# 4

# ENVIRONMENTAL ANALYSIS

Sustainable and Resilient Buildings Questionnaire
LEED Compliance
Shadow Study
Pedestrian Level Wind Analysis
Solar Glare Analysis

# SUSTAINALBLE AND RESILIENT BUILDINGS QUESTIONNAIRE

This document outlines development review application requirements in relation to the long-term environmental sustainability and climate resilience of buildings within Somerville. Development proposals that require Site Plan Approval by the Somerville Zoning Ordinance must include a completed Sustainable & Resilient Buildings Questionnaire with the required Development Review Application. A Development Review Application is considered incomplete unless a completed questionnaire is submitted with the application.

The purpose of this questionnaire is to ensure that the impacts of future climate conditions are carefully evaluated and to encourage reasonable efforts to reduce or eliminate greenhouse gas emissions and mitigate the impacts related to climate change in the design, construction, and occupancy of buildings. Completion of this questionnaire raises awareness of site specific vulnerability, ensures that future climate conditions are considered throughout the stages of development.

Please review the following documents before completing the questionnaire:

- **Somerville Climate Change Vulnerability Assessment**
- **Carbon Neutrality Pathway Assessment**

## RESOURCES:

For information on net-zero and resilient building and site design, please review the following resources:

- **Architecture 2030 Palette (Net-zero design tools)**
- **Building Resilience in Boston**
- **Enhancing Resilience in Boston**
- **A Better City's Resiliency Toolkit**
- **Ready to Respond: Strategies for Multifamily Building Resilience**

**For additional information visit www.somervillema.gov/sustainaville**

## PROCEDURE:

A completed Sustainable & Resilient Buildings Questionnaire must be submitted with a Development Review Application for all development proposals that require Site Plan Approval. New construction or alterations to existing structures of 25,000 square feet or more must also submit an updated questionnaire prior to the issuance of the first Building Permit and prior to the issuance of the first Certificate of Occupancy to identify any design changes made subsequent to Site Plan Approval or additional information determined as the development process unfolds.

## BACKGROUND: CARBON NEUTRALITY

Understanding the global imperative to reduce greenhouse gas emissions in order to prevent extreme changes to the climate, Mayor Joseph A. Curtatone set a goal for Somerville to become carbon neutral by the year 2050. In 2017, the Somerville Board of Aldermen passed a resolution re-affirming the city's carbon neutrality goal. Carbon neutrality is defined as the net-zero release of carbon dioxide and other greenhouse gases (GHG) within Somerville's municipal boundary.

To achieve carbon neutrality by 2050, Somerville will need to drastically reduce greenhouse gas emissions from electricity, buildings, transportation, and waste disposal. Development within the city will need to be high performing and progressively improve its energy performance to become carbon neutral. Buildings should be designed to maximize energy efficiency, produce or procure renewable energy, and phase out fossil fuel use.

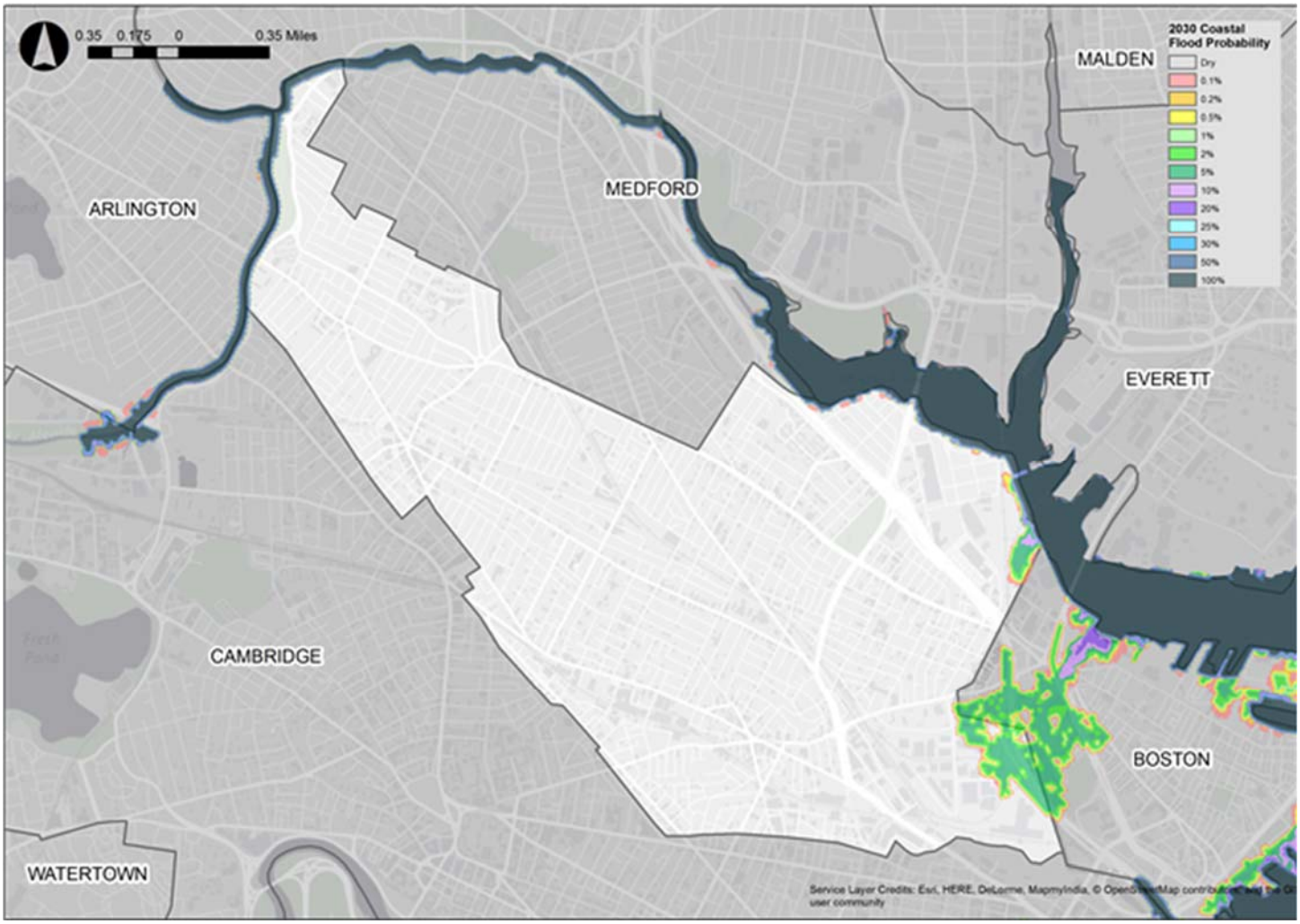
## BACKGROUND: CLIMATE CHANGE VULNERABILITY

Despite efforts to minimize greenhouse gas emissions, climate change is already impacting the City of Somerville and changes to the climate will continue to intensify unless global emissions are swiftly and significantly reduced. The City of Somerville's Climate Change Vulnerability Assessment analyses vulnerabilities associated with Somerville's key climate stressors: increased precipitation, sea level rise and storm surge, and higher temperatures. The analysis recommends that new development consider these climate impacts and take appropriate measures to address the projected climatic conditions described in the assessment.

Sea level rise and storm surge are already potential concerns for areas of East Somerville. By 2035-2040, the Amelia Earhart Dam could be regularly flanked by strong storms resulting in flooding for areas of Assembly Square, Ten Hills, and Winter Hill. Additionally, future 100-year (1% annual chance of occurrence) 24-hour storm events are projected to have a more than 30% increase in rainfall. This increased storm water will put additional stress on Somerville's water infrastructure and is likely to worsen precipitation-based flooding across many areas of the city. As the climate continues to change, average seasonal temperatures are expected to increase and the number of days above 90 degrees Fahrenheit (currently about 10 a year) could rise to 40 days by 2030, a third of the summer, and 90 days by 2070, nearly the entire summer.

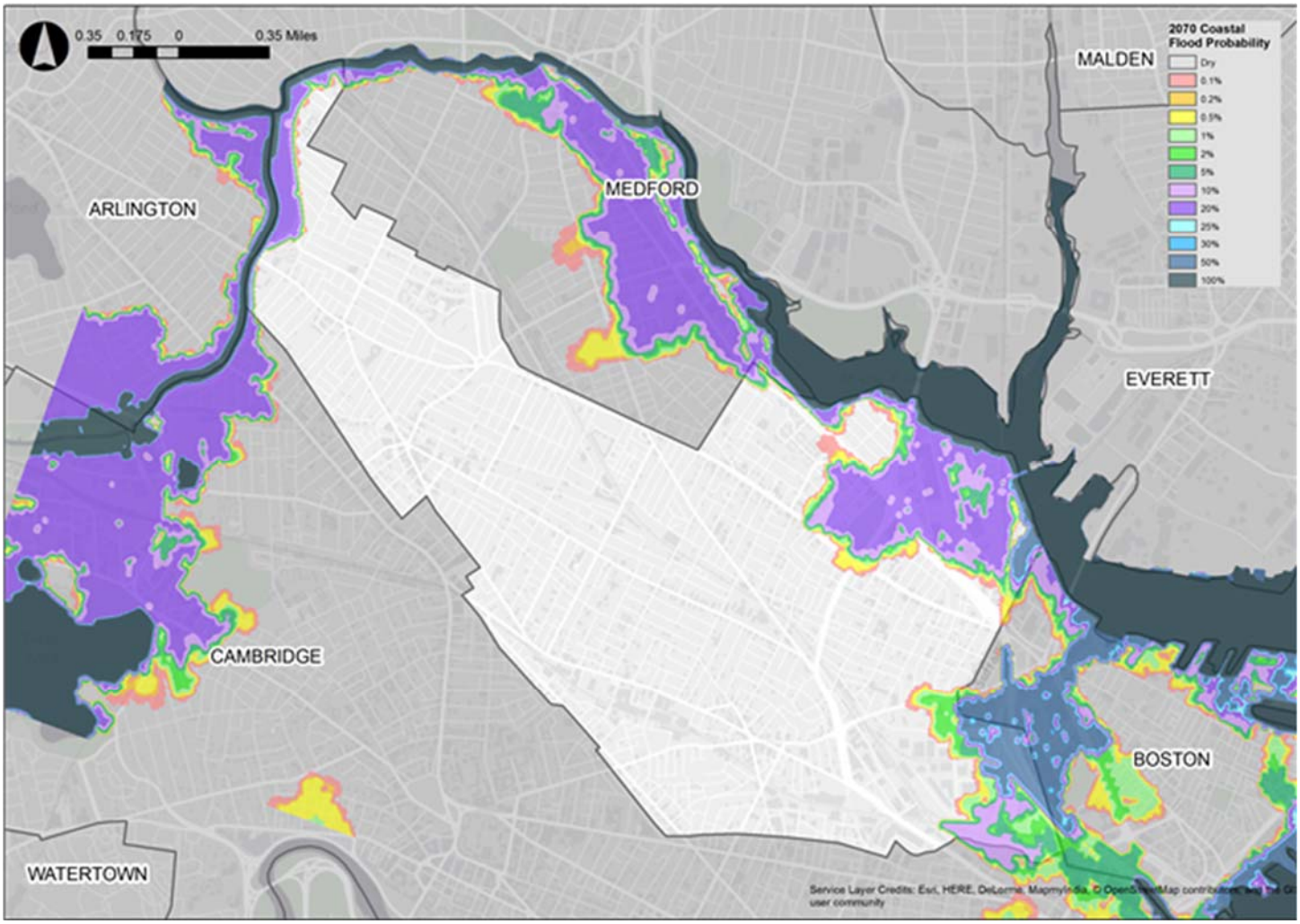
The following maps and figures provide an overview of projected climate exposure. Please review the Climate Change Vulnerability Assessment for more detailed analysis on Somerville's exposure, vulnerability, and risk to climate change.

## 2030 Coastal Flood Probability



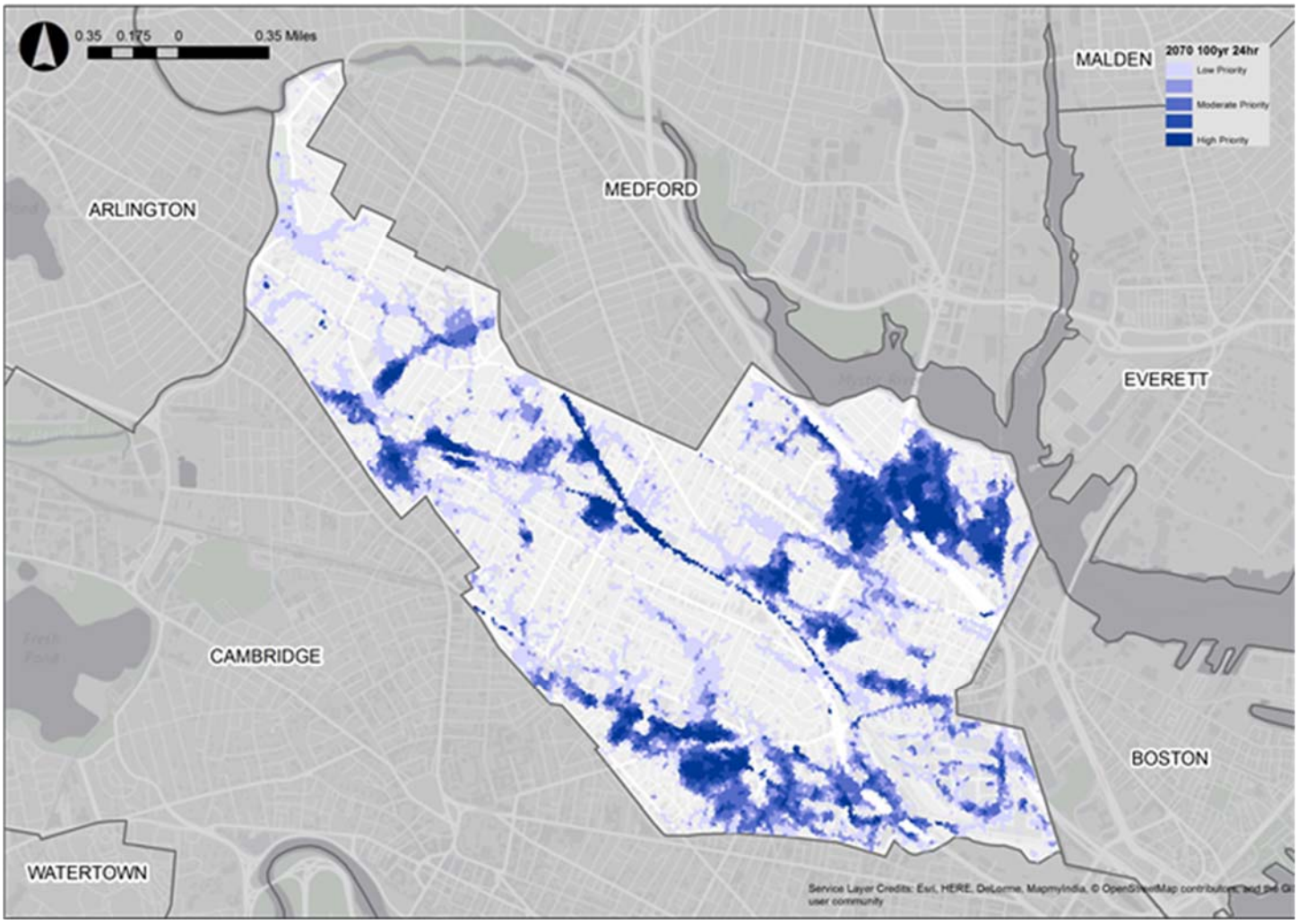

This map shows the annual chance of flooding from coastal storm events and sea level rise in 2030. A 100% chance of flooding means that area is very likely to flood that year, while a 50% chance means that there is an equal chance that it may or may not flood in a given year. A 1% chance of flooding corresponds with a '100-year event'. A 0.1% chance corresponds with a '1000-year event'. (Somerville Climate Change Vulnerability Assessment, 2017)

## 2070 Coastal Flood Probability




This map shows the annual chance of flooding from coastal storm events and sea level rise in 2070. A 100% chance of flooding means that area is very likely to flood that year, while a 50% chance means that there is an equal chance that it may or may not flood in a given year. A 1% chance of flooding corresponds with a 100-year event. A 0.1% chance corresponds with a 1000-year event. (Somerville Climate Change Vulnerability Assessment, 2017)

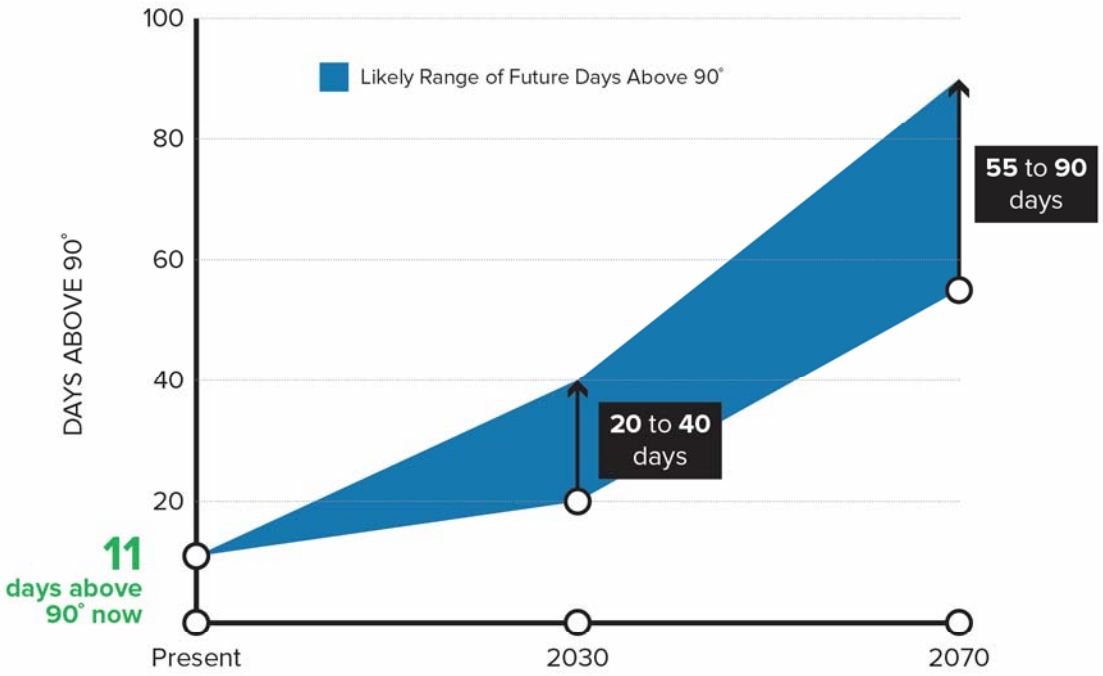
## Precipitation Projections




2070 100-year, 24-hour Design Storm Priority Areas of Flood Concern
(Somerville Climate Change Vulnerability Assessment, 2017)

| Storm Type | Present-day Rainfall | 2030 Rainfall | 2070 Rainfall |
|---|---|---|---|
| 10-year (10%), 24-hour | 4.9 in | 5.6 in | 6.4 in |
| 100-year (01%), 24-hour | 8.9 in | 10.2 in | 11.7 in |

## Temperature Projections




(Somerville Climate Change Vulnerability Assessment 2017)

| Temperature | 1971-2000 (average) | 2030 (low) | 2030 (high) | 2070 (low) | 2070 (high) |
|---|---|---|---|---|---|
| Annual | 50.0º F | 53.3º F | 53.5º F | 55.8º F | 58.7º F |
| Summer | 70.6º F | 74.5º F | 74.8º F | 77.4º F | 80.6º F |
| Winter | 29.8º F | 32.2º F | 33.0º F | 34.6º F | 38.0º F |

# SUSTAINABLE & RESILIENT BUILDINGS QUESTIONNAIRE

| Proposal Information | |
|---|---|
| Proposal Name | Union Square Redevelopment Project Parcel D2.2/2.3 |
| Address | Parcel D2.2 and D2.3 |
| Owner/Developer | Union Square RELP Master Developer LLC (US2) |
| Business Address | 31 Union Square, Somerville, MA 02143 |
| Designated Contact | Greg Karczewski |
| Telephone Number | 617.996.8255 |
| Email Address | Greg@discoverusq.com |

| Design Team | |
|---|---|
| Design Architect | Howeler + Yoon Architecture |
| Architect of Record | bKL Architecture |
| Engineer | RW Sullivan |
| Landscape Architect | Ground Landscape |
| Sustainability/LEED | dbHMS |
| Permitting | N/A |
| Construction Management | TBD |

| State Review | |
|---|---|
| Is MEPA Approval Required? | Yes |

| Building & Site Details | |
|---|---|
| Building Type | Residential with core and shell retail |
| Gross Floor Area | approximately 422,200 |
| Principal Uses | Residential |
| Ground Floor Uses | Residential lobby, back of house, retail |
| Site Elevation | Average Ground Level |
| Ground Story Elevation | 17'-0" City of Somerville Datum |
| Building Height | 26 (288'-0" roof, 300'-4" T/O parapet) |
| Below Grade Levels | There is a small portion of the parking that is below grade, and the electrical vault is also below grade. |
| Ground Water Elevation | Approx. 3.5-7.0 below grade (based on monitoring in Oct. 2014) |
| Parking Spaces | 269 in shared parking garage |
| EV Ready Spaces | None |
| EV Charging Spaces | 10 EV spots with 5 dual charging stations |

| | |
|---|---|
| Climate Vulnerability Exposure (check all that apply) | ✓ Sea Level Rise & Storm Surge<br>✓ Precipitation Induced Flooding<br>✓ Heat<br>☐ Other(s): |

| | |
|---|---|
| Green Building | |
| LEED Version | LEED for New Construction version 4 |
| LEED Certifiable | LEED certified |
| LEED Rating | Gold |
| LEED Point Score | 60 |

| | |
|---|---|
| Building Systems | |
| Expected Life of Building | 60 years |
| Critical Site Infrastructure | Pumps - 10 years, all other site infrastructure - 75 years |
| Expected Life of Key Systems | 30 years |
| Type of Heating System(s) | Gas Fired Boilers, water source heat pumps |
| Type of Cooling System(s) | Water source heat pumps with cooling tower |

**Building Energy Use & Continuity**

Reducing greenhouse gas emissions is critical to avoiding the worst impacts of climate change. To achieve Somerville's 2050 carbon neutrality goal, new construction must be designed to maximize energy efficiency, produce or procure renewable energy, and phase out fossil fuel use. At the same time, new development should make efforts to improve resiliency to disruptions in utility services, which could become more frequent with more powerful storm events and heat waves.

1. Explain how building energy loads & performance were determined:

Computer-aided building load and energy use calculations were performed using Trane Trace 700 to better understand the energy loads and improve performance of the proposed building.

| | | | |
|---|---|---|---|
| Annual Electric Load | 3,200,000 (kWh) | Peak Electric Load | 810 (kW) |
| Annual Heating Load | 6,300 (MMbtu) | Peak Heating Load | 4.6 MMBtu/hr |
| Annual Cooling Load | 161,000 (Tons/hr) | Peak Cooling Load | 825 (tons) |

| | |
|---|---|
| Energy Use Intensity | 44 (kBtu/SF) |

2. Describe any strategies that will be implemented to support continued building operations during potential utility outages.

Interruptions of power can be mitigated in the short term by the emergency generator.

Back-Up/Emergency Power Systems

| | | | |
|---|---|---|---|
| Electric Output | 1000 kW | Number of Power Units | 1 |
| System Type | Combustion Engine | Fuel Source | Diesel |

Emergency and Critical System Loads (in the event of service disruption)

| | | | |
|---|---|---|---|
| Electric | 675 (kW) | Heating | 0.25 (MMbtu/hr) |
| | | Cooling | 10 (Tons) |

2. How is the building designed to reduce energy usage? Please describe the key design features of the building including any active (equipment, controls, features, etc.) or passive (orientation, massing, systems, etc.) energy efficiency measures.

High efficiency heating & cooling systems, high efficiency water heating systems, LED lighting, occupancy and vacancy lighting controls, photocell and time-clock schedule for exterior lighting controls, energy recovery ventilation, improved building envelope, low flow shower heads, VFD's, DDC building management system will all contribute to reduced energy usage.

| | | | |
|---|---|---|---|
| Energy Use below Mass Code | 25% | Energy Use below ASHRAE 90.1 (current edition) | Not modeled (2016)% |

3. Will the building use air or ground source heat pumps or solar thermal systems? Please describe any such system. If no, please explain the building's heating and cooling systems and whether high efficiency electric or renewable powered systems were considered.

Air or ground source heat pumps or solar thermal systems were considered but are not includeed in the project. The building does not use air or ground source heat pumps or solar thermal systems. There is little roof space available for solar collectors. It is unknown if existing geologic conditions are suitable to accommodate vertical boreholes.. Given the dense urban nature of the Phase 1 project area, and the site's history of Industrial uses, extensive underground drilling is not recommended.

4. Describe any existing or planned connections to distributed energy or district energy systems.

The building does not expect to connect to a distributed energy or district energy system. After studying the possibility of district energy, it was determined that development of a new district heating and cooling system is not commercially viable for the Project due to the non-contiguous nature of the development and the infeasibility of traversing several major roadways.

5. Is on-site renewable energy generation feasible? Please describe your analysis and findings. If yes, will any renewable energy be produced onsite? If so, please describe (system type and capacity).

The building Is currently designed with conduits and structural upgrades to provide a solar-ready roof, and the project team plans to study the incorporation of solar as an on-site renewable strategy as building design continues. A preliminary solar feasibility study was conducted to determine an approximately 15,000 sf array resulted in 105 kW of power. The Applicant supports the idea of PV rooftop installations and will continue to examine the benefits of PV as design progresses; however, the technical and economic potential of PV must be evaluated based on the-current incentives, alternatives and physical constraints.

6. Describe any on-site energy storage systems.

The building does not include any on-site energy storage systems.

7. Describe any other measures intended to reduce energy use and greenhouse gas emissions.

The project targets energy and emissions reductions through multiple strategies, Including Smart Growth planning principles, transportation, energy metering, and commissioning, among others. Please reference the LEED narrative and scorecard for additional Information.

8.Does the electric utility's infrastructure have enough capacity to support the addition of your building's energy load? Please confirm that you have consulted with the local utility.

Load letters have been sent to Eversource. Associated meetings have been held and coordination is ongoing.

9. Describe measures that will be implemented to reduce building energy demands on utilities and infrastructure, such as a demand response program.

The team is studying potential for CHP in the D2.3 tower for onsite electrical generation.

The City of Somerville recognizes that as technology advances, incorporating design elements to mitigate carbon emissions and increase resilience may become more feasible. Applicants are encouraged to devise strategies that permit building systems to adapt and evolve over time to further reduce GHG emissions and to avoid path dependency that perpetuates reliance on fossil fuels. With this in mind, please answer the following questions:

10. Will the building be a net zero carbon building? A net zero carbon building is a highly energy efficient building that either produces or procures enough carbon-free renewable energy to meet building operations or offsets any remaining carbon emissions. If the building will not be a net zero carbon building, describe how the building's systems will be adapted over time to achieve net zero energy emissions. Changes could include, but are not limited to, additional renewable energy generation, energy storage, additional energy efficiency measures, or other measures that would further reduce greenhouse gas emissions.

The building will not be a net zero carbon building. As described in items 5 and 7 above, the project will provide the conduits and structural capacity to deliver a solar-ready roof. Similarly, beyond provisions to offset consumption through renewables, the building introduces sustainable strategies around parking and alternative transportation, energy commissioning, and others that specifically target tempering reliance on fossil fuels. Green Power and Carbon offsets have been studied as a potential measure that would further combat emissions. Please reference the LEED narrative and scorecard for additional Information.

11. Will the building's roof include any sustainability features? These may include, but are not limited to, high albedo roof materials, solar panels, or vegetation. If no features are included in the design, please describe why and if any features could be added in the future.

The building will have a high albedo roof, and the garage roof will feature vegetation. The potential to reuse stormwater collected from roof surfaces for irrigation and cooling tower makeup has been studied and will continue to be investigated for possible implementation. Integrated conduits and added structural capacity will deliver a solar-ready roof.

12. Has the building been planned and designed to accommodate any additional future resiliency enhancements? Please describe if designs could accommodate future additions of any of the following:

- Solar PV (roof or site is solar ready)
- Solar Thermal
- Connection to district energy system
- Potable water storage
- Wastewater storage
- Back up energy systems & fuel
- Electric Vehicle Charging
- Green roof

The project is solar ready. A large storm water detention tank is included in the overall D2 block scope. 10 Electric vehicle charging stations will be provided within the shared parking facility on site. The potential to reuse stormwater collected from roof surfaces for irrigation and cooling tower makeup has been studied and will continue to be investigated for possible implementation. Additionally, the team is studying potential for CHP in the D2.3 tower for onsite electrical generation. Additional monetary contributions to offsite infrastructure will support area-wide resiliency planning efforts. Please reference the LEED narrative for additional details on resiliency enhancements.

## Climate Change Risk and Vulnerability

13. How did you use climate change projections from Somerville's Climate Change Vulnerability Assessment (CCVA) to inform the building and site design of your project?

The CCVA identified site specific risks of flooding and heat Island Impacts and informed decision making relative to each. All Low-level uses were considered in light of the potential for flood impacts, and were designed to protect building systems. Flood sensitive systems will not be located in areas that are deemed to be susceptible to flooding without the necessary precautions to protect them for the long term Further bolstering long-term resiliency, the inclusion of emergency back-up systems, critical to future building occupants and their operations, will be addressed in more detail as specific occupant needs become known. New open spaces across the site were designed with their climate-change combatting potential in mind, incorporating green infrastructure elements paired with a new tree canopy to address the urban heat Island effect directly. By reducing the amount of storm water runoff and increasing the uptake of water by new plant materials, the amount of runoff discharged from each parcel will be reduced. Working in coordination with the City, the Project will investigate storm water management infrastructure that will allow for detention and infiltration on site to reduce rates and volumes to the maximum extent practicable. For additional information please reference Chapter 6 - 'Climate Change Resilience and Adaptation' of the Applicant's Draft Environmental Impact Report (EEA#15889)

14. Based on the information in the Climate Exposure section of the CCVA, what are the projected climate change impacts that your site might vulnerable to? Please list and describe all relevant impacts from the CCVA.

Sea level rise, storm surge, precipitation and temperature are the key stressors to the area. The existing site is already susceptible to precipitation flooding. The project's approach to stormwater management and ground level design have been designed with future resiliency In mind.

The next two sections ask specific questions about how the project is designed to manage climate-related risks from heat, coastal and inland flooding.

## Managing Heat Risks

As temperatures increase, Somerville will become more susceptible to the urban heat island effect which causes hotter temperatures due to paved surfaces and waste heat generated by energy use when compared to less developed areas. Open space, trees coverage, and impervious surfaces can help reduce heat exposure and the intensity of the urban heat island effect.

Increasing average temperatures can have wide-ranging impacts on human life, the built environment, and natural ecosystems. Rising temperatures and more intense heat waves present significant public health concerns and can contribute toward kidney, lung, and heart problems. Vulnerable populations are particularly susceptible to heat-induced illness and mortality. Buildings also demand greater electricity for cooling. Even small changes in average temperatures can significantly impact the natural environment.

15. Describe how the building and its energy systems will be adapted to efficiently manage future higher average temperatures, higher extreme temperatures, additional annual heat waves, and longer lasting heat waves.

The building heating and cooling systems are designed for 0.4% cooling and 99.6% heating weather conditions.

Temperature Design Conditions

| | | | |
|---|---|---|---|
| Low Temperature | 0 Degrees | High Temperature | 91F DB / 74F WB Degrees |
| Annual Cooling Days | 1,177 # | Annual Heating Days | 5,573 # |
| | | Days Above 90º | 20 # |

16. What design features will be implemented on site to minimize the site's contribution to the urban heat island effect? Please describe any and all design elements. Strategies could include, but are not be limited to, the following:

- High albedo pavement or roof materials
- Passive cooling or increased ventilation capacity
- Green roofs or walls
- Heat resistant trees and plants
- Additional landscaped areas

The Project includes a network of planned open spaces subject to the requirements of the Union Square Zoning regulations aligned with resilient planning practices that require vegetated areas, permeability, and the large trees that provide shade and cooling to reduce the urban heat island effect. In total, over 20 new trees will be planted at the adjacent Civic Space, provided within the

green infrastructure that will facilitate their support and growth to maturity. Additionally, the project includes a high albedo roof and vegetated roof areas. The pedestrian hardscape will have a high Solar Reflectance Index. Please refer to the LEED narrative for additional detail around sustainability Initiatives.

17. What additional design and operations strategies will be implemented to protect building occupants during extreme heat events?

Emergency generators will provide backup power for life safety systems. Residential units have operable windows to allow for natural ventilation, and the windows are to have a SHGC rating better than code to control solar heat gain.

## Managing Flood Risks

Several areas of Somerville are already prone to flooding from intense precipitation. As part of a wet region, Somerville is projected to experience more than a 30% increase in rainfall during a 100-year 24-hour event. With climate change, precipitation events will become more intense—meaning that a greater volume of rain will fall in a shorter period of time. This can lead to flooding in areas where the drainage system does not have sufficient capacity. It will be further exacerbated by the presence of impervious surfaces, such as roads and parking lots, where the water cannot be absorbed into the ground, but rather is funneled into storm drains, nearby water bodies or other low-lying areas.

In addition to flooding from precipitation, sea level rise and storm surge are already potential concerns for areas of East Somerville and by 2035-2040 the Amelia Earhart Dam could be regularly flanked by storms. More information can be found in the complete Vulnerability Assessment.

18. How has the site and building been designed to manage storm water from rain event?

A joint below-grade Storm Water Retention Tank serving all three D2 Parcels will capture D2.2 storm water mitigating outflow rate to city storm sewer. The building does not have a basement. Lowest level is at grade above base flood elevation.

19. Is the site susceptible to flooding from sea level rise and storm surge or rain events now or during its expected lifetime? Please refer to the Somerville Climate Change Vulnerability Assessment and restate your potential flood risks based on the CCVA.

The existing site is susceptible to precipitation flooding. The project's approach to stormwater management and ground level design have been designed with future resiliency In mind.

**If you answered YES to the previous question, please complete the next section.**
Otherwise, you have completed the questionnaire. Thank you.

Flooding Design Considerations

| | | | |
|---|---|---|---|
| Site Elevation - Low | 7.4 (ft) NVGD 88 | Site Elevation - High | 23.8 (ft) NVGD 88 |
| Site Elevation - Avg. | Average Ground Level | Ground Level Elevation | D2.2 = 10.8 (ft) NVGD 88 |
| Is any portion of the site in a FEMA SFHA? (1% chance floodplain) | No | What FEMA zone(s) | N/A |
| Base Flood Elevation | N/A | Design Flood Elevation | N/A |
| 2030 Flood Risk | N/A (%) | 2070 Flood Risk | N/A (%) |

20. What are the ground floor uses of the building? Are there any below ground stories of the building? If so, what uses are located below ground?

The ground floor has parking, loading, back of house spaces, the residential lobby, and retail space. A small portion of the parking is below grade relative to finish floor. The electrical vault requires a clear-height that necessitates Its floor also be below ground.

21. Are there any flood-sensitive assets, utilities, mechanical equipment, or critical site infrastructure located in areas of the building that are at risk of flooding? What measures will protect building systems during a flood or severe storm? These might include, but may not be limited to, the following:

- Elevation of utilities and mechanical systems
- Water tight utility conduits
- Waste water back flow prevention
- Storm water back flow prevention
- Systems located above the ground floor
- Securing objects at risk of becoming dislodged

The electrical utility vault and elevator pits are below the 100-year flood plain and are to have bentonite waterproofing. The vault sump pump is designed to handle incidental water, but it could be helpful as a partial strategy in case of a flood. The building's main electrical room is located on the second floor to avoid highwater. The generator is located on the roof to protect it from flooding.

The fire pump is located on the first floor (elevation 17.0ft) and will be installed on a 12" tall housekeeping pad (elevation 18.0ft)

Sanitary fixtures and storm receptors in the building that are below the rim elevation of the manhole outside the building (on site) will be provided with backwater valves to prevent the municipal systems from backing up into the building through the piping.

The fire command centers and main telecommunication room are located on the first floor (elevation 17.0ft).

22. Will any flood-damage resistant materials be used in design and construction in flood risk areas?

Per FEMA's Flood Damage-Resistant Materials Requirements (Technical Bulletin 2, dated 2008), the proposed finish materials are intended to meet the National Flood Insurance Program's (NFIP) Class Rating 4-5 ("acceptable") standard. Materials resistant to water damage will be installed at grade.

23. What flood control design elements will be used to mitigate a 2070 coastal flood event with a 10% chance to occur in any given year (a '10-year' event)? These might include, but may not be limited to, the following:

- Elevation of the site
- Structural elevation of the building
- Non-structural elevation of the ground floor
- Wet flood-proofing (allowing water to flow through building envelope)
- Dry flood-proofing (preventing water from entering building)

The site is susceptible to precipitation flooding, not coastal flooding.

24. What is the recovery plan for a 2070 coastal flood event with a 1% chance to occur in any given year (a '100-year' event)? Summarize anticipated pre- and post-event policies, strategies, and actions necessary to facilitate post-flood recovery. These might include, but may not be limited to, the following:

- Flood mitigation design (see #23)

- Recovery management team
- Annual training & exercises
- Hazard evaluation & mitigation
- Damage assessment
- Demolition & debris removal
- Repair permitting
- Business resumption

The property manager will create a flood/storm event plan to manage implementation of resiliency measures, including raising elevators, selectively turning off power, implementing temporary flood barrier system, etc.

The plan will also include methods for maintaining property operation during such events, resident and tenant communication and updates protocols, current remediation company contact information, management and maintenance personnel responsibilities, and property specific protocol and logistics for remediation, repairs, documentation, and approvals and clearances for occupancy.

The plan will be documented, reviewed and updated yearly, and kept in the management office.

25. Will hazardous or toxic material be stored on site? Where will it be stored? How will you protect hazardous or toxic material from flooding?

There are no toxic materials to be stored on site.

26. Will the building employ any temporary measures to prevent flooding on site? These could include barricades, flood gates, and other measures. Please describe any temporary measures and include the elevation the measures are designed for.

A sump can be provided as necessary during construction of temporary barricades for utility protection.

27. Will the site be accessible during a flood inundation? If yes, to what flood elevation?

According to the draft US2 - Union Square Hydraulic Modeling Report Provided by the City of Somerville, precipitation flooding caused by the 100yr24 storm reaches an elevation of approximately 10.30 (NAVD88 Vertical Datum). The proposed buildings have been set at or above this elevation to maintain accessibility.

28. Will any additional measures be employed to protect the building from storms and flooding?

Emergency power provided for elevators, life safety, and security.

# LEED COMPLIANCE

CHICAGO
GRAND RAPIDS
PHILADELPHIA
DELHI
AHMEDABAD

**Affidavit**

As the Sustainability Consultant overseeing the planning, design, and construction of the Union Square Redevelopment Project Parcel D2.2/2.3, I, Claudia Mattison, LEED AP BD+C, 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 so as to meet the prerequisites and earn the credits necessary to achieve 60 points (minimum for Gold level of certification is 60 points) using the LEED for Core and Shell v4 Rating System. Assuming that the project follows through on the green strategies described in the LEED Checklist, the project will be able to earn LEED Gold level of certification.

**Claudia (Fischmann) Mattison**
P.E., LEED AP BD+C, LEED for Homes Green Rater
Group Leader | Sustainability Planning Studio
db | HMS

**Sustainable Design Narrative**
**Union Square Redevelopment Project Parcel D2.2/2.3**

As part of meeting the Union Square Redevelopment zoning requirements, the Somerville D2.2/2.3 project goals include meeting LEED version 4 Gold level of certification requirements. The descriptions below highlight strategies to focus on to achieve the level of sustainability desired for the project. The LEED Checklist is included at the end of the document. This document has been prepared by Claudia Mattison, LEED AP BD+C, LEED for Homes Green Rater.

Integrative Process

*Integrative Process (Credit)*

During SD and the early part of DD, the project team has used cross-discipline design and decision making to identify and use opportunities to achieve synergies across disciplines and building systems. As part of the commissioning process, an Owner's Project Requirements document has been put together to guide the design and construction team. As part of the MEPA and GHG processes and in early phase energy modeling, preliminary energy models were developed to test potential strategies associated with the following opportunities: Site condition, massing and orientation, basic envelope orientation, lighting levels, thermal comfort ranges, and plug and process load needs. A preliminary water budget analysis was completed for both indoor and outdoor water demand, and process water demand and supply sources were investigated. The results of these analysis were incorporated into the design of the project where practical and economical.

Location and Transportation

*Sensitive Land Protection (Credit)*

The project is located on a previously developed site.

*High Priority Site (Credit)*

The project team expects to earn both Option 2 - Priority Designation and Option 3 – Brownfield Remediation. The site has been assessed for pollutants and measures will be taken for remediation, abatement and removal in accordance with regulations. Additionally, the site is a 2018 Difficult Development Area, which qualifies it for Option 2.

*Surrounding Density and Diverse Uses (Credit)*

The project is a new building on a previously developed site; therefore, it meets the "Previously Developed" requirements. The area round the project will satisfy the surrounding density requirement. The project team will identify building sites and buildable land within required radius of the project site, collect information on density, and perform combined residential and non-residential density calculations. To fulfill the diverse uses requirements, the development is located within ½ mile of a dense residential area and a number of amenities including but not limited to: Bronwyn, Ebi Sushi, the Museum, Reliable Market, Market Basket, Foursquare Church, St. Joseph's Church, Grace Salon, Citizens Bank, Belly Dance Somerville, Union Square Farmers Market, Community Laundry, East Boston Savings Bank, Third Life Studio, Loyal Supply, and the Somerville Fire Department.

*Access to quality Transit (Credit)*

The project is located within ¼ mile of the CT2, 85, 86, and 87 MBTA bus lines. Additionally, the project will be directly adjacent to the Green Line Extension Union Square stop, which should be complete in 12/2021, within twenty-four months of the project's completion date.

*Reduced Parking Footprint (Credit)*

The 290 parking spaces provided, which serve Parcel D2.2/2.3 and Parcel D2.1, are a 51% reduction from the LEED Baseline for parking spaces for a residential building, which meets the 40% reduction requirement. Additionally, 15 preferred parking spaces (5%) have been reserved for carpools to meet the requirement for both Parcel D2.2/2.3 and Parcel D2.1.

*Green Vehicles (Credit)*

The project will designate 5% of all parking spaces used by the project as preferred parking for green vehicles (15 spaces). These spaces will be clearly identified and enforced for sole use by green vehicles. Additionally, 6 electric vehicle charging spaces have been show on the plans to meet the 2% electric vehicle charging stations requirement for both Parcel D2.2/2.3 and Parcel D2.1.

Sustainable Sites

*Construction Activity Pollution Prevention (Prerequisite)*

An erosion and sedimentation plan will enforce measures to protect adjacent areas from pollution from wind and water-borne soil and sedimentation. The civil design team prepared the erosion and sedimentation plan that meats the local codes and the EPA Construction General Permit of the National Pollution Discharge Elimination System (NPDES) program. The construction team will implement the erosion and sedimentation measures and will follow the requirements of the stormwater pollution prevention plan during the construction.

*Site Assessment (Credit)*
The project will complete and document a site assessment that includes topography, hydrology, climate, vegetation, soils, human use, human health effects.

*Open Space*
The project will provide outdoor space greater than or equal to 30% of the total site area (including building footprint). A minimum of 25% of that outdoor space will be vegetated. The amenity deck and ground level plaza will provide accessible pedestrian hardscape, and the ground level nativeand adapted vegetation will provide the vegetated outdoor space.

*Heat Island Reduction (Credit)*
The project will meet Option 1 by using a white roof membrane over the entire roof surface. The project will meet Option 2 by placing 100% of parking area under the compliant roof. The project will earn an exemplary performance credit for meeting both options.

*Light Pollution Reduction*
The project will design the exterior lighting to meet the BUG rating requirements for Lighting Zone LZ3.

Water Efficiency
*Outdoor Water Use Reduction (Prerequisite)*
The project will reduce the project's landscape water requirement by at least 30% from the calculated baseline for the site's peak watering month. Reductions will be achieved through plant species selection and irrigation system efficiency (drip irrigation and smart controllers), as calculated by the Environmental Protection Agency (EPA) WaterSense Water Budget Tool.

*Indoor Water Use Reduction (Prerequisite)*
The project will use low flush 1.28 GPF public toilets, 1.0 GPF residential toilets, 0.125 GPF urinals, 1.0 GPM public lavatory faucets, 1.0 GPM residential lavatory faucets, 1.8 GPM kitchen faucets, and 1.5 GPM showerheads, which are are calculated to achieve a reduction in water usage of approximately 37% over the baseline. All fixtures except the kitchen faucets will be WaterSense certified, and all appliances will be ENERGY STAR.

*Building-Level Water Metering (Prerequisite)*
The project will install permanent water meters that measure the total potable water use for the building and associated grounds.

*Outdoor Water Use Reduction (Credit)*
The project will reduce the project's landscape water requirement by at least 30% from the calculated baseline for the site's peak watering month. Reductions will be achieved through plant species selection and irrigation system efficiency (drip irrigation and smart controllers), as calculated by the Environmental Protection Agency (EPA) WaterSense Water Budget Tool.

*Indoor Water Use Reduction (Credit)*
The project will use low flush 1.28 GPF public toilets, 1.0 GPF residential toilets, 0.125 GPF urinals, 0.35 GPM public lavatory faucets, 1.0 GPM residential lavatory faucets, 1.5 GPM kitchen faucets, and 1.5 GPM showerheads, which are are calculated to achieve a reduction in water usage of approximately 40% over the baseline. All fixtures except the kitchen faucets will be WaterSense certified, and all appliances will be ENERGY STAR.

*Cooling Tower Water Use (Credit)*
The project will conduct a one-time potable water analysis, measuring Ca (as $CaCO_3$), total alkalinity, $SiO_2$, $Cl^-$, and Conductivity. The project will achieve a minimum 10 cycles by increasing the level of treatment in condenser or make-up water and will study the potential for using a minimum 20% recycled nonpotable water through rainwater capture and reuse.

*Water Metering (Credit)*
The project will install permanent water meters to monitor water use for at least two water subsystems, likely irrigation and cooling tower water use.

Energy and Atmosphere

*Fundamental Commissioning (Prerequisite)*
Commissioning of mechanical, electrical, and plumbing, in accordance with ASHRAE Guideline 0-2005 and ASHRAE Guideline 1.1–2007 is under contract and will be performed. An Owner's Project Requirements has been developed, and a Basis of Design will be developed as well.

*Minimum Energy Performance (Prerequisite)*
The energy code utilized for the Project will be the Massachusetts Energy Stretch Code and ASHRAE Standard 90.1-2010 for LEED purposes. The energy model has been developed and shows approximately 21% energy cost reductions over the LEED Baseline and 25% energy savings over the Stretch Code Baseline.

*Building-Level Energy Metering (Prerequisite)*
Building-level energy meters and submeters that can be aggregated to provide building-level data representing total building energy consumption (electricity and natural gas) will be installed. Energy consumption will be tracked and shared with the USGBC for a five-year period.

*Refrigerant Management (Prerequisite)*
No CFC-based refrigerants will be utilized for the Project.

*Enhanced Commissioning (Credit)*
An independent commissioning authority has been contracted to perform on-board design reviews, verify operator training, and review building operations ten months after occupancy in accordance with ASHRAE Guideline 0–2005 and ASHRAE Guideline 1.1–2007.

*Optimize Energy Performance (Credit)*
The energy model has been developed and shows approximately 21% energy cost reductions over the LEED Baseline.

*Enhanced Refrigerant Management (Credit)*
The project team will conduct a refrigerant impact calculation to examine the global warming potential and ozone depletion potential of refrigerants used within the project scope on the final equipment selections have been made. The project team will aim to earn this credit but has assumed this point as a 'maybe' until final calculations are completed.

*Green Power (Credit 6)*
The project will investigate the cost of purchasing renewable energy credits in the amount of 50% of the electricity and gas used in the building once construction is complete.

Materials and Resources

*Storage and Collection of Recyclables (Prerequisite)*
There will be a dedicated recycling storage area within the trash room of the building. This area will store paper, corrugated cardboard, glass, plastics and metals for pick-up by local recycling haulers. This area will also include space for the storage and disposal of two of the following: batteries, mercury-containing lamps, and electronic waste.

*Construction and Demolition Waste Management Planning (Prerequisite)*
The project team will develop and implement a construction and demolition waste management plan establishing waste diversion goals and identify at least five materials targeted for diversion. The plan will specify materials that will be separated onsite, as well as comingled waste, and note the exclusion of Alternative Daily Cover from recycled materials. A final report detailing all major waste streams generated, including disposal and diversion rates, will be provided.

*Building Product Disclosure and Optimization— Environmental Product Declarations (Credit)*
The project will specify at least 20 different products sourced from at least 5 manufacturers that either have industry-wide EPD's available. The project is targeting 40 EPD's to earn the exemplary performance point for this credit.

*Building Product Disclosure and Optimization—Sourcing of Raw Materials (Credit)*
The project will use products that have recycled content and wood that is FSC-certified for at least 25%, by cost, of the total value of permanently installed building products in the project.

*Building Product Disclosure and Optimization— Material Ingredients (Credit)*
The project will use at least 20 different permanently installed products from at least five different manufacturers that have either a manufacturer inventory, a Health Product Declaration, or Cradle to Cradle certification.

*Construction and Demolition Waste Management (Credit)*
The project team will develop and implement a construction and demolition waste management plan to maximize diversion and reuse of material and identify at least five materials targeted for diversion. The project will divert at least 75% of the total construction and demolition material, and the diverted materials will include at least four material streams.

Indoor Environmental Quality
*Minimum IAQ Performance (Prerequisite)*
The ventilation code utilized for the Project will be ASHRAE Standard 62.1-2010, as required by the present Massachusetts Building Code and LEED. The mechanical systems are designed to provide the required ventilation throughout the building.

*Environmental Tobacco Smoke Control (Prerequisite)*
Smoking is prohibited anywhere in the building and within 25 feet of main entries, operable windows, and air intakes. Signage will be posted at entrances to convey this prohibition.

*Enhanced Indoor Air Quality Strategies (Credit)*
Permanent entryway systems will be provided at least 10 feet long in the primary direction of travel at all regularly used exterior entrances. Spaces where hazardous gases or chemicals may be present will be exhausted at a minimum of 0.50 cfm per square foot to create negative pressure with respect to adjacent spaces when the doors to the room are closed. For each of these spaces, self-closing doors and deck-to-deck partitions will b provided. All ventilation systems will be provided with MERV 13 filters. Carbon dioxide will be monitored in all densely occupied spaces. CO2 monitors will have an audible or visual indicator or alert the building automation system if the sensed CO2 concentration exceeds the setpoint by more than 10%.

*Low-Emitting Materials (Credit)*
Flooring, paints and coatings, adhesives and sealants, and insulation will be in compliance with the CDPH Standard Method v1.1-2010 emissions testing. Paints, coatings, adhesives, and sealants will be specified to meet the low-VOC content limits as prescribed by the respective applicable standards.

*Construction IAQ Management Plan (Credit)*
An Indoor Air Quality Management plans will be implemented during the construction phase in accordance with the SMACNA Indoor Air Quality for Buildings under Construction Guideline. Absorptive materials will be protected from moisture damage. Permanently installed air handling units will most likely not be operated, but if they are, MERV 8 filters will be used and the filtration media changed prior to occupancy.

*Indoor Air Quality Assessment (Credit)*
The project team will determine whether to do a whole building flush-out or air quality testing in accordance with the LEED guidelines once construction has started.

*Thermal Comfort (Credit)*
The HVAC system has been designed to meet ASHRAE 55-2010. Additionally, all apartments will have a thermal control and at least 50% of all individual occupant spaces (offices, reception desk, etc.) will have a thermal control. All multi-occupant spaces, such as conference rooms and amenity spaces, will have a thermal control.

*Lighting Controls (Credit)*
All bedrooms and kitchen/living rooms will have a lighting control. All individual occupant spaces will have a task light that has three levels of lighting. All multi-occupant spaces will have controls allowing three levels of lighting. The project team will aim to earn this credit but has assumed this point as a ‘maybe’ until final calculations are completed.

*Quality Views (Credit)*
At least 75% of all regularly occupied spaces will have a direct line of sight to the outdoors. View glazing in the contributing area will provide a clear image of the exterior, not obstructed by frits, fibers, patterned glazing, or added tints that distort color balance.

Additionally, 75% of all regularly occupied floor area will have views with a view factor of 3 or greater and views that include at least two of the following: flora, fauna, or sky; movement; and objects at least 25 feet from the exterior of the glazing.

*Innovation in Design*
The team will be pursuing two exemplary performance points for Heat Island Reduction and for Building Product Disclosure and Optimization - Environmental Product Declarations. The team will also be pursuing three innovation credits: Low Mercury in Lamps through all LED lighting, O&M Starter Kit though an Integrated Pest Management Plan and a Green Cleaning Policy, and Community Outreach and Development through community engagement.

*Regional Priority*
The project expects to earn one regional priority point. Two additional regional priority points may potentially be earned.

**LEED for New Construction v4 Summary: 60 'yes' points and 10 'maybe' points.**

**LEED v4 for BD+C: New Construction and Major Renovation**
Project Checklist - DSPR Submission

**UNION SQUARE, SOMERVILLE D2.2/D2.3**
02.07.2018

GOAL: **GOLD**

| Y | ? | N | | | | | |
|---|---|---|---|---|---|---|---|
| Y | | | Pif 1 | Project Information Forms | | | - Assumed 21 FTE and 85 visitors for retail. |
| 1 | | | Credit 1 | Integrative Process | 1 | RW Sullivan | - Pre-design through design - identify opportunities to achieve synergies across disciplines and building systems.<br>- Do prelim simple box energy model AND prelim water budget.<br>- Document how energy model and water budget affected design.<br>- GHG assessments should help with this. |

| 14 | 0 | 2 | | **Location and Transportation** | Possible Points: | 16 | Responsible | Strategy/Notes/Status |
|---|---|---|---|---|---|---|---|---|
| 0 | | | Credit 1 | LEED for Neighborhood Development Location | | 16 | dbHMS | - Not in a LEED ND. |
| 1 | | | Credit 2 | Sensitive Land Protection | | 1 | dbHMS | - Locate on land that has been previously developed.<br>- Meets Option 1. |
| 2 | | | Credit 3 | High Priority Site | | 2 | dbHMS / Ownership | - 2018 SADDA<br>- There will be remediation.<br>- Assessment and NFR letter required. |
| 4 | | 1 | Credit 4 | Surrounding Density and Diverse Uses | | 5 | dbHMS | - Rough estimates showing that we meet the density requirement.<br>- Within 1/2 mi of diverse uses: Bronwyn, Ebi Sushi, the Museum, Reliable Market, Market Basket, Foursquare Chirch, St. Joseph's Church, Grace Salon, Citizens Bank, Belly Dance Somerville, Union Squyare Farmers Market, Community Laundry, East Boston Savings Bank, Third LIfe Studio, Loyal Supply, Somerville Fire Department (16+). |
| 5 | | | Credit 5 | Access to Quality Transit | | 5 | dbHMS | - Buses: CT2, 85, 86, 87 = weekday 198, 91 weekend.<br>- Greenline extension completion 12/2021. Should be within 24 months of occupancy of D2.2/2.3. |
| | | 1 | Credit 6 | Bicycle Facilities | | 1 | bKL | - Bicycle network AND bike spots for 5% of FTE (long term), 2.5% of peak visitors (short term), and 30% of all residents.<br>- 1 shower per 100 FTE + 1 per every 150+.<br>- Dedicated bike lane to 10 diverse uses.<br>- Public bike room must be within 100 ft of *any* main entry. Residential bike storage must be within 100 ft of *any* functional entry.<br>- Bike spots - 242 for residents, 4 for FTE, 4 for retail visitors and MBTA.<br>- Can't earn because of locations of bike rooms. |
| 1 | | | Credit 7 | Reduced Parking Footprint | | 1 | bKL | - Do not exceed code parking required, reduce parking spaces by 40% from Baseline, AND 5% preferred parking for carpools.<br>- Baseline 1.5/DU for first bedroom plus 0.25 space for each additional bedroom.<br>- 290 preferred parking stalls - 15 preferred required for carpools on drawings.<br>- 358 spots Baseline > 290 spots current - Okay. |
| 1 | | | Credit 8 | Green Vehicles | | 1 | bKL | - 5% preferred parking LEV/FEV AND 2% electric vehicle charging.<br>- 290 parking spaces - 15 preferred spots for LEV/FEV required on drawings.<br>- 10 charging stations shown - 6 required. |

| 5 | 0 | 5 | | **Sustainable Sites** | Possible Points: | 10 | Responsible | Strategy/Notes/Status |
|---|---|---|---|---|---|---|---|---|
| Y | | | Prereq 1 | Construction Activity Pollution Prevention | | Required | GC | - ESC plan. |
| 1 | | | Credit 1 | Site Assessment | | 1 | bKL / Ground / Civil | - Conduct full site assessment: Topology, Hydrology, Climate, Vegetation, Soils, Human Use, and Human Health Effects. |
| | | 2 | Credit 2 | Site Development--Protect or Restore Habitat | | 2 | Ground | - Restore 30% of site using native/adapted plantings and appropriate restored soil OR $0.40 per sf financial support.<br>- Green roof on amenity deck. High and low roofs don't have enough space for green roof and all the mech equipment.<br>- Soil restoration required.<br>- Not enough area. |
| 1 | | | Credit 3 | Open Space | | 1 | Ground | - 30% accessible open space (vegetated and ped-oriented) AND 25% of the 30% vegetated (not turf).<br>- Amenity deck area qualifies if meets FAR ratio.<br>- All native/adapted - not turf. Grey area is D2.4 lot. |
| | | 3 | Credit 4 | Rainwater Management | | 3 | Civil | - Must manage 100% of 95th-percentile rainfall event using low impact developments and green infrastructure.<br>- Infiltration, evapotranspiration, capture, and reuse.<br>- Porous paving, bioretention, rain garden, pervious decking, etc. |
| 2 | | | Credit 5 | Heat Island Reduction | | 2 | Ground / bKL | - Site + Roof SRI requirements (2 pts) OR 75% parking under cover (1pt).<br>- Paving 3-yr SR = 0.28, Roof 3-yr SRI 68.<br>- 100% parking under cover.<br>- EP for meeting both options.<br>- Outdoor amenity deck paving and new paving at ground level must have a three-year aged SR of at least 0.28 or initial SR of 0.33. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | | | Credit 6 | Light Pollution Reduction | | 1 | RW Sullivan | - BUG method for LZ3.<br>-- Uplight U3 max.<br>-- Backlight likely B1 or maybe B3 max depending on mounting ht.<br>-- Glare G0 depending on mounting ht.<br>- Design lighting to meet this criteria. |
| 7 | 2 | 2 | **Water Efficiency** | | Possible Points: | 11 | Responsible | Strategy/Notes/Status |
| Y | | | Prereq 1 | Outdoor Water Use Reduction | | Required | Ground | - Reduce outdoor potable water use by 30% through use of native/adapted plants and irrgation efficiency.<br>- Drip irrigation and smart controllers. |
| Y | | | Prereq 2 | Indoor Water Use Reduction | | Required | RW Sullivan | - Reduct indoor potable water use by 20%.<br>- Fixtures must be WaterSense, appliances must be ENERGY STAR, AND additional requirements for cooling towers and evap condensors.<br>Suggested fixtures rates:<br>-- WC public - 1.28 gpf<br>-- WC private - 1.1 gpf<br>-- Lav public - 0.35 gpm<br>-- Lav private - 1.0 gpm<br>-- Kitchen faucet public and private - 1.5 gpm<br>-- Shower public and private - 1.5 gpm |
| Y | | | Prereq 3 | Building-Level Water Metering | | Required | RW Sullivan | - Meter total potable water usage for building and grounds. Manual or BAS.<br>- Share data with USGBC for 5 years. Portfolio Manager account to be set up. |
| 1 | 1 | | Credit 1 | Outdoor Water Use Reduction | | 2 | Ground | - Drip irrigation and smart controllers.<br>- Planning on doing rainwater harvesting for irrigation. |
| 3 | 1 | 2 | Credit 2 | Indoor Water Use Reduction | | 6 | RW Sullivan | - ~40% with 1.1 gpf toilets and 1.5 gpm showers.<br>1.9.19: Currently showing 37% with 1.8 gpm kitchen faucets and 0.5 gpm public lav faucets. |
| 2 | | | Credit 3 | Cooling Tower Water Use | | 2 | RW Sullivan | - Potable water analysis AND limit cooling tower cycles. |
| 1 | | | Credit 4 | Water Metering | | 1 | RW Sullivan | - Additional water metering for 2+ subsystems: Irrigation, indoor plumbing, DHW, Boiler, Other process water.<br>- Manual or BAS. |
| 13 | 4 | 16 | **Energy and Atmosphere** | | Possible Points: | 33 | Responsible | Strategy/Notes/Status |
| Y | | | Prereq 1 | Fundamental Commissioning and Verification | | Required | dbHMS | - Commission MEP systems, review BOD and OPR (including envelope requirements), develop Cx Plan, CD drawing review, Systems Manual, Cx Final Report.<br>- CxA and BECx required on board by 50% CD. |
| Y | | | Prereq 2 | Minimum Energy Performance | | Required | RW Sullivan | - Demonstrate 5% improvement compared with ASHRAE 90.1-2010 Baseline. |
| Y | | | Prereq 3 | Building-Level Energy Metering | | Required | RW Sullivan | - Building-level energy metering (electricity, natural gas, chilled water, etc.).<br>- Share data with USGBC for 5 years. |
| Y | | | Prereq 4 | Fundamental Refrigerant Management | | Required | RW Sullivan | - No CFCs. |
| 4 | | 2 | Credit 1 | Enhanced Commissioning | | 6 | dbHMS | - Suggest yes to Enhanced and Monitoring-based Cx.<br>-- ECx - Submittal review, 10 month site visit.<br>-- Monitoring plan and calibrated energy model.<br>- 1.9.19: No on BECx; maybe on MBCx.<br>- 2.5.19: Yes on MBCx (call with Patrick and Christopher) |
| 9 | 1 | 8 | Credit 2 | Optimize Energy Performance | | 18 | RW Sullivan | - Stretch code required 10% energy savings over ASHRAE 90.1-2013.<br>- 12.3.18: DD Energy Model 24.2%. |
| | | 1 | Credit 3 | Advanced Energy Metering | | 1 | RW Sullivan | - Meter all end-uses that represent 10% or more of total energy consumption.<br>- Automatic data collection (not manual).<br>- Not doable for residential per RW Sullivan. |
| | | 2 | Credit 4 | Demand Response | | 2 | N/A | - Infrastructure, commissioning of infrastructure, and 1-year contract. |
| | | 3 | Credit 5 | Renewable Energy Production | | 3 | N/A | - Ex. PV. |
| | 1 | | Credit 6 | Enhanced Refrigerant Management | | 1 | RW Sullivan | - Depends on mechanical system chosen and final calculations. |
| | 2 | | Credit 7 | Green Power and Carbon Offsets | | 2 | Ownership | - Green power or carbon offsets for 50-100% of electricity and gas usage. |
| 5 | 0 | 8 | **Materials and Resources** | | Possible Points: | 13 | Responsible | Strategy/Notes/Status |
| Y | | | Prereq 1 | Storage and Collection of Recyclables | | Required | bKL | - Dedicated area for recycling storage and collection. |
| Y | | | Prereq 2 | Construction and Demolition Waste Management Planning | | Required | GC | - Construction waste management plan that targets at least five materials. |
| | | 5 | Credit 1 | Building Life-Cycle Impact Reduction | | 5 | N/A | - Life-cycle assessment demonstrating 10% reduction from a baseline building. |
| 1 | | 1 | Credit 2 | Building Product Disclosure and Optimization - Environmental Product Declarations | | 2 | bKL / GC | - Use 20 products from 5 manufacturers with an EPD. Target 40 EPDs for EP point.<br>- Use third party certified products that demonstrate impact reduction below industry average for 50% by cost of all installed products. |
| 1 | | 1 | Credit 3 | Building Product Disclosure and Optimization - Sourcing of Raw Materials | | 2 | bKL / GC | - Use at least 20 different permanently installed products from at least five different manufacturers that have publicly released a report from their raw material suppliers (eco-friendly extraction).<br>- Recycled content and FSC wood for 25% of total cost of installed building products.<br>-- Structure/enclosure materials no more than 30%.<br>-- Regional (within 100 mi) counts for double. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | | 1 | Credit 4 | Building Product Disclosure and Optimization - Material Ingredients | | 2 | bKL / GC | - Use 20 products from 5 manufacturers with HPD or Cradle to Cradle (1 pt).<br>- Use products for 25% by cost that document material ingredient optimization through GreenScreen v1.2 Benchmark or Cradle to Cradle (1 pt). |
| 2 | | | Credit 5 | Construction and Demolition Waste Management | | 2 | GC | - Divert 75% of construction waste (a min of 4 waste streams).<br>- Does not include ADC. |

| 7 | 3 | 6 | **Indoor Environmental Quality** | Possible Points: | 16 | Responsible | Strategy/Notes/Status |
|---|---|---|---|---|---|---|---|
| Y | | | Prereq 1 | Minimum Indoor Air Quality Performance | Required | RW Sullivan | - Meet ASHRAE 62.1-2010.<br>- Kitchen exhaust and direct ventilation in residential units, ventilation in corridors, and exhaust in janitors closets.<br>- Airflow monitoring stations on all ventilation systems. |
| Y | | | Prereq 2 | Environmental Tobacco Smoke Control | Required | bKL | - Prohibit smoking in building and within 25 ft of entrances.<br>- Post signage at all entrances. |
| 2 | | | Credit 1 | Enhanced Indoor Air Quality Strategies | 2 | RW Sullivan | - Entryway systems, exhaust hazardous chemical/gas areas, MERV 13 filters on all ventilation systems (1 pt).<br>- CO2 monitors in all densely occupied spaces (1 pt). |
| 2 | | 1 | Credit 2 | Low-Emitting Materials | 3 | bKL / GC | - CDPH Standard Method v1.1-2010 emissions testing required in addition to other material specific requirements.<br>- Flooring, Paints, adhesives/sealants, insulation (ceiling, walls, etc.) (1 pt).<br>- Other options: Composite wood, furniture |
| 1 | | | Credit 3 | Construction Indoor Air Quality Management Plan | 1 | GC | - Construction Indoor Air Quality Plan per SMACNA guidelines AND protect absorptive materials AND MERV 8 filters on AHUs used during construction. |
| | 2 | | Credit 4 | Indoor Air Quality Assessment | 2 | GC | - Building flush-out (1 pt).<br>- Air quality testing (2 pts). |
| 1 | | | Credit 5 | Thermal Comfort | 1 | RW Sullivan | - Meet ASHRAE 55-2010 and 50% individual and 100% multi-occupant thermal controls.<br>- Plug in fans acceptable as controls for v4. |
| | 1 | 1 | Credit 6 | Interior Lighting | 2 | RW Sullivan / Lighting | - 90% Individual and 100% multi-occupant lighting controls - each with three levels of control (1 pt).<br>- Lighting quality design (1 pt) - CRI of 80+, surface reflectance, surface illuminance, ceiling illuminance, rated life of 24,000 hours, luminance requirements.<br>- Occ sensors are not okay.<br>- Three levels of control - on/off/midlevel. |
| | | 3 | Credit 7 | Daylight | 3 | N/A | - Daylight simulation.<br>- Likely have too much daylight. |
| 1 | | | Credit 8 | Quality Views | 1 | dbHMS | - 75% of regularly occupied area must have quality views: Objects further than 25 ft, flora/fauna, movement. |
| | | 1 | Credit 9 | Acoustic Performance | 1 | Acoustics Consultant | - Meet requirements for HVAC background noise, sound isolation, reverb time, and sound masking.<br>- Acoustics consultant to confirm. |

| 6 | 0 | 0 | **Innovation** | Possible Points: | 6 | Responsible | Strategy/Notes/Status |
|---|---|---|---|---|---|---|---|
| 1 | | | Credit 1.1 | Innovation: Low Mercury in Lamps | 5 | RW Sullivan | - 35 picgrams/lumen-hr max.<br>- All LED - in unit as well. |
| 1 | | | Credit 1.2 | Innovation: EP for Heat Island Reduction | 5 | dbHMS | - Meet both paths. |
| 1 | | | Credit 1.3 | Innovation: Green Education OR O&M Starter Kit | 5 | bKL | - Two of the following options:<br>-- Comprehensive signage program built into the building's spaces to educate the occupants and visitors of the benefits of green buildings<br>-- A manual, guideline, or case study to inform the design of other buildings based on the successes of this project<br>-- An educational outreach program or guided tour could be developed to focus on sustainable living, using the project as an example.<br>OR - Integrated Pest Management Policy and Green Cleaning Policy |
| 1 | | | Credit 1.4 | Innovation: Community Outreach and Engagement | 5 | Ownership | - Engage the community: Predesign (meet with local neighbors), preliminary design (1+ community meeting), modify design based on prelim meeting, ongoing communication between developer and community throughout design and construction). |
| 1 | | | Credit 1.5 | Innovation: 40 EPDs | 5 | bKL / GC | - Use 40 products from 5 manufacturers with an EPD |
| 1 | | | Credit 2 | LEED Accredited Professional | 1 | dbHMS | LEED AP BD+C (dbHMS) |

| 2 | 1 | 1 | **Regional Priority** | Possible Points: | 4 | Strategy/Notes/Status |
|---|---|---|---|---|---|---|
| 1 | | | Credit 1 | Regional Priority: Indoor Water Reduction (4 pts) | 1 | - Alternatives: Rainwater Management (2 pts) |
| 1 | | | Credit 2 | Regional Priority: High Priority Site (2 pts) | 1 | |
| | | 1 | Credit 3 | Regional Priority: Renewable Energy Production (2 pts) | 1 | |
| | 1 | | Credit 4 | Regional Priority: Optimize Energy Performance (8 pts) | 1 | |

| 60 | 10 | 40 | **Total** | Possible Points: | 110 |
|---|---|---|---|---|---|

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

# SHADOW STUDY

## SHADOW STUDY

### Existing and Net New Shadows (March, 21)


9AM


12PM


3PM

SCALE 1"=200'-0"

## SHADOW STUDY

### Existing and Net New Shadows (June, 21)


9AM


12PM


3PM


6PM

SCALE 1"=200'-0"

## SHADOW STUDY

### Existing and Net New Shadows (September, 21)


9AM


12PM


3PM


6PM

SCALE 1"=200'-0"

## SHADOW STUDY

### Existing and Net New Shadows (December, 21)


9AM


12PM


3PM

SCALE 1"=200'-0"

## SHADOW STUDY

### Cumulative New Shadows


March, 21


June, 21


September, 21


December, 21

SCALE 1"=200'-0"

# PEDESTRIAN LEVEL WIND ANALYSIS

# PRELIMINARY RESULTS

# UNION SQUARE

SOMERVILLE, MA

PEDESTRIAN WIND STUDY
RWDI #1802485
February 8, 2019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# SUMMARY

The following document provides the preliminary results for the Pedestrian Wind Study conducted for the proposed Building D2.1 and Building D2.2/2.3 of the Union Square development located in Massachusetts. The project site overlaid with wind statistics recorded at Boston Logan International Airport (**Images 1.1 through 1.5**) as well as photographs of the wind tunnel study model (**Image 2a through 2d**) are shown below. The City of Somerville Wind Suitability Criteria, which deals with both pedestrian safety and comfort as they relate to wind force, is also included in the report in order to assist with the interpretation of the results presented.

The predicted wind comfort and safety conditions pertaining to the four site and surrounding configurations assessed are graphically depicted on a site plan in **Figures 1a through 3d**. These conditions and the associated wind speeds are presented in **Tables 1 and 2**. These results are presented in the attached results package and can be summarized as follows:

- All tested locations are anticipated to meet the effective gust criterion in the No Build configuration. Exceedance of the effective gust criterion, based on the annual climate, is expected at seven locations for the Build configuration. Introducing proposed mitigating elements reduces this count to three, with the addition of future developments eliminating these to result in no exceedances of the effective gust criterion.
- Wind speeds on the site are expected to be low under the No Build configuration.
- In the Build configuration, the proposed building is predicted to increase wind speeds around it. Uncomfortable wind conditions are expected to occur around the south side of the project site, as well as one isolated area at the north corner of Building D2.1. The introduction of mitigating elements reduces these conditions by half, with the addition of future developments further limiting impacts on the D2.1, D2.2/2.3 sites. Most other areas are anticipated to be suitable for walking or better.
- With the addition of the future buildings, in the Full Build configuration, wind speeds are predicted to decrease at several areas located west through north-east of Building D2.1. However, an increase in wind speeds is predicated south of Building D2.3, including a few areas along Webster Avenue.

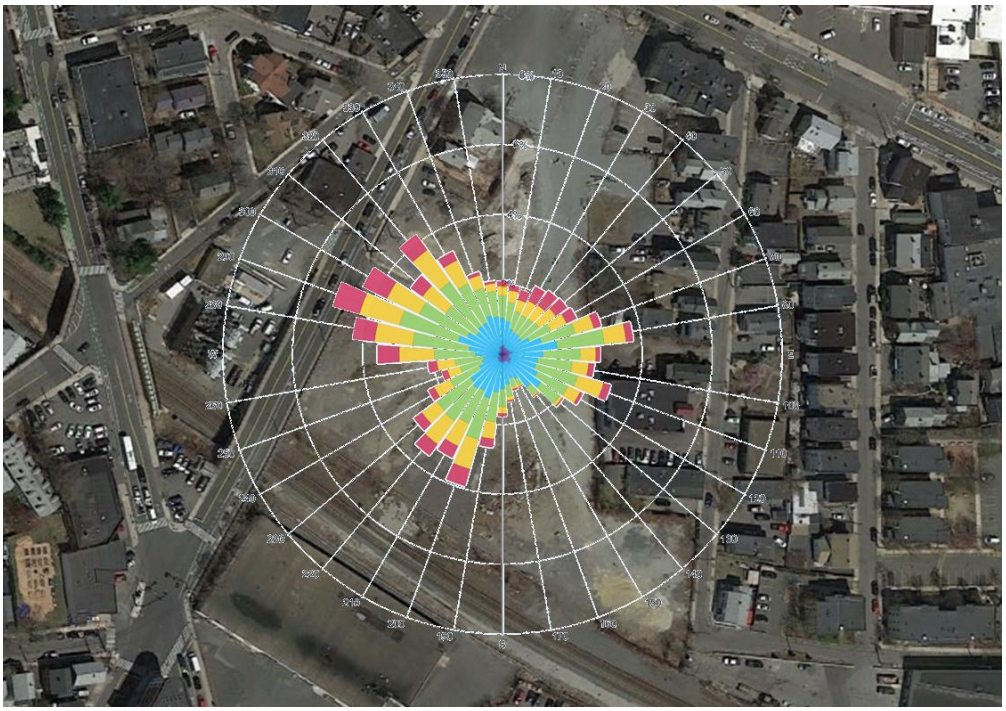
RWDI worked with the design team to review results and develop mitigating strategies coordinating with pedestrian usage at specific locations. Additional commentary regarding background on wind flow patterns, wind comfort levels, and any further recommendations for wind control measures to help moderate wind activity in areas of high wind activity will be presented within the final report. Prior to issuing the report, we suggest that we have a teleconference to go over the results and discuss the types, locations and feasibilities of possible wind control measures.

# Meteorological Data

Long-term meteorological data, recorded during the years 1995 through 2017 at Boston's Logan International Airport were used to predict full scale wind conditions. The analysis was performed separately for each of the four seasons and for the entire year. **Images 1.1 through 1.5** present "wind roses" overlaid on the Project site, summarizing the seasonal and annual wind climates in the Somerville area respectively, based on the data from Logan Airport.

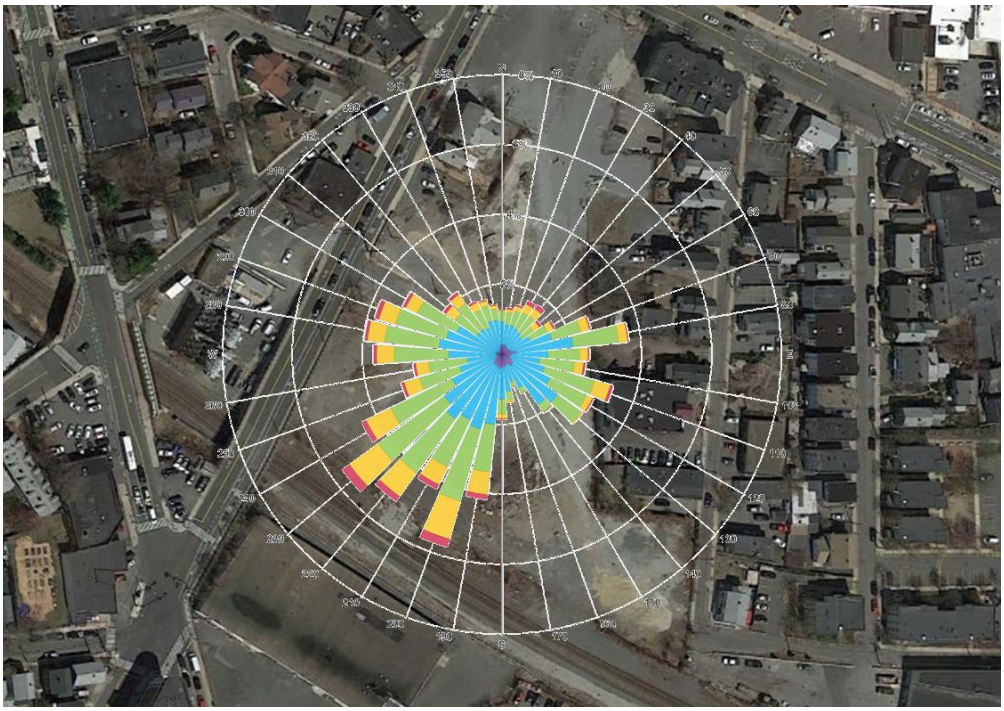
For example, **Image 1.1** summarizes the spring (March, April, and May) wind data which in general, indicate prevailing winds occurring from the northwest to south-southwest and northeast to east-southeast and strong winds (red bands), primarily occurring from the west-northwest, northwest, south-southwest and west directions.

On an annual basis, as shown in **Image 1.5**, 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 and west are the dominant wind directions.



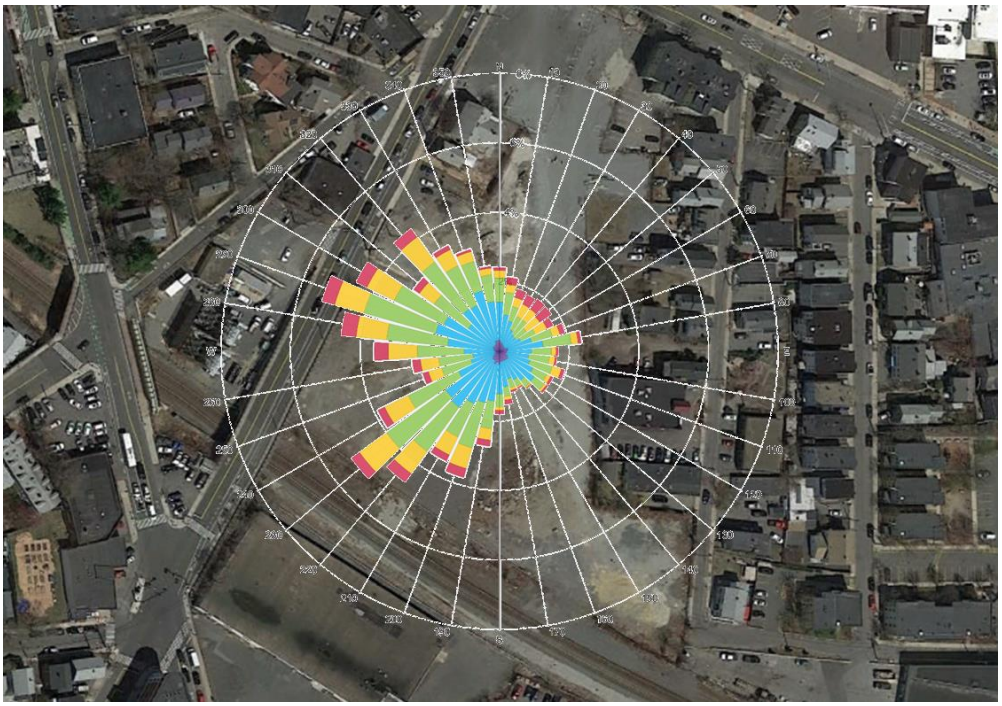
| Wind Speed (mph) | Probability (%) |
|---|---|
| Calm | 2.8 |
| 1-5 | 6.8 |
| 6-10 | 28.9 |
| 11-15 | 32.5 |
| 16-20 | 19.1 |
| >20 | 10.0 |

**Image 1.1: Spring (March-May)**



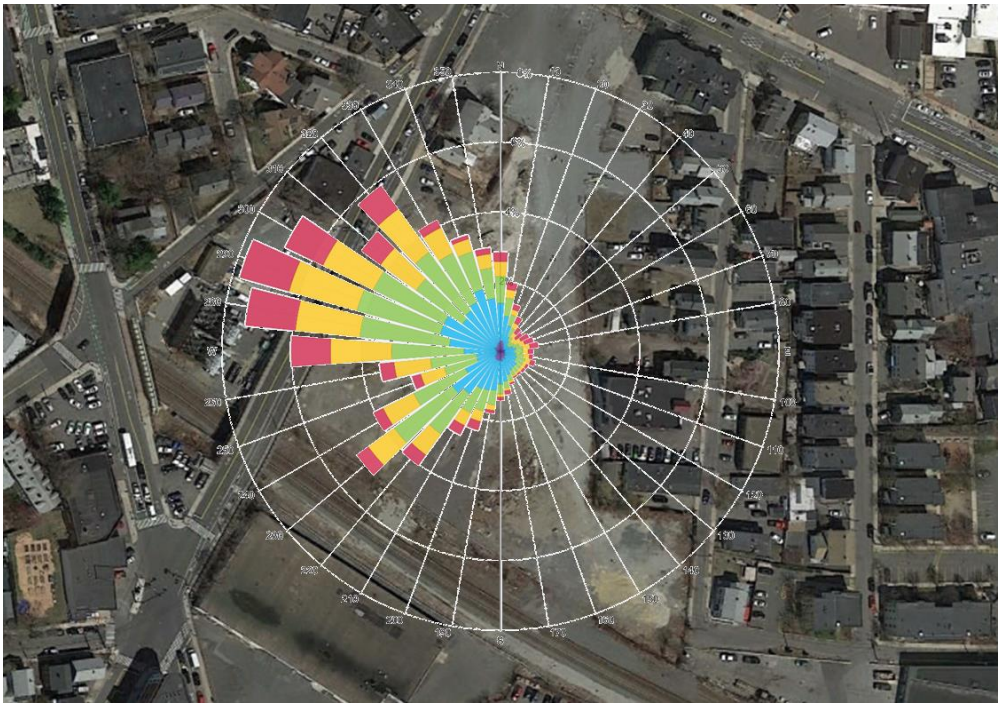
| Wind Speed (mph) | Probability (%) |
|---|---|
| Calm | 3.1 |
| 1-5 | 9.5 |
| 6-10 | 38.7 |
| 11-15 | 34.4 |
| 16-20 | 11.8 |
| >20 | 2.6 |

**Image 1.2: Summer (June-August)**



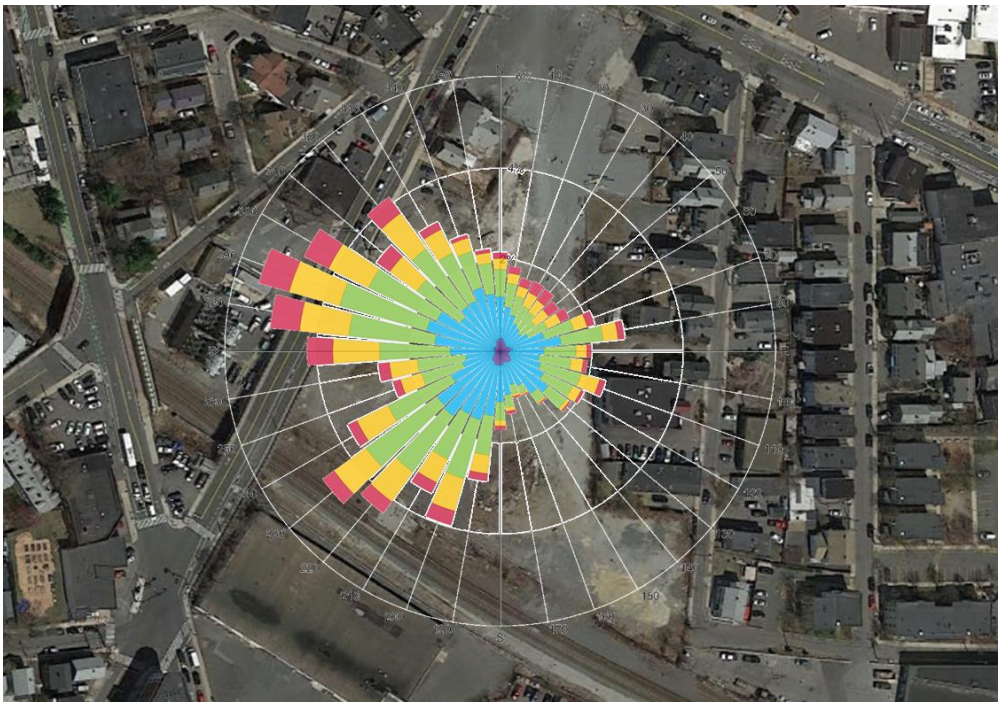
| Wind Speed (mph) | Probability (%) |
|---|---|
| Calm | 3.4 |
| 1-5 | 8.7 |
| 6-10 | 34.5 |
| 11-15 | 32.0 |
| 16-20 | 14.6 |
| >20 | 6.8 |

**Image 1.3: Fall (September- November)**



| Wind Speed (mph) | Probability (%) |
|---|---|
| Calm | 2.6 |
| 1-5 | 6.5 |
| 6-10 | 27.9 |
| 11-15 | 30.8 |
| 16-20 | 19.7 |
| >20 | 12.4 |

**Image 1.4: Winter (December-February)**



| Wind Speed (mph) | Probability (%) |
|---|---|
| Calm | 3.0 |
| 1-5 | 7.9 |
| 6-10 | 32.5 |
| 11-15 | 32.4 |
| 16-20 | 16.3 |
| >20 | 7.9 |

**Image 1.5: Annual**

**Image 2a: Wind tunnel study model – No build**

**Image 2b: Wind tunnel study model – Build**

**Image 2c: Wind tunnel study model – Build with trees**


**Image 2d: Wind tunnel study model – Full Build**

# FIGURES

# SOLAR GLARE ANALYSIS

REPORT

# UNION SQUARE DEVELOPMENT BUILDINGS D2.2 AND D2.3

## DETAILED SOLAR REFLECTION ANALYSIS

OCTOBER 2, 2018
PROJECT #: 1802485


**SUBMITTED TO**
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# EXECUTIVE SUMMARY

RWDI was retained to investigate the impact that solar reflections emanating from buildings D2.2 and D2.3 of the proposed Union Square development will have on the surrounding urban realm.

**Thermal Impacts on People**

The planar nature of the facades of the proposed buildings ensure that reflected sunlight will not focus (multiply) in any particular area. Therefore, RWDI does not expect any significant thermal impacts (i.e. risks to human safety or property damage) to occur either on the site or in the surrounding neighborhood.

**Thermal Impact on Facades**

At all studied facade areas, reflections are of low intensity and short duration. Hence, we would not expect these reflections to lead to a significant additional cooling load for a building. Should an individual choose to expose themselves to the reflected energy, they may feel warm, however this would be a temporary experience and one which would easily be remedied by closing window treatments.

**Visual Glare Impact on Drivers**

Train drivers travelling westbound to the south of the buildings are predicted to experience reflections from the buildings which can cause a high level of impact. However, the potential for high impacts is possible in less than 0.1% of the daytime. For the remainder of the drivers travelling in the neighborhood visual glare impacts are predicted to be moderate at worst.

**Visual Glare Impact on Pedestrians and Facades**

Typical levels of visual glare are possible for pedestrians and building occupants in the vicinity of the development. Some of these reflections are frequent and relatively long in duration. That said, these types of reflections represent at worst a visual nuisance, as viewers can safely look away or close blinds. Pedestrians on the rooftop of the future building D2.2 may also experience frequent reflections with moderate impacts. While not posing any risk to safety, the reflections may be a nuisance for people in these areas, making mitigation advisable if these spaces are to be used as amenity areas.

**Overall Impact of Reflections**

The impacts of buildings D2.2 and D2.3 on their surrounds are typical of any modern building of this size. However, we note that detailed facade material properties were not available. The results and conclusions presented herein may not be valid if the ultimately selected glazing and metal types are significantly more reflective than the typical values assumed by RWDI. Refer to the Assumptions and Limitations section for details.

If mitigation is desired, we have provided several strategies to minimize the reflection impacts noted herein. For further details, refer to the Mitigation Suggestions section.

# TABLE OF CONTENTS

# INTRODUCTION

This report provides the computer modeling results of reflected sunlight from buildings D2.2 and D2.3 of the proposed Union Square Development in Somerville, MA. The D2.2 and D2.3 buildings are part of a larger project that will encompass multiple blocks in the Union Square area as shown in Figure 1. It is our understanding that the development will be surrounded by typical urban spaces such as busy roadways, and other buildings.

RWDI was retained to investigate the impact that solar reflections emanating from the proposed buildings will have on the surrounding urban terrain.

A preliminary set of simulations was conducted to determine peak reflection intensities and the frequency of occurrence of reflections for a broad area around the buildings. This served to identify areas which may experience high intensity or very frequent reflections. This information informed the selection of 20 points for a more detailed analysis.

These receptor points represent drivers, pedestrians, and building facades and the detailed results allow us to quantify the frequency, intensity and duration of glare events at the receptors as well as the sources of those reflections.

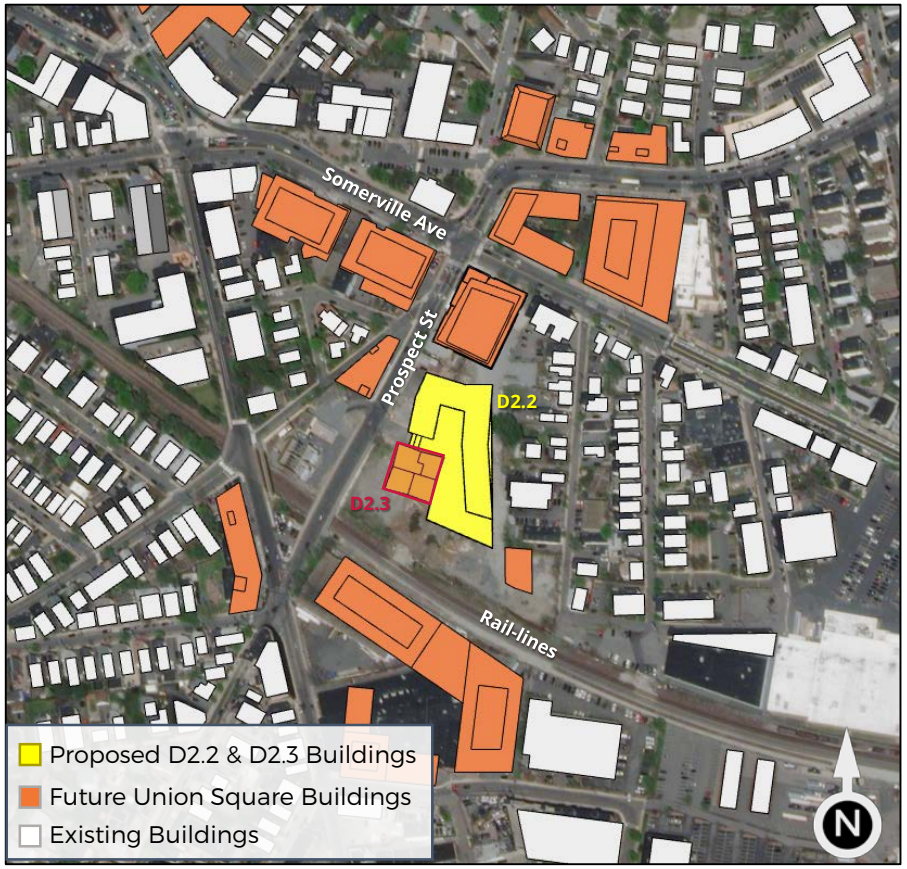



**Figure 1: Location of the Proposed Development**

## Urban Reflections

While a common occurrence, solar reflections from buildings can lead to numerous visual and thermal issues.

**Visual glare** can:

- Impair the vision of motorists and others who cannot easily look away from the source;
- Cause nuisance to pedestrians or occupants of nearby buildings; and,
- Create undesirable patterns of light throughout the urban fabric.

**Heat gain** can:

- Affect human thermal comfort;
- Be a safety concern for people and materials, particularly if multiple reflections are focused in the same area; and
- Create increased cooling needs in conditioned spaces affected by the reflections.

The most significant safety concerns with solar reflections occur with concave facades (Figure 2) which act to focus the reflected light in a single area. RWDI does not expect this to be a concern given the form of the buildings.

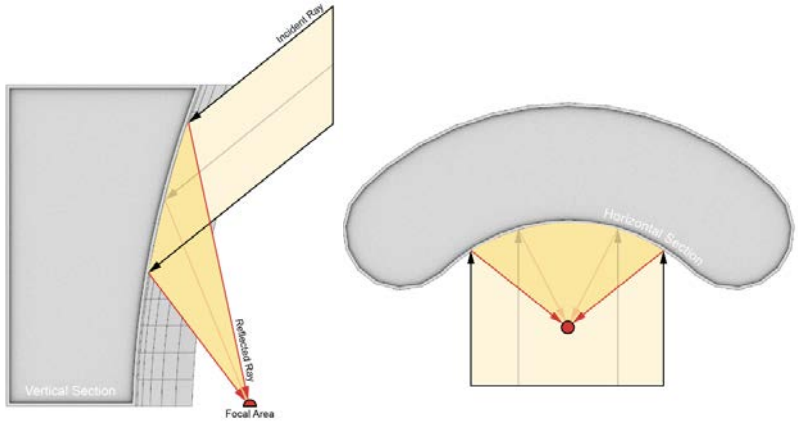



**Figure 2: Illustration of Reflection Focusing Due to a Concave Facade**

## Methodology

RWDI assessed the potential reflection issues using RWDI's in-house proprietary *Eclipse* software, in two phases as per the steps outlined below:

- The Phase 1 "Screening" assessment began with the development of a 3D model of the area of interest (as shown in Figure 3). This was then subdivided into many smaller triangular patches (see Figure 4).
- For each hour in a year, the expected solar position was determined, and "virtual rays" were drawn from the sun to each triangular patch of the 3D model. Each ray that was considered to be "unobstructed" was reflected from the building surface and tracked through the surrounding area. The study domain included the entire pedestrian realm within 1000 feet of the proposed buildings.
- The total reflected energy at that hour from all of the patches was computed and its potential for visual and thermal impacts was assessed.
- Finally, a statistical analysis was performed to assess the frequency and intensity of the glare events occurring throughout the year within the nearby airspace. The criteria used to assess the level of impact can be found in Appendix B of this report.

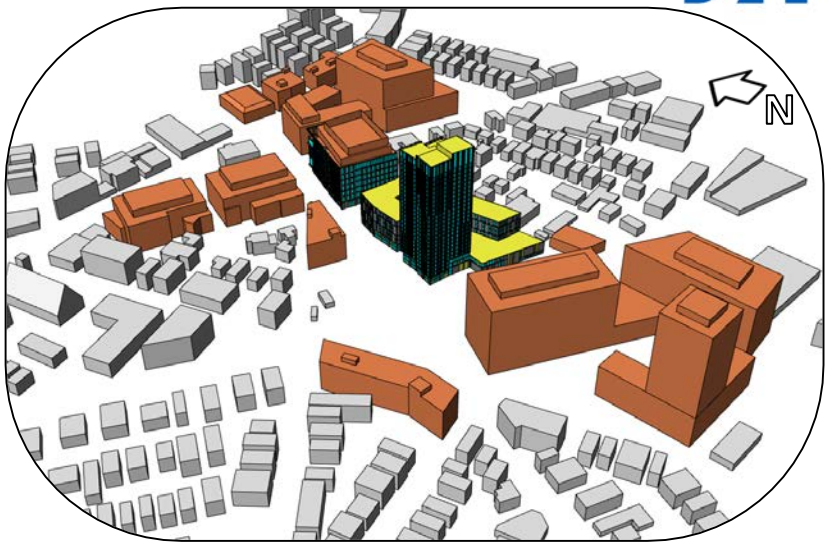



**Figure 3: 3D Computer Model of the Proposed Development and Surrounding Context**

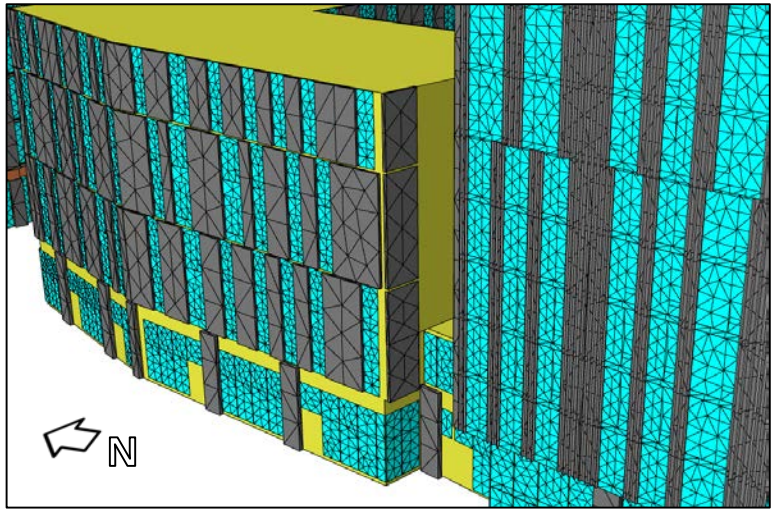



**Figure 4: Close-up View of the Model, Showing Surface Subdivisions**

## Methodology (cont'd)

- Based on the findings of the Screening analysis, representative 'receptor points' were selected to undergo the more detailed, Phase 2 analysis.

- The points were chosen to understand in greater detail how reflections from the buildings will impact drivers, pedestrians and other buildings. These points are discussed further in the Detailed Analysis sections in this report.

- The Detailed analysis process is similar in the detailed phase of work, except reflections are analyzed at 1 minute increments for the entire year.

- In addition to the frequency and duration of reflection impacts, the Detailed analysis allows for the prediction of when those impacts will occur, how long they occur for and which building element is the cause.

## Assumptions and Limitations

### Meteorological Data

This analysis used 'clear sky' solar data computed at the location of Logan International Airport. This approach uses mathematical algorithms to derive solar intensity values for a given location, ignoring local effects such as cloud cover. This provides a 'worst case' scenario showing the full extent of when and where glare could ever occur.

### Radiation Model

RWDI's analysis is only applicable to the thermal and visual impacts of solar radiation (i.e. ultraviolet, visible and infrared wavelengths) on people and property in the vicinity of the development. It does not consider the impact of the buildings related to any other forms of radiation, such as cellular telephone signals, RADAR arrays, etc.

### Study Buildings and Surrounds Models

The analysis was conducted based on the geometry provided by Howeler + Yoon Architecture on August 22, 2018 and September 11, 2018. The exceptions to this are buildings D2.4, D7.1 and D7.2 which did not have 3D models available at the time of this study. The geometry of these buildings was estimated from site plans, renderings and other documents. Given the height of these buildings and their distance from the D2.2 and D2.3 developments, we do not expect minor changes to the form of these buildings to significantly alter the findings of this report.

The surroundings model was developed based on data made available by the City of Boston and included all buildings which currently exist, are under construction or approved for construction by the BPDA. The ground surface and the surrounding buildings were topographically corrected based on a high-resolution LiDAR survey conducted by the National Oceanic and Atmospheric Administration (NOAA) in 2013-2014. According to NOAA, the horizontal accuracy of this data set is stated as 16.5 inches at a 95% confidence level. Its vertical accuracy is stated as 4.8 inches at a 95% confidence level.

Potential reductions of solar reflections due to the presence of Vegetation or other non-architectural obstructions were not included, nor are reflections from other buildings. Light that has reflected off several surfaces is assumed to have a negligible impact. As such, only a single reflection from the development was included in the analysis.

## Assumptions and Limitations (cont'd)

### Facade Material Reflectance

Detailed facade material properties are still under consideration by the design team. As such, assumptions are required for this analysis.

For glazed surfaces RWDI has assigned reflectivity characteristics which are typical for the 1-inch insulated glazing units (IGUs) used in contemporary construction in the Boston area. The visible reflectance (which relates to glare) of this IGU is 23% and the full spectrum reflectance (which relates to heat gain) is 37%. All glazing on the buildings has been assigned to these properties.

Metallic facade elements typically feature a matte finish with a low specular reflectivity as opposed to a high gloss finish. Thus, we have conservatively taken the metal elements to have a uniform 10% specular reflectance.

Figure 5 shows the location of the reflective materials on the facades of the proposed buildings. Similarly, the reflectance properties of the glazing unit are summarized in Table 1.

### Applicability of Results

The results presented in this report are highly dependent on both the form and materiality of the facade. Should there be any changes to the form or materiality of the design, it is recommended that RWDI be contacted and requested to review their potential effects on solar reflection.

**Table 1: Nominal Visible and Full Spectrum Reflectance Values of the Reflective Building Elements**

| Location | Material | Visible Reflectance | Full Spectrum Reflectance |
|---|---|---|---|
| Entire Glazed Facade Area | Representative 1" IGU | 23% | 37% |
| All Metal Elements | Generic Architectural Metal | 10% | 10% |

## Assumptions and Limitations (cont'd)

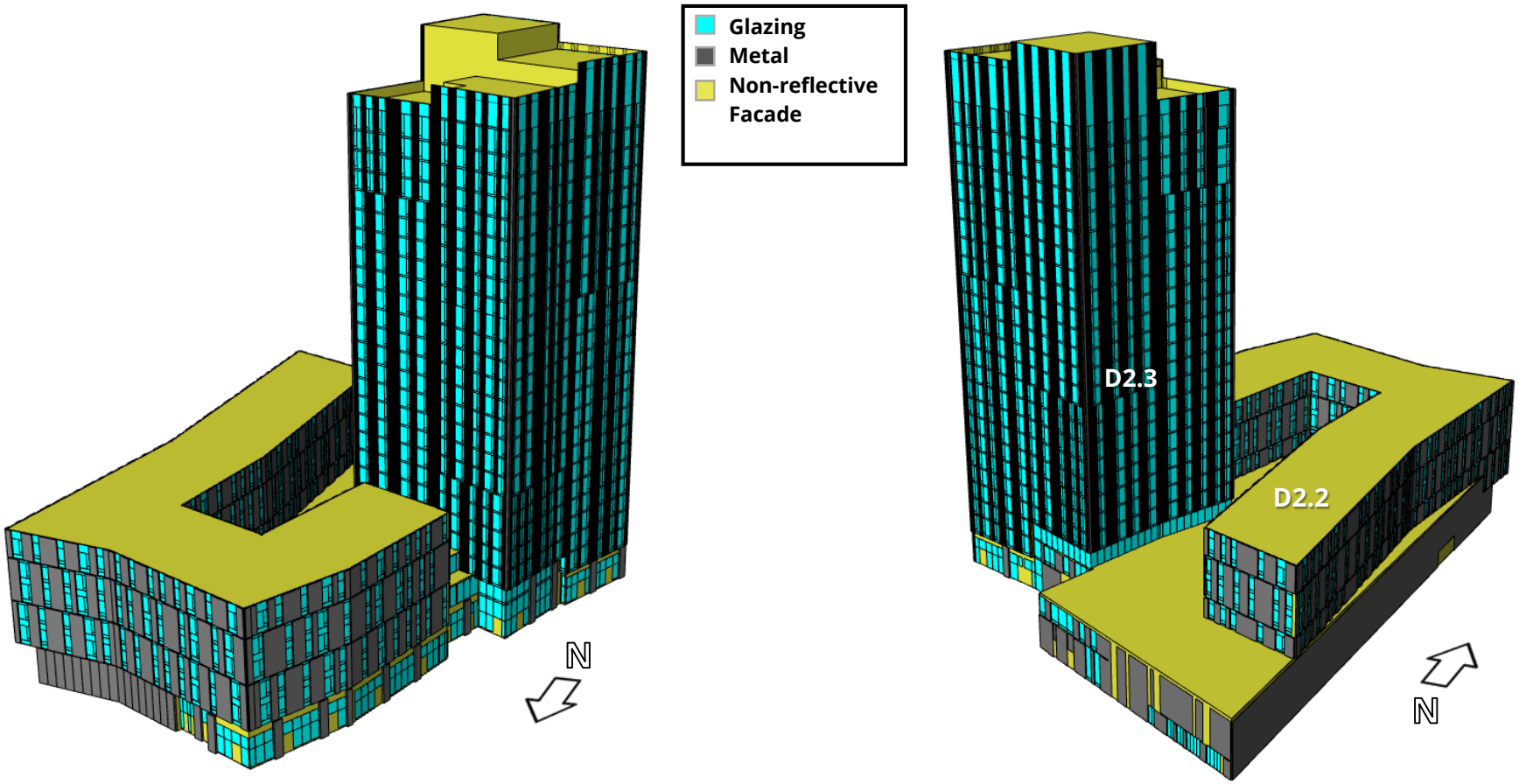



**Figure 5: Locations of Reflective Building Elements**

## Presentation of Results

This section presents the screening results pertaining to the solar impacts of the D2.2 and D2.3 buildings on the surrounding urban area. The following three plots are presented :

**Peak Annual Reflected Irradiance**
This plot displays the annual peak intensity of all reflections emanating from the development at a typical pedestrian height (5 feet) above local grade.

Two versions of this plot are included:

- **Visible Reflectance (Visual Glare):** This plot (Figure 6a) displays the intensity of reflected visible light only. Depending on the ambient conditions, reflection intensities as low as 50 W/m² could be visible to people outdoors.

- **Full Spectrum Reflectance (Heat Gain):** This plot (Figure 6b) presents the total intensity of a reflection, including both visible light and thermal energy which relates to the risk of excessive heat gain. For full spectrum reflectance, RWDI considers 1500 W/m² as a short term thermal comfort threshold and reflections above 2500 W/m² as a human safety threshold (refer to Appendix B).

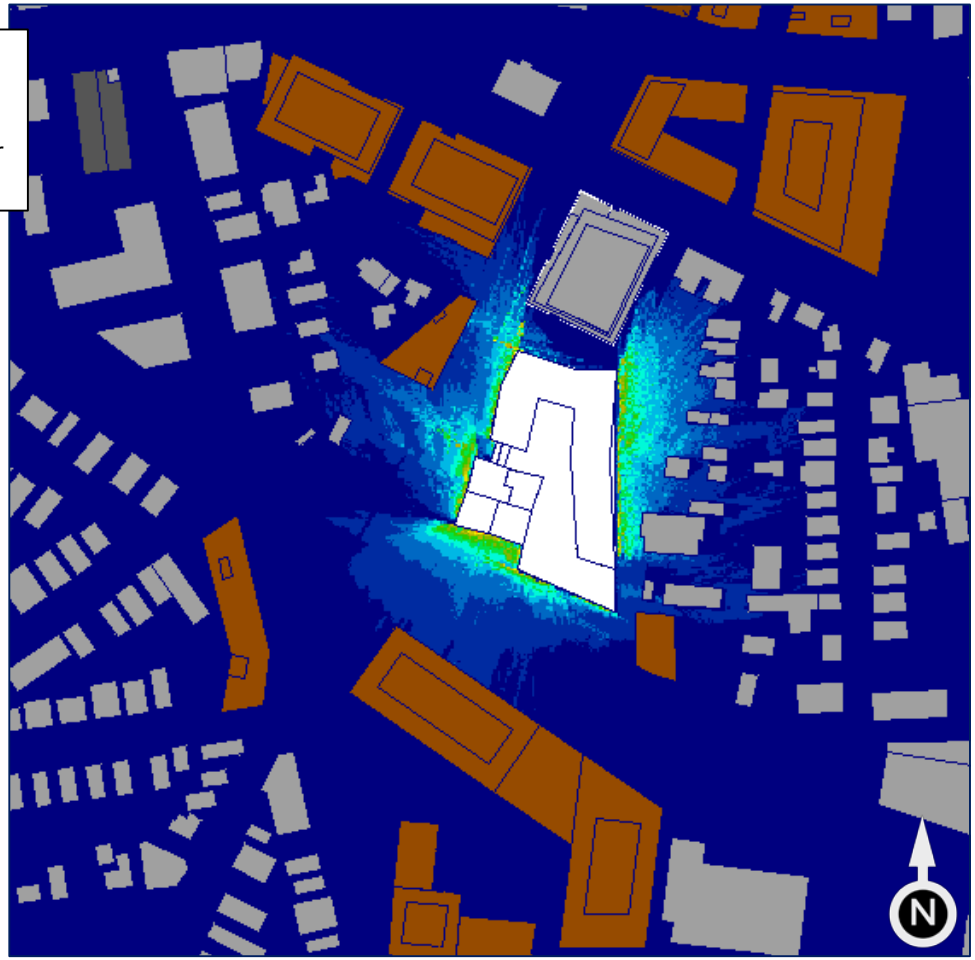
**Frequency of Significant Visual Reflections**
This plot (Figure 6c) identifies the locations of the most frequent significant reflections emanating from the facades. In this context a 'significant' reflection is one that is at least 50% as intense as one that would cause after imaging on a viewer (refer to Appendix B).

As this criteria is visually based, the visible reflectance of the facades was used.

In order to attain a complete understanding of the impact that reflections may have on drivers, other factors must be considered, including the duration of the reflections and when they occur. The following plots serve to illustrate the general characteristics of reflections from the buildings and inform the locations of the receptor points used in the detailed phase of work which will analyze these factors in greater depth.

## Peak Annual Reflected Irradiance - Visible Reflectance (Visual Glare)

Reflections as low as 50 W/m² may be visible to people, depending on outdoor lighting levels.



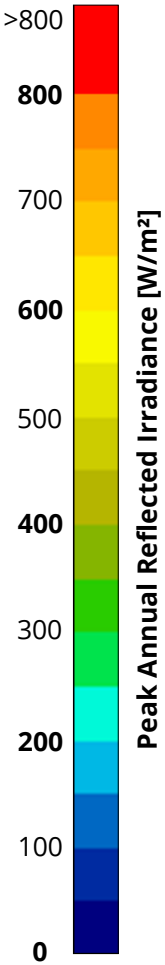
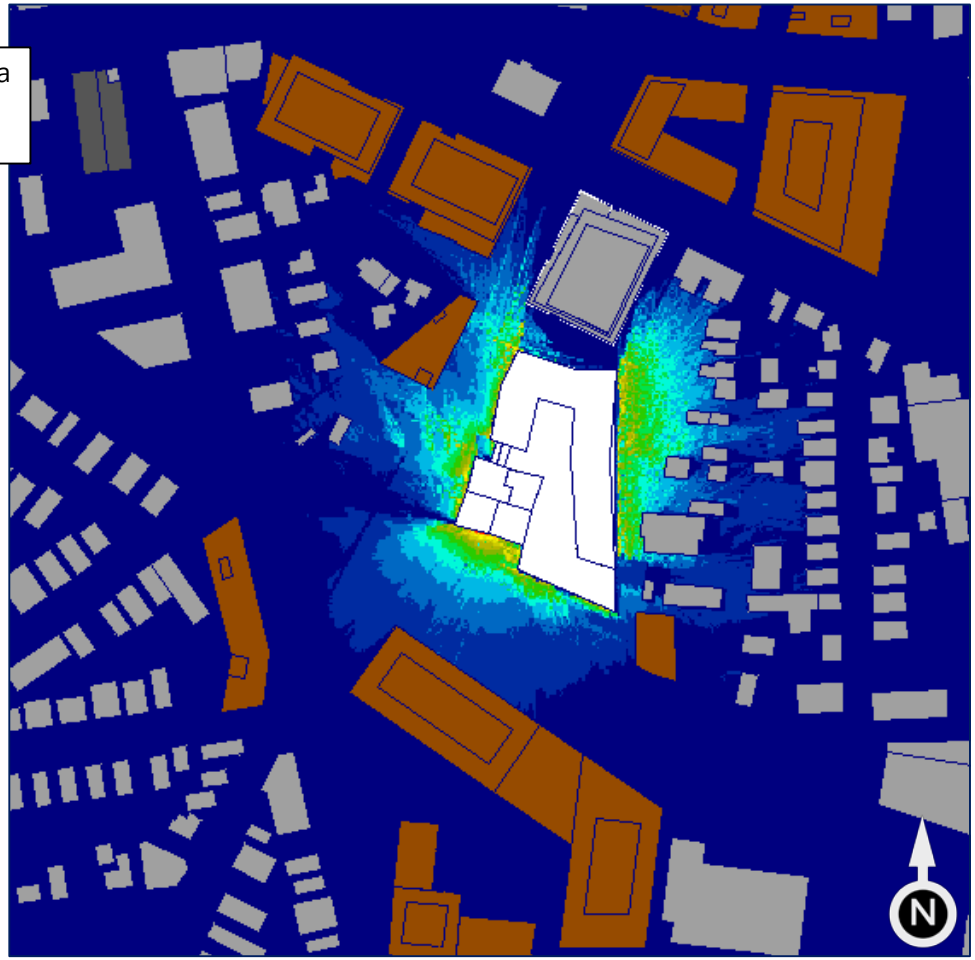




**Figure 6a: Maximum Annual Intensity of Visible Reflections at Pedestrian Height**

## Peak Annual Reflected Irradiance - Full Spectrum Reflectance (Heat Gain)

800 W/m² represents a typical intensity for direct sunlight.



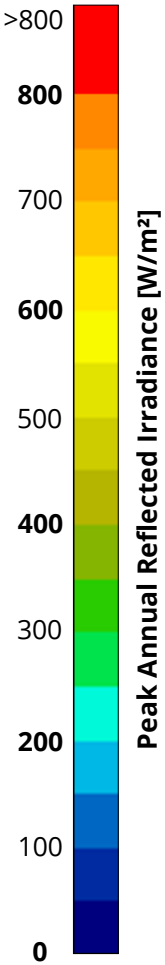




**Figure 6b: Maximum Annual Intensity of Full Spectrum Reflections at Pedestrian Height**

## Frequency of Significant Visible Reflections

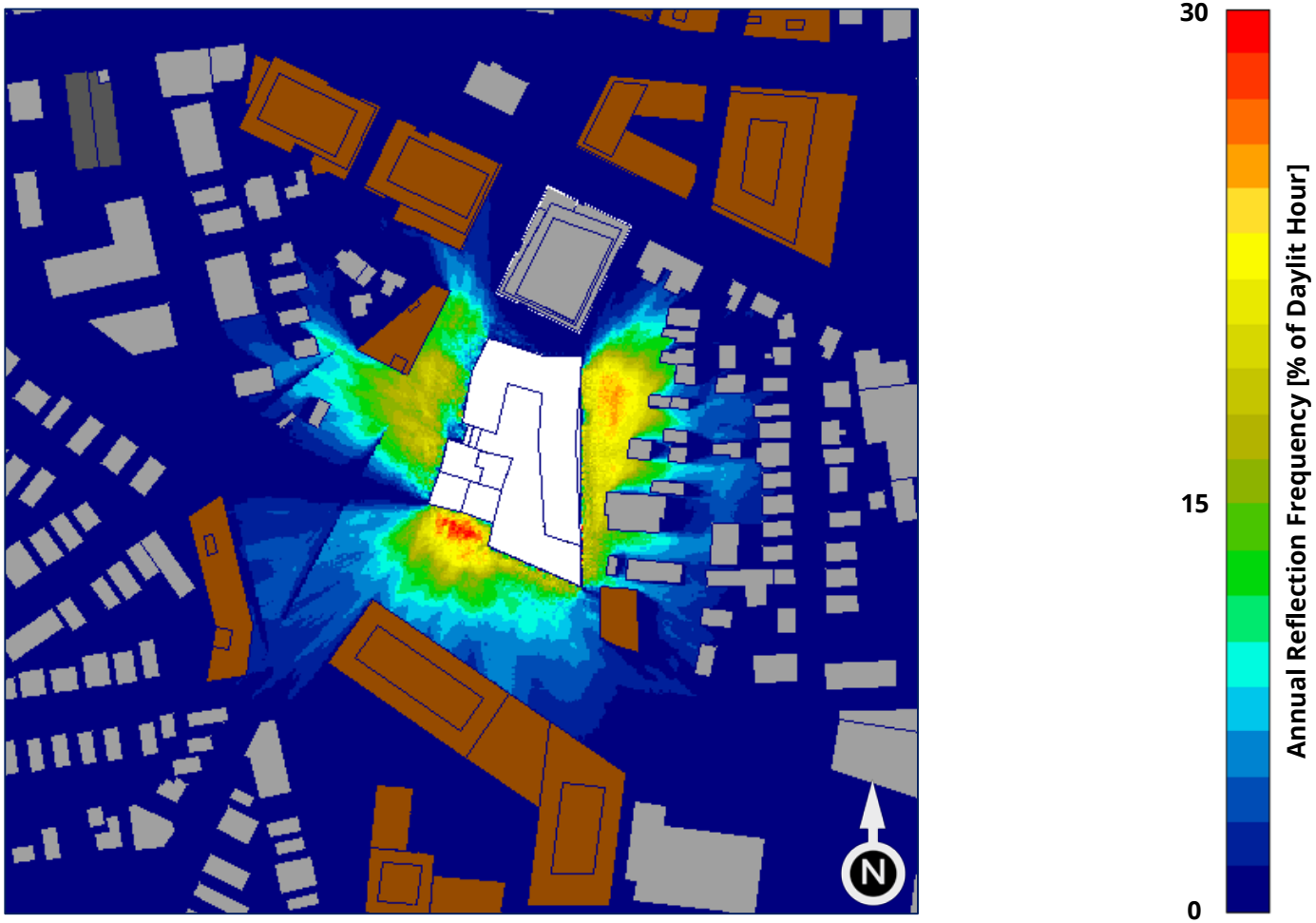



**Figure 6c: Frequency (% of Daylit Hours) Where Significant Visible Reflections Can Occur**

# SCREENING ANALYSIS OBSERVATIONS

1. Like any contemporary building, the reflective surfaces of the D2.2 and D2.3 buildings of the proposed Union Square development are naturally causing solar reflections in the surrounding neighborhood.

2. The planar nature of the facades prevents reflections emanating from the buildings from focusing (concentrating) in any particular area. Thus, RWDI does not anticipate any heat gain issues on people or property.

3. At pedestrian level, reflections are predicted to fall most frequently onto the areas immediately east, southwest, and west of the development. The remainder of the surrounding areas are expected to be impacted less frequently. The maximum frequency of glare occurrence found at pedestrian level is approximately 42% of daytime hours.

4. Reflections emanating from the west facades of the building are the primary sources of impacts along Prospect Street. These reflections may affect motorists and cyclists travelling towards the buildings. Similarly, some reflections may impact train drivers travelling to the southern region of the development. The impact of these reflections will be analyzed in detail in the following sections.

5. The occupants of the buildings located in the vicinity of buildings D2.2 and D2.3 are expected to experience visible reflections from the buildings. That being said, the reflections do not pose a risk to safety, and are likely a nuisance at worst, as the occupants can look away or close blinds.

6. Pedestrians in the vicinity of buildings D2.2 and D2.3 may also experience intermittent reflections. This condition is common in many urban centers and is unlikely to present a significant safety risk.

7. Given the density of the surrounding neighborhood, we suggest that the metal panels have a matte finish and the glazing to have a low visible reflectance to minimize potential glare. Selecting facade elements with significantly higher specular reflectivities than what was assumed herein may increase the predicted intensities and frequencies described above.

# DETAILED ANALYSIS RESULTS

Based on the findings of the Screening Analysis and the risk levels associated with reflections effecting specific areas, 20 representative points were selected for the Detailed Analysis. These points are described in Table 2 and illustrated in Figure 7.

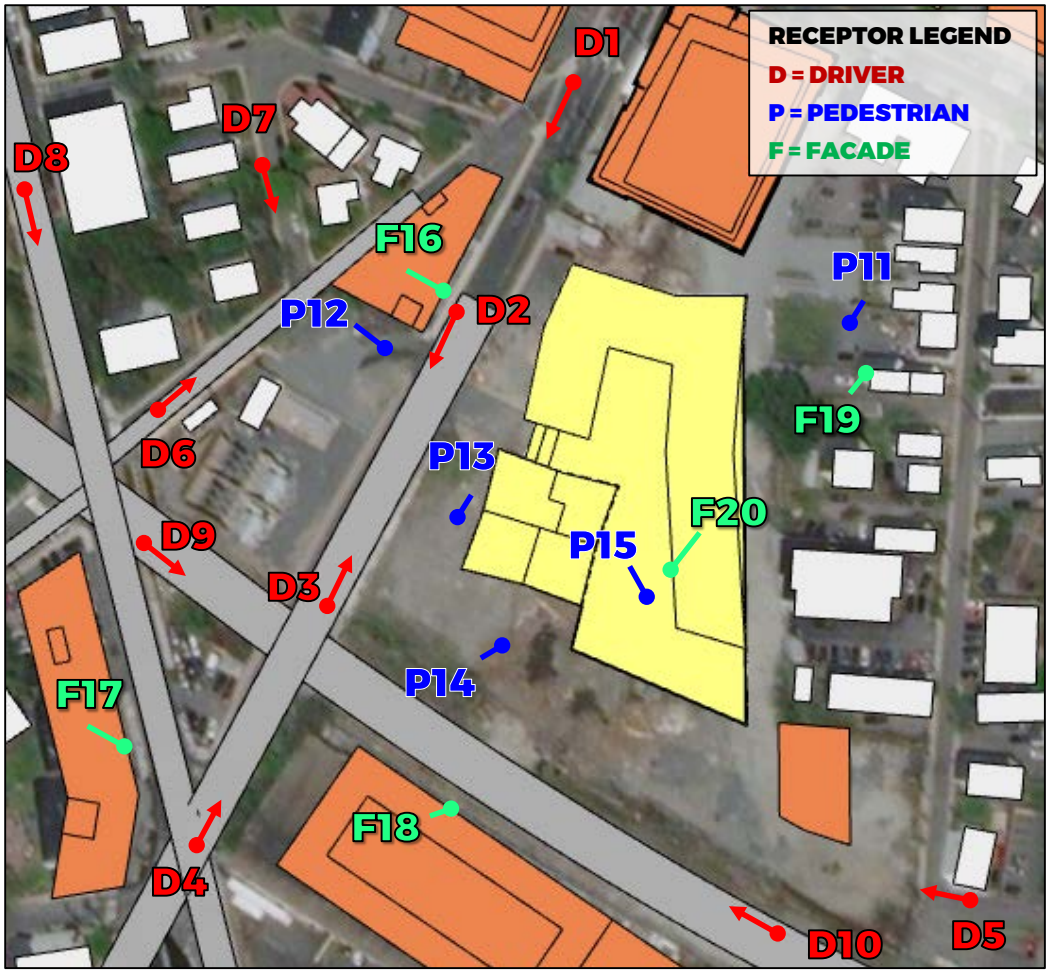



**Figure 7: Receptor Locations**

**Table 2: Receptor Descriptions**

| Receptor Number | Receptor Description |
|---|---|
| D1-D2 | Cyclists traveling southwest on Prospect St. |
| D3-D4 | Drivers traveling northeast on Prospect St. |
| D5 | Drivers traveling west on Charlestown St. |
| D6 | Drivers traveling northeast on Newton St. |
| D7 | Drivers traveling southeast on Emerson St. |
| D8 | Drivers traveling southeast on Webster Ave. |
| D9 | Eastbound train drivers |
| D10 | Westbound train drivers |
| P11 | Pedestrians to the northeast of the development |
| P12-P14 | Pedestrians in the neighborhood of the development |
| P15 | Pedestrians on the rooftop of future building D2.2 |
| F16 | Facade of future building D4.1 |
| F17 | Facade of future building D4.3 |
| F18 | Facade of future building D3.1 |
| F19 | Facade of neighboring house to the east of the development |
| F20 | Facade of building D2.2 |

# DETAILED ANALYSIS RESULTS

Table 3 summarizes the level of visual and thermal impact from the building's reflections at each of the studied locations. For each category (visual impact, thermal impacts on people, thermal impacts on facades/property), the location is classified as experiencing one of three impact levels:

- **Low** impacts indicate that either no reflections reach the receptor, or that reflections which do reach the location are unlikely to lead to visual or thermal concerns.

- **Moderate** impacts indicate the potential for visual nuisance, minor thermal discomfort to people, or heating of materials. Moderate impacts do not indicate a significant safety risk and are common in urban areas. They represent effects such as intermittent visual glare on pedestrians or occupants of adjacent buildings which can be safely self-mitigated.

- **High** impacts indicate the potential for risks to safety, either through impairing the visual acuity of a vehicle operator or through reflection intensities high enough to cause injury or property damage. When the sun is also in a driver's field of view, we would expect that brightness of the sun to dominate over the less intense reflected light, likely reducing the perceived effect of high impact reflections. This situation is noted in Table 3 where applicable, as are notes on high impact reflection frequencies and durations.

The minute-by-minute results for each point are presented as "Annual Reflection Impact Diagrams" which distill an entire years worth of data into a single diagram. The diagrams for each of the receptor points as well as an explanation for how to read the diagrams are provided in Appendix A.

For further detail on RWDI's criteria refer to Appendix B.

The level of mitigation required (discussed further in the Overall Observations & Conclusions section), is determined based on a combination of factors including the predicted level of impact, the frequency and duration of the impacts, and the risk level associated with activities likely to be engaged in at the location.

# DETAILED ANALYSIS OBSERVATIONS

**Table 3: Summary of Overall Predicted Impacts on Receptors**

| Receptor Number | Receptor Type | Assumed Activity Risk Level | Assumed Ability to Self-Mitigate | Peak Reflected Light Visual Impact | Sun in Field of View During High Impact Reflection (Y/N) | Duration / Number of Days with High Impact Reflection | Peak Reflected Solar Thermal Impact on People | Peak Reflected Solar Thermal Impact on Facade |
|---|---|---|---|---|---|---|---|---|
| **D1-D9** | Driver | High | Low | ***Moderate*** | N/A | N/A | ***Low*** | N/A |
| **D10** | Driver | High | Low | ***High**** | ***No*** | Longest Duration: **8 minutes** Average Duration: **4 minutes** No. of days: **43** | ***Low*** | N/A |
| **P11-P15** | Pedestrian | Low | High | ***Moderate*** | N/A | N/A | ***Low*** | N/A |
| **F16-F20** | Facade | Low | High | ***Moderate*** | N/A | N/A | N/A | ***Low*** |

* The majority of high impact reflections are infrequent and short in duration.

# OVERALL OBSERVATIONS & CONCLUSIONS

**Thermal Impacts on Pedestrians, Drivers, and Facades**

1. The planar facades of the proposed D2.2 and D2.3 buildings ensure that reflected sunlight will not focus (multiply) in any particular area. Therefore, RWDI does not expect any significant thermal impacts (i.e. risks to human safety or property damage) to occur either within the development or in the surrounding neighborhood.

**Visual Glare Impact on Drivers**

2. Train drivers travelling westbound to the south of the buildings (receptor D10) are expected to experience an increased level of visual glare impact during some afternoons in February, March, and October. These impacts may alter a driver's current experience.

   That said, the impacts are brief and infrequent. The reflections are predicted to occur 43 days per year at most, and last 8 minutes or less in duration. This equates to high impact glare being possible at westbound trains in 0.08% of the daytime.

   We would also note that the glare occurs near sunset when westbound drivers would naturally expect glare to occur (due to the sun) and likely have already taken mitigative actions (e.g. put on sunglasses or lower sun visors).

3. For the remainder of the driver receptors (driver receptors D1-D9), visual glare impacts are moderate at worst, hence they are not expected to pose a safety concern to drivers. For further details refer to the visual impact diagram for driver receptors D1-D10 illustrated in Appendix A.

**Visual and Thermal Impacts on Pedestrians and Facades**

4. Moderate levels of visual impact are predicted to fall on the pedestrian and facade receptors in the surrounding neighborhood (receptors P11-P14, and F16-F19). Some of these reflections are frequent and relatively long in duration. The maximum frequency of glare occurrence found at pedestrian level and at the surrounding buildings is approximately 42% of daytime hours. That said, these types of reflections would occur for any glazed building and represent at worst a visual nuisance, as viewers can look away or close blinds.

# OVERALL OBSERVATIONS & CONCLUSIONS

5. Frequent reflections with long durations are expected to impact the residential areas immediately to the east of the buildings (e.g., receptors P11 and F19). The impacts can occur for much of the morning hours throughout the year. We would not consider this a risk to safety but rather a nuisance issue. While this condition is not unprecedented in an urban environment, we would encourage the use of low reflectivity materials on the eastern elevation of D2.2 as much as practical to reduce reflection impacts.

6. Pedestrians immediately adjacent to building D2.3 (receptors P13 and P14) and on the rooftop of building D2.2 (receptor P15) may also experience long and frequent reflections with moderate impacts during morning and afternoon almost the entire year. While not posing any risk to safety, the reflections may be a nuisance for people in these areas, making mitigation advisable if these spaces are to be used as amenity areas.

7. The majority of reflected solar energy at the studied areas are of a low intensity (less than 300 $W/m^2$). Hence, the potential for thermal impacts is expected to be low.

8. Reflections emanating from D2.3 building facade with moderate levels of visual impacts may fall onto a section of the D2.2 building facade as highlighted in Figure 8. The individual reflections last approximately 20-30 minutes and occur intermittently throughout the morning hours all year (see receptor F20 in Appendix A). The reflections are of a relatively low intensity but will be visible to those inside the building D2.2. That being said, they do not pose a risk to safety, and are likely a nuisance at worst, as the occupants can easily look away or close blinds.

9. Given the density of the surrounding neighborhood, we suggest that the metal panels have a matte finish and the glazing to have a low visible reflectance to minimize potential glare. Selecting facade elements with significantly higher specular reflectivities from what was assumed herein may increase the predicted intensities and frequencies described above.

# MITIGATION SUGGESTIONS

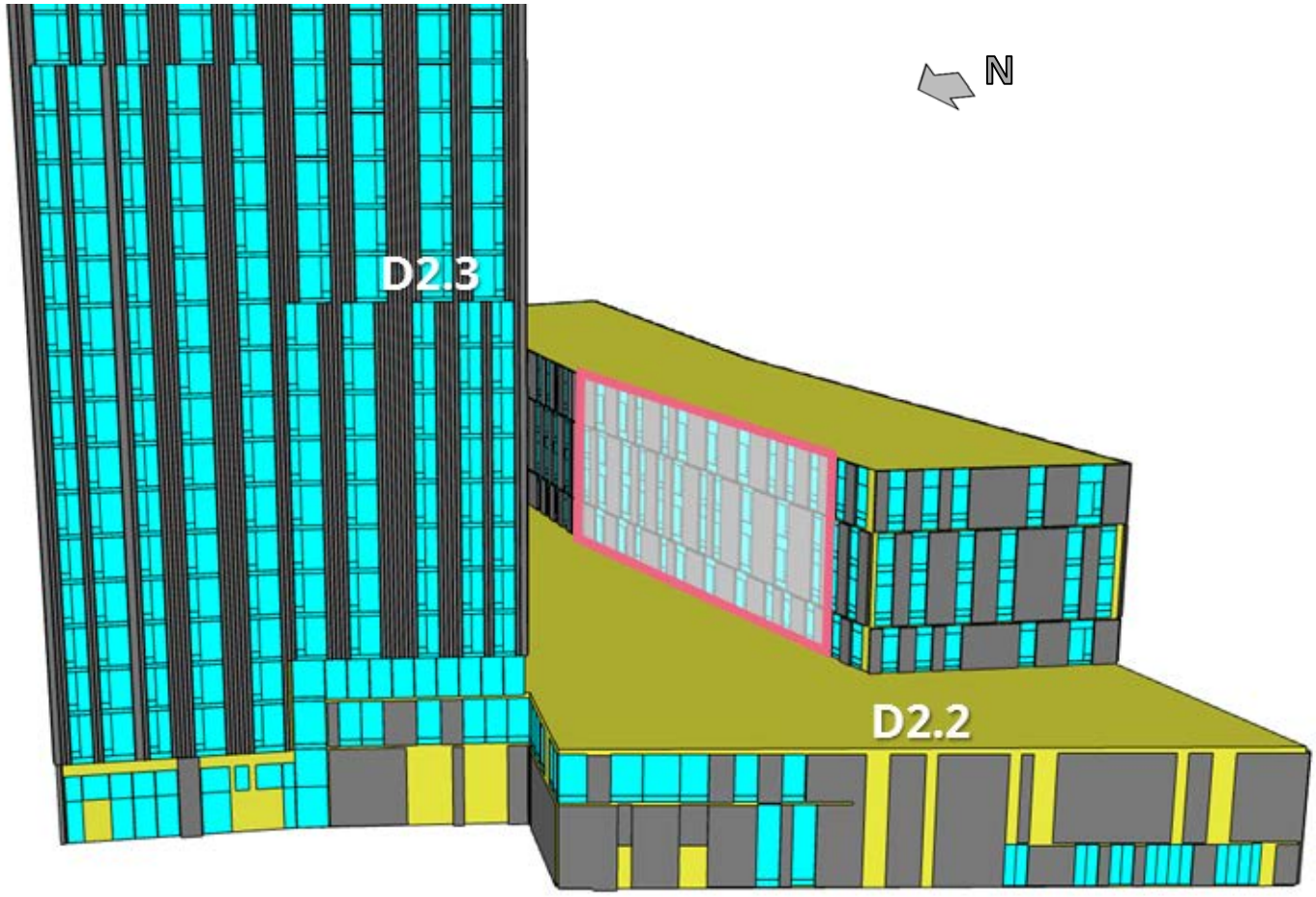



**Figure 8: Mark-up of Areas on D2.2 Building Impacted by D2.3 Building**

# MITIGATION SUGGESTIONS

Overall, the reflections emanating from the D2.2 and D2.3 buildings of the proposed Union Square development onto the surrounding neighborhood are comparable to reflections elsewhere in the city. If however, there are concerns about the predicted reflection impacts, RWDI offers the following suggestions for further consideration (refer to Figures 9-11 on the following three pages for mark-ups of these recommendations):

1. **Exterior Surface Modification:** Modifying the exterior surface of the glazing on the southern elevations of building D2.3 (glazing units inside the blue area in Figure 9) to diffuse light rather than reflect directly (i.e. by "frosting" or roughening the exterior surface) could help in reducing the frequency and duration of reflections falling onto the westbound train drivers (receptor D10).
   Applying a similar mitigation strategy on the glazing units of D2.2 building's eastern facade (area colored in white in Figure 10) could reduce the impacts on the residential areas immediately to the east of the buildings (receptors P11, and F19). In addition, using architectural metals with a matte finish on the same facade location could help in lowering the impacts.
2. **Building Mounted Shading Devices:** Breaking up some of the high-impact reflections falling onto the westbound train drivers (receptor D10) could also be accomplished by extending the depth of the vertical fins. The fins in the areas shown in Figure 9 should be approximately 6-10 inches deeper to be effective in intercepting the high impact reflections.
3. **Glazing Change-out:** In general, selecting glazing units with lower visible and full spectrum reflectance properties on the east, south and west facades of the buildings aids in reducing the frequency and duration of visual and thermal impacts on adjacent buildings (receptors F16-F20) and pedestrians in the neighborhood (receptors P11-P15) in the mornings and afternoons. In particular, we suggest that the glazing units on the eastern elevations of building D2.2 (areas colored in white in Figure 10) be selected with a low visible reflectance to minimize glare impacts on the residential areas to the east of the buildings (e.g., receptors P11, and F19).
4. **Free-Standing Shading Devices:** A practical approach to intercept some of the frequent direct and reflected sunlight immediately adjacent to building D2.3 (P13, P14) and on the podium area (e.g. receptor P15) of building D2.2 (Figure 11) may be to block reflections at pedestrian level. Strategic use of shading devices such as canopies and umbrellas will limit the impact of both direct and reflected sunlight.

# MITIGATION SUGGESTIONS

Modifying the exterior surface of the glazing on D2.3 building's southern facade (glazing units inside the outlined area) to diffuse light rather than reflect directly (i.e. by "frosting" or roughening the exterior surface) could help in reducing the impacts on westbound train drivers (receptor D10).

Another approach would be to increase the depth of the vertical fins by approximately 6-10 inches.

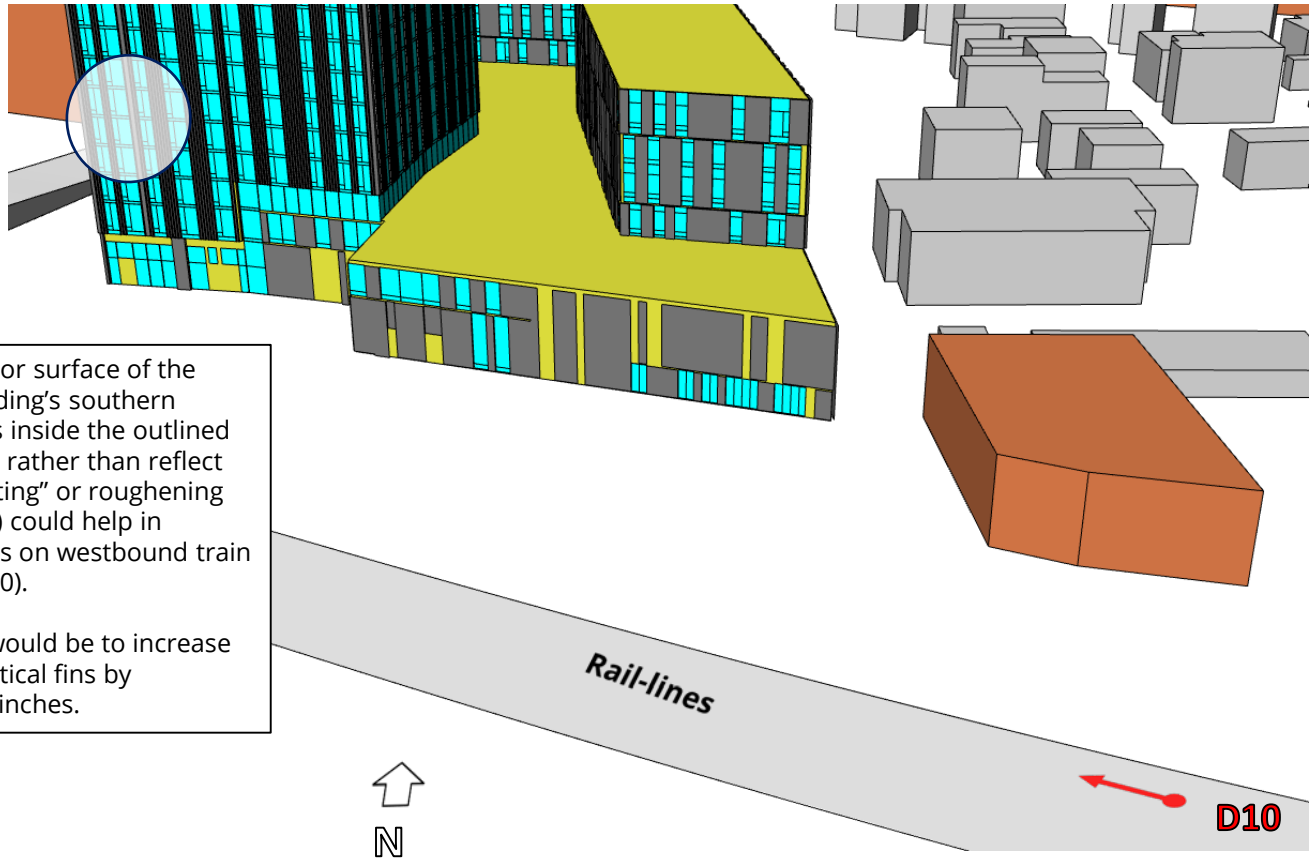



**Figure 9: Markup of Facade Locations Where Exterior Surface Modification Would be an Appropriate Approach**

# MITIGATION SUGGESTIONS

In general, selecting glazing units with lower visible and full spectrum reflectance properties on the east, south and west facades of the buildings aids in reducing the frequency and duration of visual and thermal impacts on adjacent buildings (receptors F16-F20) and pedestrians in the neighborhood (receptors P11-P15) in the mornings and afternoons.

In particular, given the proximity of the east facade to the residential buildings east of the site, we would suggest that both the glazing and the metal elements have as low of a reflectivity as practical to minimize the impact of any reflections.

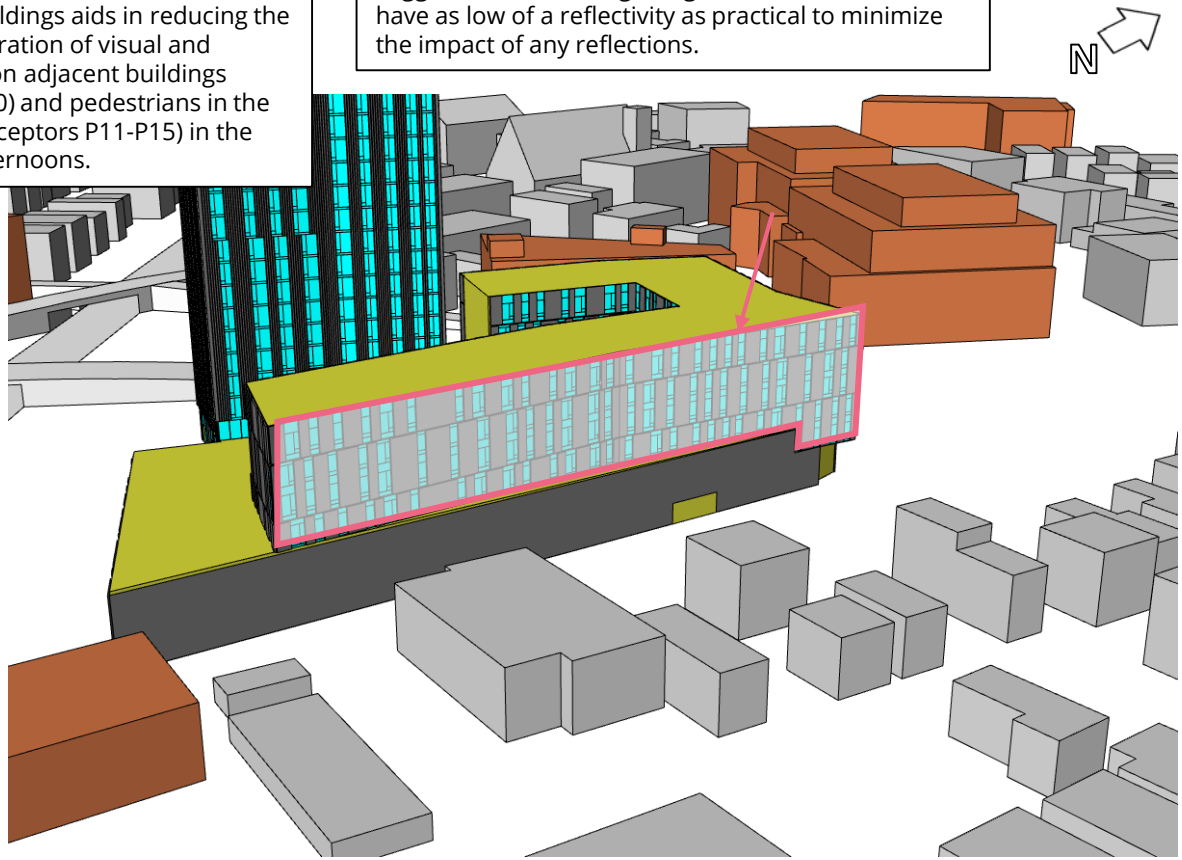



**Figure 10: Markup of Facade Locations Where Glazing Change-out Would be an Appropriate Approach**

# MITIGATION SUGGESTIONS

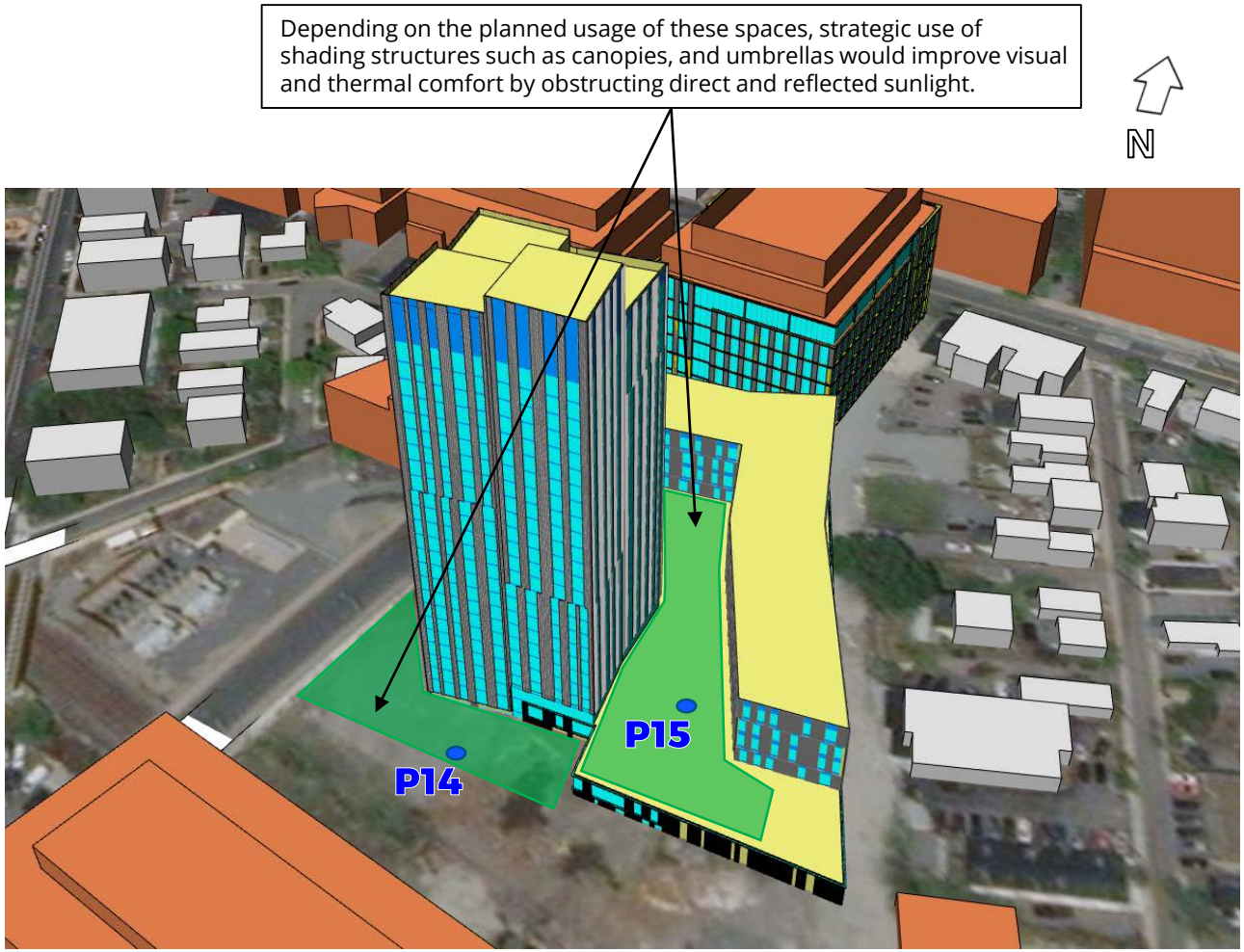



**Figure 10: Markup of Facade Locations Where Shading Devices Would be an Appropriate Approach**