5

Mainline Alternatives Analysis

From 1998 to 2025, daily and peak hour traffic volumes on I-84 are expected to increase by approximately 38 percent – about 1.2 percent per year. In general, higher growth is expected from Exit 7 to the Housatonic River where daily demand is projected to increase by more than 40 percent. Without improvements, the operational problems identified under existing conditions will only be exacerbated in the future. The sheer magnitude of growth in traffic volume will result in constrained operations along the majority of the corridor such that the available capacity will not be able to accommodate the projected peak hour demands.

5.1 Future Demand vs. Capacity

LOS E or F operations are projected during one or both peak periods for 23 of the 24 mainline segments. Table 5-1 compares the existing levels-of-service (LOS) experienced on the freeway segments of I-84 to those that would be experienced under year 2025 traffic conditions. Presently in the morning peak period, 8 of the 24 freeway segments approach or are at capacity (LOS E or F) with an overall mean volume-to-capacity (V/C) ratio of 0.99. In the evening peak period along the study section of I-84, 10 segments operate at or near the roadway's theoretical capacity, with an overall mean V/C ratio of 1.0. In the year 2025, the morning peak period will have 12 of 24 freeway segments at or exceeding capacity, with an overall mean V/C ratio of 1.26. The 2025 evening peak hour will have 21 segments operating at or beyond capacity, with an overall mean V/C ratio of 1.19.

The future LOS analyses provide a "snapshot" of the peak hour conditions given the projected "unconstrained" traffic volumes. In simple terms, this analysis demonstrates that there will be more demand for I-84 than the corridor can accommodate in the future. As the I-84 corridor approaches its capacity and is not physically able to handle additional demands placed upon it, typically one of these four actions to reduce demand for interstate travel is triggered:

- Motorists change the time of their travel to avoid the congested periods ("peak spreading");
- Motorists elect to travel by alternative modes (where options exist);
- Motorists decide to divert to other local and regional routes; or
- Motorists decide not to travel at all

Table 5-1
Comparative Levels of Service for Freeway Segments (Existing vs. 2025 Conditions)

	Eastbound					Westbound				
	Existing		Future (2025)		LOS	Existing		Future (2025)		LOS
Segment	V/C	LOS	V/C	LOS	Change	V/C	LOS	V/C	LOS	Change
New York to Exit 1										
AM	0.51	C	0.70	C	–	0.79	D	1.07	F	D-F
PM	0.80	D	1.08	F	D-F	0.69	C	0.94	E	C-E
Exit 1 to Exit 2										
AM	0.50	C	0.68	C	–	0.52	C	0.70	D	C-D
PM	0.82	D	1.10	F	D-F	0.43	B	0.59	C	B-C
Exit 2 to Exit 3										
AM	0.31	B	0.43	B	–	0.69	D	0.97	E	D-E
PM	0.66	C	0.92	E	C-E	0.43	B	0.60	C	B-C
Exit 3 to Exit 4										
AM	0.31	B	0.43	B	–	0.67	C	0.91	E	C-E
PM	0.70	D	0.97	E	D-E	0.43	B	0.58	C	B-C
Exit 4 to Exit 5										
AM	0.47	C	0.64	C	–	1.02	F	1.39	F	F-F
PM	1.01	F	1.38	F	F-F	0.70	D	0.95	E	D-E
Exit 5 to Exit 6										
AM	0.46	C	0.63	C	–	0.87	E	1.17	F	E-F
PM	0.85	E	1.15	F	E-F	0.69	D	0.94	E	D-E
Exit 6 to Exit 7										
AM	0.60	C	0.83	D	–	1.01	F	1.38	F	F-F
PM	1.02	F	1.39	F	F-F	0.86	E	1.15	F	E-F
Exit 7 to Exit 8										
AM	0.89	E	1.25	F	E-F	1.12	F	1.57	F	F-F
PM	1.22	F	1.71	F	F-F	1.04	F	1.45	F	F-F
Exit 8 to Exit 9										
AM	0.66	C	0.92	D	C-D	1.05	F	1.47	F	F-F
PM	1.07	F	1.50	F	F-F	0.81	D	1.12	F	D-F
Exit 9 to Exit 10										
AM	0.66	C	0.91	D	C-D	1.00	E	1.39	F	F-F
PM	0.99	E	1.38	F	E-F	0.81	D	1.12	F	D-F
Exit 10 to Exit 11										
AM	0.65	C	0.91	D	C-D	0.96	E	1.34	F	E-F
PM	0.99	E	1.38	F	E-F	0.76	D	1.06	F	D-F
Exit 11 to River										
AM	0.59	C	0.82	D	C-D	0.87	D	1.22	F	D-F
PM	0.92	E	1.29	F	E-F	0.74	C	1.02	F	C-F

Alternatively, the excess demands can also be accommodated through capacity enhancement options, such as adding a lane. Each of these possible outcomes, with the exception of motorists' decisions not to travel, are explored in this chapter for their potential to improve traffic operations on I-84 through the study area.

5.2 Alternatives to Reduce Demands

The preceding sections quantified the projected, and relatively unabated, I-84 demands as they relate to the highway's capacity. This section of the mainline alternatives analysis provides insight on how the corridor might respond to strategies aimed at reducing demand for travel along I-84, including:

- Peak spreading
- Shifts to alternative modes, and
- Diversions to alternate routes

5.2.1 Peak Spreading

A shorter-term effect of corridor demands approaching capacity will likely be spreading of the peak hours. To understand the effects of peak spreading, it is helpful to examine the variation of I-84 traffic over the course of the day. To do so, the hourly traffic demand data on I-84 near Exit 9 were used. The data were collected by ConnDOT in 1998, and were adjusted upward by 35 percent to approximate Year 2025 volumes for purposes of these analyses. Figures 5-1a and 5-1b graphically illustrate peak spreading as future demands approach the capacity of I-84.

As Figures 5-1a and 5-1b indicate, if drivers alter their travel times (if this flexibility exists) and continue to use I-84, the duration of the morning and evening peak demand periods could almost double. However, it is unreasonable to expect the corridor to sustain saturated flow conditions over this long a period of time. As traffic demands approach capacity, traffic flow becomes very unstable and one minor incident could trigger a breakdown in system capacity and result in lengthy traffic jams and/or gridlock. Additionally, if over time drivers become frustrated with the duration of congestion on I-84, they may instead alter their travel route, their travel mode, or decide not to travel at all, as discussed in later sections of this chapter. This could potentially increase the demands for travel on local streets and secondary highways, thus increasing delays and congestion through adjacent communities.

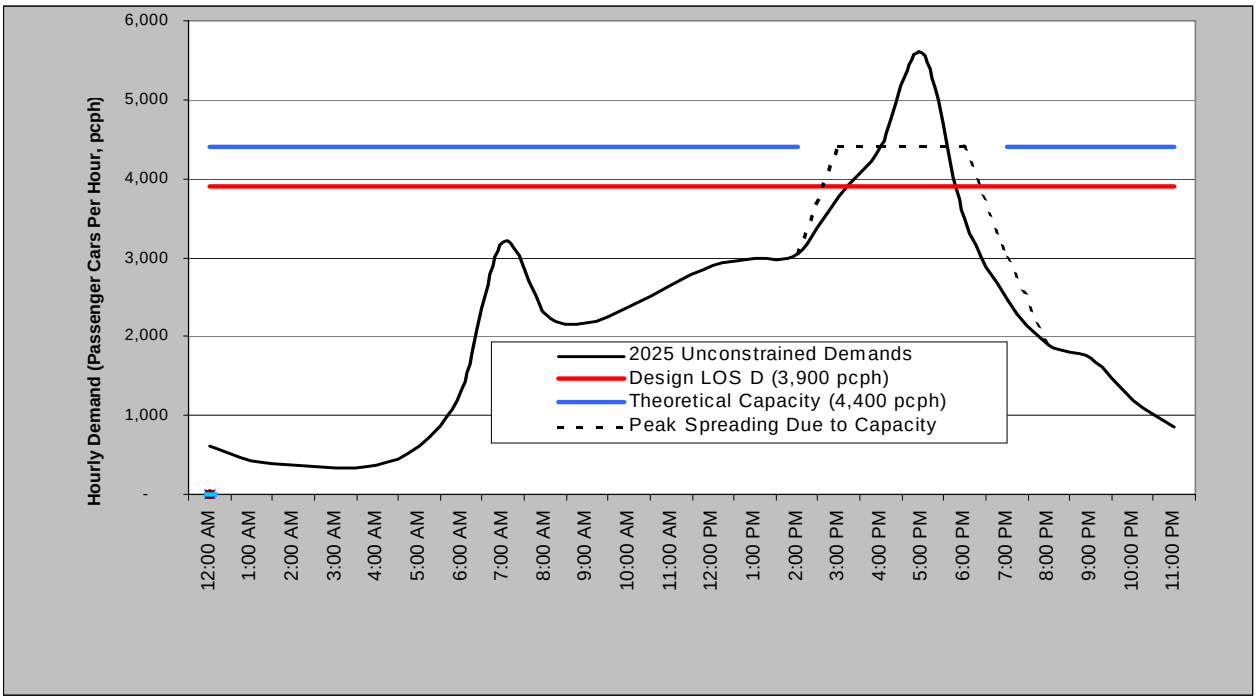

Figure 5-1a
Short-term Effects of Unmet Demand– I-84 Eastbound at Exit 9

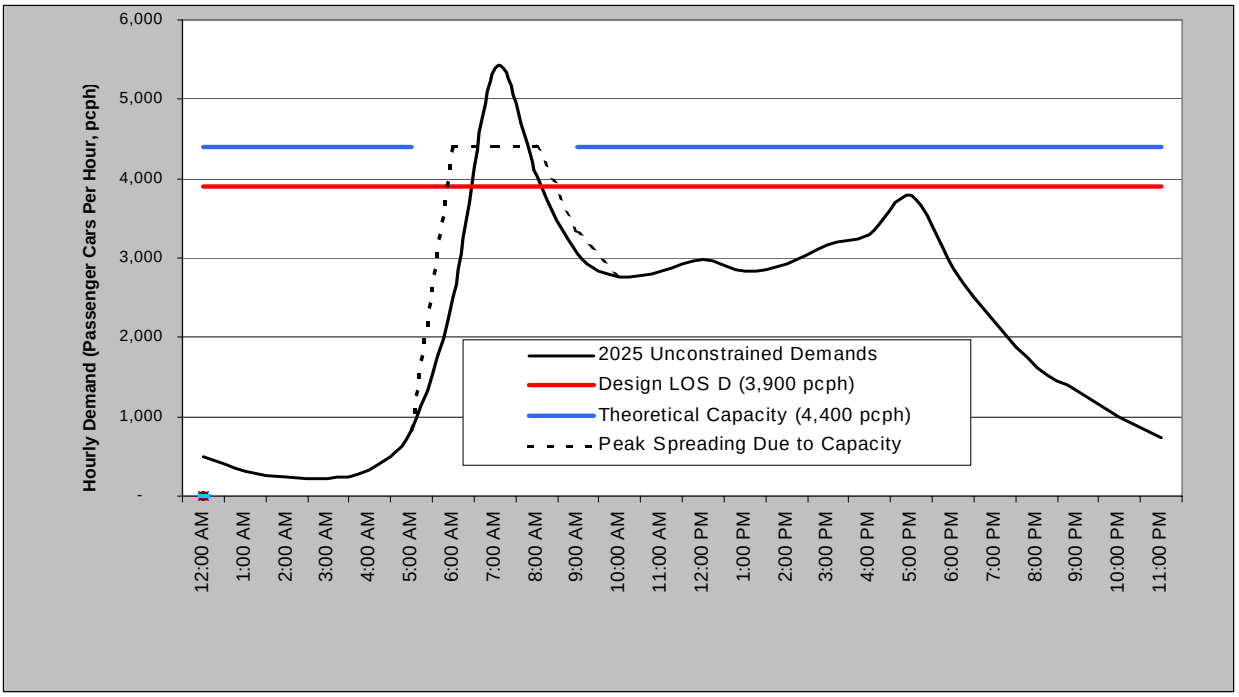

Figure 5-1b
Short-term Effects of Unmet Demand– I-84 Westbound at Exit 9

5.2.2 Alternative Modes

As part of this study, the potential for transit and travel demand management projects to relieve existing and projected peak period traffic demands on I-84 in the study area was assessed. Transit is an important tool for reducing dependence on the use of the single occupant vehicle. It is also an important component of successful Transportation Demand Management (TDM) and High Occupancy Vehicle (HOV) strategies, which are discussed in subsequent sections of this chapter and in more detailed working papers in the Appendix to this report. The potential effectiveness of these alternatives must be given consideration before a decision can be made to add capacity to the highway.

I-84 Corridor Transit Options: The Brewster Shuttle

In October 1998, HART initiated operation of the Brewster Shuttle bus service to provide a convenient and reliable connection between the Danbury area and the Metro North rail station in Brewster, NY, with commuter rail service into New York City on the Harlem Branch of the New Haven rail line. Details of this service are provided in Working Paper No. 1 in the Appendix to this report. Although the Danbury Branch also provides commuter rail service to New York, trains run more frequently on the Harlem Branch and offer shorter travel times.

The Brewster Shuttle allows Connecticut residents to take advantage of the service on the Harlem Branch without having to cope with the problems associated with driving to and parking at the commuter rail stations in Brewster. (Parking lots are filled to capacity at both Brewster stations and waiting lists prevent new riders from obtaining a parking permit.) The morning service provides four shuttles to Brewster. These shuttles pick-up in Danbury at park-and-ride lots located along I-84 at Exits 7, 2 and 1, and at White Turkey Road on Route 7, and are timed to meet departing Metro North trains at the Brewster Rail Station. Morning service is also provided from Brewster to Danbury, with fewer stops at park-and-ride lots and additional stops at Danbury Fair Mall and the HART pulse point for connections with local bus service. The evening service provides seven shuttles, which operate essentially in reverse of the morning service, meeting trains returning from New York City to Brewster, as well as providing service from Danbury back to Brewster. Service begins at 5:38 AM and terminates at 8:18 PM. All park-and-ride lots used by the shuttle furnish ample parking at no charge.

Ridership has been steadily growing on the Brewster Shuttle since its inception in October of 1998. The Brewster Shuttle carried an average of 65 passengers per day in July 1999. HART expects to capture 100 passengers per day by the end of the shuttle's initial two-year trial period (October 2000).

To determine the impacts of the Brewster Shuttle on the I-84 corridor, current trip reductions and projected further trip reductions based on HART's ridership goals

were estimated. Due to the nature of the Brewster Shuttle service, which only operates during peak hours and is primarily geared to commuter rail passengers, it was assumed that the current 65 passengers per day are equivalent to approximately 32 round trips (each with a trip in one direction in the morning and in the opposite direction in the evening). Taking into consideration the directionality of travel and vehicle occupancies, it is estimated that the Brewster Shuttle is currently removing approximately 28 automobile trips from I-84 westbound in the overall morning peak period and eastbound in the overall evening peak period.

Using this same methodology, if the shuttle captures the additional 35 daily riders HART has projected, the shuttle will remove an additional 15 vehicles from I-84 westbound in the morning peak and eastbound in the evening peak by the fall of 2000. Presumably, these numbers could continue to grow somewhat beyond the year 2000 if the vehicles were filled to capacity[1] or if HART added additional buses to the route. Based on peak period traffic demands, this translates into an overall reduction between 15 and 25 vehicles during the peak hour on I-84.[2]

I-84 Corridor Transit Options: Intercity Bus and Limousine Services

There is currently no existing or planned public, intercity bus transit service on the I-84 corridor. However, two private carriers operate regularly scheduled service in the corridor. Additional information on transit services in the I-84 corridor is provided in Working Paper No. 1 in the Appendix. Current ridership levels and future expansion plans were not available for either; however, the availability of these services are reflected in the traffic forecasts for the study area.

Bonanza

Bonanza Bus is a private, for-profit bus-transit operator that provides regularly scheduled, intercity bus service in the region. Bonanza, which is based in Providence, RI, currently has two routes that travel on the I-84 corridor within the study area.

- **New York – Danbury – Waterbury – Hartford – Providence:** This route provides 10 daily trips (9 on Sunday) in each direction, with Danbury as a regular stop on all trips. Hartford, Farmington, Waterbury and Southbury are regular stops on all Providence to New York trips and on all but one of the New York to Providence trips. During the morning peak period, this route provides four buses that travel westbound through the study area at hourly intervals and one eastbound bus.

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1 The vehicles used for the Brewster Shuttle can carry 16 passengers. HART assumed approximately 10 passengers per hour to achieve a ridership of 100 passengers per day.

2 All of these potential trip reductions on I-84 are based on the assumption that shuttle riders were previously using their cars to travel on I-84 to Brewster. However, it is not clear that this assumption is correct. Given the lack of parking at the Brewster station and the availability of rail transit on the Danbury Branch line, some shuttle riders may be shifting from travel on the Danbury Branch to travel on the Harlem line. These shuttle riders would not create vehicle trip reductions on I-84.

During the evening peak period, three buses traverse the study area eastbound and one westbound. Destinations in New York include White Plains, Yonkers, and New York City.

- **New York – Pittsfield – Williamstown – Bennington:** This route provides service through New Milford and Danbury on the way to White Plains, Yonkers, and New York City. There are three daily trips both ways. Three additional northbound trips are available on Fridays and one on Saturdays; one additional southbound trip is scheduled on Sundays and holidays. None of this service passes through the study area during the morning or evening peak-period.

Connecticut Limousine

Connecticut Limousine is a private, for-profit carrier that provides bus service between 18 cities in Southwestern Connecticut and Southern New York and four major airports: Kennedy and LaGuardia in New York, Newark in New Jersey and Bradley in Connecticut.

Connecticut Limo provides hourly service to the New York airports and service every two hours to Newark throughout the day. Service to the New York and New Jersey airports generates six westbound trips during the morning peak period in the study area and eight westbound trips in the evening peak period. Service to Bradley Airport, north of Hartford, generates three eastbound trips during the morning peak period and three eastbound trips during the evening peak period in the study area.

Again, there are currently no plans to expand either of these services in the future. Therefore, no further reduction of traffic demands on I-84 are anticipated.

I-84 Corridor Transit Options: Projects Considered

In addition to the transit services that are currently in place, HVCEO has investigated the potential for future services that could reduce trips on the I-84 corridor in the study area (see Working Paper No. 1). Following is a discussion of these services; however, neither of the projects reviewed below is currently in the Long-Range Plan or the Transportation Improvement Program for the region.

Waterbury Express Bus

In 1994, the *Waterbury Express Bus Feasibility Study* was completed. This study examined the potential for providing express bus service between Danbury and Waterbury by evaluating alternate routing and scheduling options and forecasting ridership and expenses. The feasibility study also recommended a plan for implementing service and explored potential private-sector involvement. However, estimated ridership was only 70 to 100 trips per day, because potential riders exhibited widely disbursed trip origins as well as variability in the time of day that

their work-shifts begin and end. Due to the low ridership estimates, implementation of this project was not pursued.

Extension of Rail Service on the Danbury Branch Line

In 1996, HVCEO produced an *Action Plan for Restoring Passenger Rail Service to New Milford*. This study examined four scenarios for increasing Danbury Branch commuter rail service, three of which would affect trips on I-84 in part of the study area because Route 7 and I-84 share the same alignment between Exits 4 and 7. The three alternatives are: 1) enhancing existing service and extending the enhanced service three miles north to a new Danbury North station; 2) enhancing existing service and extending it to Danbury North and to New Milford; and 3) enhancing existing service and extending it to Danbury North and to Newtown. The alternative that demonstrated the most potential to reduce trips was the first—enhancing existing service and extending it to a new Danbury North station located at the junction of Route 7 and I-84 (Exit 7) on White Turkey Road Extension. The other two alternatives, extending the service to New Milford or to Newtown captured a minimum of additional riders, and therefore would have no greater impact on I-84.

The *Action Plan for Restoring Passenger Rail Service to New Milford* estimated the additional inbound daily ridership between the current Danbury station and the new Danbury North station would be approximately 200 riders in 1999 and 400 riders in 2015. To translate this into reduced vehicle trips on I-84, factors such as the directionality of trips, travel time, and vehicle occupancy rates must be applied. Given these factors, it is estimated that extending Branch Line service to North Danbury would potentially reduce trips on the overlap portion of I-84 by as much as 145 vehicle trips westbound during the morning peak period and 145 vehicle trips eastbound during the evening peak period by 2015. However, based on travel times to/from work centers in the New York metropolitan area and preliminary plans regarding train scheduling, the vast majority of this trip reduction would occur outside of the corridor peak hours (earlier in the morning and later in the evening) and, therefore, would offer minimal relief to corridor operations.

I-84 Corridor Transit Options: Overall Effectiveness in Reducing I-84 Demands

Few transit services currently exist in the I-84 corridor, and few additional options are planned or programmed. Providing transit in this area is difficult due to the disbursed origins and destinations of the trips that funnel through the I-84 corridor. Although the transit services discussed above could create needed future trip reductions, the magnitude of these reductions is very small and would not, in and of themselves, negate the need for interchange and capacity enhancements to the I-84 corridor in the study area.

I-84 Corridor TDM

As part of the I-84 Corridor Deficiencies/Needs Study, the potential for Travel Demand Management strategies and programs, specifically those supported by MetroPool in Fairfield County, to relieve peak period traffic demands on I-84 in the study area was also assessed. Travel Demand Management, or TDM, measures are geared toward affecting the demand side of the transportation equation, rather than the supply side. By their very nature, TDM programs attempt to change people's behavior, and to be successful, they must rely on incentives or disincentives to make these shifts in behavior attractive to the commuter.[3] TDM programs are designed to maximize the people-moving capability of the transportation system by increasing the number of persons in a vehicle, by providing alternate modes of travel, or by influencing the time of, or need to, travel. More details on TDM are provided in Working Paper No. 2 in the Appendix to this report.

Commuter-based TDM Programs

The focus of this review is on employer-based TDM options. TDM measures are most often directed at commuter travel, for several reasons. First, the most significant demand placed on the transportation system usually occurs during weekday peak periods, as is the case on I-84. These time periods represent the majority of commuter travel as well, which is characterized by the lowest vehicle occupancy rates. Second, the day-to-day regularity of commuter trips makes this market the most suitable for finding alternatives. Third, conditions at the workplace, such as employer-provided free parking, are important targets for behavior modification through TDM actions.[4]

The most effective employer-based TDM programs usually employ a wide variety of TDM alternatives and supporting strategies, not just a few, and generally share the following key characteristics:

- the employer is located in an area of high employment density, such as a city center
- employee parking is controlled, either through cost or limited supply for single occupant vehicles, and preferential parking is provided for high occupancy vehicles
- public transit service is frequent and widespread
- employers provide financial incentives to those who do not drive alone, including discounted or free parking for carpools, and subsidized transit passes

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3 Implementing Effective Traffic Demand Management Measures: Inventory of Measures and Synthesis of Experience, prepared by Comsis Corporation and the Institute of Transportation Engineers, for the U.S. Department of Transportation, DOT-T-94-02, September, 1993, p. I-1.

4 Kuzmyak, J. Richard and Eric N. Schreffler, "Evaluation of the Effectiveness of Travel Demand Management Programs," Institute of Transportation Engineers, 1990 Mid-Year Conference Compendium of Technical Papers.

- employees have access to HOV facilities on area roadways with ample, free parking in park-and-ride lots along the HOV corridor
- a significant number of employees commute relatively long distances (greater than 15 miles each way)
- employees have similar and consistent work hours
- existing legal requirements, which mandate that employers take actions to reduce trips to their work sites

Of these characteristics, four are generally considered to be the most important in determining the success of a TDM program: 1) controlled parking; 2) availability of convenient transit options; 3) financial incentives/disincentives to commuters; and 4) existing legal requirements. Controlled parking supply and parking fees create instant pressure for commuters to find and use other commuting modes, and represent a strong disincentive to driving alone. Subsidized transit passes and subsidized parking for car-poolers represent a financial incentive to use another mode. Legal requirements, such as legislative requirements for employers to reduce trip-making, are extremely important for stimulating employer support of trip reduction programs. In fact, the evidence shows that TDM programs where the private sector is motivated by legal concerns are more likely to gain the type of participation and implement the types of actions that reduce vehicle travel.[5] In summary, when a TDM program is designed to provide time or financial savings to the commuter, fewer people will drive alone during the peak period. When such advantages are not provided, the program will have a minimal effect on travel demands.

Areawide commuter-focused TDM programs have not been shown to produce the same levels of trip reduction as specific employer-based programs, because they must accommodate a more diverse group of commuters who exhibit a variety of travel patterns, times and destinations. Based on the literature, it appears that a 0.3 to 4.0 percent reduction in vehicle trips can be expected from an areawide TDM program.[6] Areawide programs face the difficulty of trying to manage a diverse set of travelers and their needs, and often lack the opportunity to promote incentives to encourage behavior modification. In most instances, they have fallen short because major employers have not been incorporated into the process, or if they have, their participation and commitment has been limited.

A summary of the TDM programs available in the I-84 Corridor study area is provided in Table 5-2.

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5 Kuzmyak, J. Richard and Eric N. Schreffler, "Evaluation of the Effectiveness of Travel Demand Management Programs," Institute of Transportation Engineers, 1990 Mid-Year Conference Compendium of Technical Papers.

6 Cost and Effectiveness of TCMs: A Review and Analysis of the Literature, prepared by APOGEE Research, Inc. for the National Association of Regional Councils, January 1994, p. 18.

Table 5-2
Summary of TDM Programs in the I-84 Corridor Study Area

State Programs	™ Park-and-Ride Lots ™ Motorist Information Systems
MetroPool TDM Programs	Areawide Programs ™ Ridematching for carpools and vanpools ™ Personalized commute consultations ™ *Commuter's Register* – newsletter for commuters with ridematching classified ads ™ Marketing and Transportation Events Employer-Based Programs ™ Consultation and Technical Assistance ™ Employer-based ridematching ™ Employer shuttles to transit ™ Guaranteed Ride Home Programs ™ On-site transportation events ™ Marketing and commuter information for employers and employees – Information Kiosks – Marketing brochures – Transit schedules – "Smart Guides" – tips for employers – *Commuter Connections* – newsletter for employers ™ Employee Transportation Coordinator Training ™ Employee Incentive Programs
State and Federal Incentive Programs	State Programs Implemented by MetroPool areawide and through employers ™ Matching subsidy for transit and vanpools ™ TDM Tax Credit for Employers ™ Vanpool startup subsidies – Leasing subsidy – Seat subsidy ™ Vanpool Demonstration Project ™ The Ride Stuff Federal "Commuter Choice" Incentive Programs Implemented by MetroPool through employers ™ Qualified Transportation Fringes – Tax-free transit, vanpool and parking subsidies – Pre-tax transit, vanpool and parking benefits – Combination of tax-free subsidy and pre-tax benefits ™ Parking Cash-out

South Western Regional Planning Agency (SWRPA) and HVCEO are in the process of evaluating transit and TDM strategies that can be implemented in the Route 7 and I-95 corridors that may have impact on the I-84 study area. To meet the challenge of further trip reductions in both of these corridors, MetroPool is taking a number of actions. Under new leadership, MetroPool is shifting toward a policy of more active engagement with both business and government and a more pronounced focus on results. Using the new pre-tax transportation benefits created by TEA-21 as an entrée to work more closely with employers, MetroPool is taking a number of steps to ensure implementation of its programs on a broader basis. These include:

- Closer ties with employers
- Stronger outreach to employees
- Better communication among players in the transportation arena
- Forging closer relationships with the MPOs in its service area

Details of MetroPool's activities are described in the Appendix to this report.

Existing Park-and-Ride Lot Inventory

Park-and-ride lots are an important adjunct to successful TDM programs as they provide points of access to high occupancy vehicles, such as carpools, vanpools and bus transit. Since 1973, ConnDOT has been building park-and-ride lots on major roadways in the state to serve the needs of commuters who rideshare or use transit. ConnDOT currently operates and maintains eight commuter park-and-ride lots along I-84 corridor in the study area, which are summarized in Table 5-3.

The state is currently adding spaces to the existing park-and-ride lot inventory, where needed. However, ample capacity appears to exist in the lots in the I-84 corridor.

I-84 Corridor TDM: Overall Effectiveness in Reducing I-84 Demands

There are a number of TDM activities and strategies being pursued in southwestern Connecticut and along the Route 7 and I-95 corridors. However, several could cause a ripple effect and affect future trips on I-84. First, MetroPool is enhancing its presence with employers in the entire region, not just in the I-95 corridor. This includes New York, which is a magnet for many work-trips that use the I-84 corridor. Second, MetroPool's potential to affect commuting behaviors is strengthened by new federal incentives, which will be implemented through employers region-wide in Connecticut and New York. New state incentives will also be implemented region-wide. Connecticut has a much more comprehensive set of TDM incentive programs than are found in most states and is working more aggressively than most states to find creative ways to market "Commuter Choice" incentives to employers. Finally, at least some of the commute trips directly affected by the I-95 corridor plans and New York commuter options are trips that traverse the I-84 corridor, particularly between Exits 4 and 7, where I-84 and Route 7 overlap.

Table 5-3
Summary of Park-and-Ride Lots in the I-84 Corridor Study Area

I-84 Exit	Town	Location	Mode	Amenities	Cost	Spaces	Usage (1998)[1]
	Bethel	Durant Avenue, RRS	Rail, Local Bus, Rideshare	PLTS	no fee	199	111
Exit 1	Danbury	Route 6	Brewster Shuttle, Rideshare	PLTS	no fee	160	19
Exit 2	Danbury	Routes 6 & 202	Brewster Shuttle, Rideshare	PLS	no fee	112	32
	Danbury	Miry Brook Rd. at Rt. 7	Rideshare	PLT	no fee	171	16
Exit 4	Danbury	Segar Street	Local Bus, Rideshare	LT	no fee	50	6
	Danbury	Patriot Drive, RRS	Rail	PLTS	no fee	140	40
Exit 7	Danbury	Federal Road	Brewster Shuttle, Local Bus, Rideshare	PLT	no fee	115	12
	Danbury	White Turkey Road	Brewster Shuttle, Rideshare	PL	no fee	75	24
Exit 9	Newtown	Route 25	Rideshare	PLT	no fee	53	47
Exit 11	Newtown	Route 34 at Mile Hill Road	Rideshare	PLT	no fee	78	45

Source: Connecticut Department of Transportation, Intermodal Planning
Key to Codes: P – Paved T – Telephone RRS – Railroad Station
L – Lighted S – Shelter

1 Utilization counts provided by ConnDOT

While the above discussion argues for general optimism regarding increased trip reductions from TDM, several factors limit the potential for TDM to reduce trips in the I-84 corridor. These include the lack of transit options and the difficulty of providing HOV facilities in the corridor (as described later in this chapter). In addition, the low population density in the towns north of I-84, which feed employment centers to the south and west, makes ridematching more difficult. Also, and importantly, commuter parking at employer sites throughout the study area is generally available and free of charge.

It would therefore be reasonable to assume that an aggressive areawide TDM in the I-84 corridor might achieve a 1 to 2 percent reduction in future trip making, given national experience. (The total package of transit and TDM strategies designed for the I-95 corridor are expected to achieve a 5 percent reduction in vehicle trips over five years.) While beneficial to the environment and to employers of the region, this level of TDM effectiveness will not be sufficient to address the long-term capacity shortfall along the I-84 corridor, where demands by 2025 are projected to exceed corridor capacity by 30 to 40 percent.

5.2.3 Diversions to Alternative Routes

An undesirable, but real, consequence of deteriorating traffic conditions along the I-84 corridor is the increased potential for traffic to divert to local arterials and streets. This is happening today and was articulated as a real concern of communities adjacent to the corridor. One example expressed by the Advisory Committee is the use of Route 25 through the center of Newtown when traffic on I-84 eastbound breaks down between Exits 8 and 9 (where the cross-section drops from three lanes to two lanes). In this instance, motorists depart I-84 at Exit 9 (instead of Exits 10 or 11) and use Route 25 to bypass the delay.

There are very few good alternate routes for regional travel through the study area. Most roads adjacent to the I-84 corridor are either relatively rural, two-lane highways or residential streets. The most vulnerable roadways for traffic diversions are the Route 6/202 corridor from Exits 2 to 4, and the Route 6/25 corridor from Exit 8 to Exit 10. Neither corridor is prepared to absorb the potential traffic diversions from I-84 in the future. The Lake Avenue section of Route 6 from Exit 4 to Kenosia Avenue is in need of a widening to 4 or 5 lanes (currently under design); however, this improvement is not currently planned to carry through to the Exit 2 interchange. There are no current plans for widening Route 6/25 through Bethel and Newtown. Parts of this corridor travel through sensitive residential and historic areas where the further intrusion of cut-through traffic is likely to be adamantly opposed.

5.3 Alternatives to Increase Capacity

Another option to address the long-term needs identified along the corridor is implementing mainline widening to provide an additional general purpose lane along I-84. An engineering and impact review of this option focused on both the eastbound and westbound directions of the interstate from Danbury at the New York State Line to the Housatonic River in Newtown. The traffic information previously presented in Chapter 2 (Existing Conditions) and Chapter 3 (Future Conditions) demonstrated the need for widening the mainline to address existing congestion and accommodate anticipated over-capacity conditions during the projected 2025 design year.

In order to present a complete analysis of the corridor (recognizing that each link exhibits unique characteristics), the I-84 corridor was divided into 12 sections with these sections further evaluated by eastbound and westbound direction. In total, the widening options associated with 24 sections of the interstate study corridor were reviewed as part of this effort.

5.3.1 Approach to Mainline Widening Alternative Analysis

The objective of this task is threefold: first, to identify through a review of the existing and projected traffic volumes along I-84 those segments that warrant additional capacity; second, to review if an additional general purpose lane can provide a safe and efficient solution to the capacity constraints; and finally, to determine the design and potential implementation issues associated with the addition of lane capacity along the interstate system.

The first step was to develop criteria to be used to analyze the current and projected traffic volumes along I-84 to determine whether the traffic volumes warrant additional capacity. Both standard level-of-service (LOS) analysis and forecasted traffic volume data developed by ConnDOT are used to determine the levels of current and potential congestion at each location. By identifying the varying demands and level of service over the roadway sections, it is possible to determine if and where the roadways are operating at capacity.

The next step focuses on the potential ways to physically add capacity to the interstate and the current design standards necessary for the interstate to operate safely and efficiently.

The final task combines the previous two steps to determine, on a segment-by-segment basis, whether a new travel lane is both justified and how it can be accommodated. The cross-section, issues associated with bridges, and other physical obstructions, ramp and roadway impacts, and environmental considerations were reviewed to determine whether the geometry of the existing I-84 can accommodate an additional lane and the level of impacts. A qualitative and quantitative discussion is provided to assist in determining where, and if, a new lane should be considered.

5.3.2 Locations Warranting Additional I-84 Mainline Capacity

The criteria used to determine if a segment was a candidate for widening focused on the projected operating conditions in the 2025 design year. A segment was identified as a preliminary candidate for mainline widening where either the morning or evening peak hour operations was projected to operate at LOS F and where the volume-to-capacity (v/c) ratio was projected to exceed 1.00.

Table 5-4 illustrates the morning and evening peak hour operations for the current and projected mainline conditions under the existing geometric configuration of I-84. As the table shows, 19 of the 24 segments are projected to operate at or above capacity in the 2025 design year and warrant consideration of additional mainline capacity. Furthermore, an additional four of the segments are expected to operate at LOS E during the 2025 design year, including the two freeway segments in the tightly congested Exit 3 and 4 area and the two freeway segments between Exits 2 and 3 (which are already three lanes in each direction). Only one segment,

westbound between Exit 2 and Exit 1, does not approach or exceed the capacity criteria.

Table 5-4
Identification of Freeway Segments Warranting Added Capacity

	Eastbound					Westbound				
	Existing		Future (2025)		Need Additional	Existing		Future (2025)		Need Additional
Segment	V/C	LOS	V/C	LOS	Capacity?	V/C	LOS	V/C	LOS	Capacity?
New York to Exit 1										
AM	0.51	C	0.70	C	Yes	0.79	D	1.07	F	Yes
PM	0.80	D	1.08	F		0.69	C	0.94	E	
Exit 1 to Exit 2										
AM	0.50	C	0.68	C	Yes	0.52	D	0.70	D	No
PM	0.82	D	1.10	F		0.43	C	0.59	C	
Exit 2 to Exit 3										
AM	0.31	B	0.43	B	No	0.69	C	0.97	E	No
PM	0.66	C	0.92	E		0.43	B	0.60	C	
Exit 3 to Exit 4										
AM	0.31	B	0.43	B	No	0.67	D	0.91	E	No
PM	0.70	D	0.97	E		0.43	B	0.58	C	
Exit 4 to Exit 5										
AM	0.47	C	0.64	C	Yes	1.02	C	1.39	F	Yes
PM	1.01	F	1.38	F		0.70	B	0.95	E	
Exit 5 to Exit 6										
AM	0.46	C	0.63	C	Yes	0.87	F	1.17	F	Yes
PM	0.85	E	1.15	F		0.69	D	0.94	E	
Exit 6 to Exit 7										
AM	0.60	C	0.83	D	Yes	1.01	E	1.38	F	Yes
PM	1.02	F	1.39	F		0.86	D	1.15	F	
Exit 7 to Exit 8										
AM	0.89	E	1.25	F	Yes	1.12	F	1.57	F	Yes
PM	1.22	F	1.71	F		1.04	E	1.45	F	
Exit 8 to Exit 9										
AM	0.66	C	0.92	D	Yes	1.05	F	1.47	F	Yes
PM	1.07	F	1.50	F		0.81	F	1.12	F	
Exit 9 to Exit 10										
AM	0.66	C	0.91	D	Yes	1.00	F	1.39	F	Yes
PM	0.99	E	1.38	F		0.81	D	1.12	F	
Exit 10 to Exit 11										
AM	0.65	C	0.91	D	Yes	0.96	E	1.34	F	Yes
PM	0.99	E	1.38	F		0.76	D	1.06	F	
Exit 11 to River										
AM	0.59	C	0.82	D	Yes	0.87	E	1.22	F	Yes
PM	0.92	E	1.29	F		0.74	D	1.02	F	

5.3.3 Engineering Considerations for Widening I-84

Once a segment was determined to be a preliminary candidate for widening, the next step was to determine the design criteria for the addition of a lane and investigate how the widening could occur. There are a number of engineering issues which were taken into consideration as part of this task.

Design Criteria

Provision of additional mainline capacity along I-84 with a general purpose lane, whether in the median or through widening of the shoulders, must meet certain overall design criteria. The typical sections considered for adding additional capacity and improving safety along I-84 are shown in Figures 5-2, 5-3, and 5-4 for the four-lane, six-lane, and ramp facilities. The key design criteria used in reviewing the engineering feasibility of widening I-84 are also briefly discussed below.

Roadway Cross-Section

The current I-84 roadway cross-section will need to be widened to accommodate the locations where new lanes are considered. The American Associations of State Highway Transportation Officials (AASHTO) and the Connecticut Department of Transportation (ConnDOT) Highway Design Guide provide many of the guidelines. The recommended mainline travel lane is 3.6 meters (12 feet) wide and the desirable shoulder width is 3.6 meters, given the volume of heavy trucks on the I-84 corridor.

Bridge Structures

One critical issue along the corridor that needs to be evaluated is the impact that widening has on bridge structures. In total, there are 61 bridge structures along the study area corridor, as defined in the Appendix to this report. While the majority of the structures cross over roadways, several rivers and railroad track crossings will require special consideration when contemplating roadway widening. Should an additional lane (or lanes) be added to the I-84 mainline, many of the bridge structures will need to be reconstructed to provide adequate lane and shoulder width. As part of this study, each bridge along the I-84 corridor was evaluated to determine if the existing bridge was wide enough to carry an additional lane of traffic without being modified. If the structure requires widening, the bridge was reviewed to determine if it could be widened simply by addition of a new lane or if the bridge needed to be completely reconstructed to accommodate the widened mainline cross-section.

Clear Zones

The availability of an effective clear zone along the outside shoulder of I-84 will need to be considered when determining the impacts of adding an additional lane. The

clear zone is defined as the area free of obstructions adjacent to the travel lane (which includes the shoulder). Clear zones are provided along major roadways to provide a driver the opportunity to recover control of a vehicle that has left the paved roadway, or to stop in case of an emergency. Generally, these clear zones should be 9.0 meters (approximately 30 feet) for a freeway section similar to I-84 (wherever practical) and the slopes should be no greater than a 1:4 ratio.

Design Approach

There are several design approaches to the widening and many considerations in determining whether or not it is feasible to widen the I-84 corridor through the study area, as described below.

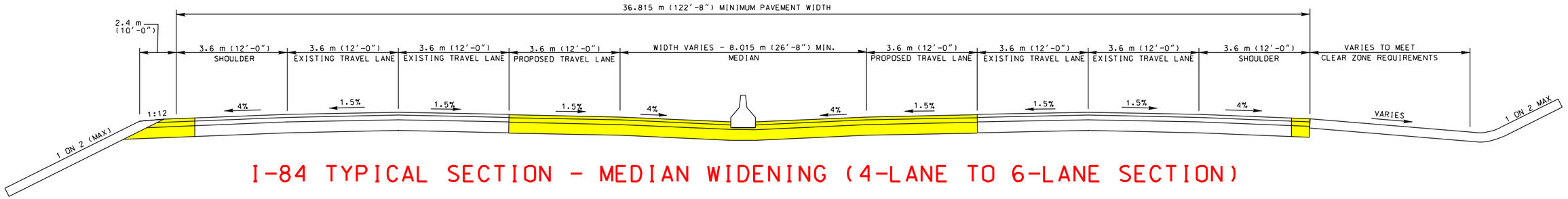
Median Widening

Median widening to accommodate an additional lane, if possible, is often the preferred option as it typically has the least impact to the surrounding property, ramp systems, and roadways. Additionally, widening into the median typically does not impact abutters, which makes this option more viable from the public's perspective. However, there are locations along I-84 where widening has already occurred and the median consists of only a concrete barrier between the eastbound and westbound directions. In these locations, it is not possible to widen at all into the median. Along many other segments of I-84, there are pinch points where the median narrows to a width insufficient to accommodate the full extent of widening necessary. Other issues potentially affecting the determination of a widening strategy include the impact to bridge structures (which typically provide an abutment or a bridge pier within the median), the impact to existing stormwater management areas, aesthetics, and wetland resource impacts.

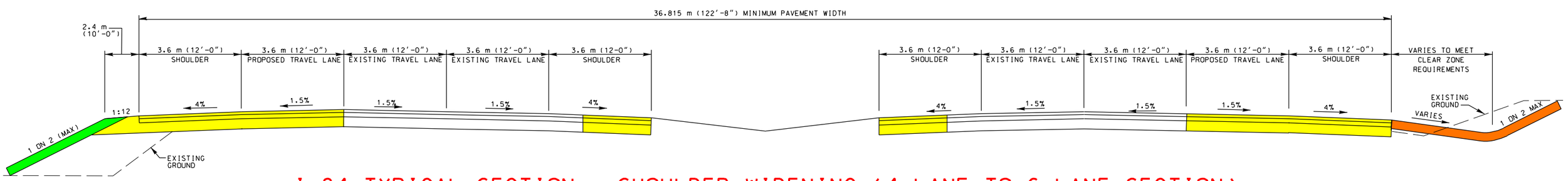
Shoulder Widening

Widening beyond the outside shoulder is a potential solution that exists along virtually the entire I-84 corridor within the study area. When considering shoulder widening, it is important to take into account the impacts to the existing ramp system at various interchanges, abutting properties, and account for the grades of the land surrounding the roadway. Additionally, in areas of higher development, widening onto the outside shoulder can impact buildings and roadways adjacent to the mainline. Whether or not a roadway directly impacts adjacent property, bringing a highway closer to these developments is generally perceived by the public as a negative impact. Shoulder widening also has the potential to impact stormwater management and wetland resource areas that exist outside the highway pavement area.

I-84 TYPICAL SECTION - EXISTING 4-LANE SECTION WITH WIDE MEDIAN



I-84 TYPICAL SECTION - MEDIAN WIDENING (4-LANE TO 6-LANE SECTION)



I-84 TYPICAL SECTION - SHOULDER WIDENING (4-LANE TO 6-LANE SECTION)

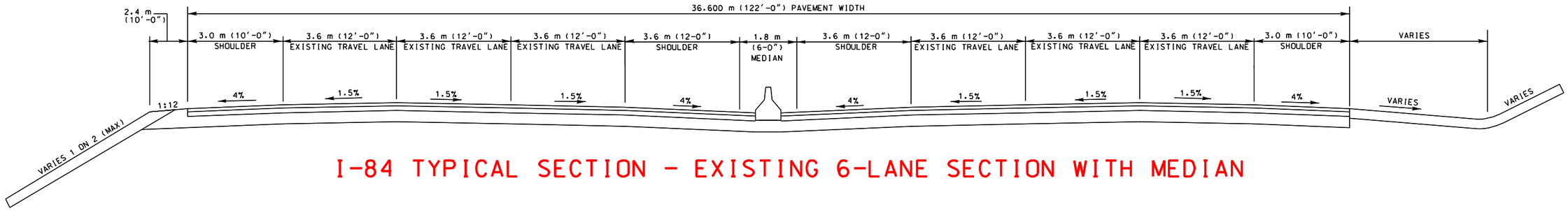
LEGEND

- PROPOSED TRAVEL WAY
- PROPOSED CUT SLOPE
- PROPOSED FILL SLOPE
- EXISTING ROADWAY

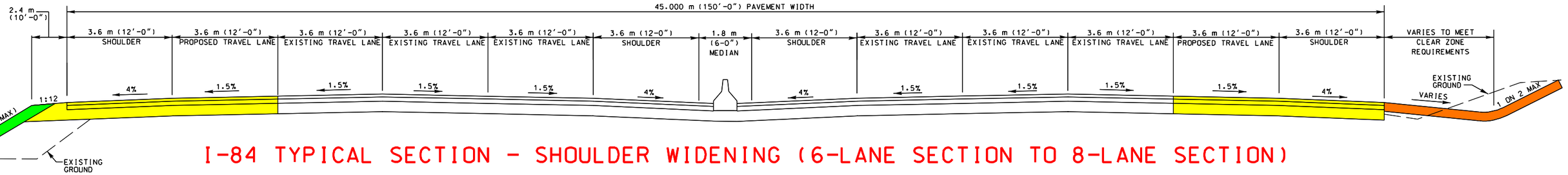
I-84 Exits 1-11

Figure 5-2

Conceptual Typical Sections
For Capacity Improvements:
4-Lane Section to 6-Lane Section



I-84 TYPICAL SECTION - EXISTING 6-LANE SECTION WITH MEDIAN



I-84 TYPICAL SECTION - SHOULDER WIDENING (6-LANE SECTION TO 8-LANE SECTION)

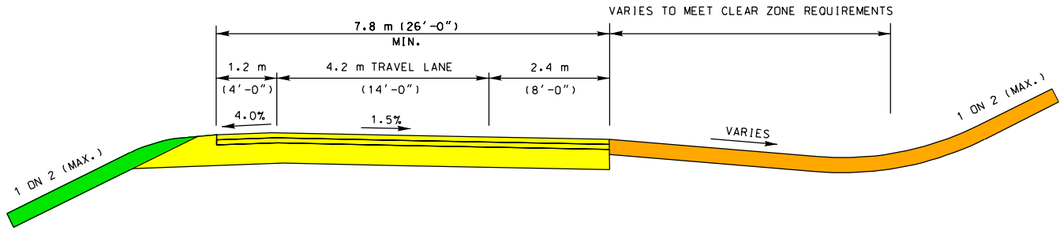
LEGEND

- PROPOSED TRAVEL WAY
- PROPOSED CUT SLOPE
- PROPOSED FILL SLOPE
- EXISTING ROADWAY

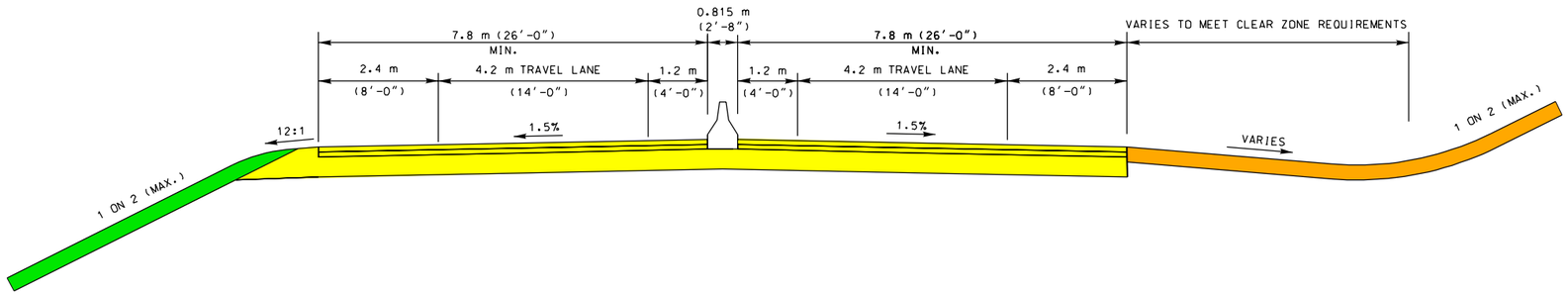
I-84 Exits 1-11

Figure 5-3

Conceptual Typical Sections
For Capacity Improvements:
6-Lane Section to 8-Lane Section



I-84 TYPICAL RAMP SECTION - ONE-WAY, ONE-LANE RAMP



I-84 TYPICAL RAMP SECTION - ABUTTING ONE-WAY, ONE-LANE RAMPS

LEGEND

- PROPOSED TRAVEL WAY
- PROPOSED CUT SLOPE
- PROPOSED FILL SLOPE

I-84 Exits 1-11

Figure 5-4

Conceptual Typical Sections
For Capacity Improvements:
Ramp Facilities

Other Issues to Consider

There are a number of other critical issues to consider when contemplating widening of a highway, including:

- **Environmental –** The presence of environmental constraints needs to be evaluated when considering widening each segment of I-84. With current regulations now in place to protect environmental resources, it is important to consider these areas when discussing mainline widening impacts. Typical areas of impact include the medians, where stormwater management areas and wetland resources are typically impacted. River crossings and wetland areas running parallel to the interstate also need to be considered as part of the environmental review. Additionally, the study area has other socio-economic or cultural resources that need to be considered when considering mainline widening. Where possible these resources were identified and are presented for informational purposes in this preliminary review.

- **Land Use –** The impact the mainline widening has on the surrounding properties is an important consideration. This evaluation focuses generally on the impacts that mainline widening might have on buildings and structures abutting the mainline. At this point, a detailed determination of the level of right-of-way impacts or costs associated with the taking of these buildings was not completed.

- **Cut and Fill Sections –** In certain locations, widening the mainline will require cut and/or fill sections in order to accommodate the required cross-section. In these instances, the slopes need to be reviewed to determine the limit of these impacts. In certain instances, the slopes associated with the cut or fill sections may affect adjacent properties.

- **Ramps and Acceleration/Deceleration Lanes –** As previously presented in Chapter 2 of this report, there are a number of acceleration/deceleration lanes which need to be modified to meet current design standards/criteria. If an additional lane were to be provided along I-84, it is likely that the ramp systems will need to be reconfigured to meet the wider mainline geometry. These impacts are considered in the next chapter of this report.

- **Slow Vehicle Lanes –** There are several locations where slow vehicle lanes exist along the I-84 corridor to minimize motorist' delays due to the slower speeds of the trucks in areas of steep grades. As part of this analysis of mainline widening, slow vehicle lanes will be retained where they currently exist.

5.3.4 Analysis of Mainline Widening Options/Impacts

This section summarizes the issues associated with each of the 24 roadway segments of I-84 with respect to adding new lane(s) along the corridor. Additional detail concerning the impacts associated with the widening into the median and shoulders are provided in the Appendix to this report. Table 5-5 provides a summary of the existing right-of-way and cross-sectional features of each segment within the I-84 corridor.

It was found that the mainline widening to add capacity along I-84 was generally feasible within the available right-of-way. A description of issues associated with each segment of the corridor is provided below. Further details of the design approach and the assumptions that were made are provided in the Appendix. It should be noted that strategies to add capacity to the mainline are also dependent on the recommendations for interchange-specific improvements. As this study progresses and its recommendations are implemented, it will be important to integrate the individual improvements at the interchanges with improvements to the mainline in the development of an overall corridor improvement plan.

Table 5-5
Add-a-Lane Improvement Alternative (Exit 1 to Exit 11)
I-84 Existing Right-of-Way and Cross-Sectional Features

I-84 Segmemt	Length (km)	Approximate Right-of-Way Width m (Feet)	Number of General Purpose Lanes		Approximate Median Width m (feet)
			Eastbound	Westbound	
NY Line to Exit 1	0.37	1246 (380)	2	2	112 (34)
Exit 1 to Exit 2	1.71	984 (300)	2	3	13-112 (4-34)
Exit 2 to Exit 3	3.25	656-820 (200-250)	3	3	13 (4)
Exit 3 to Exit 4	0.61	820 (250)	4	4	197-328 (60-100)
Exit 4 to Exit 5	2.41	820 (250)	3	3	20 (6)
Exit 5 to Exit 6	0.89	918 (280)	3	3	20 (6)
Exit 6 to Exit 7	2.78	722-820 (220-250)	3	3	20 (6)
Exit 7 to Exit 8	1.56	820 (250)	2*	2	128-656 (39-200)
Exit 8 to Exit 9	4.81	820 (250)	2*	2*	20-121 (6-37)
Exit 9 to Exit 10	6.26	984 (300)	2*	2*	102-282 (31-86)
Exit 10 to Exit 11	1.39	1640 (500)	2*	2	328 (100)
Exit 11 to Housatonic	3.61	1410 (430)	2*	2*	328 (100)

* Not including the presence of a slow vehicle lane through portions of this segment.

New York State Line to Exit 1

This short segment currently provides two general purpose travel lanes and adequate shoulder width for the entire section. The addition of a new lane could be implemented within the median or along the shoulder and would provide improvement to the over-capacity condition projected to exist along this segment. Widening this section would require coordination with the New York Department of Transportation (NYDOT) to maximize operational benefit as I-84 exits from New York with only two lanes. It should be pointed out that NYDOT currently has no plans or studies underway to improve this section of I-84. The bridge structure located at the Exit 1 interchange would need to be modified to accommodate any widening either into the median or into the shoulder.

Exit 1 to Exit 2

This segment currently provides two general purpose lanes and adequate shoulder width. The addition of a new lane could be implemented within the median or along the shoulder and would provide improvement to the over-capacity condition projected to exist along this segment. The bridge structure located at the Exit 2 interchange would need to be modified to accommodate widening either into the median or into the shoulder.

Exit 2 to Exit 3

This segment currently provides three general purpose lanes and adequate shoulder width for its entirety. This section is projected to operate under capacity during both the morning and evening peak hours through the year 2025. Since this segment does not meet the criteria for adding capacity, no improvements were considered.

Exit 3 to Exit 4

This segment currently provides two travel lanes through the Exit 3 interchange and two lanes exiting to Route 7 southbound, then adds an additional two lanes where Route 7 northbound merges with I-84 prior to Exit 4. This segment does not meet the criteria for adding capacity; however, the addition of a lane to this section is under consideration as part of the interchange improvements to provide lane continuity along I-84. The improvement options being contemplated at the Exit 3/4 interchange to address overall interchange operations will significantly influence the direction of how best to provide an additional lane, if needed, to this segment, and, as a result, no additional lane is included in this analysis.

Exit 4 to Exit 5

This segment currently provides four travel lanes through the Exit 4 interchange and drops down to three travel lanes for the remainder of the segment past Exit 5. Operations along this section could benefit by the addition of new capacity. The addition of a new lane could be implemented only along the shoulder as the mainline has previously been widened into the median. Widening the mainline into the shoulder would impact four bridge structures along the segment.

Exit 5 to Exit 6

This segment currently provides three general purpose lanes. The addition of a new lane would provide improvement to the over-capacity condition projected to exist along this segment during the evening peak period. The addition of a new lane could be implemented only along the shoulder as the mainline has previously been widened into the median. Widening the mainline into the shoulder would impact one bridge structure along this section.

Exit 6 to Exit 7

This segment currently provides three general purpose lanes. An additional lane would improve the operating conditions through this section. The addition of a new lane could be implemented only along the shoulder as the mainline has previously been widened into the median. Widening the mainline into the shoulder would impact three bridge structures along this section.

Exit 7 to Exit 8

This segment currently provides two general purpose lanes through the Exit 7 interchange and adds a third lane where Route 7 southbound merges onto I-84 at Exit 7. An additional general purpose lane would improve the operating conditions through this section. It should be noted that consideration of a frontage road eastbound in connection with improving operations at Exit 7 and Exit 8 would address this capacity shortfall and could negate the need for mainline capacity altogether. The addition of a new lane could be implemented along the shoulder for the entire length of the segment or could be implemented through the Exit 7 interchange within the median. Widening of the mainline exclusively into the median is precluded in the vicinity of Exit 8, as there is no room for this improvement. Widening the mainline into the shoulder or median would impact four bridge structures.

Exit 8 to Exit 9

This segment currently provides three lanes of traffic for approximately 1.35 miles beyond Exit 8 then narrows down to two lanes for the remainder of the segment. The addition of a new lane would provide improvement to the over-capacity condition projected to exist along this segment during the evening peak period. The addition of a new lane would need to be implemented along both the median and shoulder for

the entire length of the segment as there is only minimal room to widen into the median. Widening the mainline into the shoulder would impact three of five bridge structures along the segment. The other two bridges currently have a three-lane cross-section with an operational or slow vehicle lane over them and would also require modification to create a four-lane bridge.

Exit 9 to Exit 10

This segment currently provides 2 lanes for general purpose traffic for its entire length. Approximately half way through the segment, I-84 widens to three lanes to provide a slow vehicle lane on an uphill grade. The addition of a new lane would provide improvement to the over-capacity condition projected to exist along this segment during the evening peak period. The addition of a new lane would need to be implemented along the median and shoulder for the entire length of the segment. Widening the mainline into the median or shoulder would impact six bridge structures along this section including a rail crossing.

Exit 10 to Exit 11

This segment currently provides two general purpose lanes of traffic through the Exit 10 area and adds a third lane when the on-ramp from Exit 10 enters I-84 for the remainder of the segment. The addition of a new lane would provide improvement to the over-capacity condition projected to exist along this segment during the evening peak period. Widening the mainline into the median or shoulder would impact one bridge structure at the Exit 10 interchange. The addition of a new lane could be implemented along the median or shoulder for the entire length of the segment.

Exit 11 to Housatonic River

This segment currently provides 2 general purpose lanes of traffic from the Exit 11 interchange to the Housatonic River crossing. The addition of a new lane would provide improvement to the over-capacity condition projected to exist along this segment during both the morning and evening peak periods. The new lane could be implemented along the median or shoulder for the entire length of the section. Widening the mainline into the median or shoulders would impact four bridges. Improvements to this corridor segment would have to be transitioned to tie into the previously widened median across the Rochembeau Bridge, and coordinated with plans for I-84 to the east to gain the needed operational benefits from the widening.

I-84 Mainline Widening: Summary of Westbound Issues

Housatonic River to Exit 11

This segment currently provides two general purpose lanes of traffic from the Housatonic River crossing to the Exit 11 interchange. The addition of a new lane

would provide improvement to the over-capacity condition projected to exist along this segment during the evening peak period. The addition of a new lane could be implemented along the median or shoulder for the entire length of the segment. Widening the mainline into the median would impact six bridge structures and widening into the shoulder would only impact four structures. As previously mentioned, the design of this section must consider that the median has already been widened to accommodate a third lane across the Housatonic River.

Exit 11 to Exit 10

This segment currently provides two general purpose lanes of traffic through the Exit 11 interchange and adds a third auxiliary lane when the on-ramp from Exit 11 enters I-84 to the Exit 10 interchange. This section would need the addition of a new lane to provide improvement to the over-capacity condition projected to exist along this segment during both the morning and evening peak periods. The addition of a new lane could be implemented along the median or shoulder for the entire length of this section. Widening the mainline into the median or shoulder would impact one bridge structure at the Exit 11 interchange.

Exit 10 to Exit 9

This segment currently provides two general purpose lanes for the entire section. Approximately midway through the segment, I-84 provides a third slow vehicle lane for approximately 2,500 feet. The addition of a new lane would provide improvement to the over-capacity condition projected to exist along this segment during both the morning and evening peak periods. The widening would be implemented along both the median and shoulder for the entire length of the segment. Widening the mainline into the median would impact six bridge structures along the segment and widening into the shoulder would impact seven structures. There do not appear to be any land uses issues associated with either of the widening options.

Exit 9 to Exit 8

This segment currently provides two general purpose lanes of traffic for the majority of the segment. The addition of a new lane would provide improvement to the over-capacity condition projected to exist along this segment during both the morning and evening peak periods. The addition of a new lane would need to be implemented along both the median and shoulder for the entire length of the corridor, although there is only minimal room to widen into the median near the Exit 8 interchange. Widening the mainline into the shoulder would impact two bridge structures along the segment.

Exit 8 to Exit 7

This segment currently provides three lanes of traffic from the Exit 8 interchange through the Exit 7 interchange where one lane heads to Route 7 northbound and two

lanes continue along I-84 westbound. The addition of a new lane could be implemented along the shoulder for the entire length of the section or could be implemented through the Exit 7 interchange within the median, except in the vicinity of Exit 8 where there is no room in the median for this improvement. The addition of a new lane would provide improvement to the over-capacity condition projected to exist along this segment during both the morning and evening peak periods. Widening the mainline into the shoulder or median would impact three bridge structures. As mentioned previously, the improvement options being contemplated at the Exit 8/7 interchange to address overall interchange operations will significantly influence the direction of how best to provide additional capacity to this segment of the corridor.

Exit 7 to Exit 6

This segment currently provides three general purpose lanes. An additional lane would improve the operating conditions through this section. The addition of a new lane could be implemented only along the shoulder as the mainline has previously been widened into the median. Widening the mainline into the shoulder would impact three bridge structures along this section.

Exit 6 to Exit 5

This segment currently provides three general purpose lanes. The addition of a new lane would provide improvement to the over-capacity condition projected to exist along this segment during the evening peak period. The new lane could be implemented only along the shoulder only as the mainline has previously been widened into the median. Widening the mainline into the shoulder would impact two bridge structures along the corridor. The improvement options being contemplated at the Exit 6/5 interchanges to address overall interchange operations may influence the direction of how best to provide additional capacity to this segment of the corridor.

Exit 5 to Exit 4

This segment currently provides three travel lanes through the Exit 4 interchange and widens to four lanes approaching the Exit 3 interchange. This section would benefit by the addition of new capacity through this segment. An additional lane would improve the operating conditions through this section. The addition of a new lane could be implemented only along the shoulder as the mainline has previously been widened into the median. Widening the mainline into the shoulder would impact four bridge structures along the segment.

Exit 4 to Exit 3

This segment provides four lanes from the Exit 4 area to where two lanes exit to Route 7 southbound. From this point, I-84 carries only two general purpose lanes through the Exit 3 interchange and provides an additional lane where Route 7

northbound merges with I-84 westbound. This segment does not meet the criteria for adding capacity, however, the addition of a lane may be needed to provide lane continuity along I-84 by providing three lanes from the westbound Exit 5/4 section along into the Exit 3/2 section. This widening could be accommodated within the median or the shoulder. As mentioned previously, consideration should be given to the improvement options being contemplated at the Exit 3/4 interchange area as they will likely influence any decision on how to provide an additional lane to this segment of the corridor.

Exit 3 to Exit 2

This segment currently provides three general purpose lanes and adequate shoulder width for its entirety. This section is projected to operate at acceptable levels during both the morning and evening peak hours. Since this segment does not meet the criteria for adding capacity, no improvements were considered.

Exit 2 to Exit 1

This segment currently provides three general purpose travel lanes. This section is projected to operate under capacity during both the morning and evening peak hours. Since this segment does not meet the criteria for adding capacity, no improvements were considered.

Exit 1 to New York State Line

This short segment currently provides two travel lanes and adequate shoulder width for the section into New York. The addition of a new lane could be implemented within the median or along the shoulder and could provide improvement to the projected evening over-capacity condition. Widening this section would require coordination with the New York Department of Transportation (NYDOT) to gain any operational benefit as I-84 continues into New York with only two lanes. The bridge structure located at the Exit 1 interchange would need to be modified to accommodate any widening either into the median or shoulder.

I-84 Mainline Widening: Environmental Issues

The primary environmental concern for the I-84 mainline widening will be impacts to surface waters and wetlands. Because the widening along the corridor can be accommodated within the existing highway right-of-way, the other potential impact categories (*e.g.*, historic resources, Section 4(f) properties, farmland soils, etc.) will not be as much concern, simply because they are not present within the right-of-way.

There are thirty stream crossings within the project corridor. Many of these streams have wetlands and floodplains associated with them. The majority of the stream crossings in culverts are perpendicular to the I-84 mainline. There are, however, a number of locations where streams parallel the highway's toe-of-slope for some

distance. The longest of these locations is Tom Brook which parallels I-84 for approximately 1,980 meters (6,500 feet) just west of Exit 10 on the eastbound side. All of the streams within the project corridor, whether perpendicular or parallel to the mainline, could be affected by mainline widening.

The likelihood of affecting surface waters and wetlands will be greatest along those segments of the I-84 mainline where widening cannot be accommodated within the median. This is because streams within the median are already within cross culverts beneath the highway. Widening along the shoulders usually requires extending the highway's sideslopes, thereby causing encroachment into wetland beyond the existing toe-of-slope and requiring cross culverts to be lengthened.

The extent of wetland and stream loss from the I-84 mainline widening will depend largely on the feasibility of minimization measures such as steepening the roadway sideslopes and/or constructing retaining walls. Measures to minimize wetland impacts are typically studied and selected during the preliminary design and permitting phase of a project based on factors such as their effectiveness in reducing impacts, safety concerns, practicability, and cost. For purposes of estimating impacts at this stage of the study, we have assumed no minimization measures. Therefore, in areas where shoulders are to be widened up to 4.2 meters (14 feet) to provide a new 3.6 m (12-foot) travel lane and 3.6 m (12-foot) outside shoulder, we have assumed that wetland and stream encroachment will also be an additional 4.2 meters (14 feet).

The areas along the mainline that have the greatest potential for wetland and stream impacts are listed below. The Appendix to this report contains a matrix that presents more detailed information and describes the particular environmental issues along each segment of the corridor. It also includes preliminary estimates of potential wetland impacts based on unminimized "worst case" calculations in which the length of wetland crossed was multiplied by the width of the proposed widening to arrive at an area of wetland impact.

Notable areas that are likely to have surface water or wetland impact along the project corridor include the following.

- Between New York Line and Exit 1 – This section is within the watershed of a community reservoir and features a crossing of the Saw Mill River.
- Between Exits 1 and 2 – This section is also within the watershed of a community reservoir. An unnamed stream parallels the toe-of-slope on the eastbound side of I-84 for approximately 610 meters (2,000 feet) beginning just east of Exit 1.
- Between Exits 4 and 5 – Widening would impact a small wetland area associated with a tributary to Kahanza Brook near the midpoint of the segment.
- Between Exits 5 and 6 – Widening would have to take into account a crossing of the Kahanza Brook near Exit 5.

- Between Exits 6 and 7 - Widening would have to take into account two stream crossings (Padanaram Brook and Beaver Brook) and a long stretch (approximately 900 meters) of stream/wetland at the toe of slope along I-84 eastbound between the Great Plain Road underpass and Exit 7.
- Between Exits 7 and 8 - Route I-84 crosses the Still River and its associated wetlands for approximately 300 meters (1,000 feet) through this segment. The widening could also affect the 100-year floodplain of the Still River.
- Between Exits 8 and 9 – There are several wetlands present along the highway through this segment. Route I-84 crosses a wetland complex just west of Stony Hill Road/Old Hawleyville Road for approximately 300 meters (1,000 feet). I-84 then crosses through the southern portion of Bound Swamp in Brookfield for approximately 520 meters (1,700 feet). Just west of Exit 9, I-84 crosses Pogond Brook and its associated wetlands and floodplain for approximately 600 meters (2,000 feet). The majority of the wetlands are on the north side of I-84 (*i.e.*, westbound) between Exits 8 and 9.
- Between Exits 9 and 10 – Route I-84 crosses several small streams, that flow north under the roadway, and passes through a large wetland for approximately 550 meters (1,800 feet) in the vicinity of Tunnel Road. In the eastbound direction, Tom Brook flows parallel to I-84 at the roadway's toe-of-slope for approximately 1,980 meters (6,500 feet) between Hanover Road and Exit 10. This segment also partly overlies the sole source Pootatuck aquifer.
- Between Exits 10 and 11 – Widening would need to take into account crossing the Pootatuck River, and several smaller wetlands and stream crossings. This segment is also entirely within the Pootatuck sole source aquifer area. (The former Newtown Landfill has been identified as a potential hazardous waste site within the I-84 corridor just west of Exit 11).
- Between Exit 11 and the Housatonic River - Pole Bridge Brook flows parallel to I-84 either at the toe-of-slope or within the median for approximately 1,520 meters (5,000 feet). Widening into the shoulder would also take place within the 100-year flood plain of several rivers.

Additional environmental reviews may be warranted as selected actions are further developed.

I-84 Mainline Widening: Conceptual Construction Cost Estimates

Table 5-6 presents a breakdown of the order of magnitude construction costs associated with adding capacity and bringing the shoulder widths along the corridor up to standard. Additional detail on the costs, divided into major construction components, is provided in the Appendix to this report.

Table 5-6
I-84 Add-a-Lane Improvement Alternative (Exit 1 to Exit 11)
Conceptual Cost Estimate for Both Directions (No Interchanges)[1]

I-84 Segment	Length (km)	Total Construction Costs ($1,000s) I-84 Segment Totals
NY Line to Exit 1	0.37	$ 2,875
Exit 1 to Exit 2	1.71	4,530
Exit 2 to Exit 3	3.25	100
Exit 3 to Exit 4	0.61	2,480
Exit 4 to Exit 5	2.41	13,040
Exit 5 to Exit 6	0.89	7,680
Exit 6 to Exit 7	2.78	16,740
Exit 7 to Exit 8	1.56	16,100
Exit 8 to Exit 9	4.81	38,470
Exit 9 to Exit 10	6.26	30,220
Exit 10 to Exit 11	1.39	10,940
Exit 11 to Housatonic	3.61	15,950
Totals	29.65	$159,125

1 Includes costs associated with roadways, bridges, walls and culverts, signing and supports, roadway lighting, environmental mitigation, landscape items, traffic management, and miscellaneous items (15%). Does not include costs for right-of-way acquisition / demolition, engineering or construction inspection, or escalation to year of actual construction.

2 Costs reflect 1999 average unit bid prices.

Total construction costs, exclusive of costs for right-of-way acquisition/demolition, engineering, or construction inspection, is approximately $159 million. Development of the cost estimate is referenced to 1999 weighted unit bid prices. Cost projections for these I-84 improvements to some future year of implementation will be necessary to reflect interim inflation factors.

I-84 Mainline Widening: Feasibility of Providing an HOV Lane

In considering options to add capacity to the I-84 corridor, the question regarding what potential role, if any, HOV lanes might play in the future of I-84 is a logical one. As part of this study, the feasibility of HOV lanes were considered as part of the alternatives analysis. A summary of this analysis is provided in this section of the report with further details included in the Appendix to this report.

Design Approach

There are a number of different types of HOV facilities. They include concurrent (contiguous), separated, reversible, and contraflow facilities. Following is a description of the operational characteristics and issues associated with different types of HOV facilities.

Concurrent or Contiguous HOV Lanes operate adjacent to and in the same direction as the general purpose lanes. They are not separated from the general purpose lanes and HOV traffic is free to enter and exit the lane throughout the lane's length. Therefore, they offer a lower level of service, have higher violation rates by non-HOVs, and are more difficult to enforce than separated HOV facilities. Concurrent HOV lanes are, however, less expensive than other types of HOV facilities because they do not require the construction of barriers. Furthermore, because HOV traffic can enter and exit the lane at will, no special treatments are required at freeway interchanges. Concurrent HOV lanes can be implemented either by constructing an additional lane or by converting an existing general purpose lane to an HOV lane. They can be implemented adjacent to the median, or adjacent to the shoulder/breakdown lane. Concurrent HOV lanes can be used for either peak period or full-time use. Concurrent HOV facilities are normally implemented in locations with extreme right-of-way limitations or environmental constraints.

Separated median HOV Lanes are appropriate if sufficient median width exists, overhead and bridge structures do not require major reconstruction, and access to the HOV lanes is not needed at every interchange. Under this concept, both HOV lanes are located in the median, and are separated from one another and from the general purpose lanes.

Separated outside HOV Lanes are appropriate where median width is narrow, or where direct access to adjacent cross streets is desired. The HOV lanes are constructed on the outside of the highway, separated from the general purpose lanes. These lanes can often be constructed without impacting the existing general purpose lanes, if sufficient right-of-way is available.

Separated HOV lanes provide at least one lane of HOV traffic in each direction and are appropriate when the traffic directional split is fairly even. HOV facilities should be considered in both directions if the traffic directional split is less than 65 percent in the peak direction and more than 35 percent in the non-peak direction.[7]

Reversible HOV Lanes are added to a roadway to provide capacity in the peak direction, typically operating in one direction during the morning peak period and the opposite direction during the evening peak period. The facility must be closed to

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7 High Occupancy Vehicle (HOV) Guidelines for Planning, Design, and Operations, U.S. Department of Transportation, Publication No. DOT-T-91-17, June 1991.

entering traffic at some point during the day to allow all traffic to clear the lane(s) before the operating direction is reversed. Reversible HOV lanes generally are constructed in the center median and allow only limited ingress/egress from the lanes. Reversible operation is generally regarded as feasible where the traffic directional split is more than 65 percent in the heavier direction of flow. Again, if traffic is split fairly evenly (more than 35 percent in the non-peak direction) then it would be more appropriate to provide HOV capacity in both directions than in just the peak direction.

Contraflow HOV Lanes use excess capacity in the off-peak direction to relieve congestion in the peak direction. Basically, a lane in the off-peak direction is borrowed and converted temporarily to an HOV lane in the peak direction. Therefore, contraflow HOV lanes can be implemented without adding lanes to the freeway. This concept is typically used on multi-lane highways. Contraflow HOV lanes should always be separated from oncoming traffic in the off-peak direction. This separation is usually achieved with moveable barriers or removable pylons or stanchions; or by leaving an additional lane in the off-peak direction closed to traffic. The "Zipper Lane" on the Southeast Expressway (I-93) in Boston is an example of a contraflow HOV facility with a moveable barrier system. Again, contraflow HOV lanes are generally appropriate if the traffic directional split is 65 percent or more in the heavier direction of flow. Contraflow HOV lanes are not appropriate if significant congestion is expected to result in the off-peak direction due to the loss of lane (as it would in the case of I-84 through the study area).

Effectiveness of HOV Lanes in the I-84 Study Area

The HVCEO region has investigated the use of HOV lanes on I-84 as a strategy to increase high occupancy vehicle modes, such as carpools, vanpools and bus transit, and thus to reduce congestion and improve air quality. However, HVCEO decided, and this study concurs, that HOV lanes are not feasible on I-84 for several reasons, which include:

Lack of sufficient employment density in the corridor

Past experience has shown that there should be at least 50,000 jobs in a concentrated area to create a successful HOV facility, and the most successful HOV facilities serve areas with 150,000 or more jobs. The projected employment level for Danbury is 60,000 in 2020; however, these jobs are disbursed over a wide area and will not be concentrated in the city center.

Without this concentration of employment there are not sufficient common destinations to create a demand for high occupancy vehicles and transit. HOV facilities that primarily serve buses need 40 to 60 buses per hour (2000 to 2400 passengers) during peak to carry more people than the general-purpose lanes. As was discussed in Working Paper No. 1, this level of bus transit does not currently

exist in the corridor, and the region does not have plans to significantly increase bus transit capacity or reliance.

Lack of travel-time savings for high occupancy vehicles

Based on the literature, to attract new HOV riders, travel-time savings in the HOV lane must be at least 7 minutes—otherwise, there isn't sufficient savings to attract use of the lane. HVCEO determined that corridor congestion and corridor travel distances are not sufficient for an HOV facility to provide this level of travel-time savings.

Lack of suitable geometry on I-84 for HOV lanes

In its analysis, HVCEO found that the current geometry of the highway precludes the provision any type of HOV facility on I-84 without creating safety issues that would negate the potential advantages of the HOV lanes, specifically:

- **Concurrent HOV Lanes:** The limited right-of-way (ranging from 200 to 250 feet through Danbury) on I-84 would argue for the use of concurrent HOV lanes, utilizing an existing general purpose lane for the HOV. However, the existence of left and right hand interchange ramps make this option particularly problematic. In addition, there is not a sufficient number of high occupancy vehicles (buses, carpools or vanpools) to warrant eliminating a general purpose lane for use by HOVs.

- **Separated HOV Lanes:** The limited right-of-way and existing structures restrict the potential for separated HOV lanes, which generally require more space for adequate separation and/or addition of the HOV facility. The presence of left hand interchange ramps further complicates the design of separated HOV lanes as HOV traffic must either use the same interchange ramps as general purpose traffic, or must have separate ramps at all or selected interchanges.

- **Reversible or Contraflow Lanes:** The existence of left hand interchange ramps also poses problems for reversible or contraflow HOV lanes. More importantly, however, the traffic flows between Exits 4 and 7, where I-84 and Route 7 overlap, are too balanced to gain any benefit from a reversible or contraflow HOV facility. VHB found that, on average, 65 percent of morning peak-hour traffic is westbound and 58 percent of total evening traffic is eastbound. According to experience, reversible or contraflow lanes typically work best when 65 percent or more traffic is in the heavier direction. In addition, there are capacity constraints (Level-of-Service E/F conditions) projected along both directions of I-84 in the evening peak hour.

Conclusions Regarding Feasibility of HOV Lanes Along I-84

The existing right-of-way and highway configuration pose serious problems for all types of HOV facilities. Even if these impediments could be overcome through re-design of the highway, low employment densities and the lack of concentrated

travel-time savings would still argue against provision of an HOV facility on I-84. It should be pointed out that NYDOT currently has no plans or studies underway to implement an HOV lane along I-84, west of the study area. Given these difficulties, HVCEO concluded, and this study concurs, that building an HOV facility is not a feasible strategy for addressing congestion on I-84.

5.4 Summary of Mainline Alternatives Analysis

Growth along the I-84 study corridor is expected to continue as a result of economic growth in southwestern Connecticut, throughout the rest of the state, and New England. This conclusion is reinforced by I-84's strategic position in Connecticut's overall transportation system combined with the limited availability of viable alternative routes. Projected traffic volumes indicate that much of the study corridor will reach or exceed capacity within the next five years. By 2025, absent any action, projected demands would exceed the highway's capacity by as much as 50 percent.

The analysis of strategies to address the potential short-fall in capacity along I-84 in the future, either through demand reduction actions or capacity expansion options, generally concluded that:

With Regard to Demand:

- No new transit services are currently programmed in the study area.
- Expansion of existing transit services are projected to have a minimal effect on traffic demands on I-84 itself.
- An aggressive TDM program expansion in the region would likely only marginally reduce corridor traffic demands (on the order of 1 to 2 percent).
- Limited viable alternative routes exist for travel through the study corridor.

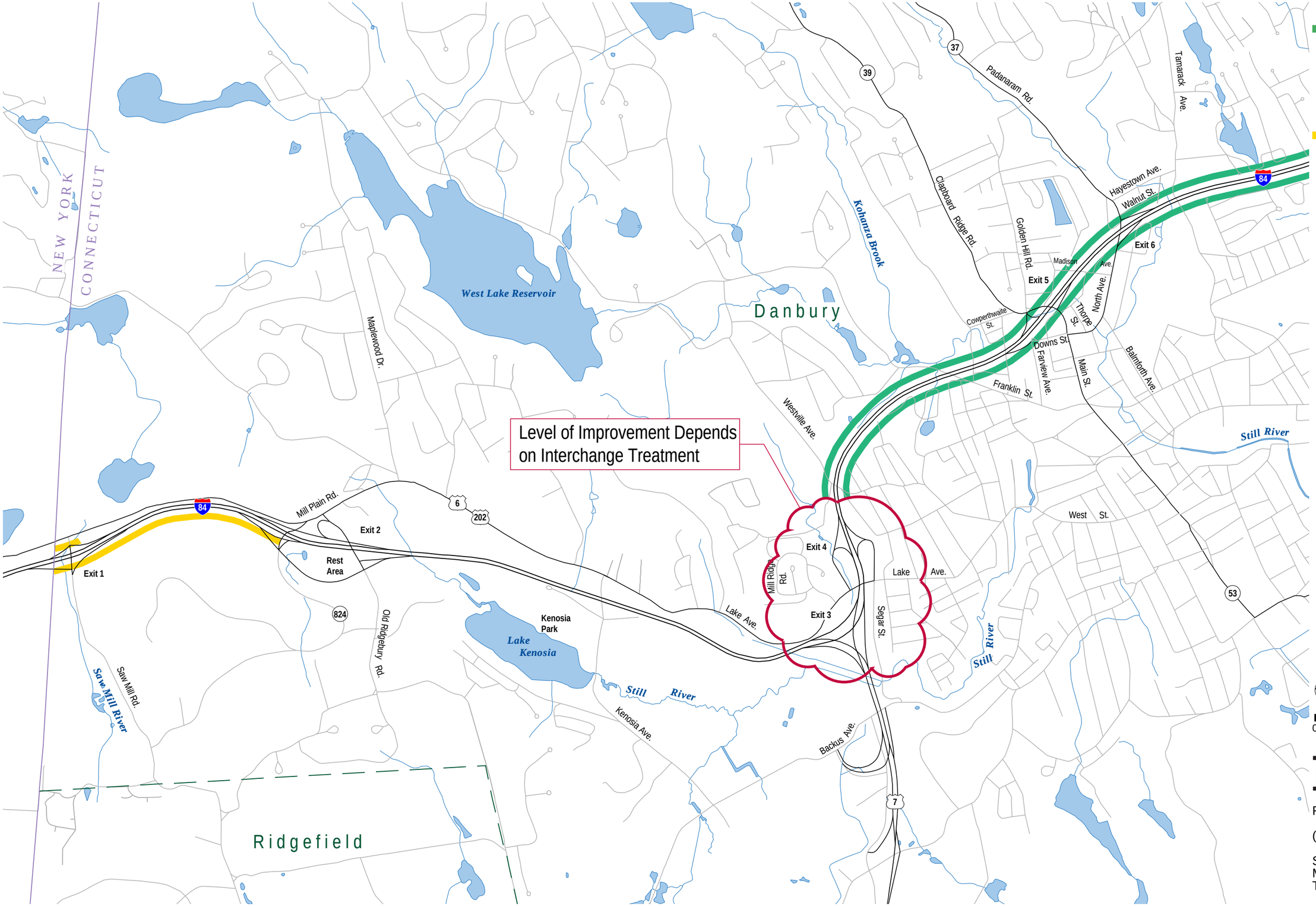
With Regard to Adding Capacity:

- Widening I-84 by a travel lane in each direction appears feasible within the existing right-of-way.
- Widening I-84 by a travel lane in each direction generally addresses the projected demands for travel through the year 2025.
- Providing an HOV lane as this part of the widening option is not feasible due primarily to the dispersed employment centers in the study area, ramp configurations along the corridor, and constrained right-of-way.

To accomplish the addition of a general purpose lane through the overlap area (Exits 3 through 7), the only option is to widen onto the existing outside shoulder. In this area, the existing shoulder would be widened and converted to a travel lane and a new shoulder constructed. The best, and most feasible, design approach through

all other areas of the study corridor that warrant capacity expansion, was found to be splitting the widening between the median and the shoulder, due to constraints associated with doing all of the widening within the median. In these locations, the inside shoulder would be widened approximately 2.4 meters (or 8 feet) into the median, the outside shoulder would be widened and converted to a travel lane, and a new shoulder would be constructed. A schematic of the preferred approach to the mainline widening that resulted from the analysis is provided in Figure 5-5.

Analysis of the effects of adding a general purpose lane to the mainline of I-84 through the study area revealed a significant benefit to traffic flow and corridor operations over the next 20 years. Between 2020 and 2025, based on current projections, some segments of the corridor will begin to experience periods of congestion similar to current conditions. Specifically, the segments between Exits 4 and 5, between Exits 6 and 7, and between Exits 7 and 8 westbound, are projected to reach their capacity by this time. The majority of the corridor, however, is projected to operate under capacity through 2025 with the addition of a general purpose lane in each direction.



3-Lane to 4-Lane Cross-Section:

Add +/- 3.6m (12ft) to outside lane

2-Lane to 3-Lane Cross-Section with Shoulder Improvements:

Add +/- 4.2m (14ft) to outside lane and add +/- 2.4m (8ft) to median

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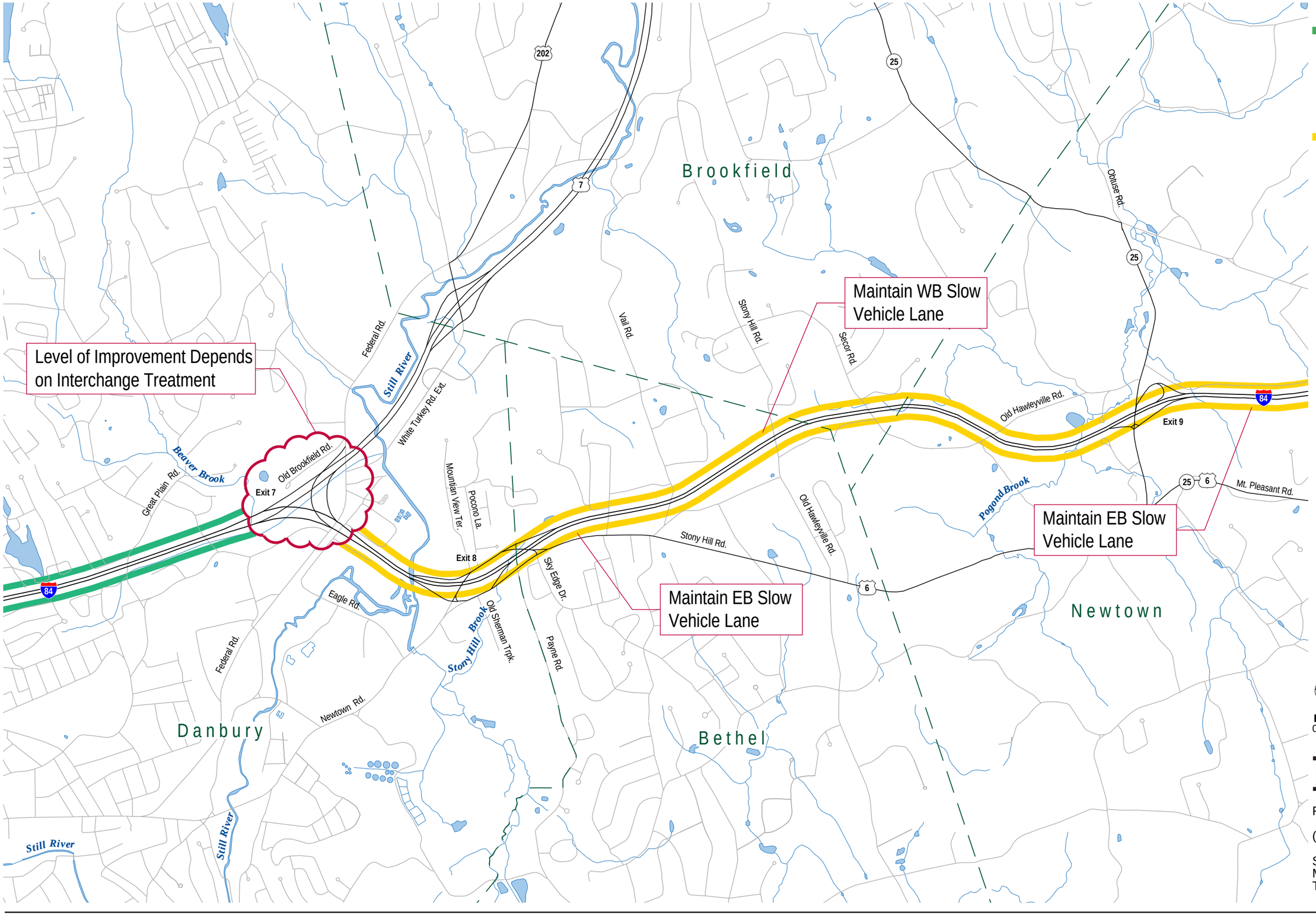
Figure 5-5

(Sheet 1 of 3)

Schematic of Preferred Mainline Widening Treatment



3-Lane to 4-Lane Cross-Section:

Add +/- 3.6m (12ft) to outside lane

2-Lane to 3-Lane Cross-Section with Shoulder Improvements:

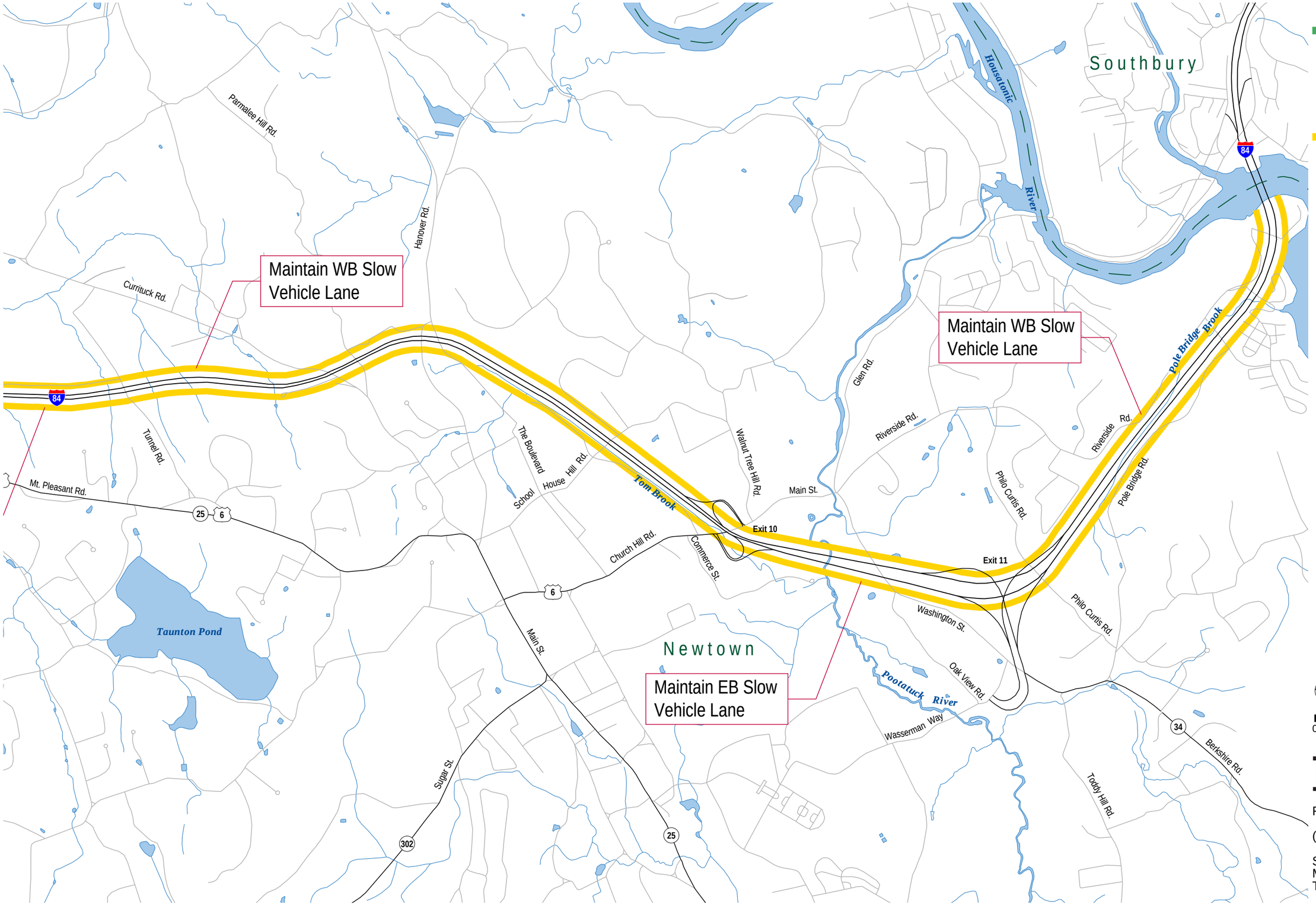
Add +/- 4.2m (14ft) to outside lane and add +/- 2.4m (8ft) to median

I-84 Exits 1-11

Figure 5-5

(Sheet 2 of 3)

Schematic of Preferred Mainline Widening Treatment



3-Lane to 4-Lane Cross-Section:

Add +/- 3.6m (12ft) to outside lane

2-Lane to 3-Lane Cross-Section with Shoulder Improvements:

Add +/- 4.2m (14ft) to outside lane and add +/- 2.4m (8ft) to median

0 1000 2000 Feet

I-84 Exits 1-11

Figure 5-5

(Sheet 3 of 3)

Schematic of Preferred Mainline Widening Treatment