4 SELECTED TRANSPORTATION ISSUES: ANALYSES AND PROPOSED IMPROVEMENTS

The study's advisory committee discussed a wide range of transportation issues and concerns, including traffic congestion at Riley Plaza and other major intersections, pedestrian crossings on Washington Street, pedestrian access to the commuter rail station, parking demand and management, lack of clear signs for motorists and pedestrians, and other issues (see Section 2.5). The committee selected the following issues to be examined in detail by this study (the selection is based on consideration of the work program of this study and on potential for near-term benefits):

- Riley Plaza traffic circulation
- Other congested intersections
- Pedestrian circulation on Washington Street
- Pedestrian access to the commuter rail station

The following sections present descriptions and analyses of the selected transportation issues, and proposed improvements.

4.1 Riley Plaza Traffic Circulation

Riley Plaza is a key location in downtown Salem where a number of major roadways meet. The area is encircled by Washington Street, Norman Street, Margin Street, and Mill Street, which once formed a large traffic rotary with counterclockwise traffic rotation and no control. In 1995–1996, the rotary was reconstructed to allow two-way traffic flow (except on Margin Street), and traffic signals were installed at the intersections of Washington Street at Norman/New Derby Street and at Canal Street/Mill Street. Figure 4-1 is an aerial view of the area.

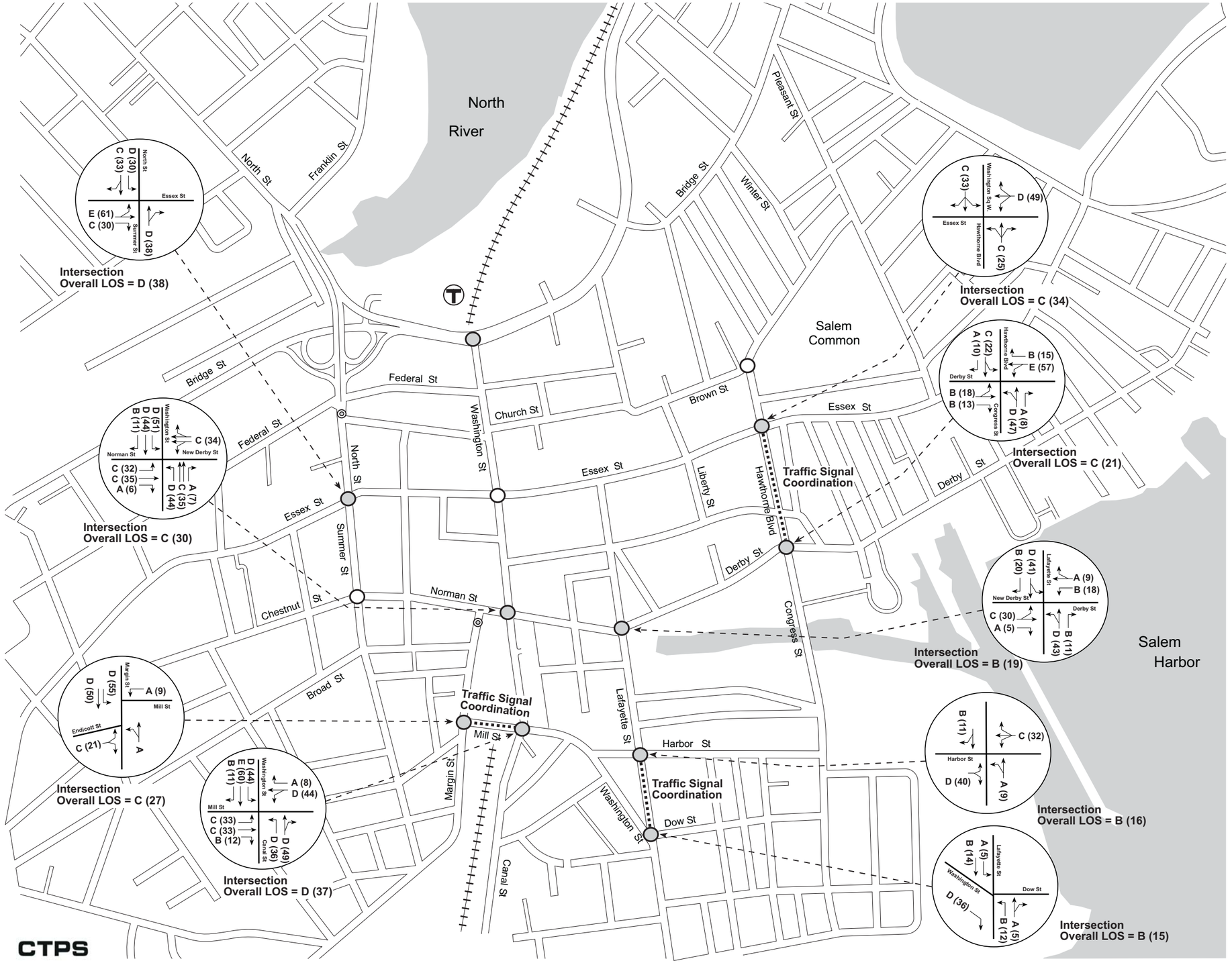
Traffic is highly congested during the morning and evening peak periods; the congestion is generally more extensive in the evening than in the morning. The evening peak period sometimes starts as early as 2:30 PM, when the nearby schools start to release students.

In addition to heavy traffic, pedestrian movement is extensive, as the area is surrounded by commercial and high-density residential developments. These developments include the post office, a convenience store on Margin Street, a Dunkin' Donuts on Norman Street, a bank on New Derby Street, and a number of stores with store-front parking on the east side of Washington Street.

Four major intersections in the area are located close to each other, with traffic conditions highly affecting one another. Analyses of traffic operations and proposed improvements for each of the intersections are discussed below. Figures 4-2 and 4-3 show the AM and PM peak hour intersection capacity analyses for the intersections in Riley Plaza (and other major intersections in the downtown area) with the proposed improvements in place, under future

Figure 4-1 Riley Plaza

Figure 4-2
Future-Year (2010) AM Peak Hour Intersection Capacity Analysis for Selected Intersections with Proposed Improvements



Legend

- Signalized Intersection
- Unsignalized Intersection
- Traffic Signal for Pedestrian Crossing
- Traffic Signal Coordination
- B (12) / E (63) Level of Service (Delay per Veh.)
- F (*) Delay per Vehicle > 120 Sec.

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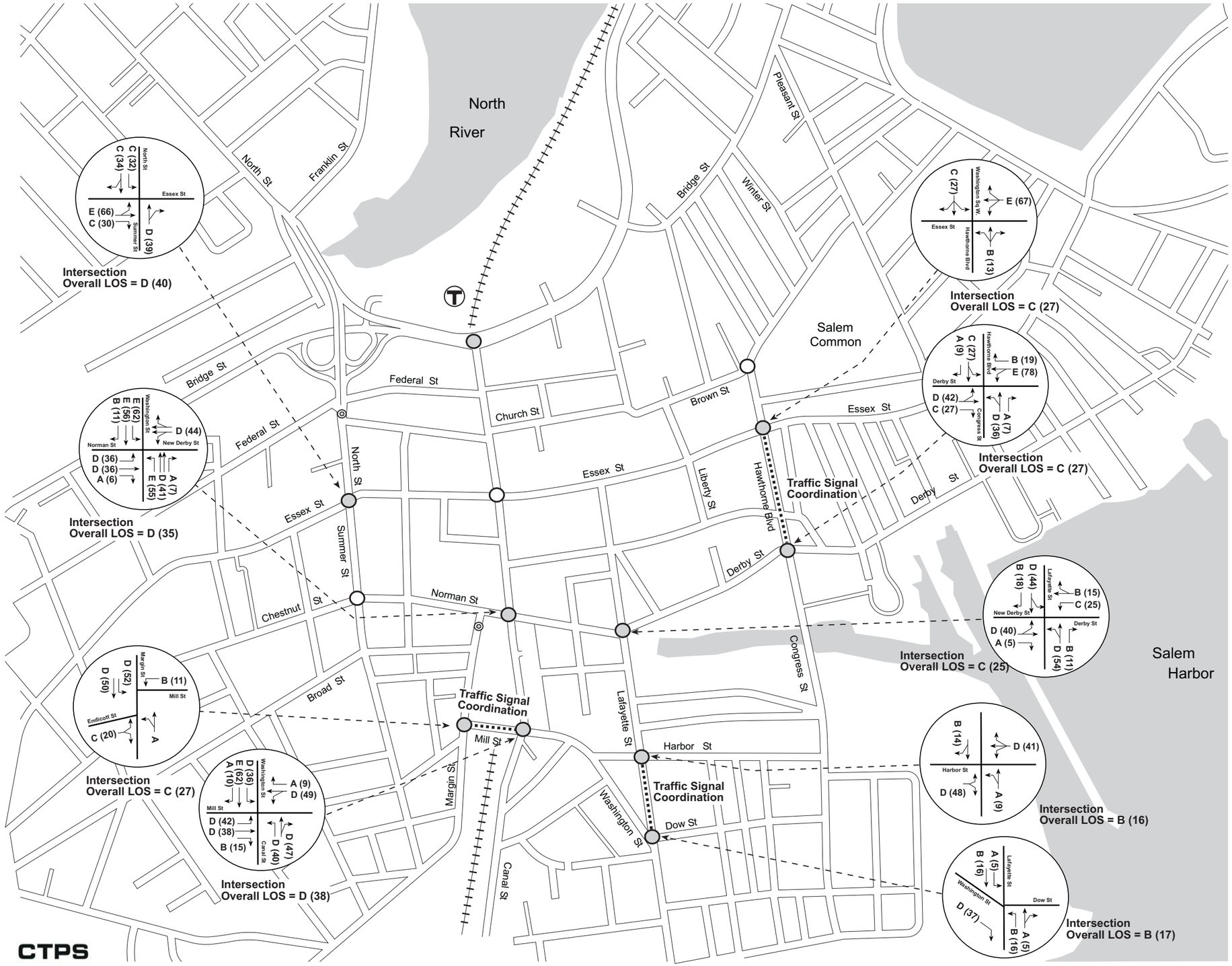
Figure 4-3
Future-Year (2010) PM Peak Hour Intersection Capacity Analysis for Selected Intersections with Proposed Improvements



Legend

- Signalized Intersection
- Unsignalized Intersection
- Traffic Signal for Pedestrian Crossing
- Traffic Signal Coordination
- B (12) / E (63) Level of Service (Delay per Veh.)
- F (*) Delay per Vehicle > 120 Sec.

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traffic conditions. Appendix D presents detailed capacity analysis results for these intersections and other major intersections with improvements proposed by this study.

4.1.1 Washington Street at Norman/New Derby Street

This intersection, located near the center of downtown Salem, is one of the busiest intersections in the city. Washington Street, running in the north/south direction, is a major arterial that goes through the downtown area, connecting Route 107 (Bridge Street) in the north and Route 1A (Lafayette Street) in the south. Norman Street, located on the west side of the intersection, is a part of Route 114, which is a route to Peabody and the northwest. New Derby Street, located on the east side of the intersection, connects to Route 1A (Derby Street), which is a route to Beverly and the north.

The intersection is signalized, and all possible movements are allowed. Exclusive lanes are provided for the left-turn, through, and right-turn movements on the northbound, southbound, and eastbound approaches. The westbound approach contains a shared left-turn/through lane and a shared right-turn/through lane. Crosswalks are installed on all four approaches, and an exclusive pedestrian phase is provided to stop traffic for pedestrian crossings.

During peak periods, the intersection is frequently blocked by traffic extending from the downstream intersections or from congestion on the downstream roadway sections. The most frequent occurrence is the spillover of traffic on Norman Street from Margin Street to this intersection, because the short section of Norman Street is frequently filled with vehicles waiting to turn left onto Margin Street. The westbound traffic leaving this intersection is thus seriously impeded. The situation is further discussed in the next section.

The intersection is also sometimes blocked by traffic extending from congestion on Washington Street north of the intersection, which mainly occurs in the PM peak period, when pedestrian crossings at Essex Street are high in volume. There is also a reduction of travel lanes from two to one on Washington Street about 150 feet past the intersection. Vehicles unprepared for the lane reduction often enter the intersection without waiting for the traffic ahead to dissipate, and they block the intersection. From time to time, the intersection is blocked by traffic congestion on New Derby Street just past the intersection, where vehicles are illegally parked near the bank and impede the eastbound traffic movement.

The intersection capacity analysis estimates that the intersection operates at acceptable level of service (LOS) C in both the AM and PM peak hours under the existing traffic conditions (see Figures 2-7 and 2-8, and Appendix B), and at LOS C in the AM peak hour and LOS D in the PM peak hour under the future traffic conditions (see Figures 3-4 and 3-5, and Appendix C). The current settings of signal phasing and timing for this intersection are considered appropriate, and no adjustments of signal settings are proposed at this moment.

To reduce the intersection blockages, a few short-term improvements are proposed:

- Enforce the "Do Not Block Intersection" rule. Recently the City placed "Do Not Block Intersection" signs temporarily at the stop lines of all the approaches. These signs should

be raised to eye level and made permanent at appropriate locations. If the situation still is not improved, strong police enforcement should be considered. The enforcement can follow one or two months of warning period.

- Enforce the parking prohibition on New Derby Street along the curb outside the bank.
- Install the "Lane Ends" (W4-2) warning sign (see Figure 4-4) at the northeast corner of the intersection to alert drivers.

Figure 4-4 "Lane Ends" Warning Sign (W4-2)

Source: Section 2C.33, *Manual on Uniform Traffic Control Devices*, 2003 Edition

4.1.2 Norman Street at Margin Street

This is a three-way intersection with no traffic controls. Norman Street, running in the east/west direction, is the major street. Margin Street, running from the intersection to the south, is the minor street that carries one-way southbound traffic leaving the intersection. A driveway from the adjacent Dunkin' Donuts is located on the north of the intersection. On the southwest corner of the intersection is a historical building currently used by the U.S. Post Office.

The intersection has a crosswalk on Norman Street crossing the eastbound approach. Just south of the intersection, a crosswalk with a traffic signal for pedestrian crossings is located on Margin Street in front of the post office. On average, there are about 50 to 100 pedestrian crossings of Norman Street and about 20 crossings of Margin Street per peak hour. Parking in front of the post office on the west side of Margin Street is provided from the intersection all the way to the intersection at the next street (Gedney Street).

During peak periods, traffic is somewhat disordered at this intersection. The intersection is located just about 100 feet west of the intersection of Washington Street at Norman/New Derby Street. The section of Norman Street between the two intersections is short and can accommodate only about two to three vehicles in each lane. Although the section has two lanes on the westbound approach, vehicles that cannot move into the occupied inside lane frequently block the entire westbound traffic movement. At the intersection with Margin Street, there are generally 250 to 300 westbound left-turn vehicles per peak hour. Many of these vehicles have difficulty in turning left onto Margin Street due to the blockage by

vehicles traveling on Norman Street eastbound that enter the intersection without waiting for the clearance of vehicles queuing at the downstream intersection. There are two "Do Not Block Intersection" signs hung on a master arm for the eastbound traffic, but the intersection is still frequently blocked. It is essential to clear the blockage because the congestion at this intersection usually spills into the intersection of Washington Street at Norman/New Derby Street and causes still more congestion.

Meanwhile, the eastbound approach of Norman Street (Route 114) is usually congested during peak periods. The approach accommodates one travel lane and on-street parking. About 150 feet from the intersection, just past the post office's driveway, on-street parking is prohibited, except for one handicapped parking space. Past the parking space, an additional lane is designated for right-turn-only traffic. With the handicapped parking space, the length of the right-turn lane is reduced to only about 120 feet. According to the police department, the handicapped parking space is actually for an employee of the post office, not for the general public, which can use the handicapped space in front of the post office.

To improve traffic operations and pedestrian safety at this intersection, three short-term improvements are proposed (see Figure 4-5):

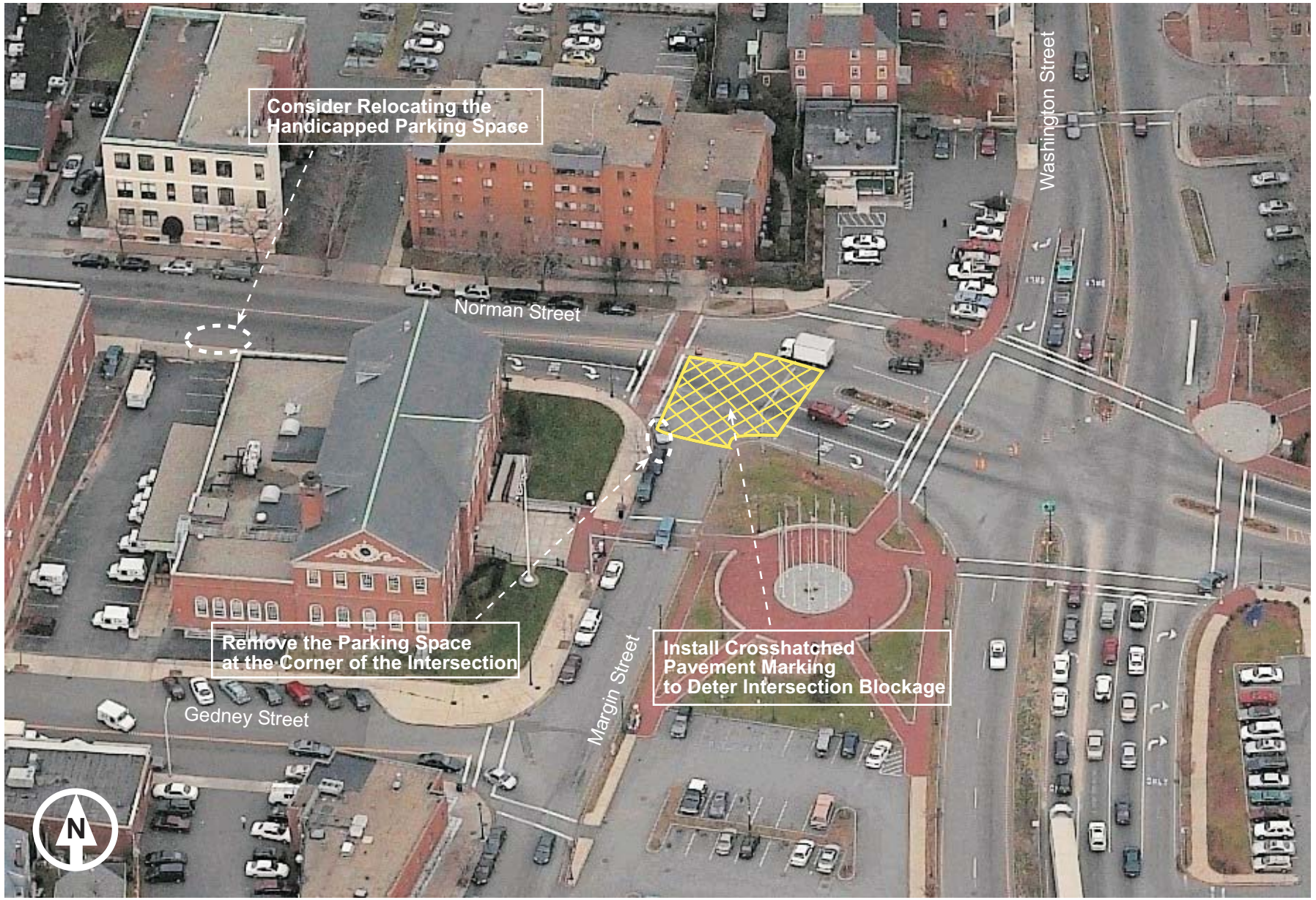
- Install crosshatched pavement marking at the intersection to deter the eastbound traffic from blocking the intersection. As described above, the clearance of blockage at this intersection is essential, as the congestion can seriously affect traffic operations at the intersection of Washington Street at Norman/New Derby Street.
- Remove the existing on-street parking space on Margin Street nearest to the intersection to preserve the intersection's functional area and to enhance the safety of crossing pedestrians. This action will not only increase operational space for vehicles entering Margin Street, but also improve the ability of the drivers of eastbound right-turning vehicles to see pedestrians on the crosswalk in front of the post office.
- Consider removing the handicapped parking space if an equally convenient space can be provided on Gedney Street or in the post office's parking lot.

4.1.3 Washington Street at Canal Street/Mill Street

This intersection is located about 500 feet south of the intersection of Washington Street at Norman/New Derby Street. Washington Street (Route 114) comes into the intersection from the north and leaves the intersection to the east. Canal Street is a major arterial that connects to Salem State College in the south. Mill Street is a short section of roadway that connects to Margin Street in the west.

The intersection is highly congested during peak periods. The congestion is due to heavy traffic and intersection geometry deficiencies. The northbound approach contains only two lanes: an inside lane shared by left-turn and through movements and an outside lane (a flared area near the intersection less than 150 feet in length) shared by through and right-turn movements. The intersection is tight and the northbound lanes are slanted to the east due to surrounding developments. Therefore, the northbound left-turn and the southbound left-turn traffic flows are in each other's path and sometimes interlocked at the middle of the intersection. This and the lack of an exclusive signal phase for the northbound left-turn traffic

Figure 4-5 Proposed Intersection Improvements:
Norman Street at Margin Street



result in extensive backups of northbound traffic during peak periods. Also happening frequently is blockage of the intersection by northbound left-turn vehicles that enter the intersection without waiting for sufficient space to become available on Mill Street. During peak periods, the entire westbound section of Mill Street is frequently filled up with traffic stopped by congestion at the downstream intersection at Margin Street.

On the southbound and eastbound approaches of the intersection, exclusive lanes are provided for the left-turn, through, and right-turn movements. Both approaches operate without excessive delays. The eastbound approach is short and traffic sometimes extends to Margin Street. The westbound approach contains a shared left-turn/through lane and an exclusive right-turn lane. From time to time, illegal parking on the north side of Washington Street near Pond Street blocks the right-turn traffic and increases traffic congestion on Washington Street. Strong enforcement of parking prohibitions should be imposed on both sides of Washington Street from the intersection to Pond Street.

The 1997–2001 crash data show that this intersection has the highest number of crashes in downtown Salem (see Table 2-2). The capacity analysis indicates that the northbound approach is expected to operate at LOS F during both the AM and PM peak hours in 2010 under the existing operation (see Figures 3-4 and 3-5).

In order to reduce traffic conflicts and delay at the intersection, it is essential to reconfigure the intersection geometry and to coordinate the traffic signal of this intersection with a proposed future traffic signal at the intersection of Mill Street at Margin Street. The reconfiguration of the intersection includes the following elements (see Figure 4-6):

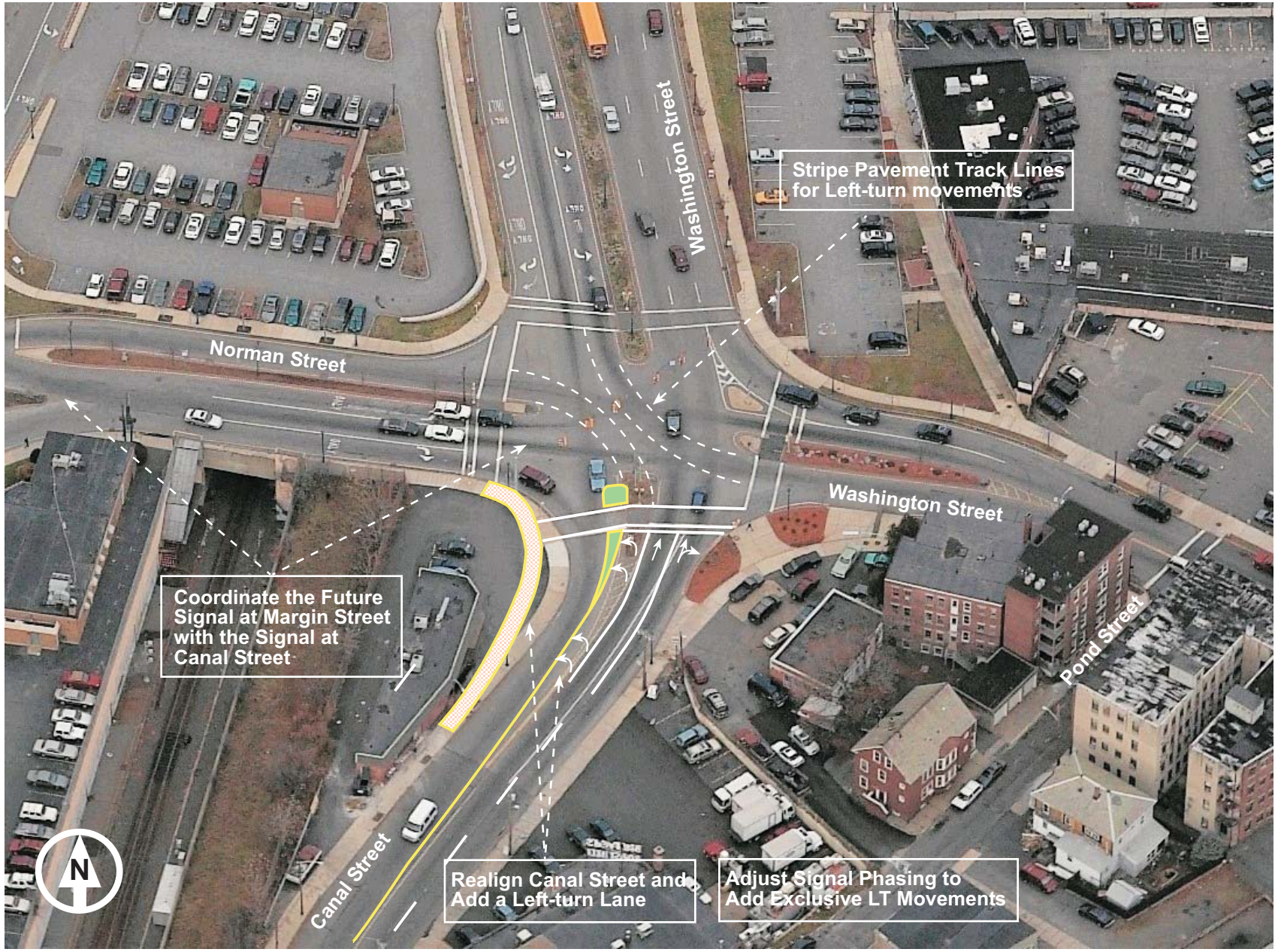
- Realign Canal Street (with minor land taking on the southwest corner of the intersection) and add an exclusive left-turn lane on the northbound approach. The realignment will also increase slightly the space on Canal Street southbound for vehicles coming from Mill Street and reduce conflicts with the vehicles from Washington Street southbound.
- Adjust signal phasing to accommodate the northbound left-turn movement.
- Stripe pavement track lines to guide the northbound and southbound left-turn traffic.
- Coordinate the future traffic signal at the intersection of Margin Street at Mill Street with the signal at this intersection. The coordination will expedite traffic movement on Mill Street and reduce traffic congestion at this intersection. The coordination is discussed further in the next two sections.

With the proposed improvements, the intersection is expected to operate at LOS D with decreased delays in both the AM and PM peak hours under future traffic conditions (see Figures 4-2 and 4-3, and Appendix D).

4.1.4 Margin Street at Mill Street

This T intersection is located at the southwest corner of Riley Plaza, about 200 feet west of the intersection of Washington Street at Canal Street/Mill Street. Margin Street, running in the north/south direction, is a major collector that connects the southwest Salem area and the downtown area. The section of Margin Street north of the intersection is a southbound-only

Figure 4-6 Proposed Intersection Reconfiguration:
Washington Street at Canal Street/Mill Street



roadway. Mill Street, located on the east side of the intersection, is a short roadway that connects Margin Street and Washington Street (Route 114).

The intersection is currently operated under stop control on the westbound approach, no control on the southbound approach, and yield control on the right-turn-only northbound approach. During peak periods, the southbound traffic is heavy and the stop-controlled westbound traffic frequently fills up the entire length of Mill Street. This congestion consequently affects traffic operations at the nearby upstream intersection at Washington Street. The intersection capacity analyses show that the westbound approach experiences intensive traffic delay of over two minutes per vehicle in both the AM and PM peak hours (see Figures 2-7 and 2-8).

A preliminary analysis of traffic signal warrants[1] indicates that the signalization of this intersection is justified (see Table 4-1). It is suggested that this intersection be signalized and be coordinated with the upstream Washington Street intersection. The signalization will reduce traffic congestion on the westbound approach, and the coordination will reduce traffic delays at the intersection of Washington Street at Canal Street/Mill Street. With the improvements, the capacity analyses indicate that the intersection is expected to operate at LOS C in both the AM and PM peak hours under the future traffic conditions (see Figures 4-2 and 4-3).

Table 4-1 Signal Warrant Analysis:
Margin Street at Mill Street

Warrant	Status
1. Eight-Hour Vehicular Volume	Not Available
2. Four-Hour Vehicular Volume	Met
3. Peak Hour Vehicular Volume	Met
4. Pedestrian Volume	Not Met
5. School Crossing	Not Applicable
6. Coordinated Signal System	Met
7. Crash Experience	Not Met
8. Roadway Network	Not Applicable

4.1.5 Coordination of Traffic Signals on Mill Street

As mentioned in the previous two sections, the two intersections on Mill Street should be coordinated, as they are located close together. Coordination will expedite traffic flow on Mill Street westbound and consequently improve traffic flow at the Washington Street intersection, which is usually seriously congested during peak periods.

The proposed scheme is to optimize the Mill Street westbound movement based on the inflow from Washington Street westbound and from the Canal Street northbound left-turn movement.

[1] Section 2C.33, *Manual on Uniform Traffic Control Devices*, 2003 Edition.

This can be achieved by synchronizing the Mill Street westbound green phase with the Washington Street westbound green phase, which is followed by the Canal Street northbound left-turn green phase in the proposed phasing sequence for the Washington Street intersection (see Appendix D). This arrangement gives priority to the Mill Street westbound approach; traffic simulations for the future conditions show that generally the Mill Street eastbound traffic moves well and the Margin Street southbound left-turn traffic is rarely affected by traffic build-up on Mill Street eastbound.

In the AM or PM peak hour, on Mill Street westbound only about 30 to 70 vehicles are from Washington Street southbound. In order to avoid the congestion on Mill Street, some vehicles destined for the southwest Salem area from Washington Street north of Riley Plaza choose to turn right at Norman Street and then turn left onto Margin Street. With the improvements at the two Mill Street intersections, some of these vehicles may choose Mill Street as a better alternative to connect to Margin Street southbound. This in turn may reduce the left-turn traffic at the intersection of Norman Street at Margin Street and improve traffic movement on the short section of Norman Street westbound.

Figure 4-7 highlights the proposed improvements for the Riley Plaza area. These improvements are expected to reduce traffic congestion at the intersection of Washington Street at Canal Street, to reduce traffic blockages at the intersection of Norman Street at Margin Street and at the intersection of Washington Street at Norman/New Derby Street, and to expedite traffic movements on Norman Street and on Mill Street. Thus, the traffic circulation at Riley Plaza will be much improved.

4.2 Other Congested Intersections

In addition to the Riley Plaza vicinity, several intersections elsewhere in the downtown area are usually congested during peak periods. The analyses and proposed improvements for each of these intersections are summarized in the following sections.

4.2.1 Essex Street at North/Summer Street

This intersection is currently signalized. North/Summer Street, running in the north/south direction, is a part of Route 114 that carries heavy traffic in both directions during peak periods. Essex Street, running in the east/west direction, is a major arterial that connects Highland Avenue (Route 107) and the downtown area. Its eastbound approach also carries heavy traffic during peak periods. Essex Street east of the intersection is one-way eastbound. At the intersection, left turns from Summer Street northbound to Essex Street are prohibited.

In addition to heavy traffic, there are usually more than 50 pedestrians crossing North/Summer Street per peak hour. The existing signal phasing sequence consists of a leading southbound left-turn and through phase, a southbound/northbound through phase, an eastbound phase, and an exclusive pedestrian phase (see Figure 4-8). Because the exclusive pedestrian phase does not come up right after the northbound/southbound phase ends, pedestrians who want to cross North/Summer Street frequently walk into the intersection without waiting for the pedestrian phase once they see the traffic stop. As a result, the eastbound left-turn vehicles usually have to yield to the pedestrians and endure delays; and when the pedestrian phase comes up, traffic

Figure 4-7 Proposed Improvements for Riley Plaza

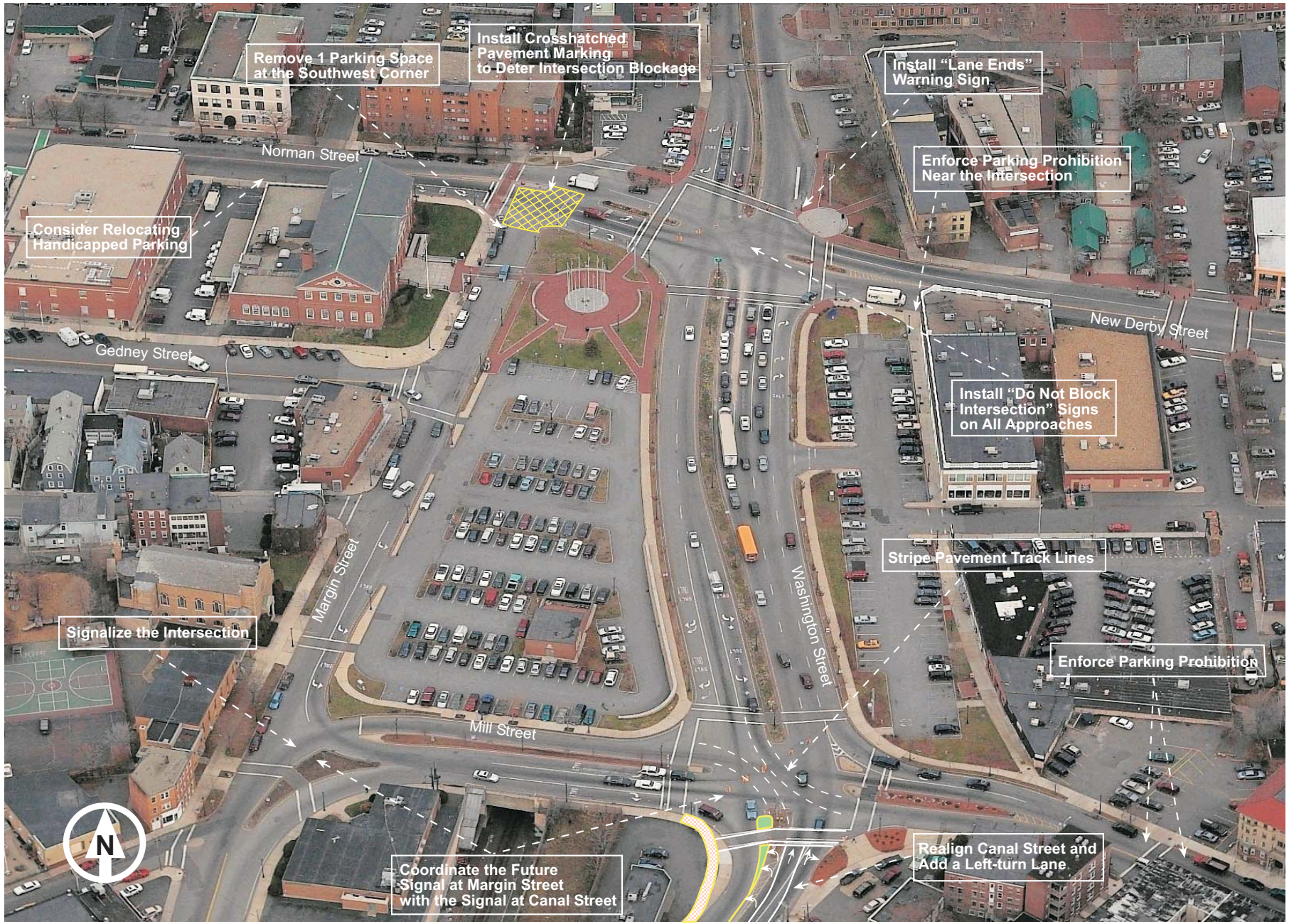
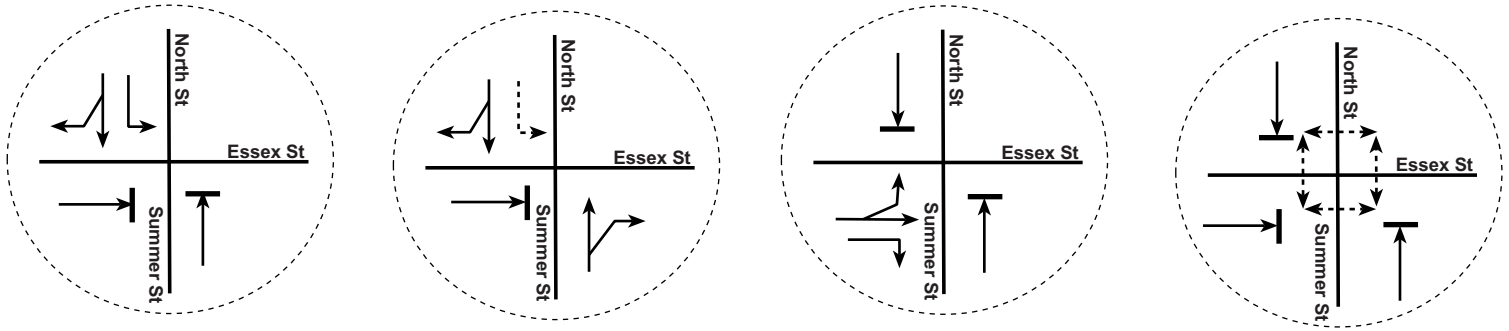


Figure 4-8 Existing and Proposed Phasing Sequences:
Essex Street at North/Summer Street



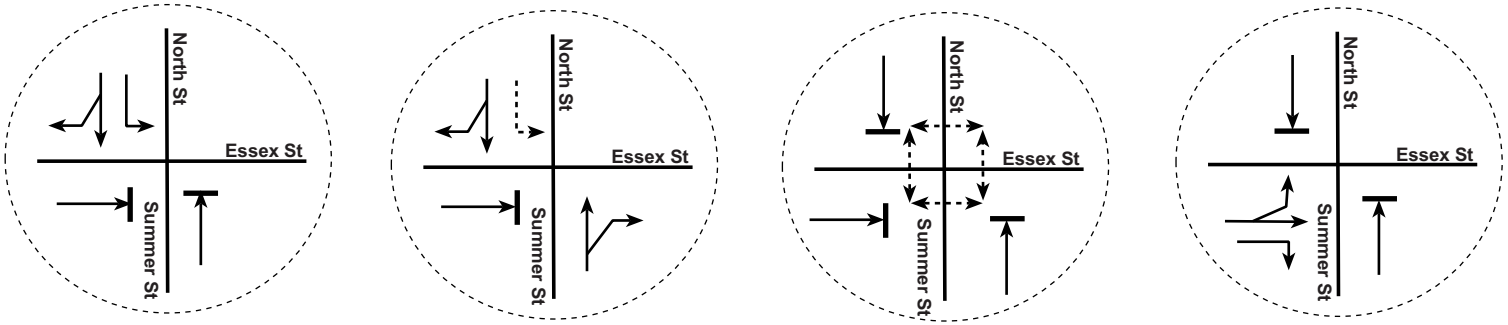
Phase 1
SB LT + SB Th
(North Street)

Phase 2
SB Th + NB Th
(North/Summer Street)

Phase 3
EB LT + EB Th
(Essex Street)

Phase 4
Pedestrian Exclusive

Existing Signal Phasing Sequence



Phase 1
SB LT + SB Th
(North Street)

Phase 2
SB Th + NB Th
(North/Essex Street)

Phase 3
Pedestrian Exclusive

Phase 4
EB LT + EB Th
(Essex Street)

Proposed Signal Phasing Sequence

from all approaches waits while no one crosses the streets. It is suggested that the phasing sequence be rearranged by switching the eastbound traffic phase and the exclusive pedestrian phase (see Figure 4-8).

There is no room for the intersection to expand for a major capacity increase. The intersection's operation can be somewhat improved by two simple signal phasing and timing adjustments:

- Rearrange the signal phasing sequence so that the exclusive pedestrian phase is placed immediately after the northbound/southbound phase and before the eastbound phase. The adjustment will not only expedite traffic flow for the eastbound traffic, but also improve pedestrian safety by reducing the conflict between pedestrians crossing North Street and the eastbound left-turn traffic.
- Relocate four seconds of green time from the southbound left-turn/through phase to the southbound/northbound through phase. As the capacity analysis shows that the southbound left-turn capacity is underutilized, this adjustment will slightly increase the northbound capacity and reduce the overall intersection traffic delay.

4.2.2 Derby Street at Congress Street/Hawthorne Boulevard

This intersection is currently under four-way stop control. It was under three-way stop control, with free traffic movement allowed on the westbound approach, until late 2004. The intersection is a major gateway to Salem's historical harbor area. A city-owned parking garage is located at the southwest corner of the intersection. A newly built hotel, along with many existing restaurants and shops, is located in the area west of the intersection. An office park that accommodates over 1,000 employees is located on Congress Street about 1,000 feet south of the intersection. Derby Street and Hawthorne Boulevard, which are Route 1A, carry heavy traffic during the AM and PM peak hours.

Traffic is congested on the westbound and southbound approaches during peak periods. In the PM peak period, the northbound traffic is also congested. The westbound traffic is especially congested due to the congestion on Hawthorne Boulevard northbound between Derby Street and Essex Street. In addition to heavy traffic, there are about 50 pedestrian crossings at the intersection per peak hour. Pedestrian crossings are much higher than this number during high tourism season.

The intersection capacity analyses indicate that traffic at the intersection currently operates at an unacceptable level of service for all the approaches except the westbound approach (see Figures 2-7 and 2-8). The 1997–2001 crash data show that this intersection has a high crash rate, with a few pedestrian-related crashes (see Table 2-2).

At the request of the study's advisory committee, CTPS conducted a comprehensive signal warrants analysis for this intersection. A preliminary analysis of the available traffic counts indicated that the four-hour vehicular volume warrant and the peak hour warrant are satisfied. To further examine signal warrants, CTPS collected recent traffic counts covering eight hours of an average day in January 2005. The data indicated that the eight-hour vehicular volume warrant is satisfied (see Table 4-2). In addition, CTPS collected the preceding three years'

crash reports for the intersection from the Salem police department and performed a detailed analysis of the reports. Table 4-3 summarizes the crash data by collision type, severity, time of day, week of day, and pavement, light, and weather conditions. On average, over five crashes happened each of the last three years. Figure 4-9 is a collision diagram that summarizes crash patterns at the intersection. The diagram shows a wide range of different types of crashes, which indicates drivers might be somewhat confused and stressed under heavy traffic conditions. As summarized in Table 4-2, the above analyses indicate that four signal warrants are satisfied and the installation of a traffic signal is justified.

Table 4-2 Signal Warrant Analysis:
Derby Street at Congress Street/Hawthorne Boulevard

Warrant	Status
1. Eight-Hour Vehicular Volume	Met
2. Four-Hour Vehicular Volume	Met
3. Peak Hour Vehicular Volume	Met
4. Pedestrian Volume	Not Met
5. School Crossing	Not Applicable
6. Coordinated Signal System	Not Applicable
7. Crash Experience	Met
8. Roadway Network	Not Applicable

A review of the future signal settings with the existing intersection geometry indicates that no modification of the intersection layout is required. An exclusive northbound right-turn lane at the intersection can be created by removing two on-street parking spaces on the east side of Congress Street. The future-year capacity analysis shows that the signalized intersection would operate at acceptable levels of service in both the AM and PM peak hours (see Figures 4-2 and 4-3). It is suggested that the future traffic signal at this intersection be coordinated with the existing traffic signal at the intersection of Essex Street at Hawthorne Boulevard/Washington Square West in order to reduce traffic congestion on Hawthorne Boulevard and consequently reduce traffic congestion at this intersection.

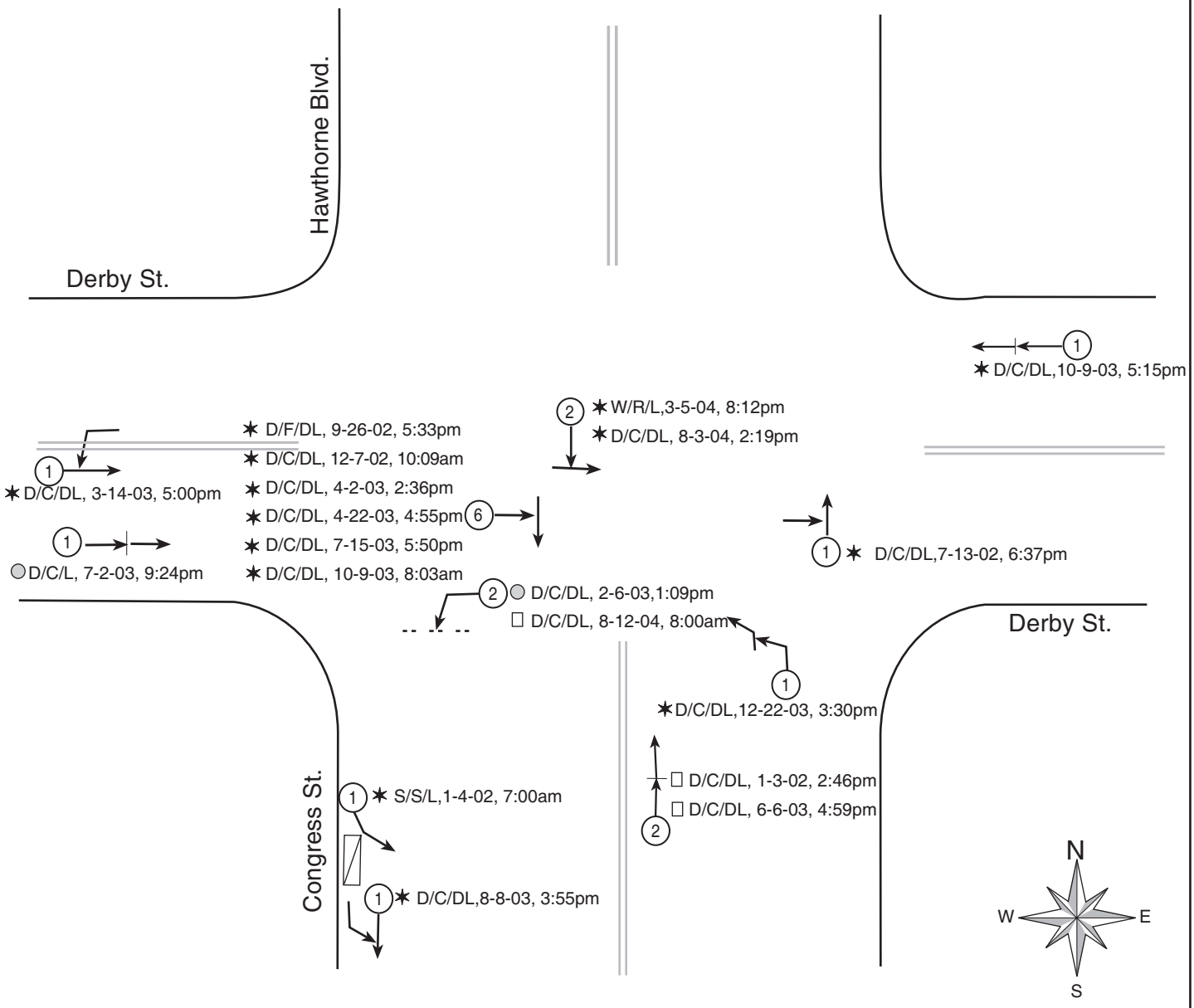
In sum, signalization of this intersection would not only reduce traffic delays but also improve pedestrian safety at this intersection. The proposed improvements for this intersection (see Figure 4-10) are summarized below.

- Install a traffic signal at this intersection. The traffic signal can be operated under a phasing plan that consists of a northbound/southbound phase, a leading westbound left-turn phase, a westbound/eastbound phase, and an exclusive pedestrian phase.
- Remove two on-street parking spaces on Congress Street for the making of an exclusive northbound right-turn lane at the intersection.

Table 4-3 Summary of Crash Data:
Derby Street at Congress Street/Hawthorne Boulevard
(1/1/2002 to 12/31/2004)

Year		2002	2003	2004
Collision Type	Rear End	1	3	
	Head On			
	Angle	3	4	
	Guardrail			
	Broadside	3	4	3
	Pedestrian		1	2
	Unknown	1	2	
	Total	8	14	5
Severity	Property Damage	7	10	3
	Personal Injury		1	
	Fatality			
	None	1	3	2
Time of Day	7:00-9:00 AM	1	1	1
	4:00-6:00 PM	3	7	1
	Other	4	6	3
Day of Week	Mon-Fri	6	14	4
	Sat-Sun	2		1
Pavement Conditions	Dry	5	8	3
	Wet			1
	Ice/Snow	1		
	Unknown	2	6	1
Light Conditions	Daylight	5	7	3
	Dawn or Dusk	3		
	Dark, No lights			
	Dark, Lighted		1	2
	Unknown		6	
Weather Conditions	Clear	4	8	3
	Foggy/Cloudy	1		
	Rain			1
	Snow/Sleet	1		
	Other/Unknown	2	6	1

Figure 4-9 Collision Diagram:
Derby Street at Congress Street/Hawthorne Boulevard
(1/1/2002 to 12/31/2004)



SYMBOLS		PAVEMENT/WEATHER/LIGHTING		TYPES OF COLLISIONS	
←	Moving Vehicle	D	Dry	→ ←	Head On
←≈	Backing Vehicle	W	Wet	↙	Angle
-- -- --	Pedestrian/Bicycle	S	Snowy, Icy	← ←	Rear End
▨	Parked Vehicle	C	Clear	← ↙	Sideswipe
✶	Property Damage Only	R	Rain	↓ ←	Broadside
●	Injury	F	Foggy/Cloudy		
■	Fatality	O	Other		
□	No Damage/Injury	DL	Daylight		
↩	Out of Control	N	Dark – No Lights		
(#)	Number of Accidents	L	Dark – Lighted		

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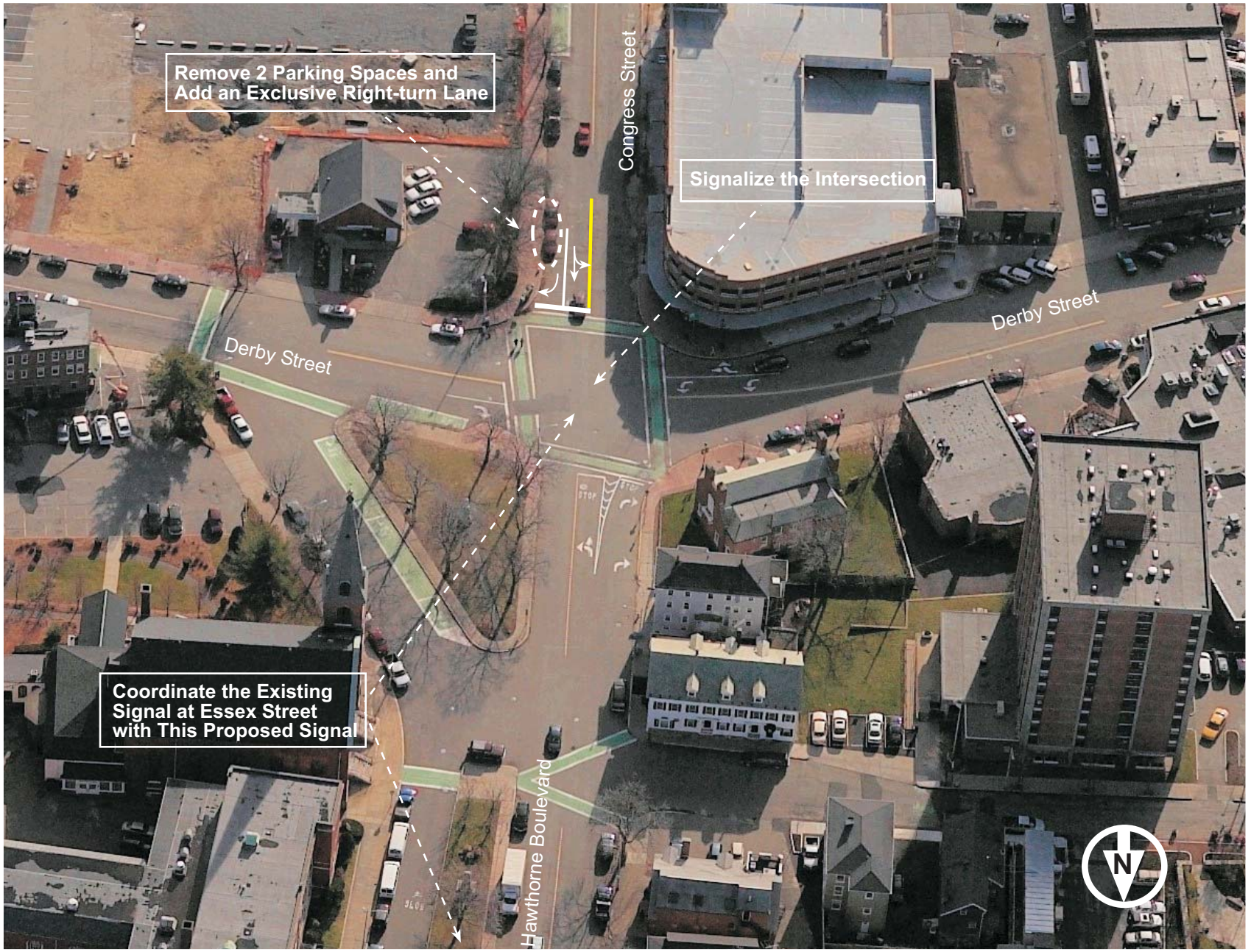
Figure 4-10 Proposed Intersection Improvements:
Derby Street at Congress Street/Hawthorne Boulevard



- Coordinate this proposed traffic signal with the traffic signal at the intersection of Essex Street at Hawthorne Boulevard. This coordination would expedite traffic movement on Route 1A northbound and reduce traffic congestion in the nearby downtown area.

4.2.3 Essex Street at Hawthorne Boulevard/Washington Square West

This intersection is located about 500 feet north of the intersection of Derby Street at Congress Street/Hawthorne Boulevard. It is adjacent to many tourist attractions, such as the Salem Common, Witch Museum, Peabody Essex Museum, Salem Visitor Center, Museum Mall Garage, pedestrian mall, and historical harbor area. Essex Street runs in the east/west direction. Hawthorne Boulevard is located on the south side of the intersection and Washington Square West on the north.

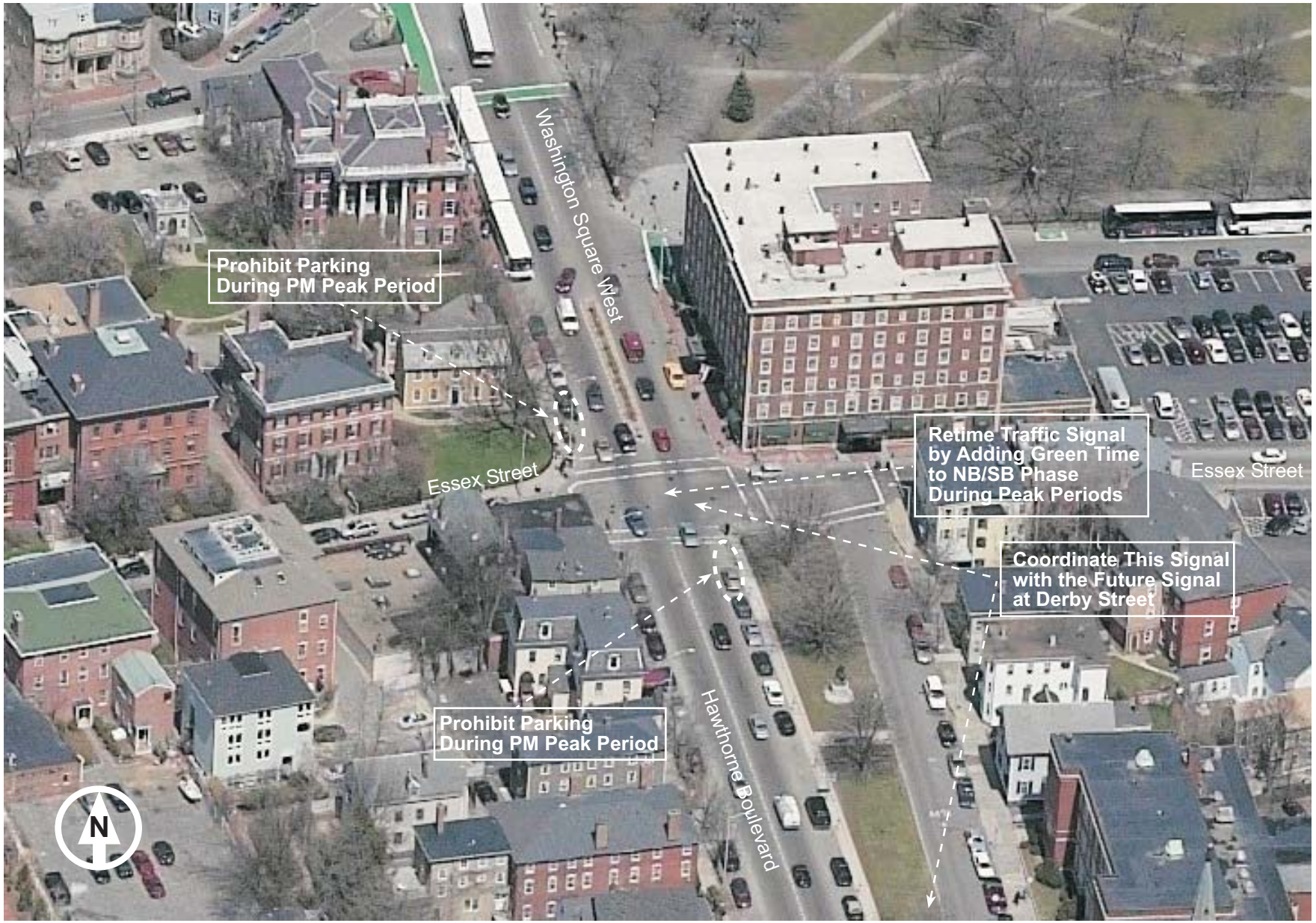
Essex Street west of the intersection is for westbound traffic only. Two-way traffic is allowed on the other three approaches. Each of these three approaches has only one lane, shared by all movements, with on-street parking permitted on the northbound and southbound approaches. The parking spaces are located very close to the intersection. During peak periods, one or two left-turning vehicles often block the entire approach.

The intersection is currently under traffic signal control. Its signal phasing scheme comprises a northbound/southbound phase, a westbound phase, and an exclusive pedestrian phase. As the intersection is adjacent to major attractions, pedestrian traffic is heavy at noontime and in the afternoon hours. In the PM peak period, traffic on Hawthorne Boulevard/Washington Square West (Route 1A) is heavy in both directions. In addition to the heavy traffic, the traffic signal has to accommodate nearly 100 pedestrian crossings per hour. The northbound traffic oftentimes backs up to the upstream intersection at Derby Street. The southbound traffic sometimes extends beyond the upstream intersection at Brown Street.

To reduce the traffic congestion at the intersection, the following improvements are proposed (see Figure 4-11):

- Prohibit on-street parking near the intersection on the northbound and southbound approaches during the PM peak period (4:00 to 6:00). The prohibition would eliminate two spaces on each of the approaches. This marginal parking reduction would create essential space for right-turning traffic and for through vehicles to weave and proceed.
- Retime the traffic signal by adding about 10 seconds of green time to the northbound/southbound phase during the AM (7:00 to 9:00) and PM (4:00 to 6:00) peak periods. The increase would reduce queue lengths in both directions and consequently reduce traffic blockage at the adjacent intersections at Derby Street and Brown Street. The expansion of cycle length would increase pedestrian waiting time somewhat but is considered acceptable in this case. As the signal is fully actuated, pedestrian waiting time would only increase slightly during the morning and evening peak periods.
- Coordinate this traffic signal with the future signal at the intersection of Hawthorne Boulevard at Derby Street. The coordination would expedite the traffic movement on Hawthorne Boulevard and improve traffic flow at the two adjacent intersections. The proposed scheme is to coordinate the northbound movement at the Essex Street intersection with the westbound left-turn movement at the Derby Street intersection.

Figure 4-11 Proposed Intersection Improvements:
Essex Street at Hawthorne Boulevard/Washington Square West



4.2.4 Lafayette Street at Washington Street

Two major state routes in the North Shore area, Route 1A and Route 114, meet at this intersection. Lafayette Street (Route 1A/114), running in the north/south direction, is the major street of this intersection. Washington Street (Route 114) runs into Lafayette Street at a 30-degree angle at the intersection, from which Route 114 continues southward on Lafayette Street.

The intersection currently operates with stop control on the Washington Street approach. The nearby areas are mostly residential, and on-street parking is allowed on all the approaches. The intersection is somewhat wide and undefined. As a result, some traffic goes through the intersection at excessive speeds. Three crosswalks, one across Washington Street and two across Lafayette Street, are located far from one another. Traffic signals to stop traffic for pedestrian crossings are installed over the crosswalks. These pedestrian-actuated signals are operated separately on Lafayette Street and on Washington Street, depending on which street the pedestrians are crossing.

During peak hours, traffic on Lafayette Street is heavy and vehicles on Washington Street experience extensive delay at the intersection. The intersection capacity analyses indicate that the Washington Street approach operates at LOS D and LOS F in the AM and PM peak hours, respectively (see Figures 2-7 and 2-8), and may be expected to operate at LOS E (AM) and LOS F (PM) under the future traffic conditions with the existing operation (see Figures 3-4 and 3-5). Data show that this location has had a high number of crashes in recent years (see Table 2-2). Particularly, it has had a much higher number of pedestrian-related crashes than other locations.

It is suggested that the intersection layout be tightened and the pedestrian signals be replaced by full traffic signal control. A preliminary analysis of signal warrants indicates that signalization of this intersection is justified (see Table 4-4).

Table 4-4 Signal Warrant Analysis:
Lafayette Street at Washington Street

Warrant	Status
1. Eight-Hour Vehicular Volume	Not Available
2. Four-Hour Vehicular Volume	Met
3. Peak Hour Vehicular Volume	Met
4. Pedestrian Volume	Not Met
5. School Crossing	Not Applicable
6. Coordinated Signal System	Not Applicable
7. Crash Experience	Met
8. Roadway Network	Not Applicable

A better-defined intersection layout and a new traffic signal will reduce drivers' confusion, improve pedestrian circulation and safety, and reduce traffic delay on Washington Street. Major elements of the proposal are (see Figure 4-12):

- Extend the triangular parkland further into the intersection. The added parkland can be made into a small open space that connects the sidewalks on the parkland and the crosswalks at the intersection. This extension will require closing the southbound right-turn traffic movement, which has a very low traffic volume (about five vehicles per hour).
- Relocate the two crosswalks adjacent to the parkland southward, closer to the intersection. This will shorten the distance for pedestrians whose trips include crossing both Washington Street and Lafayette Street.
- Replace the pedestrian crossing signals with a fully functional traffic signal that controls all the traffic and pedestrian movements at the intersection. The signal can have a simple two-phase traffic operation with an exclusive pedestrian phase.

The intersection capacity analyses indicate that the intersection is expected to operate at LOS B in both the AM and PM peak hours under the future traffic conditions with the proposed improvements (see Figures 4-2 and 4-3).

4.2.5 Lafayette Street at Harbor Street

This intersection is located about 300 feet north of the intersection of Lafayette Street at Washington Street. It is currently under two-way stop control, with stop signs installed on both approaches of Harbor Street. Harbor Street east of the intersection is a one-way westbound street. The surrounding areas are a mix of commercial and residential development. There are also a park and a church located on Lafayette Street.

During the peak hours, traffic on Lafayette Street is heavy and vehicles on Harbor Street have a hard time finding gaps in the flow. In the PM peak hour, vehicles usually back up extensively on Harbor Street east of the intersection. The capacity analyses indicate that both approaches of Harbor Street operate at LOS F in the AM and PM peak hours (see Figures 2-7 and 2-8), and may be expected to deteriorate under the future traffic conditions with the existing operation (see Figures 3-4 and 3-5).

As stores and shops are located near the intersection, vehicles oftentimes are parked very close to the intersection at all corners and obstruct drivers' and pedestrians' views of different approaches. The crash data show that this intersection has a much higher crash rate than other intersections in the downtown area (see Table 2-2). It also has a relatively high number of pedestrian-related crashes.

It is suggested that in the short term, the parking be moved farther away from the intersection, and in the long term the intersection be signalized and be coordinated with the future signal at the intersection of Lafayette Street at Washington Street. A preliminary analysis of signal warrants indicates that signalization of this intersection is justified (see Table 4-5).

Figure 4-12 Proposed Intersection Reconfiguration:
Lafayette Street at Washington Street

Table 4-5 Signal Warrant Analysis
Lafayette Street at Harbor Street

Warrant	Status
1. Eight-Hour Vehicular Volume	Not Available
2. Four-Hour Vehicular Volume	Met
3. Peak Hour Vehicular Volume	Met
4. Pedestrian Volume	Not Met
5. School Crossing	Not Applicable
6. Coordinated Signal System	Met
7. Crash Experience	Met
8. Roadway Network	Not Applicable

The proposed improvements are summarized below (see Figure 4-13 for locations of the proposed improvements).

- Preserve the intersection's functional area by removing or adjusting parking spaces at the corners of the intersection. This is the area where motorists and pedestrians are responding to the intersection operations and where obstructions should be reduced to ensure safe operations.
- Install a traffic signal at the intersection. The signal can have a simple two-phase traffic operation with an exclusive pedestrian phase. The intersection capacity analyses show that traffic delay during peak hours on both approaches of Harbor Street would be significantly reduced with the proposed signalization (see Figures 4-2 and 4-3).
- Coordinate the traffic signal with the future traffic signal at the intersection of Lafayette Street at Washington Street. The coordination will synchronize the two signals and expedite traffic flow and reduce delay on Lafayette Street. The proposed scheme is to coordinate the northbound/southbound movements at the Harbor Street intersection with the northbound/southbound movements at the Washington Street intersection.

4.2.6 Lafayette Street at Derby Street

This is a signalized intersection located just 500 feet east of the intersection of Washington Street at Norman/New Derby Street. Traffic at this intersection in the AM peak period is not overly congested. In the PM peak period, traffic is busy on New Derby Street between the two intersections, but continuous blockage of New Derby Street is rare. Traffic on the Lafayette Street northbound approach is also heavy, but vehicles usually can go through the intersection within one signal cycle.

The intersection capacity analyses indicate that the intersection currently operates at LOS B during the AM peak hour and at LOS C during the PM peak hour (see Figures 2-7 and 2-8). In the future, the intersection overall is expected to operate at similar levels of service during the AM and PM peak periods (see Figures 3-4 and 3-5). However, the northbound left-turn movement is expected to operate at LOS E in the PM peak hour, with an estimated delay of

Figure 4-13 Proposed Intersection Improvements:
Lafayette Street at Harbor Street

about a minute. A simple adjustment of the signal timing can be considered for this intersection: to reallocate about 5 seconds of green time from the east/west approach to the north/south approach during the PM peak period. The intersection capacity analysis indicates that this adjustment would somewhat reduce delays on the northbound approach without increasing too much the overall intersection delay (see Figure 4-3). No changes of signal timing are suggested for this intersection at this time. However, continuous monitoring of the traffic conditions in the future is suggested.

It is observed that the Derby Street westbound left-turn movement sometimes is blocked by traffic extending from Lafayette Street south of the intersection. The traffic backup is usually caused by congestion at the intersection of Lafayette Street at Harbor Street or double-parking on Lafayette Street. It is suggested that strong enforcement of the double-parking prohibition on Lafayette Street between Derby Street and Harbor Street be implemented during the PM peak period.

4.3 Pedestrian Circulation on Washington Street

Both traffic and pedestrian movements are heavy on Washington Street between Bridge Street and Riley Plaza. This roadway section contains seven pedestrian crosswalks, and traffic frequently must stop for pedestrian crossings. Some committee members expressed concern that the number of crosswalks may be excessive and cause major traffic delays. They suggested that the crosswalk locations, the spacing of these crosswalks, and the interaction between traffic movement and pedestrian crossings be examined. This section analyzes the observed pedestrian traffic data, examines the interaction between pedestrians and traffic, and summarizes proposed improvements for pedestrian circulation.

Existing Conditions

The section of Washington Street under study, about 1,500 feet in length, extends between Bridge Street and New Derby/Norman Street. It is a major roadway section that connects the commuter rail station in the north and Riley Plaza in the south.

Washington Street is the "Main Street" of downtown Salem. As on many main streets in other downtown areas, pedestrian traffic and vehicular traffic on Washington Street are heavy and in conflict with each other. With tourist attractions in addition to business activities, pedestrian traffic in downtown Salem is even more extensive than in some other downtown areas.

On a typical weekday, except in the month of October, pedestrians are active primarily during daytime hours. Pedestrian traffic starts early, before business hours, peaks in the midday hours (around 11:30 AM to 1:30 PM), resurges in the school-closing hour (around 2:30 PM to 3:30 PM), and dissipates after business hours. In the early nighttime hours, pedestrian traffic is still active, as a number of restaurants are located on Washington Street. During the Halloween season (covering nearly the entire month of October), pedestrian traffic is much heavier than usual in both daytime and early nighttime hours.

This section of Washington Street is a two-lane (one lane in each direction) roadway with on-street parking and sidewalks on both sides of the street. A traffic median is installed in the

roadway north of Federal Street and also south of Essex Street. The on-street parking spaces are parallel to the direction of traffic, except on the northbound side between Front Street and Essex Street, where there are 13 angled parking spaces. The on-street parking turnover rate is high; parking limits range from 15 minutes to two hours. Various parking limit signs are posted on curbs. No speed limit signs are posted in the entire study section. Traffic is usually slow due to heavy pedestrian movements and parking maneuvers. Occasionally, vehicles speed when the traffic volume is low.

There are seven pedestrian crosswalks on Washington Street in the study section: one at Federal Street, one at Church Street, one in front of City Hall, two at Essex Street, and one at Front Street (near Dunkin' Donuts). Figure 4-14 shows the locations and the spacing of these crosswalks. The spacing ranges from 70 feet to 360 feet (estimated from aerial photographs), with an average of about 220 feet (the pair of crosswalks at Essex Street are regarded as one).

Along Washington Street, side street crosswalks are present at most locations. However, there are no marked crosswalks at Church Street, at the driveway of the district court, or at Federal Street on the east side of Washington Street.

Pedestrian Counts

Pedestrian crossing counts were conducted on Monday, May 2, 2005. The weather was sunny and became cloudy after 3:30 PM. The counts were performed from 12:00 PM to 6:00 PM in three areas: (1) the district court vicinity, (2) Essex Street and City Hall, and (3) the Front Street intersection. The count period was chosen based on discussions with members of the study's advisory committee. This six-hour period covers high pedestrian activity during the midday, afternoon, and early evening hours.

In total, nearly 3,300 pedestrians were observed to cross the study section of Washington Street during the six-hour period, or an average of about 550 per hour. Figure 4-15 shows the average hourly number of pedestrians crossing Washington Street at each crossing location and the number crossing during the location's peak hour for pedestrians.

In the district court vicinity, on average each hour about 65 pedestrians used the crosswalk on the north side of Federal Street; about 45 used the crosswalk on the south side of Federal Street; about 85 used the crosswalk at the Church Street intersection; and about 30 jaywalked across Washington Street between Federal Street and Church Street.

The counts at Essex Street show that the crosswalk on the north side was used more frequently than the one on the south side most of the time. On average, the crosswalk on the north side had nearly 150 pedestrians and the crosswalk on the south side had about 80 pedestrians crossing Washington Street each hour. The crosswalk in front of City Hall had about 20 pedestrians crossing Washington Street each hour.

Figure 4-14 Locations and Spacing of Crosswalks on Washington Street

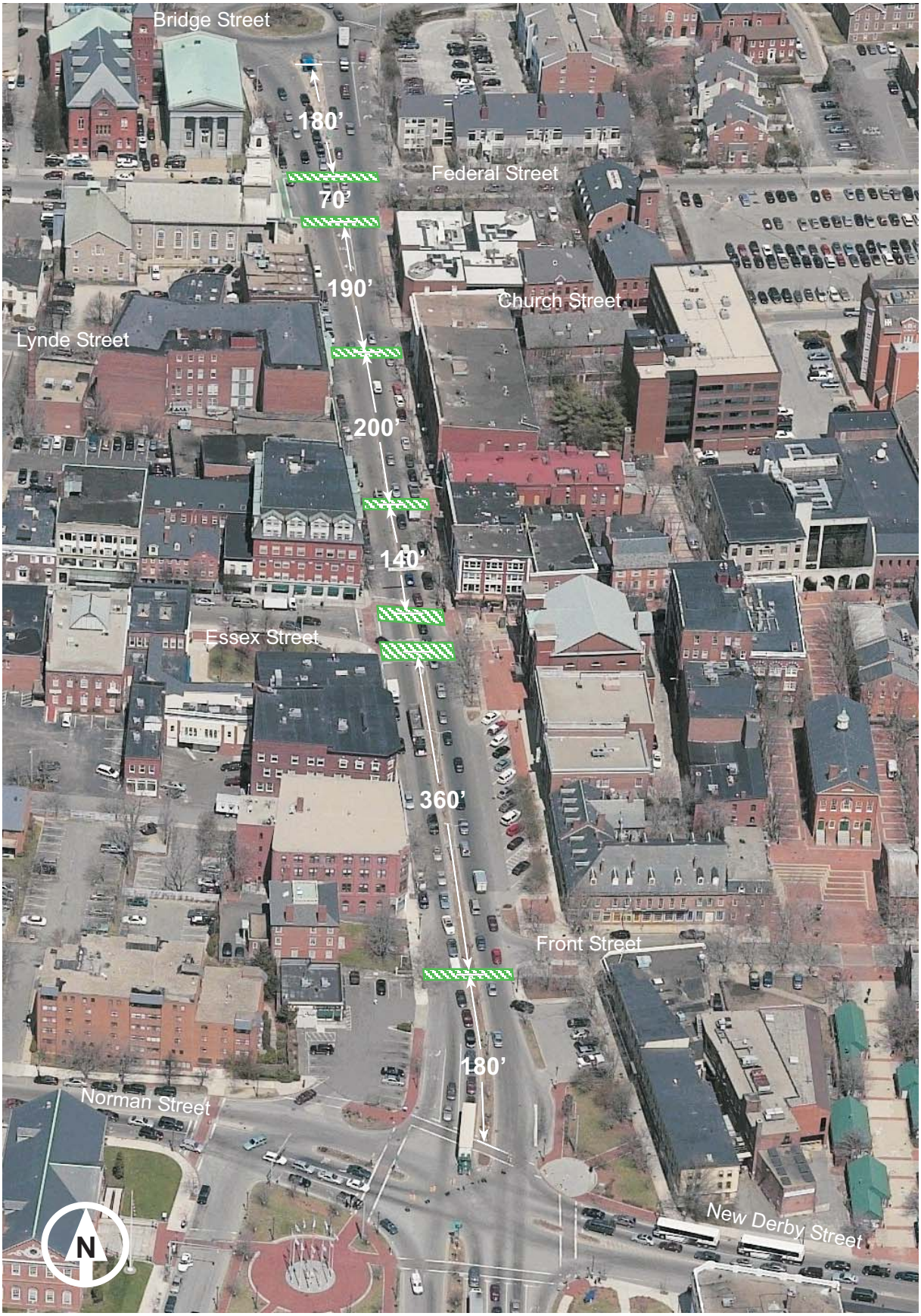
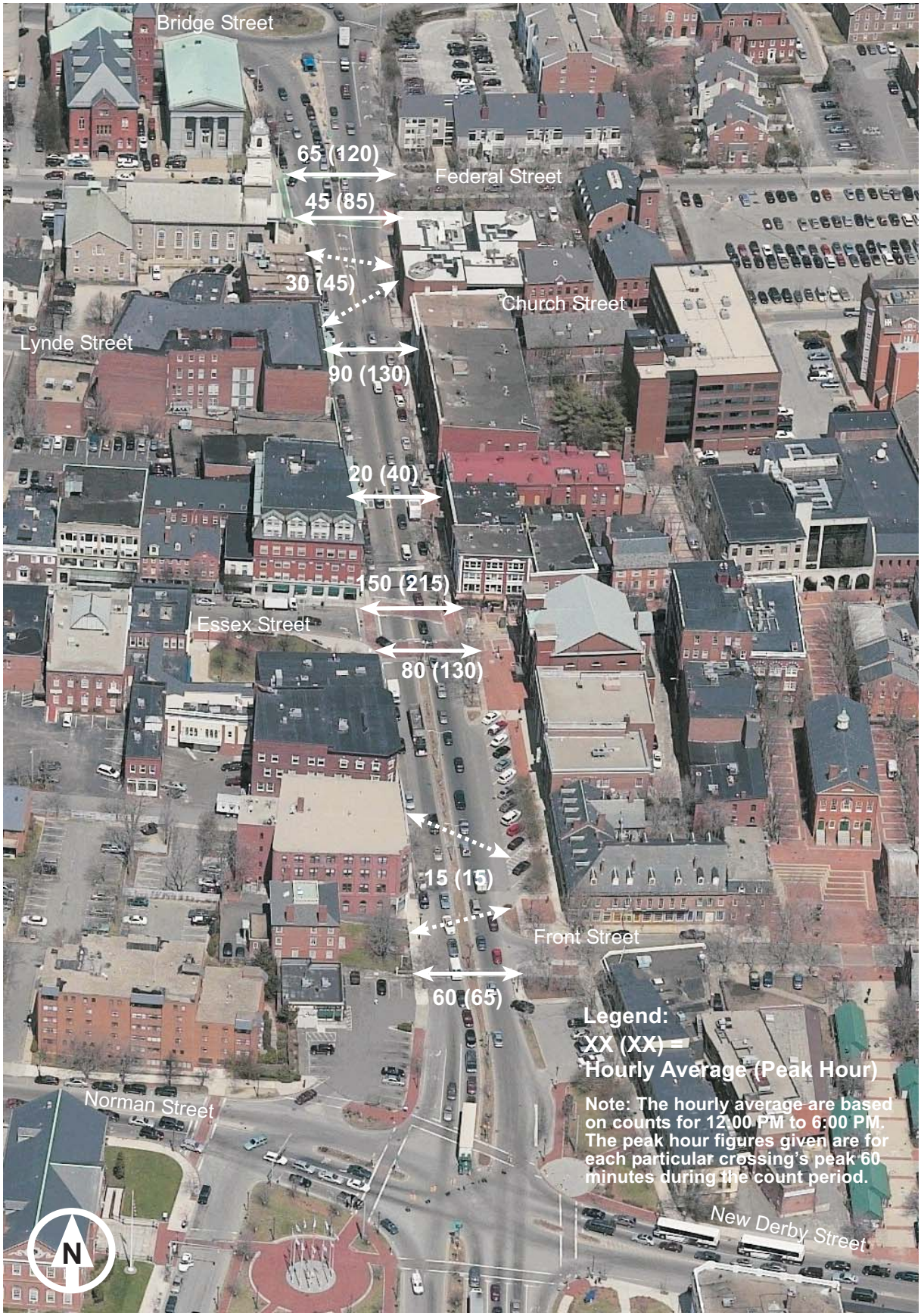


Figure 4-15 Hourly and Peak Hour Pedestrian Crossing Counts on Washington Street



The area of the Front Street intersection had about 60 pedestrians using the crosswalk and about 15 pedestrians jaywalking across Washington Street each hour. Many jaywalkers used the curb extension on the north side of Front Street.

Traffic Counts and Travel Time Data

While conducting the pedestrian counts, CTPS staff also counted the number of vehicles passing the crosswalk at the Front Street intersection. The count provides a simple profile of the traffic volume on Washington Street. On average, about 750 northbound and 550 southbound vehicles passed the crosswalk each hour. The largest hourly volume, 850 northbound and 560 southbound vehicles, was observed between 2:30 and 3:30 PM. Analysis of the count by 15-minute intervals indicates that traffic was fairly constant, with a somewhat higher volume during the 2:30–3:30 peak hour, when the nearby schools released students.

Travel time runs on Washington Street were conducted on Tuesday, May 10, 2005. The weather was sunny and warm. Travel time data were collected using a probe vehicle that traveled with the flow of traffic, based on the "average speed" technique.[2] The driver of the vehicle used a stopwatch to record the travel time. For the northbound runs, the start time was recorded when the vehicle passed the north-side crosswalk at the New Derby intersection and the end time was recorded when the vehicle passed the stop line of the right-turn lane at the Bridge Street intersection. For the southbound runs, the start time was recorded when the vehicle entered Washington Street from the Bridge Street intersection and the end time was recorded when the vehicle passed the stop line of the right-turn lane at the Norman Street intersection. The driver also observed pedestrian interruptions of the prevailing traffic. The number of pedestrian interruptions was defined as the number of stops with a delay of 3 seconds or more caused by pedestrian movements. Pedestrians walking together or closely following one another were regarded as one interruption only.

In order to observe various congested conditions, CTPS collected travel time data during three time periods: the midday period (12:30–1:30 PM), which represents moderate Washington Street traffic with peak pedestrian crossing activity; the afternoon period (2:30–3:30 PM), which represents peak Washington Street traffic with heavy pedestrian crossing activity; and the evening period (4:30–5:30 PM), which represents heavy downtown (including Washington Street, Bridge Street, and Norman Street) traffic with moderate pedestrian crossing activity.

Table 4-6 summarizes the travel time runs for the three different time periods. As shown, the northbound runs took, on average, 1 minute 48 seconds in the midday; 1 minute 54 seconds in the afternoon; and slightly over 2 minutes in the evening. The southbound runs took, on average, 1 minute 22 seconds in the midday; 1 minute 16 seconds in the afternoon; and 1 minute 24 seconds in the evening. In general, it took about two minutes to travel northbound and about one and a half minutes to travel southbound in the study section. Under free-flow traffic conditions, a vehicle traveling in either direction would take about 30 seconds (assuming a 25 miles per hour travel speed) to 40 seconds (assuming a 20 MPH travel speed) to traverse the study corridor. Traffic delays in the evening period are somewhat longer than

[2] *Transportation and Traffic Engineering Handbook*, Second Edition, Institute of Transportation Engineers.

Table 4-6 Travel Time on Washington Street between New Derby Street and Bridge Street

Observation Period: 12:30 PM - 1:30 PM

Run Sequence	Northbound		Southbound	
	Run Time (min:sec)	Pedestrian Interruptions	Run Time (min:sec)	Pedestrian Interruptions
1)	2:16	6	1:44	4
2)	2:09	2	1:16	1
3)	1:50	3	1:16	2
4)	1:19	3	1:21	2
5)	2:15	5	1:21	3
6)	1:14	2	1:18	3
7)	1:46	5	1:21	3
8)	1:38	2	1:25	3
Average	1:48	4	1:22	3

Observation Period: 2:30 PM - 3:30 PM

Run Sequence	Northbound		Southbound	
	Run Time (min:sec)	Pedestrian Interruptions	Run Time (min:sec)	Pedestrian Interruptions
1)	3:21*	3	1:08	0
2)	1:35	2	1:18	1
3)	1:33	2	1:03	1
4)	1:26	1	1:28	3
5)	1:54	0	1:09	2
6)	1:50	1	1:29	0
7)	2:29	5	1:13	1
8)	2:31	5	1:21	2
Average	1:54	2	1:16	1

* A delivery truck double-parked near City Hall (excluded from average run time estimation).

Observation Period: 4:30 PM - 5:30 PM

Run Sequence	Northbound		Southbound	
	Run Time (min:sec)	Pedestrian Interruptions	Run Time (min:sec)	Pedestrian Interruptions
1)	1:48	2	1:01	0
2)	1:13	1	1:09	1
3)	2:06	2	1:33	0
4)	1:34	1	1:57	1
5)	2:39	1	1:09	0
6)	2:17	2	1:29	1
7)	2:36	1	1:32	2
Average	2:01	1	1:24	1