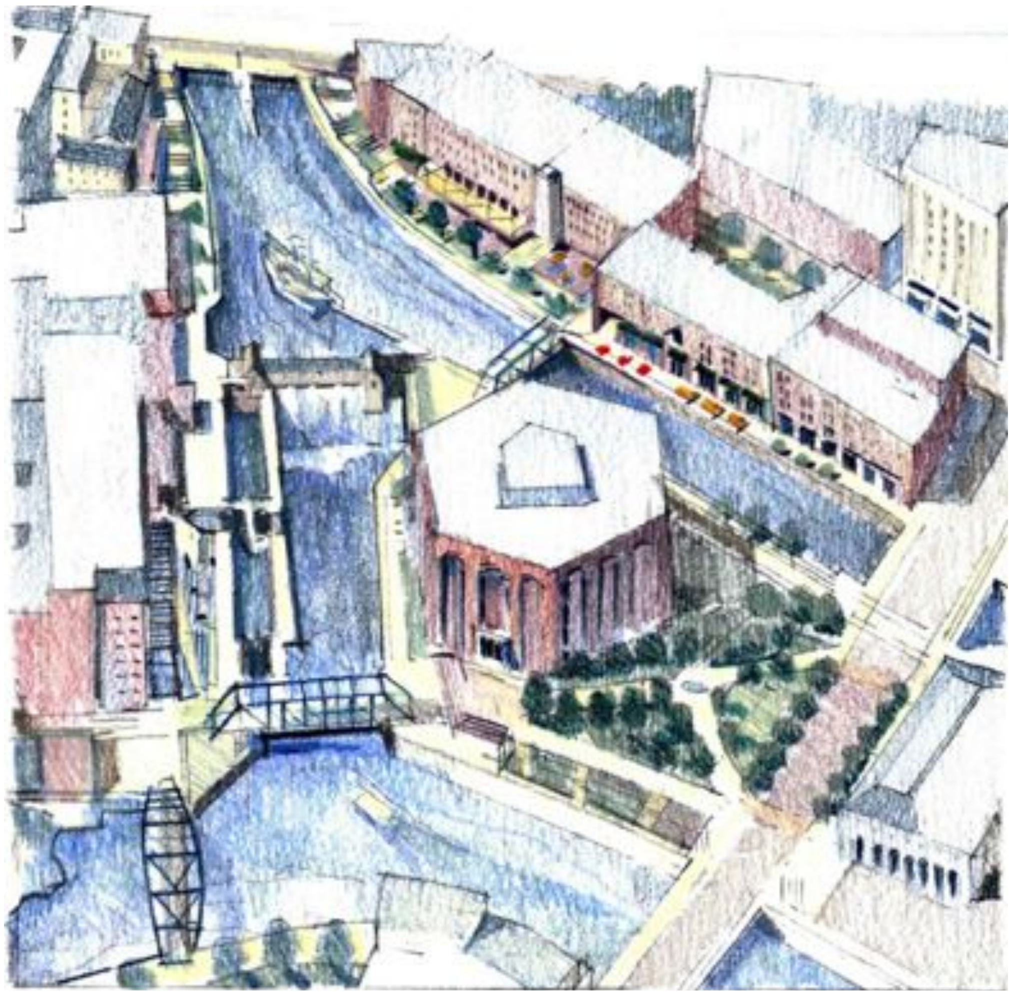
Lowell Downtown Evolution Plan



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by Speck & Associates LLC

in association with:

AECOM and Rock Maple Studios

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" . . . walk down the hillside, towards the quiet streets and houses of Galloway's suburbs—you will hear the river's ever-soughing rush—and pass beneath the leafy trees, the street-lamps, along the grass yards and the dark porches, the wooden fences. Somewhere at the end of the street there's a light, and intersections leading to the three bridges of Galloway that bring you into the heart of the town itself and to the shadow of the mill walls. Follow along to the center of town, the Square, where at noon everybody knows everybody else."

Aside from the name Galloway, Jack Kerouac does little to disguise his native Lowell in his largely autobiographical debut novel, *The Town and the City*. Yet, reading its pages, one can't help but reflect upon how much the city has changed from the time of Kerouac's youth, when "at ten o'clock, the women [came] in armies, with shopping bags, their children trailing alongside," to a downtown holding "the five-and-ten, the two or three department stores, the groceries and soda fountains and drug stores, the bars, the movie theaters. . ."

In many ways, the story of Lowell's transformation from a bustling mill-town to something quite different parallels the evolution of American early industrial cities through the second half of the 20th Century. Yet, visiting these places, it becomes clear that Lowell has fared far better than most. Today, first time visitors to the downtown remark upon the impressive collection of well-preserved historic buildings—not only mills—the unique canal system, and the healthy diversity of downtown activity and population. For the first time in perhaps fifty years, Lowell does not feel like a city that has seen better times.

Yet Lowell's downtown is still a work in progress. Sitcom-worthy coffee houses thrive next door to near-condemnable junk storage. Impeccably restored gilded-age buildings lack upstairs tenants. A first-rate sports arena sits on an empty traffic circle. Canals and rivers meet at an historic basin flanked by blank walls and parking lots. Like a polished stone, the downtown has achieved enough of a luster for the surface flaws to be visible.

Correcting these flaws, and allowing the result to reach its full potential, is the purpose of this document. It is called an Evolution Plan because so much

Merrimack Street in Jack Kerouac's Day

has already been accomplished, and so much care already lavished on this important urban landmark, that there is no need to start afresh. Yet, as will become clear, there is much to be done, from addressing the fundamentals of traffic circulation, to mitigating the errors of urban renewal, to finding uses for key "missing teeth," to building more complete neighborhoods at the downtown's edge. Some of these opportunities can be seized immediately, while others will take years or even decades to achieve. As with the creation of the Lowell National Historic Park, the most transformative proposals take time. That is why we plan.

This document is intended to shape the short- and long-term future of downtown Lowell by bringing national city-planning best practices into contact with the unique landscape, history, and culture that have contributed immeasurably to the city's more recent success. It is presented with confidence that Lowell can become even more vital and cosmopolitan while remaining a place where "at noon everybody knows everybody else."

The Process

Cities are the largest, most complex things that humans make. Planning them properly is necessarily a tremendously complicated task, one that requires both an outsider's objectivity and a local's knowledge of facts on the ground. In an attempt to meet both of these mutually exclusive criteria, the consultant team made use of an experimental process in which the lead planner moved to Lowell with his family for a full month of "urban immersion" within the study area. Living in a converted mill building with an expecting wife, a toddler, and no car, Jeff Speck did his best to develop a first-hand knowledge of the conditions facing Lowell's growing number of downtown residents. His constant presence also facilitated an ongoing schedule of not only meetings and site visits, but also coffees, dinners, and drinks with local homeowners, businesspeople, and community advocates.

This immersion process took place in April of 2010, in the early stages of a nine-month planning effort that included regular Steering Committee meetings and ongoing interface with key City officials and

Field study at Arthur's Paradise Diner.

planning staff. Public input was collected after an open lecture and subsequently on the City Manager's blog, where dozens of downtown residents and workers left thoughtful comments. It is hoped that the plan presented here adequately communicates the great degree to which it was influenced by Lowellians. Many of its best ideas are homegrown.

Past Efforts

This Plan is built atop a foundation of skillful planning efforts that have already taken place in Lowell, including (but not limited to) the following five key documents:

- Hamilton Canal District Master Plan (2008)
- City of Lowell Comprehensive Master Plan (2003)
- ULI Advisory Services Panel Report (2003)
- Lowell Downtown Plan (2001)
- Lowell Historic Preservation Committee Preservation Plan (1980)

A number of the proposals presented ahead grow directly out of ideas found in those documents, especially the 2001 Downtown Plan. Several other proposals come from local "plans" that were never written down, but which have achieved a certain momentum based on their own irrepressible logic or—one hopes—sheer inevitability.

Purpose of this Plan

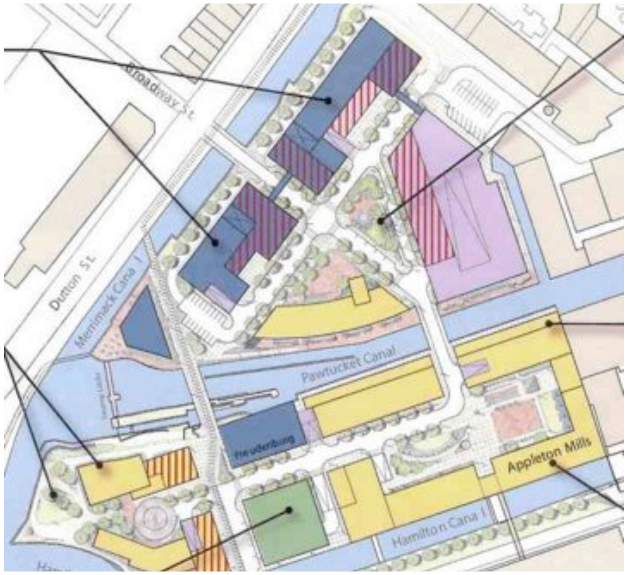
This document was created for no less ambitious a purpose than to bring the downtown to its full potential and, in so doing, to lift Lowell into the top rank of American cities known for their livability and tourist draw. This goal is achieved through a variety of measures that can be categorized as first ameliorative, second strategic, third physical, and ultimately visionary.

The ameliorative measures are about fixing problems, principally the downtown's confusing one-way street network, which frustrates drivers, shuns bicyclists, and often endangers pedestrians. Other challenges in need of attention include an inadequate downtown High School facility and an unnecessary feeling of disconnection among key downtown anchors including the Tsongas Center and LeLacheur Park.

The strategic opportunities focus on past or future investments that can be put to better use in service of the downtown. These include, most obviously, the opportunity for a comprehensive downtown streetcar and, more subtly, the vast untapped development potential that still exists in the guise of the City's five downtown parking structures.

The physical proposals pertain to certain key properties that are unused, underutilized, or currently designed in a way that they detract from the livability of the downtown. Some of these sites can be developed quickly, while others must wait until a current structure outlasts its productive life. In either case, it is essential to have a plan in place—ideally permitted as-of-right—that shows the proper reuse of each property. This effort was inspired by the Hamilton Canal District Plan, in which an entire sector of the city was given a complete plan, to be accomplished over many years, but fully zoned today. If an abandoned brownfield can benefit from such a regime of pre-planning and permitting, why shouldn't the same process be completed for the most important empty sites in the heart of the downtown?

Finally, this plan's visionary proposals are also aimed at underutilized sites, but they intentionally step beyond the currently achievable to propose the sort of transformative developments that can fundamentally alter the experience of a city as well as its reputation. These proposals are typically expensive and politically



The plan for the Hamilton Canal District pre-permits buildings of a designated footprint and height. The same process can be accomplished for individual sites downtown.

challenging but, like the creation of Lowell's National Park, they cannot ever happen unless they are first planned. For this reason, this Plan does not stop short of making several proposals—most elaborately for the Lower Locks area—that are as promising as they are unlikely.

Organization of this Plan

The Table of Contents describes a Plan organization that moves from the mundane to the exotic, and from the present to the future. First, because planning addressses not only design but also land use, **Chapter 1** considers all of the principal activities in the downtown, and makes suggestions about how each can be optimized to the benefit of the whole. Because cities live and die by their transportation systems, **Chapters 2 through 7** address the downtown's streets, transit, parking, pedestrian and bicycling facilities, with specific proposals for improving the current street system.

Chapter 8 describes the "urban triage" process by which the downtown's "network of walkability" is determined based upon its current viability and the need to connect important anchors. It is the gaps within this network that then become the proposed design interventions discussed in **Chapters 9 through 13**. These are separated, somewhat artificially, into Short-Term, Mid-Term and Long-Term Interventions. Then two discussions demand enough attention to merit their own chapters: Lowell High School, and the proposal for the Lower Locks. **A final chapter** on implementation describes next steps.

Introduction

Acknowledgements

The Downtown Evolution Plan was funded by The Lowell Plan, Inc. with assistance from the City of Lowell, University of Massachusetts Lowell, the Lowell Development and Financial Corporation, Lowell National Historical Park, Middlesex Community College, and the Greater Lowell Community Foundation. The Lowell Plan's interest in both initiating and funding this effort was to create an institutional agenda for the ensuing years, one that would be consistent with its mission while reinforcing the public/private partnership that The Lowell Plan embodies.

This effort was directed by the Downtown Evolution Plan Steering Committee, created for this purpose, which donated many hours of thoughtful attention and leadership to the project. The Steering Committee membership was as follows:

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Representing – City of Lowell

Robert Gilman
Executive Vice President, Enterprise Bank
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Franky Descoteaux
Owner of Mambo Grill and Humanity
Representing – The Lowell Plan and downtown retailers

Molly Sheehy
Dean of the Lowell Campus, Middlesex Community College
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Executive Director Facilities Management, UMass Lowell
Representing – UMass Lowell

James Cook
Executive Director, The Lowell Plan
Representing – The Lowell Plan and Lowell Development & Financial Corporation

Tremendous time and knowledge were contributed by the City of Lowell Division of Planning and Development, including more than one hundred man-hours of weekly lunchtime meetings with full planning staff. Thanks are due also to Mayor James Milinazzo and City Manager Bernard Lynch for their stewardship and contributions to this process.

The planning team is grateful to the Winn Companies and the Apartments at Boott Mills for the donation of a furnished apartment from which to conduct this project. We also thank Jim Higgins for contributing his aerial photographs of downtown.

Finally, the planning team thanks the many institutions and individuals in Lowell who contributed countless hours to this effort, including many dozens of meetings, principally during the month of April, 2010. While records were not kept of the many informal and ad-hoc meetings and conversations that took place, the following individuals each contributed significant time to one or several scheduled meetings with Jeff Speck:

Deborah Belanger, Executive Director, GMV Convention and Visitors Bureau
Richard Bolton, Chairman and CEO, Lowell Cooperative Bank
Christina Briggs, Community Planner, Lowell National Historical Park
Jane Calvin, Executive Director, Lowell Parks and Conservation Trust
Kathleen Cammerata, downtown Lowell resident
Jim Campanini, Editor, The SUN
Elizabeth Cannon, Lowell Association for the Blind
Chuck Carney, Director of Parking Services, City of Lowell
Robert Caruso, Chairman and CEO, Lowell Five
Edward "Bud" Caulfield, City Councilor
John Chemly, President, Trinity E.M.S., Inc.
Jack Clancy, CEO, Enterprise Bank
Mark Cochran, President, Jeanne D'Arc Credit Union
Patricia Coffey, Government Relations Associate, UMass Lowell
Patrick Cook, Director, Government and Civic Relations, Middlesex Community College
James L. Cooney, President, James L. Cooney Agencies
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Carolyn Cox, Vice-President, Cox Fuel Company
Michael Creasey, Superintendent, Lowell National Historical Park
Eileen Donoghue, Gallagher and Cavanaugh, LLP
George Duncan, Chairman, Enterprise Bank
Victoria Fahlberg, ONE Lowell
Terence Flahive, President, Princeton Properties
Newell Flather, Parker Foundation
Robert Forrant, Professor, History Department, UMass Lowell
Phil Hall, Parker Foundation
Eric Hanson, Chairman, Klin Spirits
James Hogan, President, Washington Savings Bank
James Linnehan, Vice President for Administration and Finance, Middlesex Community College
Bernard Lynch, City Manager, City of Lowell
Jacqueline Maloney, Executive Vice Chancellor, UMass Lowell
Brian Martin, Office of Congresswoman Niki Tsongas
Thomas McKay, Director, Mill City Manager
Martin T. Meehan, Chancellor, UMass Lowell
James Milinazzo, Vice President, Business Services, Jeanne D'Arc Credit Union
LZ Nunn, Director, Department of Cultural Affairs and Special Events, City of Lowell
Mark O'Neil, Publisher, The SUN
Theresa Park, Director of Economic Development, City of Lowell
Charles Parrott, Historical Architect, Lowell National Historical Park
John Power, Principal, Farley White Interests—Wannalancit
George Proakis, former Planning and Permitting Director, City of Lowell
Bob Roache, owner of the Round House
Meg Roberson, Director, Orientation and Mobility Department, Massachusetts Commission for the Blind
Robert Rivers, President, Eastern Bank
William Samaras, former Headmaster, Lowell High School

Introduction

James Scanlon, Administrator, LRTA
Chris Scott, Superintendent, Lowell Public Schools
William Soucy, Soucy Industries
Melissa Surprenant, Administrative Assistant, The Lowell Plan
Frank Thoms, downtown Lowell resident
Kendall Wallace, Chairman of the Board, The SUN

The Speck & Associates / AECOM / Rock Maple Studio planning team included Jeff Speck, Paul Moore, Joel Mann, Kevin Bacon, James Wassell, and Karja Hansen. This effort was led and managed principally by James Cook and Rosemary Noon of the Lowell Plan, with assistance from Germaine Vigeant-Trudel and Melissa Suprenant. Those who applaud this effort have principally The Lowell Plan to thank. Detractors are welcome to focus their attention on the planning team.

Cities exist because they bring things together. The better they do this job, the more they flourish. While some people think of Lowell as a suburb of Boston, it feels and functions more like an independent city-state. Much of this is due to its robust downtown core, which contains a surprisingly broad—and almost complete—range of daily activities. Collecting the largest number of mutually-supportive activities into the downtown, and achieving a healthy balance among them, will be a key factor in the city's future success.

Key activities in downtown Lowell include *Residential, Retail, Office, Institutional, Entertainment,* and *Hotel* uses. Each of these merits consideration regarding its current state, its contribution to the downtown, and its potential for growth.

Residential

The reinvention of downtown Lowell as an attractive and rewarding place to live is a true American success story. To a certain extent, it is the continuation of this trend that is likely to be the strongest engine behind the city's continued evolution and economic expansion. The past ten years have been particularly transformative, with more than a doubling of downtown residential units, from 1357 to 3268. Moreover, while only 21% of downtown housing was at market rate in 2000, that number has now reached almost 50%. This evolution reflects national trends towards urbanization, but more importantly manifests the gradual recognition among renters and buyers of the tremendous value that the city offers its residents. With prices well below Boston, downtown Lowell provides an urban lifestyle in a generally lively streetscape among historic buildings and a diverse population.

Lowell's large collection of Mills successfully converted to housing has served as a model for other cities nationwide.

This sort of authentic city experience is now favored by a certain brand of empty nester, who wants to retire or semi-retire into an active, culturally stimulating environment in which the essentials of daily life can be readily attained without driving a car. Downtown Lowell is one of many NORCs (Naturally Occurring Retirement Communities) where a growing number of well-off Americans are choosing to spend their late middle age and beyond.

In addition—and perhaps even more promising—is the attraction that Lowell presents to young adults, the Gen-Y'ers and Millennials, for whom the suburbs hold little appeal. Unlike the previous generations of potential residents, raised on *The Brady Bunch* and *Happy Days,* these young adults were raised on *Seinfeld* and *Friends,* and see urban life as the preferred alternative. They want a city to be gritty, not pretty, and welcome the diversity and imperfection of a real downtown. The strong artistic and university presence in Lowell only adds to this draw.

While residential construction in Lowell has slowed somewhat due to the national mortgage crisis, there is every reason to believe that the downtown will see increased residential interest as the market warms. Currently, it is remaining fairly active while many other communities have experienced a complete end to housing activity. When construction picks ups again, the City should be prepared to direct developers to key downtown sites with specific programs and incentives where possible.

For a downtown such as Lowell's, with limited office and industrial activity and limited promise as a regional shopping hub, it is likely to be the residential market that spurs its future growth in all sectors. As more and more people choose to live downtown, there will be more demand for downtown retail and office space, independent of how those markets are functioning regionally. In this environment, Lowell's greatest product will not be a good or a service, but Lowell itself, and the experience that it gives to the people who live and visit here.

Downtown is well poised to accept more housing because of the extremely light parking demand that is present in the evenings. In addition to on-street parking availability, which is high, there are typically 4000 empty parking spaces available and unused each night in the City's five downtown parking garages. As will be discussed in the Parking section, these spaces represent money in the bank when it comes to new residential development. While the entirety of the downtown is essentially within a five-minute walk of at least one of these five garages, the most practical approach suggests focusing new residential development in the upper stories of buildings in the very heart of the downtown, on Merrimack, Middle, Market, and Central Streets, where a great amount of empty upstairs space exists within a three-minute walk of the Roy and Downes Garages. This location, in addition to being the best served by empty garages, is also the most successfully urban section of the downtown, best able to give residents the quality of life that currently draws people to cities. More residents will also give this area the 24-hour occupancy that keeps them feeling safe at night, and attracts yet more people downtown.

Retail & Dining

There is relatively little retail vacancy downtown, and an eclectic mix of stores. Indeed, Merrimack Street feels a bit schizophrenic in terms of the audience served. Is it a downtown for businesspeople, residents, high schoolers, or college students? The answer is Yes—that eclectic nature is its strength, a strength to be built upon.

While some people hope for a new shopping mall, a Target, a Bass Pro, or some major new influx of retail downtown, it must be accepted that such a development is not currently in the cards. Those retailers choose their locations based on straightforward auto-oriented and large-site criteria that the downtown is not poised to satisfy. Indeed, if there were demand for a major new retail footprint downtown, you would already know about it.

The future of retail downtown is to gently improve the things that are already being done fairly well. These include:

- Convenience retail for residents, workers, and students who currently frequent the downtown on a regular basis.
- Less expensive cafes and restaurants serving the same.
- Somewhat more expensive restaurants as a destination, both on their own and in conjunction with entertainment downtown, most frequently at the Lowell Auditorium.
- Specialty stores with a unique product and a built-in clientele who will attract business independent of their location
- Funky shops, such as Freshies and Found, selling unusual, browse-able products and antiques.

Improving the performance of retail downtown should not be left to chance. An unorganized collection of independent merchants cannot be expected to compete effectively against the centrally managed suburban malls and power centers. Happily, a nascent and important effort in joint management is underway through the Retailers Roundtable. Cross promotions and sharing sales data are necessary, and beginning to happen. This effort needs to be expanded to include coordination of the following:

Special events provide a boost to restaurants on Palmer Street.

- Store hours, including key evenings, Sundays, and in coordination with entertainment venues. Currently, it is not easy to have drinks after a show, or shop after a restaurant dinner. These are activities that should be commonplace in the downtown.
- Coordination of a specific weeknight (Thursday?) as a late night for students with special discounts.
- Coordination of a specific weeknight (perhaps the same one) as a late night in conjunction with a dependable and well-marketed weekly concert series at St. Anne's Church or another well-located venue. Ideally, this concert series could highlight student groups from UMass Lowell.
- Joint marketing including sales events.
- Joint efforts to attract students with discounts, particularly around food service. A number of downtown retailers currently offer student discounts, but these are not well coordinated or communicated on campus.
- Replacement of the failed U-Card system with a simpler system for students to use their meal plans downtown. UMass Amherst provides a model here, with students able to use a simple debit card rather than requiring an entire alternative currency.
- A joint effort to conduct a void analysis and to attract specific retailers to benefit the mix.

Making More of the Student Market

Younger downtown visitors, most notably high schoolers and college kids, comment on a lack of activities geared towards them. There is a strong desire for entertainment venues such as movie theatres, bowling, and the like that would give students something more productive to do than just hang out and get into trouble. In that vein, many merchants complain of the high schoolers downtown, and feel that, if anything, they are a net negative for business. This may be true for certain upscale shops, and students complain of being eyed suspiciously in many of the places they do frequent. But, whatever the perceptions, a conservative estimate suggests that high school students spend about $10,000 daily in downtown shops, which would be dearly missed if the school were to be moved. Once again, orienting more shops towards this clientele could prove beneficial.

Incidentally, according to a school committee rule, LHS teachers are not allowed to leave the school building during the day. Whatever this might mean for education, it is bad for downtown. The retailers may wish to mount an effort to change this rule.

College students are another market that retailers have not yet fully tapped. The average UMass Lowell student spends $47 per week off-campus in Lowell, which translates into close to $20 million annually. But they spend twice as much outside of city limits. Clearly, if the downtown were able to serve these students better, it would benefit.

Due to the limited culinary offerings on campus, the Middlesex Community College students buy most of their meals in restaurants downtown, contributing greatly to their success. The leadership at the college should be encouraged to not change this situation with new college-run eateries.

Potential Anchors

A downtown supermarket is something that has been discussed for some time, and one was proposed in the 2001 Downtown Master Plan for the site currently occupied by the medical office building on Arcand Drive. According to recent studies, the downtown may be poised for such a facility to happen fairly soon. In a recent article in *Planning* magazine, "The Supermarket as a Neighborhood Building Block," authors Mark Hinshaw and Brian Vanneman describe a new generation of urban market, roughly 45,000 square feet in size, which most shoppers access on foot. The population threshold for such a market to thrive is typically about 4000 households, which downtown Lowell is fairly close to achieving. While downtown drivers are well served by the Market Basket in the Acre, and walkers rely upon the Market Street Market, it may soon be time for the City to put some resources behind attracting a mid-size supermarket into the heart of downtown.

A key anchor in many downtowns is the bookstore. Here we have a Barnes and Noble that is subsidized by UMass Lowell and its future is uncertain. In the meantime, it is not run to be competitive, and does not attract the audience a bookstore could. It's likely departure—and its current condition—make one hope for a different bookstore downtown. Can one be attracted? One proposal, that this site become the entire UML bookstore, does not seem to be the University's current thinking, but is certainly the best solution for the vitality of downtown. Whatever the solution, the key to the success of a future bookstore will be the programming that is currently missing—the readings, book clubs, knitting circles, and other events that can be found at a Brookline Booksmith or a Newtonville Books.

There is great interest in a movie theatre downtown, but that is a contracting industry. It is most likely to succeed if run as a non-profit by people who want to make it their life's work. In the absence of such an angel, this cannot be seen as an easy win. If a movie theatre is to be attracted, its best location to support other businesses would have to be very close to the downtown heart of Market and Central. While the Smith Baker Center has promise, it is too far from this location to have the desired spillover effect, and also has less parking nearby than would be available in the heart of downtown. The Somerville and West Newton cinemas were cited as models worth emulating, as well as Arlington's Capitol Theatre and the Coolidge Corner Theatre in Brookline.

An excellent business to attract downtown would be Fedex/Kinkos, which is uniquely oriented to serving the laptoppers and telecommuters who would consider making Lowell their home. A single Fedex/Kinkos can enable hundreds of businesses within walking distance. The closest one is currently 4 miles away, in Chelmsford.

One More Opportunity

There is very little presence downtown, except for the High School student body and the Brazilian Bakery, of the diversity that Lowell is known for. There are also many Lowellians from the international community who would enjoy a low-risk opportunity in the downtown to sell merchandise and foods from their native lands. Having a well-managed international market downtown could contribute a local spin on the Pike's Place phenomenon. Imagine a single large space with a farmer's market feel, independent booths for vendors, places to sit and snack a la Faneuil Hall, and a concatenation of Cambodian, Thai, Indian, African, South American (etc.) booths selling clothing, accessories, art, food (etc.) all under one roof. Key to its success would be a culturally fluent retail expert manager who understands how to create an environment that is attractive to both foreign cultures and American shoppers, who can advise, for example, that served water needs ice cubes and that televisions showing soccer must be kept at a reasonable volume. Establishments like Romeo & Juliet's on South Street could be convinced to open small branches here, and small-scale importers would be given an opportunity to share their wares. Ideal locations for this market would be the Bon Marche if the bookstore leaves or, even better, a rebuilt first floor to the former Sun printing press building connecting Prescott Street to the Lower Locks.

Office

Many people interviewed believe that bringing more office downtown is more crucial than bringing more residential downtown. Unfortunately, the presence of office space downtown is limited by the availability of daytime parking in the garages nearby. This topic will be discussed more thoroughly in the Parking section, but most downtown garages are, or will soon be, largely full during work hours, with the exception of the Roy Garage on Market Street and the Ayotte Garage by the Tsongas Center. The Roy Garage typically has a limited amount of daytime vacancy that could support more office space nearby in the empty upstairs of existing buildings and on the key "missing tooth" site next to Enterprise Bank. The Ayotte Garage is more promising, as it has its biggest peaks during evening events, and generally maintains a daily surplus of over 500 parking spaces. These circumstances, which will be discussed more completely ahead, suggest that the best location for new offices downtown would be near the Ayotte Street Garage, which conveniently places it near the current office hub at Wannalancit Mills. In this area, the most readily available land surrounds Cox circle, where new buildings would give a much-needed edge to that urban space, and where office workers would enjoy proximity to the Tsongas Center and a short walk to LeLacheur Park.

The Wannalancit Mills contain one of the largest concentrations of office space in Lowell.

Conversations with the office development community suggest that, even in this economy, there is a market for new office space in Lowell. Wannalancit Mills is 96% rented, which puts it 14 basis points above the 495 corridor office market. Some people feel that downtown Lowell could achieve critical mass in office space once it gains perhaps an additional 500,000 square feet, at which point it would transition from being a satellite into "becoming its own sun." (The large number of office uses proposed for the Hamilton Canal District will only contribute to this growth.) The recent construction of the Jeanne D'Arc Credit Union building on Father Morrissette Boulevard is seen as an ideal model for future commercial development in this area.

In the longer term, as investment in transit (to be discussed) makes downtown Lowell less auto-dependent, it is easy to imagine a significant uptick in office space downtown, since tenants will no longer demand the same parking ratio currently in force. As with residential uses, the City will need to adjust its parking requirements at that time to reflect the larger percentage of transit riders.

Institutional

One of Lowell's great strengths has been its collection of downtown institutions, including its High School, UMass Lowell, Middlesex Community College, and the National Park Service. The High School will receive its own chapter ahead.

UMass Lowell

UMass Lowell has reoriented itself to the downtown in recent years, and wisely sees its future as one of even greater integration into the heart of the city. Continued investment in the East Campus, theacquisition and repositioning of the Doubletree Hotel as the UML Inn and Conference Center, and the purchase of the Tsongas Center and adjacent properties, all offer tremendous benefit to the downtown. The University leadership has implied through its actions that its students will have a more complete academic experience if they are able to spend time in downtown Lowell on a regular basis, and it is encouraging to hear that additional plans are being considered for housing, academic buildings, and light-industrial business spinoffs in the neighborhood between the Tsongas Center and LeLacheur Park, where the University already owns considerable property. These plans are given suggested form in Chapter 11 of this report.

66% of UMass Lowell's 9000 students currently commute to the campus. The leadership's stated goal of a 50% commuting split implies that housing for over 1400 additional students is desired, and there is a strong interest in placing much of it downtown. It is imagined that 400 to 500 of these additional beds would be desired in the short term. They could be located in the East Campus / LeLacheur Park area, nearby the ICC, and/or on sites in between. These locations are expected to be particularly desirable to international students, many of whom do not own cars.

Both Middlesex Community College and UMass Lowell contribute a student presence to the Lower Locks.

Another ideal location for student housing is in the very heart of downtown, on Merrimack, Middle, Market, and Central Streets, where there is still a large amount of upstairs vacancy. For a State institution to acquire a long-term lease on the upper floors of an existing building is not a simple process, but it is possible. The complexity of this task should not impede an investigation into its potential, as this upstairs activity would contribute badly-needed evening population to this area.

Right now, UMass has no plans to place any more students in this part of the downtown. For UMass students, concerns about safety can limit their willingness to live in this area or spend time there. Interestingly, the downtown is statistically the safest of the UML campuses. Perception always lags behind reality, but this misconception will be overcome more quickly as street-lighting and wayfinding are improved, as will be discussed ahead.

In addition to student housing, UML has two other types of buildings that it may wish to locate in the downtown: academic halls and, indirectly, spin-off businesses like the light-industrial ones that can already be found on Hall Street. There are places for both of these downtown, and they are all of value in terms of the improved street edges and pedestrian activity that they can provide if designed properly. However, only the latter type allows a developed site to contribute revenue to the Lowell tax rolls, and so it is hoped that UML will work with the City to encourage many of these spinoff businesses to locate in Lowell—especially downtown Lowell—rather than elsewhere.

Middlesex Community College

Middlesex Community College is also a powerful presence in Lowell, with over 6000 students and 400 employees located within the downtown area. While these are almost entirely commuters, they still make great use of the downtown.

Most MCC students drive to Lowell and park in one of the city garages for free, as their fees are paid by the College. While one does not wish to add burdens to this population, that free parking creates a false economy that encourages driving over other transport modes. To price student parking, even modestly, would encourage some students to carpool and take transit instead. Such a protocol makes the most sense in the context of improved transit service, and should certainly be instituted in conjunction with the construction of the contemplated streetcar line.

While no-one complains of MCC's presence downtown, some merchants on Middle Street feel that the school's acquisition of adjacent properties has changed the nature of that street away from retail use, and that it no longer has the critical mass of stores to attract shoppers. To reverse this trend, future renovations of retail buildings for academic use should be sure to contain leasable ground-floor retail along the street edge, with a limited area dedicated to student access.

MCC's expansion needs include creating another major academic building, and providing nearby housing for perhaps 100 students. These uses should be located in the downtown and, as is the leadership's habit, would be best placed in empty existing buildings, with the caveat that no more street-front retail should be lost in the bargain.

MCC's current building locations have created a well-worn student path from the Lower Locks through the tunnel next to Tutto Bene, dangerously across Prescott and Central Streets, and down Middle Street. This path needs to be reinforced and made safer, with improvements to the tunnel and enhancement of the Prescott and Central Street crossings, as will be described ahead.

Also to be discussed ahead, the adjacency across East Merrimack Street of the MCC's two main buildings provides a great opportunity to create a heretofore missing campus heart, which could be further enhanced by the redevelopment of the currently underutilized "Cybercafé" building located just to the east across the Concord River.

National Park Service

It is not possible to adequately describe the tremendous boon that the National Park Service has been to the city of Lowell, in terms of investment, rehabilitation, tourism, and its stewardship of the city's heritage. Approximately 800,000 people attend Park activities every year. For many of them, it is the National Park that introduces them to Lowell, initiating a lifelong relationship with the city. The presence of National Park Service rangers in the downtown contributes a feeling of safety and care for the public realm. The schoolchildren who regularly make field trips to the NPS visitor center and museum add considerable vitality to the downtown, and the historic trolley constitutes the heart of what could be an expanded modern streetcar system. The Park Service has been a transformative partner, and that partnership deserves continual recognition.

The National Park Service has played a transformative role in the downtown.

The Park Service could play an expanded role if arrangements were made with other local institutions to make an NPS downtown tour a more automatic aspect of arrival to the city. For example, every MCC and Lowell High School student could be required, as a part of campus orientation, to take such a tour—as is currently practiced by UMass Lowell, to the tune of almost 2000 students each year. With a limited investment, canal tours could be made more common and popular, as has been accomplished by the Chicago Architectural Foundation in its city. While NPS has a restricted budget to promote such events, other city entities could help shoulder that cost, as they would all benefit from the economic spinoff.

As will be discussed ahead, the NPS ownership of certain key sites can provide procedural impediments to their redevelopment, for example the empty lot between Merrimack and Middle Streets. While these impediments can slow the evolution of these sites, they should not discourage such efforts. As long as there is collective will among the City, the Park Service, and the leading development entity, a series of steps can be identified for achieving the desired ends, and those steps can be initiated immediately.

As the chief steward of many key sites in the city, NPS has been well served by its sensible approach to historic preservation. It has recognized the tremendous asset which the old mill buildings and canals represent, and that damage to that asset weakens the viability of the Park and the appeal of the city. But it has allowed, and indeed benefited from, certain important changes to these structures, such as the opening up of the archways into the Market Street Mills. In any such transformation of a historic building or landscape, a delicate balance must be forged between communicating an understanding of a site's original design and adapting that design to serve modern needs, or even transforming it into something more compelling. Nowhere is the need for that balance more evident than in the Lower Locks, where the historic condition of the canal perimeter limits the potential of that site as the spectacular urban center that it could become. This challenge will be discussed further in Chapter 13.

Entertainment

Lowell is fortunate to possess a number of sports and performance venues that bring people regularly into the downtown, and provide downtown workers and residents with entertainment within easy reach. These include the following:

The Lowell Memorial Auditorium is booked more than 250 nights each year, and hosts the Merrimack Repertory Theatre, the largest professional theatre company between Boston and Canada. It is well located just adjacent to the heart of downtown, yet does not generate as much dinner or shopping business as it could, due in part to its feeling of disconnection from West Merrimack Street.

The Paul E. Tsongas Center is a great city asset that does yet benefit the downtown as much as it could. Its perceptual distance from the heart of the downtown is much greater than its actual distance, due to the non-pedestrian quality of French Street, Arcand Drive and Cox Circle. Very few people walk to events there, or consider pairing such an event with a dinner downtown, and cars leaving the facility are rushed out of town along a path that makes a downtown detour unlikely, thanks in part to the one-way direction of Merrimack Street. In addition, the facility's 6200-seat capacity is rarely fully used, with fewer than one large event per month. It is hoped that the new ownership of this facility by UMass might provide the sort of stewardship necessary to encourage more active booking of this venue. As it is put to better use, there will be even greater reason to improve its pedestrian and vehicular connections to the downtown. Finally, backups exiting the Ayotte Garage after large events suggest a possible reconfiguration of that parking structure, as will be discussed ahead.

One real success story in the city has been LeLacheur Park, where the Lowell Spinners boast some of the best attendance in minor league baseball, having sold out every home game for a decade. Unfortunately, as one person put it, "5000 people go to see the Spinners 40 times a year, and none of them set foot in downtown." This situation raises two separate challenges that are addressed in this plan: how to turn the area of the ballpark into a more successful neighborhood, so that people attending games have more to do and more ways to spend money there; and how to better connect that neighborhood to downtown, both via transit and through a revitalized neighborhood around the Tsongas Arena.

While a real community asset, the Tsongas Center feels disconnected from the heart of downtown.

Finally, an impressive collection of events hosted by the National Park Service are notable for the way they turn the city itself into a performing arts venue. The Summer Music Series in Boarding House Park and the justifiably famous Lowell Folk Festival, by wisely integrating themselves into the downtown, contribute significantly to its vitality. Some of the proposals in this Plan, such as the redesign of JFK Plaza, will necessarily displace some performance venues, which will need to be creatively relocated.

Hotel

The absence of a hotel in a downtown as appealing as Lowell's is one of the city's most striking incongruities. Rarely has a downtown with such character, entertainment venues, and tourist amenities lacked a hotel of significant size, and seems truly bizarre that a business visitor with meetings downtown would have to rent a room out by the highway, as the planning team did. An unscientific assessment of Lowell's size and assets suggests that the downtown should be able to support one mid-market hotel of significant size, and one smaller luxury boutique hotel for upscale tourists and business guests.

It is generally accepted that the Doubletree Hotel that has become UML's Inn & Conference Center was continually unsuccessful because of the way it was managed, not because of the non-viability of a hotel in that location. Its failure should not be seen as an indication of poor demand.

The ICC is being renovated to include a small "boutique hotel" of 40 guest rooms, which are greatly needed downtown. However, because it is located within a charmless 1980s building—and one that typically operates as a student housing facility—it is not likely to attract many luxury travelers or 4-star businesspeople. It is also too small to hold the large groups of people that come to town seeking lower price accommodations in association with events at the Lowell Auditorium. These rooms will fill a pressing temporary need, and will be particularly useful to people who come to Lowell on UMas business. In the long term, once the downtown is properly served with hotel rooms, these rooms can be converted back to other uses, as will be discussed in the Lower Locks proposal ahead.

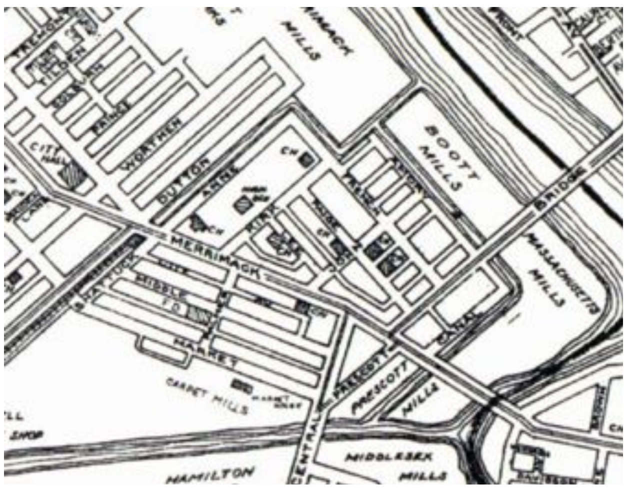
A mid-market downtown hotel would be of tremendous use to patrons of the Lowell Auditorium, as well as most of its acts. The Auditorium has lost some events recently for lack of a hotel, such as a ballroom dancing weekend that books 50 rooms per night. This year, the Auditorium was able to hold on to the large

Missing in Lowell: an urban-style downtown hotel of any scale.

Order of the Eastern Star convention—more than 1000 room nights—by arranging a bus to hotels in Tewksbury. Such a hotel in downtown Lowell would also serve visitors to events at the Tsongas Center.

Several sites in the downtown seem ready for a luxury boutique hotel. The empty lot at the corner of Market and Shattuck, across the street from the National Park Service Visitors' Center, seems to be an ideal location, and a hotel has indeed been recently proposed for that site. The Bon Marche building is also an excellent site for a 4-star hotel, with La Boniche as its lobby restaurant. An even more promising location may be the lot at the corner of Central and Warren, which currently holds the Lowell Hair Academy. The L-shaped empty lot surrounding the Hair Academy building contains some Lower Locks frontage, which would provide a real amenity to hotel guests. The ideal hotel here would also incorporate the existing building itself, as will be discussed ahead in Chapter 13.

The streets are the arteries and veins of the city, and also its principal public spaces. While traffic is vital to sustain the life of a community, traffic patterns can cause inefficiencies in movement, impede retail viability, confuse visitors, and threaten pedestrian activity. The current one-way system in downtown begs study in terms of the trade-offs it presents, and opportunities for its reformation. Other downtown streets that encourage speeding must be considered for "road diets" and the inclusion of bicycle facilities. This section of the Plan takes a thorough review of downtown streets and makes specific recommendations for their modernization to fit a community focus on place and livability.



Before Arcand and Morrissette: This 1914 map shows the original downtown street network, including a connected Moody Street north of City Hall (at left).

Background

Downtown Lowell's streets reflect its history as an industrial city. They follow the alignments of the canal system and provide land access to the mills and commercial buildings that were the city's economic foundation. However, they also reflect more recent periods of its history, including the rise in automobile use after World War II and the need for cities—and especially their business districts—to accommodate these automobiles through parking. As Lowell matures and seeks to enhance its downtown, it should seek opportunities to tailor its streets to a new set of needs.

Lowell was blessed with a wonderfully extensive street network as a legacy of its founding fathers' foresight. Downtown and the surrounding neighborhoods were built with a connected street system that, despite the presence of the two rivers and the industrial canals, provided the primary benefits of such a street framework: multiple route choices, good access to properties, and a great infrastructural capacity to subdivide and develop land. Over time, however, this network has been broken. The most notable causes of this disconnection are the Lowell Connector expressway and Dutton Street, the arterial that connects to it. The beneficial redundancy of routes and permeability that the town once gained from its street network have been severed in the name of the high speed travel enabled by the freeway-type design of these roads.

This lack of connectivity has repercussions not just for motorists, whose travel routes are extremely limited and, as a result, often congested. It has also likely contributed to the economic challenges faced by properties surrounding these facilities that remain disconnected from the vibrant downtown.

Interestingly, Dutton Street's freeway-style design ends just south of downtown Lowell. This begs the question of why a high-speed design was not be carried all the way to the ultimate destination of most drivers. No doubt the City's leadership eventually recognized the grave damage that such a highway would wreak upon its fragile historic downtown. It would appear that the last few thousand feet of freeway design along Thorndike and Dutton Streets, between the Lowell Connector and Broadway Street, provide negligible benefit to traffic flow. However, for the sake of any such benefit, much connectivity and virtually all quality of entry into downtown have been lost. Mitigating the impacts of this and similar reconfiguration is one goal of the proposals presented here.

Freeway, pedestrian mall, and 6000 parking spaces: The 1960s plan for Lowell, thankfully executed only in part, brought Father Morrissette Boulevard through the downtown in a continuous loop. The Morrissette/Arcand intersection can be seen to the upper left.

Streets in General

Balanced Street Design for Urban Areas

The last two decades have seen a renewed interest in urban living and a consequent focus on making urban infrastructure more responsive to quality-of-life concerns. The practice of street design has followed such a course, focusing on converting unnecessary travel-lane space to other uses, such as parking vehicles, bicycling, and walking. Such conversions are often referred to as "road diets," even though they can often have net positive impacts on roadway capacity.

This change in thinking is rooted in an objective to provide high-quality, livable urban environments, yet there is more benefit to a balanced approach, even from a strictly vehicular perspective. The surrounding context of a street or road has become a critical factor in making design decisions, not simply because it defines the design constraints, but also because it defines motorist expectations. In urban areas, motorists have different expectations than in suburban or rural areas. Because of a network of blocks and streets with greater development densities, they understand that there is a need for more frequent turns, that vehicles parking on streets may momentarily slow traffic, and that there is likely to be more traffic in general. In suburban and rural areas, by contrast, lower densities and greater intersection spacing suggest to motorists that there are fewer impediments to freedom of traffic movement; as a result, these motorists are likely to tolerate less congestion.

With such an understanding in mind, the design of the street cross-section does not need to be focused on maximizing vehicular capacity in places where demand for such capacity is not present. In fact, road diets present multiple functional benefits when they tailor a street's capacity to its need, as presented in the recommendations in this section of the Plan.

Maintaining Adequate Flow

The above notwithstanding, this study was completed with a full understanding that many of Lowell's downtown streets are congested much of the time. Head-shaking complaints about the 2:30 post-high-school peak and cut-through commuters are heard daily. The continued challenges to downtown traffic flow illustrate that widening roadways and adding lanes cannot shorten travel times if key intersections are experiencing delays. Lowell's limited number of river crossings place an undue burden on Bridge Street and all the streets that connect to it, while the one-way system's concentration of trips on the Dutton-Thorndike axis can put undue pressure on the Merrimack/Dutton intersection and others. These natural and manmade interruptions to an otherwise fine-grained network result in a lot of car storage—stacking—on streets that can actually handle considerably more traffic than their intersections allow them to. In this situation, additional roadway capacity only leads to speeding during off-peak hours, without reducing peak-hour congestion.

Such a system can be optimized by improved intersection design and synchronized signalization, the latter a relatively inexpensive fix that should be undertaken before the former is considered. But independent of that effort, the above understanding of how the system functions explains why many streets in the downtown can receive road diets without significantly reducing network capacity.

That said, every street required individual study. The revised circulation patterns and roadway configurations proposed below were fully modeled in a Synchro traffic simulation program, and are presented with confidence that the resulting traffic flows will meet a level of service appropriate to a downtown environment. More information on the traffic-simulation model can be found in this Plan's Appendix.

A Focus on Walkability

Perhaps the greatest decline in urban mobility has been in infrastructure and facilities for the pedestrian. Street widening to accommodate vehicles has often come at the expense of streetscape and sidewalks, especially when buildings prohibit expansion of right-of-way. This Plan promotes a richer, more functional pedestrian environment as a principal driver of balanced street design.

Walkability, however, is about more than sidewalks. Pedestrians are to cities what canaries were to coal mines. Their presence is an indication of a life and vibrancy that is clear to any visitor. The absence of pedestrians sends a signal to everyone that they are in a place which one leaves when finished with business. Other components of the physical environment and street design are instrumental in providing a better pedestrian realm, including those discussed in the following paragraphs.

A Safe Walk

While crime is always a concern, most people who avoid walking do so because the walk feels dangerous due to the very real threat of vehicles moving at high speed near the sidewalk. Statistically, automobiles are much more dangerous to pedestrians than crime, and the key to making a street safe is to keep automobiles at reasonable speeds and to protect pedestrians from them. This is achieved by meeting the following criteria, each of which will be addressed individually:

- A network of many small streets;
- Lanes of the proper width;
- Limiting use and length of left-hand turn lanes;
- Avoiding swooping geometries;
- Limiting curb cuts;
- Two-way streets;
- Continuous on-street parking; and
- Continuous street trees.

A Network of Many Small Streets

Generally, the most walkable cities are those with the smallest blocks. This is because many small blocks allow for many small streets. Because traffic is dispersed among so many streets, no one street is required to handle a great amount of traffic, and that traffic does not reach a volume or speed that is noxious to the pedestrian. In a recent California study, cities with larger blocks suffered more than three times as many vehicular fatalities as cities with smaller blocks. (Marshall and Garrick: "Street Network Types and Road Safety.") Downtown Lowell is made up of relatively small blocks, and therefore has a porous network of many streets. However, because many of these streets are one-way, the network is only half as porous as it appears. Streets like Market, which are sized for moderate-speed two-way traffic, instead carry high-speed one-way traffic. Additionally, around the JFK Civic Center, we can see what happens when the network is snipped, with traffic concentrated on the high-speed streets of Arcand Drive and Father Morrissette Boulevard. This is predictably the least walkable part of downtown.

Lanes of Proper Width

Different-width traffic lanes correspond to different travel speeds. A typical urban lane width is 10 feet, which comfortably supports speeds of 30 MPH. A typical highway lane width is 13 feet, which comfortably supports speeds of 60 MPH or more. Drivers instinctively understand the correlation between lane width and driving speed, and speed up when presented with wider lanes, even in urban locations. For this reason, any urban lane width in excess of 10 feet encourages speeds that can increase risk to pedestrians. This 10-foot dimension is entirely consistent with the AASHTO Policy on Geometric Design, a national guidebook. A number of streets in downtown Lowell contain lanes that are 12 feet wide or more, and drivers can be observed approaching highway speeds when using them.

Limiting Use and Length of Left-hand turn Lanes

Left-hand turn lanes are by no means the standard approach to intersection design. They should be used only at intersections where congestion is caused due to cars turning left. Four-lane streets with limited volumes do not need left-hand turn lanes, as the right lane provides an unimpeded path through the intersection. When unnecessary left-hand turn lanes are provided, the extra pavement width encourages speeding and lengthens crossing distances. When justified, left-hand turn lanes should be just long enough to hold the number of cars that stack in them in standard rush-hour conditions. When they are longer, they create excess unused pavement that could otherwise be used for on-street parking. Downtown Lowell does not generally suffer from an excess of left-hand turn lanes because they are made unnecessary by its one-way circulation system; any return to two-way traffic must be certain to use left-hand turn lanes judiciously, and not oversize them.

Avoiding Swooping Geometries

Pedestrian-centric environments, particularly in cities, can be characterized by their rectilinear and angled geometries and tight curb radii. It is rare to find a swooping curve in a walkable city, except when it forms the edge of a circular or oval park. In contrast, suburban auto-centric environments are characterized by long, swooping curves and generous curb radii that collectively allow drivers to coast through intersections without slowing down signifi-

Smaller blocks and narrower streets characterize the most walkable parts of downtown.

cantly. Wherever suburban swooping geometries are introduced into otherwise urban cities, cars speed up, and pedestrians feel unsafe. Father Morrisette Boulevard, Arcand Drive, and Warren Street are three locations where the downtown has been retrofitted with higher-speed suburban street geometries.

Limiting Curb Cuts

Every time a driveway crosses a sidewalk, pedestrians are endangered. In most downtowns, only rear alleys are allowed to break the curb, at a rate of one per block face. Entries into parking lots and structures, when not from alleys, must be limited and well marked. When it crosses a sidewalk, a driveway should maintain the material of the sidewalk to indicate the continuity of the pedestrian route. Drive-throughs and drop-offs—in which a vehicular path cuts into the sidewalk for driver convenience—are a suburban solution that does not belong in cities. Any drive-throughs should be accessed off of rear alleys, and drop-offs can be accomplished simply by reserving a few parking spaces for that use. Downtown Lowell is relatively free from such curb cuts, but those places where they do exist—such as along East Merrimack Street—are noticeably less welcoming to pedestrians.

Large blocks and wider streets create an inhospitable pedestrian environment while also providing less vehicle capacity than a porous grid.

Two-Way Streets

Drivers tend to speed on multiple-lane one-way streets because there is less friction from opposing traffic, and because of the temptation to jockey from lane to lane. Whichever lane you are in, the other seems faster. In contrast, when two-way traffic makes passing impossible, the driver is less likely to slip into the "road racer" frame of mind. Speeding in Lowell's one-way network is most evident on Market Street, but it occurs as expected throughout the system. Incidentally, one-way streets can also be detrimental to downtown businesses due to the way they limit the visibility of cross-street storefronts, as the attached graphic illustrates.

Downtown residents complain that drivers routinely reach 50 MPH on this stretch of Market Street, with its two oversized one-way lanes.

Continuous On-Street Parking

On-street parking provides a barrier of steel between the roadway and the sidewalk that is necessary if pedestrians are to feel fully at ease while walking. It also causes drivers to slow down out of concern for possible conflicts with cars parking or pulling out. On-street parking also provides much-needed life to city streets, which are occupied in large part by people walking to and from cars that have been parked a short distance from their destinations. A number of streets in downtown Lowell, like Dutton, have lost their parallel parking in order that additional travel lanes could further ease traffic flow. The resulting unprotected sidewalks are not hospitable to walking, and the lack of on-street parking capacity has contributed to the need for unattractive surface parking lots.

Continuous Street Trees

In the context of pedestrian safety, street trees are similar to parked cars in the way that they protect the sidewalks from the cars moving beyond them. They also create a perceptual narrowing of the street that lowers driving speeds. A consistent cover of trees can go a long way towards mitigating the impacts of an otherwise uncomfortable street space. Lowell has recognized this benefit, and has recently added street trees in some key locations. But sparse tree spacing on certain im-

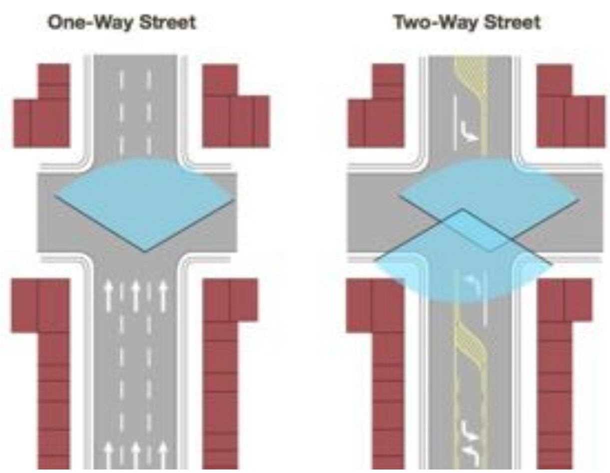
A "pork chop" on Warren Street communicates a higher-speed, auto-oriented environment.

portant streets, including Merrimack and Market, creates an uneven level of pedestrian comfort in the downtown. In some cases, underground vaults impede the insertion of tree pits, but there are fewer such impediments than the number of missing trees would suggest.

While we are on the subject of trees, it is worth stressing that most cities underestimate the value of healthy street trees. This is an easy error to make, because it is difficult to monetize the short- and long-term benefits of consistent tree cover. But the benefits are great, and include the following:

- absorption of the first 30% of most precipitation, reducing storm-water runoff;
- 5 to 15 degrees local sidewalk heat reduction in summer;
- 4 to 7 degree reduction in overall urban temperature in summer;
- ultraviolet ray protection;
- significant absorption of tailpipe emissions;
- significant reduction in ozone;
- $15-25,000 increase in typical home or business value;
- 12% higher income streams to businesses;
- 40% to 60% lengthening of pavement life.

It is plain to see how many of the benefits above ultimately accrue to City coffers. City tree-planting and maintenance policy, including the use of structural soils to ensure long life, should reflect this powerful reality. Indeed, once you do the math, it seems fiscally irresponsible to not plant trees in great quantity until consistent cover is achieved. Towards this end, it is recommended that the City launch a *Lowell Continuous Canopy Campaign.*



In a one-way street system, fully half of the businesses on cross-streets lack driver visibility. Moreover, one-way systems can result in certain shops only receiving adequate traffic half the day—and sometimes the wrong half. For example, a breakfast shop that is located along the path out of town will only entice visitors once it has closed.

The above eight criteria have been brought to bear on the analysis and recommendations that follow, in terms of both the general circulation pattern and the individual street designs. All of this chapter's proposals are made in service of a single larger goal: to improve the pedestrian—and driver—experience downtown without contributing significantly to traffic delays.

Traffic Circulation

Among first-time visitors and long-time locals alike, the most frequent complaint one hears about downtown regards the one-way circulation system. Visitors describe the many minutes spent circling—often lost—in search of a destination. Locals describe their frustration at having to drive great distances to reach nearby destinations. Both of these situations deserve our attention.

Visitors walking along Dutton Street to the American Textile History Museum must brave a narrow sidewalk against highway-width driving lanes, protected by neither parallel parking nor street trees.

Streets in General

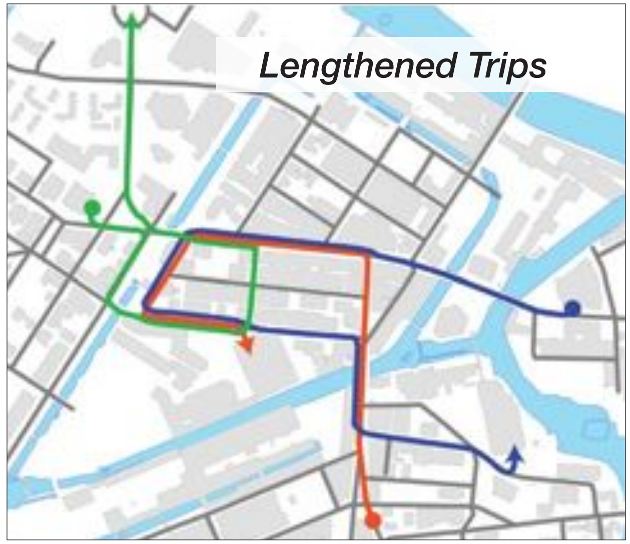
Existing Conditions

All one-way systems have the potential to create driver confusion, but in Lowell, that confusion is particularly profound, as the underlying street network lacks clarity; most cities with one-way systems benefit from a simple rectilinear grid. Lowell's overlay of a one-way system upon a cranky medieval-style street network can objectively be said to have created one of the most disorienting downtowns in America. For first-time visitors (such as this author), that confusion can lead to many minutes wasted circling in search of a destination.

Similarly, all one-way systems result in lengthened trips, but few such systems are applied to cities with as many discontinuities as Lowell. Because its limited canal crossings have resulted in an interrupted street grid, one-way loops take drivers much farther out of their way than is the norm in other cities. Some of the more preposterous trips are shown in the accompanying graphic. In addition to causing frustration, these long trips share another feature, which is that they all bring drivers through the very same few intersections, especially the confusing concatenation of Dutton, Merrimack, and Arcand. This combination of lengthened trips and concentrated traffic undermines much of the efficiency that the one-way system was intended to provide.

Which reminds us of a joke. A traffic engineer was once presented with a great idea for improving traffic flow. His colleagues told him, "it's really effective. It has been shown to work very well in practice." "That's fine," he responded. "But how does it work in theory?"

The one-way system in Lowell is an excellent example of an idea that works well in theory. In practice, it also



Lowell Auditorium to Lower Locks Garage

Central Street to Roy Garage

City Hall to Tsongas Center

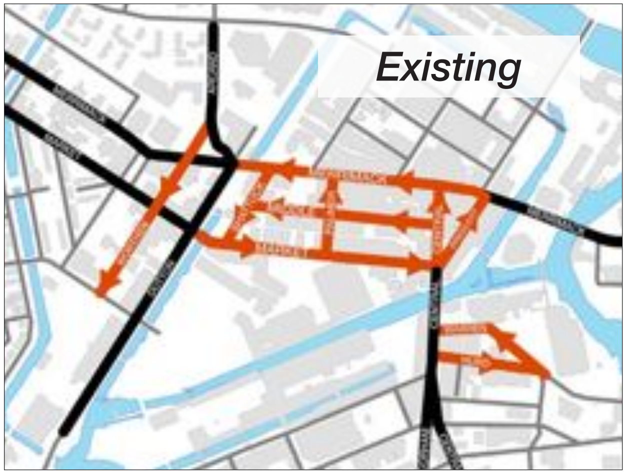
provides some distinct advantages that should not be overlooked. These include principally the capacity to allow unimpeded left-hand turns without sacrificing parallel parking, both important to a busy downtown. Any changes considered to the existing system must be accomplished with little or no loss of curbside parking, and must provide left-hand turn lanes where that motion is common. This mandate limits the extent of changes that are possible but, as we shall see, is far from prohibitive.

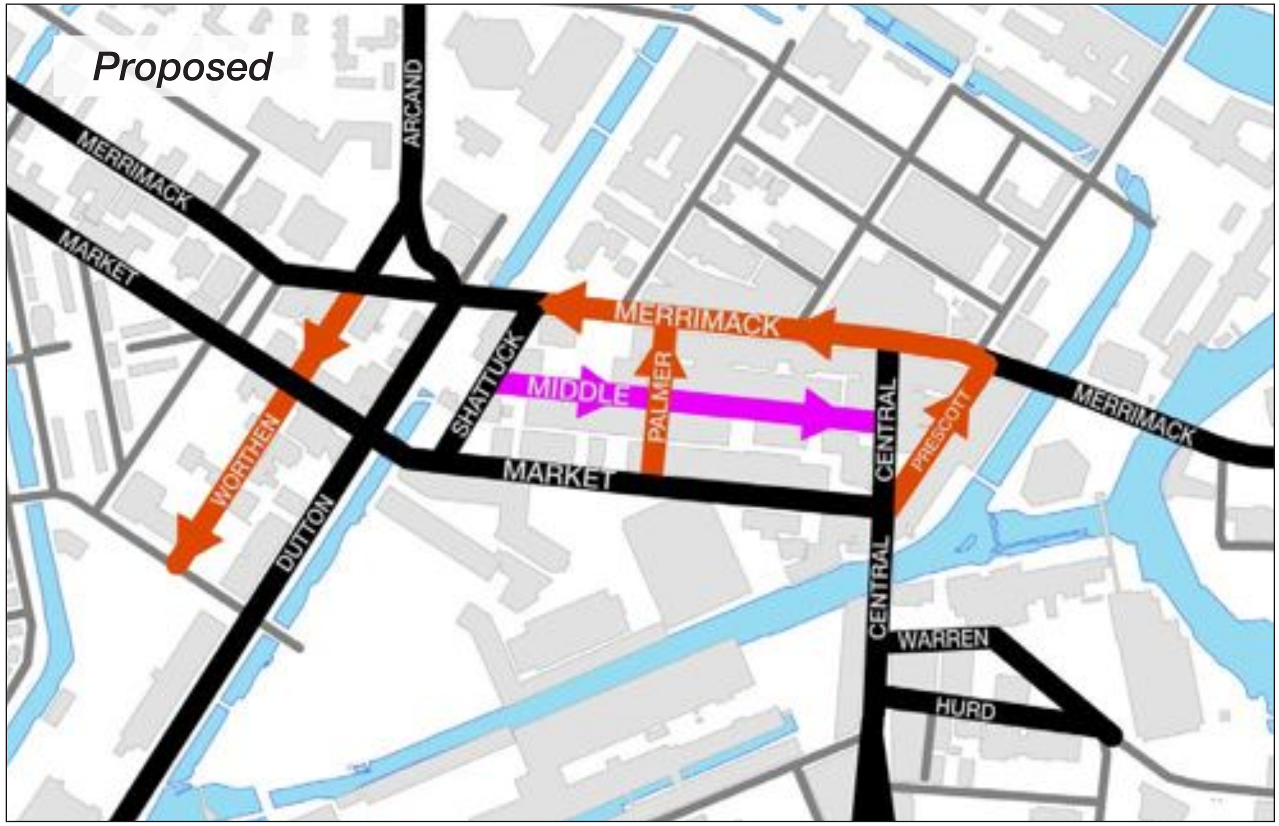
Proposed Modifications

A full range of one-way to two-way conversions was considered and modeled in this study, including a complete conversion of the entire system. Certain streets were quickly eliminated from the discussion because they could not accept two-way traffic without losing important parallel parking and/or turn lanes; these included Middle, Palmer, and Prescott Streets. The key street under intense scrutiny, necessarily, was Merrimack, whose surprisingly low traffic volumes suggest that a return to two-way traffic could be accomplished with little increased congestion. This solution was ultimately rejected, however, due to the fact that an inefficient and hard-to-change loading-zone regime would make the street's businesses extremely difficult to service in a two-way configuration. However, as will be described, one block of Merrimack can easily be converted with benefits to the larger system.

Beyond Merrimack, it was determined that the remaining one-way streets in the downtown core could all be returned to two-way traffic—Market, Central, and Shattuck—thus creating a far less circuitous

Theory vs. practice: Illegal truck unloading causes unanticipated backups on Merrimack Street.





system. Across the Lower Locks, Warren and Hurd Streets were also deemed easily returned to two-way traffic, simplifying trips, reducing visitor confusion, and slowing vehicle speeds to a more pedestrian-friendly standard.

It is encouraging to know that similar two-way conversions have been accomplished on Lowell's Appleton and Middlesex streets, the latter as recently as 2006, with only positive outcomes and supportive public comment. That experience mirrors a nationwide trend and a growing body of literature documenting the growing number of cities— more than a hundred nationwide, including West Palm Beach, Chattanooga, and Minneapolis—in which similar conversions have contributed significantly to downtown revitalization.

It is clear that the changes proposed here are not minor and will take some getting used to, but their anticipated benefits—based on experience, not theory—are expected to far outweigh their cost and temporary inconvenience.

Key Recommendations

1. Monument Square: two-way Worthen
2. Merrimack: eastbound lane to Shattuck
3. Shattuck: two-way
4. Market: two-way
5. Middle: Flow reversed
6. Central: two-way
7. Warren and Hurd: two-way

Traffic Analysis

The Evolution Plan study team performed traffic analysis to test the performance of downtown Lowell's transportation system after implementation of the Plan's recommendations. As the Plan was focused on Lowell's historic downtown core and surrounding neighborhoods, the traffic analysis covers a relatively small portion of the city; however, many of the intersections and streets analyzed are critical links to regional connections in and out of downtown. Many of the recommendations discussed in this Plan report relate to streetscape and pedestrian enhancement, and the primary actions that would affect traffic operations are the conversion of one-way streets to two-way operations.

This analysis was undertaken to illustrate two principle outcomes: how well downtown processed vehicular traffic if certain one-way streets were converted to two-way traffic flow, and how this system would continue to work in the future if traffic increases from new development and population growth. With this, the Plan study team assumed an alternative distribution of traffic onto the street network to represent newly-available travel patterns. These included, among other reassignments, that morning traffic from across the Merrimack River on Bridge Street would now access the Roy Garage directly using Central and Market Streets, and not proceed through the downtown 'loop,' and that traffic accessing Dutton Street in the afternoons could use Market in addition to Merrimack. The team also forecast traffic growth into the future, assuming that it would increase by one percent per year (or a total of over 22 percent during the 20-year period for which traffic growth was assumed).

Generally speaking, traffic volumes throughout downtown Lowell are relatively evenly distributed and are not heavily focused on one street or even a small number of intersections. For this reason, the traffic analysis suggests that few intersections experience significant congestion today. However, it is the combined effect of multiple intersections in close proximity and the unique layout of downtown Lowell's street system that complicates the real-time performance of the system and leads to motorist perceptions of traffic congestion.

When changes are made to the flow of the street system through two-way conversions, most intersections studied do not experience significant increases in congestion, even with the application of over 20 percent of additional traffic into the future. Those intersections that do experience notable increases in congestion do so primarily because of an increase in movements that compete for signal phase time, and the analysis explored a number of mitigation approaches to reduce overall delay. The Traffic Analysis Table on the following page details these particular intersections and discusses what recommendations would help to mitigate problems. It should be noted that even with forecast traffic growth and several changes in traffic flow, no intersections operate at a failing level of service by conventional engineering standards.

TRAFFIC ANALYSIS TABLE

Refer to Appendix A for a more detailed discussion of the traffic analysis and its assumptions, as well as detailed output reports from the traffic software models constructed for the purposes of this analysis.

Intersection	Today's Traffic and One-Way Streets				2030 Traffic with Recommended Two-Way Streets				Recommendations for mitigating potential traffic problems
	Morning Peak Period		Afternoon Peak Period		Morning Peak Period		Afternoon Peak Period		
	Level of Service	Average Intersection Delay	Level of Service	Average Intersection Delay	Level of Service	Average Intersection Delay	Level of Service	Average Intersection Delay	
Merrimack at Prescott-Bridge	B	12 sec	B	20 sec	B	14 sec	B	12 sec	
Merrimack at Central	A	8 sec	A	8 sec	B	11 sec	B	11 sec	
Merrimack at Dutton	A	9 sec	A	10 sec	B	11 sec	B	11 sec	
Merrimack at Worthen	A	6 sec	A	5 sec	B	6 sec	B	11 sec	
Market-Prescott at Central	B	13 sec	B	11 sec	D	40 sec	C	21 sec	
Market at Dutton	E	78 sec	F	87 sec	B	18 sec	B	17 sec	Use signal timing that allows northbound and southbound traffic to share a phase. This may require new signal infrastructure in the future.
Market at Roy Garage Entrance	Not evaluated under one-way traffic patterns				C	31 sec	B	11 sec	If westbound left turns into the garage are desired with two-way traffic, add a traffic signal that gives these turns a protected phase.
Broadway at Dutton	C	23 sec	C	34 sec	B	16 sec	C	20 sec	
Arcand at Worthen	A	No delay	A	No delay	A	1 sec	A	1 sec	
Arcand at Father Morissette	B	14 sec	B	16 sec	D	38 sec	C	31 sec	Consider an actuated signal to provide protected turning phases when needed but to make the most efficient use of signal time outside of peak periods.
French at Bridge	B	11 sec	B	11 sec	B	11 sec	B	14 sec	

Bicycle Accommodation

Given its large student population, it is surprising to see how few people ride bikes in downtown Lowell. Of those few that do, most seem to occupy the sidewalk, inconveniencing pedestrians. Both of these circumstances result not from any local cultural tradition, but rather from a street network that is unaccommodating to bicyclists in the extreme. Bicycle facilities of any sort are rarely visible, and potential bicyclists respond to this condition principally by choosing to drive instead.

It need not be this way. The last decade has witnessed a dramatic resurgence of bicycling in American cities, largely the outcome of specific local improvements in bicycle infrastructure. In New York City, for example, a commitment to an upgraded bike network caused a 35% increase in bicycling in one year alone. The experience in most places has been "build it and they will come."

Becoming more welcoming to bicyclists is important to Lowell's future success. As many younger (and some older) adults turn increasingly to biking as a more affordable, healthy, and sustainable alternative to driving, those cities that have superior biking systems will win them as residents. This group is one of the key demographics repopulating Lowell's downtown and, for many of them, the current lack of biking infrastructure is a significant black mark that they must choose to overlook.

Lowell deserves some sympathy for its current condition, as it has been very difficult to consider adding bike lanes to historic narrow streets, some of them cobblestone, that are already overtaxed with other uses. Fortunately, an effective bike network need not include every downtown street, or even the majority of them. Rather, it must connect key destinations and communicate the fact that bikes are welcome. This end is achieved through a variety of means, only some of which require dedicated roadway.

Design

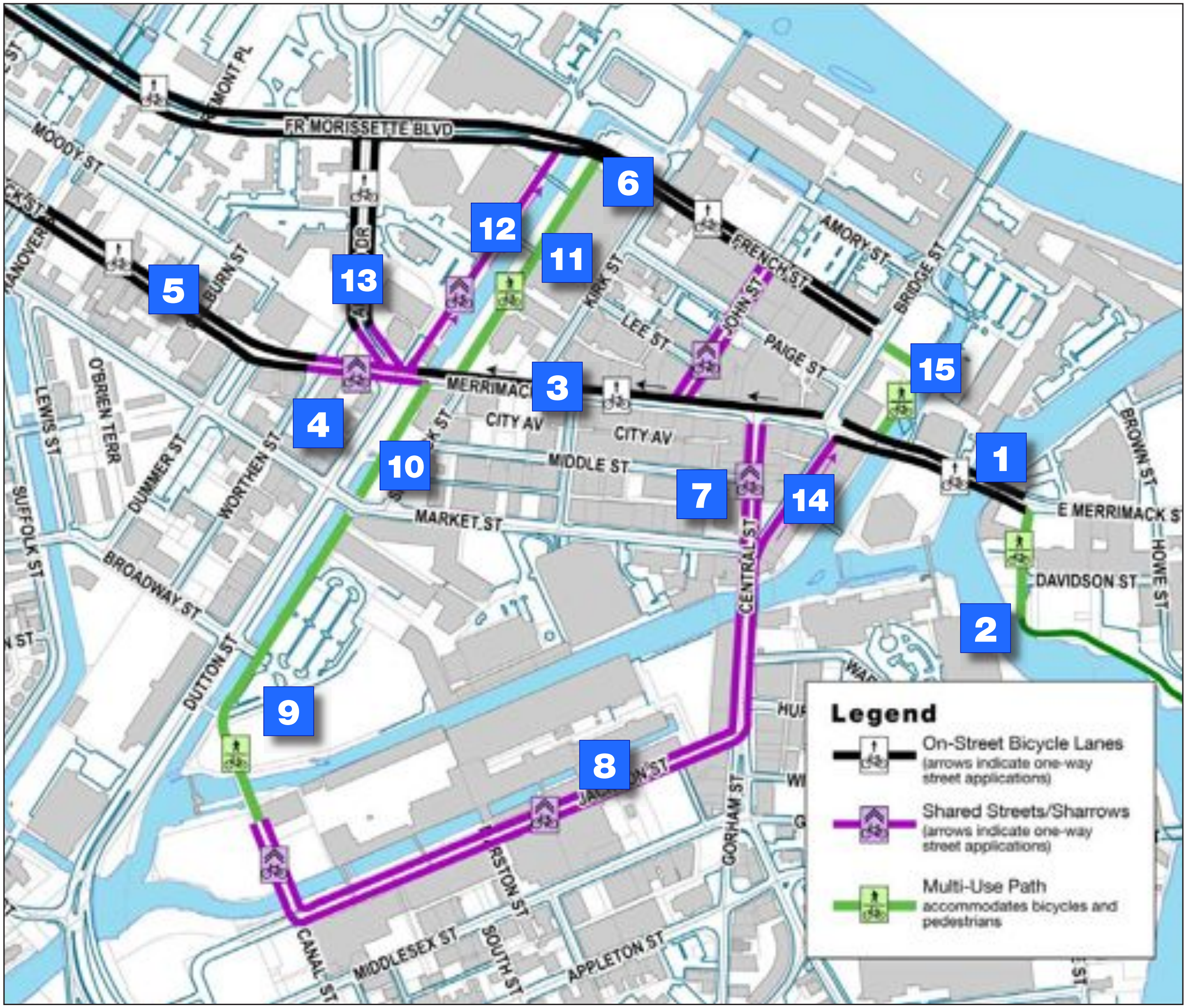
An effective cycling network consists of three basic types of facilities: bicycle paths, bicycle lanes, and shared routes. Bicycle Paths are physically separated from traffic and often occupy parks. Bicycle lanes are demarcated within moderate-speed roadways and are ideally 5' wide. Shared routes—the majority of thoroughfares—are low-speed streets in which cars and bikes mix comfortably; shared routes holding high volumes are best demarcated with a "sharrow" insignia that reminds drivers of the cyclists' presence. All three of these facility types must be put to use if Lowell is to establish an effective network. Fortunately, such infrastructure is not expensive; the major cost, which must be committed to up front, is their regular repainting—sometimes every spring.

In creating a bicycle network for Lowell, a number of key destinations were identified. These include the following:

- The downtown core between French and Market Streets;
- Lowell High School;
- The three campuses of UMass Lowell;
- The main Middlesex Community College campus;
- The Gallagher Intermodal Transportation Center;
- The Merrimack River bridges and;
- The almost-completed 200-mile Bay Circuit Trail.

As visible in diagram at right, the proposed bicycle network includes all three facility types, and can be further described as follows:

1. Bike lanes are placed on Merrimack from Bridge to Davidson, connecting the MCC campus and the Lowell Civic Auditorium to the downtown core.
2. A clear path south of East Merrimack connects to the Bay Circuit Trail along the Concord River.
3. Westbound Merrimack is restriped to include a westbound bike lane.
4. Sharrows are placed through the Ladd and Whitney Monument Square intersection to carry the bicycle connection through to West Merrimack.
5. Merrimack is restriped west of Memorial Square to include bike lanes.
6. Bicycle lanes are added to French and Father Morrissette Boulevard.
7. Sharrows are placed on Central from Merrimack to Jackson.
8. Sharrows on Jackson complete the loop to the Hamilton Canal District.
9. A sharrow and a multi-use path run through the Hamilton Canal District, as outlined in the District Master Plan. From here, the network continues south to reach the Gallagher Transportation Center.
10. A multi-use path is formalized along the Merrimack Canal between Market and Merrimack.
11. The existing trail between Merrimack and French is used to connect through Lucy Larcom Park on the Lowell High School campus.
12. A proposed LHS redesign extends Dutton into a one-way sharrow.



13. Arcand Drive is restriped to receive bike lanes between Merrimack and Morrissette.
14. Sharrows are added to the right lane of Prescott to allow cyclists access to Merrimack without dismounting between Central and Prescott.
15. A connection through Jack Kerouac Park between French and East Merrimack is made up of an east-west path along the south edge of the park and a north-south path along the canal.

Most of these modifications are illustrated in greater detail in the individual street reconfigurations that follow.

A final note: with all the talk about biking and bikeways, it is easy to overlook the need for bike racks, which seem to be in short supply, both downtown and at Lowell's educational institutions. It is recommended that the City, Lowell High School, UMass Lowell, and Middlesex Community College collaborate in short order to complete a collective bike rack inventory and plan.

While introducing a bicycle network to downtown Lowell is important, reconfiguring certain streets to create a more welcoming pedestrian and driver experience is essential. The changes proposed below result from the selective application of the safety criteria discussed in section 3.1 to the most important and/or problematic streets in the downtown. These changes include the following:

- Conversion from one-way to two-way travel;
- Insertion of bicycle facilities;
- Resizing of travel lanes to support appropriate urban driving speeds;
- Resizing of parking lanes to more economical dimensions;
- Insertion of missing parallel parking;
- Sidewalk widening and tree planting along unsafe-feeling curbs; and
- Modification of roadway geometries from suburban to urban configurations.

As with the reformation of the circulation system and the creation of a bicycle network, the proposed reconfigurations to downtown Lowell's streets are limited to those changes that are expected to produce significant results at limited cost. Most of them are accomplished with paint alone, as rebuilding curbs is needed in only a few circumstances.

The pages that follow detail the street-by-street modifications proposed for downtown. These are summarized below:

1. Market Street: converted to two-way.
2. Shattuck Street: converted to two-way, and flow on Middle Street reversed.
3. Central Street: converted to two-way and one parking lane added.
4. Ladd and Whitney Monument Square: Worthen and Merrimack segments made two-way.
5. Merrimack Street: lanes resized to include a bike lane.
6. East Merrimack Street: one parking lane traded for two bike lanes.
7. West Merrimack Street: lanes resized to include bike lanes.
8. French Street: lanes resized to include a parking lane and two bike lanes.
9. Arcand Drive: lanes resized to include bike lanes.
10. Prescott Street: one travel lane partially converted to parking and widened sidewalk.
11. Warren and Hurd Streets: converted to two-way; parking and urban geometrics added.
12. Dutton Street: Widened sidewalk and parallel parking added where possible.
13. Father Morrissette Boulevard: redesigned as complete street including a streetcar (long-term). Short Term: Two travel lanes traded for two parking lanes and two bike lanes.

3.1a **Market Street** Dutton to Palmer

Location in Downtown Lowell

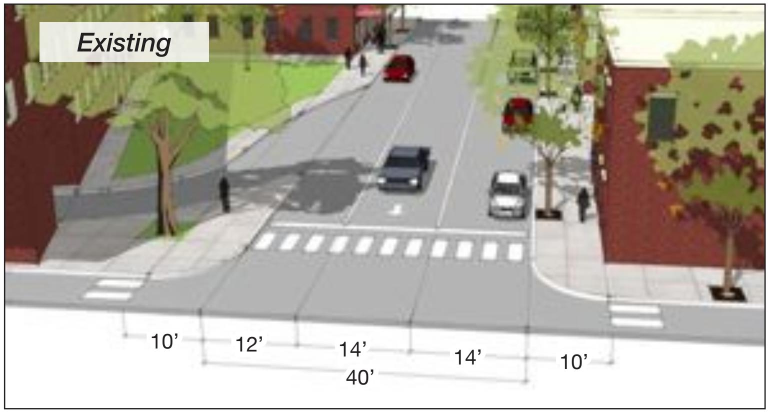
Key Recommendations

1 Parking retained on north side along bridge
2 Reversible left turn lane, can carry peak traffic as needed
3 Parking on both sides for most of the street
4 Garage entryway consolidated to eliminate high-speed entry

In what is perhaps the most important traffic recommendation of this Plan, Market Street through the core of downtown is proposed to be returned to two-way traffic. As discussed, this recommendation is made with confidence that it will both improve flow and reduce speeding in the downtown—currently a very real problem on Market Street.

This reconfiguration is made easier by the fact that Market Street is quite wide for much of its length, providing ample room for both left-hand turn lanes and parallel parking, with a few limited exceptions. As redesigned, parking is maintained on both sides of the street until the approach to the Roy Garage. This parking lane would also be used for bus and handicap drop-off in front of the National Park Service Visitors' Center at Market Mills, and marked as such.

As Market Street approaches the Roy Garage, parking must be removed on the south side to accommodate a storage lane for left turns north onto Palmer and south into the garage. The western stretch between Dutton and Shattuck Streets would feature a single reversible left-hand turn lane to allow peak queues to occur as needed. On a lighter note, this western stretch provides some useful experience regarding the performance of a two-way Market Street: local residents inform us that it is already used that way by several lost visitors daily.



The slip-lane entry into the Roy garage requires reconfiguration as Market becomes two-way. Pains should be taken to preserve the existing tree.

One complicated aspect of this recommendation is a reconfiguration of the eastbound entrance to the parking structure: the long slip lane is removed in favor of a single entry point. This slip-lane entry was designed to serve a high-speed one-way system; it is not appropriate to urban driving. The revised design intentionally allows westbound traffic to enter the garage, even though there is not a place for it to store immediately in advance of the driveway. Space is given for westbound left-turn storage on the east side of the intersection. This is not an optimal configuration, but has been proposed in an effort to preserve the mature tree currently located between the entry and exit driveways. With this layout, westbound left turns are allowed and quite manageable, but not if an eastbound vehicle is stored in its left-hand turn lane.

This solution is far from ideal, and requires additional study. It could be that a limited reconstruction of the garage entryway is needed to optimize its interface with a newly two-way Market Street.

As with Merrimack Street, more continuous tree cover is also proposed here. The above reconfiguration is principally paint, with curbs moved only at the Roy Garage. When a more comprehensive reconstruction is planned, it should include regular tree spacing and a unified streetscape that corrects the current condition in which one sidewalk is paved in concrete and the other in brick.

3.1b **Market Street** Palmer to Central

Location in Downtown Lowell

Between the Roy Garage and the approach to Central Street, Market features on-street parking on both sides (Item 2 on the diagram). As it nears Central, parking is substituted with a right-turn lane to accommodate this heavy turning movement. The traffic analysis suggests that approximately 150 feet of queuing length for this right-hand-turn lane should be provided. Left turn and through movements onto Prescott are shared in a single lane.

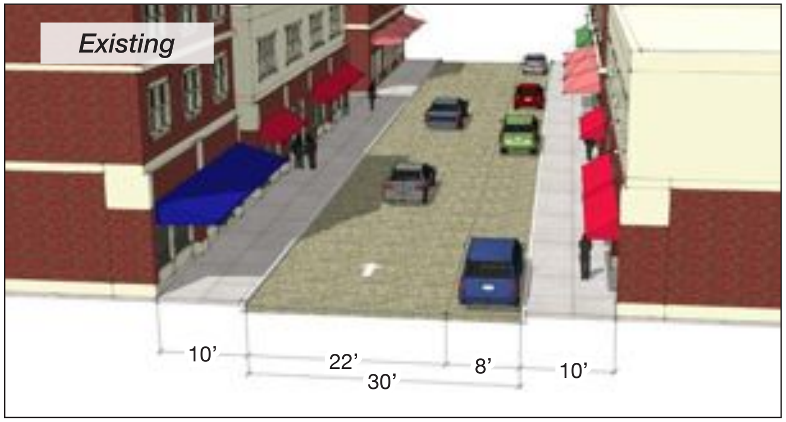
Key Recommendations

1. Left turn lane pockets to accommodate queuing
2. Parking on both sides for most of street length
3. Dedicated left turn lane for westbound turns into garage
4. Dedicated right turn lane for traffic movement (replaces south-side parking)

Market Street contains a number of popular destinations that would benefit from a slower two-way traffic pattern.

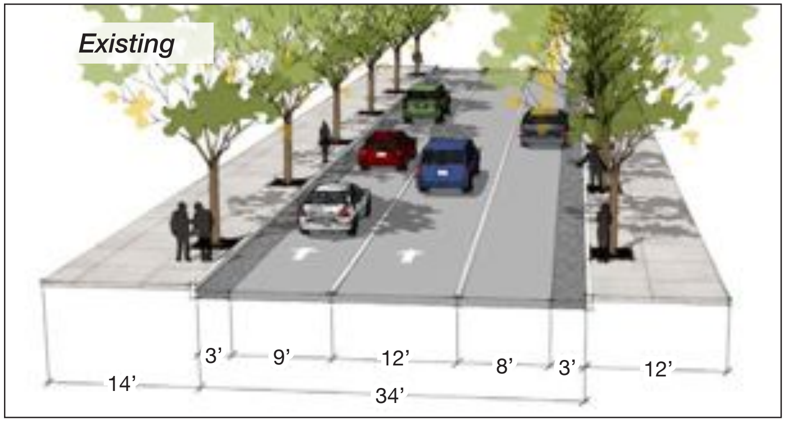
Section 3.3.6 discusses modifications to Prescott Street. It is worth noting that signal phasing, which currently allows eastbound through movements from Market to Prescott, will need to restrict northbound right turns from Central to Prescott on red lights. This restriction allows the through movements from Central to have conflict-free access to the redesigned Prescott Street.

3.2 Shattuck Street



Location in Downtown Lowell

Today Shattuck Street is a one-way (southbound) street with parking along its western side. Returning two-way traffic to this street improves system convenience and through-put while providing better access to businesses along Middle Street. Stop signs at either end will adequately handle the interface with Merrimack and Market Streets. As noted, Middle Street will keep its current configuration, but in the opposite direction. Neither of these reconfigurations requires any new curbs or signals.

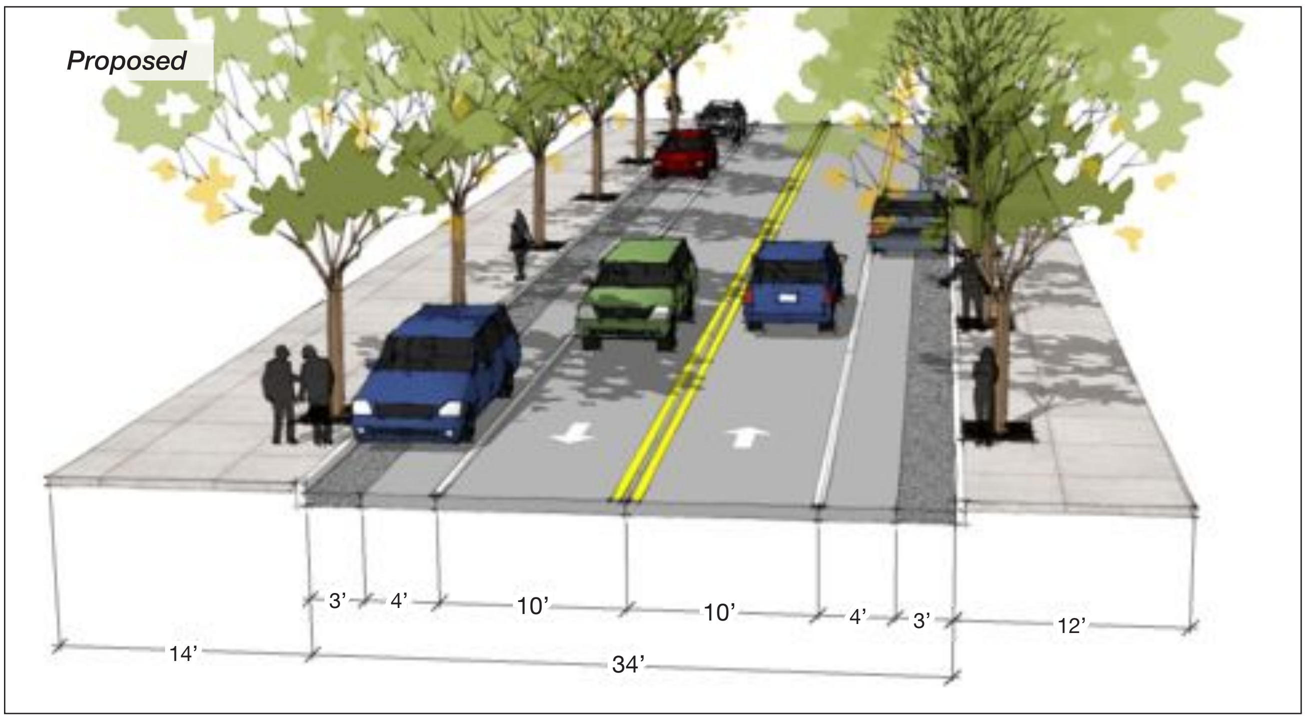


Location in Downtown Lowell

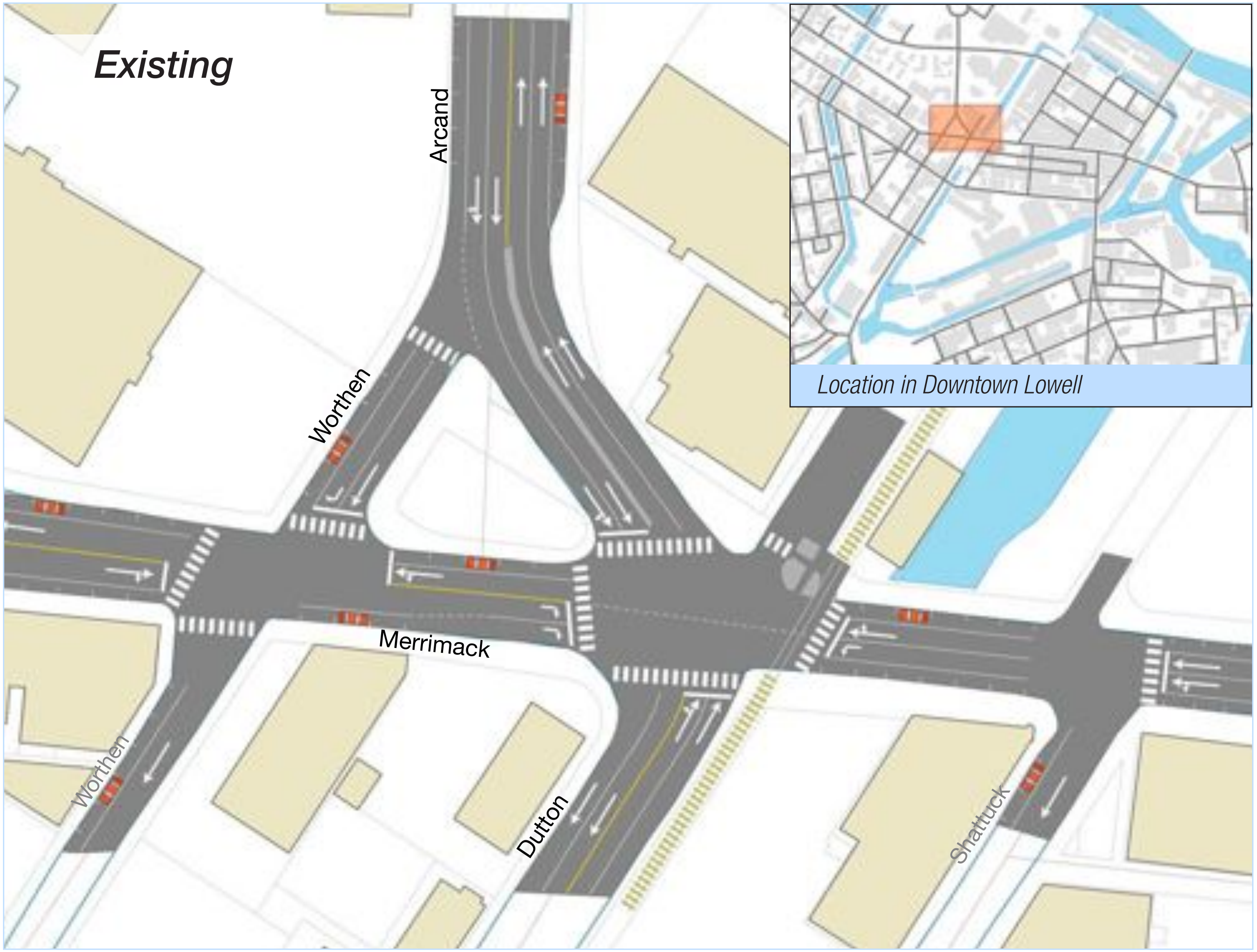
Central Street between Market and Merrimack is currently one-way northbound. This limitation to a very small segment is one of the largest causes of lengthened trips within the downtown. It should be converted to two-way traffic to allow southbound traffic from Bridge Street and East Merrimack Street to continue out of downtown without burdening the Merrimack-Market loop or the Dutton-Thorndike connection. In addition to lightening the load on Dutton, this change is highly likely to decrease demand on the right-turn movement from Market Street onto Central, allowing the traffic signal phasing to be more effectively shared between this movement and southbound trips on Central.

Additionally, Central Street is currently striped inefficiently, due to oversized lane standards and a reluctance to make use of the 3-foot-wide cobblestone surface against both curbs. These cobblestones are ideally subsumed into parking lanes, and the street’s 34-foot dimension then allows for parking to be placed along the western curb as well, where it would protect a popular seating area in front of the elderly housing facility.

The reconfiguration of Central Street will require some relocated signals but no curb reconstruction.



3.4 Ladd and Whitney Monument Square



Ladd and Whitney Monument Square is an important civic space in front of the Lowell City Hall, providing a prominent view of City Hall from Merrimack Street to the east. It is one of downtown's busiest traffic intersections as well, where Dutton and Merrimack Streets intersect and where downtown traffic from Lowell's western neighborhoods must turn onto Dutton to reach Market Street. As already described, it handles considerably more traffic now than it will once Market, Shattuck, and Central Streets are returned to two-way.

Worthen Street, which is a southbound one-way street, allows traffic from Arcand Drive to turn right onto Merrimack, thus avoiding the acute eastern Arcand/Merrimack corner of the Monument Square triangle. However, the reverse is not allowed: eastbound traffic on Merrimack Street cannot currently turn left, prohibiting a more even distribution of traffic into downtown. Additionally, due to Merrimack's one-way configuration, continuing straight east is also impossible at this intersection. Unable to go left or straight, all eastbound traffic must complete the awkward Dutton-Market dogleg into downtown.

Monument Square should be reconfigured to allow a more thorough range of traffic movements and thus a more even distribution of traffic. This limited redesign takes advantage of the built-in storage space of the triangle sides but fundamentally assumes that all three corners of the triangle work as a single intersection, made possible by coordinated signals. There is some question as to whether this reconfiguration would require a new signal at the intersection of Worthen and Arcand: the traffic study says that it is not needed to control congestion, but it may be desired for safety reasons.

In addition, Merrimack should carry a single lane of eastbound traffic through the Dutton intersection to Shattuck Street. This proposal, which has been suggested before, solves several problems simultaneously. It takes pressure off of the Dutton/Market dogleg, provides a quicker path to Central Street, and provides greater visibility to businesses on Merrimack Street. Mostly, it just makes it feel easier to spend time and money downtown.

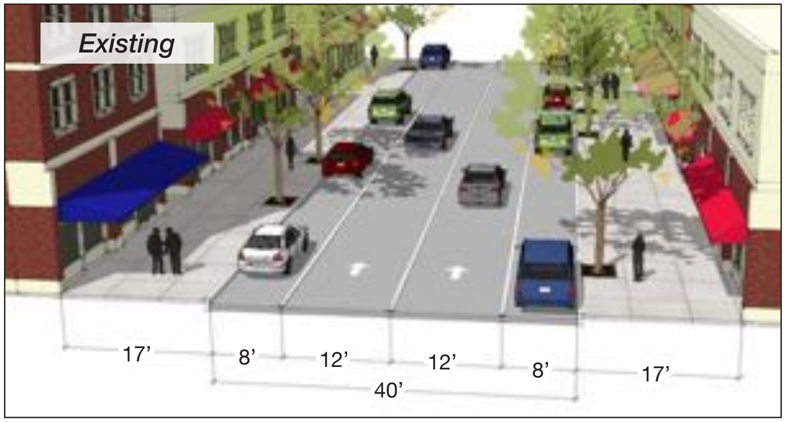
This important eastward path can be provided without losing any westward capacity on Merrimack. The two westward lanes would continue, but shifted slightly north against the canal, at the cost of a few parking spaces. Since these spaces do not abut any stores, this seems a small price to pay for easing entry into downtown.

All of the above changes in and around Ladd and Whitney Monument Square can be accomplished for the cost of paint, plus one potential new coordinated signal at the intersection of Arcand and Worthen.

Key Recommendations

1 Left turn lane allows eastbound travel to access Arcand
2 Two-way Worthen carries these turns from Merrimack
3 One lane of traffic continues east on Merrimack
4 Eastbound traffic turns right at Shattuck without impeding flow

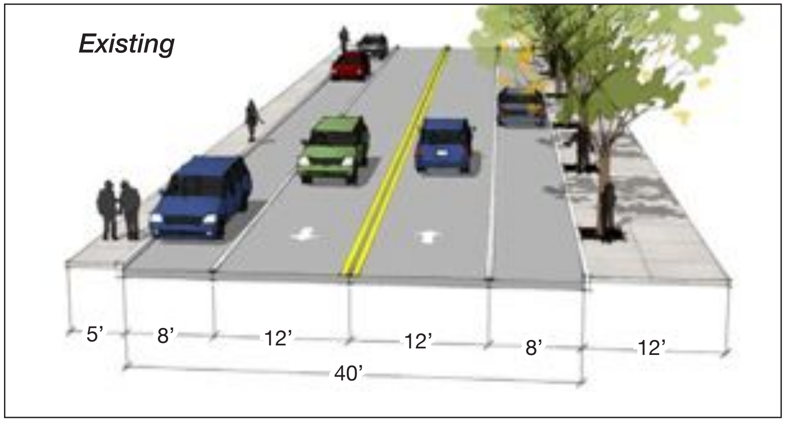
3.5 Merrimack Street



Location in Downtown Lowell

Merrimack Street's 40 foot curb-to-curb dimension currently holds parking and driving lanes whose above-standard widths encourage speeding. Reducing these widths to more standard urban dimensions creates room for a bike lane on this important thoroughfare. While these lane widths create tighter conditions for trucks and buses, the bike lane provides contingency space for their intermittent use. In practice, this street will function much as before, except that cyclists will feel welcome and drivers will be less induced to speed.

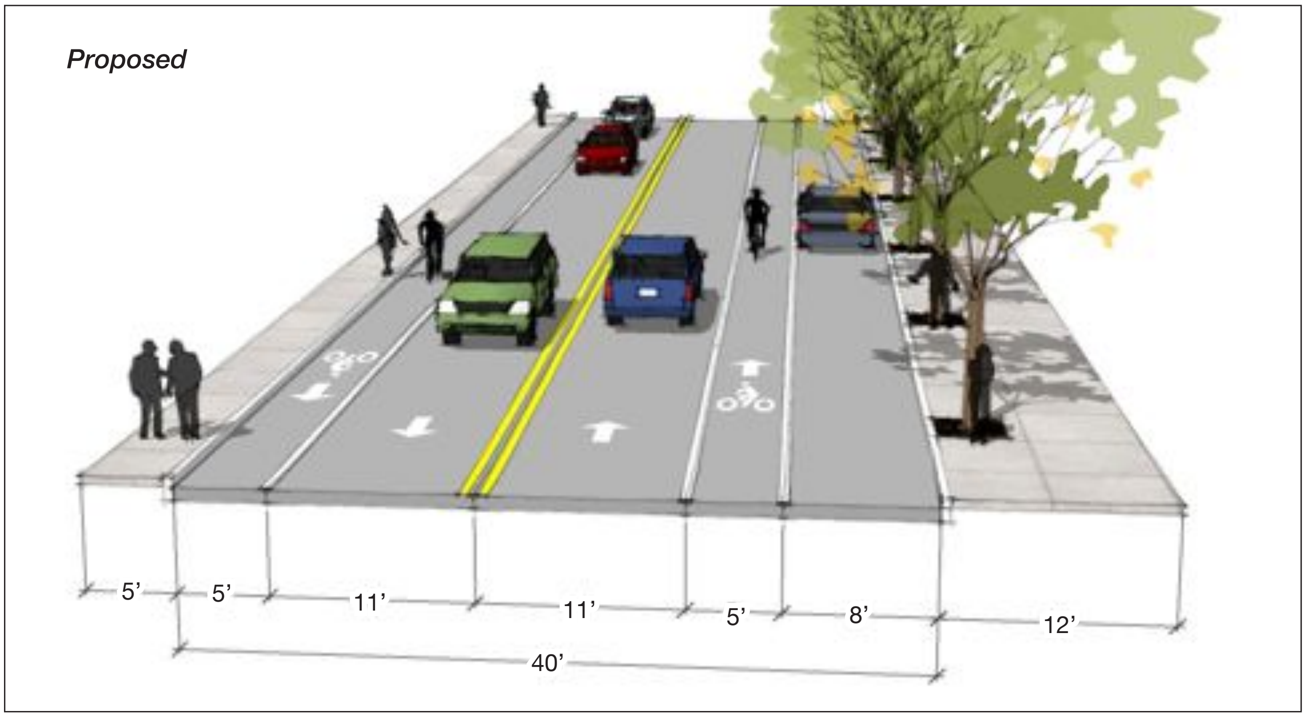
This reconfiguration requires paint alone. When budget allows, new trees should be planted in structural soil to achieve an ideal spacing of 25 to 30 feet between trees.



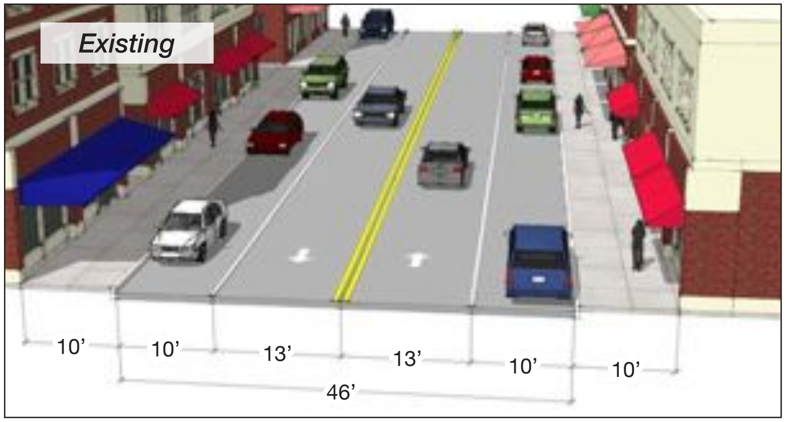
Location in Downtown Lowell

East Merrimack Street is the primary connection from the heart of downtown across the Concord River to Middlesex Community College, the Lowell Auditorium, and the almost-completed 200-mile Bay Circuit Trail. As such, it is an essential component of the downtown bicycle network, and demands dedicated bike lanes. Unfortunately, these can only be placed in the roadway at the expense of one on-street parking lane, but the (north) lane proposed for elimination does not abut any retail uses and is therefore deemed less important than the added bicycle facility.

This street is also proposed for a brick speed-table paving pattern to be introduced between the two MCC buildings, as further described in Chapter 9.

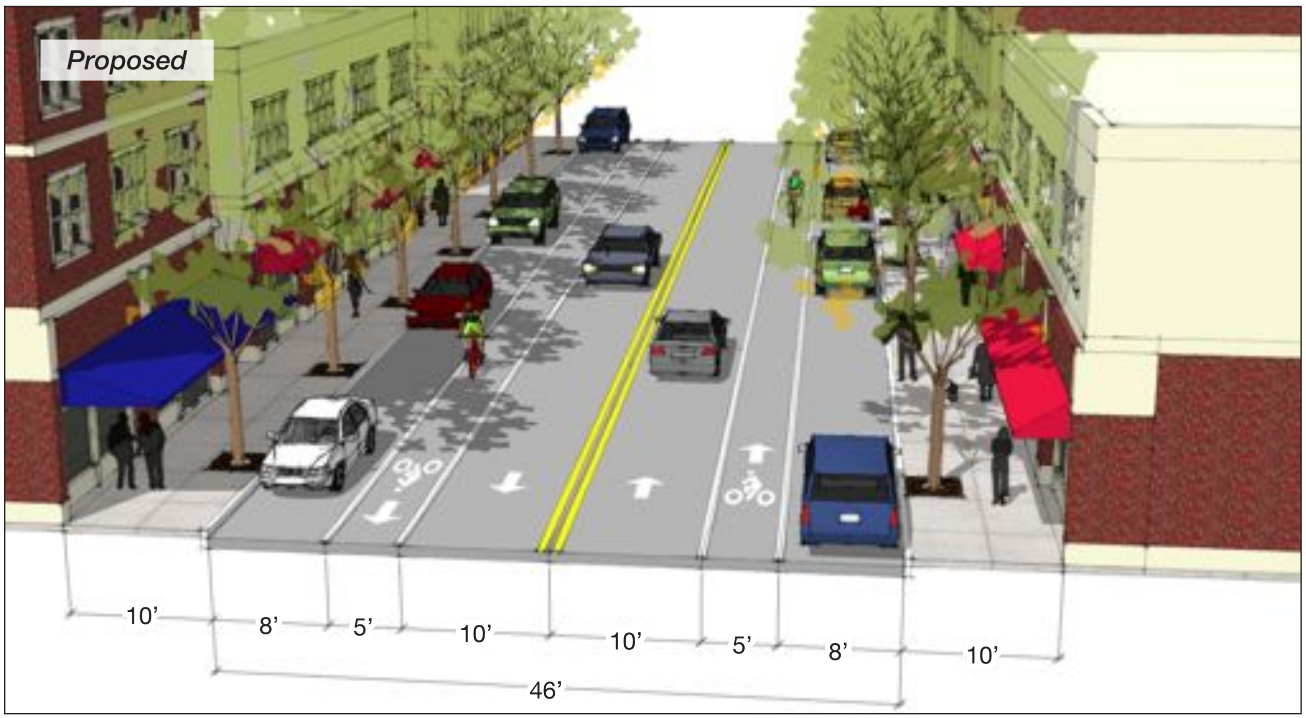


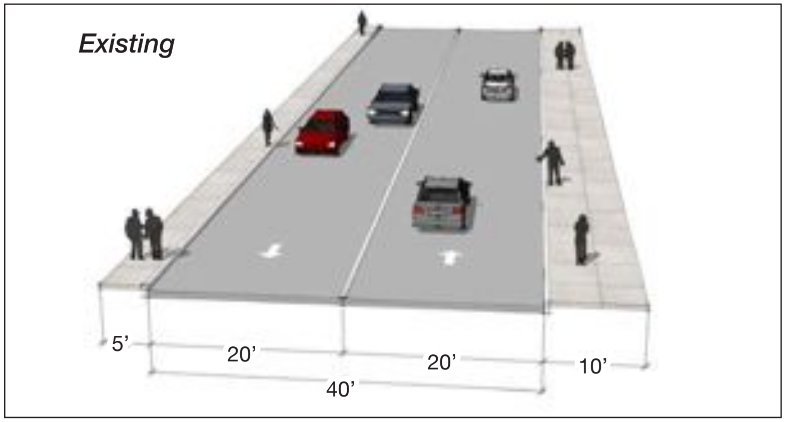
3.7 West Merrimack Street



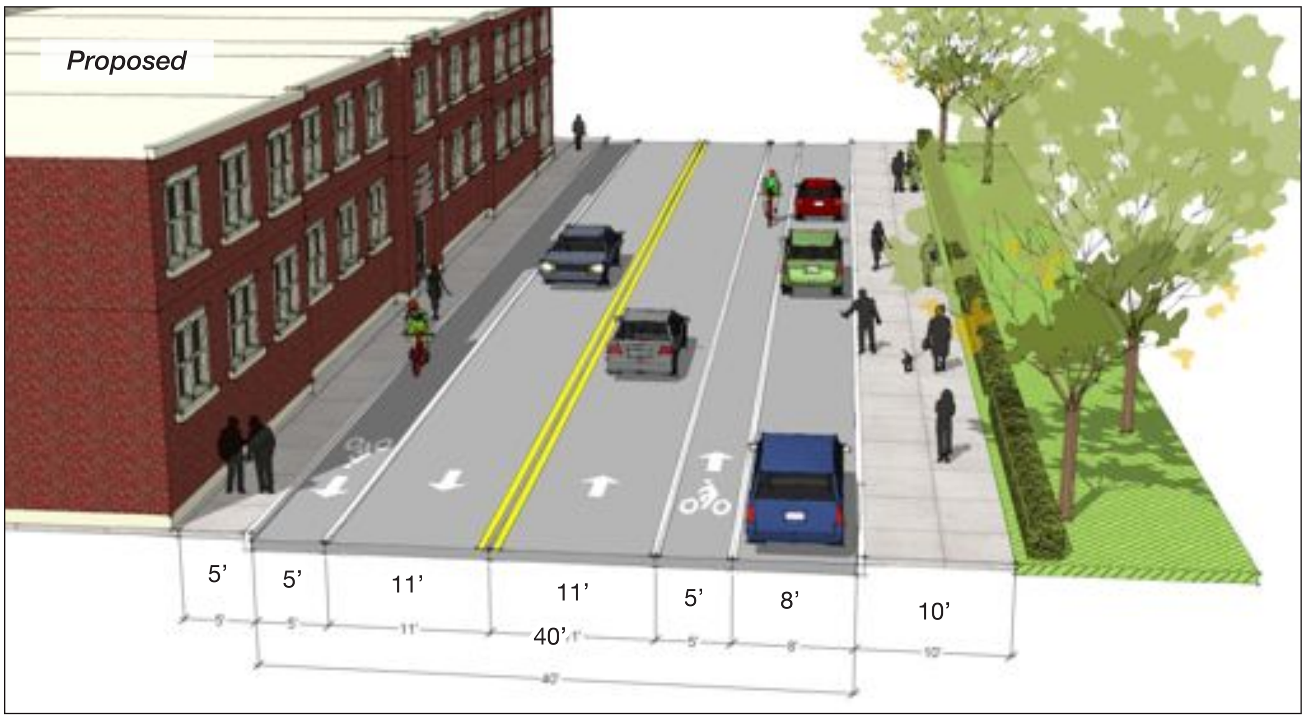
Location in Downtown Lowell

West of downtown, Merrimack Street is a two-lane, two-way street with a 46-foot curb-to-curb width. This is a wider cartway than many of downtown's other two-lane streets, and it has been subdivided into oversized parking lanes and highway-width driving lanes that invite speeding. This additional roadway dimension can easily be reconfigured to serve a broader range of users. Merrimack is an important connection from downtown to western Lowell neighborhoods and the UMass Lowell western campus, and as such should provide a dedicated route for bicycles. The street's broad dimension happily accommodates standard width driving, biking, parking, and bicycle lanes in each direction.






Location in Downtown Lowell

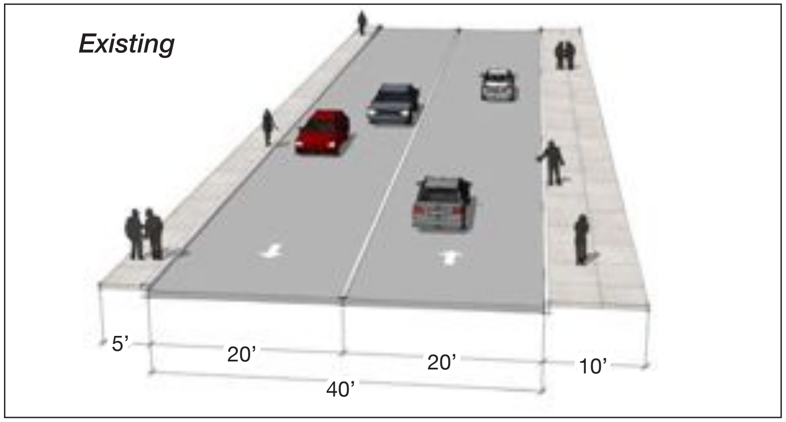


French Street currently features two double-wide travel lanes with on-street parking disallowed in most areas around the Lowell High School campus. This condition is due principally to the loading and unloading of school buses, but it does not need to be maintained along French's entire length. Moreover, the loading of school buses should ideally take place in designated parking lanes, in which parking is prohibited during pick-up and drop-off hours.*

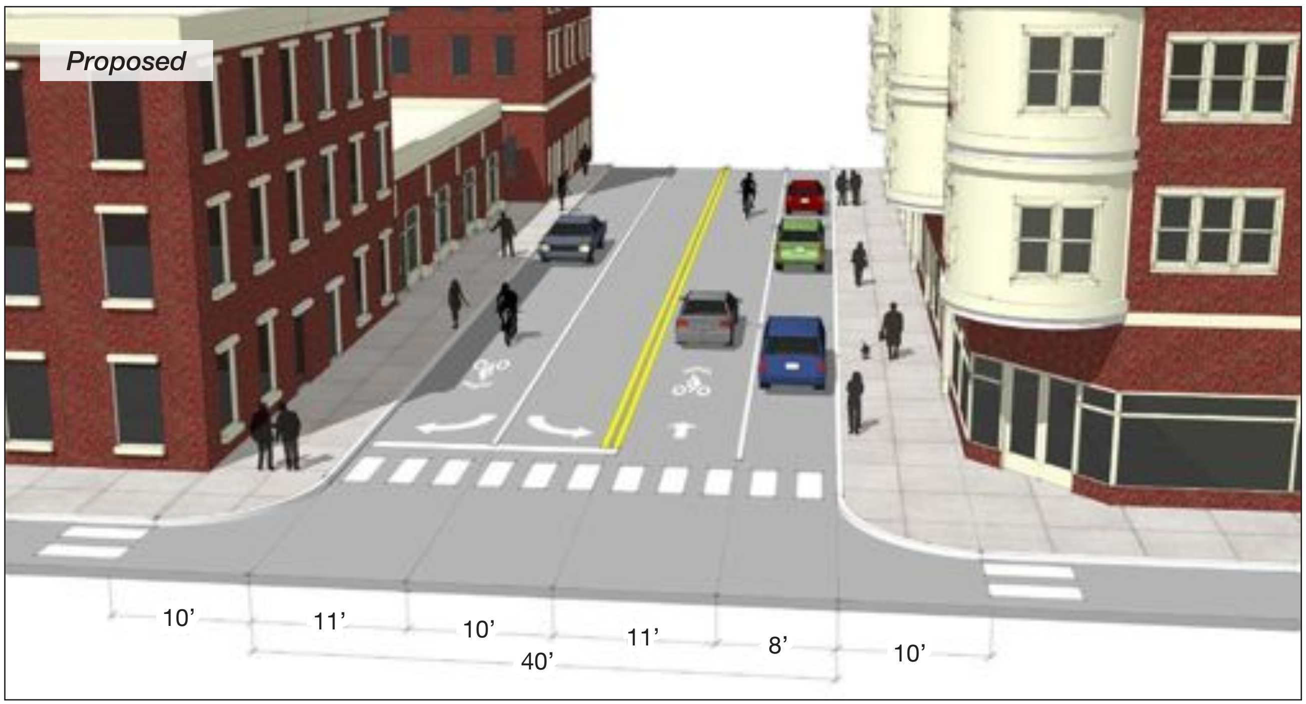
In addition to serving school buses, the double-wide lane heading east also serves as automobile storage for cars waiting to enter the Bridge Street intersection at rush hour. As is the case with Prescott Street, this traffic is due not to any lack of capacity in the roadway itself, but only to the limitations of intersections down the line. Therefore, the configuration of that storage can be altered without any significant impact on travel times. The double-width lane heading west never experiences two-lanes worth of traffic volume, and can easily become a properly-sized lane.

Based on this understanding, there is no reason not to modify French Street to allow on-street parking and to expand the downtown bicycle network. This goal is accomplished through a restriping that includes parking on the north side of the street to serve Boarding House Park and the Tsongas Industrial History Center. These parking spaces can be signed to prohibit their use at times when school buses park in this location. If additional parking (and bus storage) is desired along the front of the High School, the parking lane can shift over to the south side of the street near Kirk Street.

French Street



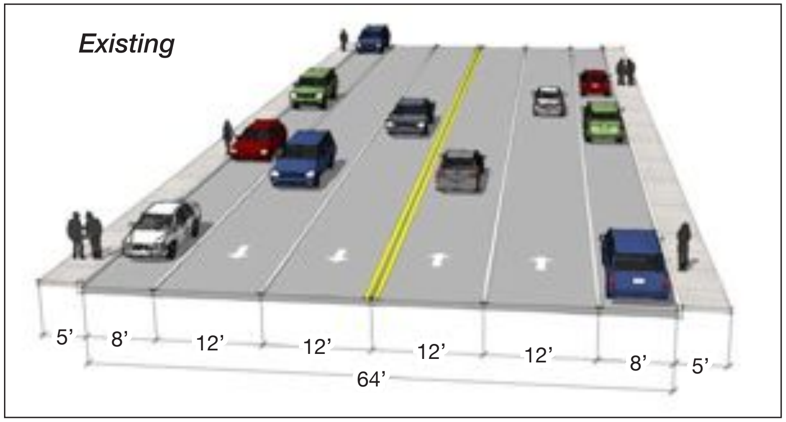
Cars double-up on French Street approaching the John Street and Bridge Street intersections.



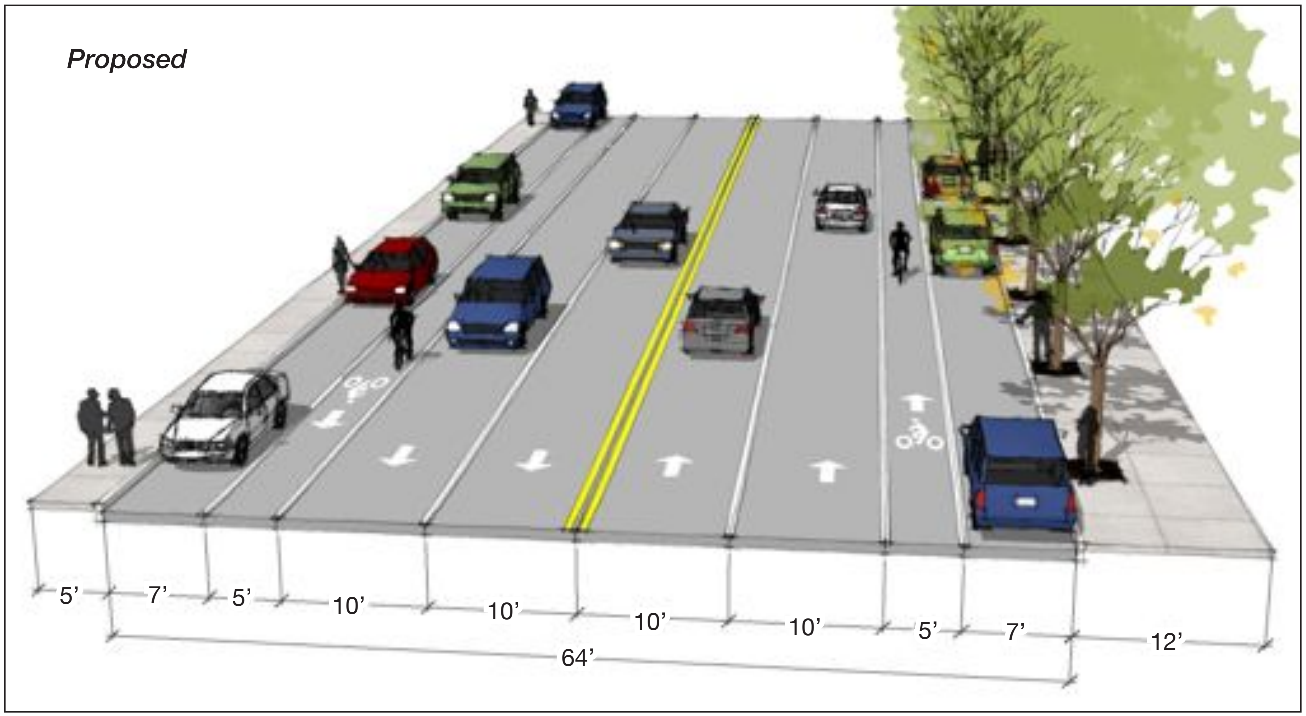
On the approach to Bridge Street, however, two eastbound lanes are still needed to accommodate turning volumes—these currently share the existing double-wide lane. Because it is important to maintain parking on the north curb in this retail location, the bike lanes must transform into shared travel lanes with sharrow markings. On the eastbound approach, the sharrow should be placed in the right turn lane, but markings should indicate a bicycle connection straight through the intersection to Kerouac Park.

With properly sized travel lanes, additional on-street parking, and continuous bicycle lanes, French Street is poised to become a much more welcoming street for bringing pedestrians from the Boott Mills Museum and Boarding House Park to Kerouac Park, and vice versa. This transformation can be accomplished with paint alone.

*Incidentally, a similarly inefficient use of curb space occurs on Paige Street, where parking is disallowed throughout the school day, rather than only during the times when buses are present. This, too, demands correction.



Location in Downtown Lowell



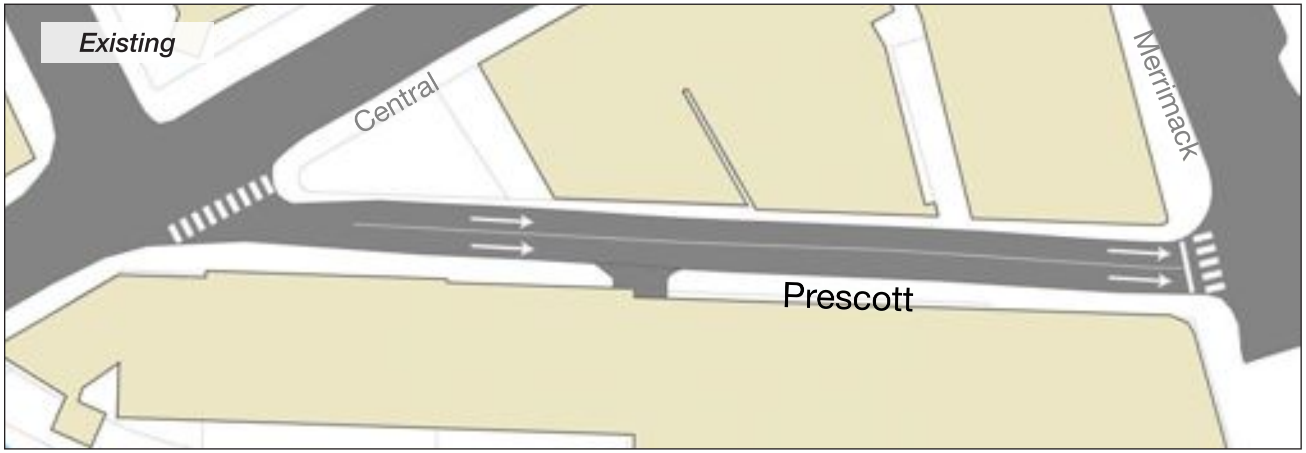
While it speeds traffic to and from the capacious Tsongas Center, Arcand Drive presents one of the least comfortable streetscapes in downtown. It is easy to understand why: the street fails four of the eight safe-street criteria presented at the beginning of this chapter. It frames an oversized block with oversized lanes and a swooping geometry, while lacking street trees completely. Fortunately, its narrow sidewalks are protected by parallel parking, and there is opportunity to restripe its roadway for safer travel without sacrificing any of its prized capacity.

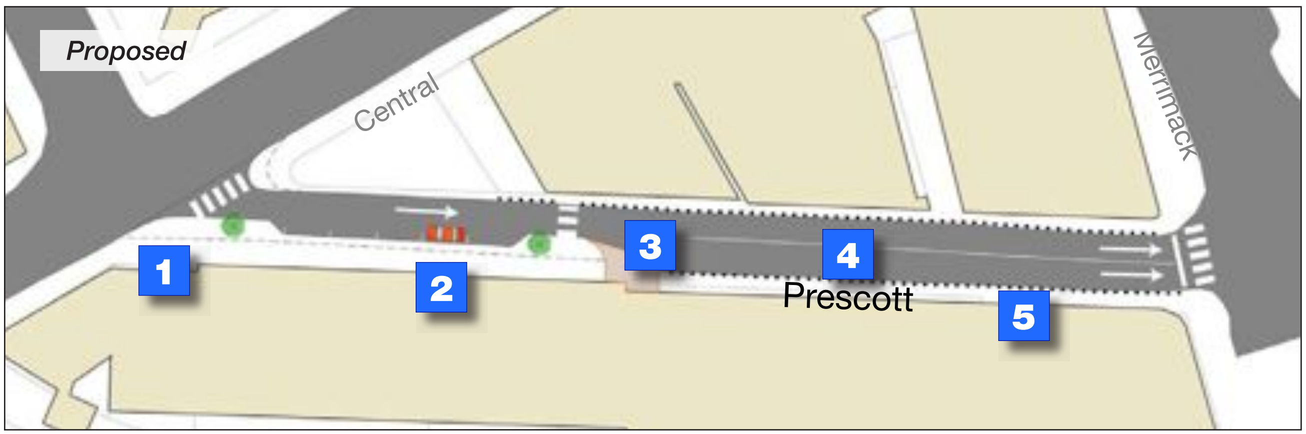
Arcand's 64-foot-wide roadway currently includes 12-foot travel lanes and 8-foot parking lanes. As discussed, 12 feet is 2 feet wider than a standard urban-speed driving lane, and 8-foot parking lanes also have room to spare. Restriping the lanes at 10 and 7 feet, respectively, introduces appropriate-speed geometrics while providing an additional 10 feet of roadway for two bike lanes.

Admittedly, 7 feet is a bit narrower a parking lane than some engineers would like to see on such a high-volume street, but the 5 feet of each bike lane provides ample contingency space. As with the redesign of Merrimack, this restriping will simply welcome bikers while bringing travel speeds closer to the posted limit.

Without spending any money on curb reconstruction or right-of-way acquisition, there is no easy fix for the narrow treeless sidewalks. However, plans for the properties east of Arcand—see Chapter 12—allow the sidewalk to be widened 5' to the east of Arcand and plant regularly-spaced trees in structural soil along the current sidewalk trajectory.

3.10 Prescott Street





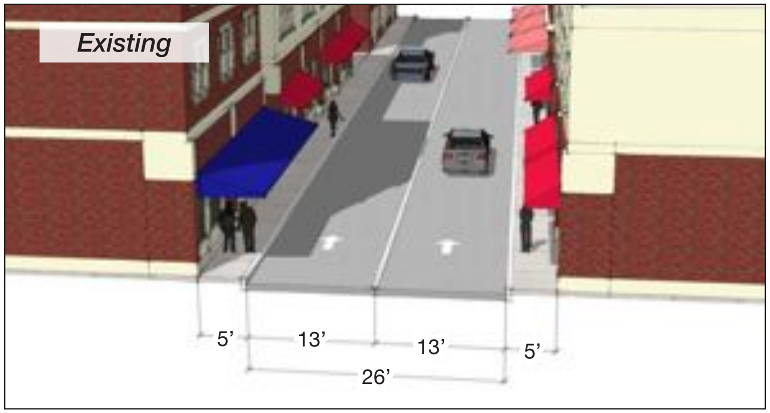
Key Recommendations

1. Reduced corner turning radius still accommodates emergency vehicles making right turns
2. Five on-street parking spaces fit into curb extension
3. Driveway reconstructed with rolled curbs to emphasize pedestrian access; mid-block crosswalk introduced
4. Bollards added to protect 5' sidewalks.
5. Two travel lanes provide ample traffic storage space

Prescott Street currently carries northbound traffic from Central and Market across Merrimack and through downtown. In its current condition it features narrow sidewalks and wide travel lanes, and is generally considered one of the least pleasant streets in downtown, as well as a bad location for retail due to its lack of parallel parking.

Key to reforming Prescott is an understanding of how the street truly functions. It is often choked with traffic, which would suggest that it lacks adequate through-put. In fact, the traffic jams result from backups at the Merrimack Street intersection and further north along Bridge Street, most prominently across the river at its notorious intersection with the VFW Highway. The impeded flow that can frequently be witnessed on Prescott—and on Central further south—is not caused by limited capacity on Prescott or Central, but by the limited capacity of these intersections. What one sees on

Location in Downtown Lowell



these streets is not inadequate through-put, but rather ample capacity that is serving as car storage for the intersections beyond.

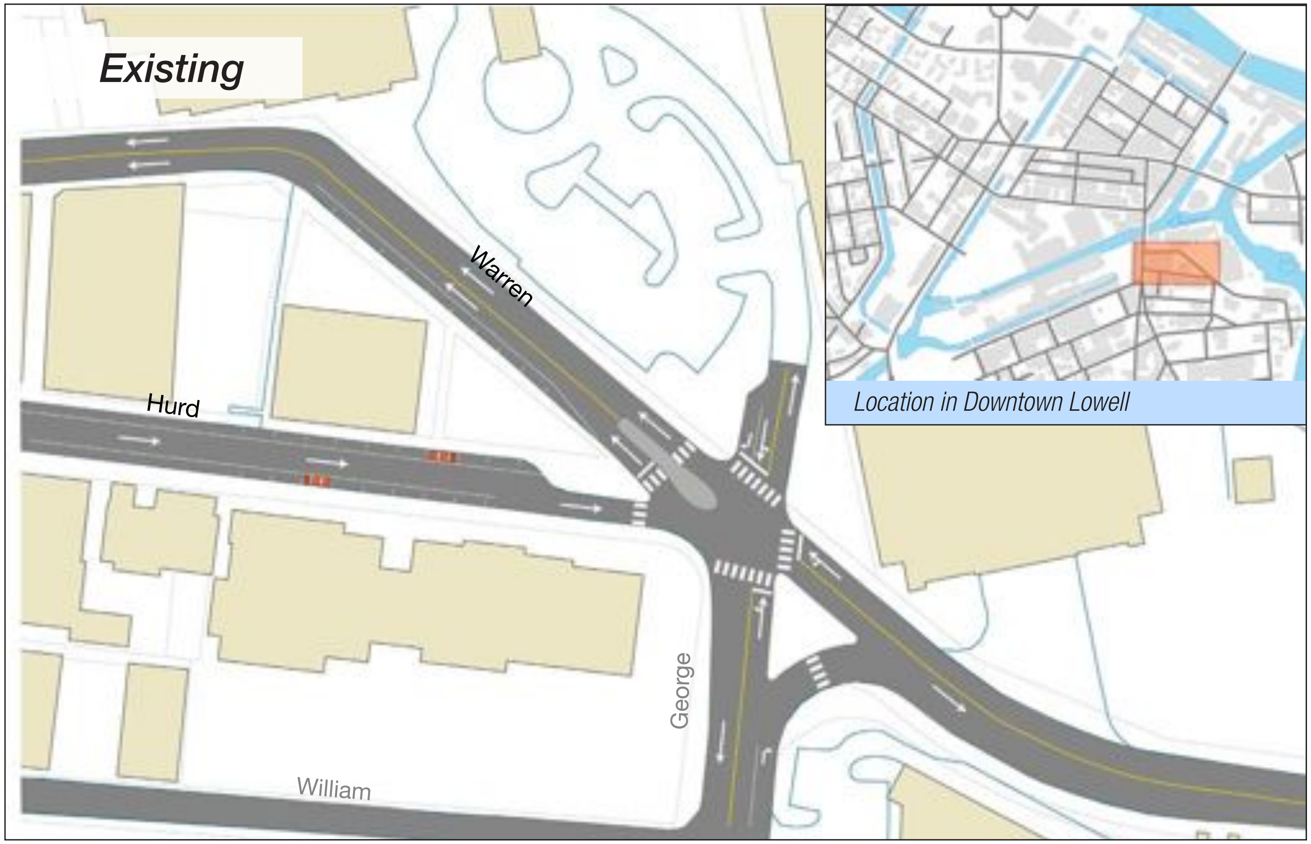
Based on the above understanding, any reduction in vehicle capacity on Prescott can be understood as no limitation to through-put, but rather only a reduction in storage area, which is provided continuously from the VFW Highway down Bridge, Prescott, and Central streets, to a varying length throughout the day. Reducing the storage area on Prescott will only stretch that storage area slightly further south, with no marked effect on travel times.

For that reason, this Plan recommends reducing Prescott to one northbound lane from Central to the driveway tunnel at midblock. This change allows a curb relocation (about 250 feet in length) to fit on-street parking and protective bulb-outs in place of one of the travel lanes. It also calls for a reconstruction of this driveway, to use materials similar to the sidewalk, emphasizing that this tunnel is primarily for pedestrian use. To the north of this driveway, Prescott resumes its existing two-lane section, providing an ample turn lane for drivers headed east on Merrimack.

The addition of parking in this block is intended to serve businesses in the adjacent buildings. Currently, the parking needs of the businesses on this street are met in a small on-site parking area behind the buildings, accessed awkwardly by the narrow tunnel already mentioned. A limited amount of short-term parallel parking on Prescott would take pressure off this rear lot, which is proposed for more productive use in Chapter 13. More importantly, it would give greater viability to retail businesses along Prescott Street, and make at least part of that street much safer for pedestrians.

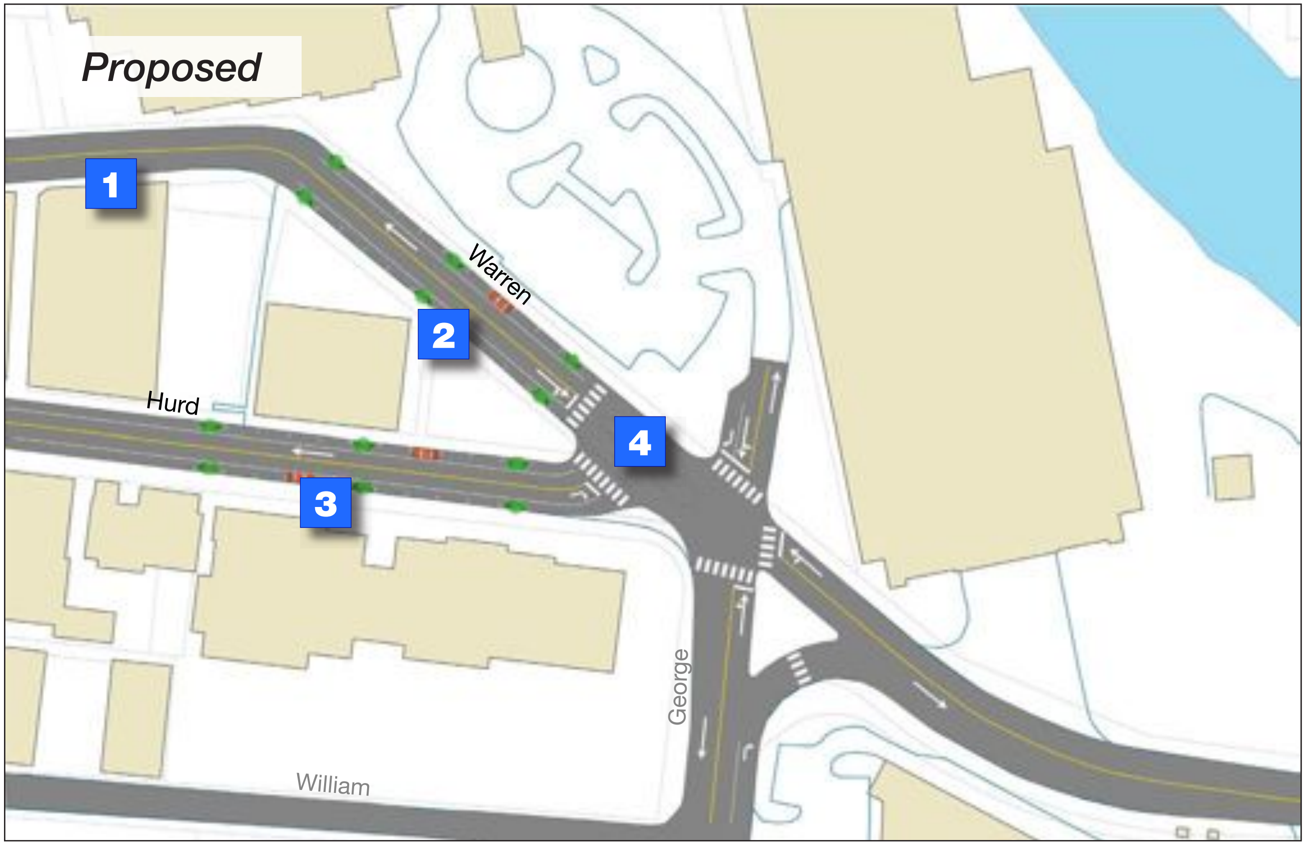
As noted, half of the east sidewalk and the entire west sidewalk of Prescott Street, both only 5 feet wide, would remain unchanged. Because they are located directly against sometimes fast-moving traffic, these sidewalk edges should be protected by metal bollards.

3.11 Warren and Hurd Streets



While most of the neighborhood east of Central Street is not particularly walkable, one key opportunity for improvement exists in the one-way loop of Warren and Hurd Streets. These streets' one-way configuration and suburban geometries can fairly easily be returned back into a more urban two-way pattern befitting the important uses along them.

Hurd Street is currently configured for eastbound one-way traffic. Warren Street is marked with conventional yellow lines indicating a separation of travel directions, but it functions effectively as a westbound one-way street. The intersection of Warren and Hurd is also confusing in terms of traffic movement and operations. A raised median currently separates Warren's two travel lanes with signage indicating that motorists should use the right lane when leaving the intersection. Perhaps more significantly, the current roadway configuration, with its swooping median, introduces a suburban highway-design vocabulary that communicates a higher-speed automotive environment. As described in Chapter 10, the reintroduction of traditional urban street design in this location would extend the walkable downtown core to include the important UMass Inn and Conference Center and the UTEC facility to its south.



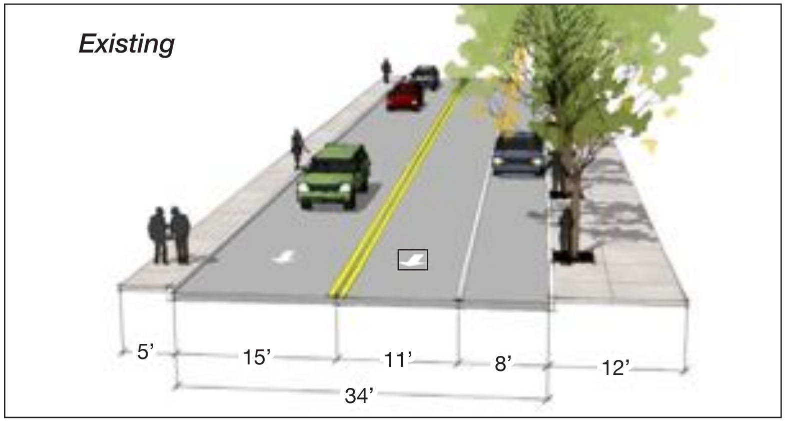
To provide improved driver access and a more accommodating pedestrian environment, both Hurd and Warren should be converted to two-way traffic operations, and should add supplemental on-street parking. The alignment of Hurd could also be changed to lessen the skew of the intersection angle, formalizing a 'T' intersection at Hurd and Warren, but this change is not necessary.

When these low-volume streets reach Central Avenue, their westbound movements can easily be accommodated with a single lane. While replacement of this one-way loop with a two-way pair does introduce more turning motions onto Central Street, these motions are not expected to cause many delays because—as mentioned—congestion in this area is the result of storage limitations, not roadway capacity. When a similar conversion occurred at Appleton and Middlesex Streets, traffic on Central was not adversely impacted.

Key Recommendations

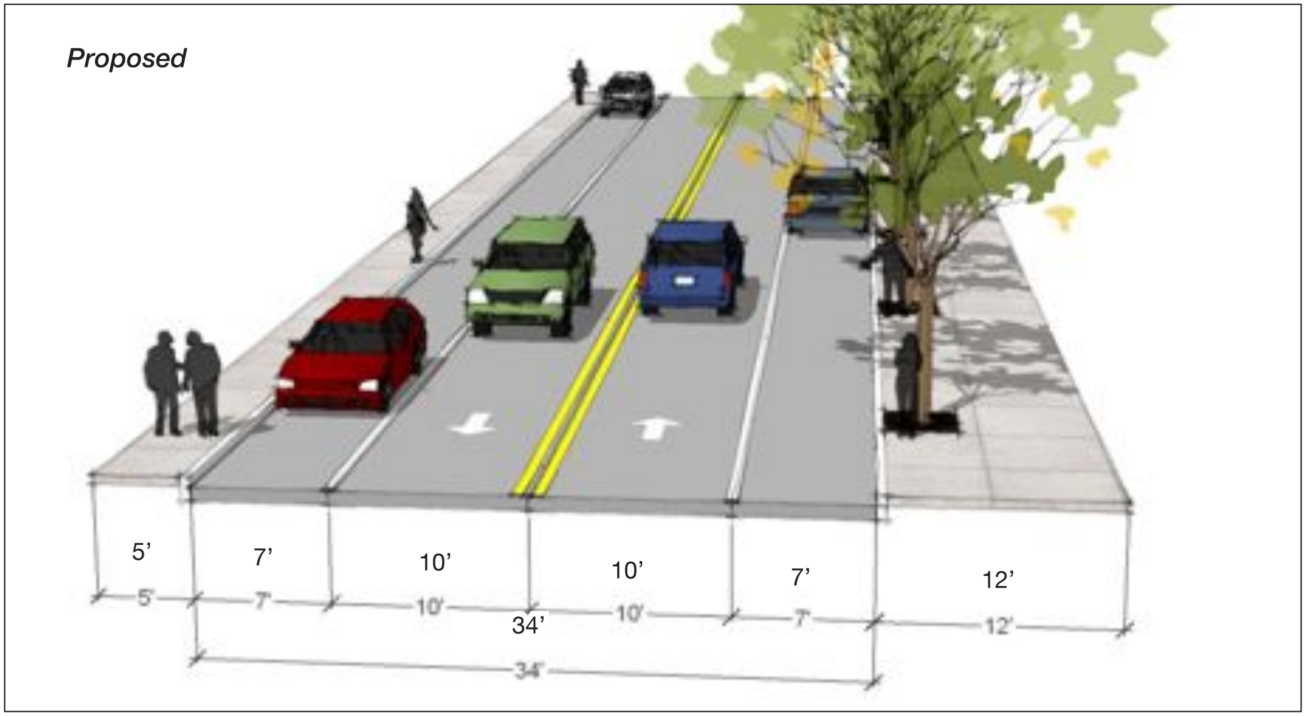
1. Two-way Warren with existing travel lane dimensions
2. Parking on both sides of Warren where space allows
3. Two-way Hurd Street with slow-flow dimensions
4. Refined intersection design: eliminate Warren median, realign Hurd into a right angle (optional)

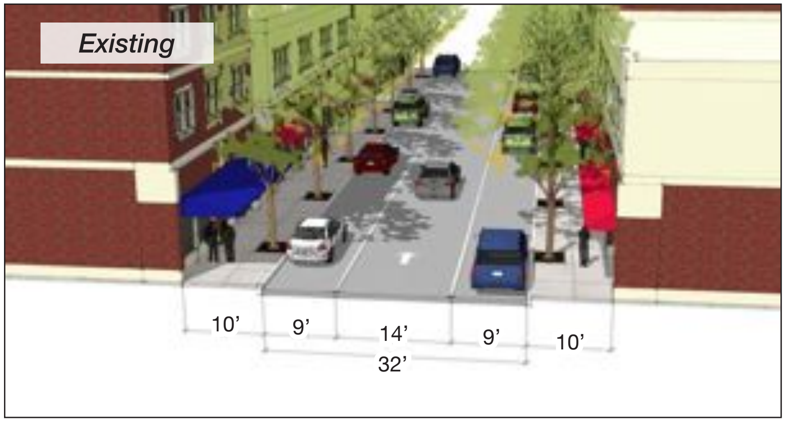
Warren and Hurd Streets



WARREN STREET AT HURD

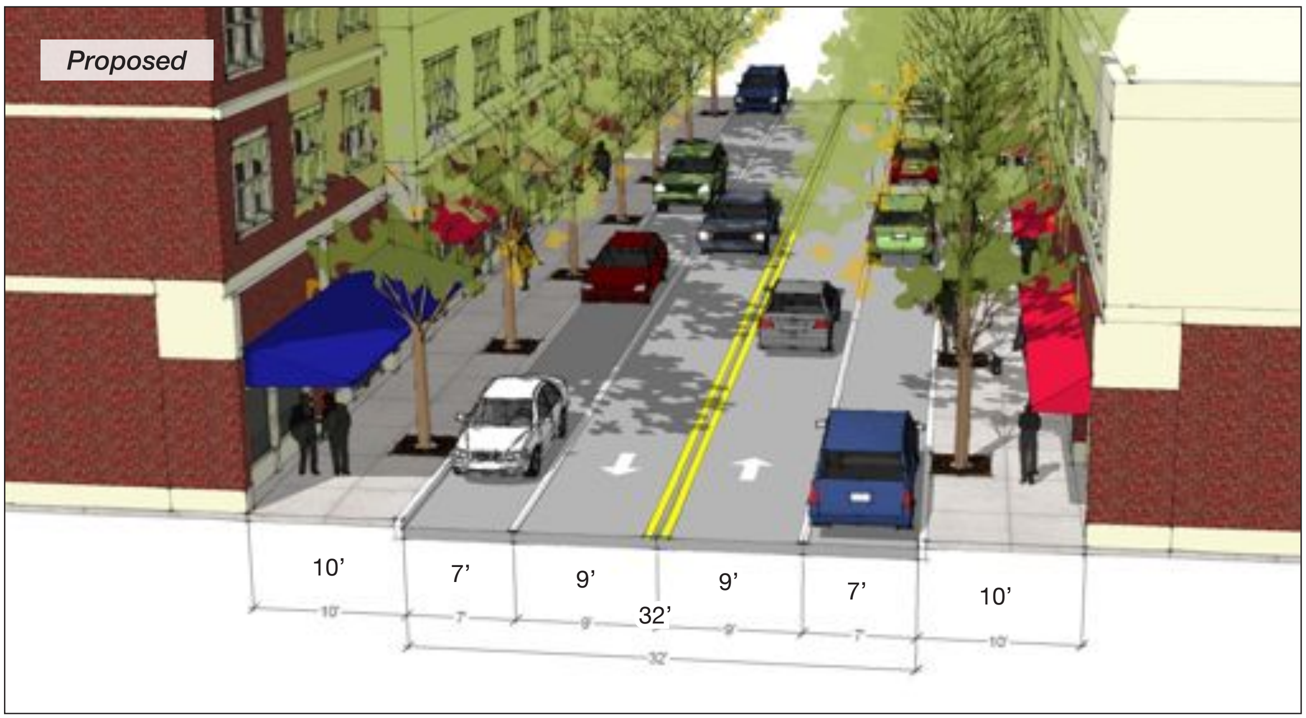
North of Hurd Street, Warren's current width will accommodate two 10-foot travel lanes and 7 feet of on-street parking on both sides of the street. As it heads toward Central Street, the curb-to-curb dimension gradually narrows. Once this dimension drops below 34 feet, parking would be limited to the north side only. Once it drops below 27 feet, parking would end.



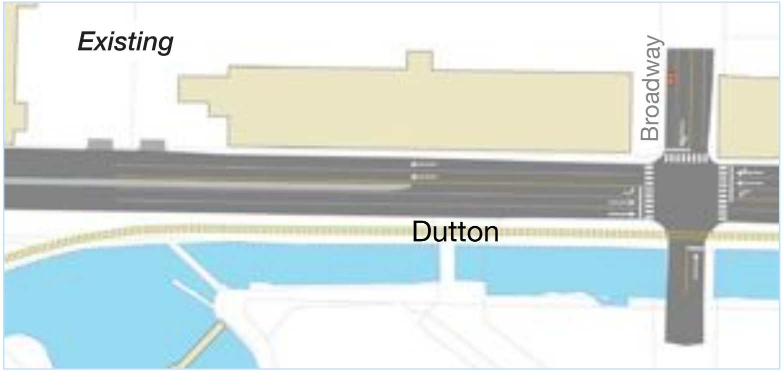


HURD STREET

Hurd Street is currently a single eastbound travel lane with parking on either side. The width of the travel lane and absence of oncoming traffic allow parking to take up more space in the cartway than needed. This street can comfortably be converted to two-way travel, taking advantage of a slower-speed 9-foot lane width dimension. Given the limited traffic flow, this dimension will not provide undue friction. A similar roadway dimension functions effectively on Central Street south of downtown.



3.12 Dutton Street

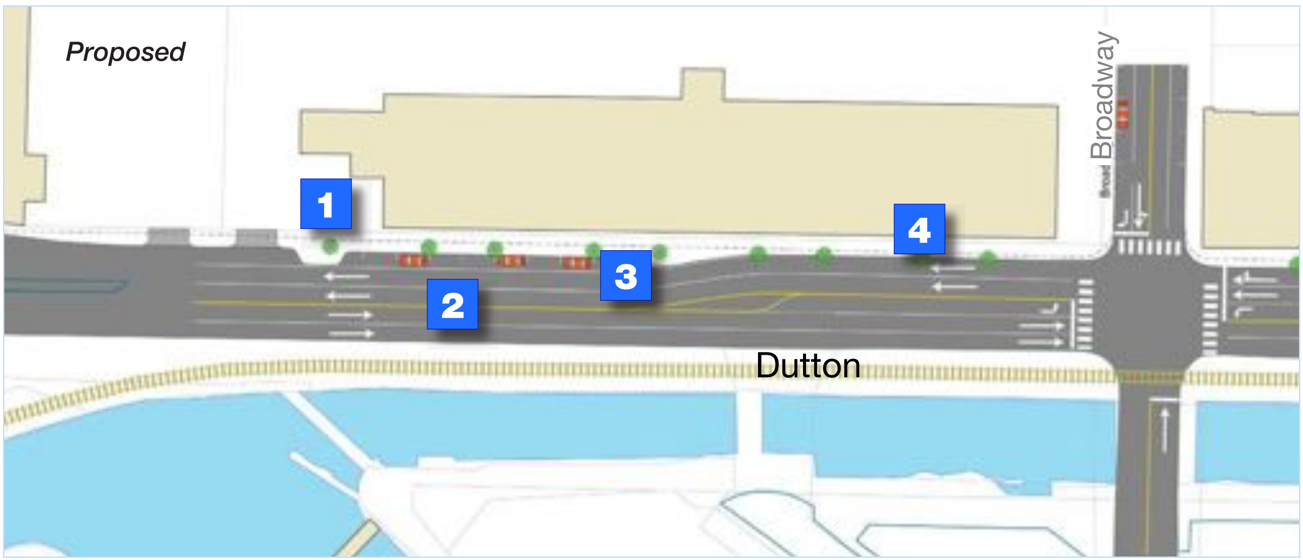


Location in Downtown Lowell

Dutton Street is one of downtown Lowell's major access points to the regional transportation network. In addition to connecting to the Lowell Connector expressway, it also provides the most direct connection from downtown to the Gallagher Intermodal Transportation Center and its MBTA commuter rail service connecting to Boston. It carries more car trips in and out of Lowell than any other individual route.

Unfortunately, it is also a significant pedestrian corridor, as it connects downtown to the Lowell Sun Building, which contains a major tourist destination, the American Textile History Museum. It does this along what may be the most inhospitable sidewalk in Lowell, 5 feet of treeless concrete sandwiched between a building wall and four to five lanes of high-speed traffic. This is not a walk that many pedestrians choose to make twice.

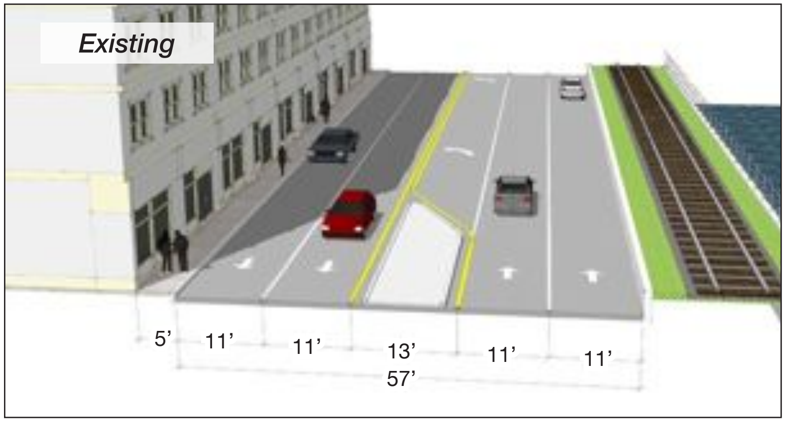
For this reason, the western sidewalk of Dutton Street from Fletcher to Broadway is recommended for one of the more expensive retrofits in this Plan. A recent reconstruction of the adjacent block, from Broadway to Market, shows what a difference a few feet of sidewalk can make when planted with continuous street trees. A similar solution is proposed for this next block, made possible by reducing the driving and turn lanes to a standard 10-foot dimension, and by eliminating the highway-style concrete median. Shortening this median, which invites highway-style driving, will also reduce speeding in this location.



Key Recommendations

1. Current section resumes at Textile History Museum driveway
2. Existing roll-curb median is removed and width transferred to sidewalk
3. Parallel parking placed where allowed by road width.
4. Properly-sized travel lanes allow a curb extension with trees to protect the sidewalk.

Dutton Street



Dutton from Market to Broadway has been vastly improved by a consistent tree planting.

As indicated in the plan drawing, 10-foot travel lanes allow for a wider sidewalk and street trees to be introduced as far north as Broadway. This sidewalk widens as the Broadway left-hand turn lane drops out, and eventually contains enough extra width to include parallel parking against the curb, protected by bulb-outs. This proposal calls for the complete reconstruction of the curb from Fletcher to the Lowell Sun building, but it transforms a memorably unpleasant walk into something much more palatable.

3.13 Father Morrissette Boulevard

Although the apocryphal vision of the 1960s plan for downtown Lowell thankfully never came to pass, it was initiated, with the construction of Father Morrissette Boulevard from University Avenue Bridge to Lowell High School. Along this trajectory, its 5-lane cross section and high-speed geometrics were appropriate to an urban expressway that was intended to circle the entire downtown. But construction then stopped, and the city was left with a roadway that lacks the continuity that would have justified its high volume, high-speed design. As a result, it has wisely been determined that this street can be rebuilt as a lower-speed 3-lane boulevard in conjunction with the construction of the proposed downtown circulator trolley.

The proposal presented here is only meant to be completed hand-in-hand with this major transit investment. In the true spirit of urban triage—please see Chapter 8—this Plan recommends that Father Morrissette Boulevard not receive a penny of local investment otherwise, because it is so poorly equipped to attract pedestrians on its own merit, it is not essential to the creation of an effective downtown pedestrian network, and it can only be reformed with a tremendous amount of public and private dollars. This money is best spent elsewhere—unless it arrives in the form of transit funding.

In optimistic anticipation of such funding, the pages that follow show a full portfolio of solutions for remaking Father Morrissette Boulevard along a right-of-way that varies from over 100 feet to as little as 60 feet in width. The drawings address this range of cross sections by applying a kit of parts that accumulate or drop off as the right-of-way grows or becomes smaller. Cumulatively, these parts all add up to a luxurious tree-lined transit boulevard with a broad median, turn lanes, bike lanes, and parallel parking. When there is not room for every part, it is important that the excluded parts drop off in the proper order.

The kit of parts functions as follows:

• Two minimum sidewalks over bridges	@5' each	+	
• Two bicycle lanes	@5' each	+	
• Two driving lanes	@10' each	+	
• Median double-tracked for streetcars	@20'	+	S
• Two expansions to sidewalk including street trees	@5' each	+	M
• Expansion to median including two turn lanes	@10' each	+	L
• Two parking lanes	@ 8' each		XL

Each underline in the above kit represents a decision point, such that four different outcomes—Small, Medium, Large, and Extra Large—are possible based on the available right-of-way. Adding up the above parts shows that the required R-O-W widths are as follows:

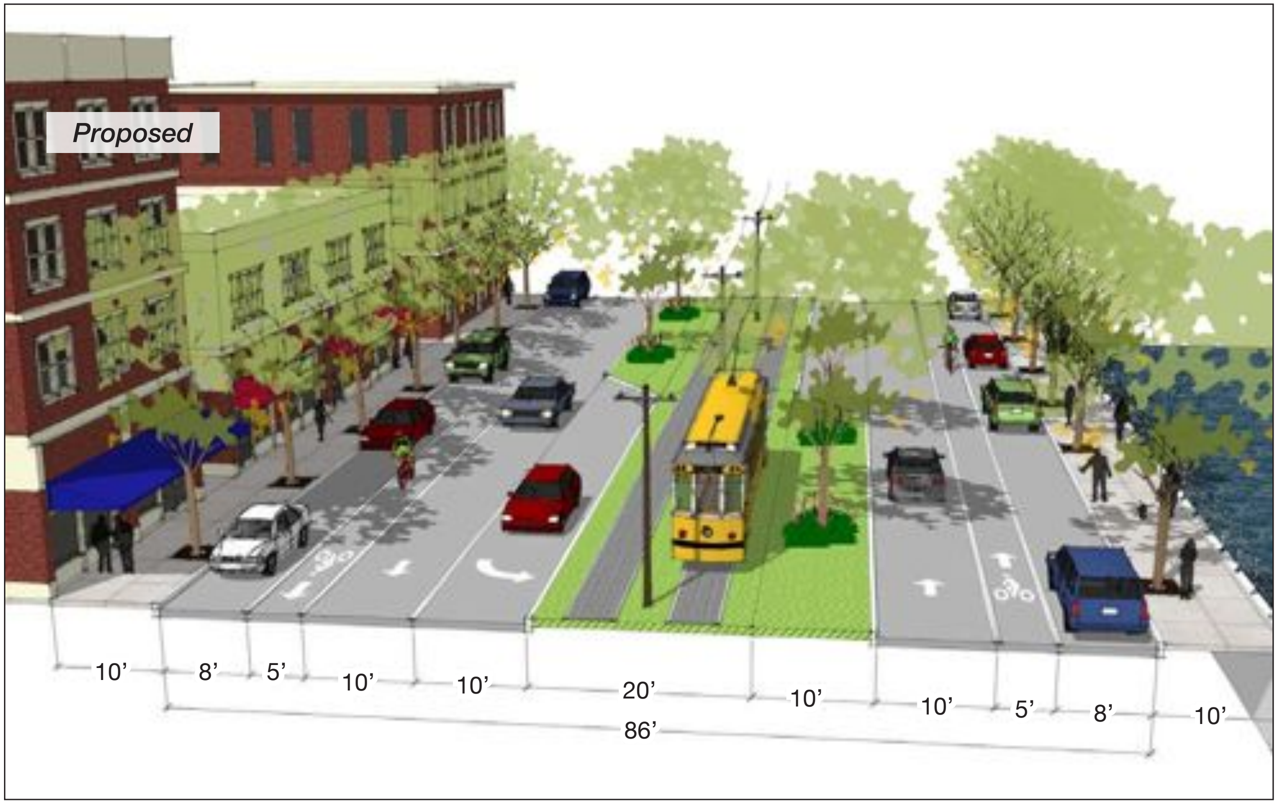
- Small 60' min.
- Medium 70' min.
- Large 90' min.
- Extra Large 106' or more.

The four above options are illustrated in these pages. There are, of course, intermediate solutions. For example, any R-O-W above 60' should have broader sidewalks, and a right-of-way of 98' would include a single parking lane instead of two, recommended for the southern curb. These decisions must be made judiciously, with excess unused R-O-W being contributed to the median so that the other street dimensions remain consistent

Father Morrissette Boulevard

EXTRA LARGE

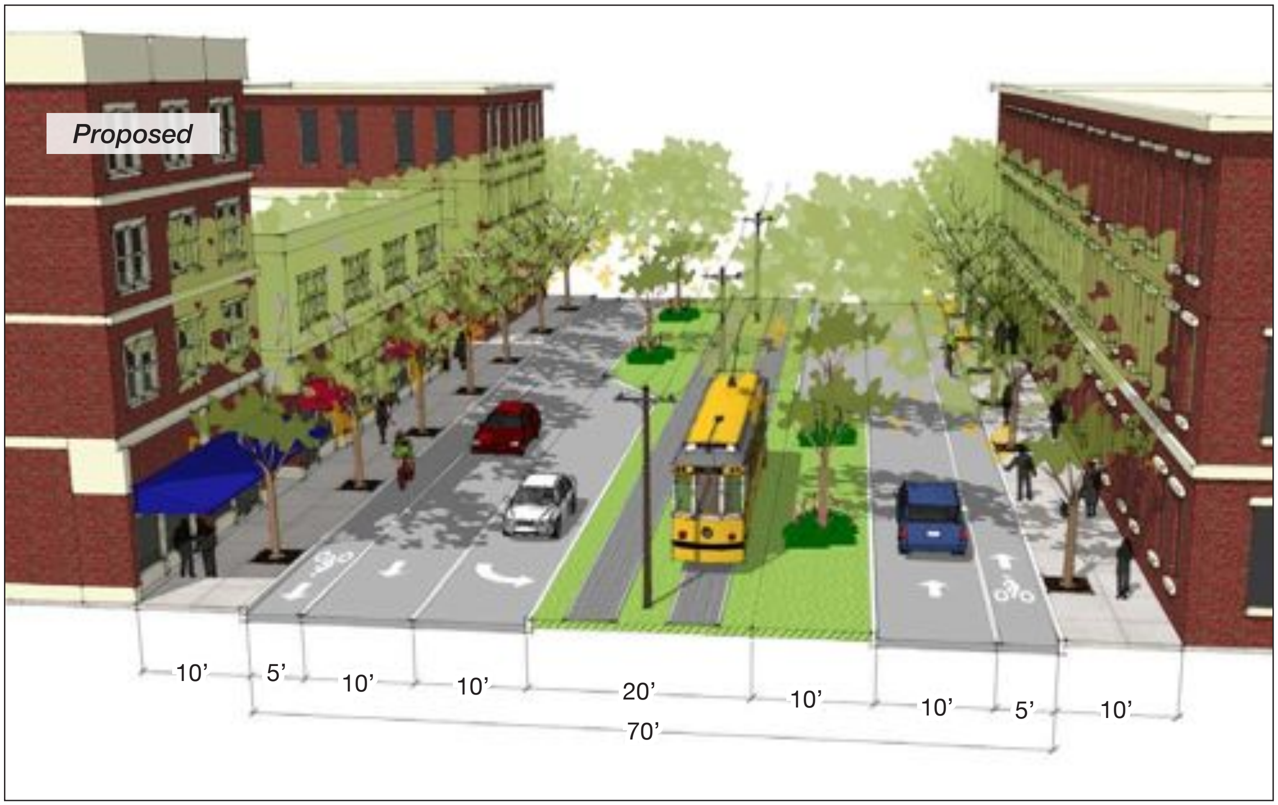
At its widest, Father Morrissette has adequate dimension to accommodate double-tracked trolley in a median alignment with additional space to hold left turn lanes as needed at intersections. As shown in the bicycle plan, it also carries on-street bicycle lanes.



Where the trolley alignment joins Father Morrissette Boulevard, the combined rights-of-way of both trajectories are available as a corridor for a complete street with a streetcar median.

LARGE

In sections where right-of-way is constrained below 100 feet, on-street parking should be eliminated, first on one side, then on both. All other street elements remain.



Elsewhere on Morrissette, the trajectory narrows and broadens, requiring a variety of solutions achieved by a cumulative kit of parts.

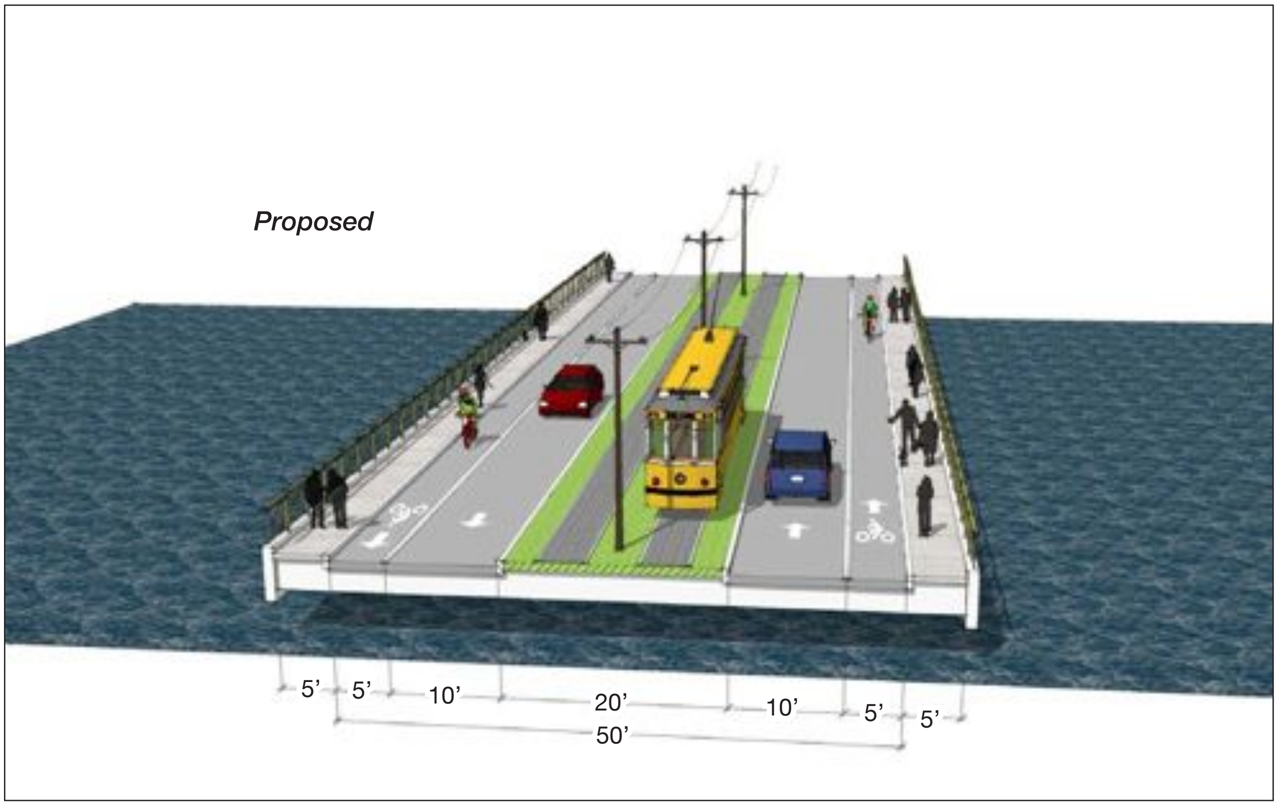
Father Morrissette Boulevard

MEDIUM

At certain locations, the right-of-way is further constrained below 90'. In these places, the median is narrowed to as little as 20' through the removal of left-hand turn lanes.

SMALL

Finally, at the pinch point across the Western Canal bridge, sidewalks should be reduced to 5 feet in width so that the existing bridge structure need not be enlarged.

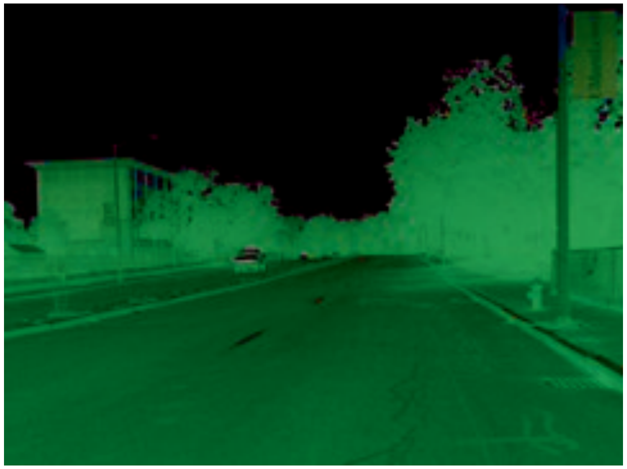


Father Morrissette Boulevard

A Shorter-Term Solution

As noted, the above plans are based on the construction of a streetcar and, without one, significant investment in Father Morrissette Boulevard is not recommended. However, given that it is currently oversized for its traffic, encourages speeding, and has roadway available for more productive uses, it is recommended that a restriping regime be implemented in conjunction with the other short-term reconfigurations presented above.

Currently, the typical Boulevard segment contains two 24-foot-wide halves, each of which holds two 12-foot travel lanes (plus turn lanes). Each of these halves should be re-striped to contain an 11-foot driving lane, a 7-foot parking lane, and a 6-foot bike lane. The parking lanes would be available for use by the high school and by overflow visitors to the Tsongas Arena and Boarding House Park, taking pressure off the Ayotte Garage. The bike lanes would immediately introduce a key component of the Bicycle Network without having to wait for the construction of a streetcar. This restriping could be accomplished for the cost of paint alone, without even requiring revised signals.



In the short term, each 24-foot-wide segment of Morrissette should be restriped into one travel lane, one bike lane, and one parking lane.

The 13 proposed reconfigurations are presented in the current order for a reason. Items 1 – 4 (below) represent a comprehensive reconfiguration of the circulation system, and must be accomplished in tandem. Items 5 – 9 are paint-only road diets that introduce bike lanes and more appropriate driving speeds to inefficiently striped streets. These should also be completed in tandem, to establish a meaningful bicycle network. Finally, items 10 – 13 are individual construction projects of higher cost that can be accomplished independently from one another.

While the first 12 projects would ideally be completed quickly, it is reasonable to consider the first 9 projects as short-term, since they are the most important and the least expensive. Projects 10 – 12 can be considered mid-term, since they are independent and more expensive. Father Morrissette Boulevard is a long-term project—but only as long as it takes to build the streetcar.

SHORT TERM
Circulation:

1. Market Street: converted to two-way.
2. Shattuck Street: converted to two-way, and flow on Middle Street reversed.
3. Central Street: converted to two-way and one parking lane added.
4. Ladd and Whitney Monument Square: Worthen and Merrimack segments made two-way.

Restriping:

5. Merrimack Street: lanes resized to include a bike lane.
6. East Merrimack Street: one parking lane traded for two bike lanes.
7. West Merrimack Street: lanes resized to include bike lanes.
8. French Street: lanes resized to include a parking lane and two bike lanes.
9. Arcand Drive: lanes resized to include bike lanes.

9b. Short-term revision to Father Morrissette Boulevard (see 13): two travel lanes traded for two parking lanes and two bike lanes.

MID-TERM
Independent Construction Projects:

10. Prescott Street: one travel lane partially converted to parking and widened sidewalk.
11. Warren and Hurd Streets: converted to two-way; parking and urban geometrics added.
12. Dutton Street: widened sidewalk and parallel parking added where possible.

LONG TERM

13. Father Morrissette Boulevard: redesigned as complete street including a streetcar (long-term). Short Term: Two travel lanes traded for two parking lanes and two bike lanes.

A final note: a number of downtown wayfinding signs appear to be damaged or missing. The traffic reconfigurations recommended here should include a budget for upgraded wayfinding facilities.

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While street design has a tremendous impact on the livability of a city, it would be a mistake to overlook traffic signals and crosswalks, which often provide a quick and relatively inexpensive way to make a downtown more welcoming. This is especially the case in places such as Lowell, where there is considerable room for improvement in the four categories of *Synchronization, Cycle Length, Signalization Regime,* and *Crosswalk Provision.*

Synchronization

Synchronization refers to the coordinated timing of traffic signals to allow drivers moving at a reasonable speed to encounter fewer red lights along heavily traveled paths. The proper synchronization of signals in downtown Lowell, particularly along the often-congested Dutton and Bridge Street corridors, has been discussed for many years, perhaps most prominently in the Urban Land Institute downtown study of 2003. Given the relatively minor cost of electronic synchronization when compared to road reconstruction, it is disappointing that no action has yet been taken on this recommendation. That said, it is also fortunate, as any recent investment in signal patterns would have been made obsolete by the more comprehensive reconfigurations recommended in this Plan.

The Dutton-Thorndike corridor is often cited as in need of synchronized signalization.

Some Lowellians have joked that signal synchronization has not been achieved in the past because it is not expensive enough. Certainly, it is sometimes easier to garner public support around bigger, more transformative ideas. The issue is raised again here just so that it is not forgotten as this Plan is implemented. The traffic and signalization recommendations contained herein are somewhat dependent upon the initiation of a properly synchronized system, which will add only marginally to their overall cost.

Cycle Length

Many of the streets in Lowell, particularly the one-way streets, have traffic signal timing focused on moving large volumes of cars very quickly. This practice has become a common approach to urban mobility throughout North America, and grew in prominence as automobile ownership increased throughout the twentieth century. One tool used to accomplish this goal is the long signal cycle. Increasing the overall cycle length has the advantage of moving large volumes of cars on each approach, especially when multiple signals along one-way streets can be timed in coordination with one another to facilitate the movement of 'platoons' of traffic. By the same token, however, these longer periods of vehicle movement mean longer waits for pedestrians trying to cross a street and longer periods of delay for vehicles who do not have a green light.

Indeed, for pedestrians, long signal timing is more than just an inconvenience. When considered over the scale of an entire walking trip, it significantly reduces the reasonable walking reach of an area within a given frame of time. In some cases, the need to reach a destination quickly may prompt pedestrians to walk against the direction of a signal, creating potential safety problems and conflicts with vehicles.

For the above reasons, it is recomended that signal timing throughout the downtown be calibrated so that no complete cycle lasts longer than 60 seconds.

Signalization Regime

The two most common crosswalk signalization regimes in cities are known as *concurrent* and *dedicated*. Concurrent signalization describes the system in which crosswalks receive a Walk signal when the cars heading in a parallel direction receive a green light. These systems are the norm in most older, walkable cities like Boston and Chicago. They require turning cars to wait for pedestrians in crosswalks, which only becomes a traffic impediment in areas of pedestrian crowding. Dedicated signalization describes the system in which pedestrians wait for traffic in both directions to complete their cycle before receiving a signal to cross, typically in either direction. These systems are the norm in more auto-dominated cities like Oklahoma City and Scottsdale, where few people walk, and an avoidance of friction at intersections has been given the highest priority. Unfortunately, this system is also the norm in downtown Lowell.

Pedestrians' preference for concurrent signalization is well founded. Concurrent phasing offers walkers significantly more crossing time than dedicated phasing. In addition, most pedestrian paths across a city are not due north, south, east, or west, but diagonal. With a standard concurrent signalization regime, they can usually keep moving at intersections by crossing in the direction allowed. In contrast, being asked to stand still for long periods is extremely frustrating. Forced to wait longer than they are willing, many pedestrians simply jaywalk. While it may have been invented in part to protect pedestrians, the dedicated crossing signal instead implies that they are second-class citizens.

The same is true of pedestrian push buttons. They are a sign that the automobile dominates, and they cannot be found in significant number in New York, San Francisco, Washington, or anywhere else with a walking culture. Pedestrians should not have to ask to cross a street. But perhaps more significantly, visually disabled pedestrians, more than a few of whom frequent downtown Lowell, find them extremely dangerous. The buttons are often hard to find and, once pushed, do not operate with consistent timing. As a result, the sightless pedestrian cannot know whether the lull in traffic noise she hears is the result of a red light or simply a gap in high-speed traffic.

Lowell's push-button signalization regime creates an environment of pedestrian inconvenience.

For all of these reasons, downtown Lowell's current push-button dedicated signalization regime should be replaced in short order with a standard concurrent system. Dedicated phasing will still remain useful in certain auto-dominated locations within Lowell, but none of these can be found within the study area of this Plan.

Crosswalk Provision

Pedestrians typically have a limited range in which they are willing to move before selecting another travel mode for their trip. Given this limited range, they need significant flexibility in routing and, in a city, this means they need frequent street-crossing opportunities. A standard walkable city block is between 250 and 500 feet in length. Whenever blocks—or crossing opportunities—are further apart than this, pedestrians will either jaywalk or simply abandon the idea of walking altogether. In downtowns where geographic constraints or historic buildings prevent the introduction of smaller blocks, cities should take pains to create mid-block pedestrian crossings. One key location for such a crossing is on Prescott Street, where Middlesex Community College students must jaywalk across a dangerous traffic flow if they are to move directly between their two campus locations.

Other sites also deserve attention, but it is most effective to have a standard policy in place to introduce a mid-block crosswalk on every downtown street where existing crosswalks are more than 600 feet apart.

On a more fundamental level, many intersections downtown, including some that receive large amounts of pedestrian traffic, are missing crosswalks and signalization. Prescott and Central, for example, both lack key western crosswalks at Merrimack Street. These missing crosswalks, which force some people to cross east in order to then head west, inconveniences pedestrians in order to enhance vehicle flow. This approach has been rejected by cities that have tried it, like New York, due to pedestrian complaints.

In addition, there are a number of pedestrian crossing signals whose timing is simply in error. These should be fixed quickly, in anticipation of system-wide reform. For example, at the intersection with Merrimack Street, pedestrians are not allowed to cross Prescott Street when only Bridge Street has a green light, even though there is no possibility for conflict at that point in the cycle. Finally, as required by law, every pedestrian crossing location downtown demands adequate handicap facilities. Handicap ramps are missing at Central & Warren, French & Bridge, and elsewhere. A full crosswalk and handicap ramp inventory should be completed in conjunction with the initial implementation of this plan.

Merrimack's west crosswalk at Central Street is one of several key locations missing pedestrian signals.

The above modifications represent an improvement that will allow downtown crosswalks to meet a reasonable standard of safety and walkability. However, as more funds are made available, additional modifications could make street crossings even more inviting and safe for pedestrians. The ideal crosswalk is not painted, but constructed of a contrasting material at a level a slightly above the road surface, where it causes turning drivers to proceed with greater caution. This type of crosswalk is ideal along (parallel to) a major street like Merrimack, where large volumes of pedestrians cross the intersecting streets of Prescott, Central, Front, etc. Similarly, as they age and become obsolete, all pedestrian signals should be replaced with the latest technology, which currently uses a numerical countdown rather than a flashing hand.

Despite its healthy urban fabric, Lowell could still be described as a driving city. The current LRTA bus system, while fairly extensive and well run, serves principally those for whom driving is not a readily available option. This situation is the norm in most mid-size American cities, where traffic is not punishing enough nor parking expensive enough to make transit a preferred alternative. Few of these cities, however, share Lowell's potential for changing their transit service from a system of need into a system of choice.

The proposed expansion of the current Park Service trolley system into a modern streetcar holds considerable promise as a transformative investment in the city's future. This chapter discusses such a trolley system's *drivers, requirements, benefits,* and *funding.*

Streetcar Demand Drivers

The large *student population,* the compact and generally *pedestrian-friendly downtown,* and the presence downtown of *key anchors* like the Gallagher Intermodal Center and the Tsongas Center are all factors that predispose Lowell to a more robust transit future.

Student Population

Given their younger age, limited incomes, and greater tendency to walk and bike, students are natural transit riders. In downtown Lowell, three distinct student populations are poised to take advantage of an expanded transit system, each for different reasons:

Three generations of public transportation in Lowell.

- Lowell High School students already make good use of the LRTA system, which takes the place of what would otherwise be a massive yellow bus program. Few cities of Lowell's size experience this phenomenon, which is a positive outcome of the high school's downtown location. The currently proposed path of the streetcar down Father Morrissette Boulevard makes it ideal for serving this population. A quick rail connection to the Gallagher Intermodal Center would make transit a more compelling choice for these students, a large proportion of whom currently drive or are driven to school. Increased high school transit ridership would also remove some student and parent cars from downtown streets and parking lots.

- The student body of Middlesex Community College is currently 100% commuters. These students spend an inordinate amount of their income (or savings) on transportation, and many of them spend two hours a day or more in traffic. Clearly, improving the connection from the Gallagher Intermodal Center to the heart of downtown would create a greater ridership among MCC students, many of whom would experience real financial and quality-of-life benefits from being able to efficiently commute without driving.

- The single greatest potential audience for a downtown trolley is the students at UMass Lowell, whose daily routine often takes them around three different campuses (North South and East) as well as to the new Inn and Conference Center on the Lower Locks. It is expected that a downtown trolley would replace a dominant portion of the University's current bus service and, indeed, the latest design of the trolley route specifically works towards that objective. It would provide more consistent service than the current buses, which cannot help but get stuck in traffic during peak hours. And it would contribute significantly to the number of students who make use of the downtown, where uncertainty about parking—and re-parking on return—often discourages them from making the trip.

Transit

The latest planned streetcar route serves key anchors including the Gallagher Intermodal Transportation Center, UMass Lowell, Middlesex Community College, the Tsongas Center, and LeLacheur Park. The important Phase 2 Broadway extension is shown as a dashed line.

Pedestrian-Friendly Downtown

Almost every transit trip begins and ends as a walk. For this reason, new transit systems have failed to attract expected ridership in cities that offer a sub-par pedestrian experience. While this study is aimed at making downtown Lowell more walkable, it must acknowledge that a good portion of the areas to be served by the proposed streetcar are already decent pedestrian environments, if not excellent ones. The improvements suggested in this Plan will only make transit more likely to succeed.

Key Anchors

In addition to the Gallagher Intermodal Center and the academic campuses already mentioned, downtown contains a number of key anchors that are located at distances just far enough to greatly benefit from transit service. Most prominently, the Tsongas Center and LeLacheur Park frequently host the sort of large events for which attendees often seek alternatives to driving (and crowded parking). These are both located in good proximity to the proposed transit line. In addition, these destinations currently have few places to eat and drink nearby, so one can imagine the appeal of taking transit to a meal or drink before or after a sports event.

Streetcar Requirements

A properly executed system is one that provides a *comprehensive route, a comprehensible route,* and *frequent headways* around the clock.

A Comprehensive Route

If the new transit line is not long enough or located properly to carry a significant ridership to meaningful destinations, then it will not be useful enough to succeed. Such appealing but inadequate new systems have earned the pejorative moniker of "toy transit." It is to avoid this outcome that the current trolley route has been increased in length to reach all the way to the UMass South Campus. It should be noted that the proposed Phase II Broadway Extension, that provides efficient travel from points west to the Gallagher Intermodal Center, seems too important to be left out of phase I, especially considering its relatively low cost. Some people have suggested introducing a “trial run” public trolley along the current Park Service line, to gauge demand for rail transit downtown, but such a short route would only demonstrate its own limited value. Any new rail line must be comprehensive enough to serve a significant percentage of downtown visitors.

A Comprehensible Route

One of the reasons that people prefer rail to buses is that the route is fixed, and typically a simple line or loop clearly understood by riders. The currently proposed system is rather complex, so it is therefore essential that the path taken *by each train route* is uncomplicated and easily comprehended. Fare payment must also be made patently obvious, so that nobody is afraid to hop on board and find themselves without the proper means of payment.

Frequent Headways

It is easy enough to call for short waiting period between trains, only to have them lengthened as budgets inevitably tighten. For this reason, it is essential to state unequivocally that a streetcar system with headways longer than 15 minutes will fail to achieve its objective of becoming a transportation mode of choice, and should not be built. Most people will not look at schedules, and will not wait more than 15 minutes for a train—and this includes riders late at night, when the wait is perceived as more dangerous—so a solid 18 hours of short-headway service is essential. And for waits longer than 5 minutes, which are the norm, GPS-enabled time-to-train clocks should be placed in all stations.

Streetcar Benefits

The introduction of a modern streetcar could have a profound impact on the success of downtown Lowell. If properly executed, a new streetcar line would benefit the downtown initially as a driver of *development demand,* eventually as a creator of *development potential,* and ultimately as a key to the city’s *future competitiveness.*

Development Demand

It has been well documented in places like Portland’s Pearl District how the introduction of a streetcar has led to dramatic increases in land development,

GPS-enabled clocks informing passengers about wait times are standard equipment in new systems.

property values, and tax base in underdeveloped neighborhoods in proximity to new transit stops. This is not a foolproof formula, and the disappointing experience in cities like Memphis suggests that the success of a trolley line depends on certain preexisting demand drivers and on proper execution of the new facility, as described above. But, when these conditions are met, the new system’s first impact will be as an amenity that increases the value and development potential of properties along the line, particularly industrial and underutilized sites. This impact is useful in the context of project funding, but does not speak directly to the success of heart of the downtown, where most sites are already substantially built out.

Development Potential

However, in the longer term, this picture can be expected to change to the direct benefit of downtown. Currently, the greatest physical constraint to increased activity and development downtown is parking provision. During the day, existing commercial and institutional activity largely fills most of the City’s five major parking structures, and any future development will have to identify (and eventually construct) expensive new parking to serve its anticipated users. As improved transit service allows residences, businesses, and institutions to become less dependent upon parking provision, this major development constraint will become less dominant. The same circumstances surround traffic: as trolley service makes roadways more efficient, Lowell’s existing street network will welcome more visitors and process more commercial activity. It is for this reason that America’ most productive cities are those in which people make the choice to take transit.

Future Competitiveness

Ultimately, though, an investment in transit today is best justified in the context of the City's long-term prosperity. It is well understood that the coming age of post-peak oil will make private automotive transport prohibitively expensive for a dramatically larger number of Americans. These circumstances will give an economic advantage to cities that do not require their citizens to drive. Similarly, commercial hubs well positioned to provide goods and services without inordinate dependence on cars will be the winners in the competition for business location and investment. Lowell has already remade itself once to remain a vital city despite the end of the industrial era and the disappearance of its original reason for being. The next great economic transformation will require a less profound transformation, but one that includes a more robust transit infrastructure.

Streetcar Funding

Given renewed federal support for transit—and the availability of other tools including Tax Increment Financing and Special Assessment Districts—the construction of the system is generally considered less difficult to finance than its operation. While additional funding sources will have to be identified, the following institutions should have reason and capacity to support the operation of the streetcar:

- UMass Lowell spends about $700,000 annually on its bus and shuttle system, much of which could theoretically be eliminated with the introduction of a streetcar.

- The Park Service spends about $300,000 annually on the operation and maintenance of their trolleys, which would be replaced entirely by the new system.

- The streetcar would probably allow for the elimination of the LRTA's downtown shuttle, downtown circulator, and perhaps other routes as well. The funding for those routes could be shifted to rail.

Even with all of these funding sources, the system is predicted to require a higher than average amount of subsidy unless additional sources can be identified. Given that transit success is tied to ridership, it is recommended that the City consider enacting a Transit Benefit Ordinance like the ones that have been implemented in such places as San Francisco and Chicago, in which employers of a certain size are required to offer a transit benefit program to employees. Far from hurting businesses, these programs take advantage of payroll tax benefits to reward companies that support employee transit use. More information about these programs can be found at *transitbenefitordinance.com.*

Investment in a modern streetcar line has contributed significantly to vitality of downtown Portland, Oregon.

Additionally, for both construction and operations, the City may wish to consider a new financing technique recommended in a recent report from the Brookings Institution. Their unprecedented but promising proposal is for a limited-partnership contractual vehicle that allows cities to share in the property value increases that are caused by the rail construction. More on this proposal can be found in the Brookings' report: "Value Capture and Tax-increment Financing Options for Streetcar Construction."

Implementation Concerns

It is very easy to support a new streetcar as the right thing to do without fully considering the needs and the capacity of the institutions that are going to be asked to make it happen and then to make it run. In the case of Lowell, it is likely that the streetcar would be the responsibility of the Lowell Regional Transit Authority, an organization that does its job admirably but is constantly strapped for cash and, in the words of its director, "barely surviving." If the LRTA is to be asked to implement such a system, which is well outside of its experience and expertise, it must be provided with the resources it needs to do that job well without harming the financial well being of the institution.

In that light, it should not be taken as a foregone conclusion that the responsibility for the streetcar should fall to the LRTA, or the LRTA alone. Other players, including the City, the National Park Service, and NMCOG could potentially play a role, as could a new entity created explicitly for this sole purpose. As it proceeds, the study of streetcar implementation should approach this question of stewardship flexibly.

Finally, it must be noted that the Lowell streetcar is a proposal that has been much studied and much debated for many years. Over that time, federal funding for such facilities has become less available, then more available, and may soon become less available again, with none of it going to Lowell. Moreover, the citizens of Lowell seem to have reached a point of trolley discussion fatigue, where any further public discourse of the matter will have to be met with decisive action or be dismissed as time and money wasted. With that challenge in mind, it is recommended that City leadership make a firm decision by January of 2011 to move full-speed-ahead on a modern streetcar or to publicly reject the proposal as unfeasible.

The city's Riverwalk and Canalway systems, which are best conceptualized collectively as a single network, make a strong contribution to the downtown that has the potential to be even stronger. The Park Service's current improvements to the Western Canal will make a big difference in the attractiveness of the system, and several of the interventions ahead are intended to make fuller use of this unique asset. However, the system will not achieve its full potential until it becomes *more continuous,* with *better wayfinding, better visibility,* and *more frequent and attractive gateways* into walkable neighborhoods.

More Continuous

Walkway systems can be used in three different ways: as recreational circuits for walking and jogging, as convenient paths between destinations, and as destinations unto themselves. Right now a limited number of people treat these walks as destinations—

The Riverwalk and Canalway systems provide an appealing alternative path through the downtown.

The continuation of the Riverwalk eastward around the Massachusetts Mills will better integrate it with the Canalway and connect it to regional trails to the east.

for fishing and hanging out—and also as recreation circuits, and a yet smaller number of people use them as convenient pathways. This last category is the most tenuous, because people who walk for mobility do not feel fully safe on these paths unless they are relatively well populated; and they will not be better populated until they are more useful as recreational circuits, something that is limited by their lack of continuity.

Currently, the incomplete nature of the system—particularly where the Riverwalk ends at the Boott Mills—is preventing it from achieving the critical mass of visitors that would make it successful. While the means at its disposal are limited, the City needs to maintain a high priority on the completion of the planned Riverwalk as it passes the Massachusetts Mills, rounds the peninsula at the confluence of the Merrimack and Concord Rivers, and connects back into the Lower Locks Canalway. With this important connection added, the system would be more useful as a recreational circuit, and would begin to attract a healthier population.

Additionally, Lowell's as-yet-incomplete connection to the 200-mile Bay Circuit Trail begins just across

Boston's freedom trail is easy to follow thanks to inlaid bricks.

the Concord River from the Lower Locks, so connecting the Canalway and Riverwalk system to the east would make it a part of something much larger, and thus all the more useful. Incidentally, Lowell is the unfortunate owner of one of very few remaining gaps in this regional trail. The map of that trail, in which gaps are shown in red, suggests that this item belongs on the front burner.

Better Wayfinding

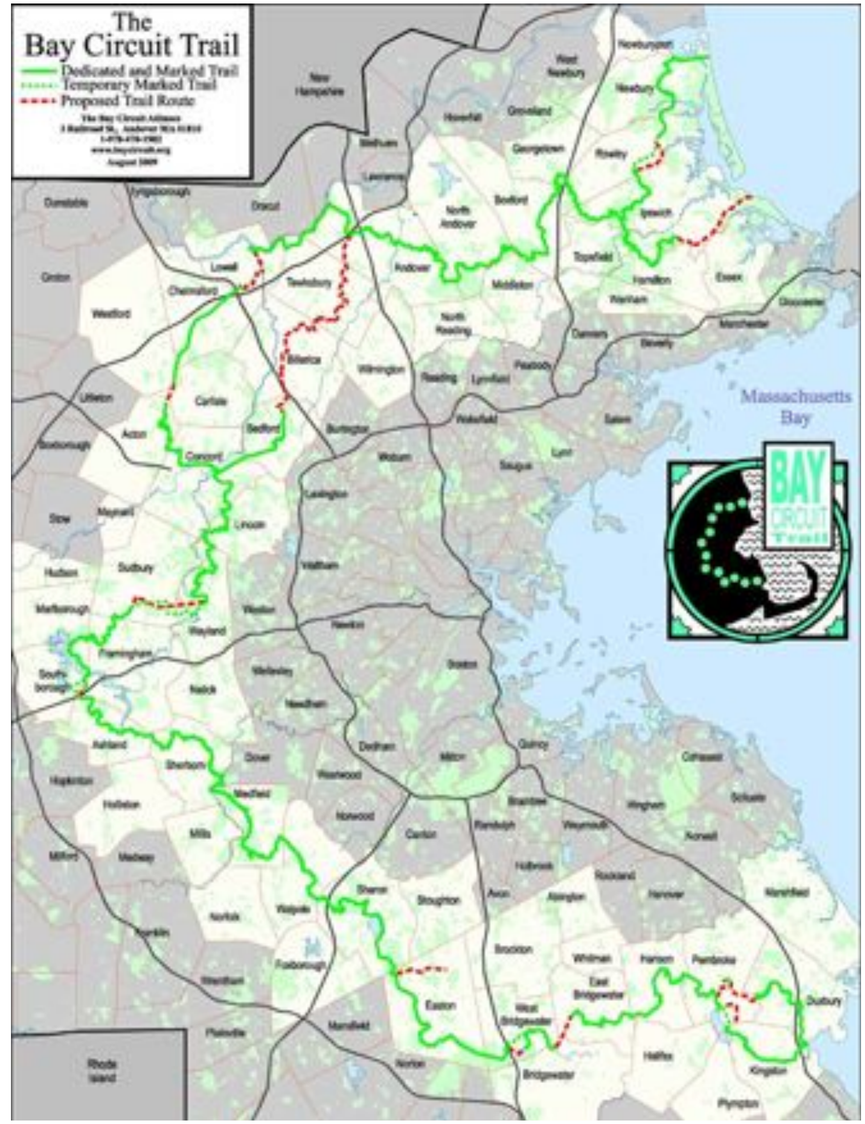
While the occasional maps along the Canalway are fairly clear, not everyone can read maps well, and fewer people yet take the time to do so. The most effective circuits, like Boston's Freedom Trail, have a continuous physical feature, like inlaid bricks, that make the route clear. In the case of Lowell's Canalway system, such a feature would be especially useful in places where the circuit does not line a canal, such as along Market Street.

Better Visibility

Many people are reluctant to walk on the Canalway and Riverwalk because they do not feel that they are safe there. Just as cities benefit from "eyes on the street," walkways are made more safe by "eyes on the path," windows and doors that offer the possibility that one is being observed. While such an arrangement is not possible along the full walkway system, there are several places where the removal of a wall or the construction of a new building would greatly enhance the perceived safety of a segment. Several of the interventions proposed in Chapters 9 – 13 are motivated in part by this objective.

Frequent Attractive Gateways

People are more likely to use a walking trail if it is easy to get to, and if the walk to it is appealing. For most of its length, the Canalway is fairly easy to get to, although the buildings that line it could be further encouraged to open directly onto it more frequently—even if that means making cuts into historic walls. The Riverwalk presents more of a challenge, as it runs for long stretches without any connections back into the urban fabric, which makes it less used and less safe—for example: between John Street and River Place. In addition, some of the streets where it does connect are not effective walkable environments. River Place has a lovely park where it meets the Riverwalk, but few people think to use that street as pedestrians, because it is lined by parking lots on both sides for its full length. Among the recommendations ahead are a new connection just to the east of River Place Towers, and improved edges to River Place.



Lowell possesses one of the few embarrassing gaps in the otherwise complete 200-mile Bay Circuit Trail.

Finally, God bless Lowell Canalwaters Cleaners, the volunteer non-profit organization that does its best to keep the canals and the rivers' edges clean! But why are they necessary? Venice, Amsterdam, and Paris do not rely on volunteers to keep their cities' waterways attractive to tourists. Canal and river trash continues to blight downtown Lowell, and it is shortsighted to shortchange the maintenance of such a key economic asset.

The Role Of Parking

According to the urbanist Neil Peirce, "no great city has ever protected parking as a fundamental right." This observation is true, but how does a car-dependent city become great without alienating its drivers? The first step is to make driving less necessary by creating a physical environment that rewards walking. As a city introduces a better balance of uses and more walkable streets, people begin to need their cars less. But it is the fate of every busy urban environment to have a parking "problem"; like roadway capacity, parking capacity generates an unmet latent demand that new capacity can rarely satisfy. For this reason, parking policy should reflect the fact that a parking problem is a good problem to have.

One of the reasons that parking demand is so high is that most people who use it do not pay its full cost. This is clearly the case in Lowell, which has some of the least expensive structured parking in the U.S., with no users paying more than $64 per month, and many paying less. While it would be a mistake to dramatically raise the cost of parking immediately, the City must operate with an awareness that parking pricing is the key tool that it has at its disposal to encourage the sort of parking and driving behaviors that would best benefit the downtown. Parking fees should not be looked to as a revenue generator, but neither should artificially low pricing be allowed to introduce dysfunction into the free market of supply and demand. This is particularly relevant as the City moves towards building an extensive streetcar system, whose ridership will be undermined by the current artificially subsidized parking rates.

On-Street Parking Strategy

In the meantime, until a competitive alternative to driving is available, the City should use its parking rates to make parking more convenient, not less. While low parking rates may seem like a gift to residents, workers, and businesses, they can instead do grave damage to a downtown by encouraging overuse that makes parking unavailable to those willing to pay more for it—those with money to spend. Overuse also causes people to circle in search of a space, which, in addition to being especially frustrating in Lowell's one-way system, causes unnecessary congestion during business hours.

This phenomenon is thoroughly discussed in the leading best-practices manual, *The High Cost of Free Parking,* by Donald Shoup. As has been effectively applied to electricity and other utilities, Mr. Shoup recommends that a congestion-pricing scheme be used to ensure continuous availability of a limited amount of on-street parking, typically one space per block face, or 15%. Under such a regime, more valuable parking spaces become more costly, wealthy shoppers can always find a place to stop, and circling is largely eliminated. Spaces on street become more expensive than spaces in garages, which encourages better use of the garage investment. Parking revenues rise, and shops prosper. Such strategies are being used to good effect in Pasadena, CA, and elsewhere.

Lowell's investment in on-street parking kiosks allow it to manage parking rates more comprehensively than is currently the practice.

The city is fortunate in that its Parking Department, under the leadership of a former high-tech CEO, has already made the wise investment in on-street parking kiosks. These sophisticated machines, in addition to all their other benefits—like allowing remote meter feeding—also make it easy and inexpensive to adjust pricing, even around the clock. That said, after a brief period of experimentation, it should be fairly easy to settle on a set parking price regime that can be readily communicated and not subject to ongoing change.

It is strongly recommend that the city actively pursue a right-pricing strategy for parking in its retail areas. Until such a system is in place however, two small and important changes, instituted right away, would begin to accomplish some of the same objectives: First, on-street parking should be made slightly more expensive per hour than parking in nearby structures, so that long-term parkers are encouraged to keep the curbs free. Currently, the opposite regime is in place, to the detriment of downtown shopping.

Second, on-street parking in retail areas should not be free between 6 PM and midnight, as it is currently. In addition to discouraging garage use, this regime encourages local residents to fill spaces in front of businesses, such that restaurant and boutique patrons are unable to park nearby. These patrons would much rather pay for parking than have to park remotely, and residents are currently incentivized to inconvenience them.

As long as nearby garage parking remains affordable, the City has every incentive to organize its on-street parking on free-market principles. Conveniently, that approach happens to generate greater parking revenue, but that is not the goal.

Finally, both driving and parking on Merrimack Street are hampered by the current size and placement of delivery, service, and drop-off zones. These zones have been distributed based not on any comprehensive plan, but on a piecemeal sequence of individual requests. As a result, some no-parking zones are larger than necessary, and some businesses lack service areas, resulting in mid-day double-parking traffic jams. While it will be opposed by certain individual businesses, a comprehensive curbside plan for Merrimack Street would benefit the collective whole.

Structured Parking Strategy

It is hard to say how downtown Lowell would have developed over the past three decades without the massive investment that was made in its municipal parking decks. While some would argue that this money would have been better spent on a streetcar, there is no doubt that these parking structures have helped to make Lowell's resurgence possible. But parking decks are extremely expensive and, with the exception of the Hamilton Canal District, the City has no plans to build any other decks soon. This strategy is wise in the context of the goal of becoming a more walkable, less automobile-dependent city, for reasons already discussed.

The good news is that, contrary to perceptions, the City's five municipal parking structures still hold significant unused capacity. All of them are mostly empty at night, and many of them still contain empty spaces during business hours: cumulatively, the lots peak at under 70% occupancy on a typical day. These empty spaces are literally money in the bank, which the City can use to float new development, fully making good on its initial parking investment.

Another factor working to the City's advantage is the relative proximity of the five downtown lots to each other, and the willingness among the lowest-rate payers—students—to be moved from garage to garage as needs dictate. Given these circumstances, the City Parking Administrator is able to play a strategic game of parking lot chess, generating capacity in garages where new development demands it.

Taking advantage of available parking essentially means two things:

First, the huge nighttime vacancies suggest that additional residential development can locate anywhere nearby an existing lot without requiring any new parking provision. This circumstance dramatically reduces the cost of new housing. The City is to be congratulated on its current parking regulation, which requires only one parking space per unit, and allows that space to be located in an existing garage within 1500' of the residence. That requirement is currently less conservative than most developers would have it, so it does no harm. Over time, however, the City would be wise to eliminate this requirement entirely, as the development community will always demand more parking as a whole than is necessary. And eventually, the City may wish to replace its parking minimums with parking maximums, to encourage residents to take advantage of its investment in a streetcar.

Second, the identification of sites for future office development will be heavily dependent on the current location of unused daytime capacity, in conjunction with the City Parking Administrator's ability to shift demand strategically. This technique is particularly relevant to the specific short-term interventions discussed in Chapter 9.

The Downes Garage, one of the City's busiest, still experiences the large nighttime vacancies typical of the entire system.

Longer term, the capacity of the lots can be increased further by applying a congestion-pricing regime to them as well. With the construction of a streetcar and its provision of a viable alternative to driving, the relative cost of parking vs. transit will be a key factor in people's choice of transportation mode. At that time, the cost of parking should be gradually increased during times of crowding, to the point where each lot always contains a small number of unused spaces. As with on-street parking, only then will the free market be allowed to operate.

Parking Design

There is perhaps no greater deterrent to pedestrian life than an exposed parking lot or structure. Surface parking lots should be hidden from walkable streets by occupied buildings, even if these buildings are extremely thin. When no other solution is available for a surface parking lot, an attractive landscaped wall or hedge, approximately 4' to 5' tall, should be built at the lot edge. While this can be considered a second-rate solution, many surface lots in Lowell would benefit from such an intervention.

Multi-story parking structures should contain occupied space at street level. Many cities now insist that all new parking structures include ground-floor retail space, but upper stories are also ideally hidden behind habitable space—20'-deep apartments are best. At the very least, parking structure facades should be detailed to resemble an occupied building, which is much easier when sloped ramps are restricted to the center of the structure so that its street edges remain flat.

Good and bad examples of parking lot edges can be found throughout the downtown. The Early Garage, with its first floor of commercial use, shows an encouraging evolution beyond the Roy Garage, which in turn provides a better building-like façade than the other three City structures. The new private garage on Perkins and Hall Streets unfortunately places unattractive car ramps directly against two sidewalks, where an inexpensive stick-built 20' liner of apartments would have created a far superior outcome, and perhaps a greater profit for the developer. The current City zoning code, while exemplary in most respects, should be modified to ensure a better performance from private garages built in designated walkable areas.

The Early Garage properly meets the sidewalk with storefronts at street level.

Previous chapters have addressed many of the factors that work together to make a downtown successful, including the proper mix of activities, efficient driving and parking, transit service, and pedestrian and bicycle access and safety. All of these factors are necessary, but even cumulatively they are not sufficient to create a thriving center city. One additional ingredient is essential to downtown success, and that is walkability. Without walkability, it is impossible to generate the pedestrian culture—the "street life"—that turns a downtown into an attraction.

Walkability requires pedestrian safety, but it is much more than that. In addition to feeling safe, pedestrians must also feel comfortable, which is a different discussion altogether. Rather than addressing the speed of cars or the potential for crime, it addresses the spatial definition of the street space, and the fact that people like to feel physically contained by the walls of buildings. Most people enjoy open spaces, long views, and the great outdoors. But people also enjoy—and need—a sense of enclosure to feel comfortable as pedestrians.

Split, Croatia: Humans are instinctively drawn to places with firm edges.

Evolutionary biologists tell us how all animals seek two things: prospect and refuge. The first allows you to see your prey and predators. The second allows you to know that your flanks are protected from attack. That need for refuge, deep in our DNA from millennia of survival, has led us to feel most comfortable in spaces with well-defined edges. This issue has been discussed since before the Renaissance, when it was argued that the ideal street space has a height-to-width ratio of 1:1. More recently, it has been suggested that any ratio beyond 1:6 fails to provide people with an adequate sense of enclosure, creating a sociofugal space: an environment that people want to flee.

Therefore, in addition to feeling safe from automobiles, humans are not likely to become pedestrians unless they feel enclosed by firm street edges. This is accomplished principally by buildings that pull up to the sidewalk. These buildings need to be of adequate height so that the 1:6 rule is not violated, ideally approaching 1:1. Gaps between buildings should not be very wide, and surface parking lots should be screened by structures, as already discussed.

This requirement presents a different kind of challenge to the City, because most of what makes streets comfortable is accomplished not by the public streetscape, but by the private buildings that flank the right-of-way. In this case, the City must take on the role of encouraging new private investment in the right places, and also of recognizing the places where the quality of private investment merits corresponding public investment—and where it doesn't.

With the exception of a few "missing teeth," the buildings surrounding Middle Street provide it with excellent spatial definition.

This issue is the central topic of this chapter, and the foundation of an approach to downtown revitalization that has come to be known as Urban Triage. Developed by Andres Duany, Urban Triage is a concept that makes many planners uncomfortable, but that is particularly necessary in these times of limited public resources.

Urban Triage: An Instrumental Urban Strategy

Most mayors, city council members, municipal planners, and other public servants feel a responsibility to their entire city. This is proper, but it can be counterproductive, because by trying to be universally good, most cities end up universally mediocre. This is particularly the case when it comes to pedestrian activity.

Walkability Analysis and Urban Triage

There are many areas of Lowell that would benefit rom concerted public investment. However, in these days of limited public resources, one has to set priorities about where municipal dollars should be invested and where private development should be most encouraged. This study begins with the assumption that the place to spend money first is in the downtown. But there are two types of areas within the downtown where public investment will have a greater impact on livability than in others.

First, only certain streets in the downtown are framed by buildings that have the potential to attract and sustain pedestrian life. There is little to be gained in livability by improving the sidewalks along a street that is lined by muffler shops and fast-food drive-throughs. These streets should not be allowed to go to seed; the trash must be collected and the potholes filled. But investments in walkability should be made first in those places where an improved public realm is given comfort and interest by an accommodating private realm—or a private realm that can be improved in short order.

Arcand Drive is an essential pedestrian axis through the downtown, but it has weak edges.

Second, there are streets of lower quality than those above, but which are essential pathways between downtown anchors, for example from the historic city center to the Tsongas Arena. These streets require greater investment to become walkable, but that investment is justified by their importance to the downtown pedestrian network.

By studying existing conditions, we can see where streets are most ready, or most needed, to support pedestrian life, and focus there. This technique of Urban Triage may seem mercenary and unfair, but it results in money being spent wisely.

The Urban Frontage Analysis

The drawing on the next page is the Urban Frontage Analysis for downtown Lowell. Frontage is another word for street edge, and it describes the quality of the face which buildings present to the street. This analysis takes into account both of the circumstances described above: where are streets already well shaped by building faces, and where else do they need to be so shaped?

Specifically, the axes marked in green comprise the current Network of Walkability, in which streets (or paths) are fairly consistently shaped by buildings that render them comfortable. In contrast, the axes marked in yellow are streets segments that are not currently comfortable, but are nonetheless very important to walkability. These streets connect key anchors to the existing network, including the two sports venues, the Civic Center, and the Lowell Memorial Auditorium, among others. These axes represent the places where investment to improve street frontage is most desired.

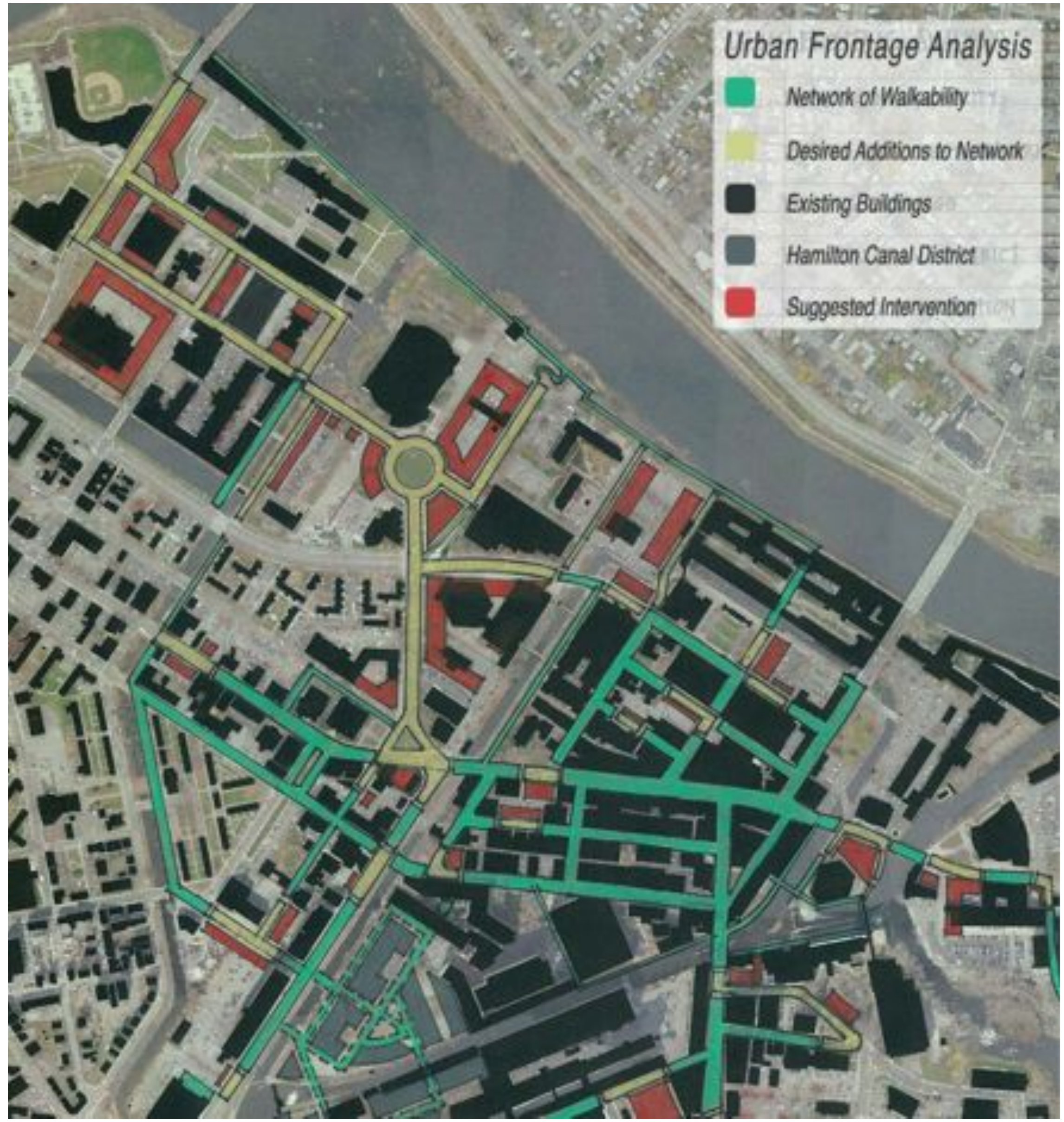
Please note that this analysis only addresses the quality of the buildings flanking the street, and does not consider the traffic or safety characteristics of the thoroughfare. This approach is based on the expectation that streets in potentially walkable areas will be reconfigured for safety in the manner recommended in Chapter 3.

In this drawing, existing buildings have been shaded in black, so it is easy to see which streets have adequate edges and which do not. The buildings in gray are anticipated construction within the Hamilton Canal District, and they are successfully arranged to create a future walkable district, shown with the dashed green line.

Finally, the objects shown in red are what planners refer to as the "missing teeth:" the new interventions that are needed to provide adequate spatial definition where it is lacking within the desired network. Most of these are buildings, but not all of them; some instead must take the form of walls or landscape. Every stretch of yellow street requires a corresponding stretch of red. As these interventions are constructed, the Network of Walkability will become increasingly complete.

In discussing this drawing, it is important to understand the nature of planning. It is not possible to simply put lines on a map and say "put buildings here." Rather, a plan is a mold designed to shape future economic energy into the most efficacious form. This plan, and others like it, allow a city to use the resources and tools at its disposal to incentivize development in the right places and in the right shape. With a plan, resources and tools are no longer distributed randomly, and synergies between efforts are more likely to occur. In other words, the plan does not say “do this;” it says, “when you do something, this is what you should do.”

That noted, the extensive research and discussions that went into this Plan suggest that all of these interventions are possible, many in the short term. The following five chapters describe in detail what these proposals are and how they might be accomplished.

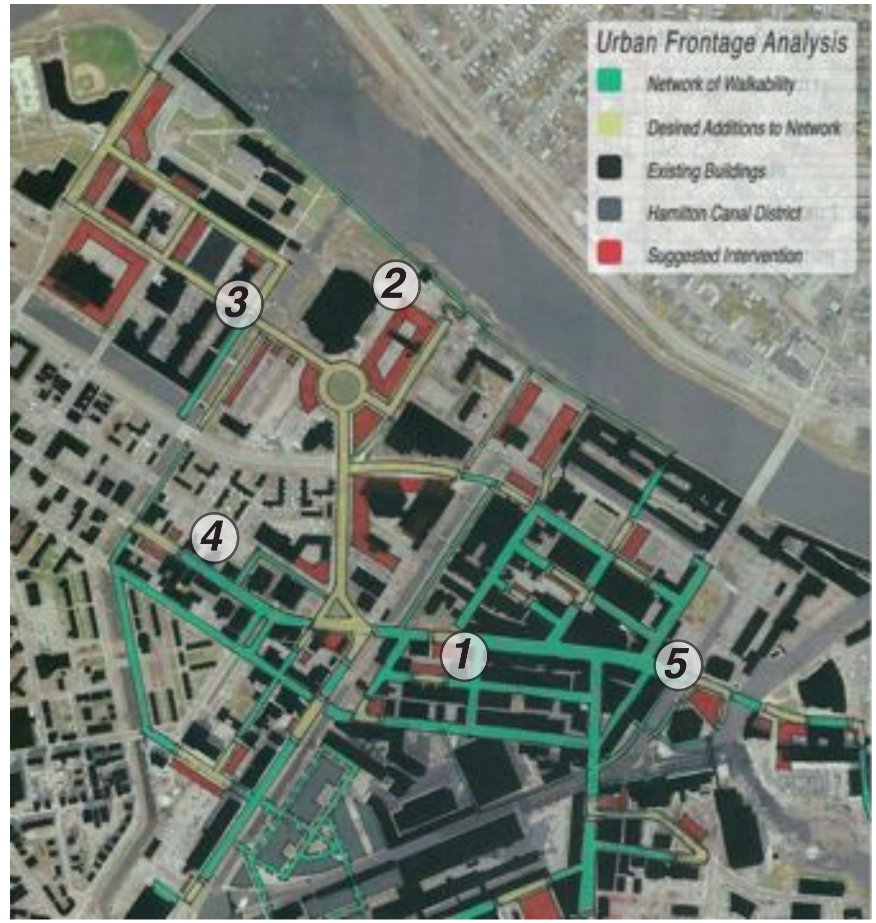


The Urban Frontage Analysis documents where street spaces are most comfortable and most in need of improvement.

The eight proposed interventions that follow can all be accomplished in the short term if significant will is brought to bear. In planning vocabulary, "short term" generally refers to five years or less, which in the chronology of the city is a blink of the eye. However, some of these projects could be completed within a year or two if begun quickly.

The eight short-term interventions are:

1. The Missing Tooth on Merrimack & Middle
2. The Tsongas Center Area: Riverplace Center
3. The Suffolk Street Canalway
4. The Moody/Merrimack Connection
5. MCC Quad



9.1 The Missing Tooth on Merrimack & Middle

One large empty lot interrupts the healthy urban fabric of the historic core.

Lowell is blessed with a remarkably intact historic downtown core centered upon Merrimack and Market streets. This core only has one significant "missing tooth," and it is in a key location on the path from Kearney Square to City Hall. A decorated wooden fence makes the most of this unfortunate situation, but fails to give activity or interest to the sidewalk. Similarly, the opposite edge of this block, occupied by a surface parking lot, provides a weak edge to an otherwise well-shaped Middle Street.

Owned by the National Park Service and adjacent to Enterprise Bank's offices in Old City Hall, this site is desired by the Bank for a contemplated expansion, and conversations have already begun on how to make its redevelopment possible. The simplest approach may involve the National Park Service selling the site to the Bank, which, as they say, would take an act of Congress—literally. But such an act is achievable over time and—if deemed the most expeditious path—needs to be initiated as quickly as possible. This effort could potentially comprise part of an omnibus bill that allows NPS to also divest of key properties that are needed for the ongoing Hamilton Canal Project to be completed as well.

Enterprise Bank's immediate needs for the site are limited: a large new building and guest parking for short-term visitors. There is interest in recreating along Merrimack Street the high quality urbanism of the original 19th-century development, which placed three party-wall buildings to the west of the Bank's building, the former Lowell City Hall. A small passageway originally traversed the block in the same location where one exists today.

The intervention proposed for this site places a single large building against Merrimack Street, with a façade that can be articulated as three smaller buildings if

The proposed building lines Merrimack Street, while a reconfigured parking lot allows trees and a decorative wall along Middle Street.

desired. This new structure would be an ideally-located home for new Enterprise Bank offices and, barring federal red tape, could be imagined as being built quite soon. This new building would place the majority of its parking in the nearby Roy Garage on Market Street, which has 300 spaces available most days.

A solution is also needed for Middle Street, where the sidewalk is interrupted by several curb cuts into the surface parking lot, and where an essentially transparent fence fails to shield the parking lot from the sidewalk. In the long term, this parking lot is available as a building site, but since there is no likely tenant at this time, it should be reconfigured to continue the existing pedestrian path through the block while eliminating one of the two curb cuts on Middle Street.

In this drawing of historic conditons, the three center buildings are the ones that have been lost.

Proposed three-part massing on Merrimack echoes the block's original architecture, while a decorative wall provides a much-needed edge to Middle Street.

The parking lot's thin fence should be replaced by a wall, ideally 4' to 5' tall. At this height, it would largely obscure the lot from the street while still allowing it to be supervised from the sidewalk for safety. With an artful design—and perhaps with the participation of a local sculptor or metalwork artist—this wall could even add some character to the street. Ideally it would also contain planters, with draped greenery along the sidewalk.

This reconfiguration of the parking lot allows it to pull back slightly from Middle Street in order to insert a row of trees overhanging the treeless sidewalk. This design also places trees along the mid-block alley, for a more humane parking lot experience.

In the long run, if no use for this site persists for many years, the site's owners may wish to consider construction of a thin lot-liner building along Middle Street, of the type described ahead in intervention 9.3.

9.2 The Tsongas Center Area: Riverplace Center

River Place provides prominent access to the Riverwalk, but it is flanked by two unattractive parking lots.

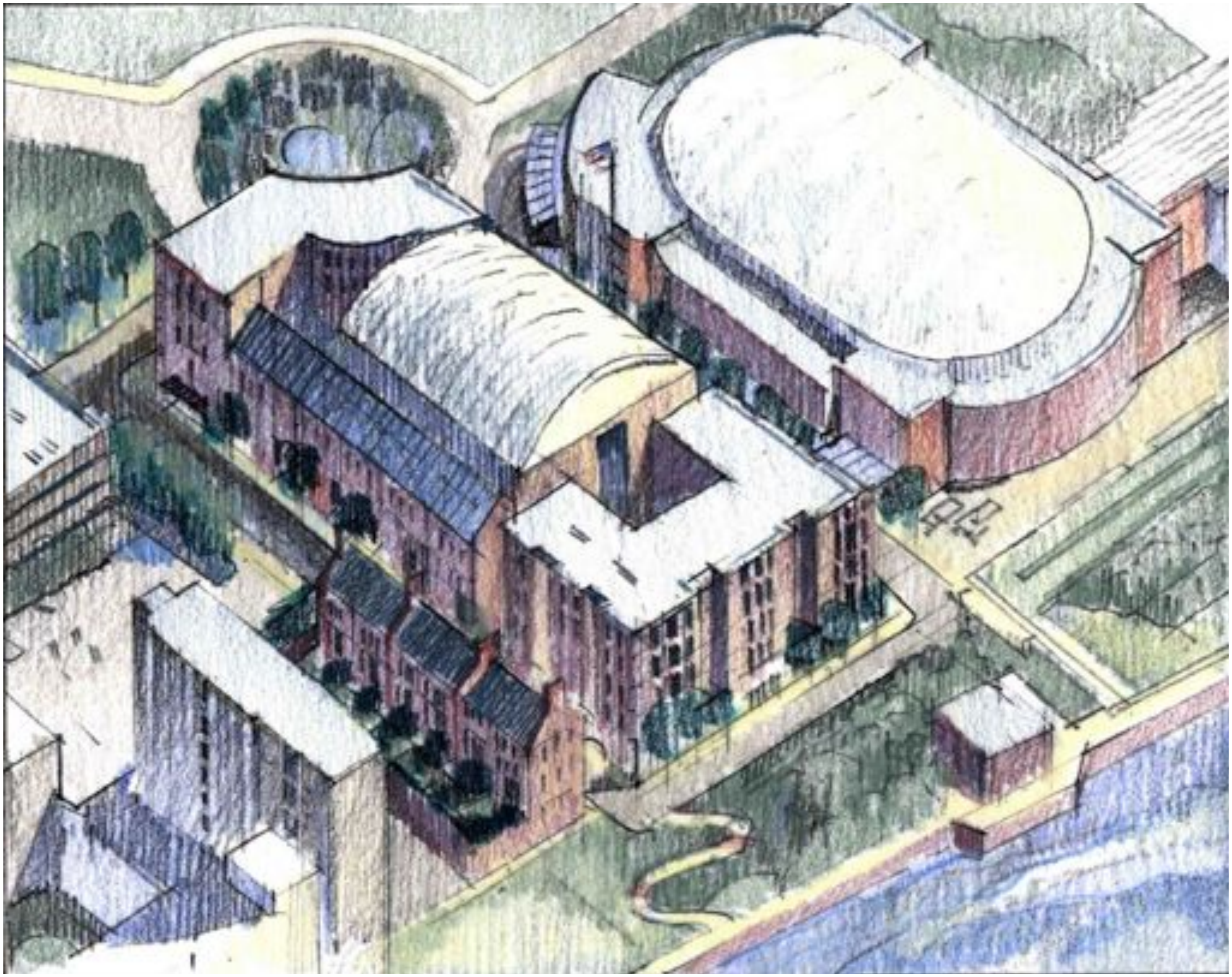
As will be discussed in point 10.1 ahead, one of the more promising opportunities downtown is the transformation of Cox Circle from a traffic rotary into a lively urban place. A key site on this Circle, just across Tsongas Way from the arena, is the block referred to as the Police Lot, which was renamed Riverplace Center in the 2001 Downtown Plan. The University is currently reaching out to private developers for proposals to redevelop this block, which has the potential to dramatically improve the surrounding public spaces of Cox Circle, River Place, and the riverwalk.

First, along Cox Circle, it is essential that a building of significant height—perhaps five stories—line the curving sidewalk edge, giving shape to the Circle. A hotel has been discussed for this site, and it is hard to imagine a better location, on a significant public space next to the Tsongas Center. Next, as development heads further north on this block, it has the opportunity to also improve the unsatisfactory condition of River Place as it approaches the Riverwalk.

Located between this block and the River Place Towers parking lot, this street terminates on a lovely little park granting access to the riverfront. Unfortunately, both sides of the street present surface parking lots that contribute to an uninviting walk. This circumstance is fairly easily remedied, by lining those sidewalks with building faces. Finally, the introduction of a new drive connecting River Place to Tsongas Way creates an opportunity to expand the existing park, creating a prominent waterfront address and a short riverfront drive.

The proposed plan shows this new waterfront drive, and its use as a location

Complete development of this UMass block puts rowhouses on both sides of River Place, and new apartments face an expanded park.



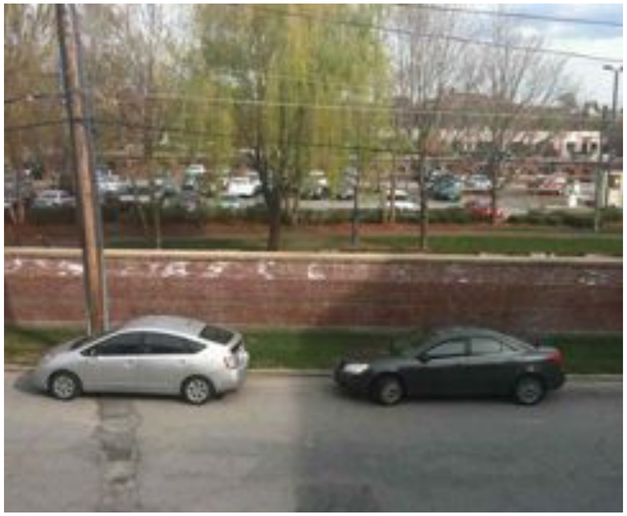
A midblock parking deck supports the second sheet of ice that UMass needs for the Tsongas Center.

for an apartment building or offices surrounding a square courtyard. This building's parking load can be handled in a new structure located at the center of the block, which also provides parking for the block's other uses, including new rowhouses that hide the parking lot from River Place. As suggested in the 2001 Downtown Master Plan, a garage in this location could put on its roof a practice ice rink, making the Tsongas Center a more versatile venue.

Finally, across River Place, eight new rowhouses face the sidewalk behind the existing evergreens, displacing about fifty parking spaces, which can be relocated either in the new lot or in the Ayotte Garage nearby. A limited number of residents would be asked to trade surface parking spaces for sheltered parking spaces, something that would seem easy enough to negotiate with City assistance.

One of the hidden gems of this area is the lovely terraced park located behind the Tsongas Center. Expanding the existing River Place green to the west would connect it to this asset in a continuous waterfront park. An existing wastewater pump station, if hidden behind evergreens, would not detract from this powerful amenity.

9.3 The Suffolk Street Canalway



A high wall separates Suffolk Street from its Canalway, while a parking lot provides a weak opposite edge.

As the National Park Service continues its renovation of downtown Lowell's canal and Canalway system, it is becoming increasingly evident how the canals provide an attractive alternative path through the city, and how they might over time begin to serve greater numbers of pedestrians. One key canal-side route is along the Western Canal from the Acre to the Merrimack River, where it connects a large population center to the amenities of the Riverwalk, the Tsongas Center, and LeLacheur Park. Unfortunately, this route loses its walkable character in the stretch between Father Morrissette Boulevard and Hall Street, where it sits unsupervised, sandwiched between a tall brick wall and a massive parking lot.

Each of these conditions is easy to fix. The wall can inexpensively be lowered to 2' to 3' in height, where it will no longer cut off the Canalway from the Wannalancit Mills. This move, in one fell swoop, would give the canal a much-needed active western edge, and turn the eastern mill buildings into a waterfront location.

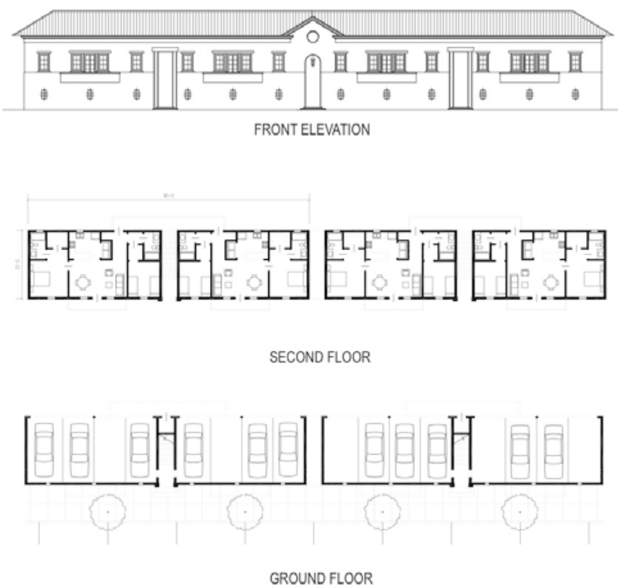
The parking lot edge requires a slightly more skillful intervention if the number of parking spaces is to remain the same. That intervention is called a Lot-Liner Building, and it consists of a thin row of apartments that sit atop parking, much in the manner of a row of garage-top granny-flats.

These buildings are inexpensively stick-built, and give an occupied edge (and supervision) to public spaces that would otherwise lack spatial definition and activity. They are not likely a big money-maker for their developer, but with limited City assistance—perhaps in association with an attainable housing program—they can be built in a way that rental revenues cover the mortgage. It is recommended that the City issue an RFP for a developer to build these structures, to whom it would cede (through

A removed or shortened wall integrates these spaces, while thin Lot-Liner buildings hold the eastern edge.

a 99-year lease) the air rights and limited ground area necessary to construct Lot Liners on this important Canalway edge.

Finally, it should be noted that the axis of Suffolk Street terminates at the vacant Lawrence Manufacturing Counting House. The owner of this building would like to see it sold, and UMass Lowell is considering its acquisition, perhaps for renovation into the University's faculty club. It certainly seems to be an ideal building in an ideal location for such a use, with waterfalls, spectacular views, and adjacency to the Tsongas Center and its park. This development should be encouraged.



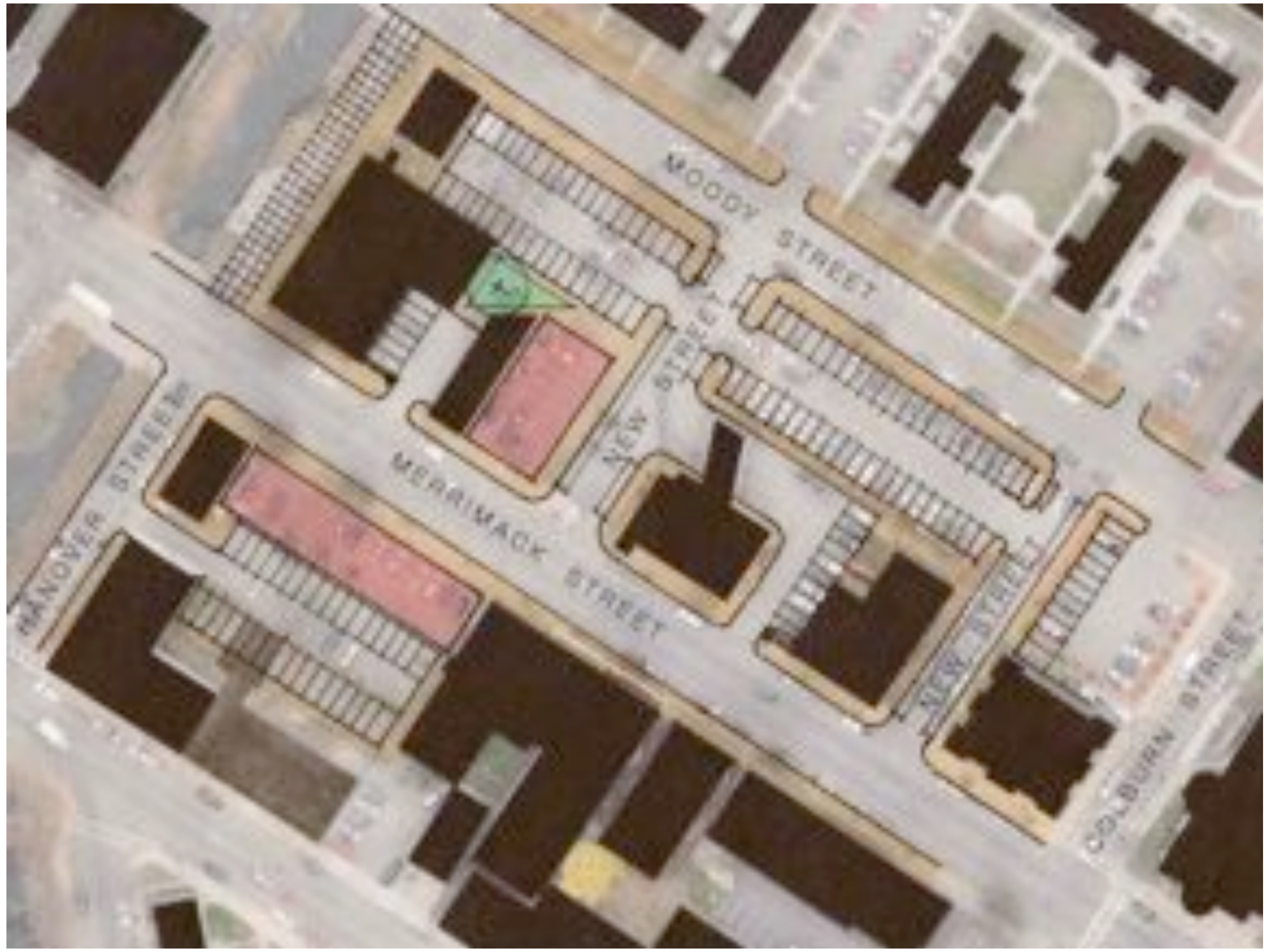
A typical lot-liner building places apartments above cars without significantly reducing parking supply. (Design by Duany Plater-Zyberk & Co.)

The former Lawrence Manufacturing Counting House terminates views down Suffolk street and is ideally situated for an institutional use.

9.4 The Moody/Merrimack Connection

Few cities have a downtown block as long as the one between Moody, Merrimack, Cabot, and Colburn.

One powerful indicator of—and contributor to—walkability is small blocks. Generally speaking, the most pedestrian-friendly cities, like Portland and New Orleans, have smaller blocks, while the least walkable ones, like Salt Lake City and Scottsdale, have larger blocks. Within older cities with once-intimate street networks, one typically finds the least pedestrians in those places where streets have been snipped to create mega-blocks. Ironically, many of these street closures were done for pedestrian convenience, in ignorance of the fact that most pedestrians don't feel safe without cars moving slowly by.



This minor intervention improves neighborhood connectivity and designates priority building sites on Merrimack.

In other words, cars are still the lifeblood of the city, and the streets are its veins and arteries. When the urban renewal team—a.k.a. highway planners—turned their attention in the 1960s to Lowell's civic center, they created a number of such mega-blocks, only one of which seems currently fixable: the very long rectangle bounded by Merrimack, Moody, Cabot and Colburn Streets. This block is even more of a no-flow lagoon than the map would suggest, as Colburn Street is one-way-out from Moody, further limiting access.

A number of small interventions can quickly improve the activity in this area. First, just west of Colburn Street is a parking lot entrance that would become the second half of a one-way street pair if it were allowed to continue through to Moody. Experienced visitors currently use it in this way, but are forced to snake through a parking lot. Second, another cross street can be inserted through the parking lots just west of Sovereign Bank, turning that bank's better side façade into a front. This second street may take longer to accomplish—and thus should not delay the execution of the first street—but it would significantly improve the function of this neighborhood. The proposal be-

Before the super-blocking of the JFK Plaza, Moody and Merrimack Streets originally met at the triangle in front of City Hall.

low shows both of these new streets, and also rationalizes the parking lots through the length of the block. Although not shown at the scale of the drawing, all new streets should be planted with trees, as consistently spaced as possible.

Interestingly, these lots could potentially hold a future parking structure which, being only one-bay deep, would require a spiral end ramp. Such a structure would need to sit above an occupied ground floor, and allow the new mid-block street to pass through it. Of course, whether future parking structures are desirable remains in question.

These changes delicately introduce a more intimate street network to the area. The proposal also shows the missing teeth that need to be filled to create a consistent street-wall along the important westward axis of Merrimack Street. Improving these frontages will help draw pedestrians west into the adjoining neighborhood, which includes the important potential redevelopment site of Lowell Community Health Center, just across the Western Canal.

The reconfiguration of these parking lots and the construction of these buildings will require a small amount of horse trading among the various property owners and the City, which should expedite the process by pre-permitting the outcome shown here and brokering any exchange.

A final note: this study area abuts a largely unheralded jewel in downtown Lowell, the Smith Baker Center on Merrimack Street. It is a unique asset, and plans for its redevelopment should receive special attention and support.

9.5 MCC Quad

A surface parking provides a weak edge to East Merrimack Street and presents a less than ideal setting for Middlesex Community College.

A final short-term opportunity of great promise lies in the hands of Middlesex Community College. This opportunity was created when MCC acquired the Federal Building across the street from its current campus center in the former Wang training facility. These two buildings together occupy what is essentially an island in the heart of downtown, an island that can now be re-imagined—and indeed re-branded—as a full-fledged college campus.

This campus is located in a key area for downtown walkability, along the path connecting dinner in the historic center to events at the Lowell Memorial Auditorium, a path that many now choose to drive rather than walk. They make this choice in part due to MCC's exposed parking lot in front of the Wang building, which also interrupts the walk from the Lower Locks Garage to downtown.

This parking lot, like all parking lots, is useful. But it is also unnecessary, with the Lower Locks Garage close at hand, and ample opportunities for visitor drop-off at the curb and also behind the federal building. Those few college employees lucky enough to hold reserved spaces in this lot—an administrative *Who's Who*—are the ones who have the most to gain from its transformation into a dignified campus green befitting a civic institution.

The College has already applied to the State of Massachusetts for funds to make this parking lot safer for pedestrians, and it can be said unequivocally that no other strategy holds more promise in this regard than removing the cars. But, perhaps more significantly, a properly designed campus green in this location, enfronting the two principal MCC buildings, would give the College a presence in the city that it currently lacks, improving student quality of life and creating a brand that could be used to attract higher enrollments.

A new campus green creates a safer and suitably academic environment.

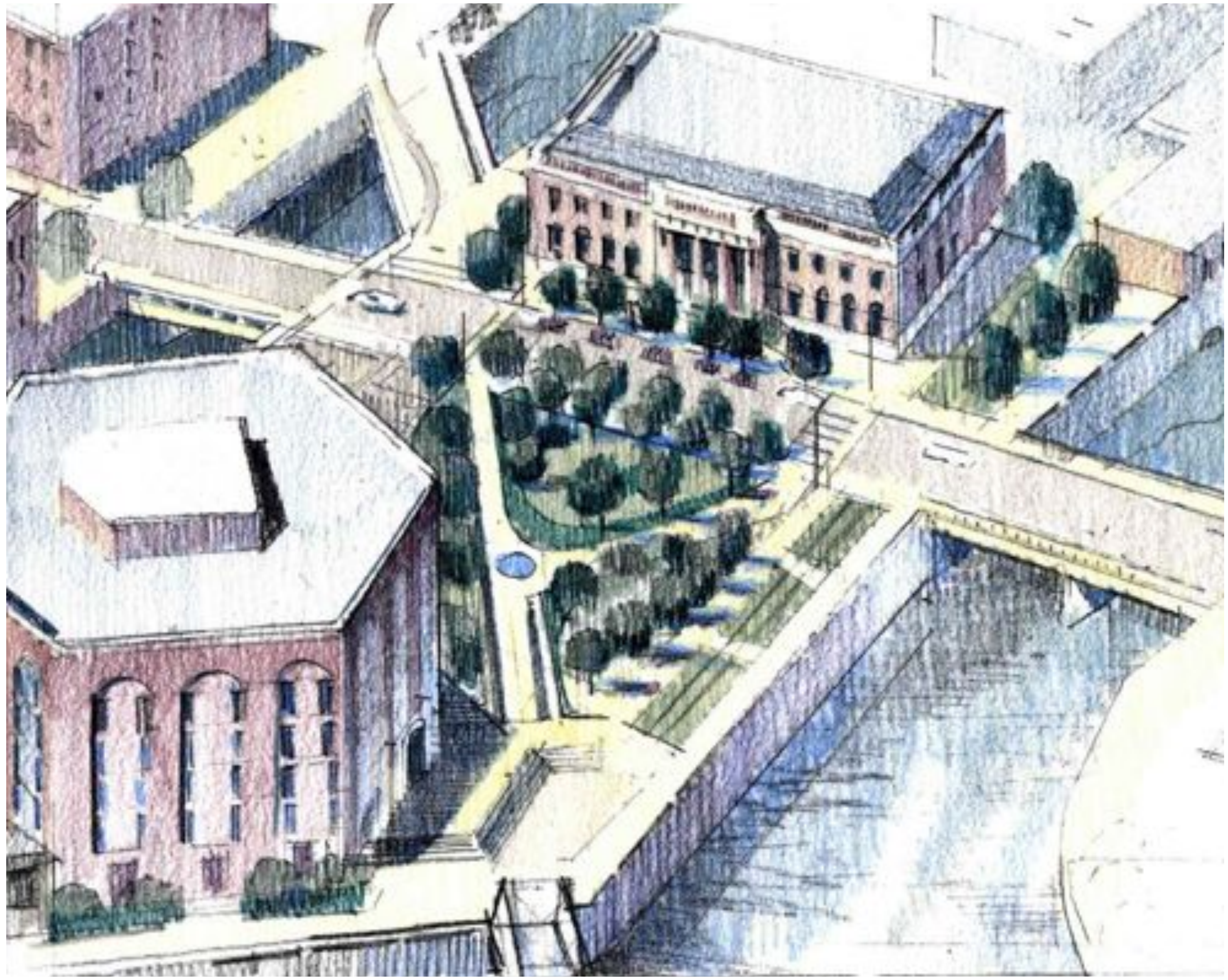
As designed here, the green accomplishes several objectives. It centers symmetrically on the lovely south-facing façade of the Federal Building, allowing it to take center stage away from its less attractive partner across the street. It creates a central gathering space with a fountain and benches. It shields the Wang building loading dock and mechanical equipment behind walls and evergreens, and provides a terraced green overlook to the Concord River. It connects pedestrian desire-lines along the site, notably continuing the axis of the Lower Locks bridge straight to Merrimack Street.

Perhaps most importantly, it continues its plaza across East Merrimack Street with a raised brick speed table, to calm traffic and claim that territory for the College. While such speed tables—with no curbs or striping, just patterned bricks to indicate movement zones—seem potentially dangerous, they are actually much safer. As described by David Owen in *Green Metropolis:*

> *"this sounds to many people like a formula for disaster, but the clear experience in the (mainly) European cities that have tried it is that increasing the ambiguity of urban road spaces actually lowers car speeds, reduces accident rates, and improves the lives of pedestrians: drivers proceed more warily when they aren't completely certain what's going on."*

As redesigned in Chapter 3, this roadway would now hold bicycle lanes in both directions, and a single parking lane to the south that would here be reserved for drop-offs. Sidewalk areas would be protected by trees, and bollards could also be added in the unlikely event that they are deemed necessary.

As with other recommended interventions, this one would require a partnership between two actors, in this case MCC and the City, who would spearhead the roadway improvements as MCC invested in its campus green. Unlike the ICC Square discussed in point 10.4, this one does not depend upon the roadway reconfiguration to be worthwhile, but that reconfiguration makes it a better and safer plan.



A limited investment gives pride of place to an important institution.

The four proposed interventions that follow are all imagined as being accomplished in mid-term. In planning vocabulary, "mid-term" generally refers to five to ten years. This time frame seems appropriate because, while these projects do not have many perceived impediments, they also lack immediate momentum. While many key players would like to see them happen, it will likely be a number of years before economic conditions and other motivating factors cause these proposals to excite concerted action.

That said, a number of these interventions could be initiated immediately if met with significant public and private support. The four mid-term interventions are:

1. Cox Circle
2. LeLacheur House
3. Boarding House Park Edge
4. ICC Square

10.1 Cox Circle

Cox Circle currently lacks walkable geometrics, usable landscape, and enfronting structures.

One definition of good city planning is the creation of scenarios in which a small amount of public investment leads to a large amount of private investment. By that definition, it is difficult to imagine a site in Lowell that is better poised to take advantage of good city planning than Cox Circle.

Simply put, Cox Circle is a space that is ready to become a place. Standing in the way of that transformation are three things: the circle's current high-speed geometrics, its decorative but useless landscape treatment, and its lack of surrounding built edges. The first two of these can be easily remedied with a limited amount of public investment. These changes, coupled with a slight re-jiggering of the City's parking obligations, can overcome the third challenge in short order.

The first step to transforming Cox Circle is to right-size its two travel lanes down to a standard high-flow width of 12' rather than their current inexplicable

The proposed plan narrows an oversized roadway and creates a public place shaped by new buildings.

20'. At this width, the circle will still comfortably handle its traffic, including semis. This narrowing enlarges the center circle to include a 16' perimeter sidewalk planted with trees on both flanks. A third ring of trees would then be planted surrounding the circle's paved center, which would hold a dramatic fountain of appropriate civic character. Grass or groundcover would separate the inner and outer paved areas, crossed by radial walks mapping pedestrian desire-lines across the site.

These changes would turn the circle into a real Circle, like DuPont Circle in Washington DC, which has become a much beloved public gathering space. This amenity would lend value to the surrounding real estate, and help to incentivize the vertical development of the three key sites surrounding it. These sites are as follows:

- The Police Lot northeast of the Circle, as already discussed in point 9.2, is poised to be redeveloped with a significant building holding the sidewalk edge. Whether a hotel or some other use, this building has the opportunity to create a prominent curved face that gives shape, interest, and activity to this new public space.

- The west flank of the circle is bounded by an area that is part Post Office parking lot and part City parking lot, but needs to become a second building site in order to properly shape the street edge. This can be accomplished by a reorganization and rationalization of the two lots, one that would ideally consolidate them also with the surface lots further west, to improve efficiencies all around. In this reorganization, the Post Office would need to end up with its original number of spaces, requiring a limited contribution from the city lot.

- Finally, the City lot to the southeast of the circle is already ideally suited to become a building site, one that would complete the circle and hide it from the uninteresting façade of the Ayotte Garage. The plan above shows this new building occupying the entirety of its site. An alternative would be to run its east wall parallel to the garage to enlarge that view corridor; each solution has its advantages. This site is currently used by the High School for band practice and informal athletics, important activities that would unfortunately have to be displaced until a better site can be designated. As discussed in Chapter 12, these activities could eventually be located on the campus of a renovated downtown High School.

What activities are best placed in the two above buildings is open to discussion, but a number of important factors all point to office uses. These include the following:

- Unlike all of the other City parking facilities, the Ayotte Garage experiences its greatest spikes in use during certain evenings, when events fill the Tsongas Center. On non-event days, it is typically more crowded during office hours than overnight, but rare is the time when 200 – 300 empty spaces are not readily available. These spaces uniquely position Cox Circle as perhaps the only location in downtown Lowell that is poised to absorb major office development without building expensive new parking decks.

- Adjacent to this site is the Wannalancit Mills and the new Jeanne D'Arc Credit Union, which already establish this neighborhood as one of the largest office sectors in Lowell. Adding yet more office to this area will help it to achieve critical mass as a regional office destination.

- The amenities of the adjacent Tsongas Center and the nearby LeLacheur Park are a plus for potential office tenants, whose employees can enjoy after-work recreation without moving their cars.

Finally, the proposed path of the new streetcar down adjacent Father Morrissette Boulevard will connect this neighborhood conveniently to the Gallagher Intermodal Center, to the benefit of rail commuters.

Surrounded by a large number of office tenants, the redesigned Cox Circle would become an even more valued amenity, particularly as a place to visit during lunch and breaks. Important to the success of this neighborhood would be the location of at least one café/restaurant/bar establishment on the ground floor of a flanking building. If this occurs within a new hotel, it must be sure to open onto the street, not just the hotel lobby.

Several conditions must be met if this comprehensive proposal for Cox Circle is to move forward. First, the city must renegotiate its current contract

Cox Circle

Offices with potential ground-floor commercial could take advantage of a newly amenitized location.

that grants Wannalancit Mills an easement to 750 spaces in the Ayotte Garage. Wannalancit has not made use of these spaces, and has no plans to do so, but the obligation remains. Fortunately, the owners of Wannalancit have expressed an interest in participating in development around Cox circle, and are well qualified to do so, thus a mutually agreeable resolution does not seem out of reach.

Second, the greatest perceived impediment to a major increase in office space in this area is traffic along the Arcand-Dutton-Thorndike axis out of town at rush hour. One major contributor to this traffic is a lack of signal synchronization, so the desire to develop Cox circle is one more reason why that long-recommended effort should be undertaken soon.

Finally, it is worth noting that there is some resistance to development as this location due to the long waits experienced by people exiting the Ayotte Garage after large events at the Tsongas Center. It has been confirmed that the worst waits are due not to the design of the circle, but to the limited capacity of the Ayotte Garage exit. A cursory investigation of the Garage suggests that there exists the opportunity to punch a secondary exit point at its eastern end, allowing cars to access Father Morrissette Boulevard directly. This strategy is recommended for further study.

10.2 LeLacheur House

Across Aiken Street from LeLacheur Park is a large vacant property owned by UMass Lowell.

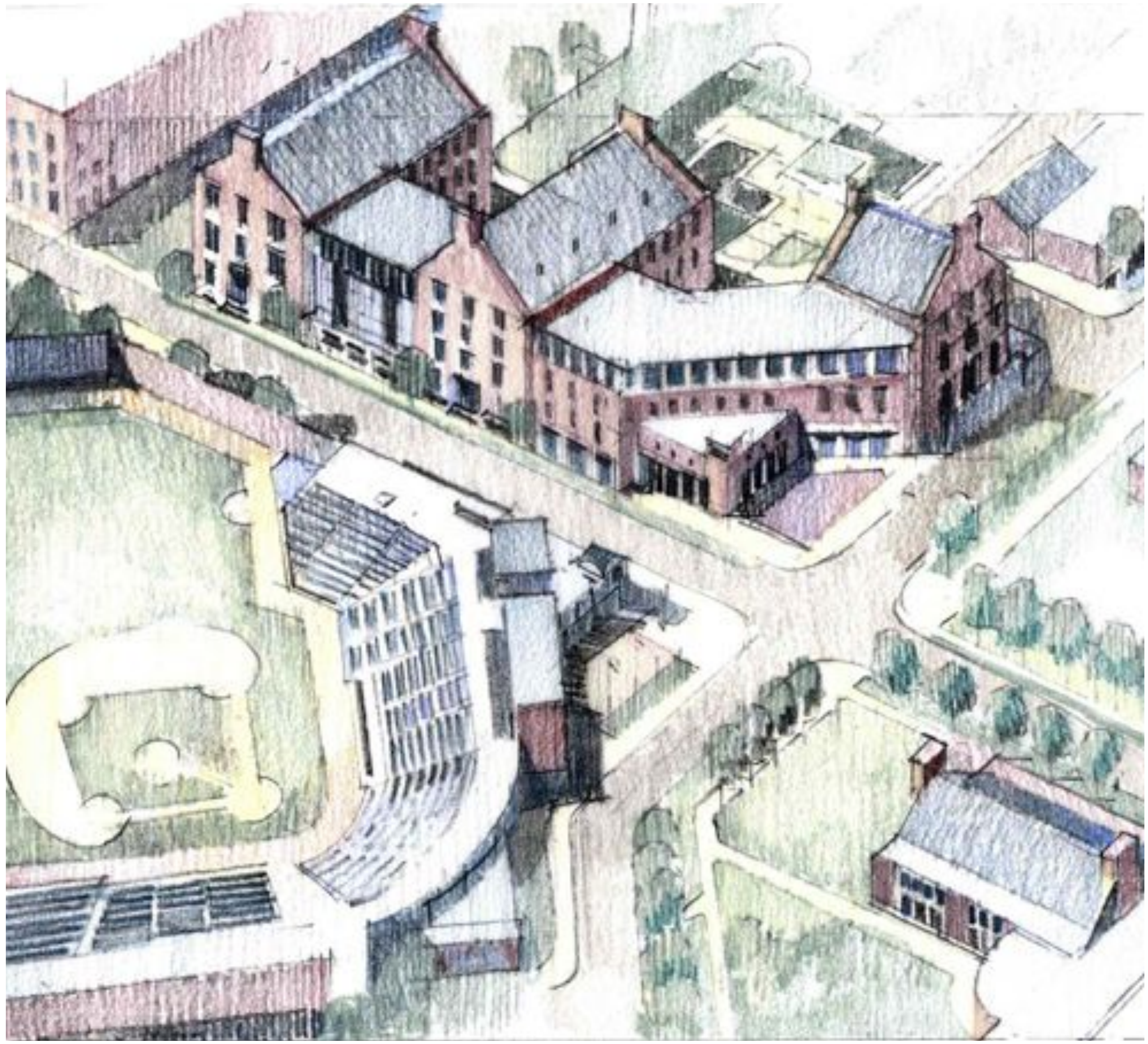
One of the most attractive anchors in the downtown is LeLacheur Park, which is close enough to the historic center to invite many pedestrian attendees to its forty annual baseball games, but which sits in a neighborhood of limited walkability. As indicated in the Urban Frontage Analysis, a number of improvements along Hall and Perkins Streets are needed if people are going to make the choice to walk there. One such improvement has the opportunity of happening fairly quickly, and that is the construction of a new UMass building on the site across Aiken Street from the ball field.

The University has previously proposed placing such a building on this sadly empty site, but was opposed by a few neighbors and delayed the process. The larger goals of a healthy city must prevail if positive growth is to occur, and a large building on this corner would add tremendously to the development of this neighborhood.

New student housing sits atop parking and surrounds rear courtyards.

The property benefits from a significant grade differential, such that a new street-level building can sit atop at least one full story of parking. That allows for a structure to fill its site, with wings embracing courtyards. The proposed building takes a cue from the ball field, and steps back from the corner of Aiken and Perkins with a 45-degree chamfer, creating a mirroring plaza. This is an excellent location for a small amount of retail space, ideally a corner store and café, which would give a gathering place to a neighborhood that lacks a social center. One could also imagine a bar/restaurant here, to serve hungry baseball fans. The principal use of this building, within limits, is fairly unimportant, as there is a range of activities that could successfully be placed on the site, including student housing, office/administration, and academic/research space.

When viewed from Aiken Street—a popular homeward commute—this new building and LeLacheur Park would form a symmetrical pair, giving a sense of place to this transitional neighborhood. Until a suitable donor is found, we recommend calling it LeLacheur House.



The new building mirrors the geometry of the ballpark with a front plaza and corner shop.

10.3 Boarding House Park Edge

The Boott Mills parking lot on John Street presents a weak edge to both Boarding House Park and French Street.

This plan places rowhouses with rear gardens in the west half of the parking lot.

One of the most attractive new public spaces in any American city is Boarding House Park, which places a lovely stepped landscape down to a large vine-covered bandstand against the backdrop of the historic Boott Mills. In addition to serving as a gateway to the Park Service's Boott Cotton Mills Museum, this park hosts world class concerts, including a solidly A-list summer music series.

A lovingly restored set of rowhouses gives a strong western edge to the park, but its eastern border is held by a parking lot that, despite containing some excellent trees, fails to shape or give activity to this important public space. This parking lot is used by office workers and residents at the restored Boott Mills lofts, but sits directly across French Street from the City's Downes Garage, which was ostensibly built so that surface parking lots could be put to other uses.

Clearly, the best use of this site would be to develop it entirely into housing, taking advantage of the Garage's massive overnight vacancy. However, owners of the Boott Mills office facility believe that some surface parking must be preserved in this location to serve the CEOs of businesses leasing at the Mills. Since a compromise is more likely to be built quickly, this plan presents a solution in which only half of the parking lot is put to more productive use, as rowhouses mirroring the renovated block across the park. It is easy to see in the plan below how these houses could be repeated facing east to take advantage of the entire block, once the landowner becomes convinced of the relative value of houses over parking. Interestingly, a similar concept for this site was proposed as early as the City's Preservation Plan of 1980.

Rowhouses have been suggested for this site for two reasons, first out of respect for the historic rowhouses across the park, and second in recognition of the need for a greater variety of housing product in downtown Lowell. Not every buyer wants a loft condominium, and rowhouses imply a slightly higher price point that is in keeping with Lowell's rising downtown demographics.

A few details of the plan bear discussion. The rowhouses are set behind the existing double-row of trees against Lower John Street, giving them a deep front public yard. Each rowhouse has a walled garden against the rear parking lot, in which overnight spaces can be reserved for their use. The southernmost rowhouse places its stoop and front door against French Street, lending character to that sidewalk, and a low wall (ideally 4' – 5' tall) limits the parking lot's exposure to French Street.

Rowhouses reflect the renovation across the park. An end-unit stoop and a low wall provide a better edge to French Street.

While a compromise solution, this scheme fully completes Boarding House Park. It also improves the walkability of a key stretch of French Street, so that residents and visitors are more likely to make the short stroll to and from Kerouac Commemorative Park, only one block east. Reintroduced parallel parking along this curb, as described in Chapter 3, will make that walk even more likely.

Much effort in recent years has gone into encouraging the redevelopment of vacant portions of the Boott Mills to the west of this site. That property is also important, especially to the success of the Riverwalk, which would benefit from increased supervision along its edge. However, the construction of buildings in this more central, prominent location will have an even more visible and immediate impact on the character of downtown.

10.4 ICC Square

The auto-zone east of Central.

A powerful lesson in the history of urban design can be found in the neighborhood east of Central Street, where postwar auto-centric planning has caused Lowell's walkable downtown core to end abruptly. Streets become wider, one-way, and more swoopy, with useless wishbone medians that introduce a highway vocabulary that encourages speeding. Buildings like the Butler Bank float in the middle of their parking lots, and the Inn and Conference Center sits behind its entrance drive with all the leafy convenience of a highway Marriott.

This area will remain suburban in nature well into the future. However, one significant opportunity exists to bring improved walkability to the key anchor of the ICC, while creating a more dignified setting for the former Saint Paul's United Methodist Church, which is being renovated to better house the United Teen Equality Center (UTEC). This proposal takes advantage of

A new UMass building atop parking enfronts lower-speed street geometrics and a renovated green.

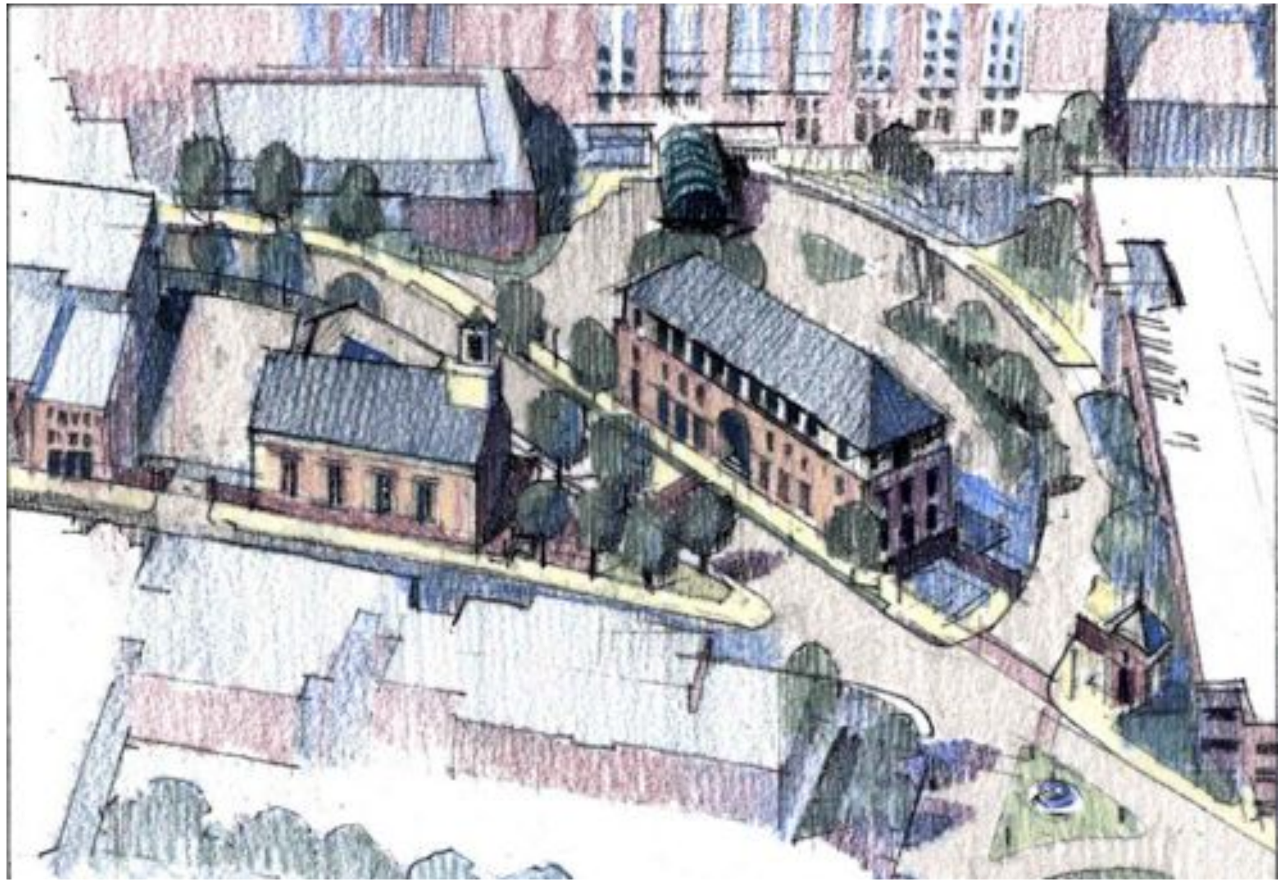
the excellent walkability of Hurd Street, and Chapter 3's plans to two-way Hurd and Warren, in order to create a complete walkable loop that embraces the Church and its front green.

The ICC parking lot provides a weak edge to Warren Street and the church's triangular green.

An intervention is made easy in this area thanks to the sunken parking lot of the ICC, which is properly located to hold a new sidewalk-edge building without losing any of its existing capacity. A new structure so located will sit above the parking lot—from which it can be serviced—and give proper shape to the churchyard. A reconfigured street corner—as described in Chapter 3—will introduce slower speeds and parallel parking to protect the northern sidewalk.

While there is no pressing reason for this proposal to be executed, it is included in this mid-term chapter due to its relative ease and low expense. If UMass can identify a need for a new building, then it makes sense for the City to make the public roadway investment—indeed, the two investments are wisest in concert. One potential use for the new building would be to move the University's new small Inn out of the existing ICC building, where it would benefit from no longer being considered part of a student housing complex.

In conjunction with this effort, perhaps UTEC would like to donate the churchyard to UMass Lowell, in exchange for an agreement to beautify and maintain it. The City can play a role in expediting such a transaction. It is worth noting that, as the District Court vacates its building to the south side of Hurd Street (planned for 2016) improvements to this neighborhood will increase the likelihood of reuse of that historic structure.



Limited reconstruction turns an automobile-era zone back into a walkable environment.

The four proposed interventions that follow are all imagined as being accomplished in the longer term. In planning vocabulary, "long term" generally refers to ten to twenty years. Twenty years may seem like an eternity, but those of us who have been planners for that long—and who have had the pleasure of witnessing projects planned twenty years ago come to fruition—understand that the most important projects can never be accomplished quickly. Indeed, plans that do not look beyond the immediate future do not truly qualify as planning at all, since immediate concerns and temporary impediments will always make bold changes seem impossible.

While some of these transformations may be accomplished more quickly, most lack funding or an economic incentive to happen immediately. Some, like the enlargement of the JFK Civic Center, should not occur until the City's facilities needs dictate. These interventions are put forth here not because they can be done, but because they should be done, and they will not happen later unless they are planned now.

The eight short-term interventions are:

1. Ladd and Whitney Monument Square
2. The Hall/Perkins Neighborhood
3. The Promontory
4. The Davidson Block

11.1 Ladd and Whitney Monument Square

Low and set back from the street, the current JFK Civic Center does little to shape the space around it.

The civic center of Lowell is literally and figuratively located at the important intersection of Merrimack, Dutton, and Arcand Streets, surrounding the historic Ladd and Whitney Monument. It is telling that this public space currently lacks a popular name; we will refer to it as the Ladd and Whitney Monument Square.

As already discussed, this site was redesigned a generation ago with the intent of speeding traffic flows in and out of town, unintentionally creating an environment that feels unsafe for pedestrians. At this time, the delicate intersection of Moody Street was eliminated to create a superblock for the JFK Civic Center, a squat building that pulls back from the street around a now damaged fountain plaza.

While modifications to the street network, discussed in Chapter 3, will help improve walkability in this important location, more change is needed if pedestrians are to once again feel welcome in Lowell's civic heart. While the surface treatments of both the Monument Square and the Civic Center Plaza are clearly in need of improvement, the greatest challenge lies in the vertical plane, where no buildings correspond to the shape of the Square. As a result, it lacks spatial definition and thus fails to function as an urban living room. While the off-angle insertion of Arcand Drive has made fixing this problem difficult, several opportunities exist to improve this intersection.

First is the JFK Civic Center and Plaza itself. One of the great questions of this study has been whether to keep it or tear it down. Certainly no large group of Lowellians could be mustered to its defense, as the building is generally felt to be a historically insignificant example of one of the least loved architectural styles of all time, "brutalism." That said, there are efforts around the country to protect a number of buildings just like this one, which is why the term Lowellian is used above. Conversations around town suggest that most defenders would be driving in from Cambridge.

But tearing down buildings because we don't like them is a frivolous and wasteful proposition. Particularly as this structure is about to undergo a significant investment in its mechanical systems, it would be profligate to just throw it away. That does not mean, however, that it cannot be modified in a dramatic fashion, one which also addresses the issue of the Plaza.

While once graced by a functioning and popular fountain, the Plaza is now unused and also unnecessary, as the deep setback of City Hall and the former trajectory of Moody Street provide ample space for gathering. This is fortunate, as various City departments have been discussing eventual expansions, and growing the Civic Center onto its Plaza allows us to solve two problems at once.

Interestingly, there is a hidden geometry in the shape of the Civic Center building that implies a symmetrical diamond pointing towards the Monument Square. Completing this diamond creates a building surrounding a pentagonal courtyard, one that can be left open or covered as a winter garden, if budget allows. The substantial new wing, which presents a strong corner to the Square, should be at least three stories tall, and can be integrated into a lightweight third-story addition to the existing building.

This design requires the removal of some fairly mature honeylocusts, which should be transplanted along the Moody Street axis to better shape that space. It also suggests a slight change to the Monument Square itself where, to improve pedestrian activity, its more recent northern appendage is resurfaced in stone and opened to pedestrians, as suggested by City Planning staff.

The other disappointing aspect of this public space is its use as the site for a large gasoline station. While cities need gas stations, these do not need to be located in zones that are intended for heavy pedestrian use, and certainly shouldn't be located among civic buildings and squares. Unfortunately, the decision to place this station here, on the site of the historic Merrimack House hotel, is now very expensive to fix, as gas stations are profitable and usually require environmental mitigation.

While no doubt profitable, the Hess Station provides a weak and unattractive edge to the Square.

An expanded Civic Center turns JFK Plaza into an interior courtyard while providing a stronger backdrop to City Hall and Ladd and Whitney Monument Square.

Ladd and Whitney Monument Square

It is for that reason that this proposal finds itself in the Long Term category. At some point in the near or distant future, it will become economically viable to put another use on this site, and the proposed intervention shows the footprint of a new building that gives a proper southern edge to the Monument Square. It also replaces the Goodyear tire store—another auto-zone land use that requires too many curb cuts to be located in a civic area—thus providing a better edge to Worthen Street.

With an expanded Civic Center and a replaced Hess Station, the Ladd Whiney Square area would be more welcoming to pedestrians.

A final reason that this proposal is considered Long Term is the proposed parking ratio, which implies either a new parking structure nearby—see point 9.3—or a reduced dependence on parking due to a future streetcar.

The former occupant of the Hess Station site.

An ideal redevelopment of the block would place a significant building mass along its entire northern edge.

11.2 The Hall/Perkins Neighborhood

The typical pedestrian view in this neighborhood is of parking lots.

It has already been discussed how more people would consider walking to games at LeLacheur Park if the neighborhood along Hall and Perkins streets were more pedestrian-friendly. That concern, coupled with UMass Lowell's large land ownership in this area, has motivated a more comprehensive proposal for the neighborhood's ideal long-term build-out. This study is provided not because it will happen quickly, but because it might happen eventually, and therefore it is essential to illustrate what a successful build-out would look like.

The proposed plan makes use of the same strategy that has been behind every intervention described thus far. With the goal of creating friendly building edges against public sidewalks, new buildings or building expansions are placed where they hide parking lots and ugly building edges from the street. Starting with the M2D2 Building to the west, the first 60'of its front parking lot is developed into a building that meets Aiken Street, directly across from the University's new Recreation Center. Its industrial-quality side flanks are also designated to receive expansions, ideally two to three stories tall, creating a better sidewalk edge. For this new development to be adequately parked, the University must acquire the large Notini block to the south, to be discussed momentarily.

The proposed infill properties shield parking lots and industrial buildings from the street.

Moving east past the Lowell Day Nursery, the plan incorporates a new building that is already proposed and ideally sited to hide the new Perkins Lofts parking structure from Cabot Street. Next, the low white brick building that houses UMass research facilities receives additions to its north and south—ideally two stories—hiding those unattractive flanks. While the front of this building is also unpopular, it faces a green containing some spectacular trees, whose preservation trumps development on this part of the site.

Finally, there is the site belonging to the Notini & Sons distribution center. This block is conveniently large enough to hold a parking lot at its center, surrounded by buildings against the street. As planned, one can imagine two stages of development on this site. First, to improve the walk along Hall Street and the view from the Brewery Exchange, the northern and eastern edges of the block would be developed, hiding a surface parking lot that serves both this new construction and the redesigned M2D2 site across the street. Then, to achieve full build-out, a central parking structure would be introduced, allowing the south and west flanks of the block to be developed, completing the donut.

As part of this development, the southern parking drive along the canal, currently barricaded against Cabot Street, would once again become a waterfront street. The new buildings against Aiken Street would be sure to leave room for preservation of the majestic trees that line the roadway. Although not shown at the scale of these drawings, consistently-spaced street trees would form a part of any reconstructed sidewalk.

Readers will note that the above discussion makes no mention of the uses to be placed on the Notini site, but rather simply designates building locations and acknowledges their need for parking. The design is not dependent on land use, and can flexibly incorporate any combination of academic buildings, student housing, spinoff industrial operations, or other residential or business activity. What matters is that, whatever uses might land on these building footprints, they face the street edge in order to contribute to the livability and success of the surrounding neighborhood.

Eventual acquisition of the large Notini distribution warehouse would allow ample parking for a large collection of new buildings.

11.3 The Promontory

Next to River Place Towers, two levels of parking occupy what may be downtown's best opportunity to reconnect to its riverfront.

Downtown Lowell is located prominently along the banks of the mighty Merrimack River, a fact that is difficult to discern until one leaves; rarely can one glimpse the River from the heart of downtown. This circumstance is the natural outcome of the expedience of placing long mill buildings against the water's edge, where most remain to this day. Only a few opportunities exist for connecting the city back to its waterfront, and the most promising of these is the site that currently houses Lowell Five's headquarters and a parking lot for River Place Towers.

This long-term proposal requires that the Bank relocate its offices, at least temporarily, so that the site can be put to more intensive use. Like earlier concepts for this site, it imagines large mixed-use buildings reaching all the way from Father Morrissette Boulevard to the Riverwalk. Unlike previous proposals, it imagines a continuous public drive surrounding this development, so that its edges, in addition to being public, would also feel public, and would thus be used.

From Ocean Drive in Miami to Venice Beach, California, the best urban waterfronts have cars on them, moving slowly, bringing constant activity and making retail possible. In this case, the waterfront drive is achieved by placing a deck above the lower River Place Towers parking lot, creating a promontory above the river. This new ground plane could fit another entire level of parking beneath it, supporting the development of the site to a mid-rise density.

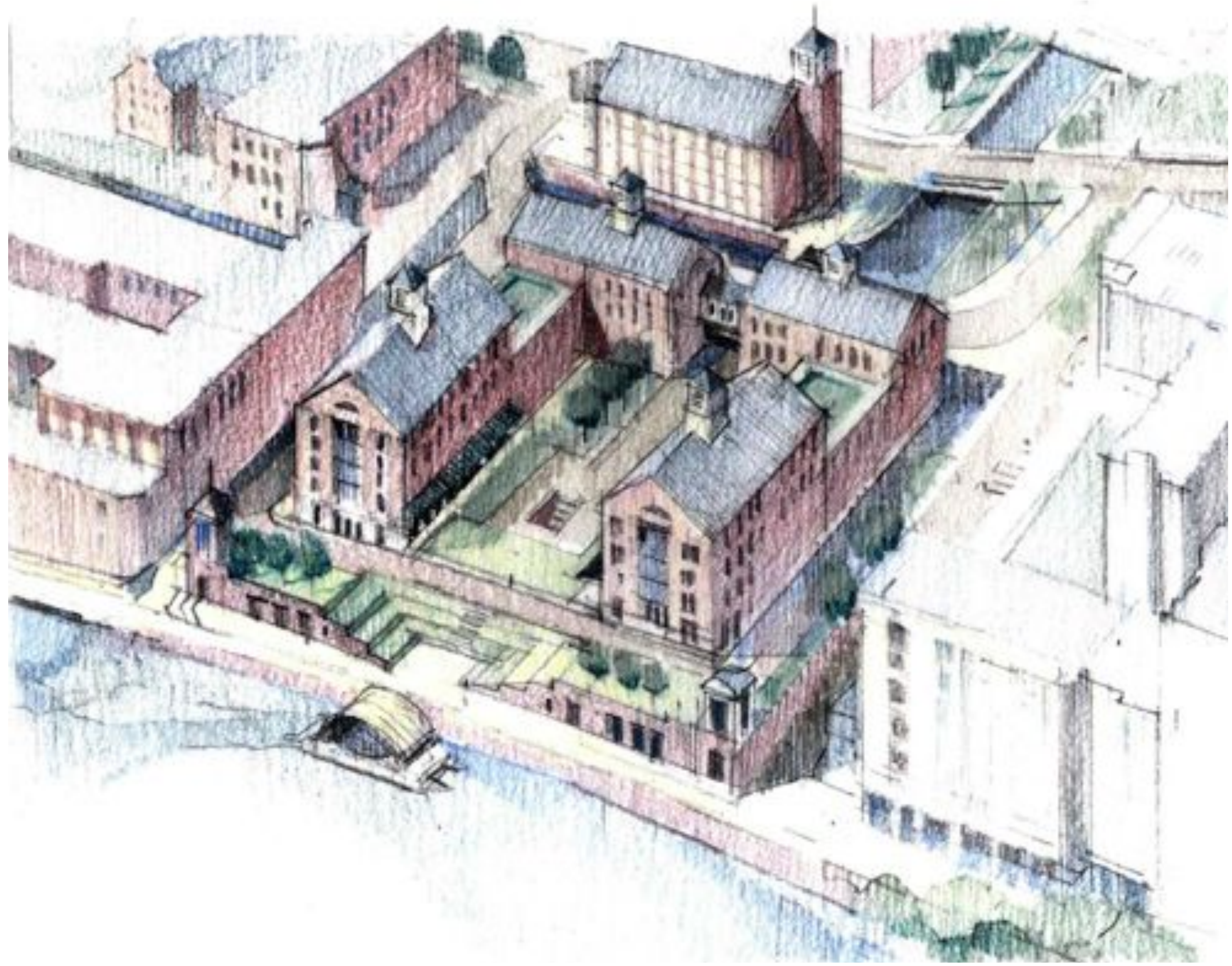
Since it is only a block long, the riverside drive created by this scheme would not invite many cruisers in the manner of an Ocean Drive. But the vehicular access is essential as one component out of many designed to bring as much life to the water's edge as possible.

A public ring road atop parking turns this site in to a new city block, with an overlook that steps down to the Riverwalk. The dashed line indicates the extent of the parking deck.

At the edge of this drive, a public overlook could give way to an amphitheatre-shaped series of steps that work their way down to the Riverwalk, providing a dramatic integration between levels. Wide sidewalks against the northern building ends would make an ideal setting for a café and/or bar, which could bring food and drink to the overlook during pleasant weather. These buildings are imagined as luxury apartments, justified by the beautiful views and perhaps mandated by the infrastructure costs.

Against the edge of the Riverwalk below, the two-story parking deck could be shielded from view by a dozen unique rowhouses boasting the rare commodity of a Riverwalk address. These "eyes on the street," including front doors, would give much needed supervision to the riverwalk.

One can imagine a bandstand barge pulling up to the river's edge to serenade the amphitheatre on a summer night. To the south of this complex, across the canal, the unused parking lot against Father Morrissette Boulevard has also been put to use, as will be discussed further in Chapter 12.



The significant infrastructure investment suggests luxury housing as an ideal use for this unique property.

11.4 The Davidson Block

A park against a parking lot does not feel like much of a park.

When it is no longer of use, the mid-block building (shadowed in gray) should be replaced by a building that enfronts Merrimack Street and the waterfront park.

The fourth long-term proposal is perhaps the least likely to happen, but it is worth suggesting for the benefits that it would provide to the downtown. It involves the Davidson Block, which sits just across the Concord River from the Lower Locks, and across the street from the Lowell Civic Auditorium, where it connects the downtown into the almost-completed 200-mile Bay Circuit Trail. This site has already received some park investment along its riverfront, but it feels disconnected from the rest of the downtown, even though it effectively forms the eastern boundary of the Lower Locks basin.

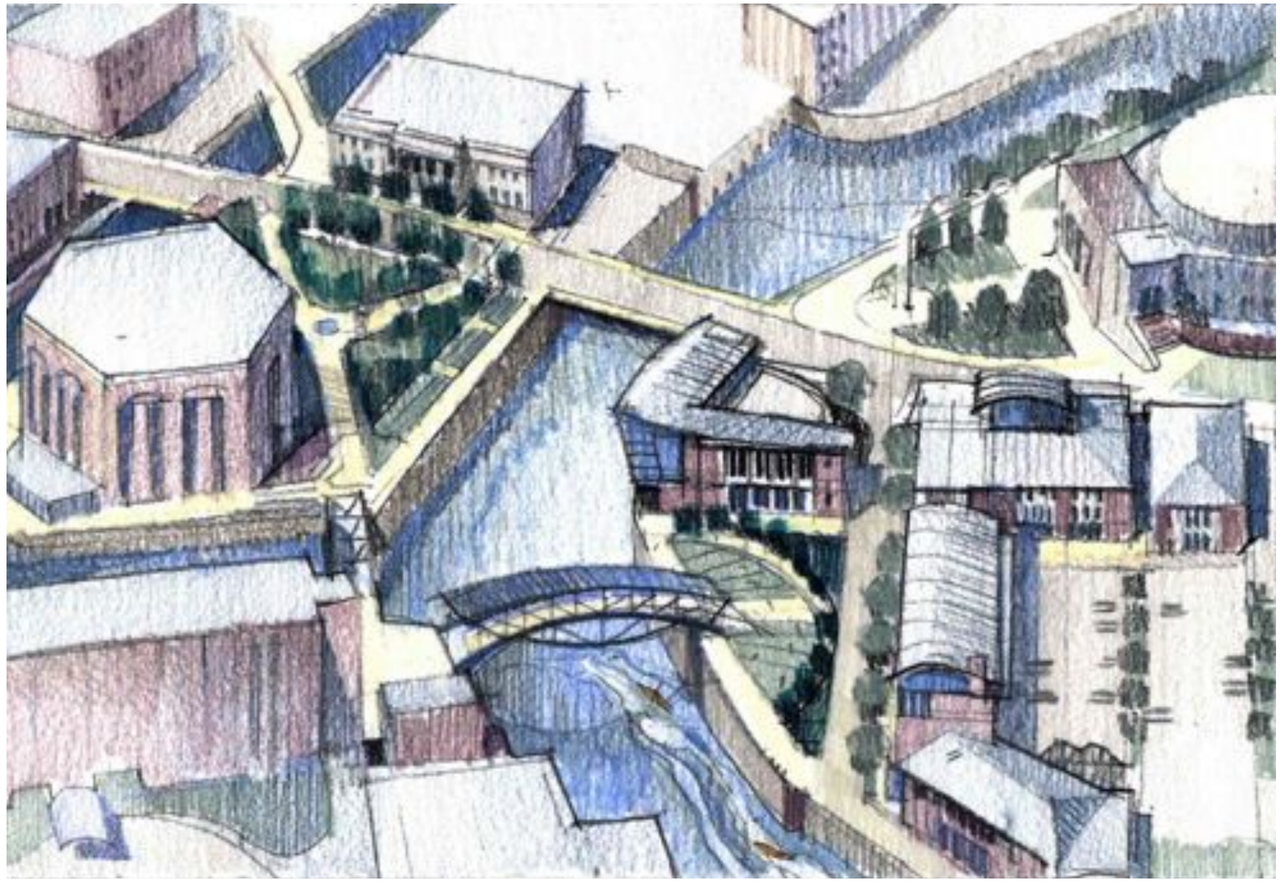
Much like the Wang building property, this site's front parking deters walking along East Merrimack Street, and its weak parking-lot corner does not welcome pedestrians to the water's edge. Its principal building mass sits in the center of the lot, where it does nothing to shape surrounding street spaces. This property is further limited by floodplain restrictions that require any future development to be matched by enough clearance to keep the site's stormwater storage capacity intact.

For this reason, this intervention is considered long-term, since redevelopment would require an economic justification for replacing an existing functioning building with another of similar footprint size. This justification could include the obsolescence of the current building, the capacity to build a taller structure (with reduced on-site parking requirement per square foot), or the perceived higher value of a building taking advantage of the waterfront park—or some combination of the above.

As part of this reconstruction, an expansion to MCC's "Cybercafé" building should replace the parking at the East Merrimack Street corner and welcome people into Davidson Street, which should be reconfigured as a real street as it curves through to Howe Street. A break in the middle of the new construction would serve as a passageway to the large parking lot, which would no longer be visible from the Lower Locks.

This intervention has received this much attention because of its prominent location against the Lower Locks, where tremendous future investment is anticipated—see Chapter 13. It is a great spot for viewing the Locks, and feels like part of the same public space. As the natural completion of a Lower Locks walking loop, it would ideally be connected to the plaza across the Concord River by a dramatic pedestrian footbridge. Also, visible in the extreme left of the plan, a new building has been proposed for the leftover lawn against the Lower Locks Garage, which would give life and a better edge to the moribund little plaza.

The new plaza against Davidson Street is shaped to embrace the view of the Locks, and serves as a frontispiece for a sunset-view restaurant, which could populate it with tables. A final suggestion for this site, which might help to justify its development, would be placed in the Concord River: the whitewater rapids that were proposed in Lowell as part of the Boston Olympic bid. While that bid failed, this powerful amenity can still be built in conjunction with the eventual rebuilding of the Middlesex Dam.



A new bridge across the Concord River allows the Davidson Block to complete the Lower Locks waterfront.

Such downtown whitewater kayaking parks, which have been built in Reno and elsewhere, can contribute significantly to local economies. In this case, such a park would be one more activity to bring critical mass to a revitalized Lower Locks area in the heart of Downtown.

High School students fill downtown sidewalks and certain LRTA buses twice daily.

One of the great questions currently under discussion in Lowell has been whether to move the High School out of the downtown to a new suburban location, most likely in the area adjacent to Cawley Stadium. This conversation, which has been underway for some time, presents the families of Lowell with two choices, both of which seem to be unacceptable:

"Keep the High School Downtown"

Lowell High School has always existed in its current location in the heart of the city. But as the high school has grown, and as driving has displaced other means of transportation, the physical impacts of its presence have become more pronounced, particularly at 2:30 in the afternoon, when it briefly becomes considerably more difficult to drive around the downtown. At this time, and during the morning rush as well, students dominate the pedestrian population, contributing an energy that some cherish and others bemoan. Teenagers jaywalking on Merrimack and Kirk Streets contribute what has been affectionately labeled as "human traffic calming" to the historic core, and cars and buses choke Father Morrissette Boulevard and French Street.

These traffic impacts are an annoyance that experienced Lowellians have learned to schedule their days around, especially since they are so brief in duration. More difficult to accept, because it impacts the students, is the current condition of the Lowell High School facility, which lags behind national and state standards in a litany of categories. It is difficult to argue for the continued use of the current high school buildings when they are not providing Lowell's children the physical space and equipment required by current educational practice. And there is no space available on the High School property for an addition of any significant size.

"Move the High School out of Town"

This proposal, which has also been called "pulling a Lawrence," involves the construction of a complete new facility located four miles from the center of the city, where land is ample and few site constraints exist. Such a facility could correct all of the perceived shortfalls of the current facility, including the need to bus students to sports practice. However, given its far-eastern peripheral location, it is likely to cause a net increase in busing time and costs, particularly since students would be less able to take advantage of existing LRTA routes.

More to the purpose of this study, the departure of the high school and its 3700 people from the downtown would have a dramatic impact on the nature of downtown life. While some complain about their demeanor, there can be no doubt that high school students contribute great activity, energy, and diversity to a downtown core that can feel under-populated in their absence. They also contribute a significant amount of cash to downtown businesses. When asked about their shopping habits, a group of students guessed that each LHS pupil spends $5 per day downtown. Even if a more accurate estimate were closer to $2, this would still add up to over $1 million annually.

Finally, it is hard to put a price on the value—to both to the students and the city—of the civilizing influence of daily urban exposure on students' lives. It is fair to say that, without the downtown high school experience, many future Lowell graduates would not make the choice to spend time downtown as adults, nor would many have the nerve to thrive in city environments. One High School student commented how Lowell graduates feel more comfortable attending urban colleges than graduates from more suburban schools, and such a broadened comfort zone can be expected to have impacts into maturity as well. Since Lowellians tend to stay in Lowell, it is difficult to fathom the long-term cost to downtown of raising a generation of students unaccustomed to urban life.

A Third Way

Informal polls among downtown residents (roughly 100 to 5) and high school students (roughly 30 to 5) suggest that people cherish the high school downtown. Only white-collar office workers seem fairly evenly divided on the issue, due principally to traffic complaints. Fortunately, this choice, which always seems presented in black-and-white terms, is what philosophers would refer to as a false dialectic. A third path exists, which is a renovated high school on the current site, made possible through the acquisition of one adjoining property, the medical office to its south.

Imagined in the City's 2001 Downtown Master Plan as a retail site, this property could more importantly provide an LHS renovation with the area it needs to properly stage construction without closing the school. This renovation would be focused primarily on the replacement of the school's newer 1980 wing which, unlike the older school buildings, has been plagued with problems since its construction. These problems include leaks, toxic carpets, code violations, and a notoriously undersized cafeteria separated from its kitchen. Without

Renovation would center on replacement of the High School's problematic 1980s wing.

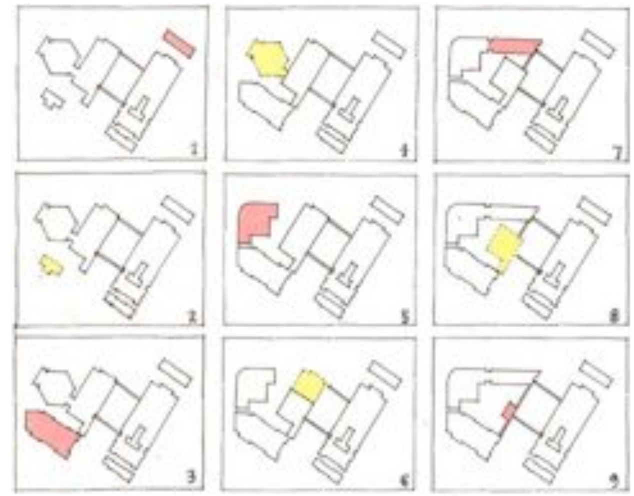
getting into details, it is important to insist that any new high school in Lowell be subject to a much improved procurement and design process than was in place in the late 1970s.

Staging

While many different approaches to renovation are possible, the most obvious solution involves construction of a new field house on the existing medical building site, and then a clockwise process of demolition and construction around the property. This process could be further eased by the acquisition of the empty and chained parking lot just across Father Morrissette Boulevard, which could be used to replace the medical building, or designated a part of the high school expansion. This lot was earlier offered to the High School for free, but "red tape" stalled its acquisition, a problem that would perhaps require City involvement to overcome. Its acquisition would add some further "breathing room" to the proposal below, but is not at all essential to its viability.

In the accompanying diagram, a nine-step renovation process is imagined as follows:

1. Begin construction on site across Morrissette, perhaps for relocated medical office (optional).
2. Demolish medical office, being sure to pro-actively relocate doctors in downtown Lowell.
3. Build new field house on cleared medical office site.
4. Demolish existing field house.
5. Build corner structure including classrooms and cafeteria.
6. Demolish northern half of building containing cafeteria.
7. Build second classroom wing.
8. Demolish southern half of building.
9. Build final pavilion along canal, most likely containing library.



This process would be slower and more complicated than the construction of a new building from scratch but, if properly handled, could be completed without any great sacrifice to student education, comfort, or convenience. It would also allow for the preservation and continued use of the school's favored older buildings, which would most likely result in a considerably lower cost than an entirely new facility.

Design

The proposed new site plan for the school aims to solve a number of current problems. First, it is larger, allowing the building to become no less complete than it would be if located on a suburban site. Second, it creates a large green space at its center, larger than the Cox Circle property that is currently being used for sports and band practice. Third, it creates a firm, attractive edge against Arcand Drive, set directly against a broadened tree-lined sidewalk, helping to invite pedestrians between the JFK Civic Center and the Tsongas Center.

Finally, it steps back from its current location directly against the canal and trolley tracks, allowing for the

The new LHS plan includes continuing Dutton Street through the site, for student drop-offs and pick-ups.

continuation of Dutton Street through the property from Merrimack Street to Father Morrissette Boulevard. This street, one way and for school use only, would take tremendous pressure off of Morrissette, Kirk, and other downtown streets, easing the mid-afternoon choke.

The proposed plan was not designed by a school architect, which—while placing it at no disadvantage to the current facility—suggests a great amount of further study.

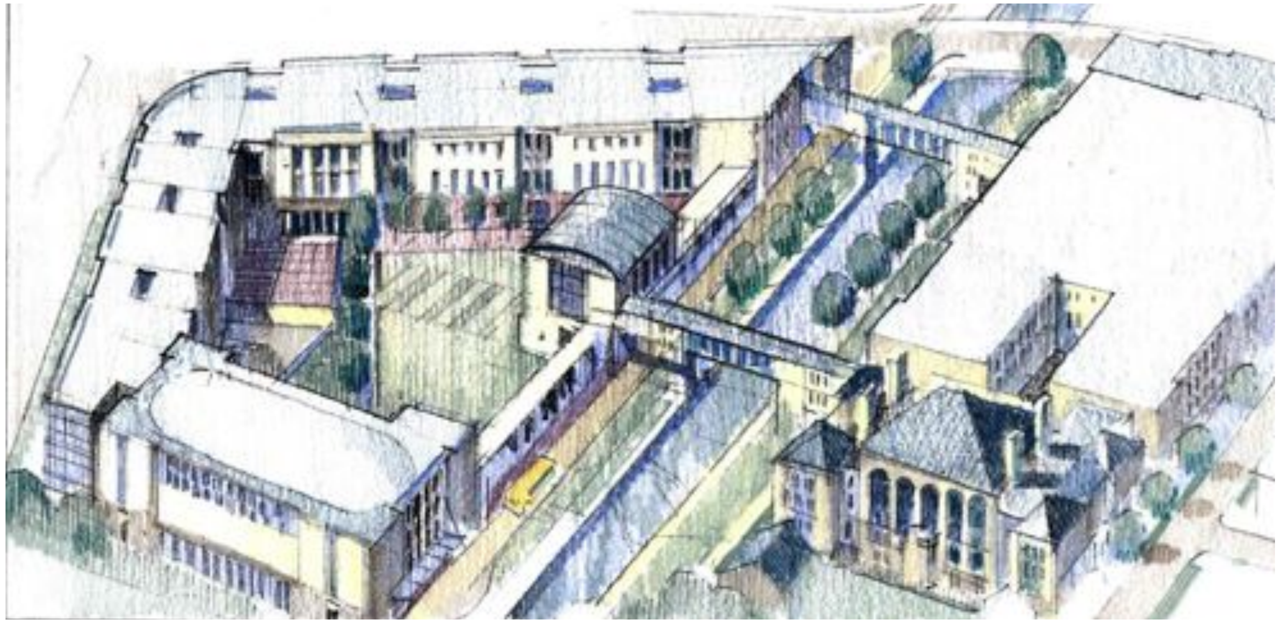
The 1980 wing and the medical office (shadowed in gray) would be replaced by a building that traces the perimeter of its site, creating a versatile central green.

With that said, here are some of its key features:

- The cafeteria extends towards the central green from under its classroom wing, with a large roof that can be a green terrace if desired.

- The frontispiece to the field house and the corner building are actually continuous at the upper stories, but a pass through at grade allows trucks in and out of a service area and loading dock next to the cafeteria.

- The central green has a tree-lined walk around its perimeter and a large grassy center that is open to a full variety of uses.
- The new pavilion against the canal, ideally a library or resource center, is placed at the nexus of the skywalk system. Beneath the canal-side skywalk is a continuous arcade offering shelter for drop-offs and pick-ups.
- Dutton Street passes alongside this arcade, with drop-off parking along one side. While this parking would more appropriately sit along the western curb, it is likely that fears of congestion at Merrimack Street will require Dutton to run one-way south to north, which would place the drop-off zone along the canal instead.



A new downtown Lowell High School gives proper edges to Arcand Drive and the Merrimack Canal.

Getting Started

Like the construction of any new high school, this proposal cannot be accomplished until State assistance is available, which is not expected soon. But such funding will materialize eventually, and when it does, it will be important to have a confirmed plan in place. Moreover, the City is much more likely to win funding for renovations once it has made application for a specific construction effort. For that reason, this long-term proposal demands short-term action if an optimal outcome is to be possible within a reasonable amount of time.

Finally, it is important to note that the City may need the State to waive certain school site-size requirements in order to receive funding for this project, since those requirements were created with suburban campuses in mind. Fortunately, Massachusetts is a national leader in Smart Growth, a movement and fiscal orientation that advocates against the replacement of urban schools with suburban facilities. For that reason, it will be useful to engage smart growth advocates within the State leadership in support of this project.

The final intervention proposed in this plan is as expensive and complicated as it is unnecessary, but holds within it the potential to fundamentally transform Lowell into a city of the first rank, both as a tourist destination and as a location for business. It surrounds Lowell's Lower Locks which, even in their current condition, make a profound impression on first-time visitors and seem to hold great potential to all but the most jaded Lowellians.

An Underutilized Asset

Lowell is distinguished from almost every other American city by two assets that it possesses in great quantity. The first is the handsome mill buildings, which form a dramatic part of the cityscape and which have been preserved and redeveloped to the great benefit of the community. The second is the vast collection of canals that once caused Lowell to be known as America's Venice, and which have yet to be fully put to use for their contribution to the city's built environment.

There are a number of reasons for this situation. First, many of the canals are located behind mill buildings, out of view, since mills benefited from that configuration. Second, many of the canal spaces are too narrow to convey any character as urban places. Third and perhaps most significantly, the ownership of the canals, their embankments, and the surrounding spaces is so fractured and complex that few have been willing to take on the challenge of transforming them. Certainly the Park Service continues to do a fine job of maintaining and sprucing up the areas under their control, but they are one party out of many. The greatest complication comes from the ownership of the canals' generation capacity by Enel, an Italian company, who at any time could theoretically alter the water level dramatically based on its system technical requirements.

More discussion of the ownership challenge will follow. But there exists in the heart of the downtown one place where the first two challenges—exposure and breadth—are amply overcome, and that is at the Lower Locks. Here, visible from Central Street, Merrimack Street, the MCC Campus, and across the Concord River, the canal system splits to form a dramatic and well-shaped public space, holding a broad body of water and interlaced with a pedestrian circuit of just the right length for a pleasant stroll.

The Lower Locks is the downtown canal location with the greatest potential to become a transformative public space.

Clearly, this location possesses many of the fundamentals of a great urban attraction—including a trolley stop. It has, as they say, "good bones." But visitors to this site equipped with the experience of other urban waterfronts can't help but consider the Lower Locks as a missed opportunity, a mere shadow of what it is poised to become. Its potential can be found in places like Providence and San Antonio, where public and private investment in urban riverwalks have contributed dramatically to the remaking of the cities around them.

Useful Precedent

Providence uncovered a portion of its downtown river to create a powerful new centerpiece for the city.

These two examples are quite different from each other, but are similar in the qualities that they possess which the Lower Locks lack. Providence's Riverwalk, one of the great new-urban design projects of the 1990s, consists of a broad river flanked primarily by public streets and the fronts of buildings. San Antonio's Riverwalk, a flood control project completed by the Works Progress Administration in the 1940s, is best known for its more intimate spaces, in which pedestrian paths and the rears of buildings surround a narrow largely waterway hidden from public streets. Both of these projects are tourist destinations, not just because they contain water, but due to the high quality of their public realm, which can be characterized as urban and civic. Large quantities of stone and heavy decorative ironwork lend a dignity to outdoor spaces properly furnished with handsome lighting, benches, and public art—a collection of details only available in fully evolved urban places.

San Antonio's Riverwalk is more intimate and commercial, but remains urban and civic in its materials and details.

In contrast to this urban experience, large areas of the Lower Locks could still be characterized as fundamentally rural in their conception. Instead of stone, iron, and sculpture, we get wood, crabgrass, and asphalt. Lighting is low and inconsistent, and many balusters and other features seem merely expedient rather than designed. Defunct steam pipes in peeling insulation mar the water's edge, and awkward ramps—and even a small parking lot—occupy spaces that are better suited to be public plazas.

Low wooden lights (mostly broken), grass, and asphalt surfaces contribute to the rural quality of this environment.

Impediments

Some of these details are temporary, awaiting a Park Service refurbishment, but most are planned to remain, due first to budget constraints, second to a preservation ethic that is wisely wary of change, and finally to the lack of a unified proposal for transforming this moribund lagoon into the great civic destination that it has every chance to become. Each of these warrants discussion.

Money

It has become abundantly clear that Lowell is a city that "gets things done," and is—at least historically—extremely skilled at raising federal funds in support of local projects. While little money currently exists for embarking upon a transformation like the one proposed here, such money cannot be pursued unless a strong proposal exists. As was the case with the National Park, the Tsongas Center, and other projects in the city, the dream must always predate the funding.

Lowell's key opportunity for a south-facing waterfront is now a parking lot for eight cars. A blank wall awaits artwork.

Preservation Ethic
Being respectful of its history has served Lowell well. There can be no doubt that, without its exemplary preservation practice, Lowell wouldn't be the appealing place that it is today. But part of that success has been allowing modifications to historic buildings, holes cut in mills, creative reconstructions, and other undertakings in which a happy compromise was forged between leaving the original artifact untouched and creating an environment that serves contemporary needs. The Lower Locks is one of many places in Lowell where a healthy tension necessarily exists between the impulse to preserve and the impulse to improve. Because these canals were historically used to move goods, provide power, and dump waste, they do not possess the urban quality that will allow them to thrive as public places. This proposal begins with the premise that a sensitive transformation of historic landscapes can be justified by the vitality that results.

A Unified Proposal
First, it must be noted that the foreign ownership of the canals' generation capacity is no excuse to avoid investing in this location. Only on rare occasions does the water briefly drop to unattractive levels. Second, like any large planning scheme for a city with people in it, this proposal necessitates a limited amount of government intervention—and perhaps even a touch of eminent domain—to make changes to a variety of properties under multiple ownerships. No historically significant transformative plan has ever avoided this practice. The most inconvenient change would probably be the proposed repurposing of the small parking lot and the lower two stories of the building that flanks it. But there can be little doubt that a massive investment of the type imagined here will only improve the values of all surrounding properties. Such an undertaking, if ultimately deemed meritorious, will demand a commitment of City leadership both to seeing it through and to ensuring that all affected parties are treated fairly and given the opportunity to share in the eventual benefits.

Two Levels of Proposals

This plan includes both a physical proposal for the Lower Locks and a programmatic one. It can be said with some confidence that a merely physical transformation to this dramatic landscape has the power, if done properly, to turn it into a tourist-worthy destination that will contribute mightily to the future success of the city. However, the impact of that physical investment can be greatly increased—indeed multiplied—if the spaces are also programmed with unique uses that give people a specific reason to visit them. The distinction between the two proposals is important to make, because a strong physical proposal should not sink or swim based upon the viability of the programmatic one. It could be that a better opportunity exists for programming these spaces and, if so, it could be coupled with a similar physical proposal to the one offered here.

We will now briefly describe each of the proposals on its own before showing how they merge into a complete conception.

The Physical Proposal

The physical proposal contains several levels of intervention. The first level is intended to correct flaws in the current scheme—narrow stairs, awkward ramps, parking lots, encroaching building additions—and to bring the entire public space up to the highest

The stone pavements used against the sites of the MCC and ICC buildings should be applied to the entirety of the Lower Locks basin.

level of civic materials and detailing, including stone, ironwork, and well-designed urban furniture. The second level involves a number of specific urban and architectural interventions including: the redesign of the back of the Prescott Street building against the aforementioned parking lot; the creation of a plaza against Prescott Street in place of the former Lowell Sun Printing Press building; the introduction of one new and one replaced footbridge; the reconstruction of the back of the Inn & Conference Center where it meets the Lower Locks; and the addition of a new building embracing the Lowell Hair Academy. Each of these will be shown ahead in detail.

The Programmatic Proposal

In discussions about the ideal use of the Lower Locks area, a wide range of different concepts was floated. By far the most compelling grew from Lowell's unique

The Lower Locks

The awkward ramp against the lower locks wastes a valuable public space. Replacing private hotel rooms with a public function room would better capitalize on the view.

status as an urban National Park, and the opportunities that locals and visitors have to interact with the city's history in a meaningful way.

Many people who visit Lowell, or who live in Lowell, aren't the type to set foot in a museum. They may come to see the mills or the canals, but their interface with the city's industrial past is something that they prefer to experience while out and about, rather than in a controlled environment. Lowell's National Park has been groundbreaking in its creation of a "City as Park," and the many opportunities that visitors have to experience our nation's industrial heritage simply by moving through the downtown are remarkable. Whether on a trolley, in a boat, or just on foot along the Canalway, visitors can't help but come to understand the city and this country better.

This more flexible understanding about the relationship between viewer and object can also be found nationally a new type of "museum" that, rather than keeping the subject matter locked up behind closed doors, integrates the exhibits thoroughly into a public space, so that all the benefits of museum-going can be shared even with those who do not go to museums. These public spaces benefit from the display of artifacts, but the depth of participation of the visitor is a matter of personal choice. Seattle's recently completed Olympic Sculpture Park is a fine example of the type.

New public parks like this one in Seattle allow a less formal interaction between visitors and objects on display.

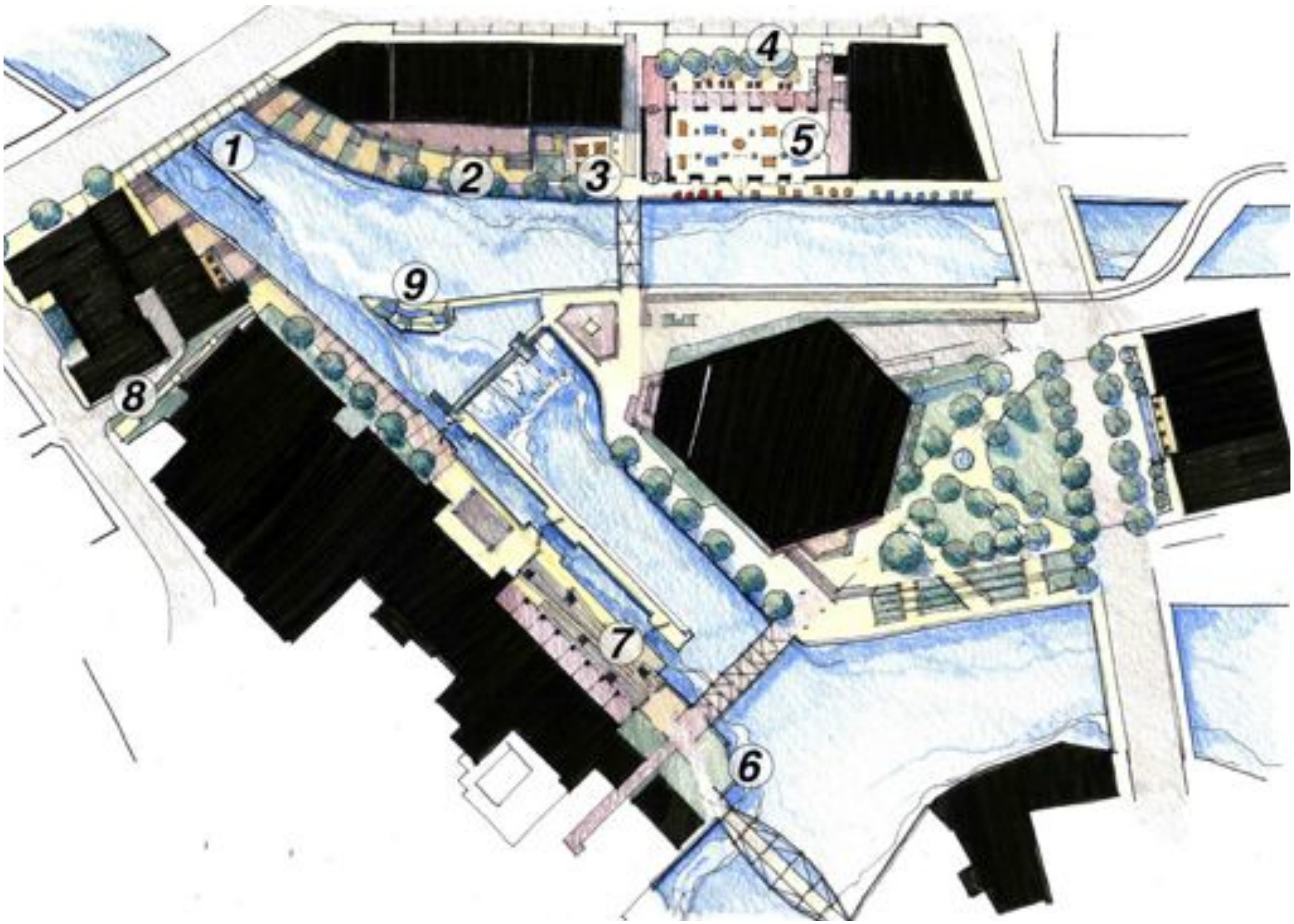
Taking the current Park Service visitor experience as inspiration, this Plan proposes that the Lower Locks area could be successfully reprogrammed as an Outdoor Museum of Water Power, at which a collection of durable industrial machinery could be displayed on pedestals throughout the public spaces. There would be no price of admission and no security guards, just a public space full of large, remarkable contraptions explained by simple plaques. They could be organized chronologically in a circuit around the lower Locks, starting and ending at Central Street, and thoroughly integrated into all of the area's other uses. Visitors could study them, enjoy them, or ignore them as they see fit, but these artifacts would be experienced by a much larger public than they would ever find indoors.

For many people—especially children—industrial objects like this one can be more attractive and compelling than the most imaginative work of modern art.

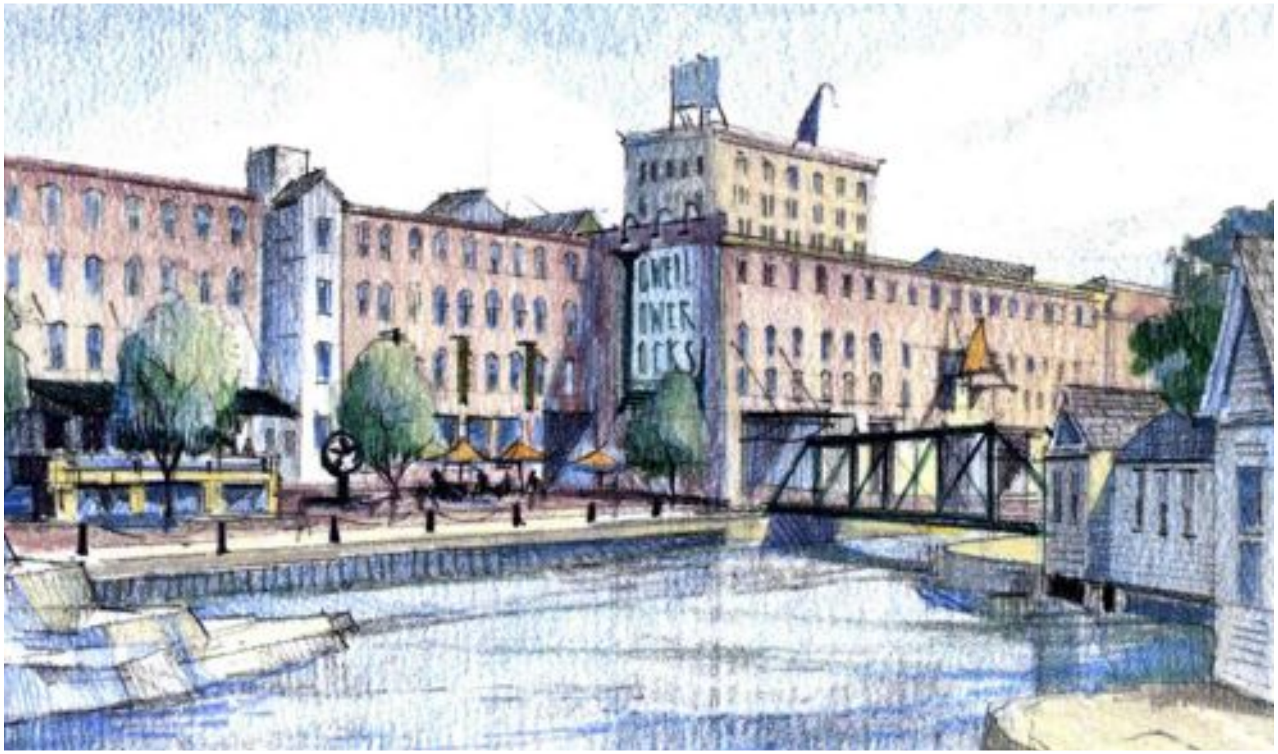
This proposal has not been studied in depth, and may not be the best use of the Lower Locks site. But it seems compelling and, for that reason, the renderings that follow show a physical proposal that has been supplemented by the inclusion of just such an outdoor museum.

Walking Through the Plan

Our tour of the Lower Locks begins and ends at Central Street, proceeding clockwise through the site. Each stop in the tour is marked in the plan.



The Lower Locks



Artisans' Walk leads to Lower Locks Plaza, decorated with industrial sculpture and a bold wall mural.

1. The Western Cascade
Entry into the Lower Locks from Central Street is now accomplished via a narrow sideways stair, with little integration between the sidewalk above and the Canalway below. This proposal peels back the bridge rail to the width of the waterway, and creates a tilted plaza that turns the Central Street sidewalk and both sides of the canal into a single public space. Stone stairs, platforms, planters, and display pedestals run gently downhill from the street, taking a full 90 feet to land at waters edge. This dramatic change to the canal edge would be detailed in a way to clearly distinguish it from the historic ground plane, so that memory of the original configuration would not be lost. That said, it would profoundly alter the nature of this space, and its anticipated benefits must be weighed against the desire to maintain a more historically authentic environment.

2. Artisans' Walk
While existing trees would be kept, the parking lot would be completely transformed into a stone public space, with owners' cars relocated to the nearby Lower Locks Garage. Customer parking for Tutto Bene and other businesses would now be available at curbside, thanks to the redesign of Prescott Street (See Chapter 3). The half-story-up/half-story-down configuration of the enfronting building would allow for a reconfiguration in which a large row of porches sit above a sunken courtyard receiving southern sun. It is recommended that these lower two stories be acquired, so that the basement can be repurposed as a colony for the industrial arts and the first floor as a gallery row. In good weather, artists can work in the lower courtyard on pieces that are sold on the porches above. As in the entirety of this scheme, pedestals displaying industrial objects would march along this circuit, probably in chronologically order of manufacture.

3. Lower Locks Plaza
Directly behind Tutto Bene, the porch and trees end, and the space opens up into a nicely sized plaza, ideal for outdoor dining. The huge blank wall of the adjacent building receives a clearly contemporary graphic mural that "brands" the space and can be used in an international tourism marketing campaign.

4. Prescott Plaza
Currently, Prescott Street feels entirely cut off from the Lower Locks, which can be reached only through a dark tunnel adjacent to Tutto Bene. The narrow street also suffers from an unrelieved "canyon" feel, exacerbated by the harsh façade of the former Lowell Sun Printing Press. This now empty building was built in front of an industrial-era mill that it now hides from the street. The two buildings together create an extremely thick structure that has proven extremely hard to rent. All of

these problems can be solved at once by removing the newer building to create a plaza against Prescott Street. This expensive proposal, while not essential to the scheme, would make a significant contribution to the downtown experience, and would eliminate the Tutto Bene tunnel, easing access to the Lower Locks from the heart of downtown. A plaza in this location makes the most sense if built in conjunction with item 5, the *International Market*, for which it would serve as a frontispiece and outdoor expansion zone. Removing the printing press building would also result in a market of the proper thinness to allow for clear views between Prescott street and the Lower Locks.

A new plaza along Prescott Street replaces the former Lowell Sun Printing Press and eases access to the Lower Locks. The first floor of the remaining canal-side building is repurposed as an International Market.

5. The International Market

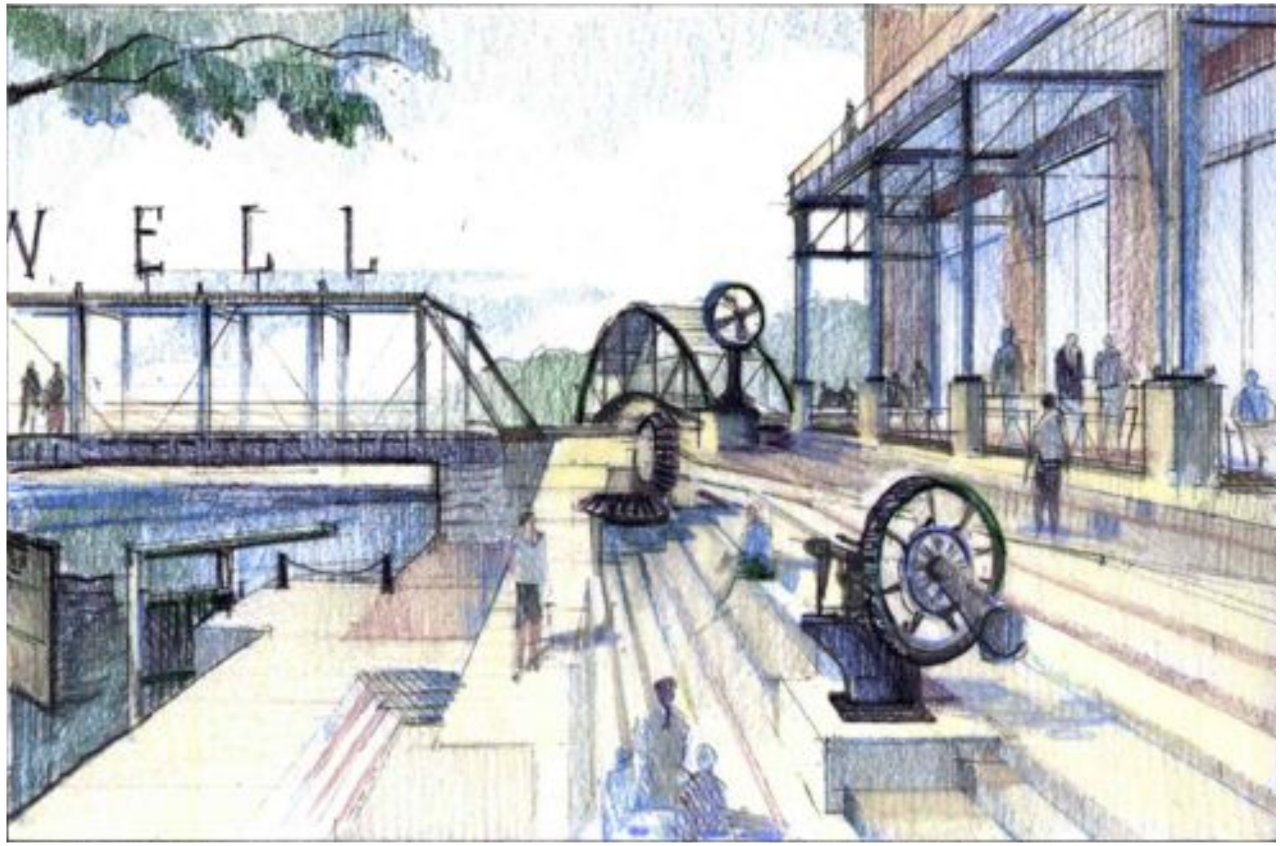
Aside from the mills and canals, Lowell is also distinguished from the surrounding region by its remarkably diverse population. Continuing traditions from centuries past, the city remains an immigrant magnet and sports an extremely wide variety of world cultures, including the second largest Cambodian population in America. Yet, aside from a few bakeries and restaurants—and the presence of high-schoolers—that diversity is little felt downtown. It is reported that most would-be merchants from recently immigrated families need a lower price of entry—ideally $0—if they are to sell goods downtown. While again not central to the larger scheme, the location of an International Market in the single large ground-floor space connecting Prescott Plaza to the Lower Locks offers an opportunity to create a new attraction downtown that proudly celebrates and benefits the immigrant community. Also, placing such a hub of activity in the Lower Locks would help the redevelopment achieve critical mass; the more reasons to visit, the better. If Seattle's sculpture garden were located next to Pike Place Market, it would be that much more of a draw.

6. The Concord River Plaza and Footbridge

As discussed in the Chapter 11, the public space of the Lower Locks really ends across the Concord River at the Davidson Block, where another long-term intervention is proposed. Both investments would be more likely to bear fruit if they were directly connected to each other by a bridge. Given its prominence, this structure would be best designed through an international artists competition, and could become a landmark in its own right. This connection would also give more purpose to

Tourists go out of their way to visit Amsterdam's new Python Bridge.

the usually deserted corner plaza, which also needs a new small building between it and the Lower Locks Garage—and repairs to its water sculpture. Please note that this scheme also replaces the unattractive and view-obscuring footbridge across the Lower Locks with a more fitting industrial-style structure, visible at right.



A repurposed ICC edge sits atop a stepped plaza reaching down to the boarding area at the lowest lock.

7. The UMass Steps

As shown several pages back, another underutilized space is located at the rear of the Inn and Conference Center, directly above the lowest of the Lower Locks, a truly formidable piece of 18th-century engineering. Here, one of the most interesting spaces in Lowell is chopped up into an ungainly switchback ramp and enfronted with the private patios of a dozen hotel rooms. This potentially popular access point for canal and river tours could also serve as a dramatic frontispiece to a new grand public room within the ICC. UMass leadership has expressed an interest in eventually making better use of this space, and placing a public front porch against a stepped sculpture garden would certainly create an unsurpassed venue for fundraising.

8. An Ideal Hotel Site

The surprising lack of a four-star hotel downtown has been much discussed, and one hopes to see a remedy underway before this plan's ink is dry. Whether or not that happens, the transformation of the Lower Locks into an international-quality destination will give new value to adjacent properties, particularly for hotel use. The most promising property in that regard is the Lowell Hair Academy, which, with the adjoining vacant parcel, presents an ample opportunity for a skillful hotelier. The proposed plan shows the historical 4-story and 2-story buildings shedding their nonconforming one-story addition, and then being wrapped by a building

Steps cascade past a renovated Lowell Hair Academy, ideally repurposed as a hotel.

that occupies the parking lot and reaches down to the canal edge with a new entrance. Between this new wing and the ICC, a new handicap ramp would allow the reconfiguration of the southern stairway to Central Street in the manner discussed in point 1. The hotel is shown with a porte-cochere along Warren Street, so that Valet Service could easily make use of the Lower Locks Garage. It would ideally place its café/restaurant against Central Street, reaching back along the stair cascade to an outdoor dining porch against its two-story wing.

9. The Central Fountain

This final proposal takes advantage of a current sore spot, the scruffy grass island that sits awkwardly in the middle of the canal basin, awaiting some form of tidying-up, if not reconstruction. This central location is the perfect spot for a large sculptural fountain. The character of this installation could range from the proudly civic to the noisily celebratory. On one end of that spectrum, a geometric granite earthwork in the manner of Andy Goldsworthy could surround a single plume of water. At the other extreme, a giant kinetic sculpture could use water power to create a festival of motion, light, and sound. If large enough, this industrial artwork would draw crowds to its on-the-clock choreography of spinning, spraying, splashing activity.

The proper choice along this spectrum can be made only by the people of Lowell. Any such solution would represent a large financial investment, but one that a wise philanthropist might wish to bequeath as the ultimate tool for bringing Lowell and the Lower Locks resoundingly into the present day.

As *Lowell Sun* columnist Kendall Wallace noted earlier this year, “It’s time for Lowell to dream again.” This comprehensive proposal for remaking the Lower Locks is planning of the dreaming sort. It is so ambitious that is should perhaps be presented as its own plan, separate from the rest of this document, which is much more focused on the art of the possible. But this proposal is indeed possible, just not probable. It will become likely only when the people of Lowell embrace it not as a planner’s wish, but as a dream of their own.

In Lowell, this has happened before.

Cumulatively, all of the above changes would transform the Lower Locks into a destination worthy of its historical significance.

An Approach to Success

This Plan document does not contain a thorough implementation discussion. This point requires emphasis, because it is precisely such a discussion which is the essential next step in its becoming a reality. While implementation is not a part of this project's Scope of Work, this brief chapter attempts to a lay a groundwork on which to base that effort.

Official Process

While this plan ultimately can only be accomplished with the enthusiastic participation of the private sector, it requires some very specific governmental actions if it is to begin to shape the future of the downtown. It is recommended that the Lowell City Council follow a three-step process in its adoption of the Plan:

1. Endorse the Plan in Concept.

This Plan contains many specific City investments as well as the effective rezoning of properties. Without specifically approving any of those financial or legal commitments, the City Council's general endorsement of the Plan document demonstrates a commitment to the principles and approach present in the plan, and further requires that the plan be consulted in conjunction with any city investment or zoning decision that relates to its recommendations.

For example, if an already-budgeted street improvement were located within the planning area, the Public Works department would be asked to consult the plan and either follow its recommendations or provide compelling arguments to the contrary. Similarly, any owner bringing private property before the City Council for rezoning—if that property is discussed in the Plan—would be asked to follow the Plan or amply justify why not. Additionally, any property owner considering as-of-right construction on a Plan subject property would be asked to meet with the Division of Planning and Development to review and consider the Plan's recommendations for that site.

None of these requirements have the force of law, but all of them ensure that the Plan is given the opportunity to influence all construction that falls under its purview. Finally, endorsing the Plan in Concept initiates the effort to adopt the Plan in the Specific.

2. Adopt the Plan in the Specific.

This Plan will not have the desired impact unless it has the force of law. Different aspects of the Plan can be made legal in different ways. Proposed street reconfigurations should be specifically approved and budgeted. Proposed building interventions—to the degree that they are not in accordance with current zoning requirements—should be pre-approved as necessary through an optional zoning overlay, or made mandatory as replacement form-based code, potentially on a site-by-site basis.

Other recommendations, for example the JFK Plaza site design, should be approved preliminary in anticipation of a future need for expansion. Finally, the key interventions at the High School and the Lower Locks—and perhaps others—need to be broken apart from the plan and addressed individually (while not delayed), due to their size, importance, and expense. In all cases, the proper strategy would be to approve all of the Plan's favored proposals so that no further action was required by Council to advance them in the future.

The first task to be accomplished in this regard, probably by the Division of Planning and Development, is to sort the Plan's many dozens of recommendations into the proper categories. The first category would include all of the recommendations that are determined to be quickly approvable by City Council, to be processed immediately in an omnibus measure. The second category would include all recommendations that warrant greater debate, to be taken up quickly, but not in such a way as to delay the first-phase recommendations. Debate would limit these recommendations to the point where they can eventually be approved in a second omnibus measure. Finally, larger issues like the Lower Locks would receive their own scrutiny and debate, and presented to Council for approval if and when their momentum dictates.

A useful document in this regard is the *Lowell Downtown Evolution Plan Executive Summary,* which presents all of the significant Plan recommendations in a more abbreviated form.

3. Create a Construction Schedule and Budget

For the projects that require City investment, the City Council will need to approve a schedule and a budget. Some of these proposals, like the reconfiguration of the one-ways, should be packaged then targeted for specific fundraising efforts. Others, like the improvement of Cox Circle, seem ideally suited for instruments such as District Improvement Financing. Clearly, recommendations of this Plan's magnitude will have to be completed in stages over a number of years, but the schedule for their funding should be established in the short term.

In addition to these three steps at the Municipal level, this Plan recommends naming a private non-profit organization that is focused almost exclusively on its implementation. Rather than just a document, the *Lowell Downtown Evolution Plan* needs to become an entity. This effort needs its own website, its own phone line, and—most importantly—its own director. There is simply no substitute for having a dedicated person who wakes up every morning and asks "What can I do today to implement this plan?"

This was the approach adopted by Plan Baton Rouge, a 1999 effort similar to this one, that by 2009 had accomplished fully 83 of its 104 "strategic actions" in transforming the heart of that city. These actions included a new hotel, planetarium, art museum, and farmers' market. Such an organization need not be costly to run, but it must be focused, high-profile, and pro-active.

Conveniently, in Lowell, we do not have to look far, as there already exists a non-profit that is properly named and positioned to play this role. At the beginning of this process, it was commented that the Lowell Plan needed a plan. Now, with that organization's continued indulgence, it has one.

Some Final Thoughts

Lowell is remarkable because people stay here. Most subjects interviewed in this study had been born in Lowell, and the majority or them were third-generation Lowellians or more. This planning team has never before worked in a place with such a high

Morning on the Industrial Canyon

percentage of family retention. Indeed, it wasn't until arriving in Lowell that we first heard the term "blow-ins," let alone its modification "Blowellians."
This continuity of population has its advantages and its disadvantages. The advantages, which dominate, include a powerful culture of stewardship, reinvestment, and philanthropy. People take better care of places where they plan to stay, and in Lowell that occurs in spades. The principal disadvantage is that the city's long institutional memory includes some pretty bad experiences, and many Lowellians' impression of Lowell remains the old Lowell of the seventies and eighties, despite a preponderance of evidence to the contrary. Indeed, there exists a surprising disconnect between the quality of the downtown and locals' opinion of it. Of course, some of the most critical haven't been downtown in years.

These critics, some of whom enjoy responding anonymously and bitterly to news articles about downtown, would benefit from more interaction with the tourists who know only the Lowell of today, or the many young families and empty nesters who are choosing to make downtown their home. For them, and for this planning team, Lowell provides most of the advantages of a Boston or Cambridge, at a fraction of the price. The more one travels the United States and experiences its gradual transformation into a repetitive collection of nondescript suburban auto-centric zones, the more precious Lowell becomes. With its handsome landscape of mills, main streets, rivers, and canals, the city has already managed to gracefully outlive its original reason for being. Taking further advantage of these assets and others—as outlined in this Plan—will give the city an even greater promise as we enter an era that increasingly values those qualities that make Lowell exceptional.

Downtown Lowell Evolution Plan

Traffic Operations and Analysis Memorandum
June 2010

The purpose of this memorandum is to detail the process of data collection, data formatting and analysis undertaken to evaluate traffic performance resulting from transportation-specific recommendations in the Downtown Lowell Evolution Plan. The plan was focused on Lowell's historic downtown core and surrounding neighborhoods, and as such the traffic analysis covers a relatively small portion of the city. The overall intent of this analysis was to demonstrate an order-of-magnitude difference in traffic operations in downtown based on the Plan's recommendations and to provide support for recommendations that are specific to traffic control.

The primary recommendations of the plan as they relate to traffic concern the conversion of one-way streets to two-way operations. With this, the Plan study team assumed an alternative distribution of traffic onto the street network to represent newly-available travel patterns. The team also considered the possible need for different traffic control devices than those in place today and made assumptions of using different signal timing schemes.

Traffic Counts

The Plan team collected intersection turning movement counts at several downtown intersections in April 2010 and supplemented these with previous counts collected for earlier efforts. All previous counts were taken in November 2007 and were used as current (i.e. no modification or adjustment was made to these counts).

The intersections for which counts were taken in April 2010 are:

- Arcand Drive at Father Morissette Boulevard
- Arcand Drive at Worthen Street
- Bridge Street at French Street
- Bridge Street at VFW Highway (across the Merrimack River from the downtown study area)
- Bridge Street-Prescott Street at Merrimack Street
- Central Street at Market Street-Prescott Street
- Central Street at Merrimack Street
- Merrimack Street at Worthen Street

The intersections for which counts were taken in November 2007 are:

- Dutton Street at Broadway Street
- Dutton Street at Fletcher Street
- Dutton Street at Market Street
- Dutton Street at Merrimack Street

Existing Conditions and Signal Timing

(Existing Conditions Scenario)

The Plan team used Synchro 7 to examine existing conditions. These relied on current traffic counts as taken and added pedestrian movement whenever data were available to account for frequent conditions where turning vehicles yield to pedestrians crossing. However, as signal timing plans for downtown were not available, the Synchro default assignments (typically using the minimum signal cycle length of 40 seconds) were used. From field observations, the Plan team observed generally short cycle lengths and felt comfortable with using this default value.

At the time of field observations for the study, the timing plan for the Market/Dutton intersection utilized a split phase timing plan allowing all southbound movements (including left turns to Market) to move in a single phase but holding all of these movements during the northbound traffic green phase. This split phase was used in Synchro, although timing was estimated at a 90-second cycle length.

Current Levels of Service

The following tables show intersection level of service as calculated and defined by Highway Capacity Manual 2000 (HCM) methodology.

AM Peak

Intersection	*Level of Service*	*Average Intersection Delay*
Merrimack at Prescott-Bridge	B	12 sec
Merrimack at Central	A	8 sec
Merrimack at Dutton	A	9 sec
Merrimack at Worthen	A	6 sec
Market-Prescott at Central	B	13 sec
Market at Dutton	E	78 sec
Broadway at Dutton	C	23 sec
Arcand at Worthen	A	No delay
Arcand at Father Morissette	B	14 sec
French at Bridge	B	11 sec

PM Peak

Intersection	*Level of Service*	*Average Intersection Delay*
Merrimack at Prescott-Bridge	B	20 sec
Merrimack at Central	A	8 sec
Merrimack at Dutton	A	10 sec
Merrimack at Worthen	A	5 sec
Market-Prescott at Central	B	11 sec
Market at Dutton	F	87 sec
Broadway at Dutton	C	34 sec
Arcand at Worthen	A	No delay
Arcand at Father Morissette	B	16 sec
French at Bridge	B	11 sec

It is apparent that many of the signals in downtown Lowell are not coordinated with one another or optimally configured to handle current traffic movements. In particular, the split phase configuration of the Market/Dutton intersection leads to significantly greater overall intersection delays than could be realized with a conventional shared phase between northbound and southbound movements.

Assuming that signal timing is similar to that used in the analysis, it is unlikely that specific intersections experience levels of service very different from those reported in the previous tables. Anecdotally, the traffic volumes used in the two peak hour analyses do not appear to be significantly more concentrated than non-peak volumes, suggesting that traffic is distributed more evenly throughout the day and not heavily focused in peak periods. However, as stated previously, apparent inefficiency in signal timing likely leads to greater delay than those reported here. This traffic analysis assumed flexibility in reconfiguring signal timing for its recommended scenarios.

Two-Way Street Conversions: Assignment of Traffic to a Two-Way System (*Recommendations with 2010 Traffic Scenario*)

As mentioned previously, many of the street recommendations of the Downtown Lowell Evolution Plan involve the conversion of streets from one-way to two-way traffic flow. In the Synchro street network, these changes included the following:

- **Central two-way conversion from Merrimack to Market.** Added a WBL to Merrimack on approach to Central. This can be accommodated in existing curb-to-curb dimensions through elimination of on-street parking on the south side of Merrimack for the block between Central and Prescott. Added one SB lane, to accommodate SBT and SBR movements at Market.
- **Market two-way conversion from Dutton to Central.** Added WBL and WBT/WBR at Market/Dutton. Added EBL to Market/Shattuck (which also becomes two-way). Added WBL and opposing EBL at Market/Palmer to allow WBL turns into the parking garage. Added signal at Market and the Roy Garage parking entrance (although the current signal at Market and Palmer today is only activated by pedestrian calls, this analysis assumes that a signal would be warranted if westbound traffic is allowed on Market). Reduced EB approach at Market/Central to two lanes (EBL/EBT and EBR) to conserve space for WB travel lane leaving intersection.
- **Monument Square conversion.** Added EBL to Merrimack/Worthen. Merrimack's Dual WB through lanes from the east drop one lane as a left turn at Merrimack/Dutton. Added NBL to Worthen/Arcand (all traffic turns left; this is essentially allowing left turns from EB Merrimack to NB Arcand). Added one EB lane to Merrimack between Dutton and Shattuck, which is dropped as a right turn at this intersection.

In order to fully evaluate these changes, the Plan team reassigned existing traffic patterns to use the new movement opportunities in the network. Certain movement opportunities, such as westbound travel on Market Street, were assumed to take significant amounts of traffic due to their access to major downtown destinations (in the case of Market Street, the Lowell City Parking Garage). The following assignments were made to utilize the two-way streets in the Plan recommendations:

- **Merrimack/Central** – Move 40% of WBT volume to WBL. This number is intended to express a conservative estimate of traffic from the Merrimack River bridge that is traveling to the Roy parking garage (although other downtown parking facilities on the north side of downtown are likely to capture at least some of this diverted traffic). Reduce this number from downstream movements (namely at the Merrimack/Dutton intersection).
- **Market/Central** – 50% of incoming volumes (from Merrimack at Central) as SBR, 50% as SBT. 100% of NBR (to Prescott) remains in this movement. Move 50% of NBT to NBL.
- **Merrimack/Dutton** – keep same balance in WB volumes but adjust for removal of 40% of volumes at Central. Move 10% of EBR to EBT, to use the Shattuck intersection. Move 10% of SBT to SBL, to make this same maneuver through the network. Remove the total number of these two transfers from SBL at Market/Dutton.
- **Merrimack at Worthen** – Add 50 vehicles to EBL now permitted with two-way Worthen.
- **Worthen at Arcand** – Add 50 vehicles to NBL.
- **Market/Garage Entrance** – Add 50% of WB volume (the sum of SBR and NBL from Market/Central) to WBL in AM only. In PM, all of this traffic goes through (assume 10 cars turn right onto Palmer). Assume that 50% entering traffic from the west (sum of SBL, NBR and EBT at Market/Dutton) continues through past garage entrance and would be in conflict with left turns.

- **Market/Dutton** - Divide remaining WB traffic after Market/Garage Entrance evenly between WBL and WBT. Assume 20 cars are generated along the corridor and will want to turn right at Dutton to continue north onto Arcand.

This analysis scenario also included Father Morissette's recommended reconstruction, which features only one travel lane per direction and a widened median to accommodate transit, to show the effects of a different roadway configuration with the same traffic volumes as in the existing conditions scenario.

After the volumes were applied, the overall signal network cycle lengths and splits were optimized to facilitate traffic flow and minimize spot congestion occurring from differing cycle lengths. At the same time, particular timing and phasing changes were made that could further improve intersection efficiency, such as the introduction of protected turn phases at signals where heavy left turn movements occur and the elimination of split phasing.

AM Peak

Intersection	*Level of Service*	*Average Intersection Delay*
Merrimack at Prescott-Bridge	B	12 sec
Merrimack at Central	A	8 sec
Merrimack at Dutton	A	9 sec
Merrimack at Worthen	A	9 sec
Market-Prescott at Central	C	28 sec
Market at Dutton	B	12 sec
Market at Palmer-Garage Entrance	B	14 sec
Broadway at Dutton	B	17 sec
Arcand at Worthen	A	1 sec
Arcand at Father Morissette	C	27 sec
French at Bridge	B	11 sec

PM Peak

Intersection	*Level of Service*	*Average Intersection Delay*
Merrimack at Prescott-Bridge	B	11 sec
Merrimack at Central	A	10 sec
Merrimack at Dutton	A	7 sec
Merrimack at Worthen	A	7 sec
Market-Prescott at Central	B	12 sec
Market at Dutton	B	10 sec
Market at Palmer-Garage Entrance	A	9 sec
Broadway at Dutton	B	12 sec
Arcand at Worthen	A	1 sec
Arcand at Father Morissette	B	19 sec
French at Bridge	B	12 sec

As the tables demonstrate, some intersections experience increases in delay due to the changed lane configurations. The most notable among these are the Market/Central/Prescott intersection and the Arcand/Father Morissette intersection. In the case of the former, this is due to northbound Central traffic that previously did not have a left turn opportunity. With the two-way operations of Market and Central and the ability to make northbound left turns, these turns add delay to northbound movement because they must wait against oncoming southbound traffic. In the case of Arcand and Father Morissette, this is due to turning movements that must share a single lane. However, neither intersection experiences failing levels of service on individual movements, and overall intersection delay stays within acceptable levels.

Forecast Traffic Growth – Two-Way Streets in 2030
(Recommendations with 2030 Traffic Scenario)

Based on conversations with City staff and review of historic population trends, the study team assumed an average annual growth rate of one percent (1%) per year and applied this to a 20-year planning period to forecast volumes for the year 2030. This results in a cumulative growth of approximately 22 percent over this window of time, higher than the City's projected increases in overall population but a reasonable growth rate to account for new development expected to result from the Downtown Evolution Plan. Although it is more likely that particular intersections and movements would see greater increases in traffic than others, the one percent growth rate was applied uniformly to all study area intersections and individual turning movements to simulate an even level of additional development around downtown Lowell.

These forecast volumes were applied to the same reassigned traffic patterns as those in the 2010 recommendations scenario. As with the reassignment using current volumes, network signal cycle lengths and splits were optimized. Specific intersection performance is listed in the following tables:

AM Peak

Intersection	*Level of Service*	*Average Intersection Delay*
Merrimack at Prescott-Bridge	B	14 sec
Merrimack at Central	B	11 sec
Merrimack at Dutton	B	11 sec
Merrimack at Worthen	B	6 sec

Market-Prescott at Central	D	40 sec
Market at Dutton	B	18 sec
Market at Palmer-Garage Entrance	C	31 sec
Broadway at Dutton	B	16 sec
Arcand at Worthen	A	1 sec
Arcand at Father Morissette	D	38 sec
French at Bridge	B	11 sec

PM Peak

Intersection	*Level of Service*	*Average Intersection Delay*
Merrimack at Prescott-Bridge	B	12 sec
Merrimack at Central	B	11 sec
Merrimack at Dutton	B	11 sec
Merrimack at Worthen	B	11 sec
Market-Prescott at Central	C	21 sec
Market at Dutton	B	17 sec
Market at Palmer-Garage Entrance	B	11 sec
Broadway at Dutton	C	20 sec
Arcand at Worthen	A	1 sec
Arcand at Father Morissette	C	31 sec
French at Bridge	B	14 sec

As demonstrated in these tables (and the accompanying output reports from Synchro), delay increases at certain intersections with the application of projected volume growth. The most notable locations of delay are the Arcand/Father Morissette and Market/Central/Prescott intersections and at the parking garage entrance from Market Street, all in the AM peak. Particular operational concerns are as follows:

1. *Entrance to the Market Street Garage.* The garage entrance presents a particular challenge in terms of delay in that left-turning vehicles may not be able to access the garage in a single signal cycle during the AM peak hour. Synchro reports a movement delay of 142 seconds for this particular movement if no protected phase is given. Using a permitted-protected phasing scheme greatly reduces delay at the intersection but increases average intersection delay to 41 seconds (LOS D), due largely to increases in delay to eastbound traffic while it must wait through a protected westbound turning phase.

   As discussed in the plan report, two options are given for configuring this intersection: the restriction on westbound left turns into the garage (which would effectively be in place if existing garage driveway design were not changed) or the permitting of turns into the garage but the placement of a semi-actuated signal that allows a protected westbound left turn phase in the AM peak and responds to calls from left turns at other times. In the PM peak, it is assumed that volumes entering the garage are negligible; this dedicated left turn phase would not be needed then.

2. *Arcand at Father Morissette.* In the AM peak, eastbound through and right-turn volumes are both reasonable within the capacity of a single lane, but face a significant westbound left turn movement and as such require separate phasing. Because of the single lane, right turn on red permission is has limited effectiveness in processing left turns. The intersection does not experience any failing movements, but reasonably balanced competing volumes cause moderate increases in delay.

3. *Market at Prescott and Central.* In the AM, the greatest delay is experienced in the eastbound right turning volumes, by far the heaviest single movement volume in the intersection. This movement processes a high number of turns through right turn on red permission, and can be helped with signal phasing that allows an overlap between this movement and a protected northbound left turn phase.

Comparison of Travel Times

To fully understand the differences in delay between different versions of the street network configuration, it is useful to look beyond specific intersection delay and consider entire trips through downtown using likely scenarios. Typical traffic analysis would examine an entire corridor, calculating its level of service on the basis of travel time and speed per HCM methodology. However, Lowell's unique street grid, with many forced turns through the network due to one-way streets and T-intersections, complicates such an analysis.

The sample trips through downtown in the AM peak shown in the table below could be taken with shorter, more direct paths with the implementation of the Plan's recommendations. The travel times between each origin and destination were calculated by adding the run times (using a constant speed of 30 miles per hour on all streets) and overall delays for each path's component streets and intersections. For both through movements and turns along a path, the specific queue and control delays for the given network were used to estimate an average travel time along that path. For intersections for which no volumes were counted, a delay of 10 seconds was assumed if the street was a secondary street (such as Shattuck at the Shattuck/Market intersection) and 5 seconds was used if it was a primary street (such as Merrimack at the Merrimack/Palmer intersection). Note that in the one-way network, each trip is longer than in the two-way network and as such a greater amount of time must be spent in motion.

Origin-Destination	Travel Distance and Time Under One-Way Network	Travel Distance and Time Under Recommended Network	Travel Distance and Time Under Recommended Network with Future Traffic
Merrimack River Bridge to Brew'd Awakening Coffeehouse	**111 seconds** (75 sec run time to cover 0.63 miles + 36 sec total delay time)	**73 seconds** (45 sec run time to cover 0.38 miles + 28 sec total delay time)	**98 seconds** (45 sec run time to cover 0.38 miles + 53 sec total delay time)
New England Quilt Museum to City Hall	**112 seconds** (77 sec run time to cover 0.65 miles + 35 sec total delay time)	**57 seconds** (20 sec run time to cover 0.17 miles + 37 sec total delay time)	**57 seconds** (20 sec run time to cover 0.17 miles + 37 sec total delay time)
National Park Visitors Center to Tsongas Center	**127 seconds** (86 sec run time to cover 0.72 miles + 41 sec total delay time)	**95 seconds** (39 sec run time to cover 0.32 miles + 56 sec total delay time)	**100 seconds** (39 sec run time to cover 0.32 miles + 61 sec total delay time)

As these examples show, delay increases are often minor enough that they are offset by the reduction in run time between destinations. This does not factor in the phenomenon of intersection coordination and as such does not account for potential queuing spillback from one intersection into the intersection behind it. However, these examples do suggest that on its own the street system is able to accommodate current and forecast traffic volumes without significant delay increases at particular intersections, even with two-way traffic operations on select streets.

Overall Conclusions

Generally speaking, traffic volumes throughout downtown Lowell are relatively evenly distributed and are not heavily focused on one street or even a small number of intersections. For this reason, analysis suggests that few intersections experience significant congestion today. However, it is the combined effect of multiple intersections in close proximity and the unique layout of downtown Lowell's street system that complicates the real-time performance of the system and leads to possible motorist perceptions of traffic congestion.

When changes are made to the flow of the street system through two-way conversions, most intersections studied do not experience significant increases in congestion, even with the application of over 20 percent of additional traffic into the future. Those intersections that do experience notable increases in congestion do so primarily because of an increase in movements that compete for signal phase time, and the analysis explored a number of mitigation approaches to reduce overall delay.

2010 Traffic and One-Way Streets (Existing Conditions)

AM Peak HCM Intersection Capacity Report

HCM Signalized Intersection Capacity Analysis — 2010 AM Peak
4: Merrimack & Worthen — Existing Volumes and Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	235	30	19	282	0	0	0	0	10	113	139
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		1.00			0.95						0.95	
Frt		0.98			1.00						0.92	
Flt Protected		1.00			1.00						1.00	
Satd. Flow (prot)		1834			3528						3252	
Flt Permitted		1.00			0.93						1.00	
Satd. Flow (perm)		1834			3290						3252	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	255	33	21	307	0	0	0	0	11	123	151
RTOR Reduction (vph)	0	11	0	0	0	0	0	0	0	0	91	0
Lane Group Flow (vph)	0	277	0	0	328	0	0	0	0	0	194	0
Turn Type				Perm						Perm		
Protected Phases		4			8						6	
Permitted Phases				8						6		
Actuated Green, G (s)		16.0			16.0						16.0	
Effective Green, g (s)		16.0			16.0						16.0	
Actuated g/C Ratio		0.40			0.40						0.40	
Clearance Time (s)		4.0			4.0						4.0	
Lane Grp Cap (vph)		734			1316						1301	
v/s Ratio Prot		c0.15										
v/s Ratio Perm					0.10						0.06	
v/c Ratio		0.38			0.25						0.15	
Uniform Delay, d1		8.5			8.0						7.7	
Progression Factor		1.00			0.52						0.29	
Incremental Delay, d2		1.5			0.4						0.2	
Delay (s)		10.0			4.6						2.5	
Level of Service		A			A						A	
Approach Delay (s)		10.0			4.6			0.0			2.5	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	5.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.26		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	36.7%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

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HCM Unsignalized Intersection Capacity Analysis
5: Dutton & Worthen

2010 AM Peak
Existing Volumes and Geometries

Movement	NBL	NBT	SBT	SBR	NEL	NER
Lane Configurations						
Volume (veh/h)	0	558	370	246	0	0
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	607	402	267	0	0
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (ft)		304	549			
pX, platoon unblocked					0.92	
vC, conflicting volume	670				839	335
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	670				663	335
tC, single (s)	4.1				6.8	6.9
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	100				100	100
cM capacity (veh/h)	916				365	661

Direction, Lane #	NB 1	NB 2	SB 1	SB 2
Volume Total	303	303	268	401
Volume Left	0	0	0	0
Volume Right	0	0	0	267
cSH	1700	1700	1700	1700
Volume to Capacity	0.18	0.18	0.16	0.24
Queue Length 95th (ft)	0	0	0	0
Control Delay (s)	0.0	0.0	0.0	0.0
Lane LOS				
Approach Delay (s)	0.0		0.0	
Approach LOS				

Intersection Summary			
Average Delay	0.0		
Intersection Capacity Utilization	21.4%	ICU Level of Service	A
Analysis Period (min)	15		

Lowell Downtown Evolution Plan
AECOM Design + Planning

May 2010
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HCM Signalized Intersection Capacity Analysis
9: Broadway & Dutton

2010 AM Peak
Existing Volumes and Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	84	87	449	22	27	15	209	707	52	27	669	16
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00			1.00		1.00	0.95		1.00	0.95	
Frt		0.90			0.97		1.00	0.99		1.00	1.00	
Flt Protected		0.99			0.98		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1669			1774		1770	3503		1770	3527	
Flt Permitted		0.95			0.84		0.31	1.00		0.26	1.00	
Satd. Flow (perm)		1596			1509		573	3503		491	3527	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	91	95	488	24	29	16	227	768	57	29	727	17
RTOR Reduction (vph)	0	59	0	0	10	0	0	14	0	0	4	0
Lane Group Flow (vph)	0	615	0	0	59	0	227	811	0	29	740	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		16.0			16.0		16.0	16.0		16.0	16.0	
Effective Green, g (s)		16.0			16.0		16.0	16.0		16.0	16.0	
Actuated g/C Ratio		0.40			0.40		0.40	0.40		0.40	0.40	
Clearance Time (s)		4.0			4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		638			604		229	1401		196	1411	
v/s Ratio Prot								0.23			0.21	
v/s Ratio Perm		c0.39			0.04		c0.40			0.06		
v/c Ratio		0.96			0.10		0.99	0.58		0.15	0.52	
Uniform Delay, d1		11.7			7.5		11.9	9.4		7.7	9.1	
Progression Factor		1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		27.9			0.3		57.3	1.8		1.6	1.4	
Delay (s)		39.6			7.8		69.2	11.1		9.2	10.5	
Level of Service		D			A		E	B		A	B	
Approach Delay (s)		39.6			7.8			23.7			10.5	
Approach LOS		D			A			C			B	

Intersection Summary			
HCM Average Control Delay	23.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.98		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	80.3%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Lowell Downtown Evolution Plan
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HCM Signalized Intersection Capacity Analysis
10: Merrimack & Central

2010 AM Peak
Existing Volumes and Geometries

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	0	0	0	662	411	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	
Lane Util. Factor				0.95	0.97	
Frt				1.00	1.00	
Flt Protected				1.00	0.95	
Satd. Flow (prot)				3539	3433	
Flt Permitted				1.00	0.95	
Satd. Flow (perm)				3539	3433	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	720	447	0
RTOR Reduction (vph)	0	0	0	0	117	0
Lane Group Flow (vph)	0	0	0	720	330	0
Turn Type						
Protected Phases				8	2	
Permitted Phases						
Actuated Green, G (s)				16.0	16.0	
Effective Green, g (s)				16.0	16.0	
Actuated g/C Ratio				0.40	0.40	
Clearance Time (s)				4.0	4.0	
Lane Grp Cap (vph)				1416	1373	
v/s Ratio Prot				c0.20	c0.10	
v/s Ratio Perm						
v/c Ratio				0.51	0.24	
Uniform Delay, d1				9.0	8.0	
Progression Factor				0.79	1.00	
Incremental Delay, d2				1.2	0.4	
Delay (s)				8.4	8.4	
Level of Service				A	A	
Approach Delay (s)	0.0			8.4	8.4	
Approach LOS	A			A	A	

Intersection Summary			
HCM Average Control Delay	8.4	HCM Level of Service	A
HCM Volume to Capacity ratio	0.37		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	36.7%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
11: Merrimack & Dutton

2010 AM Peak
Existing Volumes and Geometries

Movement	EBR	WBL	WBT	WBR	NBL	NBT	SBT
Lane Configurations							
Volume (vph)	146	317	270	73	41	488	460
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0			4.0	4.0
Lane Util. Factor	0.88		0.95			0.95	0.95
Frt	0.85		0.98			1.00	1.00
Flt Protected	1.00		0.98			1.00	1.00
Satd. Flow (prot)	2787		3399			3525	3539
Flt Permitted	1.00		0.98			0.89	1.00
Satd. Flow (perm)	2787		3399			3162	3539
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	159	345	293	79	45	530	500
RTOR Reduction (vph)	95	0	0	0	0	0	0
Lane Group Flow (vph)	64	0	717	0	0	575	500
Turn Type	custom	Perm			Perm		
Protected Phases			8			2	6
Permitted Phases	4	8			2		
Actuated Green, G (s)	16.0		16.0			16.0	16.0
Effective Green, g (s)	16.0		16.0			16.0	16.0
Actuated g/C Ratio	0.40		0.40			0.40	0.40
Clearance Time (s)	4.0		4.0			4.0	4.0
Lane Grp Cap (vph)	1115		1360			1265	1416
v/s Ratio Prot							0.14
v/s Ratio Perm	0.02		0.21			c0.18	
v/c Ratio	0.06		0.53			0.45	0.35
Uniform Delay, d1	7.4		9.1			8.8	8.4
Progression Factor	1.00		1.00			1.00	0.62
Incremental Delay, d2	0.1		1.5			1.2	0.6
Delay (s)	7.5		10.6			10.0	5.8
Level of Service	A		B			A	A
Approach Delay (s)			10.6			10.0	5.8
Approach LOS			B			A	A

Intersection Summary			
HCM Average Control Delay	8.9	HCM Level of Service	A
HCM Volume to Capacity ratio	0.49		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	56.4%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
13: Merrimack & Bridge

2010 AM Peak
Existing Volumes and Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	SBL	SBR	SBR2	NEL2	NEL	NER
Lane Configurations												
Volume (vph)	0	0	0	0	365	205	393	0	307	12	273	236
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)					4.0		4.0		4.0	4.0	4.0	
Lane Util. Factor					0.95		1.00		1.00	1.00	1.00	
Frpb, ped/bikes					0.99		1.00		0.91	1.00	1.00	
Flpb, ped/bikes					1.00		1.00		1.00	0.92	1.00	
Frt					0.95		1.00		0.85	1.00	0.93	
Flt Protected					1.00		0.95		1.00	0.95	0.97	
Satd. Flow (prot)					3318		1770		1436	1624	1688	
Flt Permitted					1.00		0.95		1.00	0.95	0.97	
Satd. Flow (perm)					3318		1770		1436	1624	1688	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	0	397	223	427	0	334	13	297	257
RTOR Reduction (vph)	0	0	0	0	134	0	0	0	160	8	78	0
Lane Group Flow (vph)	0	0	0	0	486	0	427	0	174	5	476	0
Confl. Peds. (#/hr)						18	110		110	110	110	
Turn Type									Perm	Perm		
Protected Phases					8		6!				2!	
Permitted Phases									6	2		
Actuated Green, G (s)					16.0		16.0		16.0	16.0	16.0	
Effective Green, g (s)					16.0		16.0		16.0	16.0	16.0	
Actuated g/C Ratio					0.40		0.40		0.40	0.40	0.40	
Clearance Time (s)					4.0		4.0		4.0	4.0	4.0	
Lane Grp Cap (vph)					1327		708		574	650	675	
v/s Ratio Prot					c0.15		0.24				c0.28	
v/s Ratio Perm									0.12	0.00		
v/c Ratio					0.37		0.60		0.30	0.01	0.71	
Uniform Delay, d1					8.4		9.5		8.2	7.2	10.0	
Progression Factor					1.00		1.00		1.00	0.79	0.91	
Incremental Delay, d2					0.8		3.8		1.4	0.0	5.9	
Delay (s)					9.2		13.3		9.6	5.7	15.1	
Level of Service					A		B		A	A	B	
Approach Delay (s)		0.0			9.2		11.6				14.9	
Approach LOS		A			A		B				B	

Intersection Summary			
HCM Average Control Delay	11.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	78.6%	ICU Level of Service	D
Analysis Period (min)	15		

! Phase conflict between lane groups.
c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
20: Market & Prescott

2010 AM Peak
Existing Volumes and Geometries

Movement	EBL2	EBL	EBR	NBL	NBT	NBR	SBL	SBT	SBR	SWL	SWR
Lane Configurations											
Volume (vph)	62	207	790	0	465	243	0	0	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0	4.0					
Lane Util. Factor	1.00	1.00	1.00		1.00	1.00					
Frpb, ped/bikes	1.00	1.00	0.92		1.00	0.98					
Flpb, ped/bikes	0.93	1.00	1.00		1.00	1.00					
Frt	1.00	1.00	0.85		1.00	0.85					
Flt Protected	0.95	0.95	1.00		1.00	1.00					
Satd. Flow (prot)	1650	1770	1460		1863	1559					
Flt Permitted	0.95	0.95	1.00		1.00	1.00					
Satd. Flow (perm)	1650	1770	1460		1863	1559					
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	67	225	859	0	505	264	0	0	0	0	0
RTOR Reduction (vph)	40	0	515	0	0	158	0	0	0	0	0
Lane Group Flow (vph)	27	225	344	0	505	106	0	0	0	0	0
Confl. Peds. (#/hr)	90	90	90			5					
Turn Type	Perm		Perm			Perm					
Protected Phases		4			2						
Permitted Phases	4		4			2					
Actuated Green, G (s)	16.0	16.0	16.0		16.0	16.0					
Effective Green, g (s)	16.0	16.0	16.0		16.0	16.0					
Actuated g/C Ratio	0.40	0.40	0.40		0.40	0.40					
Clearance Time (s)	4.0	4.0	4.0		4.0	4.0					
Lane Grp Cap (vph)	660	708	584		745	624					
v/s Ratio Prot		0.13			c0.27						
v/s Ratio Perm	0.02		c0.24			0.07					
v/c Ratio	0.04	0.32	0.59		0.68	0.17					
Uniform Delay, d1	7.3	8.2	9.4		9.9	7.7					
Progression Factor	1.00	1.00	1.00		1.00	1.00					
Incremental Delay, d2	0.1	1.2	4.3		4.9	0.6					
Delay (s)	7.4	9.4	13.7		14.8	8.3					
Level of Service	A	A	B		B	A					
Approach Delay (s)		12.5			12.6			0.0		0.0	
Approach LOS		B			B			A		A	

Intersection Summary			
HCM Average Control Delay	12.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	57.9%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
34: French & Bridge

2010 AM Peak
Existing Volumes and Geometries

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	128	202	179	304	463	323
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	0.94	
Flt Protected	0.95	1.00		0.98	1.00	
Satd. Flow (prot)	1770	1583		3475	3321	
Flt Permitted	0.95	1.00		0.59	1.00	
Satd. Flow (perm)	1770	1583		2083	3321	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	139	220	195	330	503	351
RTOR Reduction (vph)	0	127	0	0	211	0
Lane Group Flow (vph)	139	93	0	525	643	0
Turn Type		Perm	Perm			
Protected Phases	4			2	6	
Permitted Phases		4	2			
Actuated Green, G (s)	16.0	16.0		16.0	16.0	
Effective Green, g (s)	16.0	16.0		16.0	16.0	
Actuated g/C Ratio	0.40	0.40		0.40	0.40	
Clearance Time (s)	4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)	708	633		833	1328	
v/s Ratio Prot	c0.08				0.19	
v/s Ratio Perm		0.06		c0.25		
v/c Ratio	0.20	0.15		1.05dl	0.48	
Uniform Delay, d1	7.8	7.7		9.6	8.9	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.6	0.5		3.6	1.3	
Delay (s)	8.4	8.1		13.2	10.2	
Level of Service	A	A		B	B	
Approach Delay (s)	8.3			13.2	10.2	
Approach LOS	A			B	B	

Intersection Summary			
HCM Average Control Delay	10.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	53.8%	ICU Level of Service	A
Analysis Period (min)	15		

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

HCM Signalized Intersection Capacity Analysis
39: Fr Morrissette & Arcand

2010 AM Peak
Existing Volumes and Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	40	301	303	274	233	82	154	155	129	62	99	23
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0			4.0			4.0	
Lane Util. Factor		0.95			0.95			0.95			0.95	
Frpb, ped/bikes		1.00			1.00			0.99			1.00	
Flpb, ped/bikes		1.00			1.00			0.99			1.00	
Frt		0.93			0.98			0.96			0.98	
Flt Protected		1.00			0.98			0.98			0.98	
Satd. Flow (prot)		3279			3377			3262			3383	
Flt Permitted		0.89			0.60			0.78			0.77	
Satd. Flow (perm)		2939			2068			2583			2645	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	43	327	329	298	253	89	167	168	140	67	108	25
RTOR Reduction (vph)	0	197	0	0	32	0	0	84	0	0	15	0
Lane Group Flow (vph)	0	502	0	0	608	0	0	391	0	0	185	0
Confl. Peds. (#/hr)				5		4	37		37	37		37
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		16.0			16.0			16.0			16.0	
Effective Green, g (s)		16.0			16.0			16.0			16.0	
Actuated g/C Ratio		0.40			0.40			0.40			0.40	
Clearance Time (s)		4.0			4.0			4.0			4.0	
Lane Grp Cap (vph)		1176			827			1033			1058	
v/s Ratio Prot												
v/s Ratio Perm		0.17			c0.29			c0.15			0.07	
v/c Ratio		0.43			1.06dl			0.38			0.17	
Uniform Delay, d1		8.7			10.2			8.5			7.7	
Progression Factor		1.00			1.00			2.35			1.00	
Incremental Delay, d2		1.1			5.8			1.0			0.4	
Delay (s)		9.8			15.9			20.9			8.1	
Level of Service		A			B			C			A	
Approach Delay (s)		9.8			15.9			20.9			8.1	
Approach LOS		A			B			C			A	

Intersection Summary			
HCM Average Control Delay	14.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.56		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	76.8%	ICU Level of Service	D
Analysis Period (min)	15		

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

2010 Traffic and One-Way Streets (Existing Conditions)

PM Peak HCM Intersection Capacity Report

HCM Signalized Intersection Capacity Analysis — 2010 AM Peak
45: Market & Dutton — Existing Volumes and Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	37	306	39	0	0	0	58	454	263	248	685	19
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0						4.0			4.0	
Lane Util. Factor		0.95						0.95			0.95	
Frt		0.98						0.95			1.00	
Flt Protected		1.00						1.00			0.99	
Satd. Flow (prot)		3469						3346			3483	
Flt Permitted		1.00						0.54			0.99	
Satd. Flow (perm)		3469						1807			3483	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	40	333	42	0	0	0	63	493	286	270	745	21
RTOR Reduction (vph)	0	10	0	0	0	0	0	73	0	0	1	0
Lane Group Flow (vph)	0	405	0	0	0	0	0	769	0	0	1035	0
Turn Type	Perm						Perm			Split		
Protected Phases		4						2		6	6	
Permitted Phases	4						2					
Actuated Green, G (s)		16.0						31.0			31.0	
Effective Green, g (s)		16.0						31.0			31.0	
Actuated g/C Ratio		0.18						0.34			0.34	
Clearance Time (s)		4.0						4.0			4.0	
Lane Grp Cap (vph)		617						622			1200	
v/s Ratio Prot											c0.30	
v/s Ratio Perm		0.12						c0.43				
v/c Ratio		0.66						1.24			0.86	
Uniform Delay, d1		34.4						29.5			27.5	
Progression Factor		1.00						1.00			1.00	
Incremental Delay, d2		5.4						119.9			8.3	
Delay (s)		39.8						149.4			35.8	
Level of Service		D						F			D	
Approach Delay (s)		39.8			0.0			149.4			35.8	
Approach LOS		D			A			F			D	

Intersection Summary			
HCM Average Control Delay	78.3	HCM Level of Service	E
HCM Volume to Capacity ratio	0.97		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	70.2%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

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HCM Unsignalized Intersection Capacity Analysis
5: Dutton & Worthen

2010 PM Peak
Existing Volumes and Geometries

Movement	NBL	NBT	SBT	SBR	NEL	NER
Lane Configurations		↑↑	↑↱			
Volume (veh/h)	0	643	319	151	0	0
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	699	347	164	0	0
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (ft)		304	549			
pX, platoon unblocked					0.88	
vC, conflicting volume	511				778	255
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	511				488	255
tC, single (s)	4.1				6.8	6.9
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	100				100	100
cM capacity (veh/h)	1051				450	744

Direction, Lane #	NB 1	NB 2	SB 1	SB 2
Volume Total	349	349	231	280
Volume Left	0	0	0	0
Volume Right	0	0	0	164
cSH	1700	1700	1700	1700
Volume to Capacity	0.21	0.21	0.14	0.16
Queue Length 95th (ft)	0	0	0	0
Control Delay (s)	0.0	0.0	0.0	0.0
Lane LOS				
Approach Delay (s)	0.0		0.0	
Approach LOS				

Intersection Summary			
Average Delay	0.0		
Intersection Capacity Utilization	21.1%	ICU Level of Service	A
Analysis Period (min)	15		

Lowell Downtown Evolution Plan
AECOM Design + Planning

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HCM Signalized Intersection Capacity Analysis
9: Broadway & Dutton

2010 PM Peak
Existing Volumes and Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✣			✣		↰	↑↱		↰	↑↱	
Volume (vph)	102	29	297	30	40	19	313	778	39	13	566	40
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00			1.00		1.00	0.95		1.00	0.95	
Frt		0.91			0.97		1.00	0.99		1.00	0.99	
Flt Protected		0.99			0.98		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1669			1778		1770	3514		1770	3505	
Flt Permitted		0.90			0.82		0.36	1.00		0.25	1.00	
Satd. Flow (perm)		1524			1480		668	3514		466	3505	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	111	32	323	33	43	21	340	846	42	14	615	43
RTOR Reduction (vph)	0	86	0	0	13	0	0	9	0	0	13	0
Lane Group Flow (vph)	0	380	0	0	84	0	340	879	0	14	645	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		16.0			16.0		16.0	16.0		16.0	16.0	
Effective Green, g (s)		16.0			16.0		16.0	16.0		16.0	16.0	
Actuated g/C Ratio		0.40			0.40		0.40	0.40		0.40	0.40	
Clearance Time (s)		4.0			4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		610			592		267	1406		186	1402	
v/s Ratio Prot								0.25			0.18	
v/s Ratio Perm		c0.25			0.06		c0.51			0.03		
v/c Ratio		0.62			0.14		1.27	0.63		0.08	0.46	
Uniform Delay, d1		9.6			7.6		12.0	9.6		7.4	8.8	
Progression Factor		1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		4.7			0.5		149.0	2.1		0.8	1.1	
Delay (s)		14.3			8.1		161.0	11.7		8.2	9.9	
Level of Service		B			A		F	B		A	A	
Approach Delay (s)		14.3			8.1			53.0			9.9	
Approach LOS		B			A			D			A	

Intersection Summary			
HCM Average Control Delay	32.2	HCM Level of Service	C
HCM Volume to Capacity ratio	0.95		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	74.4%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Lowell Downtown Evolution Plan
AECOM Design + Planning

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HCM Signalized Intersection Capacity Analysis
10: Merrimack & Central

2010 PM Peak
Existing Volumes and Geometries

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	0	0	0	529	400	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.0	4.0	
Lane Util. Factor				0.95	0.97	
Frt				1.00	1.00	
Flt Protected				1.00	0.95	
Satd. Flow (prot)				3539	3433	
Flt Permitted				1.00	0.95	
Satd. Flow (perm)				3539	3433	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	575	435	0
RTOR Reduction (vph)	0	0	0	0	193	0
Lane Group Flow (vph)	0	0	0	575	242	0
Turn Type						
Protected Phases				8	2	
Permitted Phases						
Actuated Green, G (s)				16.0	16.0	
Effective Green, g (s)				16.0	16.0	
Actuated g/C Ratio				0.40	0.40	
Clearance Time (s)				4.0	4.0	
Lane Grp Cap (vph)				1416	1373	
v/s Ratio Prot				c0.16	c0.07	
v/s Ratio Perm						
v/c Ratio				0.41	0.18	
Uniform Delay, d1				8.6	7.7	
Progression Factor				0.84	1.00	
Incremental Delay, d2				0.8	0.3	
Delay (s)				8.1	8.0	
Level of Service				A	A	
Approach Delay (s)	0.0			8.1	8.0	
Approach LOS	A			A	A	

Intersection Summary			
HCM Average Control Delay	8.1	HCM Level of Service	A
HCM Volume to Capacity ratio	0.29		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	32.7%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
11: Merrimack & Dutton

2010 PM Peak
Existing Volumes and Geometries

Movement	EBR	WBL	WBT	WBR	NBL	NBT	SBT	SBR
Lane Configurations								
Volume (vph)	68	268	317	59	27	640	285	2
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0		4.0			4.0	4.0	
Lane Util. Factor	0.88		0.95			0.95	0.95	
Frt	0.85		0.99			1.00	1.00	
Flt Protected	1.00		0.98			1.00	1.00	
Satd. Flow (prot)	2787		3420			3532	3536	
Flt Permitted	1.00		0.98			0.93	1.00	
Satd. Flow (perm)	2787		3420			3309	3536	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	74	291	345	64	29	696	310	2
RTOR Reduction (vph)	44	0	0	0	0	0	1	0
Lane Group Flow (vph)	30	0	700	0	0	725	311	0
Turn Type	custom	Perm			Perm			
Protected Phases			8			2	6	
Permitted Phases	4	8			2			
Actuated Green, G (s)	16.0		16.0			16.0	16.0	
Effective Green, g (s)	16.0		16.0			16.0	16.0	
Actuated g/C Ratio	0.40		0.40			0.40	0.40	
Clearance Time (s)	4.0		4.0			4.0	4.0	
Lane Grp Cap (vph)	1115		1368			1324	1414	
v/s Ratio Prot							0.09	
v/s Ratio Perm	0.01		0.20			c0.22		
v/c Ratio	0.03		0.51			0.55	0.22	
Uniform Delay, d1	7.3		9.1			9.2	7.9	
Progression Factor	1.00		1.00			1.00	0.59	
Incremental Delay, d2	0.0		1.4			1.6	0.3	
Delay (s)	7.3		10.4			10.9	5.0	
Level of Service	A		B			B	A	
Approach Delay (s)			10.4			10.9	5.0	
Approach LOS			B			B	A	

Intersection Summary			
HCM Average Control Delay	9.5	HCM Level of Service	A
HCM Volume to Capacity ratio	0.53		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	54.9%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis — 2010 PM Peak
13: Merrimack & Bridge-Prescott — Existing Volumes and Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	SBL	SBR	SBR2	NEL2	NEL	NER
Lane Configurations												
Volume (vph)	0	0	0	0	239	199	341	0	246	19	501	139
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)					4.0		4.0		4.0	4.0	4.0	
Lane Util. Factor					0.95		1.00		1.00	1.00	1.00	
Frt					0.93		1.00		0.85	1.00	0.97	
Flt Protected					1.00		0.95		1.00	0.95	0.96	
Satd. Flow (prot)					3298		1770		1583	1770	1734	
Flt Permitted					1.00		0.95		1.00	0.95	0.96	
Satd. Flow (perm)					3298		1770		1583	1770	1734	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	0	260	216	371	0	267	21	545	151
RTOR Reduction (vph)	0	0	0	0	110	0	0	0	160	13	25	0
Lane Group Flow (vph)	0	0	0	0	366	0	371	0	107	8	671	0
Turn Type									Perm	Perm		
Protected Phases					8		6!				2!	
Permitted Phases									6	2		
Actuated Green, G (s)					16.0		16.0		16.0	16.0	16.0	
Effective Green, g (s)					16.0		16.0		16.0	16.0	16.0	
Actuated g/C Ratio					0.40		0.40		0.40	0.40	0.40	
Clearance Time (s)					4.0		4.0		4.0	4.0	4.0	
Lane Grp Cap (vph)					1319		708		633	708	694	
v/s Ratio Prot					c0.11		0.21				c0.39	
v/s Ratio Perm									0.07	0.00		
v/c Ratio					0.28		0.52		0.17	0.01	0.97	
Uniform Delay, d1					8.1		9.1		7.7	7.2	11.7	
Progression Factor					1.00		1.00		1.00	1.01	1.00	
Incremental Delay, d2					0.5		2.8		0.6	0.0	24.9	
Delay (s)					8.6		11.9		8.3	7.3	36.6	
Level of Service					A		B		A	A	D	
Approach Delay (s)		0.0			8.6		10.4				35.7	
Approach LOS		A			A		B				D	

Intersection Summary			
HCM Average Control Delay	19.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	78.1%	ICU Level of Service	D
Analysis Period (min)	15		

! Phase conflict between lane groups.
c Critical Lane Group

HCM Signalized Intersection Capacity Analysis — 2010 PM Peak
20: Market & Prescott — Existing Volumes and Geometries

Movement	EBL2	EBL	EBR	NBL	NBT	NBR	SBL	SBT	SBR	SWL	SWR
Lane Configurations											
Volume (vph)	129	186	619	0	430	508	0	0	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0		4.0	4.0					
Lane Util. Factor	1.00	1.00	1.00		1.00	1.00					
Frt	1.00	1.00	0.85		1.00	0.85					
Flt Protected	0.95	0.95	1.00		1.00	1.00					
Satd. Flow (prot)	1770	1770	1583		1863	1583					
Flt Permitted	0.95	0.95	1.00		1.00	1.00					
Satd. Flow (perm)	1770	1770	1583		1863	1583					
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	140	202	673	0	467	552	0	0	0	0	0
RTOR Reduction (vph)	84	0	404	0	0	331	0	0	0	0	0
Lane Group Flow (vph)	56	202	269	0	467	221	0	0	0	0	0
Turn Type	Perm		Perm			Perm					
Protected Phases		4			2						
Permitted Phases	4		4			2					
Actuated Green, G (s)	16.0	16.0	16.0		16.0	16.0					
Effective Green, g (s)	16.0	16.0	16.0		16.0	16.0					
Actuated g/C Ratio	0.40	0.40	0.40		0.40	0.40					
Clearance Time (s)	4.0	4.0	4.0		4.0	4.0					
Lane Grp Cap (vph)	708	708	633		745	633					
v/s Ratio Prot		0.11			c0.25						
v/s Ratio Perm	0.03		c0.17			0.14					
v/c Ratio	0.08	0.29	0.43		0.63	0.35					
Uniform Delay, d1	7.4	8.1	8.7		9.6	8.4					
Progression Factor	1.00	1.00	1.00		1.00	1.00					
Incremental Delay, d2	0.2	1.0	2.1		4.0	1.5					
Delay (s)	7.7	9.1	10.8		13.6	9.9					
Level of Service	A	A	B		B	A					
Approach Delay (s)		10.0			11.6			0.0		0.0	
Approach LOS		B			B			A		A	

Intersection Summary			
HCM Average Control Delay	10.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.53		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	48.4%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
34: French & Bridge

2010 PM Peak
Existing Volumes and Geometries

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	279	209	98	628	363	167
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	0.95	
Flt Protected	0.95	1.00		0.99	1.00	
Satd. Flow (prot)	1770	1583		3515	3372	
Flt Permitted	0.95	1.00		0.81	1.00	
Satd. Flow (perm)	1770	1583		2860	3372	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	303	227	107	683	395	182
RTOR Reduction (vph)	0	136	0	0	109	0
Lane Group Flow (vph)	303	91	0	790	468	0
Turn Type		Perm	Perm			
Protected Phases	4			2	6	
Permitted Phases		4	2			
Actuated Green, G (s)	16.0	16.0		16.0	16.0	
Effective Green, g (s)	16.0	16.0		16.0	16.0	
Actuated g/C Ratio	0.40	0.40		0.40	0.40	
Clearance Time (s)	4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)	708	633		1144	1349	
v/s Ratio Prot	c0.17				0.14	
v/s Ratio Perm		0.06		c0.28		
v/c Ratio	0.43	0.14		0.69	0.35	
Uniform Delay, d1	8.7	7.6		9.9	8.4	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	1.9	0.5		3.4	0.7	
Delay (s)	10.6	8.1		13.4	9.1	
Level of Service	B	A		B	A	
Approach Delay (s)	9.5			13.4	9.1	
Approach LOS	A			B	A	

Intersection Summary			
HCM Average Control Delay	11.0	HCM Level of Service	B
HCM Volume to Capacity ratio	0.56		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	61.0%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
39: Fr Morrissette & Arcand

2010 PM Peak
Existing Volumes and Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	25	190	197	161	265	21	364	79	129	25	74	21
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor		0.95			0.95		1.00	1.00	1.00		0.95	
Frt		0.93			0.99		1.00	1.00	0.85		0.97	
Flt Protected		1.00			0.98		0.95	1.00	1.00		0.99	
Satd. Flow (prot)		3276			3452		1770	1863	1583		3410	
Flt Permitted		0.92			0.70		0.67	1.00	1.00		0.91	
Satd. Flow (perm)		3008			2448		1247	1863	1583		3127	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	27	207	214	175	288	23	396	86	140	27	80	23
RTOR Reduction (vph)	0	128	0	0	9	0	0	0	84	0	14	0
Lane Group Flow (vph)	0	320	0	0	477	0	396	86	56	0	116	0
Turn Type	Perm			Perm			Perm		Perm	Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2		2	6		
Actuated Green, G (s)		16.0			16.0		16.0	16.0	16.0		16.0	
Effective Green, g (s)		16.0			16.0		16.0	16.0	16.0		16.0	
Actuated g/C Ratio		0.40			0.40		0.40	0.40	0.40		0.40	
Clearance Time (s)		4.0			4.0		4.0	4.0	4.0		4.0	
Lane Grp Cap (vph)		1203			979		499	745	633		1251	
v/s Ratio Prot								0.05				
v/s Ratio Perm		0.11			c0.19		c0.32		0.04		0.04	
v/c Ratio		0.27			0.49		0.79	0.12	0.09		0.09	
Uniform Delay, d1		8.1			8.9		10.5	7.5	7.5		7.5	
Progression Factor		1.00			1.00		1.84	1.90	4.54		1.00	
Incremental Delay, d2		0.5			1.7		10.6	0.3	0.2		0.1	
Delay (s)		8.6			10.7		29.9	14.6	34.1		7.6	
Level of Service		A			B		C	B	C		A	
Approach Delay (s)		8.6			10.7			28.7			7.6	
Approach LOS		A			B			C			A	

Intersection Summary			
HCM Average Control Delay	16.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.64		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	61.8%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

2010 Traffic and Recommended Streets

AM Peak HCM Intersection Capacity Report

HCM Signalized Intersection Capacity Analysis — 2010 PM Peak

45: Market & Dutton — Existing Volumes and Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		←↑↑→						←↑↑→			←↑↑	
Volume (vph)	22	220	37	0	0	0	126	575	171	163	566	27
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0						4.0			4.0	
Lane Util. Factor		0.95						0.95			0.95	
Frt		0.98						0.97			0.99	
Flt Protected		1.00						0.99			0.99	
Satd. Flow (prot)		3455						3410			3483	
Flt Permitted		1.00						0.51			0.99	
Satd. Flow (perm)		3455						1747			3483	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	24	239	40	0	0	0	137	625	186	177	615	29
RTOR Reduction (vph)	0	13	0	0	0	0	0	24	0	0	3	0
Lane Group Flow (vph)	0	290	0	0	0	0	0	924	0	0	818	0
Turn Type	Perm						Perm			Split		
Protected Phases		4						2		6	6	
Permitted Phases	4						2					
Actuated Green, G (s)		16.0						43.0			19.0	
Effective Green, g (s)		16.0						43.0			19.0	
Actuated g/C Ratio		0.18						0.48			0.21	
Clearance Time (s)		4.0						4.0			4.0	
Lane Grp Cap (vph)		614						835			735	
v/s Ratio Prot											c0.23	
v/s Ratio Perm		0.08						c0.53				
v/c Ratio		0.47						1.28dl			1.11	
Uniform Delay, d1		33.2						23.5			35.5	
Progression Factor		1.00						1.00			1.00	
Incremental Delay, d2		2.6						64.6			68.6	
Delay (s)		35.8						88.1			104.1	
Level of Service		D						F			F	
Approach Delay (s)		35.8			0.0			88.1			104.1	
Approach LOS		D			A			F			F	

Intersection Summary			
HCM Average Control Delay	86.8	HCM Level of Service	F
HCM Volume to Capacity ratio	0.98		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	64.2%	ICU Level of Service	C
Analysis Period (min)	15		

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

c Critical Lane Group

Lowell Downtown Evolution Plan — May 2010

AECOM Design + Planning — Page 9

HCM Signalized Intersection Capacity Analysis — 2010 AM Peak
4: Merrimack & Worthen — Current Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	50	235	30	19	282	0	0	0	0	10	113	139
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		1.00			0.95						1.00	
Frt		0.99			1.00						0.93	
Flt Protected		0.99			1.00						1.00	
Satd. Flow (prot)		1824			3528						1726	
Flt Permitted		0.91			0.93						1.00	
Satd. Flow (perm)		1670			3283						1726	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	54	255	33	21	307	0	0	0	0	11	123	151
RTOR Reduction (vph)	0	6	0	0	0	0	0	0	0	0	68	0
Lane Group Flow (vph)	0	336	0	0	328	0	0	0	0	0	217	0
Turn Type	Perm			Perm						Perm		
Protected Phases		4			8						6	
Permitted Phases	4			8						6		
Actuated Green, G (s)		29.0			29.0						23.0	
Effective Green, g (s)		29.0			29.0						23.0	
Actuated g/C Ratio		0.48			0.48						0.38	
Clearance Time (s)		4.0			4.0						4.0	
Lane Grp Cap (vph)		807			1587						662	
v/s Ratio Prot												
v/s Ratio Perm		c0.20			0.10						0.13	
v/c Ratio		0.42			0.21						0.33	
Uniform Delay, d1		10.0			8.9						13.0	
Progression Factor		1.00			0.67						0.79	
Incremental Delay, d2		1.6			0.3						0.9	
Delay (s)		11.6			6.2						11.2	
Level of Service		B			A						B	
Approach Delay (s)		11.6			6.2			0.0			11.2	
Approach LOS		B			A			A			B	

Intersection Summary			
HCM Average Control Delay	9.6	HCM Level of Service	A
HCM Volume to Capacity ratio	0.38		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	50.3%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Lowell Downtown Evolution Plan — May 2010
AECOM Design + Planning — Page 1

HCM Unsignalized Intersection Capacity Analysis — 2010 AM Peak
5: Arcand & Worthen — Current Volumes and Recommended Geometries

Movement	NBL	NBT	SBT	SBR	NEL	NER
Lane Configurations						
Volume (veh/h)	0	558	370	246	50	0
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	607	402	267	54	0
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (ft)		304	549			
pX, platoon unblocked					0.92	
vC, conflicting volume	670				839	335
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	670				656	335
tC, single (s)	4.1				6.8	6.9
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	100				85	100
cM capacity (veh/h)	916				367	661

Direction, Lane #	NB 1	NB 2	SB 1	SB 2	NE 1
Volume Total	303	303	268	401	54
Volume Left	0	0	0	0	54
Volume Right	0	0	0	267	0
cSH	1700	1700	1700	1700	367
Volume to Capacity	0.18	0.18	0.16	0.24	0.15
Queue Length 95th (ft)	0	0	0	0	13
Control Delay (s)	0.0	0.0	0.0	0.0	16.5
Lane LOS					C
Approach Delay (s)	0.0		0.0		16.5
Approach LOS					C

Intersection Summary			
Average Delay	0.7		
Intersection Capacity Utilization	28.1%	ICU Level of Service	A
Analysis Period (min)	15		

Lowell Downtown Evolution Plan — May 2010
AECOM Design + Planning — Page 2

HCM Signalized Intersection Capacity Analysis — 2010 AM Peak
9: Broadway & Dutton — Current Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	84	87	449	22	27	15	209	707	52	27	669	16
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00	1.00		1.00		1.00	0.95		1.00	0.95	
Frt		1.00	0.85		0.97		1.00	0.99		1.00	1.00	
Flt Protected		0.98	1.00		0.98		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1818	1583		1774		1770	3503		1770	3527	
Flt Permitted		0.84	1.00		0.89		0.31	1.00		0.26	1.00	
Satd. Flow (perm)		1569	1583		1612		573	3503		491	3527	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	91	95	488	24	29	16	227	768	57	29	727	17
RTOR Reduction (vph)	0	0	59	0	10	0	0	14	0	0	4	0
Lane Group Flow (vph)	0	186	429	0	59	0	227	811	0	29	740	0
Turn Type	Perm		Perm	Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)		16.0	16.0		16.0		16.0	16.0		16.0	16.0	
Effective Green, g (s)		16.0	16.0		16.0		16.0	16.0		16.0	16.0	
Actuated g/C Ratio		0.40	0.40		0.40		0.40	0.40		0.40	0.40	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		628	633		645		229	1401		196	1411	
v/s Ratio Prot								0.23			0.21	
v/s Ratio Perm		0.12	c0.27		0.04		c0.40			0.06		
v/c Ratio		0.30	0.68		0.09		0.99	0.58		0.15	0.52	
Uniform Delay, d1		8.2	9.9		7.5		11.9	9.4		7.7	9.1	
Progression Factor		1.00	1.00		1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2		1.2	5.8		0.3		57.3	1.8		1.6	1.4	
Delay (s)		9.4	15.6		7.8		69.2	11.1		9.2	10.5	
Level of Service		A	B		A		E	B		A	B	
Approach Delay (s)		13.9			7.8			23.7			10.5	
Approach LOS		B			A			C			B	

Intersection Summary			
HCM Average Control Delay	16.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.83		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	60.4%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis — 2010 AM Peak
10: Merrimack & Central — Current Volumes and Recommended Geometries

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	0	0	265	397	411	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)			4.0	4.0	4.0	
Lane Util. Factor			1.00	0.95	0.97	
Frt			1.00	1.00	1.00	
Flt Protected			0.95	1.00	0.95	
Satd. Flow (prot)			1770	3539	3433	
Flt Permitted			0.95	1.00	0.95	
Satd. Flow (perm)			1770	3539	3433	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	288	432	447	0
RTOR Reduction (vph)	0	0	0	0	0	0
Lane Group Flow (vph)	0	0	288	432	447	0
Turn Type			Perm			
Protected Phases				8	2	
Permitted Phases			8			
Actuated Green, G (s)			16.0	16.0	16.0	
Effective Green, g (s)			16.0	16.0	16.0	
Actuated g/C Ratio			0.40	0.40	0.40	
Clearance Time (s)			4.0	4.0	4.0	
Lane Grp Cap (vph)			708	1416	1373	
v/s Ratio Prot				0.12	c0.13	
v/s Ratio Perm			c0.16			
v/c Ratio			0.41	0.31	0.33	
Uniform Delay, d1			8.6	8.2	8.3	
Progression Factor			0.79	0.82	1.00	
Incremental Delay, d2			1.6	0.5	0.6	
Delay (s)			8.4	7.2	8.9	
Level of Service			A	A	A	
Approach Delay (s)	0.0			7.7	8.9	
Approach LOS	A			A	A	

Intersection Summary			
HCM Average Control Delay	8.2	HCM Level of Service	A
HCM Volume to Capacity ratio	0.37		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	33.5%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis — 2010 AM Peak
11: Merrimack & Dutton — Current Volumes and Recommended Geometries

Movement	EBT	EBR	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Configurations									
Volume (vph)	15	131	190	162	44	41	488	46	414
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0			4.0		4.0
Lane Util. Factor	0.95	0.95		0.95			0.95		0.95
Frt	0.88	0.85		0.98			1.00		1.00
Flt Protected	1.00	1.00		0.98			1.00		1.00
Satd. Flow (prot)	1557	1504		3398			3525		3522
Flt Permitted	1.00	1.00		0.78			0.89		0.86
Satd. Flow (perm)	1557	1504		2722			3154		3059
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	16	142	207	176	48	45	530	50	450
RTOR Reduction (vph)	39	48	0	0	0	0	0	0	0
Lane Group Flow (vph)	41	30	0	431	0	0	575	0	500
Turn Type		Perm	Perm			Perm		Perm	
Protected Phases	4			8			2		6
Permitted Phases		4	8			2		6	
Actuated Green, G (s)	23.0	23.0		23.0			29.0		29.0
Effective Green, g (s)	23.0	23.0		23.0			29.0		29.0
Actuated g/C Ratio	0.38	0.38		0.38			0.48		0.48
Clearance Time (s)	4.0	4.0		4.0			4.0		4.0
Lane Grp Cap (vph)	597	577		1043			1524		1479
v/s Ratio Prot	0.03								
v/s Ratio Perm		0.02		c0.16			c0.18		0.16
v/c Ratio	0.07	0.05		0.41			0.38		0.34
Uniform Delay, d1	11.7	11.6		13.6			9.8		9.6
Progression Factor	0.11	0.08		1.00			0.70		0.90
Incremental Delay, d2	0.2	0.2		1.2			0.6		0.5
Delay (s)	1.5	1.1		14.8			7.5		9.1
Level of Service	A	A		B			A		A
Approach Delay (s)	1.3			14.8			7.5		9.1
Approach LOS	A			B			A		A

Intersection Summary			
HCM Average Control Delay	9.3	HCM Level of Service	A
HCM Volume to Capacity ratio	0.39		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	54.7%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis — 2010 AM Peak
13: Merrimack & Bridge-Prescott — Current Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	SBL	SBR	SBR2	NEL2	NEL	NER
Lane Configurations												
Volume (vph)	0	0	0	0	365	205	393	0	307	12	273	236
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)					4.0		4.0		4.0	4.0	4.0	
Lane Util. Factor					0.95		1.00		1.00	1.00	1.00	
Frpb, ped/bikes					0.99		1.00		0.91	1.00	1.00	
Flpb, ped/bikes					1.00		1.00		1.00	0.92	1.00	
Frt					0.95		1.00		0.85	1.00	0.93	
Flt Protected					1.00		0.95		1.00	0.95	0.97	
Satd. Flow (prot)					3318		1770		1436	1624	1688	
Flt Permitted					1.00		0.95		1.00	0.95	0.97	
Satd. Flow (perm)					3318		1770		1436	1624	1688	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	0	397	223	427	0	334	13	297	257
RTOR Reduction (vph)	0	0	0	0	134	0	0	0	160	8	78	0
Lane Group Flow (vph)	0	0	0	0	486	0	427	0	174	5	476	0
Confl. Peds. (#/hr)						18	110		110	110	110	
Turn Type									Perm	Perm		
Protected Phases					8		6!				2!	
Permitted Phases									6	2		
Actuated Green, G (s)					16.0		16.0		16.0	16.0	16.0	
Effective Green, g (s)					16.0		16.0		16.0	16.0	16.0	
Actuated g/C Ratio					0.40		0.40		0.40	0.40	0.40	
Clearance Time (s)					4.0		4.0		4.0	4.0	4.0	
Lane Grp Cap (vph)					1327		708		574	650	675	
v/s Ratio Prot					c0.15		0.24				c0.28	
v/s Ratio Perm									0.12	0.00		
v/c Ratio					0.37		0.60		0.30	0.01	0.71	
Uniform Delay, d1					8.4		9.5		8.2	7.2	10.0	
Progression Factor					1.00		1.00		1.00	0.69	0.88	
Incremental Delay, d2					0.8		3.8		1.4	0.0	5.8	
Delay (s)					9.2		13.3		9.6	5.0	14.6	
Level of Service					A		B		A	A	B	
Approach Delay (s)		0.0			9.2		11.6				14.4	
Approach LOS		A			A		B				B	

Intersection Summary			
HCM Average Control Delay	11.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	78.6%	ICU Level of Service	D
Analysis Period (min)	15		

! Phase conflict between lane groups.
c Critical Lane Group

HCM Signalized Intersection Capacity Analysis — 2010 AM Peak

20: Market & Prescott

Current Volumes and Recommended Geometries

Movement	EBL2	EBL	EBR	NBL	NBT	NBR	SBL	SBT	SBR	SWL	SWR
Lane Configurations											
Volume (vph)	62	207	790	232	233	243	0	133	132	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0	4.0		4.0			
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00			
Frpb, ped/bikes		1.00	0.92		1.00	0.98		1.00			
Flpb, ped/bikes		0.86	1.00		1.00	1.00		1.00			
Frt		1.00	0.85		1.00	0.85		0.93			
Flt Protected		0.95	1.00		0.98	1.00		1.00			
Satd. Flow (prot)		1531	1460		1817	1559		1738			
Flt Permitted		0.95	1.00		0.68	1.00		1.00			
Satd. Flow (perm)		1531	1460		1257	1559		1738			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	67	225	859	252	253	264	0	145	143	0	0
RTOR Reduction (vph)	0	0	412	0	0	158	0	86	0	0	0
Lane Group Flow (vph)	0	292	447	0	505	106	0	202	0	0	0
Confl. Peds. (#/hr)	90	90	90			5					
Turn Type	Perm		Perm	Perm		Perm					
Protected Phases		4			2			6			
Permitted Phases	4		4	2		2					
Actuated Green, G (s)		16.0	16.0		16.0	16.0		16.0			
Effective Green, g (s)		16.0	16.0		16.0	16.0		16.0			
Actuated g/C Ratio		0.40	0.40		0.40	0.40		0.40			
Clearance Time (s)		4.0	4.0		4.0	4.0		4.0			
Lane Grp Cap (vph)		612	584		503	624		695			
v/s Ratio Prot								0.12			
v/s Ratio Perm		0.19	c0.31		c0.40	0.07					
v/c Ratio		0.48	0.77		1.00	0.17		0.29			
Uniform Delay, d1		8.9	10.4		12.0	7.7		8.1			
Progression Factor		1.29	2.09		1.00	1.00		1.00			
Incremental Delay, d2		2.5	8.8		41.1	0.6		1.1			
Delay (s)		14.0	30.6		53.1	8.3		9.2			
Level of Service		B	C		D	A		A			
Approach Delay (s)		26.4			37.7			9.2		0.0	
Approach LOS		C			D			A		A	

Intersection Summary			
HCM Average Control Delay	28.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.89		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	76.3%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis — 2010 AM Peak

34: French & Bridge

Current Volumes and Recommended Geometries

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	128	202	179	304	463	323
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	0.94	
Flt Protected	0.95	1.00		0.98	1.00	
Satd. Flow (prot)	1770	1583		3475	3321	
Flt Permitted	0.95	1.00		0.59	1.00	
Satd. Flow (perm)	1770	1583		2083	3321	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	139	220	195	330	503	351
RTOR Reduction (vph)	0	127	0	0	211	0
Lane Group Flow (vph)	139	93	0	525	643	0
Turn Type		Perm	Perm			
Protected Phases	4			2	6	
Permitted Phases		4	2			
Actuated Green, G (s)	16.0	16.0		16.0	16.0	
Effective Green, g (s)	16.0	16.0		16.0	16.0	
Actuated g/C Ratio	0.40	0.40		0.40	0.40	
Clearance Time (s)	4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)	708	633		833	1328	
v/s Ratio Prot	c0.08				0.19	
v/s Ratio Perm		0.06		c0.25		
v/c Ratio	0.20	0.15		1.05dl	0.48	
Uniform Delay, d1	7.8	7.7		9.6	8.9	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.6	0.5		3.6	1.3	
Delay (s)	8.4	8.1		13.2	10.2	
Level of Service	A	A		B	B	
Approach Delay (s)	8.3			13.2	10.2	
Approach LOS	A			B	B	

Intersection Summary			
HCM Average Control Delay	10.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	53.8%	ICU Level of Service	A
Analysis Period (min)	15		

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

HCM Signalized Intersection Capacity Analysis — 2010 AM Peak

39: Fr Morrissette & Arcand

Current Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	40	301	303	274	233	82	154	155	129	62	99	23
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00			0.95			0.95	
Frpb, ped/bikes	1.00	1.00		1.00	1.00			0.98			0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			0.98			0.99	
Frt	1.00	0.92		1.00	0.96			0.96			0.98	
Flt Protected	0.95	1.00		0.95	1.00			0.98			0.98	
Satd. Flow (prot)	1770	1723		1770	1782			3212			3356	
Flt Permitted	0.58	1.00		0.14	1.00			0.78			0.72	
Satd. Flow (perm)	1034	1723		266	1782			2542			2466	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	43	327	329	298	253	89	167	168	140	67	108	25
RTOR Reduction (vph)	0	61	0	0	21	0	0	76	0	0	18	0
Lane Group Flow (vph)	43	595	0	298	321	0	0	399	0	0	182	0
Confl. Peds. (#/hr)				5		4	37		37	37		37
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		4		3	8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	24.0	24.0		36.0	36.0			16.0			16.0	
Effective Green, g (s)	24.0	24.0		36.0	36.0			16.0			16.0	
Actuated g/C Ratio	0.40	0.40		0.60	0.60			0.27			0.27	
Clearance Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Grp Cap (vph)	414	689		360	1069			678			658	
v/s Ratio Prot		0.35		c0.11	0.18							
v/s Ratio Perm	0.04			c0.39				c0.16			0.07	
v/c Ratio	0.10	0.86		0.83	0.30			0.59			0.28	
Uniform Delay, d1	11.3	16.5		12.2	5.9			19.1			17.4	
Progression Factor	1.00	1.00		1.00	1.00			1.87			1.00	
Incremental Delay, d2	0.5	13.6		19.3	0.7			3.6			1.0	
Delay (s)	11.8	30.1		31.5	6.6			39.3			18.5	
Level of Service	B	C		C	A			D			B	
Approach Delay (s)		29.0			18.2			39.3			18.5	
Approach LOS		C			B			D			B	

Intersection Summary			
HCM Average Control Delay	26.9	HCM Level of Service	C
HCM Volume to Capacity ratio	0.73		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	90.1%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis — 2010 AM Peak

45: Market & Dutton

Current Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	37	306	39	86	86	20	58	454	263	187	685	19
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor		0.95		1.00	1.00			0.95			0.95	
Frt		0.98		1.00	0.97			0.95			1.00	
Flt Protected		1.00		0.95	1.00			1.00			0.99	
Satd. Flow (prot)		3469		1770	1809			3346			3491	
Flt Permitted		0.92		0.44	1.00			0.83			0.62	
Satd. Flow (perm)		3206		825	1809			2778			2198	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	40	333	42	93	93	22	63	493	286	203	745	21
RTOR Reduction (vph)	0	15	0	0	14	0	0	85	0	0	2	0
Lane Group Flow (vph)	0	400	0	93	101	0	0	757	0	0	967	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		16.0		16.0	16.0			36.0			36.0	
Effective Green, g (s)		16.0		16.0	16.0			36.0			36.0	
Actuated g/C Ratio		0.27		0.27	0.27			0.60			0.60	
Clearance Time (s)		4.0		4.0	4.0			4.0			4.0	
Lane Grp Cap (vph)		855		220	482			1667			1319	
v/s Ratio Prot					0.06							
v/s Ratio Perm		c0.12		0.11				0.27			c0.44	
v/c Ratio		0.47		0.42	0.21			0.45			0.73	
Uniform Delay, d1		18.4		18.2	17.1			6.6			8.6	
Progression Factor		1.00		1.00	1.00			1.00			0.66	
Incremental Delay, d2		1.8		5.9	1.0			0.9			3.6	
Delay (s)		20.3		24.0	18.1			7.5			9.2	
Level of Service		C		C	B			A			A	
Approach Delay (s)		20.3			20.7			7.5			9.2	
Approach LOS		C			C			A			A	

Intersection Summary			
HCM Average Control Delay	11.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	77.5%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

2010 Traffic and Recommended Streets

PM Peak HCM Intersection Capacity Report

HCM Signalized Intersection Capacity Analysis — 2010 PM Peak
4: Merrimack & Worthen — Current Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	50	126	30	16	382	0	0	0	0	5	55	84
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		1.00			1.00						1.00	
Frt		0.98			1.00						0.92	
Flt Protected		0.99			1.00						1.00	
Satd. Flow (prot)		1804			1859						1713	
Flt Permitted		0.85			0.99						1.00	
Satd. Flow (perm)		1556			1839						1713	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	54	137	33	17	415	0	0	0	0	5	60	91
RTOR Reduction (vph)	0	10	0	0	0	0	0	0	0	0	59	0
Lane Group Flow (vph)	0	214	0	0	432	0	0	0	0	0	97	0
Turn Type	Perm			Perm						Perm		
Protected Phases		4			8						6	
Permitted Phases	4			8						6		
Actuated Green, G (s)		31.0			31.0						21.0	
Effective Green, g (s)		31.0			31.0						21.0	
Actuated g/C Ratio		0.52			0.52						0.35	
Clearance Time (s)		4.0			4.0						4.0	
Lane Grp Cap (vph)		804			950						600	
v/s Ratio Prot												
v/s Ratio Perm		0.14			c0.23						0.06	
v/c Ratio		0.27			0.45						0.16	
Uniform Delay, d1		8.1			9.2						13.4	
Progression Factor		1.00			0.63						0.34	
Incremental Delay, d2		0.8			1.5						0.5	
Delay (s)		8.9			7.3						5.1	
Level of Service		A			A						A	
Approach Delay (s)		8.9			7.3			0.0			5.1	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	7.3	HCM Level of Service	A
HCM Volume to Capacity ratio	0.34		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	46.1%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

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HCM Unsignalized Intersection Capacity Analysis
5: Dutton & Worthen

2010 PM Peak
Current Volumes and Recommended Geometries

Movement	NBL	NBT	SBT	SBR	NEL	NER
Lane Configurations		↑↑	↑↱		↰	
Volume (veh/h)	0	643	319	151	50	0
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	699	347	164	54	0
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (ft)		304	549			
pX, platoon unblocked					0.89	
vC, conflicting volume	511				778	255
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	511				514	255
tC, single (s)	4.1				6.8	6.9
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	100				88	100
cM capacity (veh/h)	1051				438	744

Direction, Lane #	NB 1	NB 2	SB 1	SB 2	NE 1
Volume Total	349	349	231	280	54
Volume Left	0	0	0	0	54
Volume Right	0	0	0	164	0
cSH	1700	1700	1700	1700	438
Volume to Capacity	0.21	0.21	0.14	0.16	0.12
Queue Length 95th (ft)	0	0	0	0	11
Control Delay (s)	0.0	0.0	0.0	0.0	14.4
Lane LOS					B
Approach Delay (s)	0.0		0.0		14.4
Approach LOS					B

Intersection Summary			
Average Delay	0.6		
Intersection Capacity Utilization	27.8%	ICU Level of Service	A
Analysis Period (min)	15		

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HCM Signalized Intersection Capacity Analysis
9: Broadway & Dutton

2010 PM Peak
Current Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↰	↱		✣		↰	↑↱		↰	↑↱	
Volume (vph)	102	29	297	30	40	19	313	778	39	13	566	40
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00	1.00		1.00		1.00	0.95		1.00	0.95	
Frt		1.00	0.85		0.97		1.00	0.99		1.00	0.99	
Flt Protected		0.96	1.00		0.98		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1793	1583		1778		1770	3514		1770	3505	
Flt Permitted		0.77	1.00		0.88		0.38	1.00		0.28	1.00	
Satd. Flow (perm)		1434	1583		1595		713	3514		523	3505	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	111	32	323	33	43	21	340	846	42	14	615	43
RTOR Reduction (vph)	0	0	211	0	15	0	0	6	0	0	8	0
Lane Group Flow (vph)	0	143	112	0	82	0	340	882	0	14	650	0
Turn Type	Perm		Perm	Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)		16.0	16.0		16.0		36.0	36.0		36.0	36.0	
Effective Green, g (s)		16.0	16.0		16.0		36.0	36.0		36.0	36.0	
Actuated g/C Ratio		0.27	0.27		0.27		0.60	0.60		0.60	0.60	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		382	422		425		428	2108		314	2103	
v/s Ratio Prot								0.25			0.19	
v/s Ratio Perm		c0.10	0.07		0.05		c0.48			0.03		
v/c Ratio		0.37	0.26		0.19		0.79	0.42		0.04	0.31	
Uniform Delay, d1		17.9	17.4		17.0		9.2	6.4		4.9	5.9	
Progression Factor		1.00	1.00		1.00		1.00	1.00		0.94	0.96	
Incremental Delay, d2		2.8	1.5		1.0		14.1	0.6		0.2	0.3	
Delay (s)		20.7	18.9		18.0		23.3	7.0		4.9	6.0	
Level of Service		C	B		B		C	A		A	A	
Approach Delay (s)		19.4			18.0			11.5			6.0	
Approach LOS		B			B			B			A	

Intersection Summary			
HCM Average Control Delay	11.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	58.1%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

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HCM Signalized Intersection Capacity Analysis — 2010 PM Peak
10: Merrimack & Central — Current Volumes and Recommended Geometries

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	0	0	212	317	400	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)			4.0	4.0	4.0	
Lane Util. Factor			1.00	0.95	0.97	
Frt			1.00	1.00	1.00	
Flt Protected			0.95	1.00	0.95	
Satd. Flow (prot)			1770	3539	3433	
Flt Permitted			0.95	1.00	0.95	
Satd. Flow (perm)			1770	3539	3433	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	230	345	435	0
RTOR Reduction (vph)	0	0	0	0	0	0
Lane Group Flow (vph)	0	0	230	345	435	0
Turn Type			Perm			
Protected Phases				8	2	
Permitted Phases			8			
Actuated Green, G (s)			26.0	26.0	26.0	
Effective Green, g (s)			26.0	26.0	26.0	
Actuated g/C Ratio			0.43	0.43	0.43	
Clearance Time (s)			4.0	4.0	4.0	
Lane Grp Cap (vph)			767	1534	1488	
v/s Ratio Prot				0.10	c0.13	
v/s Ratio Perm			c0.13			
v/c Ratio			0.30	0.22	0.29	
Uniform Delay, d1			11.1	10.7	11.0	
Progression Factor			0.73	0.74	1.00	
Incremental Delay, d2			1.0	0.3	0.5	
Delay (s)			9.1	8.2	11.5	
Level of Service			A	A	B	
Approach Delay (s)	0.0			8.5	11.5	
Approach LOS	A			A	B	

Intersection Summary			
HCM Average Control Delay	9.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.30		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	30.6%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

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HCM Signalized Intersection Capacity Analysis — 2010 PM Peak
11: Merrimack & Dutton — Current Volumes and Recommended Geometries

Movement	EBT	EBR	WBL	WBT	WBR	NBL	NBT	SBL	SBT	SBR
Lane Configurations										
Volume (vph)	7	61	161	190	35	27	640	29	256	2
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0			4.0		4.0	
Lane Util. Factor	0.95	0.95		0.95			0.95		0.95	
Frt	0.88	0.85		0.99			1.00		1.00	
Flt Protected	1.00	1.00		0.98			1.00		0.99	
Satd. Flow (prot)	1560	1504		3420			3532		3518	
Flt Permitted	1.00	1.00		0.82			0.94		0.87	
Satd. Flow (perm)	1560	1504		2850			3309		3062	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	8	66	175	207	38	29	696	32	278	2
RTOR Reduction (vph)	20	23	0	0	0	0	0	0	1	0
Lane Group Flow (vph)	19	13	0	420	0	0	725	0	311	0
Turn Type		Perm	Perm			Perm		Perm		
Protected Phases	4			8			2		6	
Permitted Phases		4	8			2		6		
Actuated Green, G (s)	21.0	21.0		21.0			31.0		31.0	
Effective Green, g (s)	21.0	21.0		21.0			31.0		31.0	
Actuated g/C Ratio	0.35	0.35		0.35			0.52		0.52	
Clearance Time (s)	4.0	4.0		4.0			4.0		4.0	
Lane Grp Cap (vph)	546	526		998			1710		1582	
v/s Ratio Prot	0.01									
v/s Ratio Perm		0.01		c0.15			c0.22		0.10	
v/c Ratio	0.03	0.02		0.42			0.42		0.20	
Uniform Delay, d1	12.8	12.8		14.9			9.0		7.8	
Progression Factor	0.20	0.20		1.00			0.38		0.35	
Incremental Delay, d2	0.1	0.1		1.3			0.7		0.2	
Delay (s)	2.7	2.7		16.2			4.0		2.9	
Level of Service	A	A		B			A		A	
Approach Delay (s)	2.7			16.2			4.0		2.9	
Approach LOS	A			B			A		A	

Intersection Summary			
HCM Average Control Delay	7.1	HCM Level of Service	A
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	52.0%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

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HCM Signalized Intersection Capacity Analysis — 2010 PM Peak
13: Merrimack & Bridge-Prescott
Current Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	SBL	SBR	SBR2	NEL2	NEL	NER
Lane Configurations												
Volume (vph)	0	0	0	0	239	199	341	0	246	19	501	139
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)					4.0		4.0		4.0	4.0	4.0	
Lane Util. Factor					0.95		1.00		1.00	1.00	1.00	
Frt					0.93		1.00		0.85	1.00	0.97	
Flt Protected					1.00		0.95		1.00	0.95	0.96	
Satd. Flow (prot)					3298		1770		1583	1770	1734	
Flt Permitted					1.00		0.95		1.00	0.95	0.96	
Satd. Flow (perm)					3298		1770		1583	1770	1734	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	0	260	216	371	0	267	21	545	151
RTOR Reduction (vph)	0	0	0	0	158	0	0	0	107	8	17	0
Lane Group Flow (vph)	0	0	0	0	318	0	371	0	160	13	679	0
Turn Type									Perm	Perm		
Protected Phases					8		6!				2!	
Permitted Phases									6	2		
Actuated Green, G (s)					16.0		36.0		36.0	36.0	36.0	
Effective Green, g (s)					16.0		36.0		36.0	36.0	36.0	
Actuated g/C Ratio					0.27		0.60		0.60	0.60	0.60	
Clearance Time (s)					4.0		4.0		4.0	4.0	4.0	
Lane Grp Cap (vph)					879		1062		950	1062	1040	
v/s Ratio Prot					c0.10		0.21				c0.39	
v/s Ratio Perm									0.10	0.01		
v/c Ratio					0.36		0.35		0.17	0.01	0.65	
Uniform Delay, d1					17.9		6.1		5.3	4.8	7.9	
Progression Factor					1.00		1.00		1.00	0.59	0.75	
Incremental Delay, d2					1.2		0.9		0.4	0.0	2.8	
Delay (s)					19.0		7.0		5.7	2.9	8.7	
Level of Service					B		A		A	A	A	
Approach Delay (s)		0.0			19.0		6.5				8.5	
Approach LOS		A			B		A				A	

Intersection Summary			
HCM Average Control Delay	10.5	HCM Level of Service	B
HCM Volume to Capacity ratio	0.56		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	78.1%	ICU Level of Service	D
Analysis Period (min)	15		

! Phase conflict between lane groups.
c Critical Lane Group

HCM Signalized Intersection Capacity Analysis — 2010 PM Peak
20: Market & Prescott
Current Volumes and Recommended Geometries

Movement	EBL2	EBL	EBR	NBL	NBT	NBR	SBL	SBT	SBR	SWL	SWR
Lane Configurations											
Volume (vph)	129	186	619	215	215	508	0	106	106	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0	4.0		4.0			
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00			
Frt		1.00	0.85		1.00	0.85		0.93			
Flt Protected		0.95	1.00		0.98	1.00		1.00			
Satd. Flow (prot)		1770	1583		1817	1583		1737			
Flt Permitted		0.95	1.00		0.72	1.00		1.00			
Satd. Flow (perm)		1770	1583		1349	1583		1737			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	140	202	673	234	234	552	0	115	115	0	0
RTOR Reduction (vph)	0	0	437	0	0	251	0	56	0	0	0
Lane Group Flow (vph)	0	342	236	0	468	301	0	174	0	0	0
Turn Type	Perm		Perm	Perm		Perm					
Protected Phases		4			2			6			
Permitted Phases	4		4	2		2					
Actuated Green, G (s)		21.0	21.0		31.0	31.0		31.0			
Effective Green, g (s)		21.0	21.0		31.0	31.0		31.0			
Actuated g/C Ratio		0.35	0.35		0.52	0.52		0.52			
Clearance Time (s)		4.0	4.0		4.0	4.0		4.0			
Lane Grp Cap (vph)		620	554		697	818		897			
v/s Ratio Prot								0.10			
v/s Ratio Perm		0.19	0.15		c0.35	0.19					
v/c Ratio		0.55	0.43		0.67	0.37		0.19			
Uniform Delay, d1		15.7	14.9		10.7	8.7		7.8			
Progression Factor		0.76	0.53		1.00	1.00		1.00			
Incremental Delay, d2		3.4	2.3		5.1	1.3		0.5			
Delay (s)		15.3	10.2		15.8	9.9		8.3			
Level of Service		B	B		B	A		A			
Approach Delay (s)		11.9			12.6			8.3		0.0	
Approach LOS		B			B			A		A	

Intersection Summary			
HCM Average Control Delay	11.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	62.7%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis — 2010 PM Peak
22: Market & Palmer
Current Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	26	482	0	0	381	10	90	2	90	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0			4.0				
Lane Util. Factor	1.00	1.00			1.00			1.00				
Frt	1.00	1.00			1.00			0.93				
Flt Protected	0.95	1.00			1.00			0.98				
Satd. Flow (prot)	1770	1863			1856			1696				
Flt Permitted	0.45	1.00			1.00			0.98				
Satd. Flow (perm)	832	1863			1856			1696				
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	28	524	0	0	414	11	98	2	98	0	0	0
RTOR Reduction (vph)	0	0	0	0	2	0	0	59	0	0	0	0
Lane Group Flow (vph)	28	524	0	0	423	0	0	139	0	0	0	0
Turn Type	Perm			Perm			Perm					
Protected Phases		4			8			2				
Permitted Phases	4			8			2					
Actuated Green, G (s)	33.0	33.0			33.0			19.0				
Effective Green, g (s)	33.0	33.0			33.0			19.0				
Actuated g/C Ratio	0.55	0.55			0.55			0.32				
Clearance Time (s)	4.0	4.0			4.0			4.0				
Lane Grp Cap (vph)	458	1025			1021			537				
v/s Ratio Prot		c0.28			0.23							
v/s Ratio Perm	0.03							0.08				
v/c Ratio	0.06	0.51			0.41			0.26				
Uniform Delay, d1	6.3	8.5			7.9			15.3				
Progression Factor	1.00	1.00			0.38			1.00				
Incremental Delay, d2	0.3	1.8			1.1			1.2				
Delay (s)	6.5	10.3			4.1			16.4				
Level of Service	A	B			A			B				
Approach Delay (s)		10.1			4.1			16.4			0.0	
Approach LOS		B			A			B			A	

Intersection Summary			
HCM Average Control Delay	9.0	HCM Level of Service	A
HCM Volume to Capacity ratio	0.42		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	42.6%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

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HCM Signalized Intersection Capacity Analysis — 2010 PM Peak
34: French & Bridge
Current Volumes and Recommended Geometries

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	279	209	98	628	363	167
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	0.95	
Flt Protected	0.95	1.00		0.99	1.00	
Satd. Flow (prot)	1770	1583		3515	3372	
Flt Permitted	0.95	1.00		0.80	1.00	
Satd. Flow (perm)	1770	1583		2832	3372	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	303	227	107	683	395	182
RTOR Reduction (vph)	0	148	0	0	88	0
Lane Group Flow (vph)	303	79	0	790	489	0
Turn Type		Perm	Perm			
Protected Phases	4			2	6	
Permitted Phases		4	2			
Actuated Green, G (s)	21.0	21.0		31.0	31.0	
Effective Green, g (s)	21.0	21.0		31.0	31.0	
Actuated g/C Ratio	0.35	0.35		0.52	0.52	
Clearance Time (s)	4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)	620	554		1463	1742	
v/s Ratio Prot	c0.17				0.15	
v/s Ratio Perm		0.05		c0.28		
v/c Ratio	0.49	0.14		0.54	0.28	
Uniform Delay, d1	15.3	13.3		9.7	8.2	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	2.7	0.5		1.4	0.4	
Delay (s)	18.0	13.9		11.2	8.6	
Level of Service	B	B		B	A	
Approach Delay (s)	16.3			11.2	8.6	
Approach LOS	B			B	A	

Intersection Summary			
HCM Average Control Delay	11.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.52		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	61.0%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

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HCM Signalized Intersection Capacity Analysis — 2010 PM Peak
39: Fr Morrissette & Arcand — Current Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	25	190	197	161	265	21	364	79	129	25	74	21
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			0.95	
Frt	1.00	0.92		1.00	0.99		1.00	0.91			0.97	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.99	
Satd. Flow (prot)	1770	1721		1770	1842		1770	1690			3410	
Flt Permitted	0.46	1.00		0.27	1.00		0.67	1.00			0.89	
Satd. Flow (perm)	858	1721		508	1842		1247	1690			3062	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	27	207	214	175	288	23	396	86	140	27	80	23
RTOR Reduction (vph)	0	62	0	0	5	0	0	79	0	0	13	0
Lane Group Flow (vph)	27	359	0	175	306	0	396	147	0	0	117	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		4		3	8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	16.0	16.0		26.0	26.0		26.0	26.0			26.0	
Effective Green, g (s)	16.0	16.0		26.0	26.0		26.0	26.0			26.0	
Actuated g/C Ratio	0.27	0.27		0.43	0.43		0.43	0.43			0.43	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Grp Cap (vph)	229	459		346	798		540	732			1327	
v/s Ratio Prot		c0.21		c0.05	0.17			0.09				
v/s Ratio Perm	0.03			0.17			c0.32				0.04	
v/c Ratio	0.12	0.78		0.51	0.38		0.73	0.20			0.09	
Uniform Delay, d1	16.7	20.4		19.2	11.6		14.1	10.5			10.0	
Progression Factor	1.00	1.00		1.00	1.00		0.57	0.50			1.00	
Incremental Delay, d2	1.0	12.4		5.2	1.4		8.0	0.6			0.1	
Delay (s)	17.7	32.8		24.4	13.0		16.1	5.9			10.1	
Level of Service	B	C		C	B		B	A			B	
Approach Delay (s)		31.9			17.1			12.4			10.1	
Approach LOS		C			B			B			B	

Intersection Summary			
HCM Average Control Delay	18.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	67.8%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

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HCM Signalized Intersection Capacity Analysis — 2010 PM Peak
45: Market & Dutton — Current Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	22	220	37	90	90	20	126	575	171	127	566	27
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00			0.95			0.95	
Frt	1.00	0.98		1.00	0.97			0.97			0.99	
Flt Protected	0.95	1.00		0.95	1.00			0.99			0.99	
Satd. Flow (prot)	1770	1823		1770	1812			3410			3489	
Flt Permitted	0.68	1.00		0.45	1.00			0.73			0.66	
Satd. Flow (perm)	1266	1823		845	1812			2516			2326	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	24	239	40	98	98	22	137	625	186	138	615	29
RTOR Reduction (vph)	0	10	0	0	14	0	0	36	0	0	5	0
Lane Group Flow (vph)	24	269	0	98	106	0	0	912	0	0	777	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	17.0	17.0		17.0	17.0			35.0			35.0	
Effective Green, g (s)	17.0	17.0		17.0	17.0			35.0			35.0	
Actuated g/C Ratio	0.28	0.28		0.28	0.28			0.58			0.58	
Clearance Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Grp Cap (vph)	359	517		239	513			1468			1357	
v/s Ratio Prot		c0.15			0.06							
v/s Ratio Perm	0.02			0.12				c0.36			0.33	
v/c Ratio	0.07	0.52		0.41	0.21			0.62			0.57	
Uniform Delay, d1	15.7	18.1		17.4	16.4			8.2			7.8	
Progression Factor	1.00	1.00		1.00	1.00			0.58			0.80	
Incremental Delay, d2	0.4	3.7		5.1	0.9			1.8			1.8	
Delay (s)	16.1	21.8		22.6	17.3			6.6			8.0	
Level of Service	B	C		C	B			A			A	
Approach Delay (s)		21.3			19.7			6.6			8.0	
Approach LOS		C			B			A			A	

Intersection Summary			
HCM Average Control Delay	10.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	77.4%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

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2030 Traffic and Recommended Streets

AM Peak HCM Intersection Capacity Report

HCM Signalized Intersection Capacity Analysis — 2030 AM Peak

4: Merrimack & Worthen — Forecast Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	61	287	37	23	344	0	0	0	0	12	138	170
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		1.00			0.95						1.00	
Frt		0.99			1.00						0.93	
Flt Protected		0.99			1.00						1.00	
Satd. Flow (prot)		1824			3528						1726	
Flt Permitted		0.89			0.92						1.00	
Satd. Flow (perm)		1630			3256						1726	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	66	312	40	25	374	0	0	0	0	13	150	185
RTOR Reduction (vph)	0	6	0	0	0	0	0	0	0	0	58	0
Lane Group Flow (vph)	0	412	0	0	399	0	0	0	0	0	290	0
Turn Type	Perm			Perm						Perm		
Protected Phases		4			8						6	
Permitted Phases	4			8						6		
Actuated Green, G (s)		34.0			34.0						28.0	
Effective Green, g (s)		34.0			34.0						28.0	
Actuated g/C Ratio		0.49			0.49						0.40	
Clearance Time (s)		4.0			4.0						4.0	
Lane Grp Cap (vph)		792			1581						690	
v/s Ratio Prot												
v/s Ratio Perm		c0.25			0.12						0.17	
v/c Ratio		0.52			0.25						0.42	
Uniform Delay, d1		12.4			10.6						15.1	
Progression Factor		1.00			0.55						0.92	
Incremental Delay, d2		2.4			0.4						0.9	
Delay (s)		14.8			6.1						14.8	
Level of Service		B			A						B	
Approach Delay (s)		14.8			6.1			0.0			14.8	
Approach LOS		B			A			A			B	

Intersection Summary			
HCM Average Control Delay	11.8	HCM Level of Service	B
HCM Volume to Capacity ratio	0.48		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	59.2%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

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HCM Unsignalized Intersection Capacity Analysis
5: Arcand & Worthen

2030 AM Peak
Forecast Volumes and Recommended Geometries

Movement	NBL	NBT	SBT	SBR	NEL	NER
Lane Configurations						
Volume (veh/h)	0	661	451	300	61	0
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	718	490	326	66	0
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (ft)		304	549			
pX, platoon unblocked					0.89	
vC, conflicting volume	816				1012	408
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	816				757	408
tC, single (s)	4.1				6.8	6.9
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	100				78	100
cM capacity (veh/h)	807				304	592

Direction, Lane #	NB 1	NB 2	SB 1	SB 2	NE 1
Volume Total	359	359	327	489	66
Volume Left	0	0	0	0	66
Volume Right	0	0	0	326	0
cSH	1700	1700	1700	1700	304
Volume to Capacity	0.21	0.21	0.19	0.29	0.22
Queue Length 95th (ft)	0	0	0	0	20
Control Delay (s)	0.0	0.0	0.0	0.0	20.1
Lane LOS					C
Approach Delay (s)	0.0		0.0		20.1
Approach LOS					C

Intersection Summary			
Average Delay	0.8		
Intersection Capacity Utilization	32.1%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Signalized Intersection Capacity Analysis
9: Broadway & Dutton

2030 AM Peak
Forecast Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	102	106	548	27	33	18	255	863	63	33	816	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00	1.00		1.00		1.00	0.95		1.00	0.95	
Frt		1.00	0.85		0.97		1.00	0.99		1.00	1.00	
Flt Protected		0.98	1.00		0.98		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1818	1583		1773		1770	3503		1770	3526	
Flt Permitted		0.83	1.00		0.86		0.20	1.00		0.28	1.00	
Satd. Flow (perm)		1547	1583		1547		373	3503		531	3526	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	111	115	596	29	36	20	277	938	68	36	887	22
RTOR Reduction (vph)	0	0	17	0	15	0	0	8	0	0	3	0
Lane Group Flow (vph)	0	226	579	0	70	0	277	998	0	36	906	0
Turn Type	Perm		pm+ov	Perm			pm+pt			pm+pt		
Protected Phases		4	5		8		5	2		1	6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)		16.0	34.0		16.0		38.0	38.0		24.0	24.0	
Effective Green, g (s)		16.0	34.0		16.0		38.0	38.0		24.0	24.0	
Actuated g/C Ratio		0.23	0.49		0.23		0.54	0.54		0.34	0.34	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		354	859		354		562	1902		253	1209	
v/s Ratio Prot			c0.17				0.13	0.28		0.01	c0.26	
v/s Ratio Perm		0.15	0.19		0.04		0.14			0.04		
v/c Ratio		0.64	0.67		0.20		0.49	0.52		0.14	0.75	
Uniform Delay, d1		24.4	13.8		21.8		10.8	10.2		16.2	20.3	
Progression Factor		1.00	1.00		1.00		1.00	1.00		0.70	0.71	
Incremental Delay, d2		8.5	4.2		1.2		3.1	1.0		0.5	1.9	
Delay (s)		32.9	18.0		23.0		13.9	11.3		11.8	16.4	
Level of Service		C	B		C		B	B		B	B	
Approach Delay (s)		22.1			23.0			11.8			16.2	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	16.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	71.5%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
10: Merrimack & Central

2030 AM Peak
Forecast Volumes and Recommended Geometries

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	0	0	323	484	501	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)			4.0	4.0	4.0	
Lane Util. Factor			1.00	0.95	0.97	
Frt			1.00	1.00	1.00	
Flt Protected			0.95	1.00	0.95	
Satd. Flow (prot)			1770	3539	3433	
Flt Permitted			0.95	1.00	0.95	
Satd. Flow (perm)			1770	3539	3433	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	351	526	545	0
RTOR Reduction (vph)	0	0	0	0	0	0
Lane Group Flow (vph)	0	0	351	526	545	0
Turn Type			Perm			
Protected Phases				8	2	
Permitted Phases			8			
Actuated Green, G (s)			35.0	35.0	27.0	
Effective Green, g (s)			35.0	35.0	27.0	
Actuated g/C Ratio			0.50	0.50	0.39	
Clearance Time (s)			4.0	4.0	4.0	
Lane Grp Cap (vph)			885	1770	1324	
v/s Ratio Prot				0.15	c0.16	
v/s Ratio Perm			c0.20			
v/c Ratio			0.40	0.30	0.41	
Uniform Delay, d1			10.9	10.3	15.7	
Progression Factor			0.64	0.63	1.00	
Incremental Delay, d2			1.1	0.3	0.9	
Delay (s)			8.0	6.8	16.6	
Level of Service			A	A	B	
Approach Delay (s)	0.0			7.3	16.6	
Approach LOS	A			A	B	

Intersection Summary			
HCM Average Control Delay	10.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.40		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	36.7%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

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HCM Signalized Intersection Capacity Analysis
11: Merrimack & Dutton

2030 AM Peak
Forecast Volumes and Recommended Geometries

Movement	EBT	EBR	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Configurations									
Volume (vph)	18	160	232	198	54	50	595	56	505
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0			4.0		4.0
Lane Util. Factor	0.95	0.95		0.95			0.95		0.95
Frt	0.88	0.85		0.98			1.00		1.00
Flt Protected	1.00	1.00		0.98			1.00		1.00
Satd. Flow (prot)	1558	1504		3398			3526		3522
Flt Permitted	1.00	1.00		0.77			0.87		0.83
Satd. Flow (perm)	1558	1504		2688			3078		2944
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	20	174	252	215	59	54	647	61	549
RTOR Reduction (vph)	47	58	0	0	0	0	0	0	0
Lane Group Flow (vph)	51	38	0	526	0	0	701	0	610
Turn Type		Perm	Perm			Perm		Perm	
Protected Phases	4			8			2		6
Permitted Phases		4	8			2		6	
Actuated Green, G (s)	28.0	28.0		28.0			34.0		34.0
Effective Green, g (s)	28.0	28.0		28.0			34.0		34.0
Actuated g/C Ratio	0.40	0.40		0.40			0.49		0.49
Clearance Time (s)	4.0	4.0		4.0			4.0		4.0
Lane Grp Cap (vph)	623	602		1075			1495		1430
v/s Ratio Prot	0.03								
v/s Ratio Perm		0.03		c0.20			c0.23		0.21
v/c Ratio	0.08	0.06		0.49			0.47		0.43
Uniform Delay, d1	13.0	12.9		15.7			12.0		11.7
Progression Factor	0.16	0.13		1.00			0.64		0.96
Incremental Delay, d2	0.2	0.2		1.6			0.9		0.6
Delay (s)	2.4	1.8		17.3			8.5		11.8
Level of Service	A	A		B			A		B
Approach Delay (s)	2.1			17.3			8.5		11.8
Approach LOS	A			B			A		B

Intersection Summary			
HCM Average Control Delay	11.1	HCM Level of Service	B
HCM Volume to Capacity ratio	0.48		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	63.0%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

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HCM Signalized Intersection Capacity Analysis
13: Merrimack & Bridge-Prescott

2030 AM Peak
Forecast Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	SBL	SBR	SBR2	NEL2	NEL	NER
Lane Configurations												
Volume (vph)	0	0	0	0	445	250	480	0	375	15	333	288
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)					4.0		4.0		4.0	4.0	4.0	
Lane Util. Factor					0.95		1.00		1.00	1.00	1.00	
Frpb, ped/bikes					0.99		1.00		0.85	1.00	1.00	
Flpb, ped/bikes					1.00		1.00		1.00	0.86	1.00	
Frt					0.95		1.00		0.85	1.00	0.93	
Flt Protected					1.00		0.95		1.00	0.95	0.97	
Satd. Flow (prot)					3306		1770		1340	1514	1688	
Flt Permitted					1.00		0.95		1.00	0.95	0.97	
Satd. Flow (perm)					3306		1770		1340	1514	1688	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	0	484	272	522	0	408	16	362	313
RTOR Reduction (vph)	0	0	0	0	111	0	0	0	39	6	44	0
Lane Group Flow (vph)	0	0	0	0	645	0	522	0	369	10	631	0
Confl. Peds. (#/hr)						18	110		110	110	110	
Turn Type									Perm	Perm		
Protected Phases					8		6!				2!	
Permitted Phases									6	2		
Actuated Green, G (s)					20.0		42.0		42.0	42.0	42.0	
Effective Green, g (s)					20.0		42.0		42.0	42.0	42.0	
Actuated g/C Ratio					0.29		0.60		0.60	0.60	0.60	
Clearance Time (s)					4.0		4.0		4.0	4.0	4.0	
Lane Grp Cap (vph)					945		1062		804	908	1013	
v/s Ratio Prot					c0.20		0.29				c0.37	
v/s Ratio Perm									0.28	0.01		
v/c Ratio					0.68		0.49		0.46	0.01	0.62	
Uniform Delay, d1					22.2		7.9		7.7	5.6	8.9	
Progression Factor					1.00		1.00		1.00	0.37	0.42	
Incremental Delay, d2					4.0		1.6		1.9	0.0	2.6	
Delay (s)					26.2		9.6		9.6	2.1	6.3	
Level of Service					C		A		A	A	A	
Approach Delay (s)		0.0			26.2		9.6				6.2	
Approach LOS		A			C		A				A	

Intersection Summary			
HCM Average Control Delay	13.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.64		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	93.6%	ICU Level of Service	F
Analysis Period (min)	15		

! Phase conflict between lane groups.
c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
20: Market & Prescott

2030 AM Peak
Forecast Volumes and Recommended Geometries

Movement	EBL2	EBL	EBR	NBL	NBT	NBR	SBL	SBT	SBR	SWL	SWR
Lane Configurations											
Volume (vph)	76	253	964	283	284	297	0	162	161	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0	4.0		4.0			
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00			
Frpb, ped/bikes		1.00	1.00		1.00	0.98		1.00			
Flpb, ped/bikes		0.76	1.00		1.00	1.00		1.00			
Frt		1.00	0.85		1.00	0.85		0.93			
Flt Protected		0.95	1.00		0.98	1.00		1.00			
Satd. Flow (prot)		1352	1583		1817	1554		1737			
Flt Permitted		0.95	1.00		0.50	1.00		1.00			
Satd. Flow (perm)		1352	1583		931	1554		1737			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	83	275	1048	308	309	323	0	176	175	0	0
RTOR Reduction (vph)	0	0	381	0	0	70	0	51	0	0	0
Lane Group Flow (vph)	0	358	667	0	617	253	0	300	0	0	0
Confl. Peds. (#/hr)	90	90	90			5					
Turn Type	Perm		pt+ov	pm+pt		Perm					
Protected Phases		4	4 5	5	2			6			
Permitted Phases	4			2		2					
Actuated Green, G (s)		22.0	30.0		40.0	40.0		32.0			
Effective Green, g (s)		22.0	30.0		40.0	40.0		32.0			
Actuated g/C Ratio		0.31	0.43		0.57	0.57		0.46			
Clearance Time (s)		4.0			4.0	4.0		4.0			
Lane Grp Cap (vph)		425	678		583	888		794			
v/s Ratio Prot			c0.42		0.06			0.17			
v/s Ratio Perm		0.26			c0.54	0.16					
v/c Ratio		0.84	0.98		1.06	0.29		0.38			
Uniform Delay, d1		22.4	19.8		15.0	7.7		12.5			
Progression Factor		0.89	0.59		1.00	1.00		1.00			
Incremental Delay, d2		17.6	30.3		53.7	0.8		1.4			
Delay (s)		37.5	42.0		68.7	8.5		13.8			
Level of Service		D	D		E	A		B			
Approach Delay (s)		40.9			48.0			13.8		0.0	
Approach LOS		D			D			B		A	

Intersection Summary			
HCM Average Control Delay	39.8	HCM Level of Service	D
HCM Volume to Capacity ratio	1.00		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	4.0
Intersection Capacity Utilization	90.4%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
22: Market & Palmer

2030 AM Peak
Forecast Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	49	461	412	222	210	12	0	0	0	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0							
Lane Util. Factor	1.00	1.00		1.00	1.00							
Frt	1.00	0.93		1.00	0.99							
Flt Protected	0.95	1.00		0.95	1.00							
Satd. Flow (prot)	1770	1731		1770	1848							
Flt Permitted	0.61	1.00		0.07	1.00							
Satd. Flow (perm)	1134	1731		135	1848							
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	53	501	448	241	228	13	0	0	0	0	0	0
RTOR Reduction (vph)	0	36	0	0	2	0	0	0	0	0	0	0
Lane Group Flow (vph)	53	913	0	241	239	0	0	0	0	0	0	0
Turn Type	Perm			pm+pt			Perm					
Protected Phases		4		3	8			2				
Permitted Phases	4			8			2					
Actuated Green, G (s)	51.0	51.0		65.0	65.0							
Effective Green, g (s)	51.0	51.0		65.0	65.0							
Actuated g/C Ratio	0.57	0.57		0.72	0.72							
Clearance Time (s)	4.0	4.0		4.0	4.0							
Lane Grp Cap (vph)	643	981		279	1335							
v/s Ratio Prot		c0.53		c0.10	0.13							
v/s Ratio Perm	0.05			0.53								
v/c Ratio	0.08	0.93		0.86	0.18							
Uniform Delay, d1	8.9	17.9		27.1	4.0							
Progression Factor	1.00	1.00		1.00	1.00							
Incremental Delay, d2	0.3	16.2		28.1	0.3							
Delay (s)	9.1	34.1		55.2	4.3							
Level of Service	A	C		E	A							
Approach Delay (s)		32.8			29.7			0.0			0.0	
Approach LOS		C			C			A			A	

Intersection Summary			
HCM Average Control Delay	31.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.92		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	29.0
Intersection Capacity Utilization	68.4%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

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HCM Signalized Intersection Capacity Analysis
34: French & Bridge

2030 AM Peak
Forecast Volumes and Recommended Geometries

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	156	246	218	371	565	394
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	0.94	
Flt Protected	0.95	1.00		0.98	1.00	
Satd. Flow (prot)	1770	1583		3475	3321	
Flt Permitted	0.95	1.00		0.53	1.00	
Satd. Flow (perm)	1770	1583		1862	3321	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	170	267	237	403	614	428
RTOR Reduction (vph)	0	202	0	0	153	0
Lane Group Flow (vph)	170	65	0	640	889	0
Turn Type		Perm	Perm			
Protected Phases	4			2	6	
Permitted Phases		4	2			
Actuated Green, G (s)	17.0	17.0		45.0	45.0	
Effective Green, g (s)	17.0	17.0		45.0	45.0	
Actuated g/C Ratio	0.24	0.24		0.64	0.64	
Clearance Time (s)	4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)	430	384		1197	2135	
v/s Ratio Prot	c0.10				0.27	
v/s Ratio Perm		0.04		c0.34		
v/c Ratio	0.40	0.17		0.85dl	0.42	
Uniform Delay, d1	22.2	20.9		6.8	6.1	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	2.7	0.9		1.7	0.6	
Delay (s)	24.9	21.9		8.5	6.7	
Level of Service	C	C		A	A	
Approach Delay (s)	23.1			8.5	6.7	
Approach LOS	C			A	A	

Intersection Summary			
HCM Average Control Delay	10.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.50		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	63.5%	ICU Level of Service	B
Analysis Period (min)	15		

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

Lowell Downtown Evolution Plan
AECOM Design + Planning

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HCM Signalized Intersection Capacity Analysis
39: Fr Morrissette & Arcand

2030 AM Peak
Forecast Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	49	367	370	334	284	100	188	189	157	76	121	28
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00			0.95	
Frpb, ped/bikes	1.00	1.00		1.00	0.99		1.00	0.95			0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		0.94	1.00			0.99	
Frt	1.00	0.92		1.00	0.96		1.00	0.93			0.98	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00			0.98	
Satd. Flow (prot)	1770	1723		1770	1777		1668	1657			3337	
Flt Permitted	0.52	1.00		0.12	1.00		0.60	1.00			0.58	
Satd. Flow (perm)	965	1723		219	1777		1047	1657			1977	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	53	399	402	363	309	109	204	205	171	83	132	30
RTOR Reduction (vph)	0	52	0	0	18	0	0	43	0	0	16	0
Lane Group Flow (vph)	53	749	0	363	400	0	204	333	0	0	229	0
Confl. Peds. (#/hr)				5		4	37		37	37		37
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		4		3	8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	30.0	30.0		45.0	45.0		17.0	17.0			17.0	
Effective Green, g (s)	30.0	30.0		45.0	45.0		17.0	17.0			17.0	
Actuated g/C Ratio	0.43	0.43		0.64	0.64		0.24	0.24			0.24	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0			4.0	
Lane Grp Cap (vph)	414	738		385	1142		254	402			480	
v/s Ratio Prot		0.43		c0.15	0.23			c0.20				
v/s Ratio Perm	0.05			c0.46			0.19				0.12	
v/c Ratio	0.13	1.01		0.94	0.35		0.80	0.83			0.48	
Uniform Delay, d1	12.1	20.0		19.7	5.8		24.9	25.1			22.7	
Progression Factor	1.00	1.00		1.00	1.00		0.56	0.48			1.00	
Incremental Delay, d2	0.6	36.9		33.5	0.8		21.5	16.4			3.4	
Delay (s)	12.7	56.9		53.2	6.6		35.4	28.5			26.1	
Level of Service	B	E		D	A		D	C			C	
Approach Delay (s)		54.2			28.3			30.9			26.1	
Approach LOS		D			C			C			C	

Intersection Summary			
HCM Average Control Delay	37.7	HCM Level of Service	D
HCM Volume to Capacity ratio	0.89		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	108.1%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
45: Market & Dutton

2030 AM Peak
Forecast Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	45	373	48	105	105	24	71	554	321	228	836	23
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor		0.95		1.00	1.00			0.95			0.95	
Frt		0.98		1.00	0.97			0.95			1.00	
Flt Protected		1.00		0.95	1.00			1.00			0.99	
Satd. Flow (prot)		3468		1770	1811			3346			3491	
Flt Permitted		0.91		0.32	1.00			0.77			0.57	
Satd. Flow (perm)		3179		602	1811			2603			2008	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	49	405	52	114	114	26	77	602	349	248	909	25
RTOR Reduction (vph)	0	13	0	0	11	0	0	43	0	0	2	0
Lane Group Flow (vph)	0	493	0	114	129	0	0	985	0	0	1180	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)		17.0		17.0	17.0			45.0			45.0	
Effective Green, g (s)		17.0		17.0	17.0			45.0			45.0	
Actuated g/C Ratio		0.24		0.24	0.24			0.64			0.64	
Clearance Time (s)		4.0		4.0	4.0			4.0			4.0	
Lane Grp Cap (vph)		772		146	440			1673			1291	
v/s Ratio Prot					0.07							
v/s Ratio Perm		0.16		c0.19				0.38			c0.59	
v/c Ratio		0.64		0.78	0.29			0.59			0.91	
Uniform Delay, d1		23.7		24.8	21.6			7.2			10.8	
Progression Factor		1.00		1.00	1.00			0.66			0.74	
Incremental Delay, d2		4.0		32.9	1.7			1.3			11.1	
Delay (s)		27.8		57.7	23.3			6.1			19.1	
Level of Service		C		E	C			A			B	
Approach Delay (s)		27.8			38.7			6.1			19.1	
Approach LOS		C			D			A			B	

Intersection Summary			
HCM Average Control Delay	17.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.88		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	91.6%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			

2030 Traffic and Recommended Streets

PM Peak HCM Intersection Capacity Report

HCM Signalized Intersection Capacity Analysis
4: Merrimack & Worthen

2030 PM Peak
Forecast Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	61	154	37	20	466	0	0	0	0	6	67	102
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0			4.0						4.0	
Lane Util. Factor		1.00			1.00						1.00	
Frt		0.98			1.00						0.92	
Flt Protected		0.99			1.00						1.00	
Satd. Flow (prot)		1804			1859						1713	
Flt Permitted		0.84			0.98						1.00	
Satd. Flow (perm)		1528			1829						1713	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	66	167	40	22	507	0	0	0	0	7	73	111
RTOR Reduction (vph)	0	16	0	0	0	0	0	0	0	0	67	0
Lane Group Flow (vph)	0	257	0	0	529	0	0	0	0	0	124	0
Turn Type	Perm			Perm						Perm		
Protected Phases		4			8						6	
Permitted Phases	4			8						6		
Actuated Green, G (s)		16.0			16.0						16.0	
Effective Green, g (s)		16.0			16.0						16.0	
Actuated g/C Ratio		0.40			0.40						0.40	
Clearance Time (s)		4.0			4.0						4.0	
Lane Grp Cap (vph)		611			732						685	
v/s Ratio Prot												
v/s Ratio Perm		0.17			c0.29						0.07	
v/c Ratio		0.42			0.72						0.18	
Uniform Delay, d1		8.7			10.1						7.8	
Progression Factor		1.00			0.64						1.00	
Incremental Delay, d2		2.1			6.0						0.6	
Delay (s)		10.8			12.5						8.3	
Level of Service		B			B						A	
Approach Delay (s)		10.8			12.5			0.0			8.3	
Approach LOS		B			B			A			A	

Intersection Summary			
HCM Average Control Delay	11.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.45		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	54.4%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

HCM Unsignalized Intersection Capacity Analysis
5: Dutton & Worthen

2030 PM Peak
Forecast Volumes and Recommended Geometries

Movement	NBL	NBT	SBT	SBR	NEL	NER
Lane Configurations						
Volume (veh/h)	0	785	389	184	61	0
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	853	423	200	66	0
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (ft)		304	549			
pX, platoon unblocked					0.82	
vC, conflicting volume	623				949	311
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	623				508	311
tC, single (s)	4.1				6.8	6.9
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	100				84	100
cM capacity (veh/h)	954				407	684

Direction, Lane #	NB 1	NB 2	SB 1	SB 2	NE 1
Volume Total	427	427	282	341	66
Volume Left	0	0	0	0	66
Volume Right	0	0	0	200	0
cSH	1700	1700	1700	1700	407
Volume to Capacity	0.25	0.25	0.17	0.20	0.16
Queue Length 95th (ft)	0	0	0	0	14
Control Delay (s)	0.0	0.0	0.0	0.0	15.6
Lane LOS					C
Approach Delay (s)	0.0		0.0		15.6
Approach LOS					C

Intersection Summary			
Average Delay	0.7		
Intersection Capacity Utilization	31.7%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Signalized Intersection Capacity Analysis
9: Broadway & Dutton

2030 PM Peak
Forecast Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	124	35	362	37	49	23	382	949	48	16	691	49
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor		1.00	1.00		1.00		1.00	0.95		1.00	0.95	
Frt		1.00	0.85		0.97		1.00	0.99		1.00	0.99	
Flt Protected		0.96	1.00		0.98		0.95	1.00		0.95	1.00	
Satd. Flow (prot)		1793	1583		1779		1770	3514		1770	3504	
Flt Permitted		0.71	1.00		0.86		0.32	1.00		0.22	1.00	
Satd. Flow (perm)		1323	1583		1557		601	3514		415	3504	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	135	38	393	40	53	25	415	1032	52	17	751	53
RTOR Reduction (vph)	0	0	190	0	14	0	0	5	0	0	7	0
Lane Group Flow (vph)	0	173	203	0	104	0	415	1079	0	17	797	0
Turn Type	Perm		Perm	Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8			2			6		
Actuated Green, G (s)		16.0	16.0		16.0		46.0	46.0		46.0	46.0	
Effective Green, g (s)		16.0	16.0		16.0		46.0	46.0		46.0	46.0	
Actuated g/C Ratio		0.23	0.23		0.23		0.66	0.66		0.66	0.66	
Clearance Time (s)		4.0	4.0		4.0		4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)		302	362		356		395	2309		273	2303	
v/s Ratio Prot								0.31			0.23	
v/s Ratio Perm		c0.13	0.13		0.07		c0.69			0.04		
v/c Ratio		0.57	0.56		0.29		1.05	0.47		0.06	0.35	
Uniform Delay, d1		24.0	23.9		22.3		12.0	5.9		4.3	5.3	
Progression Factor		1.00	1.00		1.00		1.00	1.00		0.82	0.74	
Incremental Delay, d2		7.7	6.2		2.1		59.2	0.7		0.3	0.3	
Delay (s)		31.7	30.1		24.4		71.2	6.6		3.8	4.2	
Level of Service		C	C		C		E	A		A	A	
Approach Delay (s)		30.6			24.4			24.5			4.2	
Approach LOS		C			C			C			A	

Intersection Summary			
HCM Average Control Delay	20.1	HCM Level of Service	C
HCM Volume to Capacity ratio	0.93		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	67.2%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
10: Merrimack & Central

2030 PM Peak
Forecast Volumes and Recommended Geometries

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	0	0	259	387	488	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)			4.0	4.0	4.0	
Lane Util. Factor			1.00	0.95	0.97	
Frt			1.00	1.00	1.00	
Flt Protected			0.95	1.00	0.95	
Satd. Flow (prot)			1770	3539	3433	
Flt Permitted			0.95	1.00	0.95	
Satd. Flow (perm)			1770	3539	3433	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	282	421	530	0
RTOR Reduction (vph)	0	0	0	0	0	0
Lane Group Flow (vph)	0	0	282	421	530	0
Turn Type			Perm			
Protected Phases				8	2	
Permitted Phases			8			
Actuated Green, G (s)			32.0	32.0	30.0	
Effective Green, g (s)			32.0	32.0	30.0	
Actuated g/C Ratio			0.46	0.46	0.43	
Clearance Time (s)			4.0	4.0	4.0	
Lane Grp Cap (vph)			809	1618	1471	
v/s Ratio Prot				0.12	c0.15	
v/s Ratio Perm			c0.16			
v/c Ratio			0.35	0.26	0.36	
Uniform Delay, d1			12.3	11.7	13.5	
Progression Factor			0.71	0.72	1.00	
Incremental Delay, d2			1.1	0.4	0.7	
Delay (s)			9.8	8.8	14.2	
Level of Service			A	A	B	
Approach Delay (s)	0.0			9.2	14.2	
Approach LOS	A			A	B	

Intersection Summary			
HCM Average Control Delay	11.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.35		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	33.2%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
11: Merrimack & Dutton

2030 PM Peak
Forecast Volumes and Recommended Geometries

Movement	EBT	EBR	WBL	WBT	WBR	NBL	NBT	SBL	SBT	SBR
Lane Configurations										
Volume (vph)	9	74	196	232	43	33	781	35	312	2
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0			4.0		4.0	
Lane Util. Factor	0.95	0.95		0.95			0.95		0.95	
Frt	0.88	0.85		0.99			1.00		1.00	
Flt Protected	1.00	1.00		0.98			1.00		1.00	
Satd. Flow (prot)	1562	1504		3419			3532		3519	
Flt Permitted	1.00	1.00		0.82			0.93		0.84	
Satd. Flow (perm)	1562	1504		2851			3289		2980	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	10	80	213	252	47	36	849	38	339	2
RTOR Reduction (vph)	22	26	0	0	0	0	0	0	1	0
Lane Group Flow (vph)	24	18	0	512	0	0	885	0	378	0
Turn Type		Perm	Perm			Perm		Perm		
Protected Phases	4			8			2		6	
Permitted Phases		4	8			2		6		
Actuated Green, G (s)	16.0	16.0		16.0			16.0		16.0	
Effective Green, g (s)	16.0	16.0		16.0			16.0		16.0	
Actuated g/C Ratio	0.40	0.40		0.40			0.40		0.40	
Clearance Time (s)	4.0	4.0		4.0			4.0		4.0	
Lane Grp Cap (vph)	625	602		1140			1316		1192	
v/s Ratio Prot	0.02									
v/s Ratio Perm		0.01		c0.18			c0.27		0.13	
v/c Ratio	0.04	0.03		0.45			0.67		0.32	
Uniform Delay, d1	7.3	7.3		8.8			9.8		8.2	
Progression Factor	0.25	0.20		1.00			1.00		1.00	
Incremental Delay, d2	0.1	0.1		1.3			2.8		0.7	
Delay (s)	1.9	1.5		10.1			12.6		8.9	
Level of Service	A	A		B			B		A	
Approach Delay (s)	1.7			10.1			12.6		8.9	
Approach LOS	A			B			B		A	

Intersection Summary			
HCM Average Control Delay	10.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.56		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	59.8%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis 2030 PM Peak
13: Merrimack & Bridge-Prescott Forecast Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	SBL	SBR	SBR2	NEL2	NEL	NER
Lane Configurations												
Volume (vph)	0	0	0	0	292	243	416	0	300	23	611	170
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)					4.0		4.0		4.0	4.0	4.0	
Lane Util. Factor					0.95		1.00		1.00	1.00	1.00	
Frt					0.93		1.00		0.85	1.00	0.97	
Flt Protected					1.00		0.95		1.00	0.95	0.96	
Satd. Flow (prot)					3298		1770		1583	1770	1734	
Flt Permitted					1.00		0.95		1.00	0.95	0.96	
Satd. Flow (perm)					3298		1770		1583	1770	1734	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	0	317	264	452	0	326	25	664	185
RTOR Reduction (vph)	0	0	0	0	204	0	0	0	61	9	14	0
Lane Group Flow (vph)	0	0	0	0	377	0	452	0	265	16	835	0
Turn Type									Perm	Perm		
Protected Phases					8		6!				2!	
Permitted Phases									6	2		
Actuated Green, G (s)					16.0		46.0		46.0	46.0	46.0	
Effective Green, g (s)					16.0		46.0		46.0	46.0	46.0	
Actuated g/C Ratio					0.23		0.66		0.66	0.66	0.66	
Clearance Time (s)					4.0		4.0		4.0	4.0	4.0	
Lane Grp Cap (vph)					754		1163		1040	1163	1139	
v/s Ratio Prot					c0.11		0.26				c0.48	
v/s Ratio Perm									0.17	0.01		
v/c Ratio					0.50		0.39		0.26	0.01	0.73	
Uniform Delay, d1					23.5		5.5		4.9	4.2	7.9	
Progression Factor					1.00		1.00		1.00	0.49	0.76	
Incremental Delay, d2					2.4		1.0		0.6	0.0	3.1	
Delay (s)					25.9		6.5		5.5	2.1	9.2	
Level of Service					C		A		A	A	A	
Approach Delay (s)		0.0			25.9		6.1				9.0	
Approach LOS		A			C		A				A	

Intersection Summary			
HCM Average Control Delay	12.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	93.1%	ICU Level of Service	F
Analysis Period (min)	15		

! Phase conflict between lane groups.
c Critical Lane Group

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HCM Signalized Intersection Capacity Analysis 2030 PM Peak
15: Market & Worthen Forecast Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)												
Lane Util. Factor												
Frt												
Flt Protected												
Satd. Flow (prot)												
Flt Permitted												
Satd. Flow (perm)												
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	0	0	0	0	0	0	0	0	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Turn Type				Perm								
Protected Phases		4			8							
Permitted Phases				8								
Actuated Green, G (s)												
Effective Green, g (s)												
Actuated g/C Ratio												
Clearance Time (s)												
Lane Grp Cap (vph)												
v/s Ratio Prot												
v/s Ratio Perm												
v/c Ratio												
Uniform Delay, d1												
Progression Factor												
Incremental Delay, d2												
Delay (s)												
Level of Service												
Approach Delay (s)		0.0			0.0			0.0			0.0	
Approach LOS		A			A			A			A	

Intersection Summary			
HCM Average Control Delay	0.0	HCM Level of Service	A
HCM Volume to Capacity ratio	0.00		
Actuated Cycle Length (s)	20.0	Sum of lost time (s)	0.0
Intersection Capacity Utilization	0.0%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

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HCM Signalized Intersection Capacity Analysis
20: Market & Prescott

2030 PM Peak
Forecast Volumes and Recommended Geometries

Movement	EBL2	EBL	EBR	NBL	NBT	NBR	SBL	SBT	SBR	SWL	SWR
Lane Configurations											
Volume (vph)	157	227	755	262	262	620	0	129	129	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0	4.0		4.0			
Lane Util. Factor		1.00	1.00		1.00	1.00		1.00			
Frt		1.00	0.85		1.00	0.85		0.93			
Flt Protected		0.95	1.00		0.98	1.00		1.00			
Satd. Flow (prot)		1770	1583		1817	1583		1737			
Flt Permitted		0.95	1.00		0.68	1.00		1.00			
Satd. Flow (perm)		1770	1583		1260	1583		1737			
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	171	247	821	285	285	674	0	140	140	0	0
RTOR Reduction (vph)	0	0	548	0	0	169	0	51	0	0	0
Lane Group Flow (vph)	0	418	273	0	570	505	0	229	0	0	0
Turn Type	Perm		Perm	Perm		Perm					
Protected Phases		4			2			6			
Permitted Phases	4		4	2		2					
Actuated Green, G (s)		22.0	22.0		40.0	40.0		40.0			
Effective Green, g (s)		22.0	22.0		40.0	40.0		40.0			
Actuated g/C Ratio		0.31	0.31		0.57	0.57		0.57			
Clearance Time (s)		4.0	4.0		4.0	4.0		4.0			
Lane Grp Cap (vph)		556	498		720	905		993			
v/s Ratio Prot								0.13			
v/s Ratio Perm		0.24	0.17		c0.45	0.32					
v/c Ratio		0.75	0.55		0.79	0.56		0.23			
Uniform Delay, d1		21.5	19.9		11.7	9.4		7.4			
Progression Factor		0.82	1.26		1.00	1.00		1.00			
Incremental Delay, d2		8.7	4.1		8.7	2.5		0.5			
Delay (s)		26.5	29.2		20.4	11.9		7.9			
Level of Service		C	C		C	B		A			
Approach Delay (s)		28.3			15.8			7.9		0.0	
Approach LOS		C			B			A		A	

Intersection Summary			
HCM Average Control Delay	20.6	HCM Level of Service	C
HCM Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	74.2%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
22: Market & Palmer

2030 PM Peak
Forecast Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	32	588	0	0	465	12	110	2	110	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0			4.0			4.0				
Lane Util. Factor	1.00	1.00			1.00			1.00				
Frt	1.00	1.00			1.00			0.93				
Flt Protected	0.95	1.00			1.00			0.98				
Satd. Flow (prot)	1770	1863			1856			1696				
Flt Permitted	0.38	1.00			1.00			0.98				
Satd. Flow (perm)	714	1863			1856			1696				
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	35	639	0	0	505	13	120	2	120	0	0	0
RTOR Reduction (vph)	0	0	0	0	1	0	0	50	0	0	0	0
Lane Group Flow (vph)	35	639	0	0	517	0	0	192	0	0	0	0
Turn Type	Perm			Perm			Perm					
Protected Phases		4			8			2				
Permitted Phases	4			8			2					
Actuated Green, G (s)	41.0	41.0			41.0			21.0				
Effective Green, g (s)	41.0	41.0			41.0			21.0				
Actuated g/C Ratio	0.59	0.59			0.59			0.30				
Clearance Time (s)	4.0	4.0			4.0			4.0				
Lane Grp Cap (vph)	418	1091			1087			509				
v/s Ratio Prot		c0.34			0.28							
v/s Ratio Perm	0.05							0.11				
v/c Ratio	0.08	0.59			0.48			0.38				
Uniform Delay, d1	6.3	9.1			8.3			19.3				
Progression Factor	1.00	1.00			0.43			1.00				
Incremental Delay, d2	0.4	2.3			1.3			2.1				
Delay (s)	6.7	11.4			4.9			21.5				
Level of Service	A	B			A			C				
Approach Delay (s)		11.2			4.9			21.5			0.0	
Approach LOS		B			A			C			A	

Intersection Summary			
HCM Average Control Delay	10.6	HCM Level of Service	B
HCM Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	50.6%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis — 2030 PM Peak
34: Bridge &
Forecast Volumes and Recommended Geometries

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	340	255	120	766	443	204
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	0.95	
Flt Protected	0.95	1.00		0.99	1.00	
Satd. Flow (prot)	1770	1583		3515	3372	
Flt Permitted	0.95	1.00		0.75	1.00	
Satd. Flow (perm)	1770	1583		2639	3372	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	370	277	130	833	482	222
RTOR Reduction (vph)	0	186	0	0	77	0
Lane Group Flow (vph)	370	91	0	963	627	0
Turn Type		Perm	Perm			
Protected Phases	4			2	6	
Permitted Phases		4	2			
Actuated Green, G (s)	23.0	23.0		39.0	39.0	
Effective Green, g (s)	23.0	23.0		39.0	39.0	
Actuated g/C Ratio	0.33	0.33		0.56	0.56	
Clearance Time (s)	4.0	4.0		4.0	4.0	
Lane Grp Cap (vph)	582	520		1470	1879	
v/s Ratio Prot	c0.21				0.19	
v/s Ratio Perm		0.06		c0.36		
v/c Ratio	0.64	0.18		0.66	0.33	
Uniform Delay, d1	19.9	16.7		10.8	8.4	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	5.2	0.7		2.3	0.5	
Delay (s)	25.2	17.5		13.1	8.9	
Level of Service	C	B		B	A	
Approach Delay (s)	21.9			13.1	8.9	
Approach LOS	C			B	A	

Intersection Summary			
HCM Average Control Delay	14.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	72.3%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis — 2030 PM Peak
39: Fr Morrissette & Arcand
Forecast Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	31	232	240	196	323	26	444	96	157	31	90	26
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		0.95	
Frt	1.00	0.92		1.00	0.99		1.00	1.00	0.85		0.97	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00		0.99	
Satd. Flow (prot)	1770	1721		1770	1842		1770	1863	1583		3410	
Flt Permitted	0.54	1.00		0.17	1.00		0.65	1.00	1.00		0.90	
Satd. Flow (perm)	1000	1721		310	1842		1212	1863	1583		3091	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	34	252	261	213	351	28	483	104	171	34	98	28
RTOR Reduction (vph)	0	54	0	0	4	0	0	0	93	0	15	0
Lane Group Flow (vph)	34	459	0	213	375	0	483	104	78	0	145	0
Turn Type	Perm			pm+pt			Perm		Perm	Perm		
Protected Phases		4		3	8			2			6	
Permitted Phases	4			8			2		2	6		
Actuated Green, G (s)	20.0	20.0		30.0	30.0		32.0	32.0	32.0		32.0	
Effective Green, g (s)	20.0	20.0		30.0	30.0		32.0	32.0	32.0		32.0	
Actuated g/C Ratio	0.29	0.29		0.43	0.43		0.46	0.46	0.46		0.46	
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0		4.0	
Lane Grp Cap (vph)	286	492		258	789		554	852	724		1413	
v/s Ratio Prot		c0.27		c0.07	0.20			0.06				
v/s Ratio Perm	0.03			0.28			c0.40		0.05		0.05	
v/c Ratio	0.12	0.93		0.83	0.48		0.87	0.12	0.11		0.10	
Uniform Delay, d1	18.5	24.4		16.2	14.4		17.1	10.9	10.8		10.8	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00		1.00	
Incremental Delay, d2	0.8	27.0		25.0	2.0		17.1	0.3	0.3		0.1	
Delay (s)	19.3	51.4		41.2	16.4		34.2	11.2	11.2		11.0	
Level of Service	B	D		D	B		C	B	B		B	
Approach Delay (s)		49.4			25.3			25.9			11.0	
Approach LOS		D			C			C			B	

Intersection Summary			
HCM Average Control Delay	30.8	HCM Level of Service	C
HCM Volume to Capacity ratio	0.89		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	79.0%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
45: Market & Dutton

2030 PM Peak
Forecast Volumes and Recommended Geometries

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	27	268	45	110	110	24	154	702	209	155	691	33
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00			0.95			0.95	
Frt	1.00	0.98		1.00	0.97			0.97			0.99	
Flt Protected	0.95	1.00		0.95	1.00			0.99			0.99	
Satd. Flow (prot)	1770	1822		1770	1813			3410			3489	
Flt Permitted	0.65	1.00		0.33	1.00			0.64			0.58	
Satd. Flow (perm)	1204	1822		607	1813			2208			2026	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	29	291	49	120	120	26	167	763	227	168	751	36
RTOR Reduction (vph)	0	9	0	0	11	0	0	30	0	0	4	0
Lane Group Flow (vph)	29	331	0	120	135	0	0	1127	0	0	951	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	19.0	19.0		19.0	19.0			43.0			43.0	
Effective Green, g (s)	19.0	19.0		19.0	19.0			43.0			43.0	
Actuated g/C Ratio	0.27	0.27		0.27	0.27			0.61			0.61	
Clearance Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Lane Grp Cap (vph)	327	495		165	492			1356			1245	
v/s Ratio Prot		0.18			0.07							
v/s Ratio Perm	0.02			c0.20				c0.51			0.47	
v/c Ratio	0.09	0.67		0.73	0.27			0.83			0.76	
Uniform Delay, d1	19.0	22.7		23.1	20.1			10.6			9.8	
Progression Factor	1.00	1.00		1.00	1.00			0.68			1.00	
Incremental Delay, d2	0.5	7.0		24.3	1.4			5.4			4.5	
Delay (s)	19.6	29.7		47.4	21.5			12.7			14.3	
Level of Service	B	C		D	C			B			B	
Approach Delay (s)		28.9			33.2			12.7			14.3	
Approach LOS		C			C			B			B	

Intersection Summary			
HCM Average Control Delay	17.4	HCM Level of Service	B
HCM Volume to Capacity ratio	0.80		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	91.5%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

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