

**Transit-Oriented Development (TOD):  
An approach to revitalize the Gateway City of Lowell, MA**

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## **Abstract**

The main idea of my thesis is to research transit-oriented development and propose recommendations for the Gateway City of Lowell, Massachusetts to implement TOD. I looked into the existing literature available on TOD, and similar gateway cities that have or are considering potential TODs to understand their strategies towards development.

Understanding the market and planning developments is helpful in deciding the types of developments to encourage in a city, and hence, the market and demographics of the area around Lowell's Gallagher Terminal are discussed. Similarly, the foot traffic in a city is an important aspect to consider analyzing how to attract more of it to existing points of interest and to identify gaps. A before and after analysis could also be conducted to account for how foot traffic has increased or decreased after the implementation of TOD. In addition to reviewing the literature and analyses that are helpful in understanding TOD, talking to experts in the field about their experience working on projects in gateway cities and TOD gives insights into implementation. And hence, I interviewed 11 people from various agencies and gateway cities to learn about TOD from their experience. And finally, I discussed the findings and proposed recommendations to the city of Lowell based on the knowledge gained from the various methods used in this research.

The City of Lowell has been doing some robust mixed-use development and I hope that my thesis findings and recommendations add value to their ongoing work.

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# Table of Contents

<b>Chapter 1 Introduction</b> .....	<b>1</b>
<b>Transit-Oriented Development (TOD)</b> .....	<b>1</b>
<i>Thesis Overview</i> .....	1
<i>Research questions</i> .....	2
<i>Methods</i> .....	2
<b>Background</b> .....	<b>2</b>
<i>Walkable Communities</i> .....	2
<i>Streetcar suburbs as TODs</i> .....	3
<i>TOD today</i> .....	4
<b>Study Area</b> .....	<b>5</b>
<i>Gateway Cities</i> .....	5
<i>TOD in Lowell</i> .....	7
<i>Opportunity Zones</i> .....	7
<i>Thorndike Exchange</i> .....	8
<i>Hamilton Canal Innovation District</i> .....	10
<i>Brief history of Lowell</i> .....	12
<b>Chapter 2 Literature review</b> .....	<b>14</b>
Walkability .....	14
Influence of location on walkability.....	16
Path walkability indicators.....	17
Shuttles and feeder buses.....	21
Bikeability.....	21
Historic preservation.....	22
Gentrification .....	24
Coordinated planning of land use and transportation .....	27
Housing policy in TOD .....	32
MBTA Communities .....	34
Benefits of TOD .....	38
<b>Chapter 3 Case Studies</b> .....	<b>41</b>
<i>Zoning changes</i> .....	46
Building Worcester .....	47
Past and recent plans.....	48

Worcester Now   Worcester Next .....	48
Union Station Accessibility Improvements .....	50
<i>Ownership</i> .....	52
CitySquare .....	53
Brockton Station .....	56
Downtown Urban Revitalization Plan .....	59
Downtown Trout Brook (CSX Area) Master Plan .....	62
Opportunity Zones .....	65
<i>Downtown Brockton developments</i> .....	66
Wayfinding in Brockton .....	69
<b>Chapter 4 Demographic, Mobility, and Market Trends .....</b>	<b>75</b>
Demographics and socio-economic trends .....	75
Transportation and commuting patterns .....	79
Walk, bike and transit score .....	81
Retail trends (from 2017) .....	89
Housing market trends .....	91
Demographics around Gallagher Terminal .....	93
Conclusion .....	96
<b>Chapter 5 Foot traffic analysis .....</b>	<b>97</b>
What is foot traffic analysis? Why is it important to measure it? .....	97
Study area .....	98
Why Brockton? .....	99
Data .....	99
Methods .....	100
Analysis part 2: To map POI data for Lowell and Brockton based on foot traffic analysis .....	112
Inferences based on the analysis .....	116
<b>Chapter 6 Recommendations .....</b>	<b>118</b>
<b>Chapter 7 Limitations and areas for future research .....</b>	<b>135</b>
<i>Market analysis</i> .....	135
<i>Foot traffic analysis</i> .....	135
<b>Appendices .....</b>	<b>138</b>
<b>Appendix A .....</b>	<b>138</b>
Foot traffic analysis data .....	138

<b>Appendix B</b> .....	<b>140</b>
<i>List of interviewees and their role/designation</i> .....	140
<b>Appendix C</b> .....	<b>141</b>
<i>Sample interview questions</i> .....	141
<b>Bibliography</b> .....	<b>142</b>

## List of tables

Table 1. Multifamily district housing unit capacity requirement for Lowell, Brockton, and Worcester as MBTA communities.....	36
Table 2. Demographic characteristics of Lowell, Worcester, and Brockton, MA.....	41
Table 3. Properties under development in the Downtown Brockton Opportunity Zone.....	68
Table 4. Incentives available for development projects in Brockton.....	69
Table 5. Modes of transportation and travel time to work in Lowell, MA.....	81
Table 6. Population, distance from Gallagher Terminal, and walk/transit/bike scores of Lowell and its central neighborhoods.....	87
Table 7. Population, distance from Union Station, and walk/transit/bike scores of Worcester and its central neighborhoods.....	87
Table 8. Population, distance from Brockton Station, and walk/transit/bike scores of Brockton and its two zip code areas.....	88
Table 9. Summary of walk/transit/bike scores for Lowell, Worcester, and Brockton.....	88
Table 10. Retail market profile of Lowell, MA.....	89
Table 11. Summary of demographic information for the area within 0-0.5 mile radius of Gallagher Terminal in Lowell.....	93
Table 12. Summary of demographic information for the area within 0.5-1 mile radius of Gallagher Terminal in Lowell.....	94
Table 13. Durations of study in Lowell and Brockton.....	100
Table 14. Total number of Point-Of-Interest data points available for Lowell and Brockton, during spring, summer, and fall periods, 2020.....	101
Table 15. Rank 1 sectors of Point-Of-Interest data points for Lowell and Brockton, during spring, summer, and fall periods, 2020.....	108
Table 16. Rank 2 sectors of Point-Of-Interest data points for Lowell and Brockton, during spring, summer, and fall periods, 2020.....	108
Table 17. Rank 3 sectors of Point-Of-Interest data points for Lowell and Brockton, during spring, summer, and fall periods, 2020.....	108
Table 18. Rank 4 sectors of Point-Of-Interest data points for Lowell and Brockton, during spring, summer, and fall periods, 2020.....	109
Table 19. Rank 5 sectors of Point-Of-Interest data points for Lowell and Brockton, during spring, summer, and fall periods, 2020.....	109
Table 20. Percentage of Point-Of-Interest data points within 0.5 mile radius of the transit terminal in Lowell and Brockton, MA, out of all POI data points in each city.....	115

## List of figures

Figure 1. Gateway cities in Massachusetts. Source: Wikipedia. <a href="https://en.wikipedia.org/wiki/Massachusetts_gateway_cities">https://en.wikipedia.org/wiki/Massachusetts_gateway_cities</a> .....	6
Figure 2. Thorndike Exchange, a mixed-use development next to Gallagher Terminal in Lowell. Source: BLDUP. <a href="https://www.bldup.com/posts/thorndike-exchange-sold-for-33-3-million-in-lowell">https://www.bldup.com/posts/thorndike-exchange-sold-for-33-3-million-in-lowell</a> .....	9
Figure 3. Proposed developments in Hamilton Canal Innovation District, Lowell. Source: WordPress. <a href="https://returntoroom50.wordpress.com/2019/08/29/breaking-new-ground-in-the-hamilton-canal-innovation-district/">https://returntoroom50.wordpress.com/2019/08/29/breaking-new-ground-in-the-hamilton-canal-innovation-district/</a> .....	11
Figure 4. 201 Canal, a 125-unit housing development by Winn Companies, opened in 2022 in Lowell’s Hamilton Canal Innovation District. Source of the rendering: MassHousing. <a href="https://www.masshousing.com/press/2020-06-11-Hamilton-Canal">https://www.masshousing.com/press/2020-06-11-Hamilton-Canal</a> .....	12
Figure 5. Transit-Oriented Development catchment area (half-mile radius) in Lowell as defined by Transit-Oriented Development Explorer (TODEX MA). Source: TODEX MA. <a href="https://mhpcenterforhousingdata.shinyapps.io/todex/">https://mhpcenterforhousingdata.shinyapps.io/todex/</a> .....	15
Figure 6. Path walkability indicators. Source: Park, Choi, and Lee. 2017. p. 482. <a href="https://www.tandfonline-com.ezproxy.library.tufts.edu/doi/full/10.1080/15568318.2016.1226996">https://www.tandfonline-com.ezproxy.library.tufts.edu/doi/full/10.1080/15568318.2016.1226996</a> .....	18

Figure 7. Path walkability indicators. Source: Park 2008, p. 140.  
<https://escholarship.org/content/qt0ct7c30p/qt0ct7c30p.pdf?t=krncu6&v=lg>.....19

Figure 8. Path walkability indicators. Source: Park 2008, pp. 116-119.  
<https://escholarship.org/content/qt0ct7c30p/qt0ct7c30p.pdf?t=krncu6&v=lg>.....20

Figure 9. A typical land use arrangement around a transit station. Source: Sahu. 2018. p. 474. <https://www-sciencedirect-com.ezproxy.library.tufts.edu/science/article/pii/S0301479717311660>.....28

Figure 10. Components of a mid-rise neighborhood. Source: Burda and Collins-Williams. 2015. p. 2. [https://www-istor-org.ezproxy.library.tufts.edu/stable/pdf/resrep00235.pdf?ab\\_segments=0percent2Fbasic\\_search\\_gsv2percent2Fcontrol&refreqid=fastly-defaultpercent3Adb7fe3d1f56cd9c6fb8cec84c38b4eee](https://www-istor-org.ezproxy.library.tufts.edu/stable/pdf/resrep00235.pdf?ab_segments=0percent2Fbasic_search_gsv2percent2Fcontrol&refreqid=fastly-defaultpercent3Adb7fe3d1f56cd9c6fb8cec84c38b4eee).....31

Figure 11. MBTA communities in Massachusetts. Source: Commonwealth of Massachusetts 2022.  
<https://www.mass.gov/info-details/multi-family-zoning-requirement-for-mbta-communities#what-is-an-%22mbta-community%22?>.....35

Figure 12. Location map of Union Station in Worcester. The station (blue pin) is east of Worcester Common, Main Street, and the Central Business District. Source: Wikimedia Commons.  
[https://commons.wikimedia.org/wiki/Category:Union\\_Station\\_\(Worcester,\\_Massachusetts\)#/map/0/18/42.26001/-71.79502](https://commons.wikimedia.org/wiki/Category:Union_Station_(Worcester,_Massachusetts)#/map/0/18/42.26001/-71.79502).....44

Figure 13. (left) Existing Union Station in Worcester. Source: MassLive 2021.  
<https://www.masslive.com/worcester/2021/02/union-station-in-worcester-recognized-as-one-of-most-beautiful-train-stations-in-us.html>; (right) Union Station from 1875. Source: Wikipedia.  
[https://en.wikipedia.org/wiki/Union\\_Station\\_\(Worcester,\\_Massachusetts\)](https://en.wikipedia.org/wiki/Union_Station_(Worcester,_Massachusetts)).....44

Figure 14. Worcester Union Station parking garage. Source: City of Worcester.  
<https://www.worcesterma.gov/parking/municipal-garages>.....45

Figure 15. Union Station TOD area in Worcester: development within a half-mile radius. Source: CRCOG 2021.  
[https://crocog.org/wp-content/uploads/2021/04/CRCOG\\_Final-Report\\_V6\\_042921.pdf](https://crocog.org/wp-content/uploads/2021/04/CRCOG_Final-Report_V6_042921.pdf).....47

Figure 16. Map of Union Station and major land uses in Worcester. Source: Worcester Now | Worcester Next.  
<https://now-next.worcesterma.gov/about/>.....49

Figure 17. Existing Worcester Union Station. Source: MBTA 2019.  
<https://cdn.mbta.com/sites/default/files/projects/worcester-union/2019-06-06-worcester-union-stakeholder-meeting-accessible.pdf>.....50

Figure 18. Worcester Union Station Project area. Source: MBTA 2020.  
<https://cdn.mbta.com/sites/default/files/2020-05/2020-05-27-worcester-union-public-meeting-presentation-accessible-v2.pdf>.....51

Figure 19. Worcester Union Station existing and project proposal. Source: MBTA 2020.  
<https://cdn.mbta.com/sites/default/files/2020-05/2020-05-27-worcester-union-public-meeting-presentation-accessible-v2.pdf>.....51

Figure 20. Rendering of proposed improvements to the platform. Source: MBTA 2022.  
<https://www.mbta.com/projects/worcester-union-station-improvements> .....52

Figure 21: Renderings of proposed improvements to the Worcester Union Station. Source: MBTA 2022.  
<https://www.mbta.com/projects/worcester-union-station-improvements>.....52

Figure 22. Ownership of parcels in and around Worcester Union Station. Source: MBTA 2019.  
<https://d2o8eokdkim9o8.cloudfront.net/sites/default/files/projects/worcester-union/2019-06-06-worcester-union-stakeholder-meeting-accessible.pdf>.....53

Figure 23. CitySquare and Mercantile Center mixed-use developments near Worcester Union Station. Source: Leggat McCall. <https://www.lmp.com/city-square/>.....54

Figure 24. Location map of Brockton Station in Brockton, Massachusetts. Source: Wayfinding Presentation 2020.  
<https://brockton.ma.us/wp-content/uploads/2020/03/Wayfinding-Public-Presentation.pdf>.....57

Figure 25. (left): The one-story North Bridgewater station (1846) as seen around 1880; (right): the Victorian-style Brockton station (1878) before it was replaced in the 1890s. Source: Wikipedia.  
[https://en.wikipedia.org/wiki/Brockton\\_station\\_\(MBTA\)](https://en.wikipedia.org/wiki/Brockton_station_(MBTA)).....58

Figure 26. Brockton commuter rail station. Source: Wikipedia.  
[https://en.wikipedia.org/wiki/Brockton\\_station\\_\(MBTA\)](https://en.wikipedia.org/wiki/Brockton_station_(MBTA)).....59

Figure 27. Downtown Brockton Urban Revitalization Area. Source: Modified by author from Downtown Brockton URP 2016. [https://drive.google.com/file/d/1jduOGaMdeBa\\_Butw49xgWgzbw38V-J7c/view](https://drive.google.com/file/d/1jduOGaMdeBa_Butw49xgWgzbw38V-J7c/view).....60

Figure 28. Building footprints and off-street parking areas. Source: Downtown Brockton URP 2016. [https://drive.google.com/file/d/1jduOGaMdeBa\\_Butw49xgWgzbw38V-J7c/view](https://drive.google.com/file/d/1jduOGaMdeBa_Butw49xgWgzbw38V-J7c/view).....60

Figure 29. Existing land use. Source: Downtown Brockton URP 2016. [https://drive.google.com/file/d/1jduOGaMdeBa\\_Butw49xgWgzbw38V-J7c/view](https://drive.google.com/file/d/1jduOGaMdeBa_Butw49xgWgzbw38V-J7c/view).....61

Figure 30. Existing zoning. Source: Downtown Brockton URP 2016. [https://drive.google.com/file/d/1jduOGaMdeBa\\_Butw49xgWgzbw38V-J7c/view](https://drive.google.com/file/d/1jduOGaMdeBa_Butw49xgWgzbw38V-J7c/view).....61

Figure 31. Existing conditions in the Downtown Brockton Urban Revitalization District. Source: URP 2016. [https://drive.google.com/file/d/1jduOGaMdeBa\\_Butw49xgWgzbw38V-J7c/view](https://drive.google.com/file/d/1jduOGaMdeBa_Butw49xgWgzbw38V-J7c/view).....62

Figure 32. City of Brockton Conceptual Plan for the Downtown Trout Brook Redevelopment Plan. Source: BRA 2020. <https://brocktonredevelopmentauthority.files.wordpress.com/2020/02/trout-brook-redevelopment-district-rloi.pdf>.....63

Figure 33. TOD opportunities. Source: Brockton Prospectus 2019. [https://www.metroouthchamber.com/wp-content/uploads/2019/07/20190620-Brockton\\_Prospectus-Final\\_reducedsize.pdf](https://www.metroouthchamber.com/wp-content/uploads/2019/07/20190620-Brockton_Prospectus-Final_reducedsize.pdf) .....65

Figure 34. Opportunity zones in Brockton. Source: Brockton Prospectus 2019. [https://www.metroouthchamber.com/wp-content/uploads/2019/07/20190620-Brockton\\_Prospectus-Final\\_reducedsize.pdf](https://www.metroouthchamber.com/wp-content/uploads/2019/07/20190620-Brockton_Prospectus-Final_reducedsize.pdf).....66

Figure 35. Completed, Under Construction, and Planned Projects in Downtown Brockton and other Opportunity Zones. Source: Brockton Prospectus 2019. [https://www.metroouthchamber.com/wp-content/uploads/2019/07/20190620-Brockton\\_Prospectus-Final\\_reducedsize.pdf](https://www.metroouthchamber.com/wp-content/uploads/2019/07/20190620-Brockton_Prospectus-Final_reducedsize.pdf).....67

Figure 36. (left) 19 Main St; (middle) 8-66 Montello St; (right) 11, 15, 28 High St. Source: Brockton Prospectus 2019. [https://www.metroouthchamber.com/wp-content/uploads/2019/07/20190620-Brockton\\_Prospectus-Final\\_reducedsize.pdf](https://www.metroouthchamber.com/wp-content/uploads/2019/07/20190620-Brockton_Prospectus-Final_reducedsize.pdf) .....69

Figure 37. Transition from city boundary to Downtown Brockton. Source: Harriman 2020. <https://brockton.ma.us/wp-content/uploads/2020/03/Wayfinding-Public-Presentation.pdf>.....70

Figure 38. Districts to identify with wayfinding and signage within ½ mile of Brockton Station. Source: Harriman 2020. <https://brockton.ma.us/wp-content/uploads/2020/03/Wayfinding-Public-Presentation.pdf>.....71

Figure 39. Access points to Downtown destinations by different modes of transportation within ½ mile of Brockton Station. Source: Harriman 2020. <https://brockton.ma.us/wp-content/uploads/2020/03/Wayfinding-Public-Presentation.pdf>.....71

Figure 40. Existing signage in Brockton. Source: Modified by author from Harriman 2020. <https://brockton.ma.us/wp-content/uploads/2020/03/Wayfinding-Public-Presentation.pdf>.....72

Figure 41. Examples of signage precedents by scale recommended for Brockton. Source: Modified by author from Harriman 2020. <https://brockton.ma.us/wp-content/uploads/2020/03/Wayfinding-Public-Presentation.pdf>.....73

Figure 42. Phases of a wayfinding project. Source: Made by author from Harriman 2020. Phases 3 through 5 are dependent on future funding. <https://brockton.ma.us/wp-content/uploads/2020/03/Wayfinding-Public-Presentation.pdf>.....74

Figure 43. Demographic profile of City of Lowell. Source: ArcGIS Business Analyst 2021.....76

Figure 44. (left) Household income of residents of Lowell in 2021; (right) Racial groups in Lowell in 2021. Source: ArcGIS Business Analyst 2021.....76

Figure 45. Population of Lowell based on age in 2021. Source: ArcGIS Business Analyst 2021.....76

Figure 46. At risk population profile of City of Lowell. Source: ArcGIS Business Analyst 2021.....77

Figure 47. Modes of transportation and travel time to work. Source: ArcGIS Business Analyst 2021.....80

Figure 48. Walk, transit, and bike scores for the City of Lowell by WalkScore. Source: WalkScore. <https://www.walkscore.com/MA/Lowell>.....82

Figure 49. Lowell Neighborhoods Map. Source: City of Lowell website. <https://www.lowellma.gov/DocumentCenter/View/382/City-Neighborhood-Map-PDF>.....82

Figure 50. Maps and walk/transit/bike scores of Lowell’s central neighborhoods. Source: WalkScore <a href="https://www.walkscore.com/MA/Lowell/Downtown">https://www.walkscore.com/MA/Lowell/Downtown</a> ; <a href="https://www.walkscore.com/MA/Lowell/Back_Central">https://www.walkscore.com/MA/Lowell/Back_Central</a> ; <a href="https://www.walkscore.com/MA/Lowell/The_Acre">https://www.walkscore.com/MA/Lowell/The_Acre</a> .....	83
Figure 51. Walk score for the City of Lowell. Source: WalkScore. <a href="https://www.walkscore.com/MA/Lowell">https://www.walkscore.com/MA/Lowell</a> .....	84
Figure 52. Walk score and corresponding description for evaluation. Source: WalkScore. <a href="https://www.walkscore.com/methodology">https://www.walkscore.com/methodology</a> .....	85
Figure 53. Transit score and corresponding description for evaluation. Source: WalkScore. <a href="https://www.walkscore.com/methodology">https://www.walkscore.com/methodology</a> .....	86
Figure 54. Bike score and corresponding description for evaluation. Source: WalkScore. <a href="https://www.walkscore.com/methodology">https://www.walkscore.com/methodology</a> .....	86
Figure 55. Lowell Neighborhoods Map. Source: City of Lowell website. <a href="https://www.lowellma.gov/DocumentCenter/View/382/City-Neighborhood-Map-PDF">https://www.lowellma.gov/DocumentCenter/View/382/City-Neighborhood-Map-PDF</a> .....	91
Figure 56. Highest appreciating Lowell neighborhoods since 2000. Source: Modified by author from Neighborhood Scout. <a href="https://www.neighborhoodscout.com/ma/lowell/real-estate">https://www.neighborhoodscout.com/ma/lowell/real-estate</a> .....	92
Figure 57. Areas within a half-mile radius (inner circle) and one-mile radius (outer circle) of Gallagher Terminal in Lowell. Source: Map Developers. <a href="https://www.mapdevelopers.com/draw-circle-tool.php">https://www.mapdevelopers.com/draw-circle-tool.php</a> .....	93
Figure 58. Home value for the area within (left) 0-0.5 mile and (right) 0.5-1 mile radius of Gallagher Terminal in Lowell. Source: ArcGIS Business Analyst 2021.....	95
Figure 59. Annual growth rate for the area within 0-0.5 mile radius of Gallagher Terminal in Lowell. Source: ArcGIS Business Analyst 2021.....	95
Figure 60. Home value for the area within 0.5-1 mile radius of Gallagher Terminal in Lowell. Source: ArcGIS Business Analyst 2021.....	95
Figure 61. Macro-level study site and comparison site for foot traffic analysis. Source: Modified by author from Wikipedia. <a href="https://en.wikipedia.org/wiki/Massachusetts_gateway_cities">https://en.wikipedia.org/wiki/Massachusetts_gateway_cities</a> .....	96
Figure 62. Micro-level study site and comparison site for foot traffic analysis. Source: Modified by author from Wikipedia (same scale). <a href="https://en.wikipedia.org/wiki/Massachusetts_gateway_cities">https://en.wikipedia.org/wiki/Massachusetts_gateway_cities</a> .....	96
Figure 63. Distribution of top 60 percent of visited locations in Lowell, MA during May 18-25, 2020, by NAICS code. Source: SafeGraph Patterns. Image by Author. Made with Microsoft Excel.....	102
Figure 64. Distribution of top 51 percent of visited locations in Brockton, MA during May 18-25, 2020, by NAICS code. Source: SafeGraph Patterns. Image by Author. Made with Microsoft Excel.....	103
Figure 65. Distribution of top 50 percent of visited locations in Lowell, MA during July 20-26, 2020, by NAICS code. Source: SafeGraph Patterns. Image by Author. Made with Microsoft Excel.....	104
Figure 66. Distribution of top 43 percent of locations visited in Brockton, MA during July 20-26, 2020, by NAICS code. Source: SafeGraph Patterns.....	105
Figure 67. Distribution of top 57 percent of locations visited in Lowell, MA, during October 26-November 2, 2020, by NAICS code. Source: SafeGraph Patterns. Image by Author. Made with Microsoft Excel.....	106
Figure 68. Percentage of Point-Of-Interest data based on American Industry Classification System for the City of Lowell, MA. Source: Image by Author. Made with Microsoft Excel.....	107
Figure 69. Map of Point-Of-Interest data for the city of Lowell, MA between May 18 to May 25, 2020. Source: SafeGraph Patterns. Image by Author. Made with ArcGIS Pro.....	112
Figure 70. Map of Point-Of-Interest data for the city of Brockton, MA between May 18 to May 25, 2020. Source: SafeGraph Patterns. Image by Author. Made with ArcGIS Pro.....	112
Figure 71. Map of Point-Of-Interest data for the city of Lowell, MA between July 20 to July 26, 2020. Source: SafeGraph Patterns. Image by Author. Made with ArcGIS Pro.....	113
Figure 72. Map of Point-Of-Interest data for the city of Brockton, MA between July 20 to July 26, 2020. Source: SafeGraph Patterns. Image by Author. Made with ArcGIS Pro.....	113
Figure 73. Map of Point-Of-Interest data for the city of Lowell, MA between Oct 26 to Nov 2, 2020. Source: SafeGraph Patterns. Image by Author. Made with ArcGIS Pro.....	114
Figure 74. Map of Point-Of-Interest data for the city of Brockton, MA between Oct 26 to Nov 2, 2020. Source: SafeGraph Patterns. Image by Author. Made with ArcGIS Pro.....	114

## Acronyms

B&A - Boston and Albany Railroad	LIHTC - Low Income Housing Tax Credit
BAT - Brockton Area Transit	LRTA - Lowell Regional Transit Authority
BRA - Brockton Redevelopment Authority	MBTA - Massachusetts Bay Transportation Authority
BRT - Bus Rapid Transit	PCA - Pedestrian Catchment Area
CBD - Central Business District	POI - Point of Interest
CDBG - Community Development Block Grant Program	RFP - Request For Proposal
CTOD - Center for Transit Oriented Development	TAD - Transit-adjacent development
DHCD - Department of Housing and Community Development (Massachusetts)	TAZ - Traffic Analysis Zones
DPRS - Division of Planning & Regulatory Services (Worcester)	TDR - Transfer of Development Rights
FAR - Floor Area Ratio	TIG - Transit-Induced Gentrification
GHG - Green House Gas	TOD - Transit-Oriented Development
HUD - US Department of Housing and Urban Development	TTOD - Transformative Transit-Oriented Development
IDA - Individual Development Accounts	USGS - United States Geological Survey
LEED - Leadership in Energy and Environmental Design	VMT - Vehicle Miles Traveled
LICs - Low-Income Census tracts	WRA - Worcester Redevelopment Authority
	WRTA - Worcester Regional Transit Authority

# Chapter 1 Introduction

## Transit-Oriented Development (TOD)

Decision makers and urban planners are coming up with innovative ideas to create neighborhoods that are more walkable, bikeable and encourage the use of public transportation as all of these behaviors decrease Vehicle Miles Travelled (VMT). One such urban planning strategy is TOD or Transit-Oriented Development. The term TOD was coined in 1993 by urban designer and planner Peter Calthorpe (Jamme et al. 2019). Today, the Commonwealth of Massachusetts defines TOD as, “an approach to development that focuses land uses around a transit station or within a transit corridor” (Smart Growth/Energy Toolkit 2021).

### *Thesis Overview*

This thesis discusses TOD and the TOD initiative in the city of Lowell, Massachusetts. Chapter 1 provides an overview of TOD, introduces the study area, and gives the history and background of Lowell’s TOD initiative. Chapter 2 discusses the various themes associated with TOD that were encountered in the literature review. Chapter 3 describes two case studies and the lessons that Lowell can learn from them. Chapter 4 presents a market analysis of Lowell, and Chapter 5 analyzes the foot traffic of Lowell and compares it with that of Brockton. Chapter 6 discusses the findings from various methods and recommendations for the city of Lowell.

### *Research questions*

My thesis aims to answer the following research questions based on the literature review, case studies, foot traffic analysis, market analysis, and interviews.

1. How would transit-oriented development (TOD) help in revitalizing and rehabilitating the Gateway City of Lowell, Massachusetts?
2. How would TOD optimize the use of existing transit infrastructure in Lowell?
3. What roles do land use and zoning play in a transit-oriented development?
4. How could TOD attract investment while preventing gentrification?

### *Methods*

In order to answer my research questions and to understand how far Lowell is ready for transit-oriented development, I used a mixed-method approach. I employed four methods: a literature review, case studies of similar gateway cities that are focusing on TOD, a market analysis to find out the scope for development in Lowell, a foot traffic analysis to understand the current foot traffic patterns at various POIs in Lowell and to compare it with Brockton (one of the case studies), and interviews of stakeholders from the city of Lowell and other experts with experience working on TOD projects in other gateway cities.

## **Background**

### *Walkable Communities*

The idea of creating compact communities where people live, shop, and work in the same neighborhood is gaining traction. The most discussed topic in the transportation sector is to reduce auto-dependency and to promote the use of public transportation. A walkable community is defined as having a wide range of services and destinations within a 5- to 10-

minute walk of home, with streets designed to enable and encourage walking, and with access to public transportation (Opticos 2015). While the average American household spends more than half of their income on housing and transportation, in walkable communities that percentage is reduced to 41 percent (Luttrell 2019). According to the Center for Transit Oriented Development (CTOD), it is estimated that more than one in five households will seek housing in a TOD by 2025 (Guthrie and Fan 2016). Walkable communities reduce Green House Gas (GHG) emission by decreasing VMT (Smart Growth America 2020).

### *Streetcar suburbs as TODs*

Before the industrial revolution, the size of cities and towns in the United States, as elsewhere, was largely determined by how far people would walk – a circle with a radius of up to one and a half to two miles (Thomas 2019, English 2019). The invention of the steam engine led to the building of railroads in the 1830s, greatly increasing the speed and capacity of freight and passenger transportation. But commuting to work by railroad was expensive and could only be afforded by wealthy residents. It was the streetcar that revolutionized transportation for the urban working and middle classes, provided the first form of mass transit, and expanded residential and commercial development beyond the one and a half mile radius of the walking city. Omnibuses, horse-drawn wagons running on city streets, started carrying urban passengers in the 1820s. They then gave way over the following decades to horsecars or trolleys (horse-drawn cars) running on iron rails set in streets (Bellis 2019; Schrag 2002). Horses were replaced by various mechanical systems until the electric streetcar was perfected in the late 1880s and was adopted across the country. Electric streetcars quickly spread into networks

of intra- and inter-city lines, opening up previously inaccessible farmland to real estate development. Housing and businesses were built onto this new land as streetcar suburbs. Residents could now live outside the city and commute to work in the same time that it had previously taken them to walk.

As streetcar lines extended into farmland in a finger pattern, higher-density housing (apartment buildings and rowhouses) was built along the street and commercial uses clustered around the intersections. As more and more housing sprouted between the fingers (one- and two-family houses and triple-deckers), the growing population could support more commercial uses along the streetcar streets, which became commercial streets. Thus, the development of streetcars and streetcar suburbs went hand-in-hand with TOD that featured mixed uses and a variety of housing types (Saunders 2020, Newcombe 2022, Warner 1978).

#### *TOD today*

As we have seen, TOD is not a new concept (Guthrie and Fan 2016). Cities like Boston, Cleveland, and Philadelphia, even today tend to show an urban form evolved from streetcar-oriented development (Jacobson and Forsyth 2008). When the modern version of TOD emerged in the 1990s, it was initially only associated with development around train stations because heavy rail was seen as a more permanent investment, compared with bus systems, where bus routes can be modified, and bus stops relocated. Recently, however, there have been increasing interest and public investment in busway systems (roadways exclusively reserved for buses), and Bus Rapid Transit (BRT) systems. Thus, busways and their stations could make them potential sites for TOD as well (Smart Growth/Energy Toolkit 2021). This thesis focuses on TOD around train stations and not TOD around bus stations.

## **Study Area**

### *Gateway Cities*

Gateway cities are former industrial or mill cities that strive to be redeveloped with new economic activity. In their heyday, they offered good industrial jobs that were the "gateway" to the American Dream for local residents and immigrants alike. Massachusetts General Laws define gateway cities as having a population between 35,000 and 250,000, with both an average household income and average education level below the state averages. Selected Bay State cities have been called "gateway cities" since 2007 when a report by the Brookings Institution and MassINC described their challenges and assets and called on state and local cooperation to revitalize them (Samahy 2021). Lowell was identified then as a Gateway City along with ten other cities (Figure 1) – Haverhill, Lawrence, Fitchburg, Pittsfield, Holyoke, Springfield, Worcester, Brockton, Fall River and New Bedford (Hodge and Forman 2018). The state legislature endorsed the concept, developed a legal definition, set up assistance programs, and in 2010 added fifteen more cities, for a total of 26 Gateway Cities in Massachusetts.



Figure 1. Gateway cities in Massachusetts. Source: Wikipedia.  
[https://en.wikipedia.org/wiki/Massachusetts\\_gateway\\_cities](https://en.wikipedia.org/wiki/Massachusetts_gateway_cities).

The idea of TOD for Lowell started in 2019 at the Northern Massachusetts Transformative Transit-Oriented Development (TTOD) Regional Forum to which Lawrence and Haverhill also participated. The goal was to explore ways of developing these former industrial cities and their surrounding communities through TOD. Discussion topics focused on ways to bring about this transformation, including the improvement of existing and proposed rail service, and ideas for economic, real estate and community development near public transit. Lowell's Mayor affirmed the city's commitment to creating a vibrant transit-oriented district. The City Manager noted that the city had invested \$28 million in infrastructure and development in the Hamilton Canal District, a 15-minute walk away from the train station at the Gallagher Terminal and offered other examples of TOD projects.

At that summit, Christopher Coes of Smart Growth America noted that there is an increasing shift among investors who want locations with a sense of place, businesses that are moving from business parks to walkable neighborhoods, and a sizable portion of the population

that wants to move away from metro-Boston to “gateway cities” with transit access (Luttrell 2019). Coes also mentioned that cities should remember for whom they are making these improvements, “Are we making these housing and commercial spaces affordable for our local residents? Are we working with our local anchor institutions?” (Luttrell 2019).

### *TOD in Lowell*

The City of Lowell is planning to work with MassDOT and MassINC to make the area around the transit terminal in Lowell a vibrant transit-oriented district. Lowell already has a transportation asset in its downtown, as a potential focal point for TOD: the Gallagher Terminal is an inter-modal transit center serving the Massachusetts Bay Transportation Authority (MBTA) commuter rail Lowell Line and includes the Kennedy Bus Transfer Center for local and long-distance bus service. Given that Lowell’s train and bus station at the Gallagher Terminal together act as a multi-modal station, this is a great place for building TOD around a transit hub. In addition to its central train and bus terminal, the city benefits from anchor institutions such as the University of Massachusetts, Lowell, the Middlesex Community College, and the Lowell National Historical Park.

Several developers have been long-time investors in Lowell, and they know what the city and communities want in Lowell.

### *Opportunity Zones*

The Opportunity Zones Program was created by the U.S. Tax Cut and Jobs Act of 2017 to provide incentives for investment in low-income communities throughout the country. Any governor can identify up to 25 percent of low-income census tracts (LICs) to be designated as

Opportunity Zones, where “individuals can gain favorable tax treatment on their capital gains, by investing those funds (through a privately-created Opportunity Fund) into economic activities in the area.” (EOHCD n.d.) Gateway cities like Lowell could use these programs to encourage TOD. Investment incentives are provided for developments in low-income areas in federal programs which could help in increasing walkability, job opportunities, and housing density (Luttrell 2019).

There is a great potential for development projects around the Gallagher Terminal. Most notable among them are the Thorndike Exchange building and the Hamilton Canal Innovation District. Adjacent to the train station itself is Thorndike Exchange, a mixed-use project with 65 apartments in a rehabbed factory building, which has instilled interest in downtown living and development (The Sun 2019). Hamilton Canal Innovation District is about 0.7 mile from the Gallagher Terminal and consists of 15 acres of development opportunity in addition to already rehabilitated mill buildings.

### *Thorndike Exchange*

Thorndike Exchange (Figure 2) is a \$30-million apartment and retail complex developed by Lupoli Companies which opened in the fall of 2019. It consists of two adjacent buildings: a 150,000-square-foot, 5-story mill building, built in 1882, fully restored and converted into 65 market-rate apartment units, with retail and restaurant space; and a new construction, 100,000-square-foot, five-story building of 75 more apartments, for a total of 140 rental housing units (Welker 2016, BLDUP 2022). A separate, adjacent Thorndike Street project, also known as the Lord Overpass project, is expected to solve access issues to the site. The Lowell

Regional Transit Authority (LRTA) secured \$2.5-million in state grants to widen Thorndike Street to include turning lanes, dedicated bus lane and bike lanes, and for an enclosed pedestrian walkway bridge connecting Thorndike Exchange and Gallagher Terminal (The Sun 2019). These improvements are meant to solve access and mobility issues that were caused by the previous roadway design of Thorndike Street. The walkway bridge connects Thorndike Exchange with the Gallagher Terminal train station and the LRTA parking garage in which 150 parking spaces are leased by Lupoli Companies for the residents. The Thorndike Street project will improve multimodal transportation for the Hamilton Canal District as well. The owner of Lupoli Companies, Sal Lupoli has divested himself from Thorndike Exchange but is expected to play a vital role in developing the Hamilton Canal Innovation District, which is discussed next in this section (The Sun 2019).



Figure 2. Thorndike Exchange, a mixed-use development next to Gallagher Terminal in Lowell.  
Source: BLDUP. <https://www.bldup.com/posts/thorndike-exchange-sold-for-33-3-million-in-lowell>.

### *Hamilton Canal Innovation District*

The Hamilton Canal District is a 15-acre site of former mill buildings and empty lots where four canals converge near the center of Lowell.

The district has interested planners and developers since 2005. Boston-based developer Trinity Financial was selected in 2006 as the master developer of the Hamilton Canal District, developed a master plan in 2008, and worked on rehabilitation and new construction until 2015 (Nanos and Logan 2021). Hamilton Canal District was then renamed the Hamilton Canal Innovation District, and in 2016, Winn Companies was selected as the new master developer for the remaining parcels. The \$800-million Hamilton Canal Innovation District now includes more than 3.5 million square feet of rehabbed mill space, a new regional justice center housing five courts in the nine-story Lowell Justice Center, the UMass Lowell Innovation District, the Medical Device Development Center, and a 900-space parking garage (Lowell Waterways Vitality Initiative n.d.) (Figure 3). The site is a 15-minute walk from the Gallagher Terminal. There is discussion about improving the east-west bus mobility through the district in addition to the north-south commuter rail connection. The infill development and rehabilitation in the Hamilton Canal Innovation District have improved walkability along the river thereby providing a more direct connection to the train station. Hamilton Canal Innovation District is known to be the first district in Lowell where regulations and developments are defined by a Form-Based Code (Lowell, Massachusetts 2022).



Figure 3. Proposed developments in Hamilton Canal Innovation District, Lowell. Source: WordPress. <https://returntoroom50.wordpress.com/2019/08/29/breaking-new-ground-in-the-hamilton-canal-innovation-district/>.

WinnCompanies, known for their multi-family property developments and affordable housing, was designated the master developer of the HCID in 2016. They have long been involved in the district, building the 301-unit Jackson Street Lofts between 2005 and 2017. Their latest project is 201 Canal, a 125-unit, \$38.3-million new construction development of affordable, workforce and market rate housing units in the heart of Lowell's Hamilton Canal Innovation District (Figure 4) (WinnCompanies 2020).



Figure 4. 201 Canal, a 125-unit housing development by Winn Companies, opened in 2022 in Lowell's Hamilton Canal Innovation District. Source of the rendering: MassHousing. [https://www.masshousing.com/press/2020-06-11\\_Hamilton-Canal](https://www.masshousing.com/press/2020-06-11_Hamilton-Canal).

### *Brief history of Lowell*

Lowell is named after Boston merchant Francis Cabot Lowell who founded the industrial city in 1826. He was inspired by other industrial cities like Edinburgh in Scotland, and Manchester and Birmingham in England, where the Industrial Revolution began. Initially, the textile factories and mills were set up in Waltham and Chelmsford along the Charles River but later established in Lowell because the Pawtucket Falls of the Merrimack River provided a much stronger source of waterpower that was perfect for the mills. Lowell grew as a manufacturing hub between the mid-1820s to 1850 and the first steam railroad in New England was established between Boston and Lowell in 1835 (Pershey 1990).

The workforce was initially composed almost entirely (80 percent) of young women between 16 and 25 years old, who were the daughters of New England farmers (Robinson 1883; Pershey 1990). Lowell was planned to accommodate this workforce in boarding houses with the necessary amenities along Merrimack Street, Lowell's main street. The early system of

housing women workers in company boarding houses was replaced over time by densely populated ethnic neighborhoods that grew around the city (Pershey 1990).

Beginning in the 1850s, the workforce changed to increasing numbers of European immigrants, and in 1870s, Irish immigrants made up most of the workforce. They lived with their families on land that was not under the control of the mills in a neighborhood near the downtown mill district which even today is known as the “Acre”, Lowell’s first ethnic neighborhood. In the 1870s and 1880s, other immigrant populations (French Canadians, Poles, Italians, Greeks, and East European Jews) settled in Lowell (Pershey 1990).

In the 20<sup>th</sup> century, the textile industry moved to southern states due to its own aging buildings and inadequate investment in capital equipment, and the northern states’ higher union wages and lower textile prices. Apart from large-scale textile industries, other small-scale industries in Lowell were printing presses, patent medicines, and shoe manufacturing, among others. Until the 20<sup>th</sup> century, Lowell had a well-maintained canal system, rail connections, a vibrant downtown, strong ethnic neighborhoods, and most importantly was established as a central mill district. Even though the textile industry is gone, Lowell has a transportation infrastructure and intact neighborhoods that survived (Pershey 1990).

## Chapter 2 Literature review

The increasing interest in transit-oriented development and transit in the US is spurred by a combination of several factors: (1) a nationwide increase in vehicular traffic congestion; (2) increasing preference for multi-modal transportation alternatives; (3) growing awareness of quality of urban lifestyle and dislike for suburbs; (4) desire to live in walkable neighborhoods; (5) escalating cost of vehicle ownership and high gasoline prices; (6) demographic changes with decreased nuclear families, and increased single-person households, young professionals, and empty-nesters; (7) emerging support for smart growth and urban sustainability; (8) focus on rail systems by federal, state, and local government and policies (Ratner and Goetz 2013).

### *Walkability*

Different communities define TOD in different ways, and it includes various associated factors. TOD promotes vibrant, livable, high-density, mixed-use, pedestrian friendly, bikeable, public-transit accessible, and sustainable communities (TOD institute n.d.; Choi and Guhathakurta 2020). Schlossberg and Brown (2004) define TOD as an integrated approach of land use planning and transportation. The concept of TOD is also known as “transit village”, “transit-friendly design”, and “transit-supportive development” (Nasri and Zhang 2014).

Station:  
**Lowell**

Line/Route:  
**Lowell Line**

Communities in area:  
**Lowell**

Total units:  
**3,614**

Average density:  
**7.8 units per acre**

Residential Density  
(units per acre)

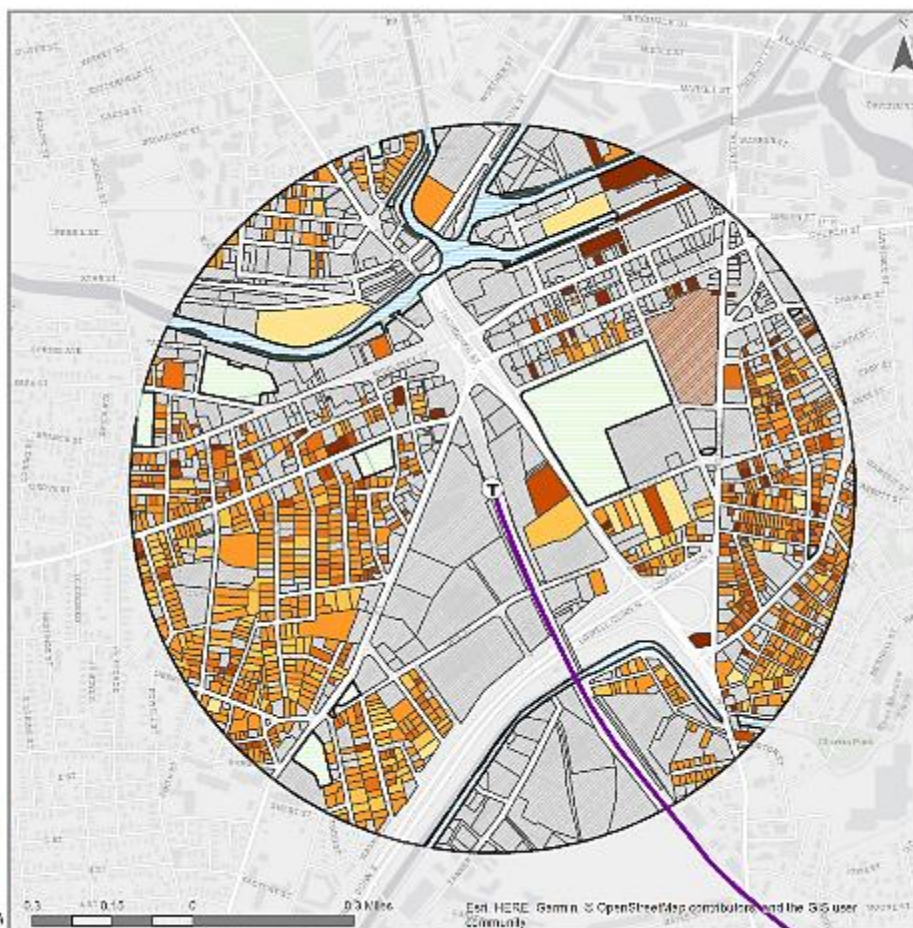
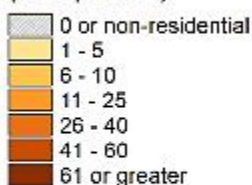


Figure 5. Transit-Oriented Development catchment area (half-mile radius) in Lowell as defined by Transit-Oriented Development Explorer (TODEX MA). Source: TODEX MA. <https://mhpcenterforhousingdata.shinyapps.io/todex/>.

A half-mile radius (Figure 5) around a transit station is the opportunity area and has potential for development (Guerra, Cervero, and Tischler 2012). The catchment areas around transit stations are the areas to rezone in order to allow for higher density development (Ruthen 2017). These transit catchment areas are distances that people are willing to walk to access transit. According to Guerra, Cervero and Tischler (2012), an appropriate catchment area for attracting jobs would be a quarter-mile radius and for households would be half-mile radius around a transit station. A pedestrian catchment area (PCA) or ped shed is the walkable area within a 5-minute or 10-minute walk from a transit station, which correspond to circles of a  $\frac{1}{4}$

mile and ½ mile radius around the station respectively. Another way to measure a PCA is through network analysis which takes into consideration only the roads that pedestrians can travel within the radius of the catchment area. Schlossberg and Brown (2004) and Khare et al. (2021) mention that a ped shed is calculated as the places accessed by an actual walk of 5 minutes rather than mere location within a circle of a ¼ mile radius (5-minute walk) around a transit station. For example, even if a store is within a ¼ mile radius, it may actually take longer than a 5-minute walk to reach it, depending on the configuration of the existing street network.

Transit-oriented developments are often associated with promoting sustainable transit modes. Choi and Guhathakurta (2020) researched the effect of rail transit access on walking behavior in TOD areas in two different Traffic Analysis Zones (TAZs) of Atlanta, Georgia. They found that the probability of walking trips increased in transit accessible TAZs when compared to that of other similar areas without transit. In another study, Park, Choi, and Lee (2017) proposes ways to measure walkability at the micro-level (street scale) rather than at the meso-level (neighborhood scale). Early studies measured walkability based on administrative boundaries such as census tracts and TAZs. A meso-level walkability cannot be used to assess the walkable environment of each street. Hence, a neighborhood that has a good meso-level walkability may have some non-walkable streets.

#### *Influence of location on walkability*

Schlossberg and Brown (2004) discuss the importance of urban form in terms of Kevin Lynch's five elements discussed in his book *Image of the City*: paths, edges, districts, nodes, and landmarks. The location and surroundings of Lowell's Gallagher Terminal, a multi-modal transit station, are similar to those of the Beaverton Transit Center which is analyzed by Schlossberg

and Brown. Both of these transit hubs are surrounded by arterials on three sides which could create some challenges in terms of pedestrian approach to the terminal and activity around the terminal. Their research across 11 TOD sites evaluated a key component of TOD theory: that it facilitates pedestrian access between a transit station and its immediately surrounding area. They found that the presence of arterials close to a transit station, particularly if they form a loop barrier around it, is counter to the theory of a walkable, urban form close to the TOD station. Understanding and evaluating the network infrastructure before locating a transit stop can be helpful in enhancing the possibility of walking between the transit hub and amenities around them (Schlossberg and Brown 2004).

#### *Path walkability indicators*

A user survey of the Mountain View Station in the city of Mountain View in Northern California collected information on the mode choice to access the station and users' walking routes from home to station. The research developed 42 path walkability indicators (Figures 6, 7, 8) that measured 30 street and building elements in 52 streets selected based on the survey. Street-related conditions that were found suitable for a walkable street environment were (1) a narrow curb-to-curb roadway; (2) a narrower traffic zone; (3) fewer and narrower through-traffic lanes; (4) more mid-block crossings; (5) fewer driveway curb-cuts; (6) wider on-street parking; (7) a narrower bike lane; (8) a wider walking zone; (9) more street trees and tree canopy; (10) more street furniture; and (11) higher luminosity. Urban form characteristics of walkable street environments included (1) shorter building-to-building distance across the street; (2) higher average building height; (3) smaller building setbacks; (4) higher façade transparency; (5) more upper-level windows; (6) lower fence coverage (length and height of

fence with respect to building height); (7) higher percentage of first-floor commercial uses; and (8) a street enclosure ratio of 1:3.3, or a building height of 20 feet for a distance between buildings across the street of 66 feet. Some of these urban design features are cost-effective and can be implemented in the short-term (Park, Choi, and Lee 2017).

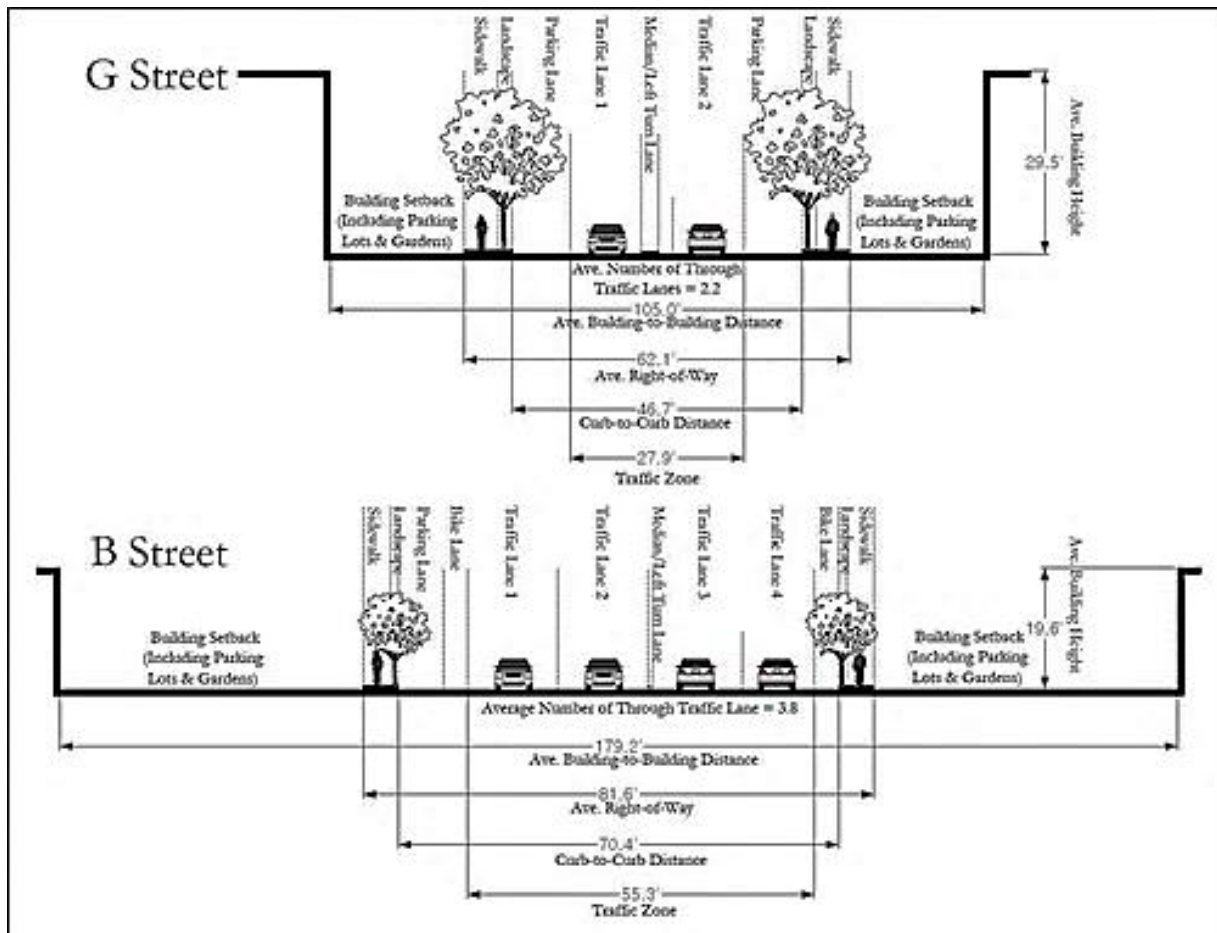


Figure 6. Path walkability indicators. Source: Park, Choi, and Lee. 2017. p. 482. <https://www.tandfonline.com.ezproxy.library.tufts.edu/doi/full/10.1080/15568318.2016.1226996>.

### Driving-Conductive Transit Walkability



### Walking-Conductive Transit Walkability



Figure 7. Path walkability indicators. Source: Park 2008, p. 140.  
<https://escholarship.org/content/qt0ct7c30p/qt0ct7c30p.pdf?t=krncu6&v=lg>.

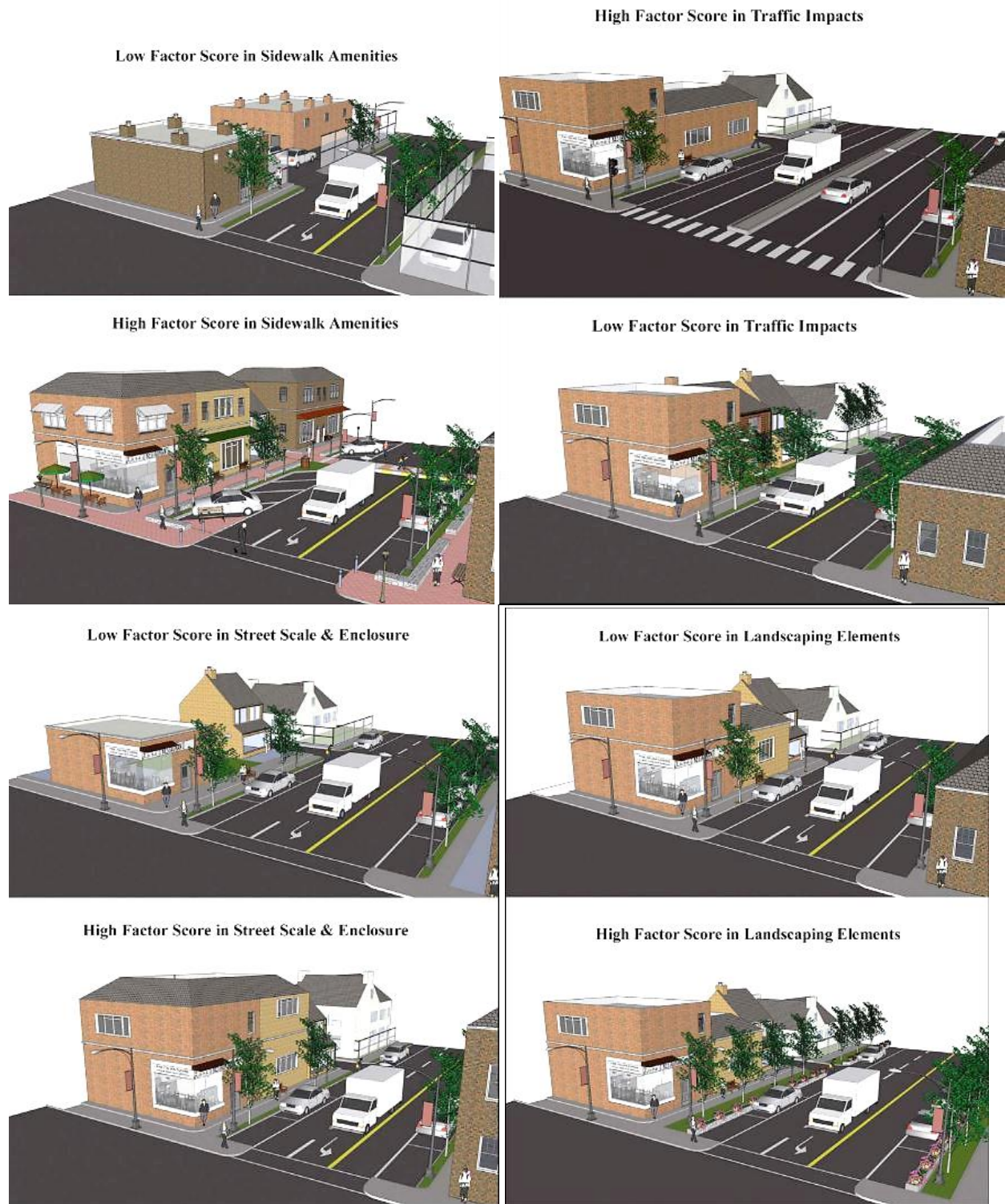


Figure 8. Path walkability indicators. Source: Park 2008, pp. 116-119.  
<https://escholarship.org/content/qt0ct7c30p/qt0ct7c30p.pdf?t=krncu6&v=lg>.

### *Shuttles and feeder buses*

A remarkable number of transit users get to a station by automobile and hence, it is essential to find a way to encourage people to walk to transit stations in order to reduce the number of parking spaces required at the station, promote walking to the station and enable sustainable transportation methods by providing an accommodating environment to walk to the station (Park, Choi, and Lee 2017; Canepa 2007). Most importantly, street connectivity, density, and mixed-use development can also potentially lead to shorter trips in general and complement pedestrian activity and transit mode share (Canepa 2007). Reducing car-travel demand, and introducing transit shuttles, feeder buses, and bike share programs can bring about a shift in transportation mode from driving to more sustainable methods. The shuttle buses and public transit bus routes need to be coordinated when establishing the routes and services to provide better connectivity and co-ordination between different transportation systems in the city.

### *Bikeability*

Providing affordable bike-sharing services with government subsidies for low-income and minority populations could potentially bridge the gap in first-and-last-mile connectivity (Zuo, Wei, and Zhang 2020). High-quality bike infrastructures like bike lanes and adequate bike parking facilities will ensure bicyclist safety, reduce risk of bike thefts, and will motivate bicycle users to bike to transit stations and other destinations within TOD thereby reducing VMT. Studies could be conducted to find ideal locations for bike parking facilities in TOD areas using point-of-interest (POI) data to make sure that these facilities are at frequent intervals and appropriate proximity to all the potential destinations within a TOD area (Fazio et al. 2021).

### *Historic preservation*

Lowell is a historic city and hence, it is essential to consider the challenges that the implementation of TOD offers for historic resources. Lowell is not alone: half of station areas in the country intersect with a national historic district, and more than half of all listed historic buildings in station areas are in TOD districts (Renne and Listokin 2019).

From its early beginnings in the 19<sup>th</sup> century, American historic preservation involved protecting buildings and sites associated with national figures and events. Preservation campaigns were few and far between. The movement evolved over time to include saving buildings of exceptional architecture representing different historical periods. Today, historic preservation is widespread and emphasizes cultural heritage. It includes residential and commercial districts, parks and landscapes, and industrial sites in recognition of these sites' contribution to a collective cultural, environmental, industrial, and social history (Alanen and Robert n.d.; Renne and Listokin 2019).

The challenge that TOD poses for historic buildings in a district is the goal of increasing density. This can result in the demolition of historic buildings unless conflict between redevelopment and preservation is resolved. Access to the right tools and programs can turn tension between TOD and preservation into opportunities for reusing as well as rehabilitating historic buildings, thereby contributing to the vibrancy of the TOD district (Renne and Listokin 2019).

Renne and Listokin (2019) identify a few challenges for historic preservation in TOD districts: (1) difficulty of maintaining historic structures without incentives; (2) financial challenges due to a gap between preservation cost and market return; (3) regulatory challenges

due to building codes and parking requirements for new construction; (4) land use and zoning that demands density, intensity of use like building height and floor area ratio (FAR); and (5) the difficulty of incorporating facades in new buildings that align with historic structures. They also describe actions that can be taken to overcome the challenges to historic preservation: (1) historic rehabilitation tax credits; (2) adoption of smart building codes; (3) context-sensitive parking requirements; (4) transfer of development rights (TDR); and (5) allowance for flexibility in criteria for historic designation thus qualifying for historic tax credits. The authors mention that the tensions between TOD and historic preservation can be made into opportunities when the historic preservationists, planners, developers, and communities have access to the right tools. Tools examined in six case studies discussed by Renne and Listokin include: (1) historic tax credits, federal new markets tax credits, Housing and Urban Development (HUD) loans, transportation grants, LIHTC; (2) combining public and private financing; (3) engaging stakeholders; (4) developing arts and entertainment to create a distinct district; (5) preservation-focused TDR.

In the six case studies, developers saw the advantage of repurposing and rehabilitating historic buildings as it could reduce production time and cost, provide incentives like federal housing tax credits and historic tax credits, and further the opportunity to revitalize the neighborhood more comprehensively. The intent of any developer would be to make the best use of the area around the transit terminal in a TOD district. In order to rehabilitate historic buildings, developers were required to produce plans and redevelopment designs that aligned with the historic value and vernacular design of that city, which also had financial and building code related challenges. Understanding the challenges that historic preservation poses to a

development can be helpful in proposing options to overcome them. Historic preservation helps in appreciating the history of the neighborhood while retaining their historic architectural design elements like large windows, high ceilings, exposed brick walls, and intricate facades thereby enhancing the value and attractiveness of the residential developments (Renne and Listokin 2019).

### *Gentrification*

The term “gentrification” was coined by sociologist Ruth Glass in 1964 as she observed working-class neighborhoods in London being invaded by middle- and upper-income groups. The new residents bought properties, upgraded them, changed the social structure and housing market of the neighborhoods, and displaced the original occupants. Since then, the term has expanded to include developers and public agencies as directly or indirectly causing gentrification (Tehrani, Wu, and Roberts 2019). Gentrification, zoning, and transit are interconnected. The positive impacts of proximity to transit stations on property are widely discussed when compared to the potential displacement of low-income and minority populations that is caused by the appreciation of property values. Low-income populations often depend on public transportation for daily necessities. Wealthy people who tend to displace them, result in a reduction of transit ridership as they prefer bikes as their mode of transport if parking at their destination or residence is unavailable (Padeiro, Louro, and da Costa 2019). The negative connotation associated with the word “gentrification” is said to be the reason why many researchers do not discuss this topic when describing the improved economic conditions of neighborhoods that may result from TOD (Deka 2016). Whereas Kennedy and Leonard (2001) cited in Deka (2016) characterize gentrification as a double-edged

sword as it could help communities by improving their municipality's tax revenue but at the same time cause the displacement of low-income residents.

When discussing gentrification in station areas and its impact on ridership, Chava, Newman, and Tiwari (2018) describe the mechanisms adopted by Bogota, Hong Kong, and the US for successfully integrating transit investments and affordable housing to prevent the equity issues of gentrification and displacement. In Bogota, Columbia, the land around transit stations is obtained by the city and affordable housing is constructed well before the transit network is announced (Tehrani, Wu, and Roberts 2019). As a result of this government's investment in transit and affordable housing, the city receives an increased revenue of about 30-50 percent due to the increased land value. In the case of Hong Kong, public agencies sold land holdings near transit stations at their after-development market rate value and negotiated to provide public and affordable housing as part of TOD. While in California, US, a public-private partnership was established to provide 12.5 to 15 percent affordable housing in order to obtain a density bonus of approximately 22 percent (Chava, Newman, and Tiwari 2018).

The improved accessibility provided by TOD might result in transit-induced gentrification (TIG) when the advantage of transit proximity is capitalized into land and housing prices. TIG is the displacement of low-income populations who should have been the actual beneficiaries of transit proximity as they may not own automobiles and rely on public transportation for their mobility. Conversely, some also suggest that since low-income populations do not own automobiles, they bid more for housing even if it is expensive for them, as they value the proximity to transit the most (Dawkins and Moeckel 2016). Some factors that can lead to this kind of gentrification are a lack of market intervention by public agencies, profit-maximizing

developers who intend to opt for high-value land uses, and increased demand for housing near transit. A 2008 report by the Federal Transit Administration estimated that the demand for transit-accessible housing would double to about 14.6 million households by 2030 (Dawkins and Moeckel 2016). As early as in 2004, Cervero et al. found through a literature review, and 10 case studies, that home prices were 6 to 45 percent higher near transit stations when compared to otherwise equivalent sites (Cervero et al 2004, 162). A 2007 meta-analysis found that the prices of residential properties located within 0.25 miles of transit stations are approximately 4 percent higher than other properties when controlling for other housing and neighborhood characteristics. This analysis further concluded that commuter rail stations have a higher positive impact on property values (meaning an increase) when compared to light and heavy rail stations (Dawkins and Moeckel 2016).

The impact of gentrification is categorized into three types by Tehrani, Wu, and Roberts (2019): residential displacement, cultural displacement, and disruption of local community ties. Gentrification leaves long-term residents of that neighborhood with financial and social pressure caused by the cost of new amenities and increases in rent and housing prices that could also result in loss of property, restricted access to food/medical care, or in the worst cases, homelessness. New developments could displace small businesses and family-owned businesses. This displacement creates a fear of isolation in a neighborhood because these businesses are the essence of a neighborhood's sense of place and community (Tehrani, Wu, and Roberts 2019).

Contradicting the studies that conclude that low-income residents are replaced when gentrification occurs, Deka (2016) questions the credibility of that statement by saying that

there is no evidence of low-income populations being displaced by non-minority populations because of gentrification. In addition, Deka (2016) notes that the increase in income of a neighborhood is due to the increase in income of existing households.

### *Coordinated planning of land use and transportation*

The mobility systems of a city shape the travel choices of its residents based on what is available compared to what is convenient among the different modes of transportation. Local government and transit agencies need to organize land uses such that they increase choice and make the best use of transit systems through transit-oriented development (Yaro and Kooris 2008). Mixed uses tend to draw more people and trips to a place, and this is the source of travel demand for transportation services. Planning and designing transportation facilities without taking land use into consideration could result in inconsistencies and problems in the future as the city keeps growing. Similarly, land use decisions made without considering transportation access and connectivity could lead to problems like congestion and traffic (Seymour and Montgomery 2011). Hence, transportation and land use planning need to be multi-disciplinary and simultaneously account for present and future connectivity, traffic patterns, and other possible components of a sustainable development. Land use, zoning and TOD development design also play a vital role in shaping compact cities thereby providing well-connected street networks with multiple route options for comfortable navigation.

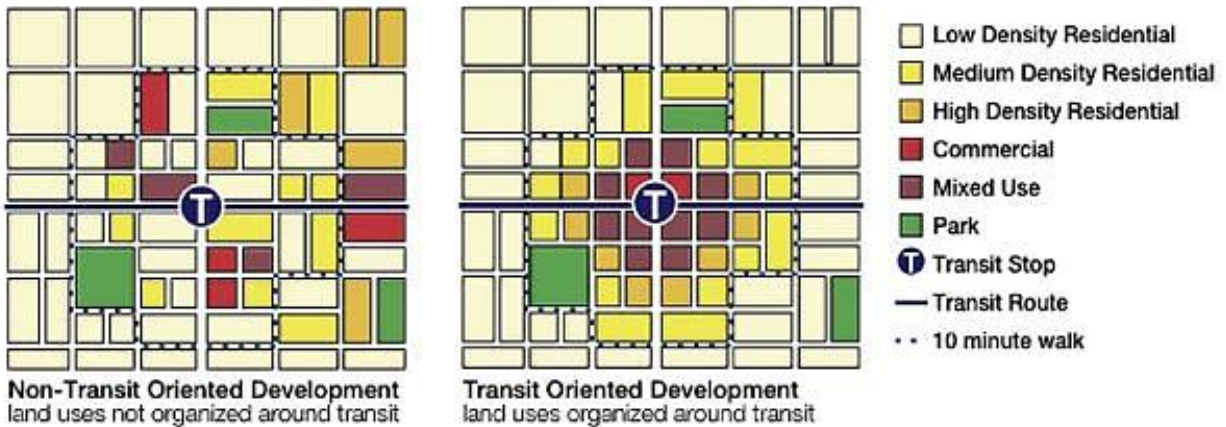


Figure 9. A typical land use arrangement around a transit station. Source: Sahu. 2018. p. 474. <https://www-sciencedirect-com.ezproxy.library.tufts.edu/science/article/pii/S0301479717311660>.

Land use impacts travel patterns and behavior while TOD impacts land use and urban form. Cities should engage in thoughtful land use planning to provide effective development. Making changes to the existing land uses could add value for the development as a whole. Based on a GIS analysis of the city of Naya Raipur in India, Sahu (2018) calculated the density and diversity of uses in land use cells around transit stations, categorized cells, and evaluated the land uses assigned to them (Figure 9). These were compared with successful TODs in Curitiba, Brazil and Arlington County, Virginia, U. S. The study evaluated several alternative plans for a TOD district, from which an ideal plan was selected. It was obvious from the results that in the ideal plan mixed uses are closer to transit. There was no proper mix of uses in the actual site of Naya Raipur but the generated ideal land use plan had more randomness and mix of commercial, residential and other uses (Sahu 2018).

In another study, three types of transit station areas were identified to study density and walkability. These three types of areas around transit stations are TOD, Hybrid, and Transit-Adjacent Development (TAD). Here, TOD is defined as stations with a walk score greater than 70 and gross housing density greater than 8 units per acre. Stations that met only one of these

two categories were categorized as Hybrids. And stations that met none of these categories were categorized as TADs. In Boston in 2016, there were 116 TODs, 56 Hybrids and 150 TADs (Renne et al. 2016). In another point-based scoring study, Pollack et al. (2014, cited in Zandiatashbar et al. 2019) categorizes transit-accessible areas into four categories: (1) transit-oriented areas; (2) transit-supportive areas; (3) transit-related areas; and (4) transit-adjacent areas (Zandiatashbar et al. 2019).

Addressing the short-comings of point-based studies, Kamruzzaman et al. (2014, cited in Zandiatashbar et al. 2019) used cluster analysis to define a finer-grain set of six types: (1) urban TODs; (2) balanced TADs; (3) suburban TODs; (4) undersupplied transit TODs; (5) unbalanced TODs; and (6) future TODs (Zandiatashbar et al. 2019).

The need to develop coordinated indicators for transportation and land use has been emphasized by a few researchers, although they do not specify which measures must be used. This is due to the powerful impact of transportation on land development which could shape land use for years to come. For example, considering land use and transportation while planning can overcome barriers for pedestrian connectivity to transit stops. The main goal that can be achieved by coordinating transportation and land use, as discussed by Miller and Evans (2011), is that solutions to various issues should be context-specific and policies should be crafted based on community character. There are a limited number of articles and studies on the land use features of TOD due to a lack of data to track slow dynamic transformation. Using traditional data like lot coverage or FAR, makes it difficult to describe precise land use characteristics, especially over time. However, new data sources such as POI and OpenStreetMap are increasingly used to assess land use data (Tong et al. 2018). POI are the

points of interest data for various locations in a city. OpenStreetMap is a free, collaborative, editable geographic database of the world which is open to the public (OpenStreetMap 2022). POI and OpenStreetMap data are preferred over traditional data, like lot coverage or floor area ratio (FAR), as they have more precise land use data and are readily available (Tong et al. 2018).

Transit-oriented development creates valuable resources and improvements in infrastructure but may yet result in residential segregation, gentrification, and displacement if zoning, neighborhood design, and affordability are not taken into consideration. In the first decades of the 20<sup>th</sup> century, urban planners proposed zoning as a solution to overcome the problems caused by industrialization in the built environment. Such solutions included separating incompatible land uses (factories from housing) and regulating the height and setbacks of buildings. But racial exclusion was also part of zoning from the beginning, to ban people of color from white neighborhoods. Discriminatory planning and exclusionary zoning, both in public policies and in the real estate market, have caused residential segregation that separates people based on their race, income, and socioeconomic status. It is important to make sure that TOD does not perpetuate such practices (Tehrani, Wu, and Roberts 2019). TOD gives the cities an opportunity to re-establish their neighborhoods to be more inclusive of both who were included and excluded in the past (Baker 2020).

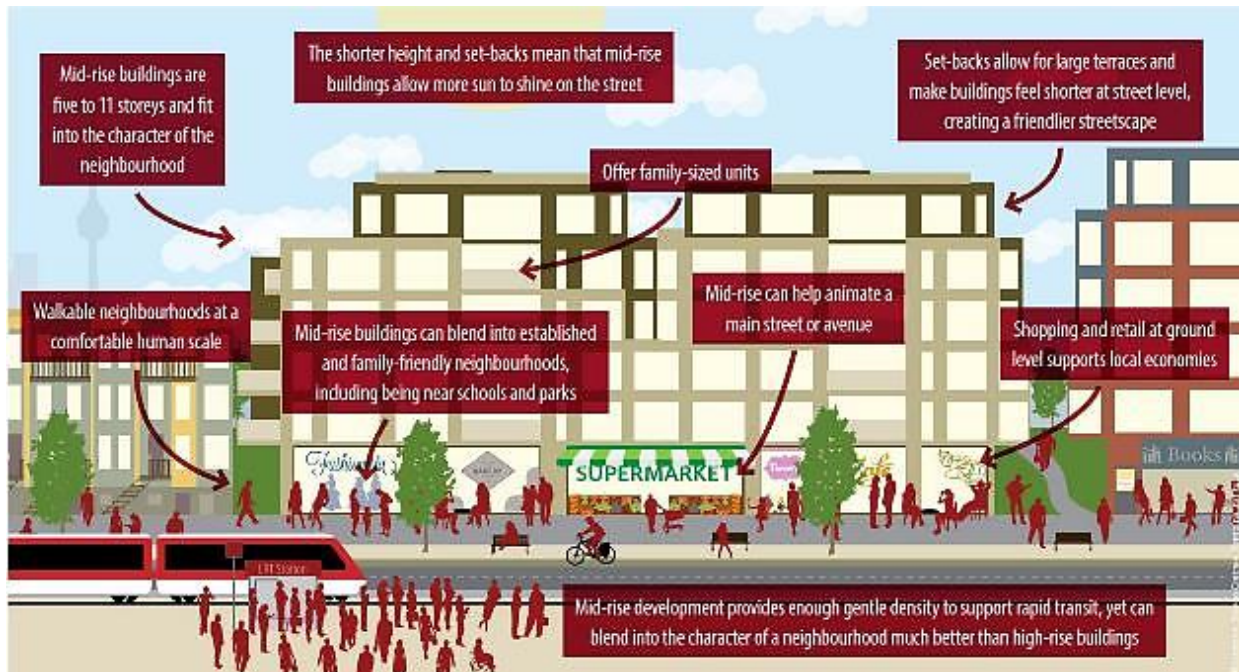


Figure 10. Components of a mid-rise neighborhood. Source: Burda and Collins-Williams. 2015. p. 2. [https://www-jstor-org.ezproxy.library.tufts.edu/stable/pdf/resrep00235.pdf?ab\\_segments=0percent2Fbasic\\_search\\_gsv2percent2Fcontrol&refreqid=fastly-defaultpercent3Adb7fe3d1f56cd9c6fb8cec84c38b4eee](https://www-jstor-org.ezproxy.library.tufts.edu/stable/pdf/resrep00235.pdf?ab_segments=0percent2Fbasic_search_gsv2percent2Fcontrol&refreqid=fastly-defaultpercent3Adb7fe3d1f56cd9c6fb8cec84c38b4eee).

Burda and Collins-Williams point out few ways for municipalities and developers to make mid-rise, mixed-use districts economically feasible (Figure 10). For municipalities, they recommend establishing minimum density requirements along transit lines, eliminate minimum parking requirements, and develop regulations to dedicate open space and park areas. For developers, they advise to acquire pre-approval for mid-rise developments along transit corridors, and conduct retail planning before building the development (Burda and Collins-Williams 2015).

Ingredients for successful TODs include attractive walking paths to quality transit service, and compact, mixed land uses (Suzuki et al 2013 cited in Zegras et al. 2016). The optimal impact of TOD districts can be achieved with coordinated policies and regulations (such

as parking restrictions and suitable zoning), transit station and transit corridor alignment, local economic growth, and some demand for density (Handy 2005 cited in Zegras et al. 2016).

Often times, land regulations, transportation planning, transit operations, and funding for investments are the responsibility of various entities from different levels of government and require a high degree of integration for TOD to be successful (Zegras et al. 2016).

Regulations and programs that could potentially encourage for-profit developers to finance affordable and mixed-income housing while also ensuring equity and efficiency include the following: (1) inclusionary zoning; (2) mixed-income and mixed-tenure housing policies; (3) rent subsidies; (4) property tax relief for homeowners; (5) education and resources through Individual Development Accounts (IDAs) for low-income tenants to improve their ability to become homeowners; (6) infill development of vacant or under-used parcels; (7) regulatory policies to control private housing market; (8) stabilization policies like zoning, land use and rent control to reduce the volatility of the market (Tehrani, Wu, and Roberts 2019).

Local governments should consider adopting LEED (Leadership in Energy and Environmental Design) for Neighborhood Development standards as guidance to ensure that proposed developments contribute to more sustainable neighborhoods. These standards could not only reform local land use regulations but also encourage developers to build more sustainable (re)developments (Nolon 2012). These standards could also act as a blueprint for local governments to encourage and promote development.

#### *Housing policy in TOD*

In a study of the San Francisco Bay market, Cervero points out that residents of transit-oriented housing mostly tend to be childless young professionals who work downtown or in

transit-served areas (1996, cited in Guthrie and Fan 2016). Also, young adults in the 2010s drove less when compared to young adults of the previous decade, translating into an increasing preference to live near transit or in transit-accessible areas (Deka 2016). In 2015, about 30 percent to 50 percent of the entire population of the US preferred to live in transit-served areas while about 63 percent of the young generation preferred to access jobs without driving (Renne et al. 2016). Cervero suggests two strategies to promote TOD projects: lower parking ratios in transit-oriented housing, and Location-Efficient Mortgages (LEMs) (Cervero 1996 cited in Guthrie and Fan 2016). People who buy a home in locations where they don't need to rely on automobiles for transportation are eligible for LEMs. Housing units in TODs need to be mixed income to include residents of different income groups. This is important to address the fact that people who depend on transit and do not own private vehicles should be able to afford these housing units as well.

This raises the questions of how TOD developments will accommodate the increase in residents and other users who wish to share these spaces and how the public engagement process will be designed to accommodate all stakeholders (Jacobson and Forsyth 2008). Place-making strategies that involve resident participation tend to be more inclusive and effective than presentations and meetings. Place-making includes components of interconnected place construction, place-naming, and place-describing that engage new and existing residents in building identity together in the planning process of TOD areas (Baker 2020).

Ensuring that the benefits of transit improvements are shared throughout the community requires affordable housing in station areas. The construction of affordable housing is often hampered by neighborhood opposition, particularly in suburban areas. Suburbanites

often equate affordable housing with low-income minorities, recipients of public assistance, and crime. Whatever their reasons might be, suburban communities often oppose the provision of affordable housing on a large scale. Providing affordable housing in transit station areas may be complicated by persistent perceptions (particularly in suburban areas) that transit improvements cause increased crime rates, despite evidence to the contrary (Guthrie and Fan 2016).

### *MBTA Communities*

As part of Massachusetts' economic development bill passed in 2021 (An Act Enabling Partnerships for Growth), the MBTA Communities law (Section 3A of Chapter 40A) requires cities and towns served by the MBTA transportation network to establish multifamily housing zoning districts near stations. A total of 175 out of 351 communities were identified as MBTA Communities, categorized by their type of transportation service: subway, bus, commuter rail, or MBTA adjacent. Figure 11 shows the MBTA communities by category of service. Lowell and Worcester are categorized as commuter rail MBTA communities while Brockton is a bus MBTA community (Commonwealth of Massachusetts 2022).

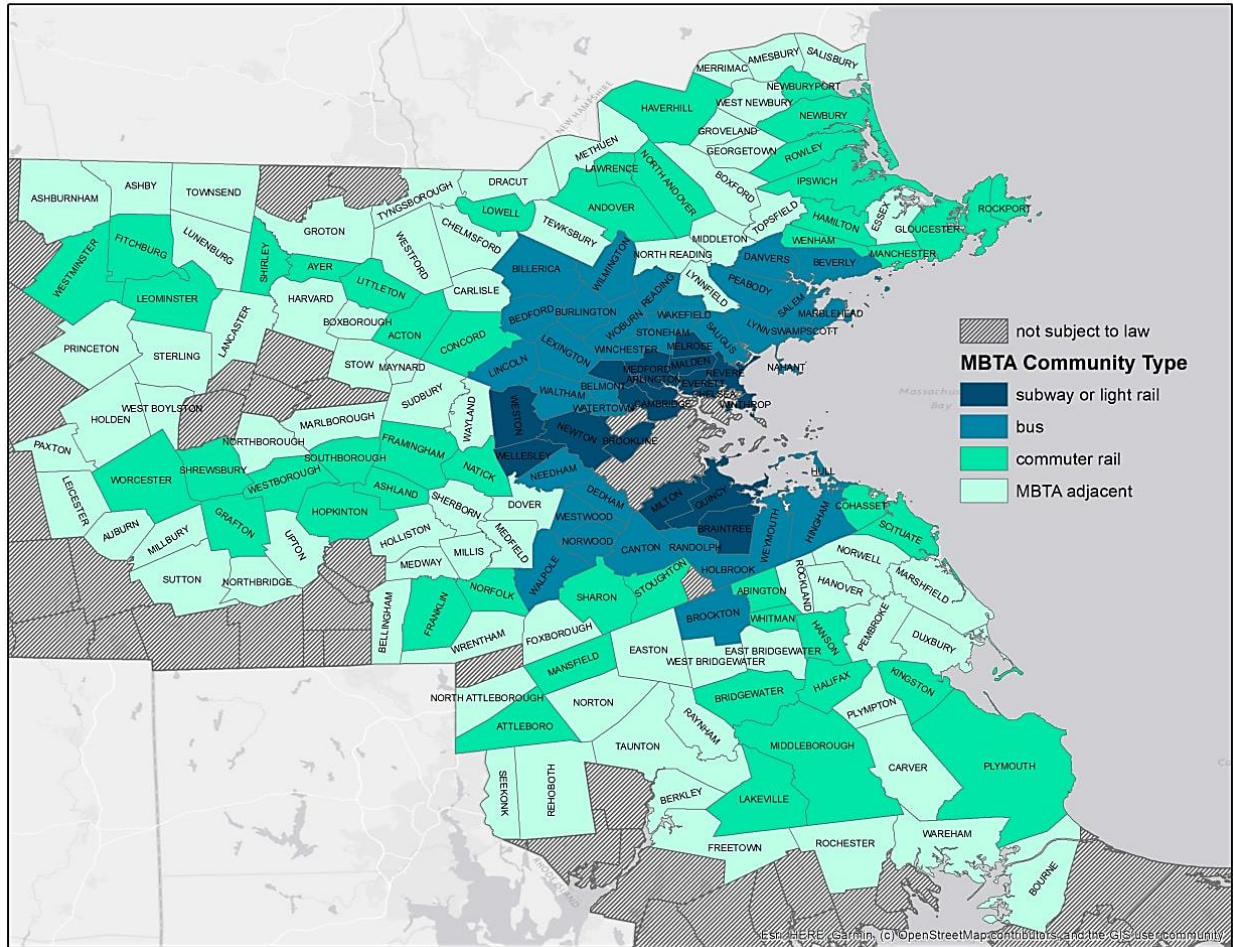


Figure 11. MBTA communities in Massachusetts. Source: Commonwealth of Massachusetts 2022. <https://www.mass.gov/info-details/multi-family-zoning-requirement-for-mbta-communities#what-is-an-%22mbta-community%22?>

As per this new law, the requirement is to designate at least one district of a minimum of 50 acres zoned for multifamily housing permitted as-of-right, with no age restrictions, and suitable for families with children. This district needs to be located within 0.5 miles of the subway, commuter rail, or bus station, and have a minimum gross density of 15 units per acre. The law does not require that multifamily housing be built, only that a zoning district be established that allows it as of right for the future. The capacity of the district – the number of units that can be built over time – is a function of each community’s total number of existing units. The capacity must be 25 percent more units for subway communities, 20 percent for bus

communities, 15 percent for commuter rail communities, and 10 percent for MBTA-adjacent communities. This results in different required capacities for different cities and towns (Table 1).

Table 1. Multifamily district housing unit capacity requirement for Lowell, Brockton, and Worcester as MBTA communities.

Municipality	MBTA Community Type	2020 Housing Units (Census PL-94)	Minimum multifamily district unit capacity requirement
Brockton	Bus	37,304	7,461
Lowell	Commuter rail	43,482	6,522
Worcester	Commuter rail	84,281	12,642

Source: Modified by author from Commonwealth of Massachusetts 2022. <https://www.mass.gov/info-details/multi-family-zoning-requirement-for-mbta-communities#what-is-an-%22mbta-community%22?-.>

An MBTA community that does not comply with the above mentioned requirements may not be eligible for state funds from the Housing Choice Initiative, the Local Capital Projects Fund, and the MassWorks infrastructure program (Commonwealth 2017).

### *Economic Challenges of TOD*

From an economic development consultant’s perspective, providing affordable housing in a TOD is difficult due to the increased cost of land near existing transit stations, but it is possible by accessing Low Income Housing Tax Credits (LIHTC) and other sources of subsidies to support the development costs. Developers also see parking as an issue in TODs, as they do in all built-up town and city centers, when businesses want parking in front of their stores instead of shared parking lots behind street-facing buildings, or in a centralized parking structure (Noland et al. 2017).

According to a fiscal specialist, residential developments are considered long-term revenue generators when compared to businesses and retail (Noland et al. 2017). Based on

studies by Dawkins and Moeckel, imposing an affordable housing restriction or introducing a housing voucher program had very little impact on regional housing costs (Dawkins and Moeckel 2016). While another study found that, requiring affordable housing units in TODs was a better strategy than providing housing vouchers to ensure that housing near transit stations is available to low-income populations (Tehrani, Wu, and Roberts 2019).

The high costs of housing in TOD areas are due to the proximity effect (impact of proximity to transit on socio-economic and other characteristics) and the amenity effect (impact of accessible amenities). However, there is a difference between the impact of a TOD around a new transit station and that of a TOD around an existing station. This is because, for residents who already live near the existing station, TOD does not cause a proximity effect. It is important to consider that residents in areas near existing transit are more likely to be renters and tend to get displaced more easily than homeowners (Deka 2016). Renne et al. discuss five effects of TOD which are mostly independent of each other and based on variations in transportation costs in TOD areas. When combined, these effects can be quite powerful and were significantly associated with lower levels of household transportation spending. They are: (1) gross housing density of greater than 8 units per acre in households and walk score greater than 70 in TOD areas; (2) transit frequency effect due to high frequency transit station; (3) downtown effect which is proximity to Central Business District (CBD); (4) density/intensity effect due to high population and job density; (5) network effect of population within a half-mile catchment area of TOD (Renne et al. 2016).

### *Benefits of TOD*

In a study of TOD areas in New Jersey, Noland et al (2017) identified twelve benefits of TOD as perceived by professionals involved with TOD planning and development as follows: (1) improved quality of life of residents through increased access to jobs and shopping; (2) a stronger sense of community; (3) lower transportation costs; (4) shared parking facilities; (5) increased physical activity; (6) reduction in environmental impacts; (7) place-making; (8) attracting regional businesses; (9) lowering residential turnover; (10) creating more local job opportunities; (11) improved job access to non-car users; and (12) protection of natural habitats (higher-density, compact development in a smaller geographic area). Professionals in this study mentioned fewer negative aspects: (1) increase in traffic congestion due to economic development and attractive mixed-use developments; (2) increase in housing costs; (3) reluctance of retailers to rely on structured parking; (4) necessity of high quality transit to provide substantial benefits; and (5) safety concern for pedestrians due to increased traffic in TOD (Noland et al. 2017). The authors also interviewed residents in and near TODs and concluded that perceptions of TOD's benefits outweighed their drawbacks for both professionals and residents.

### *Conclusion*

Interpretations of the TOD concept can be different for each transit station as there is no one-size-fits-all approach (Tong et al. 2018). Renne and Listokin mention that TOD is a multi-faceted planning strategy that depends on different stakeholders' points of view (Renne and Listokin 2019; Baker 2020). For example, transit agencies aim to increase ridership, while

developers focus on maximizing their return-on-investment, and cities seek to foster the economic development of their communities (Renne and Listokin 2019).

People who “self-select” to live in TOD areas are said to have “TOD-positive attitudes” meaning that they prefer to walk, bike or use public transit to reach their destinations (Noland et al. 2017). A TOD design is said to be a good design when it allows uses to change easily over time as and when people and activities change for that place, be it in the short-term or long-term. Also, even though there are discussions of providing street life and mixed uses, there still needs to be more focus on programming, that is, planning events and activities like concerts, flea markets, farmer’s market, art shows, outdoor theater, etc. (Jacobson and Forsyth 2008). Pedestrian connectivity can be calculated using street network classifications and intersection densities (Cottrell 2007). Banai finds that in TOD, the street networks enhance the functions of streets and differentiates them to provide both pedestrian orientation and vehicular circulation. TOD was introduced as a solution to problems such as the lack of pedestrian access due to the segregation of land uses (Banai 1998). Pedestrian-friendly street networks can be achieved by limiting the average block perimeter in order to create fine-grained blocks with frequent intersections (Jacobson and Forsyth 2008; Miller and Evans 2011).

Local governments need to work with transit agencies, planners, developers, community members and other stakeholders throughout the process of implementing TOD. They should plan in advance to include housing affordability, through inclusionary zoning, mixed-income and mixed-tenure housing policies, rent subsidies, property tax relief for homeowners, and other stabilization measures (Tehrani, Wu, and Roberts 2019; Guthrie and Fan 2016). They should also monitor any changes and address negative impacts immediately as

and when they arise to come up with suitable policies, regulations, and strategies to overcome them and to make sure that TOD promotes inclusivity, social justice, diversity, and well-being for all the residents of the community (Tehrani, Wu, and Roberts 2019). TOD could possibly bring about urban design interventions that foster safer mobility among pedestrians of various ages and abilities (Zegras et al. 2016). The benefits of TOD such as reduced pollution and traffic congestion, affordable and accessible public transportation, increased walkability, and economic development should be inclusive and experienced by all residents (Tehrani, Wu, and Roberts 2019).

## Chapter 3 Case Studies

In this section, I discuss two case studies – Worcester Union Station and Downtown Brockton Station – to understand the evolution of the commuter stations, the improvements being made to them, and how they have instilled economic development in their respective cities. Worcester and Brockton, suggested as case studies by the interviewees, are gateway cities like Lowell and hence are ideal cases from which to learn their approach to transit-oriented and economic development. This discussion is helpful to produce recommendations that might be applicable to Lowell to enhance the economic growth and to adapt strategies that help in revitalizing areas around the commuter rail stations.

The rising affordability crisis in and near downtown Boston results in people moving to cities that have public transportation connectivity to downtown Boston (Schachter 2018). Currently, many improvement projects are being implemented in Worcester ranging from improving accessibility to increasing the frequency of trains to Boston. Similarly, Brockton has undertaken the rehabilitation and restoration of historic buildings in the Downtown Brockton District to promote transit-oriented development as part of their Urban Revitalization Project.

Table 2 compares the main demographic characteristics of Lowell, Worcester, and Brockton.

Table 2. Demographic characteristics of Lowell, Worcester, and Brockton, MA.

	Racial and ethnic demographics (percent)	Population (2020)	Land area (square miles) (2020)	Population density (persons per square mile) (2020)	Median household income (\$) (2020)	Median home value (\$) (2016-2020)	Poverty rate (percent) (2020)
Lowell	White alone: 60.3	113,994	13.61	8,490 (2020)	\$62,196	285,200	17.3

	White alone, not Hispanic or Latino: 49.8 Black or African American alone: 8.9 Asian alone: 21.2 Two or more races: 4.3 Hispanic or Latino: 17.9						
Worcester	White alone: 67.7 White alone, not Hispanic or Latino: 54.4 Black or African American alone: 13 Asian alone: 7.2 Two or more races: 6.4 Hispanic or Latino: 23.1	205,918	37.36	5,525.5	\$51,647	241,800	19.7
Brockton	White alone: 33.9 White alone, not Hispanic or Latino: 29.1 Black or African American alone: 43.7 Asian alone: 1.8 Two or more races: 8.9 Hispanic or Latino: 11.9	105,446	21.33	4,952.3	\$62,249	279,600	13.0

Source:

U.S. Census Bureau. 2021. Quick facts for Lowell, Worcester and Brockton, MA.

<https://www.census.gov/quickfacts/fact/table/lowellcitymassachusetts,worcestercitymassachusetts,brocktoncitymassachusetts/PST045221>

Lowell and Brockton have similar population sizes (114,000 and 105,500), while Worcester has considerably more residents (206,000). Worcester and Brockton have similar population densities (5,525 and 4,952 persons/sq. mi.) while Lowell's density is significantly higher (8,490). Worcester has the largest land area (37 sq. mi.) and both Brockton (21 sq. mi.) and Lowell (14 sq. mi.) could fit within Worcester's boundaries. All three cities are diverse: Lowell and Worcester's proportions of white alone residents are 49.8 percent and 54.4 percent, while Brockton's is much lower at 29 percent. Brockton has the highest proportion of Black residents (43.7 percent), Worcester the second (13 percent) and Lowell the smallest (9 percent). Conversely, Worcester has the highest proportion of Hispanic residents (23 percent), with Lowell second (18 percent) and Brockton third (12 percent). Lowell has a high proportion

of Asian residents (21 percent), while Worcester's and Brockton's are very small (7 percent and 2 percent). Lowell and Brockton have the same median household income (\$62K) while Worcester's is lower (\$52K). Median home values are almost the same in Lowell and Brockton (\$285K and \$280K) but lower in Worcester (\$242K). Poverty levels are highest in Worcester (almost 20 percent) followed by Lowell (17 percent), while Brockton has the lowest (13 percent). In short, Worcester is the largest city of the three, has the highest burdens of poverty (low income, low property values, and high poverty rate), and the highest proportion of Hispanic residents. But all three cities are gateway cities and are more similar to each other in their demographics than to the rest of the state.

#### **Case study: Worcester Union Station**

Worcester, also known as the “heart of the Commonwealth,” is the second largest city in New England. Its 2020 population was 206,601, a significant increase from its 2010 population of 181,045 (U.S. Census 2021; UMass n.d.; City of Worcester (a) n.d.). Table 2 gives the other demographic characteristics of Worcester.

Worcester is home to eight colleges and universities and has a student population of more than 35,000. These institutions are: (1) Assumption University; (2) Clark University; (3) College of the Holy Cross; (4) MCPHS University; (5) Quinsigamond Community College; (6) Worcester Polytechnic Institute; (7) Worcester State University; and (8) University of Massachusetts Medical School, the largest employer of Worcester, which is located 2 miles from the Union Station (City of Worcester (b) n.d.; UMass 2014).

Worcester Union Station is located on the eastern edge of downtown, and is east of Worcester Common and the Main Street commercial downtown (Figure 12) (CRCOG 2021; Di Pasquale 2006; Stevenson 2012).

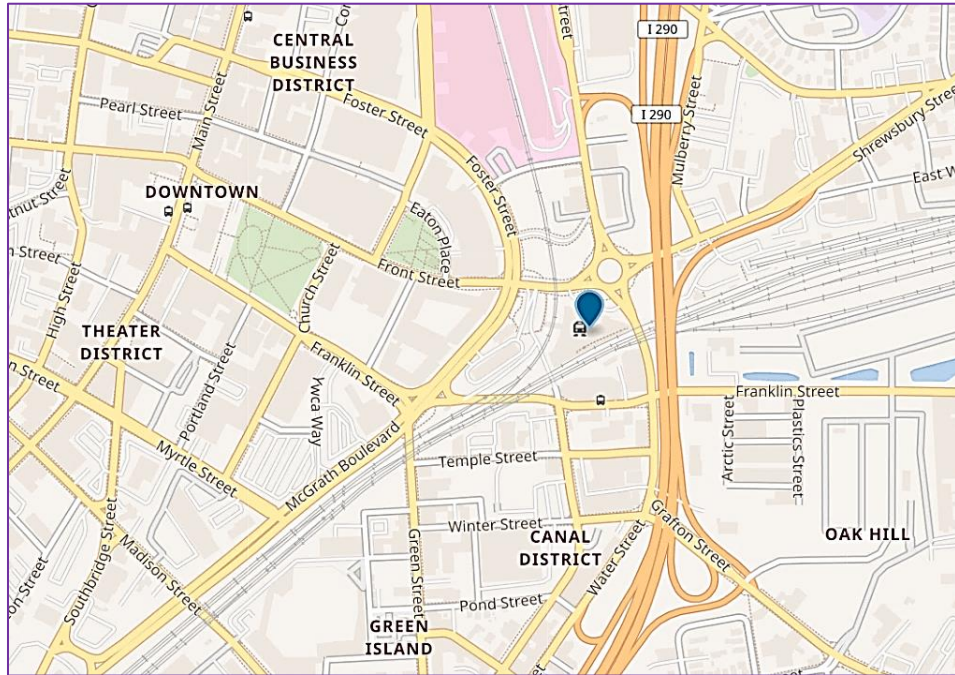


Figure 12. Location map of Union Station in Worcester. The station (blue pin) is east of Worcester Common, Main Street, and the Central Business District. Source: Wikimedia Commons.

[https://commons.wikimedia.org/wiki/Category:Union\\_Station\\_\(Worcester,\\_Massachusetts\)#/map/0/18/42.26001/-71.79502](https://commons.wikimedia.org/wiki/Category:Union_Station_(Worcester,_Massachusetts)#/map/0/18/42.26001/-71.79502)



Figure 13. (left) Existing Union Station in Worcester. Source: MassLive 2021.

<https://www.masslive.com/worcester/2021/02/union-station-in-worcester-recognized-as-one-of-most-beautiful-train-stations-in-us.html>; (right) Union Station from 1875. Source: Wikipedia.

[https://en.wikipedia.org/wiki/Union\\_Station\\_\(Worcester,\\_Massachusetts\)](https://en.wikipedia.org/wiki/Union_Station_(Worcester,_Massachusetts)).

The Union Station area serves as a major Intermodal Transportation Center for Worcester and central Massachusetts: it hosts the western terminus of the Framingham/Worcester MBTA commuter rail line, an Amtrack passenger rail station, an intercity bus station for Peter Pan and Greyhound lines, and a regional bus hub for the Worcester Regional Transit Authority (WRTA) (MBTA 2022). WRTA’s annual bus passenger trips is about 3.6 million and the travel time from MBTA commuter rail to Boston is about an hour (UMass 2014; City of Worcester (a) n.d.). A 500-space parking garage (Figure 14), located behind the station, was completed in July 2008 as a park-and-ride facility for transit users (Union Station 2.0 2019, Worcester 2022; The Great American Stations. n.d.). The roundabout in front of the station’s main entrance was completed in 2009 to better connect the station with Shrewsbury Street and the Canal District (The Great American Stations. n.d.). Worcester is the second busiest station in the MBTA commuter rail system with 16 round trips each weekday (before the pandemic), and about 9,300 users making round trips each weekday (CRCOG 2021).



Figure 14. Worcester Union Station parking garage. Source: City of Worcester.  
<https://www.worcesterma.gov/parking/municipal-garages>

The existing station was completed in 1911 for the Boston and Albany Railroad (B&A), replacing a station from 1875 (The Great American Stations. n.d.) (Figure 13). The existing station building consists of 175-foot high twin white towers, a three-story Grand Hall, and approximately 15,000 square feet of retail space (Chamber of Commerce 2019; Kotsopoulos 2019). The vast interior space of the station offers provisions to host public and private events in the Grand Hall which contains a restaurant, lounge, grille, and outdoor patio managed by the Maxwell Silverman's Banquet & Conference Center. The Worcester Redevelopment Authority provides this hall space for free for up to three dates per year for fundraising events held by the disability community (Union Station 2.0 2019, Worcester 2022). Although revenue generation is an important aspect for commuter rail lines, creating multi-use spaces within the terminal and at times providing them for free for special events, promotes a sense of community. The station currently contains Luciano's Restaurant, the state's Cannabis Control Commission, and a Worcester Police Department precinct. Possible spaces to be added are a Worcester Regional Food Hub (open 24/7), Shabby Gourmet Juices, and 961 Restaurant and Lounge (Lemmon 2022; Union Station 2.0 2019; The Great American Stations. n.d.). These developments could potentially increase the foot traffic of the station as there will be commuters going in and out of the station and workers in the retail and other spaces within the facility (Union Station 2.0 2019).

### *Zoning changes*

The city of Worcester is working on revising the zoning near the intermodal hub to allow larger mixed-use developments (Di Pasquale 2006). In a 2018 study on the potential for

transformative TOD in Massachusetts' Gateway Cities by MassINC, Worcester was included as one of the intensive case studies. Based on an analysis of vacant and underused properties, this study found that, with an “aggressive public strategy and optimal buildout, Union Station’s half-mile walkshed could accommodate nearly 24,000 net new residents (a nine-fold increase at that time) and nearly 7000 net new jobs (1/3<sup>rd</sup> increase), achieving a model TOD balance of 50 percent population, 50 percent jobs” (CRCOG 2021) (Figure 15).



Figure 15. Union Station TOD area in Worcester: development within a half-mile radius. Source: CRCOG 2021. [https://crcog.org/wp-content/uploads/2021/04/CRCOG\\_Final-Report\\_V6\\_042921.pdf](https://crcog.org/wp-content/uploads/2021/04/CRCOG_Final-Report_V6_042921.pdf)

### *Building Worcester*

Currently, the city of Worcester is working on various small- and large-scale transformation and redevelopment projects under the “Building Worcester” program/initiative across the city to attract new residents, visitors, and businesses. These projects are: (1) Union

Station Accessibility Improvements; (2) CitySquare; (3) Main Street reimagined; (4) Chandler Street Redesign Project; (5) Various school building projects; (6) Clean Worcester Waters; (7) Worcester Red Sox; (8) 95 Grand Street; (9) Boys Club Building; (10) Former Courthouse; (11) North Main Street; (12) Washington Square Redevelopment; (13) Worcester Memorial Auditorium; I have listed most of the current projects from the city's website and discussed a few of them in more detail below.

### *Past and recent plans*

The city's last comprehensive planning effort was in 1987, and since then, the city and its partners have undertaken numerous topic-specific planning efforts, such as: (1) the City of Worcester Strategic Plan (2020); (2) the Green Worcester Plan (2021); (3) a Regional Housing & Economic Study (2019); (4) the Becoming Worcester Cultural Plan (2019); (5) the Worcester Public Schools Strategic Plan (2018); and (6) the Greater Worcester Community Health Improvement Plan (2016).

### *Worcester Now | Worcester Next*

Another initiative by the city is "Worcester Now | Worcester Next" which is an eighteen-month long city-wide planning process, begun in the spring of 2022, to develop a city-wide long-range plan (Master Plan) for the next 30 years. The plan will address and explore issues related to transportation, mobility, housing, economic development, climate, urban form, and land use, among other themes (City of Worcester (d) n.d.) (Figure 16).

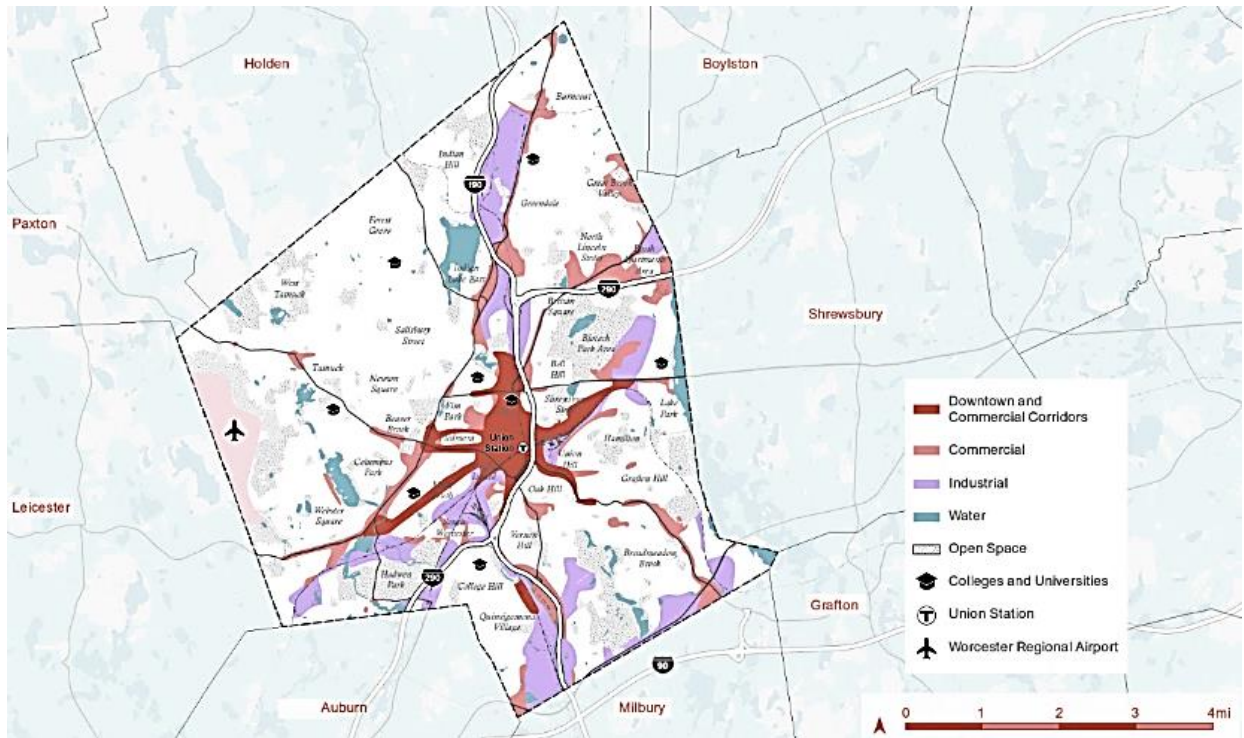


Figure 16. Map of Union Station and major land uses in Worcester. Source: Worcester Now | Worcester Next. <https://now-next.worcesterma.gov/about/>

The planning team for the Master Plan consists of: (1) the city’s Division of Planning & Regulatory Services (DPRS); (2) the Worcester Planning Board to review progress and provide guidance; (3) a consultant team led by the urban planning and design firm Utile; (4) a 13-member appointed Advisory Committee made up of Worcester residents and representatives of business and planning groups; and (5) three Working Groups in Housing, Transportation and Mobility, and Economic Opportunity (City of Worcester (d) n.d.). The most notably developments near the station are the MBTA’s Union Station Accessibility Improvements and the private development CitySquare, which are discussed in detail below.

## *Union Station Accessibility Improvements*

In addition to these ongoing planning initiatives led by the city of Worcester and private partners, the MBTA is making significant improvements to the platform, track, and accessibility of Union Station (Figures 17, 18, 19, 20, 21).



Figure 17. Existing Worcester Union Station. Source: MBTA 2019.

<https://cdn.mbta.com/sites/default/files/projects/worcester-union/2019-06-06-worcester-union-stakeholder-meeting-accessible.pdf>

The platform and track improvements were initiated because the existing station allows only one train at the station at a time and this limits the operation and capacity at the station for the Worcester/Framingham MBTA commuter rail line ( The Great American Stations. n.d.). The accessibility improvements are being made to the station, commuter parking area, and connections to the nearby neighborhoods. The improvements include a new center island platform, elongated tracks, wayfinding signage, upgrades to train signals and communication systems, new elevators, stairways, and a pedestrian bridge. With a budget of about \$45-million, the project started in October 2021 and is estimated to be completed by winter 2023 (MBTA 2022). The accessibility improvement projects have the potential to significantly increase the usability of the station.



Figure 18. Worcester Union Station Project area. Source: MBTA 2020.

<https://cdn.mbta.com/sites/default/files/2020-05/2020-05-27-worcester-union-public-meeting-presentation-accessible-v2.pdf>

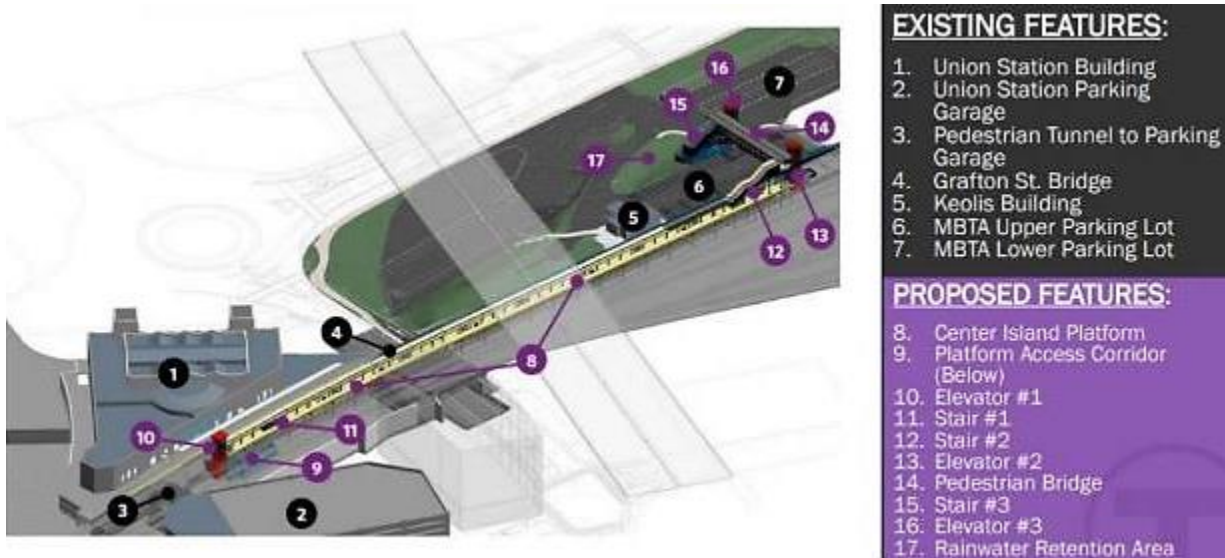


Figure 19. Worcester Union Station existing and project proposal. Source: MBTA 2020.

<https://cdn.mbta.com/sites/default/files/2020-05/2020-05-27-worcester-union-public-meeting-presentation-accessible-v2.pdf>



Figure 20. Rendering of proposed improvements to the platform. Source: MBTA 2022.  
<https://www.mbta.com/projects/worcester-union-station-improvements>



Figure 21: Renderings of proposed improvements to the Worcester Union Station. Source: MBTA 2022.  
<https://www.mbta.com/projects/worcester-union-station-improvements>

### *Ownership*

Union Station and its surrounding parcels are owned by different entities (Figure 22).

The multiple ownerships show that MBTA's improvements will necessitate close coordination

among public agencies and with private companies and hence, the process of planning transit-oriented development around the station will be no less complex.



Figure 22. Ownership of parcels in and around Worcester Union Station. Source: MBTA 2019.

<https://d2o8eokdkim9o8.cloudfront.net/sites/default/files/projects/worcester-union/2019-06-06-worcester-union-stakeholder-meeting-accessible.pdf>

- The City of Worcester owns the parking garage and leases the ground floor to the Worcester Redevelopment Authority (WRA).
- The Massachusetts Bay Transportation Authority owns the platform and track.
- CSX and G+W, private freight railroad companies, own and maintain some railroad around the station.
- The WRA owns Worcester Union Station and leases the ground floor of the parking garage behind the station from the City of Worcester.

### *CitySquare*

A three-minute walk west from Union Station is CitySquare, a \$565-million, 2.2 million-square foot mixed-use transit-oriented development in the heart of the city. CitySquare is located on the 20-acre site of the former Worcester Center Galleria, also known as Worcester Commons (Commonwealth 2017; City of Worcester (a) n.d.; CRCOG 2021).



Figure 23. CitySquare and Mercantile Center mixed-use developments near Worcester Union Station. Source: Leggat McCall. <https://www.lmp.com/city-square/>.

The CitySquare development (Figure 23) includes the following components.

- \$70-million, 214,000 sq. ft Paul Revere Life Insurance office building that employs 550 employees, with an 860-car parking garage
- 66,000 sq. ft expansion of Saint Vincent Hospital campus with \$30-million Cancer and Wellness Center
- \$90-million, 365 housing units of residential development with 479 parking spaces
- 13,000 sq. ft Roseland Properties with ground floor retail
- \$33.1-million Marriott hotel with 168 rooms
- Mercantile Center: a 640,000 sq. ft office and retail complex with a 1,647-car parking garage. This complex includes two office towers, three retail/commercial developments,

UMass Memorial Health Care (with 700 UMass workers), and a coffee roaster and café by Fuel America.

- Other investments include the 110-Grill, the Protein House, and the Fidelity Cooperative Bank.

Financing for CitySquare consists of \$25-million from state financing, \$16.25-million from Growth District Initiative, \$27.25-million from MassWorks Funding, and \$7.5-million from DIF Financing (Commonwealth 2017; City of Worcester (a) n.d.). Since the start of the project, a roughly \$90 million public investment has generated \$298 million in private development at the CitySquare project site (City of Worcester (a) n.d.).

The key takeaways for Lowell from the Worcester Station case study include the leveraging of various station improvements to attract private investment, the use of different funding strategies, and a focus on mixed-use developments. The benefits of economic development resulting from federal spending on large transportation projects are increased employment, increased development, population growth adjacent to public transportation, increasing property values, and environmental benefits (Di Pasquale 2006). Advocates and critics of ‘transportation-induced economic development’ agree that in order for the cities to succeed, transportation projects require public policies and land use regulations, such as zoning changes to increase density near transit stations; mixed-use development; policies that encourage the use of public transportation while discouraging automobile.

### **Case study: Brockton Station**

The City of Brockton, also known as “the City of Champions”, is a Gateway City 25 miles south of Boston, and is the sixth largest city in Massachusetts. The population of the city was

105,643 in 2020. Table 2 at the beginning of this chapter displays Brockton’s other demographic characteristics. Brockton is home to various educational institutions like Bridgewater State University, Stonehill College, Massasoit Community College, Signature Healthcare - Brockton Hospital School of Nursing, Fisher College, Eastern Nazarene College, MassHire, Brockton High School + Adult Learning Center, and Southeastern Regional Vocational Technical High School. Land uses and economic activities in Brockton consist of residential development, commercial clusters that include food production, life sciences, electronics, healthcare, and minority-owned and small businesses (City of Brockton (a) n.d.).

In an effort to attract investment, the city created public partnerships at the local, state, and federal levels to raise necessary resources, and initiated private partnerships with landowners and developers. As part of its “Open For Business Initiative”, the City of Brockton in collaboration with the Old Colony Planning Council and funding from the MA Office of Business Development, it developed the “Brockton MA City of Champions” application (app). Developed to assist Brockton businesses to recover from the pandemic, the app also acts as a business directory that provides residents and visitors with accurate information about businesses in Brockton (City of Brockton (a) n.d.; Brockton, MA 2022).

### *Brockton Station*

Brockton Station is located in the center of the city (Figure 24).

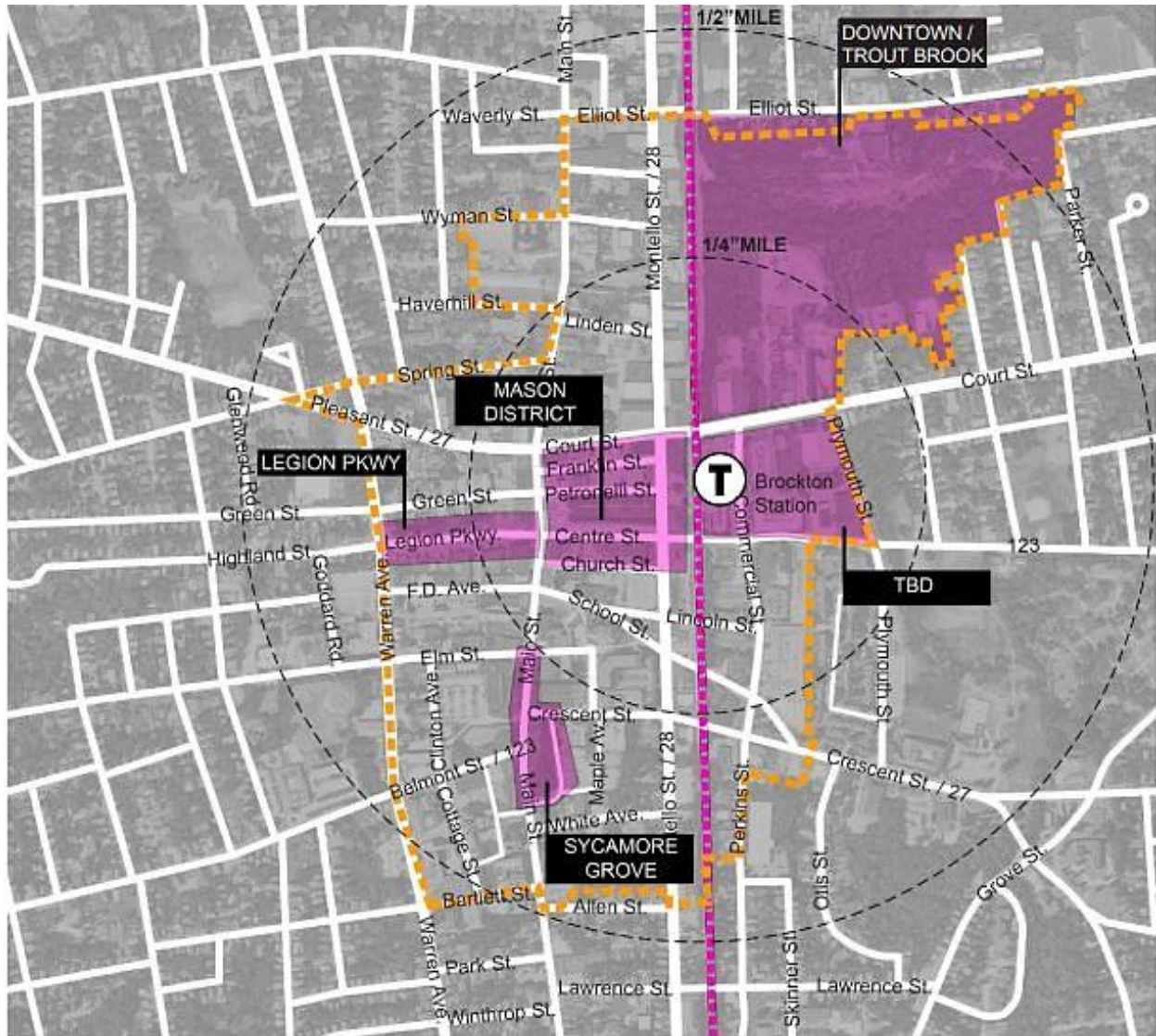


Figure 24. Location map of Brockton Station in Brockton, Massachusetts. Source: Wayfinding Presentation 2020. <https://brockton.ma.us/wp-content/uploads/2020/03/Wayfinding-Public-Presentation.pdf>

The first station was initially known as North Bridgewater station and was a one-story building built in 1846 (Figure 25). When the town of North Bridgewater was renamed Brockton in 1874, the station was renamed Brockton Station. The station was replaced with a Victorian-Style building in 1878 (Figure 25). It was replaced again in 1897 with a granite building after a three-year grade separation project that raised the tracks and lowered the streets (Brockton Station 2021).

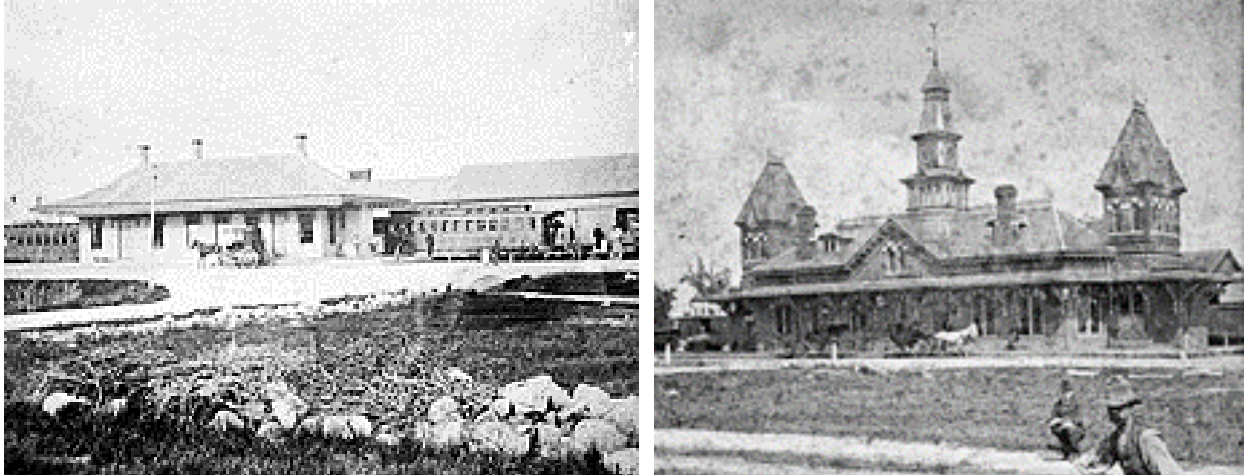


Figure 25. (left): The one-story North Bridgewater station (1846) as seen around 1880; (right): the Victorian-style Brockton station (1878) before it was replaced in the 1890s. Source: Wikipedia.  
[https://en.wikipedia.org/wiki/Brockton\\_station\\_\(MBTA\)](https://en.wikipedia.org/wiki/Brockton_station_(MBTA))

Passenger rail service started to decline in the 1920s with the rise of car travel and was further reduced with the construction of the parallel Southeast Expressway in the late 1950s. The station buildings were torn down as part of 1960s urban renewal projects. However, after decades of planning, it was rebuilt again since it was an important node of connectivity. In 1997, the Middleborough/Lakeville Line and Kingston/Plymouth Line opened for commuter service thereby restoring commuter rail service to the MBTA Brockton station.

One block away from the commuter rail station, the Brockton Area Transit (BAT) Authority provides local bus service. The BAT Intermodal Center was designed to replicate the architecture of the former railroad station. This project initially included a 250-space surface parking lot. In 2001, funding for constructing a parking garage was secured, and the garage opened in 2004. In 2015, Brockton became one of the stops on the CapeFLYER seasonal rail line between Boston and Hyannis on Cape Cod (from Memorial Day weekend through Labor Day) (Brockton Station 2021).



Figure 26. Brockton commuter rail station. Source: Wikipedia.  
[https://en.wikipedia.org/wiki/Brockton\\_station\\_\(MBTA\)](https://en.wikipedia.org/wiki/Brockton_station_(MBTA))

### *Downtown Urban Revitalization Plan*

The Brockton Downtown Urban Revitalization Plan aims at redeveloping the downtown to create a vibrant, inclusive, and diverse district. This plan was approved by the Brockton Redevelopment Authority (the BRA) on January 6, 2016, and by DHCD on May 9, 2016. The overall Downtown Brockton Urban Revitalization District area is 65.8 acres out of which off-street parking and paved roadways take up 45 percent (29.6 acres) (Downtown Brockton URP 2016). The maps below show various aspects of the Downtown area in Brockton. Figure 27 shows the extent of Downtown Brockton Urban Revitalization Area. Figure 28 portrays the availability of off-street parking and building footprints. This map is helpful in showing the extent of land within the Downtown area for future development. Figure 29 maps the existing land uses within the Downtown area, which consist of residential, commercial, mixed-use, industrial, religious, and lands for public use. The next map, Figure 30, shows the existing zoning of the Downtown area, C-2 General Commercial Zone, C-3 Central Business Zone, Downtown Core Sub-District, and Art/Culture Sub-District. And the final image, Figure 31 presents the recent rehabilitation projects identified within this Downtown area.

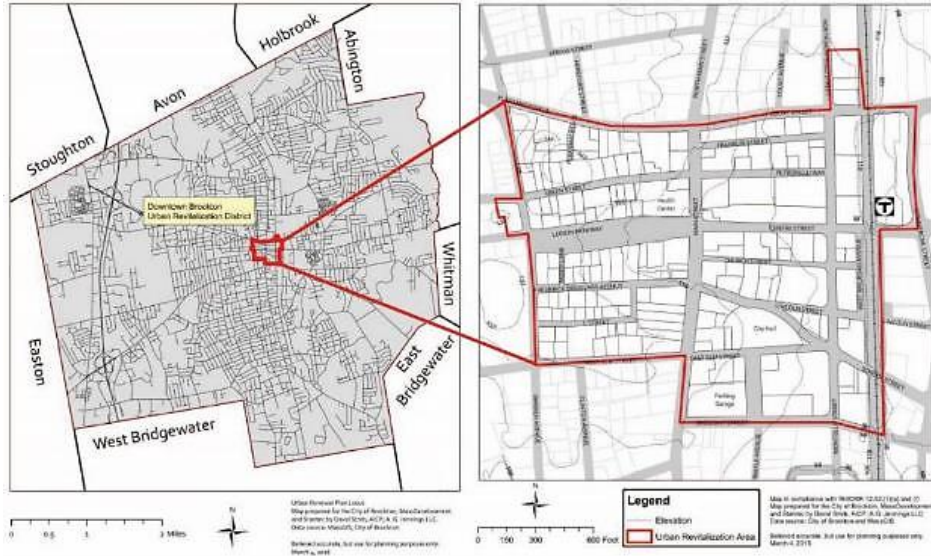


Figure 27. Downtown Brockton Urban Revitalization Area. Source: Modified by author from Downtown Brockton URP 2016. [https://drive.google.com/file/d/1jduOGaMdeBa\\_Butw49xgWgzbw38V-J7c/view](https://drive.google.com/file/d/1jduOGaMdeBa_Butw49xgWgzbw38V-J7c/view).

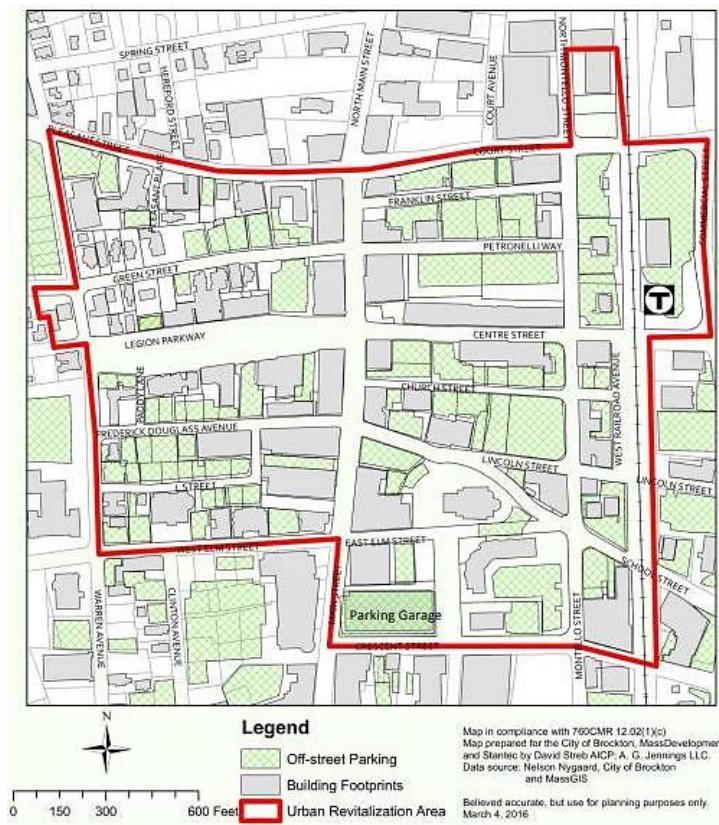


Figure 28. Building footprints and off-street parking areas. Source: Downtown Brockton URP 2016. [https://drive.google.com/file/d/1jduOGaMdeBa\\_Butw49xgWgzbw38V-J7c/view](https://drive.google.com/file/d/1jduOGaMdeBa_Butw49xgWgzbw38V-J7c/view).

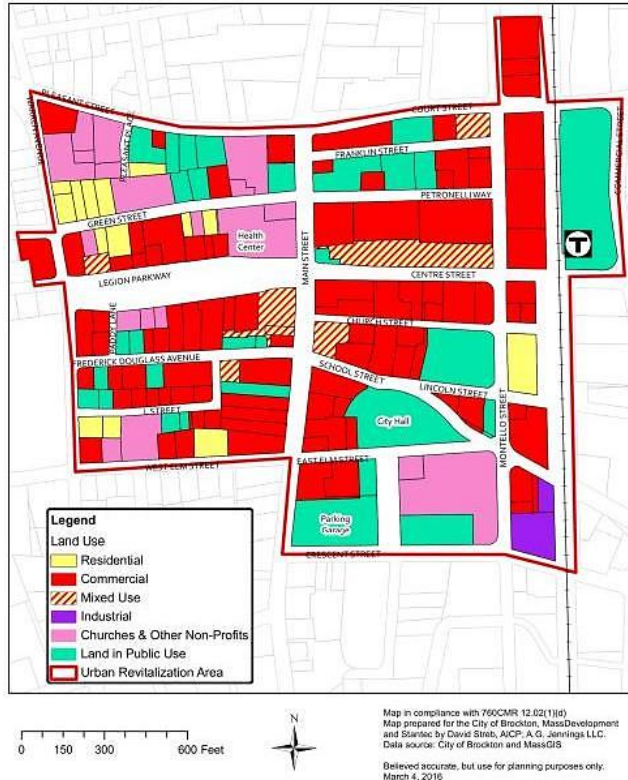


Figure 29. Existing land use. Source: Downtown Brockton URP 2016.  
[https://drive.google.com/file/d/1jduOGaMdeBa\\_Butw49xgWgzbw38V-J7c/view](https://drive.google.com/file/d/1jduOGaMdeBa_Butw49xgWgzbw38V-J7c/view)

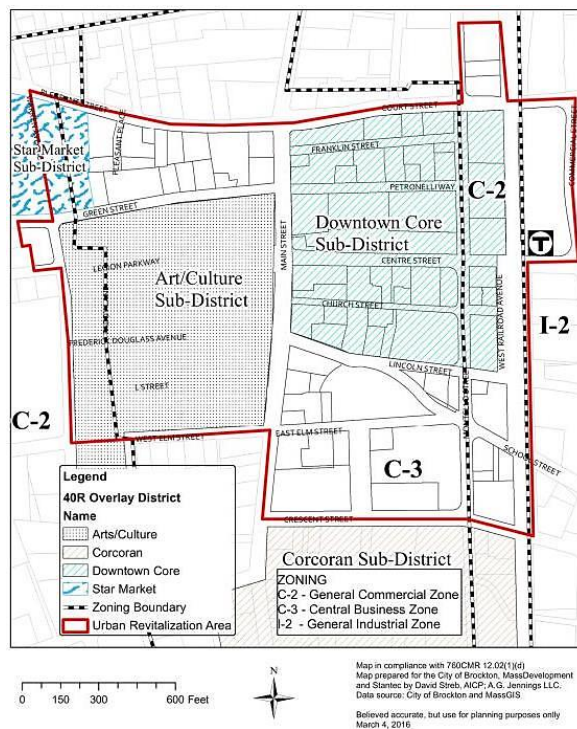


Figure 30. Existing zoning. Source: Downtown Brockton URP 2016.  
[https://drive.google.com/file/d/1jduOGaMdeBa\\_Butw49xgWgzbw38V-J7c/view](https://drive.google.com/file/d/1jduOGaMdeBa_Butw49xgWgzbw38V-J7c/view)



Figure 31. Existing conditions in the Downtown Brockton Urban Revitalization District. Source: URP 2016.  
[https://drive.google.com/file/d/1jduOGaMdeBa\\_Butw49xgWgzbw38V-J7c/view](https://drive.google.com/file/d/1jduOGaMdeBa_Butw49xgWgzbw38V-J7c/view)

### *Downtown Trout Brook (CSX Area) Master Plan*

CSX is a private freight railroad company which owns a large area around the Brockton Station (Figure 32). This is underutilized land and hence, the city came to an agreement with the freight company and proposed the Downtown Trout Brook project which is on the site of a former CSX rail yard. Trout Brook bisects the Downtown Trout Brook planning study area and the rail yard. This 66-acre study area is northeast of downtown and is bordered by the MBTA Commuter Rail Tracks on the west, Parker Street on the east, Elliot Street to the north, and Court Street to the south, with narrower portions extending north and south. This area is

mostly vacant with few industrial uses, separating the Downtown from existing residential neighborhoods, and it is within walking distance of the Brockton Commuter Rail Station and BAT Center (City of Brockton (b) n.d.).



Figure 32. City of Brockton Conceptual Plan for the Downtown Trout Brook Redevelopment Plan. Source: BRA 2020. <https://brocktonredevelopmentauthority.files.wordpress.com/2020/02/trout-brook-redevelopment-district-rloi.pdf>

After holding public meetings to discuss the different development scenarios identified in the CSX Master Plan Study (2019), the city adopted a preferred development plan for the Downtown Trout Brook project, with the following goals and desired components (City of Brockton (b) n.d.).

- (1) Build multifamily residential units along Court Street to leverage commuter and bus services within walkable distance, and to increase demand for goods and services, which will support further revitalization of the businesses along Main Street.
- (2) Include active retail and commercial uses at the ground floors, such as a café or small convenience store to support the needs of both residents and commuters.
- (3) Develop commercial flex buildings (hybrid office, retail, and industrial) along the rail tracks to provide additional spaces for businesses and jobs to support the economy of the City and downtown.
- (4) On and south of Elliot Street, build a single-family development and extend now unconnected streets to knit the existing neighborhood together, create more access to public transit, and foster a better pedestrian network.
- (5) Build a neighborhood playground connected to the multiuse path and build a shared pedestrian/bicycle pathway on the east side of the Brook connecting Puffer Playground to the north and Snow Park to the south of the site.
- (6) Remove invasive plants to restore the function of Trout Brook.
- (7) Identify flood storage areas to the west of Trout Brook, to help mitigate existing and anticipated flood conditions

Throughout these planning initiatives, the City of Brockton decided to preserve the historic buildings as much as possible to keep the texture of downtown (Sweeney 2022). Preserving downtown historic buildings retains the character of the city and thereby keeps the history intact in built form while also helping to attract more visitors to the area's unique architecture.

## TOD Opportunities

### TOD Opportunities

**Three commuter rail stops in Brockton**, with 30-minute commute time to Downtown Boston and the Red Line

**Class A commercial rents of \$15-\$20** (\$ p.s.f.) vs. \$65 in Boston, \$87 in Cambridge, and \$42 on Route 128

**Market rate rents** for new 2 BR product are **\$1,750** per month in Downtown

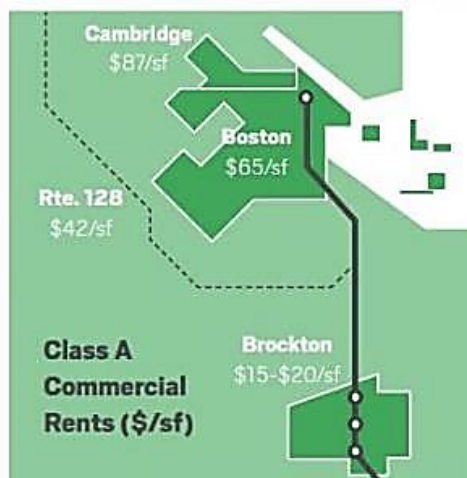


Figure 33. TOD opportunities. Source: Brockton Prospectus 2019. [https://www.metroouthchamber.com/wp-content/uploads/2019/07/20190620-Brockton Prospectus-Final\\_reducedsize.pdf](https://www.metroouthchamber.com/wp-content/uploads/2019/07/20190620-Brockton Prospectus-Final_reducedsize.pdf)

### Opportunity Zones

The Downtown Trout Brook project area coincides with one of Brockton's four Opportunity Zones (Figures 33 and 34). Based on an analysis of U.S. Census Bureau American Community Survey data, the city identified four Opportunity Zones eligible for the federal program. An Opportunity Zone designation gives special federal tax benefits to investors who support and/or develop projects within these zones. There are 8,764 opportunity zones across the U.S. (Opportunity Zones n.d.).

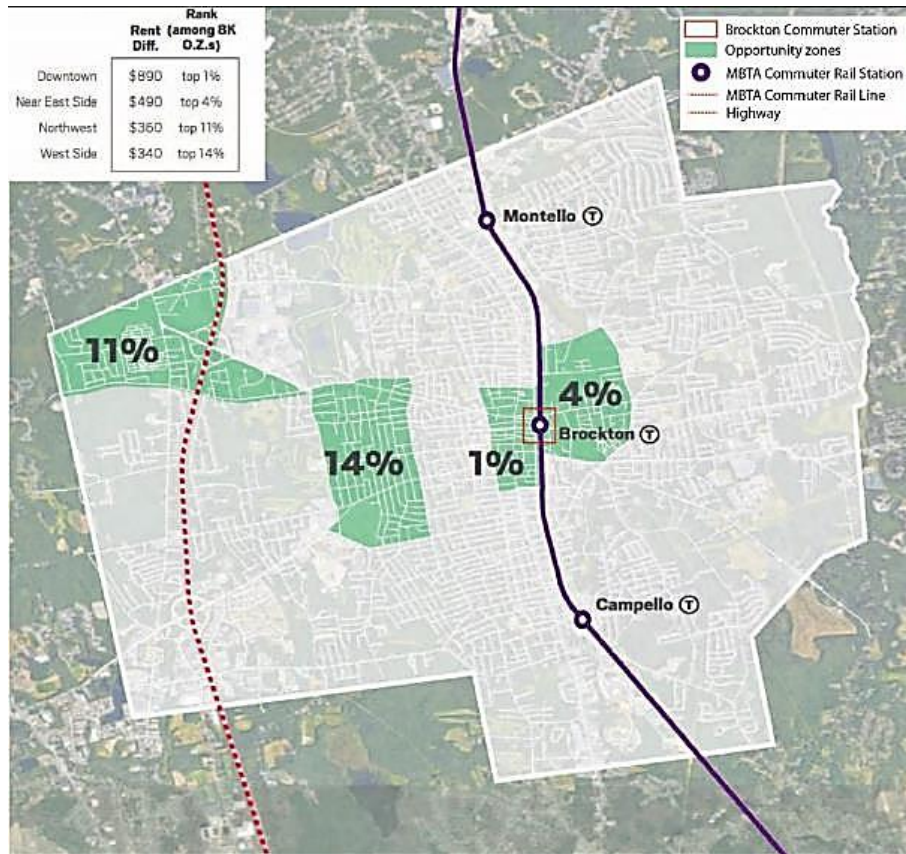


Figure 34. Opportunity zones in Brockton. Source: Brockton Prospectus 2019.

<https://www.metro-southchamber.com/wp-content/uploads/2019/07/20190620-Brockton-Prospectus-Final-reducedsize.pdf>

Among the four federal opportunity zones, Downtown Brockton ranks among the top 1 percent for financial upside, or the potential for high returns on investment. Other opportunity zones ranked are the Near East Side (top 4 percent), Northwest (top 11 percent) and West Side (top 14 percent) (Brockton Prospectus 2019).

#### *Downtown Brockton developments*

The Brockton Prospectus (2019) discusses the developments happening in Downtown Brockton and other Opportunity Zones. Some of the projects discussed in the Prospectus are highlighted below (Figure 35).



Recently Completed Projects (10)	Under Construction (5)	Pipeline, Permitted, in Permitting Process (7)
<p><b>1.) Standard Modern</b> 24 mkt. rate units, 2-bed rent: \$1,750 Completed: 2018 (fully leased) Financing Tools: Historic Tax Cred. / HDIP/ MassDevelopment Loan</p> <p><b>2.) Vicente's Supermarket</b> 32K sf. Supermarket Completed: 2015</p> <p><b>3.) Enterprise Main</b> 52K sf retail/commercial space Completed: 2015</p> <p><b>4.) Centre 50 and Enso Flats</b> 114 mkt. rate units, 2-bed rent: \$1,600 Completed: 2015</p> <p><b>5.) WB Mason</b> 85K sf. Office Completed: 2016</p> <p><b>6.) Station Lofts</b> 24 mixed income units, 2-bed mkt. rent: \$1,750 Completed: 2014</p> <p><b>7.) Brophy &amp; Phillips Co.</b> 26K sf. Office Completed: N/A</p> <p><b>8.) Registry of Deeds</b> 5K sf. Office Completed: 2018</p> <p><b>9.) District Attorney Office</b> 32K sf. Office Completed: 2017</p> <p><b>10.) Self Storage</b> 75K sf. Storage space Completed: 2018</p>	<p><b>1.) 75 Commercial</b> 24 mkt. rate units, 1-bed rent: \$1,400 Est. Completion: 1Q 2019 Financing Tools: Private Equity, Traditional Bank Financing</p> <p><b>2.) 121 Main Street</b> 48 unit (workforce + market), &amp; 3,000 sf. commercial space, 2-bed rent: N/A Est. Completion: 2020 Financing Tools: LIHTC/HOME</p> <p><b>3.) 47 W. Elm</b> 44 mkt. rate units, 2-bed rent: &gt;\$1,600 Status: Breaking ground 2Q 2019</p> <p><b>4.) Parking Garage</b> 414 Spots Est. Completion: 4Q 2019</p> <p><b>5.) Registry of Deeds (Phase II)</b> 7K sf. Office Est. Completion: TBD</p>	<p><b>1.) 26 School</b> Residential development, units TBD Status: Recently Purchased</p> <p><b>2.) 93 Centre</b> 55 mkt. rate units Status: 40R permits issued</p> <p><b>3.) 140 School</b> 24 mkt. rate units Status: Est. Const. Start 1Q 2020</p> <p><b>4.) Ganley Building</b> State Unemployment Office Status: Est. Const. Start 3Q 2019</p> <p><b>5.) 155 Crescent</b> 4-8 mkt. rate units, 2-bed rent: N/A Status: Plans approved</p> <p><b>6.) Trinity Financial</b> 103 mkt. rate units Status: 40R permits issued</p> <p><b>7.) Corcoran Mixed Use Development</b> 90 units planned (across two sites)</p>

Figure 35. Completed, Under Construction, and Planned Projects in Downtown Brockton and other Opportunity Zones. Source: Brockton Prospectus 2019. <https://www.metro-southchamber.com/wp-content/uploads/2019/07/20190620-Brockton-Prospectus-Final-reducedsize.pdf>

Table 3. Properties under development in the Downtown Brockton Opportunity Zone.

Address	Proposed units	Completion date, number of stories	Features
28 Petronelli Way	<ul style="list-style-type: none"> <li>• 18 market rate apartments</li> <li>• Commercial space on ground floor</li> </ul>	<ul style="list-style-type: none"> <li>• Expected to be completed by the end of 2022</li> <li>• 4 stories</li> </ul>	Importance given to pedestrian friendly storefront
19 Main St (Figure 36 left)	<ul style="list-style-type: none"> <li>• 20 units</li> <li>• Commercial on first floor (Bistro, 2 office/commercial spaces)</li> </ul>	<ul style="list-style-type: none"> <li>• 72 percent completed by February 2022</li> <li>• 3 stories</li> </ul>	<ul style="list-style-type: none"> <li>• 14 on-site parking spaces.</li> <li>• Development will require additional parking</li> </ul>
Anglim building, 93 Centre St	<ul style="list-style-type: none"> <li>• 55 residential units: 44 market rate, 11 affordable</li> <li>• 1500 sq. ft commercial space on first floor</li> </ul>	<ul style="list-style-type: none"> <li>• Started in September 2021, estimated to be completed by Fall 2022</li> <li>• 8 stories</li> </ul>	Property taken by eminent domain
Hotel Grayson 32 Fredrick Ave	<ul style="list-style-type: none"> <li>• 16 units of studio apartments (~340 sq. ft to ~410 sq. ft)</li> <li>• Community and commercial space on ground floor</li> </ul>	<ul style="list-style-type: none"> <li>• Not started</li> <li>• 3 stories</li> </ul>	<ul style="list-style-type: none"> <li>• Bought by NeighborWorks Housing Solutions</li> <li>• Conversion will include an elevator since the building is not currently handicapped accessible</li> </ul>
132 Court Street (Home Court)	<ul style="list-style-type: none"> <li>• 150 market rate rental units and 4,000 Sq feet of mixed use commercial space</li> <li>• 110 one-bedroom units (~700 sq. ft) and 40 two-bedroom units (~1000 sq. ft)</li> <li>• 150 parking spaces (57 underground parking)</li> </ul>	<ul style="list-style-type: none"> <li>• Not started</li> <li>• New construction</li> <li>• 6 stories</li> </ul>	<ul style="list-style-type: none"> <li>• Purchased in 1994</li> <li>• Proposed transit-oriented and mixed-use development project</li> <li>• Within 250 feet of Brockton Station</li> <li>• Traffic signalization at its border</li> </ul>

Source: Compiled by author from information at Sweeney 2022. "What's Happening in Brockton?" Facebook page. 28 Petronelli Way. <https://www.facebook.com/groups/611094259031723/posts/2345281748946290/>. 19 Main Street. <https://www.facebook.com/groups/611094259031723/posts/2345328408941624/>. Anglim Building, 93 Centre Street and The Greyson Hotel, Frederick Douglass Avenue. <https://www.facebook.com/groups/611094259031723/permalink/2345338712273927/>. Downtown Urban Revitalization Plan Final Draft Amendment, April 15, 2022. <https://brockton.ma.us/wp-content/uploads/2022/04/Downtown-Urban-Revitalization-Plan-Final-Draft-Amendment.pdf>.

Other developments include 8-66 Montello St (Figure 36 middle) and 11, 15, 28 High St (Figure 36 right) for which only images are available.



Figure 36. (left) 19 Main St; (middle) 8-66 Montello St; (right) 11, 15, 28 High St. Source: Brockton Prospectus 2019. [https://www.metrosouthchamber.com/wp-content/uploads/2019/07/20190620-Brockton Prospectus-Final\\_reducedsize.pdf](https://www.metrosouthchamber.com/wp-content/uploads/2019/07/20190620-Brockton Prospectus-Final_reducedsize.pdf).

Table 4. Incentives available for development projects in Brockton.

Incentive	Type	Description
<b>Housing Development Incentive Program (HDIP)</b>	State (City)	<ul style="list-style-type: none"> <li>• 25% tax credit, up to \$2M on market-rate housing developments</li> <li>• Local-option RE tax exemption</li> </ul>
<b>District Improving Financing (DIF)</b>	State (City)	<ul style="list-style-type: none"> <li>• Dedicated funding for infrastructure and development priorities within district</li> </ul>
<b>Urban Revitalization Plan + Urban Renewal Authority</b>	State (City)	<ul style="list-style-type: none"> <li>• Provides authority to municipalities to gain site control and assemble development sites in order to redevelop and revitalize decadent and blighted areas</li> </ul>
<b>Chapter 40R Smart Growth Zoning District</b>	State	<ul style="list-style-type: none"> <li>• Allows for high density office, mixed use and residential development by right, with permitting completed in under 6 months</li> </ul>
<b>Historic Rehabilitation Tax Credits</b>	State and Federal	<ul style="list-style-type: none"> <li>• 20% tax credit for qualified rehab. expenditures of qualified historic structure</li> <li>• 10% tax credit for qualified rehab. expenditures of building not certified as a historic structure, but built before 1936</li> </ul>
<b>New Markets Tax Credits</b>	Federal	<ul style="list-style-type: none"> <li>• Federal tax credit for development projects that include a commercial component – such as mixed use, retail/office, performance space – for job creation and material improvement in the lives of residents of low-income communities</li> </ul>
<b>Opportunity Zones</b>	Federal	<ul style="list-style-type: none"> <li>• Temp. tax deferral on unrealized capital gains invested in RE and businesses within Opportunity Zones</li> <li>• Step-up in basis for capital gains reinvested in an Opportunity Fund for at least 5 years, increases for longer investment periods</li> </ul>

Source: Brockton Prospectus 2019. [https://www.metrosouthchamber.com/wp-content/uploads/2019/07/20190620-Brockton Prospectus-Final\\_reducedsize.pdf](https://www.metrosouthchamber.com/wp-content/uploads/2019/07/20190620-Brockton Prospectus-Final_reducedsize.pdf)

### Wayfinding in Brockton

Brockton also developed a *Wayfinding Plan and Signage Program* (Harriman 2020).

Wayfinding is defined on Brockton’s website as “how we orient ourselves to a physical space,

and travel from place to place.” A Wayfinding plan identifies various levels of signage which range from the greater city recognition signage “Welcome to Brockton” through the district identification signage “Downtown Brockton” to the destination acknowledgement such as “City Hall,” “Train Station,” or “Library” (Harriman 2020; City of Brockton (c) n.d.).

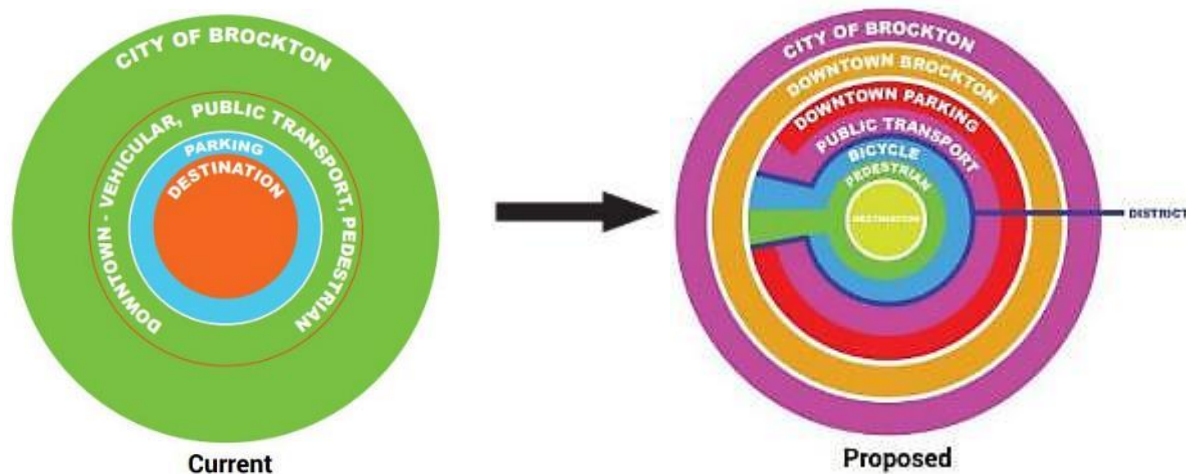


Figure 37. Transition from city boundary to Downtown Brockton. Source: Harriman 2020.  
<https://brockton.ma.us/wp-content/uploads/2020/03/Wayfinding-Public-Presentation.pdf>

Brockton’s *Wayfinding Plan and Signage Program* identifies the benefits of wayfinding as: (1) name recognition; (2) destination attendance increase; (3) reduction in private vehicle use; (4) improved pedestrian experience; and (5) increased awareness of place and events. The goals of the *Wayfinding Plan and Signage Program* are to: (1) enhance visitors and residents’ sense of place in Downtown Brockton; (2) allow visitors to easily find Downtown Brockton; (3) allow vehicle-driving visitors to conveniently find parking and explore downtown area on foot to easily find services and amenities; (4) improve the downtown’s business opportunities; and (5) improve the way people identify the downtown area (Figures 38, 39, 30, 41, and 42) (City of Brockton (c) n.d.; Harriman 2020).

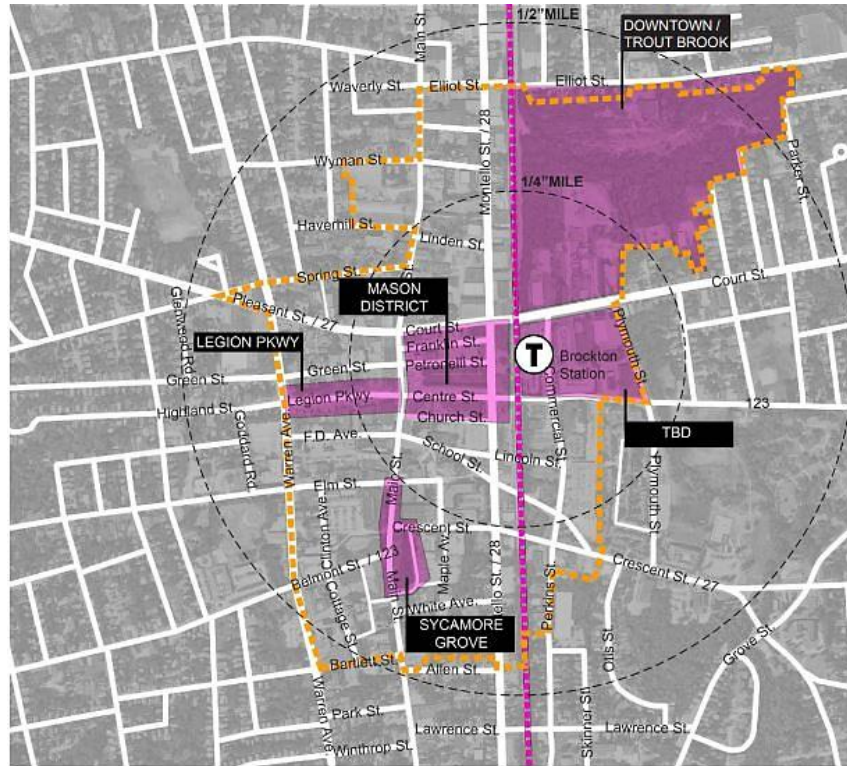


Figure 38. Districts to identify with wayfinding and signage within 1/2 mile of Brockton Station. Source: Harriman 2020. <https://brockton.ma.us/wp-content/uploads/2020/03/Wayfinding-Public-Presentation.pdf>

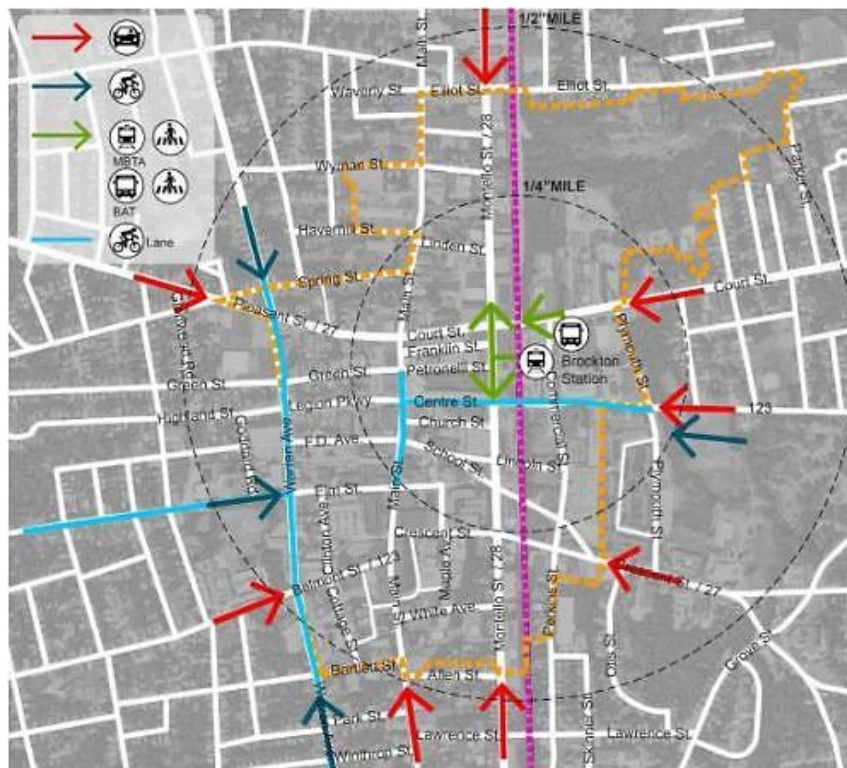


Figure 39. Access points to Downtown destinations by different modes of transportation within 1/2 mile of Brockton Station. Source: Harriman 2020. <https://brockton.ma.us/wp-content/uploads/2020/03/Wayfinding-Public-Presentation.pdf>



Figure 40. Existing signage in Brockton. Source: Modified by author from Harriman 2020. <https://brockton.ma.us/wp-content/uploads/2020/03/Wayfinding-Public-Presentation.pdf>.

City scale



Source: City of Alexandria - Design Guidelines Manual

City scale



Upper Perkiomen Valley - Photo by CVE Design



City of Ellaville - Photo by Denyse Co.

Downtown scale



Leesburg Sign System- Photo by Frazier Associates



Downtown Fredericksburg - by Madame Comm.



Pedestrian Wayfinding and Signage Program

District scale



Old Sanford District - Photo by Sanford365



City Sign - by Denyse Co.



Fort Wayne - by Mitch Harper



Downtown Banff - Courtesy of Travel Pockets



City of Columbus. Photo by RSD

Destination scale



Cleveland Public Library - Photo by Karen Skunta & Co.



Spelman College - Photo by Praxis 3



Charles City Signage - By Charles City Press

Figure 41. Examples of signage precedents by scale recommended for Brockton. Source: Modified by author from Harriman 2020. <https://brockton.ma.us/wp-content/uploads/2020/03/Wayfinding-Public-Presentation.pdf>.

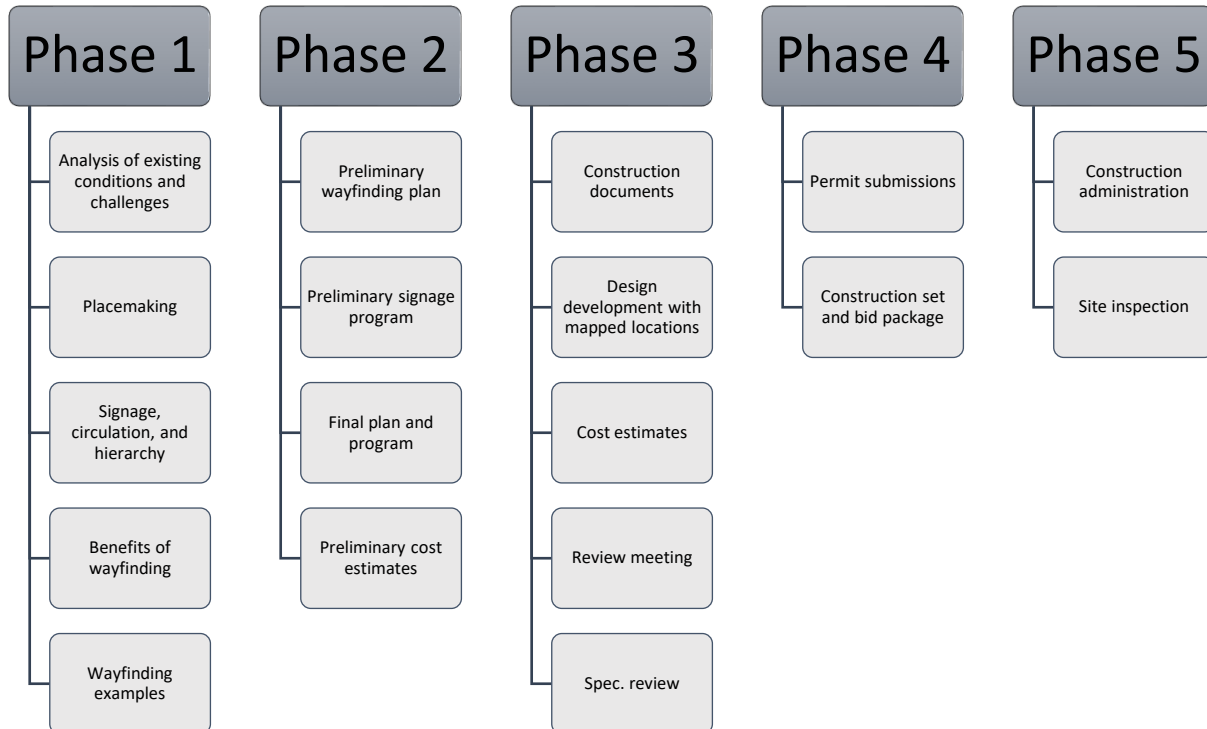


Figure 42. Phases of a wayfinding project. Source: Made by author from Harriman 2020. Phases 3 through 5 are dependent on future funding. <https://brockton.ma.us/wp-content/uploads/2020/03/Wayfinding-Public-Presentation.pdf>.

### Conclusion

Worcester and Brockton are progressive gateway cities that keep working on various development and rehabilitation projects. The themes discussed under the Case Studies chapter will be helpful for Lowell to identify new improvement opportunities while also focusing on short, mid, and long term projects. Some takeaways for the city of Lowell would be the multi-use and revenue generating station strategy by Worcester and the wayfinding program by Brockton.

## Chapter 4 Demographic, Mobility, and Market Trends

The Market Analysis chapter discusses the trends of population, demographics, commuting, housing, retail, and commercial development in Lowell. This gives the decision-makers an opportunity to support local businesses and to make sure that there is an inclusive and diverse environment in the city's retail and commercial market. When implementing TOD around the transit terminal in Lowell, understanding the demographics of the city and the area around the terminal is important to know who the end-users are, what their needs are, and to estimate the gap in retail and commercial uses so that these services can be provided in the new TOD district. This analysis is followed by a foot traffic analysis which discusses the foot traffic patterns in the city as well as around the transit terminal in Lowell. Based on the type of demand, the market need varies. For example, retail demand is driven by local income and spending, while office and industrial real estate demand is driven by business and employment growth (Rao 2012).

### *Demographics and socio-economic trends*

The feasibility of any development is directly associated with demographic and socio-economic trends. Hence it is essential to analyze and understand these parameters. The most recent US Census data for Lowell's population, as of July 2021, is 113,995. This chapter's analysis is based on a 2021 ESRI Market Analysis of Lowell which has the population as 109,934. All socio-economic trends therefore are based on numbers and percentages from a population size of 109,394.

Table 2 at the beginning of the Case Studies chapter displays the Census demographic data for Lowell. The ESRI charts below further illustrate them (Figures 43, 44, and 45).

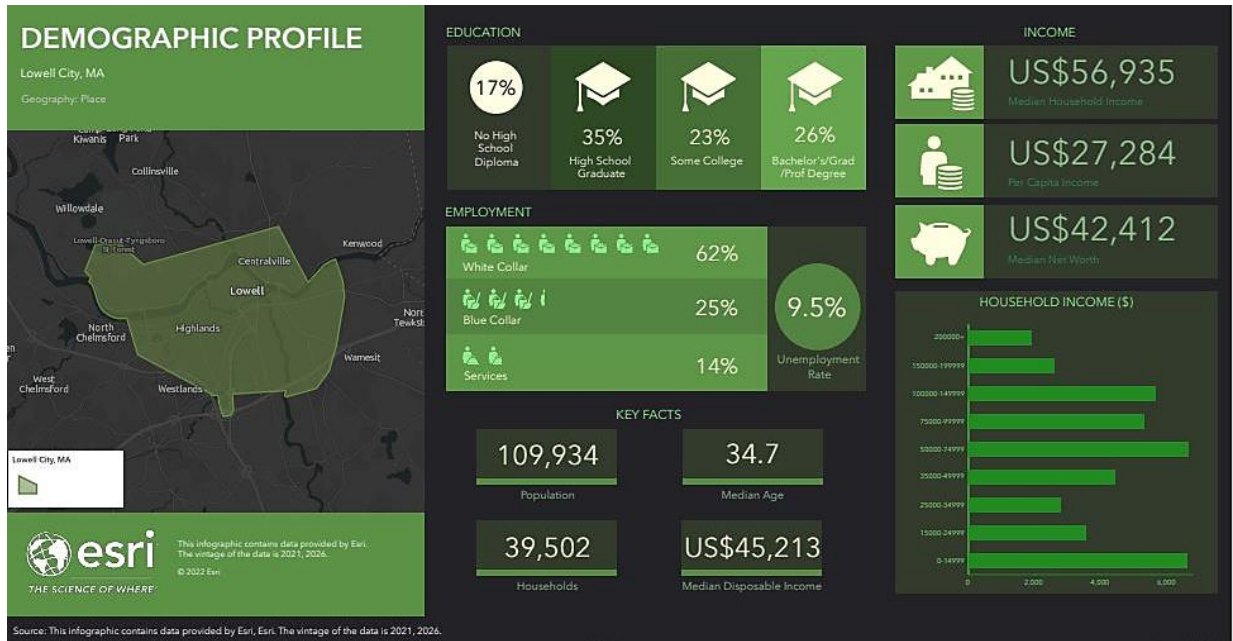
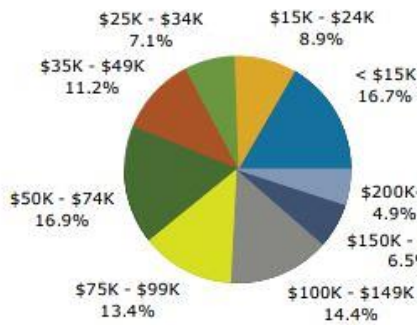


Figure 43. Demographic profile of City of Lowell. Source: ArcGIS Business Analyst 2021.

2021 Household Income



2021 Population by Race

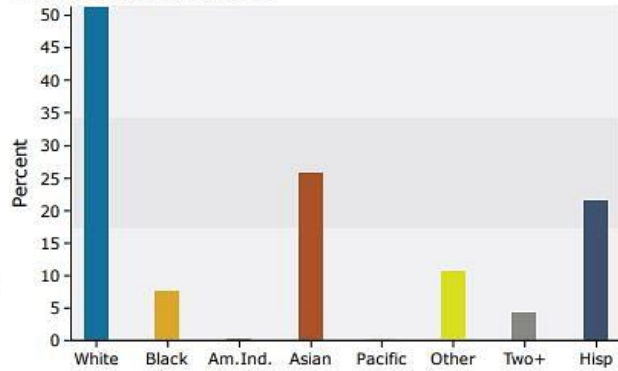


Figure 44. (left) Household income of residents of Lowell in 2021; (right) Racial groups in Lowell in 2021. Source: ArcGIS Business Analyst 2021.

Population by Age

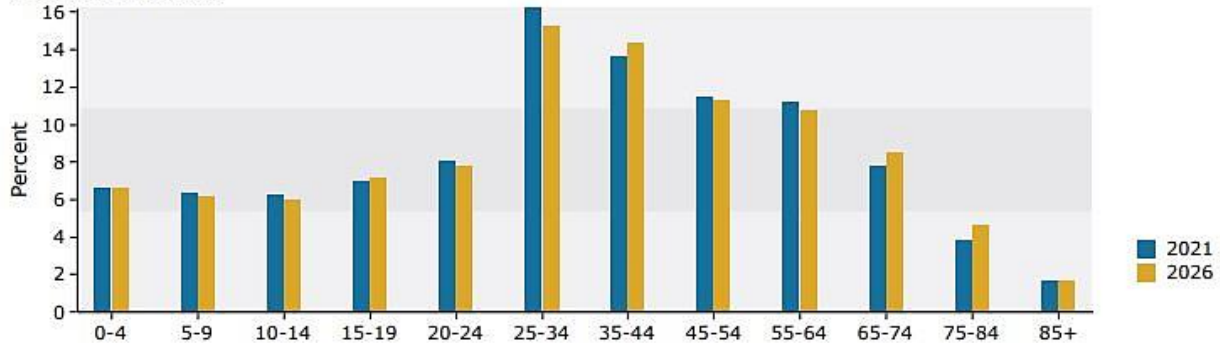


Figure 45. Population of Lowell based on age in 2021. Source: ArcGIS Business Analyst 2021.

According to ESRI, at-risk population denotes low-income families, the elderly, the homeless, and those with underlying health conditions (Sones 2020). At-risk populations need to be understood and included in planning transit-oriented development. There are five indicators to identify at-risk populations in Lowell: disability, age, no car ownership, poverty, and language barriers (Figure 46). Each presents challenges for increasing mobility and physical and economic access to and within TOD.

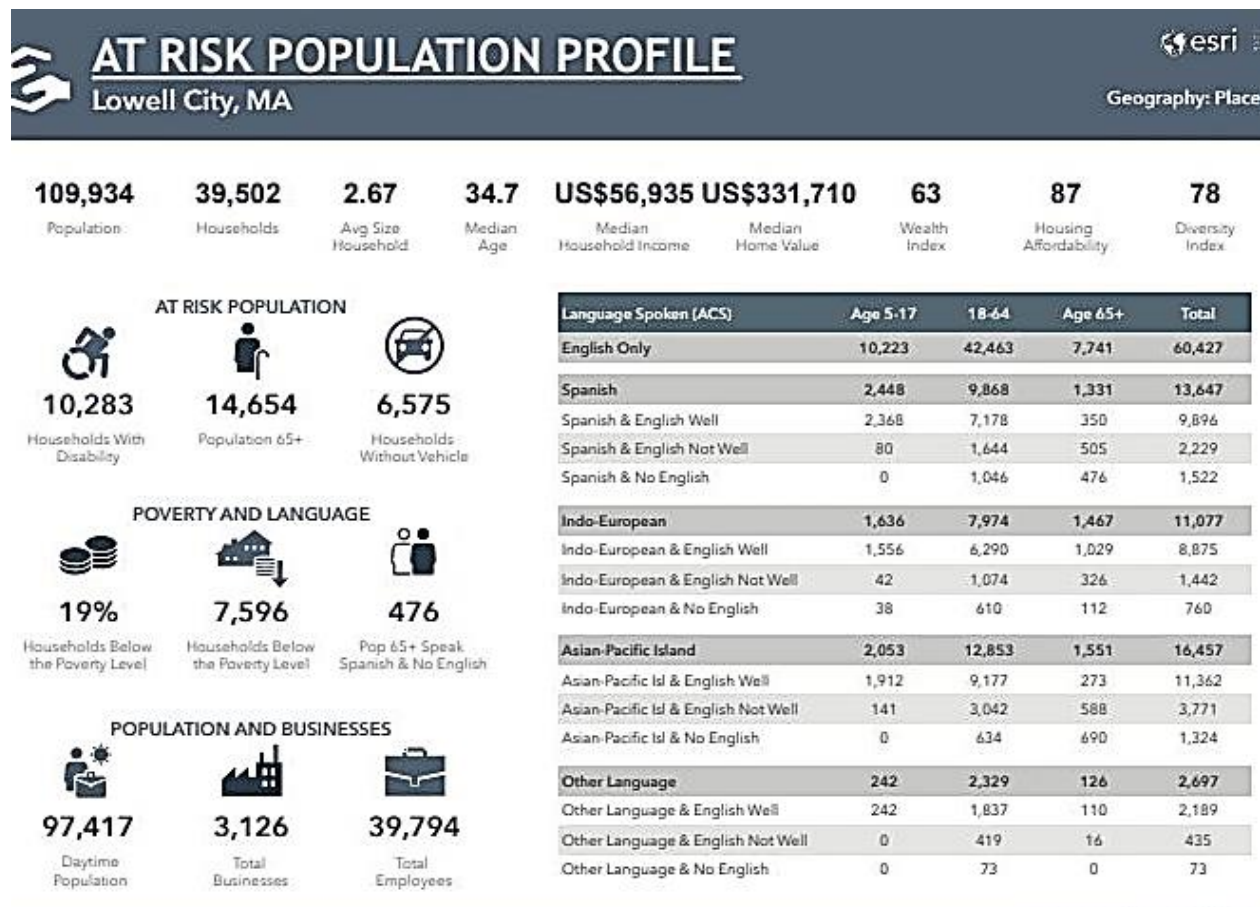


Figure 46. At risk population profile of City of Lowell. Source: ArcGIS Business Analyst 2021.

One out of four households in Lowell (10,284 out of 39,502) have disabilities; 13% of the city's population (14,654 persons) are 65 years old or older; 17% of households (6,575) do not

own a car; 19% of the city's population in 7,596 households are below the poverty line; and 44% of the population speak another language than, or in addition to, English (Figure 46).

The 10,284 households (25%) who have disabilities and the 14,654 elderly people (13%) require that increased attention be brought to walkability and wayfinding. The 6,575 households (17%) that do not own a private vehicle depend on public transportation and other alternative modes of transportation to get around. The 7,596 households (19%) who live below the poverty line emphasize the need for affordability to be included in TOD planning, particularly around housing. Based on the household income data from Business Analyst, however, Lowell has a healthy mix of varied income groups which is very promising (Figure 44) (Lowell, Massachusetts 2022).

Only half the population in Lowell is White (49.8 percent). The other half is made up of people who are Asian American (21.2 percent), Hispanic or Latino (17.9 percent), African American (8.9 percent), and of two or more races (4.3 percent) (US Census 2020). In 2010, Lowell had the highest proportion of residents from Cambodian origin in the country. Today, it is the second city with the largest population of Cambodian Americans, after Long Beach, California. In January 2022, Lowell elected the nation's first Cambodian American mayor (Betancourt 2022). Despite this high level of racial and ethnic diversity, only 3% of residents do not speak English. On the contrary, most non-English native speakers are at least bilingual, with some speaking more than two languages. Two fifths of Lowell residents over 5 years old (40%), or four in ten, speak another language than English at home (US Census 2020).

According to the Greater Merrimack Valley Convention and Visitors Bureau, the overall visitors population for the city of Lowell is 2,000,000 visitors per year which includes the visitors

of Tsongas Center, LeLacheur Park, Lowell National Historical Park, Museums, the Lowell Folk Festival, Winterfest, and other events in Lowell (City of Lowell n.d.).

### *Transportation and commuting patterns*

Lowell is a mix of urban and suburban urban form. As the population is increasing, a significant number of residents work in nearby towns as well as in Lowell, which can be deduced based on the time taken to travel as discussed in this section.

The percentage of Lowell residents whose commute to work is 19 minutes or less is 40.5 percent (18 percent (15-19 minutes) + 14.5 percent (10-14 minutes) + 6.5 percent (5-9 minutes) + 1.5 percent (<5 minutes)) (Figure 47). Of all modes of transportation, driving alone has the greatest share, at 75.7 percent. We need to focus on the 75.7 percent that drive to work and replace the 40.5 percent who have less than 20 minutes of commute with alternative modes of transportation.

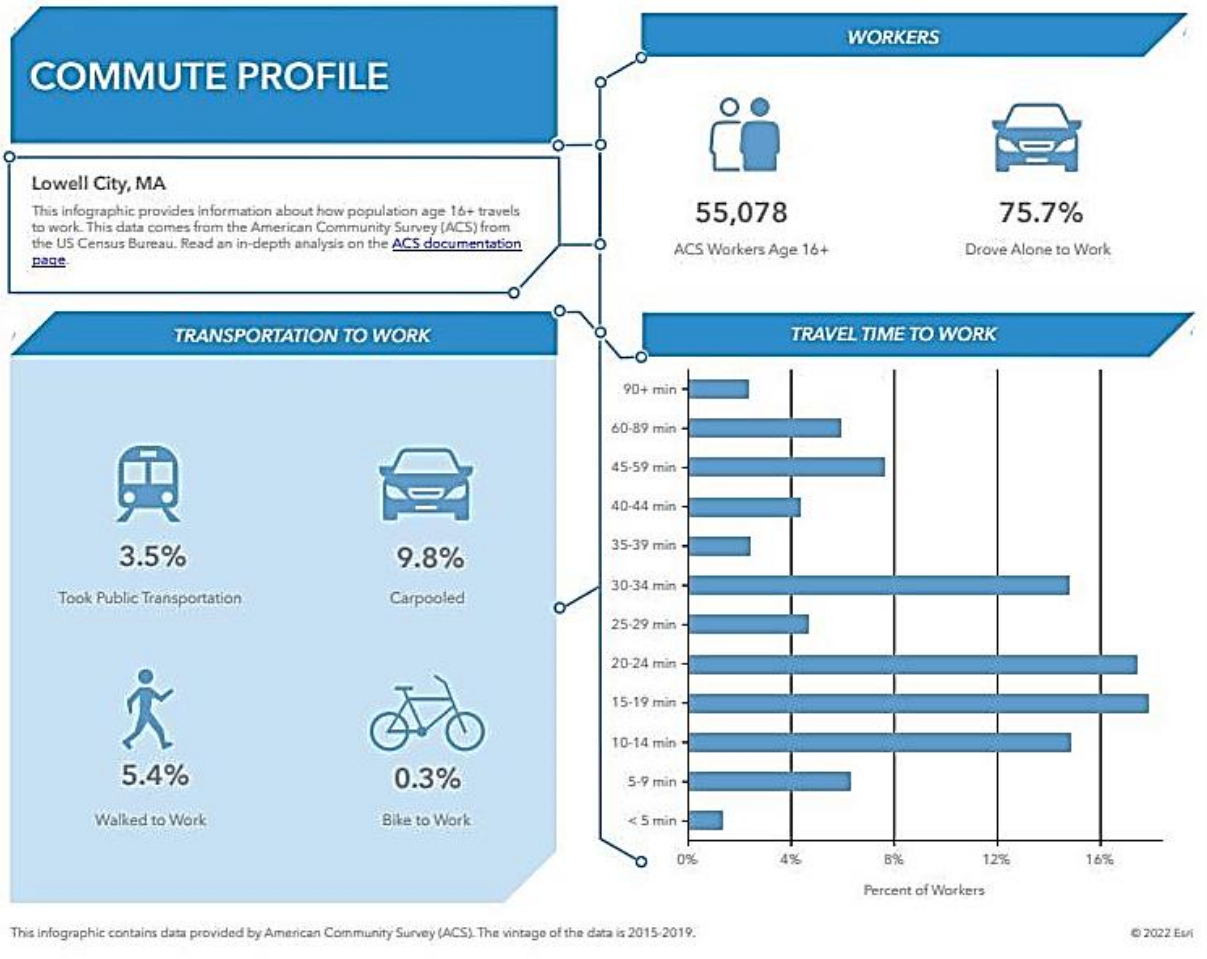


Figure 47. Modes of transportation and travel time to work. Source: ArcGIS Business Analyst 2021.

The percentage of trips that are made in private vehicles can be transformed into trips made with sustainable modes of transportation by providing the necessary infrastructure. This could include more bike lanes, more frequent service on existing bus routes, new bus routes based on most car-travelled roads and streets, and more frequent rail service.

Table 5 Modes of transportation and travel time to work in Lowell, MA.

	2015 - 2019 ACS Estimate	Percent	NOE(±)	Reliability
<b>WORKERS AGE 16+ YEARS BY MEANS OF TRANSPORTATION TO WORK</b>				
Total	55,078	100.0%	1,152	■■■
Drove alone	41,710	75.7%	1,124	■■■
Carpooled	5,386	9.8%	656	■■■
Public transportation (excluding taxicab)	1,943	3.5%	352	■■■
Bus or trolley bus	1,042	1.9%	273	■■
Light rail, streetcar or trolley	0	0.0%	29	■
Subway or elevated	152	0.3%	91	■■
Long-distance/Commuter Train	749	1.4%	192	■■
Ferryboat	0	0.0%	29	■
Taxicab	146	0.3%	97	■
Motorcycle	36	0.1%	50	■
Bicycle	164	0.3%	125	■
Walked	2,969	5.4%	462	■■■
Other means	650	1.2%	216	■■
Worked at home	2,054	3.7%	356	■■■
<b>WORKERS AGE 16+ YEARS (WHO DID NOT WORK FROM HOME) BY TRAVEL TIME TO WORK</b>				
Total	53,024	100.0%	1,228	■■■
Less than 5 minutes	700	1.3%	165	■■
5 to 9 minutes	1,361	6.3%	430	■■■
10 to 14 minutes	7,883	14.9%	716	■■■
15 to 19 minutes	9,466	17.9%	684	■■■
20 to 24 minutes	9,341	17.4%	856	■■■
25 to 29 minutes	2,468	4.7%	346	■■■
30 to 34 minutes	7,827	14.8%	637	■■■
35 to 39 minutes	1,295	2.4%	243	■■■
40 to 44 minutes	2,314	4.4%	378	■■■
45 to 59 minutes	4,057	7.7%	441	■■■
60 to 89 minutes	1,158	6.0%	474	■■■
90 or more minutes	1,234	2.3%	289	■■
Average Travel Time to Work (in minutes)	26.2		1.2	■■■

Source: ArcGIS Business Analyst 2021.

### *Walk, bike and transit score*

Having taken a look at the commuting patterns data, it is equally important to know the current walk, transit, and bike scores so that, we can see where and how to improve walkability, access to transit and bikeability. To assess more closely how Lowell currently supports transportation modes other than car travel, we can look at the city's performance in being walkable, providing public transit, and being bikeable, as measured by the commercial site WalkScore (Figure 48).



Figure 48. Walk, transit, and bike scores for the City of Lowell by WalkScore. Source. WalkScore.  
<https://www.walkscore.com/MA/Lowell>

While the above numbers are averages for the city as a whole, individual neighborhoods fare better. Of Lowell’s 11 neighborhoods, three central ones surround Gallagher Terminal: Downtown, Back Central, and The Acre (Figure 49).

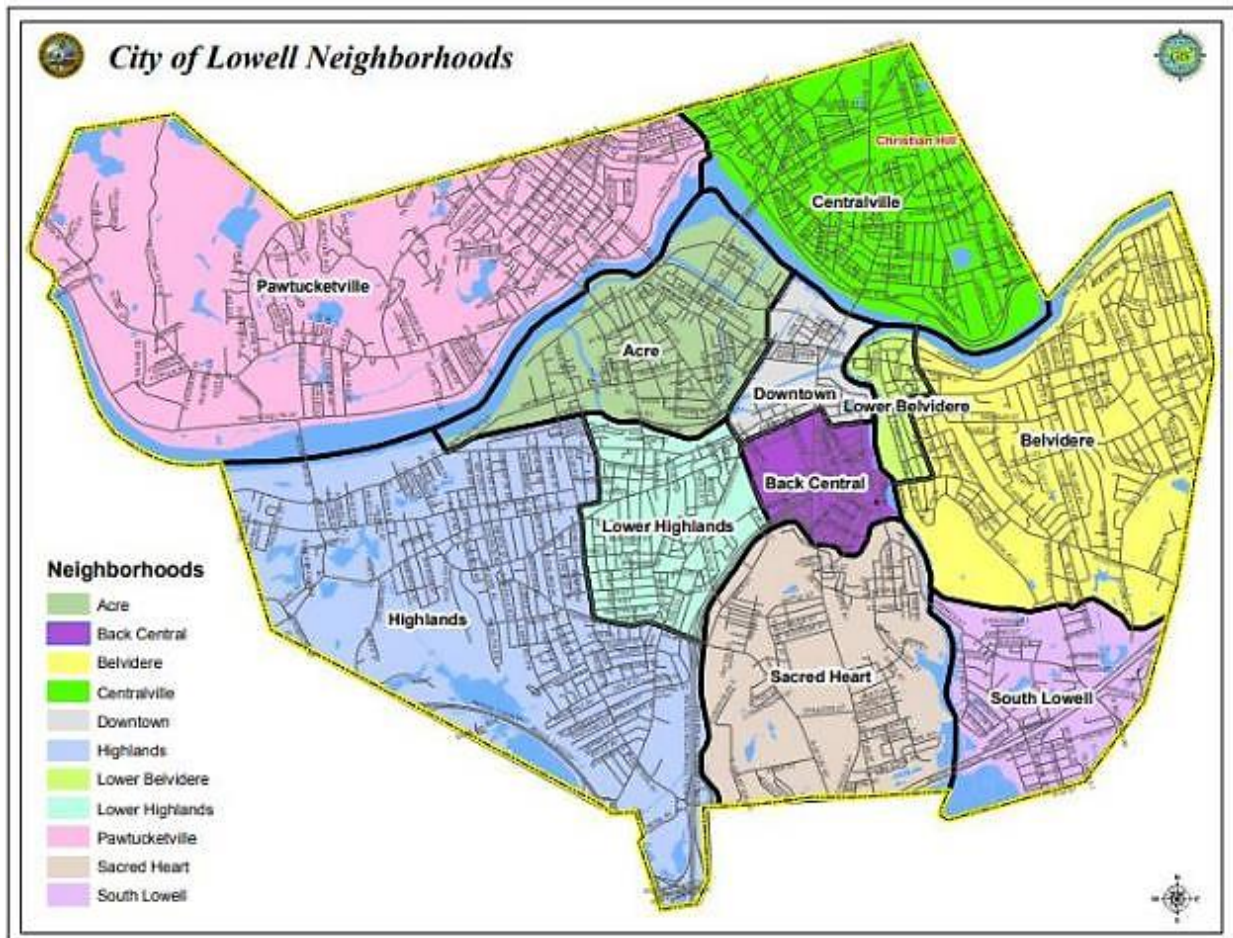


Figure 49. Lowell Neighborhoods Map. Source: City of Lowell website.  
<https://www.lowellma.gov/DocumentCenter/View/382/City-Neighborhood-Map-PDF>

These three neighborhoods have better walk/transit/bike scores than those of the city (Figure 50).

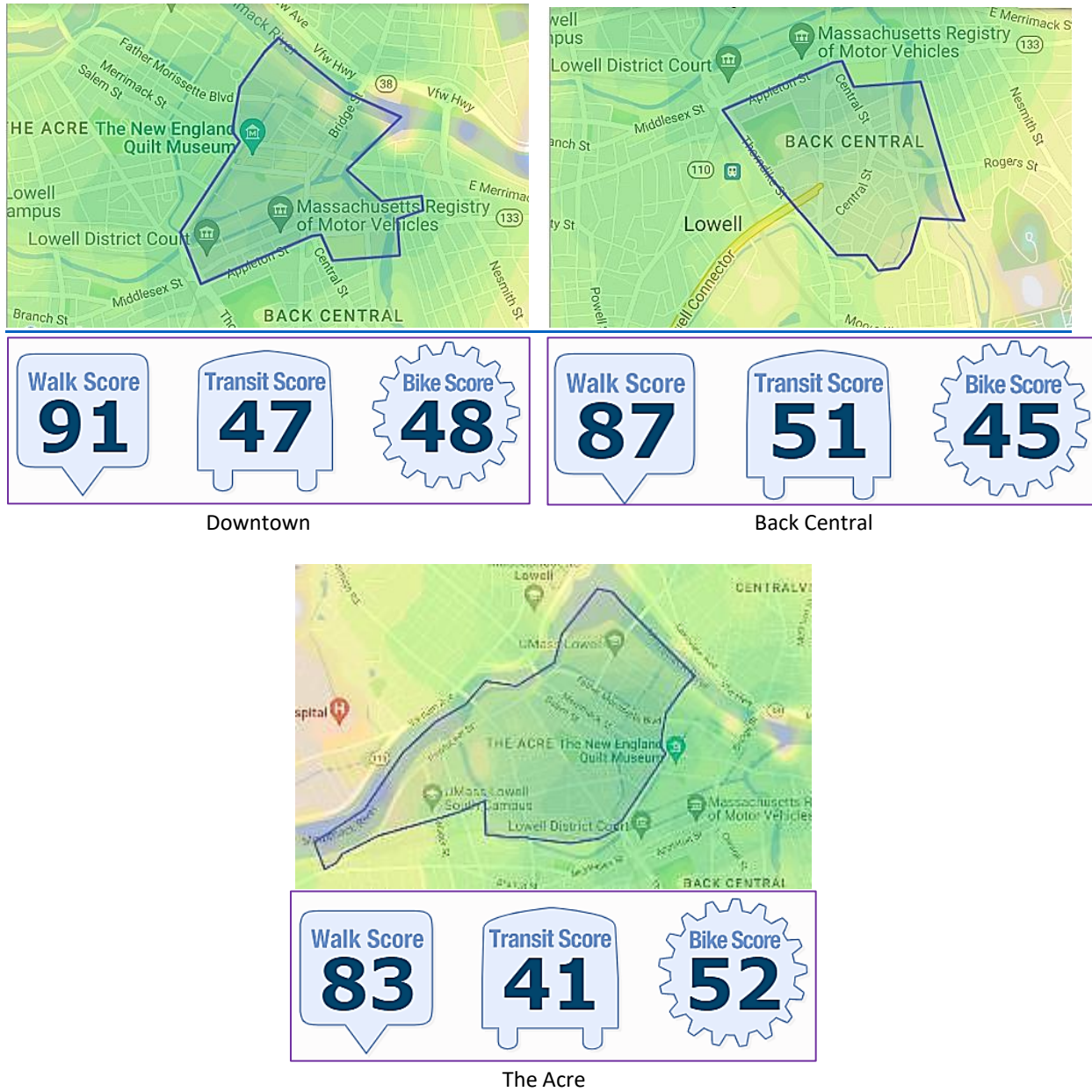


Figure 50. Maps and walk/transit/bike scores of Lowell’s central neighborhoods. Source: WalkScore <https://www.walkscore.com/MA/Lowell/Downtown>; [https://www.walkscore.com/MA/Lowell/Back\\_Central](https://www.walkscore.com/MA/Lowell/Back_Central); [https://www.walkscore.com/MA/Lowell/The\\_Acre](https://www.walkscore.com/MA/Lowell/The_Acre)

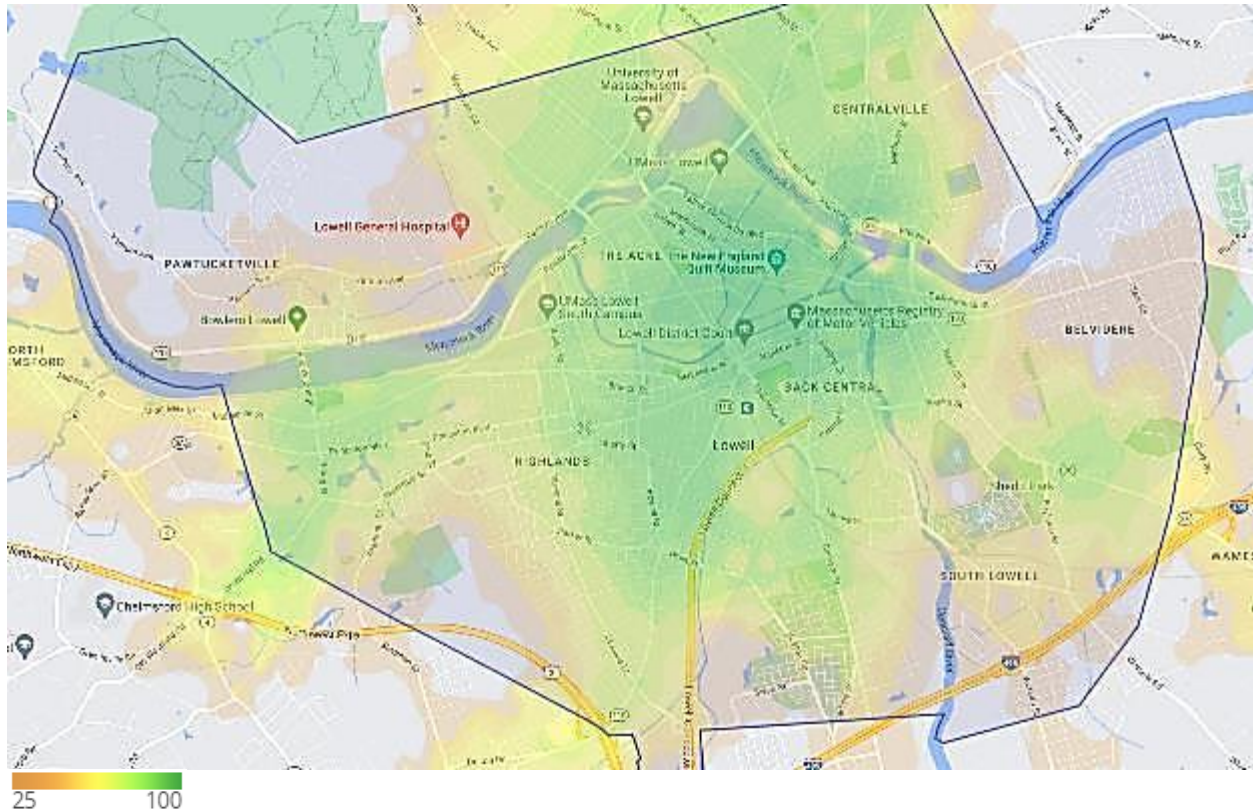


Figure 51. Walk score for the City of Lowell. Source: WalkScore. <https://www.walkscore.com/MA/Lowell>

From Figures 50 and 51, we can see that the central neighborhoods of Lowell – Downtown, Back Central, and The Acre – have higher walk/transit/bike scores than other areas in Lowell. To bring about the necessary changes and to upgrade the mobility infrastructure, I discuss below how these scores are evaluated. Understanding this will be helpful to focus on providing infrastructure and facilities that directly impact the walkability, access to transit, and bikeability of a city (Walk Score n.d.).

WalkScore measures the walkability, access to transit, and bikeability of a city, and provides scores in the form of points, which are calculated based on distances to amenities.

Walk Score®	Description
90-100	<b>Walker's Paradise</b> Daily errands do not require a car.
70-89	<b>Very Walkable</b> Most errands can be accomplished on foot.
50-69	<b>Somewhat Walkable</b> Some errands can be accomplished on foot.
25-49	<b>Car-Dependent</b> Most errands require a car.
0-24	<b>Car-Dependent</b> Almost all errands require a car.

Figure 52. Walk score and corresponding description for evaluation. Source: WalkScore. <https://www.walkscore.com/methodology>

The walk scores are based on how pedestrian friendly the roads are, with a consideration to the population density and road metrics such as length of blocks and intersection densities. Data sources used by WalkScore for this analysis are Google, Factual, Great Schools, Open Street Map, the U.S. Census, Localeze, and places added by the WalkScore user community (Walk Score n.d.).

Transit score is a patented measure of how well the area is served by public transit. This is calculated based on data provided in a standard format by public transit agencies. In addition to that, a transit score is calculated by the usefulness value to nearby transit routes based on their frequency, type of route (rail or bus), and distance to the nearest stop on the route. This "usefulness" value of all nearby routes is summed and then normalized to a score between 0 – 100 (Walk Score n.d.).

Transit Score <sup>®</sup>	Description
<b>90-100</b>	<b>Rider's Paradise</b> World-class public transportation.
<b>70-89</b>	<b>Excellent Transit</b> Transit is convenient for most trips.
<b>50-69</b>	<b>Good Transit</b> Many nearby public transportation options.
<b>25-49</b>	<b>Some Transit</b> A few nearby public transportation options.
<b>0-24</b>	<b>Minimal Transit</b> It is possible to get on a bus.

Figure 53. Transit score and corresponding description for evaluation. Source: WalkScore. <https://www.walkscore.com/methodology>

Bike score measures whether an area is fit for biking, and this is calculated by measuring bike infrastructure (such as lanes and trails), topography, destinations, road connectivity, and the number of bike commuters. Data sources used by WalkScore for this analysis are the United States Geological Survey (USGS), Open Street Map, and the U.S. Census (Walk Score n.d.).

Bike Score	Description
<b>90-100</b>	<b>Biker's Paradise</b> Daily errands can be accomplished on a bike.
<b>70-89</b>	<b>Very Bikeable</b> Biking is convenient for most trips.
<b>50-69</b>	<b>Bikeable</b> Some bike infrastructure.
<b>0-49</b>	<b>Somewhat Bikeable</b> Minimal bike infrastructure.

Figure 54. Bike score and corresponding description for evaluation. Source: WalkScore. <https://www.walkscore.com/methodology>

WalkScore gives a walk score of 67, a transit score of 44, and a bike score of 36 for Lowell as a whole. As mentioned previously, the city's central neighborhoods fare better on all

scores, with the walk scores alone being 91 for Downtown, 88 for the Acre, and 85 for Back Central (Figure 51). These neighborhoods are the closest to the intermodal station of Gallagher Terminal.

Table 6. Population, distance from Gallagher Terminal, and walk/transit/bike scores of Lowell and its central neighborhoods.

	Population	Outer border from Gallagher Terminal	Center from Gallagher Terminal	Walk Score	Transit Score	Bike Score
Lowell	106,519	3.6 miles	N/A	67	44	36
Downtown	4,717	1 mile	0.6 mile	91	47	48
Back Central	5,608	0.7 mile	0.4 mile	85	51	45
The Acre	12,444	1.3 mile	0.8 mile	88	41	52

Source: WalkScore and Google Maps.

In Table 6, the “Outer border” is the distance between Gallagher Terminal and the furthest point of the neighborhood’s border from the station. The “Center” is the distance between Gallagher Terminal and the center of the neighborhood. The population numbers are from WalkScore.

I looked into the walk/transit/bike scores of the case studies discussed earlier and found that Worcester overall has a walk score of 56, transit score of 34, and bike score of 35. However, as in Lowell, its three central neighborhoods closest to Union Station – the Central Business District, Green Island, and Main Middle – are more walkable, have better transit access, and are more bikeable than the city as a whole. The walk score for the Central Business District is 84, for Green Island is 89, and for Main Middle is 92 (Table 7).

Table 7. Population, distance from Union Station, and walk/transit/bike scores of Worcester and its central neighborhoods.

	Population	Outer border from Worcester Station	Center from Worcester Station	Walk Score	Transit Score	Bike Score
Worcester	181,045	6.3 miles	N/A	56	34	35

Central Business District	2,790	0.8 mile	0.3 mile	84	53	43
Green Island	1,960	1 mile	0.4 mile	89	52	48
Main Middle	7,700	1.5 mile	1 mile	92	48	49

Source: WalkScore and Google Maps.

Brockton has a walk score of 51, transit score of 34, and bike score of 43. Although Brockton has neighborhoods, WalkScore doesn't recognize them and instead divides the city into two zip code areas. It also only has walk scores for those two areas, no transit or bike scores (Table 8).

Table 8. Population, distance from Brockton Station, and walk/transit/bike scores of Brockton and its two zip code areas.

	Population	Outer border from Brockton Station	Center from Brockton Station	Walk Score	Transit Score	Bike Score
Brockton	93,810	3.5 miles	N/A	51	34	43
Zip Code 02301	60,834	3.5 miles	1.4 miles	56	-	-
Zip Code 02302	32,685	3 miles	1 mile	42	-	-

Source: WalkScore and Google Maps.

When comparing the walkability, access to transit, and bikeability of the three cities, Lowell has better overall scores than Worcester which has better overall scores than Brockton, although Brockton has a better bike score (Table 9). Comparing central neighborhoods would give a more accurate picture of existing alternative modes of transportation near the rail stations, but WalkScore has not done this for Brockton (WalkScore n.d.;)

Table 9. Summary of walk/transit/bike scores for Lowell, Worcester, and Brockton.

	Walk Score	Transit Score	Bike Score
Lowell	67	44	36
Worcester	56	34	35
Brockton	51	34	43

Source: WalkScore.

Retail trends (from 2017)

Accessibility to a variety of land and building uses is a major influential factor in measuring a cities or neighborhood’s walk, access to transit, and bike scores. Because proximity to uses is the deciding factor for choosing a mode of transportation, it is useful to analyze the existing available uses within Lowell and its potential TOD area.

Table 10. Retail market profile of Lowell, MA.

Summary Demographics						
2021 Population						109,934
2021 Households						39,502
2021 Median Disposable Income						US\$45,213
2021 Per Capita Income						US\$27,284
<b>NOTE: This database is in mature status. While the data are presented in current year geography, all supply- and demand-related estimates remain vintage 2017.</b>						
2017 Industry Summary	NAICS	Demand (Retail Potential)	Supply (Retail Sales)	Retail Gap	Leakage/Surplus Factor	Number of Businesses
Total Retail Trade and Food & Drink	44-45,722	US\$1,200,787,545	US\$1,006,168,580	US\$194,618,965	8.8	651
Total Retail Trade	44-45	US\$1,079,010,825	US\$888,068,853	US\$190,941,972	9.7	426
Total Food & Drink	722	US\$121,776,720	US\$118,099,727	US\$3,676,993	1.5	225
2017 Industry Group	NAICS	Demand (Retail Potential)	Supply (Retail Sales)	Retail Gap	Leakage/Surplus Factor	Number of Businesses
Motor Vehicle & Parts Dealers	441	US\$212,426,060	US\$251,745,067	-US\$39,319,007	-8.3	55
Automobile Dealers	4411	US\$178,240,132	US\$236,898,863	-US\$58,658,731	-14.1	38
Other Motor Vehicle Dealers	4412	US\$37,000,548	US\$22,744,486	US\$14,745,062	76.4	7
Auto Parts, Accessories & Tire Stores	4413	US\$17,165,380	US\$12,573,718	US\$4,591,662	15.4	15
Furniture & Home Furnishings Stores	442	US\$30,721,575	US\$36,427,139	-US\$14,294,436	-30.3	15
Furniture Stores	4421	US\$16,739,785	US\$9,401,870	US\$7,337,915	28.1	9
Home Furnishings Stores	4422	US\$13,981,790	US\$7,025,269	US\$6,956,521	33.3	6
Electronics & Appliance Stores	443	US\$45,267,397	US\$60,059,953	-US\$14,792,556	-14.0	25
Big Box Retail, Garden Equip. & Supply Stores	444	US\$61,851,097	US\$48,339,704	US\$13,311,393	12.3	22
Big Material & Supplies Dealers	4441	US\$57,195,262	US\$46,700,704	US\$10,494,558	10.1	19
Lawn & Garden Equip & Supply Stores	4442	US\$4,455,835	US\$1,639,000	US\$2,816,835	46.2	3
Food & Beverage Stores	445	US\$218,716,099	US\$184,313,106	US\$34,402,993	8.5	97
Grocery Stores	4451	US\$187,507,169	US\$160,987,393	US\$26,519,776	7.6	65
Specialty Food Stores	4452	US\$8,277,333	US\$5,463,001	US\$2,814,332	20.5	11
Beer, Wine & Liquor Stores	4453	US\$22,931,597	US\$17,862,712	US\$5,068,885	12.4	21
Health & Personal Care Stores	446,4461	US\$68,786,319	US\$80,987,560	-US\$12,201,441	-8.3	30
Gasoline Stations	447,4471	US\$97,450,882	US\$119,015,490	-US\$21,564,608	-10.0	26
Clothing & Clothing Accessories Stores	448	US\$81,149,701	US\$39,359,481	US\$41,790,220	61.2	48
Clothing Stores	4481	US\$57,632,231	US\$13,541,985	US\$44,090,246	61.9	30
Shoe Stores	4482	US\$9,883,442	US\$1,599,372	US\$8,284,070	72.1	4
Jewelry, Luggage & Leather Goods Stores	4483	US\$13,634,028	US\$4,418,124	US\$9,215,904	51.1	14
Sporting Goods, Hobby, Book & Music Stores	451	US\$42,969,340	US\$12,636,328	US\$30,333,012	54.6	20
Sporting Goods/Hobby/Musical Instr Stores	4511	US\$37,627,355	US\$5,294,366	US\$32,332,989	73.3	12
Book, Periodical & Music Stores	4512	US\$5,341,985	US\$7,341,962	-US\$1,999,977	-15.8	8
General Merchandise Stores	452	US\$135,586,236	US\$55,498,384	US\$80,087,852	41.9	25
Department Stores Excluding Leased Depts.	4521	US\$96,378,074	US\$43,429,344	US\$52,948,730	37.8	7
Other General Merchandise Stores	4529	US\$39,308,162	US\$12,069,040	US\$27,239,122	53.0	18
Miscellaneous Store Retailers	453	US\$41,640,863	US\$13,454,107	US\$28,186,756	51.2	54
Florists	4531	US\$2,901,113	US\$2,924,992	-US\$23,879	-0.4	10
Office Supplies, Stationery & Gift Stores	4532	US\$19,149,136	US\$3,052,684	US\$16,096,452	84.5	13
Used Merchandise Stores	4533	US\$3,337,729	US\$1,924,936	US\$1,412,793	26.8	13
Other Miscellaneous Store Retailers	4539	US\$21,256,885	US\$5,551,495	US\$15,705,390	58.6	18
Nomstore Retailers	454	US\$42,645,756	US\$26,032,534	US\$16,613,222	24.2	9
Electronic Shopping & Mail-Order Houses	4541	US\$36,538,431	US\$12,999,923	US\$23,538,508	47.5	5
Vending Machine Operators	4542	US\$590,073	US\$428,109	US\$161,964	13.9	1
Direct Selling Establishments	4543	US\$5,517,252	US\$12,604,502	-US\$7,087,250	-39.1	3
Food Services & Drinking Places	722	US\$121,776,720	US\$118,099,727	US\$3,676,993	1.5	225
Special Food Services	7223	US\$4,138,615	US\$755,887	US\$3,382,728	70.3	3
Drinking Places - Alcoholic Beverages	7224	US\$6,185,851	US\$5,328,203	US\$867,648	5.6	14
Restaurants/Other Eating Places	7225	US\$111,252,254	US\$111,815,637	-US\$563,383	-0.3	208

Source: ArcGIS Business Analyst 2021.

According to ArcGIS Business Analyst, “the Demand column represents the total expenditures in a category for all households in an area. The Supply column displays the total retail sales by the retailers in an area. If demand exceeds supply, the Retail Gap and Leakage/Surplus Factor values are displayed in green, indicating unmet demand in the area. If supply exceeds demand, the Retail Gap and Leakage/Surplus Factors values are displayed in red, indicating that sales exceed purchases in this category for the area” (Miller n.d).

When observing the demand, supply, and retail gap in Lowell according to ArcGIS Business Analyst 2021, we see that retail businesses that are undersupplied and for which there is demand are direct selling establishments; book, periodical, and music stores; automobile dealers, electronics and appliance stores, and gas stations. Others with a leakage of less than 1 include florists, restaurants, and health and personal care stores (Table 10).

Conversely, retail businesses that show a surplus and attract a regional customer base are sporting goods/hobby/musical instrument stores, shoe stores, food specialty stores, office supplies and stationary stores, clothing stores, and general merchandise stores (Table 10).

There are 208 restaurants in Lowell and yet there is a leakage factor of -0.3 which indicates that there is a potential for establishing more restaurants. To varying degrees, this is the case for all the other highlighted businesses with negative numbers in Table 10. A more specific retail analysis is needed to understand and to promote essential services when considering development within TOD area.

## Housing market trends

Proximity to essential amenities is usually considered an important factor when households decide to move to specific places. In that way, retail gap analysis and housing market trends are directly related, and it is vital to understand them from a development viewpoint.

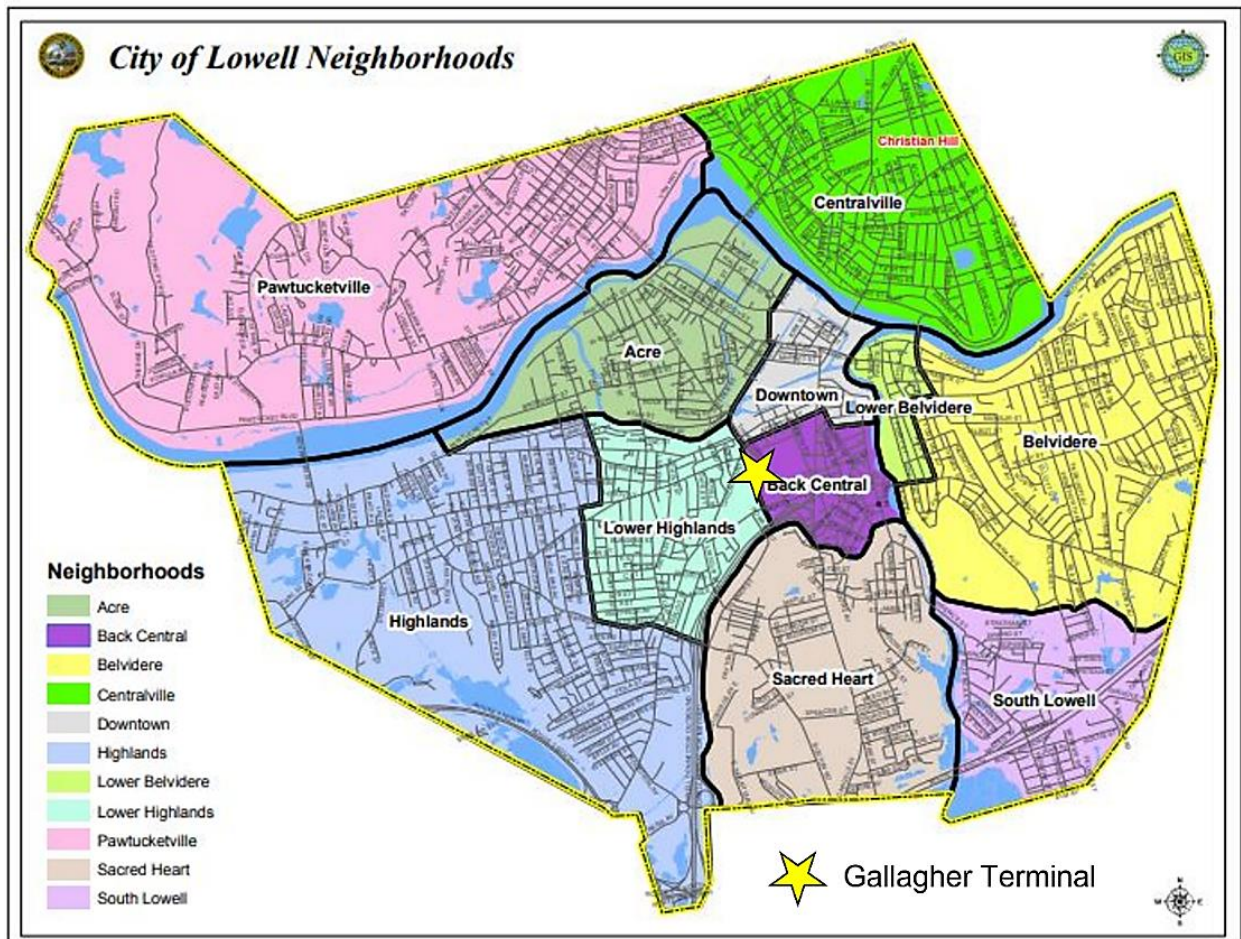


Figure 55. Lowell Neighborhoods Map. Source: City of Lowell website.  
<https://www.lowellma.gov/DocumentCenter/View/382/City-Neighborhood-Map-PDF>

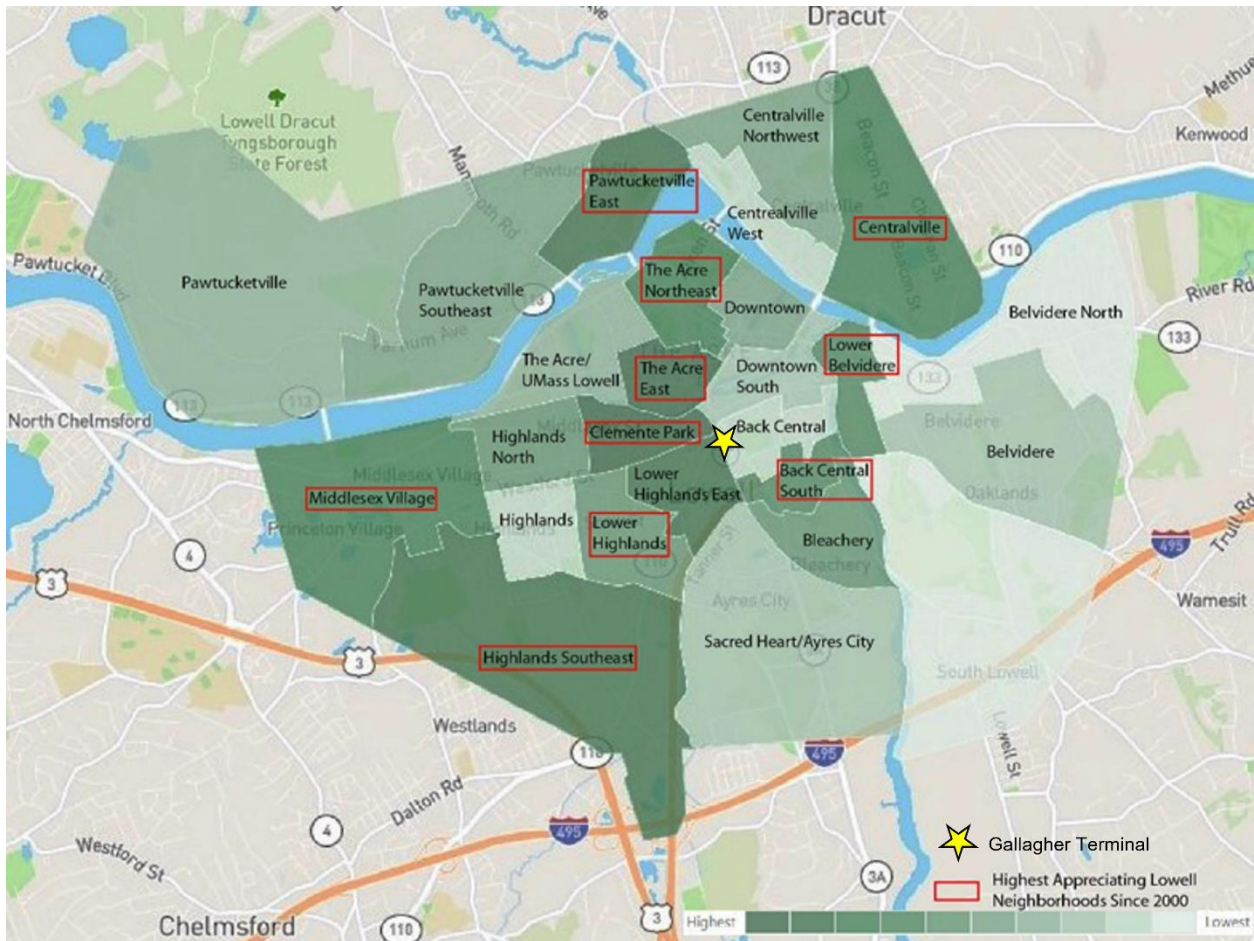


Figure 56. Highest appreciating Lowell neighborhoods since 2000. Source: Modified by author from Neighborhood Scout. <https://www.neighborhoodscout.com/ma/lowell/real-estate>.

Figures 55 and 56 show, respectively, the neighborhoods of Lowell and the highest appreciating ones as per housing market trends. TOD is an exclusively focused development area identified around the transit terminal which could overlap with the neighborhoods of Lowell. The circle of a 0.5-mile radius around the terminal, and the ring of a 0.5-1-mile radius around the circle could become appreciating areas in Lowell with careful consideration of what development would include.

## Demographics around Gallagher Terminal

The themes discussed above were for the city of Lowell in general. More focused information about the areas within a mile radius of Gallagher Terminal is discussed below.

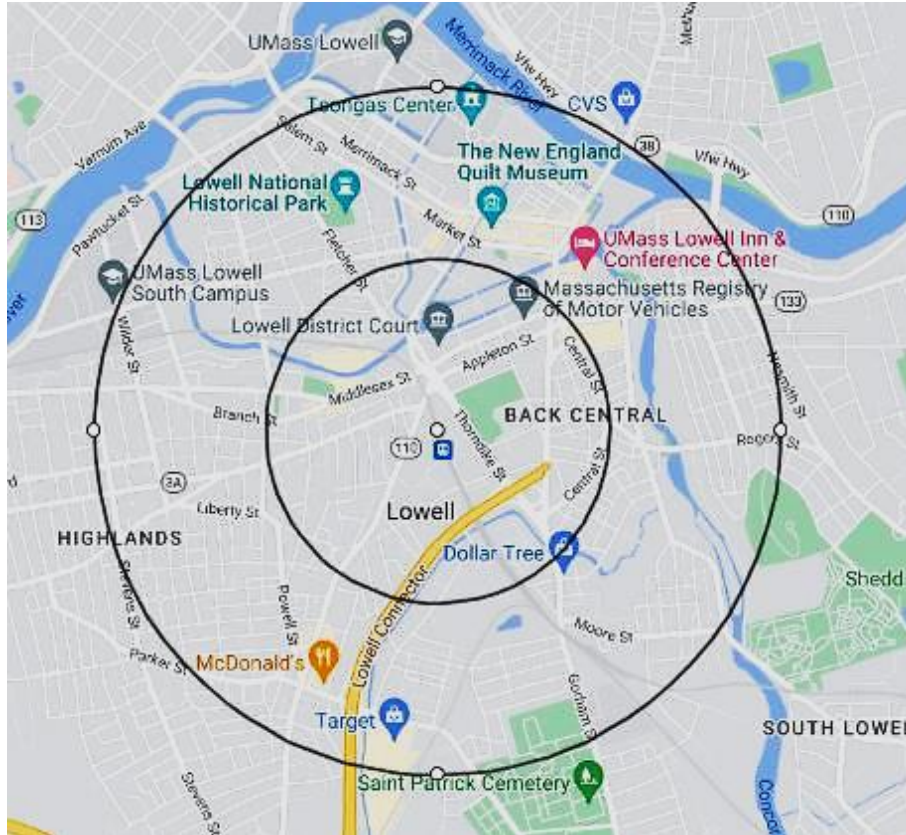


Figure 57. Areas within a half-mile radius (inner circle) and one-mile radius (outer circle) of Gallagher Terminal in Lowell. Source: Map Developers. <https://www.mapdevelopers.com/draw-circle-tool.php>

Table 11. Summary of demographic information for the area within a 0.5 mile radius of Gallagher Terminal in Lowell.

Summary	Census 2010	2021	2026	2021-2026 Change	2021-2026 Annual Rate
Population	10,953	11,965	12,334	369	0.61%
Households	4,163	4,646	4,816	170	0.72%
Average Household Size	2.57	2.52	2.51	-0.01	-0.08%
Median Age	32.0	33.6	34.8	1.2	0.70%
Median Male Age	32.2	33.8	34.8	1.0	0.58%
Median Female Age	31.7	33.5	34.8	1.3	0.76%

Source: ArcGIS Business Analyst 2021.

Table 11 shows that the population and number of households within ½ mile of Gallagher Terminal increased slightly but steadily from 2010 to 2021 and are estimated to

increase from 2021 to 2026 by 0.61 percent and 0.72 percent respectively. At the same time, the average household size decreased from 2010 to 2021 to 2.52 and is estimated to further decrease by 2026.

Table 12. Summary of demographic information for the area within 0.5-1 mile radius of Gallagher Terminal in Lowell.

<b>Summary</b>	<b>Census 2010</b>	<b>2021</b>	<b>2026</b>	<b>2021-2026 Change</b>	<b>2021-2026 Annual Rate</b>
Population	32,540	33,518	34,095	577	0.34%
Households	11,621	11,871	12,081	210	0.35%
Average Household Size	2.72	2.74	2.74	0.00	0.00%
Median Age	31.1	33.2	34.4	1.2	0.71%
Median Male Age	30.4	32.6	33.9	1.3	0.79%
Median Female Age	31.8	33.8	34.9	1.1	0.64%

Source: ArcGIS Business Analyst 2021.

Table 12 shows that the population and number of households within a ring of between ½ mile and one mile of Gallagher Terminal increased more slowly from 2010 to 2021 than in the ½ mile circle and are estimated to increase from 2021 to 2026 by 0.34 percent and 0.35 percent respectively. The average household size is larger than in the ½ mile area, has increased by 0.02 from 2010 to 2021 to 2.74, and is estimated to stay the same till 2026. The median age in the ½ mile circle is slightly higher (33.6) than in the ring between ½ mile and one mile (33.2).

Implementing TOD and proposing developments around the transit terminal usually take place in phases to bring about the changes with minimum disturbance to the area. Figures 58 and 59 below show the trends of the area around the terminal in two sections – one is the 0-0.5 mile circle around the terminal while the other is the 0.5-1 mile ring around the terminal.

When comparing the number of households within 0-0.5 mile and 0.5-1 mile, there are 4,646 and 11,871 households respectively (as of 2021). The population density (as of 2021) of these areas are 15,242.04 persons/sq mile within the 0.5-mile-radius circle and 14,232,7

persons/sq mile within the 0.5 – 1-mile-radius ring. TOD promotes providing more housing around the transit terminal and hence, there is potential for an increase in the number of households and housing units within 0-0.5 mile once TOD is implemented.

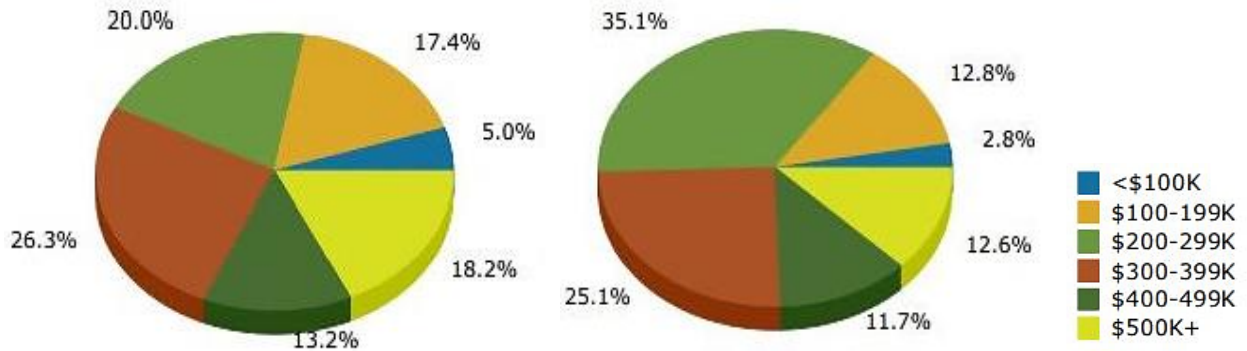


Figure 58. Home value for the area within (left) 0-0.5 mile and (right) 0.5-1 mile radius of Gallagher Terminal in Lowell. Source: ArcGIS Business Analyst 2021.

When comparing home values, the 0-0.5-mile circle has lower home values and therefore is more affordable than the higher home values in the 0.5-1-mile-radius ring around the terminal.

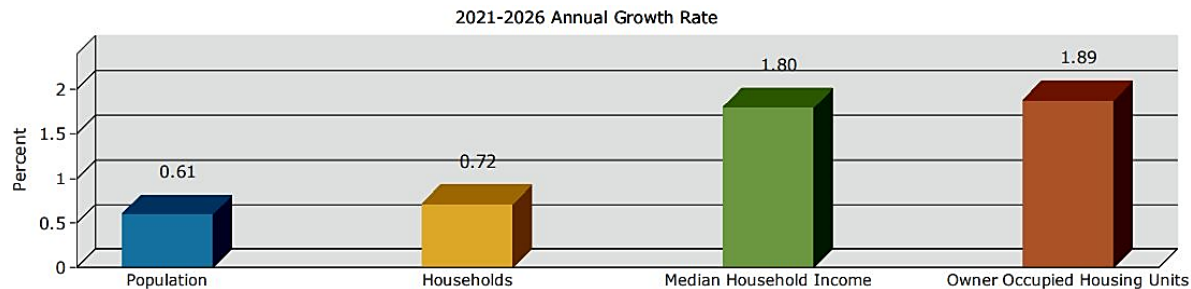


Figure 59. Annual growth rate for the area within 0-0.5 mile radius of Gallagher Terminal in Lowell. Source: ArcGIS Business Analyst 2021.

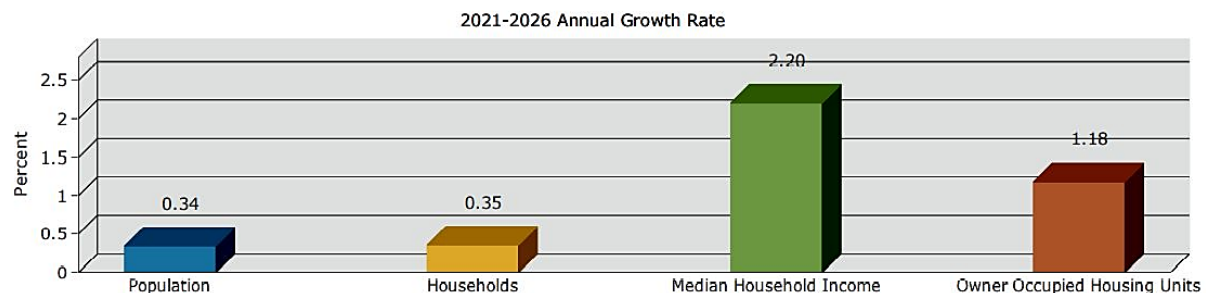


Figure 60. Home value for the area within 0.5-1 mile radius of Gallagher Terminal in Lowell. Source: ArcGIS Business Analyst 2021.

Figures 59 and 60 show the projected annual growth rates from 2021 to 2026, in four demographic indicators: population, households, median household income, and owner-occupied housing units. The area within the 0-0.5-mile radius of Gallagher Terminal (Figure 59) is projected to increase in three of those indicators – population, households and owner occupied housing units – while the area within the 0.5-1-mile radius (Figure 60) will only grow in one indicator: median household income.

### *Conclusion*

This chapter discussed the various trends in demographics, mobility, and the retail and housing market, in the city of Lowell as well as specific to a 0.5-mile-radius circle and a 0.5-1-mile-radius ring around the terminal. This comparison shows that there is potential for growth around the terminal when TOD is implemented in phases in Lowell. A detailed market analysis of businesses and other services within Lowell could give a better understanding of what to include within the TOD area. The diverse population and neighborhoods of Lowell provide wide range of opportunities for further developments to take place in order to create an even more vibrant community.

## Chapter 5 Foot traffic analysis

Foot traffic data, also called mobility data is the count of how many people walk to, from, and around Points-Of-Interest (POI), including businesses, in a given area. This analyzes the current foot traffic pattern in the whole of city of Lowell. Based on the available POI data, this analysis shows current foot traffic patterns thereby providing an idea of how much footfall current businesses experience and how many of them are within the potential transit-oriented development district.

The aim of this part of the study is to provide a different kind of evidence to support the hypothesis that Lowell is ready for TOD – It showcases the current footfall and the potential for development around the terminal that can increase the footfall at the transit terminal as well as in the TOD district. The introduction of TOD could change the travel behavior of residents and visitors by allowing them to use sustainable modes of transportation for work, daily necessities, shopping, dining, entertainment, and other trips.

This foot traffic analysis could act as a pre-TOD assessment of foot traffic around the transit terminal in Lowell. After TOD is implemented, the Lowell Regional Transit Authority (LRTA) or the city of Lowell could conduct a post-TOD assessment, and both these analyses can be compared to see how much footfall has increased after the implementation of transit-oriented development around the terminal in Lowell.

*What is foot traffic analysis? Why is it important to measure it?*

All our trips start and end by foot. Also, the most sustainable mode of mobility is by foot. I am interested in measuring the footfall at different points-of-interest within the city of Lowell to understand which businesses and sectors (types of destinations) have the most

amount of footfall. I further want to compare Lowell's foot traffic with that of Brockton's to analyze how they differ and make inferences based on the comparison. This will also be helpful in identifying places to propose in Lowell's TOD district to help combine the work and non-work trips of people by providing all needed services in and around the train station.

*Study area*

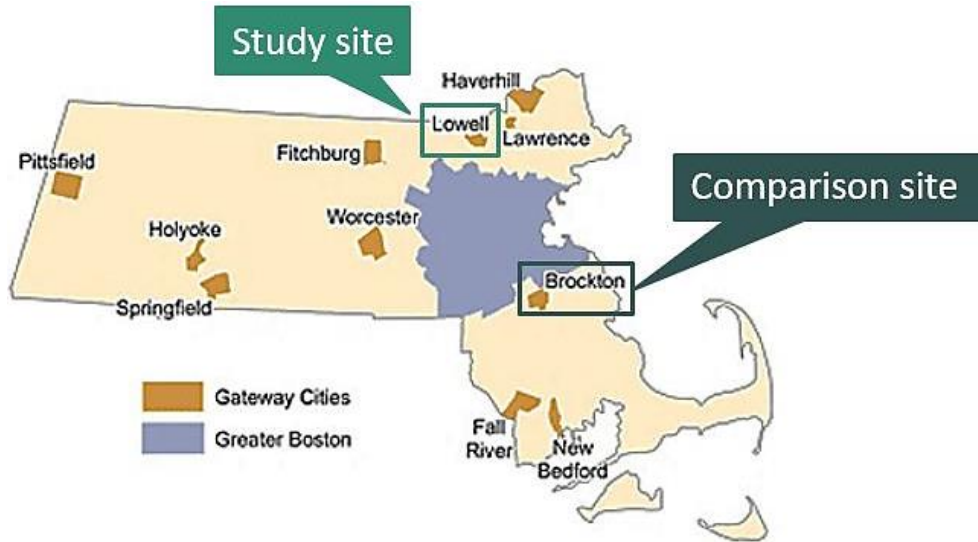


Figure 61. Macro-level study site and comparison site for foot traffic analysis. Source: Modified by author from Wikipedia. [https://en.wikipedia.org/wiki/Massachusetts\\_gateway\\_cities](https://en.wikipedia.org/wiki/Massachusetts_gateway_cities).

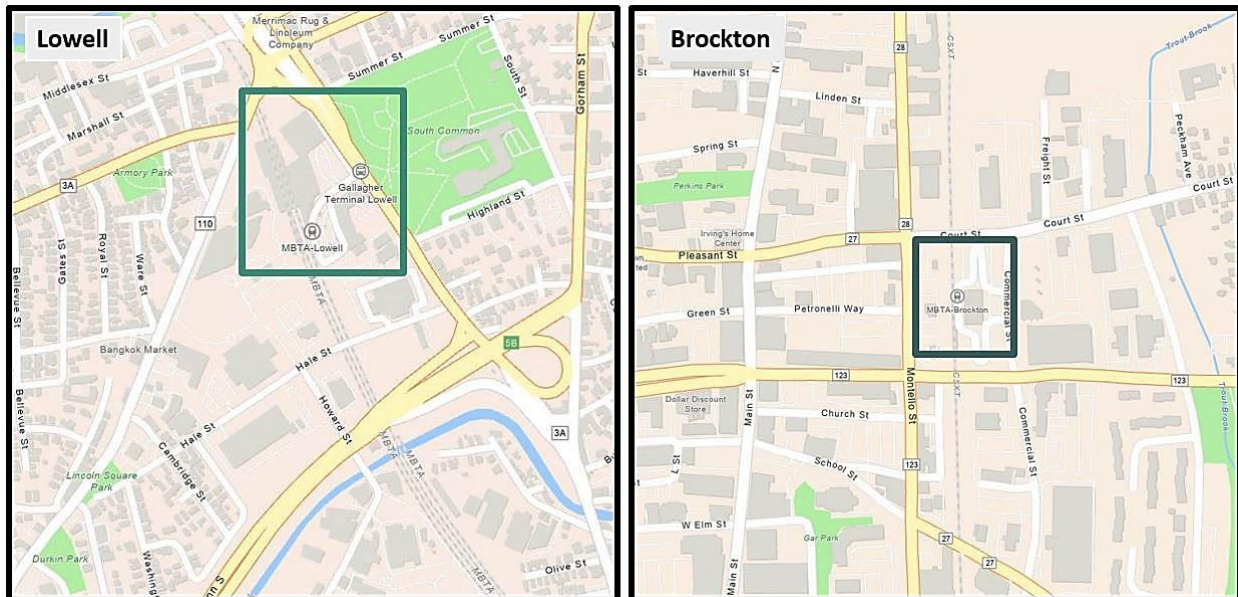


Figure 62. Micro-level study site and comparison site for foot traffic analysis. Source: Modified by author from Wikipedia (same scale). [https://en.wikipedia.org/wiki/Massachusetts\\_gateway\\_cities](https://en.wikipedia.org/wiki/Massachusetts_gateway_cities).

I have considered the 0.5-mile radius around both transit terminals as the transit catchment areas for this study in addition to a general analysis for the whole cities of Lowell and Brockton.

### *Why Brockton?*

I chose to compare Lowell with Brockton because they are both Gateway cities, which are former industrial or mill cities that strive to be redeveloped with new economic activity. Similar to Lowell, Brockton's terminal is also an intermodal transit hub with a bus center and commuter rail station. Even though there are no specific plans for TOD in Brockton, there are a lot of economic development projects happening in Brockton, which will pave the way for the idea of TOD in Brockton in the future. Since Brockton is similar in all these respects, Brockton's POI data is compared and analyzed with that of the city of Lowell.

### *Research questions for the analysis*

1. What are the major differences in POI data between Lowell and Brockton?
2. Does the foot traffic analysis support the idea of implementing TOD in Lowell?
3. What are the recommendations that can be made for the city of Lowell based on the results of comparing Lowell's with Brockton's POI data analysis?

### *Data*

I obtained foot traffic data from SafeGraph (also known as mobility data). This aggregated and anonymized dataset is collected from SafeGraph Patterns, which is known as Point-Of-Interest data obtained based on the count of smart mobile phone devices in the study area during the durations of study. This data is available as hourly data, while for my analysis, I have aggregated it as weekly data for the durations of study. The study area is calculated based

on the 0.5-mile radius of catchment area around the transit terminal which can also be termed as the potential TOD district. I chose three weeks from three different seasons in 2020 for my analysis. Since this timeframe coincides with the initial months of Covid-19, it is likely that the foot traffic data could be impacted by the pandemic. Also, Lowell has a lot of tourist attractions, educational institutions, and other major businesses when compared to that of Brockton, and hence might have more footfall.

Table 13. Durations of study in Lowell and Brockton.

<b>Season</b>	<b>From</b>	<b>To</b>
<b>Spring</b>	May 18, 2020	May 24, 2020
<b>Summer</b>	July 20, 2020	July 26, 2020
<b>Fall</b>	October 26, 2020	November 1, 2020

*Methods*

I have conducted two analyses based on the POI foot traffic data. The first one is to calculate the percent of foot traffic for three weeks in spring, summer, and fall of 2020 and to identify the hierarchy of sectors (types of destinations) based on the foot traffic they attract. This is done to understand which sectors have the maximum footfall and to see if it would be feasible to attract and promote these kinds of destinations within the terminal or around the terminal within the TOD district. The second analysis is to classify the POI data points based on their counts and to infer which week of study has the maximum number of POIs.

*Analysis part 1: To find out the types of locations that receive the most foot traffic*

The following charts and tables denote the percentage of footfall for each sector based on the North American Industry Classification System (NAICS) Code. “Sector” here means type of establishment. The NAICS Code classifies not only industries but all types of institutions, including museums, parks, churches, schools, civil and social organizations, and many others. The charts are organized by the spring, summer, and fall study durations for Lowell and Brockton. Total number of Point-Of-Interest data points available for Lowell and Brockton, during spring, summer, and fall periods of 2020 can be found in the tabulation below (Table 14). These counts are tabulated to understand the different sectors for which foot traffic data is available, to analyze which ones have the highest, and to compare them between the two cities.

Table 14. Total number of Point-Of-Interest data points available for Lowell and Brockton, during spring, summer, and fall periods, 2020.

	<b>Lowell</b>	<b>Brockton</b>
<b>Spring (May 18, 2020 - May 24, 2020)</b>	171 points	75 points
<b>Summer (July 20, 2020 - July 26, 2020)</b>	598 points	75 points
<b>Fall (October 26, 2020 - November 1, 2020)</b>	344 points	76 points

**Chart for May 18 - May 25, 2020  
(1) Lowell**

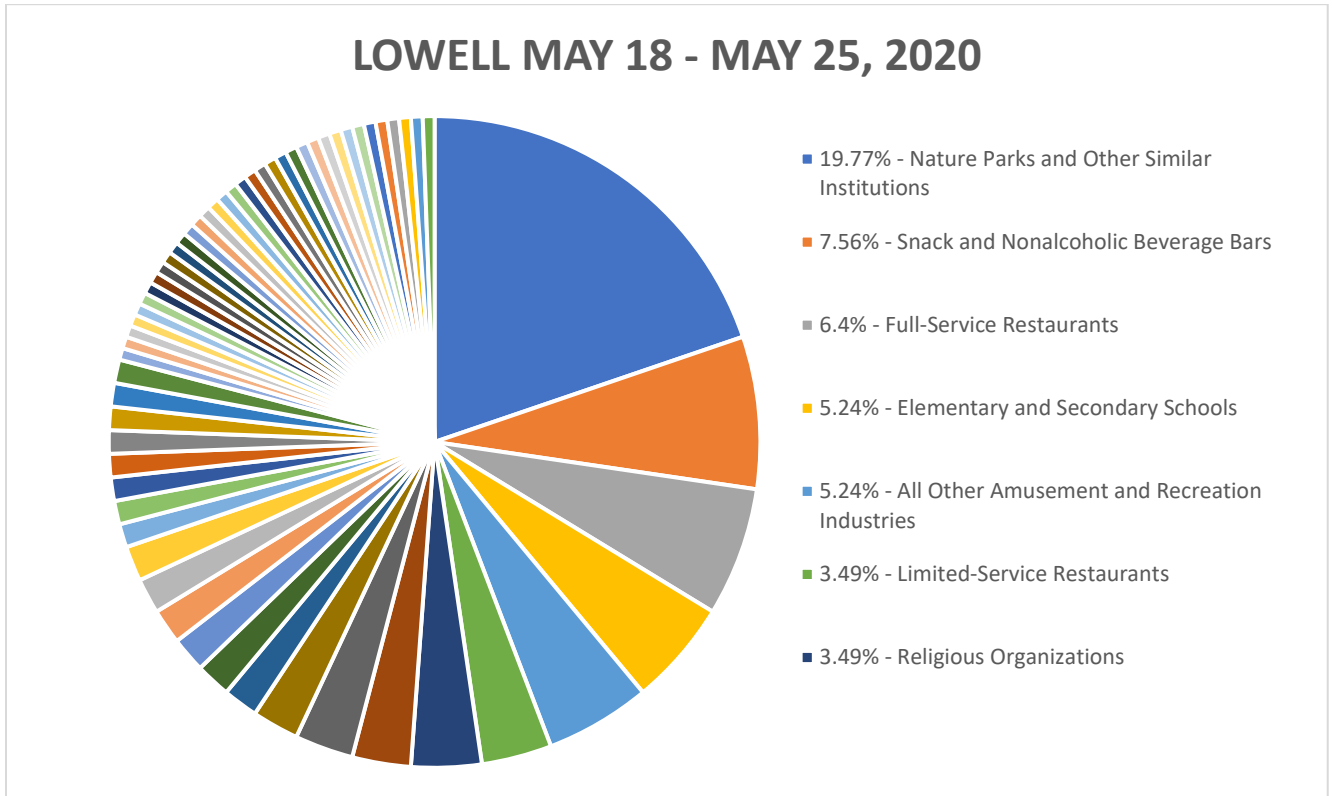


Figure 63. Distribution of top 60 percent of visited locations in Lowell, MA during May 18-25, 2020, by NAICS code. Source: SafeGraph Patterns. Image by Author. Made with Microsoft Excel.

**(2) Brockton**

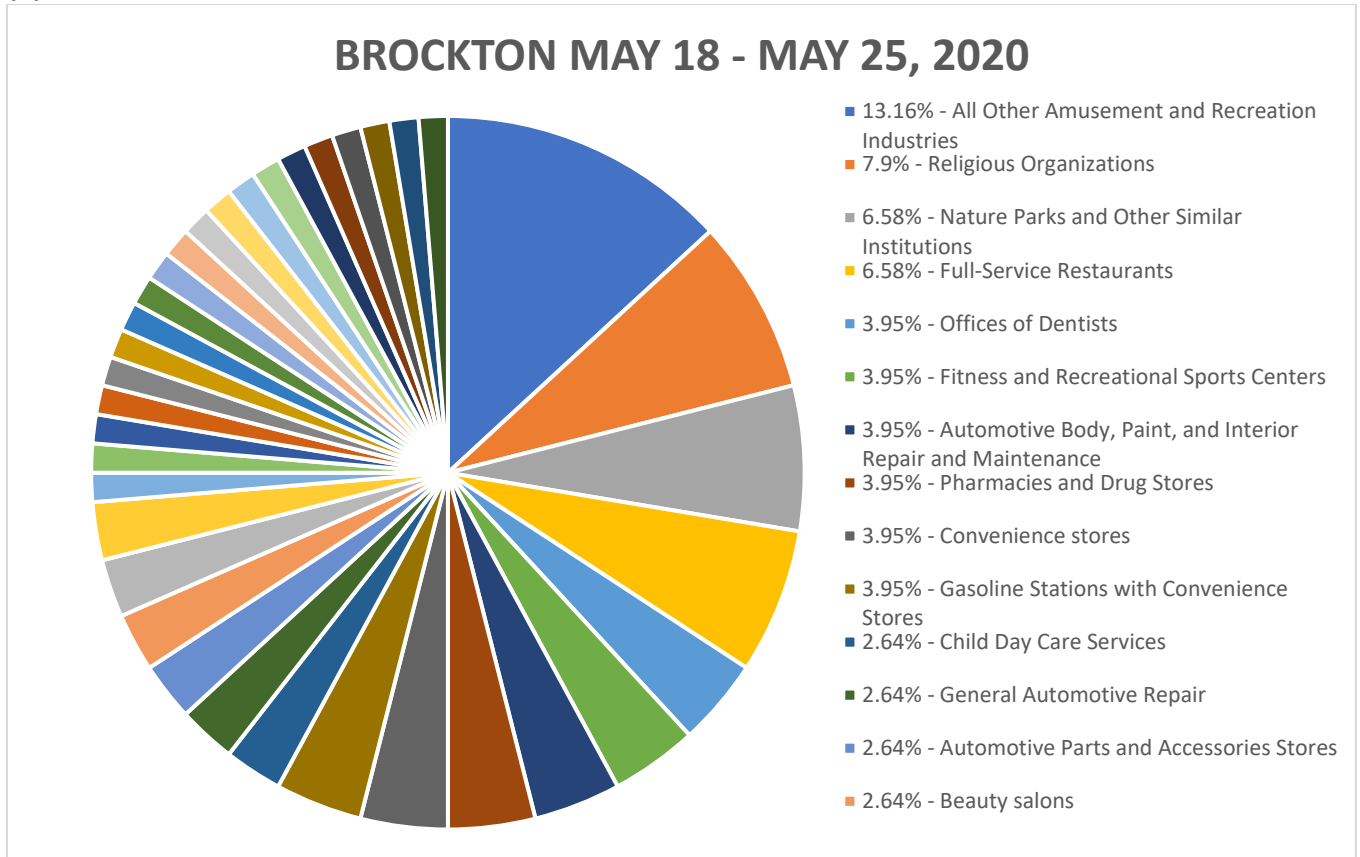


Figure 64. Distribution of top 51 percent of visited locations in Brockton, MA during May 18-25, 2020, by NAICS code. Source: SafeGraph Patterns. Image by Author. Made with Microsoft Excel.

Chart for July 20 - July 26, 2020  
(1) Lowell

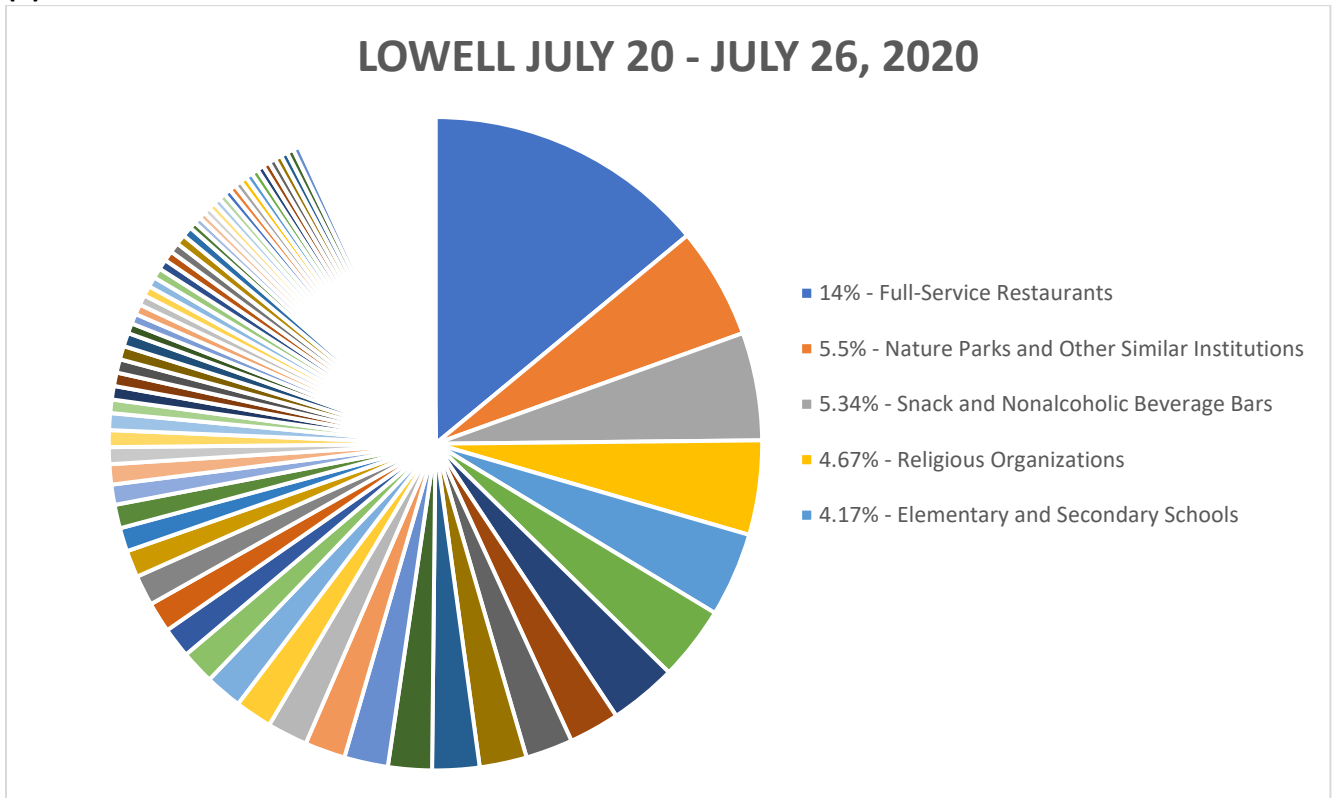


Figure 65. Distribution of top 50 percent of visited locations in Lowell, MA during July 20-26, 2020, by NAICS code.  
Source: SafeGraph Patterns. Image by Author. Made with Microsoft Excel.

**(2) Brockton**

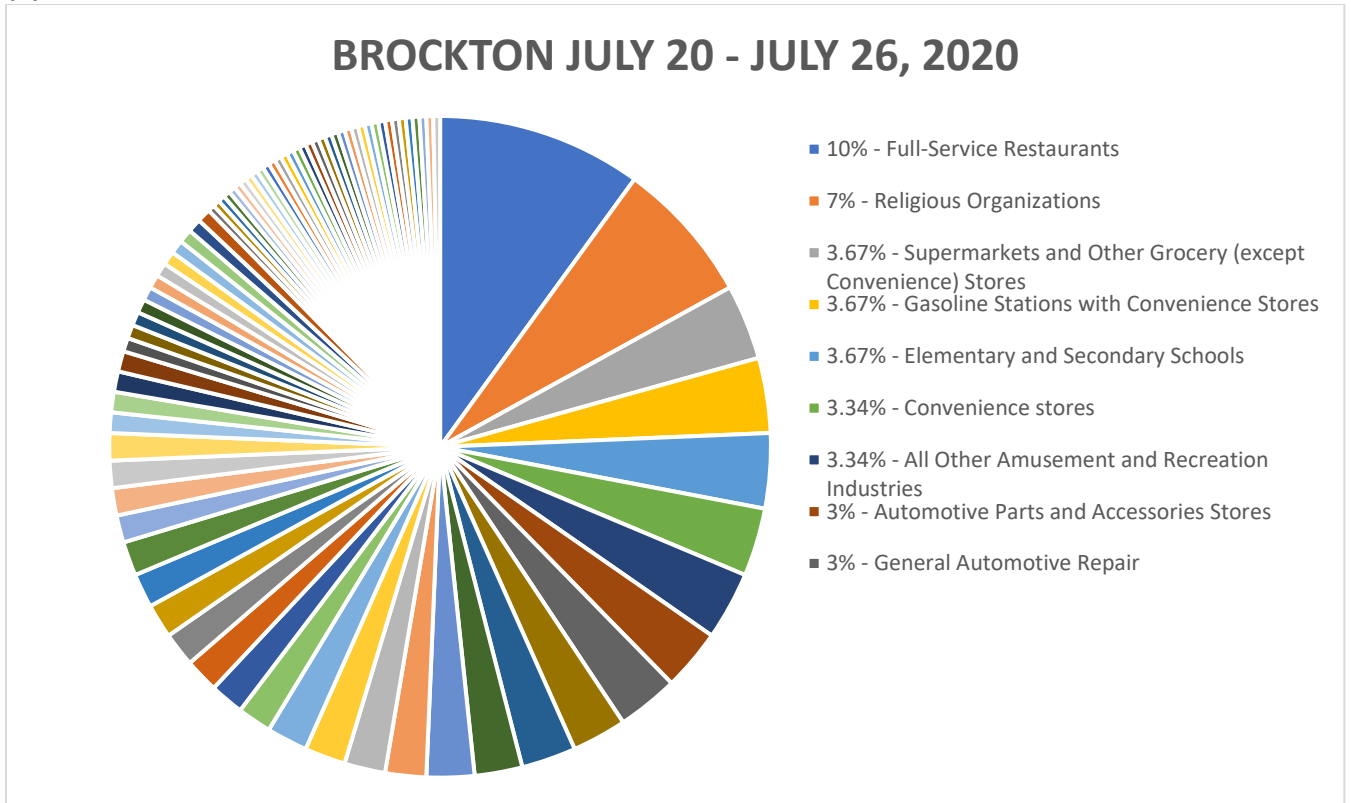


Figure 66. Distribution of top 43 percent of locations visited in Brockton, MA during July 20-26, 2020, by NAICS code. Source: SafeGraph Patterns.

Chart for October 26 - November 2, 2020  
(1) Lowell

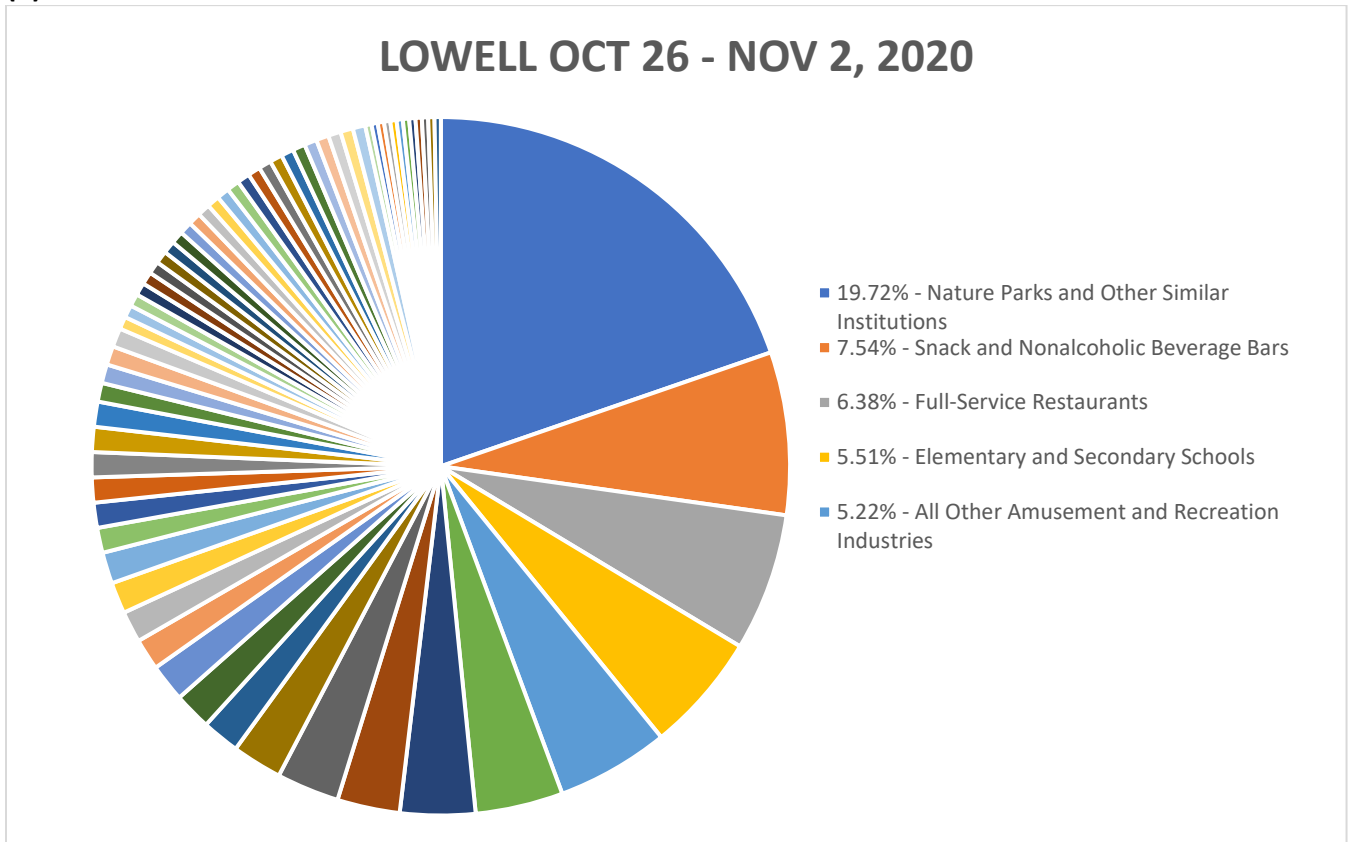


Figure 67. Distribution of top 57 percent of locations visited in Lowell, MA, during October 26-November 2, 2020, by NAICS code. Source: SafeGraph Patterns. Image by Author. Made with Microsoft Excel.

**(2) Brockton**

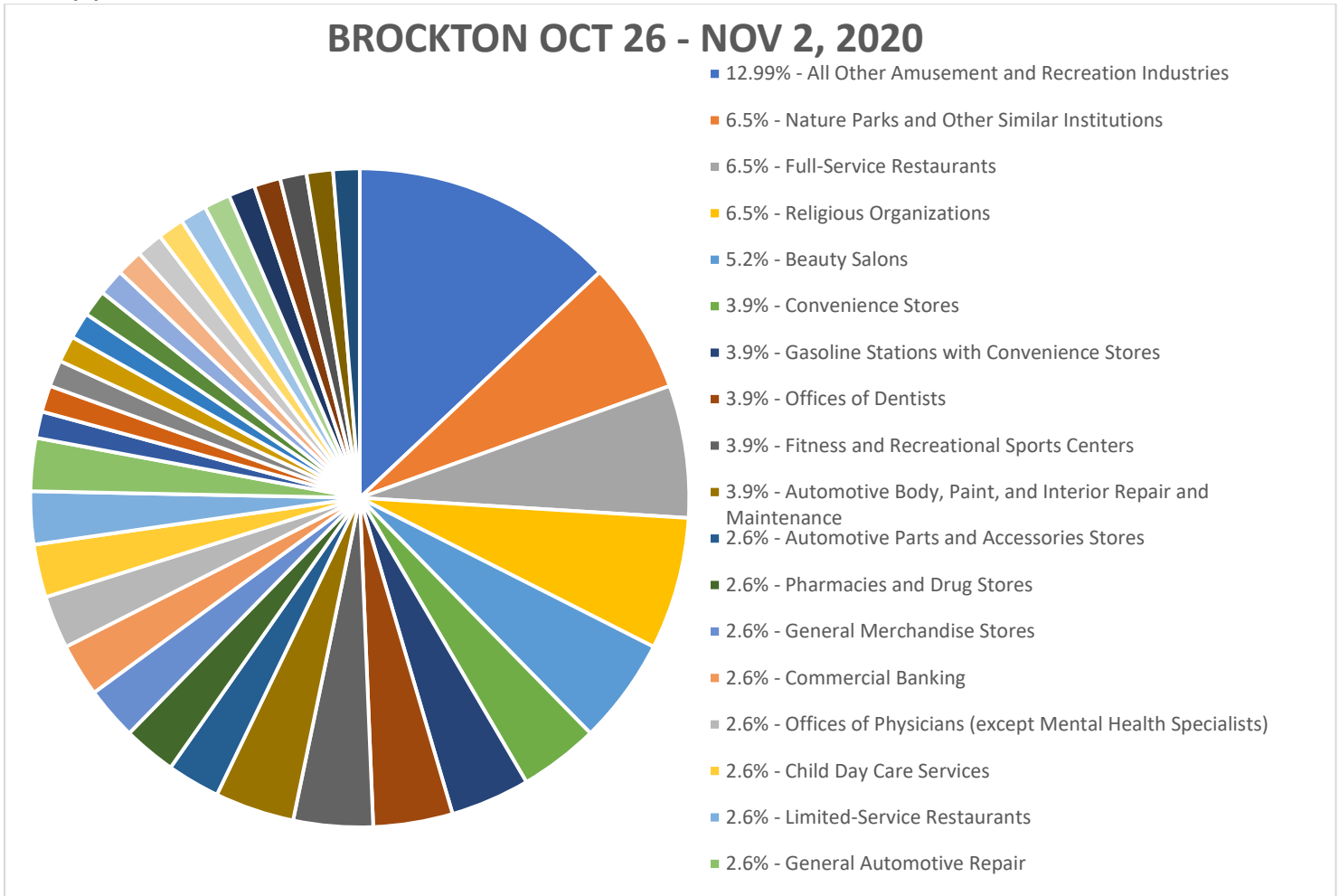


Figure 68. Percentage of Point-Of-Interest data based on American Industry Classification System for the City of Lowell, MA. Source: Image by Author. Made with Microsoft Excel.

The results of aggregating and analyzing the percentage of Point-Of-Interest data based on the NAICS Code for the cities of Lowell and Brockton are tabulated in Tables 15, 16, 17, 18 and 19 below. For both Lowell and Brockton, the sectors that rank 1 at the top had significantly higher percentages of POI data points when compared to the subsequent ranks of visited places.

Table 15. Rank 1 sectors of Point-Of-Interest data points for Lowell and Brockton, during spring, summer, and fall periods, 2020.

<b>Rank 1 sectors</b>	<b>Lowell</b>	<b>Brockton</b>
<b>May 18 – May 25, 2020</b>	Nature parks and other similar institutions (19.8 percent)	All other amusement and recreation industries* (13.2 percent)
<b>July 20 – July 26, 2020</b>	Full-service restaurants (14 percent)	Full-service restaurants (10 percent)
<b>October 26 – November 2, 2020</b>	Nature parks and other similar institutions (19.7 percent)	All other amusement and recreation Industries* (13 percent)

\*: excluding amusement parks, arcades, and gambling industries

Table 16. Rank 2 sectors of Point-Of-Interest data points for Lowell and Brockton, during spring, summer, and fall periods, 2020.

<b>Rank 2 sectors</b>	<b>Lowell</b>	<b>Brockton</b>
<b>May 18 – May 25, 2020</b>	Snack and non-alcoholic beverage bars (7.6 percent)	Religious organizations (7.9 percent)
<b>July 20 – July 26, 2020</b>	Nature parks and other similar institutions (5.5 percent)	Religious organizations (7 percent)
<b>October 26 – November 2, 2020</b>	Snack and non-alcoholic beverage bars (7.5 percent)	3 tied (each at 6.5 percent): Religious organizations, Full-service restaurants, and Nature parks and other similar institutions

Table 17. Rank 3 sectors of Point-Of-Interest data points for Lowell and Brockton, during spring, summer, and fall periods, 2020.

<b>Rank 3 sectors</b>	<b>Lowell</b>	<b>Brockton</b>
<b>May 18 – May 25, 2020</b>	Full-service restaurants (6.4 percent)	2 tied (each at 6.6 percent): Nature parks and other similar institutions and Full-service restaurants
<b>July 20 – July 26, 2020</b>	Snack and non-alcoholic beverage bars (5.3 percent)	3 tied (each at 3.67 percent): Gasoline stations with convenience stores, Elementary and secondary schools, and Convenience stores
<b>October 26 – November 2, 2020</b>	Full-service restaurants (6.4 percent)	Beauty salons (5.2 percent)

Table 18. Rank 4 sectors of Point-Of-Interest data points for Lowell and Brockton, during spring, summer, and fall periods, 2020.

<b>Rank 4 sectors</b>	<b>Lowell</b>	<b>Brockton</b>
<b>May 18 – May 25, 2020</b>	2 tied (each at 5.2 percent): Elementary and secondary schools and All other amusement and recreation industries, *	6 tied (each at 3.95 percent): Gasoline stations with convenience stores, Convenience stores, Pharmacies and drugstores, Automotive body, paint, and interior repair and maintenance, Fitness and recreational sports centers, and Offices of dentists
<b>July 20 – July 26, 2020</b>	Religious organizations (4.7 percent)	2 tied (each at 3.34 percent): All other amusement and recreation industries * and Convenience stores
<b>October 26 – November 2, 2020</b>	Elementary and secondary schools (5.5 percent)	5 tied (each at 3.9 percent): Automotive body, paint, and interior repair and maintenance, Fitness and recreational sports centers, Offices of dentists, Gasoline stations with convenience stores, and Convenience stores

\*: excluding amusement parks, arcades, and gambling industries

Table 19. Rank 5 sectors of Point-Of-Interest data points for Lowell and Brockton, during spring, summer, and fall periods, 2020.

<b>Rank 5 sectors</b>	<b>Lowell</b>	<b>Brockton</b>
<b>May 18 – May 25, 2020</b>	Religious organizations (3.5 percent)	4 tied (each at 2.64 percent): Child Day Care Services, General Automotive Repair, Automotive Parts and Accessories Stores and Beauty Salons
<b>July 20 – July 26, 2020</b>	Elementary and secondary schools (4.2 percent)	2 tied (each at 3 percent): General Automotive Repair and Automotive Parts and Accessories Stores
<b>October 26 – November 2, 2020</b>	All other amusement and recreation industries* (5.2 percent)	8 Tied (each at 2.6 percent): Automotive Parts and Accessories Stores, Pharmacies and drugstores, General Merchandise Stores, Commercial Banking, Office of Physicians (except Mental health Specialists), Child Day Care Services, limited-service restaurants, and General Automotive Repair,

\*: excluding amusement parks, arcades, and gambling industries

Sectors that attract the most foot traffic in Lowell and Brockton, across all three periods, are recreation, food, and religious organizations. These dominate the destinations ranked 1 and 2 in the foot traffic they attract. It is only in rank 3 sectors that a non-food business appears in Brockton (beauty salons in the fall), and other non-food commercial establishments multiply after that, but only in Brockton. Lowell's most visited destinations remain non-commercial (nature, parks, recreation and educational and religious organizations) while their most visited commercial businesses are in the food and beverage sector only.

Rank 1 sectors for Lowell are recreation (nature, parks and similar) in the spring and fall while food (full-service restaurants) in summer. For Brockton, it is recreation in the spring and fall, and food in the summer. In both cities, full-service restaurants receive the most foot traffic of all other destinations in the summer (14 percent and 10 percent respectively). As previously mentioned, rank 1 sectors are dominant: they attract a much larger share of foot traffic than lower rank sectors (Table 15).

Rank 2 sectors for Lowell are food (snacks and non-alcoholic beverages) in the spring and fall, and recreation (nature parks) in the summer. In Brockton, it is religious organizations that receive the most foot traffic in the spring, summer, and fall, tied with restaurants and recreation in the fall (Table 16).

Rank 3 sectors in Lowell continue to be dominated by food: full-service restaurants in the spring and fall, and snacks and non-alcoholic beverages in the summer. In Brockton, destinations are more diverse: they are restaurants and recreation in the spring, gasoline

stations with convenience stores, elementary and secondary schools, and convenience stores in the summer, and beauty salons in the fall (Table 17).

Ranks 4 sectors are splintered into more destinations, attracting a smaller share of foot traffic. In Lowell, in the spring and fall, elementary and secondary schools, tied with amusement and recreation industries in spring see the most visitors. In the summer, it is religious organizations. In Brockton in the spring, six types of establishments are tied for rank 4, all under 4 percent of foot traffic (Table 16). In the summer, rank 4 sectors are recreation and convenience stores (Table 18). The establishments that are common between the destinations of spring and fall in Brockton are gasoline stations with convenience stores, convenience stores, automotive body, paint, and interior repair and maintenance, fitness and recreational sports centers, and offices of dentists. The one Rank 4 sector that is unique to the spring in Brockton is pharmacies and drug stores.

Rank 5 sectors in Lowell are religious organizations in the spring, elementary and secondary schools in the summer, and amusement and recreation industries in the fall. Brockton has 4 ties, child day care services, general automotive repair, automotive parts and accessories stores and beauty salons sectors in the spring with each less than 3 percent. And in fall, there are 8 ties, automotive parts and accessories stores, pharmacies and drugstores, general merchandise stores, commercial banking, office of physicians (except mental health specialists), child day care services, limited-service restaurants, and general automotive repair with each 2.6 percent (Table 19).

*Analysis part 2: To map POI data for Lowell and Brockton based on foot traffic analysis*

The following maps denote the locations of footfall based on the POI data for Lowell and Brockton. These POI data are represented as points in these maps based on the amount of footfall received by each location. The maps are organized by the spring, summer, and fall study durations for Lowell and Brockton. A comparison of percentage of footfall for Lowell and Brockton are given for 0-0.5 mile radius.

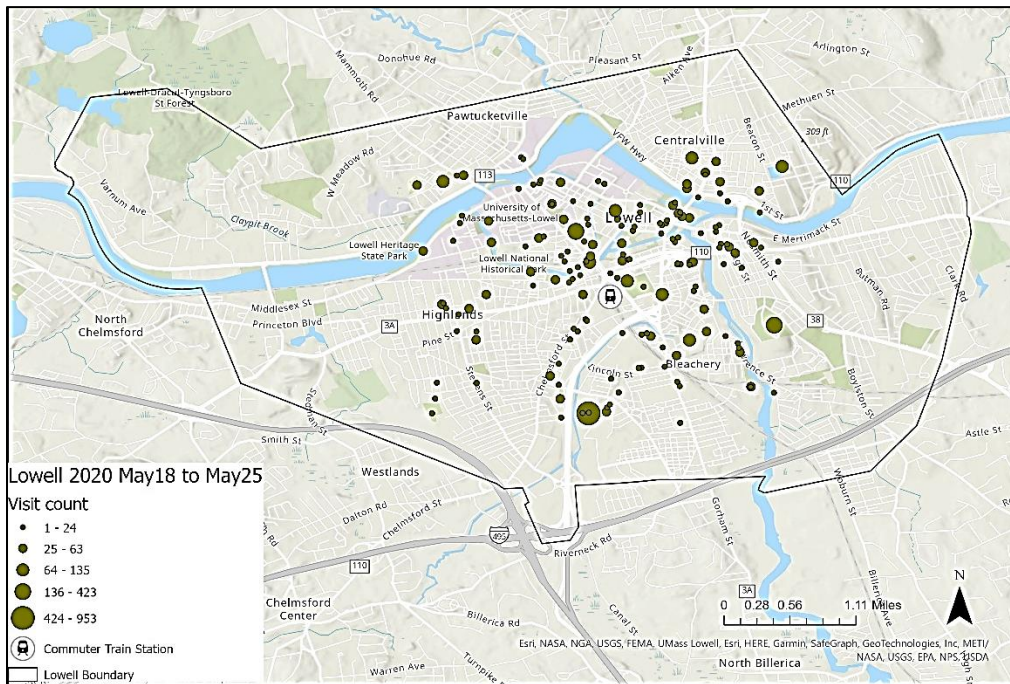


Figure 69. Map Of Point-Of-Interest data for the city of Lowell, MA between May 18 to May 25, 2020. Source: SafeGraph Patterns. Image by Author. Made with ArcGIS Pro.

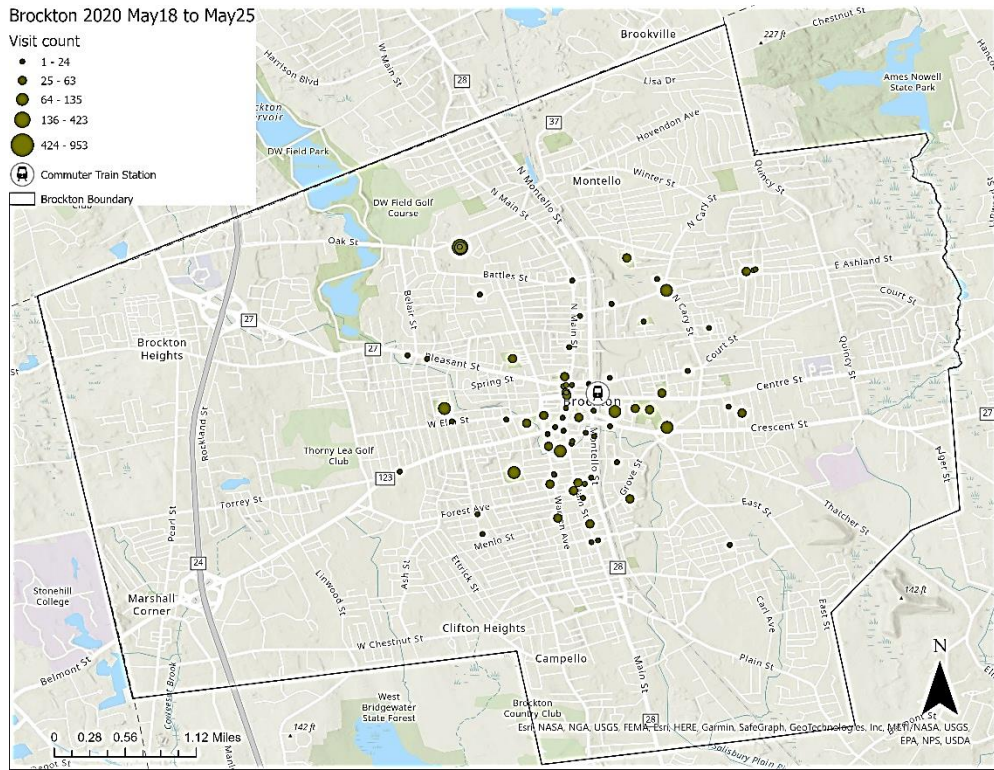


Figure 70. Map of Point-Of-Interest data for the city of Brockton, MA between May 18 to May 25, 2020. Source: SafeGraph Patterns. Image by Author. Made with ArcGIS Pro.

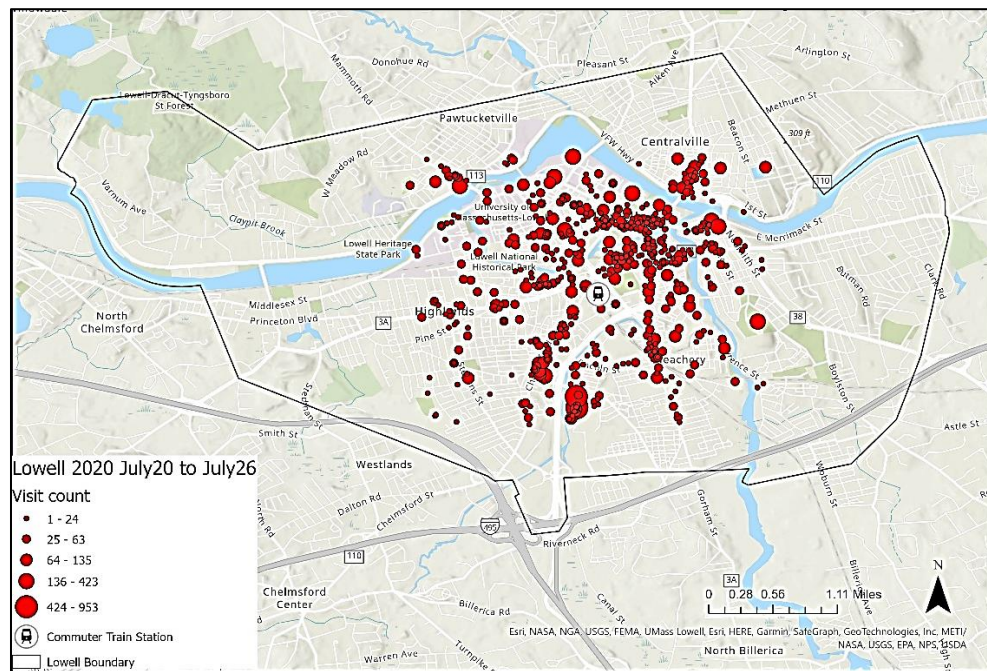


Figure 71. Map of Point-Of-Interest data for the city of Lowell, MA between July 20 to July 26, 2020. Source: SafeGraph Patterns. Image by Author. Made with ArcGIS Pro.

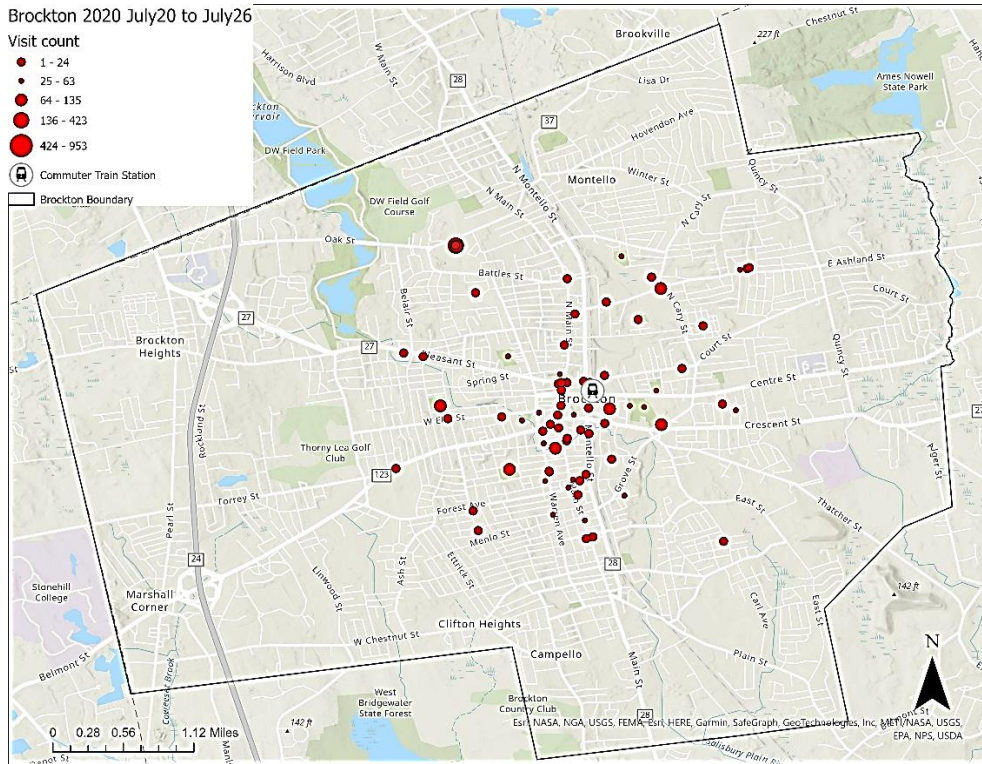


Figure 72. Map of Point-Of-Interest data for the city of Brockton, MA between July 20 to July 26, 2020.  
 Source: SafeGraph Patterns. Image by Author. Made with ArcGIS Pro.

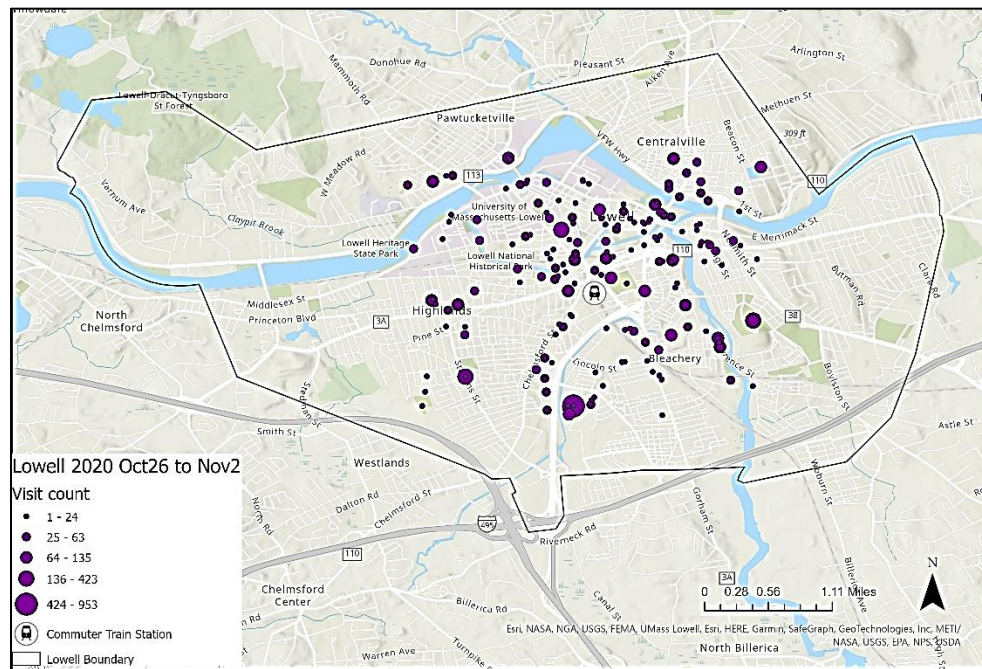


Figure 73. Map of Point-Of-Interest data for the city of Lowell, MA between Oct 26 to Nov 2, 2020.  
 Source: SafeGraph Patterns. Image by Author. Made with ArcGIS Pro.

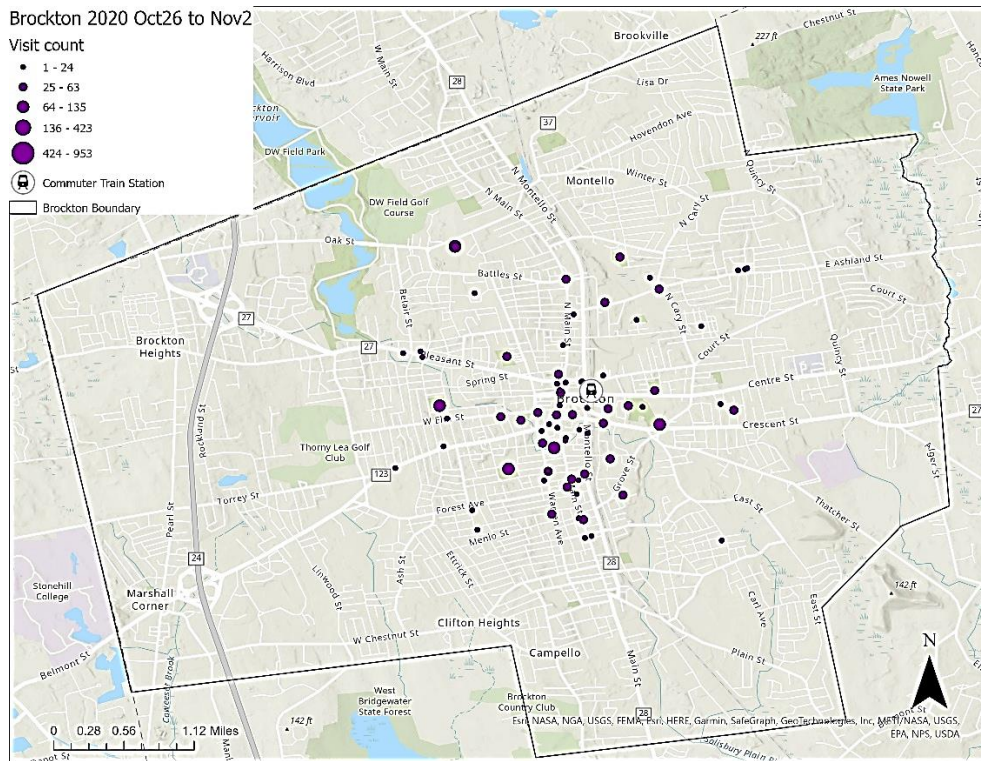


Figure 74. Map of Point-Of-Interest data for the city of Brockton, MA between Oct 26 to Nov 2, 2020. Source: SafeGraph Patterns. Image by Author. Made with ArcGIS Pro.

From the maps above, I compared the number of POIs within 0.5-mile of each terminal with that of the total number of POIs in Lowell and Brockton. I could see that for all three durations of study, ~23 percent POI data points were within ½ mile of Lowell’s transit terminal and ~41 percent of POI data points were within ½ mile of Brockton’s transit terminal out of the total POI data points.

Table 20. Percentage of Point-Of-Interest data points within 0.5 mile radius of the transit terminal in Lowell and Brockton, MA, out of all POI data points in each city.

Date	Lowell	Brockton
May 18 to May 25, 2020 (Summer)	23%	40%
July 20 to July 26, 2020 (Spring)	23%	41%
October 26 to Nov 2, 2020 (Fall)	22.5%	41%

### *Inferences based on the analysis*

For the foot traffic analysis, I aggregated all three weeks' data for both Lowell and Brockton to identify the top 10 points of interest for each week. On analyzing this data, I could see that there is a lot of traction for chain stores in Lowell. Meanwhile in Brockton, local restaurants, recreation places like playgrounds, and postal services had higher footfall. Detailed tabulation of this aggregation analysis to identify the top 10 POIs can be found in the Appendix A. Overall, looking closer at the comparison of foot traffic data, both Lowell and Brockton have high footfall for service-based and recreation-based locations. However, Brockton does not have as much foot traffic as that of Lowell. It could also be seen that the week of July 20 to July 26, 2020, has the highest footfall compared to the other weeks in both Lowell and Brockton. When taking a closer look at the urban form, in terms of development, there is a lot of scope for development given that there are many vacant and underutilized land parcels around the terminal in Lowell, which when developed could increase points-of-interest around the terminal. As a result of an integrated development approach where land use and transportation systems are coordinated and developed, there could be a potential increase in footfall for ridership as well as visitors in TOD district.

### *Conclusion*

Based on foot traffic analysis inferences, I have identified the places with maximum footfall based on the available POI data points. This analysis has shed light on the places that are most popular among people and visit most often. By providing the most popular destinations closer to and within the TOD district, the number of separate automobile trips can

be reduced as all services will be either in walkable distance for people living within the TOD district or on the way to and from the transit hub for people living beyond TOD district. Also, classification of the POI data points suggests that there is a lot of scope for development around the transit terminal which could indeed increase the foot fall in the TOD district as well as promote the use of public transit due to the proximity to amenities.

Retail analysis focused mainly on businesses available within Lowell, while the foot traffic analysis considered services like recreation. On comparing the data from Market Analysis and Foot traffic analysis, the results of Market analysis indicate the need for more restaurants in Lowell and foot traffic analysis shows that restaurants are a major POI irrespective of the seasons. Hence, there is a need to establish more restaurants in Lowell.

## Chapter 6 Recommendations

### *Interviews*

I conducted 11 interviews with various stakeholders which include interviewees from the city of Lowell and other experts with experience working on TOD projects in other gateway cities. I wanted to understand TOD from their perspective and to converse about what Lowell can learn from other gateway cities. A detailed list of interviewees is in Appendix B. The main themes that emerged from the interviews were about the challenges posed for implementing TOD in gateway cities, the importance of considering a transit terminal as more than just a station, and the need to identify parcels around the terminal to redevelop to support the economic development of the city as a whole. Recommendations based on the interviews are accompanied by quotes from interviewees. There are a lot of developments and improvements happening in many gateway cities, slowly but steadily. I appreciate all the work done by experts to revitalize these gateway cities while preserving the distinct character of each of these cities. Insights shared by experts helped me to develop the recommendations for the city of Lowell that are described below.

### *Recommendations*

The city of Lowell is very progressive and has been doing a great job in terms of the projects and the developments happening in Lowell. Unlike many other gateway cities, Lowell already has a significant advantage in the amount of research and information available from city officials, planners, and academics. Similar to the focused development within the Hamilton Canal Innovation District, a focused development around the transit terminal is possible. Lowell

is ready for TOD, has issued a Request for Proposals for a TOP Plan, and could potentially set an example for other gateway cities to implement TOD. In this chapter, I have developed recommendations based on the various methods discussed in previous chapters, to add value to the work that the city of Lowell is doing to implement TOD. The recommendations are listed below (numbered 1-18) with additional considerations (labelled A-F) within each recommendation.

### **Recommendation 1: Establish a sustainable TOD district**

*“Every community on the commuter rail has to do its part to make sure that every stop is a true node, because we don’t necessarily want people going all the way from Lowell to Boston. There should be destinations all along the way that provide people with opportunities to live and work so that the whole corridor becomes more attractive and denser. That has to happen in order to justify higher frequency service.”*

– Benjamin Forman

In January 2022, the city of Lowell issued a Request for Proposal (RFP) for a Transit-Oriented Development Special Plan (TOD-SP) for the area around the Gallagher Terminal. As mentioned in the RFP, having a designated TOD district around the transit terminal is highly recommended.

Independently of what is contained in the RFP, below are my recommendations and considerations about establishing a TOD district.

**1 (A):** The boundary of the TOD district should be determined by a 5-minute or walking distance or quarter-mile distance from Gallagher Terminal. It could potentially extend, in whole or in portions, to the 10-minute, half-mile distance. In either case, the boundary should be determined using a street network analysis around the terminal (the time it actually takes to

walk to a destination given the configuration of the street network) rather than geometric circles around the terminal.

Additional considerations.

1. Identify the total amount of paved area within this TOD district, the number and location of paved areas, and ways to make them permeable surfaces.
2. Identify the total area within the TOD district that has surface parking separating streets from storefronts. For the TOD district to be walkable, create a guideline for the buildings within district to provide parking lots only behind the buildings such that the street-facing building facades make the street pedestrian-friendly.
3. Identify the number of existing grocery stores, convenience stores, restaurants, and bars within the potential TOD district. Conduct a market analysis to understand which type of stores need to be implemented in the new development to accommodate the demand of the upcoming growth and development.

**1 (B):** Draft a “transit-oriented development district or TOD district” around the transit terminal to focus infill development within this area. Some considerations in doing so are:

- Under potential new zoning, what land uses would qualify to be within the TOD district?
- If there are existing land uses that do not qualify to be within TOD, should they be relocated elsewhere within Lowell?

**1 (C):** First steps to implement TOD in Lowell

Overarching first steps to create a TOD district are the following.

Step 1: Identify the TOD district boundary (see Recommendation 1).

Step 2: Identify vacant and underused land and buildings within that area (see Recommendation 2) with their size, ownership, current uses, and other characteristics.

Step 3: Focus on city-owned land for redevelopment first.

Step 4: Talk to private and public owners of properties not owned by the city to discuss the advantages and importance of redeveloping to promote/instill economic development in and around the transit station in Lowell.

Step 5: Conduct a market analysis (see Recommendation 3) to understand which types of new businesses, housing, and civic amenities should be attracted to the district, to complement existing ones and meet the demand of upcoming growth and development.

## **Recommendation 2: Identify existing amenities and redevelopment opportunities**

*“Each train station is different. For transit-oriented development, we also saw what kind of site and land was available for redevelopment around the train station. This is what we would call as the soft sites, sites that are susceptible to change.”*

– Kartik Shah

Inventory existing residential, commercial, and civic amenities within the TOD district. In addition to completed, under development, and proposed residential developments, this should include grocery stores, pharmacies, convenience stores, and other basic necessities; restaurants, bars, shops, and all other retail establishments; and schools, places of worship, parks, playgrounds, public squares and plazas, community spaces, and other non-commercial destinations.

Identify vacant and underused parcels within the TOD district and adopt a redevelopment goal of providing live, work and play spaces for residents. List parcels for potential redevelopment with their size, ownership, current uses, assessed value, zoning, estimated redevelopment costs, and other characteristics needed for planning.

## **Recommendation 3: Conduct a market analysis**

*“There are probably opportunities to build more housing near the train station. This would depend on what type of demand it is. Is it for more apartments or single-family housing? If there is a market, then somebody has seen that opportunity and has tried to capitalize on that opportunity.”*

– Kartik Shah

*“A lot of these projects are happening because there is a demand for it.”*

-Regional Transit Manager

A market analysis is essential to guide development in the city. Cities around the world are slowly recovering from the impact of the pandemic, which changed our lifestyle in a lot of ways and resulted in different levels of demand for various uses. Hence, conducting a proper market analysis to understand the current market demand could be helpful to focus on developments for those potential uses. Also, a lesson learnt from the pandemic is to design buildings with flexibility such that they could be repurposed for other uses if needed.

Conduct the market analysis not only to understand which types of new businesses, housing, and civic amenities should be attracted to the district, but also to complement existing ones and not compete with them. Market the TOD district to these preferred residential, commercial, and civic amenities.

Services proposed in the district should complement each other to increase the overall economic development of the city. A yoga studio and smoothie bar for example, could complement each other, as well as a used-books store, coffee shop, and different kinds of thrift and resale stores close to each other.

#### **Recommendation 4: Control land value growth**

*“When thinking about the benefits of TOD, first of all, it will increase the tax base of the city. The city becomes more vibrant. Lowell is still one of those cities that rolls up the sidewalk at night. It is not a hustle and bustle city after a certain hour at night. As more developments happen, that is going to change. Like all downtowns, historically, there were people coming and commuting there and leaving at night. Over time, it is changing. It is becoming where people live. And that will make a huge difference.”*

-Regional Transit Manager

In order to prevent gentrification and displacement while implementing TOD, Lowell could pursue strategies discussed in the literature review. One is for the city to encourage and prioritize the building of affordable housing around the terminal before officially announcing the TOD district. Lowell already has a robust Inclusionary Housing ordinance requiring that 20 percent of units in new developments be affordable. Within the TOD district, it could negotiate with developers set asides of 25 percent in exchange for density bonuses. Another strategy is for the city to sell city-owned parcels suitable for development at their after-development market rate value. Yet another is to establish property tax abatements or caps for current homeowners within the boundaries of the future TOD district, and to regulate increases in commercial rents to protect existing small businesses.

For these measures to be successful, they must be decided and put forward before new zoning is established and before the TOD district is marketed to developers. In addition, the new housing has to prioritize people who will actually rely on public transit. The goal of all these strategies is to help control land values before development.

#### **Recommendation 5: Make Gallagher Terminal more than a transit station**

*“If you go to Union station in Worcester, it was built in the heyday of train travel, so it has that feel. It was boarded up and closed for decades but when it was refurbished by the city, it made sure to preserve the historic nature of that landmark. Union Station in Springfield is the same situation. It is a beautiful environment and a real entry point to the city. It was closed for decades, really deteriorated, and costed over a 100 million dollars to fix that. You know, Lowell station was built in a later period, and it wasn’t meant to serve that kind of function. If you look at the stations that are being added in New Bedford and Fall river, they are basically a shelter and not even a station. That’s what the state thinks of transit right now. Those are huge historical cities and ports of regional anchors. New Bedford station is the gateway to the Cape and islands because the ferries leave there. And they are going to basically put a shed there instead of building a real station, which I think is tragic. Again, says everything we need to know about how seriously we take these assets today.”*

– Benjamin Forman

*“People are not going to completely abandon their cars and just use buses over here. Even if the train station is connected, a lot of the other things are not connected to the bus service, so they don’t have enough service around the bus station or around the bus routes. Grocery stores may not be around the bus routes, some of them are, I know but not all of them are and the frequency is not that high, so we cannot just abandon our car and decide to take buses. With the recent gas prices, the transit agencies have the opportunity to increase transit usage, if they lowered fares. Right now, lot of people are hurt. Specially along the commuter line, as people’s income reduce, they stay farther away from the CBDs and in turn spend more on the commute. Currently, the commuter train fare structure for anyone living in Lowell (\$340 per month) is comparable to owning a car. If they really want to make people ride transit, they need to widen the gap between choice of car ownership or transit usage. Make transit much lighter on the wallet so that people move away from the cars.”*

– Kartik Shah

Most of the commuter rail stations are usually just a sheltered, linear platform with surface parking spaces for people to park-and-ride. In contrast, the transit station building in Lowell has a lot of scope to include shops and restaurants within it because of its size and built form. From a revenue generating perspective, this is an excellent opportunity for the city to attract more users due to accessible amenities within the terminal building, not only for people commuting to work but also for Lowell residents, tourists, and other travelers who are visiting the TOD district.

Based on the inferences from results of the foot traffic analysis, providing the most essential services for people commuting to/from work through the transit terminal would yield benefits beyond consumer convenience and business support. Providing a small grocery store, pharmacy, or convenience store, for example, would help people to combine trips thereby reducing VMT. Similarly, attracting local businesses like cafés and restaurants within and around the terminal could invite more people to the TOD district.

#### **Recommendation 6: Build parking garages for future repurposing**

*“In many ways, Lowell is well positioned. They have good leadership and wonderful infrastructure. Most of the Gateway Cities are the equivalent of “architectural museums” in various conditions of repair. My first admonition when I come to a place is, don’t demolish*

*anything, whatever you've got, try to repair, and repurpose...don't eradicate. If you lose your historic structures, you have lost your charm."*

– Joseph Mulligan

Lowell has done a great job in focusing on rehabilitating vacant and underused historic mill buildings instead of demolishing them. I recommend that the city of Lowell continue their good work in preserving historic buildings and their city's character by revitalizing old mill buildings.

Given that Lowell is still a car-centric city, promoting TOD could potentially decrease the number of cars in the vicinity when it provides an opportunity to reach destinations by walking, biking, or other sustainable modes of transportation. Hence, the parking garages that are to be constructed hereafter need to be built in sizes and heights which allow them to be repurposed as mixed-use buildings with commercial uses on the first floor and other uses above. This future-facing approach could help prevent the demolition of parking structures and ease their renovation into other uses when the demand for garages reduces as more people live in the TOD area, as well as in response to national trends, while allowing visitors to increasingly visit the city by sustainable modes of transportation.

### **Recommendation 7: Promote the use of transit**

*"If you talk to any developer, they will say that the train is kind of an amenity that is nice to have but is not driving market value. In large part because the service isn't that great - takes too long, undependable, expensive, and limited quality of the service. The value of real estate next to it is not what it should be or could be. You know, if one is spending several hundred dollars a month just to pay and ride a train, that money is not going to rent." He also shares that MassINC has been "advocating for dramatic improvements to the quality of service and reductions in fare."*

– Benjamin Forman

*"Invest in commuter rails in a way that leads to faster, frequent, reliable service, and electrified trains."*

– Benjamin Forman

*"I think living a carless lifestyle near a transit station works if transit is affordable, robust, clean, runs predictably and is an enticing experience that you want to do. If this is not the case, then it is hard to persuade someone to get rid of their car. Unfortunately, regional transit systems in Massachusetts are extremely underfunded, which is a problem that only the state and federal government can solve. I think these challenges will hurt the case for transit-oriented development in gateway cities like Lowell, despite our efforts to advance it."*

– Francesca Cigliano

*"The only constraining factor in the area around the terminal for more development is, MACOM Technology Solutions which is an industrial chip manufacturer, that occupies a large stretch of Chelmsford street which abuts the terminal as well. So that constrains what is available for more transit-oriented development."*

-Regional Transit Manager

**7 (A):** The LRTA recently updated their routes based on ridership data. I recommend that in the future LRTA bus routes be updated with a focus on connecting essential services like grocery stores in addition to serving the ridership's most traveled paths. This could combine work and non-work trips thereby reducing VMT and also serve as first- and last-mile connectivity to commuter rail users. Studying riders' origin and destination patterns over a period of time would help to identify most visited places of work, schools, grocery stores and other necessities. The source and destination of a trip can be same, but in-between stops can be many and when they are not connected by public transportation, people tend to drive in order to get to places.

**7 (B):** Institute a pilot program called the "Free Bus Day": LRTA buses would be free for people on this day, which could be either once or twice a week for a year duration of the pilot. People could use this opportunity to try taking public transit and see how they could effectively use the services provided by LRTA buses. Now is a perfect time to exercise this pilot as a lot of activities have slowly started to open up since April 2022 after the impact of the pandemic and hence, this pilot could attract more people to try out the updated LRTA routes.

**7 (C):** Encourage LRTA and MBTA to collect foot traffic data for the transit terminal as well as all bus and train stops under their operation and maintenance, in order to study the pattern of mobility of transit users anonymously to provide effective service based on transit users' needs.

**7 (D):** The city of Lowell and the LRTA could promote the use of transit by providing free transit passes to city staff members to take public transit to work. Similarly, the city should motivate transit-adjacent employers – industrial and commercial, including office and retail – to provide transit passes for their employees. By increasing the employees who use transit, in the near future, the surface parking lots of these properties can be converted into housing, green spaces, or other uses and buildings.

### **Recommendation 8: Improve the infrastructure for pedestrians and bicyclists**

*“A quarter mile is not a quarter mile if it is really unpleasant, uncomfortable, and unsafe.”*

– Adam Baacke

*“The Thorndike Exchange project, that was an old mill building that was adjacent to the transit authority and it was partly retail, partly manufacturing. Together with the Lowell Regional Transit Authority, we funded it because the lower level of the Thorndike Exchange is going to be commercial. Because it makes an official TOD, we were able to get federal funding to build a bridge from the Exchange building right into our façade on the third floor, where we walk to catch the train. Recently the bridge way was opened to the public.”*

–Regional Transit Manager

*“The train station itself is still physically separated from all of the land in the other direction. When you come out on Thorndike street, you can access the Hamilton Canal Innovation District, and downtown. But if you try to go the other way, as you head into Lower Highlands, there's the little Cambodian Neighborhood Community Center right there. And it's so close to the train but is not connected or accessible.”*

– George Proakis

A well-planned and thoughtfully designed circulation network for pedestrians and bicyclists would draw people and make them comfortable to use the transit terminal and TOD district while also making them visit again. For a place like a transit terminal which has a specific main purpose, the circulation within the site plays a vital role in saving time and preventing

getting lost in large spaces designed to accommodate people rushing in and out of the terminal.

The first recommendation below is inspired from case studies.

**8 (A):** Provide a segregated entrance with walking paths for pedestrians, bike lanes for bicyclists with bike racks, vehicle drop-off and pick-up spots which then circulates back to the parking garage in order to streamline the circulation of different modes without conflict.

**8 (B):** To ensure the safety of pedestrians and bicyclists approaching the terminal, proper sidewalks, crosswalks, and bike lanes with minimum conflicts are necessary. To achieve this, traffic calming techniques like road diets near the intersections of entrances and exits of the terminal would be helpful.

**8 (C):** To promote the use of bikes:

- Bike parking facilities are important. Hence, provisions for secure bike racks at all entrances and exits of the terminal are recommended.
- For transit users and others who are willing to a bike but do not have bike, establishing BlueBike stations in the terminal and within the TOD district could help achieve the first- and last-mile connectivity.
- An inclusive environment for bikers of all levels of comfort can be achieved by providing bike infrastructure along all streets within 0.5 mile radius of terminal. This could encourage people of all ages and comfort levels to bike within the TOD district as well as to the terminal.

**8 (D):** A pedestrian bridge is proposed connecting the terminal and the nearby Cambodian neighborhood as currently, they do not have direct access to the terminal in spite of being right next to it.

**Recommendation 9: Make buses universally accessible**

*“The transit terminal in Lowell is actually owned and managed by the Lowell Regional Transit Authority. If you actually look at the Stage 5 on the Lord Overpass maps, we rehabbed the main structure recently, probably in the last 5 years. We recently redid the lobby, now all our buses have GPS, we have digital sign boards inside and outside of the terminal that show when the bus will be here.”*

-Regional Transit Manager

The LRTA has made appreciable efforts to provide well-connected bus routes to residents and others. Redoing of the terminal’s lobby, equipping LRTA buses with GPS, and digital sign boards showing the updates on bus arrival both inside and outside of the terminal are some of the recent upgrades. Another addition that could add value is upgrading all LRTA buses to include a disability access ramp in order to be more inclusive of the transit users.

#### **Recommendation 10: Restore the trolley network**

*“The other thing that was really kind of always on our radar that just never took off was the idea of taking the local heritage trolley that runs as a tourist attraction and try to turn it into an actual transit system. We had a drawing, a route, and a plan that the trolley would get right into where the Kennedy bus area is, and that you could pick up a trolley and it would go across South Common and kind of into the other side of downtown and then hook the loop that they've already done and then eventually head over to the UMass campus. So that you could connect UMass Lowell, downtown, and the station on an actual rail system that also was these historic trolleys. The rest of the neighborhoods still kind of need connections. It's a great 'park and ride' station still, it's got huge amounts of parking, but still want to make it walkable to those neighborhoods behind it. And it's been a tough link to make.”*

– George Proakis

*“Within the city, there have been talks for decades now about taking the trolley that the National Park in Lowell operates as a visitor amenity and converting it to an actual transit operation. And there has been a lot of attention paid to potential routing and capital costs and, in a way, it has been easy to do that part. The hard part, that no one has ever solved is, how do you make it economically viable to operate? And nobody seems to know what pocket to subsidize it from.”*

– Adam Baacke

*“It is a project more than a corridor. But it has looked at corridors in order to analyze whether the project can go anywhere or not. And the corridor is generally an upside down U shape, where one end is the Gallagher terminal connecting to Downtown, connecting to the Tsongas Center, which is the arena in Downtown Lowell, which is actually owned by the university, connecting to the baseball stadium, connecting to the university’s east, north and south campuses. And those are the obvious potential anchor points for any kind of transit ridership that would be of significance.”*

The free trolleys operated by the Lowell National Historical Park are unique to Lowell. They bring visitors to different points of the Park between the Visitor Center, Boott Cotton Mills Museum, and Suffolk Mill. Reestablishing and expanding the trolley system have been discussed for decades and deemed economically unfeasible. With an influx of population and activity in the TOD district, however, the idea could be revisited and add value to the existing transportation system in Lowell. This could be achieved by creating partnerships with developers and anchor institutions, such as UMass Lowell, to fund a loop that would connect the transit terminal, downtown, the Hamilton Canal Innovation District, the National Park, and UMass Lowell.

#### **Recommendation 11: Include the terminal in the Wayfinding Plan**

Wayfinding is an essential design element in any city in order to provide a great experience of navigating around the city at ease. Clear signs and sign boards help the residents as well as visitors to be aware of various places within the city and at the same time give them an opportunity to independently wander around without getting lost.

Recognizing this key role, Lowell started a Wayfinding Master Plan project in 2021. I recommend that it incorporate wayfinding within the terminal. The ongoing project analyzed gateway and wayfinding needs throughout the downtown and for different modes of transportation. It could emphasize the transit terminal area as an arrival point for people to explore the city by foot and bike and appreciate all that Lowell has to offer instead of driving around.

The Master Plan should result in downtown and neighborhood standard design guidelines for wayfinding as discussed in the Brockton case study, while acknowledging the distinct neighborhoods, diverse populations, and different languages of Lowell.

### **Recommendation 12: Develop urban design guidelines**

*“I think the Form-Based Code in the Hamilton Canal District has done exactly what it was supposed to do, which is to make it easy for people to follow the rules.”*

– George Proakis

*“Back in 2019, we did a study which summarized that zoning needs to be studied, changed, and rewritten. If we wanted to do the type of development that we would do for transit-oriented development around the station, the current zoning does not work, and we need to change it. That was the recommendation.”*

– Camilo Espitia

Lowell adopted in 2009 a Form Based Code for the Hamilton Canal District, in conjunction with the then master developer and residents of surrounding neighborhoods. The city could adopt design standards or guidelines for building types and the public realm within the TOD district similar to or derived from a Form-Based Code. This could include urban design goals and standards, a typology of streets and corresponding landscape and streetscape treatments, building types, heights, and relationships to streets, guidelines for parks and green spaces, historic preservation guidelines, parking policies, parklet policies, and wayfinding.

Conduct a feasibility study to understand the effectiveness of a form-based code and to review how it overcomes the shortcomings of traditional zoning. A study area like the Hamilton Canal District offers a useful precedent from which various aspects of form-based code can be extrapolated and applied to the TOD district. Lowell would have two districts with form-based

codes. In the future, this zoning can be implemented to whole of Lowell based on the results of the feasibility study.

### **Recommendation 13: Mark the gateway to Lowell**

*“We are looking to create a district that is a five-minutes’ walk to the Hamilton Canal Innovation District from the station. And then probably another four-five minutes to downtown. We are trying to forge that connection and that story of being an urban environment. Creating a sense of gateway to Lowell so that when people arrive at the Gallagher Station, they sense the spirit of Lowell, an urban environment, the vibrancy, and they start seeing what the city is about, the diversity, stores, children, people biking and walking. Activating the place in such a way that as soon as you arrive at the Gallagher Station, people see what Lowell is about.”*

– Camilo Espitia

*“I think the biggest challenge for the transit terminal is that it is very auto oriented. It isn’t really connected to what is around it. It is a hub where various transit modes meet at the moment. It is where the commuter rail comes, it is where all the buses come, it has lots of parking spaces. So, a lot of vehicles come there every day. Almost everyone who comes there, comes on one form of transportation, and leaves on another with neither their origin nor destination being the transit terminal. The terminal is just a stop on the way.”*

– Adam Baacke

The transit terminal is the “gateway” to the city of Lowell for people who get to the city by train. Similarly, the Lowell Connector near the terminal is the “gateway” for people approaching the city by car. Hence, I recommend having an arch or public art or a visually appealing welcome sign at the various entrances to Lowell as well as at the terminal to welcome people entering Lowell. Lowell is a historic and diverse city and hence, this public art piece should showcase what Lowell is about thereby giving people an essence of Lowell as soon as they enter.

### **Recommendation 14: Ensure an inclusive process for public transit**

*“We are gearing up to do our master plan updates in the coming years. We will be asking our TOD questions as a part of our master plan community engagement process. We have been*

*really focused on trying to improve our community engagement strategies to be more inclusive and more accessible. So, instead of doing traditional public meetings formats at say 6 pm on a Tuesday, we are trying to do a lot of pop-up public meetings. For example, set up a tent in a park and talk to those who are there on a Saturday and get their input. And that has been really successful. We are also partnering up with our Cultural Affairs and Special Events (CASE) office whenever there are cultural festivals, concerts, or other events. People are already going to these events and a lot of them are people who won't be coming to a public meeting. So, showing up in these places and asking them questions on whatever planning projects we are working on, we are hoping to get demographics in our participation that better reflect the demographics of the city."*

– Jessica Wilson

*"One of the biggest challenges is the vicious circle of, "why invest in public transit if everyone uses a car?"— "well, if we invest in public transit, not everyone would have to use a car". We need to try to overcome that, "nobody takes the bus, or nobody takes the train. Why should we worry about it?" Because, people do take the bus, people do take the train. Because they have to, and they don't have any other option."*

– Jessica Wilson

The city of Lowell has been involved for years in robust community engagement around various projects with innovative strategies to include more diverse population in Lowell into the planning process. It should continue its engagement efforts around the use of public transit.

There is a common notion in the US that public transit is for low-income folks or people who cannot afford a private vehicle. My recommendation is to dissolve this common notion by including awareness materials in all community engagement processes about TOD and related projects. This could also include organizing campaigns that encourage people to take transit irrespective of their socio-economic status and participate in the "Free Bus Day" pilot to explore options to take public transit for all their trips.

### **Recommendation 15: Intentionally plan spaces for overlooked populations**

*"We have this huge open space, South Common which is a historic restored park in Lowell. For that, we got a Parkland Acquisitions and Renovations for Communities (PARC) grant to make some improvements this year. So that is one of the big projects that I am working on. I think it is really an asset to have open space at the heart of our TOD. I think it is going to be a unique*

*feature to this TOD district and I hope that open space can be like a central part of the vision for TOD here. When we talk about increasing density, walkability and reducing parking, open space, recreation, and leisure are going to be the central component of any TOD project that we do."*

– Jessica Wilson

Lowell has a lot of open and recreational spaces around the terminal. These open spaces can further include more intentionally planned places for kids, especially teens as they are often the overlooked population. Creating interesting spaces for teens could make them feel inclusive within the community, give them an opportunity to be in open spaces, and experience nature. South Common which is located across the train station is an asset for TOD. Just as housing and mixed-use developments are important for a successful TOD, open spaces are equally vital for residents living in the TOD district. Given that City of Lowell recently received a grant and that South Common is under an upgrading process, this would be an ideal location to rethink open spaces to accommodate all age groups in Lowell.

## Chapter 7 Limitations and areas for future research

### Limitations

There are some limitations in the two methods that I discussed in previous chapters of my thesis, and I have listed them below.

#### *Market analysis*

The global market was impacted by the unprecedented pandemic and is slowly recovering. The brick-and-mortar retail sector in particular was already dramatically downsizing before 2020, and the pandemic only exacerbated the trend. The office real estate market is similarly shifting to less space and shorter leases. Most of the data used in the Market Analysis are aggregated from ArcGIS Business Analyst and are based on the period from 2015 to 2019. Hence, they do not include the impact of the pandemic. While some of the data are derived from 2020 and 2021 which includes the impact of the pandemic, these data might change again when things go back to a new and different normal in the near future.

#### *Foot traffic analysis*

- As the POI data from SafeGraph is obtained from smartphones, people who visited these places without a smart phone may not be included. This could impact the POI data. POI data is an emerging database, and therefore has some inconsistencies and biases in the foot traffic data. Among other drawbacks, it collects people visits at destination points and does not differentiate between modes of transportation to reach the destination.
- The impact of the pandemic could be a potential factor that caused differences in POI data for the year 2020. Post-2022 data, especially if compared with pre-2020 data, would give a more accurate picture of foot traffic.

- Even though the weeks for analysis were carefully chosen with considerations to climate, there could still be an increase or decrease in footfall based on the weather of the days in the selected weeks.
- Lowell has a major student population from the anchor institution of UMass Lowell whereas Brockton may not have a similar student population in spite of having schools and universities.
- SafeGraph Patterns POI data are currently mostly used by businesses and marketing agencies to monitor and improve consumer visits to commercial destinations. As a methodology still in its infancy, however, it holds promise if it could be used by cities, transportation planners, and academics for transportation planning and research. This thesis hopes to contribute a step in that direction.

### **Areas for future research**

Even though TOD is a concept that has been applied and studied for a long time, only recently has it gained traction. Before outlining areas for future research, a potential topic for immediate consideration is whether the American Rescue Plan Act (ARPA) could be used to fund free buses in Lowell, as Mayor Wu did for Boston. LRTA in Lowell recently modified routes to better serve the communities and this funding could be the next step, to provide free transit to these communities.

An area for future research would be to uncover the difference between transit-oriented development and transit-adjacent development and develop metrics to measure this difference. Will the developments near and around the Gallagher Terminal be considered transit-oriented merely because of their proximity to transit terminal? The question is whether these developments are developed because of their access to the transit station or if they are

developments that would have occurred anyway because of favorable market conditions and could leverage access to the station, if necessary, as part of their marketing.

Further, a more detailed foot traffic analysis could be an interesting study. Currently, there is a gap in the availability of the foot traffic data used in this thesis due to the impact of the pandemic, and other limitations outlined above. Given that the pattern of mobility of people is changing due to the pandemic and post-pandemic preferences, there is less of a focus on measuring AM/PM peak hours, where transit held an advantage over congested car traffic. The emphasis now, more than ever, is on the reliability and frequency of public transit. Improvements of these two factors are needed to convince drivers to use public transit.

There has been a lot of mixed-use development projects being undertaken in Lowell. Given the amount of development happening in Lowell and in proximity to Gallagher Terminal, which is situated at a strategic location, TOD initiative could induce more focused development around the terminal. And for this to happen, I hope that the recommendations proposed in this thesis are helpful.

# Appendices

## Appendix A

Foot traffic analysis data

### Data for Lowell's Top 10 POIs for three durations of study

<b>Lowell 2020 May 18 to May 25</b>	
<b>Location</b>	<b>Visit counts</b>
Chuck E. Cheese	526
Rogers Fort Hill Park	197
Market Basket	164
Dunkin'	100
Dunkin'	92
South Common Park	92
Baseball playground Father Maguires Park	78
Lowell City Fire Department	73
Xtramart	70
Christian Hill Reservoir Park	67

<b>Lowell 2020 July 20 to July 26</b>	
<b>Location</b>	<b>Visit counts</b>
Chuck E. Cheese	953
Target	562
Market Basket	248
McDonald's	214
Lowell General Hospital Saints Campus	198
Edward A. LeLacheur Baseball Park	188
McDonald's	174
Vihangi Thakore DMD, Dentist	168
Rogers Fort Hill Park	161
CVS	135

<b>Lowell 2020 November 16 to November 23</b>	
<b>Location</b>	<b>Visit counts</b>
Chuck E. Cheese	895
Lowell Catholic High School	255
Market Basket	185
The Luna Theater	129
Rogers Fort Hill Park	126
Christian Hill Reservoir Park	126
Xtramart/fuels	114
Residence - Lawrence St	106
South Common Park	103
Oliveria park baseball ground	94

**Data for Brockton's Top 10 POIs for three durations of study**

<b>Brockton 2020 May18 to May25</b>	
<b>Location</b>	<b>Visit counts</b>
La Baguette Divine bakery	141
James Edgar Playground	91
Family Dollar Stores	90
Cumberland Farms	81
Bent Playground	75
United States Postal Service (USPS)	69
Unknown shopping complex	65
Parmeter playground	56
John L O'Donnell Playground	55

<b>Brockton 2020 July20 to July26</b>	
<b>Location</b>	<b>Visit counts</b>
CVS	187
Vicente's Supermarket (160 Pleasant St)	174
Unknown office building	141
James Edgar Playground	139
Bent Playground	131
East Side Package Liquors	127
La Baguette Divine bakery	115
El Bochinche Dominican restaurant	105
Vicente's Supermarket (686 Main St)	104
Boulangerie Saint Antoine Bakery	99

<b>Brockton 2020 Nov16 to Nov23</b>	
<b>Location</b>	<b>Visit counts</b>
James Edgar Playground	97
Cumberland Farms	82
Brockton Veterans Trail Central	82
La Baguette Divine bakery	81
Flames Jamaican restaurant	62
United States Postal Service (USPS)	58
John L O'Donnell Playground	53
Unknown shopping complex	50
Brockton Neighborhood Health Center	48
Old Colony Y Youth Development Center	47

## **Appendix B**

### *List of interviewees and their role/designation*

1. Adam Baacke, Executive Director, UMass Lowell
2. Francesca Cigliano, Senior Planner, City of Lowell
3. Camilo Espitia, Chief Design Planner, City of Lowell
4. Benjamin Forman, Research Director, MassINC
5. Alan Heredia, Assistant Transportation Engineer, City of Lowell
6. Regional Transit Manager, Northern Middlesex Council of Governments (NMCOG)
7. Rob May, Director of Planning and Economic Development, City of Brockton
8. Joseph Mulligan, Project Manager (MBTA's Transit Oriented Development group), MBTA
9. George Proakis, Executive Director of the Mayor's Office of Strategic Planning and Community Development, City of Somerville
10. Karthik Shah, Campus Planner, UMass Lowell
11. Jessica Wilson, Design Planner, City of Lowell

## Appendix C

### *Sample interview questions*

1. What is your role? How long have you been in this role?
2. Are you aware of the transit-oriented development initiative in Lowell? If so, could you talk about the status of transit-oriented development initiative in Lowell? If not, could you share the processes involved in any TOD initiative?
3. What is your opinion on the potential for transit-oriented development in Gateway cities like Lowell?
4. How important is it to identify a transit corridor in TOD initiative? What role does it play in the development?
5. What are the measures to be taken to upgrade the Gallagher Transit Terminal and/or Kennedy Bus Transfer Center to support the transit-oriented development in Lowell in addition to the upgrades already made?
6. How has the pandemic affected or improved transit-oriented development projects in Gateway cities/Lowell?
7. In your opinion, what do you think are the benefits for any gateway city/Lowell when transit-oriented development is implemented?
8. What are your expectations on the increase in number of transit users from Lowell transit station when transit-oriented development project is completed in Lowell?
9. What has been the requirements/demands of community for transit-oriented development in Lowell? And how did you come to know about them?
10. As planner/designer, what are some of the challenges involved in a transit-oriented development?
11. Are there any other gateway city or former industrial city that has implemented transit-oriented development already? Did City of Lowell look into any such case studies?
12. Do you recommend speaking with anyone else regarding my thesis?

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