

June 30, 2022

**BY HAND DELIVERY, OVERNIGHT DELIVERY
& ELECTRONIC MAIL**

Town of Needham Planning Board Members
Public Service Administration Building
500 Dedham Avenue
Needham, MA 02492
Attn: Lee Newman, Planning Director

Re: 557 Highland Avenue, Needham Heights, Massachusetts (the “Property”)

Dear Planning Board Members:

As you know, we are counsel to 557 Highland, LLC, an affiliate of The Bulfinch Companies, Inc. (the “Applicant”), in connection with the redevelopment of the Property with a new, mixed-use development of office, laboratory, research and development uses, and retail/restaurant uses (the “Project”), all as described in our prior cover letter dated April 5, 2022 (the “Prior Letter”) submitting the Application for Site Plan Review and issuance of Special Permits in connection with development of the Project (the “Application”).

Since submission of our Prior Letter, the Applicant has engaged in seven (7) community meetings with the general public and multiple productive discussions with interested neighbors, members of the community at large, and representatives of various Town of Needham departments. At the first public hearing with the Planning Board on June 7, 2022 the Applicant discussed the following aspects of the Project:

- Project Architecture and Site Overview
- Landscape Architecture
- Sustainability
- Environmental Lab Safety
- Transportation
- Zoning Compliance

Based on feedback from the Planning Board, Town departments, and members of the community, and in anticipation of the next public hearing for the Project on July 7, 2022, enclosed as **Exhibit F** is a presentation that illustrates further refinements to the Project design based on input we have received to date, and outlines the transportation improvements proposed in connection with the Project.

Planning Board Members
June 30, 2022

Additionally, attached hereto as **Exhibit A** are the Applicant's responses to aggregated comments from the Planning Board Members at the June 7th hearing and attached hereto as **Exhibit B** are the Applicant's responses to comments received from other Town departments.

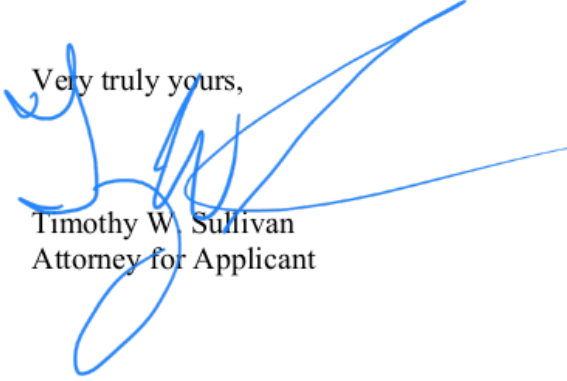
Furthermore, attached hereto as **Exhibit C**, is a response from VHB, Inc. to GPI's peer-review comments on the Project's Transportation Impact and Access Study and attached hereto as **Exhibit D** is a separate response from VHB, Inc. to Nitsch Engineering's peer-review comments on the Transportation Impact and Access Study.

Finally, attached hereto as **Exhibit E** is a copy of the Preliminary Exterior/Community Noise Evaluation/Narrative prepared by Acentech Incorporated examining compliance with MassDEP noise limits.

As detailed in the Prior Letter and affected by the supplemental materials submitted herewith, the Project continues to satisfy each of the applicable criteria for the relief requested in the Prior Letter.

We appreciate your attention to this matter. The Applicant and the entire Project team look forward to meeting with you and discussing the transportation aspects of the Project at the next public hearing on July 7, 2022.

Very truly yours,



Timothy W. Sullivan
Attorney for Applicant

Enclosures

EXHIBIT A

**RESPONSES TO TOWN OF NEEDHAM PLANNING BOARD COMMENTS AT
JUNE 7, 2022 PUBLIC HEARING (557 HIGHLAND AVENUE)**

Question/Topic	Response
PLANNING BOARD	
<i>Whether the current setback on Gould Street is measured from the current layout of the street.</i>	The plan filed with the Special Permit application contemplates that all of the Gould Street improvements will be subject to an easement in favor of the Town of Needham for public travel. Accordingly, the plan measures all setbacks and dimensional requirements based on the existing lot. The Applicant is working with Town Counsel regarding the application of setbacks in the context of the proposed roadway improvements.
<i>Provide an itemized list of strategies to address climate change as referenced in the applicant's cover letter.</i>	Impacts from climate change on the Project may include urban flooding and extreme heat events. With respect to urban flooding, the Property is located in Zone X (area of minimal flood hazard) according to FEMA Flood Insurance Rate Mapping. The existing site consists almost completely of impervious buildings and paved parking lots. The proposed Project represents a 1.8-acre decrease in impervious coverage compared to the existing condition. This reduction in impervious coverage, and the addition of a surface stormwater detention basin, will result in decreased stormwater peak runoff rates and volumes from the Site overall. The project represents a significant decrease in peak rates to the offsite MassDOT and municipal drainage systems to which the site is tributary, reducing downstream flooding potential should those systems become surcharged in extreme precipitation events. Extreme heat event mitigation strategies include: improved envelope insulation and infiltration to minimize cooling demand and better maintain indoor temperature conditions; high efficiency chilled water plant to minimize cooling demand and energy usage; laboratory exhaust monitoring controls to minimize outside air cooling load.

Question/Topic	Response
<i>Whether the planned solar array will violate any height restrictions in zoning.</i>	Pursuant to Section 4.11.2 of the Zoning By-Law, the parking garage may be allowed a maximum height of 55 ft. by special permit. Pursuant to Section 4.11.1(1)(e) “Structures erected on a building and not used for human occupancy, such as . . . solar or photovoltaic panels . . . and the like may exceed the maximum building height provided that no part of such structure shall project more than 15 feet above the maximum allowable building height, the total horizontal coverage of all of such structures on the building does not exceed 25 percent, and all of such structures are set back from the roof edge by a distance no less than their height.” The parking structure is proposed at 55 ft. in height and the Applicant has requested a special permit for this increased height. The proposed solar photovoltaic canopies on the parking structure may not exceed the 15 ft. limit imposed by Section 4.1.1(1)(e), which we assume is applicable to parking structures, depending upon final design. However, the proposed solar photovoltaic canopies would likely exceed the maximum horizontal coverage limitation of 25%.
<i>Is there an opportunity to further reduce parking and what the impacts on the project might result?</i>	The Project is requesting a reduction in proposed parking based upon documented employment densities of other peer research and development centers in eastern Massachusetts. With approximately 1,408 parking spaces proposed on-site, there will be adequate parking provided for the Project.
<i>Can additional green space be incorporated into the design?</i>	The site design has been revised to address prior community comments with an aim to include less grass and to maximize diverse and native plantings.
<i>Will all amenities be accessible by the community?</i>	All outdoor amenities for the Project are intended to be available to the public, as will the retail/restaurant tenant spaces.
<i>Can the bike lanes/infrastructure be designed to favor families instead of commuters?</i>	In close consultation with our neighbors, we are working to develop transportation improvements, including separated bike lanes/infrastructure that

Question/Topic	Response
	address neighborhood concerns along Gould Street on or adjacent to the Property.
<i>Can the scale of the structures along Gould Street be further offset or reduced?</i>	As we further studied moving the North Loading Dock from the Gould Street elevation to the north side of the building, we have studied different fenestration options which may help the building read at a smaller scale on this elevation, but will still provide the areas needed to best serve the building tenants and community. Additional trees/planting are being considered in order to help further screen the building from view along Gould Street.
<i>Can the planned greenbelt be connected to the park/trail across from TV Place on neighboring property?</i>	This is currently part of a separate property at 0 Gould Street and no changes to this property are anticipated at this time.
<i>What will acoustic levels be from rooftop mechanicals?</i>	The Applicant has engaged Acentech as an acoustical consultant to provide a qualitative report on this topic and the results of the report are included as Exhibit E to this letter.
<i>Provide additional clarity on loading dock operations and whether loading dock access can be provided off of TV Place rather than facing Gould Street.</i>	Due to the location of the garage structure, as required by the recent rezoning, locating the North Building's loading dock off of TV Place was not achievable. However, the team has reviewed moving the loading dock to the north side of the North Building so the loading dock no longer faces Gould Street, which adds additional window area and a park along the west face of the North Building.
<i>Has the Fire Department approved of the driveway/roadway widths and can a permeable paving material be used for emergency lanes?</i>	In our meeting with the Fire Department on March 24, 2022, the Fire Department requested fire access lanes around the building which are being provided. These lanes are to be 18' minimum width, but 20' preferred due to snow clearing. The landscape architect is planning to provide the fitness path as bituminous concrete or gravel, then flank the sides with permeable structured grass or permeable pavers if allowed by the Fire Department.

Question/Topic	Response
<i>Can additional public transportation be provided through relocating or adding an MBTA bus route?</i>	The Applicant will reach out to MBTA to evaluate the feasibility of providing additional MBTA service. However, in light of the MBTA’s Bus Network Redesign plan, released in May 2022, which proposes to maintain Route 59’s existing alignment in Needham while eliminating route variations in Newton, the Applicant thinks it unlikely that the MBTA will agree to shift a segment of Route 59 from serving residential neighborhoods to serving the Project site. The Applicant will be providing a direct shuttle service (via use of an electric shuttle) that will connect the site with nearby transit nodes.

EXHIBIT B

**RESPONSES TO TOWN OF NEEDHAM DEPARTMENT COMMENTS
(557 HIGHLAND AVENUE)**

Question/Topic	Response
FIRE DEPARTMENT	
<i>Confirm with the Fire Department to ensure public safety vehicle access during the winter.</i>	Final plans will be resubmitted for Fire Department approval including all truck turn requirements, etc., to confirm acceptable access as is required by applicable codes and regulations.
POLICE DEPARTMENT	
<i>Address potential for use of cut-through streets off of Gould Street and address potential use of Noanett, Ellis, Kearney, Beech and Arnold Streets as cut-through streets to avoid light at Gould and Central intersection. Place signage at these locations restricting traffic during commuting hours.</i>	The Applicant will work with the Town to design and install signage at Noanett Road to deter unwanted cut-through turning movements during the weekday peak commuting hours. In addition, the installation of a traffic signal at Central Avenue and Gould Street will improve operations on Gould Street and reduce the desire for vehicles to use side streets as a cut-through by providing gaps for vehicles to turn efficiently at that intersection. The Applicant will supplement these actions with information dissemination and enforcement funding in connection with close collaboration with the Needham Police Department.
<i>Address potential impacts on Hunting and Greendale from drivers utilizing these streets during hours of heavy traffic on Route 128.</i>	Traffic volumes on Hunting and Greendale have decreased in the last several years due to the completion of the Route 128 add-a-lane project in the area, and most notably, due to the implementation of the new interchange connection at Kendrick Street. The Project is expected to add only a very small number of new trips to Hunting and Greendale, as the additional southbound left-turn lane on Gould Street will make it easier for drivers from the site to directly access Route 128 via Highland Ave. In addition, the Applicant will fund the installation of radar embedded speed limit signs along Hunting Road as a measure to deter speeding during off-peak hours.

Question/Topic	Response
<i>Confirm that walking paths, bike paths, and similar spaces running around perimeter of project site have adequate emergency vehicle access.</i>	The perimeter paths along Highland Avenue / Route 128 have been designed with stabilized gravel shoulders that will provide 20' wide emergency access. A 20' wide gravel access drive has also been provided around the proposed garage.
BUILDING DEPARTMENT	
<i>The site as presented appears to meet the zoning regulations for the site, Special Permits are required for some dimensional requirements based on the design of the structures.</i>	The Applicant has requested such special permit relief in its Application.
PUBLIC WORKS DEPARTMENT	
<i>We are seeking clarification for the facility's proposed water use of 129,172 GPD while the wastewater design flow generation is 54,554 GPD.</i>	Water demand and sewer generation for lab uses can vary and are highly dependent on the specific processes involved. These numbers have been estimated by the Project's MEP Engineer. The difference between the water demand and sewer generation represents water that will be consumed or otherwise used up by lab processes and mechanical equipment (such as evaporative cooling).
<i>We expect to work with the developer on determining the optimum water loop design. The current proposal shows a 10-inch water connection to the site off a 12-inch main on Gould Street and a connection to an existing 8-inch water main on TV place. The additional loop connection may be more optimum if connected from Highland Avenue in front of the development instead of, or an addition to the 8-inch on TV Place connection.</i>	The Applicant will work with the Town to coordinate the water loop connection points. Connections to the 12-inch mains in Highland and Gould as described can be incorporated into a future revised utility plan.
<i>We concur with traffic comments/ recommendations prepared by GPI in their April 25, 2022 letter to the Planning and Community Development Office.</i>	Responses to the peer review comments by GPI are included as Exhibit C .
<i>We expect the Developer to work with the town in providing an alteration/taking plan and recordings for a new Road Right of Way layout on Gould Street and to optimize the traffic signals at Highland at Gould.</i>	The Applicant will work with the Town to develop and finalize the necessary alteration/taking plan and recordings for a new Road Right of Way layout on Gould Street and to optimize the traffic signals at Highland at Gould.

Question/Topic	Response
<i>For the new facility, four times the increased flow equates to a total of 126,004 GPD I/I removal anticipated from the development. This may be satisfied by either undertaking a construction project or paying a fee to the Town's I&I program at a rate of \$8.00 per gallon required to be removed. We are in the process of analyzing the target areas for the inflow/infiltration to be removed and expect to work with the developer through the site plan approval process</i>	The Applicant will work with the Town to satisfy the I/I removal requirements.
<i>As part of the NPDES requirements, the applicant must comply with the Public Outreach & Education and Public Participation & Involvement control measures. The applicant shall submit a letter to the town identifying the measures selected and dates by which the measures will be completed in order to incorporate it into the Planning Board's decision</i>	The Applicant understands that the Town's Stormwater Management Program, prepared in accordance with NPDES MS4 General Permit, requires the Town to perform public education and outreach / public involvement and participation. The Applicant will work with the Town to satisfy any of these requirements applicable to the Project.
<i>If emergency generators are proposed, they should indicate on the plans with proper screening and noise reduction according to a sound study for the proposed generators</i>	Emergency Generators will be provided as required by code for life safety and emergency uses. Separate tenant backup generators may also be provided to support the lab and office uses of the building. All emergency generators are currently planned to be located on the roofs behind the mechanical screen walls with final number and locations being determined. The generators will be designed to meet all sound and noise reduction requirements of the Town and state.
PUBLIC HEALTH DIVISION	
<i>Food Establishments will require approval through Food Permit Plan Review, including evaluation of adequacy of dumpsters, grease traps, etc.</i>	Upon selection of final tenants for the restaurant space, all Food Establishment tenants will undergo the necessary permitting and approval process, including review by Needham's Public Health Division. Adequate grease traps are planned for the retail and restaurant space with final design to be determined as the Project advances and tenants are chosen. There will be interior waste/recycling rooms.
<i>Continue working on environmental remediation of the site and provide continual updates to Public Health on remediation efforts.</i>	The Applicant will comply with applicable environmental laws and will provided updates to the Needham Public Health Department as appropriate.

Question/Topic	Response
<i>Obtain MassDEP approval for reclaiming water, specifically for - cooling tower water, toilet and urinal flushing, boiler feed, industrial process water and irrigation for landscaped areas, etc. All these uses are allowed under 314 CMR 20.00., if approved.</i>	No wastewater re-use is planned for the Project. The Project will capture and reuse stormwater and will file for necessary MassDEP permitting.
<i>Any biolaboratory proposed as part of the Project must complete the Public Health Division's online permitting application including provision of proper biohazardous waste containment.</i>	The Applicant will require any life sciences tenants to comply with all applicable rules and regulations.
DESIGN REVIEW BOARD	
<i>Provide Design Review Board with updates to project landscaping, lighting, and screening in connection with the Design Review Board's comments.</i>	The Applicant intends to submit the information requested by the Design Review Board's comments for the Board's consideration.

Planning Board Members
June 30, 2022

EXHIBIT C

**RESPONSE TO GPI COMMENTS ON
TRANSPORTATION IMPACT AND ACCESS STUDY
(557 HIGHLAND AVENUE)**

[see attached]



Memorandum

To: Lee Newman
Director of Community Planning and Development
Town of Needham, MA

Date: June 29, 2022

Project #: 15306.00

From: Sean Manning, PE, PTOE
Matthew Duranleau, PE

Re: Response to Transportation Impact and Access Study
Traffic Peer Review Comments dated May 27, 2022
By Greenman-Pedersen Inc. (GPI)
557 Highland Avenue
Needham, Massachusetts

Overview

VHB has received and reviewed the Transportation Impact and Access Study (TIAS) Transportation Engineering Peer Review submitted to the Town of Needham by the Town's traffic review firm, Greenman-Pederson, Inc (GPI), dated May 27, 2022, for the proposed 557 Highland Avenue redevelopment in Needham, Massachusetts. This memorandum summarizes VHB's responses to the comments. Each comment raised by the reviewer is listed below followed by the response by VHB. The comments follow the format and structure outlined in the Transportation Engineering Peer Review.

Since the submittal of the Transportation Engineering Peer Review, the Proponent has received feedback from the community and the Town of Needham on the proposed Gould Street off-site improvements, including the desire for more family-friendly bicycle accommodations and the wish to reduce the amount of new pavement added on Gould Street. Based on this feedback, the following roadway improvement concepts have been developed:

- › Option 1: Previously Proposed Concept
- › Option 2: Two-Way Separated Bicycle Lanes on East Side with Reduced Gould Street Cross-Section
- › Option 3: Two-Way Separated Bicycle Lanes on West Side with Reduced Gould Street Cross-Section

Concept plans for the three improvement alternatives along Gould Street as well as for the intersection of Central Avenue at Gould Street are included in the Attachments to this memorandum.

The two additional improvement concept plans include dedicated sidewalk-level bicycle facilities in each direction along Gould Street between Highland Avenue and just north of TV Place. In addition, the two additional concepts eliminate the Gould Street dedicated northbound right-turn lane into TV Place and the dedicated southbound right-turn lane onto Highland Avenue based on feedback from the Town of Needham to reduce the amount of pavement. While these turn lanes were included in the initial concept design, the lanes are not required to provide an adequate level of operations for vehicles. Intersection traffic analyses for the new concepts are included in the Attachments to this memorandum.

Peer Review Comments

General Comments

1. As the project directly abuts the state highway layout (SHLO) on Interstate 95 / Route 128 and is anticipated to generate more than 3,000 vehicle trips per day (vpd), the project will require review by the Massachusetts Environmental Policy Act (MEPA) office in the form of an Environmental Notification Form (ENF) and a

mandatory Environmental Impact Report (EIR). An ENF was prepared by the Applicant and noticed in the Environmental Monitor on April 8, 2022. The TIAS was included as a chapter within the ENF. A Certificate on the ENF was issued by MEPA on May 9, 2022. GPI previously provided comments to the MEPA office on behalf of the Town of Needham regarding the ENF, and a copy of these comments is included as an Attachment for reference. Many of GPI's comments were incorporated into the recommendations of the ENF Certificate, which include:

- a. Table 2-9 of the ENF indicates that the traffic operations at the intersections of Highland Avenue / West Street will drop from LOS C to D and the operations of Highland Avenue / Gould Street / Hunting Road will degrade from LOS E to F as a result of the additional traffic generated by the project. The Applicant is requested to explore the feasibility of implementing additional measures to improve operations at these locations, including an additional northbound lane on Hunting Road.
- b. Collision diagrams should be prepared for any study area intersections experiencing an average of more than 3.0 collisions per year and a crash rate higher than the statewide or district-wide average. The Applicant should investigate measures to improve safety and mitigate collision occurrence at any locations where five or more collisions of a similar type have occurred over the analysis period.
- c. The Applicant should perform an estimate of the potential bicycle parking demand generated by the project to ensure adequate bicycle parking is provided for an effective Transportation Demand Management (TDM) program.

Applicant Response: The Draft Environmental Impact Report (DEIR) will incorporate all comments received on the ENF and will include a response to comments chapter that will provide written responses to each respective comment. The DEIR is expected to be submitted on July 15, 2022.

2. The project will also require a Vehicular Access Permit from MassDOT for the proposed change-in-use of the property, as well as for the construction of off-site roadway improvements within the SHLO. As such, the ENF was reviewed by the MassDOT District 6 office, as well as the Public-Private Development Unit (PPDU). The following comments from MassDOT were incorporated into the ENF Certificate issued by MEPA:
 - a. The Applicant should evaluate queuing at the study area intersections to ensure that lengthier queues do not impact the operation of roadways and railways within the study area.

Applicant Response: To understand the queueing impacts of operations at each study area intersection under the 2022 Existing Conditions, 2029 No Build Conditions, and 2029 Build Conditions, queue diagrams have been developed for the weekday morning and weekday evening peak hours. The queue diagrams for each study area intersection are provided in the Attachments to this memorandum.

As shown in the queue diagrams, the addition of the Project-generated vehicle trips is expected to result in minimal changes in queue lengths at most of the study area intersections. For intersections where there is a noticeable impact in queue caused by the Project, mitigation has been proposed to try and offset those impacts.

While the maximum queues on the Highland Avenue westbound approach are expected to extend beyond the I-95 southbound off-ramp under the 2029 Build Conditions with mitigation during both

peak hours, this situation is expected to occur as well under the 2029 No Build Conditions without the Project. As the I-95 southbound off-ramp is over 1,500 feet in length, any queue on the I-95 southbound off-ramp is not expected to spill back onto the I-95 southbound mainline. In addition, the queues on Highland Avenue westbound are not expected to extend back far enough in the 2029 Build Condition to impact the weaving operations between the I-95 northbound off-ramp and the I-95 southbound on-ramp, which are expected to operate at LOS B or better.

- b. The Applicant should perform an analysis of the existing and proposed weave conditions on Highland Avenue to ensure that the increased traffic volumes will not lead to degraded safety conditions in the area of the I-95 / Highland Avenue interchange.

Applicant Response: Weaving analyses based on methodology from the Highway Capacity Manual (HCM) were conducted on Highland Avenue at the I-95 interchange and presented in the TIA. For informational purposes, the weaving analyses results are presented below as well.

Weaving segment analyses were conducted at the following ramp junction locations:

- › Highland Avenue Eastbound between the I-95 Southbound Off-Ramp and the I-95 Northbound On-Ramp
- › Highland Avenue Westbound between the I-95 Northbound Off-Ramp and the I-95 Southbound On-Ramp

Analyses were conducted during the weekday morning and weekday evening peak hours under the 2022 Existing, 2029 No Build, and 2029 Build Conditions. A summary of the weave segment analyses is presented in Table 1 and the detailed analysis worksheets are provided in the Attachments to this memorandum.

Table 1 Weave Segment Capacity Analysis Summary

Location/Period	2022 Existing Conditions			2029 No Build Conditions			2029 Build Conditions		
	v/c ^a	Density ^b	LOS ^c	Demand	Density	LOS	Demand	Density	LOS
Highland Avenue EB between I-95 SB Off-Ramp and I-95 NB On-Ramp									
Weekday Morning	0.53	18.5	B	0.66	24.3	C	0.66	24.7	C
Weekday Evening	0.30	10.2	A	0.38	13.0	B	0.44	15.2	B
Highland Avenue WB between I-95 NB Off-Ramp and I-95 SB On-Ramp									
Weekday Morning	0.22	6.5	A	0.26	7.9	A	0.34	10.1	A
Weekday Evening	0.31	10.9	A	0.38	13.9	B	0.40	14.3	B

a volume to capacity ratio

b density, in passenger cars per mile per lane

c level of service

As shown in Table 1, the weaving locations for the interchange of Highland Avenue at I-95 are expected to operate at LOS C or better during the weekday morning and weekday evening peak hours under the 2022 Existing, 2029 No Build, and 2029 Build Conditions. The addition of Site-

generated traffic is not expected to result in a degrade in level of service for either Highland Avenue weaving location.

- c. The Applicant should coordinate with the Massachusetts Bay Transit Authority (MBTA) to determine the feasibility of additional MBTA Bus Route 59 service closer to the project site and include feasible options in the Draft EIR.

Applicant Response: Prior to the submittal of the FEIR, the Proponent will reach out to the MBTA to understand if there are opportunities to modify bus access in the area to better support transit connectivity to the Project site. As noted in the TIA, the nearest MBTA bus stop to the Site for MBTA Route 59 is nearly a half-mile away on Webster Street. Since the publication of the ENF, the MBTA released a draft plan of the Bus Network Redesign in May 2022. The Bus Network Redesign is a full review and overhaul of all bus routes operated by the MBTA with the goal to create a better experience for current and future bus riders. The MBTA spent several years developing the draft Bus Network Redesign plan based on demographics, employment districts, traffic congestion, and travel patterns. As shown in the draft plan of the Bus Network Redesign, Route 59 is proposed to maintain its existing alignment through Needham while eliminating different variations of the route through Newton to simplify operations. Route 59 is expected to operate every 60 minutes or less between at least 6:00 AM and 7:00 PM, seven days a week.

The Proponent was requested in the ENF certificate to review the feasibility of providing additional MBTA Bus Route 59 service closer to the Site. As currently proposed, Route 59 will not travel closer to the Site than it does under existing conditions and will continue to operate along Webster Street and Central Avenue. As one of the goals of the Bus Network Redesign is to simplify operations, it is unlikely that a new variation of Route 59 would be supported that stops at the Site for some routes and continues to serve the residential areas along Webster Street and Central Avenue for other routes. If Route 59 was revised to directly serve the Site, it would no longer provide access to the residential areas along Webster Street and Central Avenue.

To maintain transit service to the residential areas along Webster Street and Central Avenue while also providing transit connection to the Site, the Proponent is committed to providing a dedicated shuttle service that will run between the Site and nearby public transportation stations, such as the commuter rail at Needham Heights and the Green Line D Branch at Newton Highlands. This will provide a direct connection between the Site and the public transportation network throughout greater Boston without negatively impacting transit service to the existing residential areas in Needham served by Route 59.

- d. MassDOT requests that the Applicant consider installing bicycle and pedestrian improvements on Highland Avenue at the I-95 Interchange to connect with the proposed Complete Streets improvements being installed as part of MassDOT Project #606635 along Highland Avenue.

Applicant Response: Portions of Highland Avenue within the study area are currently under construction as part of the MassDOT Needham-Newton Corridor Project (MassDOT Project No. 606635). As part of this project, new raised bicycle lanes will be constructed in each direction along

Highland Avenue between Webster Street and just east of Gould Street / Hunting Road and between Wexford Street and the Charles River.

The segment of Highland Avenue within the I-95 interchange (including the bridge over I-95) was recently rebuilt and reconstructed as part of the Route 128/I-95 add-a-lane project. Construction was completed in 2018 and included significant improvements to the pedestrian and bicycle accommodations, including new sidewalks and buffered bicycle lanes on each side of Highland Avenue. The buffered bicycle lanes in each direction are separated from the general-purpose travel lanes on Highland Avenue by a painted buffer 2-4 feet in width which provides greater separation between vehicles and bicyclists than provided by traditional bicycle lanes. In addition, pedestrian and bicycle crossings were provided across all the interstate on-ramps and off-ramps, with signage and pavement markings included to enhance the visibility of the crossing pedestrians and bicyclists, with green paint used for the bicycle crossings.

The Proponent will coordinate with MassDOT to ensure the proposed improvements along Gould Street will tie into the accommodations along Highland Avenue. As the design for Highland Avenue went through many years of review and coordination, the Proponent will respect the recent and ongoing work on Highland Avenue and enhance the connections between Highland Avenue, the Site, and the nearby residential areas.

- e. The Applicant should provide a description of the methodology to be used to estimate the effectiveness of the proposed Transportation Demand Management (TDM) measures and discuss what remedial measures will be taken if the monitoring program indicates that the TDM program is less effective than anticipated in reducing single-occupant vehicle (SOV) trips and encouraging alternative means of travel to/from the site.

Applicant Response: The success of the TDM plan will be measured based on the results of the transportation monitoring program. The transportation monitoring program will include annual 24-hour driveway and parking garage counts on-Site, peak hour turning movement counts and operational capacity analyses at four nearby intersections, and a travel survey for employees and customers on-Site. The transportation monitoring program will begin six months after full occupancy of the proposed development and continue for a period of five years. The results of each transportation monitoring program will be summarized in a report and provided to MassDOT and to the Town of Needham.

Based on the results of the transportation monitoring program, the Proponent will evaluate the TDM program to see if any modifications are necessary to further engage the employees and patrons of the Site to encourage the use of walking/biking, carpooling, and public transportation. If the transportation monitoring program indicates that the actual traffic increase generated by the Project exceeds the traffic projections contained within the TIA by ten percent or more, the Proponent will increase funding for the TDM program and add more measures to try and reduce the share of single occupancy vehicles accessing the Site. The Proponent will coordinate with the Town of Needham and MassDOT to determine potential additional TDM measures that could be implemented if the actual Site-generated volumes exceeds the projections in the TIA by 10-percent or more.

- f. The proposed Transportation Monitoring Program should include a travel survey of employees and patrons of the site. Although MassDOT did not provide any further details on this request, it is assumed that the travel survey will be designed to verify the distribution of site-generated trips and mode share in order to assess the efficacy of the proposed TDM program.

Applicant Response: The proposed transportation monitoring program will include an annual travel survey of employees and patrons of the Site. The survey will be conducted by the Proponent and will include details on the mode of transportation employees and patrons use to access the Site as well as the effectiveness of the proposed TDM programs. The survey will also ask about hybrid work schedules to determine how frequently employees commute to the Site versus working from home. The results of the survey will be used to review the current TDM program and decide if any tweaks are necessary to further engage the employees and patrons of the Site to encourage the use of walking/biking, carpooling, and public transportation.

Study Area

3. The TIAS includes an evaluation of the impact to traffic operations associated with the project at a total of twenty (20) intersections, which include all nine of the study intersections included as part of the Traffic Impact Study prepared for the original rezoning. GPI concurs that the study area is appropriate for the size and scale of the development and includes those intersections which are likely to experience a measurable impact from the proposed redevelopment.

Applicant Response: No response needed

Existing Conditions

4. The TIAS included an evaluation of the operations of the study area intersections during the weekday AM and PM peak periods, which are consistent with typical commuter peaks on the adjacent roadway networks. GPI concurs that these time periods represent the critical time periods for analysis as they represent the peak hours of both adjacent street traffic and site-generated vehicle trips.

Applicant Response: No response needed

5. The Existing Conditions Vehicle Volumes were derived from traffic counts obtained from a number of sources, many of which were collected prior to the COVID-19 pandemic. New traffic counts were collected in July 2021 at the following intersections:
- Central Avenue at Cedar Street
 - Central Avenue at Webster Street
 - Highland Avenue at Hunnewell Street

All other traffic counts contained within the traffic study were collected pre-pandemic and adjusted to existing conditions utilizing MassDOT's approved Yearly Growth Factors and balancing between intersections. Regardless of which traffic count was collected more recently, the traffic volumes between intersections were always balanced upward to the higher traffic count. GPI concurs that this methodology is acceptable and will result in the most conservative (highest) estimate of existing traffic conditions through the study area intersections.

Applicant Response: No response needed

6. Traffic counts at many of the study area intersections were obtained from previously seasonally-adjusted traffic volumes from other traffic studies. However, raw traffic counts collected in April 2017 were obtained from the Highland Avenue Reconstruction Functional Design Report for the Highland Avenue / Webster Street intersection. Similarly, raw traffic counts collected in January 2018 were obtained from the Northland Newton Development DEIR for the Highland Avenue intersections with the I-95 Northbound and Southbound ramps. MassDOT Weekday Seasonal Factors data was provided in the TIAS Appendix for the 2019 year only. Since the traffic counts were collected in 2017 and 2018, it would be expected that seasonal adjustment factors for those years would have been used to seasonally adjust the raw traffic volumes. MassDOT's Weekday Seasonal Factors data for 2017 and 2019 both indicate that traffic volumes in April represent above-average conditions for Group Factors U3-U7. Therefore, no seasonal adjustment would be required for the Highland Avenue / Webster Street intersection. It is unclear what, if any, seasonal adjustment factor was applied to the volumes at the Highland Avenue intersections with the I-95 ramps. However, the MassDOT Weekday Seasonal Factors data for 2018 indicates that January traffic volumes for Factor Group U3 represent above-average month conditions. Therefore, no seasonal adjustment factor would be required for the Highland Avenue intersections with the I-95 ramps.

Applicant Response: No seasonal adjustments were applied to the intersection of Highland Avenue at Webster Street, as both the 2017 and 2019 MassDOT seasonal adjustment factors indicate that April represents a month with above-average traffic volumes. To provide a conservative analysis, the volumes at the Highland Avenue intersection with the I-95 ramps were seasonally adjusted by six percent based on the 2019 MassDOT seasonal adjustment factors, which indicate that traffic volumes in the month of January were approximately six-percent lower than average conditions for U3 roadways (principal arterials). While it would have been more accurate to use the 2018 MassDOT seasonal adjustment factors (since the counts were conducted in January 2018), using the 2019 MassDOT seasonal adjustment factors results in a more conservative analysis as the 2018 factors would have resulted in no seasonal adjustment.

7. No adjustment was applied to the traffic volumes collected in July 2021 to account for any variations due to COVID-19. However, these traffic counts were balanced upward with traffic counts collected at adjacent intersections under pre-COVID conditions. GPI concurs that this methodology for adjustment is acceptable.

Applicant Response: No response needed

Collision History

8. Per MassDOT guidelines, collision diagrams should be prepared for any locations that experience an average of more than 3 crashes per year or a crash rate higher than the state or district-wide average. The intersection of Highland Avenue / West Street experienced an average of 4.4 crashes per year and a crash rate higher than the state and district-wide averages. Similarly, the Highland Avenue / Second Avenue intersection experiences an average of 6.6 collisions per year and a crash rate above the state and district-wide averages. Therefore, the Applicant should obtain detailed collision reports for these intersections and prepare collision diagrams to identify any collision patterns occurring at these locations, as well as potential measures to reduce the occurrence of such collisions.

Applicant Response: Based on a review of the crash data, the following five intersections either have a crash rate above the district average or experienced an average of three or crashes per year:

- › Highland Avenue at West Street
- › Highland Avenue at Gould Street / Hunting Road
- › Highland Avenue at 1st Avenue
- › Highland Avenue at 2nd Avenue
- › Hunting Road at Kendrick Street

Of these five intersections signalized intersections, only the intersection of Highland Avenue at West Street has a crash rate higher than the state and district-wide averages. Table 2 summarizes the crash rate for each intersection as compared to the district and state averages:

Table 2 Intersection Crash Rate Comparison

Location	Highland Ave at West St	Highland Ave at Gould St / Hunting Rd	Highland Ave at 1 st Ave	Highland Ave at 2 nd Ave	Hunting Rd at Kendrick St
Intersection Crash Rate ^a	0.86	0.44	0.41	0.64	0.63
District Average Crash Rate ^b	0.71	0.71	0.71	0.71	0.71
Statewide Average Crash Rate ^c	0.78	0.78	0.78	0.78	0.78
Exceeds District/ State Averages?	Yes	No	No	No	No

a intersection crash rates as reported in Table 2 (Vehicular Crash Summary) in the TIA.

b Average crash rate for signalized intersections in District 6 (the district in which Needham is located) based on MassDOT website.

c Statewide crash rate for signalized intersections based on MassDOT website.

It should be noted that several of these intersections are currently being reconstructed or have recently been reconstructed in connection with ongoing roadway improvements being led by MassDOT. The intersections of Highland Avenue at Gould Street/Hunting Road and Highland Avenue at 2nd Avenue are both currently being reconstructed as part of the MassDOT roadway improvements, and the intersection of Highland Avenue at 1st Avenue was reconstructed in 2018. Since the crash data reviewed was between 2015 and 2019, these improvements are expected to address some of the safety concerns and are not reflected in the crash data.

Collision diagrams have been developed at the identified intersections above, except for the intersections of Highland Avenue at 1st Avenue and 2nd Avenue, as the crash data does not reflect roadway improvements

and the project-related impacts are smaller at those two intersections. The collision diagrams are included in the Attachments to this memorandum.

As shown in the collision diagrams, angle crashes were most prevalent at the three intersections studied. At Highland Avenue and West Street, 6 angle crashes and 3 side-swipe, same direction crashes occurred at the intersection and 2 crashes involved bicyclists. At Highland Avenue and Gould Street/Hunting Road, 6 angle and 4 side-swipe, same direction crashes occurred. At Hunting Road and Kendrick Street, 7 angle crashes occurred.

The high prevalence of angle crashes may indicate conflicts between turning vehicles and through vehicles. This could be caused by drivers becoming frustrated with congestion and trying to turn when there are insufficient gaps in opposing traffic. To improve operations and reduce congestion at the three intersections where collision diagrams were developed, signal timing modifications are proposed as mitigation.

9. The following additional intersections also experienced an average of more than three (3) collisions per year, and collision diagrams should be prepared to identify any collision patterns or potential mitigating measures at these intersections:
 - Highland Avenue / First Avenue
 - Hunting Road / Kendrick Street

Applicant Response: As noted in the response to Comment 8, a collision diagram was developed for the intersection of Hunting Road at Kendrick Street. A collision diagram was not developed for the intersection of Highland Avenue at 1st Avenue, as that location was recently reconstructed which is not fully reflected in the crash data.

10. Although the intersection of Highland Avenue / Gould Street / Hunting Road also experienced more than three collisions per year, the crash rate was well below the state and district-wide averages. In addition, significant improvements were recently constructed by MassDOT that may reduce collisions at this location. Further, additional improvements are proposed at this intersection as mitigation for the proposed development, which may also impact collision occurrence. Therefore, preparation of a collision diagram for this location is not required. However, GPI recommends that the proposed Post-Occupancy Monitoring Program include a review of collisions occurring at this location following construction of the proposed mitigation measures to ensure that a new safety issue is not introduced.

Applicant Response: Since the Project is expected to impact operations at the intersection of Highland Avenue at Gould Street/Hunting Road and the proposed mitigation will include geometric and signal changes at this location, a collision diagram was developed, as noted in the response to Comment 8. If requested by the Town of Needham and MassDOT, the Proponent will review crash data at the intersection as part of the proposed Post-Occupancy Monitoring Program to ensure that a new safety issue is not introduced.

2029 No-Build Conditions

11. The Applicant has projected traffic volumes to a seven-year design horizon consistent with MassDOT guidelines utilizing a background growth rate of 1.0 percent per year and adding traffic to be generated by other proposed or approved developments in the surrounding area. GPI concurs with this methodology.

Applicant Response: No response needed

Trip Generation

12. Table 3 of the TIAS notes that the existing site-generated trips were estimated based on empirical traffic counts collected at the site driveways, which show only 887 daily trips are currently generated by the site. It is important to note that these empirical counts were collected in the fall of 2021, during COVID, and as a result, may under-estimate the trips generated by the site pre-COVID when it was fully operational. The use of the lower existing site-generated trips will result in a more conservative (higher) estimate of the net increase in trips generated by the proposed redevelopment.

Applicant Response: Due to a lack of data for traffic volume entering and exiting the existing driveways on-Site prior to the beginning of the pandemic, the existing site-generated trips were counted on July 14, 2021. While this represents a condition during the COVID-19 pandemic, the counts were conducted after the Commonwealth was beginning to enter a "new normal" phase and after the emergency order was rescinded.

To see if the site-generated trips observed in July 2021 generally aligns with the trip generation levels of a car wash and a car dealership, the empirical counts have been compared against the expected rates from the Institute of Transportation Engineers (ITE). Table 3 provides a comparison of the empirical rates for the previous uses and the ITE-generated rates (based on data provided in the ITE Trip Generation Manual). The ITE worksheets for the previous uses on-Site are included in the Attachments to this memorandum.

Table 3 Comparison of Empirical and ITE Trips for Existing Site Uses

	<u>Empirical Counts (July 2021) ^a</u>			<u>ITE Trip Generation</u>		
	<u>Car Dealership</u>	<u>Car Wash</u>	<u>Total</u>	<u>Car Dealership ^b</u>	<u>Car Wash ^c</u>	<u>Total</u>
Weekday Daily						
Enter	233	177	410	489	n/a	n/a
<u>Exit</u>	<u>300</u>	<u>177</u>	<u>477</u>	<u>489</u>	<u>n/a</u>	<u>n/a</u>
Total	533	354	887	978	n/a	n/a
Weekday Morning						
Enter	27	10	37	40	n/a	n/a
<u>Exit</u>	<u>19</u>	<u>5</u>	<u>24</u>	<u>34</u>	<u>n/a</u>	<u>n/a</u>
Total	46	15	61	75	n/a	n/a
Weekday Evening						
Enter	8	21	29	42	27	69
<u>Exit</u>	<u>33</u>	<u>24</u>	<u>57</u>	<u>50</u>	<u>27</u>	<u>77</u>
Total	41	45	86	92	54	146

a Based on actual counts by VHB in July 2021.

b Based on ITE LUC 840 (Automobile Car Sales (New)), using regression equation for daily trips and peak hour of generator trips.

c Based on ITE LUC 948 (Automated Car Wash), using average rates for peak hour of generator trips. No data provided for daily or weekday morning peak hour trips.

As shown in the table above, the empirical counts conducted in July 2021 are measurably lower than what would be expected based on ITE rates. The summer is generally a slower time for the previous uses on Site, especially for a car wash that commonly is busiest in the Winter and early Spring. Since the ITE trip rates are based on data collected at sites across the country over several decades and most-likely from different times of the year, it is not surprising that the empirical volumes do not exactly match the ITE-projected volumes and variation between the two sets of data is generally to be expected.

While July 2021 empirical data may represent a slightly lower volume of existing Site-generated trips than the Site may have generated on an average non-summer weekday prior to the pandemic, no adjustments have been made to the trip generation or the analyses presented in the TIA. Since the Site-generated volumes presented in the TIA include a credit for the trips currently generated by the Site, using the lower empirical data provides a much more conservative analysis for the trip generation and intersection operational analyses. Therefore, no changes have been made to the analyses to take further credit for the higher volume of trips that the Site may have generated by the previous uses on-Site.

- The Applicant has estimated the site-generated vehicle trips based on Institute of Transportation Engineers (ITE) trip generation rates for Land Use Codes (LUC) 710 (General Office Building), 760 (Research and Development Center) and 822 (Strip Retail Plaza (<40,000 sf)) and applied a modest credit for internal capture of trips shared between uses on the site. In addition, the Applicant has assumed that 25 to 40 percent of the retail trips will be from pass-by trips (vehicles already on the adjacent roadway network passing by the site while traveling to another destination). GPI concurs with this methodology.

Applicant Response: No response needed

14. Although the Applicant has proposed a significant Transportation Demand Management (TDM) program, the Applicant has not applied any reduction in vehicle trips generated by the project for the implementation of the TDM program. While GPI agrees that this methodology will result in the most conservative (worst case) estimate of project's impacts on traffic operations through the study area, it should not excuse the Applicant from developing an effective TDM program or identify target mode share goals for the proposed TDM program. The Applicant should estimate the potential mode share and vehicle trip reduction anticipated from implementing the proposed TDM program and identify mode share goals to be monitored and evaluated as part of the Post-Occupancy Monitoring Program.

Applicant Response: The Proponent is strongly committed to implementing the TDM measures to the greatest extent feasible to reduce single-occupancy vehicle travel to and from the Site. The Proponent will use the 128 Business Council as a resource when implementing the TDM measures as the 128 Business Council has many years of experience with TDM plans as a Transportation Management Association.

As presented in the TIA, the trip generation estimates were developed assuming 100-percent of the Site-generated traffic would use private vehicles to access the Site. This was a conservative analysis used to identify the "worst-case" scenario of vehicular impacts that the Site could generate. With the proposed TDM program, the investment in pedestrian and bicycle infrastructure, and the dedicated shuttle between the Site and nearby transit stations, the Proponent is committed to ensuring that the percentage of Site-generated traffic using private vehicles is measurably less than 100-percent. With the future of hybrid work schedules and employees working from home, it is also likely that not all employees who work on-Site will commute to the workplace five days a week.

Data from the US Census Bureau was reviewed to determine the actual mode share characteristics for employees who commute to workplaces in the Town of Needham. Based on the data, approximately 95-percent of all employees who commute to workplaces in the Town of Needham do so via private automobile while two percent use public transit and three percent walk or bike. With the strong TDM program and mitigation measures, the percentage of employees that take alternative forms of transportation is anticipated to be higher than that generated by other workplaces within the Town of Needham. The existing mode share data is included in the Attachments to this memorandum.

The success of the TDM plan will be measured based on the results of the transportation monitoring program. The Proponent will use the results of the transportation monitoring program to review the current TDM program and decide if any tweaks are necessary to further engage the employees and patrons of the Site to encourage the use of walking/biking, carpooling, and public transportation.

Transportation Demand Management (TDM) Measures

15. The Applicant has proposed the following transit-related measures as part of the TDM program:
- Explore the feasibility of providing shuttle service connectivity to nearby public transportation nodes (commuter rail and Green Line);

- Require tenants to provide a 50 percent transit pass subsidy for their employees;
- Carpool assistance and incentives;
- Emergency ride home;
- Display in the Main Lobby transportation-related information for tenants' employees and visitors; and
- Promotional efforts.

The Applicant should provide additional information on how carpool assistance and emergency ride home services will be provided, as well as what incentive program may be implemented. In addition to providing shuttle service to nearby commuter rail and Green Line services, the Applicant should explore the possibility of extending bus service to the site.

Applicant Response: The Proponent is committed to having an on-Site Employee Transportation Coordinator. Part of the job of the Employee Transportation Coordinator may be to assist in helping employees coordinate carpools, such as by creating a database of employees interested in carpooling and linking them with other employees interested in carpooling who live in the same direction. The Employee Transportation Coordinator may also provide incentives such as raffles with small prizes and other events to promote carpooling and commuting via transit, walking, and biking.

In addition, the Proponent is committed to joining the 128 Business Council, which serves as the Transportation Management Association (TMA) for the local area. As members of the 128 Business Council, employees on-Site will be able to take advantage of their emergency ride home program. The program provides commuters who use alternative transportation with a guaranteed ride home in the event of an emergency. To use this program, employees can be reimbursed for a taxi or ride-share ride for trips within 10 miles of the Site or be reimbursed for the cost of a rental car for trips more than 10 miles away from the Site. Details of the 128 Business Council's emergency ride home program can be found at the link below:

<https://128bc.org/resources/emergency-ride-home/>

As noted in the traffic study, the nearest MBTA bus stop to the Site is nearly a half-mile away on Webster Street along MBTA Route 59. The MBTA in May 2022 released a draft plan of the Bus Network Redesign which proposes to keep Route 59 on its existing alignment through Needham while eliminating variations of Route 59 through Newton to simplify operations. If Route 59 was revised to directly serve the Site, it would no longer provide access to the residential areas along Webster Street and Central Avenue. To maintain transit service to the residential areas along Webster Street and Central Avenue while also providing transit connection to the Site, the Proponent is committed to providing a dedicated shuttle service that will run between the Site and nearby public transportation stations, such as the commuter rail at Needham Heights and the Green Line D Branch at Newton Highlands. This will provide a direct connection between the Site and the public transportation network throughout greater Boston without negatively impacting the existing MBTA bus service through Needham.

Bicycle Accommodations

16. Section 2.3.4.1 of the ENF notes that a total of 89 bicycle parking spaces will be provided indoors and outdoors, while the TIAS describes a total of only 70 bicycle parking spaces proposed on the site. The Applicant should clarify this discrepancy.

Applicant Response: The number of bicycle parking spaces to be provided on-Site has increased since the submittal of the TIA. As currently proposed, the Project will provide covered and secured bicycle parking spaces within its buildings and in outdoor spaces, where public bicycle racks will be installed near building entrances for Project visitors. Specifically, the Project will include up to 104 indoor and secure bicycle parking spaces on-Site for employees and up to 50 outdoor bicycle parking spaces on public bicycle racks for visitors and customers for a total of up to 154 bicycle parking spaces on-Site.

17. No description has been provided within the ENF or TIAS on how many bicycle parking spaces will be indoors and how many will be outdoors. The studies also do not contain any assessment of the potential bicycle parking demand that could be generated and the adequacy of the number of bicycle parking spaces provided to accommodate this demand. The Applicant should provide an evaluation of the potential bicycle parking demand to ensure that adequate bicycle parking is provided to encourage use of bicycle as a means of traveling to/from the site.

Applicant Response: The Project will include up to 104 indoor and secure bicycle parking spaces on-Site for employees and up to 50 outdoor bicycle parking spaces on public bicycle racks for visitors and customers to the Site.

As presented in the TIA, the trip generation estimates were developed assuming 100-percent of the Site-generated traffic would use private vehicles to access the Site. This was a conservative analysis used to identify the “worst-case” scenario of vehicular impacts that the Site could generate. The actual percentage of employees commuting by private vehicle will be less than 100-percent.

To determine if the proposed bicycle parking supply is sufficient for the anticipated bicycle demand, data from the US Census Bureau was reviewed to determine the existing mode share characteristics for employees who commute to workplaces in the Town of Needham. Based on the data, approximately one percent of all existing employees who commute to workplaces in the Town of Needham do so by bicycle (the existing mode share data is included in the Attachments). With the proposed TDM program and the investment in pedestrian and bicycle infrastructure, the percentage of employees arriving and departing by alternative modes of transportation, including by bicycle, is expected to exceed the rates for existing workplaces in the Town of Needham. For the purposes of determining if the proposed bicycle parking supply is sufficient for the anticipated bicycle demand, a conservative five-percent bicycle mode share has been assumed.

Table 4 summarizes the proposed bicycle parking demand for the Project Site based on the trip generation presented in the TIA.

Table 4 Proposed Bicycle Parking Spaces

				Proposed Bicycle Parking		
Period	Vehicle Trips ^a	Bike Mode Share Estimate ^b	Bike Trip Estimate ^c	Long-term Spaces	Short-term Spaces	Total Bike Spaces
Weekday Daily						
Enter	2,536	5% enter	127	104	50	154
Exit	2,469	5% exit	124			

a Total Net New Vehicle Trips expected to be generated by the Project, as presented in Table 2-5 of the TIA.

b Conservative bicycle mode share of five percent based on area projects.

c Estimated daily bike trips generated by the Project assuming a five-percent bike share.

Using a conservative estimated bicycle trip rate, a maximum of 127 entering bicycle trips would be expected to be generated by the Project over the course of an average weekday. As shown in Table 4, up to 154 bicycle parking spaces will be provided on-Site. Since the total number of bicycle parking spaces on-Site will exceed the maximum daily bicycle trips generated by the Site, the bicycle parking supply is expected to be sufficient for the anticipated bicycle parking demand. This is true without considering that not all bicyclists will be on-Site at the same time and thus not all bicyclists will need their own dedicated bicycle parking spaces.

In addition, the Proponent will monitor the actual level of bicycle demand on-Site once the Project opens. If it is determined that the bicycle mode share exceeds the five percent assumed in the bicycle parking demand and additional bicycle parking is required, the Proponent will install additional bicycle parking spaces on-Site.

Proposed Mitigation

- The TIAS describes geometric improvements that are proposed at the intersection of Highland Avenue / Gould Street / Hunting Road as mitigation for the project, which are shown graphically in Figure 16. The widening of the roadway that will be required to accommodate the additional lanes at this location will also likely require reconstruction of the traffic signal at this intersection to accommodate new signal indications and mast arms, as well as vehicle detection and pedestrian signal equipment. No mention of the signal upgrades was provided in the TIAS and no signal improvements are shown in Figure 16.

Applicant Response: The widening of Gould Street will likely require the reconstruction of the traffic signal at the intersection of Highland Avenue at Gould Street/Hunting Road to accommodate new signal indications, mast arms, vehicle detection, and pedestrian signal equipment. The Proponent will coordinate with MassDOT and the Town of Needham on this additional construction work as the off-Site mitigation design progresses.

- Figure 16 of the TIAS provides a graphic depiction of the roadway geometry proposed at the intersection of Highland Avenue / Gould Street / Hunting Road and along Gould Street fronting the site. The Figure does not include the Highland Avenue eastbound or Hunting Road northbound approaches to the intersection, so it is difficult to identify what, if any, improvements are proposed on those approaches. However, Figure 1.4 of the ENF also provides a similar graphic that includes all approaches to the intersection. While the geometry on the majority of the approaches appears consistent with the conceptual improvement sketches prepared as part of the former rezoning effort, the Hunting Road northbound approach to Highland Avenue and the

receiving approach on Gould Street are inconsistent with the rezoning plans. The analysis and plans prepared as part of the rezone indicated that two through lanes would be required on Hunting Road with two receiving lanes on Gould Street to accommodate the traffic generated by the project. The capacity and queue analysis summarized in Table 15 of the TIAS indicates that even with the mitigation measures proposed by the Applicant, the Hunting Road northbound movement will operate over capacity at level-of-service (LOS) F during the weekday AM and PM peak hours under 2029 Build with Mitigation conditions. The Highland Avenue eastbound left-turn movement will also operate at LOS F during the weekday AM peak hour. Therefore, the Applicant should consider the feasibility of providing an additional northbound lane on Hunting Road to improve the capacity and operations of this intersection.

Applicant Response: The conceptual improvements proposed as part of the rezoning of the Site were reviewed when developing the mitigation for the Project. The traffic study submitted by GPI for the rezoning of the Site included a conceptual improvement plan at the intersection of Highland Avenue at Gould Street/Hunting Road that included two lanes on the Hunting Road northbound approach, a shared left-turn/through lane and a right-turn lane, and one receiving lane on Gould Street north of the intersection. This geometry matches what is currently proposed by the Proponent. As noted in the ENF, the only difference between the previous concept plan and the plan proposed in the TIA is the exclusion of a dedicated right-turn lane on the Highland Avenue westbound approach, as adding a right-turn lane would introduce a weaving conflict between vehicles on Highland Avenue westbound and vehicles on the I-95 southbound off-ramp that would cause safety concerns. A figure of the concept plan from the GPI traffic study supporting the rezoning of the Site is included in the Attachments of this memorandum for reference.

While expanding the Hunting Road cross-section would provide additional capacity at the intersection, an additional northbound lane cannot be implemented without taking significant property outside of the right-of-way. This would have a major impact on the property at 580 Highland Avenue and could require the razing of the existing house on that property. Therefore, to limit the right-of-way impacts, no expansion of Hunting Road is proposed.

To improve operations on the Hunting Road approach, the proposed signal cycle lengths and/or phase splits during the weekday morning and weekday evening peak hours were further reviewed and adjusted from what was proposed in the previously submitted traffic study. Since the new signalized intersection of Gould Street at the Site driveway is proposed to be coordinated with the intersection of Highland Avenue at Gould Street/Hunting Road, timing adjustments and operation changes at one intersection will also impact operations at the second intersection.

As noted previously, based on feedback from the community and from the Town of Needham, the Proponent has revised the design for the proposed improvements on Gould Street and developed two additional concept plans. The new concept plans both includes sidewalk-level bicycle facilities to provide a family-friendly bicycle accommodation and eliminates the dedicated southbound right-turn lane from Gould Street to Highland Avenue and the dedicated northbound right-turn lane from Gould Street to TV Place to reduce the amount of pavement. The removal of the dedicated southbound right-turn lane also has the added benefit of shortening the pedestrian crossing. The wider Gould Street cross-section was proposed in the 2020 traffic study to support the rezoning of the site based on the "worst-case" scenario for the full buildout of the site and the adjacent Channel 5 property, which included up to 130,000 SF of retail space. As the actual

Project will generate fewer trips than what was evaluated when the cross-section was designed, Gould Street no longer needs to be as expansive to accommodate the Site-generated traffic.

Table 5 summarizes the intersection capacity analyses at the intersections of Highland Avenue at Gould Street/Hunting Road and Gould Street at Site driveway during the weekday morning and weekday evening peak hours with the revised southbound geometry and the revised signal timings in place. The intersection capacity worksheets are included in the Attachments to this memorandum. It should be noted that the elimination of the Gould Street northbound right-turn lane onto TV Place is not expected to impact operations as the northbound approach is under free-flow conditions.

Table 5 Intersection Capacity Analysis Summary – Highland Avenue at Gould Street/Hunting Road

Location / Movement	2029 No-Build Condition					2029 Build without Mitigation					2029 Build with Mitigation				
	v/c ^a	Del ^b	LOS ^c	50 Q ^d	95 Q ^e	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q
Highland Avenue at Gould Street and Hunting Road															
Weekday Morning															
Highland Ave EB L	1.04	>120	F	~93	#234	>1.20	>120	F	~190	#353	0.96	115.7	F	153	#330
Highland Ave EB T/R	0.86	40.2	D	364	#512	0.79	36.6	D	364	#512	0.66	30.2	C	363	503
Highland Ave WB L	0.58	58.6	E	36	83	0.61	65.3	E	38	83	0.42	61.4	E	42	83
Highland Ave WB T/R	0.94	52.1	D	362	#545	1.15	117.8	F	~616	#841	0.97	54.3	D	587	#797
Hunting Rd NB L/T	0.96	89.0	F	206	#434	1.13	>120	F	~263	#480	0.96	96.8	F	265	#433
Hunting Rd NB R	0.48	39.8	D	48	102	0.51	44.0	D	52	102	0.53	46.1	D	93	136
Gould St SB L	0.82	64.8	E	145	#281	0.91	84.5	F	182	#347	0.70	71.7	E	136	180
Gould St SB L/T/R	0.78	59.4	E	137	#264	0.88	77.3	E	175	#335	0.57	72.7	E	107	166
Overall	0.98	55.1	E	-	-	1.20	100.2	F	-	-	0.95	55.5	E	-	-
Weekday Evening															
Highland Ave EB L	>1.20	>120	F	19	57	>1.20	>120	F	27	72	0.60	58.2	E	24	57
Highland Ave EB T/R	0.81	42.3	D	287	440	0.81	42.4	D	290	442	0.74	32.8	C	252	#373
Highland Ave WB L	0.86	83.3	F	100	194	0.87	84.5	F	101	196	0.78	61.6	E	89	#182
Highland Ave WB T/R	1.00	61.7	E	~535	#774	1.07	84.0	F	~599	#861	1.02	61.3	E	~527	#702
Hunting Rd NB L/T	0.56	51.4	D	66	127	0.58	52.2	D	70	134	0.73	61.0	E	65	#126
Hunting Rd NB R	0.10	35.7	D	4	24	0.10	35.7	D	4	24	0.07	34.2	C	0	5
Gould St SB L	0.91	61.1	E	295	#574	>1.20	>120	F	~681	#1051	0.97	61.6	E	310	#376
Gould St SB L/T/R	0.88	56.9	E	284	#554	>1.20	>120	F	~653	#1022	0.76	45.5	D	228	#239
Overall	1.03	59.5	E	-	-	>1.20	>120	F	-	-	1.05	52.9	D	-	-
Gould Street at Wingate Driveway / Project Site Driveway															
Weekday Morning															
Wingate Dwy EB L/T/R	Intersection unsignalized under 2029 No Build Conditions without Mitigation	Intersection unsignalized under 2029 Build Conditions without Mitigation				0.01	61.9	E	0	0					
Site Dwy WB L						0.50	65.0	E	46	90					
Site Dwy WB L/T/R						0.29	62.1	E	25	68					
Gould St NB L/T						0.57	5.0	A	153	m273					
Gould St NB R						0.31	4.0	A	22	m78					
Gould St SB L						0.08	3.1	A	3	24					
Gould St SB T/R						0.15	3.0	A	20	88					
Overall						0.54	7.8	A							
Weekday Evening															
Wingate Dwy EB L/T/R	Intersection unsignalized under 2029 No Build Conditions without Mitigation	Intersection unsignalized under 2029 Build Conditions without Mitigation				0.03	43.4	D	0	12					
Site Dwy WB L						0.75	44.2	D	174	187					
Site Dwy WB L/T/R						0.70	41.6	D	163	176					
Gould St NB L/T						0.31	10.7	B	56	m252					
Gould St NB R						0.07	13.2	B	1	m30					
Gould St SB L						0.03	8.8	A	4	21					
Gould St SB T/R						0.37	11.4	B	124	270					
Overall						0.44	21.8	C							

a Volume to capacity ratio.

b Average total delay, in seconds per vehicle.

c Level-of-service.

d 50th percentile queue, in feet.

e 95th percentile queue, in feet.

95th percentile volume exceeds capacity, queue may be longer.

m Volume for 95th percentile queue is metered by upstream signal.

As shown in the table above, the southbound shared through/right-turn lane is expected to operate at acceptable levels of service without providing dedicated through and right-turn lanes and queues are not expected to spill back to the upstream intersection at the Site driveway. The shared lane is expected to operate at LOS E during the weekday morning peak hour and LOS D during the weekday evening peak hour with volume-to-capacity ratios of less than 0.80 during both peak hours.

During the weekday morning peak hour, while the Hunting Road northbound left-turn/through movements and the Highland Avenue eastbound left-turn movements are still expected to operate at LOS F under the 2029 Build Conditions with the proposed mitigation, the amount of delay and volume-to-capacity ratios are expected to be better than or similar to operations under the 2029 No Build Conditions and the overall intersection delay is expected to be nearly the same as under the 2029 No Build Conditions. During the weekday evening peak hour, the Hunting Road northbound left-turn/through movement is expected to operate at LOS E with the proposed mitigation, which is similar to operations for movements on the other approaches. The intersection of Gould Street at the Site driveway is expected to operate at overall LOS C or better under the 2029 Build Conditions with mitigation.

As noted in the traffic study, construction is currently ongoing on the MassDOT Needham-Newton corridor project along Highland Avenue to improve safety and pedestrian/bicycle accommodations. The project includes geometric and signal improvements along the corridor and new sidewalks and separated bicycle lanes. The roadway redesign project has been in the works for many years and has gone through several rounds of public comments to reach the current construction plan. It should be noted that the MassDOT reconstruction project does not include a significant enhancement of capacity at the intersections along Highland Avenue, as the design prioritizes safety and active transportation enhancements over additional vehicle capacity and several movements are expected to operate at LOS F with the roadway project in place. Since the 2029 No Build Conditions reflect the completed MassDOT roadway design at the intersection of Highland Avenue at Gould Street/Hunting Road, the proposed mitigation at the intersection has been designed to accommodate the additional Site-generated traffic while operating similarly to the 2029 No Build Conditions, which reflects the MassDOT vision of the corridor.

20. Figure 15 of the TIAS depicts improvements to be constructed at the Central Avenue / Gould Street intersection as mitigation for the project, which include restriping of Central Avenue to provide a westbound left-turn lane and installation of a fully-actuated traffic signal. The proposed signal equipment is not depicted on the plans. The Applicant should obtain survey information at this location to verify whether the proposed improvements can be constructed within the publicly-available right-of-way and whether any easements will be required for the proposed signal equipment. In addition, the Applicant should perform vehicle turning movement analysis to verify that the proposed curb radii and STOP line locations will allow emergency vehicles and trucks to safely navigate the intersection without encroaching on opposing traffic flows.

Applicant Response: An updated concept plan has been developed for the proposed improvements at the intersection of Central Avenue at Gould Street and is included in the Attachments to this memorandum. The updated concept plan is based on survey data and includes the proposed location of the signal equipment. As noted on the modified concept plan, a small easement is likely to be required for the installation of a mast arm on the north side of Central Avenue between the driveways for 153 Gould Street and 161 Gould Street. All other signal equipment is proposed to be located within the existing roadway right of-way.

The intersection has been designed to accommodate the turning radii of a WB-40 turning from Central Avenue onto Gould Street without encroaching on opposing traffic flows. This is an improvement over existing conditions where the largest vehicles that can make the turning maneuver without encroaching on opposing traffic flow is a SU-30. Larger vehicles will be able to perform turning maneuvers at the intersection but may result in slight encroachment into the opposing travel lane, which is similar to existing turning movements at intersections along Central Avenue and Gould Street.

It should be noted that the proposed improvements at the intersection of Central Avenue at Gould Street are still in the early design phases and the Proponent will coordinate with the Town of Needham on the specific details of the final design.

Transportation Operations Analysis

21. According to Table 9, the Highland Avenue southbound approach to West Street will operate over capacity with long delays during the weekday PM peak hour under 2029 Build conditions, with an increase in delay of 22 seconds per vehicle generated by the project. The Applicant has not proposed any measures to mitigate this impact. The Applicant should investigate measures to mitigate this significant impact to operations.

Applicant Response: The Proponent has reviewed the signal timings at the intersection of Highland Avenue at West Street during the weekday evening peak hour and determined that if the following signal timing adjustments were made, operations would improve for the southbound approach without adversely impacting movements on the other approaches:

- › Increase cycle length to 125 seconds
- › Provide the following splits for each movement:
 - 51 seconds for the West Street eastbound/westbound approaches, with a 17 second leading eastbound left-turn phase
 - 54 seconds for the Highland Avenue northbound/southbound approaches
 - 20 seconds for exclusive pedestrian crossings

Table 6 summarizes the intersection capacity analyses at the intersection of Highland Avenue at West Street during the weekday evening peak hour with the revised signal timings in place and the intersection capacity worksheets are included in the Attachments to this memorandum.

Table 6 Intersection Capacity Analysis Summary – Highland Avenue at West Street

Location / Movement	2029 No-Build Condition					2029 Build without Mitigation					2029 Build with Mitigation				
	v/c ^a	Del ^b	LOS ^c	50 Q ^d	95 Q ^e	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q
Highland Avenue at West Street															
<i>Weekday Evening</i>															
West St EB L	0.60	26.2	C	70	154	0.61	26.7	C	73	159	0.64	31.4	C	87	178
West St EB T/R	0.46	20.9	C	123	251	0.46	20.9	C	123	251	0.48	24.9	C	148	281
West St WB L	0.36	30.7	C	35	88	0.36	30.7	C	35	88	0.39	36.2	D	42	98
West St WB T/R	0.66	36.3	D	117	229	0.66	36.3	D	117	229	0.71	44.3	D	140	256
Highland Ave NB L/T/R	0.82	28.1	C	225	#664	0.83	29.0	C	229	#675	0.78	26.2	C	254	#669
Highland Ave SB L/T/R	0.97	50.7	D	320	#889	1.05	72.0	E	369	#978	0.98	53.4	D	408	#994
Overall	0.81	35.3	D	-	-	0.85	43.3	D	-	-	0.84	38.4	D	-	-

- a Volume to capacity ratio.
 b Average total delay, in seconds per vehicle.
 c Level-of-service.
 d 50th percentile queue, in feet.
 e 95th percentile queue, in feet.
 # 95th percentile volume exceeds capacity, queue may be longer.

As shown in the table above, modifying the signal timings at this location would reduce the delay for the Highland Avenue southbound movements from 72 seconds to 53 seconds, which nearly offsets the increase in delay caused by the additional Site-generated traffic through the intersection. With the modified signal timings, the overall intersection delay of 38 seconds under the 2029 Build Conditions would be similar to the overall intersection delay of 35 seconds under the 2029 No Build Conditions without the Project in place. In addition, the signal timing adjustments results in volume-to-capacity ratios of less than 1.00 for all movements.

22. The Highland Avenue eastbound through/right-turn movement at the intersection with Webster Street will operate over capacity during the weekday AM peak hour under 2029 Build conditions, with an increase in delay of 26 seconds per vehicle generated by the project. The Applicant has not proposed any measures to mitigate this impact. The Applicant should investigate measures to mitigate this significant impact to operations.

Applicant Response: The Proponent has reviewed the signal timings at the intersection of Highland Avenue at Webster Street during the weekday morning peak hour and determined that if the following signal timing adjustments were made, operations would improve for the eastbound approach without adversely impacting movements on the other approaches:

- › Increase cycle length to 130 seconds
- › Provide the following splits for each movement:
 - 65 seconds for the Highland Avenue eastbound/westbound approaches, with a 16 second leading westbound left-turn phase
 - 28 seconds for exclusive pedestrian crossings
 - 37 seconds for the Webster Avenue northbound/southbound approaches

Table 7 summarizes the intersection capacity analyses at the intersection of Highland Avenue at Webster Street during the weekday morning peak hour with the revised signal timings in place and the intersection capacity worksheets are included in the Attachments to this memorandum.

Table 7 Intersection Capacity Analysis Summary – Highland Avenue at Webster Street

Location / Movement	2029 No-Build Condition					2029 Build without Mitigation					2029 Build with Mitigation				
	v/c ^a	Del ^b	LOS ^c	50 Q ^d	95 Q ^e	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q
Highland Ave at Webster Street															
<i>Weekday Morning</i>															
Highland Ave EB L	0.14	22.7	C	13	50	0.14	22.7	C	13	50	0.12	22.1	C	14	52
Highland Ave EB T/R	1.00	67.6	E	290	#745	1.08	93.4	F	330	#830	0.92	49.1	D	366	#861
Highland Ave WB L	0.55	20.9	C	32	109	0.55	21.5	C	32	109	0.63	27.0	C	39	#152
Highland Ave WB T/R	0.64	18.5	B	180	473	0.64	18.6	B	182	480	0.61	19.1	B	223	531
Webster St NB L/T	0.90	56.0	E	189	#471	0.90	56.0	E	189	#471	0.86	54.6	D	223	#474
Webster St NB R	0.40	24.4	C	25	122	0.40	24.4	C	25	122	0.47	30.2	C	51	177
Webster St SB L/T/R	>1.20	35.0	D	69	#160	>1.20	35.0	D	69	#160	>1.20	39.1	D	82	164
Overall	0.91	39.2	D	-	-	0.95	46.3	D	-	-	0.87	36.8	D	-	-

a Volume to capacity ratio.

b Average total delay, in seconds per vehicle.

c Level-of-service.

d 50th percentile queue, in feet.

e 95th percentile queue, in feet.

95th percentile volume exceeds capacity, queue may be longer.

As shown in the table above, modifying the signal timings at this location would reduce the delay for the Highland Avenue eastbound through/right movements from 93 seconds to 49 seconds, which more than offsets the increase in delay caused by the additional Site-generated traffic through the intersection. With the modified signal timings, the overall intersection delay of 37 seconds under the 2029 Build Conditions would be lower than the overall intersection delay of 39 seconds under the 2029 No Build Conditions without the Project in place.

23. Although not heavily impacted by project-generated traffic, the Highland Avenue westbound left/through movement at the intersection with 1st Avenue will be well over capacity during the weekday PM peak hour under both 2029 No-Build and Build conditions. GPI recommends the Applicant consider measures to reduce delay and improve operations at this location.

Applicant Response: The Proponent has reviewed the signal timings at the intersection of Highland Avenue at 1st Avenue during the weekday evening peak hour and determined that if the following signal timing adjustments were made, operations would improve for the westbound approach without adversely impacting movements on the other approaches:

- › Increase cycle length to 115 seconds
- › Provide the following splits for each movement:
 - 50 seconds for the Highland Avenue eastbound/westbound approaches, with 3 second leading pedestrian intervals
 - 29 seconds for the southbound driveway approach and the crosswalk across Highland Avenue
 - 36 seconds for the 1st Avenue northbound approach

Table 8 summarizes the intersection capacity analyses at the intersection of Highland Avenue at 1st Avenue during the weekday evening peak hour with the revised signal timings in place and the intersection capacity worksheets are included in the Attachments to this memorandum.

Table 8 Intersection Capacity Analysis Summary – Highland Avenue at 1st Avenue

Location / Movement	2029 No-Build Condition					2029 Build without Mitigation					2029 Build with Mitigation				
	v/c ^a	Del ^b	LOS ^c	50 Q ^d	95 Q ^e	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q
Highland Avenue at 1st Avenue															
<i>Weekday Evening</i>															
Highland Ave EB L/T	0.65	23.6	C	192	#418	0.68	24.2	C	203	#444	0.58	22.0	C	231	427
Highland Ave EB R	0.19	2.4	A	0	12	0.19	2.4	A	0	12	0.19	2.7	A	0	24
Highland Ave WB L/T	>1.20	>120	F	~626	#975	>1.20	>120	F	~630	#980	1.08	76.8	E	~651	#1090
1 st Ave NB L	0.69	27.3	C	222	296	0.69	27.3	C	222	296	0.82	46.4	D	291	#532
1 st Ave NB L/T/R	0.55	23.9	C	144	216	0.55	23.9	C	144	216	0.68	37.6	D	207	#396
Driveway SB L/T/R	0.10	44.5	D	2	15	0.10	44.5	D	2	15	0.06	52.1	D	3	13
Overall	0.99	81.5	F	-	-	0.99	82.0	F	-	-	0.95	50.1	D	-	-

a Volume to capacity ratio.

b Average total delay, in seconds per vehicle.

c Level-of-service.

d 50th percentile queue, in feet.

e 95th percentile queue, in feet.

~ Volume exceeds capacity, queue is theoretically infinite.

95th percentile volume exceeds capacity, queue may be longer.

As shown in the table above, modifying the signal timings at this location would reduce the delay for the Highland Avenue eastbound through/right movements from over 120 seconds to 77 seconds, which is better than the operations under the 2029 No Build Conditions without the Project in place. The overall intersection level of service would improve from LOS F to LOS D with the signal timing adjustments.

24. Similarly, the Hunting Road northbound approach to Kendrick Street will be well over capacity during the weekday AM peak hour under 2029 No-Build and Build conditions. GPI recommends the Applicant consider options for reducing delay and improving operations at this location.

Applicant Response: The Proponent has reviewed the signal timings at the intersection of Hunting Road at Kendrick Street during the weekday morning peak hour and determined that if the following signal timing adjustments were made, operations would improve for the northbound approach without adversely impacting movements on the other approaches:

- › Maintain cycle length of 90 seconds
- › Provide the following splits for each movement:
 - 29 seconds for the Kendrick Street eastbound/westbound approaches, with a 12 second leading westbound left-turn phase
 - 37 seconds for the Hunting Road northbound/southbound approaches, with an 11 second lagging southbound left-turn phase
 - 24 seconds for exclusive pedestrian crossings

Table 9 summarizes the intersection capacity analyses at the intersection of Hunting Road at Kendrick Street during the weekday morning peak hour with the revised signal timings in place and the intersection capacity worksheets are included in the Attachments to this memorandum.

Table 9 Intersection Capacity Analysis Summary – Hunting Road at Kendrick Street

Location / Movement	2029 No-Build Condition					2029 Build without Mitigation					2029 Build with Mitigation				
	v/c ^a	Del ^b	LOS ^c	50 Q ^d	95 Q ^e	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q
Hunting Road at Kendrick Street															
<i>Weekday Morning</i>															
Kendrick St EB L/T/R	0.43	19.5	B	109	#252	0.43	19.6	B	110	#253	0.49	23.5	C	124	#298
Kendrick St WB L	0.23	11.0	B	20	71	0.23	11.0	B	20	71	0.26	13.6	B	23	77
Kendrick St WB T/R	0.31	12.4	B	72	213	0.33	12.7	B	78	227	0.37	15.8	B	93	249
Hunting Rd NB T/R	>1.20	>120	F	~285	#461	>1.20	>120	F	~285	#461	0.93	60.3	E	219	#386
Hunting Rd NB R	0.39	0.7	A	0	0	0.39	0.7	A	0	0	0.39	0.7	A	0	0
Hunting Rd SB L	0.42	38.0	D	32	65	0.45	38.2	D	34	69	0.39	34.1	C	31	63
Hunting Rd SB T/R	0.14	24.3	C	28	60	0.14	24.3	C	27	60	0.11	20.8	C	24	54
Overall	0.68	41.7	D	-	-	0.68	42.1	D	-	-	0.67	22.3	C	-	-

a Volume to capacity ratio.

b Average total delay, in seconds per vehicle.

c Level-of-service.

d 50th percentile queue, in feet.

e 95th percentile queue, in feet.

~ Volume exceeds capacity, queue is theoretically infinite.

95th percentile volume exceeds capacity, queue may be longer.

As shown in the table above, modifying the signal timings at this location would reduce the delay for the Hunting Road northbound movements from over 120 seconds to 60 seconds, which is better than the operations under the 2029 No Build Conditions without the Project in place. The overall intersection level of service would improve from LOS D to LOS C with the signal timing adjustments.

It should be noted that the traffic signal at this intersection is coordinated with the intersection of Kendrick Street at the I-95 Southbound Ramps to the east, which was not included as a study area intersection in the TIA. It should be confirmed that modifying the splits at the Hunting Road at Kendrick Street intersection will not adversely impact operations at the adjacent signalized intersection before implementing the signal timing adjustments.

25. The Webster Street and Cedar Street approaches to Central Avenue are expected to operate well over capacity with long delays and queues under 2029 No-Build and Build conditions, particularly during the weekday AM peak hour. The Applicant should investigate options for improving the operations of these intersections,

including conducting a signal warrant analysis to assess whether a warrant for installation of traffic signal will be met at either of these locations.

Applicant Response: As requested, signal warrants have been conducted at the intersections of Central Avenue at Cedar Street and Central Avenue at Webster Street. The warrants have been conducted for the 2022 Existing Conditions, 2029 No Build Conditions, and 2029 Build Conditions. The warrants are based on peak hour data projected throughout the day based on the hourly distribution of traffic at a nearby MassDOT count station on Highland Avenue. Table 10 presents the results of the signal warrant analyses and the warrant analysis worksheets are included in the Attachments to this memorandum.

Table 10 Traffic Signal Warrants Analysis Summary

Location	Condition	Warrant 1 (8-Hour) Met	Warrant 2 (4-Hour) Met	Warrant 3 (Peak Hour) Met
Central Avenue at Cedar Street	2022 Existing	Yes	Yes	No
	2029 No Build	Yes	Yes	No
	2029 Build	Yes	Yes	Yes
Central Avenue at Webster Street	2022 Existing	Yes	No	No
	2029 No Build	Yes	Yes	No
	2029 Build	Yes	Yes	No

Note: Based on 85th-percentile speeds under 40 miles per hour, per posted speed limits on Central Avenue

As shown in the table above, both intersections are warranted by at least one warrant under the 2022 Existing, 2029 No Build, and 2029 Build Conditions. The addition of Site-generated traffic does not trigger an intersection from not having a traffic signal being warranted to warranting a traffic signal.

Since both intersections are warranted under Existing and No Build Conditions and since less than 10-percent of the Project-generated trips are expected to travel through these two intersections, the Proponent is not proposing to signalize either of these intersections. Mitigation for the proposed Project is focused on locations that are expected to carry a higher proportion of Site-generated traffic. However, the signal warrants conducted provide knowledge to the Town of Needham that a signal is warranted to be installed at each of these locations. In addition, the Proponent is proposing to fund the installation of a traffic signal at the intersection of Central Avenue at Gould Street, which is expected to also help operations at these two unsignalized intersections by creating additional gaps in the traffic flow along Central Avenue that will help create additional opportunities for vehicles turning from Cedar Street and Webster Street onto Central Avenue.

26. As noted in Comment 19, even with the proposed mitigation at the Highland Avenue / Gould Street / Hunting Road intersection, some movements will continue operating at LOS F under 2029 Build with Mitigation conditions. Therefore, the Applicant should investigate the feasibility of providing additional capacity at this location to accommodate 2029 Build traffic volumes.

Applicant Response: As noted in the response to Comment 19, additional capacity cannot be provided on the Hunting Road northbound approach without impacting the existing property at 580 Highland Avenue and

potentially requiring the razing of the building. However, the signal timings were reviewed to try and improve operations expected to operate at LOS F.

With the proposed mitigation and signal timing adjustments, the intersection will operate similar to the 2029 No Build Conditions. The 2029 No Build Conditions include the completion of the MassDOT Needham-Newton corridor project along Highland Avenue, which does not include a significant enhancement of capacity at the intersections along Highland Avenue, as the design prioritizes safety and active transportation enhancements over additional vehicle capacity. As the roadway redesign project has been in the works for many years and has gone through several rounds of public comments to reach the current construction plan, the design reflects state and local vision of the Highland Avenue corridor, which allows for occasional movements operating at LOS F in the future.

In addition, the design of the Gould Street cross-section has been revised since receiving the Transportation Engineering Peer Review and two additional alternatives have been created. In response to The Town of Needham directing the Proponent to evaluate concepts that would result in less additional pavement, the revised concepts include a three-lane cross section on the Gould Street southbound approach to Highland Avenue; two left-turn lanes and one shared through/right-turn lane. These concepts result in less pavement and a shorter crossing distance for pedestrians while still providing adequate capacity for the existing and future traffic volumes on Gould Street.

Traffic Monitoring Program

27. The TIAS describes a transportation monitoring program that will be conducted post-occupancy to monitor parking occupancy and traffic operations at four of the study area intersections, including the site driveway. The Applicant should also provide monitoring of the effectiveness of the proposed TDM program in encouraging walking/biking, carpooling, and public transportation travel to/from the site.

Applicant Response: The proposed transportation monitoring program will be expanded to include a travel survey of employees and patrons of the Site. The survey will be conducted by the Proponent and will include details on the mode of transportation employees and patrons use to access the Site as well as the effectiveness of the proposed TDM programs. The survey will also ask about hybrid work schedules to determine how frequently employees commute to the Site versus working from home. The results of the survey will be used to review the current TDM program and decide if any tweaks are necessary to further engage the employees and patrons of the Site to encourage the use of walking/biking, carpooling, and public transportation.

28. The proposed traffic monitoring program will include the collection of vehicle turning movement counts during the weekday AM and PM peak periods at the following study area intersections:
- Central Avenue / Gould Street
 - Gould Street / TV Place
 - Gould Street / Project Site Driveway
 - Highland Avenue / Gould Street / Hunting Road

GPI agrees that these represent the critical locations that would experience the greatest increase in traffic due to the project. However, should the result of the monitoring study indicate that the actual traffic increase generated by the project exceeds the traffic projections contained within the ENF by ten percent or more, the study area for the monitoring program should be expanded to include additional locations to verify that the project's impacts does not create any operation deficiencies at nearby locations. In addition, the monitoring programs should include a capacity and queue analysis to verify the operations of each of the study area intersections under post-occupancy conditions. The monitoring program should also include the collection of daily traffic volumes on TV Place and the Project Site driveway to verify the daily traffic generated by the project.

Applicant Response: The proposed transportation monitoring program will include simultaneous automatic traffic recorder (ATR) counts at each Site driveway for a continuous 48-hour period during a typical week as well as a capacity and queue analyses to verify the operations at the four intersections listed above under post-occupancy condition. If the results of the monitoring study indicate that the actual traffic increase generated by the Project exceeds the traffic projections contained within the ENF by ten percent or more, the Proponent will work with the Town of Needham and MassDOT to determine if the monitoring program should be expanded, and if so, which additional intersections should be included. The Proponent will also further evaluate the TDM program to see if any tweaks are necessary to further engage the employees and patrons of the Site to encourage the use of walking/biking, carpooling, and public transportation if the actual traffic increase generated by the Project exceeds the traffic projections contained within the ENF by ten percent or more.

Site Access and Circulation

29. Figure 2 of the TIAS provides a site plan depicting the proposed layout and traffic circulation on the site. The plan appears to indicate that a loading/unloading area will be provided at the front of the site between Buildings A and B. This loading area is located in close proximity of the signalized intersection of the main site driveway and Gould Street. Vehicles, particularly trucks, stopped in this area could cause a back up of traffic into Gould Street. The Applicant should consider modifications to the site plan that provide a clear separation of loading/unloading areas and through traffic access to the parking fields to ensure traffic does not back up onto Gould Street. In addition, the Applicant should consider limiting hours of deliveries to the site, as a condition of approval, to avoid deliveries occurring between 7:00 AM and 9:00 AM when a high volume of traffic may be entering the site from Gould Street to access the parking garage.

Applicant Response: The Project Site will include two dedicated loading docks, one in each building. The loading docks will allow trucks to load and unload safely within the loading dock area and will not impede traffic flow on the circulating Site roadway. The area in front of the atrium is intended to be used as a pick-up/drop-off area and will likely be used as well by small deliveries, such as food deliveries and UPS/FedEx. The pick-up/drop-off area will be wide enough so that vehicles idling along the curbside will not impede through movements on the circulating Site roadway. Signage and pavement markings will be provided on-Site indicating the use of this area as a pick-up/drop-off zone and directing employees and visitors to the parking fields.

30. A large parking garage is proposed at the northerly end of the site, as well as a small surface parking lot near Gould Street. The Applicant should clearly define who will utilize the surface parking lot. In order to avoid congestion along the main drive aisle through the site, the surface parking lot should be restricted to use by accessible parking spaces, visitors, and brewery patrons (if a brewery is provided) only. All employees of both buildings, including brewery employees, should be directed to park in the parking garage.

Applicant Response: The small surface parking lot is proposed to be used by accessible parking spaces, visitors, and patrons to the retail establishments on Site (the retail tenants for the Site are currently unknown). All employees on-Site (including those for the retail establishment) will be directed to the parking garage and the underground parking area.

31. The site plan included in Figure 2 does not depict any pedestrian connections between the proposed surface parking lot and the buildings. The Applicant should modify the site plan to provide fully accessible pedestrian routes between the surface parking lot and both buildings, as well as to the pedestrian loops around the site.

Applicant Response: The plan has been revised to include a crosswalk and accessible access from the parking lot to the buildings as well as access to the pedestrian loop.

32. The entering travel lane on TV Place is aligned with the sidewalk as it passes by the proposed site driveway. In addition, the exiting lane west of the site driveway is aligned with the entering lane east of the driveway. This has the potential to create a head-on collision between drivers entering and exiting the site as they cross between lanes through the site driveway intersection with TV Place. It also has the potential for entering vehicles on TV Place to drive onto the sidewalk. The Applicant should modify the layout of TV Place to provide better alignment of entering and exiting travel lanes, which may involve additional widening of TV Place to the east of the site driveway and introduction of a raised or striped median island.

Applicant Response: The geometry of TV Place has been modified to better align the entering and exiting travel lanes. In addition, a dashed lane line extension pavement marking will be installed for the through movements on TV Place at the Site driveway to better align eastbound and westbound traffic on TV Place. The modified TV Place geometry is included in the revised Gould Street concept plan included in the Attachments to this memorandum.

33. The Applicant should perform a vehicle turning movement analysis to verify that emergency vehicles and trucks can safely access and navigate the site. This includes delivery, postal, and trash removal vehicles. The Applicant should provide this turning analysis to the Needham Police and Fire Departments for verification that safe and adequate access is provided.

Applicant Response: Turning diagrams within the site have been studied and are provided in the Attachments to this memorandum. The emergency vehicles as well as delivery vehicles can safely access and navigate the site.

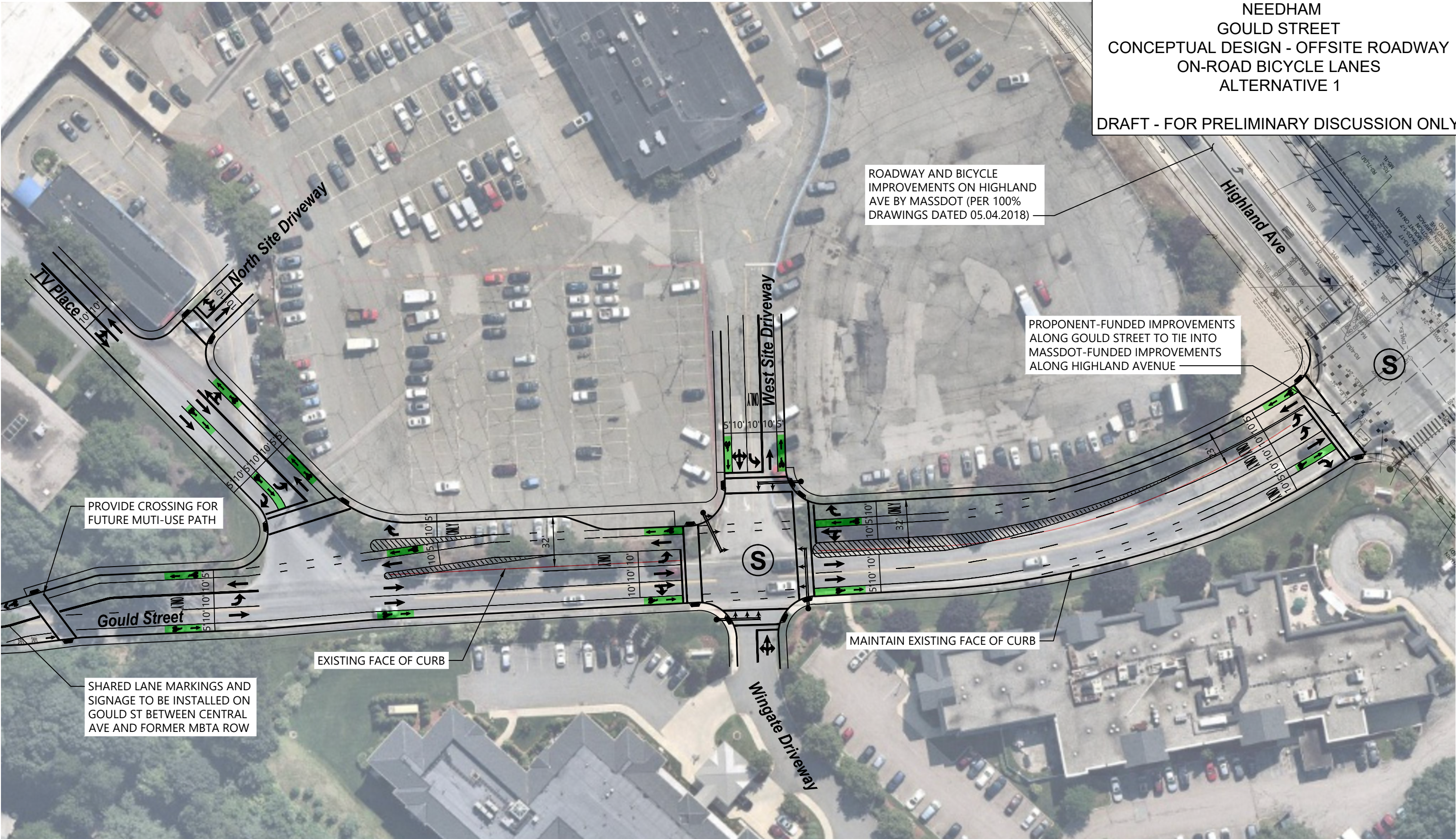
34. Table 15 of the TIAS indicates that queues of nearly 200 feet (eight vehicles) could occur in each lane exiting the site driveway during the weekday PM peak hour. Although the provided plan on Figure 2 is not scaled to be able to accurately measure the available stacking distance, it appears that only 60 feet of stacking distance is proposed in each lane on the site driveway approaching Gould Street before reaching the loading area. Therefore, the queues exiting the site will regularly back up into the loading area and around the corner beyond the driveway to the surface parking lot during the weekday PM peak hour. The Applicant should consider modifications to the site plan to provide additional vehicle stacking exiting the site without interference with the loading area, parking areas, or on-site circulation.

Applicant Response: The Site driveway will be designed to accommodate the queues waiting at the traffic signal at Gould Street. The garage entrance closest to the traffic signal will only provide access to the loading dock, which will be designed so that loading and unloading vehicles will not block the circulating Site roadway. The development is not expected to receive many deliveries during the weekday evening peak hour, but if a delivery truck needs to leave the loading dock and the queue at the signal extends past the loading dock, the delivery truck will be able to turn right onto the circulating Site roadway and exit the Site via TV Place. The entrances to the underground parking area and the free-standing parking garage are around the corner and more than 200 feet away from the signal, providing sufficient room for vehicles to queue without spilling back into the main parking areas. While a queue of 200 feet may extend past the pick-up/drop-off area, that should not be an operational issue as the pick-up/drop-off area will be located on the other side of the circulating Site roadway. Drivers using the pick-up/drop-off area are expected to enter the Site at the signalized driveway and exit the Site at TV Place, traveling in a counterclockwise direction.

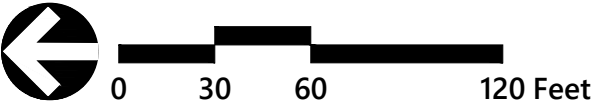
Attachments

- Updated Off-Site Mitigation Roadway Concept Plans
- Queue Diagrams (*Comment 2a*)
- Weave Segment Capacity Analysis Worksheets (*Comment 2b*)
- Collision Diagrams (*Comment 8*)
- Existing Site Trip Generation Calculations (*Comment 12*)
- Existing Town of Needham Mode Share Data (*Comment 14*)
- GPI Gould Street Improvement Concept Plan (*Comment 19*)
- Intersection Capacity Analysis Worksheets (*Comments 19 and 21-24*)
- Traffic Signal Warrant Analysis Worksheets (*Comment 25*)
- Turning Movement Diagrams (*Comment 33*)

Updated Off-Site Mitigation Roadway Concept Plans



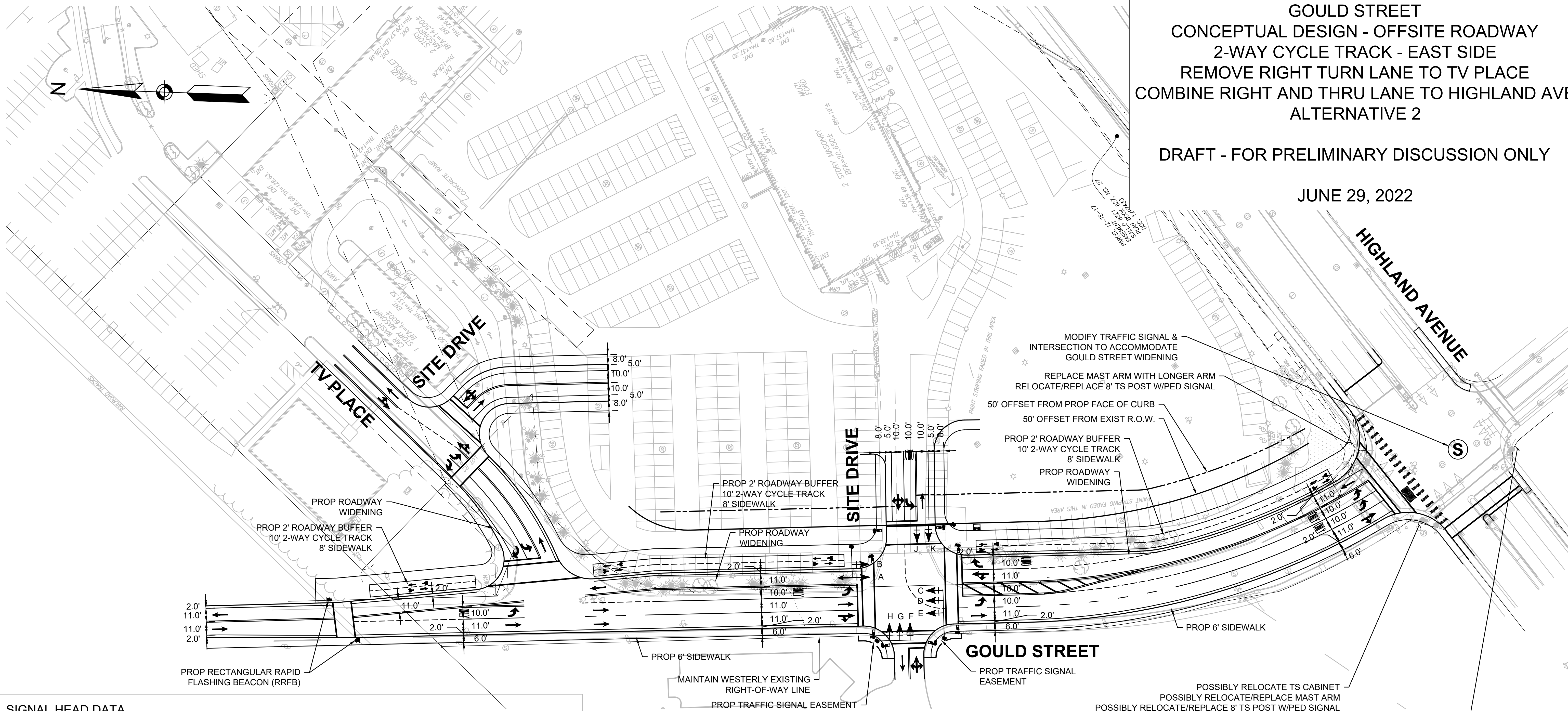
NOT FOR CONSTRUCTION



NEEDHAM
GOULD STREET
CONCEPTUAL DESIGN - OFFSITE ROADWAY
2-WAY CYCLE TRACK - EAST SIDE
REMOVE RIGHT TURN LANE TO TV PLACE
COMBINE RIGHT AND THRU LANE TO HIGHLAND AVE
ALTERNATIVE 2

DRAFT - FOR PRELIMINARY DISCUSSION ONLY

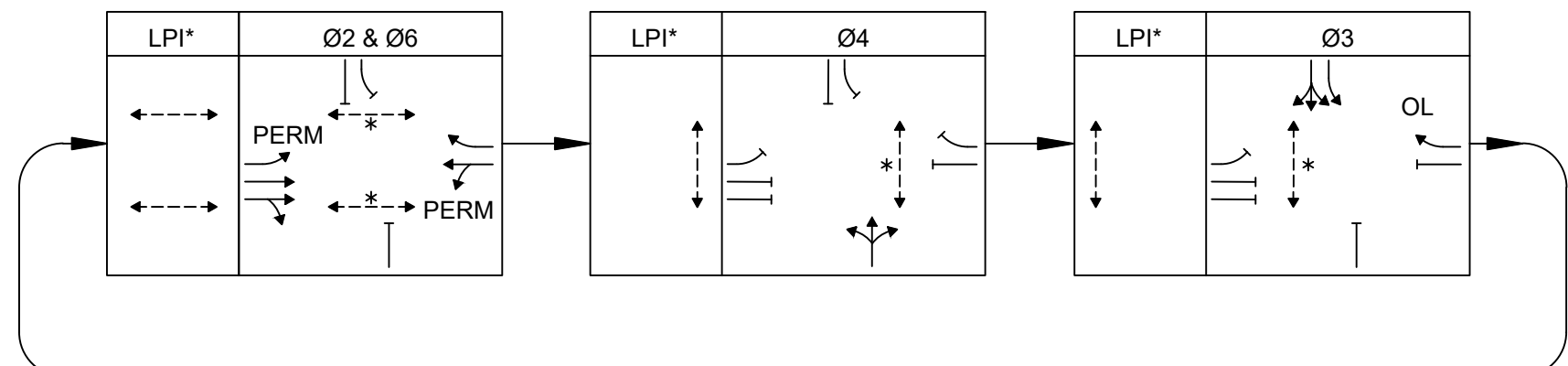
JUNE 29, 2022



SIGNAL HEAD DATA					
A,D,E,H,K	B	C	F	G,J	ALL
ALL 12" LENS					

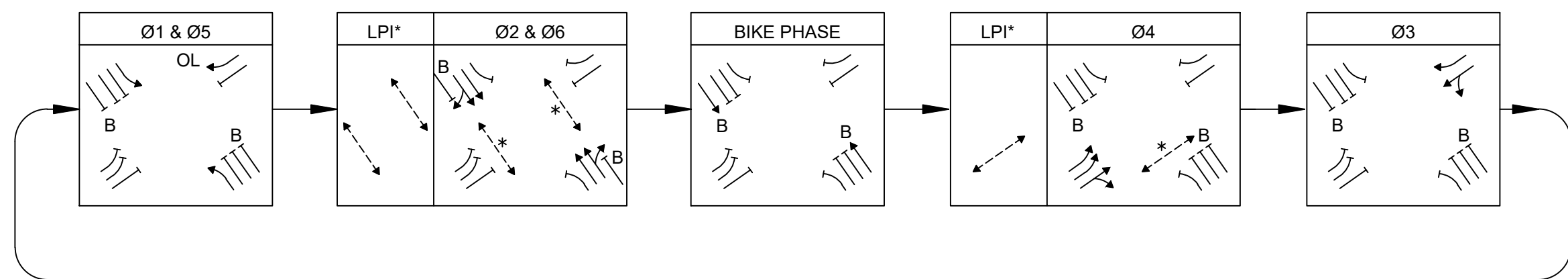
- NOTES:
- ALL SIGNAL HEADS SHALL BE RIGID MOUNTED.
 - ALL SIGNAL HEADS SHALL BE EQUIPPED WITH 5 1/2" NON- LOUVERED BACKPLATES. ALL BACKPLATES SHALL CONTAIN A 3" WIDE YELLOW REFLECTIVE BORDER.
 - ALL SIGNAL HEADS SHALL BE EQUIPPED WITH TUNNEL VISORS.
 - ALL SIGNAL DISPLAYS SHALL BE EQUIPPED WITH L.E.D. MODULES.

SITE DRIVEWAY
PREFERENTIAL PHASE SEQUENCE

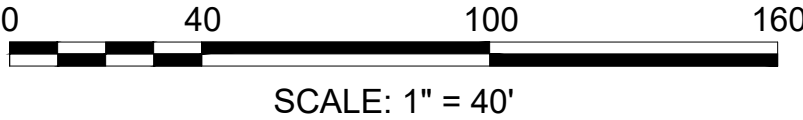


* NORMALLY DW, W/FDW UPON PEDESTRIAN PUSH BUTTON ACTUATION
PERM = PERMISSIVE
LPI = LEADING PEDESTRIAN INTERVAL

HIGHLAND AVENUE
PREFERENTIAL PHASE SEQUENCE



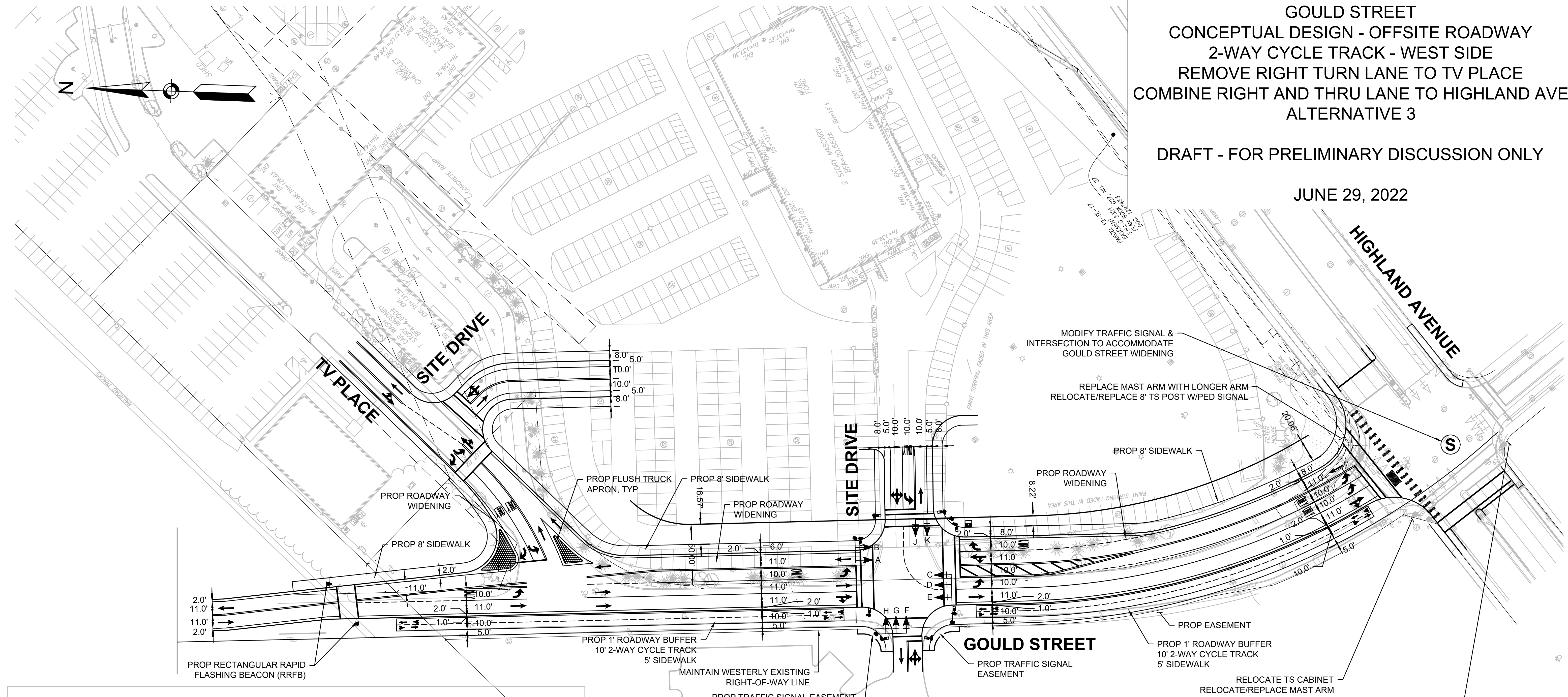
* NORMALLY DW, W/FDW UPON PEDESTRIAN PUSH BUTTON ACTUATION
OL = OVERLAP
LPI = LEADING PEDESTRIAN INTERVAL
B = HIGHLAND AVENUE SEPARATED BIKE LANE



NEEDHAM
GOULD STREET
CONCEPTUAL DESIGN - OFFSITE ROADWAY
2-WAY CYCLE TRACK - WEST SIDE
REMOVE RIGHT TURN LANE TO TV PLACE
COMBINE RIGHT AND THRU LANE TO HIGHLAND AVE
ALTERNATIVE 3

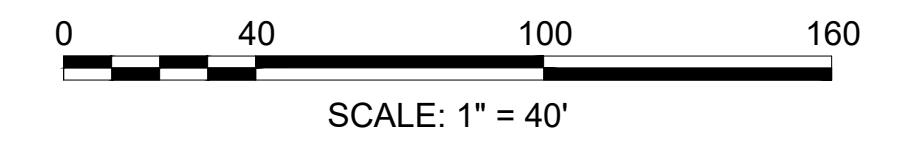
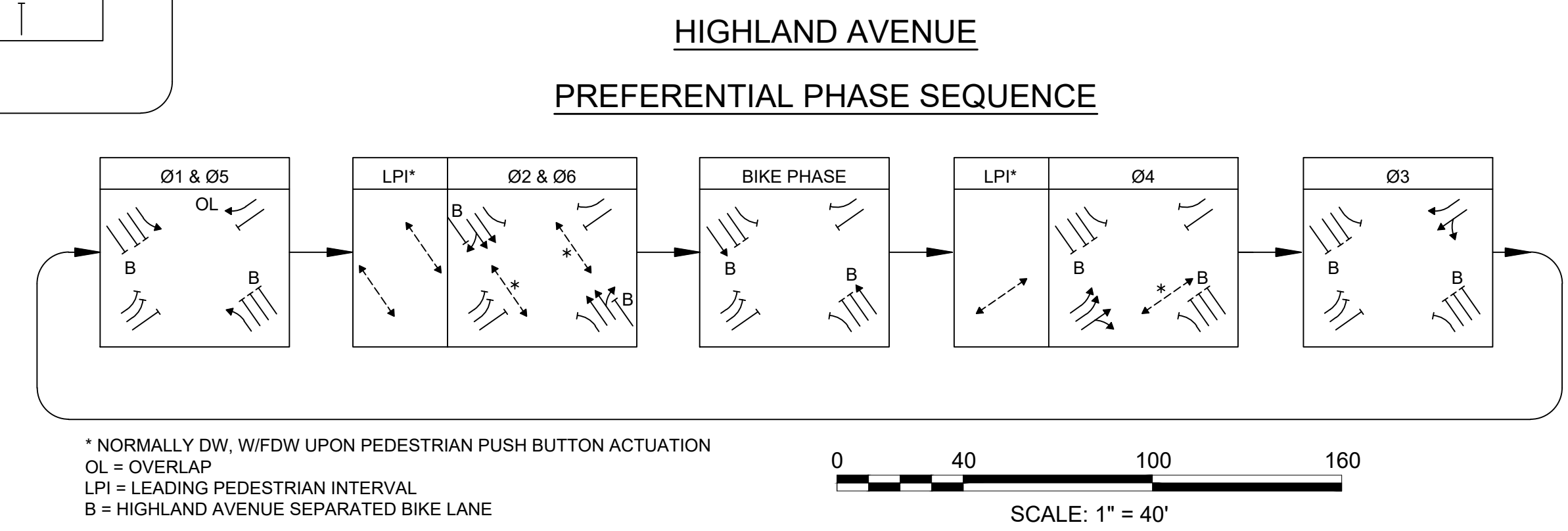
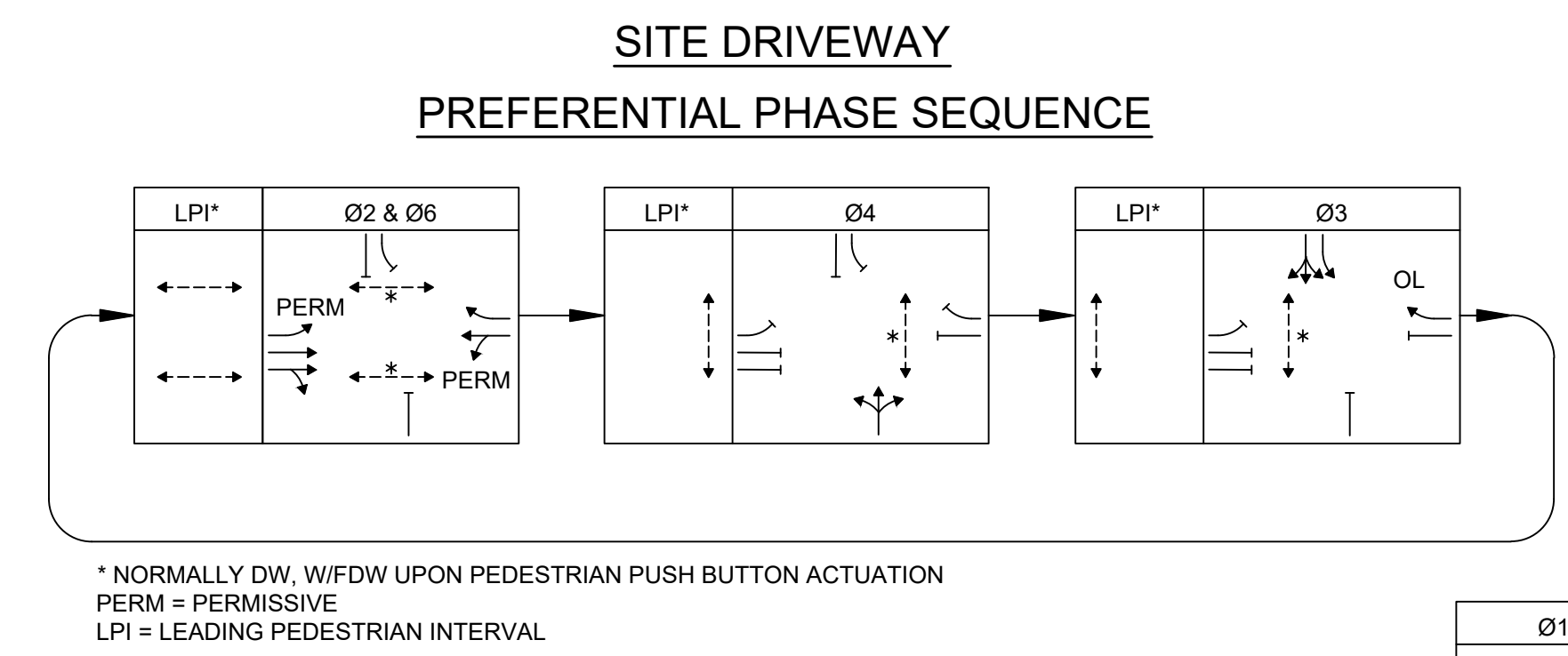
DRAFT - FOR PRELIMINARY DISCUSSION ONLY

JUNE 29, 2022



SIGNAL HEAD DATA					
A,D,E,H,K	B	C	F	G,J	ALL
ALL 12" LENS					

- NOTES:
1. ALL SIGNAL HEADS SHALL BE RIGID MOUNTED.
 2. ALL SIGNAL HEADS SHALL BE EQUIPPED WITH 5"± NON- LOUVERED BACKPLATES. ALL BACKPLATES SHALL CONTAIN A 3" WIDE YELLOW REFLECTIVE BORDER.
 3. ALL SIGNAL HEADS SHALL BE EQUIPPED WITH TUNNEL VISORS.
 4. ALL SIGNAL DISPLAYS SHALL BE EQUIPPED WITH L.E.D. MODULES.



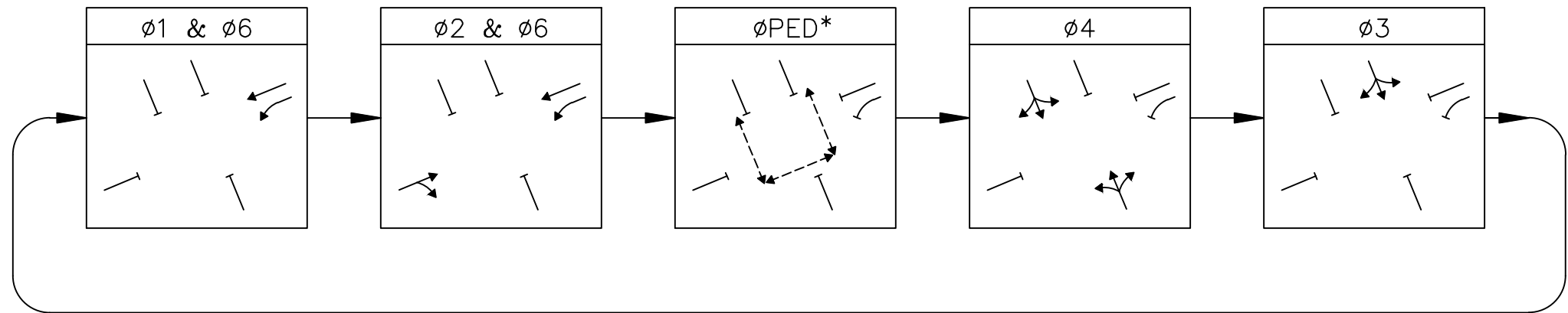
NEEDHAM
GOULD STREET @ CENTRAL AVENUE
CONCEPTUAL LAYOUT

DRAFT - FOR PRELIMINARY DISCUSSION ONLY

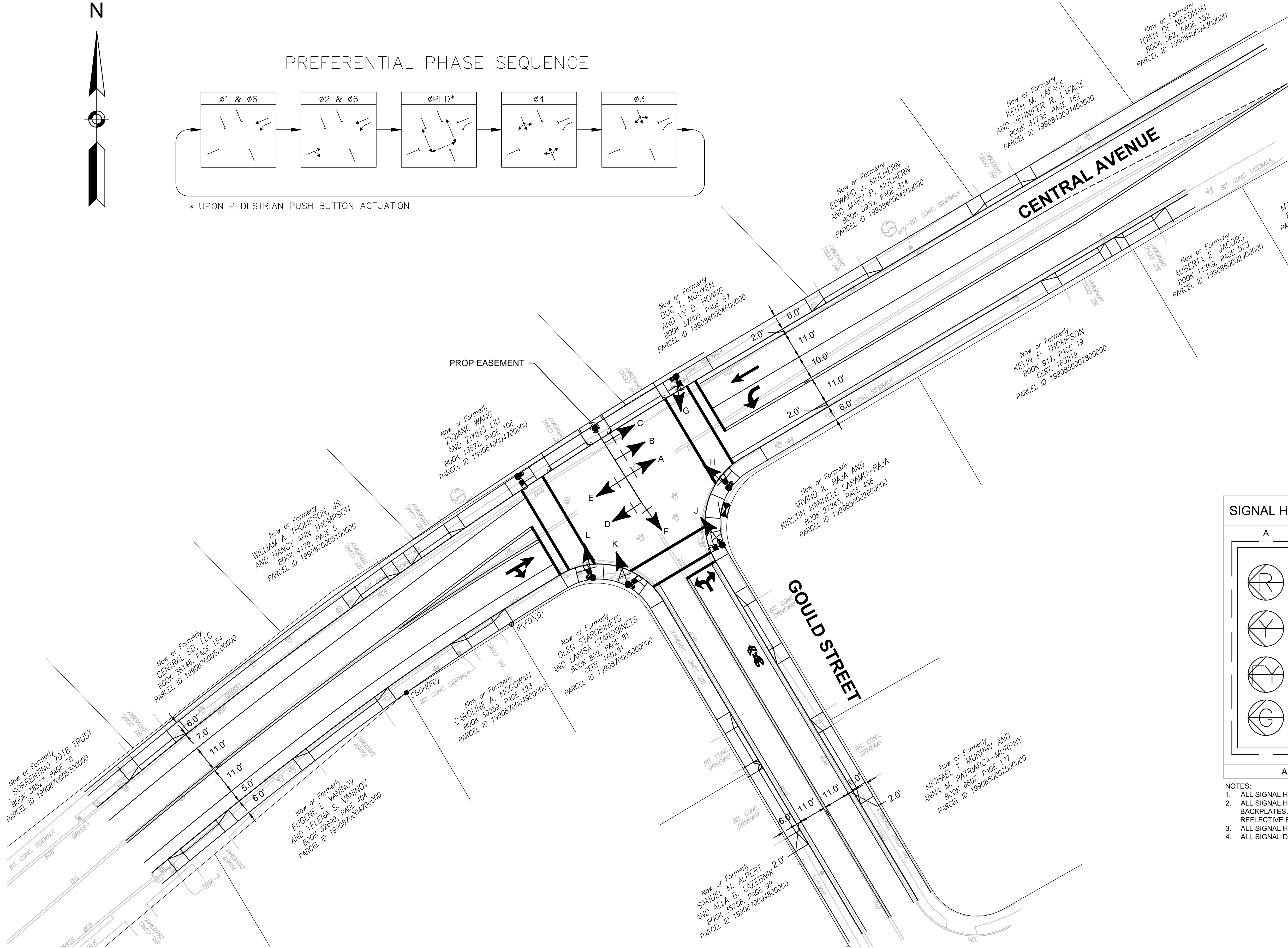
JUNE 27, 2022

N

PREFERENTIAL PHASE SEQUENCE



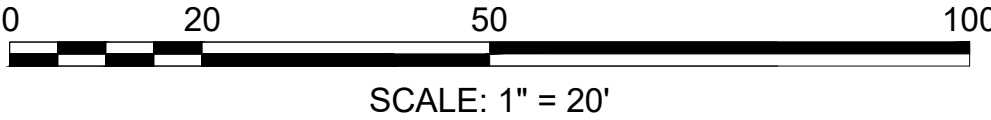
* UPON PEDESTRIAN PUSH BUTTON ACTUATION



SIGNAL HEAD DATA

A	B,C,D,E,F,G,H,J,K,L	ALL
ALL 12" LENS		

- NOTES:
1. ALL SIGNAL HEADS SHALL BE RIGID MOUNTED.
 2. ALL SIGNAL HEADS SHALL BE EQUIPPED WITH 5'± NON- LOUVERED BACKPLATES. ALL BACKPLATES SHALL CONTAIN A 3" WIDE YELLOW REFLECTIVE BORDER.
 3. ALL SIGNAL HEADS SHALL BE EQUIPPED WITH TUNNEL VISORS.
 4. ALL SIGNAL DISPLAYS SHALL BE EQUIPPED WITH L.E.D. MODULES.



Queue Diagrams

Comment 2a

Central Avenue at Cedar Street and Webster Street (Unsignalized)

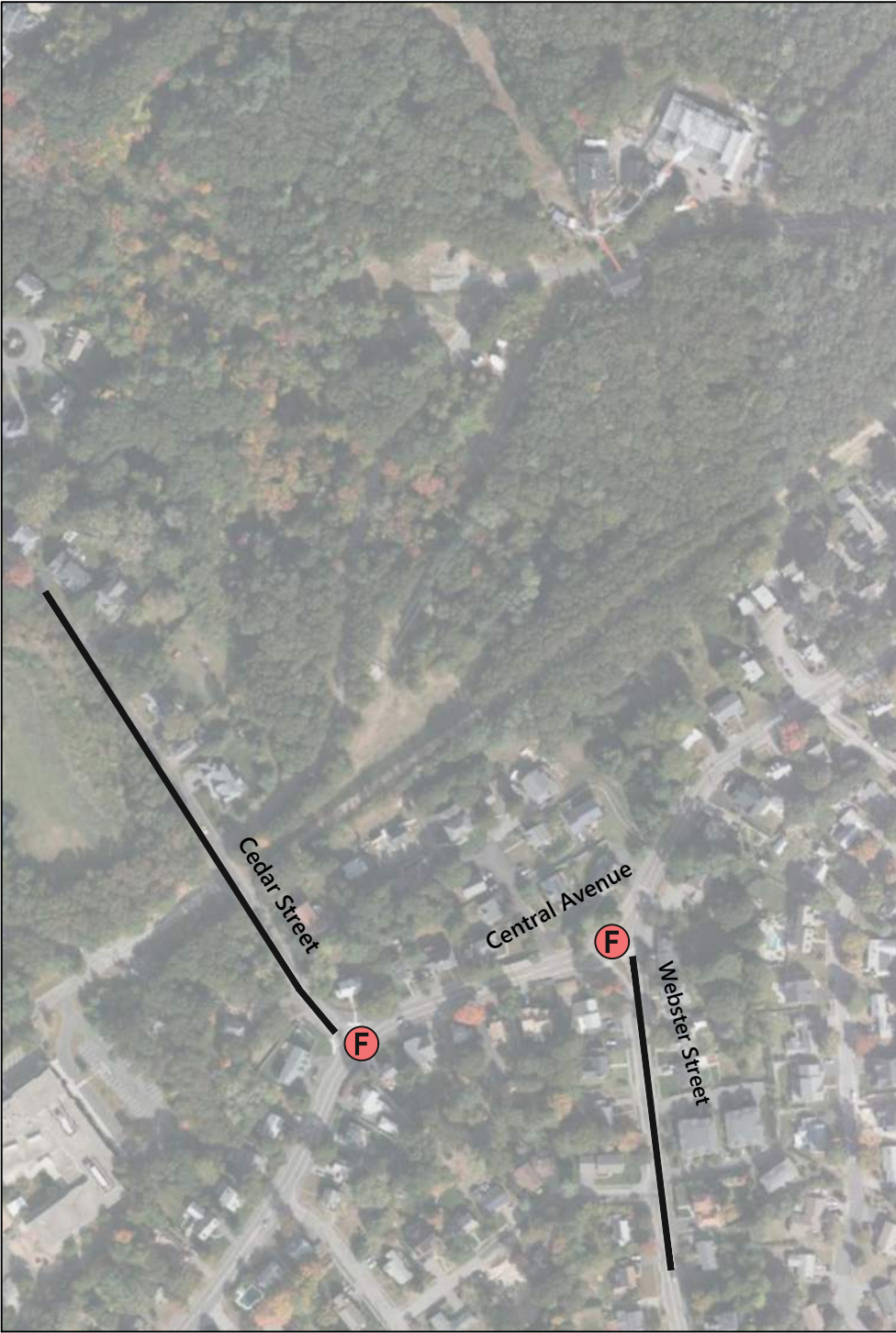
- X

Signalized Intersection Level of Service
- X

Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2022 Existing



2029 No-Build



2029 Build



Central Avenue at Cedar Street and Webster Street (Unsignalized)

- X

Signalized Intersection Level of Service
- X

Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2022 Existing



2029 No-Build



2029 Build



Central Avenue at Gould Street, Hampton Avenue, and River Park Street (Unsignalized)

- X

Signalized Intersection Level of Service
- X

Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2022 Existing



2029 No-Build



2029 Build Without Mitigation



Queue Diagrams
Weekday Morning Peak Hour

557 Highland Avenue
Needham, Massachusetts

Central Avenue at Gould Street, Hampton Avenue, and River Park Street (Unsignalized)

- X

Signalized Intersection Level of Service
- X

Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2022 Existing



2029 No-Build



2029 Build Without Mitigation

* Movement beyond capacity, no results reported.



Queue Diagrams
Weekday Evening Peak Hour

557 Highland Avenue
Needham, Massachusetts

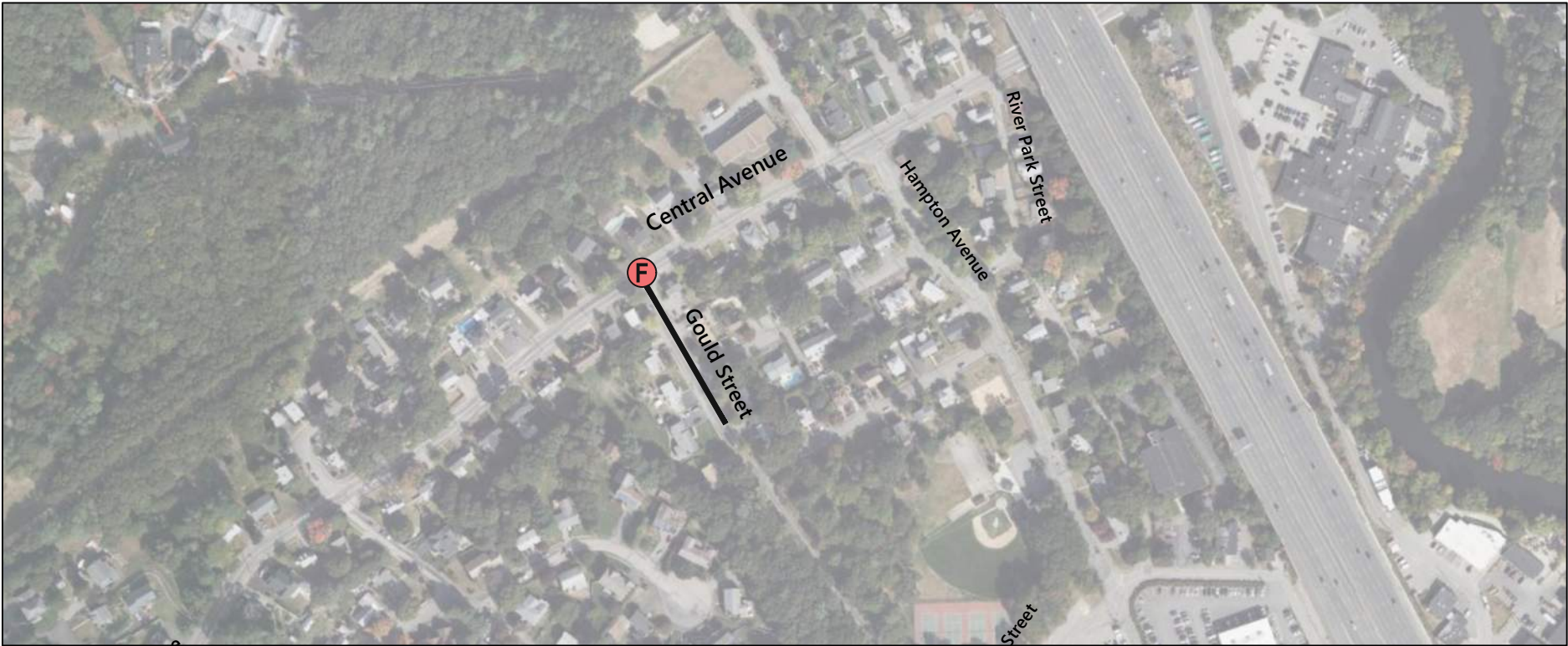


Central Avenue at Gould Street (Unsignalized)

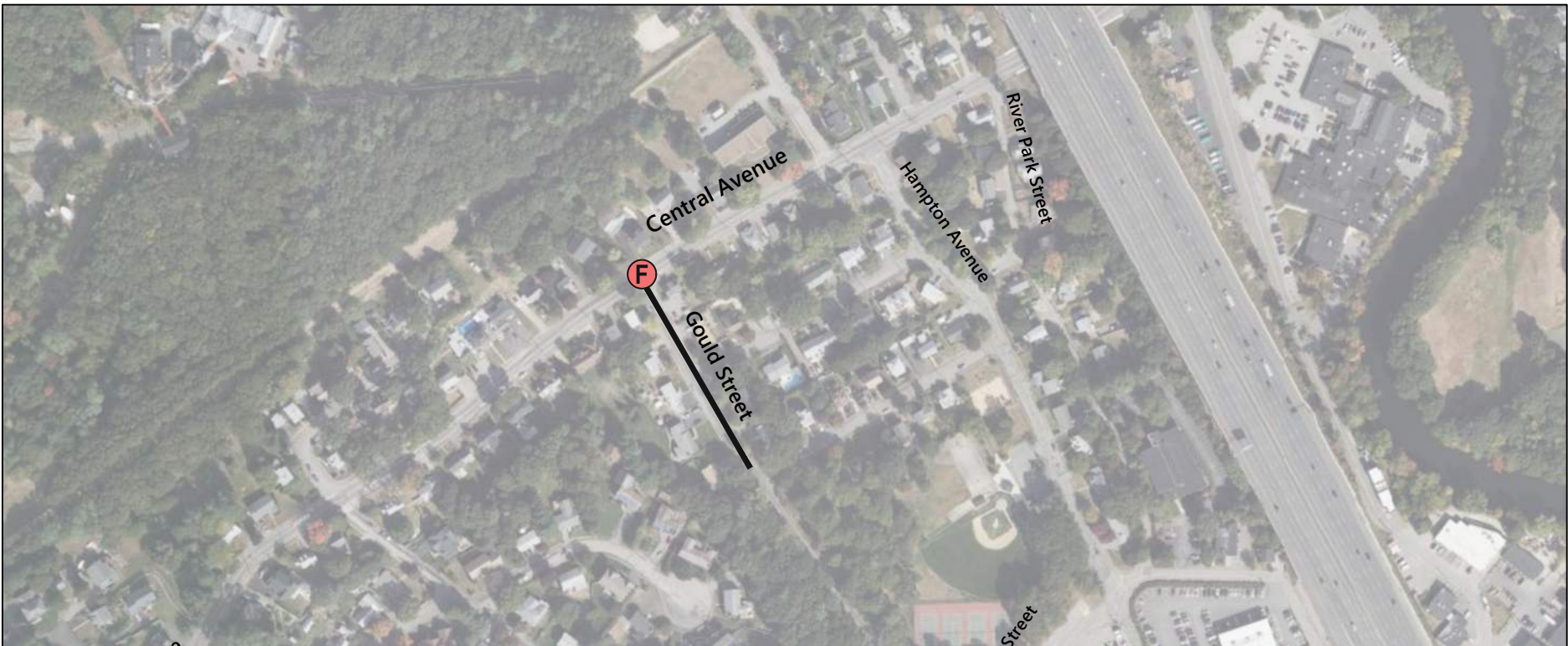
- X

Signalized Intersection Level of Service
- X

Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2029 No-Build



2029 Build Without Mitigation



2029 Build With Mitigation

Central Avenue at Gould Street signalized under mitigation conditions.



Queue Diagrams
Weekday Morning Peak Hour



0 150 300 Feet

557 Highland Avenue
Needham, Massachusetts

Central Avenue at Gould Street (Unsignalized)

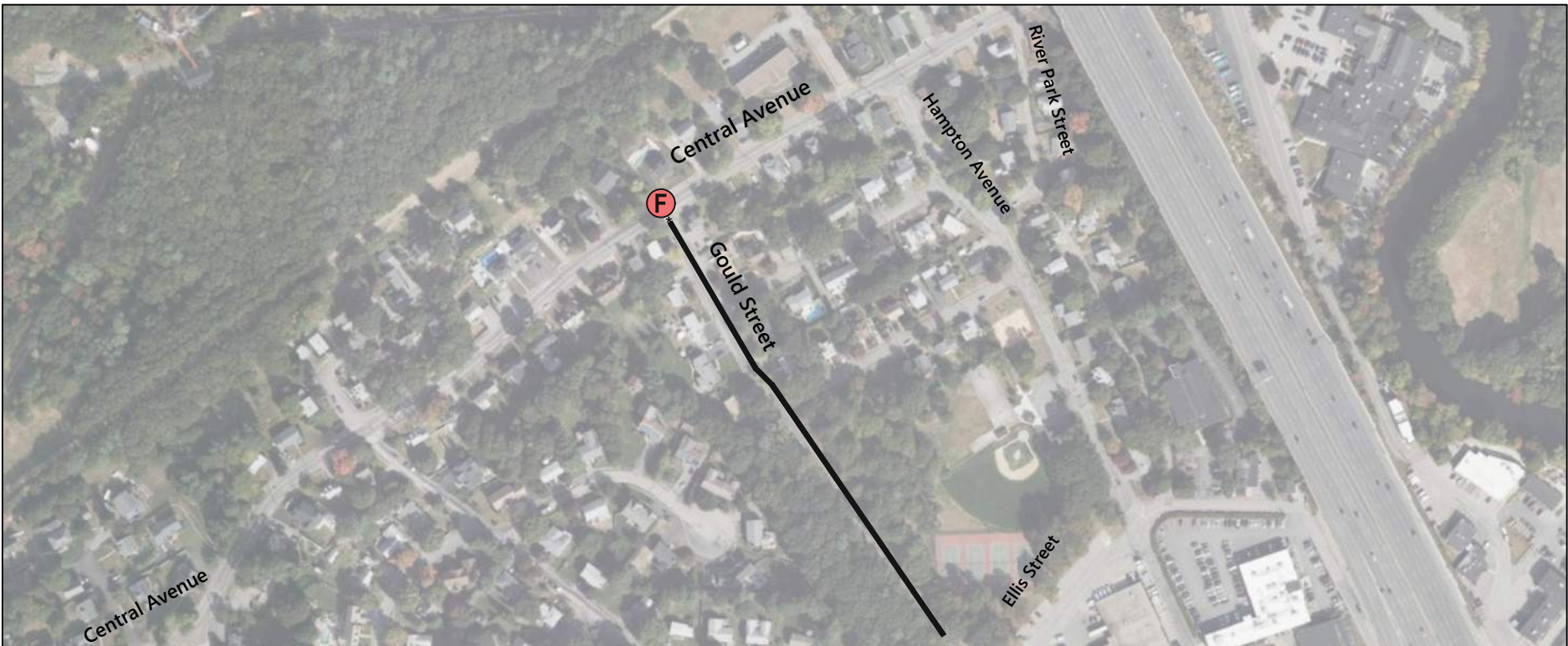
- X

Signalized Intersection Level of Service
- X

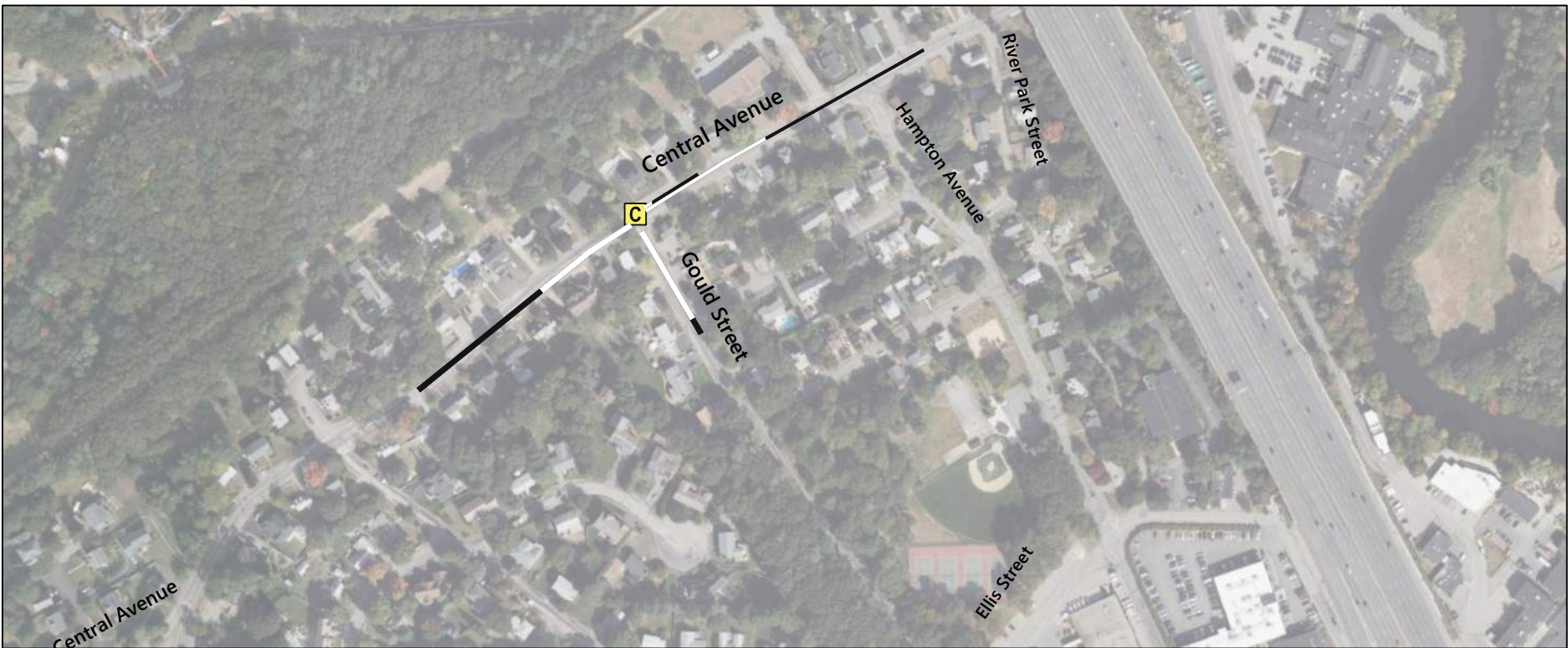
Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2029 No-Build



2029 Build Without Mitigation



2029 Build With Mitigation

* Movement beyond capacity, no results reported.
Central Avenue at Gould Street signalized under mitigation conditions.

Gould Street at Ellis Treet, Kearney Road, Station Road, and Noanett Road (Unsignalized)

- X

Signalized Intersection Level of Service
- X

Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2022 Existing



2029 No-Build



2029 Build

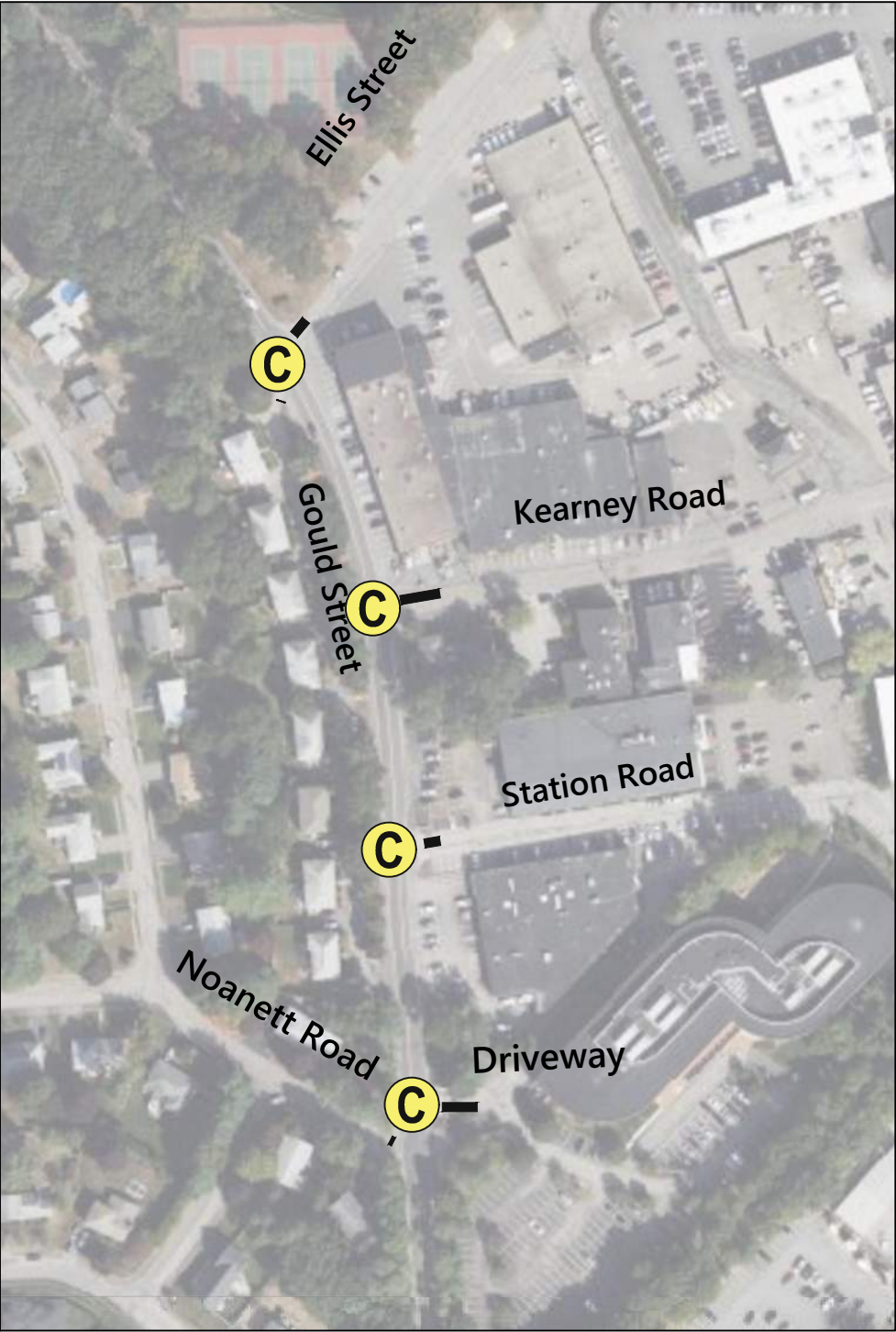


Gould Street at Ellis Treet, Kearney Road, Station Road, and Noanett Road (Unsignalized)

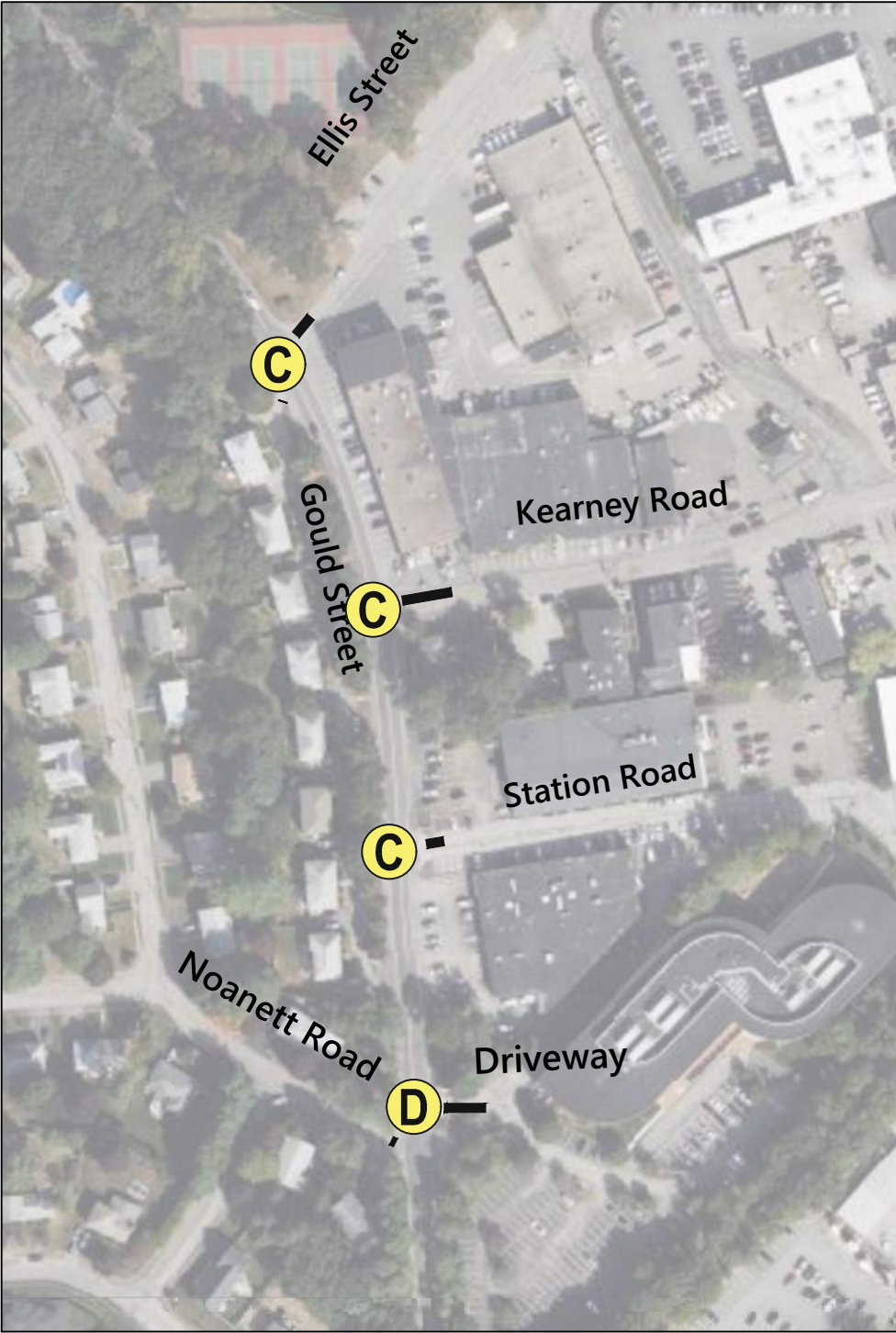
- X

Signalized Intersection Level of Service
- X

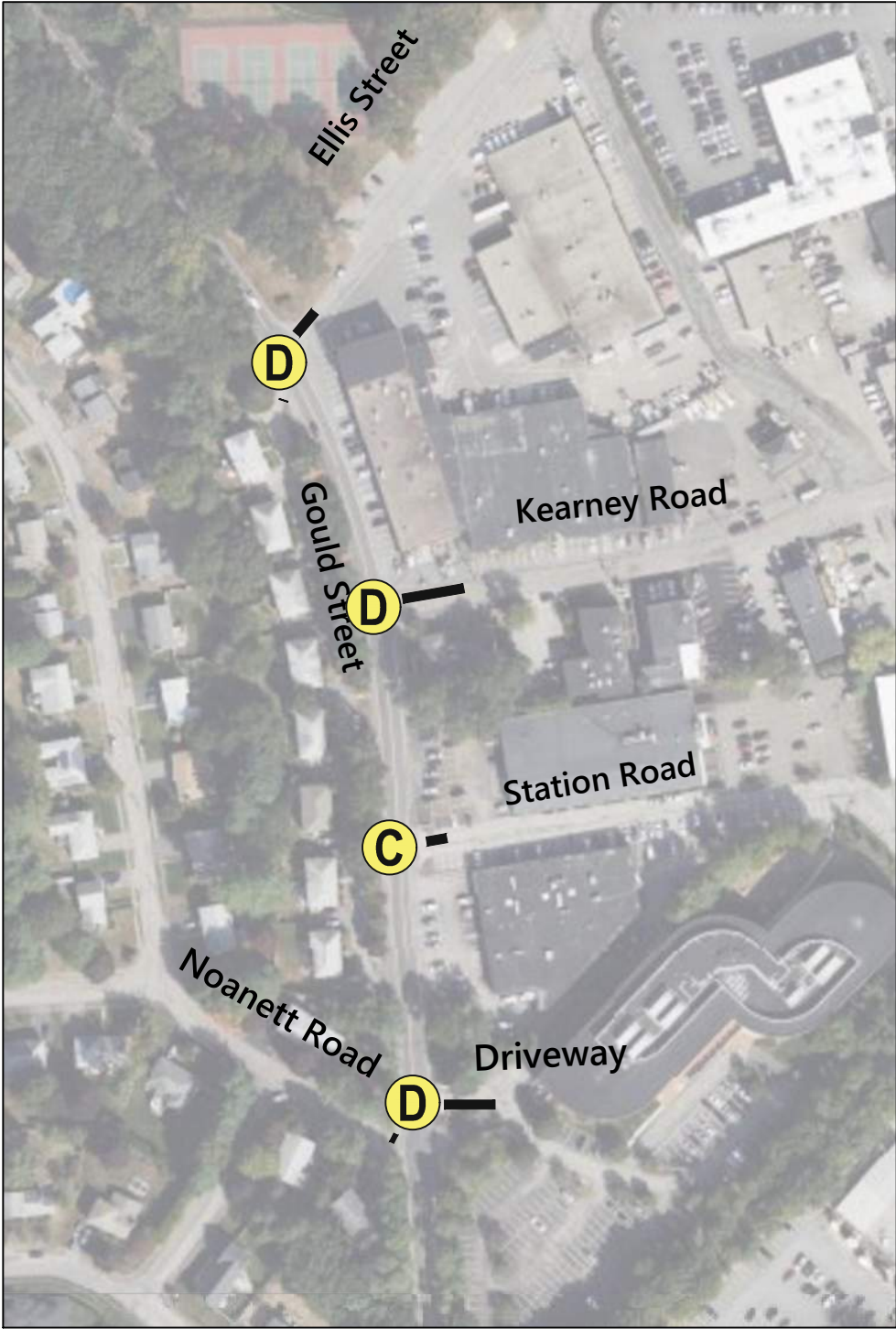
Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2022 Existing



2029 No-Build



2029 Build



Gould Street at Highland Avenue (Signalized), Site Driveway (Unsignalized), and TV Place (Unsignalized)

- X

Signalized Intersection Level of Service
- X

Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2022 Existing



2029 No-Build



2029 Build Without Mitigation



Queue Diagrams
Weekday Morning Peak Hour

557 Highland Avenue
Needham, Massachusetts



0 200 400 Feet

Gould Street at Highland Avenue (Signalized), Site Driveway (Unsignalized), and TV Place (Unsignalized)

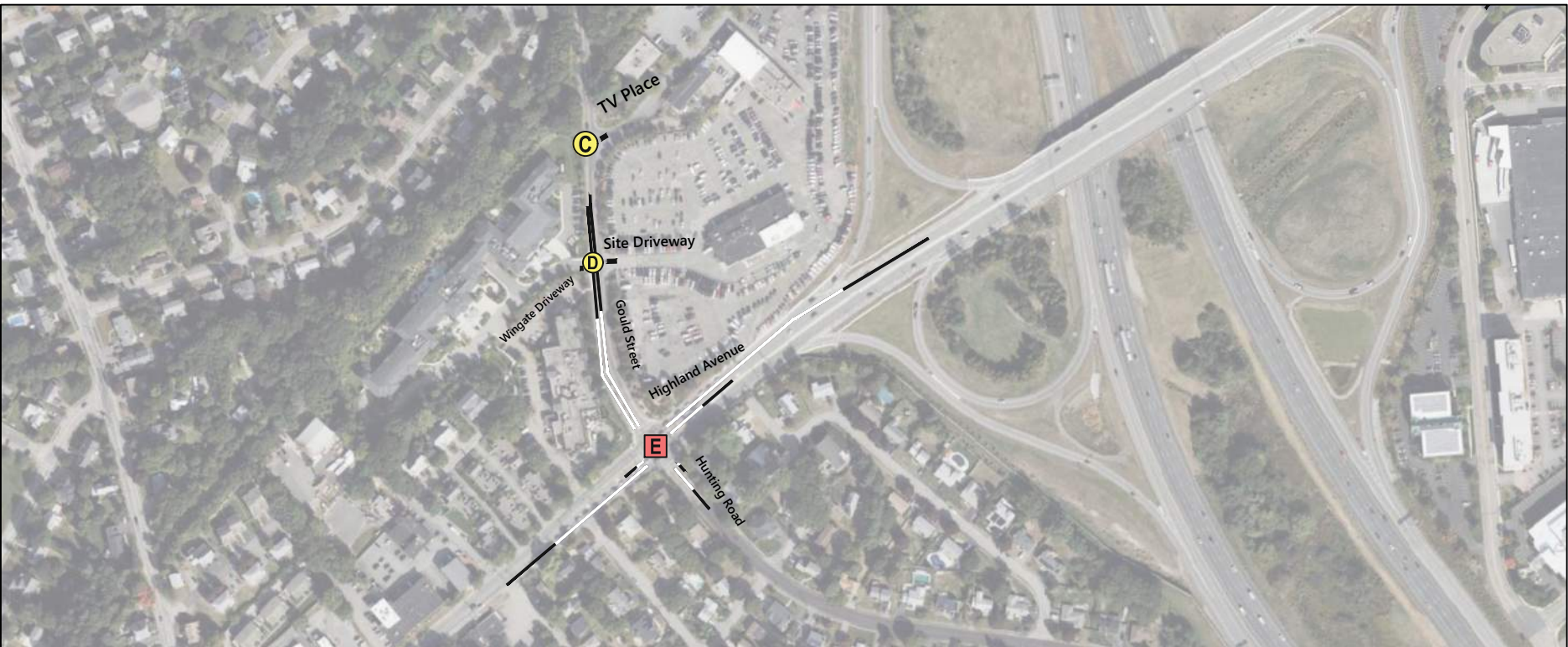
- X

Signalized Intersection Level of Service
- X

Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2022 Existing



2029 No-Build



2029 Build Without Mitigation

* Movement beyond capacity, no results reported.



Queue Diagrams
Weekday Evening Peak Hour

557 Highland Avenue
Needham, Massachusetts



0 200 400 Feet

Gould Street at Highland Avenue (Signalized), Site
Driveway (Unsignlaized), and TV Place (Unsignalized)

[X] Signalized Intersection Level of Service
[X] Unsignalized Intersection Level of Service

50th Percentile Queue
95th Percentile Queue



2029 No-Build



2029 Build Without Mitigation



2029 Build With Mitigation

* Movement beyond capacity, no results reported.
Gould Street at Site Driveway signalized under Mitigation Condition



Queue Diagrams
Weekday Evening Peak Hour



557 Highland Avenue
Needham, Massachusetts

Highland Avenue at West Street (Signalized) and Hunnewell Street (Unsignalized)

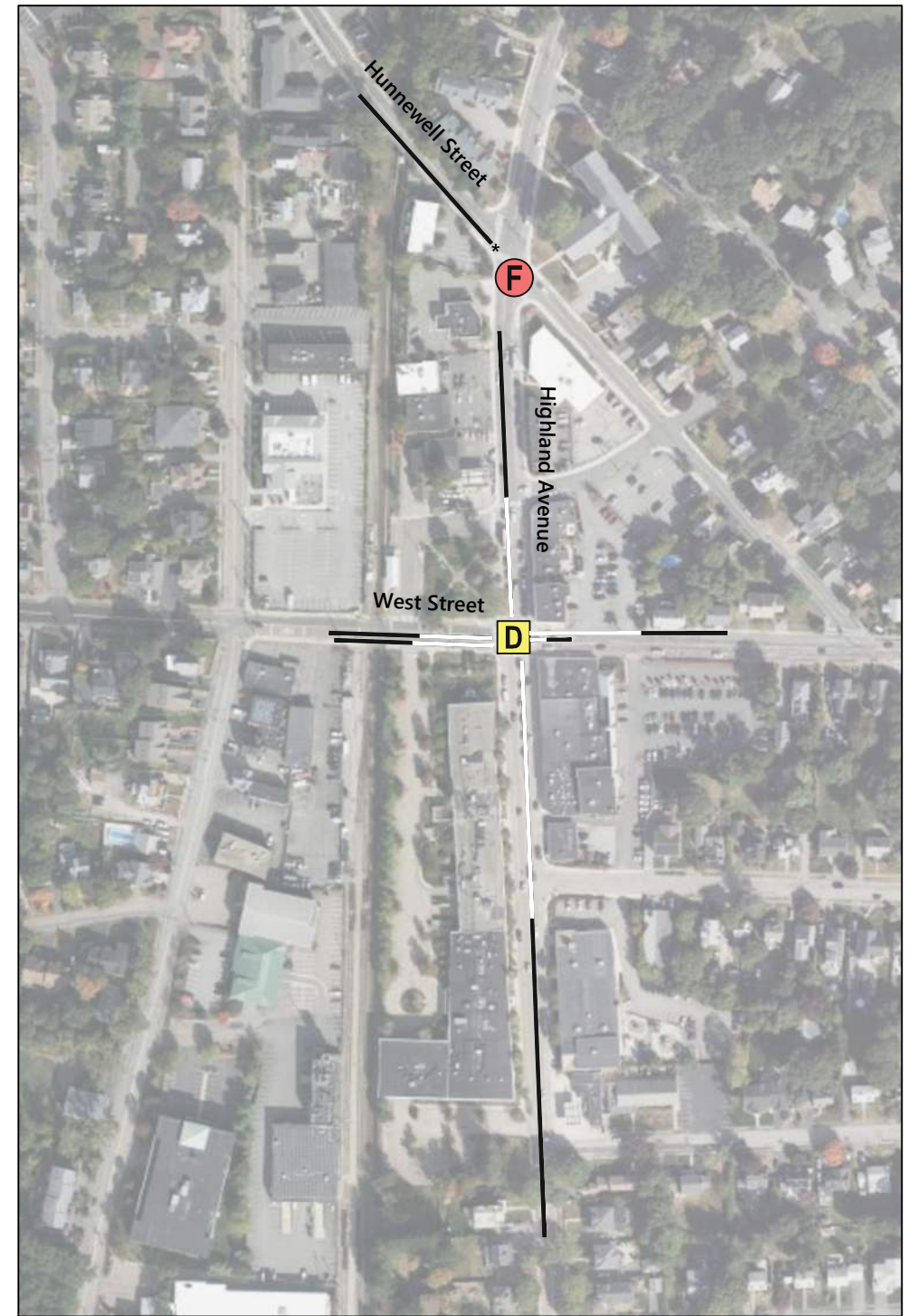
[X] Signalized Intersection Level of Service 50th Percentile Queue
[X] Unsignalized Intersection Level of Service 95th Percentile Queue



2022 Existing

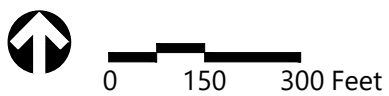


2029 No-Build



2029 Build Without Mitigation

* Movement beyond capacity, no results reported.



Queue Diagrams
Weekday Morning Peak Hour

557 Highland Avenue
Needham, Massachusetts

Highland Avenue at West Street (Signalized) and Hunnewell Street (Unsignalized)

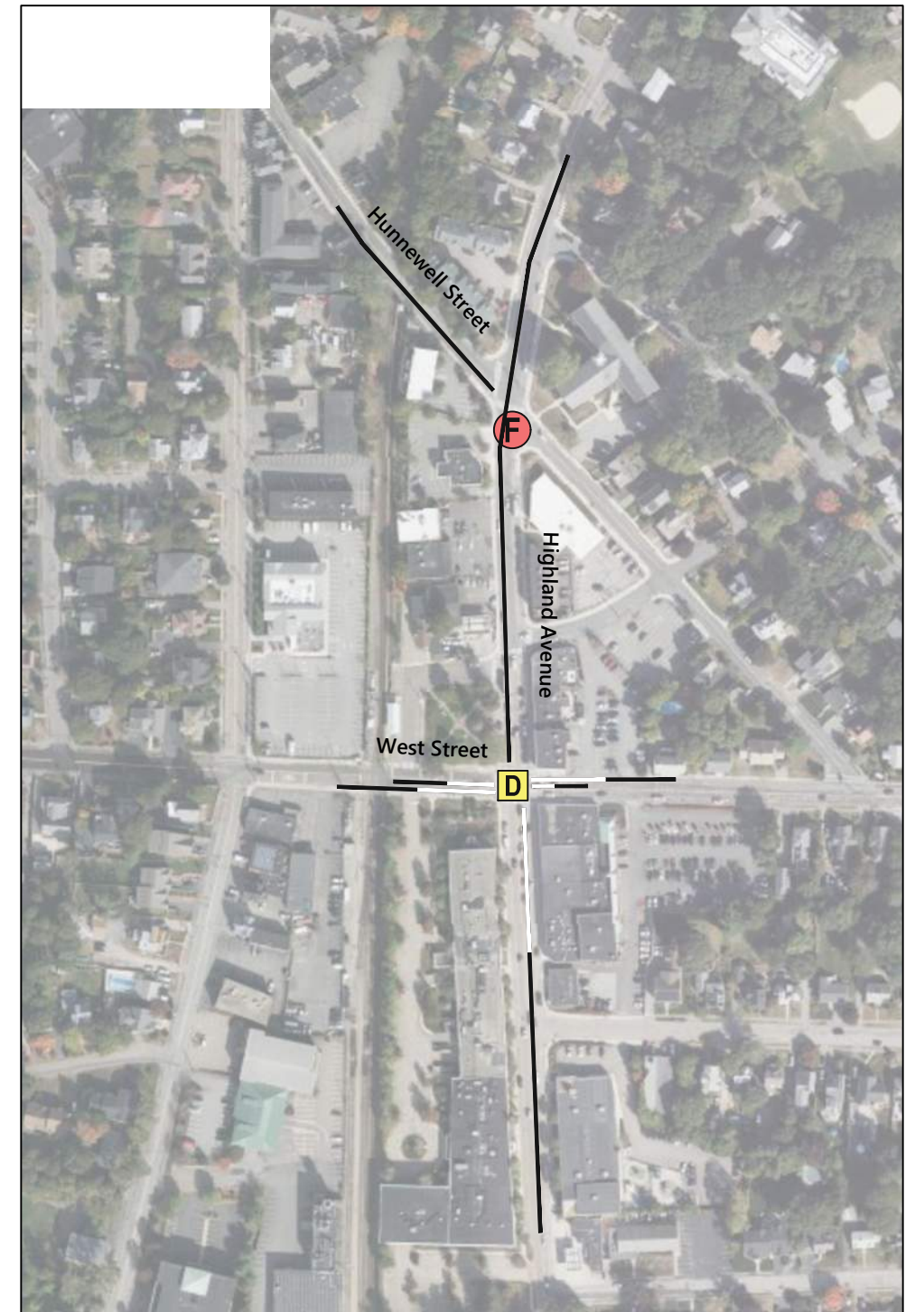
[X] Signalized Intersection Level of Service [Grey Line] 50th Percentile Queue
[X] Unsignalized Intersection Level of Service [Thick Black Line] 95th Percentile Queue



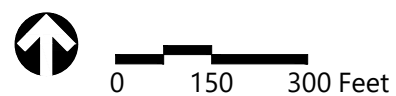
2022 Existing



2029 No-Build



2029 Build Without Mitigation



Queue Diagrams
Weekday Evening Peak Hour

**557 Highland Avenue
Needham, Massachusetts**

Highland Avenue at West Street (Signalized)

- X

Signalized Intersection Level of Service
- X

Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2029 No-Build



2029 Build Without Mitigation



2029 Build With Mitigation

Signal timings modified under Mitigation Conditions



Highland Avenue at West Street (Signalized)

- X

Signalized Intersection Level of Service
- X

Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2029 No-Build



2029 Build Without Mitigation



2029 Build With Mitigation

Signal timings modified under Mitigation Conditions



 Queue Diagrams
Weekday Evening Peak Hour

557 Highland Avenue
Needham, Massachusetts

Highland Avenue at Webster Street (Signalized)

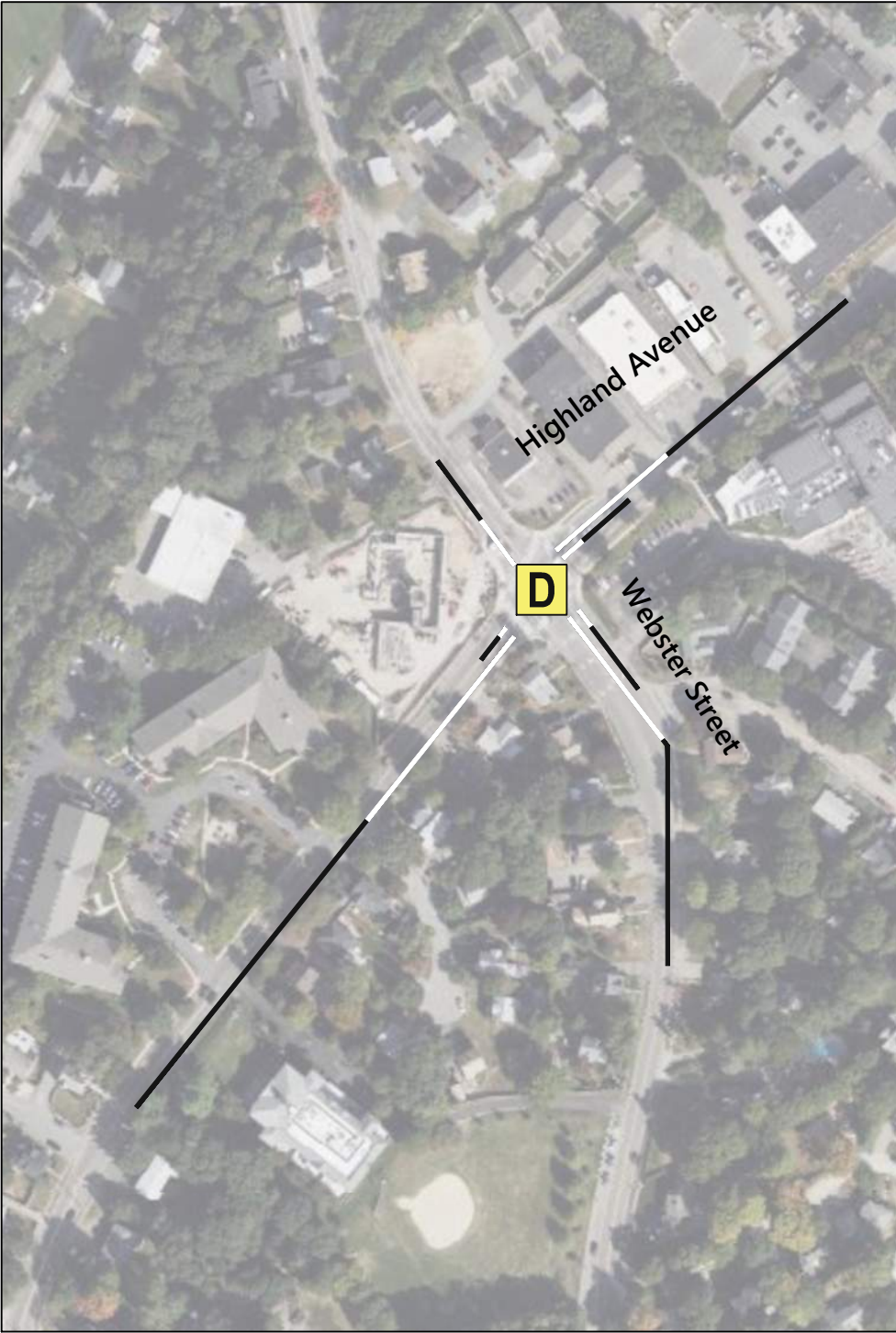
- X

Signalized Intersection Level of Service
- X

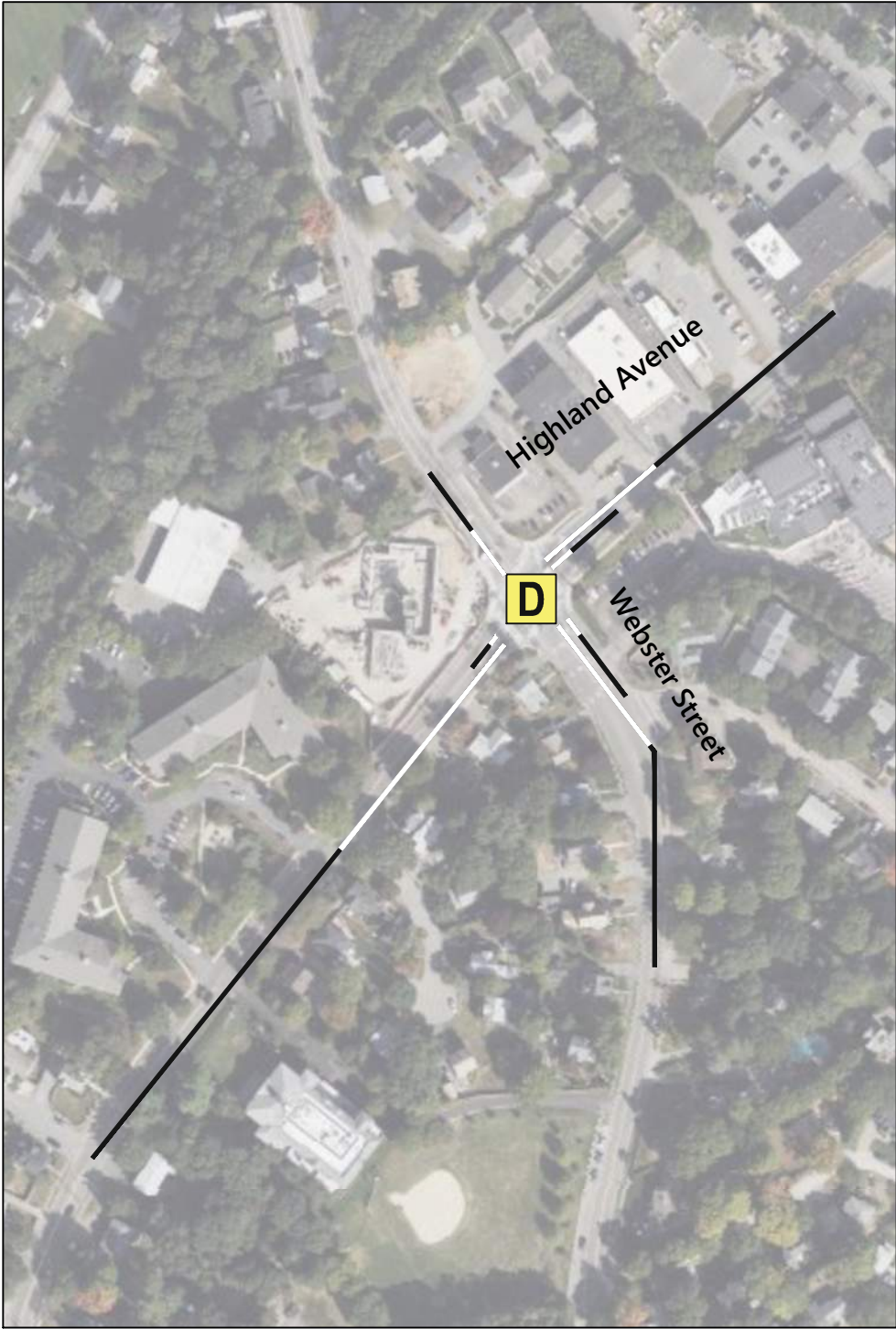
Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2022 Existing



2029 No-Build



2029 Build Without Mitigation



Highland Avenue at Webster Street (Signalized)

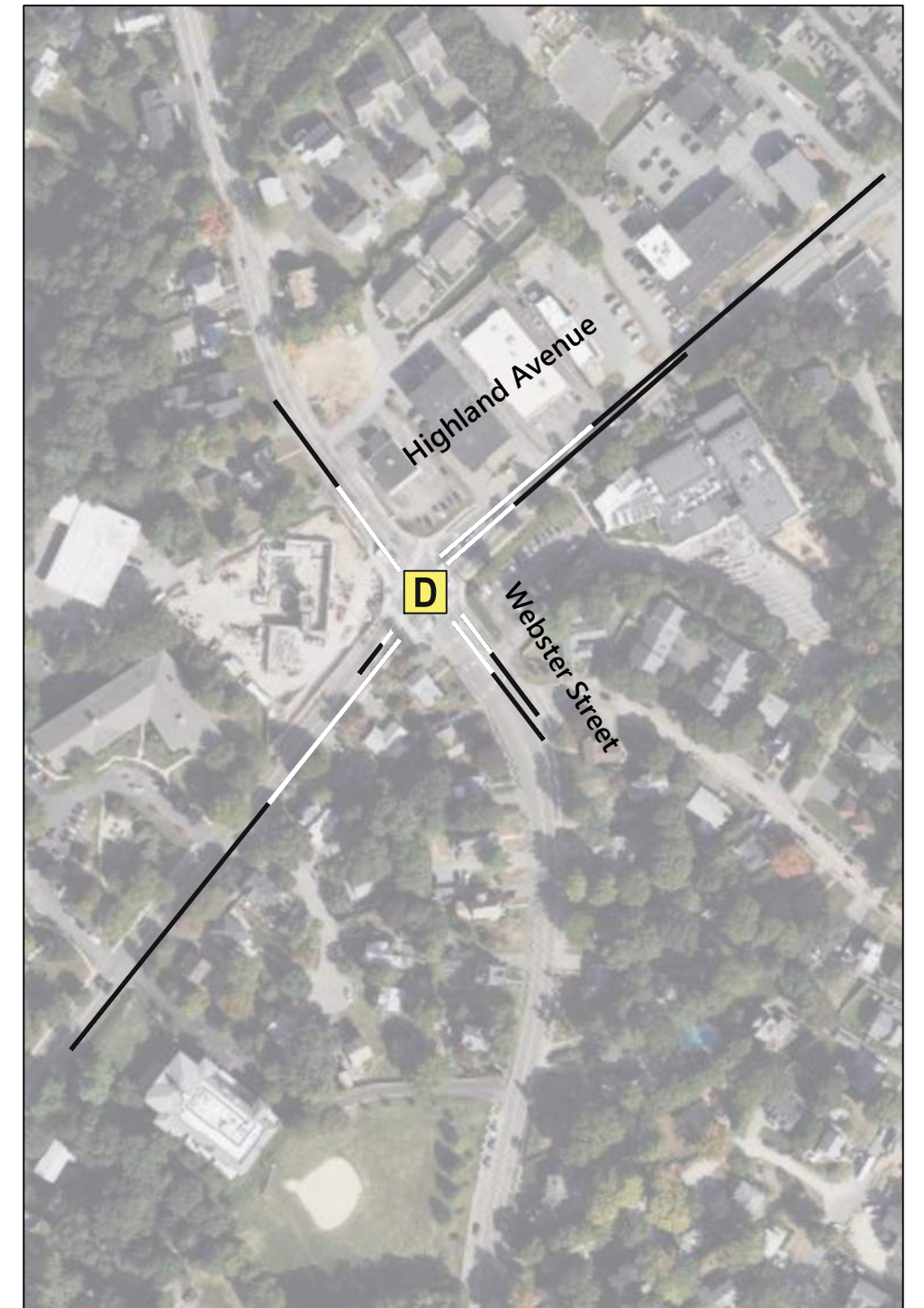
[X] Signalized Intersection Level of Service
[X] Unsignalized Intersection Level of Service
50th Percentile Queue
95th Percentile Queue



2022 Existing



2029 No-Build



2029 Build Without Mitigation



0 100 200 Feet

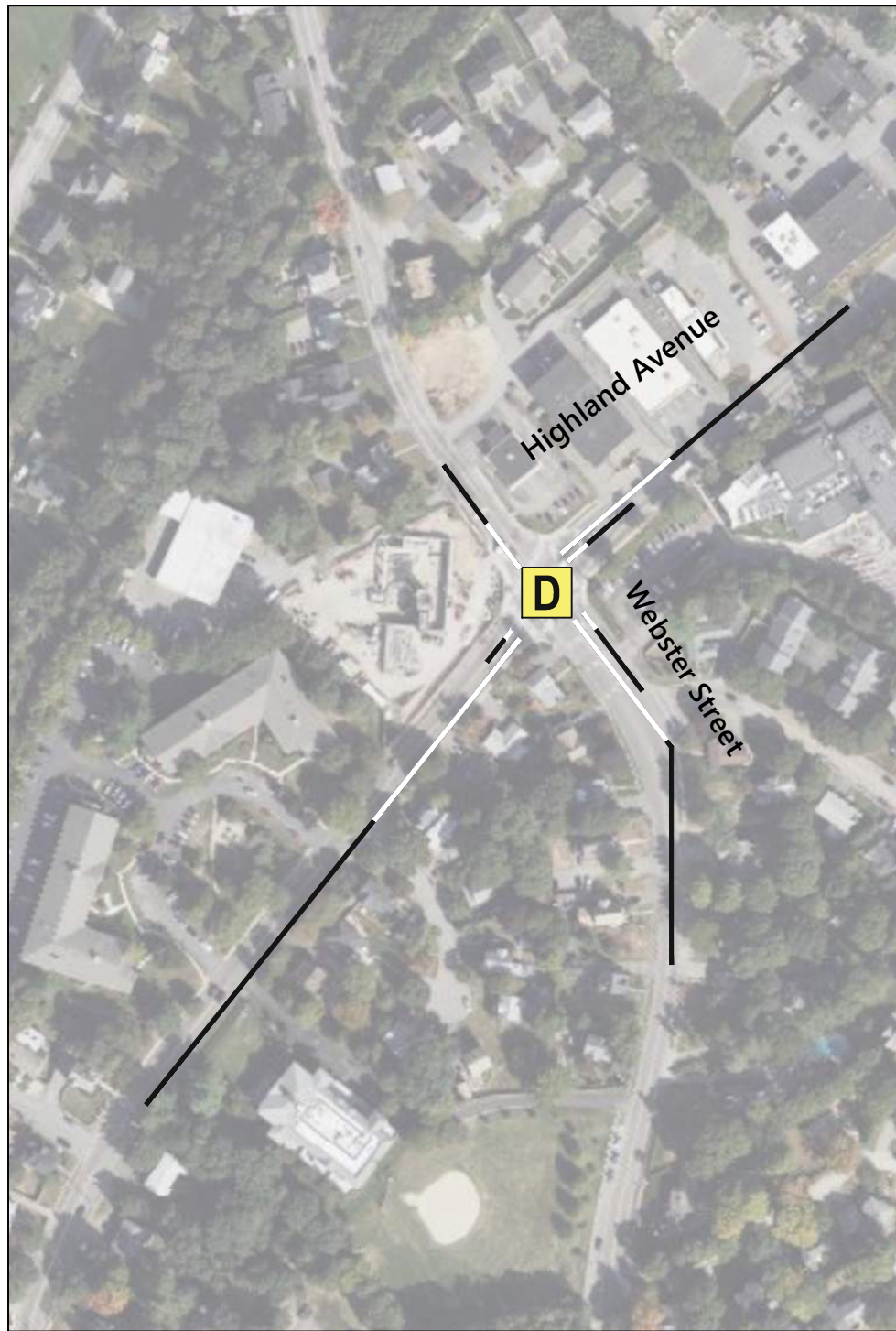


Queue Diagrams
Weekday Evening Peak Hour

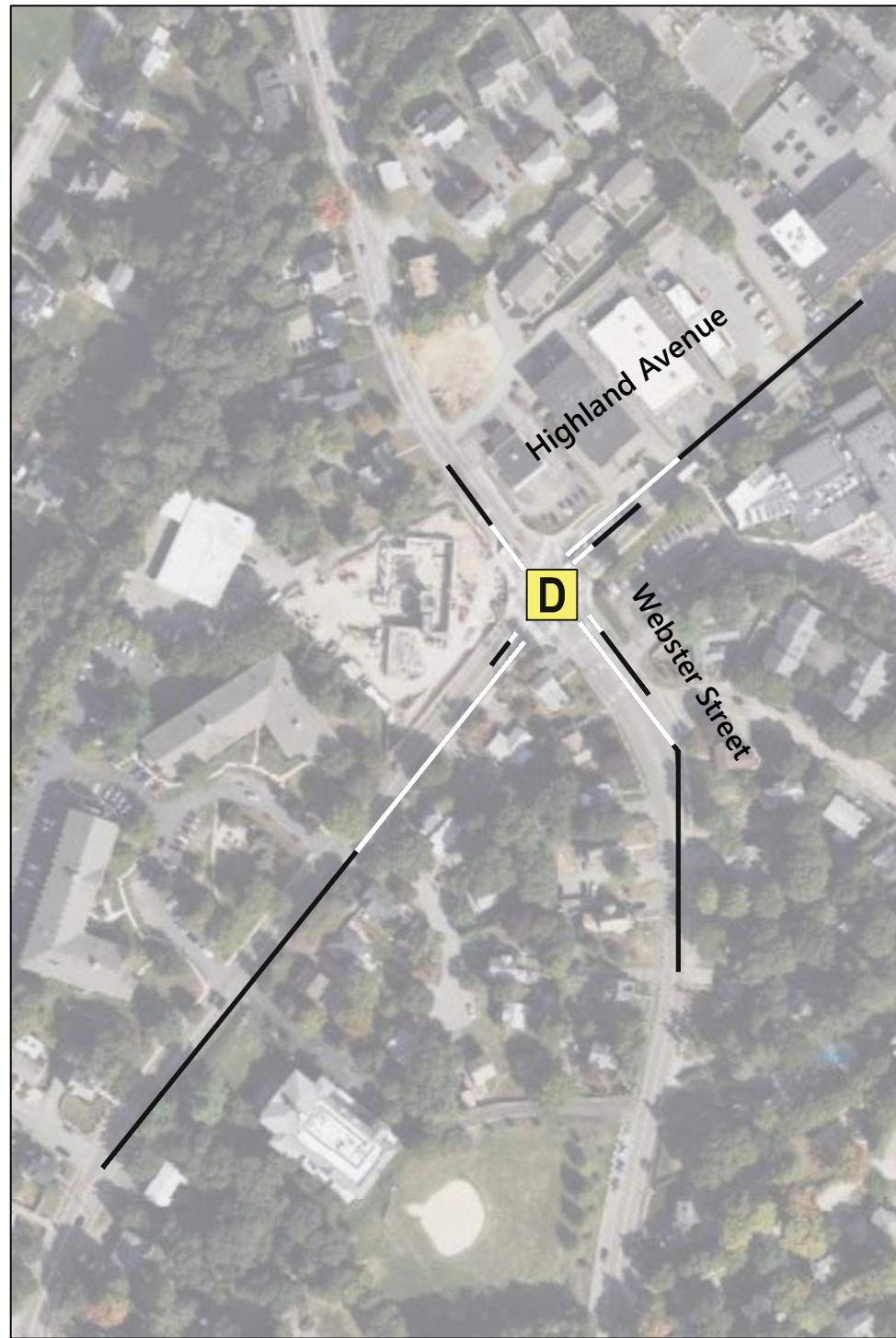
557 Highland Avenue
Needham, Massachusetts

Highland Avenue at Webster Street (Signalized)

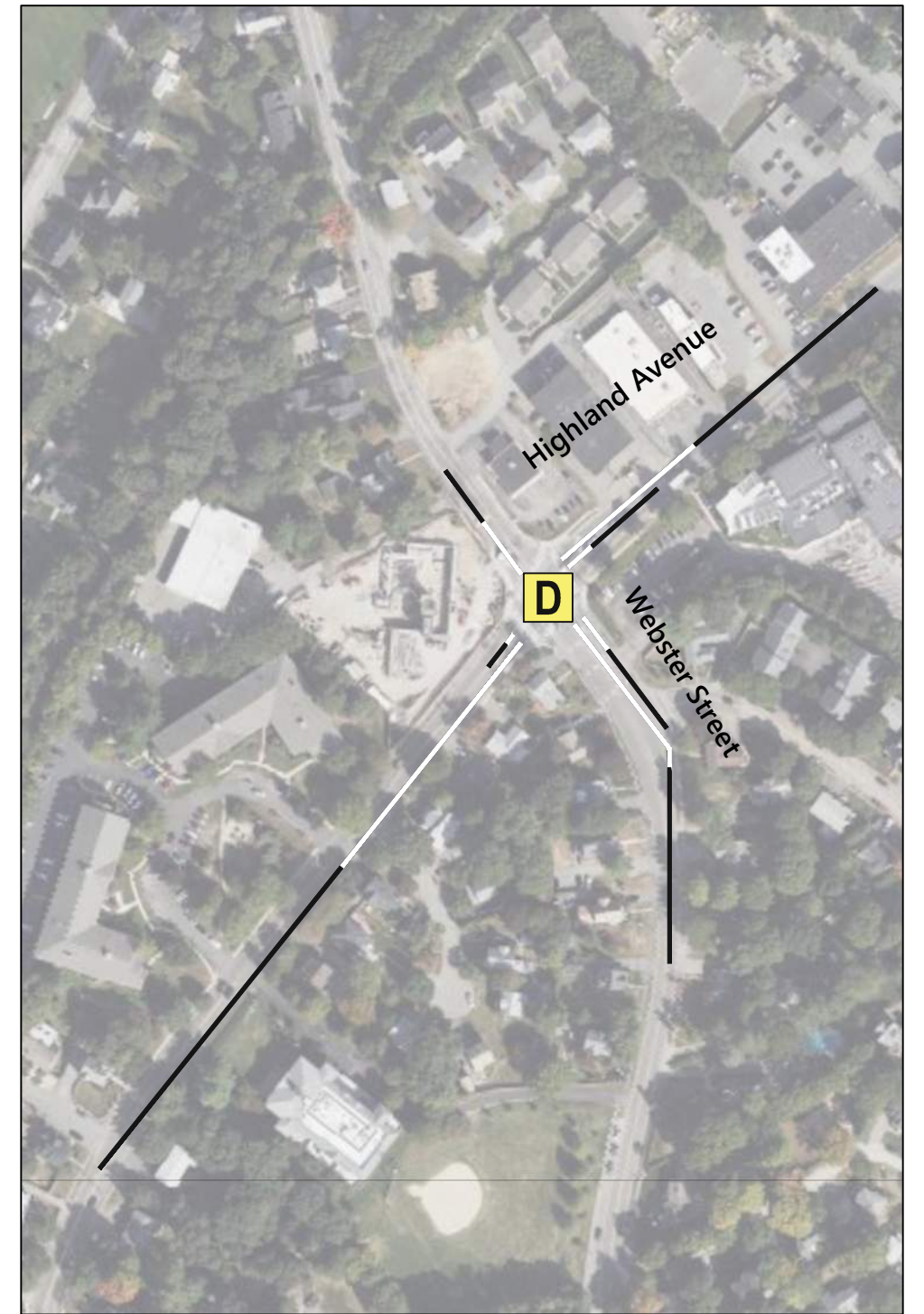
[X] Signalized Intersection Level of Service [Grey Line] 50th Percentile Queue
[X] Unsignalized Intersection Level of Service [Thick Black Line] 95th Percentile Queue



2029 No-Build



2029 Build Without Mitigation



2029 Build With Mitigation

Signal Timings modified under Mitigation Conditions



Queue Diagrams
Weekday Morning Peak Hour

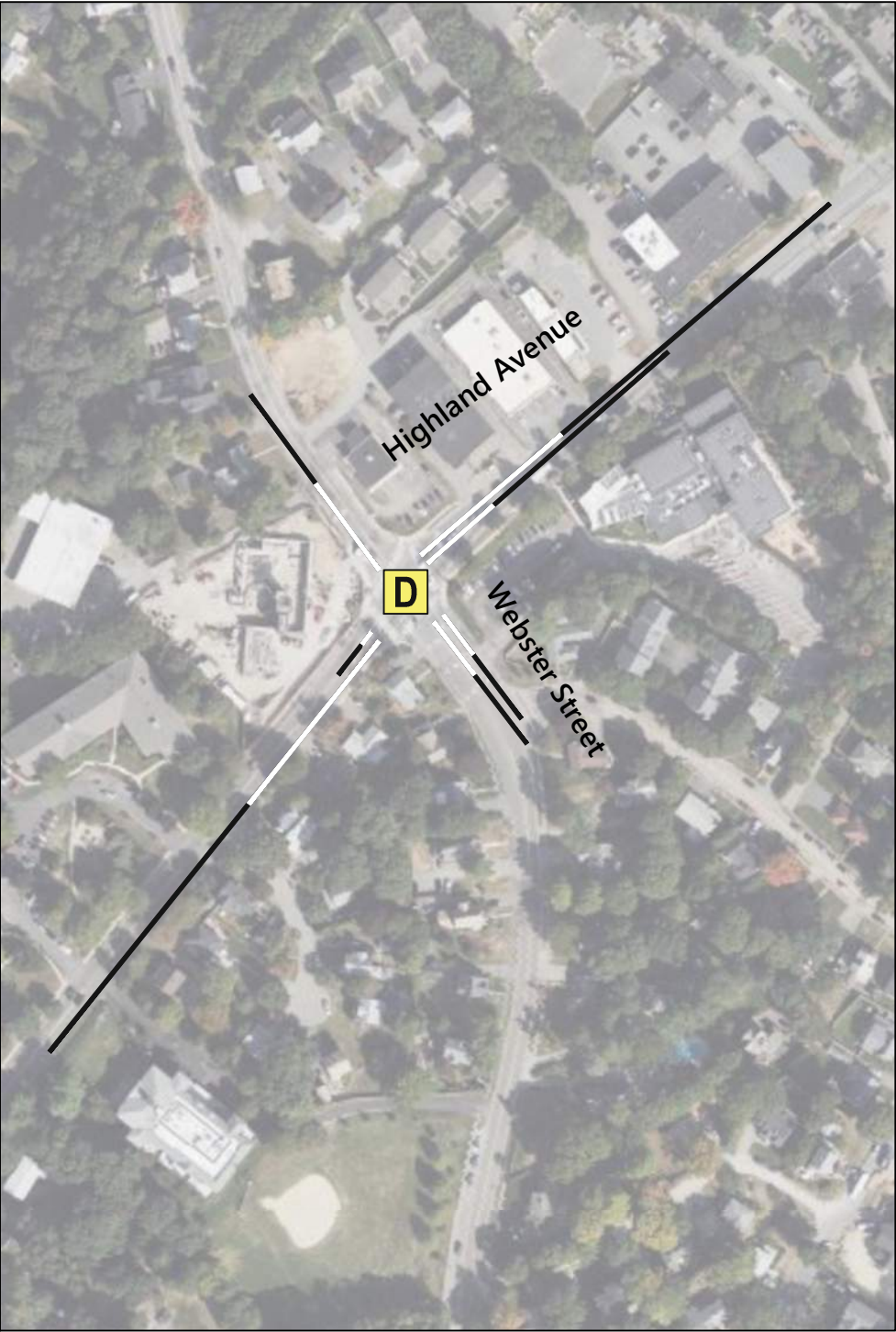
**557 Highland Avenue
Needham, Massachusetts**

Highland Avenue at Webster Street (Signalized)

- X

Signalized Intersection Level of Service
- X

Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2029 No-Build



2029 Build Without Mitigation



2029 Build With Mitigation

Signal Timings modified under Mitigation Conditions



Highland Avenue at I-95 Ramps, 1st Avenue, and 2nd Avenue (Signalized)

- X

Signalized Intersection Level of Service
- X

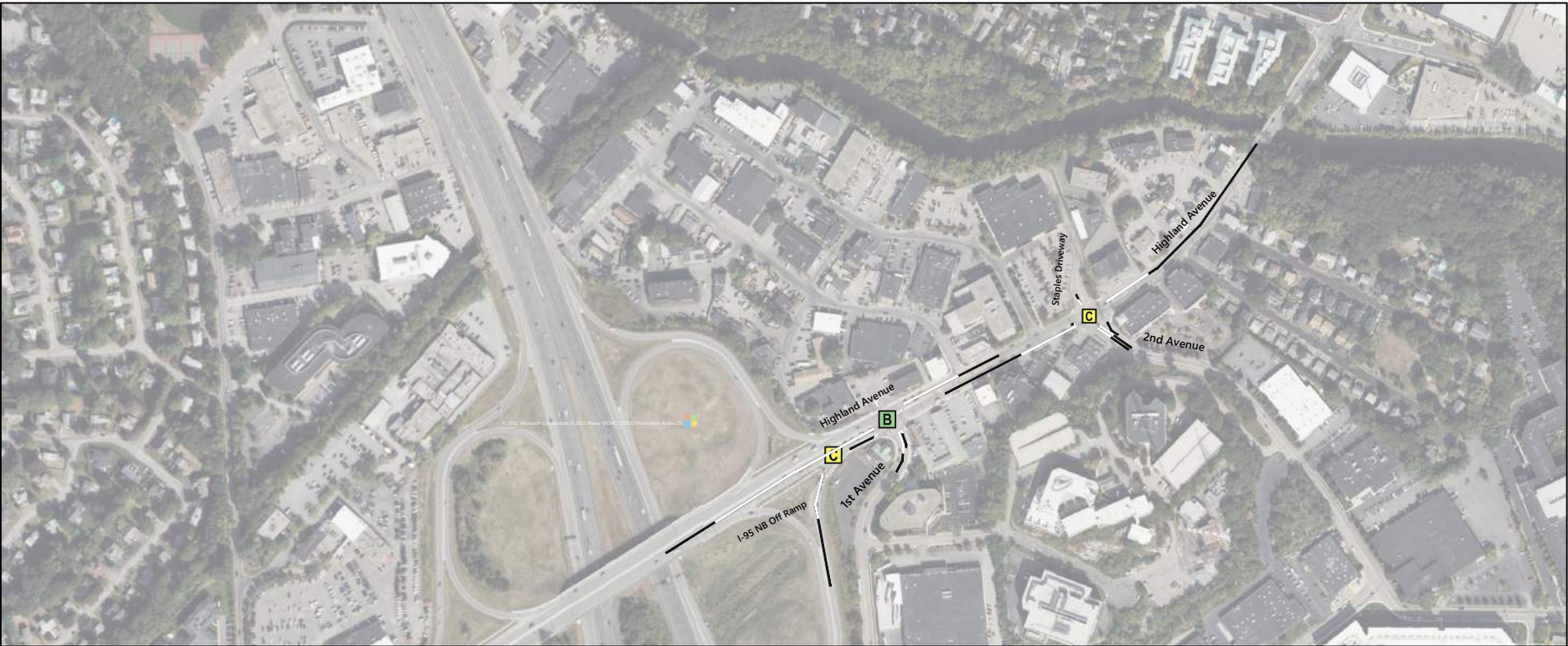
Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2022 Existing



2029 No-Build



2029 Build Without Mitigation

Highland Avenue at I-95 Ramps, 1st Avenue, and 2nd Avenue (Signalized)

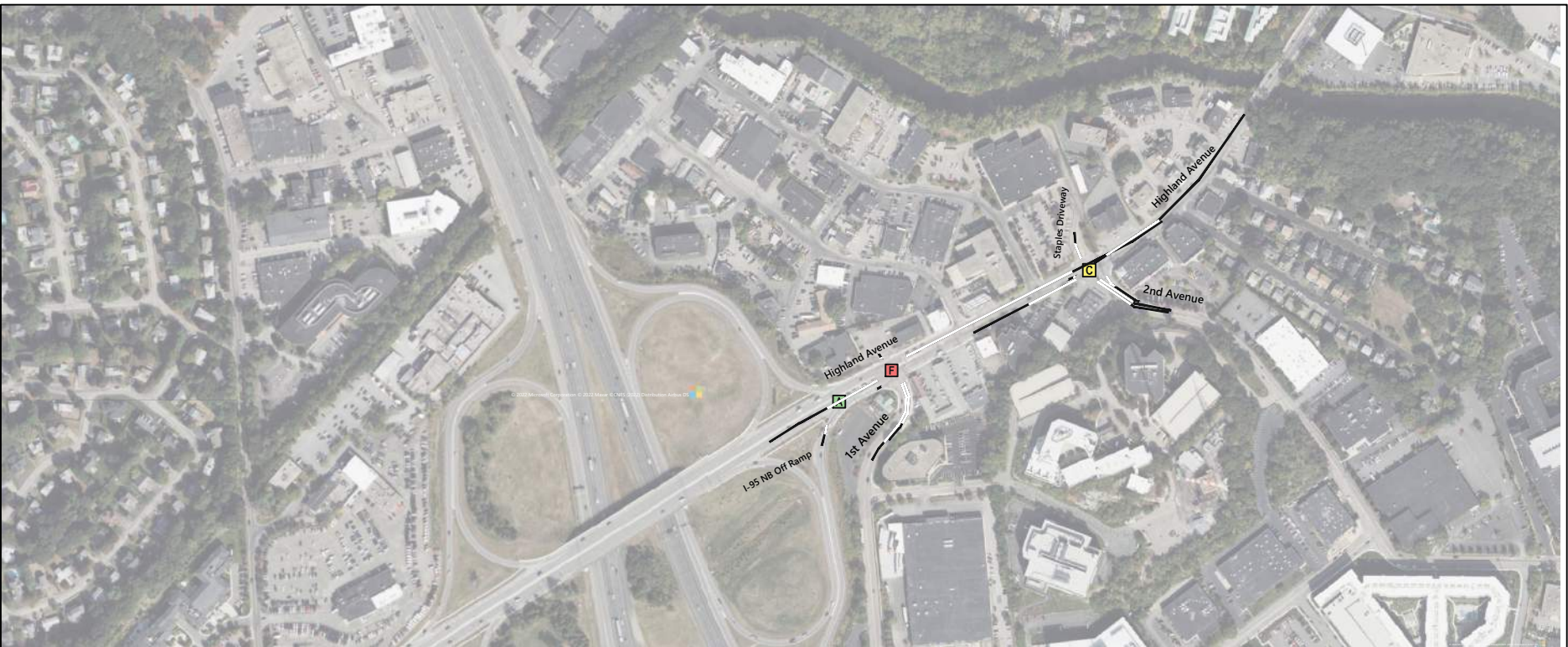
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Signalized Intersection Level of Service
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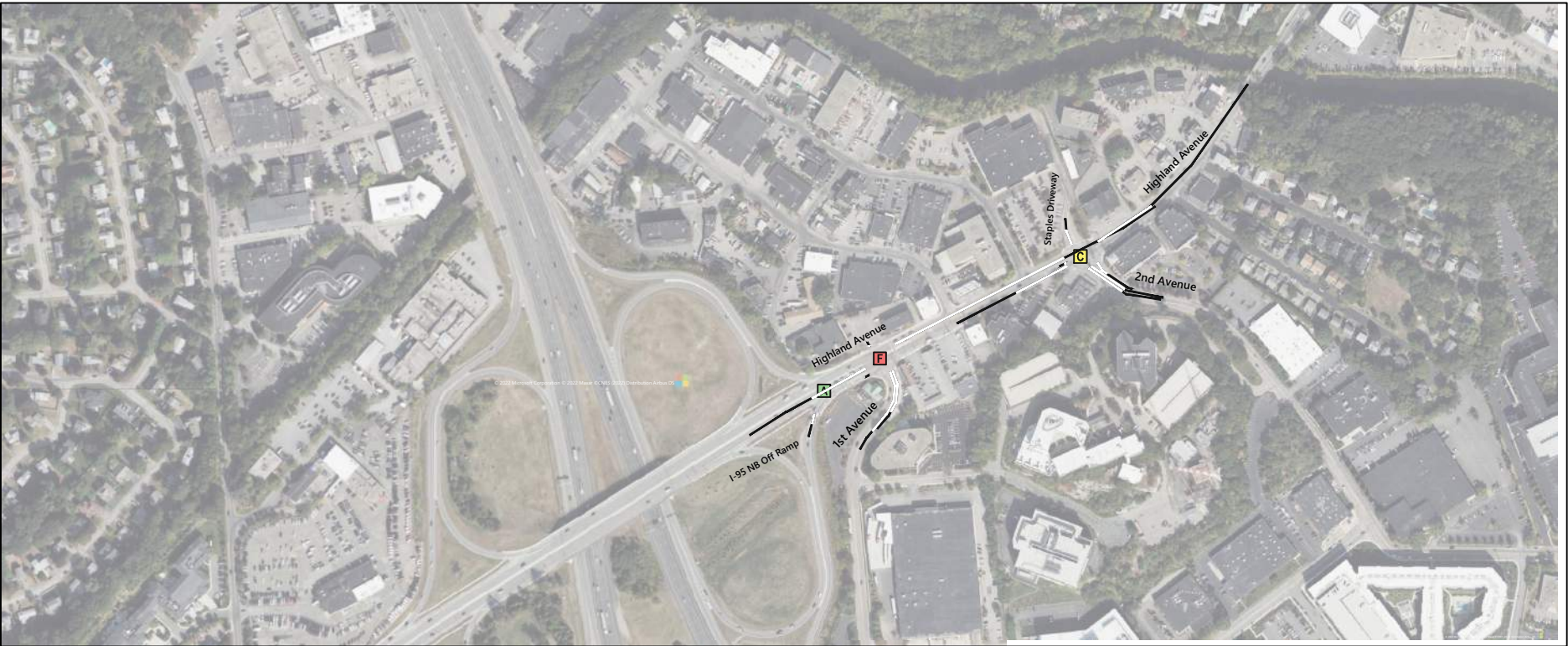
Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2022 Existing



2029 No-Build



2029 Build Without Mitigation

Highland Avenue at 1st Avenue (Signalized)

- X

Signalized Intersection Level of Service
- X

Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2029 No-Build



2029 Build Without Mitigation



2029 Build With Mitigation

Signal Timings modified under Mitigation Conditions



Queue Diagrams
Weekday Morning Peak Hour



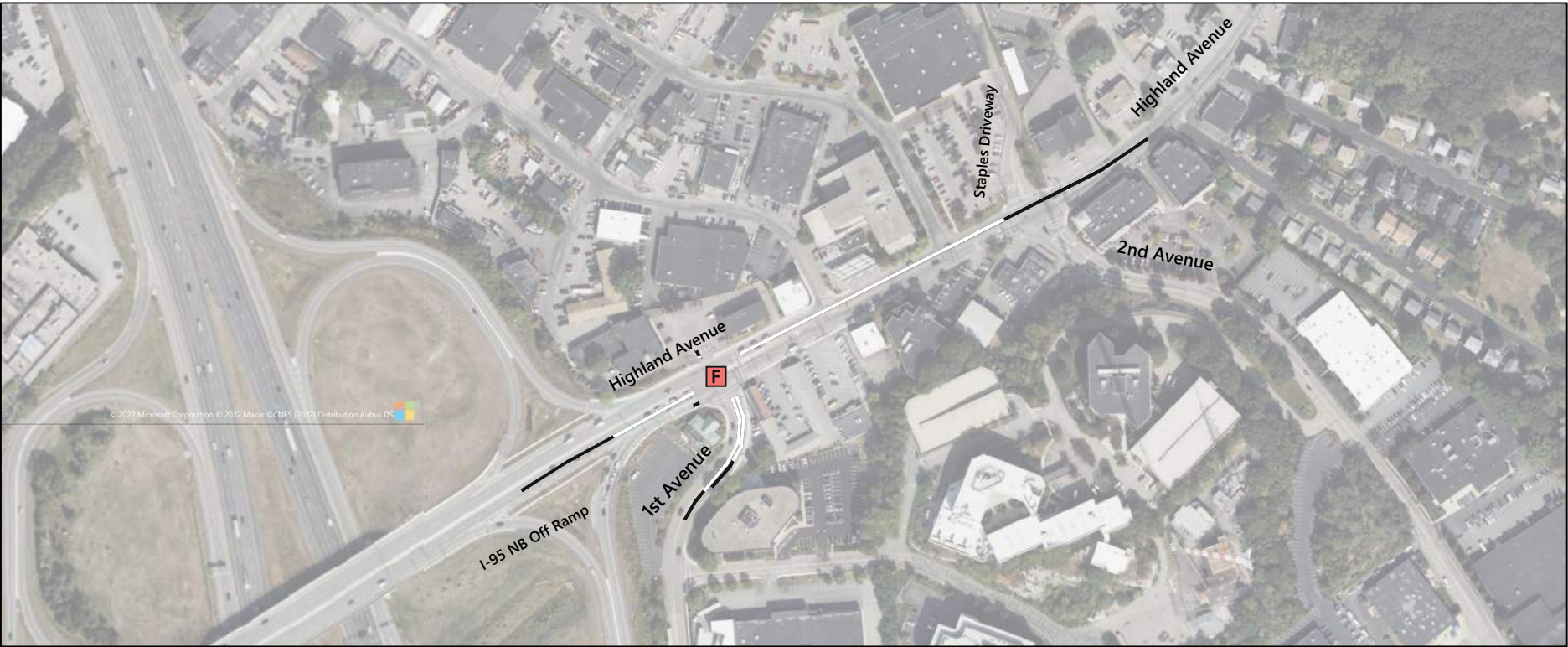
557 Highland Avenue
Needham, Massachusetts

Highland Avenue at 1st Avenue (Signalized)

- X

Signalized Intersection Level of Service
- X

Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2029 No-Build



2029 Build Without Mitigation



2029 Build With Mitigation

Signal Timings modified under Mitigation Conditions

 Queue Diagrams
Weekday Evening Peak Hour



557 Highland Avenue
Needham, Massachusetts

Hunting Road at Kendrick Street (Signalized)

- X

 Signalized Intersection Level of Service
- X

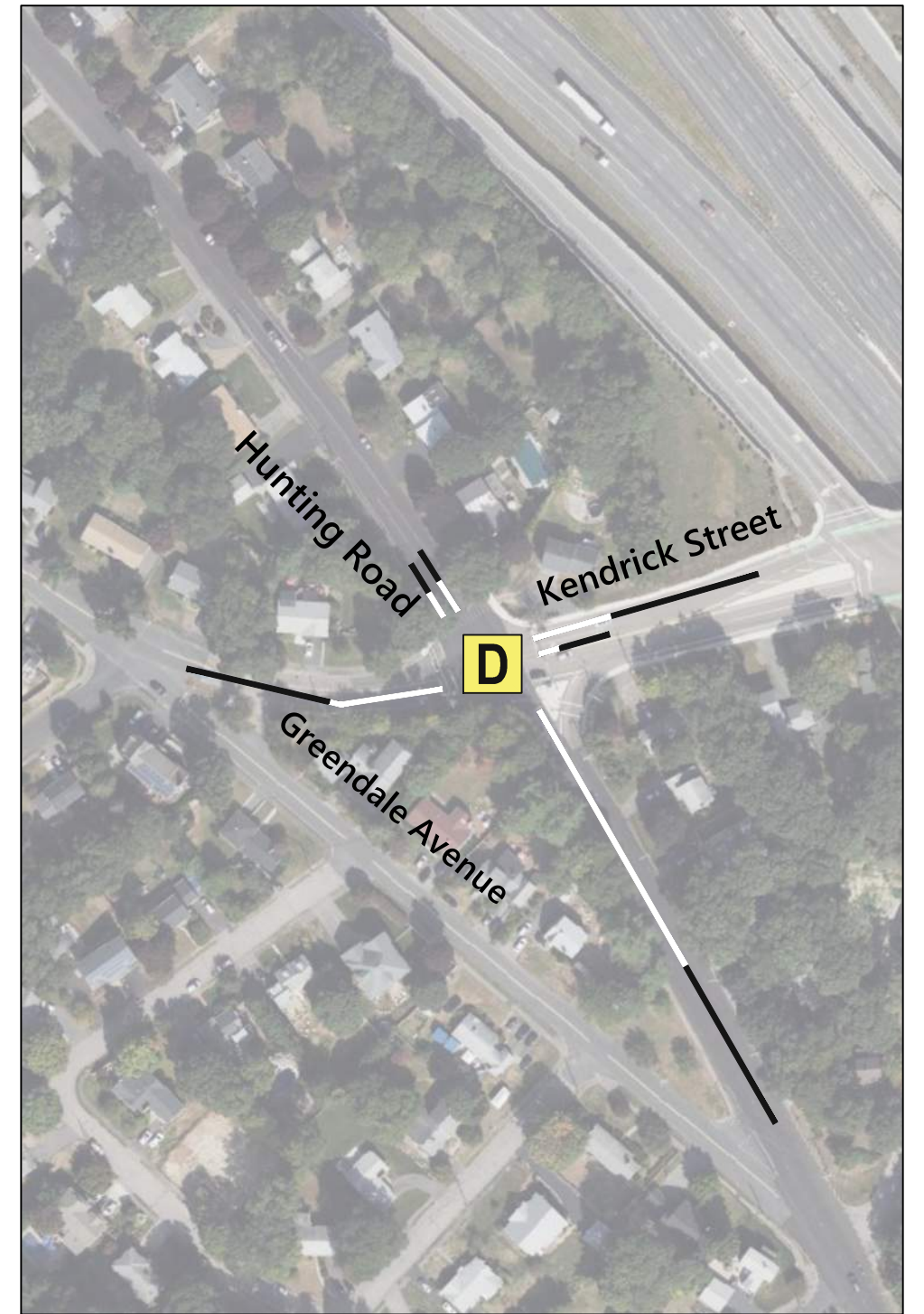
 Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2022 Existing



2029 No-Build



2029 Build Without Mitigation



Queue Diagrams
Weekday Morning Peak Hour

557 Highland Avenue
Needham, Massachusetts

Hunting Road at Kendrick Street (Signalized)

- X

 Signalized Intersection Level of Service
- X

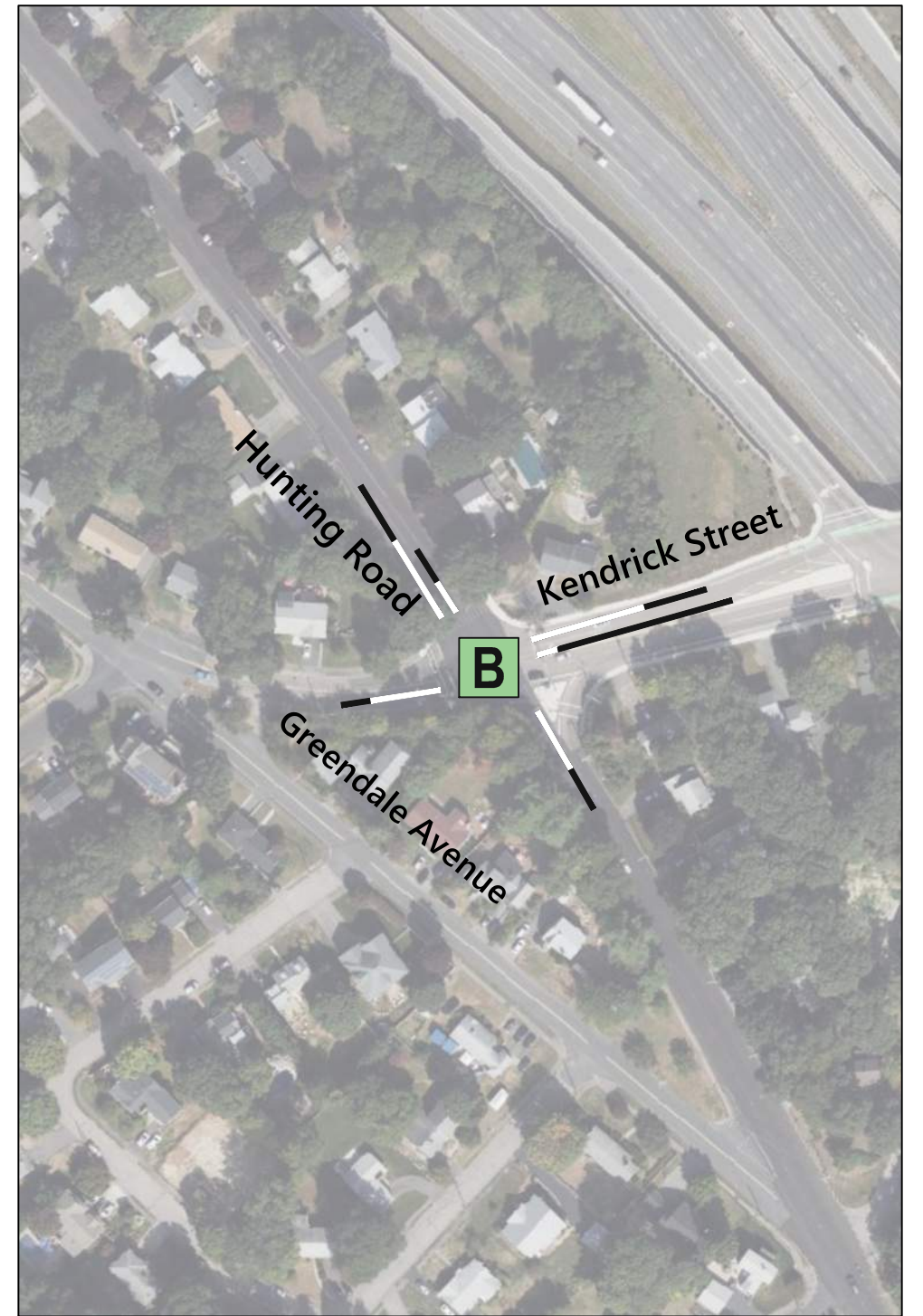
 Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2022 Existing



2029 No-Build



2029 Build Without Mitigation



0 100 200 Feet



Queue Diagrams
Weekday Evening Peak Hour

557 Highland Avenue
Needham, Massachusetts

Hunting Road at Kendrick Street (Signalized)

- X

 Signalized Intersection Level of Service
- X

 Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2029 No-Build



2029 Build Without Mitigation



2029 Build With Mitigation

Signal timings modified under Mitigation Conditions



vhb Queue Diagrams
Weekday Morning Peak Hour

**557 Highland Avenue
Needham, Massachusetts**

Hunting Road at Kendrick Street (Signalized)

- X

Signalized Intersection Level of Service
- X

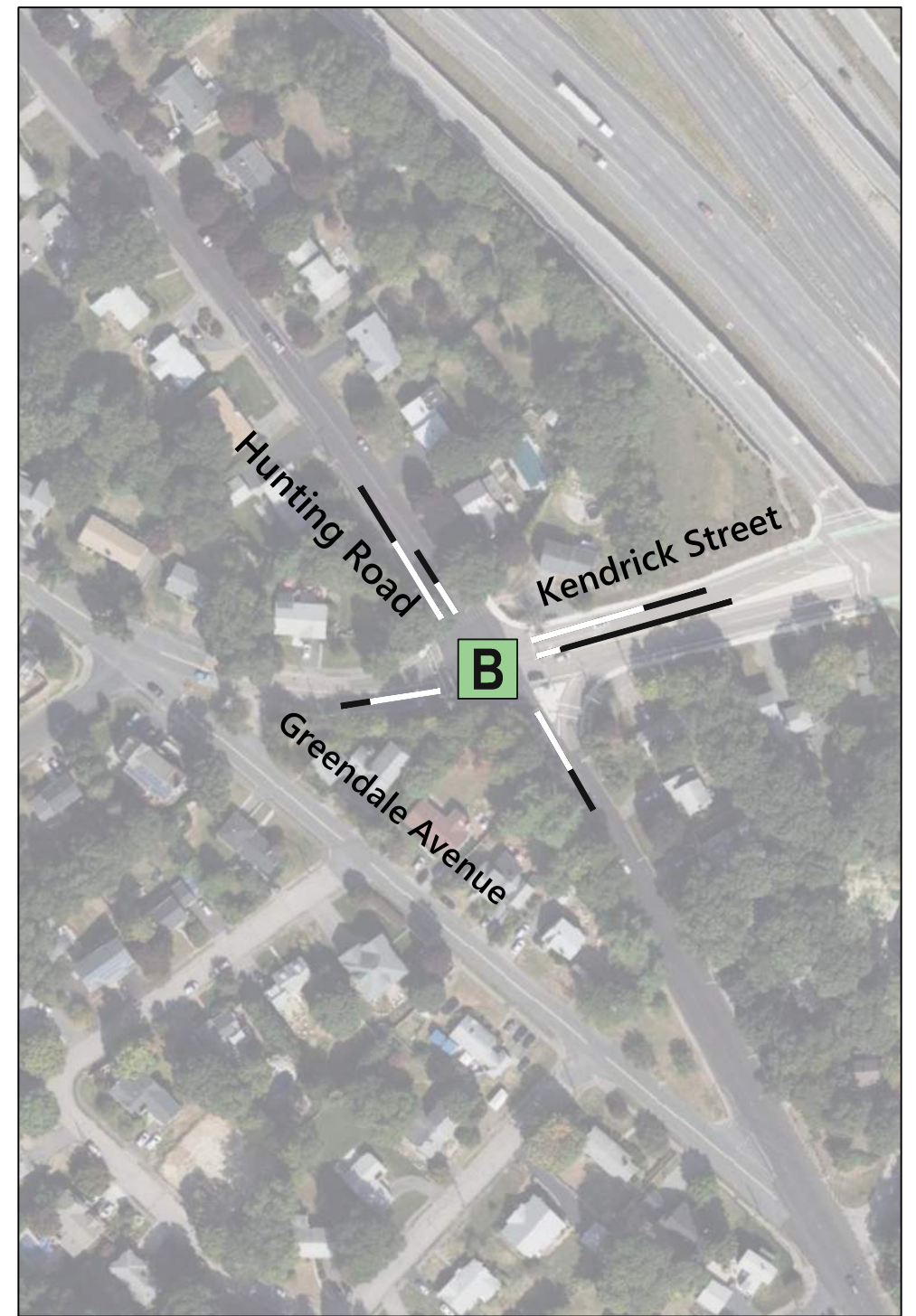
Unsignalized Intersection Level of Service
- 50th Percentile Queue
- 95th Percentile Queue



2029 No-Build



2029 Build Without Mitigation



2029 Build With Mitigation

Signal timings modified under Mitigation Conditions



Queue Diagrams
Weekday Evening Peak Hour

557 Highland Avenue
Needham, Massachusetts

Weave Segment Capacity Analysis Worksheets

Comment 2b

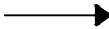
Source: Based on methodology presented in the Highway Capacity Manual: 6th Edition (HCM 6).

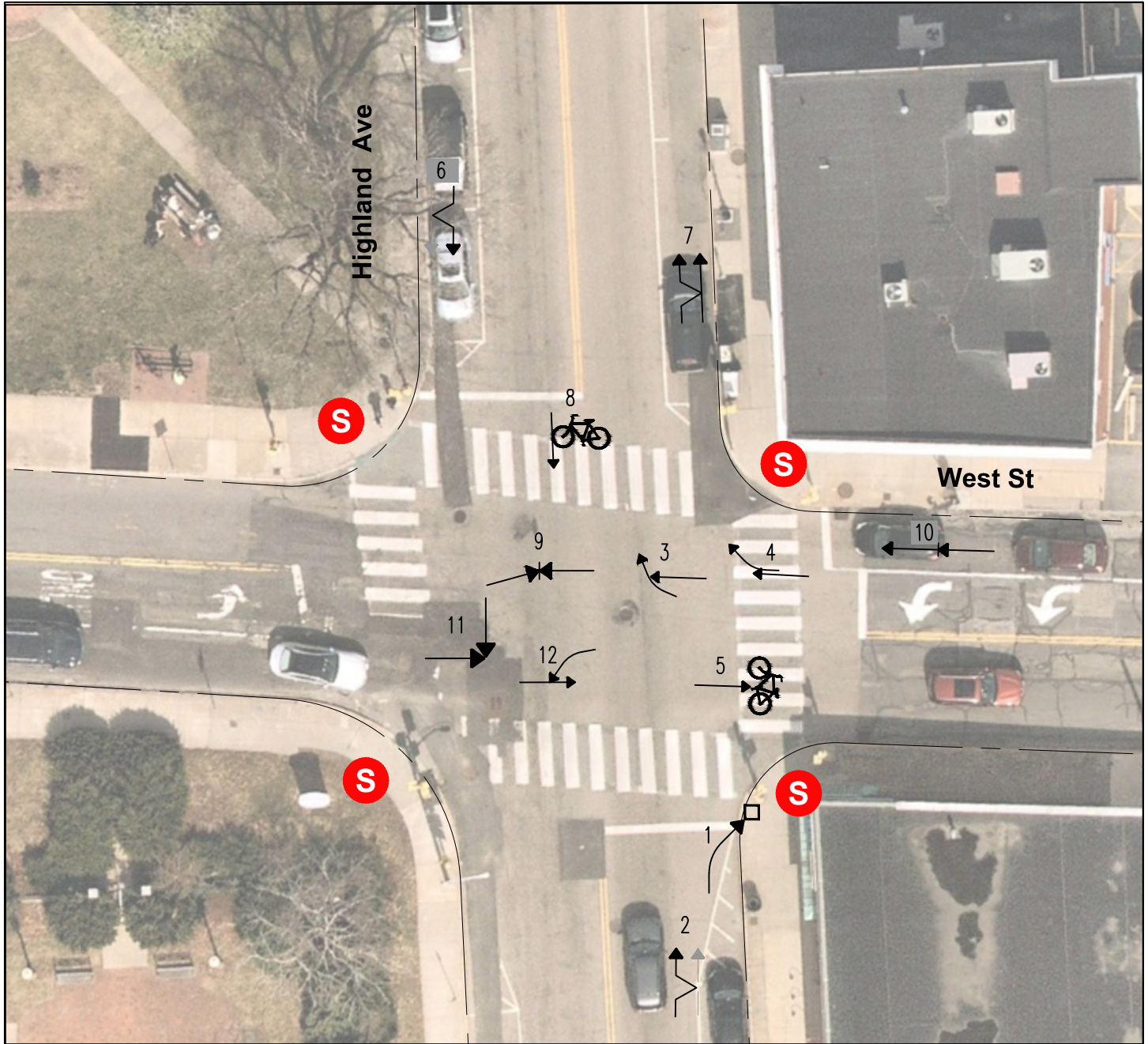
Source: Based on methodology presented in the Highway Capacity Manual: 6th Edition (HCM 6).

Source: Based on methodology presented in the Highway Capacity Manual: 6th Edition (HCM 6).

Collision Diagrams

Comment 8

SYMBOLS		TYPES OF CRASH		SEVERITY	TRAFFIC CONTROL
	Moving Vehicle		Head on		
	Backing Vehicle		Rear End		
	Non-Involved Vehicle		Angle		
Involved	Non-Involved		Turning Movement		
					
					
					
					
					
					
			Out of Control		
			Night Time Crash		



TIME PERIOD ANALYZED: 2017-2019
SOURCE OF CRASH REPORTS: Needham Police Dept.



Collision Diagram
Highland Avenue at
West Street
Needham, MA

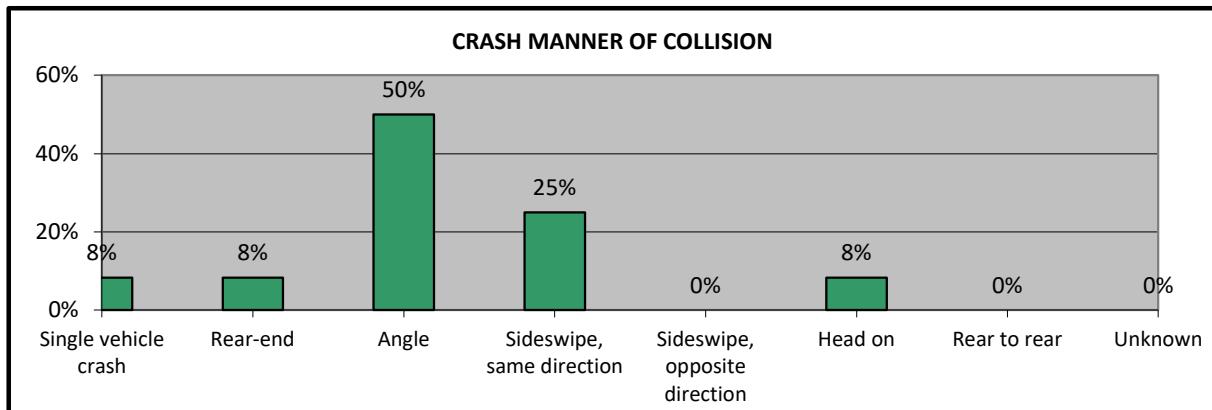
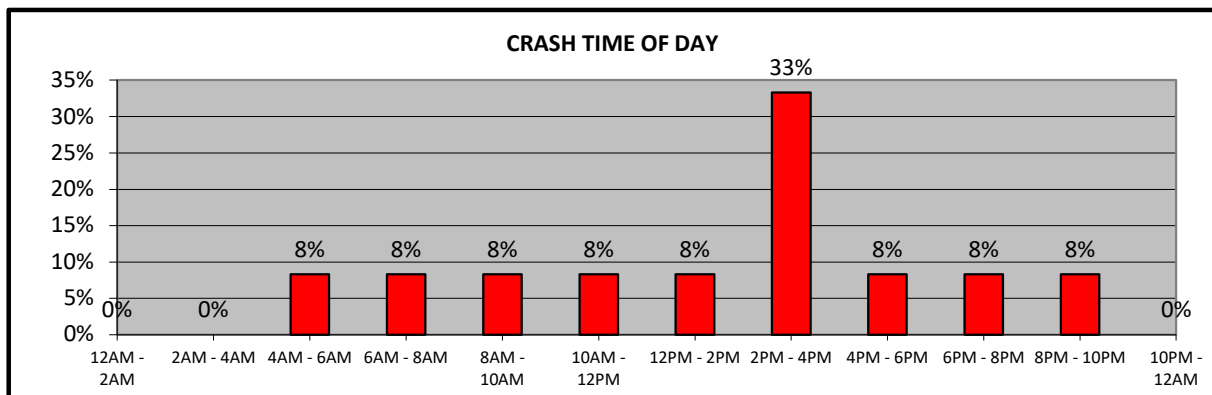
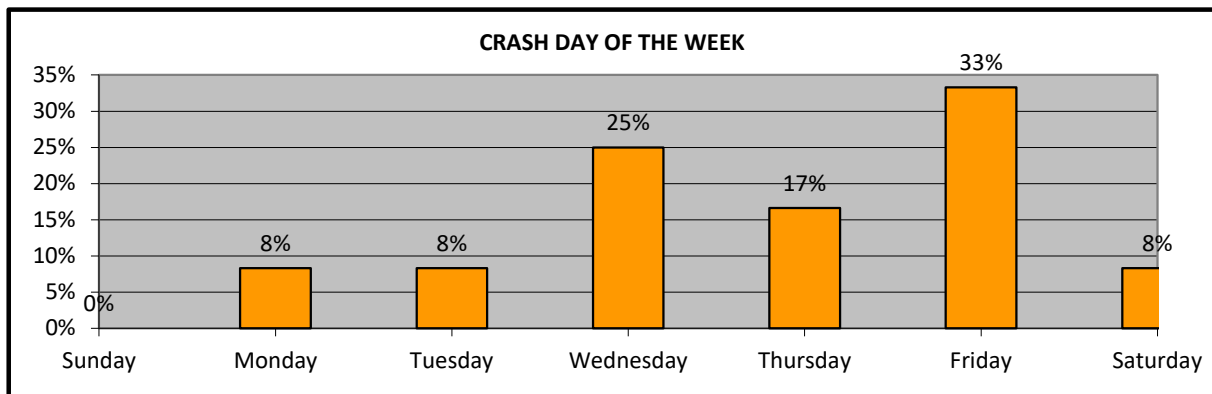
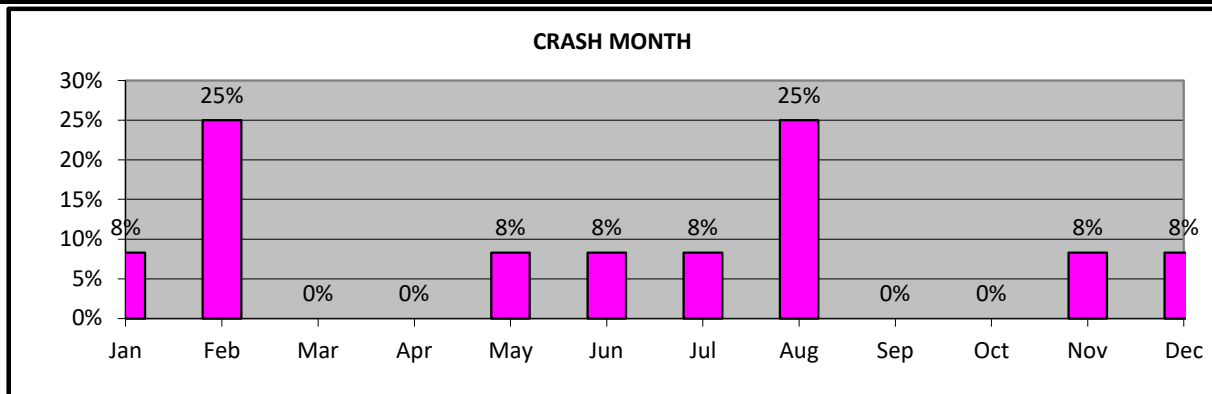
Crash Data Summary Table

Highland Ave at West St
2017 - 2019

Crash Diagram Ref #	Crash Date	Crash Day	Time of Day	Manner of Collision	Light Condition	Weather Condition	Road Surface	Driver Contributing Code	D1 Age	D2 Age	D3 Age	D4 Age	Comments
#	mm/dd/yy	Day	hh:mm	Type	Type	Type	Type	Type	#	#	#	#	
1	02/03/17	Friday	4:11 PM	Single vehicle crash	Daylight	Clear	Dry	Inattention	Unknown	Unknown			Tractor trailer struck and knocked down a light post, then continued driving. Truck took a right from Highland Ave onto West St. Light portion of the traffic pole was knocked down and hanging on pole by 3 wires.
2	02/08/17	Wednesday	5:45 AM	Sideswipe, same direction	Daylight	Clear	Ice	No improper driving	Unknown	Unknown			Vehicle #2 was traveling north on Highland Ave. Flash freeze on the roads at the time. Vehicle #2 stopped for red light signal and its trailer slid sideways striking Vehicle #1 which was parked.
3	05/19/17	Friday	2:09 PM	Angle	Daylight	Clear	Dry	Disregarded traffic signs, signals, road markings	Unknown	Unknown			Vehicle #2 was stopped at red light at the intersection of Highland Ave and West St. Vehicle #2 was in a marked left turn only lane. To the right of Vehicle #2 is a separate lane for right turns and for traffic going straight. When the light turned green, Vehicle #2 took a right turn, failing to follow the marked lane, and caused a collision with Vehicle #1. Vehicle #1 was to the right of Vehicle #2 at the red light. Property damage, no injury.
4	07/19/17	Wednesday	3:59 PM	Sideswipe, same direction	Daylight	Clear	Dry	Unknown	Unknown	Unknown			Bus turning right from West St to Highland Ave. Rear of Bus struck the right side of Vehicle that was sitting to the left of it. No injuries.
5	08/28/17	Monday	10:45 AM	Angle	Daylight	Clear	Dry	Failed to yield right of way	Unknown	Unknown			Vehicle crash involving a cyclist. Vehicle #1 was moving eastbound on West St towards Highland Ave with a green light. Cyclist entered crosswalk to cross the intersection. Property damaged, no injury.
6	02/07/19	Thursday	8:41 PM	Angle	Dark - lighted roadway	Clear	Dry	Unknown	Unknown	Unknown			Hit and run crash to a parked vehicle. Vehicle parked on Corner of Highland Ave facing south, truck hit her vehicle while taking a left turn into Trader Joes.
7	08/15/19	Thursday	2:57 PM	Sideswipe, same direction	Daylight	Clear	Dry	Unknown	Unknown	Unknown			Hit and run. No injuries were reported. Vehicle #1 was attempting to park on Highland Ave, tractor trailer truck was turning onto Highland Ave from West St and clipped the driver's side of Vehicle #1.
8	08/23/19	Friday	12:09 PM	Angle	Daylight	Clear	Dry	Failed to yield right of way	Unknown	Unknown			Vehicle #1 was stopped at the red light on West St in the left turn only lane. The cyclist entered the crosswalk just before the walk signal ended and was proceeding thru the crosswalk. The light turned to green and Vehicle #1 started the left turn and was about half way through the crosswalk when the cyclist ran into the passenger side of vehicle #1. The cyclist fell off the bicycle on the ground. No injuries or damages.
9	12/07/19	Saturday	8:00 AM	Head on	Daylight	Clear	Dry	Other improper action	Unknown	Unknown			Vehicle #1 was turning left to go northbound onto Highland Ave from West St. Vehicle #2 was travelling westbound on West St crossing over Highland Ave. Vehicle #2 was struck vehicle #1 as it was making the turn. Both vehicles sustained moderate damage, but did not have to be towed from the scene. No injuries were reported.
10	01/25/17	Wednesday	6:11 PM	Rear-end	Dark - lighted roadway	Clear	Dry	Unknown	Unknown	Unknown			No injuries. Vehicle #1 was unable to stop when Vehicle #2 in front of her stopped. Vehicle #1 had heavy front end damage, there was damage to the rear of vehicle #2.
11	06/01/18	Friday	6:38 AM	Angle	Daylight	Clear	Dry	Disregarded traffic signs, signals, road markings	Unknown	Unknown			Vehicle #2 was traveling north on Highland Ave and was struck by Vehicle #1 that was traveling WB on West St.
12	11/13/18	Tuesday	3:49 PM	Angle	Daylight	Clear	Dry	Failed to yield right of way	Unknown	Unknown			No injuries. Vehicle #1 was traveling down West St and turning left. Vehicle #2 was on West St going towards Webster St when the operator of Vehicle #1 turned left and hit vehicle #2. Vehicle #1 was removed by tow.

Crash Data Summary Charts

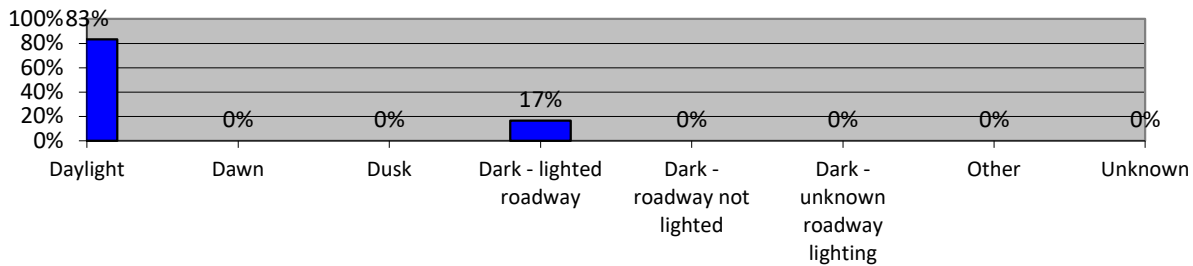
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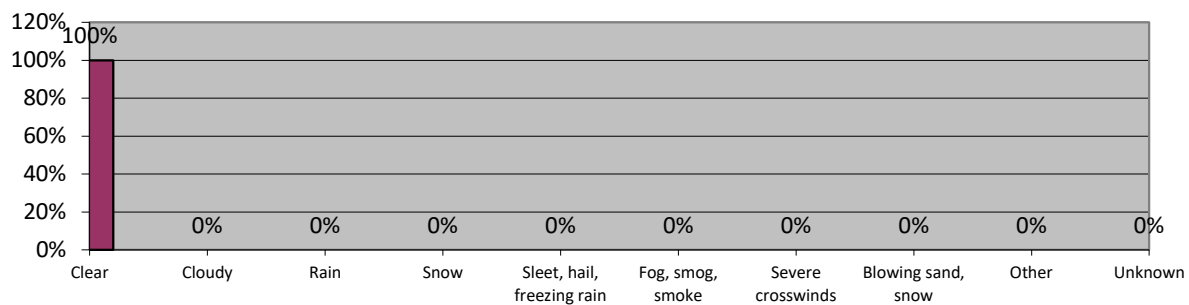
Crash Data Summary Charts

Highland Ave at West St

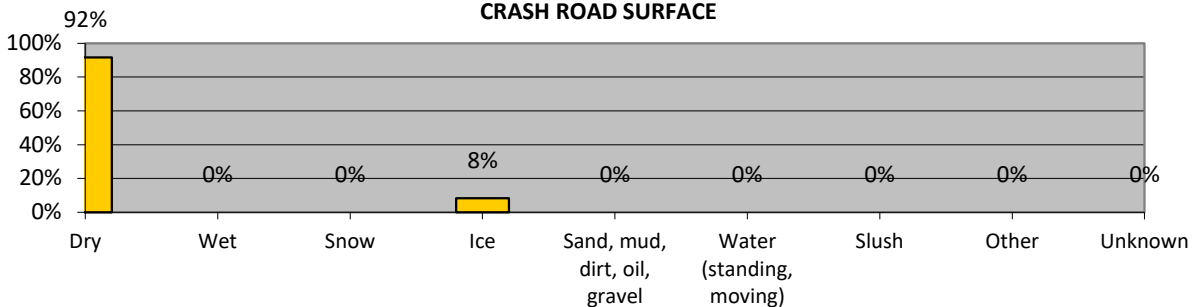
CRASH LIGHT CONDITION



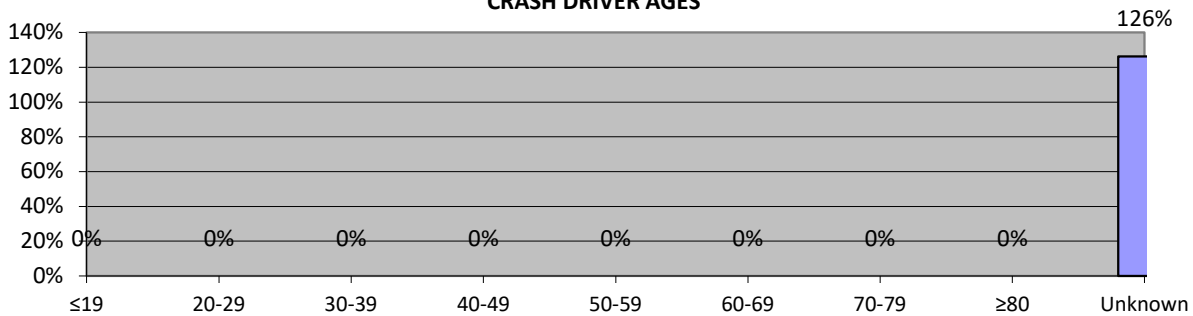
CRASH WEATHER CONDITION

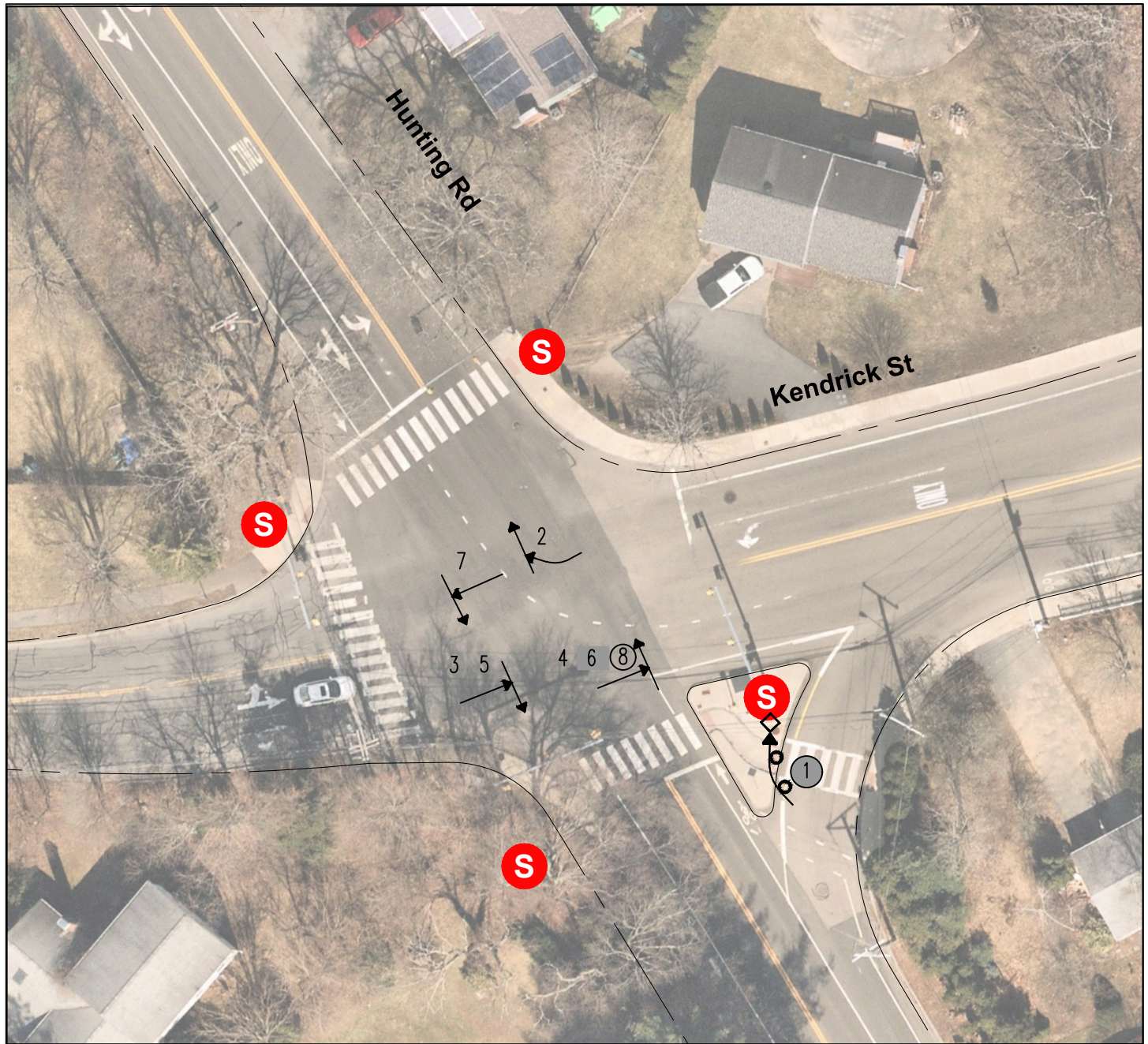
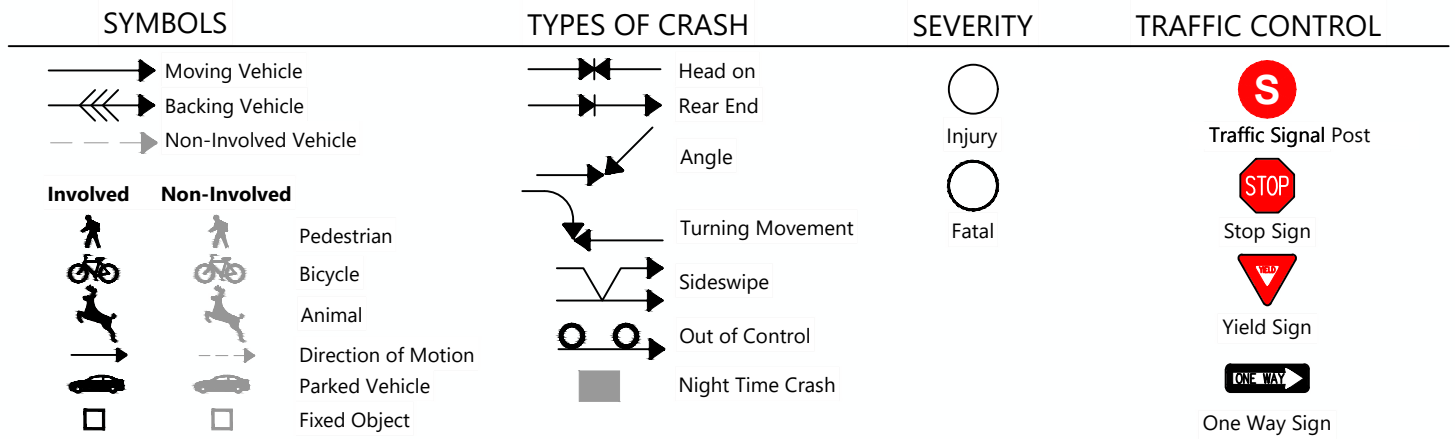


CRASH ROAD SURFACE



CRASH DRIVER AGES





TIME PERIOD ANALYZED: 2017-2019
 SOURCE OF CRASH REPORTS: Needham Police Dept.



Collision Diagram
 Hunting Road at
 Kendrick Street
 Needham, MA

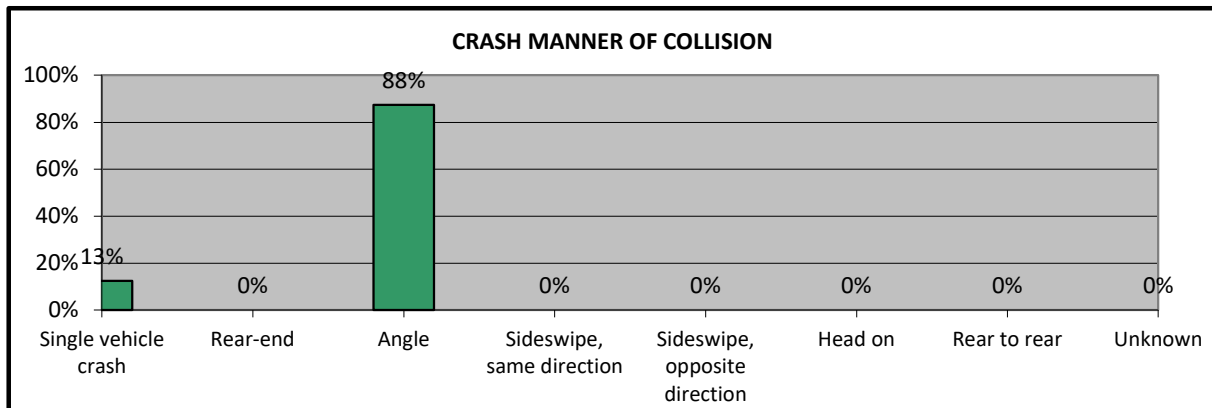
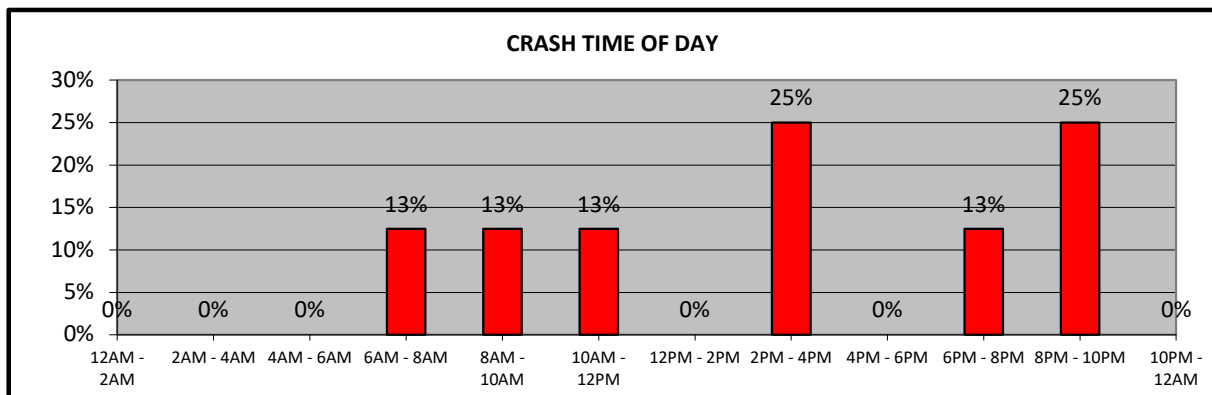
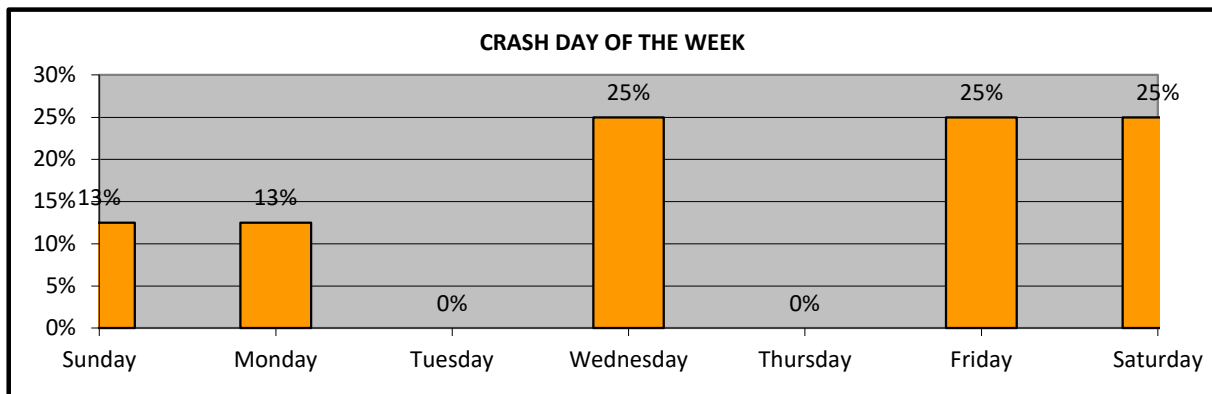
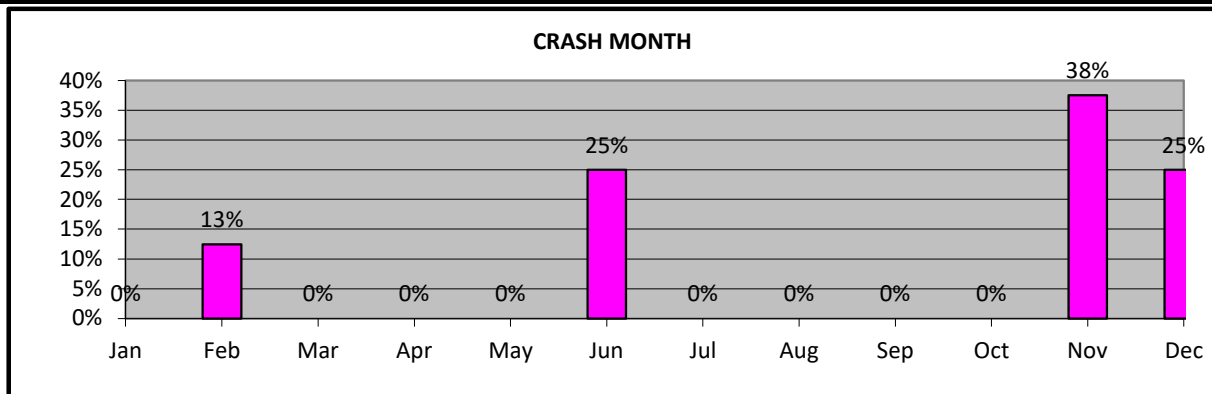
Crash Data Summary Table

Hunting Rd at Kendrick St
2017 - 2019

Crash Diagram Ref #	Crash Date	Crash Day	Time of Day	Manner of Collision	Light Condition	Weather Condition	Road Surface	Driver Contributing Code	D1 Age	D2 Age	D3 Age	D4 Age	Comments
#	mm/dd/yy	Day	hh:mm	Type	Type	Type	Type	Type	#	#	#	#	
1	02/08/17	Wednesday	6:30 AM	Single vehicle crash	Dark - lighted roadway	Clear	Ice	No improper driving	Unknown				Vehicle #1 was traveling northbound on Hunting Road when the extremely ice condition caused him to slide up onto a curb and struck the base of the a traffic light pole. Driver complained of dizziness and was evaluated. Flash freeze. Pole was not damaged.
2	11/10/17	Friday	10:57 AM	Angle	Daylight	Clear	Dry	Failed to yield right of way	Unknown	Unknown			Vehicle #1 was traveling on Hunting Rd and crossing through a green light over Kendrick St to continue on Hunting Rd. Vehicle #2 stated he was stopped at red light on Kendrick St when he tried to take a right turn on red onto Hunting Rd. Vehicle #2 struck Vehicle #1 as it attempted to turn onto Hunting Rd. Vehicle #1 suffered minor damage to the passenger side of front door. Vehicle #2 suffered minor damage to the driver's side front wheel well and front driver's side panel. No injuries were reported.
3	06/18/18	Monday	9:37 PM	Angle	Daylight	Clear	Dry	Disregarded traffic signs, signals, road markings	Unknown	Unknown			Vehicle #1 was traveling on Hunting Rd SB heading towards Cheney St. Vehicle #2 was on Kendrick St heading EB towards Newton. No injuries reported, Vehicle #1 had minor to moderate passenger side damage. Vehicle #2 had moderate front end damage.
4	11/03/18	Saturday	8:41 PM	Angle	Daylight	Clear	Dry	Disregarded traffic signs, signals, road markings	Unknown	Unknown			Vehicle #1 east on Hunting, Vehicle #2 north of Kendrick. No injury, minor to moderate damage.
5	11/21/18	Wednesday	2:44 PM	Angle	Daylight	Clear	Dry	Failed to yield right of way	Unknown	Unknown			Vehicle #1 traveling EB on Kendrick St heading towards Newton. Vehicle #2 traveling WB on Kendrick St, making a left turn onto Hunting Rd. No injuries reported, moderate damages to vehicles
6	06/28/19	Friday	7:50 PM	Angle	Dark - lighted roadway	Clear	Dry	Inattention	Unknown	54			Vehicle #2 was traveling west on Kendrick Street with the right of way when vehicle #1 entered the intersection on a red light. No reported injuries and both vehicles had to be towed from the scene.
7	12/28/19	Saturday	3:48 PM	Angle	Daylight	Clear	Dry	Failed to yield right of way	Unknown	Unknown			Vehicle #1 traveling south on Hunting Rd when vehicle #2 crashed into the left side of his car. No injuries, both vehicles were towed.
8	12/01/19	Sunday	8:48 AM	Angle	Daylight	Clear	Dry	Unknown	Unknown	Unknown			Vehicle #1 was travelling EB on Kendrick St. Vehicle #2 was travelling northbound on Hunting Road. Serious damage to both vehicles.

Crash Data Summary Charts

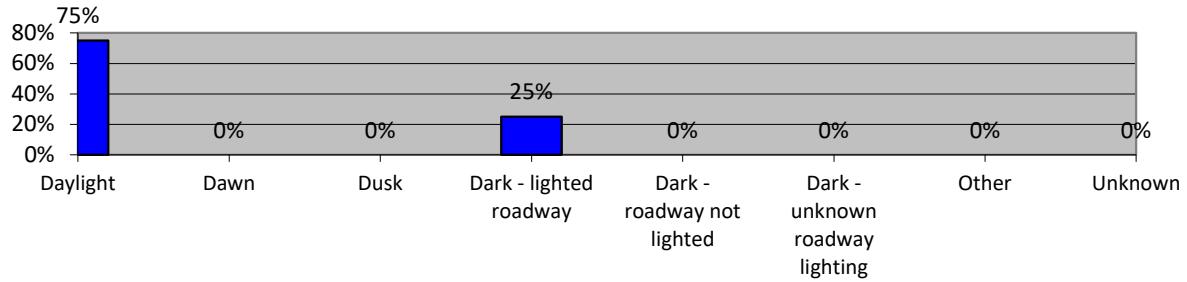
Hunting Rd at Kendrick St



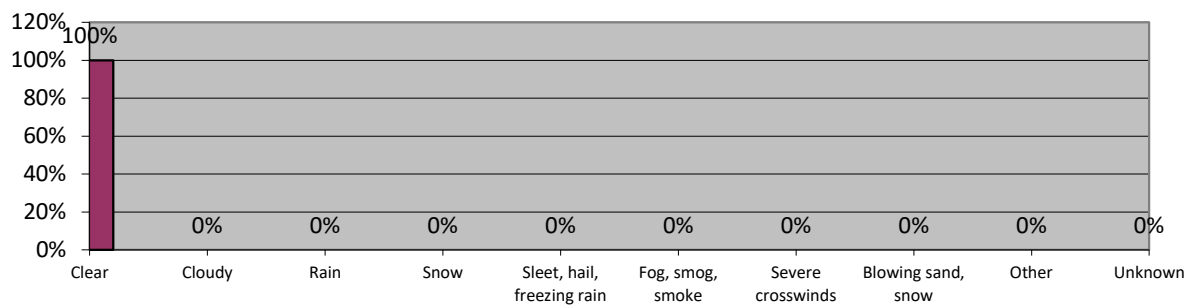
Crash Data Summary Charts

Hunting Rd at Kendrick St

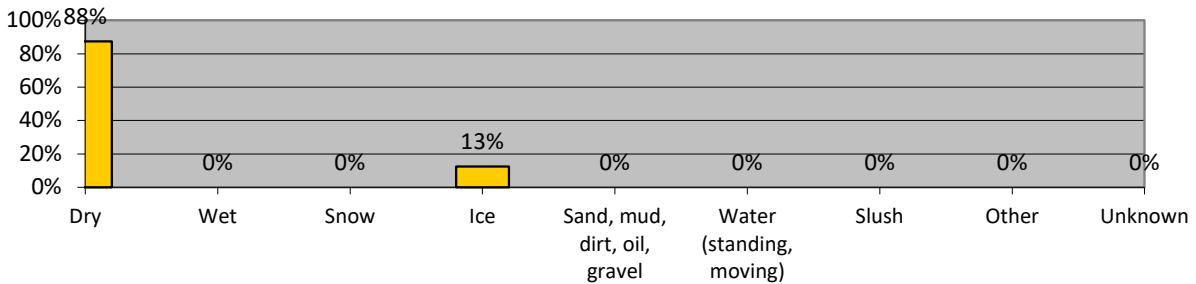
CRASH LIGHT CONDITION



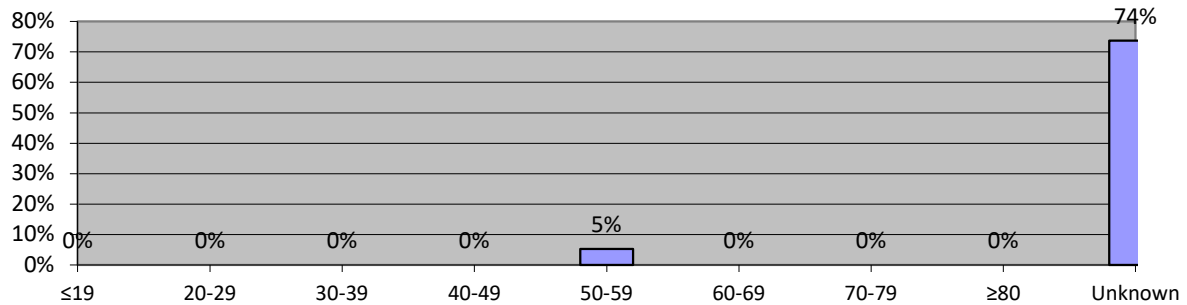
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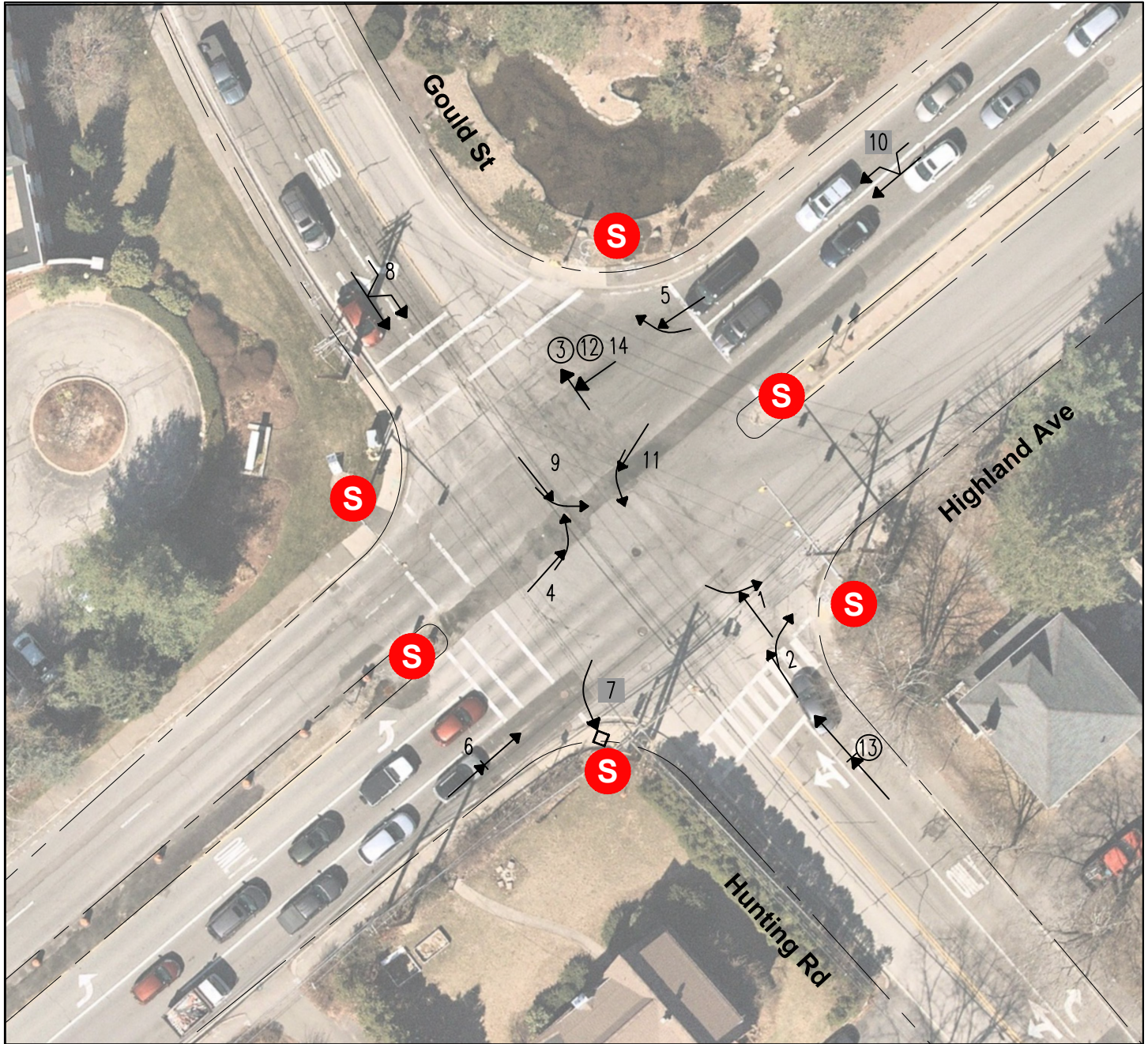
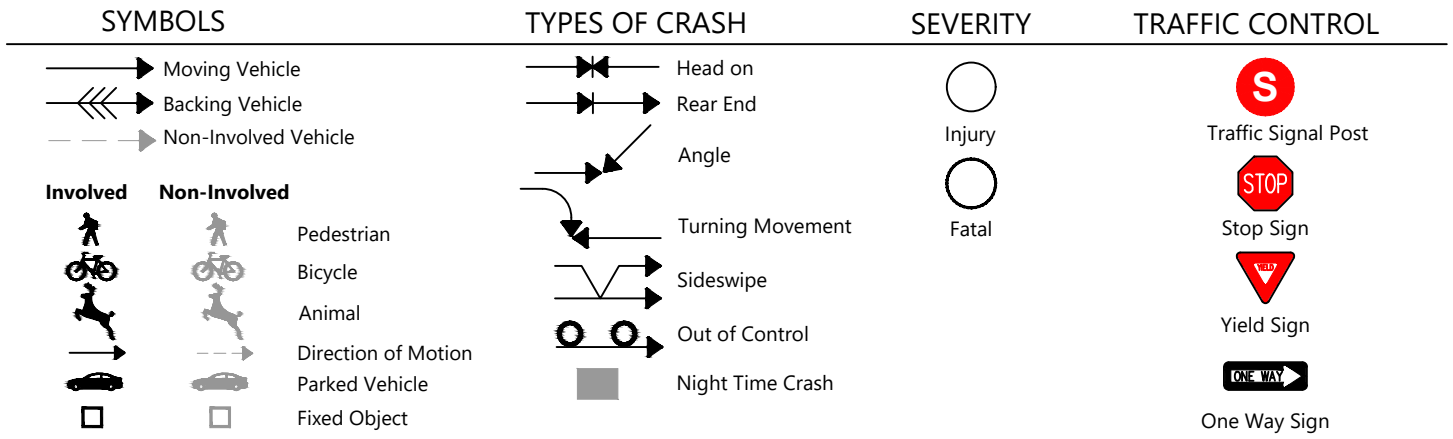


CRASH ROAD SURFACE



CRASH DRIVER AGES





TIME PERIOD ANALYZED: 2017-2019
SOURCE OF CRASH REPORTS: Needham Police Dept.



Collision Diagram
Highland Avenue at
Hunting Road/Gould Street
Needham, MA

Crash Data Summary Table

Highland Ave at Gould St / Hunting Rd
2017 - 2019

Crash Diagram Ref #	Crash Date	Crash Day	Time of Day	Manner of Collision	Light Condition	Weather Condition	Road Surface	Driver Contributing Code	D1 Age	D2 Age	D3 Age	D4 Age	Comments
#	mm/dd/yy	Day	hh:mm	Type	Type	Type	Type	Type	#	#	#	#	
1	08/03/19	Saturday	2:55 PM	Angle	Daylight	Clear	Dry	Unknown	Unknown	Unknown			Vehicle #1 was turning onto Highland Ave at green. Vehicle #2 took a right on red and crashed into the passenger side of Vehicle #1.
2	03/01/17	Wednesday	1:31 PM	Sideswipe, same direction	Daylight	Clear	Dry	Disregarded traffic signs, signals, road markings	Unknown	Unknown			Vehicle #2 was turning right onto Highland Ave from Hunting Road. Vehicle #1 was behind Vehicle #2 and attempted to pass it on the right and turn right onto Highland Ave as well. Vehicle #2 sustained moderate damage to the left rear and side. Vehicle #1 sustained minor damage to the right front corner. There were no reported injuries and both vehicles were able to be driven from the scene.
3	06/27/18	Wednesday	7:23 AM	Angle	Daylight	Clear	Dry	Disregarded traffic signs, signals, road markings	Unknown	Unknown			Vehicle #2 stated he got a green arrow to turn right from his traffic signal, but accidentally continued straight and vehicle #1 drove into him. Air bag deployment in both vehicles. Witness stated that Vehicle #1's lane of traffic had a green light, all of a sudden vehicle #2 came across the intersection at a high rate of speed and vehicle 1 drove into vehicle 2.
4	12/09/19	Monday	11:10 AM	Sideswipe, same direction	Daylight	Clear	Dry	Failure to keep in proper lane or running off road	Unknown	Unknown			Vehicle #1 and Vehicle #2 were turning eastbound from Gould Street onto Highland Ave when Vehicle #1 did not stay in the proper lane, striking Vehicle #2 on the driver's side closest to the driver side door. Vehicle #1 had minor damage to the front right side bumper. Vehicle #2 had substantial damage to the left side mirror. No injuries were reported.
5	03/22/18	Thursday	4:40 PM	Rear-end	Daylight	Clear	Dry	Failed to yield right of way	Unknown	Unknown			Vehicle #2 was in the left lane on Gould St when she realized she needed to be on the right. Vehicle #2 was changing lanes and her vehicle struck Vehicle #1. Vehicle #2 sustained minor rear end damage, and Vehicle #1 sustained minor damage to the front fender and bumper.
6	05/04/18	Friday	6:00 PM	Rear-end	Daylight	Clear	Dry	Distracted	Unknown	Unknown			No injuries. Vehicle #1 was stopped at the lights on Highland Ave waiting to travel westbound on Highland Ave, when he was rear ended by vehicle #2.
7	07/17/18	Tuesday	2:03 AM	Single vehicle crash	Dark - lighted roadway	Clear	Dry	Inattention	Unknown	Unknown			Report of flashing lights possibly caused by a passing construction vehicle. Truck operator struck two signs along Highland Ave as well. The traffic signal was struck.
8	07/26/18	Thursday	8:20 AM	Sideswipe, same direction	Daylight	Clear	Dry	Failure to keep in proper lane or running off road	Unknown	Unknown			Vehicle #2 was stopped in traffic on Highland Ave facing eastbound. According to Vehicle #2, vehicle #1 drove by his stopped vehicle and sideswiped it, knocking his mirror off and damaging it. Vehicle #1 then turned onto Gould St and never stopped. No injuries were reported. Vehicle #2 had very minor damage.
9	12/12/18	Wednesday	12:11 PM	Angle	Daylight	Clear	Dry	No improper driving	Unknown	Unknown			Vehicle #2 was in the left lane, which is a left turn only lane. Vehicle #1 was in the right lane which has no turning restrictions. The light was red and when it turned green vehicle #1 turned left and vehicle #2 went straight ahead. Vehicle #2 struck vehicle #1 in the left rear and then fled the area on Highland Ave towards Netwon.
10	02/05/19	Tuesday	7:21 PM	Sideswipe, same direction	Dark - lighted roadway	Clear	Dry	No improper driving	Unknown	Unknown			Hit and run accident. Vehicle #2 stated that she was traveling west on Highland Ave, approaching the Gould St intersection, when Vehicle #1 sideswiped the right side of her vehicle as unknown vehicle #1 passed her on the right side. No one reported injury. Vehicle #2 sustained right side damage. Unknown vehicle #1 did not pull over after the accident and there is no information available for the vehicle make or operator.
11	03/23/19	Saturday	11:04 AM	Angle	Daylight	Clear	Dry	Unknown	Unknown	Unknown			Vehicle #1 was facing southbound on Gould St attempting to make a left turn onto Highland Ave eastbound. Vehicle #1 started from inside travel lane of Gould Street. Vehicle #2 was facing on Gould St in the outside lane attempting to make a left turn onto Highland Ave eastbound. At some point during the turn the vehicles collided. The paint line delineating the traffic lanes at this intersection are faded. No injuries are reported. Vehicle #1 had minor right front bumper damage and vehicle #2 had minor left rear quarter panel damage (dents and scrape marks).

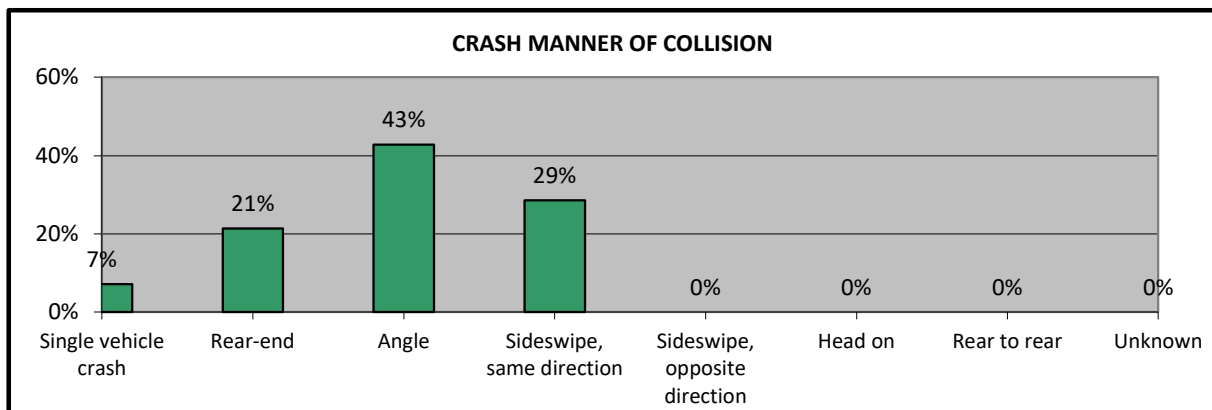
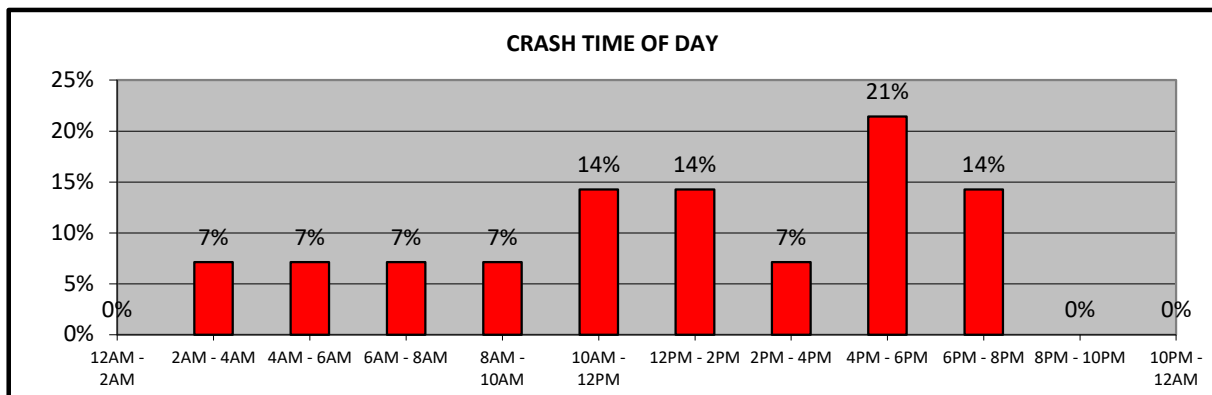
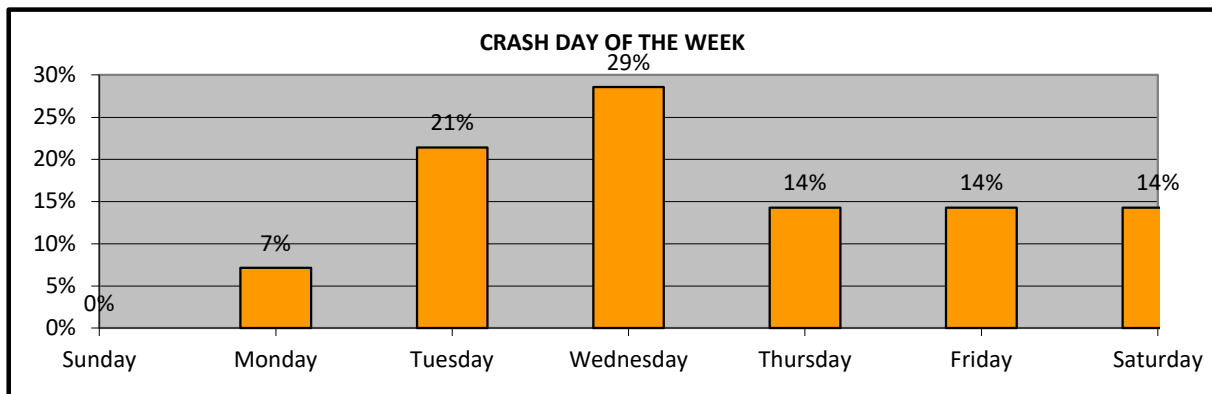
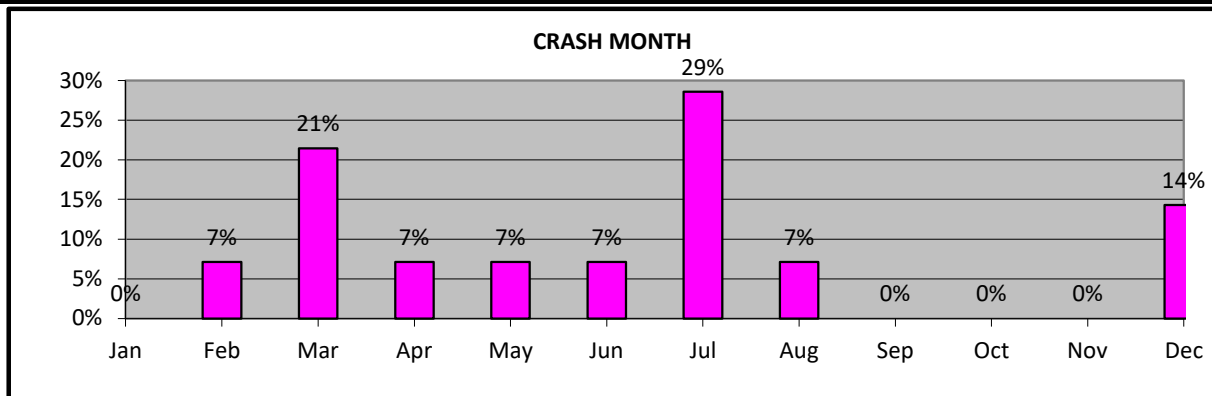
Crash Data Summary Table

Highland Ave at Gould St / Hunting Rd
2017 - 2019

Crash Diagram Ref #	Crash Date	Crash Day	Time of Day	Manner of Collision	Light Condition	Weather Condition	Road Surface	Driver Contributing Code	D1 Age	D2 Age	D3 Age	D4 Age	Comments
#	mm/dd/yy	Day	hh:mm	Type	Type	Type	Type	Type	#	#	#	#	
12	04/30/19	Tuesday	4:49 AM	Angle	Daylight	Clear	Dry	Unknown	Unknown	Unknown			At 4:49 am, 2 car crash at intersection of Highland Ave and Gould St with no reported injuries. Vehicle #1 stated she was driving on Highland Ave (west) and turning right (north) onto Gould St when she struck vehicle #2. Some left shoulder pain of vehicle #2. Vehicle #2 was towed from the scene.
13	07/13/18	Friday	5:59 PM	Rear-end	Daylight	Clear	Dry	Unknown	Unknown	Unknown			Vehicle #2 at the intersection of Highland Ave at Hunting Rd. Vehicle #1 rear ends Vehicle #2 while it is stopped. No injuries reported at the scene. Vehicles had significant damage but neither had to be towed from the scene. No injuries.
14	07/31/19	Wednesday	4:35 PM	Angle	Daylight	Clear	Dry	Unknown	Unknown	Unknown			Vehicle #1 was going southwest on Highland Ave. Vehicle #2 was driving towards her. Minimal damage on Vehicle #1. No injury.

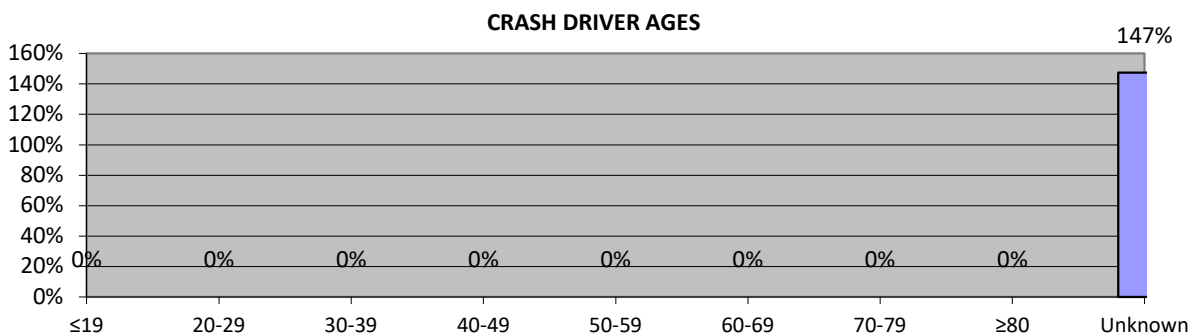
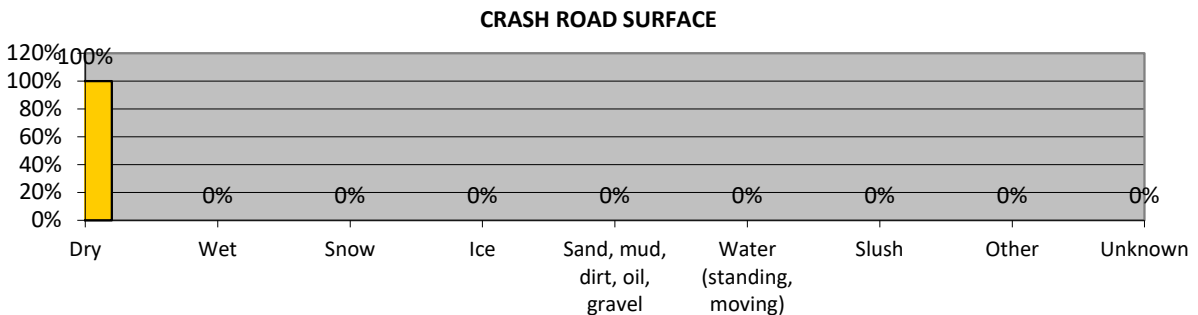
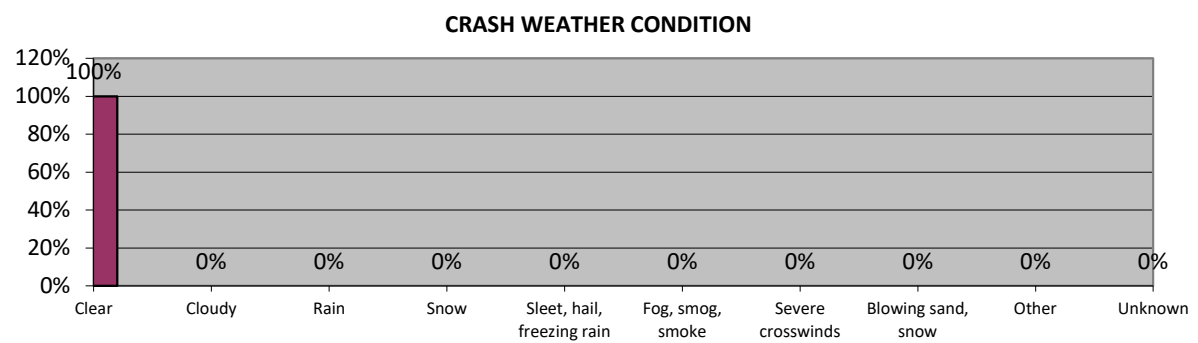
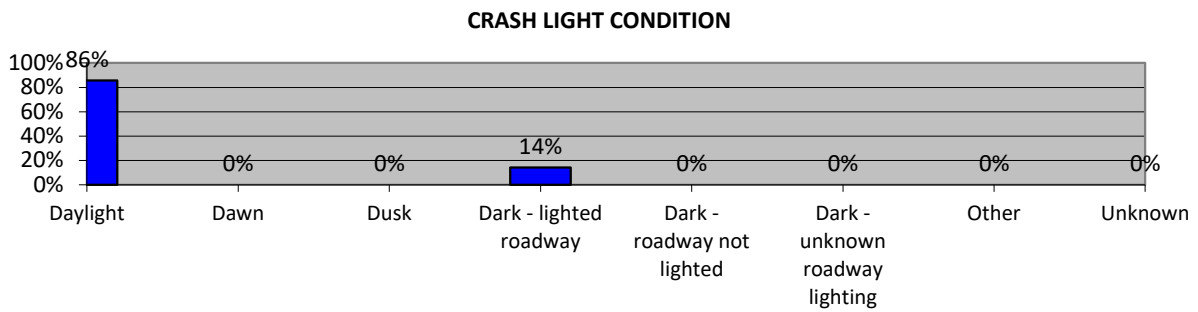
Crash Data Summary Charts

Highland Ave at Gould St / Hunting Rd



Crash Data Summary Charts

Highland Ave at Gould St / Hunting Rd



Existing Site Trip Generation Calculations

Comment 12

ITE TRIP GENERATION WORKSHEET*(11th Edition, Updated 2021)***LANDUSE:** Automated Car Wash**LANDUSE CODE:** 948

Independent Variable --- 1,000 Sq. Feet Gross Floor Area

SETTING/LOCATION:**JOB NAME:** 557 Highland Avenue**FLOOR AREA (KSF):** 4.60**JOB NUMBER:****WEEKDAY**

RATES:		# Studies	R^2	Total Trip Ends			Independent Variable Range			Directional Distribution	
				Average	Low	High	Average	Low	High	Enter	Exit
	DAILY	--	--	--	--	--	--	--	--	--	--
	AM PEAK OF GENERATOR	--	--	--	--	--	--	--	--	--	--
	PM PEAK OF GENERATOR	2	--	11.66	8.35	16.63	5.00	4.39	6.59	50%	50%

TRIPS:

	BY AVERAGE			BY REGRESSION		
	Total	Enter	Exit	Total	Enter	Exit
DAILY	--	--	--	--	--	--
AM PEAK OF GENERATOR	--	--	--	--	--	--
PM PEAK OF GENERATOR	54	27	27	--	--	--

SATURDAY

RATES:		# Studies	R^2	Total Trip Ends			Independent Variable Range			Directional Distribution	
				Average	Low	High	Average	Low	High	Enter	Exit
	DAILY	--	--	--	--	--	--	--	--	--	--
	PEAK OF GENERATOR	3	--	30.40	14.20	37.75	3.00	1.69	5.00	50%	50%

TRIPS:

	BY AVERAGE			BY REGRESSION		
	Total	Enter	Exit	Total	Enter	Exit
DAILY	--	--	--	--	--	--
PEAK OF GENERATOR	140	70	70	--	--	--

SUNDAY

RATES:		# Studies	R^2	Total Trip Ends			Independent Variable Range			Directional Distribution	
				Average	Low	High	Average	Low	High	Enter	Exit
	DAILY	--	--	--	--	--	--	--	--	--	--
	PEAK OF GENERATOR	--	--	--	--	--	--	--	--	--	--

TRIPS:

	BY AVERAGE			BY REGRESSION		
	Total	Enter	Exit	Total	Enter	Exit
DAILY	--	--	--	--	--	--
PEAK OF GENERATOR	--	--	--	--	--	--

ITE TRIP GENERATION WORKSHEET
(11th Edition, Updated 2021)

LANDUSE: Automobile Sales (New)
LANDUSE CODE: 840
SETTING/LOCATION: General Urban/Suburban
JOB NAME: 557 Highland Avenue
JOB NUMBER:

Independent Variable --- 1,000 Sq. Feet Gross Floor Area

FLOOR AREA (KSF): 35.15**WEEKDAY**

RATES:	# Studies	R^2	Total Trip Ends			Independent Variable Range			Directional Distribution	
			Average	Low	High	Average	Low	High	Enter	Exit
DAILY	18	0.80	27.84	14.98	41.78	36	15.00	77.00	50%	50%
AM PEAK OF GENERATOR	40	0.65	2.15	0.59	4.13	32	9.34	80.00	54%	46%
PM PEAK OF GENERATOR	39	0.61	2.65	0.89	5.64	33	9.34	80.00	46%	54%

TRIPS:

	BY AVERAGE			BY REGRESSION		
	Total	Enter	Exit	Total	Enter	Exit
DAILY	980	490	490	978	489	489
AM PEAK OF GENERATOR	76	41	35	75	40	34
PM PEAK OF GENERATOR	93	43	50	92	42	50

SATURDAY

RATES:	# Studies	R^2	Total Trip Ends			Independent Variable Range			Directional Distribution	
			Average	Low	High	Average	Low	High	Enter	Exit
DAILY	1	--	52.24	52.24	52.24	33	33	33	50%	50%
PEAK OF GENERATOR	4	0.92	4.02	1.41	5.64	21	16	33	50%	50%

TRIPS:

	BY AVERAGE			BY REGRESSION		
	Total	Enter	Exit	Total	Enter	Exit
DAILY	1,838	919	919	--	--	--
PEAK OF GENERATOR	141	71	71	206	103	103

SUNDAY

RATES:	# Studies	R^2	Total Trip Ends			Independent Variable Range			Directional Distribution	
			Average	Low	High	Average	Low	High	Enter	Exit
DAILY	1	--	21.73	21.73	21.73	33	33	33	50%	50%
PEAK OF GENERATOR	--	--	--	--	--	--	--	--	--	--

TRIPS:

	BY AVERAGE			BY REGRESSION		
	Total	Enter	Exit	Total	Enter	Exit
DAILY	764	382	382	--	--	--
PEAK OF GENERATOR	--	--	--	--	--	--

Existing Town of Needham Mode Share Data

Comment 14

2012-2016 American Community Survey - Work in Needham

Mode Share - Aggregate

Mode	Total	Percent
Car, Truck, or Van - Drove Alone	16,089	82.5%
Carpool - In 2-Person Carpool	1,072	5.5%
Carpooled - In 3-Person Carpool	181	0.9%
Carpooled - In 4-Person Carpool	65	0.3%
Carpooled - In a 5 or 6 Person Carpool	20	0.1%
Carpooled - In a 7 or More Person Carpool	140	0.7%
Public Transportation	302	1.5%
Walked	287	1.5%
Bicycle	99	0.5%
Taxicab / Motorcycle / Other	71	0.4%
Worked at Home	1,185	6.1%
Total	19,511	100.0%

Note: Based on Journey to Work data from the US Census Bureau (2012-2016
5-Year American Community Survey) for those who work in Needham.

Mode Share - Combined

Mode	Total	Percent
Vehicle	17,638	90.4%
Transit	302	1.5%
Bicycle	99	0.5%
Walked	287	1.5%
Worked at home	1,185	6.1%
Total	19,511	100.0%

Mode Share - For Comparison

Mode	Total	Percent	% Rounded
Vehicle	17,638	96.2%	95%
Transit	302	1.6%	2%
Bike	99	0.5%	1%
Walk	287	1.6%	2%
Total	18,326	100.0%	100.0%

Note: Worked at home not included in dataset

Vehicle Occupancy Rate

Vehicle Occupancy	Total
1	16,160
2	1,072
3	181
4	65
5	10
6	10
7	140
VOR	1.15

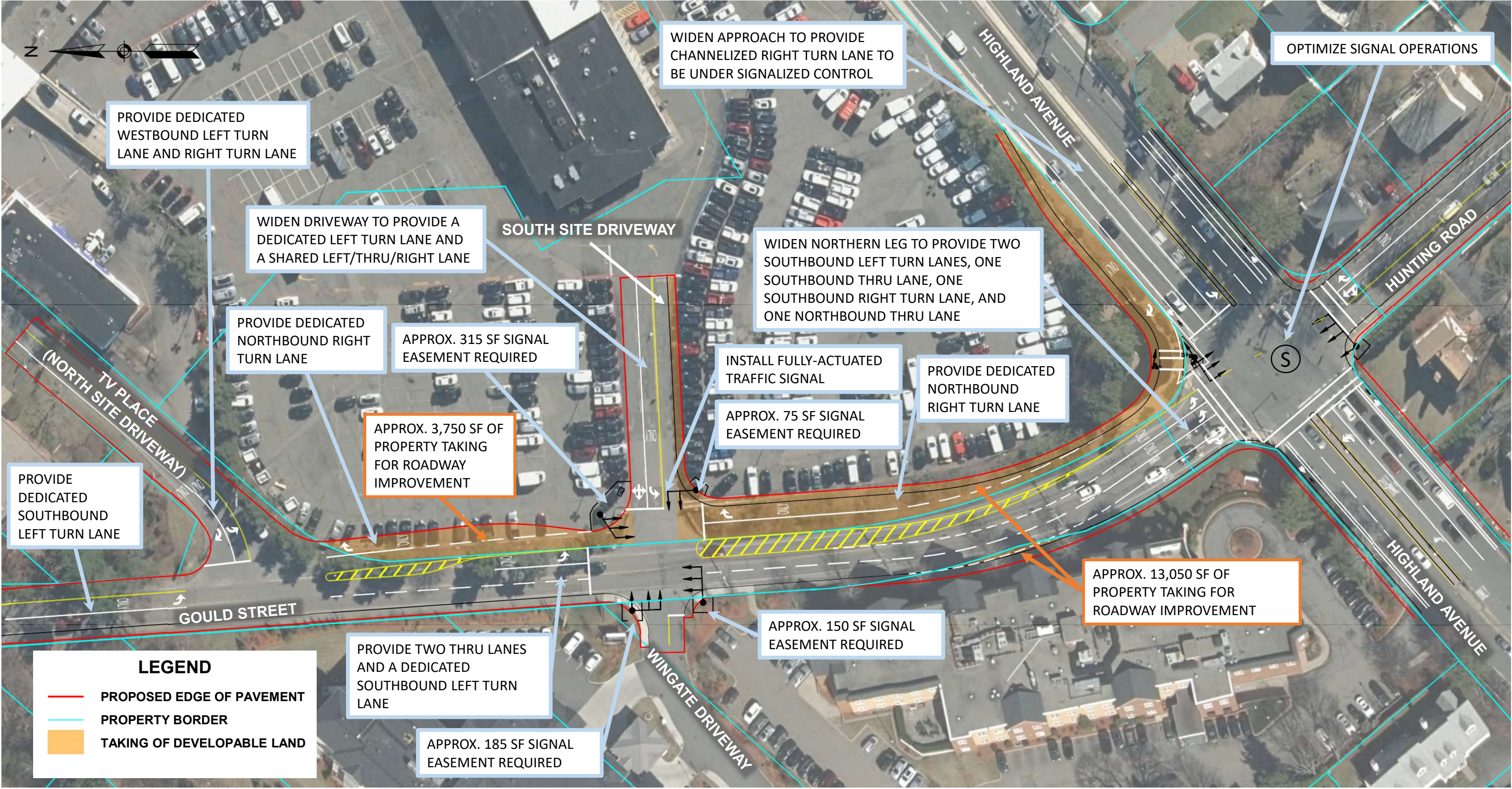


FIGURE 11
CONCEPT PLAN — ALTERNATIVE 1

Intersection Capacity Analysis Worksheets

Comments 19 and 21-24

Intersection						
Int Delay, s/veh	2.1					
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Vol, veh/h	25	20	635	135	85	355
Future Vol, veh/h	25	20	635	135	85	355
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	150	-	-	150	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	60	60	95	95	91	91
Heavy Vehicles, %	0	0	2	2	0	3
Mvmt Flow	42	33	668	142	93	390
Major/Minor	Minor1	Major1	Major2			
Conflicting Flow All	1315	739	0	0	810	0
Stage 1	739	-	-	-	-	-
Stage 2	576	-	-	-	-	-
Critical Hdwy	6.4	6.2	-	-	4.1	-
Critical Hdwy Stg 1	5.4	-	-	-	-	-
Critical Hdwy Stg 2	5.4	-	-	-	-	-
Follow-up Hdwy	3.5	3.3	-	-	2.2	-
Pot Cap-1 Maneuver	176	421	-	-	825	-
Stage 1	476	-	-	-	-	-
Stage 2	566	-	-	-	-	-
Platoon blocked, %			-	-	-	-
Mov Cap-1 Maneuver	156	421	-	-	825	-
Mov Cap-2 Maneuver	156	-	-	-	-	-
Stage 1	476	-	-	-	-	-
Stage 2	502	-	-	-	-	-
Approach	WB	NB	SB			
HCM Control Delay, s	26.5	0	1.9			
HCM LOS	D					
Minor Lane/Major Mvmt	NBT	NBR	WBLn1	WBLn2	SBL	SBT
Capacity (veh/h)	-	-	156	421	825	-
HCM Lane V/C Ratio	-	-	0.267	0.079	0.113	-
HCM Control Delay (s)	-	-	36.3	14.3	9.9	-
HCM Lane LOS	-	-	E	B	A	-
HCM 95th %tile Q(veh)	-	-	1	0.3	0.4	-

												
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	0	5	70	1	20	15	750	385	30	350	2
Future Volume (vph)	1	0	5	70	1	20	15	750	385	30	350	2
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width (ft)	12	12	12	12	13	13	12	12	12	12	12	12
Storage Length (ft)	0		0	0		0	0		100	150		0
Storage Lanes	0		0	1		0	0		1	1		0
Taper Length (ft)	25			25			25			25		
Right Turn on Red			Yes			Yes			Yes			Yes
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		151			225			398			315	
Travel Time (s)		3.4			5.1			9.0			7.2	
Confl. Bikes (#/hr)									1			
Peak Hour Factor	0.63	0.63	0.63	0.90	0.90	0.90	0.90	0.90	0.90	0.83	0.83	0.83
Shared Lane Traffic (%)				34%								
Lane Group Flow (vph)	0	10	0	51	50	0	0	850	428	36	424	0
Turn Type	Split	NA		Split	NA		Perm	NA	Perm	Perm	NA	
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2		2	6		
Detector Phase	4	4		8	8		2	2	2	6	6	
Switch Phase												
Minimum Initial (s)	6.0	6.0		6.0	6.0		10.0	10.0	10.0	10.0	10.0	
Minimum Split (s)	27.0	27.0		11.0	11.0		15.0	15.0	15.0	23.0	23.0	
Total Split (s)	27.0	27.0		13.0	13.0		95.0	95.0	95.0	95.0	95.0	
Total Split (%)	20.0%	20.0%		9.6%	9.6%		70.4%	70.4%	70.4%	70.4%	70.4%	
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0	1.0	1.0	1.0	
Lost Time Adjust (s)		0.0		0.0	0.0			0.0	0.0	0.0	0.0	
Total Lost Time (s)		4.0		4.0	4.0			4.0	4.0	4.0	4.0	
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	None	None		None	None		C-Min	C-Min	C-Min	C-Min	C-Min	
v/c Ratio		0.07		0.43	0.36			0.55	0.32	0.08	0.14	
Control Delay		0.8		70.6	44.5			7.1	3.2	5.8	4.0	
Queue Delay		0.0		0.0	0.0			4.5	1.2	0.0	0.0	
Total Delay		0.8		70.6	44.5			11.6	4.5	5.8	4.0	
Queue Length 50th (ft)		0		46	25			153	22	3	20	
Queue Length 95th (ft)		0		90	68			m273	m78	24	88	
Internal Link Dist (ft)		71			145			318			235	
Turn Bay Length (ft)									100	150		
Base Capacity (vph)		313		128	147			1550	1339	447	2978	
Starvation Cap Reductn		0		0	0			611	669	0	0	
Spillback Cap Reductn		0		0	0			0	0	0	0	
Storage Cap Reductn		0		0	0			0	0	0	0	
Reduced v/c Ratio		0.03		0.40	0.34			0.91	0.64	0.08	0.14	

Intersection Summary

Area Type: Other
 Cycle Length: 135
 Actuated Cycle Length: 135
 Offset: 15 (11%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
 Natural Cycle: 80
 Control Type: Actuated-Coordinated
 m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 11: Gould St & Windgate Dwy/Muzi Ford Dwy

																		
95 s	95 s	95 s	95 s	95 s	95 s	95 s	95 s	95 s	95 s	95 s	95 s	95 s	95 s	95 s	95 s	95 s	95 s	95 s
27 s	27 s	27 s	27 s	27 s	27 s	27 s	27 s	27 s	27 s	27 s	27 s	27 s	27 s	27 s	27 s	27 s	27 s	27 s
13 s	13 s	13 s	13 s	13 s	13 s	13 s	13 s	13 s	13 s	13 s	13 s	13 s	13 s	13 s	13 s	13 s	13 s	13 s

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	0	5	70	1	20	15	750	385	30	350	2
Future Volume (vph)	1	0	5	70	1	20	15	750	385	30	350	2
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	12	12	12	13	13	12	12	12	12	12	12
Total Lost time (s)		4.0		4.0	4.0			4.0	4.0	4.0	4.0	
Lane Util. Factor		1.00		0.95	0.95			1.00	1.00	1.00	0.95	
Frpb, ped/bikes		1.00		1.00	1.00			1.00	0.98	1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00			1.00	1.00	1.00	1.00	
Frt		0.89		1.00	0.93			1.00	0.85	1.00	1.00	
Flt Protected		0.99		0.95	0.97			1.00	1.00	0.95	1.00	
Satd. Flow (prot)		1645		1681	1663			1861	1551	1770	3537	
Flt Permitted		0.99		0.95	0.97			0.99	1.00	0.29	1.00	
Satd. Flow (perm)		1645		1681	1663			1841	1551	531	3537	
Peak-hour factor, PHF	0.63	0.63	0.63	0.90	0.90	0.90	0.90	0.90	0.90	0.83	0.83	0.83
Adj. Flow (vph)	2	0	8	78	1	22	17	833	428	36	422	2
RTOR Reduction (vph)	0	10	0	0	21	0	0	0	40	0	0	0
Lane Group Flow (vph)	0	0	0	51	29	0	0	850	388	36	424	0
Confl. Bikes (#/hr)									1			
Turn Type	Split	NA		Split	NA		Perm	NA	Perm	Perm	NA	
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2		2	6		
Actuated Green, G (s)		5.8		8.3	8.3			108.9	108.9	108.9	108.9	
Effective Green, g (s)		5.8		8.3	8.3			108.9	108.9	108.9	108.9	
Actuated g/C Ratio		0.04		0.06	0.06			0.81	0.81	0.81	0.81	
Clearance Time (s)		4.0		4.0	4.0			4.0	4.0	4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)		70		103	102			1485	1251	428	2853	
v/s Ratio Prot		c0.00		c0.03	0.02						0.12	
v/s Ratio Perm								c0.46	0.25	0.07		
v/c Ratio		0.01		0.50	0.29			0.57	0.31	0.08	0.15	
Uniform Delay, d1		61.8		61.3	60.5			4.7	3.4	2.7	2.9	
Progression Factor		1.00		1.00	1.00			0.98	1.14	1.00	1.00	
Incremental Delay, d2		0.0		3.7	1.6			0.4	0.2	0.4	0.1	
Delay (s)		61.9		65.0	62.1			5.0	4.0	3.1	3.0	
Level of Service		E		E	E			A	A	A	A	
Approach Delay (s)		61.9			63.6			4.7			3.0	
Approach LOS		E			E			A			A	
Intersection Summary												
HCM 2000 Control Delay		7.8										
HCM 2000 Volume to Capacity ratio		0.54										
Actuated Cycle Length (s)		135.0										
Intersection Capacity Utilization		67.0%										
Analysis Period (min)		15										
c Critical Lane Group												

Bulfinch Muzi Needham
12: Highland Ave & West St

2029 Build AM Condition - with Mitigation v2

Timing Plan: Weekday Morning

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø9
Lane Configurations													
Traffic Volume (vph)	225	220	30	40	190	60	30	555	60	25	305	105	
Future Volume (vph)	225	220	30	40	190	60	30	555	60	25	305	105	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	
Storage Length (ft)	120		0	100		0	0		0	0		0	
Storage Lanes	1		0	1		0	0		0	0		0	
Taper Length (ft)	25			25			25			25			
Right Turn on Red			No			No			No			No	
Link Speed (mph)		30			30			30			30		
Link Distance (ft)		318			371			476			549		
Travel Time (s)		7.2			8.4			10.8			12.5		
Confl. Peds. (#/hr)	14		4	4		14	4		22	22		4	
Peak Hour Factor	0.94	0.94	0.94	0.87	0.87	0.87	0.87	0.87	0.87	0.96	0.96	0.96	
Heavy Vehicles (%)	4%	2%	4%	0%	2%	0%	4%	4%	0%	0%	7%	5%	
Bus Blockages (#/hr)	0	0	0	0	0	0	2	2	2	0	0	0	
Parking (#/hr)							0	0	0	0	0	0	
Shared Lane Traffic (%)													
Lane Group Flow (vph)	239	266	0	46	287	0	0	741	0	0	453	0	
Turn Type	D.P+P	NA		Perm	NA		Perm	NA		Perm	NA		
Protected Phases	1	1 2			2			3			3		9
Permitted Phases	2	2		2			3			3			
Detector Phase	1	1 2		2	2		3	3		3	3		
Switch Phase													
Minimum Initial (s)	6.0			10.0	10.0		10.0	10.0		10.0	10.0		7.0
Minimum Split (s)	11.0			15.0	15.0		15.0	15.0		15.0	15.0		20.0
Total Split (s)	15.0			35.0	35.0		60.0	60.0		60.0	60.0		20.0
Total Split (%)	11.5%			26.9%	26.9%		46.2%	46.2%		46.2%	46.2%		15%
Yellow Time (s)	4.0			4.0	4.0		4.0	4.0		4.0	4.0		2.0
All-Red Time (s)	1.0			1.0	1.0		1.0	1.0		1.0	1.0		0.0
Lost Time Adjust (s)	0.0			0.0	0.0			0.0			0.0		
Total Lost Time (s)	5.0			5.0	5.0			5.0			5.0		
Lead/Lag	Lead			Lag	Lag								
Lead-Lag Optimize?													
Recall Mode	None			None	None		Min	Min		Min	Min		None
v/c Ratio	0.88	0.42		0.20	0.77			0.91			0.60		
Control Delay	60.4	29.2		38.0	55.1			42.6			24.5		
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0		
Total Delay	60.4	29.2		38.0	55.1			42.6			24.5		
Queue Length 50th (ft)	114	128		25	176			407			189		
Queue Length 95th (ft)	#258	252		65	313			#913			453		
Internal Link Dist (ft)		238			291			396			469		
Turn Bay Length (ft)	120			100									
Base Capacity (vph)	273	778		320	508			811			761		
Starvation Cap Reductn	0	0		0	0			0			0		
Spillback Cap Reductn	0	0		0	0			0			0		
Storage Cap Reductn	0	0		0	0			0			0		
Reduced v/c Ratio	0.88	0.34		0.14	0.56			0.91			0.60		

Intersection Summary

Area Type: Other

Cycle Length: 130

Actuated Cycle Length: 106.5

Natural Cycle: 130

Control Type: Actuated-Uncoordinated

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

Splits and Phases: 12: Highland Ave & West St

Ø1	Ø2	Ø3	Ø9
15 s	35 s	60 s	20 s

													
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
Lane Configurations													
Traffic Volume (vph)	225	220	30	40	190	60	30	555	60	25	305	105	
Future Volume (vph)	225	220	30	40	190	60	30	555	60	25	305	105	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	
Total Lost time (s)	5.0	5.0		5.0	5.0			5.0			5.0		
Lane Util. Factor	1.00	1.00		1.00	1.00			1.00			1.00		
Flpb, ped/bikes	1.00	1.00		1.00	0.99			1.00			0.99		
Flpb, ped/bikes	1.00	1.00		0.99	1.00			1.00			1.00		
Frt	1.00	0.98		1.00	0.96			0.99			0.97		
Flt Protected	0.95	1.00		0.95	1.00			1.00			1.00		
Satd. Flow (prot)	1730	1819		1793	1781			1606			1545		
Flt Permitted	0.29	1.00		0.60	1.00			0.97			0.94		
Satd. Flow (perm)	524	1819		1123	1781			1554			1456		
Peak-hour factor, PHF	0.94	0.94	0.94	0.87	0.87	0.87	0.87	0.87	0.87	0.96	0.96	0.96	
Adj. Flow (vph)	239	234	32	46	218	69	34	638	69	26	318	109	
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	0	
Lane Group Flow (vph)	239	266	0	46	287	0	0	741	0	0	453	0	
Confl. Peds. (#/hr)	14		4	4		14	4		22	22		4	
Heavy Vehicles (%)	4%	2%	4%	0%	2%	0%	4%	4%	0%	0%	7%	5%	
Bus Blockages (#/hr)	0	0	0	0	0	0	2	2	2	0	0	0	
Parking (#/hr)							0	0	0	0	0	0	
Turn Type	D.P+P	NA		Perm	NA		Perm	NA		Perm	NA		
Protected Phases	1	12			2			3			3		
Permitted Phases	2	2		2			3			3			
Actuated Green, G (s)	32.3	37.3		22.2	22.2			55.7			55.7		
Effective Green, g (s)	32.3	37.3		22.2	22.2			55.7			55.7		
Actuated g/C Ratio	0.30	0.35		0.21	0.21			0.52			0.52		
Clearance Time (s)	5.0			5.0	5.0			5.0			5.0		
Vehicle Extension (s)	3.0			3.0	3.0			3.0			3.0		
Lane Grp Cap (vph)	269	628		231	366			802			751		
v/s Ratio Prot	c0.08	0.15			0.16								
v/s Ratio Perm	c0.18			0.04				c0.48			0.31		
v/c Ratio	0.89	0.42		0.20	0.78			0.92			0.60		
Uniform Delay, d1	33.3	27.1		35.5	40.6			24.1			18.3		
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00		
Incremental Delay, d2	27.7	0.5		0.4	10.5			16.2			1.4		
Delay (s)	61.0	27.5		35.9	51.1			40.3			19.7		
Level of Service	E	C		D	D			D			B		
Approach Delay (s)		43.4			49.0			40.3			19.7		
Approach LOS		D			D			D			B		
Intersection Summary													
HCM 2000 Control Delay			37.9			HCM 2000 Level of Service				D			
HCM 2000 Volume to Capacity ratio			0.88										
Actuated Cycle Length (s)			107.9			Sum of lost time (s)				17.0			
Intersection Capacity Utilization			81.4%			ICU Level of Service				D			
Analysis Period (min)			15										

c Critical Lane Group

Bulfinch Muzi Needham
14: Webster St & Highland Ave

2029 Build AM Condition - with Mitigation v2

Timing Plan: Weekday Morning

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø9
Lane Configurations													
Traffic Volume (vph)	35	595	15	125	460	60	20	315	405	85	140	30	
Future Volume (vph)	35	595	15	125	460	60	20	315	405	85	140	30	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	
Storage Length (ft)	150		0	150		0	0		150	0		200	
Storage Lanes	1		0	1		0	0		1	0		1	
Taper Length (ft)	25			25			25			25			
Right Turn on Red			Yes			No			Yes			No	
Link Speed (mph)		30			30			30			30		
Link Distance (ft)		1325			691			391			2983		
Travel Time (s)		30.1			15.7			8.9			67.8		
Confl. Peds. (#/hr)	7					7	1		7	7		1	
Confl. Bikes (#/hr)			1										
Peak Hour Factor	0.94	0.94	0.94	0.88	0.88	0.88	0.87	0.87	0.87	0.88	0.88	0.88	
Heavy Vehicles (%)	4%	3%	0%	0%	2%	4%	1%	1%	0%	0%	1%	0%	
Shared Lane Traffic (%)													
Lane Group Flow (vph)	37	649	0	142	591	0	0	385	466	0	290	0	
Turn Type	Perm	NA		pm+pt	NA		Perm	NA	pm+ov	Perm	NA		
Protected Phases		6		5	2			8	5		4		9
Permitted Phases	6			2			8		8	4			
Detector Phase	6	6		5	2		8	8	5	4	4		
Switch Phase													
Minimum Initial (s)	10.0	10.0		6.0	10.0		6.0	6.0	6.0	6.0	6.0		7.0
Minimum Split (s)	17.5	17.5		13.5	17.5		12.5	12.5	13.5	12.5	12.5		28.0
Total Split (s)	49.0	49.0		16.0	65.0		37.0	37.0	16.0	37.0	37.0		28.0
Total Split (%)	37.7%	37.7%		12.3%	50.0%		28.5%	28.5%	12.3%	28.5%	28.5%		22%
Yellow Time (s)	4.0	4.0		4.0	4.0		3.5	3.5	4.0	3.5	3.5		3.0
All-Red Time (s)	3.5	3.5		3.5	3.5		3.0	3.0	3.5	3.0	3.0		4.0
Lost Time Adjust (s)	0.0	0.0		0.0	0.0			0.0	0.0		0.0		
Total Lost Time (s)	7.5	7.5		7.5	7.5			6.5	7.5		6.5		
Lead/Lag	Lag	Lag		Lead				Lead					
Lead-Lag Optimize?													
Recall Mode	Min	Min		None	Min		None	None	None	None	None		None
v/c Ratio	0.12	0.87		0.60	0.58			0.82	0.62		0.90dl		
Control Delay	25.4	44.6		26.6	20.6			52.2	11.5		40.4		
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0		
Total Delay	25.4	44.6		26.6	20.6			52.2	11.5		40.4		
Queue Length 50th (ft)	14	366		39	223			223	51		82		
Queue Length 95th (ft)	52	#861		#152	531			#474	177		164		
Internal Link Dist (ft)		1245			611			311			2903		
Turn Bay Length (ft)	150			150					150				
Base Capacity (vph)	311	743		237	1019			537	747		566		
Starvation Cap Reductn	0	0		0	0			0	0		0		
Spillback Cap Reductn	0	0		0	0			0	0		0		
Storage Cap Reductn	0	0		0	0			0	0		0		
Reduced v/c Ratio	0.12	0.87		0.60	0.58			0.72	0.62		0.51		

Intersection Summary

Area Type: Other

Cycle Length: 130

Actuated Cycle Length: 104.2

Natural Cycle: 130

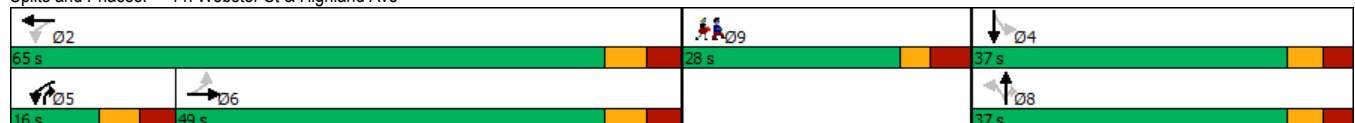
Control Type: Actuated-Uncoordinated

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 14: Webster St & Highland Ave



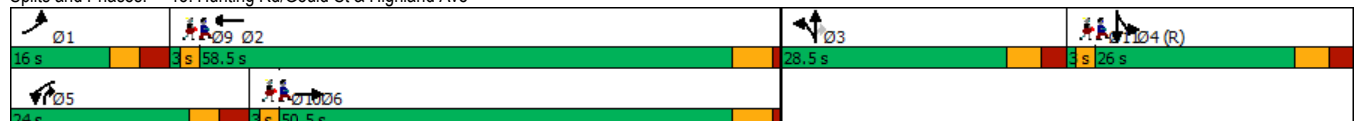
												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	35	595	15	125	460	60	20	315	405	85	140	30
Future Volume (vph)	35	595	15	125	460	60	20	315	405	85	140	30
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	7.5	7.5		7.5	7.5			6.5	7.5		6.5	
Lane Util. Factor	1.00	1.00		1.00	1.00			1.00	1.00		0.95	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			1.00	0.98		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00	1.00		1.00	
Frt	1.00	1.00		1.00	0.98			1.00	0.85		0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00	1.00		0.98	
Satd. Flow (prot)	1729	1839		1805	1821			1875	1578		3453	
Flt Permitted	0.42	1.00		0.10	1.00			0.96	1.00		0.54	
Satd. Flow (perm)	772	1839		184	1821			1811	1578		1907	
Peak-hour factor, PHF	0.94	0.94	0.94	0.88	0.88	0.88	0.87	0.87	0.87	0.88	0.88	0.88
Adj. Flow (vph)	37	633	16	142	523	68	23	362	466	97	159	34
RTOR Reduction (vph)	0	1	0	0	0	0	0	0	224	0	0	0
Lane Group Flow (vph)	37	648	0	142	591	0	0	385	242	0	290	0
Confl. Peds. (#/hr)	7					7	1		7	7		1
Confl. Bikes (#/hr)			1									
Heavy Vehicles (%)	4%	3%	0%	0%	2%	4%	1%	1%	0%	0%	1%	0%
Turn Type	Perm	NA		pm+pt	NA		Perm	NA	pm+ov	Perm	NA	
Protected Phases		6		5	2			8	5		4	
Permitted Phases	6			2			8		8	4		
Actuated Green, G (s)	42.2	42.2		58.3	58.3			27.2	35.8		27.2	
Effective Green, g (s)	42.2	42.2		58.3	58.3			27.2	35.8		27.2	
Actuated g/C Ratio	0.38	0.38		0.53	0.53			0.25	0.33		0.25	
Clearance Time (s)	7.5	7.5		7.5	7.5			6.5	7.5		6.5	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0		3.0	
Lane Grp Cap (vph)	296	706		224	966			448	514		471	
v/s Ratio Prot		c0.35		0.05	c0.32				0.04			
v/s Ratio Perm	0.05			0.29				c0.21	0.12		0.15	
v/c Ratio	0.12	0.92		0.63	0.61			0.86	0.47		0.90dl	
Uniform Delay, d1	21.9	32.2		21.2	17.9			39.5	29.5		36.7	
Progression Factor	1.00	1.00		1.00	1.00			1.00	1.00		1.00	
Incremental Delay, d2	0.2	16.8		5.8	1.2			15.1	0.7		2.4	
Delay (s)	22.1	49.1		27.0	19.1			54.6	30.2		39.1	
Level of Service	C	D		C	B			D	C		D	
Approach Delay (s)		47.6			20.6			41.2			39.1	
Approach LOS		D			C			D			D	
Intersection Summary												
HCM 2000 Control Delay			36.8			HCM 2000 Level of Service					D	
HCM 2000 Volume to Capacity ratio			0.87									
Actuated Cycle Length (s)			109.9			Sum of lost time (s)					28.5	
Intersection Capacity Utilization			87.5%			ICU Level of Service					E	
Analysis Period (min)			15									
dl Defacto Left Lane. Recode with 1 though lane as a left lane.												
c Critical Lane Group												

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø9	Ø10	Ø11
Lane Configurations															
Traffic Volume (vph)	150	890	15	45	605	760	25	240	240	290	90	45			
Future Volume (vph)	150	890	15	45	605	760	25	240	240	290	90	45			
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900			
Storage Length (ft)	175		0	165		400	0		150	200		200			
Storage Lanes	1		0	1		0	0		1	1		0			
Taper Length (ft)	25			25			25			25					
Right Turn on Red			Yes			Yes			Yes			Yes			
Link Speed (mph)		30			30			30			30				
Link Distance (ft)		345			745			3028			398				
Travel Time (s)		7.8			16.9			68.8			9.0				
Confl. Peds. (#/hr)	1		1	1		1									
Confl. Bikes (#/hr)									1						
Peak Hour Factor	0.87	0.87	0.87	0.92	0.92	0.92	0.88	0.88	0.88	0.94	0.94	0.94			
Heavy Vehicles (%)	3%	2%	0%	0%	5%	1%	0%	1%	0%	3%	2%	0%			
Shared Lane Traffic (%)															
Lane Group Flow (vph)	172	1040	0	49	1484	0	0	301	273	309	144	0			
Turn Type	Prot	NA		Prot	NA		Split	NA	pm+ov	Split	NA				
Protected Phases	1	6		5	2		3	3	5	4	4		9	10	11
Permitted Phases									3						
Detector Phase	1	6		5	2		3	3	5	4	4				
Switch Phase															
Minimum Initial (s)	6.0	10.0		6.0	10.0		6.0	6.0	6.0	6.0	6.0		1.0	1.0	1.0
Minimum Split (s)	12.0	20.0		12.0	25.0		12.0	12.0	12.0	29.5	29.5		3.0	3.0	3.0
Total Split (s)	16.0	50.5		24.0	58.5		28.5	28.5	24.0	26.0	26.0		3.0	3.0	3.0
Total Split (%)	11.9%	37.4%		17.8%	43.3%		21.1%	21.1%	17.8%	19.3%	19.3%		2%	2%	2%
Yellow Time (s)	3.0	4.0		3.0	4.0		3.5	3.5	3.0	3.5	3.5		2.0	2.0	2.0
All-Red Time (s)	3.0	1.0		3.0	1.0		2.5	2.5	3.0	2.5	2.5		0.0	0.0	0.0
Lost Time Adjust (s)	0.0	0.0		0.0	0.0			0.0	0.0	0.0	0.0				
Total Lost Time (s)	6.0	5.0		6.0	5.0			6.0	6.0	6.0	6.0				
Lead/Lag	Lead			Lead			Lead	Lead	Lead				Lag	Lag	Lag
Lead-Lag Optimize?															
Recall Mode	None	Min		None	Min		Min	Min	None	C-Min	C-Min		None	None	None
v/c Ratio	0.96	0.66		0.42	1.00			0.96	0.61	0.66	0.56				
Control Delay	117.3	33.3		70.2	56.2			98.4	22.8	68.6	63.4				
Queue Delay	15.8	0.0		0.0	2.4			0.0	0.0	0.0	0.0				
Total Delay	133.2	33.3		70.2	58.6			98.4	22.8	68.6	63.4				
Queue Length 50th (ft)	153	363		42	587			265	93	136	107				
Queue Length 95th (ft)	#330	503		83	#797			#433	136	180	166				
Internal Link Dist (ft)		265			665			2948			318				
Turn Bay Length (ft)	175			165					150	200					
Base Capacity (vph)	179	1574		240	1479			312	548	509	280				
Starvation Cap Reductn	0	0		0	0			0	0	0	0				
Spillback Cap Reductn	11	0		0	13			0	0	0	0				
Storage Cap Reductn	0	0		0	0			0	0	0	0				
Reduced v/c Ratio	1.02	0.66		0.20	1.01			0.96	0.50	0.61	0.51				

Intersection Summary

Area Type: Other
 Cycle Length: 135
 Actuated Cycle Length: 135
 Offset: 0 (0%), Referenced to phase 4:SBTL, Start of Green
 Natural Cycle: 145
 Control Type: Actuated-Coordinated
 # 95th percentile volume exceeds capacity, queue may be longer.
 Queue shown is maximum after two cycles.

Splits and Phases: 15: Hunting Rd/Gould St & Highland Ave



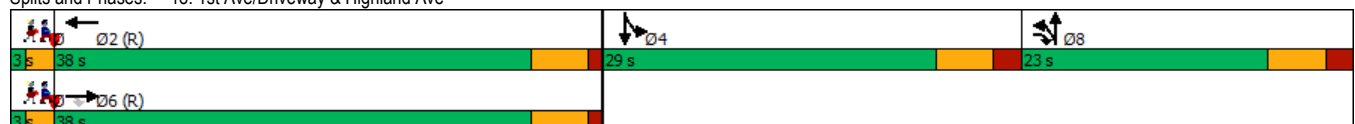
												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	150	890	15	45	605	760	25	240	240	290	90	45
Future Volume (vph)	150	890	15	45	605	760	25	240	240	290	90	45
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	5.0		6.0	5.0			6.0	6.0	6.0	6.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00	1.00	0.97	1.00	
Frpb, ped/bikes	1.00	1.00		1.00	0.99			1.00	0.99	1.00	1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00	1.00	1.00	1.00	
Frt	1.00	1.00		1.00	0.92			1.00	0.85	1.00	0.95	
Flt Protected	0.95	1.00		0.95	1.00			1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1752	3530		1805	3178			1874	1600	3400	1781	
Flt Permitted	0.95	1.00		0.95	1.00			1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1752	3530		1805	3178			1874	1600	3400	1781	
Peak-hour factor, PHF	0.87	0.87	0.87	0.92	0.92	0.92	0.88	0.88	0.88	0.94	0.94	0.94
Adj. Flow (vph)	172	1023	17	49	658	826	28	273	273	309	96	48
RTOR Reduction (vph)	0	1	0	0	159	0	0	0	74	0	14	0
Lane Group Flow (vph)	172	1039	0	49	1325	0	0	301	199	309	130	0
Confl. Peds. (#/hr)	1		1	1		1						
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	2%	0%	0%	5%	1%	0%	1%	0%	3%	2%	0%
Turn Type	Prot	NA		Prot	NA		Split	NA	pm+ov	Split	NA	
Protected Phases	1	6		5	2		3	3	5	4	4	
Permitted Phases									3			
Actuated Green, G (s)	13.8	60.2		8.9	58.2			22.5	31.4	17.5	17.5	
Effective Green, g (s)	13.8	60.2		8.9	58.2			22.5	31.4	17.5	17.5	
Actuated g/C Ratio	0.10	0.45		0.07	0.43			0.17	0.23	0.13	0.13	
Clearance Time (s)	6.0	5.0		6.0	5.0			6.0	6.0	6.0	6.0	
Vehicle Extension (s)	2.0	2.0		2.0	2.0			2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	179	1574		118	1370			312	372	440	230	
v/s Ratio Prot	c0.10	0.29		0.03	c0.42			c0.16	0.04	c0.09	0.07	
v/s Ratio Perm									0.09			
v/c Ratio	0.96	0.66		0.42	0.97			0.96	0.53	0.70	0.57	
Uniform Delay, d1	60.3	29.4		60.6	37.5			55.9	45.4	56.3	55.2	
Progression Factor	1.00	1.00		1.00	1.00			1.00	1.00	1.12	1.14	
Incremental Delay, d2	55.3	0.8		0.9	16.8			40.9	0.7	9.0	9.6	
Delay (s)	115.7	30.2		61.4	54.3			96.8	46.1	71.7	72.7	
Level of Service	F	C		E	D			F	D	E	E	
Approach Delay (s)		42.3			54.5			72.7			72.1	
Approach LOS		D			D			E			E	
Intersection Summary												
HCM 2000 Control Delay			55.5			HCM 2000 Level of Service				E		
HCM 2000 Volume to Capacity ratio			0.95									
Actuated Cycle Length (s)			135.0			Sum of lost time (s)				27.0		
Intersection Capacity Utilization			91.0%			ICU Level of Service				E		
Analysis Period (min)			15									
c Critical Lane Group												

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø1	Ø5
Lane Configurations		↔↔	↗		↔↔		↗	↔↔			↔↔			
Traffic Volume (vph)	5	1170	1005	0	965	15	175	0	70	5	5	10		
Future Volume (vph)	5	1170	1005	0	965	15	175	0	70	5	5	10		
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900		
Storage Length (ft)	0		0	0		0	75		0	0		0		
Storage Lanes	0		1	0		0	1		0	0		0		
Taper Length (ft)	25			25			25			25				
Right Turn on Red			Yes			Yes			Yes			Yes		
Link Speed (mph)		30			30			30			30			
Link Distance (ft)		176			681			500			267			
Travel Time (s)		4.0			15.5			11.4			6.1			
Confl. Peds. (#/hr)			1	1					8	8				
Confl. Bikes (#/hr)			2											
Peak Hour Factor	0.88	0.88	0.88	0.95	0.95	0.95	0.91	0.91	0.91	0.39	0.39	0.39		
Heavy Vehicles (%)	0%	4%	2%	0%	5%	0%	11%	0%	6%	33%	0%	0%		
Shared Lane Traffic (%)							28%							
Lane Group Flow (vph)	0	1336	1142	0	1032	0	138	131	0	0	52	0		
Turn Type		NA	pm+ov		NA		Split	NA		Split	NA			
Protected Phases		6	8		2		8	8		4	4		1	5
Permitted Phases			6											
Detector Phase		6	8		2		8	8		4	4			
Switch Phase														
Minimum Initial (s)		10.0	6.0		10.0		6.0	6.0		6.0	6.0		1.0	1.0
Minimum Split (s)		25.0	20.0		20.0		20.0	20.0		29.0	29.0		3.0	3.0
Total Split (s)		38.0	23.0		38.0		23.0	23.0		29.0	29.0		3.0	3.0
Total Split (%)		40.9%	24.7%		40.9%		24.7%	24.7%		31.2%	31.2%		3%	3%
Yellow Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0		2.0	2.0
All-Red Time (s)		1.0	2.0		1.0		2.0	2.0		2.0	2.0		0.0	0.0
Lost Time Adjust (s)		0.0	0.0		0.0		0.0	0.0			0.0			
Total Lost Time (s)		5.0	6.0		5.0		6.0	6.0			6.0			
Lead/Lag		Lag			Lag								Lead	Lead
Lead-Lag Optimize?														
Recall Mode		C-Min	None		C-Min		None	None		None	None		None	None
v/c Ratio		1.68	0.81		0.56		0.44	0.33			0.27			
Control Delay		334.2	7.4		19.2		36.1	9.9			24.3			
Queue Delay		0.0	0.0		0.0		0.0	0.0			0.0			
Total Delay		334.2	7.4		19.2		36.1	9.9			24.3			
Queue Length 50th (ft)		~611	11		203		73	7			15			
Queue Length 95th (ft)		#806	#103		354		140	58			10			
Internal Link Dist (ft)		96			601			420			187			
Turn Bay Length (ft)							75							
Base Capacity (vph)		794	1419		1840		347	421			419			
Starvation Cap Reductn		0	0		0		0	0			0			
Spillback Cap Reductn		0	0		0		0	0			0			
Storage Cap Reductn		0	0		0		0	0			0			
Reduced v/c Ratio		1.68	0.80		0.56		0.40	0.31			0.12			

Intersection Summary

Area Type: Other
 Cycle Length: 93
 Actuated Cycle Length: 93
 Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
 Natural Cycle: 150
 Control Type: Actuated-Coordinated
 ~ Volume exceeds capacity, queue is theoretically infinite.
 Queue shown is maximum after two cycles.
 # 95th percentile volume exceeds capacity, queue may be longer.
 Queue shown is maximum after two cycles.

Splits and Phases: 18: 1st Ave/Driveway & Highland Ave



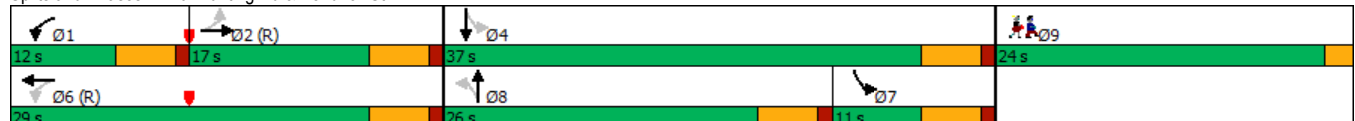
												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	5	1170	1005	0	965	15	175	0	70	5	5	10
Future Volume (vph)	5	1170	1005	0	965	15	175	0	70	5	5	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	6.0		5.0		6.0	6.0			6.0	
Lane Util. Factor		0.95	1.00		0.95		0.95	0.95			1.00	
Frpb, ped/bikes		1.00	0.98		1.00		1.00	0.99			1.00	
Flpb, ped/bikes		1.00	1.00		1.00		1.00	1.00			1.00	
Frt		1.00	0.85		1.00		1.00	0.91			0.93	
Flt Protected		1.00	1.00		1.00		0.95	0.98			0.99	
Satd. Flow (prot)		3471	1557		3433		1545	1472			1617	
Flt Permitted		0.95	1.00		1.00		0.95	0.98			0.99	
Satd. Flow (perm)		3300	1557		3433		1545	1472			1617	
Peak-hour factor, PHF	0.88	0.88	0.88	0.95	0.95	0.95	0.91	0.91	0.91	0.39	0.39	0.39
Adj. Flow (vph)	6	1330	1142	0	1016	16	192	0	77	13	13	26
RTOR Reduction (vph)	0	0	281	0	1	0	0	93	0	0	24	0
Lane Group Flow (vph)	0	1336	862	0	1031	0	138	38	0	0	28	0
Confl. Peds. (#/hr)			1		1				8	8		
Confl. Bikes (#/hr)			2									
Heavy Vehicles (%)	0%	4%	2%	0%	5%	0%	11%	0%	6%	33%	0%	0%
Turn Type		NA	pm+ov		NA		Split	NA		Split	NA	
Protected Phases		6	8		2		8	8		4	4	
Permitted Phases			6									
Actuated Green, G (s)		48.6	67.5		48.6		18.9	18.9			8.5	
Effective Green, g (s)		48.6	67.5		48.6		18.9	18.9			8.5	
Actuated g/C Ratio		0.52	0.73		0.52		0.20	0.20			0.09	
Clearance Time (s)		5.0	6.0		5.0		6.0	6.0			6.0	
Vehicle Extension (s)		2.0	2.0		2.0		2.0	2.0			2.0	
Lane Grp Cap (vph)		1724	1230		1794		313	299			147	
v/s Ratio Prot			c0.14		0.30		0.09	0.03			c0.02	
v/s Ratio Perm		c0.40	0.41									
v/c Ratio		0.77	0.70		0.57		0.44	0.13			0.19	
Uniform Delay, d1		17.8	7.1		15.1		32.4	30.3			39.1	
Progression Factor		1.00	1.00		1.00		1.00	1.00			1.00	
Incremental Delay, d2		3.5	1.5		1.3		0.4	0.1			0.2	
Delay (s)		21.3	8.6		16.5		32.8	30.4			39.3	
Level of Service		C	A		B		C	C			D	
Approach Delay (s)		15.4			16.5			31.6			39.3	
Approach LOS		B			B			C			D	
Intersection Summary												
HCM 2000 Control Delay			17.2		HCM 2000 Level of Service						B	
HCM 2000 Volume to Capacity ratio			0.74									
Actuated Cycle Length (s)			93.0		Sum of lost time (s)						19.0	
Intersection Capacity Utilization			77.3%		ICU Level of Service						D	
Analysis Period (min)			15									
c Critical Lane Group												

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø9
Lane Configurations		↔↔		↔	↔			↔	↔	↔	↔		
Traffic Volume (vph)	30	455	0	85	230	85	5	355	575	75	60	10	
Future Volume (vph)	30	455	0	85	230	85	5	355	575	75	60	10	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	
Storage Length (ft)	0		100	190		0	0		400	125		0	
Storage Lanes	0		1	1		0	0		1	1		0	
Taper Length (ft)	25			25			25			25			
Right Turn on Red			Yes			Yes			Yes			Yes	
Link Speed (mph)		30			30			30			30		
Link Distance (ft)		442			443			907			3028		
Travel Time (s)		10.0			10.1			20.6			68.8		
Confl. Peds. (#/hr)							2					2	
Confl. Bikes (#/hr)			1										
Peak Hour Factor	0.83	0.83	0.83	0.97	0.97	0.97	0.91	0.91	0.91	0.92	0.92	0.92	
Heavy Vehicles (%)	0%	1%	0%	4%	4%	3%	0%	1%	0%	2%	2%	8%	
Shared Lane Traffic (%)													
Lane Group Flow (vph)	0	584	0	88	325	0	0	395	632	82	76	0	
Turn Type	Perm	NA		pm+pt	NA		Perm	NA	Free	pm+pt	NA		
Protected Phases		2		1	6			8		7	4		9
Permitted Phases	2			6			8		Free	4			
Detector Phase	2	2		1	6		8	8		7	4		
Switch Phase													
Minimum Initial (s)	10.0	10.0		7.0	10.0		10.0	10.0		2.0	10.0		1.0
Minimum Split (s)	16.0	16.0		12.0	28.0		15.0	15.0		7.0	27.0		24.0
Total Split (s)	17.0	17.0		12.0	29.0		26.0	26.0		11.0	37.0		24.0
Total Split (%)	18.9%	18.9%		13.3%	32.2%		28.9%	28.9%		12.2%	41.1%		27%
Yellow Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0		2.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0		1.0	1.0		0.0
Lost Time Adjust (s)		0.0		0.0	0.0			0.0		0.0	0.0		
Total Lost Time (s)		5.0		5.0	5.0			5.0		5.0	5.0		
Lead/Lag	Lag	Lag		Lead			Lead	Lead		Lag			
Lead-Lag Optimize?													
Recall Mode	C-Min	C-Min		None	C-Min		None	None		None	None		None
v/c Ratio		0.44		0.24	0.36			0.93	0.39	0.37	0.13		
Control Delay		26.4		17.7	17.3			65.0	0.7	30.5	17.8		
Queue Delay		0.0		0.0	0.0			0.0	0.0	0.0	0.0		
Total Delay		26.4		17.7	17.3			65.0	0.7	30.5	17.8		
Queue Length 50th (ft)		124		23	93			219	0	31	24		
Queue Length 95th (ft)		#298		77	249			#386	0	63	54		
Internal Link Dist (ft)		362			363			827			2948		
Turn Bay Length (ft)				190					400	125			
Base Capacity (vph)		1327		373	912			437	1615	231	647		
Starvation Cap Reductn		0		0	0			0	0	0	0		
Spillback Cap Reductn		0		0	0			0	0	0	0		
Storage Cap Reductn		0		0	0			0	0	0	0		
Reduced v/c Ratio		0.44		0.24	0.36			0.90	0.39	0.35	0.12		

Intersection Summary

Area Type: Other
 Cycle Length: 90
 Actuated Cycle Length: 90
 Offset: 11 (12%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green
 Natural Cycle: 90
 Control Type: Actuated-Coordinated
 # 95th percentile volume exceeds capacity, queue may be longer.
 Queue shown is maximum after two cycles.

Splits and Phases: 20: Hunting Rd & Kendrick St



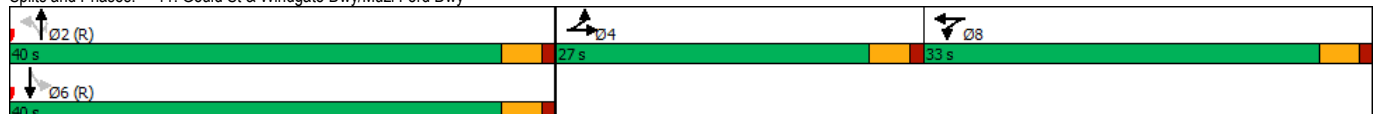
												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	30	455	0	85	230	85	5	355	575	75	60	10
Future Volume (vph)	30	455	0	85	230	85	5	355	575	75	60	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0		5.0	5.0			5.0	4.0	5.0	5.0	
Lane Util. Factor		0.95		1.00	1.00			1.00	1.00	1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00			1.00	1.00	1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00			1.00	1.00	1.00	1.00	
Frt		1.00		1.00	0.96			1.00	0.85	1.00	0.98	
Flt Protected		1.00		0.95	1.00			1.00	1.00	0.95	1.00	
Satd. Flow (prot)		3565		1736	1757			1880	1615	1770	1801	
Flt Permitted		0.91		0.30	1.00			1.00	1.00	0.23	1.00	
Satd. Flow (perm)		3269		544	1757			1876	1615	420	1801	
Peak-hour factor, PHF	0.83	0.83	0.83	0.97	0.97	0.97	0.91	0.91	0.91	0.92	0.92	0.92
Adj. Flow (vph)	36	548	0	88	237	88	5	390	632	82	65	11
RTOR Reduction (vph)	0	0	0	0	10	0	0	0	0	0	7	0
Lane Group Flow (vph)	0	584	0	88	315	0	0	395	632	82	69	0
Confl. Peds. (#/hr)							2					2
Confl. Bikes (#/hr)			1									
Heavy Vehicles (%)	0%	1%	0%	4%	4%	3%	0%	1%	0%	2%	2%	8%
Turn Type	Perm	NA		pm+pt	NA		Perm	NA	Free	pm+pt	NA	
Protected Phases		2		1	6			8		7	4	
Permitted Phases	2			6			8		Free	4		
Actuated Green, G (s)		32.9		43.6	43.6			20.4	90.0	30.0	30.0	
Effective Green, g (s)		32.9		43.6	43.6			20.4	90.0	30.0	30.0	
Actuated g/C Ratio		0.37		0.48	0.48			0.23	1.00	0.33	0.33	
Clearance Time (s)		5.0		5.0	5.0			5.0		5.0	5.0	
Vehicle Extension (s)		2.0		2.0	2.0			2.0		2.0	2.0	
Lane Grp Cap (vph)		1195		339	851			425	1615	209	600	
v/s Ratio Prot				0.02	0.18					0.02	0.04	
v/s Ratio Perm		c0.18		0.11				c0.21	c0.39	0.11		
v/c Ratio		0.49		0.26	0.37			0.93	0.39	0.39	0.11	
Uniform Delay, d1		22.1		13.5	14.6			34.1	0.0	33.7	20.8	
Progression Factor		1.00		1.00	1.00			1.00	1.00	1.00	1.00	
Incremental Delay, d2		1.4		0.1	1.2			26.2	0.7	0.4	0.0	
Delay (s)		23.5		13.6	15.8			60.3	0.7	34.1	20.8	
Level of Service		C		B	B			E	A	C	C	
Approach Delay (s)		23.5			15.3			23.6			27.7	
Approach LOS		C			B			C			C	
Intersection Summary												
HCM 2000 Control Delay			22.3			HCM 2000 Level of Service				C		
HCM 2000 Volume to Capacity ratio			0.67									
Actuated Cycle Length (s)			90.0			Sum of lost time (s)				22.0		
Intersection Capacity Utilization			74.7%			ICU Level of Service				D		
Analysis Period (min)			15									
c Critical Lane Group												

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↔		↔	↔			↔	↔	↔	↔	
Traffic Volume (vph)	1	0	30	360	1	40	5	285	80	15	700	5
Future Volume (vph)	1	0	30	360	1	40	5	285	80	15	700	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width (ft)	12	12	12	12	13	13	12	12	12	12	12	12
Storage Length (ft)	0		0	0		0	0		100	150		0
Storage Lanes	0		0	1		0	0		1	1		0
Taper Length (ft)	25			25			25			25		
Right Turn on Red			Yes			Yes			Yes			Yes
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		151			225			398			315	
Travel Time (s)		3.4			5.1			9.0			7.2	
Peak Hour Factor	0.75	0.75	0.75	0.72	0.72	0.72	0.86	0.86	0.86	0.92	0.92	0.92
Shared Lane Traffic (%)				44%								
Lane Group Flow (vph)	0	41	0	280	277	0	0	337	93	16	766	0
Turn Type	Split	NA		Split	NA		Perm	NA	Perm	Perm	NA	
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2		2	6		
Detector Phase	4	4		8	8		2	2	2	6	6	
Switch Phase												
Minimum Initial (s)	6.0	6.0		6.0	6.0		10.0	10.0	10.0	10.0	10.0	
Minimum Split (s)	27.0	27.0		11.0	11.0		15.0	15.0	15.0	23.0	23.0	
Total Split (s)	27.0	27.0		33.0	33.0		40.0	40.0	40.0	40.0	40.0	
Total Split (%)	27.0%	27.0%		33.0%	33.0%		40.0%	40.0%	40.0%	40.0%	40.0%	
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0	1.0	1.0	1.0	
Lost Time Adjust (s)		0.0		0.0	0.0			0.0	0.0	0.0	0.0	
Total Lost Time (s)		4.0		4.0	4.0			4.0	4.0	4.0	4.0	
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	None	None		None	None		C-Min	C-Min	C-Min	C-Min	C-Min	
v/c Ratio		0.20		0.75	0.71			0.30	0.09	0.03	0.36	
Control Delay		8.5		48.3	43.8			14.0	8.2	15.4	13.9	
Queue Delay		0.0		0.0	0.0			0.6	0.0	0.0	0.1	
Total Delay		8.5		48.3	43.8			14.6	8.2	15.4	14.0	
Queue Length 50th (ft)		0		174	163			56	1	4	124	
Queue Length 95th (ft)		12		187	176			m252	m30	21	270	
Internal Link Dist (ft)		71			145			318			235	
Turn Bay Length (ft)									100	150		
Base Capacity (vph)		413		487	503			1112	986	568	2134	
Starvation Cap Reductn		0		0	0			437	0	0	0	
Spillback Cap Reductn		4		0	0			0	0	0	276	
Storage Cap Reductn		0		0	0			0	0	0	0	
Reduced v/c Ratio		0.10		0.57	0.55			0.50	0.09	0.03	0.41	

Intersection Summary

Area Type: Other
Cycle Length: 100
Actuated Cycle Length: 100
Offset: 0 (0%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Natural Cycle: 65
Control Type: Actuated-Coordinated
m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 11: Gould St & Windgate Dwy/Muzi Ford Dwy



												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	0	30	360	1	40	5	285	80	15	700	5
Future Volume (vph)	1	0	30	360	1	40	5	285	80	15	700	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	12	12	12	13	13	12	12	12	12	12	12
Total Lost time (s)		4.0		4.0	4.0			4.0	4.0	4.0	4.0	
Lane Util. Factor		1.00		0.95	0.95			1.00	1.00	1.00	0.95	
Flt		0.87		1.00	0.97			1.00	0.85	1.00	1.00	
Flt Protected		1.00		0.95	0.96			1.00	1.00	0.95	1.00	
Satd. Flow (prot)		1615		1681	1705			1861	1583	1770	3536	
Flt Permitted		1.00		0.95	0.96			0.99	1.00	0.51	1.00	
Satd. Flow (perm)		1615		1681	1705			1842	1583	941	3536	
Peak-hour factor, PHF	0.75	0.75	0.75	0.72	0.72	0.72	0.86	0.86	0.86	0.92	0.92	0.92
Adj. Flow (vph)	1	0	40	500	1	56	6	331	93	16	761	5
RTOR Reduction (vph)	0	38	0	0	10	0	0	0	32	0	0	0
Lane Group Flow (vph)	0	3	0	280	267	0	0	337	61	16	766	0
Turn Type	Split	NA		Split	NA		Perm	NA	Perm	Perm	NA	
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2		2	6		
Actuated Green, G (s)		7.0		22.3	22.3			58.7	58.7	58.7	58.7	
Effective Green, g (s)		7.0		22.3	22.3			58.7	58.7	58.7	58.7	
Actuated g/C Ratio		0.07		0.22	0.22			0.59	0.59	0.59	0.59	
Clearance Time (s)		4.0		4.0	4.0			4.0	4.0	4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)		113		374	380			1081	929	552	2075	
v/s Ratio Prot		c0.00		c0.17	0.16						c0.22	
v/s Ratio Perm								0.18	0.04	0.02		
v/c Ratio		0.03		0.75	0.70			0.31	0.07	0.03	0.37	
Uniform Delay, d1		43.3		36.2	35.8			10.4	8.9	8.7	10.9	
Progression Factor		1.00		1.00	1.00			0.99	1.48	1.00	1.00	
Incremental Delay, d2		0.1		8.0	5.8			0.4	0.1	0.1	0.5	
Delay (s)		43.4		44.2	41.6			10.7	13.2	8.8	11.4	
Level of Service		D		D	D			B	B	A	B	
Approach Delay (s)		43.4			42.9			11.2			11.3	
Approach LOS		D			D			B			B	
Intersection Summary												
HCM 2000 Control Delay		21.8				HCM 2000 Level of Service			C			
HCM 2000 Volume to Capacity ratio		0.44										
Actuated Cycle Length (s)		100.0				Sum of lost time (s)			12.0			
Intersection Capacity Utilization		44.1%				ICU Level of Service			A			
Analysis Period (min)		15										
c Critical Lane Group												

																		
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø9					
Lane Configurations																		
Traffic Volume (vph)	180	235	50	70	155	60	25	420	55	30	570	100						
Future Volume (vph)	180	235	50	70	155	60	25	420	55	30	570	100						
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900						
Storage Length (ft)	120		0	100		0	0		0	0		0						
Storage Lanes	1		0	1		0	0		0	0		0						
Taper Length (ft)	25			25			25			25								
Right Turn on Red			No			No			No			No						
Link Speed (mph)		30			30			30			30							
Link Distance (ft)		318			371			476			549							
Travel Time (s)		7.2			8.4			10.8			12.5							
Confl. Peds. (#/hr)	7		8	8		7	4		36	36		4						
Peak Hour Factor	0.87	0.87	0.87	0.86	0.86	0.86	0.89	0.89	0.89	0.93	0.93	0.93						
Heavy Vehicles (%)	3%	0%	0%	0%	2%	2%	1%	8%	0%	0%	3%	6%						
Bus Blockages (#/hr)	0	0	0	0	0	0	2	2	2	0	0	0						
Parking (#/hr)							0	0	0	0	0	0						
Shared Lane Traffic (%)																		
Lane Group Flow (vph)	207	327	0	81	250	0	0	562	0	0	753	0						
Turn Type	D.P+P	NA		Perm	NA		Perm	NA		Perm	NA							
Protected Phases	1	1 2			2			3			3		9					
Permitted Phases	2	2		2			3			3								
Detector Phase	1	1 2		2	2		3	3		3	3							
Switch Phase																		
Minimum Initial (s)	6.0			10.0	10.0		10.0	10.0		10.0	10.0		7.0					
Minimum Split (s)	11.5			15.0	15.0		15.0	15.0		15.0	15.0		20.0					
Total Split (s)	17.0			34.0	34.0		54.0	54.0		54.0	54.0		20.0					
Total Split (%)	13.6%			27.2%	27.2%		43.2%	43.2%		43.2%	43.2%		16%					
Yellow Time (s)	4.5			3.0	3.0		4.0	4.0		4.0	4.0		2.0					
All-Red Time (s)	1.0			1.0	1.0		1.0	1.0		1.0	1.0		0.0					
Lost Time Adjust (s)	0.0			0.0	0.0			0.0			0.0							
Total Lost Time (s)	5.5			4.0	4.0			5.0			5.0							
Lead/Lag	Lead			Lag	Lag													
Lead-Lag Optimize?																		
Recall Mode	None			None	None		Min	Min		Min	Min		None					
v/c Ratio	0.65	0.49		0.38	0.70			0.76			0.97							
Control Delay	35.2	28.2		40.5	48.3			31.4			52.7							
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0							
Total Delay	35.2	28.2		40.5	48.3			31.4			52.7							
Queue Length 50th (ft)	87	148		42	140			254			408							
Queue Length 95th (ft)	178	281		98	256			#669			#994							
Internal Link Dist (ft)		238			291			396			469							
Turn Bay Length (ft)	120			100														
Base Capacity (vph)	320	854		323	540			735			777							
Starvation Cap Reductn	0	0		0	0			0			0							
Spillback Cap Reductn	0	0		0	0			0			0							
Storage Cap Reductn	0	0		0	0			0			0							
Reduced v/c Ratio	0.65	0.38		0.25	0.46			0.76			0.97							

Intersection Summary

Area Type: Other

Cycle Length: 125

Actuated Cycle Length: 99.6

Natural Cycle: 120

Control Type: Actuated-Uncoordinated

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

Splits and Phases: 12: Highland Ave & West St



												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	180	235	50	70	155	60	25	420	55	30	570	100
Future Volume (vph)	180	235	50	70	155	60	25	420	55	30	570	100
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5		4.0	4.0			5.0			5.0	
Lane Util. Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Frpb, ped/bikes	1.00	0.99		1.00	0.99			0.99			1.00	
Flpb, ped/bikes	1.00	1.00		0.99	1.00			1.00			1.00	
Frt	1.00	0.97		1.00	0.96			0.99			0.98	
Flt Protected	0.95	1.00		0.95	1.00			1.00			1.00	
Satd. Flow (prot)	1749	1840		1782	1766			1552			1613	
Flt Permitted	0.33	1.00		0.56	1.00			0.95			0.96	
Satd. Flow (perm)	614	1840		1056	1766			1473			1556	
Peak-hour factor, PHF	0.87	0.87	0.87	0.86	0.86	0.86	0.89	0.89	0.89	0.93	0.93	0.93
Adj. Flow (vph)	207	270	57	81	180	70	28	472	62	32	613	108
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	207	327	0	81	250	0	0	562	0	0	753	0
Confl. Peds. (#/hr)	7		8	8		7	4		36	36		4
Heavy Vehicles (%)	3%	0%	0%	0%	2%	2%	1%	8%	0%	0%	3%	6%
Bus Blockages (#/hr)	0	0	0	0	0	0	2	2	2	0	0	0
Parking (#/hr)							0	0	0	0	0	0
Turn Type	D,P+P	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases	1	1 2			2			3			3	
Permitted Phases	2	2		2			3			3		
Actuated Green, G (s)	31.9	37.4		20.2	20.2			49.8			49.8	
Effective Green, g (s)	31.9	37.4		20.2	20.2			49.8			49.8	
Actuated g/C Ratio	0.32	0.37		0.20	0.20			0.49			0.49	
Clearance Time (s)	5.5			4.0	4.0			5.0			5.0	
Vehicle Extension (s)	3.0			3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)	325	680		210	352			725			766	
v/s Ratio Prot	c0.07	0.18			c0.14							
v/s Ratio Perm	0.13			0.08				0.38			c0.48	
v/c Ratio	0.64	0.48		0.39	0.71			0.78			0.98	
Uniform Delay, d1	27.4	24.4		35.1	37.7			21.1			25.2	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	4.1	0.5		1.2	6.6			5.2			28.1	
Delay (s)	31.4	24.9		36.2	44.3			26.2			53.4	
Level of Service	C	C		D	D			C			D	
Approach Delay (s)		27.5			42.4			26.2			53.4	
Approach LOS		C			D			C			D	
Intersection Summary												
HCM 2000 Control Delay			38.4			HCM 2000 Level of Service					D	
HCM 2000 Volume to Capacity ratio			0.84									
Actuated Cycle Length (s)			101.1			Sum of lost time (s)				16.5		
Intersection Capacity Utilization			82.3%			ICU Level of Service				E		
Analysis Period (min)			15									

c Critical Lane Group

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø9
Lane Configurations													
Traffic Volume (vph)	45	460	15	315	630	75	25	125	175	95	300	45	
Future Volume (vph)	45	460	15	315	630	75	25	125	175	95	300	45	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	
Storage Length (ft)	150		0	150		0	0		150	0		200	
Storage Lanes	1		0	1		0	0		1	0		1	
Taper Length (ft)	25			25			25			25			
Right Turn on Red			Yes			Yes			No			No	
Link Speed (mph)		30			30			30			30		
Link Distance (ft)		1325			691			391			2983		
Travel Time (s)		30.1			15.7			8.9			67.8		
Confl. Peds. (#/hr)	2					2	2					2	
Peak Hour Factor	0.91	0.91	0.91	0.97	0.97	0.97	0.87	0.87	0.87	0.88	0.88	0.88	
Heavy Vehicles (%)	0%	0%	0%	1%	2%	1%	0%	0%	0%	0%	0%	0%	
Shared Lane Traffic (%)													
Lane Group Flow (vph)	49	521	0	325	726	0	0	173	201	0	500	0	
Turn Type	Perm	NA		pm+pt	NA		Perm	NA	pm+ov	Perm	NA		
Protected Phases		6		5	2			8	5		4		9
Permitted Phases	6			2			8		8	4			
Detector Phase	6	6		5	2		8	8	5	4	4		
Switch Phase													
Minimum Initial (s)	10.0	10.0		6.0	10.0		6.0	6.0	6.0	6.0	6.0		7.0
Minimum Split (s)	17.5	17.5		13.5	17.5		12.5	12.5	13.5	12.5	12.5		28.0
Total Split (s)	37.5	37.5		22.5	37.5		31.5	31.5	22.5	31.5	31.5		28.0
Total Split (%)	31.4%	31.4%		18.8%	31.4%		26.4%	26.4%	18.8%	26.4%	26.4%		23%
Yellow Time (s)	4.0	4.0		4.0	4.0		3.5	3.5	4.0	3.5	3.5		3.0
All-Red Time (s)	3.5	3.5		3.5	3.5		3.0	3.0	3.5	3.0	3.0		4.0
Lost Time Adjust (s)	0.0	0.0		0.0	0.0			0.0	0.0		0.0		
Total Lost Time (s)	7.5	7.5		7.5	7.5			6.5	7.5		6.5		
Lead/Lag	Lag	Lag		Lead				Lead					
Lead-Lag Optimize?													
Recall Mode	Min	Min		None	Min		None	None	None	None	None		None
v/c Ratio	0.21	0.85		0.85	0.70			0.53	0.27		0.75		
Control Delay	30.6	46.0		42.4	21.9			39.9	18.2		42.8		
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0		
Total Delay	30.6	46.0		42.4	21.9			39.9	18.2		42.8		
Queue Length 50th (ft)	20	268		115	257			83	62		134		
Queue Length 95th (ft)	68	#673		#409	#750			191	162		#271		
Internal Link Dist (ft)		1245			611			311			2903		
Turn Bay Length (ft)	150			150				150					
Base Capacity (vph)	233	614		384	1042			378	752		768		
Starvation Cap Reductn	0	0		0	0			0	0		0		
Spillback Cap Reductn	0	0		0	0			0	0		0		
Storage Cap Reductn	0	0		0	0			0	0		0		
Reduced v/c Ratio	0.21	0.85		0.85	0.70			0.46	0.27		0.65		

Intersection Summary

Area Type: Other

Cycle Length: 119.5

Actuated Cycle Length: 94

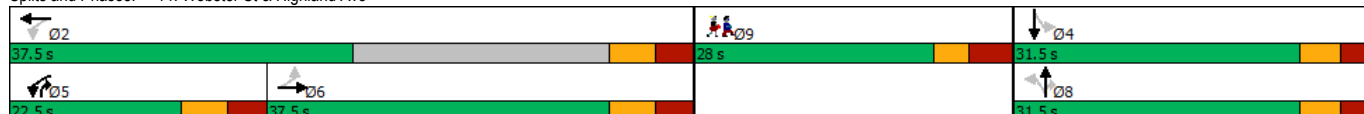
Natural Cycle: 130

Control Type: Actuated-Uncoordinated

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

Splits and Phases: 14: Webster St & Highland Ave



												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	45	460	15	315	630	75	25	125	175	95	300	45
Future Volume (vph)	45	460	15	315	630	75	25	125	175	95	300	45
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	7.5	7.5		7.5	7.5			6.5	7.5		6.5	
Lane Util. Factor	1.00	1.00		1.00	1.00			1.00	1.00		0.95	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			1.00	1.00		1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00	1.00		1.00	
Frt	1.00	1.00		1.00	0.98			1.00	0.85		0.98	
Flt Protected	0.95	1.00		0.95	1.00			0.99	1.00		0.99	
Satd. Flow (prot)	1803	1891		1787	1831			1884	1615		3508	
Flt Permitted	0.38	1.00		0.12	1.00			0.74	1.00		0.80	
Satd. Flow (perm)	716	1891		232	1831			1401	1615		2841	
Peak-hour factor, PHF	0.91	0.91	0.91	0.97	0.97	0.87	0.87	0.87	0.87	0.88	0.88	0.88
Adj. Flow (vph)	49	505	16	325	649	77	29	144	201	108	341	51
RTOR Reduction (vph)	0	1	0	0	3	0	0	0	0	0	0	0
Lane Group Flow (vph)	49	520	0	325	723	0	0	173	201	0	500	0
Confl. Peds. (#/hr)	2					2	2					2
Heavy Vehicles (%)	0%	0%	0%	1%	2%	1%	0%	0%	0%	0%	0%	0%
Turn Type	Perm	NA		pm+pt	NA		Perm	NA	pm+ov	Perm	NA	
Protected Phases		6		5	2			8			4	
Permitted Phases	6			2			8		8	4		
Actuated Green, G (s)	30.6	30.6		53.4	53.4			21.9	37.2		21.9	
Effective Green, g (s)	30.6	30.6		53.4	53.4			21.9	37.2		21.9	
Actuated g/C Ratio	0.31	0.31		0.54	0.54			0.22	0.37		0.22	
Clearance Time (s)	7.5	7.5		7.5	7.5			6.5	7.5		6.5	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0	3.0		3.0	
Lane Grp Cap (vph)	219	580		363	981			308	603		624	
v/s Ratio Prot		0.28		0.14	c0.40				0.05			
v/s Ratio Perm	0.07			c0.34				0.12	0.07		c0.18	
v/c Ratio	0.22	0.90		0.90	0.74			0.56	0.33		0.80	
Uniform Delay, d1	25.7	33.0		25.3	17.7			34.6	22.3		36.8	
Progression Factor	1.00	1.00		1.00	1.00			1.00	1.00		1.00	
Incremental Delay, d2	0.5	16.4		23.4	2.9			2.3	0.3		7.3	
Delay (s)	26.2	49.4		48.7	20.6			36.9	22.7		44.1	
Level of Service	C	D		D	C			D	C		D	
Approach Delay (s)		47.4			29.3			29.3			44.1	
Approach LOS		D			C			C			D	
Intersection Summary												
HCM 2000 Control Delay		36.4			HCM 2000 Level of Service				D			
HCM 2000 Volume to Capacity ratio		0.87										
Actuated Cycle Length (s)		99.6			Sum of lost time (s)				28.5			
Intersection Capacity Utilization		89.9%			ICU Level of Service				E			
Analysis Period (min)		15										

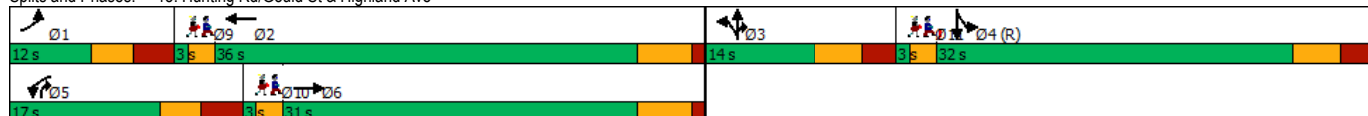
c Critical Lane Group

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø9	Ø10	Ø11
Lane Configurations															
Traffic Volume (vph)	35	725	20	135	1015	270	20	65	90	765	190	135			
Future Volume (vph)	35	725	20	135	1015	270	20	65	90	765	190	135			
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900			
Storage Length (ft)	175		0	165		400	0		150	200		200			
Storage Lanes	1		0	1		0	0		1	1		0			
Taper Length (ft)	25			25			25			25					
Right Turn on Red			Yes			Yes			Yes			Yes			
Link Speed (mph)		30			30			30			30				
Link Distance (ft)		345			745			3028			398				
Travel Time (s)		7.8			16.9			68.8			9.0				
Confl. Bikes (#/hr)						1									
Peak Hour Factor	0.91	0.91	0.91	0.95	0.95	0.95	0.83	0.83	0.83	0.83	0.83	0.83			
Shared Lane Traffic (%)															
Lane Group Flow (vph)	38	819	0	142	1352	0	0	102	108	922	392	0			
Turn Type	Prot	NA		Prot	NA		Split	NA	pt+ov	Split	NA				
Protected Phases	1	6		5	2		3	3	3 5	4	4		9	10	11
Permitted Phases															
Detector Phase	1	6		5	2		3	3	3 5	4	4				
Switch Phase															
Minimum Initial (s)	6.0	10.0		6.0	10.0		6.0	6.0		6.0	6.0		1.0	1.0	1.0
Minimum Split (s)	12.0	20.0		12.0	25.0		12.0	12.0		21.0	21.0		3.0	3.0	3.0
Total Split (s)	12.0	31.0		17.0	36.0		14.0	14.0		32.0	32.0		3.0	3.0	3.0
Total Split (%)	12.0%	31.0%		17.0%	36.0%		14.0%	14.0%		32.0%	32.0%		3%	3%	3%
Yellow Time (s)	3.0	4.0		3.0	4.0		3.5	3.5		3.5	3.5		2.0	2.0	2.0
All-Red Time (s)	3.0	1.0		3.0	1.0		2.5	2.5		2.5	2.5		0.0	0.0	0.0
Lost Time Adjust (s)	0.0	0.0		0.0	0.0			0.0		0.0	0.0				
Total Lost Time (s)	6.0	5.0		6.0	5.0			6.0		6.0	6.0				
Lead/Lag	Lead			Lead			Lead	Lead					Lag	Lag	Lag
Lead-Lag Optimize?															
Recall Mode	None	Min		None	Min		Min	Min		C-Min	C-Min		None	None	None
v/c Ratio	0.36	0.80		0.78	1.02			0.73	0.26	0.93	0.74				
Control Delay	55.0	40.1		71.9	62.3			74.0	2.7	54.5	41.2				
Queue Delay	0.0	0.0		0.0	0.2			5.4	0.0	5.1	1.1				
Total Delay	55.0	40.1		71.9	62.5			79.4	2.7	59.6	42.3				
Queue Length 50th (ft)	24	252		89	~527			65	0	310	228				
Queue Length 95th (ft)	57	#373		#182	#702			#126	5	#376	#239				
Internal Link Dist (ft)		265			665			2948			318				
Turn Bay Length (ft)	175			165					150	200					
Base Capacity (vph)	106	1027		194	1324			147	424	987	527				
Starvation Cap Reductn	0	0		0	0			0	0	43	32				
Spillback Cap Reductn	0	0		0	1			17	0	0	0				
Storage Cap Reductn	0	0		0	0			0	0	0	0				
Reduced v/c Ratio	0.36	0.80		0.73	1.02			0.78	0.25	0.98	0.79				

Intersection Summary

Area Type: Other
 Cycle Length: 100
 Actuated Cycle Length: 100
 Offset: 0 (0%), Referenced to phase 4:SBTL, Start of Green
 Natural Cycle: 110
 Control Type: Actuated-Coordinated
 ~ Volume exceeds capacity, queue is theoretically infinite.
 Queue shown is maximum after two cycles.
 # 95th percentile volume exceeds capacity, queue may be longer.
 Queue shown is maximum after two cycles.

Splits and Phases: 15: Hunting Rd/Gould St & Highland Ave



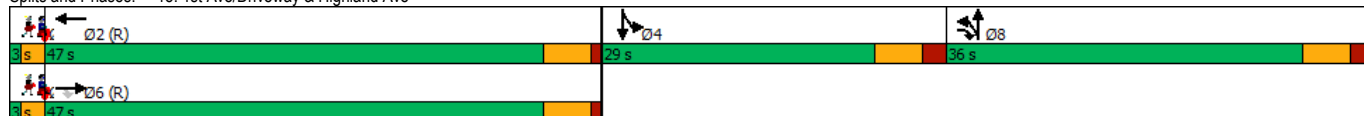
												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	35	725	20	135	1015	270	20	65	90	765	190	135
Future Volume (vph)	35	725	20	135	1015	270	20	65	90	765	190	135
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	5.0		6.0	5.0			6.0	6.0	6.0	6.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00	1.00	0.97	1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			1.00	1.00	1.00	1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00	1.00	1.00	1.00	
Frt	1.00	1.00		1.00	0.97			1.00	0.85	1.00	0.94	
Flt Protected	0.95	1.00		0.95	1.00			0.99	1.00	0.95	1.00	
Satd. Flow (prot)	1770	3525		1770	3413			1841	1583	3433	1747	
Flt Permitted	0.95	1.00		0.95	1.00			0.99	1.00	0.95	1.00	
Satd. Flow (perm)	1770	3525		1770	3413			1841	1583	3433	1747	
Peak-hour factor, PHF	0.91	0.91	0.91	0.95	0.95	0.95	0.83	0.83	0.83	0.83	0.83	0.83
Adj. Flow (vph)	38	797	22	142	1068	284	24	78	108	922	229	163
RTOR Reduction (vph)	0	2	0	0	22	0	0	0	89	0	25	0
Lane Group Flow (vph)	38	817	0	142	1330	0	0	102	19	922	367	0
Confl. Bikes (#/hr)						1						
Turn Type	Prot	NA		Prot	NA		Split	NA	pt+ov	Split	NA	
Protected Phases	1	6		5	2		3	3	3 5	4	4	
Permitted Phases												
Actuated Green, G (s)	3.6	31.5		10.3	38.2			7.6	17.9	27.6	27.6	
Effective Green, g (s)	3.6	31.5		10.3	38.2			7.6	17.9	27.6	27.6	
Actuated g/C Ratio	0.04	0.32		0.10	0.38			0.08	0.18	0.28	0.28	
Clearance Time (s)	6.0	5.0		6.0	5.0			6.0		6.0	6.0	
Vehicle Extension (s)	2.0	2.0		2.0	2.0			2.0		2.0	2.0	
Lane Grp Cap (vph)	63	1110		182	1303			139	283	947	482	
v/s Ratio Prot	0.02	0.23		c0.08	c0.39			c0.06	0.01	c0.27	0.21	
v/s Ratio Perm												
v/c Ratio	0.60	0.74		0.78	1.02			0.73	0.07	0.97	0.76	
Uniform Delay, d1	47.5	30.5		43.7	30.9			45.2	34.1	35.8	33.2	
Progression Factor	1.00	1.00		1.00	1.00			1.00	1.00	1.09	1.07	
Incremental Delay, d2	10.7	2.2		17.8	30.4			15.8	0.0	22.4	10.0	
Delay (s)	58.2	32.8		61.6	61.3			61.0	34.2	61.6	45.5	
Level of Service	E	C		E	E			E	C	E	D	
Approach Delay (s)		33.9			61.3			47.2			56.8	
Approach LOS		C			E			D			E	
Intersection Summary												
HCM 2000 Control Delay		52.9			HCM 2000 Level of Service				D			
HCM 2000 Volume to Capacity ratio		1.05										
Actuated Cycle Length (s)		100.0			Sum of lost time (s)			27.0				
Intersection Capacity Utilization		84.3%			ICU Level of Service			E				
Analysis Period (min)		15										
c Critical Lane Group												

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø1	Ø5
Lane Configurations		↑↑	↑		↑↑		↑	↑↓			↑↓			
Traffic Volume (vph)	0	915	285	0	1675	5	630	0	110	1	1	10		
Future Volume (vph)	0	915	285	0	1675	5	630	0	110	1	1	10		
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900		
Storage Length (ft)	0		0	0		0	75		0	0		0		
Storage Lanes	0		1	0		0	1		0	0		0		
Taper Length (ft)	25			25			25			25				
Right Turn on Red			Yes			Yes			Yes			Yes		
Link Speed (mph)		30			30			30				30		
Link Distance (ft)		176			681			500				267		
Travel Time (s)		4.0			15.5			11.4				6.1		
Confl. Peds. (#/hr)									1	1				
Confl. Bikes (#/hr)						1								
Peak Hour Factor	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.63	0.63	0.63		
Heavy Vehicles (%)	0%	0%	2%	0%	2%	0%	2%	0%	1%	0%	0%	0%		
Shared Lane Traffic (%)							40%							
Lane Group Flow (vph)	0	1028	320	0	1888	0	425	407	0	0	20	0		
Turn Type		NA	pm+ov		NA		Split	NA		Split	NA			
Protected Phases		6	8		2		8	8		4	4		1	5
Permitted Phases			6											
Detector Phase		6	8		2		8	8		4	4			
Switch Phase														
Minimum Initial (s)		10.0	6.0		10.0		6.0	6.0		6.0	6.0		1.0	1.0
Minimum Split (s)		25.0	12.0		16.0		12.0	12.0		29.0	29.0		3.0	3.0
Total Split (s)		47.0	36.0		47.0		36.0	36.0		29.0	29.0		3.0	3.0
Total Split (%)		40.9%	31.3%		40.9%		31.3%	31.3%		25.2%	25.2%		3%	3%
Yellow Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0		2.0	2.0
All-Red Time (s)		1.0	2.0		1.0		2.0	2.0		2.0	2.0		0.0	0.0
Lost Time Adjust (s)		0.0	0.0		0.0		0.0	0.0			0.0			
Total Lost Time (s)		5.0	6.0		5.0		6.0	6.0			6.0			
Lead/Lag		Lag			Lag								Lead	Lead
Lead-Lag Optimize?														
Recall Mode		C-Min	None		C-Min		None	None		None	None		None	None
v/c Ratio		0.55	0.22		1.02		0.82	0.72					0.13	
Control Delay		22.5	0.9		53.9		51.1	34.9					23.6	
Queue Delay		0.0	0.0		0.0		0.0	0.0					0.0	
Total Delay		22.5	0.9		53.9		51.1	34.9					23.6	
Queue Length 50th (ft)		231	0		651		291	207					3	
Queue Length 95th (ft)		427	24		#1090		#532	#396					13	
Internal Link Dist (ft)		96			601			420					187	
Turn Bay Length (ft)							75							
Base Capacity (vph)		1874	1447		1856		518	568				350		
Starvation Cap Reductn		0	0		0		0	0				0		
Spillback Cap Reductn		0	0		0		0	0				0		
Storage Cap Reductn		0	0		0		0	0				0		
Reduced v/c Ratio		0.55	0.22		1.02		0.82	0.72				0.06		

Intersection Summary

Area Type: Other
Cycle Length: 115
Actuated Cycle Length: 115
Offset: 0 (0%), Referenced to phase 2:WBT and 6:EBT, Start of Green
Natural Cycle: 150
Control Type: Actuated-Coordinated
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 18: 1st Ave/Driveway & Highland Ave



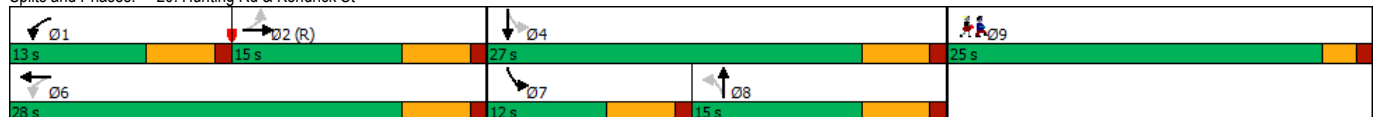
																		
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR						
Lane Configurations																		
Traffic Volume (vph)	0	915	285	0	1675	5	630	0	110	1	1	10						
Future Volume (vph)	0	915	285	0	1675	5	630	0	110	1	1	10						
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900						
Total Lost time (s)		5.0	6.0		5.0		6.0	6.0			6.0							
Lane Util. Factor		0.95	1.00		0.95		0.95	0.95			1.00							
Frpb, ped/bikes		1.00	1.00		1.00		1.00	1.00			1.00							
Flpb, ped/bikes		1.00	1.00		1.00		1.00	1.00			1.00							
Frt		1.00	0.85		1.00		1.00	0.95			0.89							
Flt Protected		1.00	1.00		1.00		0.95	0.97			1.00							
Satd. Flow (prot)		3610	1583		3538		1681	1630			1686							
Flt Permitted		1.00	1.00		1.00		0.95	0.97			1.00							
Satd. Flow (perm)		3610	1583		3538		1681	1630			1686							
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.63	0.63	0.63						
Adj. Flow (vph)	0	1028	320	0	1882	6	708	0	124	2	2	16						
RTOR Reduction (vph)	0	0	63	0	0	0	0	66	0	0	15	0						
Lane Group Flow (vph)	0	1028	257	0	1888	0	425	341	0	0	5	0						
Confl. Peds. (#/hr)									1	1								
Confl. Bikes (#/hr)						1												
Heavy Vehicles (%)	0%	0%	2%	0%	2%	0%	2%	0%	1%	0%	0%	0%						
Turn Type	NA	pm+ov		NA	Split		NA	Split		NA	NA							
Protected Phases	6	8		2	8		8	8		4	4							
Permitted Phases		6																
Actuated Green, G (s)	56.7	92.2		56.7	35.5		35.5	5.8		5.8								
Effective Green, g (s)	56.7	92.2		56.7	35.5		35.5	5.8		5.8								
Actuated g/C Ratio	0.49	0.80		0.49	0.31		0.31	0.05		0.05								
Clearance Time (s)	5.0	6.0		5.0	6.0		6.0	6.0		6.0								
Vehicle Extension (s)	2.0	2.0		2.0	2.0		2.0	2.0		2.0								
Lane Grp Cap (vph)	1779	1351		1744	518		503	85		85								
v/s Ratio Prot	0.28	0.06		c0.53	c0.25		0.21	c0.00		c0.00								
v/s Ratio Perm		0.10																
v/c Ratio	0.58	0.19		1.08	0.82		0.68	0.06		0.06								
Uniform Delay, d1	20.7	2.7		29.1	36.8		34.8	52.0		52.0								
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00								
Incremental Delay, d2	1.4	0.0		47.7	9.6		2.9	0.1		0.1								
Delay (s)	22.0	2.7		76.8	46.4		37.6	52.1		52.1								
Level of Service	C	A		E	D		D	D		D								
Approach Delay (s)	17.4			76.8			42.1			52.1								
Approach LOS	B			E			D			D								
Intersection Summary																		
HCM 2000 Control Delay	50.1		HCM 2000 Level of Service				D											
HCM 2000 Volume to Capacity ratio	0.95																	
Actuated Cycle Length (s)	115.0		Sum of lost time (s)				19.0											
Intersection Capacity Utilization	83.1%		ICU Level of Service				E											
Analysis Period (min)	15																	
c Critical Lane Group																		

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø9
Lane Configurations													
Traffic Volume (vph)	15	235	2	475	405	45	1	110	135	85	190	15	
Future Volume (vph)	15	235	2	475	405	45	1	110	135	85	190	15	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	
Storage Length (ft)	0		100	190		0	0		400	125		0	
Storage Lanes	0		1	1		0	0		1	1		0	
Taper Length (ft)	25			25			25			25			
Right Turn on Red			Yes			Yes			Yes			Yes	
Link Speed (mph)		30			30			30			30		
Link Distance (ft)		442			443			907			3028		
Travel Time (s)		10.0			10.1			20.6			68.8		
Peak Hour Factor	0.91	0.91	0.91	0.95	0.95	0.95	0.83	0.83	0.83	0.94	0.94	0.94	
Shared Lane Traffic (%)													
Lane Group Flow (vph)	0	276	0	500	473	0	0	134	163	90	218	0	
Turn Type	Perm	NA		pm+pt	NA		Perm	NA	Free	pm+pt	NA		
Protected Phases		2		1	6			8		7	4		9
Permitted Phases		2		6					Free	4			
Detector Phase		2	2	1	6		8	8		7	4		
Switch Phase													
Minimum Initial (s)	10.0	10.0		7.0	10.0		10.0	10.0		5.0	10.0		7.0
Minimum Split (s)	15.0	15.0		12.0	16.0		15.0	15.0		10.0	27.0		25.0
Total Split (s)	15.0	15.0		13.0	28.0		15.0	15.0		12.0	27.0		25.0
Total Split (%)	18.8%	18.8%		16.3%	35.0%		18.8%	18.8%		15.0%	33.8%		31%
Yellow Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0		2.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0		1.0	1.0		1.0
Lost Time Adjust (s)		0.0		0.0	0.0			0.0		0.0	0.0		
Total Lost Time (s)		5.0		5.0	5.0			5.0		5.0	5.0		
Lead/Lag	Lag	Lag		Lead			Lag	Lag		Lead			
Lead-Lag Optimize?													
Recall Mode	C-Min	C-Min		None	Min		None	None		None	None		None
v/c Ratio		0.53		0.57	0.41			0.58	0.10	0.33	0.48		
Control Delay		33.7		11.4	9.3			43.8	0.1	26.1	28.2		
Queue Delay		0.0		0.0	0.0			0.0	0.0	0.0	0.0		
Total Delay		33.7		11.4	9.3			43.8	0.1	26.1	28.2		
Queue Length 50th (ft)		68		126	113			64	0	34	87		
Queue Length 95th (ft)		97		196	176			109	0	71	150		
Internal Link Dist (ft)		362			363			827			2948		
Turn Bay Length (ft)				190					400	125			
Base Capacity (vph)		523		875	1159			232	1583	277	510		
Starvation Cap Reductn		0		0	0			0	0	0	0		
Spillback Cap Reductn		0		0	0			0	0	0	0		
Storage Cap Reductn		0		0	0			0	0	0	0		
Reduced v/c Ratio		0.53		0.57	0.41			0.58	0.10	0.32	0.43		

Intersection Summary

Area Type: Other
Cycle Length: 80
Actuated Cycle Length: 80
Offset: 5 (6%), Referenced to phase 2:EBTL, Start of Green
Natural Cycle: 90
Control Type: Actuated-Coordinated

Splits and Phases: 20: Hunting Rd & Kendrick St



												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	15	235	2	475	405	45	1	110	135	85	190	15
Future Volume (vph)	15	235	2	475	405	45	1	110	135	85	190	15
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0		5.0	5.0			5.0	4.0	5.0	5.0	
Lane Util. Factor		0.95		1.00	1.00			1.00	1.00	1.00	1.00	
Frt		1.00		1.00	0.99			1.00	0.85	1.00	0.99	
Flt Protected		1.00		0.95	1.00			1.00	1.00	0.95	1.00	
Satd. Flow (prot)		3525		1770	1835			1862	1583	1770	1842	
Flt Permitted		0.91		0.38	1.00			1.00	1.00	0.42	1.00	
Satd. Flow (perm)		3202		704	1835			1857	1583	781	1842	
Peak-hour factor, PHF	0.91	0.91	0.91	0.95	0.95	0.95	0.83	0.83	0.83	0.94	0.94	0.94
Adj. Flow (vph)	16	258	2	500	426	47	1	133	163	90	202	16
RTOR Reduction (vph)	0	1	0	0	3	0	0	0	0	0	4	0
Lane Group Flow (vph)	0	275	0	500	470	0	0	134	163	90	214	0
Turn Type	Perm	NA		pm+pt	NA		Perm	NA	Free	pm+pt	NA	
Protected Phases		2		1	6			8		7	4	
Permitted Phases	2			6			8		Free	4		
Actuated Green, G (s)		12.0		49.4	49.4			10.0	80.0	20.6	20.6	
Effective Green, g (s)		12.0		49.4	49.4			10.0	80.0	20.6	20.6	
Actuated g/C Ratio		0.15		0.62	0.62			0.12	1.00	0.26	0.26	
Clearance Time (s)		5.0		5.0	5.0			5.0		5.0	5.0	
Vehicle Extension (s)		2.0		2.0	2.0			2.0		2.0	2.0	
Lane Grp Cap (vph)		480		866	1133			232	1583	270	474	
v/s Ratio Prot				c0.23	0.26					0.02	c0.12	
v/s Ratio Perm		0.09		c0.12				c0.07	0.10	0.06		
v/c Ratio		0.57		0.58	0.42			0.58	0.10	0.33	0.45	
Uniform Delay, d1		31.6		8.6	7.9			33.0	0.0	23.4	25.0	
Progression Factor		1.00		1.00	1.00			1.00	1.00	1.00	1.00	
Incremental Delay, d2		4.9		0.6	0.1			2.2	0.1	0.3	0.3	
Delay (s)		36.5		9.2	8.0			35.2	0.1	23.7	25.2	
Level of Service		D		A	A			D	A	C	C	
Approach Delay (s)		36.5			8.6			15.9			24.8	
Approach LOS		D			A			B			C	
Intersection Summary												
HCM 2000 Control Delay			16.6		HCM 2000 Level of Service					B		
HCM 2000 Volume to Capacity ratio			0.65									
Actuated Cycle Length (s)			80.0		Sum of lost time (s)					23.0		
Intersection Capacity Utilization			58.5%		ICU Level of Service					B		
Analysis Period (min)			15									
c Critical Lane Group												

c Critical Lane Group

Intersection						
Int Delay, s/veh	6.6					
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations	↵	↵	↵		↵	↵
Traffic Vol, veh/h	105	70	305	20	15	615
Future Vol, veh/h	105	70	305	20	15	615
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	150	-	-	150	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	81	81	75	75	73	73
Heavy Vehicles, %	0	0	0	0	0	6
Mvmt Flow	130	86	407	27	21	842
Major/Minor	Minor1	Major1	Major2			
Conflicting Flow All	1305	421	0	0	434	0
Stage 1	421	-	-	-	-	-
Stage 2	884	-	-	-	-	-
Critical Hdwy	6.4	6.2	-	-	4.1	-
Critical Hdwy Stg 1	5.4	-	-	-	-	-
Critical Hdwy Stg 2	5.4	-	-	-	-	-
Follow-up Hdwy	3.5	3.3	-	-	2.2	-
Pot Cap-1 Maneuver	178	637	-	-	1136	-
Stage 1	667	-	-	-	-	-
Stage 2	407	-	-	-	-	-
Platoon blocked, %			-	-	-	-
Mov Cap-1 Maneuver	175	637	-	-	1136	-
Mov Cap-2 Maneuver	175	-	-	-	-	-
Stage 1	667	-	-	-	-	-
Stage 2	400	-	-	-	-	-
Approach	WB	NB		SB		
HCM Control Delay, s	45.7	0		0.2		
HCM LOS	E					
Minor Lane/Major Mvmt	NBT	NBR	WBLn1	WBLn2	SBL	SBT
Capacity (veh/h)	-	-	175	637	1136	-
HCM Lane V/C Ratio	-	-	0.741	0.136	0.018	-
HCM Control Delay (s)	-	-	68.5	11.5	8.2	-
HCM Lane LOS	-	-	F	B	A	-
HCM 95th %tile Q(veh)	-	-	4.7	0.5	0.1	-

2009 MUTCD

TRAFFIC SIGNAL WARRANT ANALYSIS (VOLUME BASED)

Intersection: **Central Street at Cedar Street**

Major Street Direction: Eastbound-Westbound ▼

Year: **2022** Condition: **Existing Conditions**

Operating speed on major roadway: **35** mph

Number of approaches: **3**

Required approach volumes

Warrant 1 EIGHT-HOUR VEHICULAR VOLUME				Minimum*	Adjusted Minimum**
Warrant 1A MINIMUM VEHICULAR VOLUME (8 hours of day)					
	Major Street :	1 Lane(s) on each approach		500	500
	Minor Street :	1 Lane(s) on each approach		150	150
Warrant 1B INTERRUPTION OF CONTINUOUS TRAFFIC (8 hours of day)					
	Major Street :	1 Lane(s) on each approach		750	750
	Minor Street :	1 Lane(s) on each approach		75	75
80 PERCENT SATISFACTION OF WARRANT 1A AND WARRANT 1B				Warrant 1A	Warrant 1B
	Major Street :	1 Lane(s) on each approach		400	600
	Minor Street :	1 Lane(s) on each approach		120	60

Warrant 2 FOUR HOUR VEHICULAR VOLUME				
	Major Street :	1 Lane(s) on each approach		If "verify" indicated, see Figure 4C-1 or 4C-2. 25 = accuracy of regression equations
	Minor Street :	1 Lane(s) on each approach		

Warrant 3 PEAK HOUR VOLUME				
	Major Street :	1 Lane(s) on each approach		If "verify" indicated, see Figure 4C-3 or 4C-4. 25 = accuracy of regression equations
	Minor Street :	1 Lane(s) on each approach		

Hour	Entering Vol. Minor Road+	Entering Vol. on Major Road		Tot. Ent. Vol. On Major Rd	Meets the following volume-based warrants?				
		Eastbound	Westbound		1A	1B	80%(1A&1B)	2	3
6:00 - 7:00 AM	100	324	121	445	No	No	No	No	No
7:00 - 8:00 AM	203	656	226	882	Yes	Yes	Yes	Yes	No
8:00 - 9:00 AM	204	660	230	890	Yes	Yes	Yes	Yes	No
9:00 - 10:00 AM	156	505	215	720	Yes	No	Yes	No	No
10:00 - 11:00 AM	132	428	223	651	No	No	Yes	No	No
11:00 - 12:00 AM	140	451	243	694	No	No	Yes	No	No
12:00 - 1:00 PM	140	450	247	697	No	No	Yes	No	No
1:00 - 2:00 PM	150	314	401	715	No	No	Yes	No	No
2:00 - 3:00 PM	159	330	395	725	Yes	No	Yes	No	No
3:00 - 4:00 PM	184	384	367	751	Yes	Yes	Yes	Yes	No
4:00 - 5:00 PM	175	366	422	788	Yes	Yes	Yes	Yes	No
5:00 - 6:00 PM	141	295	540	835	No	Yes	Yes	Yes	No
6:00 - 7:00 PM	136	283	471	754	No	Yes	Yes	No	No
					No	No	Yes	Yes	No
						1		2	3
						Yes		Yes	No

Note: Major road volumes include through and left-turning vehicles.

Note: Minor Road volumes include 100% of left-turning volumes and 25% of right-turning volumes

*From the criteria described for the warrant in the MUTCD.

**If the operating speed is higher than 40mph then the volumes can be adjusted to 70%. (If no adjusted minimum, the minimum from the previous column is shown)

+If more than one approach, report the approach that has the higher volume.

NON-VOLUME-BASED WARRANTS

Warrant 4, Minimum Pedestrian Volume: **No**
*107 pedestrians per hour is the minimum threshold

Peak Four Hour Pedestrian Volumes: <100 7:00 AM
<100 8:00 AM
<100 4:00 PM
<100 5:00 PM

Warrant 5, School Crossing: **No**
See MUTCD for details.

Warrant 6, Coordinated Signal System: **No**
See MUTCD for details.

Warrant 7, Crash Experience: **No**
of accidents "correctable by signalization" occurring in the last 12 months:
(threshold is 5 crashes in last year correctable by signalization)

Warrant 8, Roadway Network: **No**
See MUTCD for details.

Total Crashes 2015-2019 4
based on MassDOT crash portal

Warrant 9, Grade Crossing: **No**

2009 MUTCD

TRAFFIC SIGNAL WARRANT ANALYSIS (VOLUME BASED)

Intersection: **Central Street at Cedar Street**

Major Street Direction: Eastbound-Westbound ▼

Year: **2029** Condition: **No Build Conditions**

Operating speed on major roadway: **35** mph

Number of approaches: **3**

Required approach volumes

Warrant 1 EIGHT-HOUR VEHICULAR VOLUME				Minimum*	Adjusted Minimum**
Warrant 1A MINIMUM VEHICULAR VOLUME (8 hours of day)					
	Major Street :	1 Lane(s) on each approach		500	500
	Minor Street :	1 Lane(s) on each approach		150	150
Warrant 1B INTERRUPTION OF CONTINUOUS TRAFFIC (8 hours of day)					
	Major Street :	1 Lane(s) on each approach		750	750
	Minor Street :	1 Lane(s) on each approach		75	75
80 PERCENT SATISFACTION OF WARRANT 1A AND WARRANT 1B				Warrant 1A	Warrant 1B
	Major Street :	1 Lane(s) on each approach		400	600
	Minor Street :	1 Lane(s) on each approach		120	60

Warrant 2 FOUR HOUR VEHICULAR VOLUME				
	Major Street :	1 Lane(s) on each approach		If "verify" indicated, see Figure 4C-1 or 4C-2. 25 = accuracy of regression equations
	Minor Street :	1 Lane(s) on each approach		

Warrant 3 PEAK HOUR VOLUME				
	Major Street :	1 Lane(s) on each approach		If "verify" indicated, see Figure 4C-3 or 4C-4. 25 = accuracy of regression equations
	Minor Street :	1 Lane(s) on each approach		

Hour	Entering Vol. Minor Road+	Entering Vol. on Major Road		Tot. Ent. Vol. On Major Rd	Meets the following volume-based warrants?				
		Eastbound	Westbound		1A	1B	80%(1A&1B)	2	3
6:00 - 7:00 AM	109	349	132	481	No	No	No	No	No
7:00 - 8:00 AM	219	705	245	950	Yes	Yes	Yes	Yes	No
8:00 - 9:00 AM	220	710	250	960	Yes	Yes	Yes	Yes	No
9:00 - 10:00 AM	169	543	234	777	Yes	Yes	Yes	Yes	No
10:00 - 11:00 AM	143	462	242	704	No	No	Yes	No	No
11:00 - 12:00 AM	150	485	264	749	Yes	No	Yes	No	No
12:00 - 1:00 PM	150	484	268	752	Yes	Yes	Yes	No	No
1:00 - 2:00 PM	162	335	431	766	Yes	Yes	Yes	Yes	No
2:00 - 3:00 PM	171	352	425	777	Yes	Yes	Yes	Yes	No
3:00 - 4:00 PM	198	410	394	804	Yes	Yes	Yes	Yes	No
4:00 - 5:00 PM	190	391	453	844	Yes	Yes	Yes	Yes	No
5:00 - 6:00 PM	153	315	580	895	Yes	Yes	Yes	Yes	No
6:00 - 7:00 PM	146	302	506	808	No	Yes	Yes	No	No
					Yes	Yes	Yes	Yes	No
						1		2	3
						Yes		Yes	No

Note: Major road volumes include through and left-turning vehicles.

Note: Minor Road volumes include 100% of left-turning volumes and 25% of right-turning volumes

*From the criteria described for the warrant in the MUTCD.

**If the operating speed is higher than 40mph then the volumes can be adjusted to 70%. (If no adjusted minimum, the minimum from the previous column is shown)

+If more than one approach, report the approach that has the higher volume.

NON-VOLUME-BASED WARRANTS

Warrant 4, Minimum Pedestrian Volume: **No**
*107 pedestrians per hour is the minimum threshold

Peak Four Hour Pedestrian Volumes: <100 7:00 AM
<100 8:00 AM
<100 4:00 PM
<100 5:00 PM

Warrant 5, School Crossing: **No**
See MUTCD for details.

Warrant 6, Coordinated Signal System: **No**
See MUTCD for details.

Warrant 7, Crash Experience: **No**
of accidents "correctable by signalization" occurring in the last 12 months:
(threshold is 5 crashes in last year correctable by signalization)

Warrant 8, Roadway Network: **No**
See MUTCD for details.

Total Crashes 2015-2019 4
based on MassDOT crash portal

Warrant 9, Grade Crossing: **No**

2009 MUTCD

TRAFFIC SIGNAL WARRANT ANALYSIS (VOLUME BASED)

Intersection: **Central Street at Cedar Street**

Major Street Direction: Eastbound-Westbound ▼

Year: **2029** Condition: **Build Conditions**

Operating speed on major roadway: **35** mph

Number of approaches: **3**

Required approach volumes

Warrant 1 EIGHT-HOUR VEHICULAR VOLUME				Minimum*	Adjusted Minimum**
Warrant 1A MINIMUM VEHICULAR VOLUME (8 hours of day)					
	Major Street :	1 Lane(s) on each approach		500	500
	Minor Street :	1 Lane(s) on each approach		150	150
Warrant 1B INTERRUPTION OF CONTINUOUS TRAFFIC (8 hours of day)					
	Major Street :	1 Lane(s) on each approach		750	750
	Minor Street :	1 Lane(s) on each approach		75	75
80 PERCENT SATISFACTION OF WARRANT 1A AND WARRANT 1B				Warrant 1A	Warrant 1B
	Major Street :	1 Lane(s) on each approach		400	600
	Minor Street :	1 Lane(s) on each approach		120	60

Warrant 2 FOUR HOUR VEHICULAR VOLUME				
	Major Street :	1 Lane(s) on each approach		If "verify" indicated, see Figure 4C-1 or 4C-2. 25 = accuracy of regression equations
	Minor Street :	1 Lane(s) on each approach		

Warrant 3 PEAK HOUR VOLUME				
	Major Street :	1 Lane(s) on each approach		If "verify" indicated, see Figure 4C-3 or 4C-4. 25 = accuracy of regression equations
	Minor Street :	1 Lane(s) on each approach		

Hour	Entering Vol. Minor Road+	Entering Vol. on Major Road		Tot. Ent. Vol. On Major Rd	Meets the following volume-based warrants?				
		Eastbound	Westbound		1A	1B	80%(1A&1B)	2	3
6:00 - 7:00 AM	112	355	133	488	No	No	No	No	No
7:00 - 8:00 AM	230	723	248	971	Yes	Yes	Yes	Yes	Yes
8:00 - 9:00 AM	235	736	253	989	Yes	Yes	Yes	Yes	Yes
9:00 - 10:00 AM	173	551	240	791	Yes	Yes	Yes	Yes	No
10:00 - 11:00 AM	147	469	249	718	No	No	Yes	No	No
11:00 - 12:00 AM	155	492	277	769	Yes	Yes	Yes	No	No
12:00 - 1:00 PM	158	497	281	778	Yes	Yes	Yes	Yes	No
1:00 - 2:00 PM	169	346	439	785	Yes	Yes	Yes	Yes	No
2:00 - 3:00 PM	177	363	433	795	Yes	Yes	Yes	Yes	No
3:00 - 4:00 PM	204	419	404	824	Yes	Yes	Yes	Yes	No
4:00 - 5:00 PM	193	398	473	870	Yes	Yes	Yes	Yes	No
5:00 - 6:00 PM	155	320	604	923	Yes	Yes	Yes	Yes	No
6:00 - 7:00 PM	147	304	509	812	No	Yes	Yes	No	No
					Yes	Yes	Yes	Yes	Yes
					Warrants Met?	1		2	3
						Yes		Yes	Yes

Note: Major road volumes include through and left-turning vehicles.

Note: Minor Road volumes include 100% of left-turning volumes and 25% of right-turning volumes

*From the criteria described for the warrant in the MUTCD.

**If the operating speed is higher than 40mph then the volumes can be adjusted to 70%. (If no adjusted minimum, the minimum from the previous column is shown)

+If more than one approach, report the approach that has the higher volume.

NON-VOLUME-BASED WARRANTS

Warrant 4, Minimum Pedestrian Volume: **No**
*107 pedestrians per hour is the minimum threshold

Peak Four Hour Pedestrian Volumes: <100 7:00 AM
<100 8:00 AM
<100 4:00 PM
<100 5:00 PM

Warrant 5, School Crossing: **No**
See MUTCD for details.

Warrant 6, Coordinated Signal System: **No**
See MUTCD for details.

Warrant 7, Crash Experience: **No**
of accidents "correctable by signalization" occurring in the last 12 months:
(threshold is 5 crashes in last year correctable by signalization)

Warrant 8, Roadway Network: **No**
See MUTCD for details.

Total Crashes 2015-2019 4
based on MassDOT crash portal

Warrant 9, Grade Crossing: **No**

2009 MUTCD

TRAFFIC SIGNAL WARRANT ANALYSIS (VOLUME BASED)

Intersection: **Central Street at Webster Street**

Major Street Direction: Eastbound-Westbound ▼

Year: **2022** Condition: **Existing Conditions**

Operating speed on major roadway: **35** mph

Number of approaches: **3**

Required approach volumes

Warrant 1 EIGHT-HOUR VEHICULAR VOLUME				Minimum*	Adjusted Minimum**
Warrant 1A MINIMUM VEHICULAR VOLUME (8 hours of day)					
	Major Street :	1 Lane(s) on each approach		500	500
	Minor Street :	1 Lane(s) on each approach		150	150
Warrant 1B INTERRUPTION OF CONTINUOUS TRAFFIC (8 hours of day)					
	Major Street :	1 Lane(s) on each approach		750	750
	Minor Street :	1 Lane(s) on each approach		75	75
80 PERCENT SATISFACTION OF WARRANT 1A AND WARRANT 1B				Warrant 1A	Warrant 1B
	Major Street :	1 Lane(s) on each approach		400	600
	Minor Street :	1 Lane(s) on each approach		120	60

Warrant 2 FOUR HOUR VEHICULAR VOLUME				
	Major Street :	1 Lane(s) on each approach		If "verify" indicated, see Figure 4C-1 or 4C-2. 25 = accuracy of regression equations
	Minor Street :	1 Lane(s) on each approach		

Warrant 3 PEAK HOUR VOLUME				
	Major Street :	1 Lane(s) on each approach		If "verify" indicated, see Figure 4C-3 or 4C-4. 25 = accuracy of regression equations
	Minor Street :	1 Lane(s) on each approach		

Hour	Entering Vol. Minor Road+	Entering Vol. on Major Road		Tot. Ent. Vol. On Major Rd	Meets the following volume-based warrants?				
		Eastbound	Westbound		1A	1B	80%(1A&1B)	2	3
6:00 - 7:00 AM	64	347	198	545	No	No	No	No	No
7:00 - 8:00 AM	128	700	369	1069	No	Yes	Yes	Yes	No
8:00 - 9:00 AM	129	705	375	1080	No	Yes	Yes	Yes	No
9:00 - 10:00 AM	99	539	351	890	No	Yes	No	No	No
10:00 - 11:00 AM	84	458	364	822	No	Yes	No	No	No
11:00 - 12:00 AM	88	482	395	877	No	Yes	No	No	No
12:00 - 1:00 PM	88	481	402	883	No	Yes	No	No	No
1:00 - 2:00 PM	92	341	553	894	No	Yes	No	No	No
2:00 - 3:00 PM	97	358	545	903	No	Yes	No	No	No
3:00 - 4:00 PM	112	417	506	923	No	Yes	No	No	No
4:00 - 5:00 PM	107	397	583	980	No	Yes	No	No	No
5:00 - 6:00 PM	86	320	745	1065	No	Yes	No	No	No
6:00 - 7:00 PM	83	307	649	956	No	Yes	No	No	No
					No	Yes	No	No	No
					Warrants Met?	1		2	3
						Yes		No	No

Note: Major road volumes include through and left-turning vehicles.

Note: Minor Road volumes include 100% of left-turning volumes and 25% of right-turning volumes

*From the criteria described for the warrant in the MUTCD.

**If the operating speed is higher than 40mph then the volumes can be adjusted to 70%. (If no adjusted minimum, the minimum from the previous column is shown)

+If more than one approach, report the approach that has the higher volume.

NON-VOLUME-BASED WARRANTS

Warrant 4, Minimum Pedestrian Volume: **No**
*107 pedestrians per hour is the minimum threshold

Peak Four Hour Pedestrian Volumes: <100 7:00 AM
<100 8:00 AM
<100 4:00 PM
<100 5:00 PM

Warrant 5, School Crossing: **No**
See MUTCD for details.

Warrant 6, Coordinated Signal System: **No**
See MUTCD for details.

Warrant 7, Crash Experience: **No**
of accidents "correctable by signalization" occurring in the last 12 months:
(threshold is 5 crashes in last year correctable by signalization)

Warrant 8, Roadway Network: **No**
See MUTCD for details.

Total Crashes 2015-2019 1
based on MassDOT crash portal

Warrant 9, Grade Crossing: **No**

2009 MUTCD

TRAFFIC SIGNAL WARRANT ANALYSIS (VOLUME BASED)

Intersection: **Central Street at Webster Street**

Major Street Direction: Eastbound-Westbound ▼

Year: **2029** Condition: **No Build Conditions**

Operating speed on major roadway: **35** mph

Number of approaches: **3**

Required approach volumes

Warrant 1 EIGHT-HOUR VEHICULAR VOLUME				Minimum*	Adjusted Minimum**
Warrant 1A MINIMUM VEHICULAR VOLUME (8 hours of day)					
	Major Street :	1	Lane(s) on each approach	500	500
	Minor Street :	1	Lane(s) on each approach	150	150
Warrant 1B INTERRUPTION OF CONTINUOUS TRAFFIC (8 hours of day)					
	Major Street :	1	Lane(s) on each approach	750	750
	Minor Street :	1	Lane(s) on each approach	75	75
80 PERCENT SATISFACTION OF WARRANT 1A AND WARRANT 1B				Warrant 1A	Warrant 1B
	Major Street :	1	Lane(s) on each approach	400	600
	Minor Street :	1	Lane(s) on each approach	120	60

Warrant 2 FOUR HOUR VEHICULAR VOLUME

Major Street : 1 Lane(s) on each approach
Minor Street : 1 Lane(s) on each approach

If "verify" indicated, see Figure 4C-1 or 4C-2.
25 = accuracy of regression equations

Warrant 3 PEAK HOUR VOLUME

Major Street : 1 Lane(s) on each approach
Minor Street : 1 Lane(s) on each approach

If "verify" indicated, see Figure 4C-3 or 4C-4.
25 = accuracy of regression equations

Hour	Entering Vol. Minor Road+	Entering Vol. on Major Road		Tot. Ent. Vol. On Major Rd	Meets the following volume-based warrants?				
		Eastbound	Westbound		1A	1B	80%(1A&1B)	2	3
6:00 - 7:00 AM	67	374	213	587	No	No	No	No	No
7:00 - 8:00 AM	135	755	398	1153	No	Yes	Yes	Yes	No
8:00 - 9:00 AM	136	760	405	1165	No	Yes	Yes	Yes	No
9:00 - 10:00 AM	104	581	379	960	No	Yes	No	No	No
10:00 - 11:00 AM	89	494	392	886	No	Yes	No	No	No
11:00 - 12:00 AM	93	519	427	946	No	Yes	No	No	No
12:00 - 1:00 PM	93	518	435	953	No	Yes	No	No	No
1:00 - 2:00 PM	100	367	602	969	No	Yes	No	No	No
2:00 - 3:00 PM	105	386	593	979	No	Yes	No	No	No
3:00 - 4:00 PM	123	449	551	1000	No	Yes	Yes	Yes	No
4:00 - 5:00 PM	117	428	634	1062	No	Yes	No	Yes	No
5:00 - 6:00 PM	94	345	810	1155	No	Yes	No	Yes	No
6:00 - 7:00 PM	90	331	706	1037	No	Yes	No	No	No
					No	Yes	No	Yes	No
						1		2	3
						Yes		Yes	No

Note: Major road volumes include through and left-turning vehicles.

Note: Minor Road volumes include 100% of left-turning volumes and 25% of right-turning volumes

*From the criteria described for the warrant in the MUTCD.

**If the operating speed is higher than 40mph then the volumes can be adjusted to 70%. (If no adjusted minimum, the minimum from the previous column is shown)

+If more than one approach, report the approach that has the higher volume.

NON-VOLUME-BASED WARRANTS

Warrant 4, Minimum Pedestrian Volume:

No

*107 pedestrians per hour is the minimum threshold

Peak Four Hour Pedestrian Volumes: <100 7:00 AM
<100 8:00 AM
<100 4:00 PM
<100 5:00 PM

Warrant 5, School Crossing:

No

See MUTCD for details.

Warrant 6, Coordinated Signal System:

No

See MUTCD for details.

Warrant 7, Crash Experience:

No

of accidents "correctable by signalization" occurring in the last 12 months:
(threshold is 5 crashes in last year correctable by signalization)

Warrant 8, Roadway Network:

No

See MUTCD for details.

Total Crashes 2015-2019
based on MassDOT crash portal

1

Warrant 9, Grade Crossing:

No

2009 MUTCD

TRAFFIC SIGNAL WARRANT ANALYSIS (VOLUME BASED)

Intersection: **Central Street at Webster Street**

Major Street Direction: Eastbound-Westbound ▼

Year: **2029** Condition: **Build Conditions**

Operating speed on major roadway: **35** mph

Number of approaches: **3**

Required approach volumes

Warrant 1 EIGHT-HOUR VEHICULAR VOLUME				Minimum*	Adjusted Minimum**
Warrant 1A MINIMUM VEHICULAR VOLUME (8 hours of day)					
	Major Street :	1 Lane(s) on each approach		500	500
	Minor Street :	1 Lane(s) on each approach		150	150
Warrant 1B INTERRUPTION OF CONTINUOUS TRAFFIC (8 hours of day)					
	Major Street :	1 Lane(s) on each approach		750	750
	Minor Street :	1 Lane(s) on each approach		75	75
80 PERCENT SATISFACTION OF WARRANT 1A AND WARRANT 1B				Warrant 1A	Warrant 1B
	Major Street :	1 Lane(s) on each approach		400	600
	Minor Street :	1 Lane(s) on each approach		120	60

Warrant 2 FOUR HOUR VEHICULAR VOLUME

Major Street : 1 Lane(s) on each approach
Minor Street : 1 Lane(s) on each approach

If "verify" indicated, see Figure 4C-1 or 4C-2.
25 = accuracy of regression equations

Warrant 3 PEAK HOUR VOLUME

Major Street : 1 Lane(s) on each approach
Minor Street : 1 Lane(s) on each approach

If "verify" indicated, see Figure 4C-3 or 4C-4.
25 = accuracy of regression equations

Hour	Entering Vol. Minor Road+	Entering Vol. on Major Road		Tot. Ent. Vol. On Major Rd	Meets the following volume-based warrants?				
		Eastbound	Westbound		1A	1B	80%(1A&1B)	2	3
6:00 - 7:00 AM	67	384	214	598	No	No	No	No	No
7:00 - 8:00 AM	135	784	402	1186	No	Yes	Yes	Yes	No
8:00 - 9:00 AM	136	801	411	1212	No	Yes	Yes	Yes	No
9:00 - 10:00 AM	104	594	388	982	No	Yes	No	No	No
10:00 - 11:00 AM	89	505	404	909	No	Yes	No	No	No
11:00 - 12:00 AM	93	531	448	979	No	Yes	No	No	No
12:00 - 1:00 PM	93	539	455	994	No	Yes	No	No	No
1:00 - 2:00 PM	100	385	615	1000	No	Yes	No	No	No
2:00 - 3:00 PM	105	403	605	1008	No	Yes	No	Yes	No
3:00 - 4:00 PM	123	464	568	1031	No	Yes	Yes	Yes	No
4:00 - 5:00 PM	117	438	665	1104	No	Yes	No	Yes	No
5:00 - 6:00 PM	94	352	848	1200	No	Yes	No	Yes	No
6:00 - 7:00 PM	90	334	710	1044	No	Yes	No	No	No
					No	Yes	No	Yes	No
						1		2	3
						Yes		Yes	No

Note: Major road volumes include through and left-turning vehicles.

Note: Minor Road volumes include 100% of left-turning volumes and 25% of right-turning volumes

*From the criteria described for the warrant in the MUTCD.

**If the operating speed is higher than 40mph then the volumes can be adjusted to 70%. (If no adjusted minimum, the minimum from the previous column is shown)

+If more than one approach, report the approach that has the higher volume.

NON-VOLUME-BASED WARRANTS

Warrant 4, Minimum Pedestrian Volume:

No

*107 pedestrians per hour is the minimum threshold

Peak Four Hour Pedestrian Volumes: <100 7:00 AM
<100 8:00 AM
<100 4:00 PM
<100 5:00 PM

Warrant 5, School Crossing:

No

See MUTCD for details.

Warrant 6, Coordinated Signal System:

No

See MUTCD for details.

Warrant 7, Crash Experience:

No

of accidents "correctable by signalization" occurring in the last 12 months:
(threshold is 5 crashes in last year correctable by signalization)

Warrant 8, Roadway Network:

No

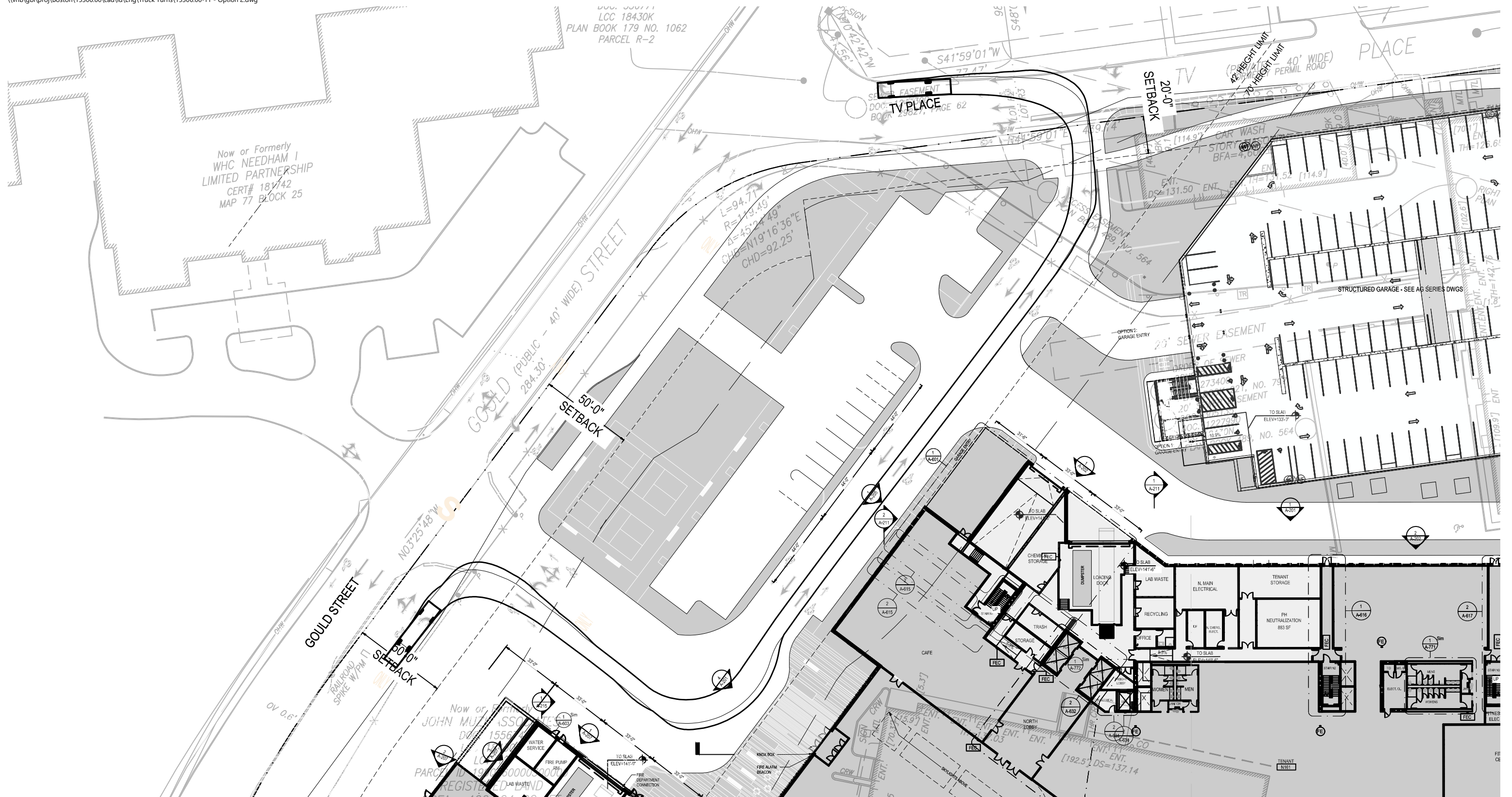
See MUTCD for details.

Total Crashes 2015-2019
based on MassDOT crash portal

1

Warrant 9, Grade Crossing:

No

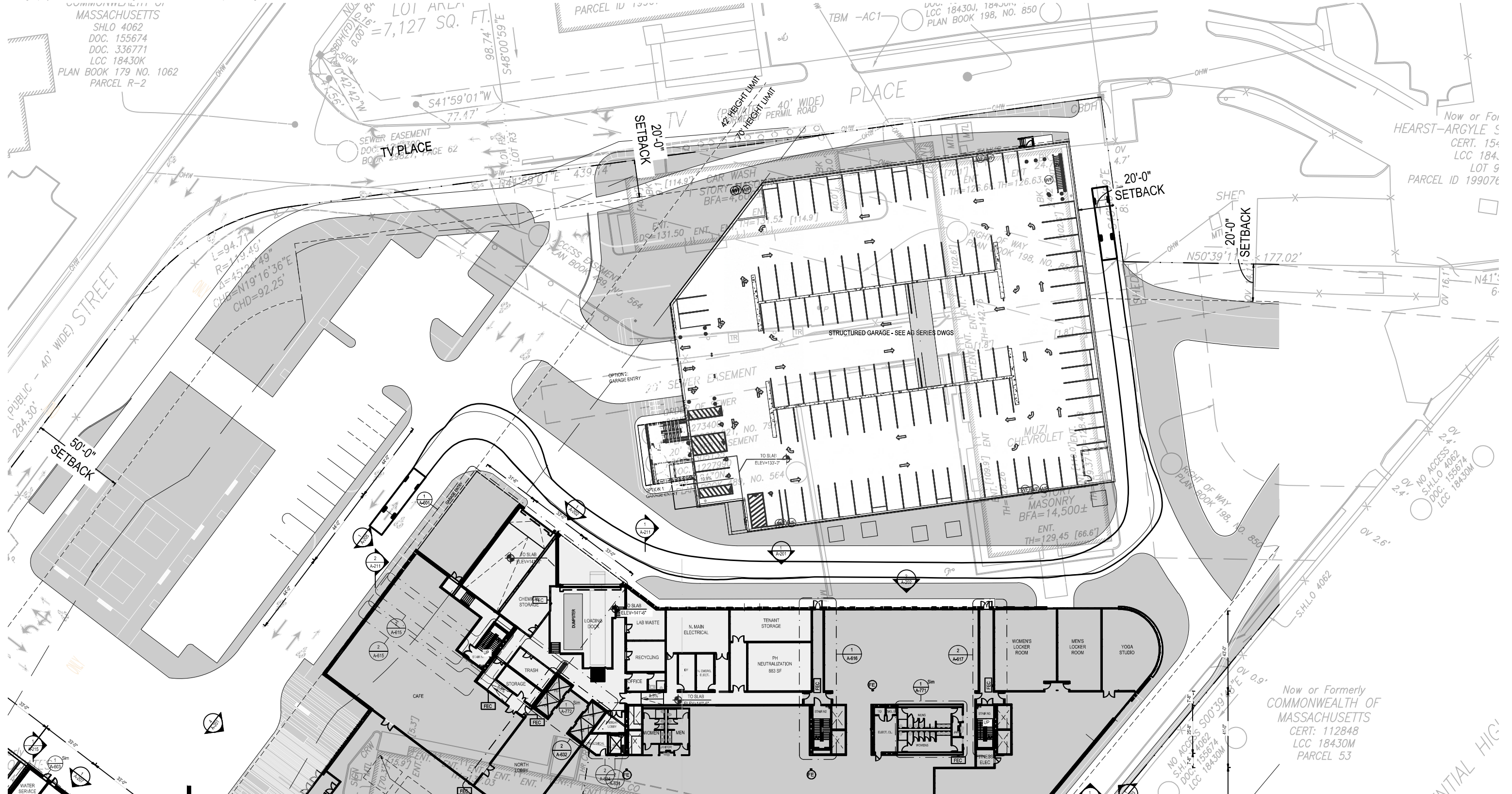


Firetruck Turn Figure 5A

**557 Highland Ave
Needham, MA**

Source:
Prepared for:
Date: **2021-10-26**



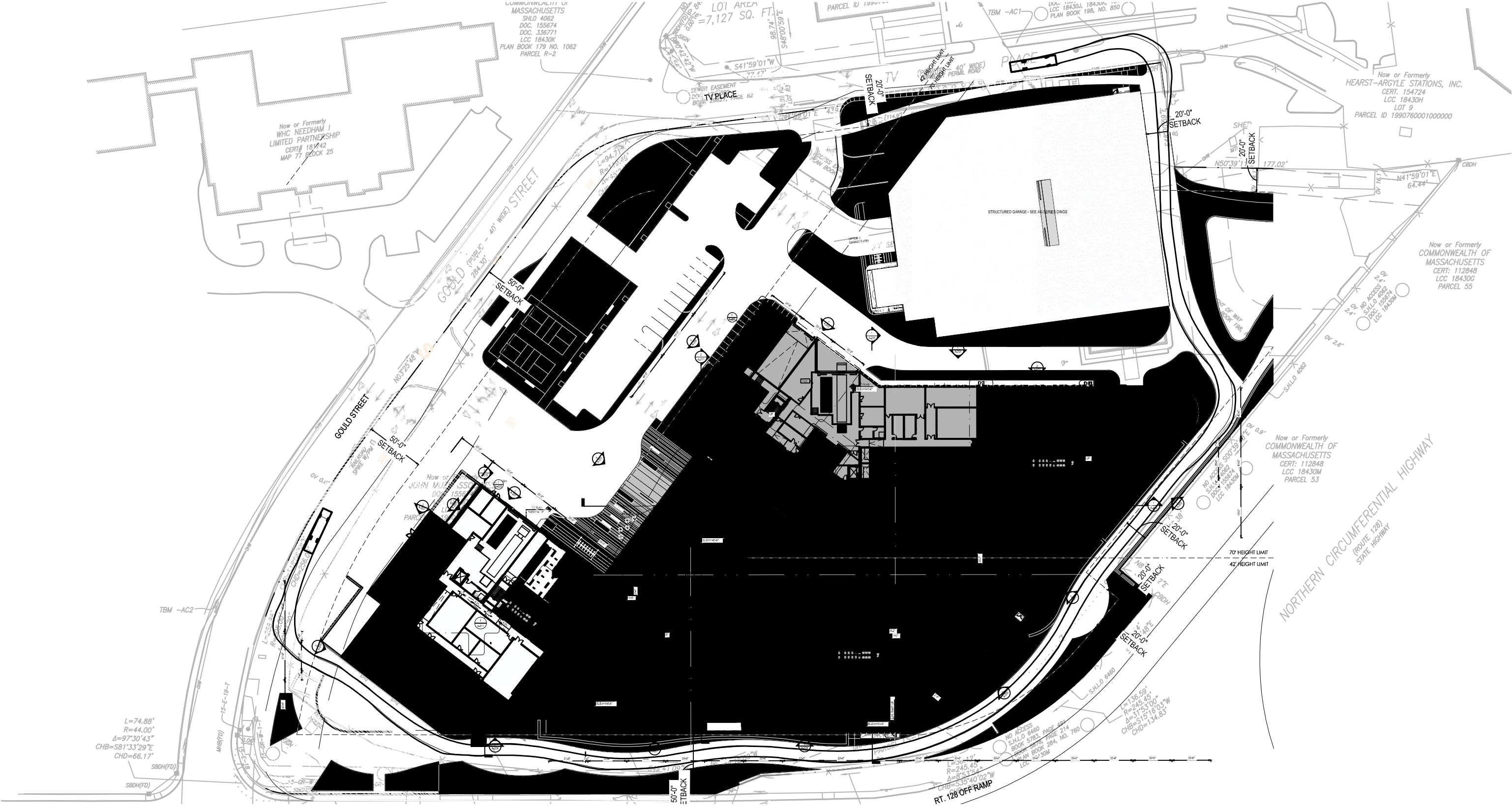


Firetruck Turn Figure 5B

**557 Highland Ave
Needham, MA**

Source:
Prepared for:
Date: **2021-10-26**





Firetruck Turn Figure 5C

557 Highland Ave

Needham, MA

Source:
Prepared for:
Date: 2021-10-26





A diagram showing a path of 50 feet. The path is represented by a horizontal line with a vertical segment in the middle. The total length is 50 feet, and the width of the path is 25 feet. A north arrow is shown in the top left corner.







A diagram showing a path of 50 feet. The path is represented by a horizontal line with a vertical segment in the middle. The total length is 50 feet, and the width of the path is 25 feet. A circular arrow icon is shown at the start of the path.

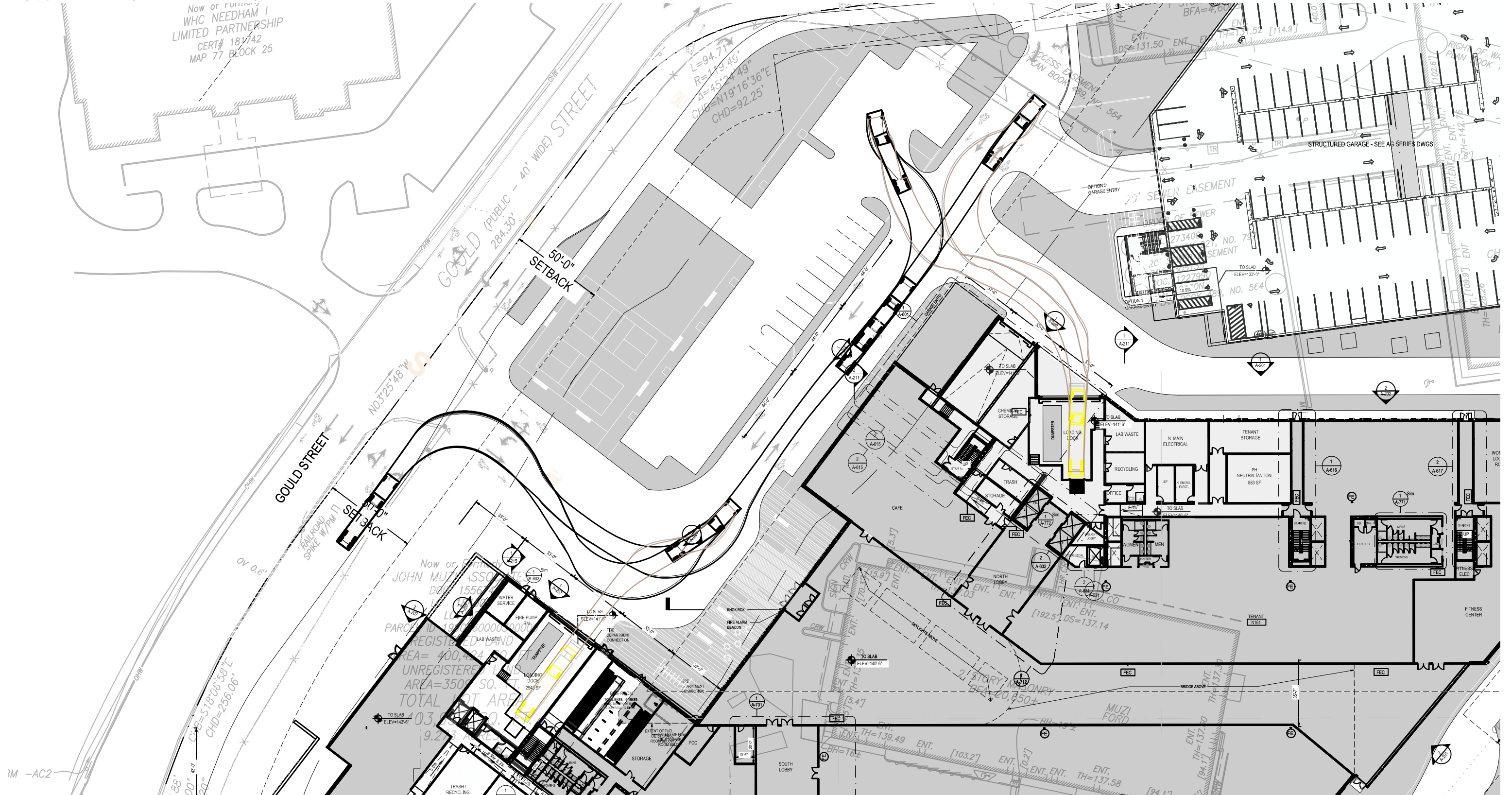




A diagram showing a path of 50 feet. The path is represented by a horizontal line with a vertical segment in the middle. The total length is 50 feet, and the width of the path is 25 feet. A circular arrow icon is shown at the start of the path.



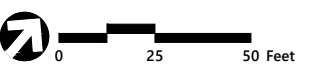
Now or Formerly
WHC NEEDHAM I
LIMITED PARTNERSHIP
CERT# 181742
MAP 77 BLOCK 25



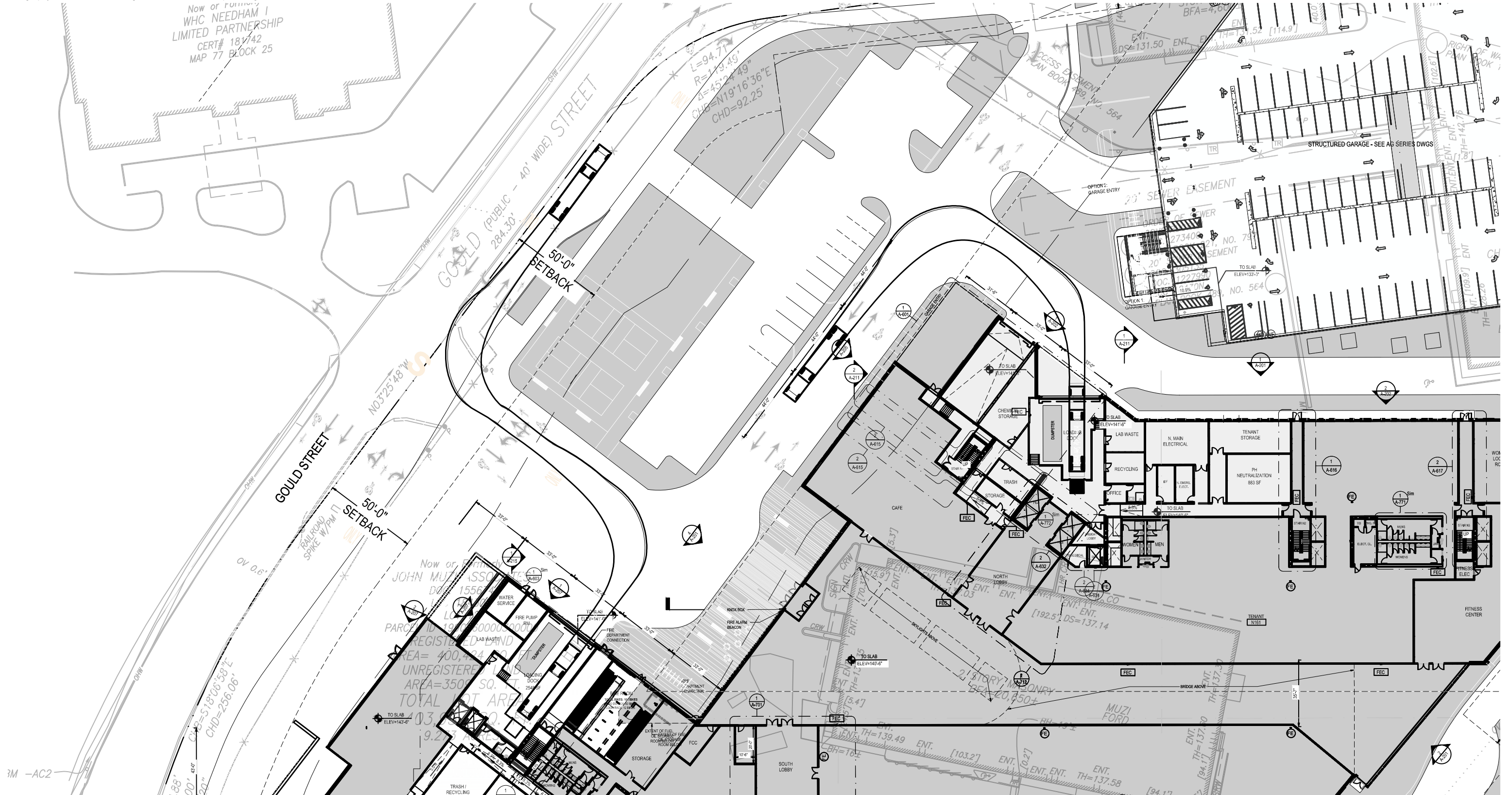
WB-40 Truck Turn Figure 3A

557 Highland Ave Needham, MA

Source:
Prepared for:
Date: 2021-10-26



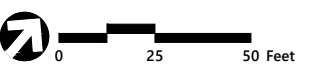
Now or Formerly
WHC NEEDHAM I
LIMITED PARTNERSHIP
CERT# 181742
MAP 77 BLOCK 25



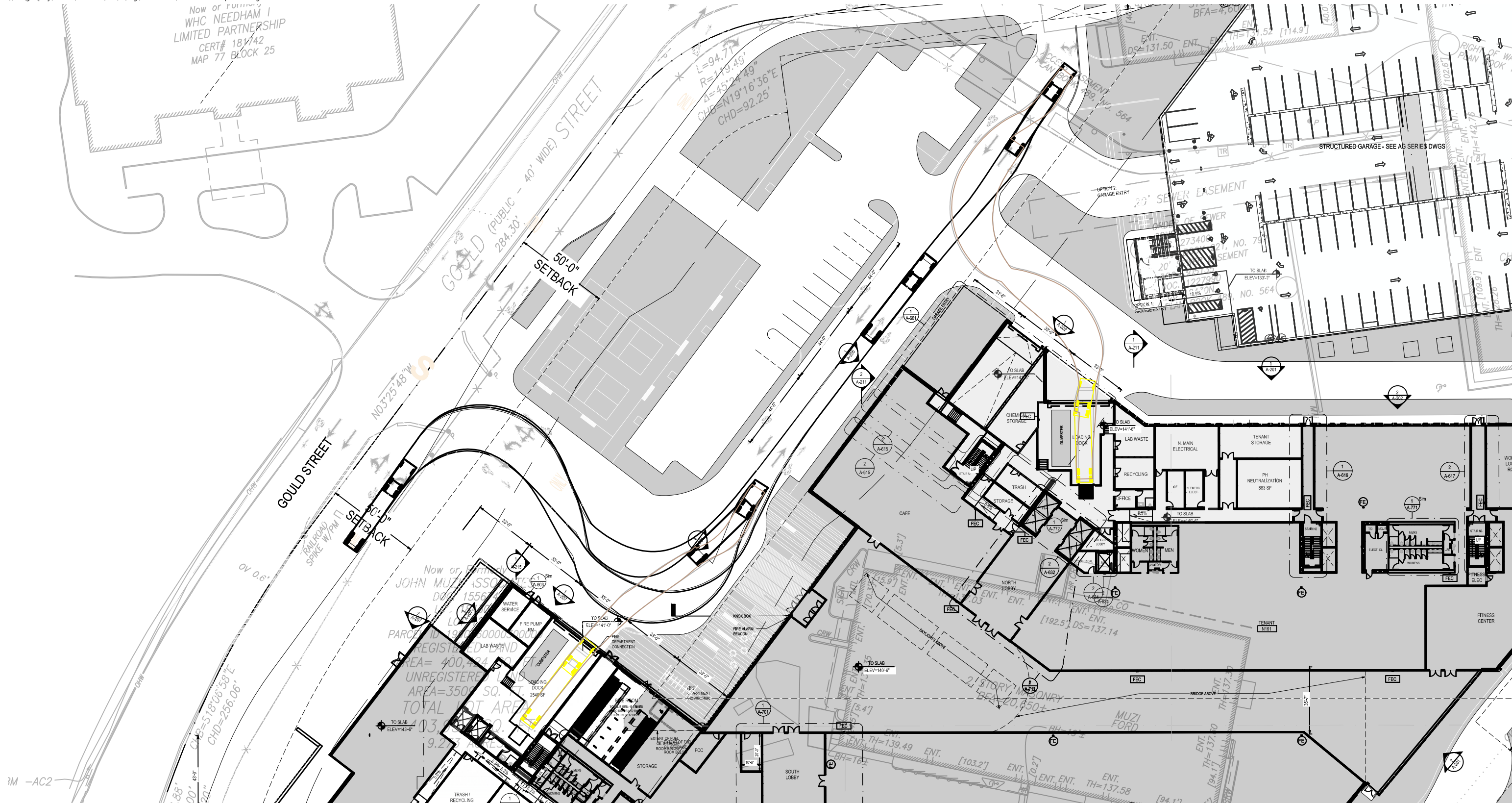
WB-40 Truck Turn Figure 3B

557 Highland Ave Needham, MA

Source:
Prepared for:
Date: 2021-10-26



Now or Formerly
WHC NEEDHAM I
LIMITED PARTNERSHIP
CERT# 181742
MAP 77 BLOCK 25



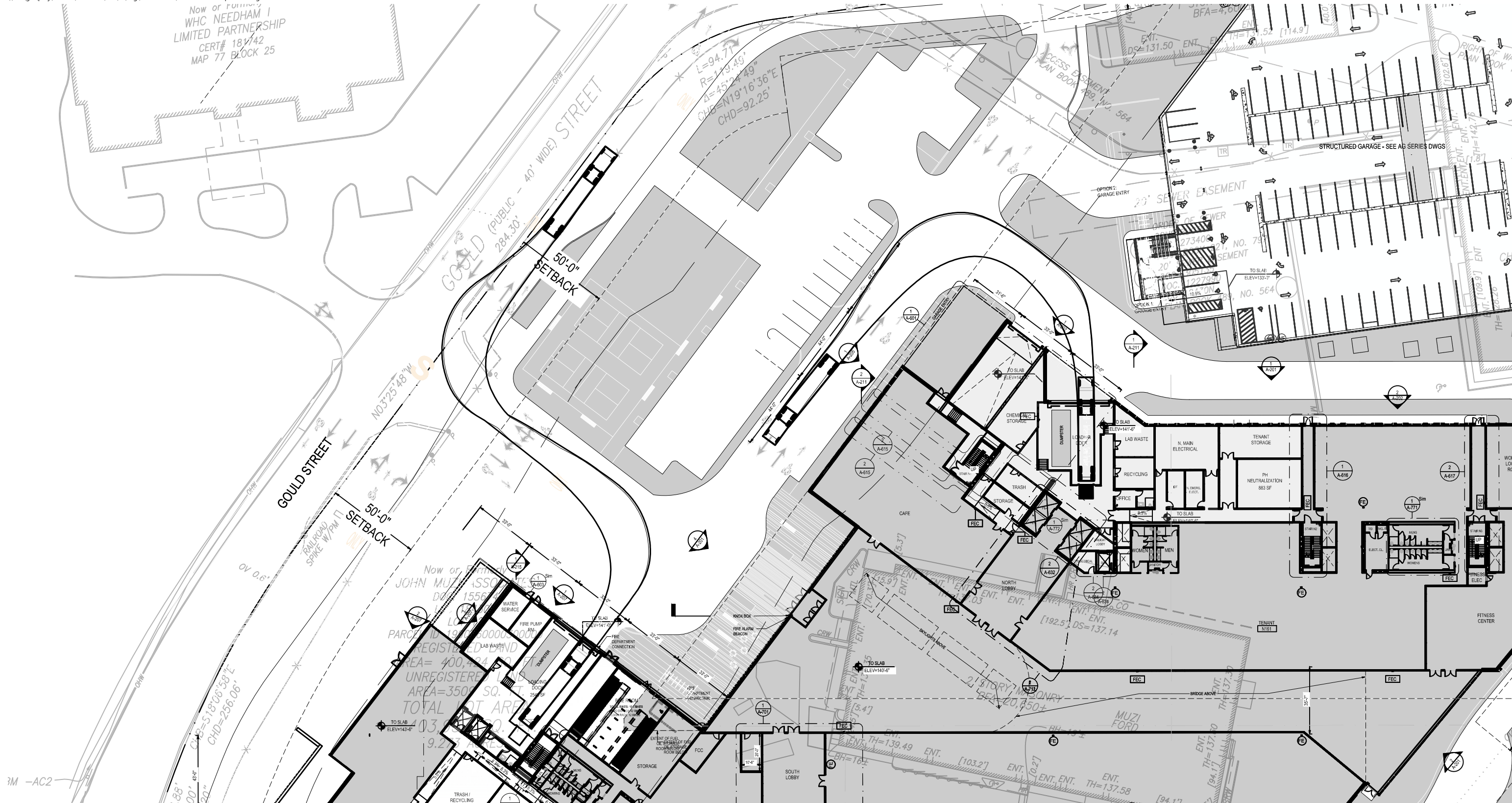
WB-50 Truck Turn Figure 4A

557 Highland Ave Needham, MA

Source:
Prepared for:
Date: 2021-10-26



Now or Formerly
WHC NEEDHAM I
LIMITED PARTNERSHIP
CERT# 181742
MAP 77 BLOCK 25



WB-50 Truck Turn Figure 4B

557 Highland Ave Needham, MA

Source:
Prepared for:
Date: 2021-10-26



Planning Board Members
June 30, 2022

EXHIBIT D

**RESPONSE TO NITSCH COMMENTS ON
TRANSPORTATION IMPACT AND ACCESS STUDY
(557 HIGHLAND AVENUE)**

[see attached]



To: Holly Charbonnier
Needham Heights Alliance

Date: June 29, 2022

Memorandum

Project #: 15306.00

From: Sean Manning, PE, PTOE
Matthew Duranleau, PE
Ariella Liebman, EIT

Re: Response to Transportation Impact and Access Study
Traffic Peer Review Comments dated June 9, 2022
By Nitsch Engineering
557 Highland Avenue
Needham, Massachusetts

Overview

VHB has received and reviewed the Transportation Impact and Access (TIA) study Transportation Engineering Peer Review submitted to the Needham Heights Alliance by Nitsch Engineering, dated June 9, 2022, for the proposed 557 Highland Avenue redevelopment in Needham, Massachusetts. This memorandum summarizes VHB's responses to the comments in that review. Each comment raised by the reviewer is listed below followed by the response by VHB. The comments follow the format and structure outlined in the Transportation Engineering Peer Review.

Since the submittal of the Transportation Engineering Peer Review, the Proponent has received feedback from the community and the Town of Needham on the proposed Gould Street off-site improvements, including the desire for more family-friendly bicycle accommodations and the wish to reduce the amount of new pavement added on Gould Street. Based on this feedback, new additional improvement concepts have been developed. Concept plans for the following three improvement alternatives along Gould Street are included in the Attachments to this memorandum:

- › Option 1: Previously Proposed Concept
- › Option 2: Two-Way Separated Bicycle Lanes on East Side with Reduced Gould Street Cross-Section
- › Option 3: Two-Way Separated Bicycle Lanes on West Side with Reduced Gould Street Cross-Section

The two additional improvement concept plans include dedicated sidewalk-level bicycle facilities in each direction along Gould Street between Highland Avenue and just north of TV Place. In addition, the two additional concepts eliminate the Gould Street dedicated northbound right-turn lane into TV Place and the dedicated southbound right-turn lane onto Highland Avenue based on feedback from the Town of Needham to reduce the amount of pavement. While these turn lanes were included in the initial concept design, the lanes are not required to provide an adequate level of operations for vehicles. Intersection traffic analyses for the new concepts are included in the Attachments to this memorandum.

Peer Review Comments

Existing Conditions

Study Area

1. The Applicant studied/examined 20 intersections including:

- › Central Avenue at Cedar Street
- › Central Avenue at Webster Street
- › Central Avenue at Gould Street
- › Central Avenue at Hampton Avenue
- › Central Avenue at River Park Street
- › Gould Street at Ellis Street
- › Gould Street at Kearney Road
- › Gould Street at Station Road
- › Gould Street at Noanett Road
- › Gould Street at TV Place
- › Gould Street at Muzi Ford/Wingate Residences driveways
- › Highland Avenue at West Street
- › Highland Avenue at Hunnewell Street
- › Highland Avenue at Webster Street
- › Highland Avenue at Gould Street / Hunting Road
- › Highland Avenue at I-95 SB Ramps
- › Highland Avenue at I-95 NB Ramps
- › Highland Avenue at 1st Avenue
- › Highland Avenue at 2nd Avenue
- › Kendrick Street at Hunting Road

Nitsch agrees with the selected Study Area.

Applicant Response: No response needed

Existing Traffic Data

2. Traffic volumes were collected during the weekday morning and weekday evening peak periods at each of the study area intersections. Applicant indicates that since traffic volumes may not have represented normal travel conditions due to the coronavirus (COVID-19) pandemic, they used MassDOT guidelines, and 2019 data were considered as existing traffic volumes. At locations where pre-pandemic counts were not available, new traffic counts were conducted in July 2021 and adjusted to represent "pre-pandemic" conditions based on traffic volumes at nearby intersections. ***Nitsch agrees with the Applicant's data collection methodology.***

Applicant Response: No response needed

Seasonal Adjustment

3. The Applicant utilized MassDOT's 2019 Weekday Seasonal Adjustment Factor data sheet to quantify the seasonal variation of traffic volumes in the area. **Nitsch finds the Applicant's methodology to be conservative and thereby acceptable.**

[Applicant Response:](#) No response needed

Public Transportation

4. **Nitsch finds the Applicant's discussion on public transportation in the area to be adequate.**

[Applicant Response:](#) No response needed

Pedestrian and Bike Facilities

5. **Nitsch finds the Applicant's discussion on existing pedestrian and bicycle facilities to be adequate.**

[Applicant Response:](#) No response needed

Safety Analysis

6. The Applicant examined crash data from the MassDOT Crash Database for the years of 2015 to 2019 at all study area intersections. **Nitsch finds the crash data analysis appropriate.**

[Applicant Response:](#) No response needed

Future Conditions

7. Traffic volumes in the study area were projected to the year 2029, reflecting a typical seven-year traffic-planning horizon as required by MassDOT. **Nitsch finds the Applicant's methodology to be acceptable.**

[Applicant Response:](#) No response needed

Background Growth

8. Background traffic growth was examined the historic traffic data, project-specific growth and roadway improvement projects. The Applicant determined that a growth rate of 1.0 percent to be appropriate for the study. **Nitsch finds the Applicant's methodology to be conservative and thereby acceptable.**

[Applicant Response:](#) No response needed

Build Conditions

Trip Generation

9. Projected trip generation for the proposed development was estimated using the following Land Use Codes (LUC) from the Institute of Transportation Engineers' (ITE) Trip Generation Manual, 11th Edition:

- › LUC 710 – General Office Building
- › LUC 760 – Research and Development Center
- › LUC 822 – Retail Plaza (<40,000 SF)

Nitsch finds the Applicant's trip generation estimation acceptable.

Applicant Response: No response needed

Internal Capture Trips and Mode Share

10. **Nitsch finds the Applicant's discussion and methodology for these sections to be acceptable.**

Applicant Response: No response needed

Pass-By-Trips

11. For this evaluation, the Applicant used ITE pass-by rates for LUC 821 (Shopping Plaza) for the retail trip generation and applied to existing trips on Gould Street. ITE identifies LUC 821 as a Shopping Plaza (40-150KSF). For project related trip generation, the Applicant used LUC 822-Retail Plaza (<40K SF) since the retail portion of the project consists of approximately 10,000 SF. However, for pass-by-trips they used LUC 821.

Nitsch requests the Applicant provide additional information detailing the estimated pass-by-trips for a LUC 822.

Applicant Response: The most recent edition of the Institute of Transportation Engineers (ITE) Trip Generation Manual (11th edition, 2021) was reviewed to determine trip generation characteristics and applicable pass-by rates for the retail portion of the Site. Pass-by rates are provided for different land uses in the Appendix to the Trip Generation Manual. As the retail portion of the Site is proposed to consist of 10,000 square feet (SF) of space, the most applicable land use code (LUC) was determined to be LUC 822 (Strip Retail Plaza (<40 ksf)). However, no pass-by rates are included in the Appendix to the Trip Generation Manual for LUC 822, as data have not been provided. Instead, the pass-by rates for LUC 821 (Shopping Plaza (40-150 ksf)) were applied to the Site-generated retail trips. While the two land use codes are not identical, it is expected that the pass-by rates for LUC 822 and LUC 821 would be similar, as the two uses consist of the same types of retail establishments; the only difference between the two land use codes is the total SF of retail included in a Site. Therefore, due to a lack of specific pass-by rate data for LUC 822, the pass-by rates for LUC 821 are expected to provide an accurate estimate of the pass-by trips for the proposed retail uses on Site.

It is also important to note that pass-by trips are only applicable to the retail portion of the Project. Retail constitutes only a very small portion of the total Project (approximately 10,000 SF, or roughly 2 percent of the Project). The retail pass-by trips total only 4 trips during the weekday morning peak hour and 30 trips during

the evening peak hour. Exclusion of these trips from the project trip generation would have no measurable impact on the findings of the TIA or the level of transportation improvements and mitigation that is being proposed.

Project-generated Trips

12. As stated by the Applicant in the report, the pass-by-trips include trips for the retail uses already traveling on the roadway network under Existing Conditions. However, these trips still enter and exit the project site. They should only be adjusted for adjacent roadways, but not for entering and exiting the project site. **Nitsch requests the Applicant provide update Table 5, as well as Figures 11 through 14. Also, the capacity analysis for Build Condition may need to be revised.**

Applicant Response: VHB agrees that pass-by trips still enter and exit the Project Site and should only be adjusted for adjacent roadways. Table 5 in the TIA provides a summary of the total Project-generated trips and includes both the total number of vehicles expected to enter and exit the Project Site as well as the total net new trips added to the roadway network. The "Adjusted Vehicle Trips – Total" column in Table 5 presents the number of total trips to enter and exit the Project Site and the "Total Net New Vehicle Trips" column in Table 5 presents the new trips added to the roadway, which does not include the pass-by trips or the existing trips already on the roadway that were generated by the previous uses on-Site.

Figures 11 and 12 presented in the TIA only showed the total net new vehicle trips and did not include the pass-by trips that will enter and exit the Project Site. These figures have been updated to also illustrate the pass-by trips and are included in the Attachments to this memorandum.

Figures 13 and 14 presented in the TIA illustrate the 2029 Build Conditions peak hour traffic volumes. The traffic volumes include all Project-generated trips entering and exiting the Project Site, including existing trips generated by the previous uses and the pass-by trips. The intersection capacity analyses for the Build Condition are based on the traffic volumes presented in Figure 13 and 14 and include the pass-by trips. Therefore, the intersection capacity analyses for the Build Condition do not need to be revised, as they already include the pass-by trips entering and exiting the Project Site.

Comparison to Previous Zoning Traffic Study

13. The Applicant provides a comparison of the trip generation presented in the GPI's 2020 traffic study with the trip generation for the proposed development. **Nitsch requests the Applicant provide clarification for providing this comparison and how it impacts the analysis.**

Applicant Response: The comparison of the proposed Project-generated trips to the site-generated trips in the 2020 GPI traffic study was included for comparison purposes only. No analyses were conducted based on the comparison to the site-generated trips in the 2020 GPI traffic study.

The 2020 traffic study was conducted to support the rezoning of the Site and the trip generation presented in the study was based on the maximum build-out of the Site and the adjacent Channel 5 property based on the new zoning guidelines. The purpose of including the comparison in the TIA was to simply illustrate that the proposed Project will generate significantly fewer trips than what was estimated in the 2020 traffic study to

support the rezoning of the Site. However, the proposed mitigation for the Project along Gould Street mirrors what was proposed by GPI in the 2020 traffic study. The Proponent is committed to providing the full set of proposed improvements along Gould Street plus additional significant bicycle accommodations, even though the Site will generate fewer trips than anticipated when the concept was presented in the 2020 traffic study.

Project Trip Distribution

14. Projected vehicle trips generated to the site were distributed to the study area network based on Journey-to-Work data for the Town of Needham with the 2010 U.S. Census data. **Nitsch finds the Applicant's trip distribution estimation acceptable.**

Applicant Response: No response needed

Transportation Operations Analysis

15. The Applicant examined Existing and projected No-Build and Build traffic conditions for both weekday morning and weekday evening peak hours at the 20 study area intersections. The Applicant also analyzed the interchange of Highland Avenue at I-95 (Ramp) using methodology for merge, diverge, and weaving conflicts. **Nitsch finds the Applicant's methodology to be acceptable.**

Applicant Response: No response needed

Signal Warrant Analysis

16. To determine the feasibility of potential mitigation measures, signal warrant analyses were conducted at two intersections: Central Avenue at Gould Street and Gould Street at the Project Site driveway / Wingate Driveway. Based on the analysis, both intersections meet the three-traffic volume-based warrants (Warrant 1-8-Hour, Warrant 2 4-Hour and Warrant 3 Peak Hour). **Nitsch finds the Applicant's analysis to be acceptable.**

Applicant Response: No response needed

Transportation Mitigation

17. As mitigation measures the Applicant proposes to add on-road bicycle accommodations along Gould Street to create a new north-south bicycle network within this area of Needham and connect Mills Field and the commercial and residential uses on Gould Street with the under-construction bicycle accommodations along Highland Avenue and the existing bicycle lanes in each direction on Hunting Road that include the following:

- › Bicycle accommodations consisting of on-road bicycle lanes in each direction for approximately 900 feet between Highland Avenue and the former MBTA railroad ROW just north of TV Place.
- › Between the former MBTA railroad ROW and Central Avenue, a distance of approximately ½ mile, the Proponent will fund the installation of shared lane pavement markings and signage in each direction.
- › Coordinate with the Town of Needham to fund a study evaluating the feasibility of converting the former railroad ROW into a shared-use path between the Charles River and the commuter rail at Needham Heights.
- › A crosswalk at the location of the future shared-use path.

On-road and shared bicycle lanes are intended for commuter, intermediate and experienced cyclists and primarily assist in promoting alternative means of travel for the development. They are not recommended for leisure use and do not provide sufficient accommodations for residents, including children, to access the new rail-trail and Mills Field Playground. **Nitsch feels it's pertinent for the Applicant to provide wider sidewalks and separated (buffered) bike lanes for leisure bicyclists from Highland Avenue to Ellis Street (Mills Field Playground) for a safe means of community connectivity for all users, especially for children.**

Applicant Response: As presented in the TIA, the Proponent is proposing significant pedestrian and bicycle improvements along Gould Street. Based on feedback received in neighborhood community meetings and from the Town of Needham since the submittal of the TIA, the Proponent is now in the process of revising those preliminary pedestrian and bicycle improvements to provide a higher level of accommodations, including separated bicycle facilities. The currently proposed Gould Street pedestrian and bicycle accommodation improvements are as follows:

- › Sidewalk-level separated bicycle facilities in both directions on Gould Street between Highland Avenue and just north of TV Place
- › Shared lane pavement markings and signage in each direction for bicyclists along Gould Street for approximately ½ mile between just north of TV Place and Central Avenue
- › Sidewalk improvements along the west side of Gould Street between Highland Avenue and Noanett Road.
- › A new pedestrian facility on the east side of Gould Street along the Site frontage between Highland Avenue and just north of TV Place
- › A new crosswalk across Gould Street at the location of the abandoned railroad right-of-way with either an LED Warning sign or a rapid rectangular flashing beacon (RRFB) to alert drivers.

The Gould Street pedestrian and bicycle accommodations will tie into the Highland Avenue accommodations that are currently under construction by MassDOT as well as a potential future shared-use path along the former MBTA railroad right-of-way north of the Site. The Proponent will work with the Town of Needham to support additional funding for a study of the feasibility of converting the former MBTA railroad right-of-way north of the Project Site and the Channel 5 property into a shared use path that would connect with Needham Heights to the south.

As noted above, the Proponent will fund the design and construction of approximately 800 feet of sidewalk-level separated bicycle facilities in both directions on Gould Street between Highland Avenue and just north of TV Place. The Proponent reviewed the feasibility of providing separated bicycle facilities on Gould Street between TV Place and Central Avenue, extending past Mills Field. However, dedicated bicycle facilities cannot



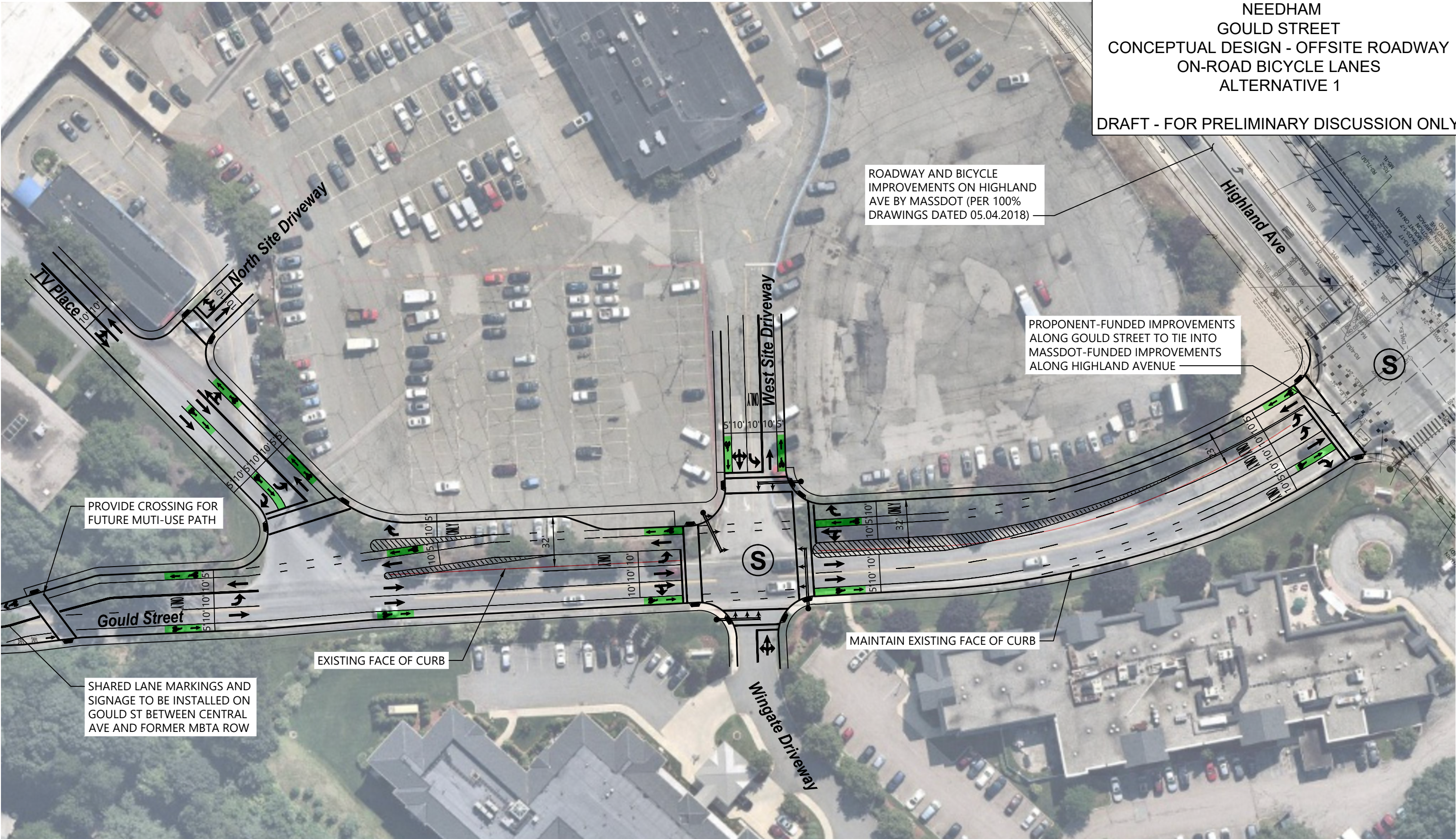
be added within the existing width of the Gould Street cross-section, as the right-of-way is too narrow. Any expansion of the right-of-way north of TV Place would require significant impact to adjacent properties along Gould Street, which the Proponent does not control. Based on coordination with the Town of Needham, the Proponent is proposing the installation of shared lane pavement markings and signage for the segments of Gould Street that are beyond the control of the Proponent.

Attachments

- › Revised Off-Site Roadway Mitigation
 - Concept Plans
 - Intersection Capacity Analyses
- › Revised Site-Generated Peak Hour Traffic Volume Networks

Revised Off-Site Roadway Mitigation

Concept Plans



NEEDHAM
GOULD STREET
CONCEPTUAL DESIGN - OFFSITE ROADWAY
ON-ROAD BICYCLE LANES
ALTERNATIVE 1

DRAFT - FOR PRELIMINARY DISCUSSION ONLY

ROADWAY AND BICYCLE
IMPROVEMENTS ON HIGHLAND
AVE BY MASSDOT (PER 100%
DRAWINGS DATED 05.04.2018)

PROPONENT-FUNDED IMPROVEMENTS
ALONG GOULD STREET TO TIE INTO
MASSDOT-FUNDED IMPROVEMENTS
ALONG HIGHLAND AVENUE

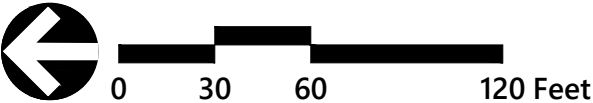
PROVIDE CROSSING FOR
FUTURE MULTI-USE PATH

SHARED LANE MARKINGS AND
SIGNAGE TO BE INSTALLED ON
GOULD ST BETWEEN CENTRAL
AVE AND FORMER MBTA ROW

EXISTING FACE OF CURB

MAINTAIN EXISTING FACE OF CURB

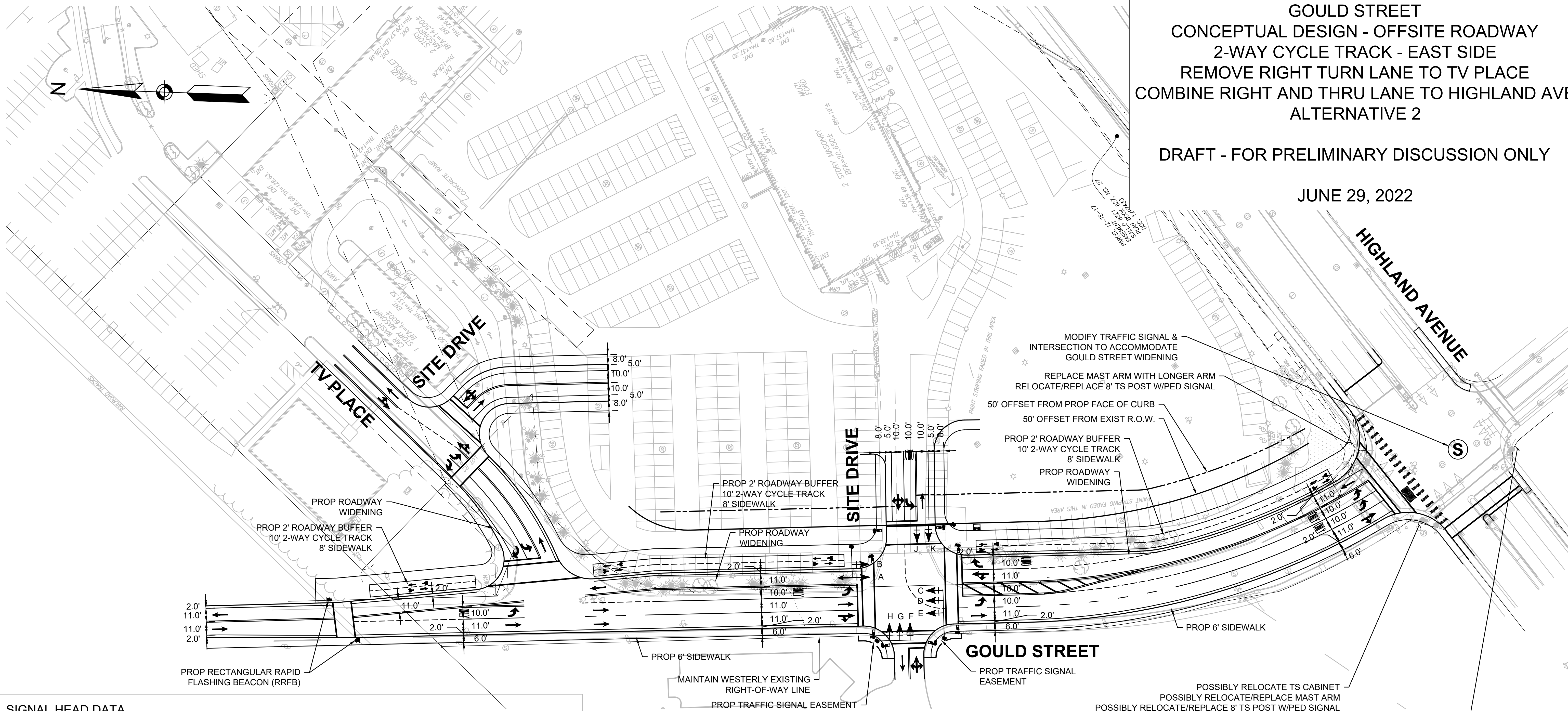
NOT FOR CONSTRUCTION



NEEDHAM
GOULD STREET
CONCEPTUAL DESIGN - OFFSITE ROADWAY
2-WAY CYCLE TRACK - EAST SIDE
REMOVE RIGHT TURN LANE TO TV PLACE
COMBINE RIGHT AND THRU LANE TO HIGHLAND AVE
ALTERNATIVE 2

DRAFT - FOR PRELIMINARY DISCUSSION ONLY

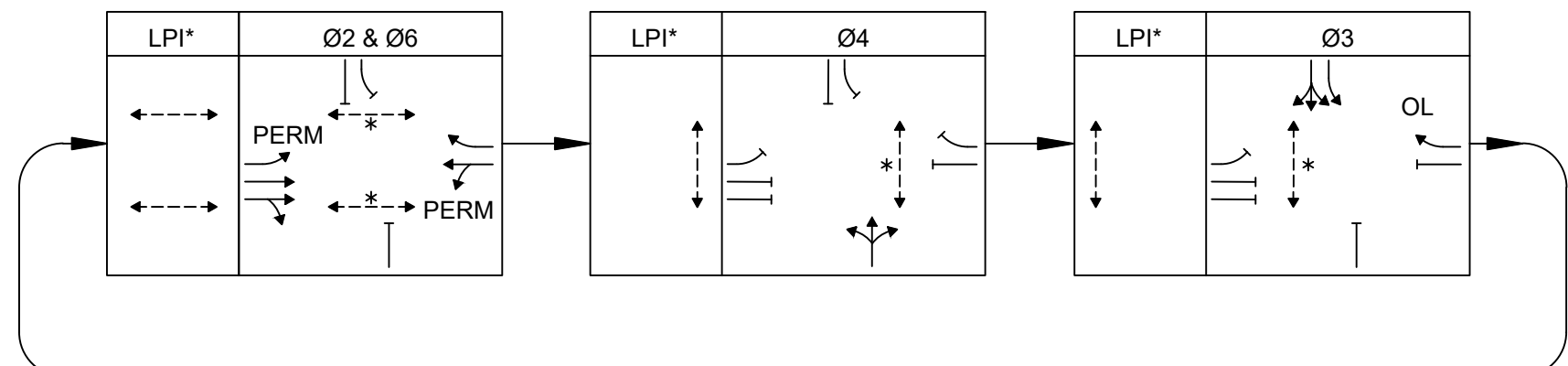
JUNE 29, 2022



SIGNAL HEAD DATA					
A,D,E,H,K	B	C	F	G,J	ALL
ALL 12" LENS					

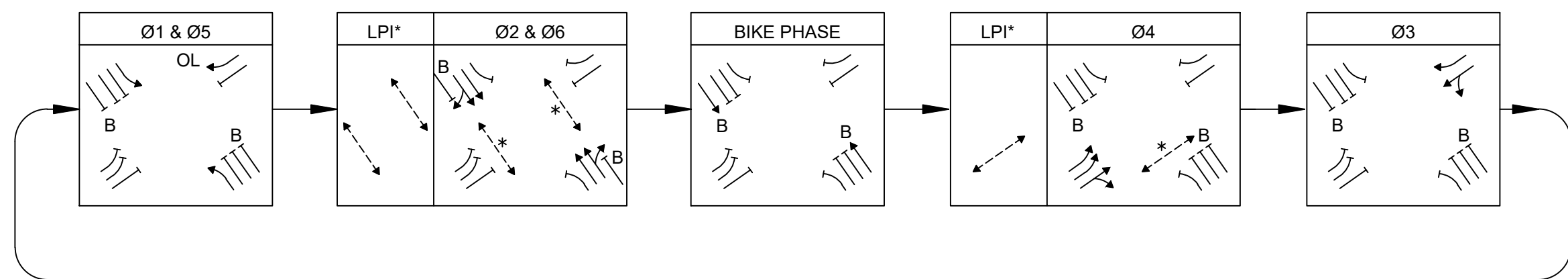
- NOTES:
- ALL SIGNAL HEADS SHALL BE RIGID MOUNTED.
 - ALL SIGNAL HEADS SHALL BE EQUIPPED WITH 5 1/2" NON- LOUVERED BACKPLATES. ALL BACKPLATES SHALL CONTAIN A 3" WIDE YELLOW REFLECTIVE BORDER.
 - ALL SIGNAL HEADS SHALL BE EQUIPPED WITH TUNNEL VISORS.
 - ALL SIGNAL DISPLAYS SHALL BE EQUIPPED WITH L.E.D. MODULES.

SITE DRIVEWAY
PREFERENTIAL PHASE SEQUENCE

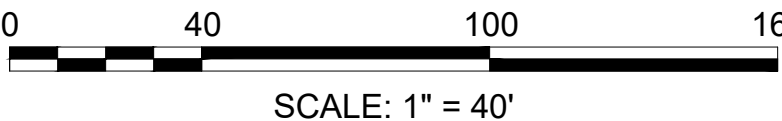


* NORMALLY DW, W/FDW UPON PEDESTRIAN PUSH BUTTON ACTUATION
PERM = PERMISSIVE
LPI = LEADING PEDESTRIAN INTERVAL

HIGHLAND AVENUE
PREFERENTIAL PHASE SEQUENCE



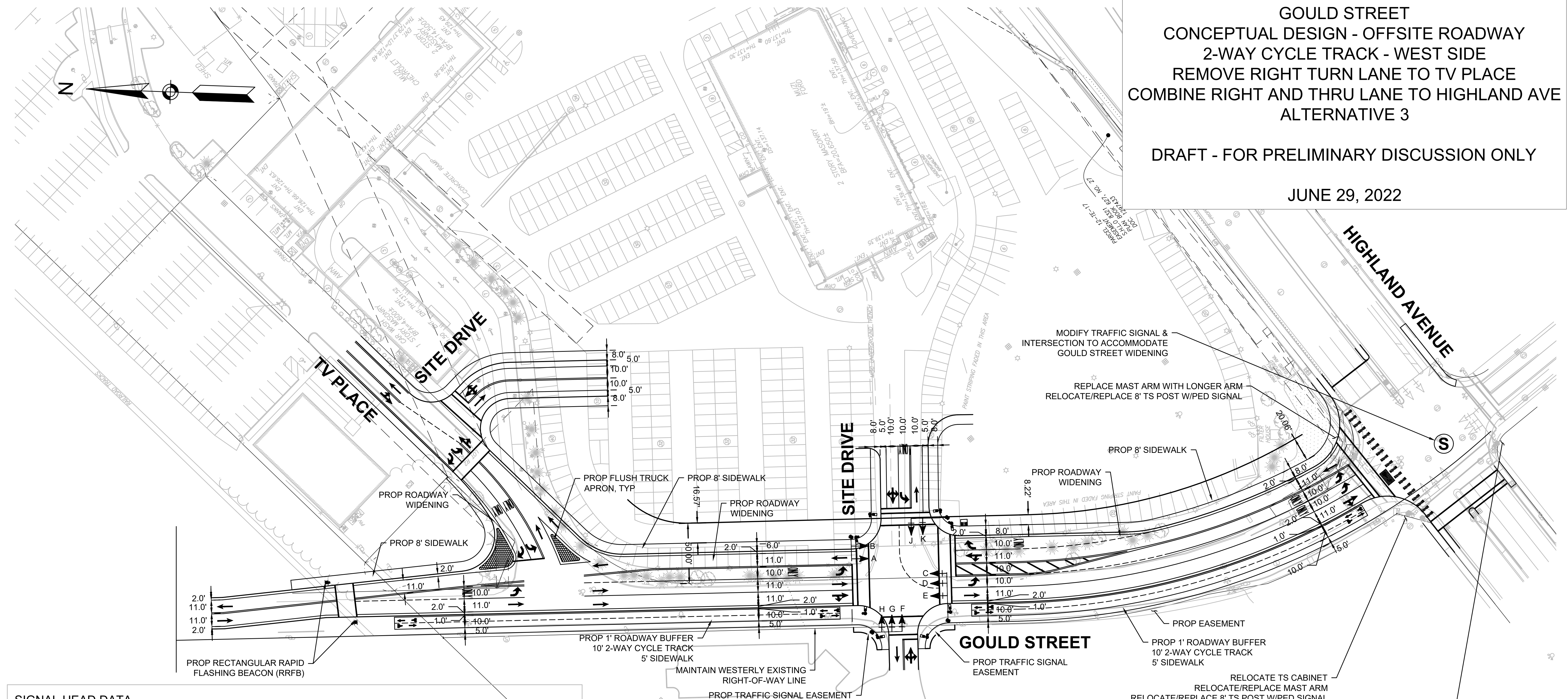
* NORMALLY DW, W/FDW UPON PEDESTRIAN PUSH BUTTON ACTUATION
OL = OVERLAP
LPI = LEADING PEDESTRIAN INTERVAL
B = HIGHLAND AVENUE SEPARATED BIKE LANE



NEEDHAM
GOULD STREET
CONCEPTUAL DESIGN - OFFSITE ROADWAY
2-WAY CYCLE TRACK - WEST SIDE
REMOVE RIGHT TURN LANE TO TV PLACE
COMBINE RIGHT AND THRU LANE TO HIGHLAND AVE
ALTERNATIVE 3

DRAFT - FOR PRELIMINARY DISCUSSION ONLY

JUNE 29, 2022

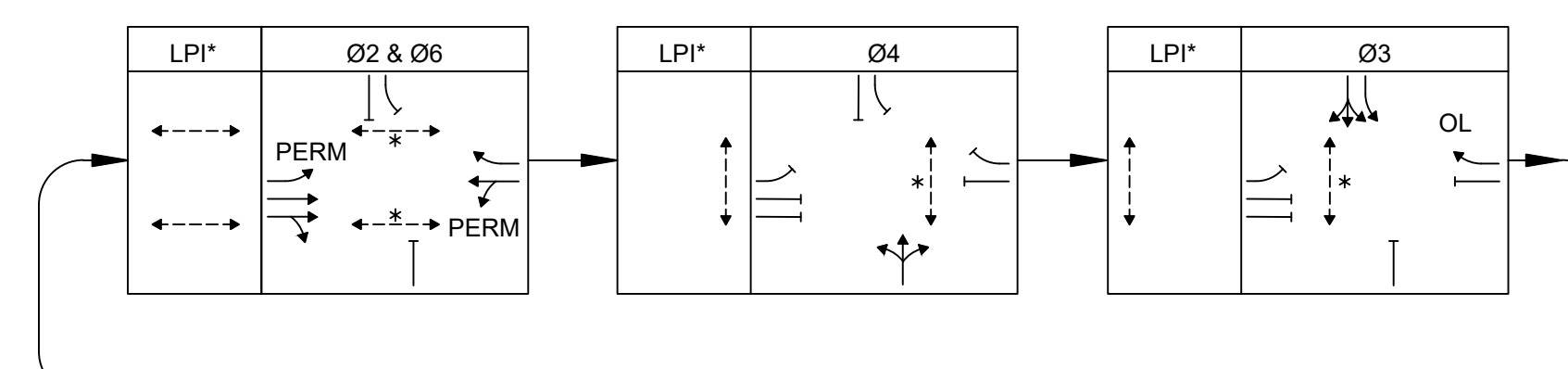


SIGNAL HEAD DATA

A,D,E,H,K	B	C	F	G,J	ALL
ALL 12" LENS					

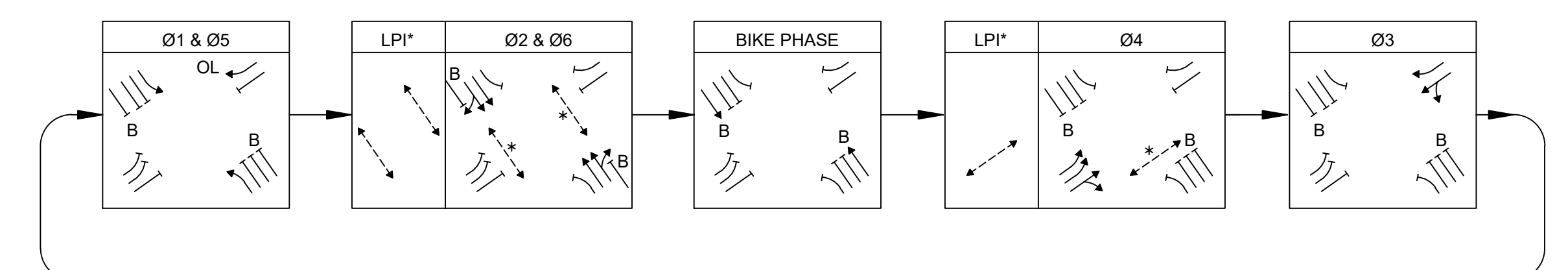
- NOTES:
1. ALL SIGNAL HEADS SHALL BE RIGID MOUNTED.
 2. ALL SIGNAL HEADS SHALL BE EQUIPPED WITH 5"± NON- LOUVERED BACKPLATES. ALL BACKPLATES SHALL CONTAIN A 3" WIDE YELLOW REFLECTIVE BORDER.
 3. ALL SIGNAL HEADS SHALL BE EQUIPPED WITH TUNNEL VISORS.
 4. ALL SIGNAL DISPLAYS SHALL BE EQUIPPED WITH L.E.D. MODULES.

SITE DRIVEWAY
PREFERENTIAL PHASE SEQUENCE



* NORMALLY DW, W/FDW UPON PEDESTRIAN PUSH BUTTON ACTUATION
PERM = PERMISSIVE
LPI = LEADING PEDESTRIAN INTERVAL

HIGHLAND AVENUE
PREFERENTIAL PHASE SEQUENCE



* NORMALLY DW, W/FDW UPON PEDESTRIAN PUSH BUTTON ACTUATION
OL = OVERLAP
LPI = LEADING PEDESTRIAN INTERVAL
B = HIGHLAND AVENUE SEPARATED BIKE LANE

0 40 100 160
SCALE: 1" = 40'

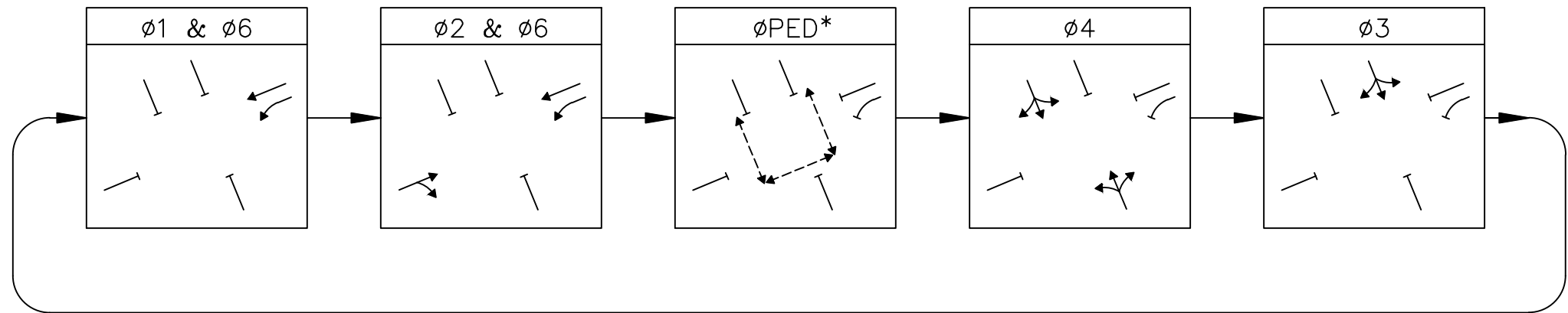
NEEDHAM
GOULD STREET @ CENTRAL AVENUE
CONCEPTUAL LAYOUT

DRAFT - FOR PRELIMINARY DISCUSSION ONLY

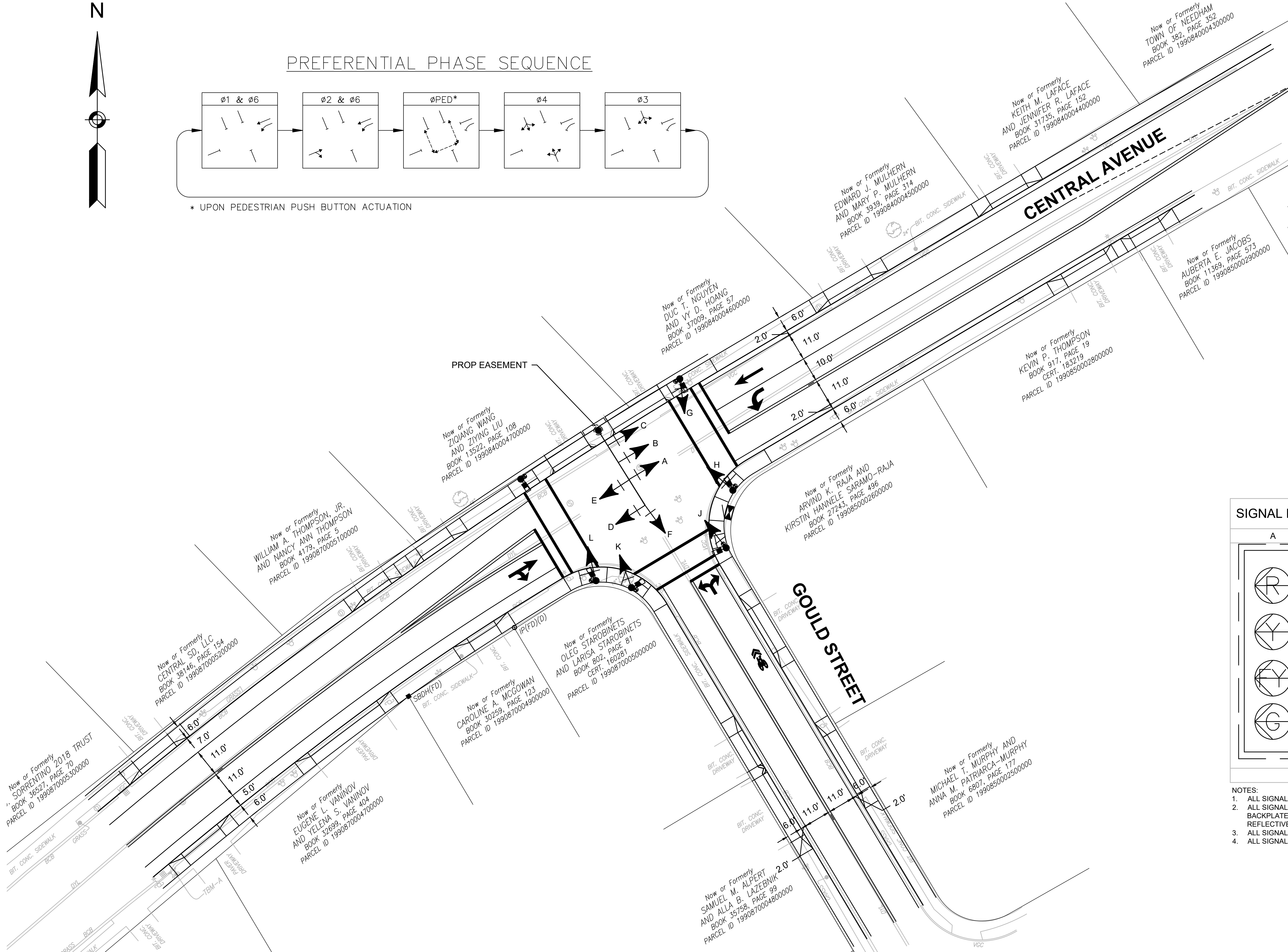
JUNE 27, 2022

N

PREFERENTIAL PHASE SEQUENCE

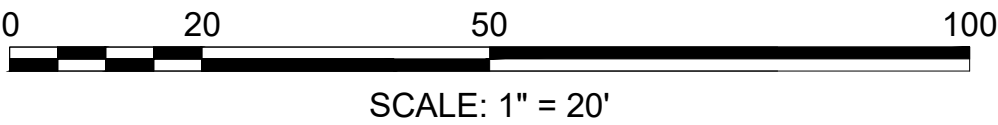


* UPON PEDESTRIAN PUSH BUTTON ACTUATION



SIGNAL HEAD DATA		
A	B,C,D,E,F,G,H,J,K,L	ALL
ALL 12" LENS		

- NOTES:
- ALL SIGNAL HEADS SHALL BE RIGID MOUNTED.
 - ALL SIGNAL HEADS SHALL BE EQUIPPED WITH 5'± NON- LOUVERED BACKPLATES. ALL BACKPLATES SHALL CONTAIN A 3" WIDE YELLOW REFLECTIVE BORDER.
 - ALL SIGNAL HEADS SHALL BE EQUIPPED WITH TUNNEL VISORS.
 - ALL SIGNAL DISPLAYS SHALL BE EQUIPPED WITH L.E.D. MODULES.



Revised Off-Site Roadway Mitigation
Intersection Capacity Analyses

Table A Signalized Intersection Capacity Analysis Summary – Revised Gould Street Concepts

Location / Movement	2029 No-Build Condition					2029 Build without Mitigation					2029 Build with Mitigation									
	v/c ^a	Del ^b	LOS ^c	50 Q ^d	95 Q ^e	v/c	Del	LOS	50 Q	95 Q	v/c	Del	LOS	50 Q	95 Q					
Highland Avenue at Gould Street and Hunting Road																				
Weekday Morning																				
Highland Ave EB L	1.04	>120	F	~93	#234	>1.20	>120	F	~190	#353	0.96	115.7	F	153	#330					
Highland Ave EB T/R	0.86	40.2	D	364	#512	0.79	36.6	D	364	#512	0.66	30.2	C	363	503					
Highland Ave WB L	0.58	58.6	E	36	83	0.61	65.3	E	38	83	0.42	61.4	E	42	83					
Highland Ave WB T/R	0.94	52.1	D	362	#545	1.15	117.8	F	~616	#841	0.97	54.3	D	587	#797					
Hunting Rd NB L/T	0.96	89.0	F	206	#434	1.13	>120	F	~263	#480	0.96	96.8	F	265	#433					
Hunting Rd NB R	0.48	39.8	D	48	102	0.51	44.0	D	52	102	0.53	46.1	D	93	136					
Gould St SB L	0.82	64.8	E	145	#281	0.91	84.5	F	182	#347	0.70	71.7	E	136	180					
Gould St SB L/T/R	0.78	59.4	E	137	#264	0.88	77.3	E	175	#335	0.57	72.7	E	107	166					
Overall	0.98	55.1	E	-	-	1.20	100.2	F	-	-	0.95	55.5	E	-	-					
Weekday Evening																				
Highland Ave EB L	>1.20	>120	F	19	57	>1.20	>120	F	27	72	0.60	58.2	E	24	57					
Highland Ave EB T/R	0.81	42.3	D	287	440	0.81	42.4	D	290	442	0.74	32.8	C	252	#373					
Highland Ave WB L	0.86	83.3	F	100	194	0.87	84.5	F	101	196	0.78	61.6	E	89	#182					
Highland Ave WB T/R	1.00	61.7	E	~535	#774	1.07	84.0	F	~599	#861	1.02	61.3	E	~527	#702					
Hunting Rd NB L/T	0.56	51.4	D	66	127	0.58	52.2	D	70	134	0.73	61.0	E	65	#126					
Hunting Rd NB R	0.10	35.7	D	4	24	0.10	35.7	D	4	24	0.07	34.2	C	0	5					
Gould St SB L	0.91	61.1	E	295	#574	>1.20	>120	F	~681	#1051	0.97	61.6	E	310	#376					
Gould St SB L/T/R	0.88	56.9	E	284	#554	>1.20	>120	F	~653	#1022	0.76	45.5	D	228	#239					
Overall	1.03	59.5	E	-	-	>1.20	>120	F	-	-	1.05	52.9	D	-	-					
Gould Street at Wingate Driveway / Project Site Driveway																				
Weekday Morning						Intersection unsignalized under 2029 No Build Conditions without Mitigation					Intersection unsignalized under 2029 Build Conditions without Mitigation									
Wingate Dwy EB L/T/R	Intersection unsignalized under 2029 No Build Conditions without Mitigation															0.01	61.9	E	0	0
Site Dwy WB L																0.50	65.0	E	46	90
Site Dwy WB L/T/R																0.29	62.1	E	25	68
Gould St NB L/T																0.57	5.0	A	153	m273
Gould St NB R																0.31	4.0	A	22	m78
Gould St SB L																0.08	3.1	A	3	24
Gould St SB T/R																0.15	3.0	A	20	88
Overall											0.54	7.8	A							
Weekday Evening						Intersection unsignalized under 2029 No Build Conditions without Mitigation					Intersection unsignalized under 2029 Build Conditions without Mitigation									
Wingate Dwy EB L/T/R	Intersection unsignalized under 2029 No Build Conditions without Mitigation															0.03	43.4	D	0	12
Site Dwy WB L																0.75	44.2	D	174	187
Site Dwy WB L/T/R																0.70	41.6	D	163	176
Gould St NB L/T																0.31	10.7	B	56	m252
Gould St NB R																0.07	13.2	B	1	m30
Gould St SB L																0.03	8.8	A	4	21
Gould St SB T/R																0.37	11.4	B	124	270
Overall											0.44	21.8	C							
a	Volume to capacity ratio.																			
b	Average total delay, in seconds per vehicle.																			
c	Level-of-service.																			
d	50th percentile queue, in feet.																			
e	95th percentile queue, in feet.																			
#	95th percentile volume exceeds capacity, queue may be longer.																			
m	Volume for 95th percentile queue is metered by upstream signal.																			

Note: Elimination of Gould Street northbound right-turn lane onto TV Place does not impact operations as northbound approach is under free-flow conditions.

Intersection						
Int Delay, s/veh	2.1					
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations	↰	↰	↰		↰	↰
Traffic Vol, veh/h	25	20	635	135	85	355
Future Vol, veh/h	25	20	635	135	85	355
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	150	-	-	150	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	60	60	95	95	91	91
Heavy Vehicles, %	0	0	2	2	0	3
Mvmt Flow	42	33	668	142	93	390
Major/Minor	Minor1	Major1	Major2			
Conflicting Flow All	1315	739	0	0	810	0
Stage 1	739	-	-	-	-	-
Stage 2	576	-	-	-	-	-
Critical Hdwy	6.4	6.2	-	-	4.1	-
Critical Hdwy Stg 1	5.4	-	-	-	-	-
Critical Hdwy Stg 2	5.4	-	-	-	-	-
Follow-up Hdwy	3.5	3.3	-	-	2.2	-
Pot Cap-1 Maneuver	176	421	-	-	825	-
Stage 1	476	-	-	-	-	-
Stage 2	566	-	-	-	-	-
Platoon blocked, %			-	-	-	-
Mov Cap-1 Maneuver	156	421	-	-	825	-
Mov Cap-2 Maneuver	156	-	-	-	-	-
Stage 1	476	-	-	-	-	-
Stage 2	502	-	-	-	-	-
Approach	WB	NB	SB			
HCM Control Delay, s	26.5	0	1.9			
HCM LOS	D					
Minor Lane/Major Mvmt	NBT	NBR	WBLn1	WBLn2	SBL	SBT
Capacity (veh/h)	-	-	156	421	825	-
HCM Lane V/C Ratio	-	-	0.267	0.079	0.113	-
HCM Control Delay (s)	-	-	36.3	14.3	9.9	-
HCM Lane LOS	-	-	E	B	A	-
HCM 95th %tile Q(veh)	-	-	1	0.3	0.4	-

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	0	5	70	1	20	15	750	385	30	350	2
Future Volume (vph)	1	0	5	70	1	20	15	750	385	30	350	2
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width (ft)	12	12	12	12	13	13	12	12	12	12	12	12
Storage Length (ft)	0		0	0		0	0		100	150		0
Storage Lanes	0		0	1		0	0		1	1		0
Taper Length (ft)	25			25			25			25		
Right Turn on Red			Yes			Yes			Yes			Yes
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		151			225			398			315	
Travel Time (s)		3.4			5.1			9.0			7.2	
Confl. Bikes (#/hr)									1			
Peak Hour Factor	0.63	0.63	0.63	0.90	0.90	0.90	0.90	0.90	0.90	0.83	0.83	0.83
Shared Lane Traffic (%)				34%								
Lane Group Flow (vph)	0	10	0	51	50	0	0	850	428	36	424	0
Turn Type	Split	NA		Split	NA		Perm	NA	Perm	Perm	NA	
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2		2	6		
Detector Phase	4	4		8	8		2	2	2	6	6	
Switch Phase												
Minimum Initial (s)	6.0	6.0		6.0	6.0		10.0	10.0	10.0	10.0	10.0	
Minimum Split (s)	27.0	27.0		11.0	11.0		15.0	15.0	15.0	23.0	23.0	
Total Split (s)	27.0	27.0		13.0	13.0		95.0	95.0	95.0	95.0	95.0	
Total Split (%)	20.0%	20.0%		9.6%	9.6%		70.4%	70.4%	70.4%	70.4%	70.4%	
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0	1.0	1.0	1.0	
Lost Time Adjust (s)		0.0		0.0	0.0			0.0	0.0	0.0	0.0	
Total Lost Time (s)		4.0		4.0	4.0			4.0	4.0	4.0	4.0	
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	None	None		None	None		C-Min	C-Min	C-Min	C-Min	C-Min	
v/c Ratio		0.07		0.43	0.36			0.55	0.32	0.08	0.14	
Control Delay		0.8		70.6	44.5			7.1	3.2	5.8	4.0	
Queue Delay		0.0		0.0	0.0			4.5	1.2	0.0	0.0	
Total Delay		0.8		70.6	44.5			11.6	4.5	5.8	4.0	
Queue Length 50th (ft)		0		46	25			153	22	3	20	
Queue Length 95th (ft)		0		90	68			m273	m78	24	88	
Internal Link Dist (ft)		71			145			318			235	
Turn Bay Length (ft)									100	150		
Base Capacity (vph)		313		128	147			1550	1339	447	2978	
Starvation Cap Reductn		0		0	0			611	669	0	0	
Spillback Cap Reductn		0		0	0			0	0	0	0	
Storage Cap Reductn		0		0	0			0	0	0	0	
Reduced v/c Ratio		0.03		0.40	0.34			0.91	0.64	0.08	0.14	

Intersection Summary

Area Type: Other
 Cycle Length: 135
 Actuated Cycle Length: 135
 Offset: 15 (11%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
 Natural Cycle: 80
 Control Type: Actuated-Coordinated
 m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 11: Gould St & Windgate Dwy/Muzi Ford Dwy

																																																																																																																																																																																																																																							
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Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	0	5	70	1	20	15	750	385	30	350	2
Future Volume (vph)	1	0	5	70	1	20	15	750	385	30	350	2
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	12	12	12	13	13	12	12	12	12	12	12
Total Lost time (s)		4.0		4.0	4.0			4.0	4.0	4.0	4.0	
Lane Util. Factor		1.00		0.95	0.95			1.00	1.00	1.00	0.95	
Frpb, ped/bikes		1.00		1.00	1.00			1.00	0.98	1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00			1.00	1.00	1.00	1.00	
Frt		0.89		1.00	0.93			1.00	0.85	1.00	1.00	
Flt Protected		0.99		0.95	0.97			1.00	1.00	0.95	1.00	
Satd. Flow (prot)		1645		1681	1663			1861	1551	1770	3537	
Flt Permitted		0.99		0.95	0.97			0.99	1.00	0.29	1.00	
Satd. Flow (perm)		1645		1681	1663			1841	1551	531	3537	
Peak-hour factor, PHF	0.63	0.63	0.63	0.90	0.90	0.90	0.90	0.90	0.90	0.83	0.83	0.83
Adj. Flow (vph)	2	0	8	78	1	22	17	833	428	36	422	2
RTOR Reduction (vph)	0	10	0	0	21	0	0	0	40	0	0	0
Lane Group Flow (vph)	0	0	0	51	29	0	0	850	388	36	424	0
Confl. Bikes (#/hr)									1			
Turn Type	Split	NA		Split	NA		Perm	NA	Perm	Perm	NA	
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2		2	6		
Actuated Green, G (s)		5.8		8.3	8.3			108.9	108.9	108.9	108.9	
Effective Green, g (s)		5.8		8.3	8.3			108.9	108.9	108.9	108.9	
Actuated g/C Ratio		0.04		0.06	0.06			0.81	0.81	0.81	0.81	
Clearance Time (s)		4.0		4.0	4.0			4.0	4.0	4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)		70		103	102			1485	1251	428	2853	
v/s Ratio Prot		c0.00		c0.03	0.02						0.12	
v/s Ratio Perm								c0.46	0.25	0.07		
v/c Ratio		0.01		0.50	0.29			0.57	0.31	0.08	0.15	
Uniform Delay, d1		61.8		61.3	60.5			4.7	3.4	2.7	2.9	
Progression Factor		1.00		1.00	1.00			0.98	1.14	1.00	1.00	
Incremental Delay, d2		0.0		3.7	1.6			0.4	0.2	0.4	0.1	
Delay (s)		61.9		65.0	62.1			5.0	4.0	3.1	3.0	
Level of Service		E		E	E			A	A	A	A	
Approach Delay (s)		61.9			63.6			4.7			3.0	
Approach LOS		E			E			A			A	
Intersection Summary												
HCM 2000 Control Delay		7.8										
HCM 2000 Volume to Capacity ratio		0.54										
Actuated Cycle Length (s)		135.0										
Intersection Capacity Utilization		67.0%										
Analysis Period (min)		15										

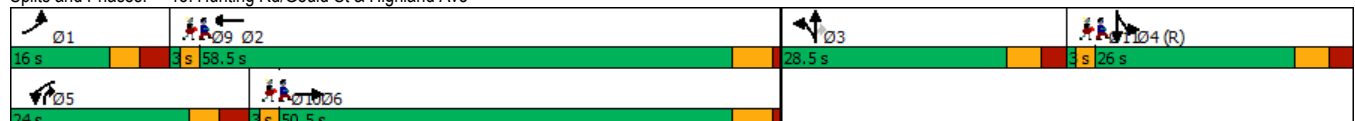
c Critical Lane Group

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø9	Ø10	Ø11
Lane Configurations															
Traffic Volume (vph)	150	890	15	45	605	760	25	240	240	290	90	45			
Future Volume (vph)	150	890	15	45	605	760	25	240	240	290	90	45			
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900			
Storage Length (ft)	175		0	165		400	0		150	200		200			
Storage Lanes	1		0	1		0	0		1	1		0			
Taper Length (ft)	25			25			25			25					
Right Turn on Red			Yes			Yes			Yes			Yes			
Link Speed (mph)		30			30			30			30				
Link Distance (ft)		345			745			3028			398				
Travel Time (s)		7.8			16.9			68.8			9.0				
Confl. Peds. (#/hr)	1		1	1		1									
Confl. Bikes (#/hr)									1						
Peak Hour Factor	0.87	0.87	0.87	0.92	0.92	0.92	0.88	0.88	0.88	0.94	0.94	0.94			
Heavy Vehicles (%)	3%	2%	0%	0%	5%	1%	0%	1%	0%	3%	2%	0%			
Shared Lane Traffic (%)															
Lane Group Flow (vph)	172	1040	0	49	1484	0	0	301	273	309	144	0			
Turn Type	Prot	NA		Prot	NA		Split	NA	pm+ov	Split	NA				
Protected Phases	1	6		5	2		3	3	5	4	4		9	10	11
Permitted Phases									3						
Detector Phase	1	6		5	2		3	3	5	4	4				
Switch Phase															
Minimum Initial (s)	6.0	10.0		6.0	10.0		6.0	6.0	6.0	6.0	6.0		1.0	1.0	1.0
Minimum Split (s)	12.0	20.0		12.0	25.0		12.0	12.0	12.0	29.5	29.5		3.0	3.0	3.0
Total Split (s)	16.0	50.5		24.0	58.5		28.5	28.5	24.0	26.0	26.0		3.0	3.0	3.0
Total Split (%)	11.9%	37.4%		17.8%	43.3%		21.1%	21.1%	17.8%	19.3%	19.3%		2%	2%	2%
Yellow Time (s)	3.0	4.0		3.0	4.0		3.5	3.5	3.0	3.5	3.5		2.0	2.0	2.0
All-Red Time (s)	3.0	1.0		3.0	1.0		2.5	2.5	3.0	2.5	2.5		0.0	0.0	0.0
Lost Time Adjust (s)	0.0	0.0		0.0	0.0			0.0	0.0	0.0	0.0				
Total Lost Time (s)	6.0	5.0		6.0	5.0			6.0	6.0	6.0	6.0				
Lead/Lag	Lead			Lead			Lead	Lead	Lead				Lag	Lag	Lag
Lead-Lag Optimize?															
Recall Mode	None	Min		None	Min		Min	Min	None	C-Min	C-Min		None	None	None
v/c Ratio	0.96	0.66		0.42	1.00			0.96	0.61	0.66	0.56				
Control Delay	117.3	33.3		70.2	56.2			98.4	22.8	68.6	63.4				
Queue Delay	15.8	0.0		0.0	2.4			0.0	0.0	0.0	0.0				
Total Delay	133.2	33.3		70.2	58.6			98.4	22.8	68.6	63.4				
Queue Length 50th (ft)	153	363		42	587			265	93	136	107				
Queue Length 95th (ft)	#330	503		83	#797			#433	136	180	166				
Internal Link Dist (ft)		265			665			2948			318				
Turn Bay Length (ft)	175			165					150	200					
Base Capacity (vph)	179	1574		240	1479			312	548	509	280				
Starvation Cap Reductn	0	0		0	0			0	0	0	0				
Spillback Cap Reductn	11	0		0	13			0	0	0	0				
Storage Cap Reductn	0	0		0	0			0	0	0	0				
Reduced v/c Ratio	1.02	0.66		0.20	1.01			0.96	0.50	0.61	0.51				

Intersection Summary

Area Type: Other
 Cycle Length: 135
 Actuated Cycle Length: 135
 Offset: 0 (0%), Referenced to phase 4:SBTL, Start of Green
 Natural Cycle: 145
 Control Type: Actuated-Coordinated
 # 95th percentile volume exceeds capacity, queue may be longer.
 Queue shown is maximum after two cycles.

Splits and Phases: 15: Hunting Rd/Gould St & Highland Ave



												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	150	890	15	45	605	760	25	240	240	290	90	45
Future Volume (vph)	150	890	15	45	605	760	25	240	240	290	90	45
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	5.0		6.0	5.0			6.0	6.0	6.0	6.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00	1.00	0.97	1.00	
Frpb, ped/bikes	1.00	1.00		1.00	0.99			1.00	0.99	1.00	1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00	1.00	1.00	1.00	
Frt	1.00	1.00		1.00	0.92			1.00	0.85	1.00	0.95	
Flt Protected	0.95	1.00		0.95	1.00			1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1752	3530		1805	3178			1874	1600	3400	1781	
Flt Permitted	0.95	1.00		0.95	1.00			1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1752	3530		1805	3178			1874	1600	3400	1781	
Peak-hour factor, PHF	0.87	0.87	0.87	0.92	0.92	0.92	0.88	0.88	0.88	0.94	0.94	0.94
Adj. Flow (vph)	172	1023	17	49	658	826	28	273	273	309	96	48
RTOR Reduction (vph)	0	1	0	0	159	0	0	0	74	0	14	0
Lane Group Flow (vph)	172	1039	0	49	1325	0	0	301	199	309	130	0
Confl. Peds. (#/hr)	1		1	1		1						
Confl. Bikes (#/hr)									1			
Heavy Vehicles (%)	3%	2%	0%	0%	5%	1%	0%	1%	0%	3%	2%	0%
Turn Type	Prot	NA		Prot	NA		Split	NA	pm+ov	Split	NA	
Protected Phases	1	6		5	2		3	3	5	4	4	
Permitted Phases									3			
Actuated Green, G (s)	13.8	60.2		8.9	58.2			22.5	31.4	17.5	17.5	
Effective Green, g (s)	13.8	60.2		8.9	58.2			22.5	31.4	17.5	17.5	
Actuated g/C Ratio	0.10	0.45		0.07	0.43			0.17	0.23	0.13	0.13	
Clearance Time (s)	6.0	5.0		6.0	5.0			6.0	6.0	6.0	6.0	
Vehicle Extension (s)	2.0	2.0		2.0	2.0			2.0	2.0	2.0	2.0	
Lane Grp Cap (vph)	179	1574		118	1370			312	372	440	230	
v/s Ratio Prot	c0.10	0.29		0.03	c0.42			c0.16	0.04	c0.09	0.07	
v/s Ratio Perm									0.09			
v/c Ratio	0.96	0.66		0.42	0.97			0.96	0.53	0.70	0.57	
Uniform Delay, d1	60.3	29.4		60.6	37.5			55.9	45.4	56.3	55.2	
Progression Factor	1.00	1.00		1.00	1.00			1.00	1.00	1.12	1.14	
Incremental Delay, d2	55.3	0.8		0.9	16.8			40.9	0.7	9.0	9.6	
Delay (s)	115.7	30.2		61.4	54.3			96.8	46.1	71.7	72.7	
Level of Service	F	C		E	D			F	D	E	E	
Approach Delay (s)		42.3			54.5			72.7			72.1	
Approach LOS		D			D			E			E	
Intersection Summary												
HCM 2000 Control Delay			55.5			HCM 2000 Level of Service				E		
HCM 2000 Volume to Capacity ratio			0.95									
Actuated Cycle Length (s)			135.0			Sum of lost time (s)				27.0		
Intersection Capacity Utilization			91.0%			ICU Level of Service				E		
Analysis Period (min)			15									
c Critical Lane Group												

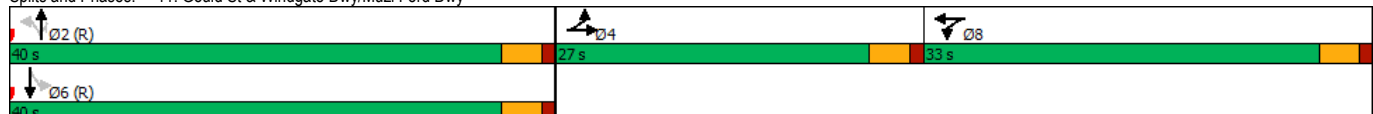
Intersection						
Int Delay, s/veh	6.6					
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Traffic Vol, veh/h	105	70	305	20	15	615
Future Vol, veh/h	105	70	305	20	15	615
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	150	-	-	150	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	81	81	75	75	73	73
Heavy Vehicles, %	0	0	0	0	0	6
Mvmt Flow	130	86	407	27	21	842
Major/Minor	Minor1	Major1		Major2		
Conflicting Flow All	1305	421	0	0	434	0
Stage 1	421	-	-	-	-	-
Stage 2	884	-	-	-	-	-
Critical Hdwy	6.4	6.2	-	-	4.1	-
Critical Hdwy Stg 1	5.4	-	-	-	-	-
Critical Hdwy Stg 2	5.4	-	-	-	-	-
Follow-up Hdwy	3.5	3.3	-	-	2.2	-
Pot Cap-1 Maneuver	178	637	-	-	1136	-
Stage 1	667	-	-	-	-	-
Stage 2	407	-	-	-	-	-
Platoon blocked, %			-	-	-	-
Mov Cap-1 Maneuver	175	637	-	-	1136	-
Mov Cap-2 Maneuver	175	-	-	-	-	-
Stage 1	667	-	-	-	-	-
Stage 2	400	-	-	-	-	-
Approach	WB	NB		SB		
HCM Control Delay, s	45.7	0		0.2		
HCM LOS	E					
Minor Lane/Major Mvmt	NBT	NBR	WBLn1	WBLn2	SBL	SBT
Capacity (veh/h)	-	-	175	637	1136	-
HCM Lane V/C Ratio	-	-	0.741	0.136	0.018	-
HCM Control Delay (s)	-	-	68.5	11.5	8.2	-
HCM Lane LOS	-	-	F	B	A	-
HCM 95th %tile Q(veh)	-	-	4.7	0.5	0.1	-

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↔		↔	↔			↔	↔	↔	↔	
Traffic Volume (vph)	1	0	30	360	1	40	5	285	80	15	700	5
Future Volume (vph)	1	0	30	360	1	40	5	285	80	15	700	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width (ft)	12	12	12	12	13	13	12	12	12	12	12	12
Storage Length (ft)	0		0	0		0	0		100	150		0
Storage Lanes	0		0	1		0	0		1	1		0
Taper Length (ft)	25			25			25			25		
Right Turn on Red			Yes			Yes			Yes			Yes
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		151			225			398			315	
Travel Time (s)		3.4			5.1			9.0			7.2	
Peak Hour Factor	0.75	0.75	0.75	0.72	0.72	0.72	0.86	0.86	0.86	0.92	0.92	0.92
Shared Lane Traffic (%)				44%								
Lane Group Flow (vph)	0	41	0	280	277	0	0	337	93	16	766	0
Turn Type	Split	NA		Split	NA		Perm	NA	Perm	Perm	NA	
Protected Phases	4	4		8	8			2			6	
Permitted Phases							2		2	6		
Detector Phase	4	4		8	8		2	2	2	6	6	
Switch Phase												
Minimum Initial (s)	6.0	6.0		6.0	6.0		10.0	10.0	10.0	10.0	10.0	
Minimum Split (s)	27.0	27.0		11.0	11.0		15.0	15.0	15.0	23.0	23.0	
Total Split (s)	27.0	27.0		33.0	33.0		40.0	40.0	40.0	40.0	40.0	
Total Split (%)	27.0%	27.0%		33.0%	33.0%		40.0%	40.0%	40.0%	40.0%	40.0%	
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0	1.0	1.0	1.0	
Lost Time Adjust (s)		0.0		0.0	0.0			0.0	0.0	0.0	0.0	
Total Lost Time (s)		4.0		4.0	4.0			4.0	4.0	4.0	4.0	
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	None	None		None	None		C-Min	C-Min	C-Min	C-Min	C-Min	
v/c Ratio		0.20		0.75	0.71			0.30	0.09	0.03	0.36	
Control Delay		8.5		48.3	43.8			14.0	8.2	15.4	13.9	
Queue Delay		0.0		0.0	0.0			0.6	0.0	0.0	0.1	
Total Delay		8.5		48.3	43.8			14.6	8.2	15.4	14.0	
Queue Length 50th (ft)		0		174	163			56	1	4	124	
Queue Length 95th (ft)		12		187	176			m252	m30	21	270	
Internal Link Dist (ft)		71			145			318			235	
Turn Bay Length (ft)									100	150		
Base Capacity (vph)		413		487	503			1112	986	568	2134	
Starvation Cap Reductn		0		0	0			437	0	0	0	
Spillback Cap Reductn		4		0	0			0	0	0	276	
Storage Cap Reductn		0		0	0			0	0	0	0	
Reduced v/c Ratio		0.10		0.57	0.55			0.50	0.09	0.03	0.41	

Intersection Summary

Area Type: Other
Cycle Length: 100
Actuated Cycle Length: 100
Offset: 0 (0%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Natural Cycle: 65
Control Type: Actuated-Coordinated
m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 11: Gould St & Windgate Dwy/Muzi Ford Dwy



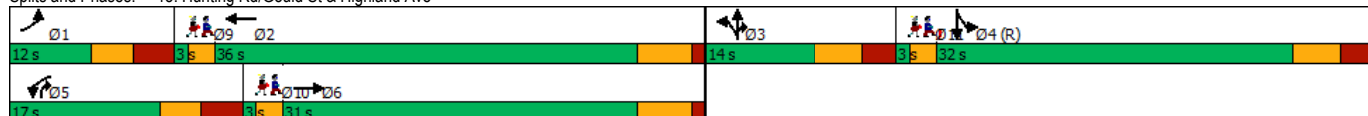
												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	0	30	360	1	40	5	285	80	15	700	5
Future Volume (vph)	1	0	30	360	1	40	5	285	80	15	700	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	12	12	12	13	13	12	12	12	12	12	12
Total Lost time (s)		4.0		4.0	4.0			4.0	4.0	4.0	4.0	
Lane Util. Factor		1.00		0.95	0.95			1.00	1.00	1.00	0.95	
Flt		0.87		1.00	0.97			1.00	0.85	1.00	1.00	
Flt Protected		1.00		0.95	0.96			1.00	1.00	0.95	1.00	
Satd. Flow (prot)		1615		1681	1705			1861	1583	1770	3536	
Flt Permitted		1.00		0.95	0.96			0.99	1.00	0.51	1.00	
Satd. Flow (perm)		1615		1681	1705			1842	1583	941	3536	
Peak-hour factor, PHF	0.75	0.75	0.75	0.72	0.72	0.72	0.86	0.86	0.86	0.92	0.92	0.92
Adj. Flow (vph)	1	0	40	500	1	56	6	331	93	16	761	5
RTOR Reduction (vph)	0	38	0	0	10	0	0	0	32	0	0	0
Lane Group Flow (vph)	0	3	0	280	267	0	0	337	61	16	766	0
Turn Type	Split	NA		Split	NA		Perm	NA	Perm	Perm	NA	
Protected Phases	4	4		8	8			2	2	6	6	
Permitted Phases							2		2	6		
Actuated Green, G (s)		7.0		22.3	22.3			58.7	58.7	58.7	58.7	
Effective Green, g (s)		7.0		22.3	22.3			58.7	58.7	58.7	58.7	
Actuated g/C Ratio		0.07		0.22	0.22			0.59	0.59	0.59	0.59	
Clearance Time (s)		4.0		4.0	4.0			4.0	4.0	4.0	4.0	
Vehicle Extension (s)		3.0		3.0	3.0			3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)		113		374	380			1081	929	552	2075	
v/s Ratio Prot		c0.00		c0.17	0.16						c0.22	
v/s Ratio Perm								0.18	0.04	0.02		
v/c Ratio		0.03		0.75	0.70			0.31	0.07	0.03	0.37	
Uniform Delay, d1		43.3		36.2	35.8			10.4	8.9	8.7	10.9	
Progression Factor		1.00		1.00	1.00			0.99	1.48	1.00	1.00	
Incremental Delay, d2		0.1		8.0	5.8			0.4	0.1	0.1	0.5	
Delay (s)		43.4		44.2	41.6			10.7	13.2	8.8	11.4	
Level of Service		D		D	D			B	B	A	B	
Approach Delay (s)		43.4			42.9			11.2			11.3	
Approach LOS		D			D			B			B	
Intersection Summary												
HCM 2000 Control Delay		21.8				HCM 2000 Level of Service			C			
HCM 2000 Volume to Capacity ratio		0.44										
Actuated Cycle Length (s)		100.0				Sum of lost time (s)			12.0			
Intersection Capacity Utilization		44.1%				ICU Level of Service			A			
Analysis Period (min)		15										
c Critical Lane Group												

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Ø9	Ø10	Ø11
Lane Configurations															
Traffic Volume (vph)	35	725	20	135	1015	270	20	65	90	765	190	135			
Future Volume (vph)	35	725	20	135	1015	270	20	65	90	765	190	135			
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900			
Storage Length (ft)	175		0	165		400	0		150	200		200			
Storage Lanes	1		0	1		0	0		1	1		0			
Taper Length (ft)	25			25			25			25					
Right Turn on Red			Yes			Yes			Yes			Yes			
Link Speed (mph)		30			30			30			30				
Link Distance (ft)		345			745			3028			398				
Travel Time (s)		7.8			16.9			68.8			9.0				
Confl. Bikes (#/hr)						1									
Peak Hour Factor	0.91	0.91	0.91	0.95	0.95	0.95	0.83	0.83	0.83	0.83	0.83	0.83			
Shared Lane Traffic (%)															
Lane Group Flow (vph)	38	819	0	142	1352	0	0	102	108	922	392	0			
Turn Type	Prot	NA		Prot	NA		Split	NA	pt+ov	Split	NA				
Protected Phases	1	6		5	2		3	3	3 5	4	4		9	10	11
Permitted Phases															
Detector Phase	1	6		5	2		3	3	3 5	4	4				
Switch Phase															
Minimum Initial (s)	6.0	10.0		6.0	10.0		6.0	6.0		6.0	6.0		1.0	1.0	1.0
Minimum Split (s)	12.0	20.0		12.0	25.0		12.0	12.0		21.0	21.0		3.0	3.0	3.0
Total Split (s)	12.0	31.0		17.0	36.0		14.0	14.0		32.0	32.0		3.0	3.0	3.0
Total Split (%)	12.0%	31.0%		17.0%	36.0%		14.0%	14.0%		32.0%	32.0%		3%	3%	3%
Yellow Time (s)	3.0	4.0		3.0	4.0		3.5	3.5		3.5	3.5		2.0	2.0	2.0
All-Red Time (s)	3.0	1.0		3.0	1.0		2.5	2.5		2.5	2.5		0.0	0.0	0.0
Lost Time Adjust (s)	0.0	0.0		0.0	0.0			0.0		0.0	0.0				
Total Lost Time (s)	6.0	5.0		6.0	5.0			6.0		6.0	6.0				
Lead/Lag	Lead			Lead			Lead	Lead					Lag	Lag	Lag
Lead-Lag Optimize?															
Recall Mode	None	Min		None	Min		Min	Min		C-Min	C-Min		None	None	None
v/c Ratio	0.36	0.80		0.78	1.02			0.73	0.26	0.93	0.74				
Control Delay	55.0	40.1		71.9	62.3			74.0	2.7	54.5	41.2				
Queue Delay	0.0	0.0		0.0	0.2			5.4	0.0	5.1	1.1				
Total Delay	55.0	40.1		71.9	62.5			79.4	2.7	59.6	42.3				
Queue Length 50th (ft)	24	252		89	~527			65	0	310	228				
Queue Length 95th (ft)	57	#373		#182	#702			#126	5	#376	#239				
Internal Link Dist (ft)		265			665			2948			318				
Turn Bay Length (ft)	175			165					150	200					
Base Capacity (vph)	106	1027		194	1324			147	424	987	527				
Starvation Cap Reductn	0	0		0	0			0	0	43	32				
Spillback Cap Reductn	0	0		0	1			17	0	0	0				
Storage Cap Reductn	0	0		0	0			0	0	0	0				
Reduced v/c Ratio	0.36	0.80		0.73	1.02			0.78	0.25	0.98	0.79				

Intersection Summary

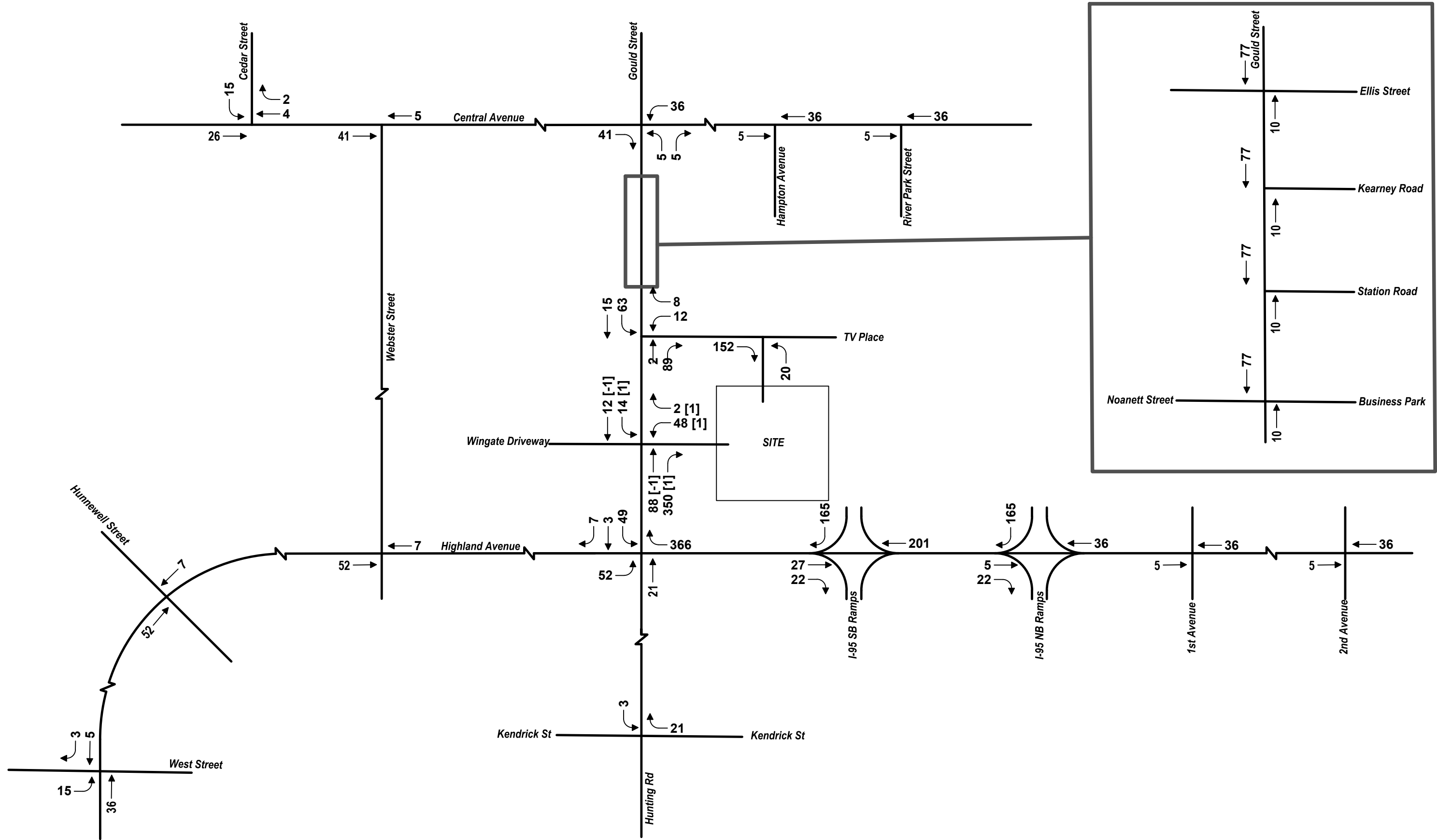
Area Type: Other
 Cycle Length: 100
 Actuated Cycle Length: 100
 Offset: 0 (0%), Referenced to phase 4:SBTL, Start of Green
 Natural Cycle: 110
 Control Type: Actuated-Coordinated
 ~ Volume exceeds capacity, queue is theoretically infinite.
 Queue shown is maximum after two cycles.
 # 95th percentile volume exceeds capacity, queue may be longer.
 Queue shown is maximum after two cycles.

Splits and Phases: 15: Hunting Rd/Gould St & Highland Ave



												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	35	725	20	135	1015	270	20	65	90	765	190	135
Future Volume (vph)	35	725	20	135	1015	270	20	65	90	765	190	135
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	5.0		6.0	5.0			6.0	6.0	6.0	6.0	
Lane Util. Factor	1.00	0.95		1.00	0.95			1.00	1.00	0.97	1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			1.00	1.00	1.00	1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00	1.00	1.00	1.00	
Frt	1.00	1.00		1.00	0.97			1.00	0.85	1.00	0.94	
Flt Protected	0.95	1.00		0.95	1.00			0.99	1.00	0.95	1.00	
Satd. Flow (prot)	1770	3525		1770	3413			1841	1583	3433	1747	
Flt Permitted	0.95	1.00		0.95	1.00			0.99	1.00	0.95	1.00	
Satd. Flow (perm)	1770	3525		1770	3413			1841	1583	3433	1747	
Peak-hour factor, PHF	0.91	0.91	0.91	0.95	0.95	0.95	0.83	0.83	0.83	0.83	0.83	0.83
Adj. Flow (vph)	38	797	22	142	1068	284	24	78	108	922	229	163
RTOR Reduction (vph)	0	2	0	0	22	0	0	0	89	0	25	0
Lane Group Flow (vph)	38	817	0	142	1330	0	0	102	19	922	367	0
Confl. Bikes (#/hr)						1						
Turn Type	Prot	NA		Prot	NA		Split	NA	pt+ov	Split	NA	
Protected Phases	1	6		5	2		3	3	3 5	4	4	
Permitted Phases												
Actuated Green, G (s)	3.6	31.5		10.3	38.2			7.6	17.9	27.6	27.6	
Effective Green, g (s)	3.6	31.5		10.3	38.2			7.6	17.9	27.6	27.6	
Actuated g/C Ratio	0.04	0.32		0.10	0.38			0.08	0.18	0.28	0.28	
Clearance Time (s)	6.0	5.0		6.0	5.0			6.0		6.0	6.0	
Vehicle Extension (s)	2.0	2.0		2.0	2.0			2.0		2.0	2.0	
Lane Grp Cap (vph)	63	1110		182	1303			139	283	947	482	
v/s Ratio Prot	0.02	0.23		c0.08	c0.39			c0.06	0.01	c0.27	0.21	
v/s Ratio Perm												
v/c Ratio	0.60	0.74		0.78	1.02			0.73	0.07	0.97	0.76	
Uniform Delay, d1	47.5	30.5		43.7	30.9			45.2	34.1	35.8	33.2	
Progression Factor	1.00	1.00		1.00	1.00			1.00	1.00	1.09	1.07	
Incremental Delay, d2	10.7	2.2		17.8	30.4			15.8	0.0	22.4	10.0	
Delay (s)	58.2	32.8		61.6	61.3			61.0	34.2	61.6	45.5	
Level of Service	E	C		E	E			E	C	E	D	
Approach Delay (s)		33.9			61.3			47.2			56.8	
Approach LOS		C			E			D			E	
Intersection Summary												
HCM 2000 Control Delay		52.9			HCM 2000 Level of Service				D			
HCM 2000 Volume to Capacity ratio		1.05										
Actuated Cycle Length (s)		100.0			Sum of lost time (s)			27.0				
Intersection Capacity Utilization		84.3%			ICU Level of Service			E				
Analysis Period (min)		15										
c Critical Lane Group												

Revised Site-Generated Peak Hour Traffic Volume Networks



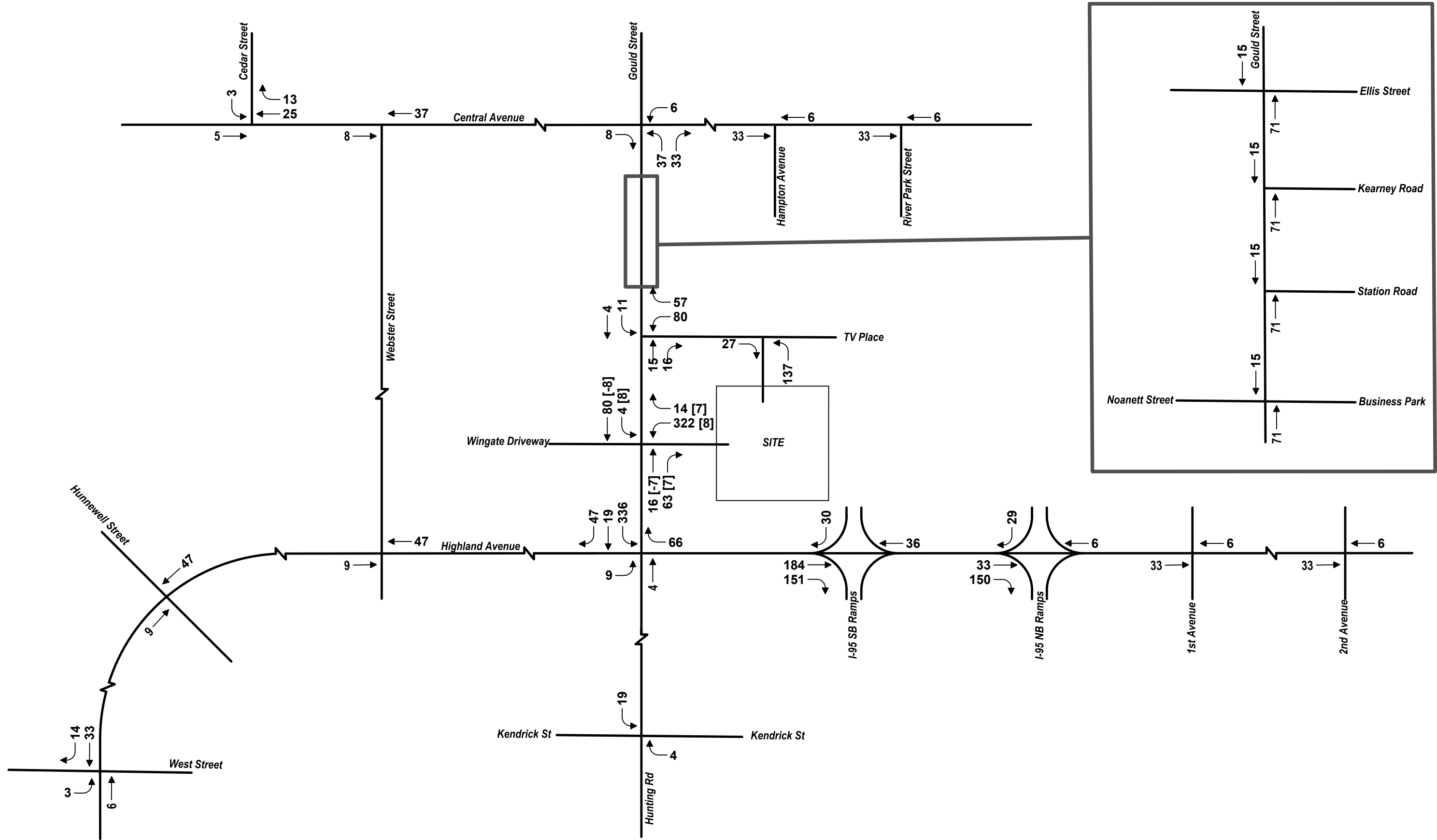
Not to Scale

XX = New Project Generated Vehicles
[XX] = Pass-By Vehicles



Project Generated Vehicle Volumes
Weekday Morning Peak Hour
Highland Science Center
Needham, Massachusetts

Figure 11



Not to Scale

XX = New Project Generated Vehicles
[XX] = Pass-By Vehicles



Project Generated Vehicle Volumes
Weekday Evening Peak Hour
Highland Science Center
Needham, Massachusetts

Figure 12

Planning Board Members
June 30, 2022

EXHIBIT E

**ACENTECH PRELIMINARY NOISE EVALUATION
(557 HIGHLAND AVENUE)**

[see attached]



June 28, 2022

Mr. Robert Schlager, CPM
Bulfinch Companies
116 Huntington Avenue, Suite 600
Boston, MA 02116
Via email: RAS@Bulfinch.com

Subject **Preliminary Exterior/Community Noise Evaluation/Narrative – Revision 1**
557 Highland Avenue (former Muzi Ford Site), Office & Lab Conversion
Needham, MA
Acentech Project J635632.00

Dear Robert:

This letter provides a preliminary discussion of the community (exterior) noise emissions at 557 Highland Avenue, the proposed research and development office at the former Muzi Ford dealership site in Needham, Massachusetts. We understand this project consists of two buildings and a parking garage. The South Building will be 3-stories with 215,000 square feet of office and lab space. The North Building will have 5-stories with 255,000 square feet of office and lab space. There will be a connecting glass atrium of 2-stories between the two buildings. Sound from the proposed campus described above will have to comply applicable noise limits from the Town of Needham and the Commonwealth of Massachusetts as discussed below.

SOUND LIMITS

TOWN OF NEEDHAM

It is our understanding that the Town of Needham does not have numerical noise limits that are part of the town bylaws. We have identified Section 3.8, Noise Regulation of the Town's General bylaws dated July 2021. Section 3.8.1 simply states:

Except in an emergency, construction activity conducted pursuant to a building permit, which causes noise that extends beyond the property line, shall be limited to the hours of 7AM to 8PM unless authorized by rules or regulations adopted by the Select Board. The penalty for violation of this regulation shall be a \$50 fine.

COMMONWEALTH OF MASSACHUSETTS

The Commonwealth of Massachusetts has enacted regulations for the control of air pollution (310 CMR 7.10¹). To enforce these regulations, the Massachusetts Department of Environmental Protection (MassDEP) has issued guidelines that limit noise levels at property lines and the nearest residence. These limitations are: (a) not to increase the residual overall A-weighted background sound level by more than 10 dB and (b) not to produce a pure tone condition; where the sound pressure level (SPL) in one octave band exceeds the levels in the two adjacent octave bands by 3 dB or more.

¹ 310 Massachusetts Regulation 7.10, U Noise:
<https://casetext.com/regulation/code-of-massachusetts-regulations/department-310-cmr-department-of-environmental-protection/title-310-cmr-700-air-pollution-control/section-710-u-noise>

BACKGROUND SOUND SURVEY

In order to determine compliance with the MassDEP noise limits, a background sound survey was performed from March 2 to 7, 2022. Acentech deployed two sound levels meters at the locations (A and B) shown in Figure 1. We monitored sound continuously for a period over 6 days. During this period, we measured the A-weighted ninetieth percentile sound pressure level (L_{90}) on an hourly basis 24 hours per day along with other metrics that can be reported as needed.

INSTRUMENTATION

We used Type 1 sound level meters (SLMs) in accordance with IEC 61672-1. The SLMs were factory-calibrated to National Institute of Standards and Technology (NIST) traceable sources within the previous 12 months; the laboratory calibration certificates are available upon request. Each SLM was also field-calibrated before and after the start of the survey. Each SLM was set to slow response, and recorded L_{90} sound pressure levels in one hour increments in octave-bands with center frequencies between 31.5 and 8,000 Hz. The equivalent continuous (L_{EQ}) A-weighted sound level (dBA), and unweighted (dBZ) octave-band SPLs were also recorded and will be used as necessary.

RESULTS

Figure 2 is a graph of the A-weighted L_{90} sound levels for the 6-day period. For unknown reasons, the data collection at Location A (Gould Street) abruptly stopped after 19-hours of monitoring. Given the limited amount of data, we are recommending a retest of Location A only. We have compiled the L_{90} sound level and determined the lowest L_{90} sound level for the daytime (7:00 am to 10:00 pm), and nighttime (10:00 pm to 7:00 am) as given in Table 1.

TABLE 1: Summary of L_{90} Sound Levels and MassDEP Limits

PERIOD	Day (7:00 am-10:00 pm)	Night (10:00 pm-7:00 am)
Location A (Gould Street)	51	40
Location B (I-95 Ramps)	49	42
MassDEP Limit (min + 10 dB)	59*	50*

* These limits are preliminary subject to potential change after the retesting.

PROJECT NOISE LIMIT

The project noise limit is 10 dB higher than the minimum of the two locations. For daytime the limit would be 59 dBA (49 dBA + 10 dB), and for nighttime the limit is 50 dBA (40 dBA + 10 dB).

NOISE MODELING

The equipment that will generate sound from this Project includes:

- Two Air Handling Units (AHU)
- Two Cooling Towers (CT)
- Loading dock Exhaust Fans
- Multiple Garage Exhaust Fans
- Multiple General Exhaust Fans
- Multiple Exhaust Air Handling Unit (EAHU)
- Multiple Emergency Generators

All of the above equipment will be located on the roof of Building A or Building B. We will conduct a noise evaluation using Cadna/A acoustic modeling software, which complies with the international standard ISO 9613-2, "Attenuation of sound during propagation outdoors -- Part 2: General method of calculation". All rooftop equipment will be evaluated for sound transmission to abutting properties, especially the Wingate Residences at Needham located at 235 Gould Street. As necessary to achieve noise limits, we will recommend noise control features such as acoustic screens/barriers, silencers, acoustic louvers, enclosures, and other treatments.

SUMMARY

We believe the Project at 557 Highland Avenue will be compliant with the local and State limits noted above, given the potential use of sound mitigation. Once we have completed our evaluation, a final report will be issued that will document the predicted sound levels at various receptor points.

Please contact me at 617-499-8058 or mBahtiarian@acentech.com with any questions or comments.

Sincerely,
ACENTECH INCORPORATED



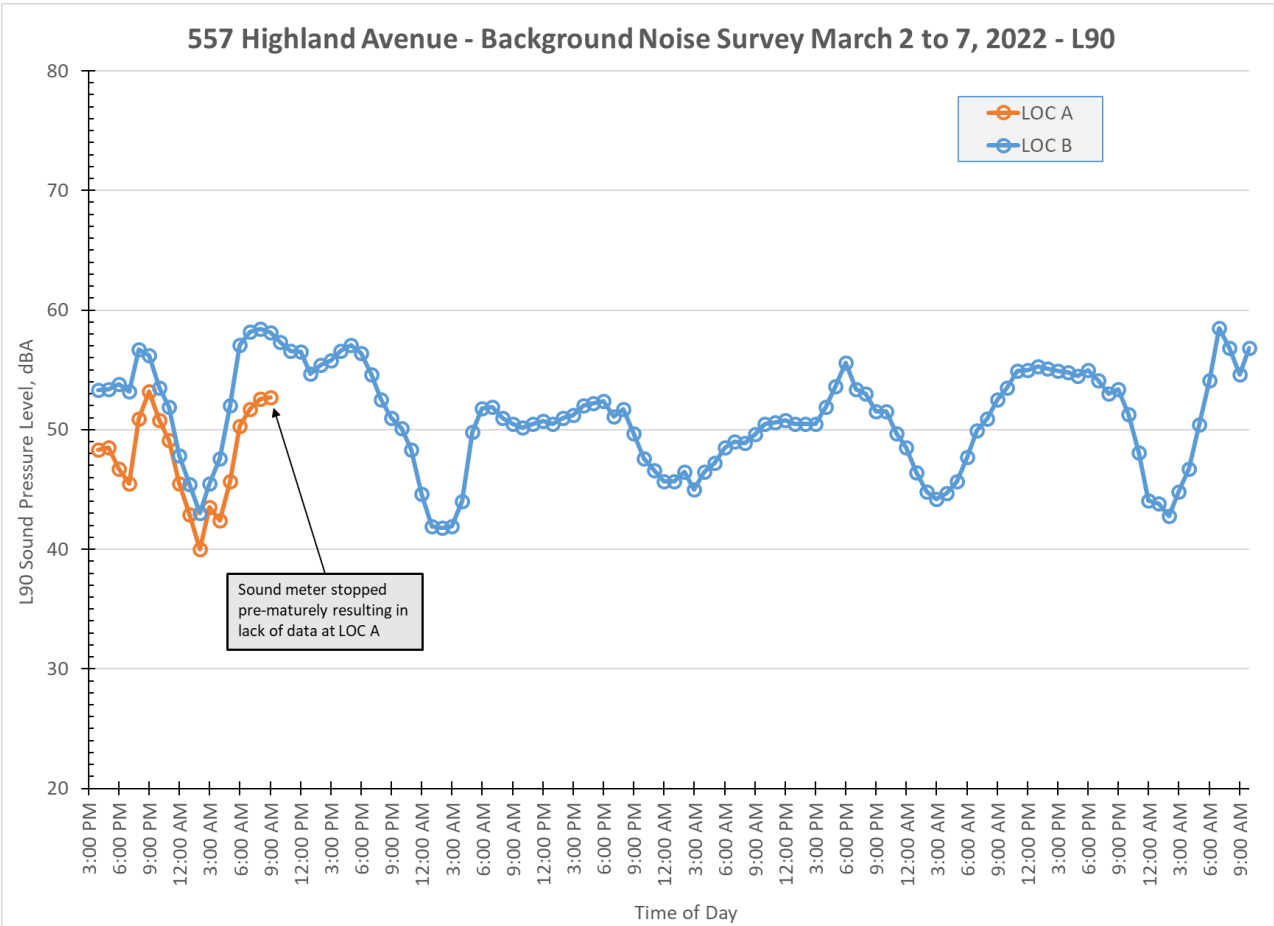
Michael Bahtiarian, INCE Bd. Cert.

Cc: Marc Newmark, Acentech
Ben Stracco, Stantec

FIGURE 1: Background Sound Survey Monitoring Locations, A & B



FIGURE 2: Background Sound Levels, hourly L₉₀, dBA



Planning Board Members
June 30, 2022

EXHIBIT F

**JULY 7, 2022 HEARING PRESENTATION
(557 HIGHLAND AVENUE)**

[see attached]

Highland Innovation Center Planning Board Meeting #2, July 07, 2022

Meeting #1 June 07, 2022

557highland.com

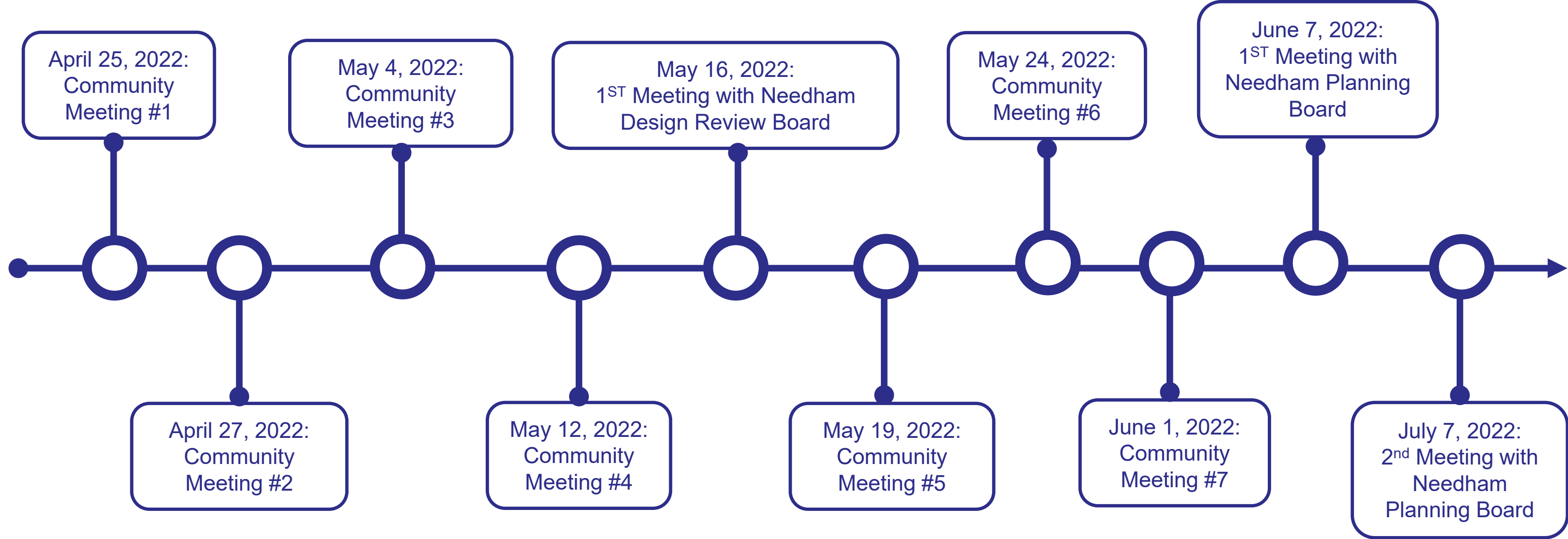
557 Highland Ave, Needham MA

Bulfinch

 **HIGHLAND**
INNOVATION CENTER

 **Stantec**

PROJECT OUTREACH



ADDITIONAL PROJECT MEETINGS:

- TOWN PLANNING
- TOWN ENGINEERING
- FIRE DEPARTMENT
- TOWN ARBORIST
- TRAFFIC

PROJECT TEAM



Margaret Murphy
Community Resources Group
SLS Consulting



July 7, 2022



AGENDA

1. Response to Planning Board Comments from June 7th
2. Plan Updates in Response to Comments on June 7th
3. Transportation Overview
4. Questions and Answers

EXHIBIT A

**RESPONSES TO TOWN OF NEEDHAM PLANNING BOARD COMMENTS AT
JUNE 7, 2022 PUBLIC HEARING (557 HIGHLAND AVENUE)**

Question/Topic	Response
PLANNING BOARD	
<i>Whether the current setback on Gould Street is measured from the current layout of the street.</i>	The plan filed with the Special Permit application contemplates that all of the Gould Street improvements will be subject to an easement in favor of the Town of Needham for public travel. Accordingly, the plan measures all setbacks and dimensional requirements based on the existing lot. The Applicant is working with Town Counsel regarding the application of setbacks in the context of the proposed roadway improvements.
<i>Provide an itemized list of strategies to address climate change as referenced in the applicant's cover letter.</i>	Impacts from climate change on the Project may include urban flooding and extreme heat events. With respect to urban flooding, the Property is located in Zone X (area of minimal flood hazard) according to FEMA Flood Insurance Rate Mapping. The existing site consists almost completely of impervious buildings and paved parking lots. The proposed Project represents a 1.8-acre decrease in impervious coverage compared to the existing condition. This reduction in impervious coverage, and the addition of a surface stormwater detention basin, will result in decreased stormwater peak runoff rates and volumes from the Site overall. The project represents a significant decrease in peak rates to the offsite MassDOT and municipal drainage systems to which the site is tributary, reducing downstream flooding potential should those systems become surcharged in extreme precipitation events. Extreme heat event mitigation strategies include: improved envelope insulation and infiltration to minimize cooling demand and better maintain indoor temperature conditions; high efficiency chilled water plant to minimize cooling demand and energy usage; laboratory exhaust monitoring controls to minimize outside air cooling load.

Question/Topic	Response
<i>Whether the planned solar array will violate any height restrictions in zoning.</i>	Pursuant to Section 4.11.2 of the Zoning By-Law, the parking garage may be allowed a maximum height of 55 ft. by special permit. Pursuant to Section 4.11.1(1)(e) “Structures erected on a building and not used for human occupancy, such as . . . solar or photovoltaic panels . . . and the like may exceed the maximum building height provided that no part of such structure shall project more than 15 feet above the maximum allowable building height, the total horizontal coverage of all of such structures on the building does not exceed 25 percent, and all of such structures are set back from the roof edge by a distance no less than their height.” The parking structure is proposed at 55 ft. in height and the Applicant has requested a special permit for this increased height. The proposed solar photovoltaic canopies on the parking structure may not exceed the 15 ft. limit imposed by Section 4.1.1(1)(e), which we assume is applicable to parking structures, depending upon final design. However, the proposed solar photovoltaic canopies would likely exceed the maximum horizontal coverage limitation of 25%.
<i>Is there an opportunity to further reduce parking and what the impacts on the project might result?</i>	The Project is requesting a reduction in proposed parking based upon documented employment densities of other peer research and development centers in eastern Massachusetts. With approximately 1,408 parking spaces proposed on-site, there will be adequate parking provided for the Project.
<i>Can additional green space be incorporated into the design?</i>	The site design has been revised to address prior community comments with an aim to include less grass and to maximize diverse and native plantings.
<i>Will all amenities be accessible by the community?</i>	All outdoor amenities for the Project are intended to be available to the public, as will the retail/restaurant tenant spaces.
<i>Can the bike lanes/infrastructure be designed to favor families instead of commuters?</i>	In close consultation with our neighbors, we are working to develop transportation improvements, including separated bike lanes/infrastructure that

Question/Topic	Response
	address neighborhood concerns along Gould Street on or adjacent to the Property.
<i>Can the scale of the structures along Gould Street be further offset or reduced?</i>	As we further studied moving the North Loading Dock from the Gould Street elevation to the north side of the building, we have studied different fenestration options which may help the building read at a smaller scale on this elevation, but will still provide the areas needed to best serve the building tenants and community. Additional trees/planting are being considered in order to help further screen the building from view along Gould Street.
<i>Can the planned greenbelt be connected to the park/trail across from TV Place on neighboring property?</i>	This is currently part of a separate property at 0 Gould Street and no changes to this property are anticipated at this time.
<i>What will acoustic levels be from rooftop mechanicals?</i>	The Applicant has engaged Acentech as an acoustical consultant to provide a qualitative report on this topic and the results of the report are included as Exhibit E to this letter.
<i>Provide additional clarity on loading dock operations and whether loading dock access can be provided off of TV Place rather than facing Gould Street.</i>	Due to the location of the garage structure, as required by the recent rezoning, locating the North Building's loading dock off of TV Place was not achievable. However, the team has reviewed moving the loading dock to the north side of the North Building so the loading dock no longer faces Gould Street, which adds additional window area and a park along the west face of the North Building.
<i>Has the Fire Department approved of the driveway/roadway widths and can a permeable paving material be used for emergency lanes?</i>	In our meeting with the Fire Department on March 24, 2022, the Fire Department requested fire access lanes around the building which are being provided. These lanes are to be 18' minimum width, but 20' preferred due to snow clearing. The landscape architect is planning to provide the fitness path as bituminous concrete or gravel, then flank the sides with permeable structured grass or permeable pavers if allowed by the Fire Department.

Question/Topic	Response
<i>Can additional public transportation be provided through relocating or adding an MBTA bus route?</i>	The Applicant will reach out to MBTA to evaluate the feasibility of providing additional MBTA service. However, in light of the MBTA’s Bus Network Redesign plan, released in May 2022, which proposes to maintain Route 59’s existing alignment in Needham while eliminating route variations in Newton, the Applicant thinks it unlikely that the MBTA will agree to shift a segment of Route 59 from serving residential neighborhoods to serving the Project site. The Applicant will be providing a direct shuttle service (via use of an electric shuttle) that will connect the site with nearby transit nodes.

EXHIBIT B

RESPONSES TO TOWN OF NEEDHAM DEPARTMENT COMMENTS (557 HIGHLAND AVENUE)

Question/Topic	Response
FIRE DEPARTMENT	
<i>Confirm with the Fire Department to ensure public safety vehicle access during the winter.</i>	Final plans will be resubmitted for Fire Department approval including all truck turn requirements, etc., to confirm acceptable access as is required by applicable codes and regulations.
POLICE DEPARTMENT	
<i>Address potential for use of cut-through streets off of Gould Street and address potential use of Noanett, Ellis, Kearney, Beech and Arnold Streets as cut-through streets to avoid light at Gould and Central intersection. Place signage at these locations restricting traffic during commuting hours.</i>	The Applicant will work with the Town to design and install signage at Noanett Road to deter unwanted cut-through turning movements during the weekday peak commuting hours. In addition, the installation of a traffic signal at Central Avenue and Gould Street will improve operations on Gould Street and reduce the desire for vehicles to use side streets as a cut-through by providing gaps for vehicles to turn efficiently at that intersection. The Applicant will supplement these actions with information dissemination and enforcement funding in connection with close collaboration with the Needham Police Department.
<i>Address potential impacts on Hunting and Greendale from drivers utilizing these streets during hours of heavy traffic on Route 128.</i>	Traffic volumes on Hunting and Greendale have decreased in the last several years due to the completion of the Route 128 add-a-lane project in the area, and most notably, due to the implementation of the new interchange connection at Kendrick Street. The Project is expected to add only a very small number of new trips to Hunting and Greendale, as the additional southbound left-turn lane on Gould Street will make it easier for drivers from the site to directly access Route 128 via Highland Ave. In addition, the Applicant will fund the installation of radar embedded speed limit signs along Hunting Road as a measure to deter speeding during off-peak hours.

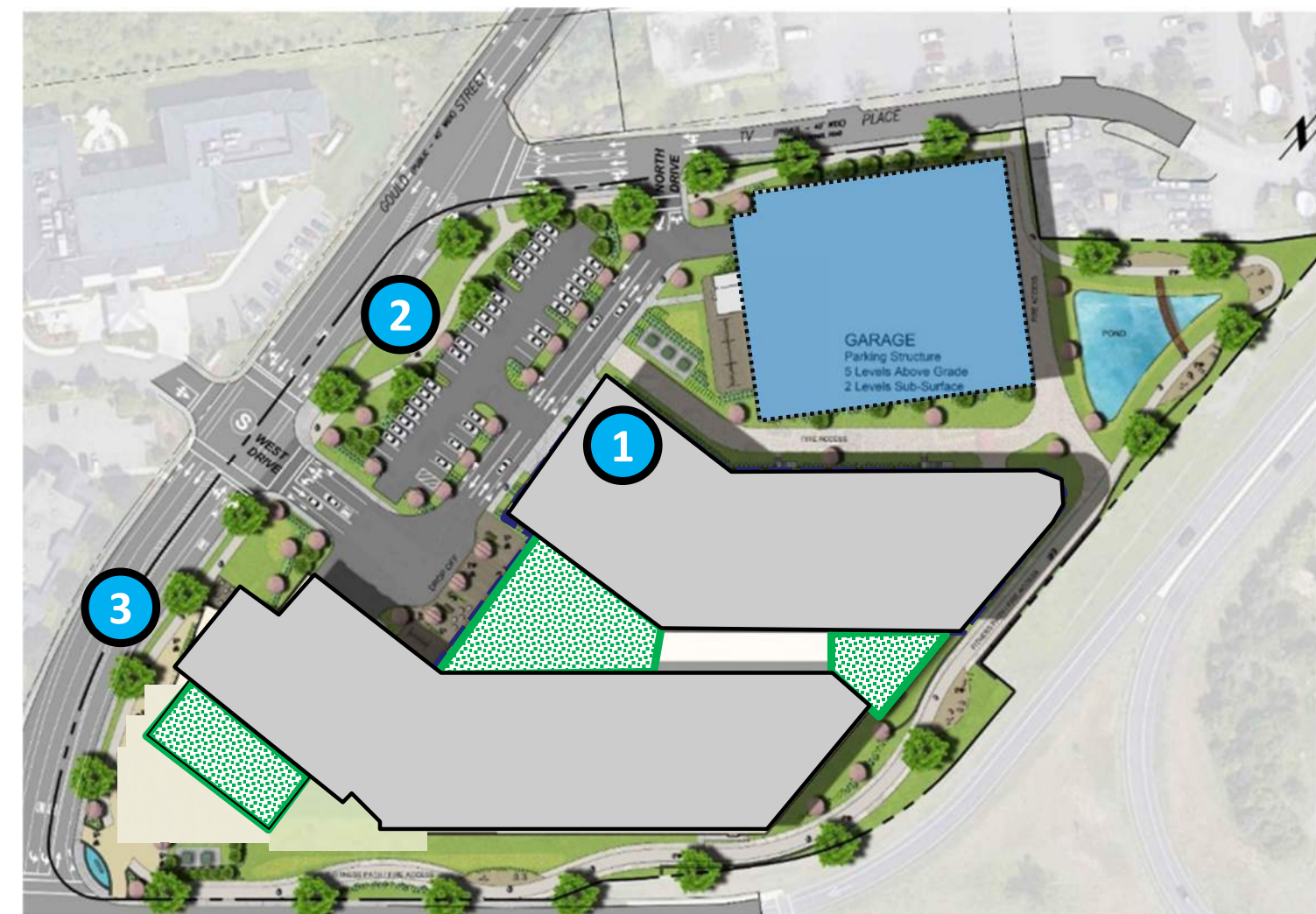
Question/Topic	Response
<i>Confirm that walking paths, bike paths, and similar spaces running around perimeter of project site have adequate emergency vehicle access.</i>	The perimeter paths along Highland Avenue / Route 128 have been designed with stabilized gravel shoulders that will provide 20' wide emergency access. A 20' wide gravel access drive has also been provided around the proposed garage.
BUILDING DEPARTMENT	
<i>The site as presented appears to meet the zoning regulations for the site, Special Permits are required for some dimensional requirements based on the design of the structures.</i>	The Applicant has requested such special permit relief in its Application.
PUBLIC WORKS DEPARTMENT	
<i>We are seeking clarification for the facility's proposed water use of 129,172 GPD while the wastewater design flow generation is 54,554 GPD.</i>	Water demand and sewer generation for lab uses can vary and are highly dependent on the specific processes involved. These numbers have been estimated by the Project's MEP Engineer. The difference between the water demand and sewer generation represents water that will be consumed or otherwise used up by lab processes and mechanical equipment (such as evaporative cooling).
<i>We expect to work with the developer on determining the optimum water loop design. The current proposal shows a 10-inch water connection to the site off a 12-inch main on Gould Street and a connection to an existing 8-inch water main on TV place. The additional loop connection may be more optimum if connected from Highland Avenue in front of the development instead of, or an addition to the 8-inch on TV Place connection.</i>	The Applicant will work with the Town to coordinate the water loop connection points. Connections to the 12-inch mains in Highland and Gould as described can be incorporated into a future revised utility plan.
<i>We concur with traffic comments/ recommendations prepared by GPI in their April 25, 2022 letter to the Planning and Community Development Office.</i>	Responses to the peer review comments by GPI are included as Exhibit C .
<i>We expect the Developer to work with the town in providing an alteration/taking plan and recordings for a new Road Right of Way layout on Gould Street and to optimize the traffic signals at Highland at Gould.</i>	The Applicant will work with the Town to develop and finalize the necessary alteration/taking plan and recordings for a new Road Right of Way layout on Gould Street and to optimize the traffic signals at Highland at Gould.

Question/Topic	Response
<i>For the new facility, four times the increased flow equates to a total of 126,004 GPD I/I removal anticipated from the development. This may be satisfied by either undertaking a construction project or paying a fee to the Town's I&I program at a rate of \$8.00 per gallon required to be removed. We are in the process of analyzing the target areas for the inflow/infiltration to be removed and expect to work with the developer through the site plan approval process</i>	The Applicant will work with the Town to satisfy the I/I removal requirements.
<i>As part of the NPDES requirements, the applicant must comply with the Public Outreach & Education and Public Participation & Involvement control measures. The applicant shall submit a letter to the town identifying the measures selected and dates by which the measures will be completed in order to incorporate it into the Planning Board's decision</i>	The Applicant understands that the Town's Stormwater Management Program, prepared in accordance with NPDES MS4 General Permit, requires the Town to perform public education and outreach / public involvement and participation. The Applicant will work with the Town to satisfy any of these requirements applicable to the Project.
<i>If emergency generators are proposed, they should indicate on the plans with proper screening and noise reduction according to a sound study for the proposed generators</i>	Emergency Generators will be provided as required by code for life safety and emergency uses. Separate tenant backup generators may also be provided to support the lab and office uses of the building. All emergency generators are currently planned to be located on the roofs behind the mechanical screen walls with final number and locations being determined. The generators will be designed to meet all sound and noise reduction requirements of the Town and state.
PUBLIC HEALTH DIVISION	
<i>Food Establishments will require approval through Food Permit Plan Review, including evaluation of adequacy of dumpsters, grease traps, etc.</i>	Upon selection of final tenants for the restaurant space, all Food Establishment tenants will undergo the necessary permitting and approval process, including review by Needham's Public Health Division. Adequate grease traps are planned for the retail and restaurant space with final design to be determined as the Project advances and tenants are chosen. There will be interior waste/recycling rooms.
<i>Continue working on environmental remediation of the site and provide continual updates to Public Health on remediation efforts.</i>	The Applicant will comply with applicable environmental laws and will provided updates to the Needham Public Health Department as appropriate.

Question/Topic	Response
<i>Obtain MassDEP approval for reclaiming water, specifically for - cooling tower water, toilet and urinal flushing, boiler feed, industrial process water and irrigation for landscaped areas, etc. All these uses are allowed under 314 CMR 20.00., if approved.</i>	No wastewater re-use is planned for the Project. The Project will capture and reuse stormwater and will file for necessary MassDEP permitting.
<i>Any biolaboratory proposed as part of the Project must complete the Public Health Division's online permitting application including provision of proper biohazardous waste containment.</i>	The Applicant will require any life sciences tenants to comply with all applicable rules and regulations.
DESIGN REVIEW BOARD	
<i>Provide Design Review Board with updates to project landscaping, lighting, and screening in connection with the Design Review Board's comments.</i>	The Applicant intends to submit the information requested by the Design Review Board's comments for the Board's consideration.

WHAT WE UPDATED - REV. #3, 7/07/2022

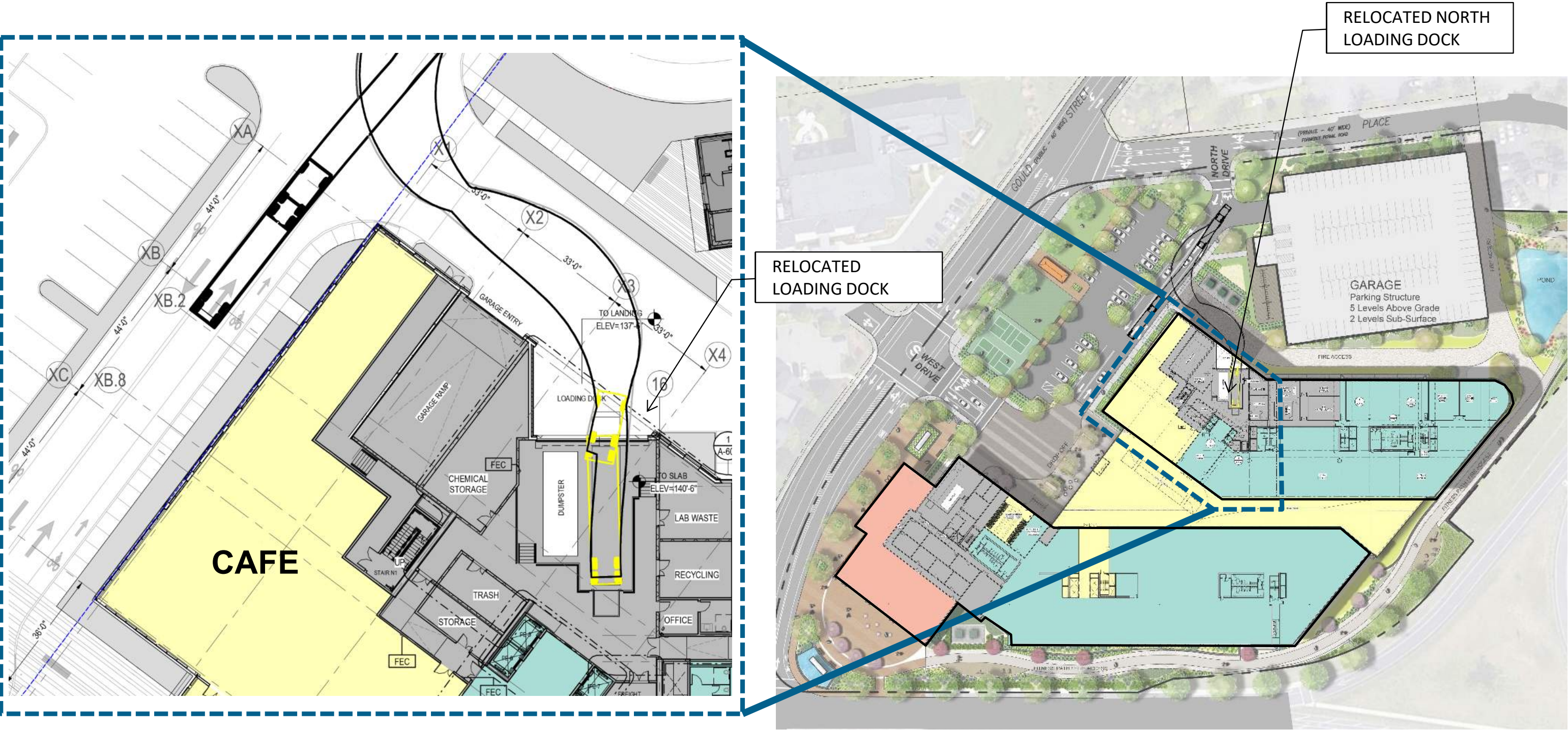
1. Relocated North Loading Dock and Garage Access from Gould St. Elevation around to Service Driveway
2. Studied incorporation of Family-Friendly separated bike lanes along Gould St.
3. Roadway improvements on Gould St.



PROPOSED DESIGN REV #3, 7/07/2022: SITE PLAN



PROPOSED DESIGN REV #3, 7/07/2022: LOADING DOCK



PROPOSED DESIGN REV #3, 7/07/2022: AERIAL LOOKING NORTH



Proposed Program:
506,694 SF / 1.25 FAR
1408 Proposed Parking

NORTH BUILDING
5 Stories (70' H.)

STRUCTURED GARAGE
5 Stories (55' H.)

PV SOLAR ARRAY

128 S

Highland Ave

CONNECTING ATRIUM
2 Stories (30' H.)

SOUTH BUILDING
3 Stories (42' H.)

MASSING PULLED BACK

OUTDOOR SEATING

RETAIL PLAZA

10,000 SF Retail

Gould Street

½ MILE FITNESS AND WALKING
PATH W/ EXERCISE STATIONS

GOULD ST AMENITY: OPEN
LAWN, SHADE STRUCTURE,
PICKLE BALL COURTS,
SEASONAL ICE SKATING

RELOCATED NORTH LOADING DOCK
& CREATED MORE ACTIVE FAÇADE
ALONG PEDESTRIAN PATH

PROPOSED DESIGN REV. #3, 7/07/2022: AERIAL LOOKING N-W



GOULD ST AMENITY: OPEN LAWN, SHADE STRUCTURE, PICKLE BALL COURTS, SEASONAL ICE SKATING

MASSING PULLED BACK TO SOFTEN CORNER & PROVIDE ADDITIONAL OPEN SPACE

Gould Street

GREEN ROOF
ROOF TERRACE

Highland Ave

INCREASED PLANTINGS & SCREENING. FITNESS PATH PUSHED BACK. ADDED LANDSCAPE VARIETY

PROPOSED DESIGN REV. #3, 7/07/2022: PEDESTRIAN VIEW AT GOULD



PROPOSED DESIGN REV. #3, 7/07/2022: AERIAL LOOKING SOUTH





Highland Innovation Center
557 Highland Ave, Needham, MA
Transportation Summary Focus

Planning Board Meeting #2 – July 7, 2022

Sean Manning, PE | smanning@vhb.com
Matt Duranleau, PE | mduranleau@vhb.com



Highland Innovation Center (557 Highland Avenue)

Transportation Summary

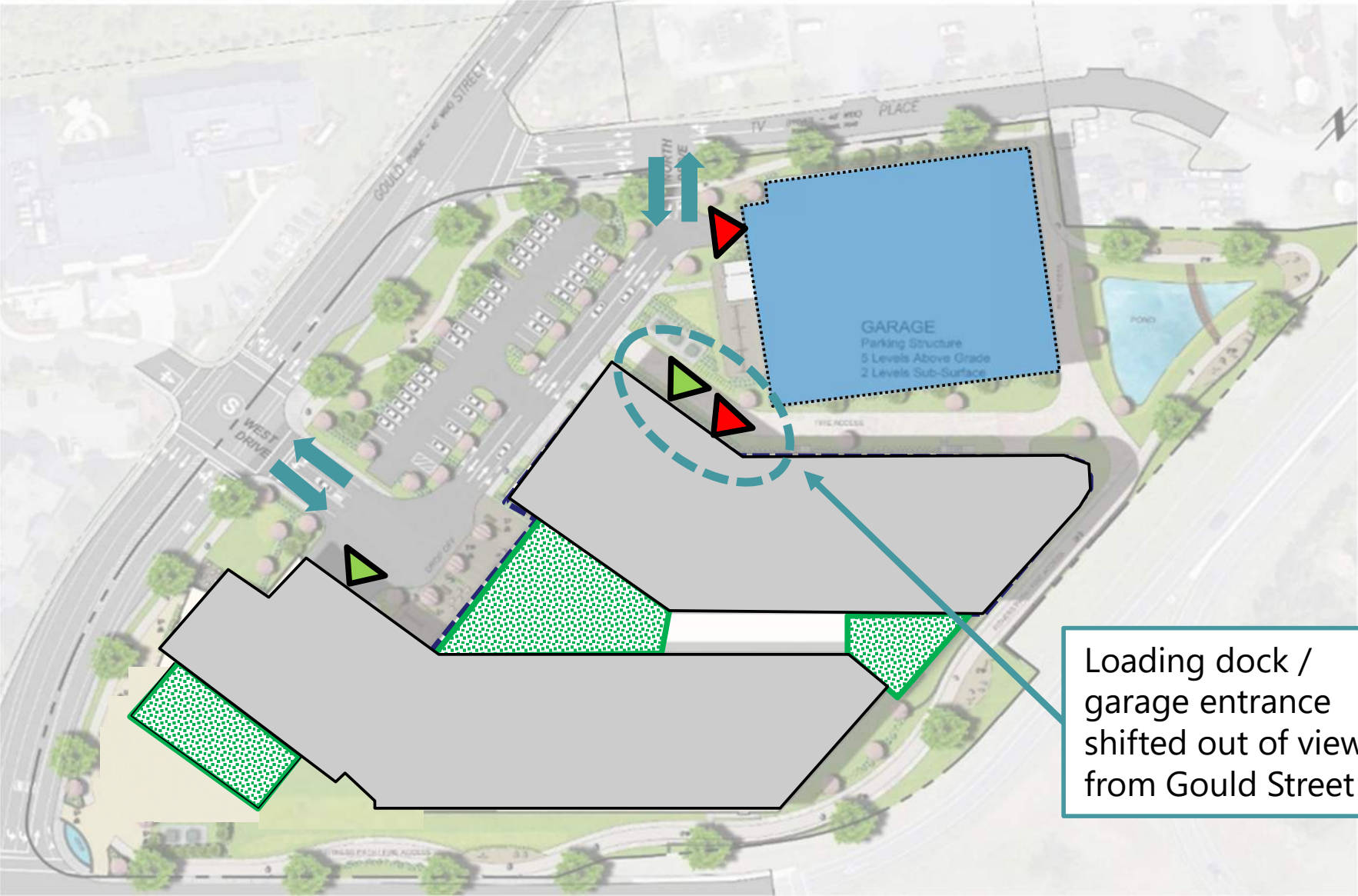
Agenda

- Project Summary
- Traffic Study Methodology
- Project Trip Generation
- Transportation Mitigation

Project Site Plan

Building Program

Use	Size (SF)
Office	248,347
R&D	248,347
Retail	10,000
Total	506,694



-  Garage Access
-  Loadings Access

Transportation Study Process

Comprehensive Transportation Impact and Access Study conducted by VHB supporting both Special Permit (town) and MEPA (state) application processes

Prior to study:

- Transportation Scoping Letter submitted to MassDOT.
- Coordination with Town of Needham and Greenman-Pederson, Inc. (GPI) (the Town's transportation consultant).
- Careful review of the 2020 GPI Transportation Study and related outcomes commissioned by the Town in connection with the recent rezoning effort for this site.

Local Submittal Timeline:

- Special Permit Submission with Traffic Study: April 8, 2022
- Neighborhood community meetings and coordination with Town departments: April-June 2022
- GPI Peer Review report: May 27, 2022
- First Planning Board Meeting: June 7, 2022

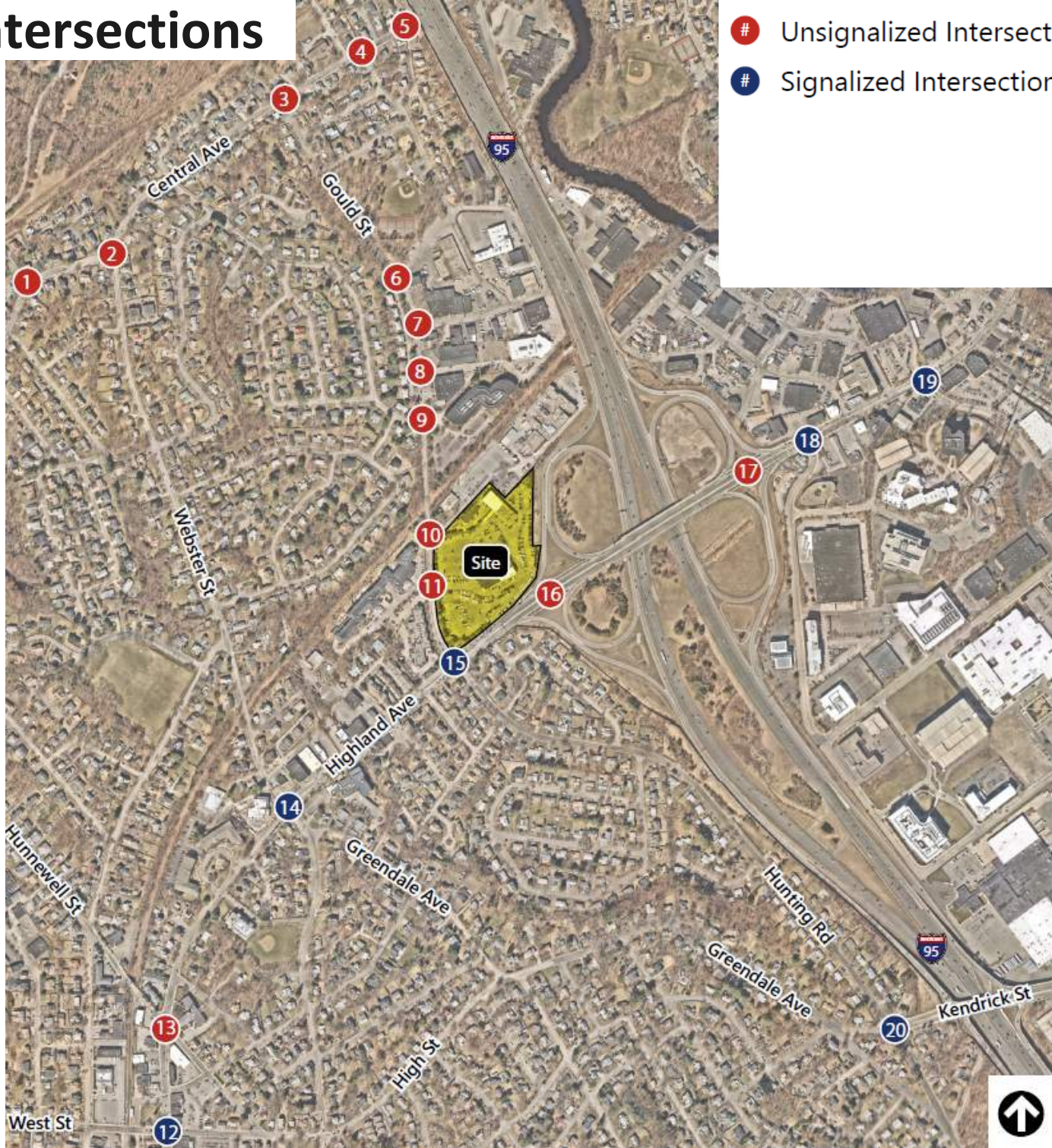
State Submittal Timeline:

- State MEPA ENF Submission with Traffic Study: April 1, 2022
- Certificate / Comment Letters Received: May 9, 2022
- Draft Environmental Impact Report to be submitted July 15, 2022

Traffic Study Overview

- Review of Existing (2022) Conditions
- Assessment of Future (2029) Conditions without the proposed Project
 - › Includes completion of MassDOT reconstruction of Highland Avenue
 - › Includes other nearby developments (100 West Street, Boston Children's Hospital at Founders Park, Newton Northland Development)
- Assessment of Future (2029) Conditions with the proposed Project
 - › Impacts with and without mitigation
 - › Summary of Transportation mitigation and TDM

Study Area Intersections



- 1 Central Avenue at Cedar Street
- 2 Central Avenue at Webster Street
- 3 Central Avenue at Gould Street
- 4 Central Avenue at Hampton Avenue
- 5 Central Avenue at River Park Street
- 6 Gould Street at Ellis Street
- 7 Gould Street at Kearney Road
- 8 Gould Street at Station Road
- 9 Gould Street at Noanett Street
- 10 Gould Street at TV Place
- 11 Gould Street at Muzi Ford/Wingate Res.
- 12 Highland Avenue at West Street
- 13 Highland Avenue at Hunnewell Street
- 14 Highland Avenue at Webster Street
- 15 Highland Avenue at Gould Street
- 16 Highland Avenue at I-95 SB Ramps
- 17 Highland Avenue at I-95 NB Ramps
- 18 Highland Avenue at 1st Avenue
- 19 Highland Avenue at 2nd Avenue
- 20 Kendrick Street at Hunting Road

Trip Generation | Existing Site Trips

Existing Site Vehicle Trips	
Weekday Daily	
Total	887
Weekday Morning Peak Hour	
Enter	37
<u>Exit</u>	<u>24</u>
Total	61
Weekday Evening Peak Hour	
Enter	29
<u>Exit</u>	<u>57</u>
Total	87

Note: based on empirical counts conducted by VHB in July 2021, during COVID-19, and during the "slow" portion of the season

- Car wash alone was known to service **up to 1,300 cars/day at peak times** with daily averages between October and May approximately 600 cars/day as reported by Felix Taranto of Wash World, the car wash operator since the 1990s
- Car wash was **busiest in late Winter/Spring**, less busy in Summer
- Existing daily trips for Muzi site included Chevrolet dealership, Ford dealership, body shop, service center, new car sales, used car sales, outsourced sales, and parts pick-up (new and used) including gas, fuel, hazardous waste, and other removals constituting commercial trucks
- Existing trips quantified during COVID (July 2021) and **pre-COVID volumes were likely measurably higher** than what is quantified in the Transportation Study (conservative assumption)

Trip Generation | Estimated Proposed Site Trips

Adjusted Vehicle Trips

	Office	R&D	Retail	Total Driveway Trips	Pass-by	Existing Site Trips	Total Net-New Vehicle Trips
Weekday Daily							
Total	2,658	2,763	629	6,050	(-158)	(-887)	5,005 *
Weekday Morning Peak Hour							
Enter	334	209	11	554	(-2)	(-37)	515 *
<u>Exit</u>	<u>42</u>	<u>44</u>	<u>9</u>	<u>94</u>	<u>(-2)</u>	<u>(-24)</u>	<u>68 *</u>
Total	376	253	20	649	(-4)	(-61)	584 *
Weekday Evening Peak Hour							
Enter	62	39	36	136	(-15)	(-29)	92 *
<u>Exit</u>	<u>303</u>	<u>204</u>	<u>38</u>	<u>545</u>	<u>(-15)</u>	<u>(-57)</u>	<u>473 *</u>
Total	365	242	74	681	(-30)	(-87)	565 *

* Trip Generation Likely Over-Estimated, Does Not Account For:

1. Local Trip Rates
2. Transit Use or Walk / Bike Trips
3. Work from Home / Hybrid Work Environment

Trip Generation | “Actual” Site Trips - Local Trip Rates

Estimated vs “Actual” Trip Rates

- Estimated trip rates based on national data from the Institute of Transportation Engineers (ITE) between the 1980s and 2010s
- Data provided based on three different land use codes: Office, R&D, and Retail
- Local trip rate data for office and R&D sites was reviewed from actual developments in the City of Cambridge from 2017/2018 to determine a more accurate representation of Project-generated trips

Office Trip Rate per 1,000 SF

	ITE National Data	Local Cambridge Data	Percent Difference
Weekday Daily			
Total	10.25	8.29	-19%
Weekday Morning Peak Hour			
Total	1.46	1.15	-21%
Weekday Evening Peak Hour			
Total	1.41	1.25	-11%

R&D Trip Rate per 1,000 SF

	ITE National Data	Local Cambridge Data	Percent Difference
Weekday Daily			
Total	10.65	5.95	-44%
Weekday Morning Peak Hour			
Total	0.98	0.72	-27%
Weekday Evening Peak Hour			
Total	0.94	0.72	-23%

Trip rates include all commuters (drivers, transit riders, walkers, and bikers)

Trip Generation | “Actual” Site Trips – Mode Share

Estimated vs “Actual” Mode Share / Work from Home

- Estimated Site-generated trips assume 100% of commuters will drive to work
- Estimated Site-generated trips do not include the impact of work from home / hybrid work schedules
- Analyses are highly conservative as some commuters will take transit (with shuttle connection), walk, bike, and/or work from home
- US Census data for City of Newton reviewed to determine potential transit/walk/bike/work from home mode share for Site
 - Newton data reviewed as Site is expected to operate more similarly to workplaces in Newton with connections to transit and direct interstate access
- Pre-COVID work from home share assume to double in future (at a minimum) to account for new hybrid work environment

Site Mode Share			
	Vehicle	Transit, Walk, Bike	Work From Home
Estimated in Traffic Study	100%	0%	0%
City of Newton pre-COVID data ^a	77%	16%	7%
Potential Site “Actual” Mode Share ^b	72%	14%	14%

a – Mode shares determined from US Census Journey to Work Data (2012-2016) for workplaces located within the City of Newton, MA.

b – The estimated work from home mode share was doubled to account for the impacts of COVID-19 on the remote working environment.

Trip Generation | “Actual” Site Trips

“Actual” Site-Generated Trips estimated based on

1. Local Trip Rates
2. Transit Use and Walk / Bike Trips
3. Work from Home / Hybrid Work Environment

- To be conservative, traffic analyses conducted without these estimated credits applied
- All roadway improvements designed to accommodate “worse-case” scenario

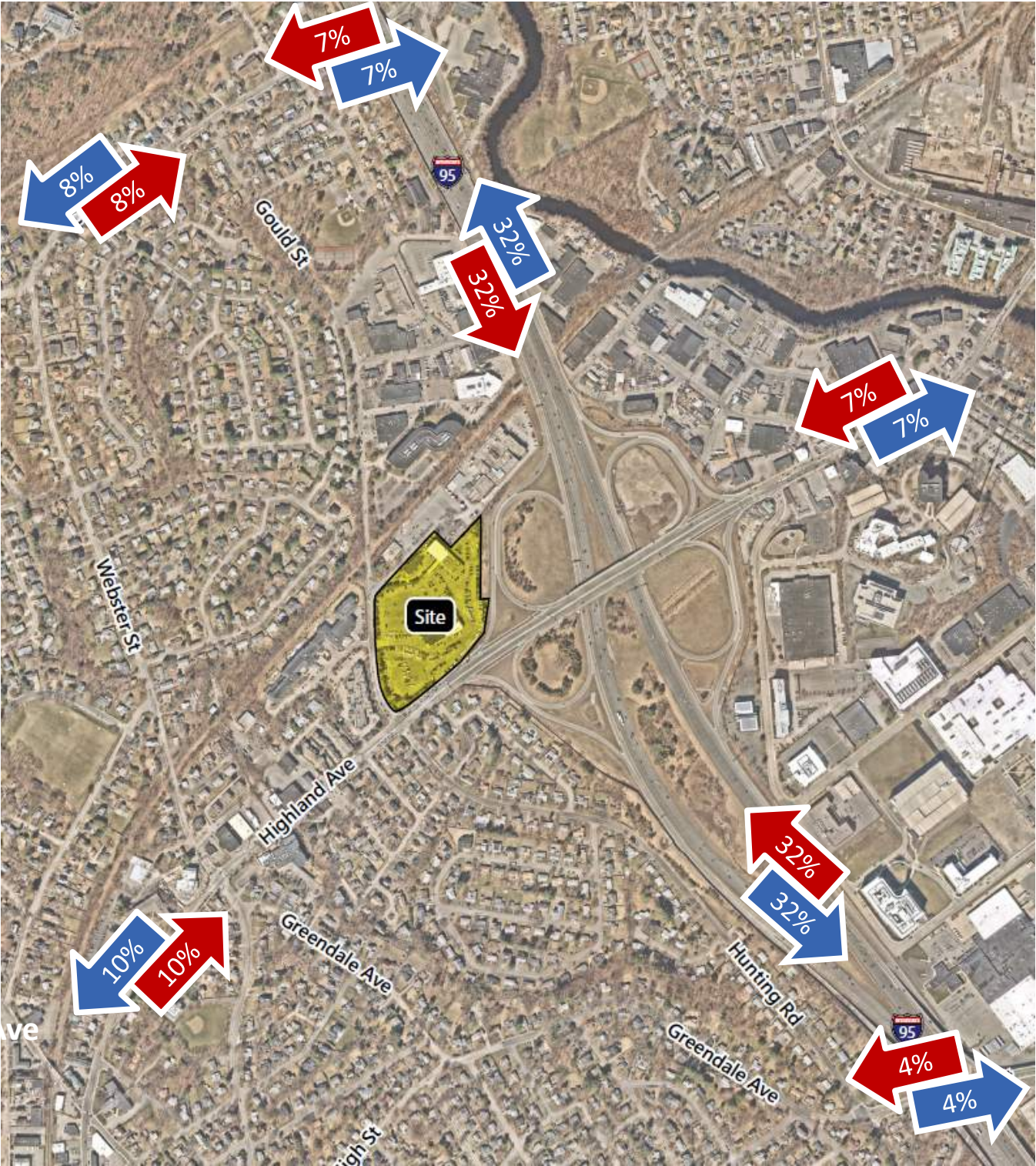
Total New Project Vehicle Trips

	Estimated New Vehicle Trips	“Actual” New Vehicle Trips	Percent Difference
Weekday Daily			
Total	5,005	2,072	-59%
Weekday Morning Peak Hour			
Enter	515	291	
Exit	<u>68</u>	<u>-12</u>	
Total	584	279	-52%
Weekday Evening Peak Hour			
Enter	92	29	
Exit	<u>473</u>	<u>273</u>	
Total	565	302	-47%

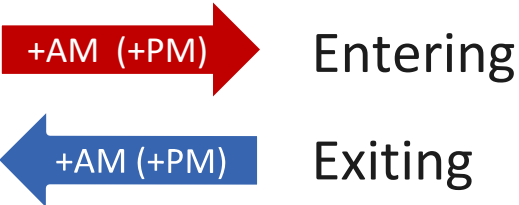
Trip Distribution



Source: Trip Distribution based on US Census Journey to Work Data (2012-2016) for workplaces located within the Town of Needham, MA.



New Project-Generated Trips



- * Trip Generation Likely Over-Estimated, Does Not Account For:
- 1. Transit Use or Walk / Bike Trips
 - 2. Work from Home / Hybrid Work Environment

Based on higher Trip Generation to determine proposed mitigation



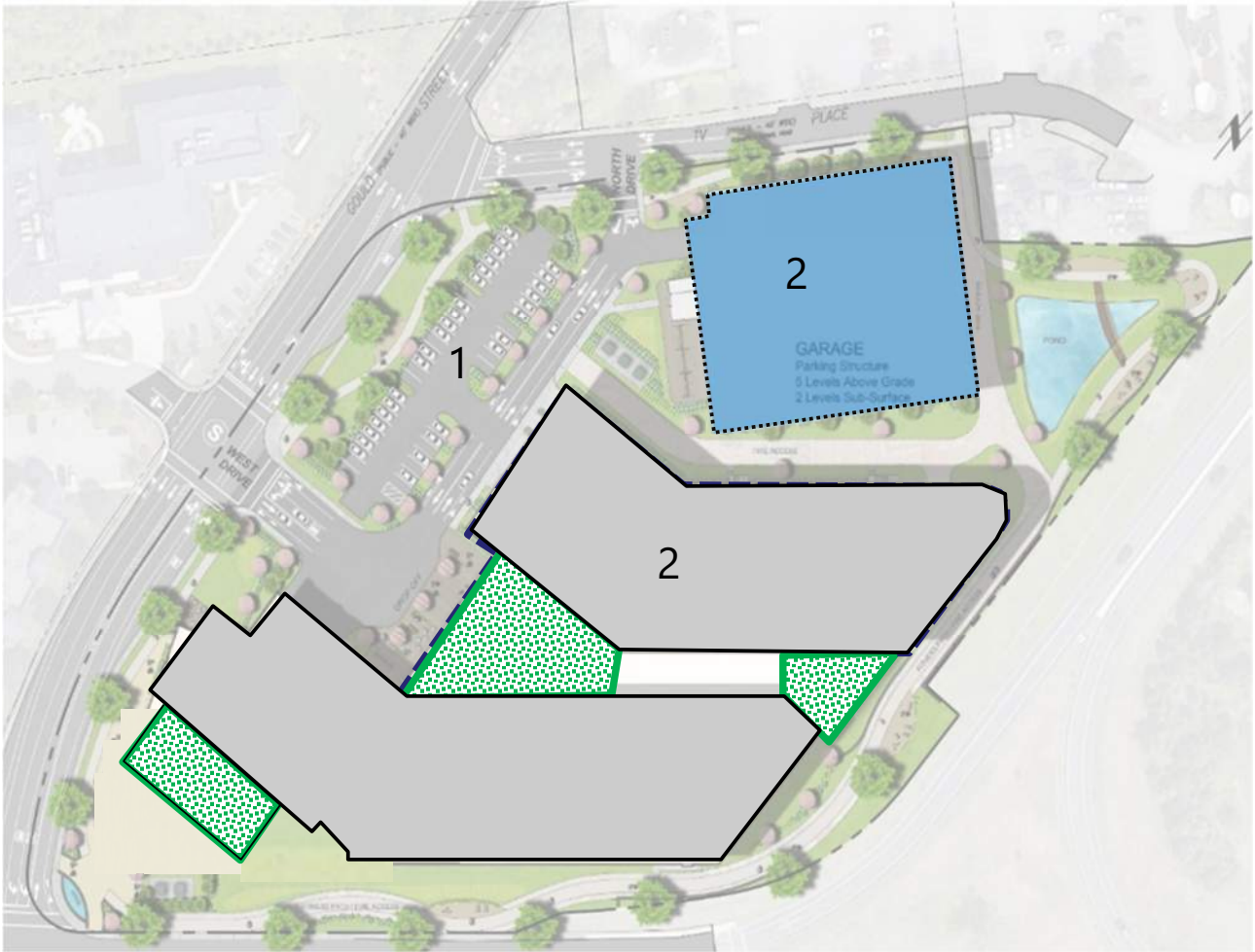
Parking Supply

Type	Spaces
Vehicle	1,408 spaces
Bike	154 spaces

- 1. Small surface parking lot for patrons and visitors
- 2. Stand-alone garage and underground parking for employees



25% of all parking spaces will include **EV charging stations**



Parking Demand

Conservative Analysis based on 100% Auto Use

The proposed Project parking supply of up to **1,408 off-street parking spaces** exceeds the expected demand.

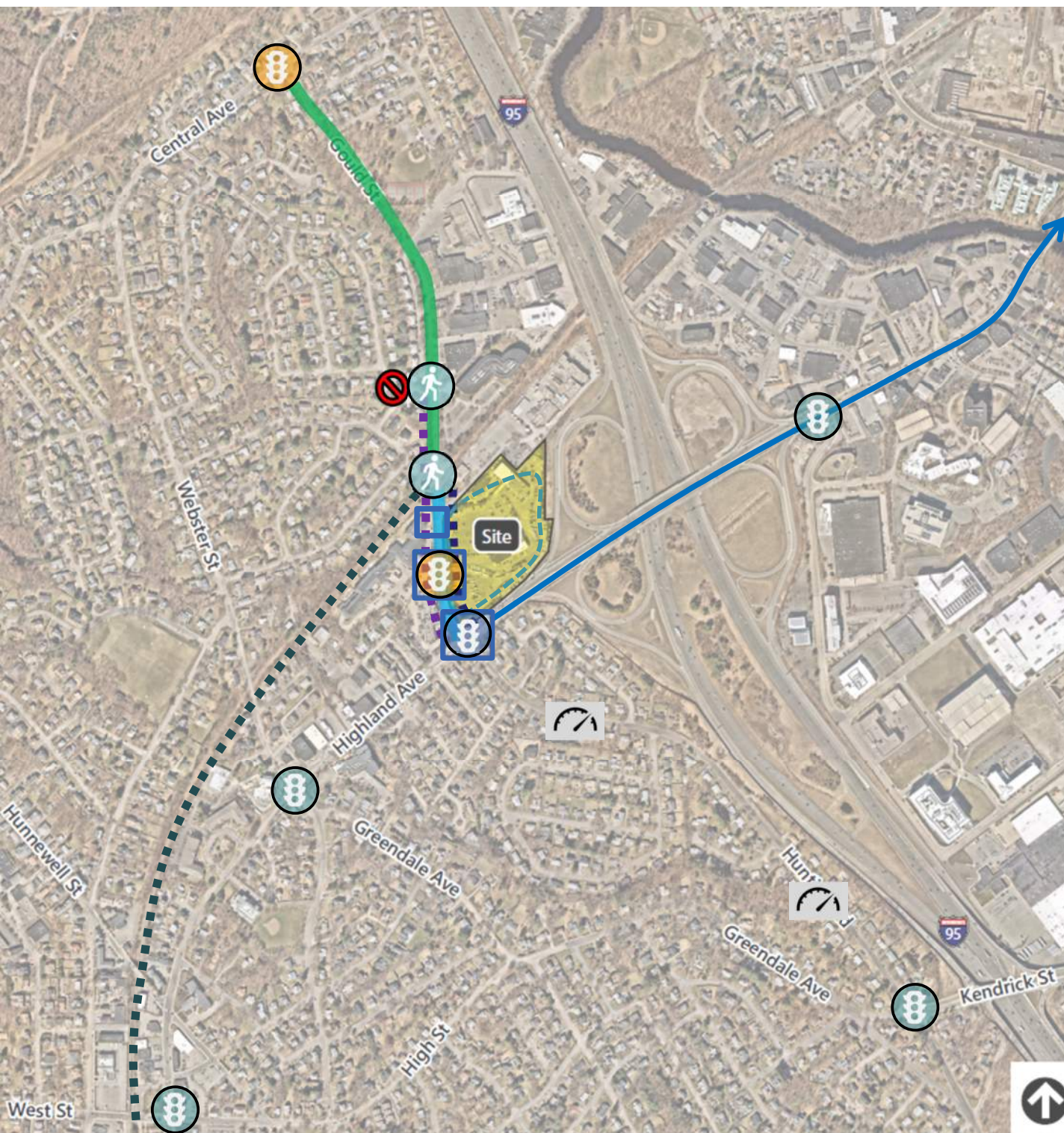
Use	Size (SF)	Employee/Patron Density ^a	VOR ^b	Parking Demand
Office	248,347	3.33/ksf	1.15	719 spaces
R&D	248,347	2.46/ksf	1.15	531 spaces
Retail	10,000	3.33/ksf	1.15	29 spaces
Total				1,279 spaces ^c

a – Based on Town of Needham zoning requirements for office and retail and employee density data from existing sites in Cambridge for R&D

b – Vehicle Occupancy Rates (VOR) based on Existing data for workplaces within Needham

c – Would result in parking rate of 2.52 spaces per kSF

Parking demand likely to be lower than 1,279 spaces due to transit/walk/bike commuters and hybrid work environment
*25% of all parking spaces to include **EV charging stations***



Mitigation Measures

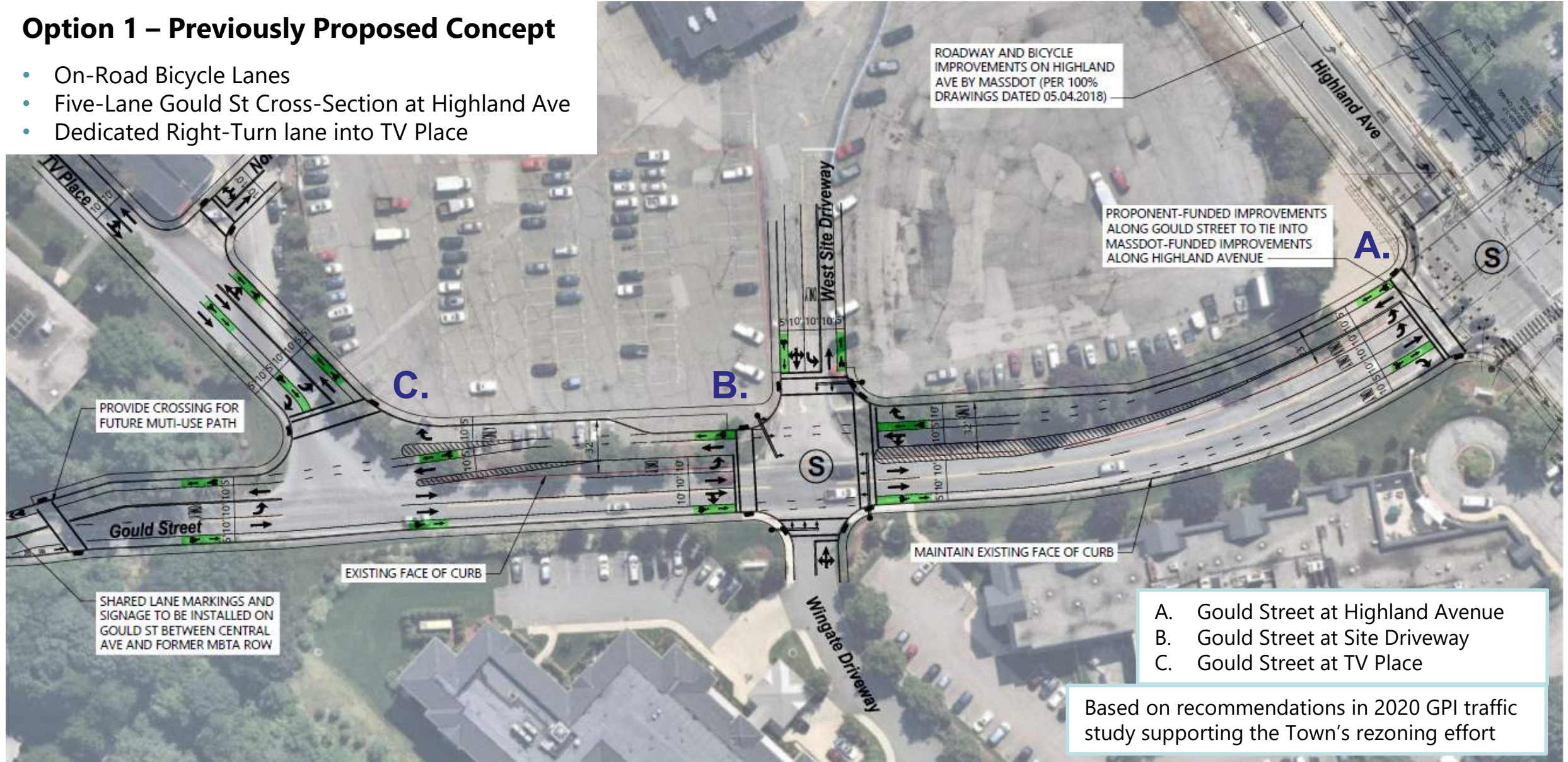
-  New traffic signal
-  Signal Timing and Equipment Improvement
-  Signal Timing Modifications
-  Geometric Improvements
-  Sidewalk Level Separated Bicycle Facilities
-  Shared Bicycle Lane Markings and Signage
-  Reconstruction of Sidewalk
-  New Pedestrian Facility
-  Pedestrian Infrastructure Improvements
-  Signage to deter cut-through traffic during peak hours
-  Installation of radar-embedded speed limit signs
-  On-Site Walking/Fitness Path
-  Shared Use Path Feasibility Study
-  Shuttle Service (Connection to Transit Station)

Transportation Mitigation | Gould Street

DRAFT – FOR PRELIMINARY DISCUSSION ONLY

Option 1 – Previously Proposed Concept

- On-Road Bicycle Lanes
- Five-Lane Gould St Cross-Section at Highland Ave
- Dedicated Right-Turn lane into TV Place



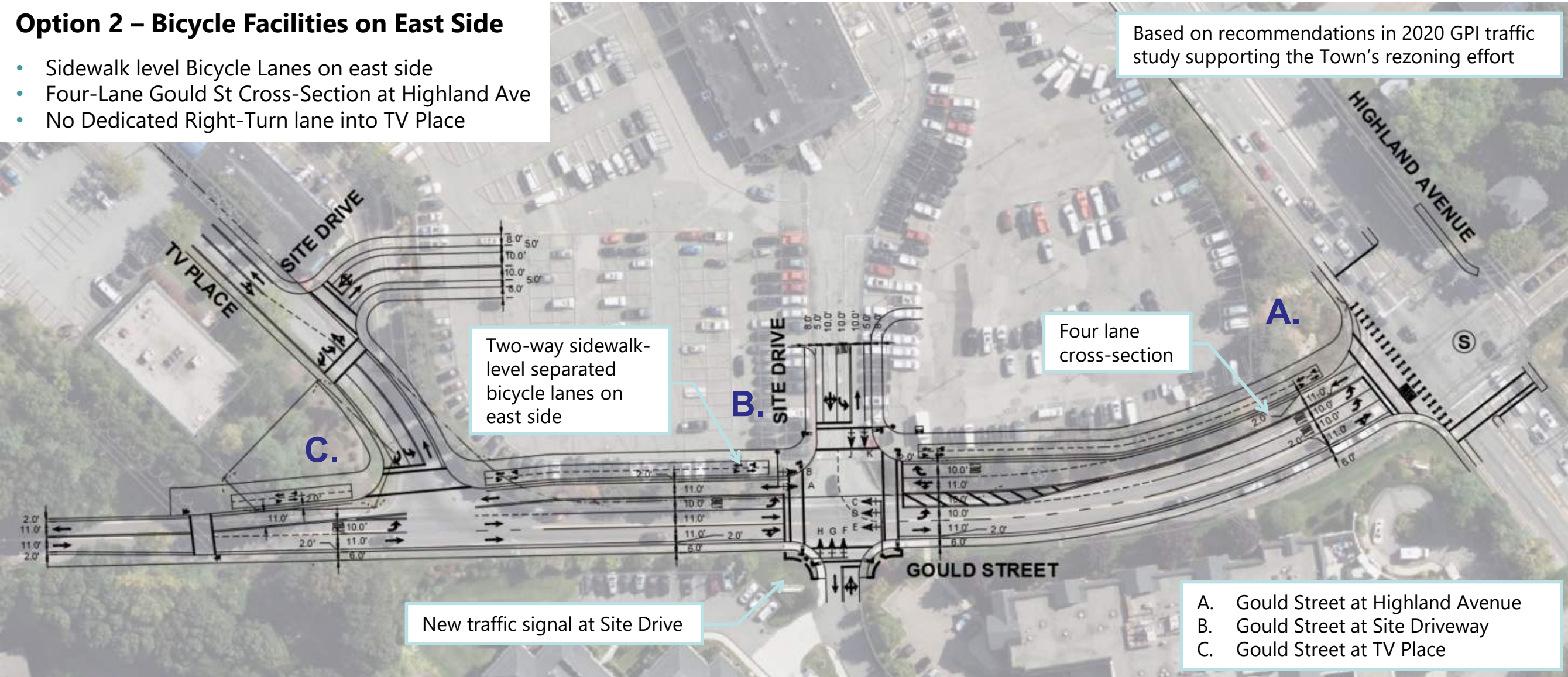
Transportation Mitigation | Gould Street

DRAFT – FOR PRELIMINARY DISCUSSION ONLY

Option 2 – Bicycle Facilities on East Side

- Sidewalk level Bicycle Lanes on east side
- Four-Lane Gould St Cross-Section at Highland Ave
- No Dedicated Right-Turn lane into TV Place

Based on recommendations in 2020 GPI traffic study supporting the Town's rezoning effort



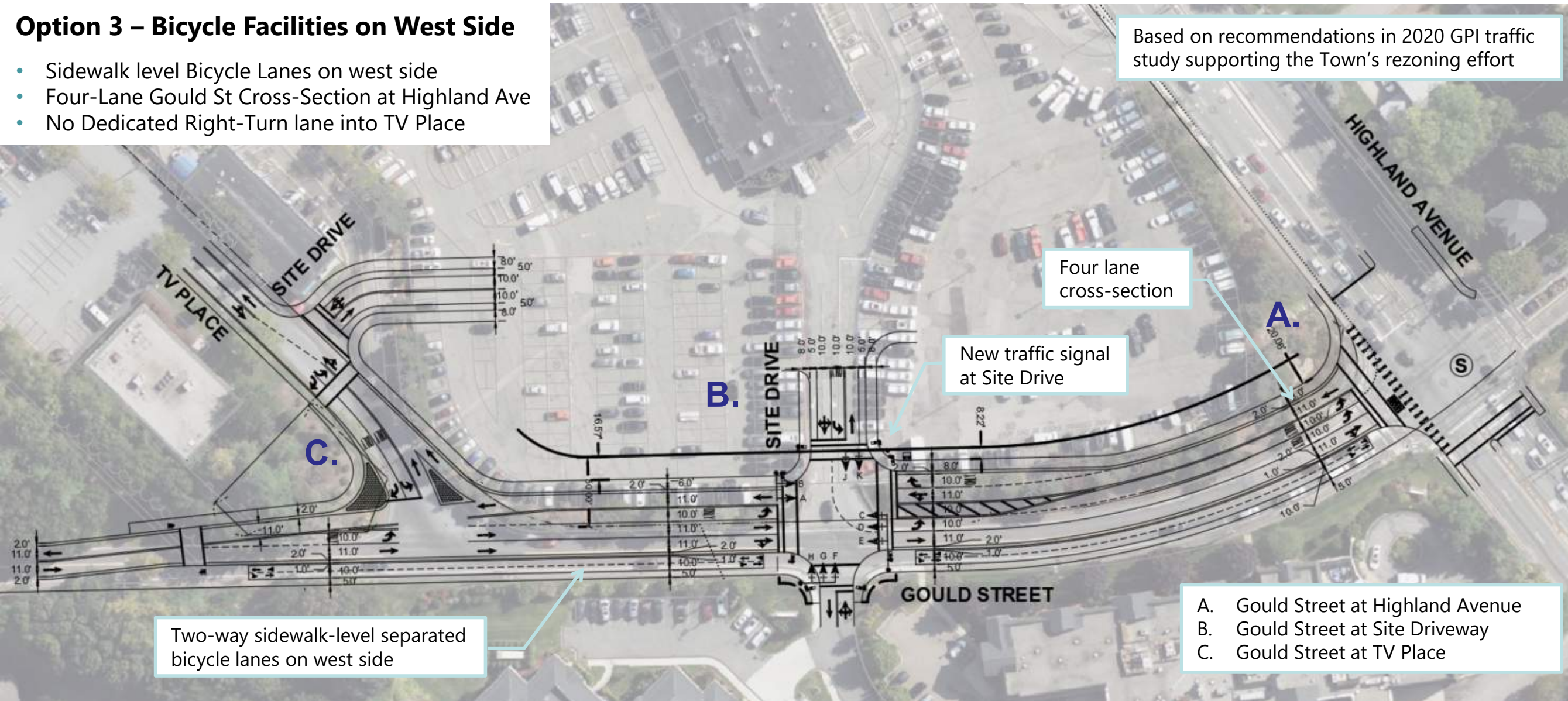
Transportation Mitigation | Gould Street

DRAFT – FOR PRELIMINARY DISCUSSION ONLY

Option 3 – Bicycle Facilities on West Side

- Sidewalk level Bicycle Lanes on west side
- Four-Lane Gould St Cross-Section at Highland Ave
- No Dedicated Right-Turn lane into TV Place

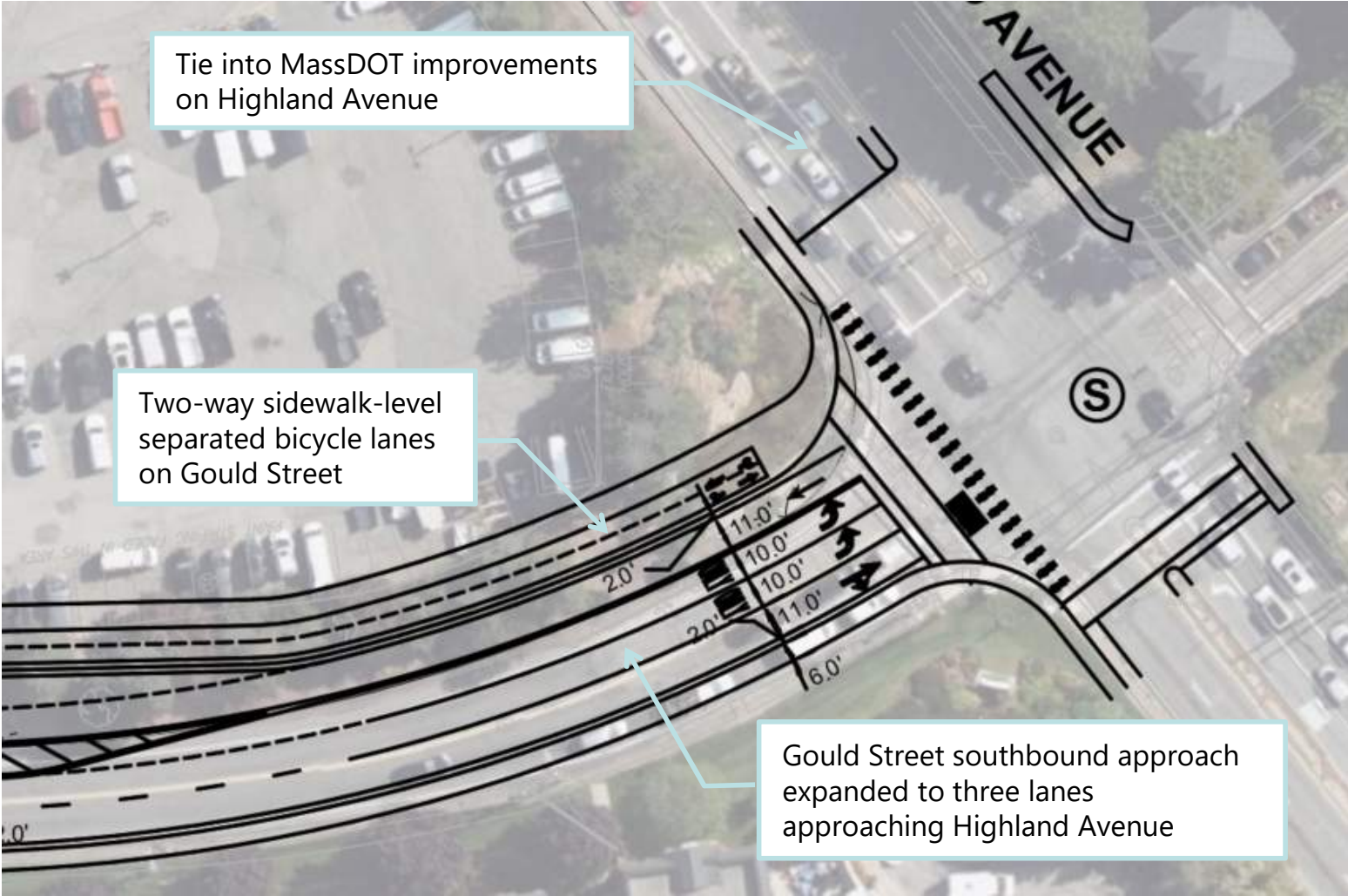
Based on recommendations in 2020 GPI traffic study supporting the Town's rezoning effort



Transportation Mitigation | Gould Street at Highland Avenue

DRAFT – FOR PRELIMINARY DISCUSSION ONLY

A.

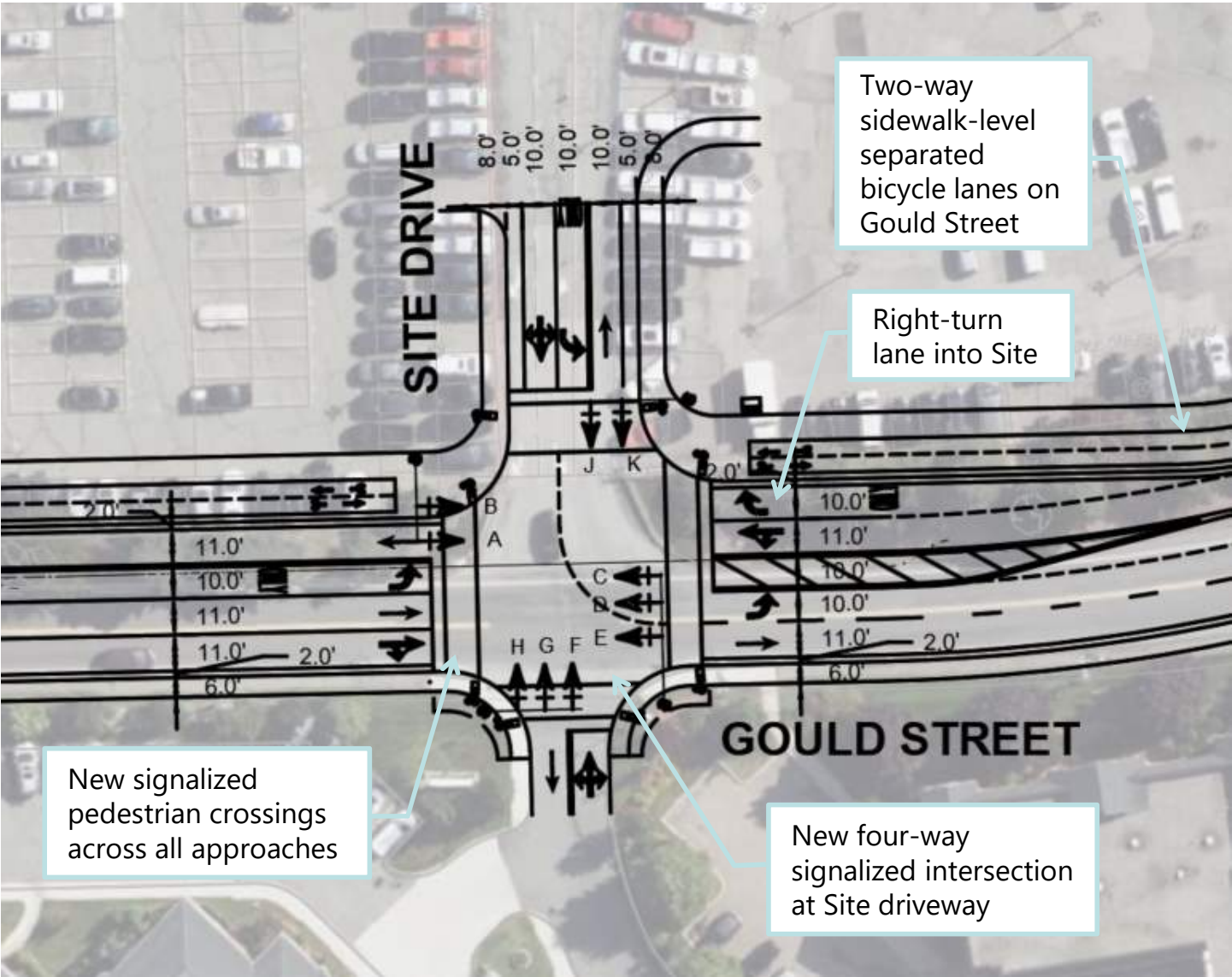


Option 2 (Separated bike facility on east side) shown for reference

Transportation Mitigation | Gould Street at Site Driveway

DRAFT – FOR PRELIMINARY DISCUSSION ONLY

B.

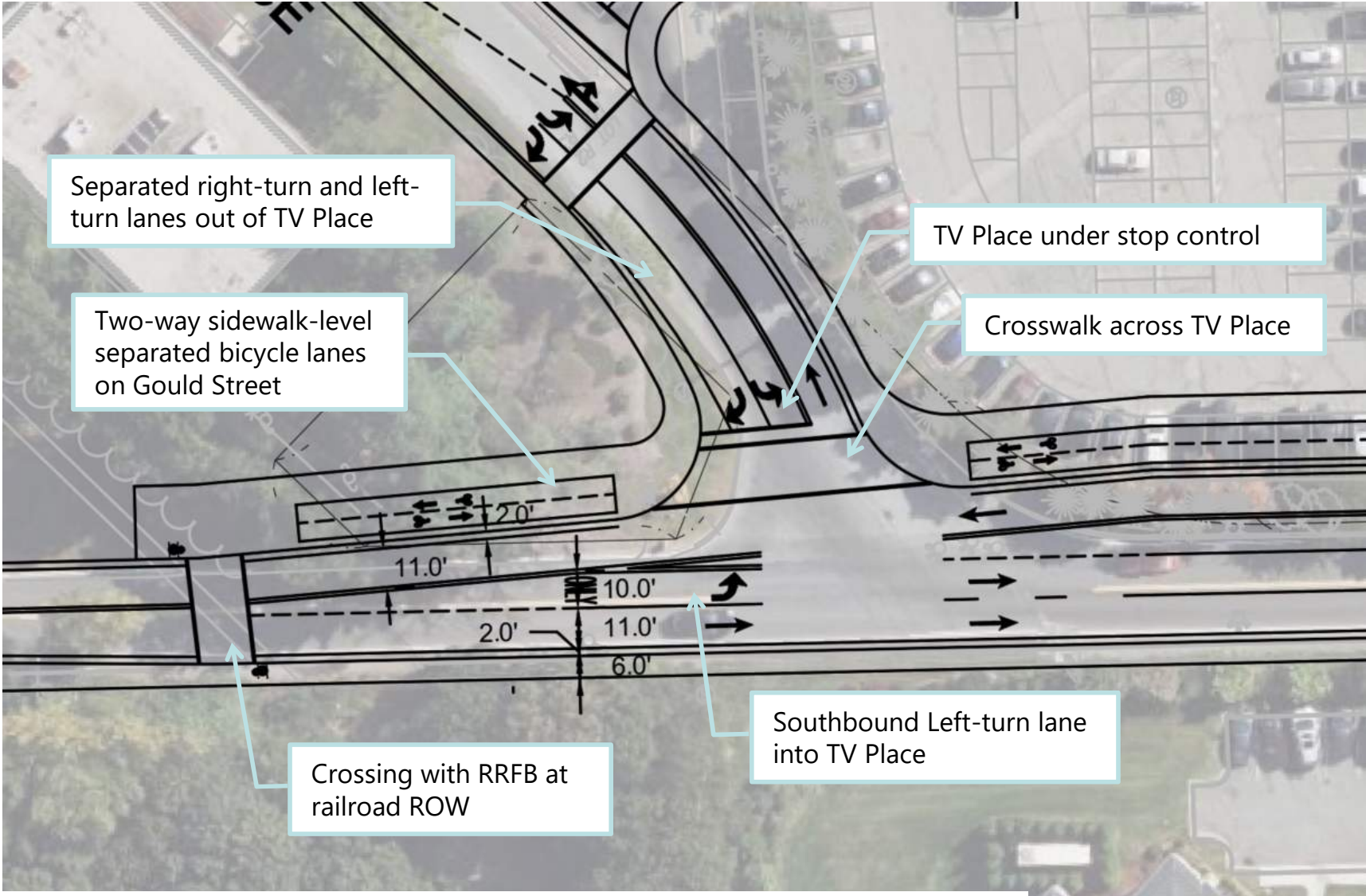


Option 2 (Separated bike facility on east side) shown for reference

Transportation Mitigation | Gould Street at TV Place

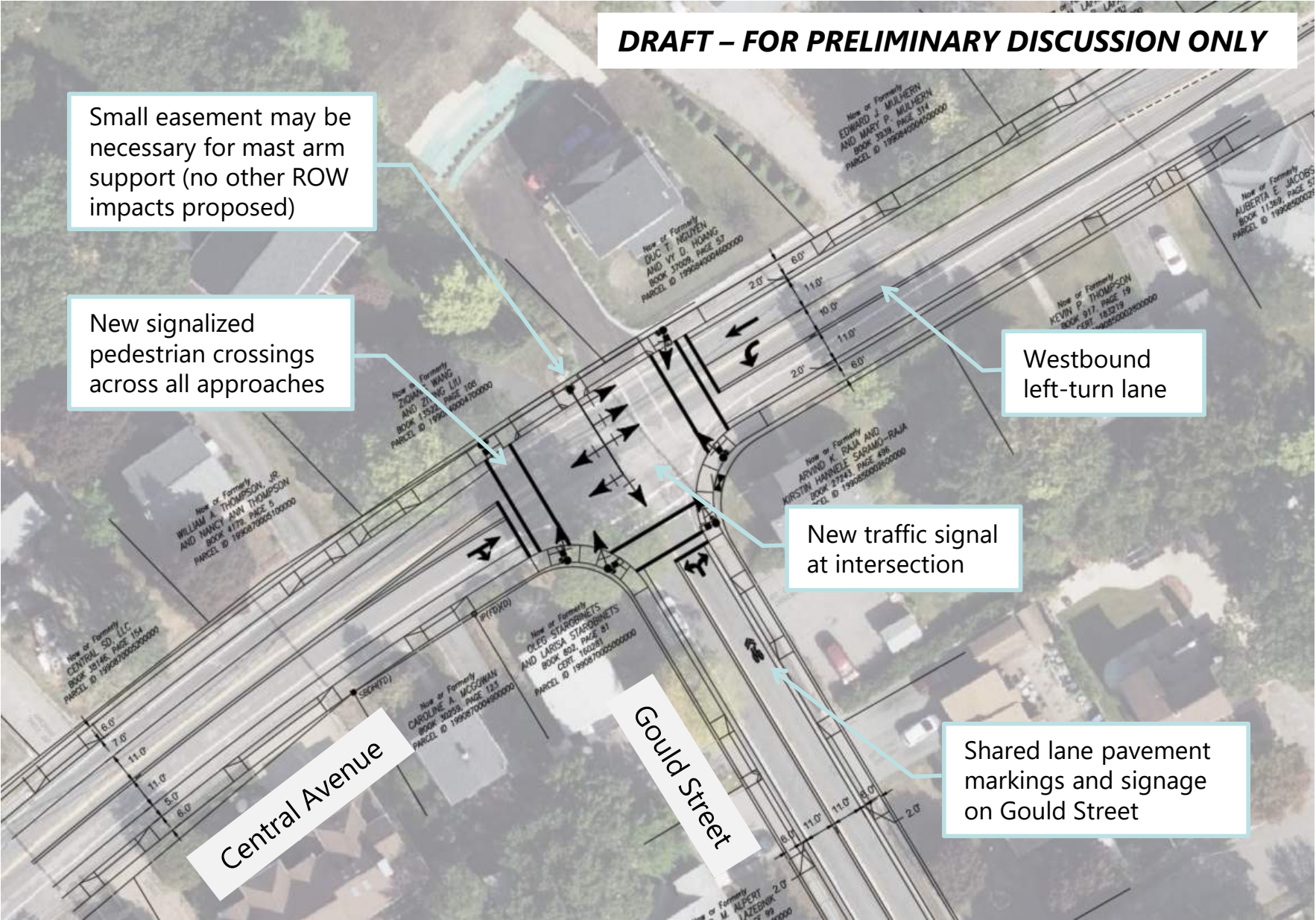
DRAFT – FOR PRELIMINARY DISCUSSION ONLY

C.



Option 2 (Separated bike facility on east side) shown for reference

Transportation Mitigation | Gould Street at Central Avenue



Transportation Mitigation | Pedestrian and Bicycle Accommodations

1. Up to **154 bicycle parking spaces** on-site
 - 104 secure spaces for employees in bike room
 - 50 spaces for visitors in outdoor public bike racks
2. Walking/fitness path on-site (0.5 miles) open to public
3. Construction of **two-way sidewalk-level separated bike lanes** on Gould Street between Highland Avenue and former MBTA ROW to provide a family-friendly facility
4. Full **Reconstruction of sidewalk** on west side of Gould Street between Highland Avenue and Noanett Road



Arsenal Street in Watertown, Massachusetts

Transportation Mitigation | Pedestrian and Bicycle Accommodations (cont.)

5. Support Town of Needham with additional funding for feasibility study of converting the former MBTA railroad ROW north of the Project Site into a **shared use path**
6. Construction of crosswalk across Gould Street at former MBTA ROW with **Rapid Rectangular Flashing Beacon (RRFB)** or **LED Warning signs**



Rapid Rectangular Flashing Beacon (RRFB)

LED lights flash only when the pedestrian push button is activated to warn drivers that a pedestrian is present in the crosswalk and lights flash only for the time needed to safely cross the roadway



LED Pedestrian Warning Sign

Illuminates 24/7 the pedestrian warning sign for added awareness

Transportation Mitigation | Transit Connection

- Direct connection to nearby public transit stations via an **electric shuttle**
- Potential connections to **Green Line D Branch** (at Newton Highlands) and/or **Commuter Rail** (at Needham Heights)
- Provides access to Site for employees who live closer to Boston



Transportation Mitigation | Noanett Road

Mitigation proposed based on feedback from neighborhood residents:

1. Reconfiguring the sidewalk ramps on the northwest and southwest corners of the intersection with Gould Street to be ADA accessible and striping of a crosswalk across the Noanett Road approach to Gould Street
2. Installing “Do Not Enter” signs between 7:00-10:00 AM and 3:00-6:00 PM such that the road will be limited to residents only – no through traffic.
3. Commissioning a police detail stationed in an unmarked cruiser, who will issue citations to violators upon opening of the project for the first three months and at such other intervals from time-to-time, as required (as done by the Proponent in Cambridge, MA on Acorn Park Drive)
4. Installing a traffic light at Gould Street and Central Avenue to facilitate traffic and encourage users to utilize the Gould/Central light in both directions.
5. Installing “Blind Driveway” signs and “Slow Children” signs as needed.



Example of peak period “Do Not Enter” sign in Cambridge, MA

Transportation Mitigation | Hunting Road



1. Speed limit signs with embedded radar
 - Alerts drivers to current speed in comparison to posted speed limit to try to slow speeds and increase driver awareness
 - Can be permanent or temporary installments
2. Intermittent police speed detail to enforce speed limit
3. Traffic monitoring to understand if cut-through traffic activity occurs and when
4. Installing directional signage to deter through traffic on Hunting Road

Transportation Mitigation | Sachem Road



Transportation Demand Management (TDM)

Proposed Measures

1. Shuttle Service to nearby transit stations
2. Transportation Employee Advisor
3. Secure/Indoor bicycle parking (104 spaces)
4. 50-percent transit pass subsidy
5. Emergency ride home
6. Carpool assistance and incentives
7. Bicycling/walking incentives and amenities
8. On-site locker rooms and showers
9. On-site amenities for employees to reduce midday trips
10. Telecommuting and compressed workweeks
11. Display real-time transportation-related information
12. Promotional efforts
13. EV charging stations (25-percent of all spaces)

Transportation Management Association (TMA):

The Proponent will join and become an active member of the 128 Business Council.

Transportation Monitoring:

Annual traffic collection program for five year, including:

- Parking garage counts
- Intersection counts at four off-site locations
- Intersection capacity analyses
- Travel survey of employees and patrons

Proponent will work with Town of Needham on monitoring commitment to not exceed projected trip generation

Project Mitigation Summary

Sustainable Transportation Modes:



- Gould St sidewalk level separated bicycle facilities between Highland Ave and former MBTA ROW
- Gould St shared lane markings and signage between former MBTA ROW and Central Ave
- Reconstruction of the sidewalk on the west side of Gould St between Highland Ave and Noanett Road
- Construction of a new pedestrian facility on the east side of Gould St along Site frontage
- New crossing of Gould St at former MBTA ROW with rectangular rapid flashing beacons
- Reconfiguring the sidewalk ramps on the corners of Noanett Rd and Gould St
- Support Town of Needham with Shared use path feasibility study for former MBTA ROW
- Transit connector shuttle service (with electric shuttle)

Targeted Intersection/Signal/Roadway Improvements:



- Highland Ave at Gould St/Hunting Rd: Geometric improvements, signal timing and equipment improvements, expansion of Gould St SB approach, and pedestrian infrastructure improvements
- Central Ave at Gould St: Traffic signal installation and pedestrian infrastructure improvements
- Gould St at Site Driveway/Wingate Driveway: Traffic signal installation, expansion of Gould St cross-section, and pedestrian infrastructure improvements
- Gould St at TV Place: Geometric improvements
- Signal timing modifications at Highland Ave at West St, at Webster St, at 1st Ave, and Hunting Rd at Kendrick St



Speed and Traffic Calming:

- Installation of signage to deter cut-through traffic during the peak hours at Noanett Rd
- Installation of two radar-embedded speed limit signs on Hunting Rd to encourage lower vehicle speeds

FOR ANY QUESTIONS, PLEASE E-MAIL
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Offices located throughout the east coast

PUBLIC BENEFITS

- Bicycle lanes incorporated into site circulation
- Plaza adjacent to public retail amenities
- Enhanced pedestrian accessibility
- Ground level activation with retail and community space at the corner of Gould Street and Highland Avenue
- Provide approximately 1,250 permanent jobs at full occupancy
- Provide 300 construction jobs
- Tax revenue of approximately \$5 million (annually), to support Town of Needham's educational and recreational programs, housing initiatives, community and open spaces, and other Town priorities
- Improved water quality and stormwater management
- Improved open space along Highland Avenue



Q+A

