requirements based on ASHRAE 62.1-2016 - Dedicated outdoor air units with energy recovery
Domestic Hot Water:	(9) 120 gallon electric water heaters
Interior Lighting:	- All LED lighting fixtures with occupancy and daylight controls - LPDs based on MA 2020 Stretch Code w/ 10% reduction
Exterior Lighting:	All LED lighting fixtures with installed capacity of ~5.0 kW
Other Equipment:	Plug Loads – 1.5 W/SF in the office spaces, 8.0 W/SF in the lab spaces

Systems Commissioning Process:

MIT will commission building systems to maintain performance and ensure maximum energy savings and emissions reductions as outlined in LEED v4 Enhanced Commissioning Requirements.

BUILDING ENERGY PERFORMANCE MEASURES

Overview:

Land Uses:	The building will include commercial office and/or lab uses on the upper floors, retail and active uses on the Ground Floor, and below-grade parking. The open space will promote connections with the environment, encourage retail spill-out from the building, and engage outdoor activities. The project will provide bicycle infrastructure and connectivity to multimodal public transportations to promote walking and bicycling throughout the development. Site connectivity and careful planning of loading and servicing of buildings enhances pedestrian-friendly circulation. To reduce stormwater runoff, thesite will collect, reuse, and infiltrate excess stormater that falls within the boundary of the development.
Building Orientation and Massing:	The massing of the building is intended to complement the ensemble of buildings within the Volpe development. Designed in tandem with an adjacent park, its form complements pedestrian flow. The park and ground floor amenities work to create a civic space in the “Heart of Kendall Square” that reinforces pedestrian connectivity to the Charles River and MIT Campus. Building footprints defined by the street grid allow connectivity through a previous super-block site. From there, setbacks have been designed to maximize daylight to the street level, while park areas have been located to take advantage of the best solar exposures and daylight.
Envelope Systems:	The building’s exterior envelope is composed of triple-insulated high-performance glazing in a unitized aluminum curtain wall system. Glazing sizes have been maximized to reduce thermal bridging and optimize daylight and views to the exterior.
Mechanical Systems:	- High-performance on-site chiller and boiler plant - High-performance run-around glycol energy recovery coil for the lab exhaust - Higher supply air temperature reset for the DOAS AHUs to reduce the reheat energy - A decoupled system with DOAS units and active chilled beams for conditioning the tenant spaces - Variable speed exhaust fan system
Renewable Energy Systems:	After accounting for day 1 MEP equipment, tenant rooftop footprint allowance, and electrification space needs, there is no additional rooftop space available for on-site renewable energy.
District-Wide Energy Systems:	The team will continue to investigate advances in technologies that may provide district solutions; however, a standalone approach for efficiency and resiliency will be pursued in line with flexibility in construction timeline and ownership factors. Given the competing infrastructure below grade, such as the Eversource electric transmission line, I&I culvert, and groundwater infiltration tanks (see Figure 1), the feasibility of ground source heat pumps is limited at the site.
Other Systems:	N/A

Integrative Design Process

The design team has pursued an integrated design process that includes continuous participation from the technical experts to enhance and improve the overall design. This comprehensive approach allows the development to incorporate sustainability best practices in design and operation, stormwater capture and reuse, transportation, and landscape strategies.

The team conducted a preliminary energy analysis and water budget before the completion of the Schematic Design (SD) phase, and both will be documented in the buildings' OPR & BOD.

MIT, NBBJ, RedGate, TCCO, DREAM Collaborative, Buro Happold, ARUP, and Soden Sustainability, engaged in robust conversations on sustainability. Beyond the regular team meetings and discussions incorporating sustainability concepts, the design process included numerous workshops centered on sustainability.

- Sustainability Workshop – August 10, 2022
- Façade and Daylighting Meeting – October 13, 2022
- Water Use Reduction conversations – October 13, 2022
- SD Energy Analysis Meeting – October 13, 2022
- Sustainability/ LEED approach meeting – October 13, 2022
- Building electrification discussions – October 13, 2022
- Renewable Energy feasibility studies/meetings – October 1, 2022
- Sustainability Meetings – Weekly consultant coordination meetings

MIT has continued to employ an integrative team process throughout the design development phase to maintain focus on sustainability and building performance.

Green Building Incentive Program Assistance

The project team is considering financial support opportunities available through Mass Save. Applicable programs include the Commercial New Construction and Major Renovations program. MIT is familiar working with Eversource for the Mass Save program through other projects such as the Residences at 165 Main Street (Kendall Square Site 1), Commercial building at 238 Main street (Kendall Square Site 3), Academic administrative offices at Buildings E37, E38 (Kendall Square Site 4), and Commercial building at 314 Main Street (Kendall Square Site 5).

The Commercial New Construction and Major Renovations program offers multiple pathways for achieving financial support. Path 2: Whole Buildings Energy Use Intensity (EUI) Reduction has been identified as the most applicable pathway for this project. The program provides financial incentives based on percent EUI reductions beyond the Mass Save Baseline and provides cost share for technical assistance (up to 75%) as well as financial incentives to help projects achieve the EUI goal. Projects begin earning incentives for a 10% EUI reduction relative to the Mass Save Baseline. In addition, an optional Verification Incentive will be explored which would provide financial support to assist projects in ensuring the EUI target set during design is achieved post occupancy. The project team will investigate these incentive opportunities further to ensure the project is eligible for the maximum incentive benefit possible.

The team will continue to evaluate the applicable incentive programs as the design progresses.

NET ZERO SCENARIO TRANSITION

	Net Zero Condition:	Transition Process:
Building Envelope:	No modification. High performance envelope with optimized thermal properties in BOD	N/A
HVAC Systems:	Heat recovery chiller(s) + ASHPs + Exhaust source heat pumps shall supply (100%) of the building's peak heating load at the ASHRAE 99.6% winter climatic design condition. Electric boilers for supplemental heating on peak demand days. Condensing boilers will be in place as backup.	Additional ASHPs to be added to meet greater than 25% of peak load and swap existing gas-fired boilers that are in design for super-peak cold days for electric resistance boilers, or ASHPs in the case that the technology has advanced to handle lower outdoor air temperatures
Domestic Hot Water:	Electric (Same as BOD)	N/A
Lighting:	All LED Lightning design (Same as BOD)	N/A
Renewable Energy Systems:	N/A	N/A
Other Strategies:	Electrical infrastructure in the BOD shall be designed to handle the all-electric HVAC infrastructure	N/A

ENERGY SYSTEM COMPARISON
Overview

The non-carbon fuel scenario is identical to the net zero scenario. Please refer to the information above for the Net Zero scenario for a description of how the building would operate without combustion-based fuels for non-backup equipment.

Assumptions

	Included in analysis?		Describe the systems for which this was analyzed or explain why it was not included in the analysis:
	Yes	No	
Solar Photovoltaics:		X	After accounting for day 1 MEP equipment, projected tenant rooftop footprint allowance, and electrification space needs there appear to be limited space opportunities for rooftop renewable energy. MIT will continue to evaluate rooftop space opportunities as tenant needs become defined and are committed to maximizing the potential of on-site renewable energy.
Solar Hot Water:		X	Excluded. The rooftop area is fully utilized.
Ground-Source Heat Pumps (Geothermal):		X	Geothermal capacity within feasible area of the project site boundary would meet a marginal demand of project.
Water-Source Heat Pumps:	X		Description in Net Zero Scenario above.
Air-Source Heat Pumps:	X		Description in Net Zero Scenario above.
Non-Carbon Fuel District Energy:		X	Building is owned and operated independently of adjacent buildings
Other Non-Carbon-Fuel Systems:		N/A	N/A

Non-Carbon-Fuel Scenario

The non-carbon fuel scenario is identical to the net zero scenario. Please refer to the information above for the Net Zero scenario for a description of what systems would be used in a non-carbon fuel scenario. The proposed design has been optimized to become 100% electric and results in no fossil fuel consumption. The Volpe C1 Net Zero plan can be achieved with off-site renewable energy options, or with a 100% future all-renewable grid.

Solar-Ready Roof Assessment

Total Roof Area (sq. ft.):	+/- 27,300 SF
Unshaded Roof Area (sq. ft.):	+/- 27,300 SF, before self-shading from massing and design +/- 14,300 SF, after self-shading from massing and design
Structural Support:	Rooftop can support PV installation
Electrical Infrastructure:	Electrical infrastructure is installed day 1 for proposed PV installation.
Other Roof Appurtenances:	After accounting for day 1 MEP equipment, tenant rooftop footprint allowance, and electrification space needs, there is minimal rooftop space available for on-site renewable energy on Day 1 (see orange area in Figure 10).
Solar-Ready Roof Area (sq. ft.):	~900 SF of rooftop area is available for installation, pending tenant needs
Capacity of Solar Array:	~12 kW
Financial Incentives:	Incentives can be evaluated at a future date pending rooftop availability.
Cost Feasibility:	Cost can be evaluated at a future date pending rooftop availability.

Figure 10: Rooftop Solar Availability (in Orange) after all projected Rooftop Equipment Installed

Results (TBD)

(Briefly summarize the results of the analysis and how it has informed the design of the project. Also include figures for the "Non-Carbon-Fuel Scenario" in the concluding Summary Table at the end of the Net Zero Narrative. Attachments can be provided with more specific figures and metrics regarding installation, maintenance, and upkeep costs (exclusive of operating fuel expenses), but a full report is not necessary.)

	Proposed Design		Non-Carbon-Fuel Scenario	
	Installation Cost	Maintenance Cost	Installation Cost	Maintenance Cost
Space Heating				
Space Cooling				
Heat Rejection				
Pumps & Aux.				
Ventilation				
Domestic Hot Water				
(Financial Incentives)	TBD		N/A	
Total Building Energy System Cost	Estimate under development		N/A	

The design team is encouraged by the reduction in operational energy, specifically heating energy exhibited by the heat pump chillers and air-source heating equipment. The additional cost of heating will be evaluated against the potential decrease in future carbon emissions to determine what measures could be included in the final design.

MIT and the design team are excited about the future of electrification, the team is conscious of the realities on the use and reliability of an all-electric lab building. As utility grid emissions improve for increased electricity generation and renewable sources, the ASHPs/ Electric boilers can be installed to make a significant reduction in operational carbon emissions. The design team is committed to preparing for an all-electric future and is evaluating in greater depth the potential feasibility for the hybrid solution with a heat-pump chiller at the site. The heat pump chiller would be designed similarly to the full-electrification scenario and would serve the primary heating demand however, natural gas boilers would provide secondary heating loads and heating in power-loss situations. MIT and the design team will ensure the project will have the capability to transition to all-electric in the future.

ANTICIPATED ENERGY LOADS AND GREENHOUSE GAS EMISSIONS
Assumptions

The project will demonstrate energy code compliance by adhering to the 10th Edition of the Massachusetts Building Code - 780 CMR, Chapter 4 – Commercial Energy Efficiency. Compliance will be via the Relative Performance Compliance Path.

This path requires the Proposed building to be compliant with minimum requirements as proposed in MA Stretch Code and ASHRAE 90.1-2019 Appendix G, with specific MA amendments.

The anticipated energy analysis results included in this documentation are based on the 100% Design Development phase drawings and are subject to change through the final design. Updated energy results will be performed with each major design submission. The model considers current design assumptions about occupancy, hours of operation, internal loads, envelope criteria, and mechanical system design. Tenant areas were modeled assuming a 60/40 distribution of lab and office areas with generic space layouts, consistent with the building design criteria.

Annual Projected Energy Consumption and Greenhouse Gas (GHG) Emissions

	Baseline Building		Proposed Design		Future Scenario		Non-Carbon-Fuel Scenario	
	MMBTU	% of Total	MMBTU	% of Total	MMBTU	% of Total	MMBTU	% of Total
Space Heating	56,877	52%	6,244	11%	5,536	10%	N/A	N/A
Space Cooling	5,362	5%	3,874	7%	3,874	7%	N/A	N/A
Heat Rejection	1,369	1%	1,032	2%	1,032	2%	N/A	N/A
Pumps & Aux.	399	0%	636	1%	636	1%	N/A	N/A
Ventilation	16,726	15%	17,841	32%	17,841	32%	N/A	N/A
Domestic Hot Water	1,541	1%	1,541	3%	1,541	3%	N/A	N/A
Interior Lighting	5,457	5%	3,955	7%	3,955	7%	N/A	N/A
Exterior Lighting	0	0%	0	0%	0	0%	N/A	N/A
Misc. Equipment	21,123	19%	21,123	38%	21,123	38%	N/A	N/A
	$US, MMBTU, kBTU/SF		$US, MMBTU, kBTU/SF	% Reduction from Baseline	$US, MMBTU, kBTU/SF	% Reduction from Baseline	$US, MMBTU, kBTU/SF	% Reduction from Baseline
Site EUI	212.3		109.7	48.3%	108.3	49.0%	N/A	N/A
Source EUI	400.3		300.5	24.9%	303.3	24.2%	N/A	N/A
Total Energy Use	108,855		56,246	48.3%	55,538	49.0%	N/A	N/A
Total Energy Cost	~$3.1 M		~2.7 M	~12.0 %	~2.6 M	~13.0 %	N/A	N/A
	kWh or Therms	% of Total Energy	kWh or Therms	% of Total Energy	kWh or Therms	% of Total Energy	kWh or Therms	% of Total Energy
On-Site Renewable Energy Generation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Off-Site Renewable Energy Generation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

	Baseline Building	Proposed Design	
	Tons CO2 [/SF]	*Tons CO2 [/SF]*	*% Reduction from Baseline*
GHG Emissions	6,705	3,951	41.1%
GHG Emissions per SF	0.013	0.008	41.8%

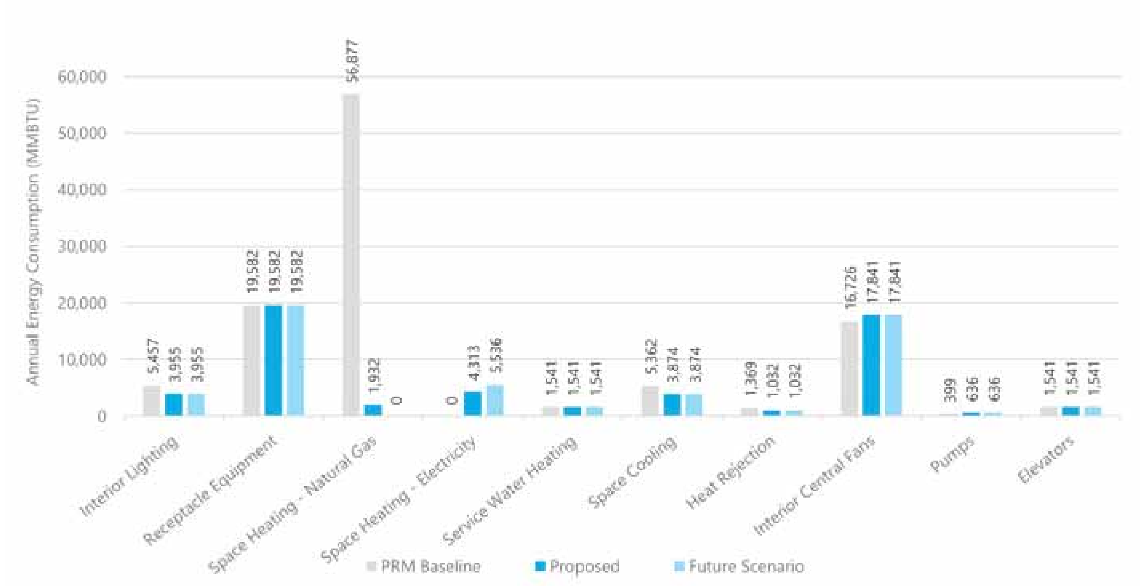

Figure 12: Annual Energy Consumption by System (Baseline, Proposed and Future)

4.2 Acoustical Narrative

ACENTECH

33 Moulton Street
Cambridge MA 02138
617 499 8000
acentech.com

April 11, 2023

Rishi Nandi
NBBJ
One Center Plaza, Suite 800
Boston, MA 02110

Subject **Environmental Noise Study - DRAFT**
Volpe Site Redevelopment – Building C1
Cambridge, MA
Acentech Project No. J635985

Dear Rishi:

This report presents our evaluation of exterior mechanical equipment noise for the Volpe Site Redevelopment Building C1, based on mechanical drawings and mechanical equipment sound data received as of March 3, 2023.

EXECUTIVE SUMMARY

We have estimated the noise levels generated by specified project mechanical equipment at properties surrounding the project site based on the most recent design drawings.

As currently specified, all project mechanical and electrical equipment will comply with City of Cambridge noise regulations at all nearby properties.

APPLICABLE NOISE CRITERIA

Commonwealth of Massachusetts

The Commonwealth of Massachusetts has enacted regulations for the control of air pollution (310 CMR 7.10). To enforce these regulations, MassDEP has issued guidelines that limit the level of noise transmission to adjacent properties as follows:

a) Do not increase the residual ambient sound level by more than 10 dBA and

b) Do not produce a pure tone condition where the sound pressure level in one octave band exceeds the levels in the two adjacent octave bands by 3 dB or more.

City of Cambridge

The City of Cambridge Code of Ordinances, Chapter 8.16: Noise Control Ordinance defines the maximum allowable noise limits generated by project equipment. These noise limits are enforced at adjacent property lines, and are defined in A-weighted sound pressure levels (dBA) and by frequency bands, based on zoning districts. Residential zones (which the project area is within) have the most stringent noise criteria, with maximum daytime (7 AM – 6 PM) limits of 60 dBA and nighttime (6 PM – 7 AM) limits of 50 dBA. These standards are enforced only for the source sound levels as a project owner has no control over the ambient sound levels.

We understand based on discussions with the City of Cambridge that an emergency generator in a commercial area with no residences nearby does not need to meet the City's noise requirements. Since there

are nearby residences, the emergency generator should meet the residential daytime limits and be tested during daytime hours.

Project Sound Goals

Based on the project site noise monitoring results, the City of Cambridge noise requirements are the more stringent of the two applicable regulations. Therefore, we will use these noise level limits of 60 dBA during daytime hours and 50 dBA during nighttime hours as the basis of design.

EQUIPMENT EVALUATION

Based on information that you provided us, we developed a sound model with a widely-accepted computer software program (Cadna/A) to estimate the contributions of various Project sources to the community sound levels.

Equipment

We modeled C1 sound sources based on sound data provided by the mechanical engineer and the roof HVAC plan received 3/3/2023 and subsequent supplemental information as part of our analysis. The C1 equipment includes:

- Air-source heat pumps (ASHPs, qty. 32 modules total)
- Air handling units (AHUs, qty. 6).
- Exhaust air handling units (EAHUs, qty. 6; discharge fans qty. 12)
- Cooling towers (CTs, qty. 4)
- Emergency Generators, Base Building 2500 kW (qty. 1) and Tenant 1500 kW (qty. 1)

Noise Mitigation Provided for Equipment

The following noise mitigation strategies have been incorporated into the architectural and mechanical design of the project to comply with the City of Cambridge noise requirements:

- Parts of the building façade will act as an acoustical barrier around the rooftop equipment.
- The ASHPs will be provided with manufacturer's discharge sound attenuators and acoustical compressor wraps.
- The AHUs will be provided with sound attenuators for the outside air inlet ductwork.
- The EAHUs will be provided with discharge sound attenuators on the exhaust side.
- The cooling towers will be equipped with the manufacturer's reduced noise fans and controlled with variable-frequency drives.
- The emergency generators will be provided with sound-reducing weatherproof enclosures.

RESULTING COMMUNITY NOISE LEVELS

The total community noise levels produced by the submitted project mechanical equipment are listed in TABLE 1. Location of C1 and associated receiver locations are shown in FIGURE 1. The receivers are conservatively located near the upper floors of each building. Some of these receivers are associated with future residential buildings at the Volpe site. Emergency generator noise levels are not included in Table 2 (generators are discussed in the following section).

MEP Systems Evaluation

Based on the equipment listed above, all airside building mechanical equipment will comply with the City of Cambridge noise regulations at all nearby properties as currently specified.

TABLE 1. Predicted Sound Levels from Community Noise Model
Including Recommended Noise Mitigation

Receiver	Receiver Zoning Usage	Sound Level (dBA) Daytime (7 AM – 6 PM)	Sound Level (dBA) Nighttime (6 PM – 7 AM)
Rec 1	Residential	33	30
Rec 2	Commercial	23	20
Rec 3	Commercial	25	22
Rec 4	Commercial	33	31
Rec 5	Residential	33	31
Rec 6	Residential	44	42
Rec 7	Residential	40	36
Rec 8	Commercial	40	36
Rec 9	Commercial	40	38
Rec 10	Residential	45	43
Rec 11	Commercial	33	31
Rec 12	Residential	47	44
Rec 13	Residential	47	45
Rec 14	Residential	43	41
Rec 15	Residential	47	44
Maximum Allowable Noise Requirements (Residential)		**60 dBA**	**50 dBA**

EMERGENCY GENERATORS

Emergency generator noise levels were not included in TABLE 1. The sum of the building mechanical equipment and emergency generator sound is estimated to produce community noise levels of up to 55 dBA during testing at the nearest residential receiver. Generator noise levels at all other nearby neighbors are estimated to be quieter than this receiver location.

As currently specified, the emergency generator will meet MassDEP and Cambridge community noise Code requirements for daytime testing. Nighttime testing of the emergency generator is not expected.

****

I trust this letter provides the information that you need at this time. Please feel free to reach out with any comments or questions.

Sincerely,

Alexander Roehl
Senior Consultant
Direct: 617-499-8026
aroehl@acentech.com

Alex Odom
Senior Consultant
Direct: 617-499-8027
aodom@acentech.com

Figures 1-7

cc: Rose Mary Su, Jay Bliefnick, Jim Barnes/ Acentech

FIGURE 1.
MODELED RECEIVER LOCATIONS FOR COMMUNITY NOISE EVALUATION.

4.3 Wind Study

FINAL REPORT

VOLPE REDEVELOPMENT BUILDING C1

CAMBRIDGE, MA

PEDESTRIAN WIND STUDY
RWDI # 2205694
April 10, 2023

SUBMITTED TO

Alan Peterson
Senior Associate | Project Manager
APeterson@nbbj.com

NBBJ
One Beacon Street
Suite 5200
Boston, MA 02108

SUBMITTED BY

Kamran Shirzadeh, M.E.Sc., E.I.T.
Technical Coordinator
Karman.Shirzadeh@rwdi.com

Neetha Vasan, M.A.Sc., LEED A.P.
Senior Specialist / Associate
Neetha.Vasan@rwdi.com

Sonia Beaulieu, M.Sc., PMP, P.Eng.
Senior Project Manager / Principal
sonia.beaulieu@rwdi.com

RWDI
600 Southgate Drive
Guelph, Ontario, Canada
N1G 4P6
T: 519.823.1311

EXECUTIVE SUMMARY

RWDI was retained to conduct a pedestrian wind assessment for the proposed Volpe Redevelopment Building C1 in Cambridge, MA (Image 1). The potential wind conditions have been assessed for several site configurations represented as:

A. Build C1 & C2 – Buildings C1 & C2 with existing surroundings.
B. Build C1 & C3 – Buildings C1 & C3 with existing surroundings.
C. Build C1, C2, C3 & R1 – Buildings C1, C2, C3 & R1 with existing surroundings.
D. Build – Buildings C1, C2, C3, R1, R2 & R3 with existing surroundings.
E. Build with Landscaping – Configuration D with addition of the proposed landscaping.
F. Full Build – Configuration E with addition of the future surroundings.

The results of the assessment are shown on site plans in Figures 1A through 2F, while the associated wind speeds are listed in Table 1 and 2.

The key findings are summarized as follows:

Effective Gust

In all configurations, wind speeds are expected to meet the effective gust criterion at all locations assessed around Building C1.

Mean Speed

Wind conditions are expected to be comfortable for passive use in on-site areas including the main entrances. In interim scenarios where Building R1 is present (Configurations C and D) potentially uncomfortable wind speeds are expected occasionally in a small area of the sidewalk between buildings C1 and R1; however, these conditions will be ameliorated with the proposed landscaping on the C1 site and adjacent sidewalk. Wind speeds on the site will be further reduced with the addition of all the Volpe masterplan buildings, the proposed masterplan landscaping and future surrounding buildings.

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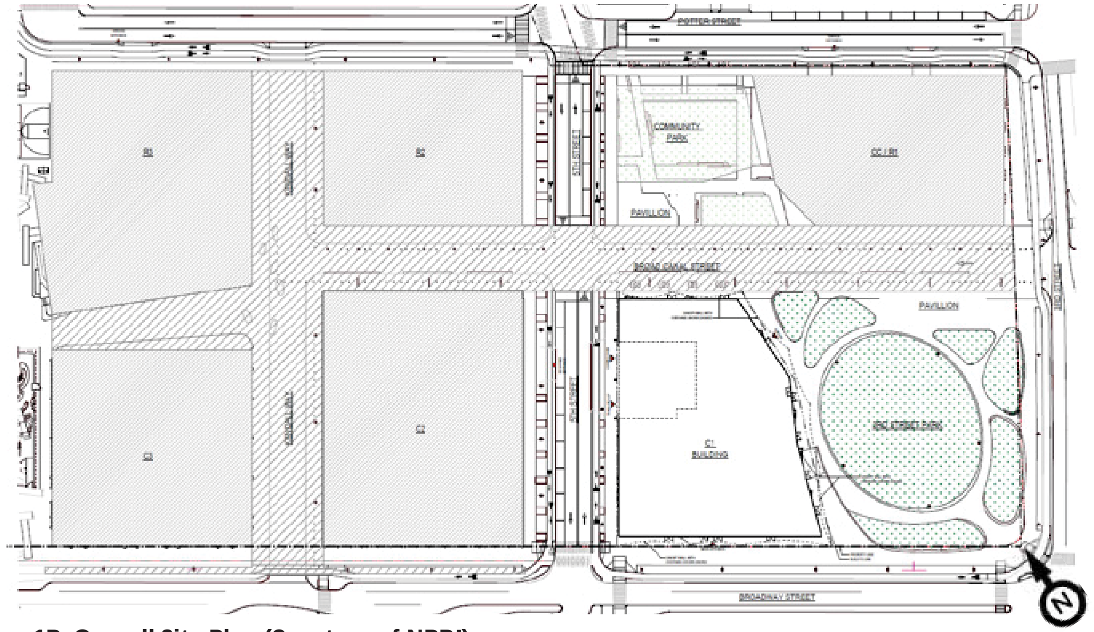


Image 1B: Overall Site Plan (Courtesy of NBBJ)

2 BACKGROUND AND APPROACH

2.1 Methodology

To assess the wind environment around the proposed project, a 1:300 scale model of the project site and surroundings was constructed for the wind tunnel tests of the following configurations:

A. Build C1 & C2 – Buildings C1 & C2 with existing surroundings (Image 2A),
B. Build C1 & C3 – Buildings C1 & C3 with existing surroundings (Image 2B),
C. Build C1, C2, C3 & R1 – Buildings C1, C2, C3 & R1 with existing surroundings (Image 2C),
D. Build – Buildings C1, C2, C3, R1, R2 & R3 with existing surroundings (Image 2D),
E. Build with Landscaping – Configuration D with addition of the proposed landscaping (Image 2E), and
F. Full Build – Configuration E with addition of the future surroundings (Image 2F).

The wind tunnel model included all relevant surrounding buildings and topography within an approximately 1200 ft radius of the study site. The wind and turbulence profiles in the atmospheric boundary layer beyond the modelled area were also simulated in RWDI's wind tunnel. The wind tunnel model for C1 Building was instrumented with 44 specially designed wind speed sensors to measure mean and gust speeds at a full-scale height of approximately 5 ft above local grade in pedestrian areas throughout the study site. Wind speeds were measured for 36 directions in a 10-degree increment. The measurements at each sensor location were recorded in the form of ratios of local mean and gust speeds to the mean wind speed at a reference height above the model. The placement of wind measurement locations was based on our experience and understanding of the pedestrian usage for this site and reviewed by the design team.

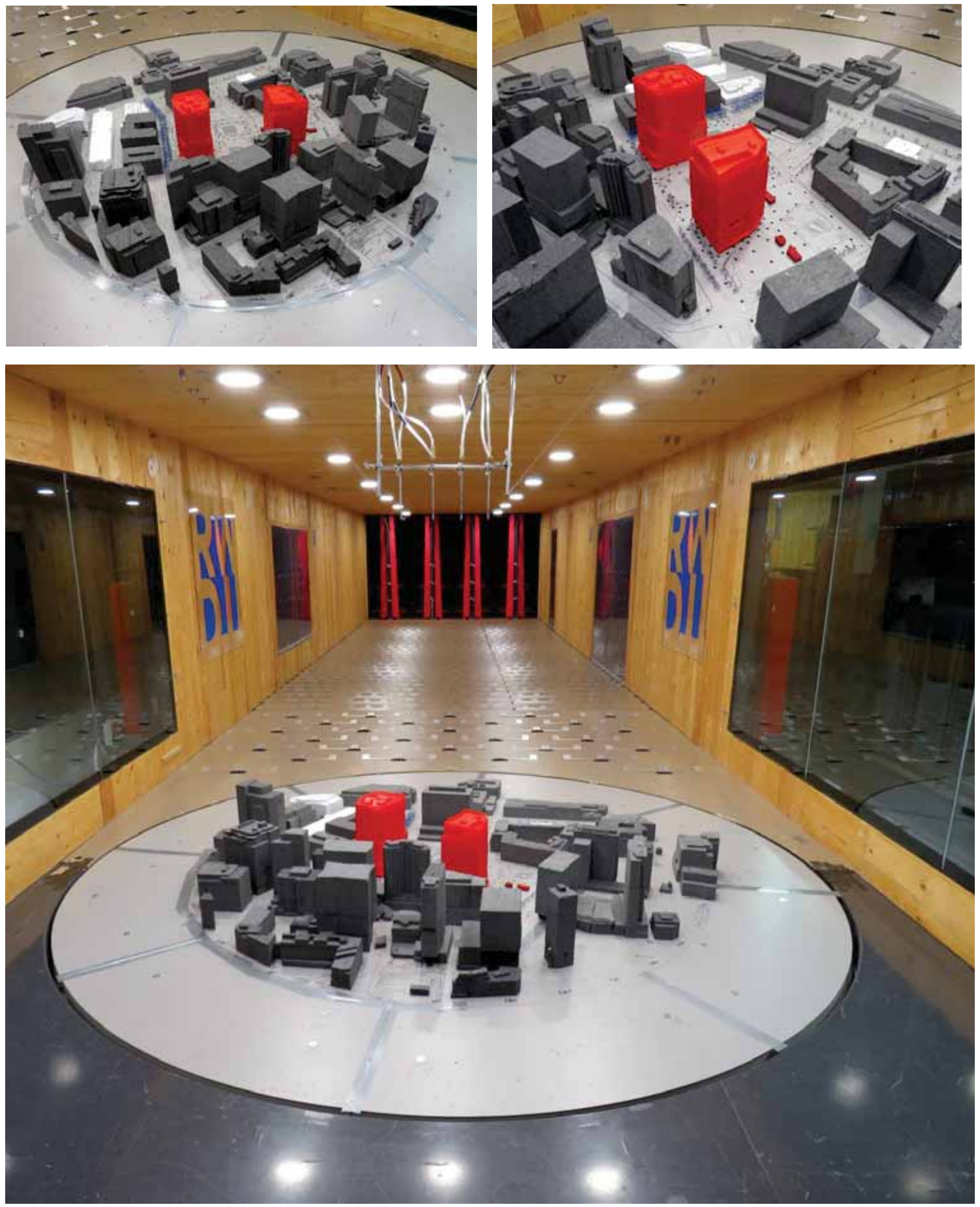


Image 2B: Wind Tunnel Study Model – Build C1 & C3

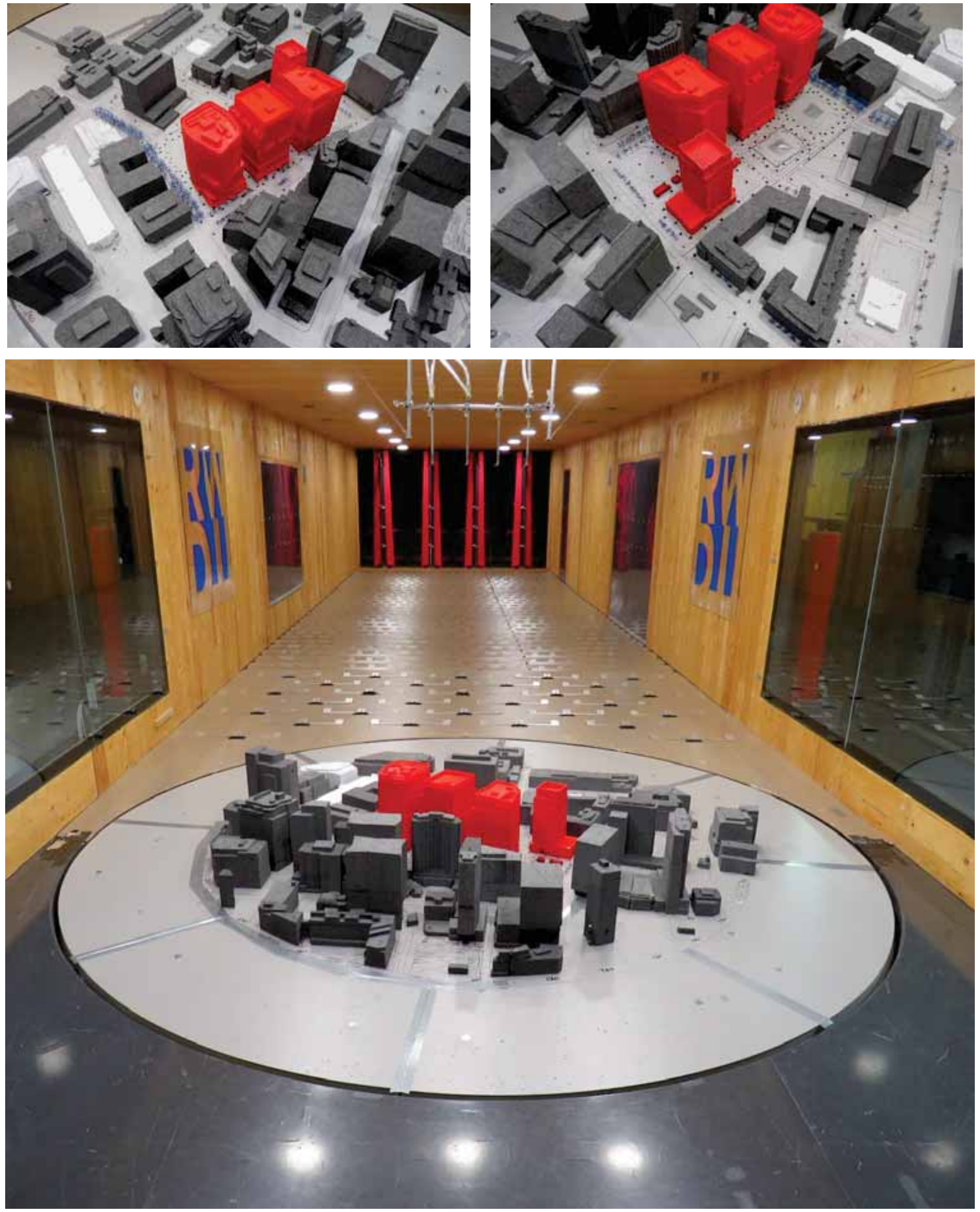


Image 2C: Wind Tunnel Study Model – Build C1, C2, C3 & R1

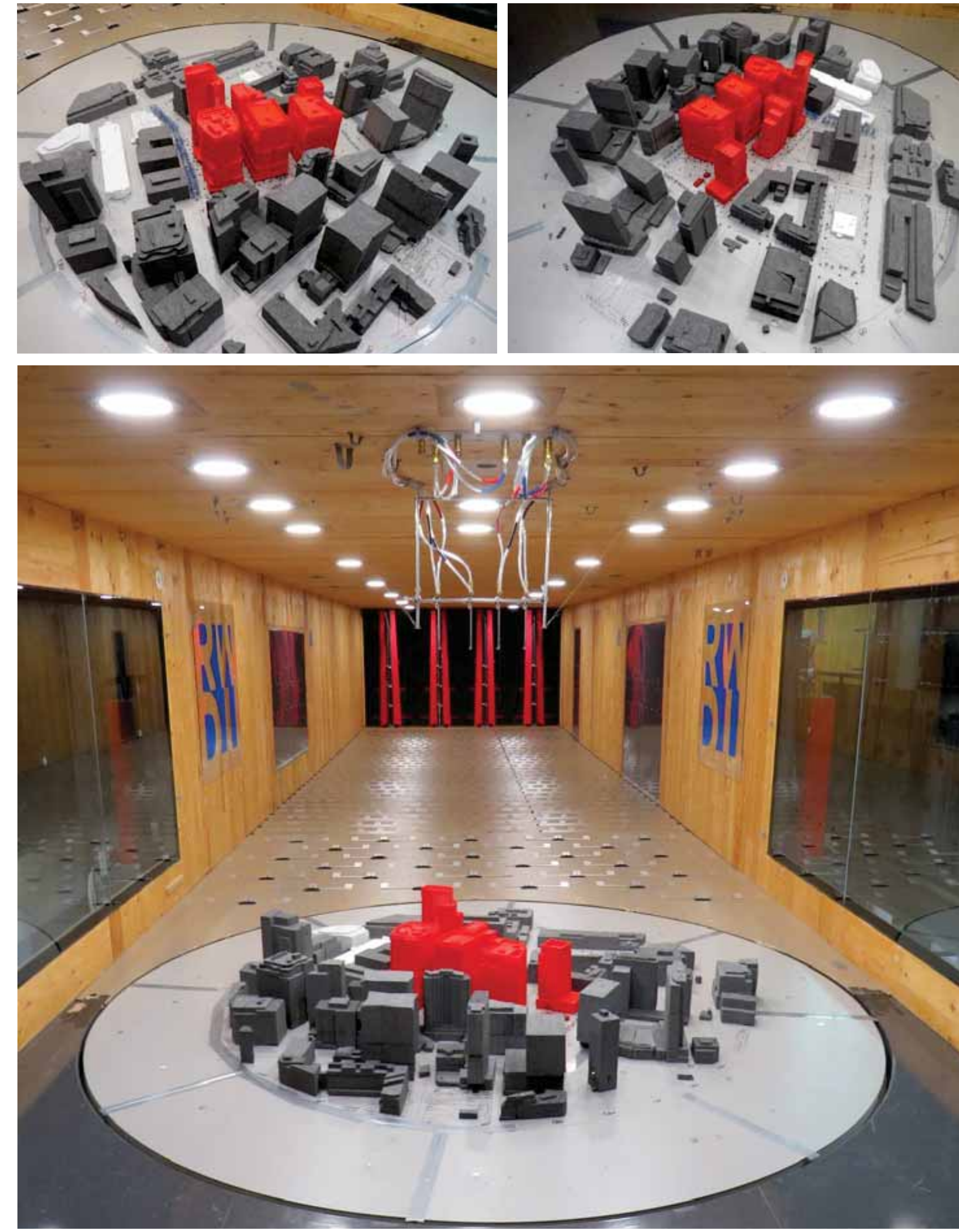


Image 2D: Wind Tunnel Study Model – Build

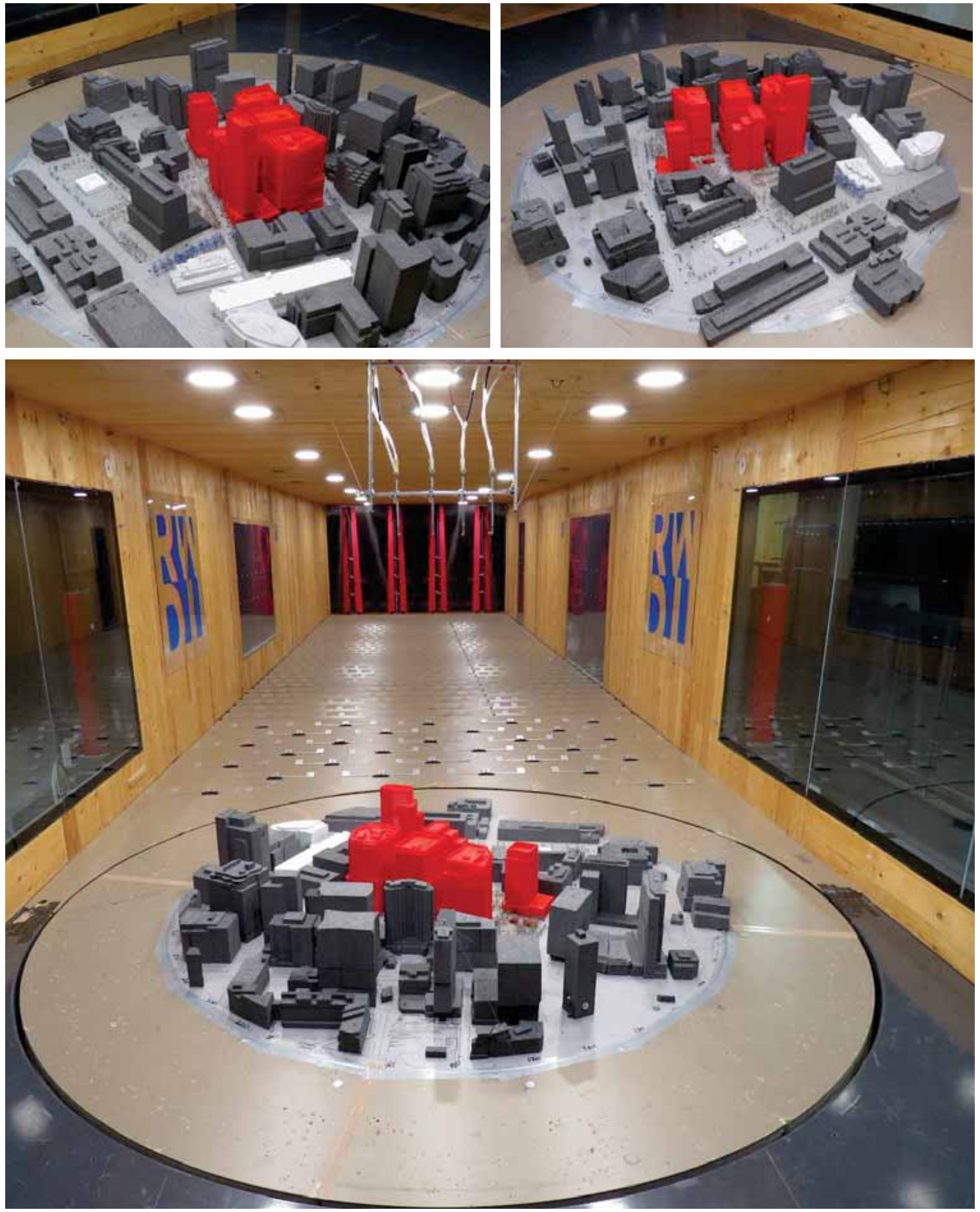


Image 2E: Wind Tunnel Study Model – Build with Landscaping

PEDESTRIAN WIND STUDY
VOLPE REDEVELOPMENT BUILDING C1
RWDI #2205694
April 10, 2023

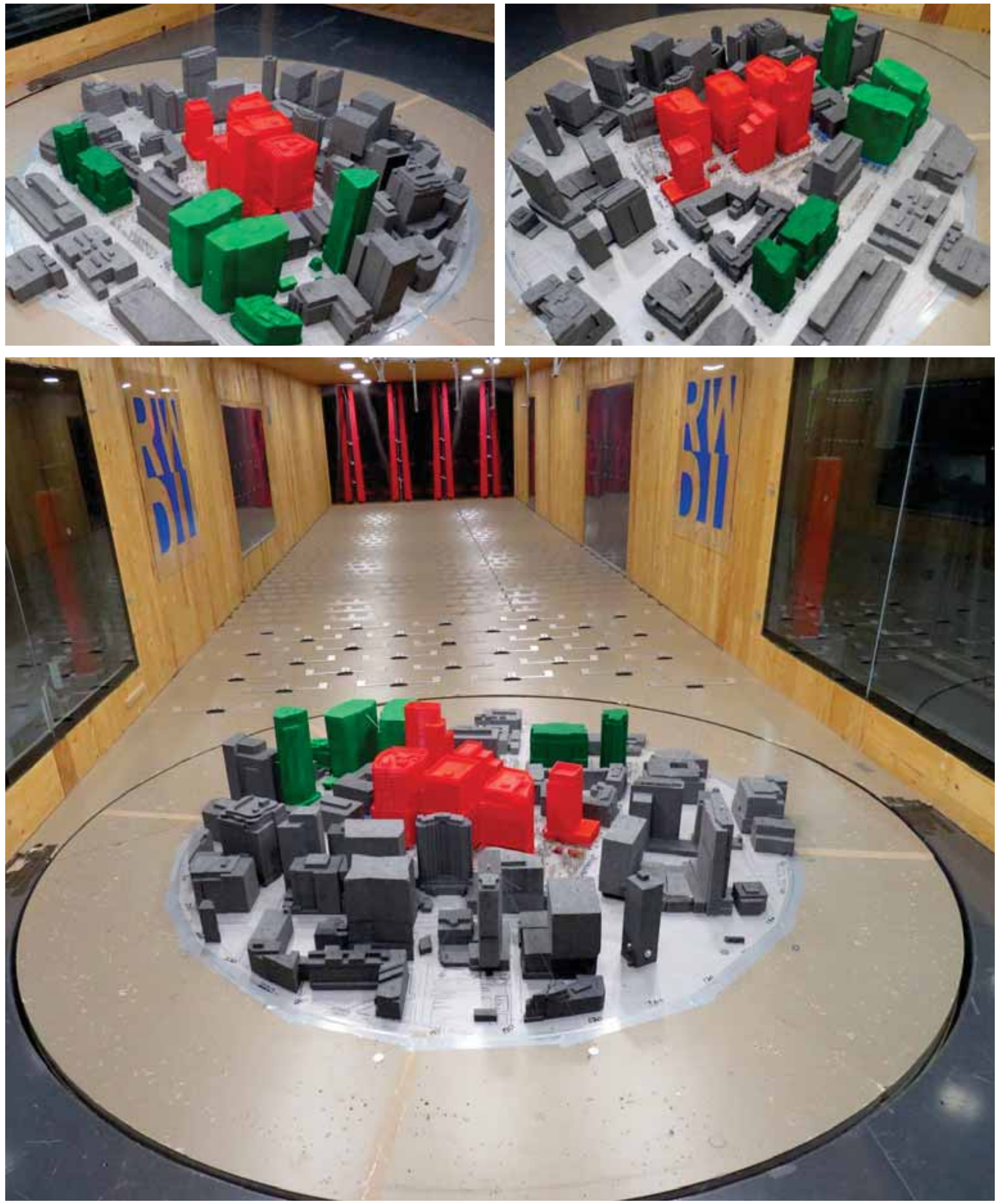


Image 2F: Wind Tunnel Study Model – Full Build

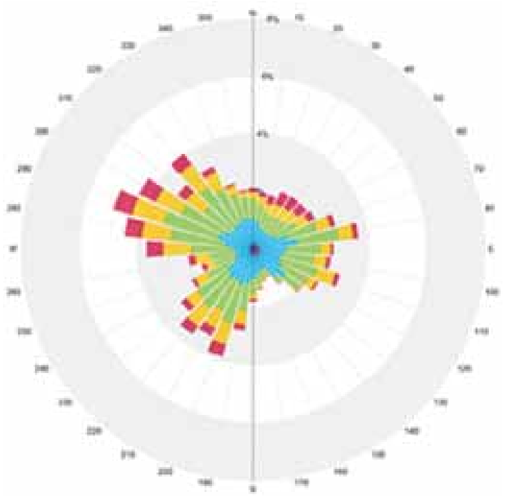
2.2 Meteorological Data

The data from the wind tunnel tests was combined with long-term meteorological data recorded during the years from 1995 through 2020 at Boston Logan International Airport to predict full scale wind conditions. The analysis was performed separately for the entire year and for each of the four seasons. Images 3 and 4 present "wind roses", summarizing the annual and seasonal wind climates in the Boston area, respectively, based on the data from Logan Airport.

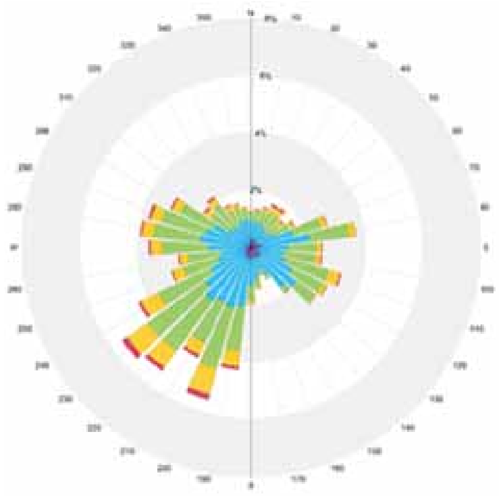
On an annual basis, the most common wind directions are those between north-northwest and south-southwest. Winds from the east-northeast to the east-southeast are also relatively common. In the case of strong winds, west-northwest, northwest, west and northeast are the dominant wind directions. A similar directional distribution is seen in the seasonal wind roses as well (Image 4).

Wind Speed (mph)	Probability (%) Annual
Calm	3.0
1-5	7.9
6-10	32.5
11-15	35.3
16-20	14.5
>20	6.8

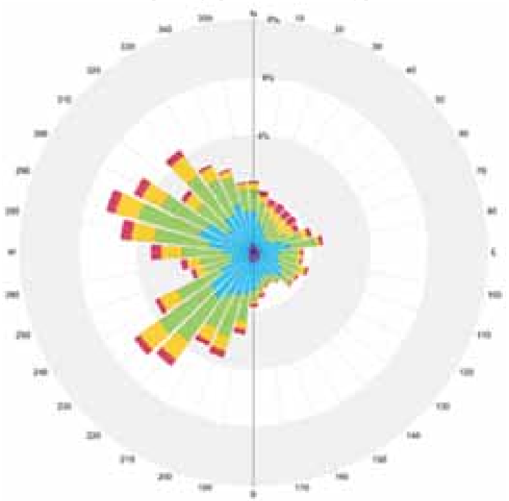
Image 3: Annual Directional distribution of winds approaching Boston Logan International Airport from 1995 through 2020



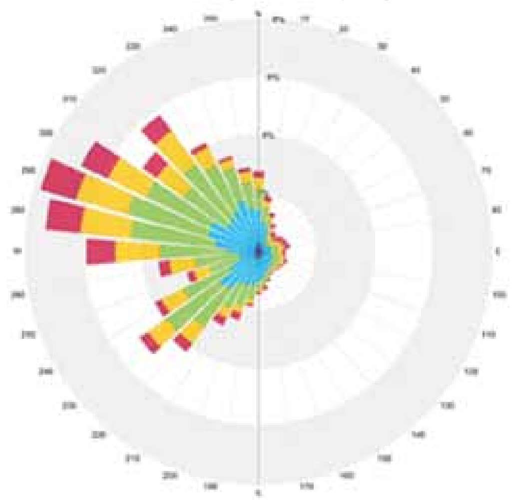
Spring (March – May)



Summer (June – August)



Fall (September – November)



Winter (December – February)

Wind Speed (mph)	Probability (%) Spring	Summer	Fall	Winter
Calm	2.7	3.1	3.4	2.6
1-5	6.8	9.5	8.7	6.6
6-10	28.6	38.9	34.5	28.2
11-15	35.9	36.7	34.6	34.2
16-20	17.2	9.9	13.0	17.7
>20	8.8	1.9	5.9	10.7

Image 4: Seasonal Directional Distribution of Winds Approaching Boston Logan International Airport from 1995 through 2020

2.3 Wind Criteria

Two standards for assessing the relative wind comfort of pedestrians have been used. Wind speeds have been assessed for the impact on pedestrian safety and comfort.

Pedestrian safety relates to high wind gusts that are infrequent, but important to assess as they impact peoples' balance and footing. The criterion is that the effective gust velocity (hourly mean wind speed +1.5 times the root-mean-square wind speed) of 31 mph should not be exceeded more than 1% of the time (Wind Safety / Acceptability).

The second set of criteria is used to determine the relative level of pedestrian wind comfort for activities such as sitting, standing, or walking. The criteria are expressed in terms of benchmarks for the 1-hour mean wind speed exceeded 1% of the time.

Wind Acceptability	Effective Gust Speed (mph)
Acceptable	≤ 31
Unacceptable	> 31
Comfort Category	**Mean Wind Speed (mph)**
Comfortable for Sitting	< 12
Comfortable for Standing	≤ 15
Comfortable for Walking	≤ 19
Uncomfortable for Walking	> 19
Dangerous	> 27

**Effective gust and mean wind speeds are based on a 1% exceedance or 99 percentile wind speeds.

These metrics are used by the Boston Planning and Development Agency (BPDA) and have been generally accepted by the planning department in Cambridge as well.

The consideration of wind in planning outdoor activity areas is important since high winds in an area tend to deter pedestrian use. For example, winds should be light or relatively light in areas where people would be sitting, such as outdoor cafes or playgrounds. For bus stops and other locations where people would be standing, somewhat higher winds can be tolerated. For frequently used sidewalks, where people are primarily walking, stronger winds are acceptable. For infrequently used areas, the wind comfort criteria can be relaxed even further. The actual effects of wind can range from pedestrian inconvenience, due to the blowing of dust and other loose material in a moderate breeze, to severe difficulty with walking due to the wind forces on the pedestrian.

This study involved state-of-the-art measurement and analysis techniques to predict wind conditions. Nevertheless, some uncertainty remains in predicting wind comfort, and this must be kept in mind. For example, the sensation of comfort among individuals can be quite variable. Variations in age, individual health, clothing, and other human factors can change a particular response of an individual. The comfort limits used in this report represent an average for the total population. Also, unforeseen changes in the project area, such as the construction or removal of buildings, can affect the conditions experienced at the site. Finally, the prediction of wind speeds is necessarily a statistical procedure. The wind speeds reported are for the frequency of occurrence stated (1% of the time). Higher wind speeds will occur but on a less frequent basis.

3 RESULTS AND DISCUSSION

The predicted wind conditions in terms of mean and effective gust speeds pertaining to the assessed configurations are graphically depicted on site plans in Figures 1A through 2F located in the "Figures" section of this report. These conditions and the associated wind speeds are presented in Tables 1 and 2, located in the "Tables" section of this report.

3.1 Pedestrian Wind Safety

All areas assessed are expected to meet the effective gust criterion for pedestrian safety on both annual and seasonal basis in all the configurations considered (Figures 2A through 2F).

3.2 Pedestrian Wind Comfort

Generally, wind conditions comfortable for walking are appropriate for sidewalks and walkways as pedestrians will be active and less likely to remain in one area for prolonged periods of time. Lower wind speeds conducive to standing are preferred at main entrances where pedestrians are apt to linger. Wind speeds comfortable for sitting are ideal during the summer for areas intended for prolonged periods of passive activities.

Mean wind conditions that are categorized as "Dangerous" are not predicted in any of the areas assessed on either an annual or seasonal basis in all the configurations considered. The following discussion of pedestrian wind comfort is based on the annual winds for each configuration tested. Typically, the summer and fall winds tend to be more comfortable than those on an annual basis. Conversely, winter and spring winds are typically less comfortable than annual winds.

Please note that the proposed landscaping was excluded in the interim scenarios (Configurations A through D). The proposed landscaping included in Configurations E and F features deciduous trees which shed leaves in winter, thereby providing reduced wind protection during cold months. The assessment herein is based on the worst-case scenario (i.e., the trees were modeled in their winter form for the annual and seasonal assessments).

3.2.1 Build C1 & C2 / Configuration A

Mean wind speeds in this site configuration are predicted to be comfortable for standing or sitting. Conditions comfortable for walking are expected at walkways near the northeast corner and to the west of the building due to corner acceleration flows and channeling flows. The results are presented in Figure 1A. These wind conditions are suitable for the intended usage.

3.2.2 Build C1 & C3 / Configuration B

Mean winds in this site configuration are predicted to be comfortable for sitting or standing. The west corners of Building C1 would be more exposed to the prevailing winds and to the associated corner accelerations; higher wind speeds comfortable for walking are therefore expected near these areas. The resulting wind conditions are appropriate for the intended usage on an annual basis. However, conditions locally at the western corners can be potentially uncomfortable in the spring and winter (Location 12 & 16 in Table 2). Note that speeds at these locations are only marginally over the comfort criterion for "walking" and reflect a worst-case wind-exposure scenario without the benefits of the proposed landscaping.

3.2.3 Build C1, C2, C3 & R1 / Configuration C

In this site configuration, the wind speeds are expected to be comfortable for sitting, standing, or walking in most areas, which is suitable for the intended usage. The exception is at a localized area of the walkway between Buildings C1 and R1 (Locations 23 & 26 in Figure 1C) where potentially uncomfortable wind speeds are expected due to wind being redirected towards the area by Building R1. Note that the speeds at these locations exceed the threshold for "walking" by at most 2 mph. The wind assessment is further based on a worst-case exposure scenario without the benefits of proposed landscaping.

3.2.4 Build / Configuration D

With the addition of Buildings R2 and R3 to the northwest of the site, wind conditions will be improved (in comparison to previous site configurations) due to the sheltering provided by those buildings from the predominant winds. Wind speeds at most areas on-site are predicted to be comfortable for sitting, with higher speeds comfortable for walking to the northeast of Building C1 and on the walkway between Buildings C1 and C2. Wind speeds at a localized area on the walkway between Buildings C1 and R1, that were considered potentially uncomfortable in Configuration C, are also expected to be reduced, with speeds exceeding the threshold for "walking" occasionally, and marginally by 1 mph (Location 23 in Figure 1D). Wind speeds at an egress location on the northeast side (Location 22) are expected to exceed the criterion for "standing" by 1 mph on annual basis; these conditions may be considered acceptable if the egress location are not used frequently. Moreover, these wind speeds are expected to be reduced to be appropriate for the intended use with the addition of the proposed landscaping (see Section 3.2.5, Configuration E).

3.2.5 Build with Landscaping / Configuration E

For a conservative assessment of wind conditions, the proposed trees were modelled in their winter form (i.e., without leaves) as the proposed trees are deciduous and have reduced wind protection benefits in the cold months. Wind conditions at most areas in this site configuration are expected to be comfortable for sitting with conditions comfortable for standing or walking to the northeast, between Buildings C1 and R1. These wind speeds are suitable for the intended usage. Higher wind speeds may occur occasionally immediately around the northeast corner of Building C1 (Location 23), which could be seasonally uncomfortable in the spring (Table2).

3.2.6 Full Build / Configuration F

The addition of the future surrounding developments will further improve the wind conditions on site. Wind speeds are expected to be mostly comfortable for sitting or standing at all areas.

4 STATEMENT OF LIMITATIONS

Limitations

This report was prepared by Rowan Williams Davies & Irwin, Inc. ("RWDI") for NBBJ ("Client"). The findings and conclusions presented in this report have been prepared for the Client and are specific to the project described herein ("Project"). The conclusions and recommendations contained in this report are based on the information available to RWDI when this report was prepared.

The conclusions and recommendations contained in this report have also been made for the specific purpose(s) set out herein. Should the Client or any other third party utilize the report and/or implement the conclusions and recommendations contained therein for any other purpose or project without the involvement of RWDI, the Client or such third party assumes any and all risk of any and all consequences arising from such use and RWDI accepts no responsibility for any liability, loss, or damage of any kind suffered by Client or any other third party arising therefrom.

Finally, it is imperative that the Client and/or any party relying on the conclusions and recommendations in this report carefully review the stated assumptions contained herein and to understand the different factors which may impact the conclusions and recommendations provided.

Design Assumptions

RWDI confirms that the pedestrian wind assessment (the "**Assessmen**t") discussed herein was performed by RWDI in accordance with generally accepted professional standards at the time when the Assessment was performed and in the location of the Project. No other representations, warranties, or guarantees are made with respect to the accuracy or completeness of the information, findings, recommendations, or conclusions contained in this Report. This report is not a legal opinion regarding compliance with applicable laws.

The findings and recommendations set out in this report are based on the following information disclosed to RWDI. Drawings and information listed below were received from NBBJ and used to construct the scale model of the Volpe C1 Building ("**Project Data**").

File Name	File Type	Date Received (dd/mm/yyyy)
VOLPE C1 - DESIGN PACKAGE 3 50% DD DRAWINGS	PDF	11/01/2023
2022 12 02 MITIMCO-C1_Rhino Model.3dm	Rhino	02/12/2022

The recommendations and conclusions are based on the assumption that the Project Data and Climate Data are accurate and complete. RWDI assumes no responsibility for any inaccuracy or deficiency in information it has received from others. In addition, the recommendations and conclusions in this report are partially based on historical data and can be affected by a number of external factors, including but not limited to Project design, quality of materials and construction, site conditions, meteorological events, and climate change. As such, the conclusions and recommendations contained in this report do not list every possible outcome.

The opinions in this report can only be relied upon to the extent that the Project Data and Project Specific Conditions have not changed. Any change in the Project Data or Project Specific Conditions not reflected in this report can impact and/or alter the recommendations and conclusions in this report. Therefore, it is incumbent upon the Client and/or any other third party reviewing the recommendations and conclusions in this report to contact RWDI in the event of any change in the Project Data and Project Specific Conditions in order to determine whether any such change(s) may impact the assumptions upon which the recommendations and conclusions were made.

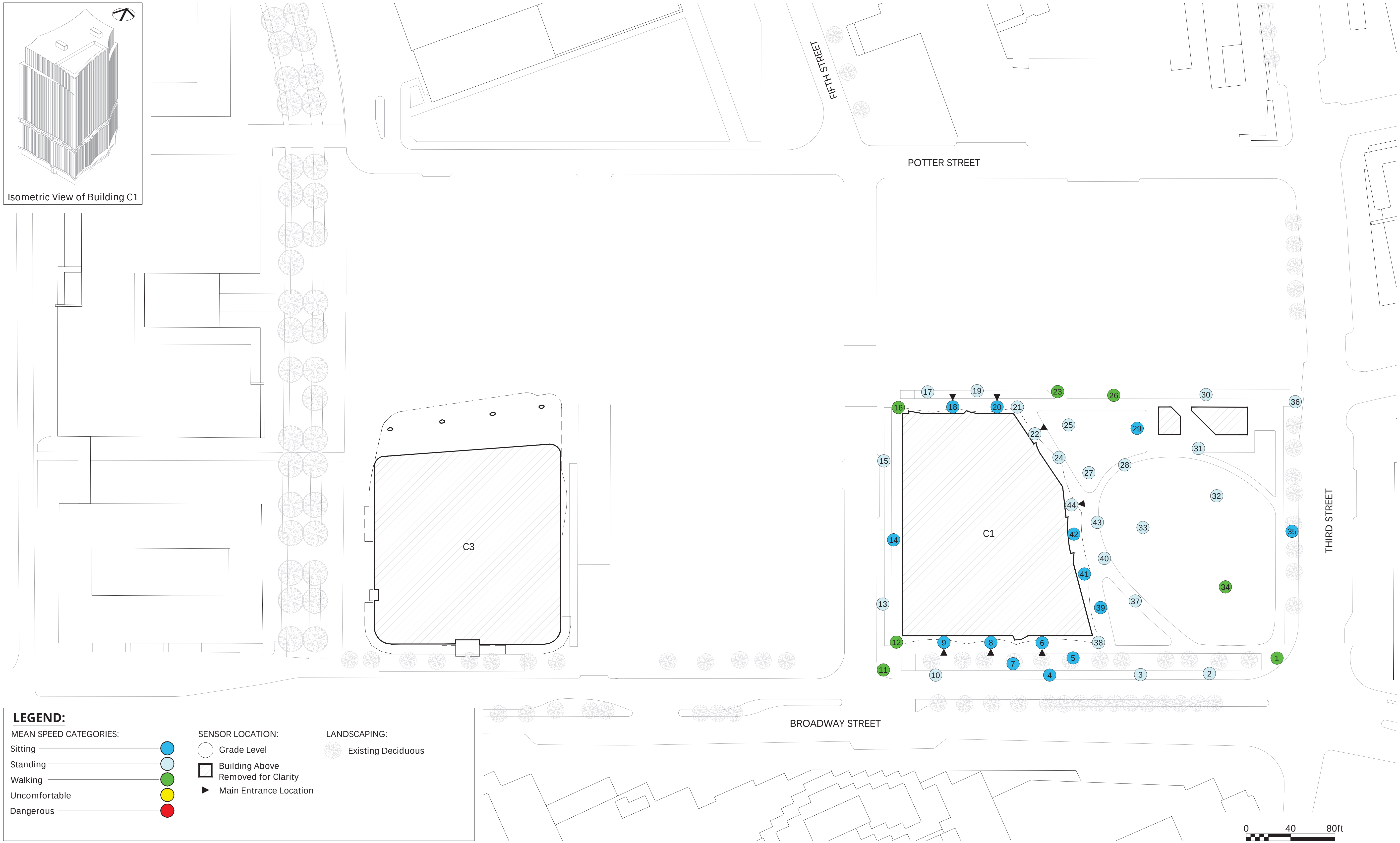
FIGURES

Pedestrian Wind Conditions - Mean Speed
Build - C1 & C2
Annual (January to December)

Volpe Redevelopment Building C1 - Cambridge, MA

Project #2205694

Drawn by: GRE	Figure: 1A
Approx. Scale:	1"=80'
Date Revised:	Apr. 6, 2023



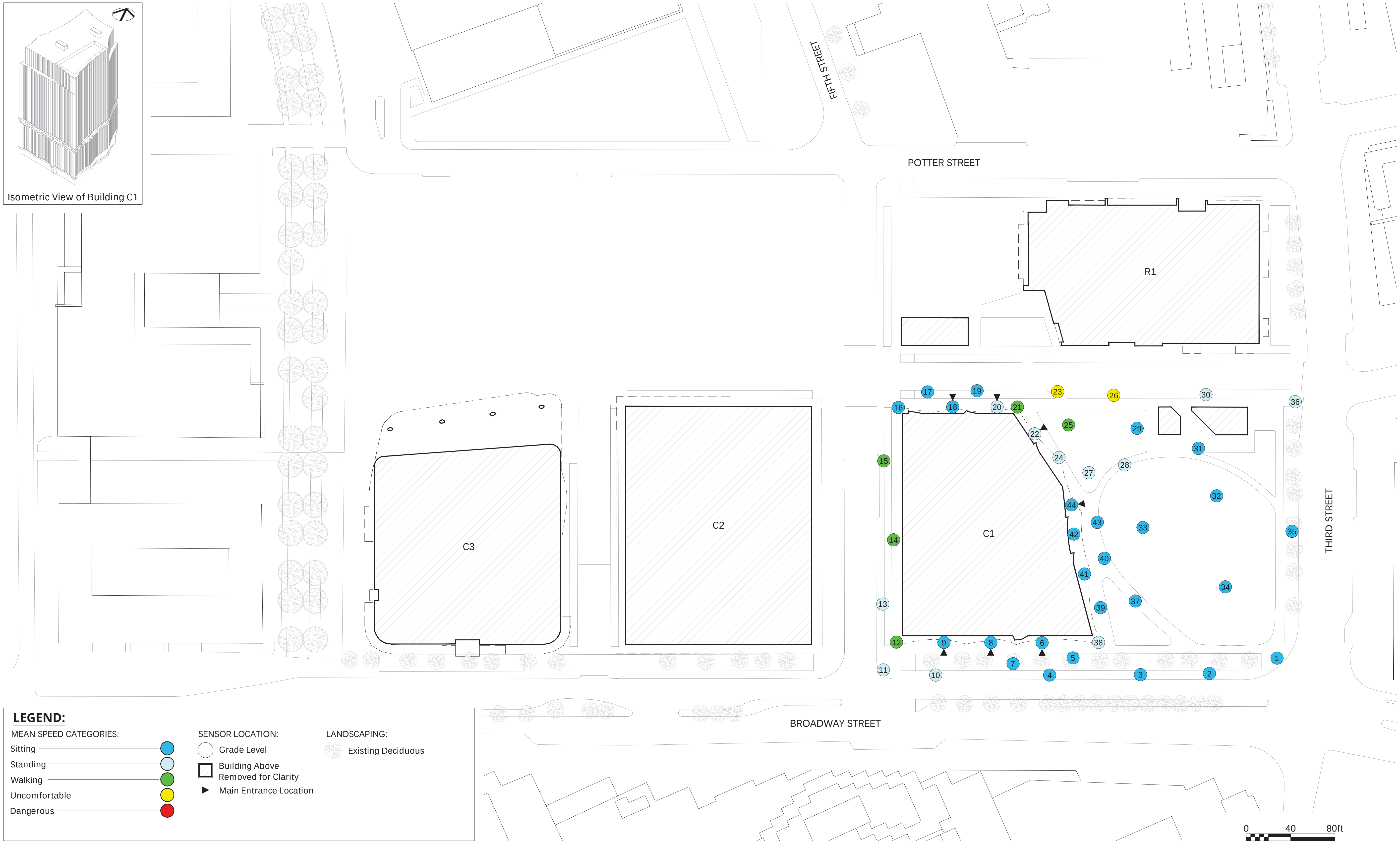
Pedestrian Wind Conditions - Mean Speed
Build - C1 & C3
Annual (January to December)

Volpe Redevelopment Building C1 - Cambridge, MA

True North

Project #2205694

Drawn by: GRE	Figure: 1B
Approx. Scale:	1"=80'
Date Revised:	Apr. 6, 2023



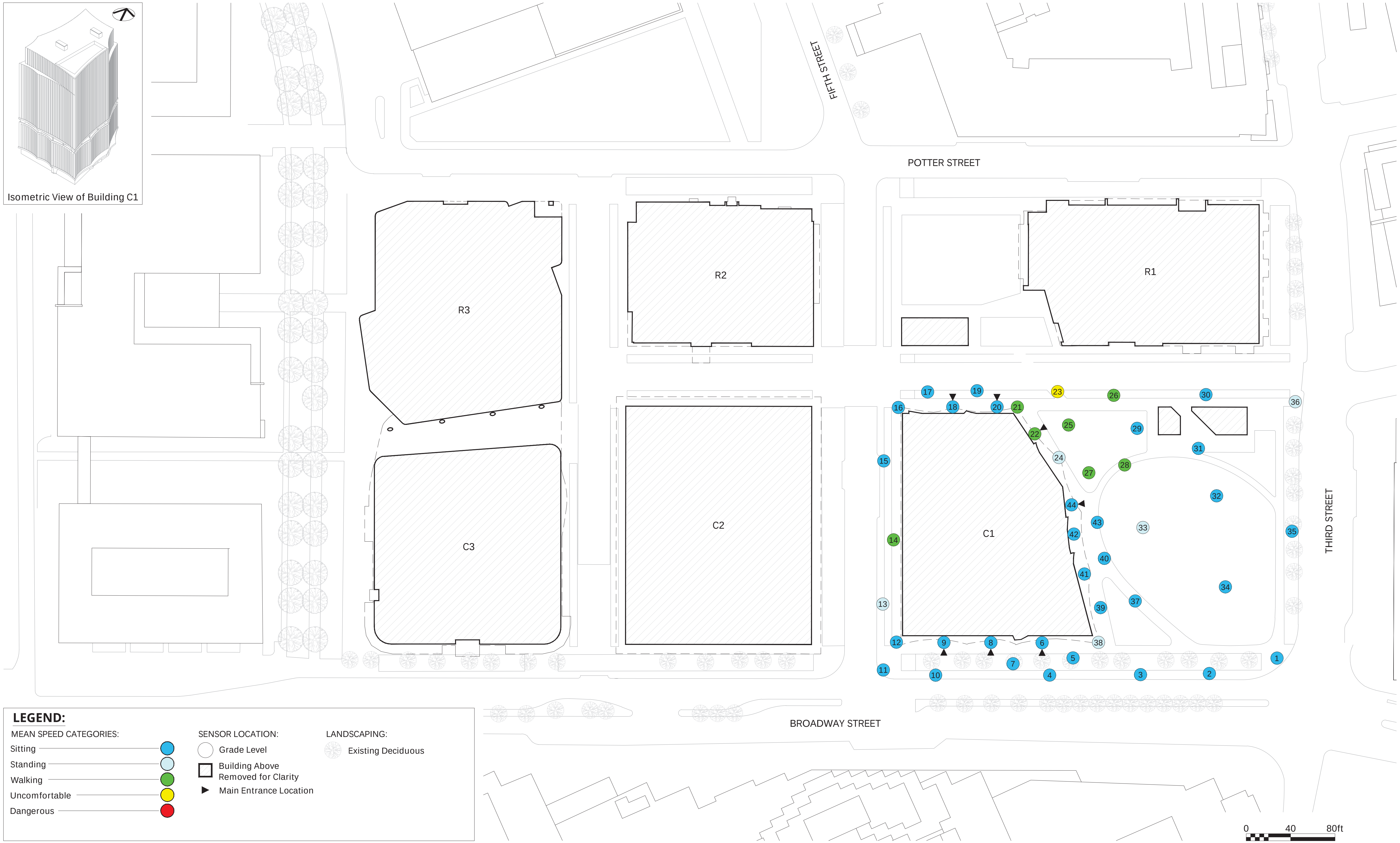
Pedestrian Wind Conditions - Mean Speed
Build - C1, C2, C3, & R1
Annual (January to December)

Volpe Redevelopment Building C1 - Cambridge, MA

True North

Project #2205694

Drawn by: GRE	Figure: 1C
Approx. Scale:	1"=80'
Date Revised:	Apr. 6, 2023



Pedestrian Wind Conditions - Mean Speed
Build
Annual (January to December)

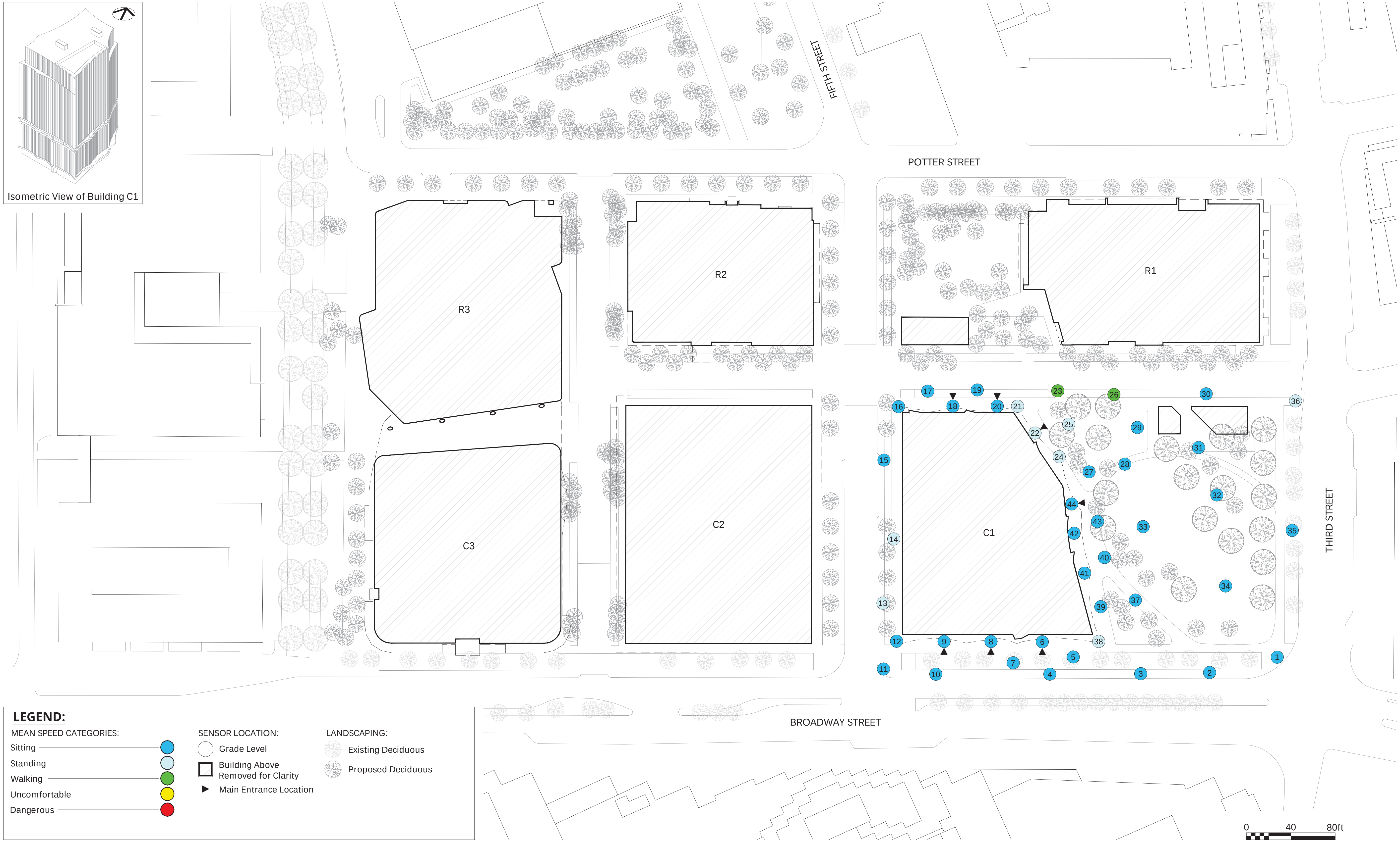
Volpe Redevelopment Building C1 - Cambridge, MA

True North

Project #2205694

Drawn by: GRE	Figure: 1D
Approx. Scale:	1"=80'
Date Revised:	Apr. 6, 2023

RWDI



Pedestrian Wind Conditions - Mean Speed
Build with Landscaping
Annual (January to December)

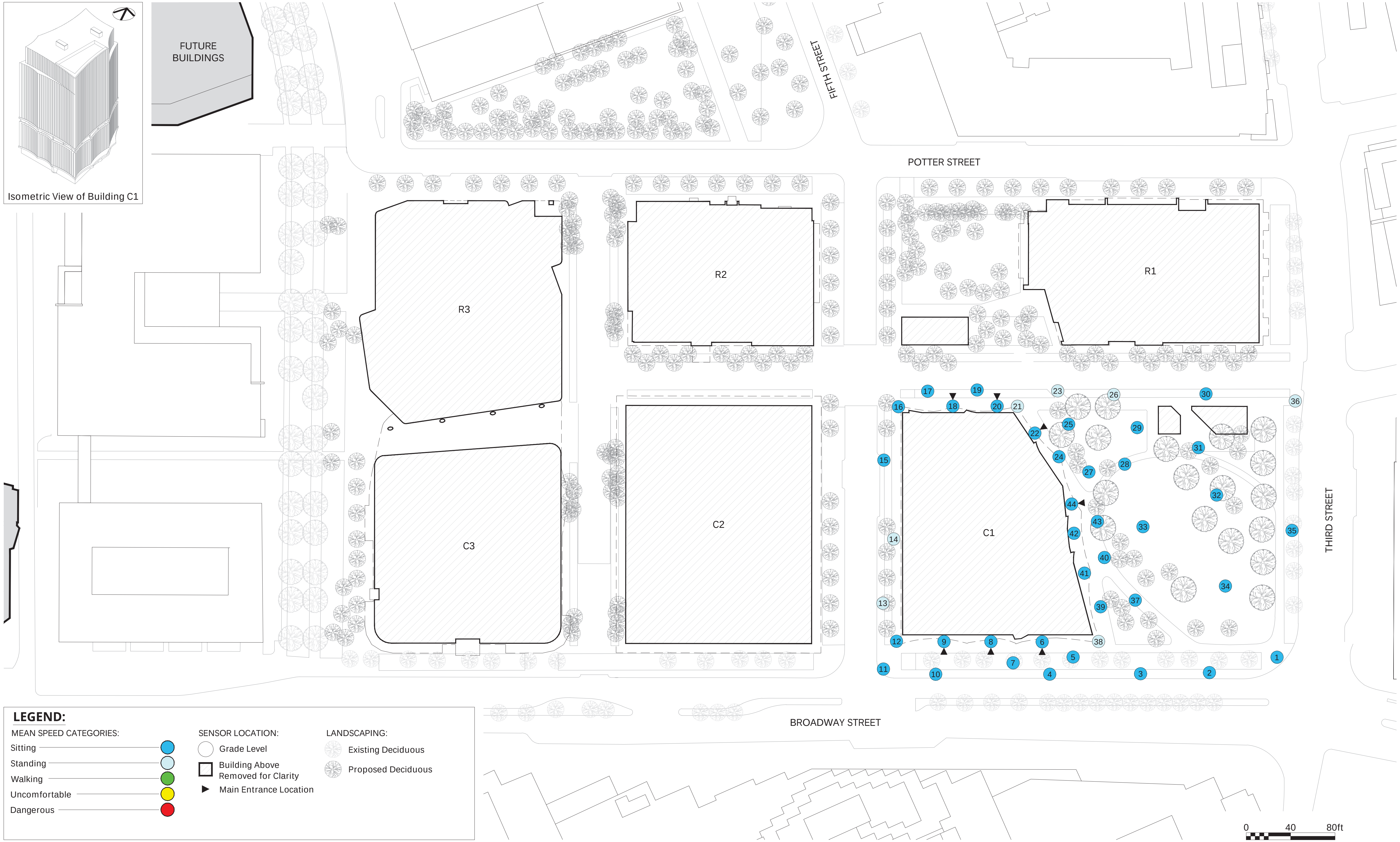
Volpe Redevelopment Building C1 - Cambridge, MA

True North

Project #2205694

Drawn by: GRE	Figure: 1E
Approx. Scale:	1"=80'
Date Revised:	Apr. 6, 2023

RWDI



Pedestrian Wind Conditions - Mean Speed
Full Build
Annual (January to December)

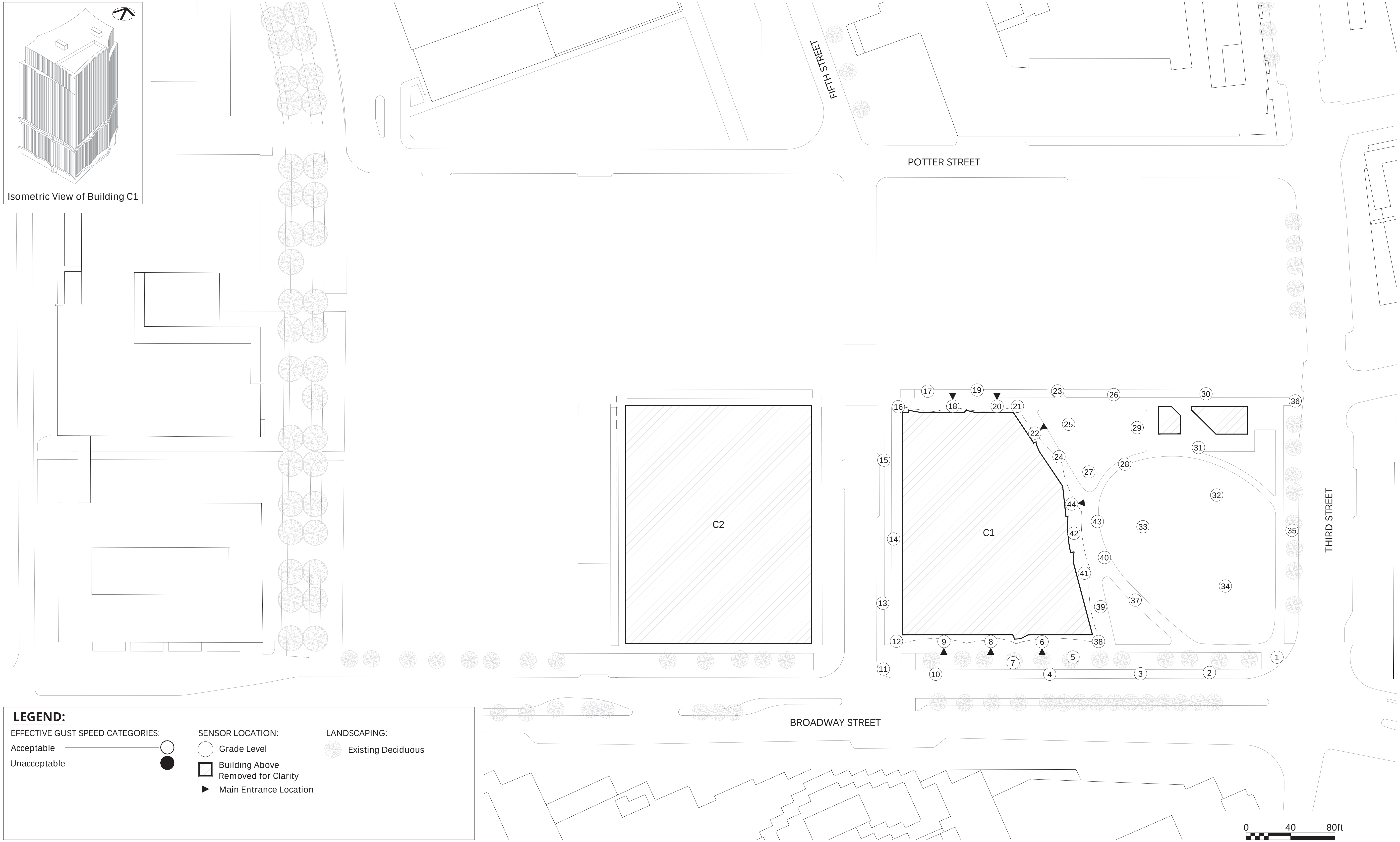
Volpe Redevelopment Building C1 - Cambridge, MA

True North

Project #2205694

Drawn by: GRE	Figure: 1F
Approx. Scale:	1"=80'
Date Revised:	Apr. 6, 2023

RWDI

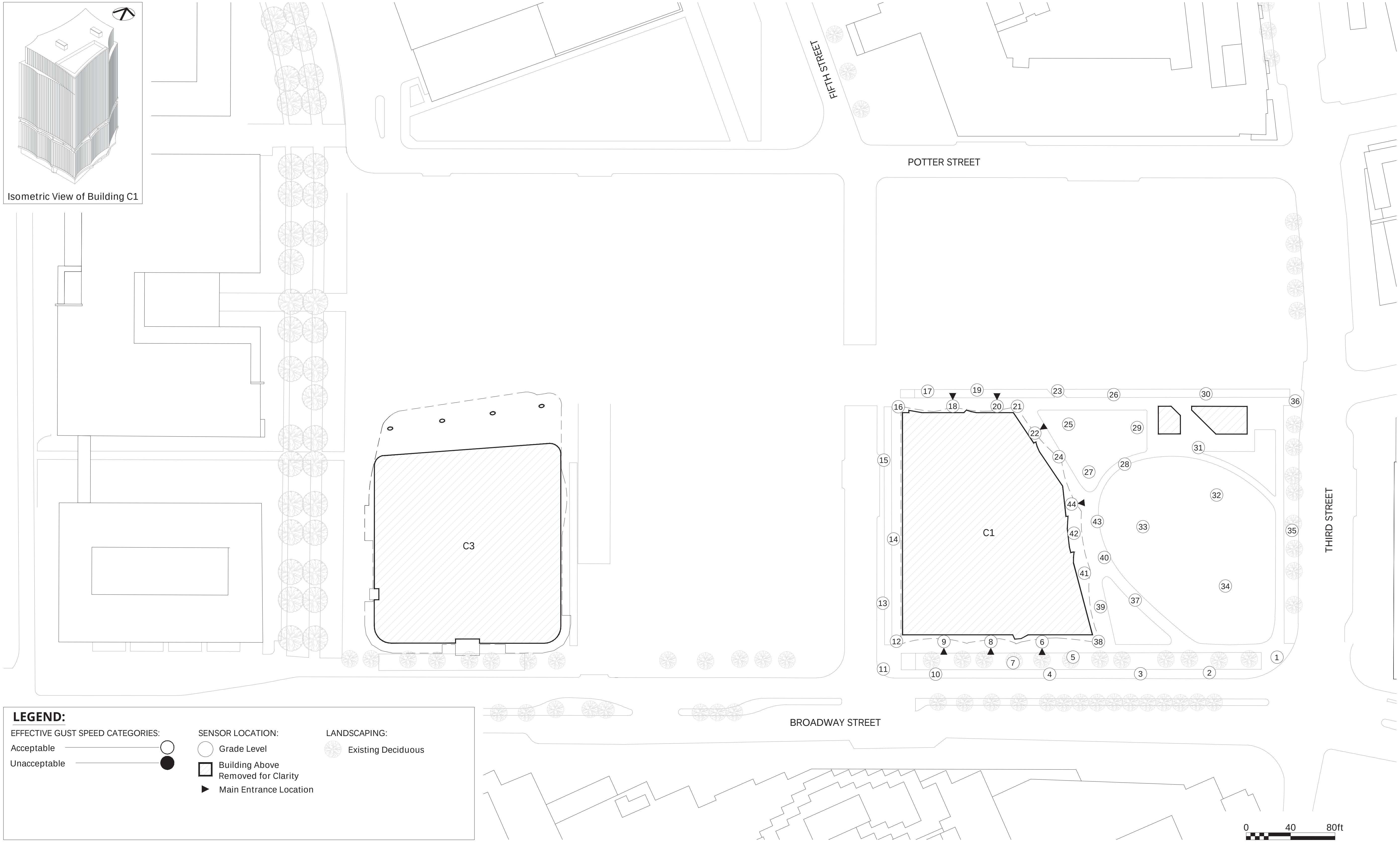


Pedestrian Wind Conditions - Effective Gust Speed
Build - C1 & C2
Annual (January to December)

Volpe Redevelopment Building C1 - Cambridge, MA

Project #2205694

Drawn by: GRE	Figure: 2A
Approx. Scale:	1"=80'
Date Revised:	Apr. 6, 2023



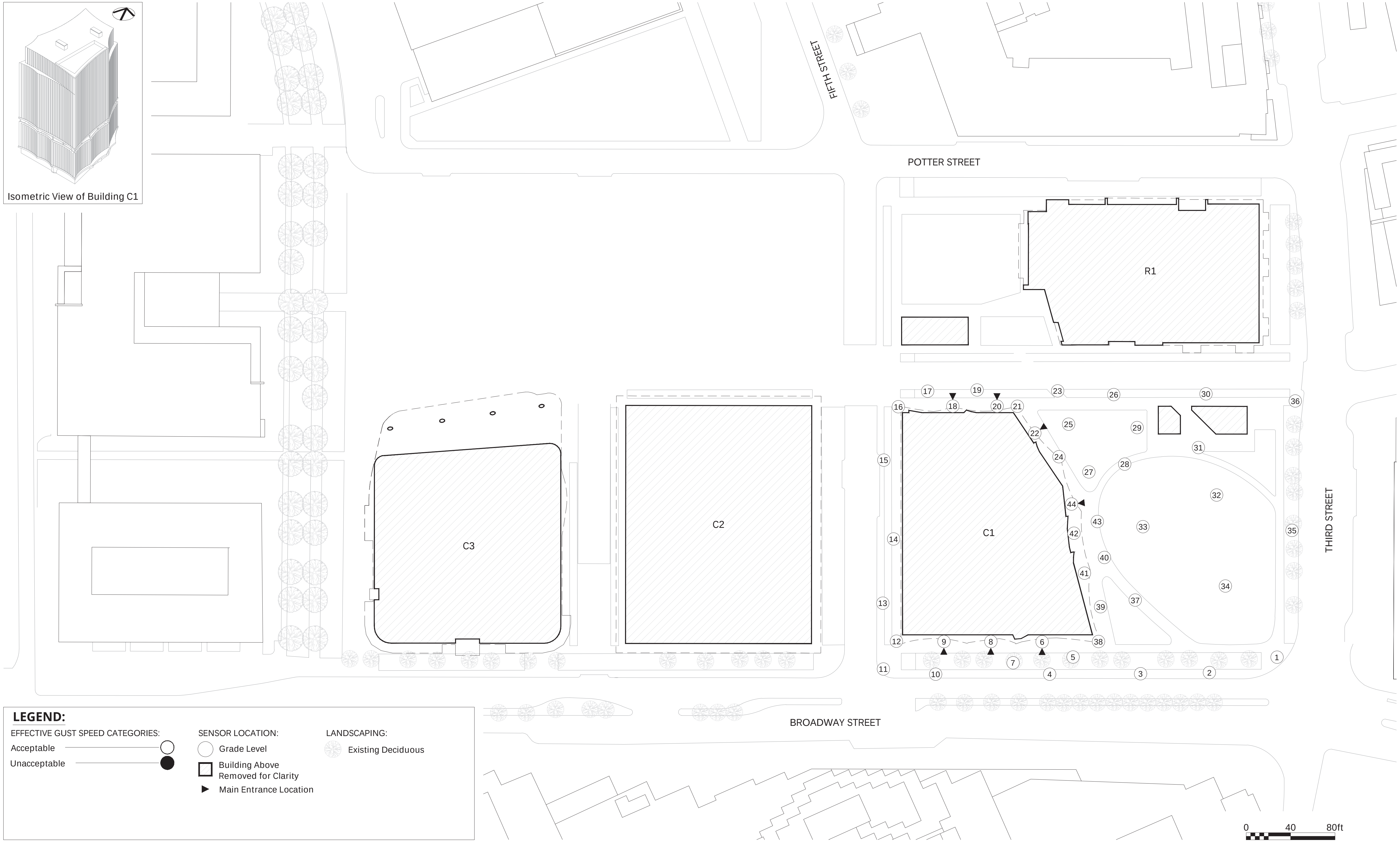
Pedestrian Wind Conditions - Effective Gust Speed
Build - C1 & C3
Annual (January to December)

Volpe Redevelopment Building C1 - Cambridge, MA

True North

Project #2205694

Drawn by:	GRE	Figure:	2B
Approx. Scale:	1"=80'		
Date Revised:	Apr. 6, 2023		



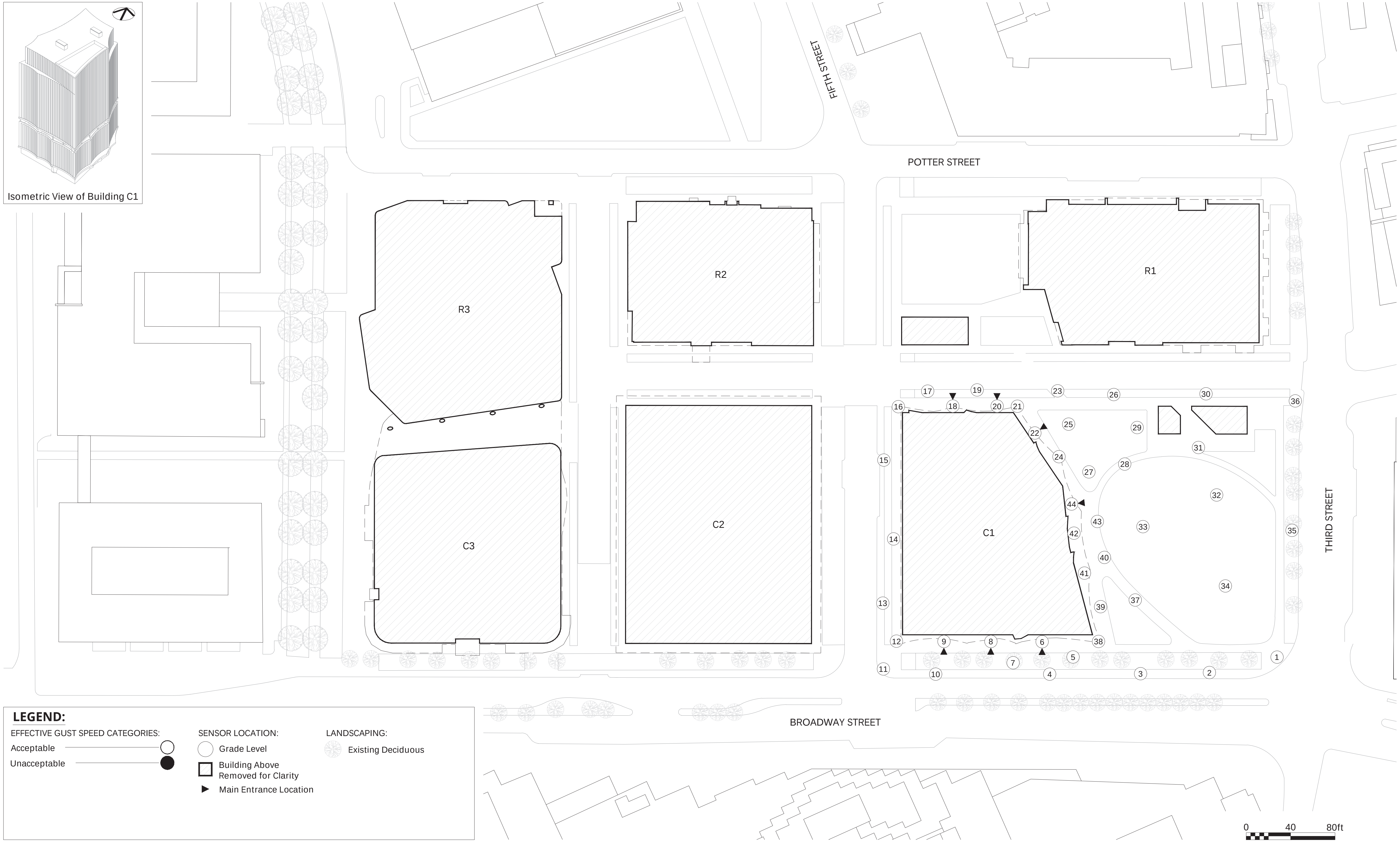
Pedestrian Wind Conditions - Effective Gust Speed
Build - C1, C2, C3, & R1
Annual (January to December)

Volpe Redevelopment Building C1 - Cambridge, MA

True North

Project #2205694

Drawn by:	GRE	Figure:	2C
Approx. Scale:	1"=80'		
Date Revised:	Apr. 6, 2023		



Pedestrian Wind Conditions - Effective Gust Speed

Build

Annual (January to December)

Volpe Redevelopment Building C1 - Cambridge, MA

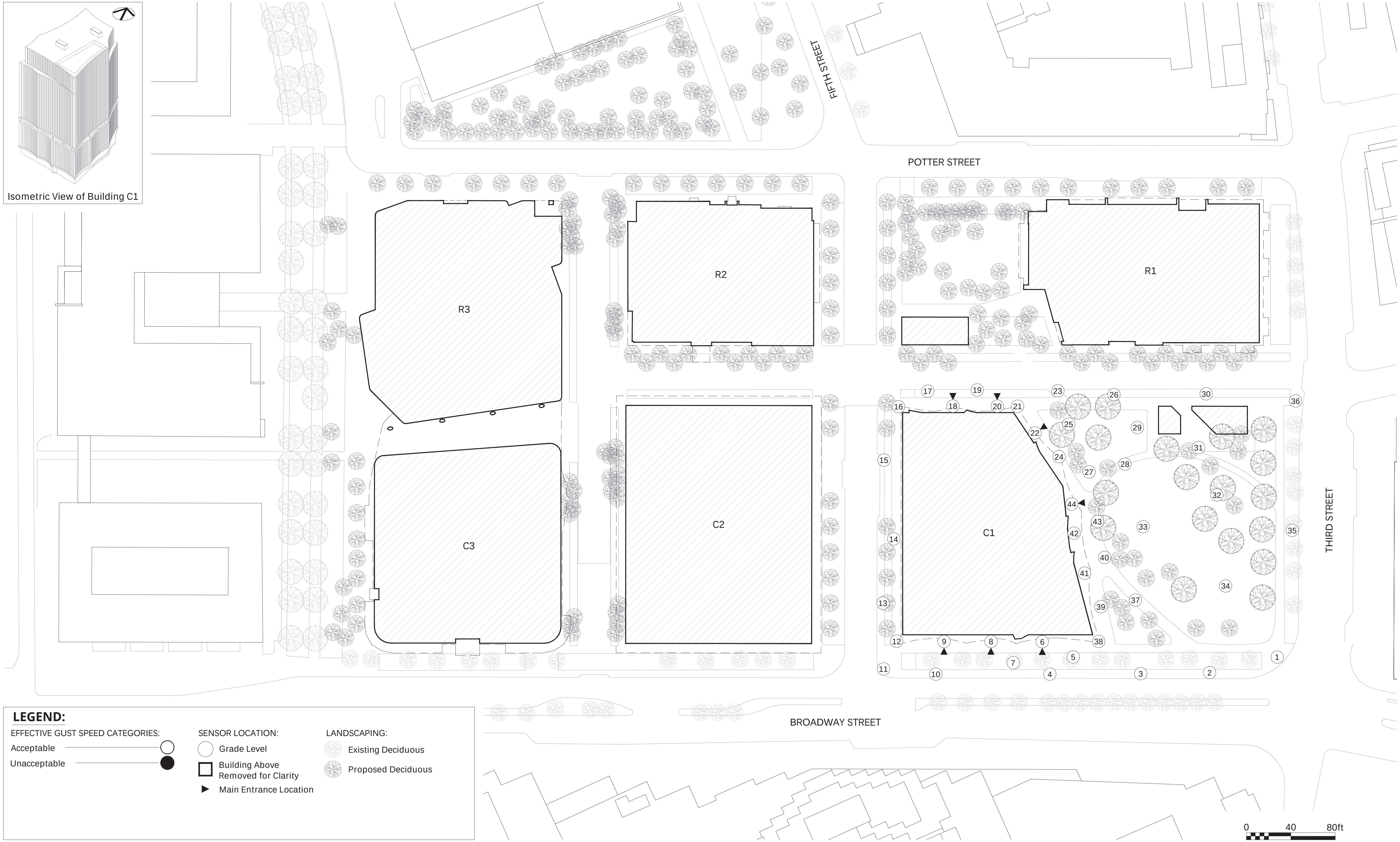
True North

Project #2205694

Drawn by: GRE Figure: 2D

Approx. Scale: 1"=80'

Date Revised: Apr. 6, 2023



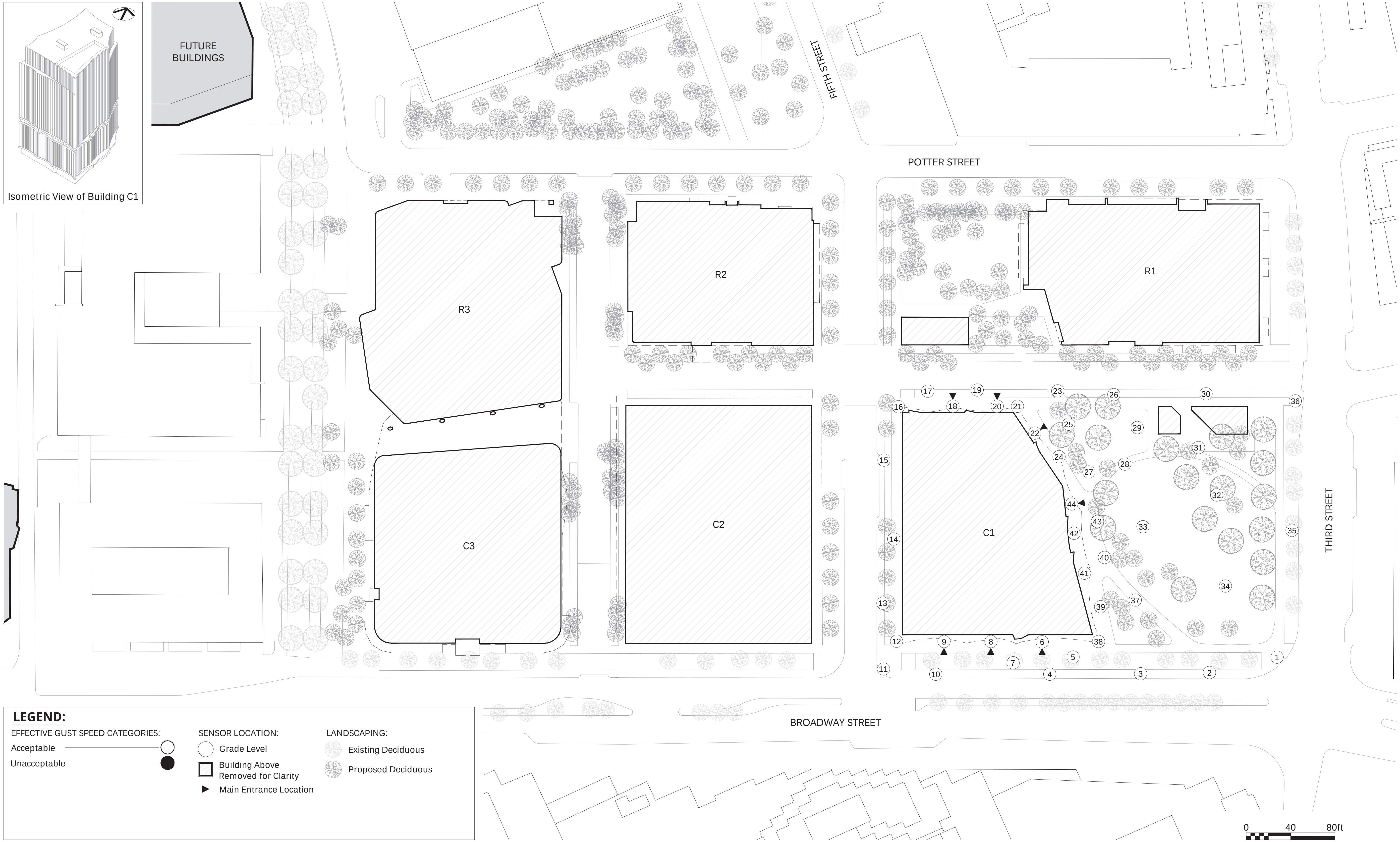
Pedestrian Wind Conditions - Effective Gust Speed
Build with Landscaping
Annual (January to December)

Volpe Redevelopment Building C1 - Cambridge, MA

True North

Project #2205694

Drawn by: GRE	Figure: 2E
Approx. Scale:	1"=80'
Date Revised:	Apr. 6, 2023



LEGEND:

EFFECTIVE GUST SPEED CATEGORIES:
- Acceptable
- Unacceptable

SENSOR LOCATION:
- Grade Level
- Building Above Removed for Clarity
- Main Entrance Location

LANDSCAPING:
- Existing Deciduous
- Proposed Deciduous

Pedestrian Wind Conditions - Effective Gust Speed
Full Build
Annual (January to December)

Volpe Redevelopment Building C1 - Cambridge, MA

True North

Project #2205694

Drawn by: GRE	Figure: 2F
Approx. Scale:	1"=80'
Date Revised:	Apr. 6, 2023

TABLES

Table 1: Mean Speed and Effective Gust Categories - Annual

Location	Configuration	Season	Mean Wind Speed: Speed (mph)	Mean Wind Speed: Rating	Effective Gust Wind Speed: Speed (mph)	Effective Gust Wind Speed: Rating
1	Build C1 & C2	Annual	16	Walking	22	Acceptable
	Build C1 & C3	Annual	16	Walking	22	Acceptable
	Build C1, C2, C3 & R1	Annual	12	Sitting	18	Acceptable
	Build	Annual	12	Sitting	17	Acceptable
	Build with Landscaping	Annual	12	Sitting	17	Acceptable
	Full Build	Annual	11	Sitting	16	Acceptable
2	Build C1 & C2	Annual	14	Standing	20	Acceptable
	Build C1 & C3	Annual	14	Standing	20	Acceptable
	Build C1, C2, C3 & R1	Annual	11	Sitting	17	Acceptable
	Build	Annual	11	Sitting	17	Acceptable
	Build with Landscaping	Annual	10	Sitting	16	Acceptable
	Full Build	Annual	11	Sitting	16	Acceptable
3	Build C1 & C2	Annual	15	Standing	21	Acceptable
	Build C1 & C3	Annual	15	Standing	21	Acceptable
	Build C1, C2, C3 & R1	Annual	12	Sitting	18	Acceptable
	Build	Annual	12	Sitting	17	Acceptable
	Build with Landscaping	Annual	12	Sitting	17	Acceptable
	Full Build	Annual	12	Sitting	18	Acceptable
4	Build C1 & C2	Annual	12	Sitting	19	Acceptable
	Build C1 & C3	Annual	12	Sitting	19	Acceptable
	Build C1, C2, C3 & R1	Annual	12	Sitting	18	Acceptable
	Build	Annual	12	Sitting	18	Acceptable
	Build with Landscaping	Annual	12	Sitting	18	Acceptable
	Full Build	Annual	12	Sitting	17	Acceptable
5	Build C1 & C2	Annual	11	Sitting	18	Acceptable
	Build C1 & C3	Annual	12	Sitting	19	Acceptable
	Build C1, C2, C3 & R1	Annual	11	Sitting	18	Acceptable
	Build	Annual	11	Sitting	17	Acceptable
	Build with Landscaping	Annual	11	Sitting	18	Acceptable
	Full Build	Annual	11	Sitting	17	Acceptable
6	Build C1 & C2	Annual	12	Sitting	18	Acceptable
	Build C1 & C3	Annual	12	Sitting	19	Acceptable
	Build C1, C2, C3 & R1	Annual	12	Sitting	17	Acceptable
	Build	Annual	12	Sitting	17	Acceptable
	Build with Landscaping	Annual	12	Sitting	16	Acceptable
	Full Build	Annual	11	Sitting	16	Acceptable
7	Build C1 & C2	Annual	11	Sitting	17	Acceptable
	Build C1 & C3	Annual	11	Sitting	17	Acceptable
	Build C1, C2, C3 & R1	Annual	10	Sitting	15	Acceptable
	Build	Annual	11	Sitting	16	Acceptable
	Build with Landscaping	Annual	11	Sitting	16	Acceptable
	Full Build	Annual	12	Sitting	16	Acceptable

Table 1: Mean Speed and Effective Gust Categories - Annual

Location	Configuration	Season	Mean Wind Speed: Speed (mph)	Mean Wind Speed: Rating	Effective Gust Wind Speed: Speed (mph)	Effective Gust Wind Speed: Rating
8	Build C1 & C2	Annual	10	Sitting	16	Acceptable
	Build C1 & C3	Annual	10	Sitting	17	Acceptable
	Build C1, C2, C3 & R1	Annual	9	Sitting	14	Acceptable
	Build	Annual	8	Sitting	13	Acceptable
	Build with Landscaping	Annual	8	Sitting	13	Acceptable
	Full Build	Annual	8	Sitting	12	Acceptable
9	Build C1 & C2	Annual	11	Sitting	17	Acceptable
	Build C1 & C3	Annual	10	Sitting	18	Acceptable
	Build C1, C2, C3 & R1	Annual	10	Sitting	14	Acceptable
	Build	Annual	10	Sitting	15	Acceptable
	Build with Landscaping	Annual	10	Sitting	15	Acceptable
	Full Build	Annual	11	Sitting	15	Acceptable
10	Build C1 & C2	Annual	15	Standing	23	Acceptable
	Build C1 & C3	Annual	15	Standing	23	Acceptable
	Build C1, C2, C3 & R1	Annual	13	Standing	20	Acceptable
	Build	Annual	12	Sitting	17	Acceptable
	Build with Landscaping	Annual	12	Sitting	17	Acceptable
	Full Build	Annual	12	Sitting	17	Acceptable
11	Build C1 & C2	Annual	14	Standing	21	Acceptable
	Build C1 & C3	Annual	16	Walking	23	Acceptable
	Build C1, C2, C3 & R1	Annual	15	Standing	21	Acceptable
	Build	Annual	12	Sitting	17	Acceptable
	Build with Landscaping	Annual	12	Sitting	18	Acceptable
	Full Build	Annual	12	Sitting	17	Acceptable
12	Build C1 & C2	Annual	15	Standing	22	Acceptable
	Build C1 & C3	Annual	19	Walking	26	Acceptable
	Build C1, C2, C3 & R1	Annual	17	Walking	22	Acceptable
	Build	Annual	12	Sitting	17	Acceptable
	Build with Landscaping	Annual	12	Sitting	17	Acceptable
	Full Build	Annual	12	Sitting	16	Acceptable
13	Build C1 & C2	Annual	15	Standing	22	Acceptable
	Build C1 & C3	Annual	14	Standing	22	Acceptable
	Build C1, C2, C3 & R1	Annual	15	Standing	22	Acceptable
	Build	Annual	14	Standing	20	Acceptable
	Build with Landscaping	Annual	13	Standing	18	Acceptable
	Full Build	Annual	13	Standing	18	Acceptable
14	Build C1 & C2	Annual	16	Walking	24	Acceptable
	Build C1 & C3	Annual	12	Sitting	19	Acceptable
	Build C1, C2, C3 & R1	Annual	17	Walking	24	Acceptable
	Build	Annual	16	Walking	21	Acceptable
	Build with Landscaping	Annual	15	Standing	20	Acceptable
	Full Build	Annual	15	Standing	20	Acceptable

Table 1: Mean Speed and Effective Gust Categories - Annual

Location	Configuration	Season	Mean Wind Speed: Speed (mph)	Mean Wind Speed: Rating	Effective Gust Wind Speed: Speed (mph)	Effective Gust Wind Speed: Rating
15	Build C1 & C2	Annual	18	Walking	24	Acceptable
	Build C1 & C3	Annual	13	Standing	22	Acceptable
	Build C1, C2, C3 & R1	Annual	18	Walking	24	Acceptable
	Build	Annual	12	Sitting	18	Acceptable
	Build with Landscaping	Annual	10	Sitting	16	Acceptable
	Full Build	Annual	9	Sitting	14	Acceptable
16	Build C1 & C2	Annual	14	Standing	21	Acceptable
	Build C1 & C3	Annual	18	Walking	27	Acceptable
	Build C1, C2, C3 & R1	Annual	11	Sitting	17	Acceptable
	Build	Annual	12	Sitting	18	Acceptable
	Build with Landscaping	Annual	12	Sitting	18	Acceptable
	Full Build	Annual	10	Sitting	15	Acceptable
17	Build C1 & C2	Annual	11	Sitting	18	Acceptable
	Build C1 & C3	Annual	15	Standing	23	Acceptable
	Build C1, C2, C3 & R1	Annual	10	Sitting	16	Acceptable
	Build	Annual	10	Sitting	16	Acceptable
	Build with Landscaping	Annual	10	Sitting	16	Acceptable
	Full Build	Annual	9	Sitting	14	Acceptable
18	Build C1 & C2	Annual	11	Sitting	17	Acceptable
	Build C1 & C3	Annual	12	Sitting	18	Acceptable
	Build C1, C2, C3 & R1	Annual	10	Sitting	17	Acceptable
	Build	Annual	8	Sitting	14	Acceptable
	Build with Landscaping	Annual	8	Sitting	13	Acceptable
	Full Build	Annual	7	Sitting	11	Acceptable
19	Build C1 & C2	Annual	12	Sitting	18	Acceptable
	Build C1 & C3	Annual	13	Standing	20	Acceptable
	Build C1, C2, C3 & R1	Annual	12	Sitting	19	Acceptable
	Build	Annual	11	Sitting	17	Acceptable
	Build with Landscaping	Annual	11	Sitting	17	Acceptable
	Full Build	Annual	11	Sitting	17	Acceptable
20	Build C1 & C2	Annual	14	Standing	20	Acceptable
	Build C1 & C3	Annual	12	Sitting	19	Acceptable
	Build C1, C2, C3 & R1	Annual	15	Standing	21	Acceptable
	Build	Annual	10	Sitting	16	Acceptable
	Build with Landscaping	Annual	9	Sitting	16	Acceptable
	Full Build	Annual	8	Sitting	13	Acceptable
21	Build C1 & C2	Annual	16	Walking	22	Acceptable
	Build C1 & C3	Annual	15	Standing	22	Acceptable
	Build C1, C2, C3 & R1	Annual	18	Walking	24	Acceptable
	Build	Annual	16	Walking	22	Acceptable
	Build with Landscaping	Annual	15	Standing	21	Acceptable
	Full Build	Annual	13	Standing	18	Acceptable

Table 1: Mean Speed and Effective Gust Categories - Annual

Location	Configuration	Season	Mean Wind Speed: Speed (mph)	Mean Wind Speed: Rating	Effective Gust Wind Speed: Speed (mph)	Effective Gust Wind Speed: Rating
22	Build C1 & C2	Annual	13	Standing	20	Acceptable
	Build C1 & C3	Annual	13	Standing	20	Acceptable
	Build C1, C2, C3 & R1	Annual	14	Standing	22	Acceptable
	Build	Annual	16	Walking	23	Acceptable
	Build with Landscaping	Annual	15	Standing	21	Acceptable
	Full Build	Annual	11	Sitting	16	Acceptable
23	Build C1 & C2	Annual	17	Walking	23	Acceptable
	Build C1 & C3	Annual	17	Walking	24	Acceptable
	Build C1, C2, C3 & R1	Annual	21	Uncomfortable	26	Acceptable
	Build	Annual	20	Uncomfortable	25	Acceptable
	Build with Landscaping	Annual	17	Walking	23	Acceptable
	Full Build	Annual	14	Standing	18	Acceptable
24	Build C1 & C2	Annual	14	Standing	20	Acceptable
	Build C1 & C3	Annual	13	Standing	20	Acceptable
	Build C1, C2, C3 & R1	Annual	13	Standing	20	Acceptable
	Build	Annual	15	Standing	21	Acceptable
	Build with Landscaping	Annual	14	Standing	19	Acceptable
	Full Build	Annual	10	Sitting	15	Acceptable
25	Build C1 & C2	Annual	15	Standing	21	Acceptable
	Build C1 & C3	Annual	14	Standing	20	Acceptable
	Build C1, C2, C3 & R1	Annual	18	Walking	23	Acceptable
	Build	Annual	17	Walking	23	Acceptable
	Build with Landscaping	Annual	15	Standing	20	Acceptable
	Full Build	Annual	10	Sitting	15	Acceptable
26	Build C1 & C2	Annual	15	Standing	22	Acceptable
	Build C1 & C3	Annual	16	Walking	22	Acceptable
	Build C1, C2, C3 & R1	Annual	20	Uncomfortable	26	Acceptable
	Build	Annual	16	Walking	23	Acceptable
	Build with Landscaping	Annual	17	Walking	23	Acceptable
	Full Build	Annual	13	Standing	17	Acceptable
27	Build C1 & C2	Annual	14	Standing	20	Acceptable
	Build C1 & C3	Annual	14	Standing	20	Acceptable
	Build C1, C2, C3 & R1	Annual	13	Standing	20	Acceptable
	Build	Annual	16	Walking	22	Acceptable
	Build with Landscaping	Annual	9	Sitting	13	Acceptable
	Full Build	Annual	7	Sitting	11	Acceptable
28	Build C1 & C2	Annual	15	Standing	21	Acceptable
	Build C1 & C3	Annual	15	Standing	21	Acceptable
	Build C1, C2, C3 & R1	Annual	15	Standing	22	Acceptable
	Build	Annual	16	Walking	23	Acceptable
	Build with Landscaping	Annual	12	Sitting	17	Acceptable
	Full Build	Annual	9	Sitting	13	Acceptable

Table 1: Mean Speed and Effective Gust Categories - Annual

Location	Configuration	Season	Mean Wind Speed: Speed (mph)	Mean Wind Speed: Rating	Effective Gust Wind Speed: Speed (mph)	Effective Gust Wind Speed: Rating
29	Build C1 & C2	Annual	12	Sitting	17	Acceptable
	Build C1 & C3	Annual	12	Sitting	17	Acceptable
	Build C1, C2, C3 & R1	Annual	12	Sitting	17	Acceptable
	Build	Annual	12	Sitting	17	Acceptable
	Build with Landscaping	Annual	10	Sitting	14	Acceptable
	Full Build	Annual	8	Sitting	11	Acceptable
30	Build C1 & C2	Annual	12	Sitting	20	Acceptable
	Build C1 & C3	Annual	13	Standing	21	Acceptable
	Build C1, C2, C3 & R1	Annual	15	Standing	22	Acceptable
	Build	Annual	8	Sitting	13	Acceptable
	Build with Landscaping	Annual	8	Sitting	13	Acceptable
	Full Build	Annual	8	Sitting	13	Acceptable
31	Build C1 & C2	Annual	12	Sitting	18	Acceptable
	Build C1 & C3	Annual	13	Standing	19	Acceptable
	Build C1, C2, C3 & R1	Annual	11	Sitting	17	Acceptable
	Build	Annual	8	Sitting	13	Acceptable
	Build with Landscaping	Annual	7	Sitting	12	Acceptable
	Full Build	Annual	7	Sitting	10	Acceptable
32	Build C1 & C2	Annual	14	Standing	21	Acceptable
	Build C1 & C3	Annual	15	Standing	22	Acceptable
	Build C1, C2, C3 & R1	Annual	11	Sitting	18	Acceptable
	Build	Annual	10	Sitting	16	Acceptable
	Build with Landscaping	Annual	9	Sitting	13	Acceptable
	Full Build	Annual	8	Sitting	13	Acceptable
33	Build C1 & C2	Annual	15	Standing	21	Acceptable
	Build C1 & C3	Annual	15	Standing	22	Acceptable
	Build C1, C2, C3 & R1	Annual	11	Sitting	18	Acceptable
	Build	Annual	14	Standing	21	Acceptable
	Build with Landscaping	Annual	9	Sitting	14	Acceptable
	Full Build	Annual	8	Sitting	14	Acceptable
34	Build C1 & C2	Annual	15	Standing	21	Acceptable
	Build C1 & C3	Annual	16	Walking	22	Acceptable
	Build C1, C2, C3 & R1	Annual	11	Sitting	18	Acceptable
	Build	Annual	11	Sitting	18	Acceptable
	Build with Landscaping	Annual	10	Sitting	15	Acceptable
	Full Build	Annual	10	Sitting	15	Acceptable
35	Build C1 & C2	Annual	11	Sitting	17	Acceptable
	Build C1 & C3	Annual	12	Sitting	18	Acceptable
	Build C1, C2, C3 & R1	Annual	10	Sitting	16	Acceptable
	Build	Annual	11	Sitting	16	Acceptable
	Build with Landscaping	Annual	11	Sitting	17	Acceptable
	Full Build	Annual	11	Sitting	17	Acceptable

Table 1: Mean Speed and Effective Gust Categories - Annual

Location	Configuration	Season	Mean Wind Speed: Speed (mph)	Mean Wind Speed: Rating	Effective Gust Wind Speed: Speed (mph)	Effective Gust Wind Speed: Rating
36	Build C1 & C2	Annual	13	Standing	19	Acceptable
	Build C1 & C3	Annual	13	Standing	19	Acceptable
	Build C1, C2, C3 & R1	Annual	13	Standing	19	Acceptable
	Build	Annual	13	Standing	20	Acceptable
	Build with Landscaping	Annual	14	Standing	21	Acceptable
	Full Build	Annual	14	Standing	19	Acceptable
37	Build C1 & C2	Annual	14	Standing	21	Acceptable
	Build C1 & C3	Annual	15	Standing	21	Acceptable
	Build C1, C2, C3 & R1	Annual	11	Sitting	17	Acceptable
	Build	Annual	11	Sitting	17	Acceptable
	Build with Landscaping	Annual	10	Sitting	16	Acceptable
	Full Build	Annual	11	Sitting	16	Acceptable
38	Build C1 & C2	Annual	15	Standing	21	Acceptable
	Build C1 & C3	Annual	15	Standing	21	Acceptable
	Build C1, C2, C3 & R1	Annual	14	Standing	19	Acceptable
	Build	Annual	13	Standing	19	Acceptable
	Build with Landscaping	Annual	14	Standing	20	Acceptable
	Full Build	Annual	15	Standing	20	Acceptable
39	Build C1 & C2	Annual	13	Standing	18	Acceptable
	Build C1 & C3	Annual	12	Sitting	18	Acceptable
	Build C1, C2, C3 & R1	Annual	8	Sitting	13	Acceptable
	Build	Annual	8	Sitting	12	Acceptable
	Build with Landscaping	Annual	6	Sitting	11	Acceptable
	Full Build	Annual	7	Sitting	11	Acceptable
40	Build C1 & C2	Annual	13	Standing	19	Acceptable
	Build C1 & C3	Annual	13	Standing	19	Acceptable
	Build C1, C2, C3 & R1	Annual	8	Sitting	13	Acceptable
	Build	Annual	8	Sitting	13	Acceptable
	Build with Landscaping	Annual	7	Sitting	11	Acceptable
	Full Build	Annual	6	Sitting	10	Acceptable
41	Build C1 & C2	Annual	10	Sitting	15	Acceptable
	Build C1 & C3	Annual	10	Sitting	15	Acceptable
	Build C1, C2, C3 & R1	Annual	7	Sitting	12	Acceptable
	Build	Annual	7	Sitting	11	Acceptable
	Build with Landscaping	Annual	6	Sitting	10	Acceptable
	Full Build	Annual	7	Sitting	11	Acceptable
42	Build C1 & C2	Annual	11	Sitting	15	Acceptable
	Build C1 & C3	Annual	10	Sitting	15	Acceptable
	Build C1, C2, C3 & R1	Annual	9	Sitting	12	Acceptable
	Build	Annual	9	Sitting	11	Acceptable
	Build with Landscaping	Annual	9	Sitting	11	Acceptable
	Full Build	Annual	9	Sitting	11	Acceptable

Table 1: Mean Speed and Effective Gust Categories - Annual

Location	Configuration	Season	Mean Wind Speed: Speed (mph)	Mean Wind Speed: Rating	Effective Gust Wind Speed: Speed (mph)	Effective Gust Wind Speed: Rating
43	Build C1 & C2	Annual	14	Standing	20	Acceptable
	Build C1 & C3	Annual	14	Standing	20	Acceptable
	Build C1, C2, C3 & R1	Annual	9	Sitting	15	Acceptable
	Build	Annual	10	Sitting	16	Acceptable
	Build with Landscaping	Annual	8	Sitting	13	Acceptable
	Full Build	Annual	7	Sitting	12	Acceptable
44	Build C1 & C2	Annual	14	Standing	19	Acceptable
	Build C1 & C3	Annual	14	Standing	19	Acceptable
	Build C1, C2, C3 & R1	Annual	9	Sitting	15	Acceptable
	Build	Annual	9	Sitting	14	Acceptable
	Build with Landscaping	Annual	9	Sitting	14	Acceptable
	Full Build	Annual	9	Sitting	13	Acceptable

Configurations		Mean Wind Criteria Speed (mph)		Effective Gust Criteria (mph)	
Build C1 & C2	Proposed C1 & C2 buildings and existing surrounding	≤ 12	Comfortable for Sitting	≤ 31	Acceptable
Build C1 & C3	Proposed C1 & C3 buildings and existing surrounding	13 - 15	Comfortable for Standing	> 31	Unacceptable
Build C1, C2, C3 & R1	Proposed C1, C2, C3, & R1 buildings and existing surrounding	16 - 19	Comfortable for Walking		
Build	Proposed C1, C2, C3, R1, R2 & R3 buildings and existing surrounding	20 - 27	Uncomfortable for Walking		
Build with Landscaping	Addition of proposed landscaping	> 27	Dangerous Conditions		
Full Build	Addition of future developments				

Wind speeds are for a 1% probability of exceedance

Table 2: Mean Speed and Effective Gust Categories - Seasonal

Location	Configuration	Mean Wind Speed (mph)				Effective Gust Wind Speed (mph)			
		Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
1	Build C1 & C2	17	13	16	16	24	18	22	23
	Build C1 & C3	18	13	17	16	25	18	23	23
	Build C1, C2, C3 & R1	13	11	13	13	19	15	18	19
	Build	13	10	12	13	18	15	18	18
	Build with Landscaping	12	10	12	12	17	15	17	18
	Full Build	12	10	12	12	17	15	17	17
2	Build C1 & C2	15	11	14	14	21	16	20	20
	Build C1 & C3	16	11	14	14	22	16	20	20
	Build C1, C2, C3 & R1	11	9	11	11	18	14	17	18
	Build	11	9	11	11	17	14	17	18
	Build with Landscaping	11	9	10	11	17	14	16	17
	Full Build	11	9	11	12	17	14	16	18
3	Build C1 & C2	16	12	15	15	23	17	21	22
	Build C1 & C3	16	12	15	15	23	17	21	22
	Build C1, C2, C3 & R1	12	10	12	13	18	15	17	19
	Build	12	10	12	13	18	15	17	18
	Build with Landscaping	12	10	12	13	18	15	17	19
	Full Build	13	11	12	13	18	16	18	19
4	Build C1 & C2	12	10	11	12	21	16	19	20
	Build C1 & C3	13	10	12	12	21	16	20	20
	Build C1, C2, C3 & R1	13	10	12	12	19	15	18	19
	Build	12	9	11	12	19	15	18	19
	Build with Landscaping	13	10	12	13	19	15	18	19
	Full Build	12	10	12	13	18	15	17	19
5	Build C1 & C2	12	10	11	11	20	16	18	18
	Build C1 & C3	13	10	12	12	21	16	19	19
	Build C1, C2, C3 & R1	12	10	11	11	20	16	18	18
	Build	12	9	11	11	18	15	17	17
	Build with Landscaping	12	10	11	11	19	16	17	18
	Full Build	12	10	11	11	19	16	17	17
6	Build C1 & C2	13	10	12	13	20	14	18	19
	Build C1 & C3	14	10	13	13	21	15	19	19
	Build C1, C2, C3 & R1	12	9	12	12	18	13	17	17
	Build	13	9	12	13	19	13	17	18
	Build with Landscaping	13	9	12	12	18	13	17	17
	Full Build	12	9	11	12	16	13	16	17
7	Build C1 & C2	12	8	11	12	18	13	17	17
	Build C1 & C3	12	9	11	11	19	14	18	18
	Build C1, C2, C3 & R1	11	8	10	11	16	12	15	16
	Build	11	9	10	12	16	12	15	17
	Build with Landscaping	12	9	11	13	16	12	15	17
	Full Build	12	9	11	13	16	12	15	17
8	Build C1 & C2	10	8	10	10	17	13	16	16
	Build C1 & C3	11	8	10	11	18	13	17	17
	Build C1, C2, C3 & R1	9	7	9	9	15	12	14	15
	Build	8	7	8	8	13	11	13	13
	Build with Landscaping	8	7	8	8	13	11	13	13
	Full Build	8	7	8	8	13	11	13	13

Table 2: Mean Speed and Effective Gust Categories - Seasonal

Location	Configuration	Mean Wind Speed (mph)				Effective Gust Wind Speed (mph)			
		Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
9	Build C1 & C2	11	8	10	12	18	13	17	18
	Build C1 & C3	12	8	11	11	20	14	18	18
	Build C1, C2, C3 & R1	10	8	9	10	15	12	14	16
	Build	11	8	10	11	15	12	15	16
	Build with Landscaping	11	8	10	12	15	12	15	16
	Full Build	11	8	10	12	15	12	15	17
10	Build C1 & C2	16	12	15	16	24	18	22	24
	Build C1 & C3	15	11	14	16	24	18	22	24
	Build C1, C2, C3 & R1	14	11	13	14	21	16	19	22
	Build	12	10	11	12	18	15	17	18
	Build with Landscaping	12	10	12	13	18	15	17	18
	Full Build	12	10	11	12	18	15	17	18
11	Build C1 & C2	15	12	14	14	22	18	20	22
	Build C1 & C3	16	13	15	17	24	18	22	24
	Build C1, C2, C3 & R1	15	12	14	16	22	18	21	23
	Build	12	11	12	12	19	16	17	18
	Build with Landscaping	13	11	12	12	19	16	18	18
	Full Build	12	11	12	12	18	16	17	18
12	Build C1 & C2	16	13	15	16	23	18	22	23
	Build C1 & C3	20	15	19	20	27	20	25	28
	Build C1, C2, C3 & R1	17	14	16	18	23	18	22	24
	Build	13	11	12	12	18	15	17	17
	Build with Landscaping	13	11	12	12	18	15	17	17
	Full Build	12	11	12	12	17	15	16	16
13	Build C1 & C2	16	12	14	16	23	18	21	24
	Build C1 & C3	15	11	14	16	23	17	21	23
	Build C1, C2, C3 & R1	16	12	15	17	23	18	21	24
	Build	15	11	14	16	21	16	19	22
	Build with Landscaping	13	10	12	14	19	15	18	20
	Full Build	13	11	13	15	18	15	18	20
14	Build C1 & C2	17	12	15	17	25	18	22	26
	Build C1 & C3	13	9	12	13	20	15	18	21
	Build C1, C2, C3 & R1	17	13	16	18	25	19	23	26
	Build	16	12	14	18	21	16	20	24
	Build with Landscaping	15	11	14	17	20	15	19	23
	Full Build	16	12	14	17	20	16	19	23
15	Build C1 & C2	19	14	17	19	26	19	24	26
	Build C1 & C3	14	10	12	13	24	17	21	22
	Build C1, C2, C3 & R1	19	14	17	19	26	19	23	26
	Build	13	9	12	13	20	14	19	20
	Build with Landscaping	11	8	10	11	17	12	16	17
	Full Build	10	7	9	10	15	11	14	16
16	Build C1 & C2	16	11	15	15	24	16	22	22
	Build C1 & C3	20	14	18	20	29	20	26	29
	Build C1, C2, C3 & R1	11	8	11	11	18	13	16	18
	Build	13	10	12	13	20	14	18	20
	Build with Landscaping	12	9	11	12	19	14	17	19
	Full Build	11	8	10	11	16	12	15	17

Table 2: Mean Speed and Effective Gust Categories - Seasonal

Location	Configuration	Mean Wind Speed (mph)				Effective Gust Wind Speed (mph)			
		Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
17	Build C1 & C2	11	9	11	12	19	14	17	20
	Build C1 & C3	16	12	15	17	23	18	22	25
	Build C1, C2, C3 & R1	10	8	10	10	17	13	16	17
	Build	11	8	10	11	17	13	16	17
	Build with Landscaping	11	8	10	11	17	13	16	17
	Full Build	9	7	8	9	15	12	14	15
18	Build C1 & C2	11	8	10	11	18	13	16	18
	Build C1 & C3	12	9	11	13	19	14	18	20
	Build C1, C2, C3 & R1	11	8	10	11	18	13	16	18
	Build	9	7	8	9	15	11	13	15
	Build with Landscaping	9	6	9	9	14	10	13	14
	Full Build	7	5	7	7	12	9	11	12
19	Build C1 & C2	13	11	11	13	19	16	17	19
	Build C1 & C3	14	11	12	14	21	17	19	21
	Build C1, C2, C3 & R1	13	10	12	13	20	16	18	20
	Build	12	10	11	11	18	15	17	18
	Build with Landscaping	12	10	11	12	18	15	17	18
	Full Build	12	10	11	12	18	15	16	18
20	Build C1 & C2	14	11	13	15	21	16	19	21
	Build C1 & C3	13	9	12	13	20	15	18	20
	Build C1, C2, C3 & R1	15	12	14	16	22	16	20	22
	Build	11	8	10	10	17	13	16	16
	Build with Landscaping	11	7	10	10	17	12	16	16
	Full Build	8	6	8	8	14	11	13	14
21	Build C1 & C2	16	13	15	17	23	18	21	23
	Build C1 & C3	16	12	15	16	23	18	21	23
	Build C1, C2, C3 & R1	19	14	18	19	25	19	23	25
	Build	17	13	16	17	23	18	22	23
	Build with Landscaping	15	12	14	16	22	17	20	22
	Full Build	14	11	13	14	19	15	18	19
22	Build C1 & C2	15	10	14	13	22	15	21	21
	Build C1 & C3	15	10	14	13	22	16	21	21
	Build C1, C2, C3 & R1	16	11	14	14	25	17	23	22
	Build	17	12	15	16	25	18	23	23
	Build with Landscaping	16	11	15	15	24	16	21	22
	Full Build	12	9	11	11	18	12	16	17
23	Build C1 & C2	18	13	16	18	25	18	23	24
	Build C1 & C3	18	13	16	18	25	18	23	25
	Build C1, C2, C3 & R1	22	16	20	22	28	20	26	28
	Build	21	16	19	21	27	20	25	27
	Build with Landscaping	20	14	18	18	25	18	23	23
	Full Build	15	10	14	14	20	14	18	19
24	Build C1 & C2	15	10	14	14	22	15	21	21
	Build C1 & C3	15	10	14	14	22	15	21	21
	Build C1, C2, C3 & R1	14	10	13	13	22	15	20	21
	Build	16	12	15	16	23	17	21	23
	Build with Landscaping	15	11	14	14	21	15	19	20
	Full Build	11	8	10	11	17	12	15	16

Table 2: Mean Speed and Effective Gust Categories - Seasonal

Location	Configuration	Mean Wind Speed (mph)				Effective Gust Wind Speed (mph)			
		Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
25	Build C1 & C2	16	12	15	16	22	16	21	22
	Build C1 & C3	15	11	14	15	21	16	20	21
	Build C1, C2, C3 & R1	19	14	17	19	25	18	23	25
	Build	18	14	17	19	24	18	22	25
	Build with Landscaping	15	11	14	16	21	15	19	21
	Full Build	11	8	10	11	16	12	15	16
26	Build C1 & C2	17	12	15	16	24	17	22	22
	Build C1 & C3	17	12	15	16	24	18	22	23
	Build C1, C2, C3 & R1	21	15	19	21	27	20	24	27
	Build	18	13	16	17	25	18	22	24
	Build with Landscaping	19	14	17	19	24	18	23	24
	Full Build	14	10	12	14	18	14	17	18
27	Build C1 & C2	16	11	15	14	23	16	21	21
	Build C1 & C3	16	11	14	14	23	16	21	21
	Build C1, C2, C3 & R1	14	10	12	14	21	15	19	21
	Build	17	12	15	17	23	17	21	24
	Build with Landscaping	10	7	9	10	14	10	13	14
	Full Build	8	6	7	8	11	9	11	12
28	Build C1 & C2	17	12	15	16	23	17	21	23
	Build C1 & C3	16	12	15	16	23	17	21	22
	Build C1, C2, C3 & R1	16	12	15	17	23	17	21	24
	Build	17	12	15	17	24	18	22	24
	Build with Landscaping	12	9	11	12	18	13	17	18
	Full Build	9	7	8	9	14	11	13	14
29	Build C1 & C2	13	9	11	12	18	13	16	18
	Build C1 & C3	12	9	11	12	18	13	16	18
	Build C1, C2, C3 & R1	13	9	12	13	18	13	16	19
	Build	12	9	11	12	18	13	16	18
	Build with Landscaping	10	8	9	10	14	11	13	15
	Full Build	8	6	7	8	12	9	11	12
30	Build C1 & C2	14	10	13	12	22	15	20	20
	Build C1 & C3	15	10	13	13	23	16	21	21
	Build C1, C2, C3 & R1	15	11	14	16	23	17	21	24
	Build	8	7	8	9	14	11	13	14
	Build with Landscaping	8	6	8	9	14	10	13	14
	Full Build	8	7	8	9	14	11	13	14
31	Build C1 & C2	13	10	12	13	19	14	18	19
	Build C1 & C3	14	10	13	14	21	15	19	20
	Build C1, C2, C3 & R1	11	9	10	12	18	14	16	19
	Build	8	7	8	9	14	11	13	14
	Build with Landscaping	8	6	7	8	12	10	11	12
	Full Build	6	6	7	7	10	9	10	11
32	Build C1 & C2	16	11	14	15	23	17	21	22
	Build C1 & C3	17	12	15	15	24	17	22	22
	Build C1, C2, C3 & R1	12	9	11	12	19	14	18	19
	Build	11	8	10	10	17	13	16	17
	Build with Landscaping	9	7	8	9	14	11	13	14
	Full Build	9	7	8	9	13	11	13	14

Table 2: Mean Speed and Effective Gust Categories - Seasonal

Location	Configuration	Mean Wind Speed (mph) Spring	Summer	Fall	Winter	Effective Gust Wind Speed (mph) Spring	Summer	Fall	Winter
33	Build C1 & C2	17	12	16	15	24	17	22	22
	Build C1 & C3	17	12	16	15	24	17	22	22
	Build C1, C2, C3 & R1	12	8	11	12	19	14	17	19
	Build	14	11	13	15	22	16	20	22
	Build with Landscaping	9	7	9	9	15	12	14	15
	Full Build	9	7	8	9	14	12	13	15
34	Build C1 & C2	17	12	15	15	24	17	22	22
	Build C1 & C3	18	12	16	15	25	17	23	22
	Build C1, C2, C3 & R1	12	9	11	12	19	14	18	19
	Build	12	9	11	12	19	14	18	19
	Build with Landscaping	10	8	10	10	15	12	15	16
	Full Build	10	8	10	11	15	13	15	16
35	Build C1 & C2	12	9	11	12	18	13	17	18
	Build C1 & C3	13	9	12	12	20	14	18	19
	Build C1, C2, C3 & R1	11	8	10	11	17	13	16	17
	Build	11	9	10	11	17	13	16	18
	Build with Landscaping	11	9	11	12	17	13	16	18
	Full Build	12	9	11	12	17	13	16	18
36	Build C1 & C2	13	11	12	14	20	16	19	20
	Build C1 & C3	14	11	13	14	20	16	19	21
	Build C1, C2, C3 & R1	13	10	12	14	20	15	19	20
	Build	14	11	13	15	21	16	20	22
	Build with Landscaping	14	11	13	15	21	16	20	22
	Full Build	14	11	13	15	20	15	19	21
37	Build C1 & C2	16	11	15	14	23	16	21	21
	Build C1 & C3	16	12	15	15	23	17	21	22
	Build C1, C2, C3 & R1	12	9	11	12	18	15	17	19
	Build	11	9	10	11	18	15	17	18
	Build with Landscaping	10	9	10	11	16	14	15	17
	Full Build	11	9	10	11	17	14	16	18
38	Build C1 & C2	15	12	14	15	22	18	21	22
	Build C1 & C3	15	13	14	16	22	18	21	23
	Build C1, C2, C3 & R1	14	12	13	15	20	17	19	21
	Build	14	12	13	14	20	17	19	20
	Build with Landscaping	14	12	14	15	20	17	20	21
	Full Build	15	13	15	16	21	17	20	21
39	Build C1 & C2	14	10	13	12	20	14	18	18
	Build C1 & C3	14	9	12	12	20	14	18	18
	Build C1, C2, C3 & R1	8	7	8	8	14	11	13	14
	Build	8	6	7	8	13	11	12	13
	Build with Landscaping	7	5	6	7	12	9	11	11
	Full Build	7	6	7	7	12	10	11	12
40	Build C1 & C2	16	10	14	13	22	15	19	18
	Build C1 & C3	15	10	14	12	21	14	19	18
	Build C1, C2, C3 & R1	8	6	8	8	14	10	13	13
	Build	8	6	8	8	14	10	13	13
	Build with Landscaping	7	5	7	7	12	9	11	11
	Full Build	7	5	6	7	11	8	10	11

Table 2: Mean Speed and Effective Gust Categories - Seasonal

Location	Configuration	Mean Wind Speed (mph) Spring	Summer	Fall	Winter	Effective Gust Wind Speed (mph) Spring	Summer	Fall	Winter
41	Build C1 & C2	11	8	11	11	17	12	16	16
	Build C1 & C3	11	8	10	10	16	12	15	16
	Build C1, C2, C3 & R1	7	6	7	8	12	10	11	13
	Build	7	6	7	7	11	9	11	12
	Build with Landscaping	7	5	6	7	11	9	10	11
	Full Build	7	6	7	7	11	9	11	12
42	Build C1 & C2	12	8	11	11	16	11	15	15
	Build C1 & C3	11	8	11	11	16	11	15	15
	Build C1, C2, C3 & R1	9	7	9	10	12	10	12	13
	Build	9	7	9	10	11	9	11	12
	Build with Landscaping	9	7	9	10	11	9	11	12
	Full Build	9	8	9	10	12	10	11	12
43	Build C1 & C2	16	11	14	13	22	15	20	19
	Build C1 & C3	16	11	14	13	23	15	20	19
	Build C1, C2, C3 & R1	10	7	9	10	16	11	15	15
	Build	11	8	10	11	18	13	16	17
	Build with Landscaping	9	6	8	8	14	10	13	13
	Full Build	8	6	7	8	12	10	12	12
44	Build C1 & C2	16	10	14	13	21	15	20	19
	Build C1 & C3	15	10	14	13	22	15	20	19
	Build C1, C2, C3 & R1	10	8	9	10	16	12	15	16
	Build	9	8	9	10	15	12	14	15
	Build with Landscaping	10	7	9	9	15	11	14	14
	Full Build	9	7	9	9	13	10	13	14

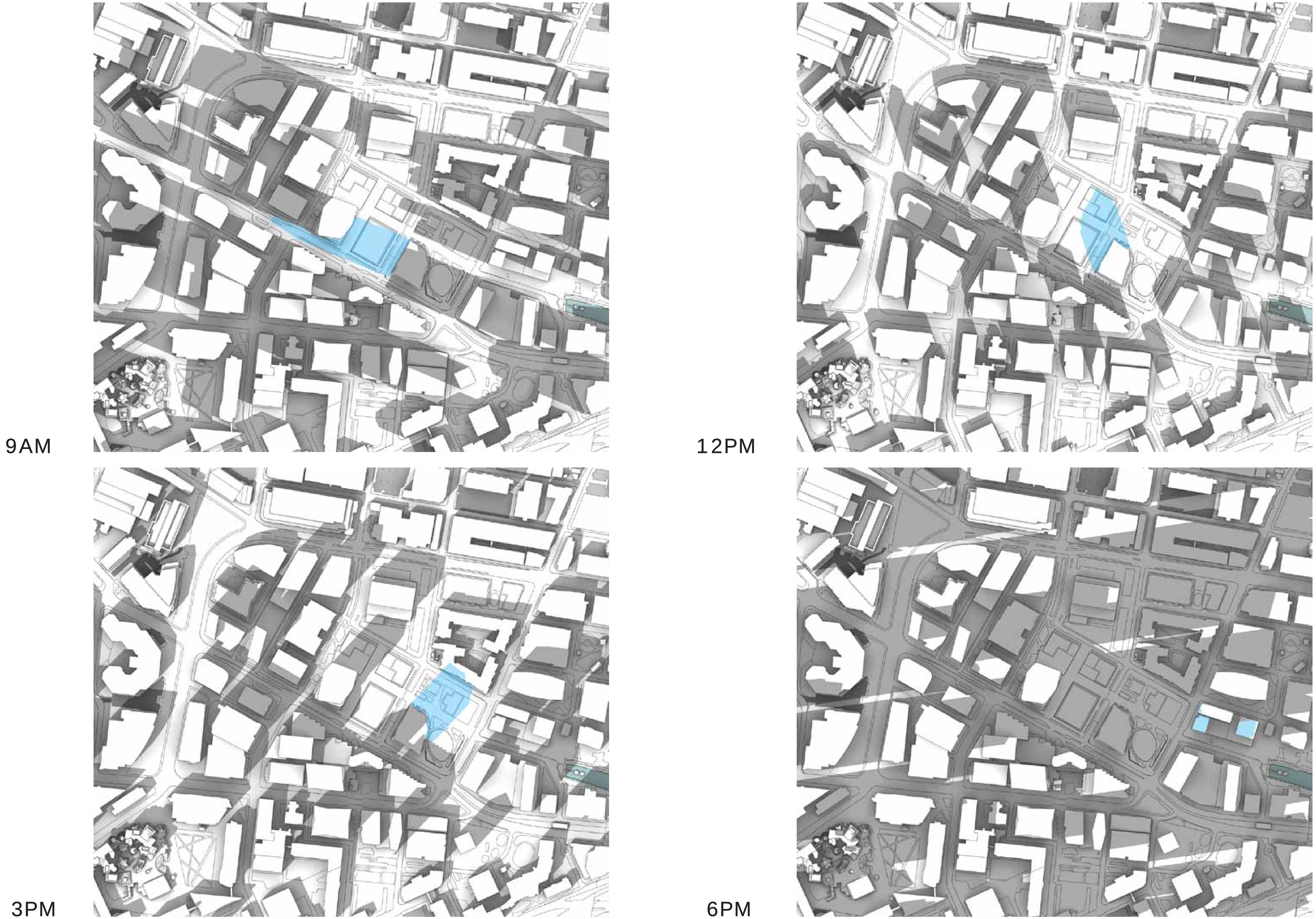
Seasons	Months	Mean Wind Criteria Speed (mph)		Effective Gust Criteria (mph)	
Spring	March - May	≤ 12	Comfortable for Sitting	≤ 31	Acceptable
Summer	June - August	13 - 15	Comfortable for Standing	> 31	Unacceptable
Fall	September - November	16 - 19	Comfortable for Walking		
Winter	December - February	20 - 27	Uncomfortable for Walking		
Annual	January - December	> 27	Dangerous Conditions		

Configurations

C1 & C2	Proposed C1 & C2 buildings and existing surrounding
C1 & C3	Proposed C1 & C3 buildings and existing surrounding
C1, C2, C3 & R1	Proposed C1, C2, C3, & R1 buildings and existing surrounding
Build	Proposed C1, C2, C3, R1, R2 & R3 buildings and existing surrounding
Build with Landscaping	Addition of the proposed landscaping
Full Build	Addition of the future developments

4.4 Shadow Study

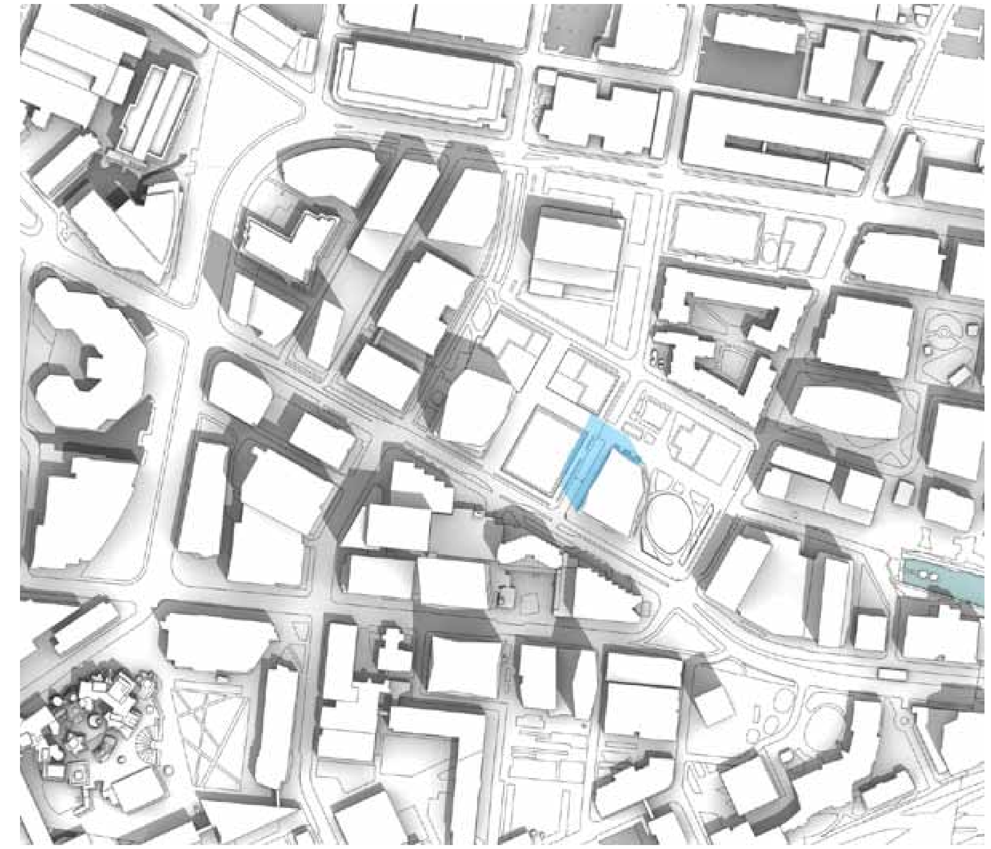
Shadow Analysis - March 21st



Shadow Analysis - June 21st

9AM

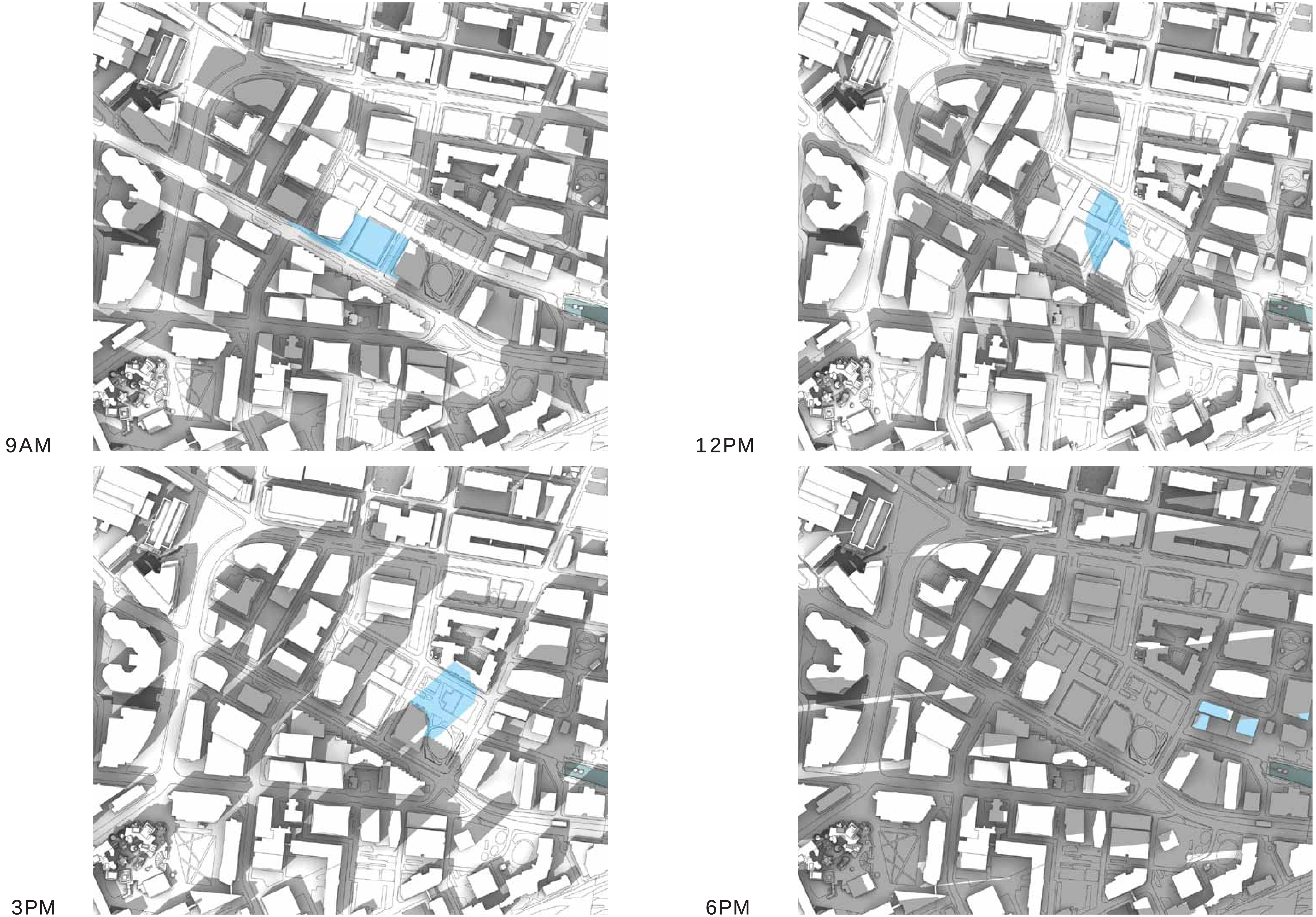
12PM



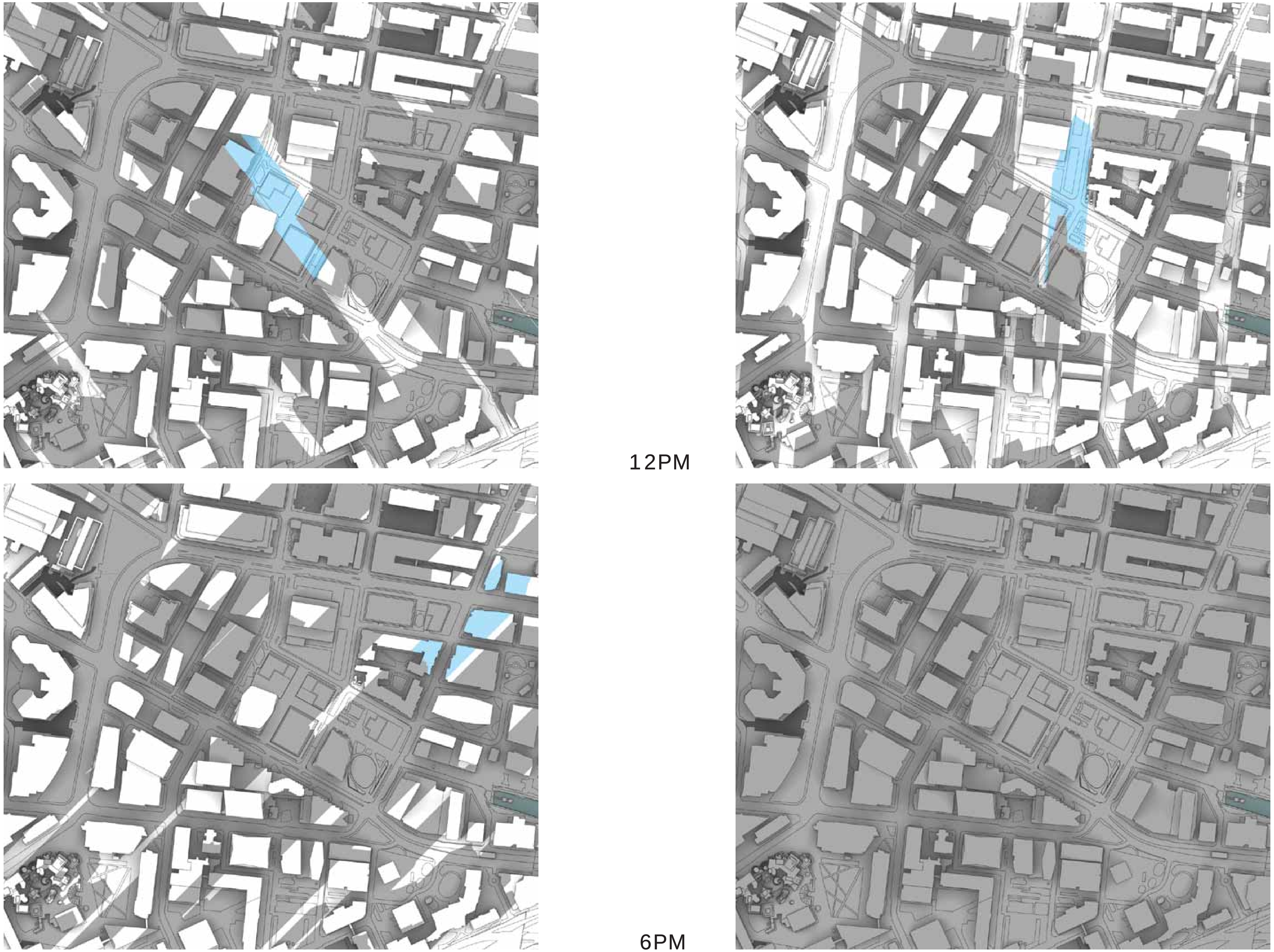
3PM

6PM

Shadow Analysis - September 21st



Shadow Analysis - September 21st



9AM

12PM

3PM

6PM